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14. ABSTRACT
Air quality assessments for proposed federal actions are required for compliance with the National Environmental Policy Act, the Clean Air Act and other environment-related regulations and directives. This handbook is a comprehensive guide intended to assist the air quality analyst in assessing the air quality impact of Federal Aviation Administration actions and projects. It provides guidance, procedures and methodologies for use in carrying out such assessments.

Version 3 Update 1 clarifies language on air quality assessment determinations and improves equation formatting.

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EXECUTIVE SUMMARY

The long-standing relationship between aviation and air quality continues to endure as the aviation industry seeks to (i) develop, expand, and/or improve its facilities, equipment, and procedures; (ii) repair/replace aging infrastructure; and/or (iii) accommodate the forecasted growth in air traffic; while implementing sustainable practices. Meanwhile, air quality regulatory agencies continually strive to safeguard human health and the natural environment from the effects of air pollution – including the air emissions associated with aviation.

In support of this relationship, this *Aviation Emissions and Air Quality Handbook* (the *Handbook*) has been published by the Federal Aviation Administration (FAA) as a tool and resource to assist in the planning and completion of *air quality assessments*[1] conducted for aviation-related projects and/or actions. More specifically, the purpose of this *Handbook* is essentially three-fold:

- To provide guidance, procedures, and methodologies appropriate for use in carrying out air quality assessments prepared in association with FAA-supported projects/actions;
- To help ensure that these air quality assessments meet the requirements of the National Environmental Policy Act (NEPA), the federal Clean Air Act (CAA), and other relevant laws and regulations; and
- To provide a process for users to determine when an air quality assessment is considered necessary, the type of analysis that is appropriate, and the level of effort that is warranted.

Notably, this *Handbook* was prepared for use by the FAA, its lines of business, and offices as well as airport sponsors and/or their representatives that are involved in the assessment of air quality impacts associated with aviation-related projects/actions. However, it is intended that other stakeholders will likewise find it useful including federal/state/local governmental agencies and others with an interest in ensuring that the nation’s airports are continually modernized while safeguarding air quality. By necessity, the *Handbook* is also designed to be used by both seasoned practitioners and newcomers to the aviation air quality assessment process.

The earliest version of the *Handbook* was published in 1982 by the FAA and the U.S. Air Force, was fully revised in 1997, and subsequently updated by *Addendum* in 2004. While some of the materials contained in these earlier versions are reused, it is intended that this version of the *Handbook* replace and supersede these documents. As of the publication of this version of the *Handbook*, previous versions are cancelled. Moreover, as a guidance document, the *Handbook* is not intended to replace laws, regulations, or other requirements pertaining to air quality. This *Handbook* is a guidance document and should not be cited as the source for legal requirements. In the case of any discrepancies or differences found between the laws/regulations and the *Handbook*, users should defer to the specific language and requirements contained in the laws/regulations.

Finally, the contents of the *Handbook* are organized around a framework of topics and sections that build upon one another in a progressive fashion. However, for those that wish to focus on particular topics of interest, each section is designed to be self-supporting and comprehensive. To aid in the understanding and use of this material, a set of Appendices are also provided that present detailed "how to" instructions, examples and further explanation.

For general questions regarding this *Handbook* contact the FAA Office of Environment and Energy (AEE), Emissions Division.

[1] For the purpose of this *Handbook* an air quality assessment encompasses both the qualitative and the technical aspects of assessing air quality such as performing air emissions inventories, dispersion modeling, etc., as well as determining whether compliance with the CAA, NEPA, and if applicable, other state and local air regulations is achieved.

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1. Introduction and Background

This section discusses the purposes for which this *Aviation Emissions and Air Quality Handbook* (the *Handbook*) was prepared, the intended audience, its primary objectives, and its contents.

1.1. Purpose of This Handbook

This *Handbook* has been published by the Federal Aviation Administration (FAA) as explanatory guidance, and is a tool and resource designed to assist the FAA and others that are responsible for the planning, organization, and completion of air quality assessments for aviation-related projects and/or actions. Following the guidance in this *Handbook* will help to ensure that air quality assessments for these projects/actions are comprehensive, consistent, and appropriate for use in the disclosure and decision-making processes.

The effects on air quality from aviation and aviation-related developments and operations have long been an important and significant subject matter. On one hand, airports perform vital civic and economic functions by serving scheduled and unscheduled operations of air carriers which enable the transportation of passengers and cargo safely and efficiently across the country and throughout the world. For over 100 years, airports (including general aviation [GA] airports) have remained among the enabling resources for progress and prosperity within the communities they serve. On the other hand, air pollutants associated with aircraft and other airport emission sources are an inevitable consequence of these activities and can have impacts on local and regional air quality.

This long-term connection between aviation and air quality has been growing in importance as the aviation industry seeks to (i) develop, expand, and/or improve their facilities, equipment, and procedures; (ii) repair/replace aging infrastructure; and/or (iii) accommodate the forecasted growth in air traffic; while implementing sustainable practices. Meanwhile, air quality regulatory agencies continually strive to safeguard human health and the natural environment from the effects of air pollution – including the air emissions associated with aviation.

Historically, the junction where aviation and air quality most often intersects is in the federal Clean Air Act (CAA) and other environmental-related regulations and directives which are often discussed in environmental documents prepared in accordance with the National Environmental Policy Act (NEPA) (discussed in greater detail in **Section 2**, *Regulatory Framework*). In short, such rules and requirements mandate that the air quality impacts associated with federal actions and projects do, in the case of the CAA, not cause, or worsen, violations of relevant air quality standards, criteria and/or thresholds and environmental impacts are disclosed under NEPA to the public.

For the FAA, these demonstrations of disclosure and compliance for air quality are regularly accomplished in conjunction with the more encompassing environmental analyses of aviation-related projects/actions conducted under NEPA as part of Environmental Assessments / Environmental Impact Statements (EAs/EISs) and/or in association with General Conformity Determinations performed under the CAA. In many cases, the air quality analysis is an integral component of these assessments. Therefore, in support of the documentation of these air quality assessments, the purpose of this *Handbook* is essentially three-fold:

- To provide guidance, procedures, and methodologies appropriate for use in carrying out air quality assessments prepared in association with FAA-supported projects and/or actions;
- To help ensure that these air quality assessments adequately disclose air quality impacts in accordance with NEPA and meet the requirements of the General Conformity Rule and NAAQS of the CAA; and
- To provide a process for users to determine when an air quality assessment is considered necessary, the type of analysis that is appropriate, and the level of effort that is warranted.

1.2. Intended Users of the *Handbook*

This *Handbook* was purposefully prepared for use by the FAA, its lines of business, and staff offices as well as airport sponsors and/or their representatives that are involved in the assessment of air quality impacts associated with aviation-related projects and/or actions. In addition, other stakeholders may also find it useful including the U.S. Environmental Protection Agency (EPA), federal, state/local governmental agencies, and others with an interest in ensuring that the nation's airports are continually modernized while safeguarding the nations' air quality. Notably, the *Handbook* is designed to be used by both seasoned practitioners and newcomers to the air quality assessment process.

1.3. Use of the *Handbook*

This *Handbook* was developed to assist the FAA, its partner agencies, and other stakeholders in assessing aviation-related air quality impacts associated with a wide assortment of aviation/airport projects and/or actions. Therefore, it is necessarily broad and extensive. Moreover, it cannot be expected to provide the level of detail necessary for every type of project, action, or circumstance. Rather, it is designed to provide the user with a sufficient overview of the overall approaches and the assessment methods for conducting the analyses.

The earliest version of the *Handbook* was published in 1982 by the FAA and the U.S. Air Force. This document was fully updated in 1997 by the FAA and subsequently updated by *Addendum* in 2004. While some of the materials contained in these earlier versions are reused, it is intended that this version of the *Handbook* replace and supersede these documents. As of the publication of this version of the *Handbook*, previous versions are cancelled. However, as a technical manual or guidance document, the *Handbook* is not intended to replace laws, regulations, or other requirements pertaining to airport air quality. In the case of any discrepancies or differences found between these and the *Handbook*, readers should defer to the specific language and requirements contained in the governing documents.

1.4. Contents of the *Handbook*

The contents of the *Handbook* are organized around a framework of topics and sections that build upon one another in a progressive fashion. However, for those that wish to focus on particular topics of interest, each section is designed to be self-supporting and comprehensive. The following provides a summary description of each section:

- ***Section 1: Introduction and Background*** – Provides basic and introductory information that helps the user to understand why this *Handbook* was created, its intended audience, and the overall objectives.
- ***Section 2: Regulatory Framework*** – Identifies and summarizes pertinent regulations (e.g., acts, laws, policies, standards, etc.) that stipulate or drive the need for an air quality assessment.
- ***Section 3: Sources and Types of Air Emissions*** – Describes the most common sources of air emissions associated with aviation, including the types of emissions that typically characterize each source.
- ***Section 4: Air Quality Assessment Process*** – Discusses and delineates the overall approach to assessing air quality impacts associated with aviation-related projects, actions, and activities. Flowcharts and matrices are provided to help guide the process of selecting which assessment method(s) is most appropriate.
- ***Section 5: Air Quality Assessment Models*** – Describes the various assessment models that are available and recommended to conduct aviation-related air quality assessments. Typical data requirements and documentation of the results are also discussed.
- ***Section 6: Preparing an Emissions Inventory*** – Describes the recommended methods for preparing aviation-related emission inventories for the EPA "criteria" pollutants, hazardous air pollutants (HAPs), and greenhouse gases (GHGs) and for reporting the results of these analyses.
- ***Section 7: Conducting Dispersion Modeling*** – Describes the recommended methods for conducting atmospheric dispersion modeling around airports and airport roadways and for reporting the results of these analyses.
- ***Section 8: Conformity*** – Discusses the Conformity regulations of the federal CAA and how it applies to airport projects and actions.
- ***Section 9: Coordination Best Practices*** – Discusses the objectives, benefits, and methods of conducting agency coordination in support of aviation-related air quality assessment processes.

To aid in the comprehension and use of this material, a ***Glossary***, lists of ***References***, and ***Acronyms*** and ***Abbreviations*** are provided at the end of the *Handbook*. A set of ***Appendices*** are also provided that present detailed "how to" instructions, examples and further explanation.

2. Regulatory Framework

With a focus on aviation-related projects and/or actions, this section identifies and summarizes pertinent regulations (e.g., acts, laws, policies, standards, etc.) that stipulate, or drive, the purpose(s) and need(s) for conducting an air quality assessment.

2.1. National Environmental Policy Act

In 1970, the National Environmental Policy Act (NEPA), and its amendments, established a broad national policy to protect the quality of the human environment and provide for the establishment of a Council on Environmental Quality (CEQ). The act provides polices and goals to ensure that environmental considerations are given careful attention and appropriate weight in all decisions of the federal government. The NEPA environmental review process discloses these impacts on the human environment including, but not limited to, impacts to the "natural environment", air quality, biological resources, water resources, noise, induced socioeconomic impacts, and land uses that result from federal actions. It should reflect a thorough review of all relevant environmental factors, utilizing a systematic, interdisciplinary approach. Major federal actions potentially subject to NEPA include grants, loans, contracts, leases, construction, research, rulemaking, and regulatory actions, certifications, licensing, and permitting.

As such, the CEQ regulations require a federal agency to evaluate and disclose the potential environmental effects of their actions prior to its implementation. Importantly, the agency must also notify and involve the public in the agency's decision-making process. The regulations emphasize the importance of integrating the NEPA process into early project planning, and of consulting with the appropriate federal, state, and local agencies early in the proceeding.

The regulations also identify and describe the appropriate environmental documents (e.g., Categorical Exclusions [CATEXes], Environmental Assessments [EAs], Finding of No Significant Impact [FONSIs], Environmental Impact Statements [EISs], and Records of Decisions [RODs]) that serve to document compliance with NEPA requirements.

The CEQ oversees the procedural provisions of NEPA and the administration of the NEPA process for all federal agencies. In order to further ensure compliance with the requirements of NEPA, the implementing regulations of CEQ, and other special purpose laws, the FAA has published policies, procedures, and guidance documents that establishes agency procedures for the consideration of environmental impacts associated with aviation- and aviation-related projects/actions. These guidance documents are entitled and summarized as follows[2]:

- FAA Order 1050.1 and accompanying Desk Reference[3] - The order establishes the NEPA process in terms of planning, procedures, content and format, and public participation for FAA actions. It provides an overview of the various NEPA documents.
- FAA Order 5050.4 and accompanying Desk Reference - This order establishes specific guidance for FAA procedures for processing NEPA documents for airport actions under

[2] FAA, *Orders and Notices*, https://www.faa.gov/regulations_policies/orders_notices/.
[3] Revisions to FAA Order 1050.1 are forthcoming along with a Desk Reference; visit https://www.faa.gov/regulations_policies/orders_notices/ for updates to FAA Orders and Notices.

FAA authority. It is recommended for airport personnel, sponsors, and others involved in airport actions when considering environmental impacts.

- FAA Order JO 7400.2 and subsequent Orders - This order prescribes policy, criteria, guidelines, and procedures applicable to the System Operations Services, System Operations Airspace and Aeronautical Information Manual (AIM); Technical Operations ATC Spectrum Engineering Services; the Office of Airport Planning and Programming (APP); the Office of Airport Safety and Standards (AAS); Technical Operations Aviation System Standards (AVN); and the Flight Standards Service (AFS).

2.2. Clean Air Act

The Clean Air Act (CAA)[4] and the Amendments (CAAA) set the overall policy for managing air quality across the nation. The CAA is comprised of seven major Titles, designed to promulgate and implement necessary regulations that would safeguard ambient air:

- *Title I: Provisions for Attainment and Maintenance of National Ambient Air Quality Standards* – Establishes the framework by which outdoor air pollutant levels are measured, evaluated, and if required, reduced;
- *Title II: Provisions Relating to Mobile Sources* – Gives EPA (and in some cases other federal agencies) the ability to establish emissions regulations for engines and fuels;
- *Title III: Air Toxics* – Provides a mechanism to define, assess and control air toxics from major sources;
- *Title IV: Acid Deposition Control* – Identifies special provisions for pollutant emissions that return to the earth in acidic rain, fog, or snow and are shown to damage ecosystems, and structures, and impact health;
- *Title V: Permits* – Mandates eligible air emissions sources to secure and maintain an operating permit such that all applicable requirements of the CAA are met;
- *Title VI: Stratospheric Ozone and Protection of the Global Climate* – Pursuant to the Montreal Protocol of 1990, identifies a timeline by which substances with stratospheric ozone depleting potential will be phased out; and
- *Title VII: Provisions Relating to Enforcement* – Identifies a broad array of authorities and penalties designed to enhance the enforceability of the CAA.

Of the seven Titles listed, the subjects discussed in subsequent sections of this *Handbook* pertain mostly to *Titles I, II,* and *III*.

[4] CAA Public Law 88-206, http://www.epw.senate.gov/envlaws/cleanair.pdf.

2.2.1. National Ambient Air Quality Standards

EPA has promulgated National Ambient Air Quality Standards (NAAQS)[5] to safeguard public health and environmental welfare against the detrimental effects of outdoor air pollution. Primary NAAQS are health-based standards geared toward protecting sensitive or at-risk portions of the population such as asthmatics, children, and the elderly. Secondary NAAQS are welfare oriented and are designed to prevent decreased visibility and damage to animals, vegetation, and physical structures.

NAAQS have been established for six criteria air pollutants shown in **Table 2-1** (*National Ambient Air Quality Standards*) and they include carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM), and sulfur dioxide (SO_2). EPA periodically reviews the NAAQS to determine if revisions or supplements are warranted.

Table 2-1. National Ambient Air Quality Standards

Pollutant		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)[1]		Primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead (Pb)[2]		Primary and Secondary	Rolling 3 month average	0.15 $\mu g/m^3$ [3,7]	Not to be exceeded
Nitrogen Dioxide (NO_2)[3]		Primary	1-hour	100 ppb	98th percentile, averaged over three years
		Primary and Secondary	Annual	53 ppb[8]	Annual mean
Ozone (O_3)[4]		Primary and Secondary	8-hour	0.075 ppm[9]	Annual fourth-highest daily maximum 8-hr concentration, averaged over three years
Particulate Matter[5]	$PM_{2.5}$	Primary	Annual	12 $\mu g/m^3$	Annual mean, averaged over three years
		Secondary	Annual	15 $\mu g/m^3$	Annual mean, averaged over three years
		Primary and secondary	24-hour	35 $\mu g/m^3$	98th percentile, averaged over three years
	PM_{10}	Primary and Secondary	24-hour	150 $\mu g/m^3$	Not to be exceeded more than once per year on average over three years
Sulfur Dioxide (SO_2)[6]		Primary	1-hour	75 ppb[10]	99th percentile of 1-hour daily maximum concentrations, averaged over three years
		Secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

Source: EPA, *National Ambient Air Quality Standards (NAAQS)*, 2013, http://www.epa.gov/air/criteria.html.
Notes: ppb = parts per billion, ppm = parts per million, $\mu g/m^3$ = micrograms per cubic meter of air.
Federal Registers: [1] 76 FR 54294, [2] 73 FR 66964, [3] 75 FR 6474 and 61 FR 52852, [4] 73 FR 16436, [5] 78 FR 3086, [6] 75 FR 35520, and 38 FR 25678.
[7] Final rule signed October 15, 2008. The 1978 lead standard (1.5 $\mu g/m^3$ as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.
[8] The official level of the annual NO_2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard.
[9] Final rule signed March 12, 2008. The 1997 ozone standard (0.08 ppm, annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years) and related implementation rules remain in place. In 1997, EPA revoked the 1-hour ozone standard (0.12 ppm, not to be exceeded more than once per year) in all areas, although some areas have continued obligations under that standard ("anti-backsliding"). The 1-hour ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is less than or equal to 1.
[10] Final rule signed June 2, 2010. The 1971 annual and 24-hour SO_2 standards were revoked in that same rulemaking.

5 Title 40 CFR Part 50 – National Primary and Secondary Ambient Air Quality Standards, http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&tpl=/ecfrbrowse/Title40/40cfr50_main_02.tpl.

However, these standards remain in effect until one year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.

2.2.2. Attainment/Nonattainment Areas

Within two years of promulgating a NAAQS, EPA must work with state and local governance to designate areas as either meeting or not meeting the NAAQS based on the most recently available air monitoring data. Areas possessing monitored outdoor air concentrations within the NAAQS are considered "Attainment" areas; areas possessing outdoor air concentrations in excess of the NAAQS are considered "Nonattainment". Once a nonattainment area meets the NAAQS and additional redesignation requirements in the CAA[6], EPA will designate the area as a "Maintenance area." (See **Section 8**, *Conformity,* for more information on attainment/nonattainment areas.)

2.2.3. State Implementation Plans

The State Implementation Plan (SIP) is a collection of air quality measurements, modeling, regulations, controls, programs, and other measures used to identify air quality issues and to remedy or prevent violations of the NAAQS. Within three years of the promulgation of a NAAQS, states must submit an "Infrastructure SIP" to EPA regardless of whether or not there are any designated nonattainment or maintenance areas in their jurisdiction. The purpose of the Infrastructure SIP is to demonstrate that a state has the legal authority, regulatory structure, and necessary resources to implement and enforce the NAAQS as required by the CAA.

Additional types of SIPs are required for nonattainment and maintenance areas and include the following (as applicable):

- *Attainment Demonstration* – Contains ambient monitoring, emissions inventory, modeling, and proposed control strategies for the initial year, interim year(s), and attainment year as established by the CAA supporting a demonstration to EPA that the NAAQS will be attained by CAA-required deadlines;
- *Control/Program SIP* – Documents the initiation or revision of specific control measures necessary to demonstrate attainment or otherwise show CAA compliance (e.g., vehicle inspection/maintenance programs, fee programs, and reasonably-available control technologies);
- *Maintenance Plan* – Once a nonattainment area attains and continues to attain the NAAQS for three years, a maintenance plan is required to show EPA that the NAAQS will be attained for a period of 10 to 20 years; and
- *Milestone/Progress SIP* – Also known as Rate of Progress or Reasonable Further Progress Plans (ROP/RFP), these are only required for certain O_3 nonattainment areas, showing that plans and controls designed to attain the NAAQS will decrease nonattainment area emissions by at least 15 percent in the first six years and by 9 percent every three years thereafter until the standard is attained.

6 See Section 107(d) (3) (E) of the CAA.

Special purpose plans can also be prepared to address unique issues in select nonattainment or maintenance areas, such as transport of pollutants across large areas in the case of O_3, and the formation of regional haze in the case of PM.

2.2.4. General/Transportation Conformity Rules

The General Conformity Rule of the CAA ensures that actions occurring in EPA-designated NAAQS nonattainment or maintenance areas that receive federal funding, support, approval, or permitting are accounted within, or do not in any way interfere with, the attainment strategy of an EPA-approved SIP(s).[7]

The Transportation Conformity Rule of the CAA governs the federal funding and approval of highway and transit projects occurring in NAAQS nonattainment or maintenance areas such that these activities will not cause new NAAQS violations, exacerbate existing violations, or otherwise interfere with an area's attainment strategy outlined within an EPA-approved SIP(s).[8]

General and Transportation Conformity applicability to airport actions, analysis considerations, coordination points and demonstration options are discussed in **Section 8** *(Conformity).* Areas where General Conformity, Transportation Conformity, and NEPA requirements interface with one another are also highlighted.

2.2.5. Indirect Source Review

Indirect source review (ISR) requirements are state-specific, and in some states it may be required as part of their SIP when proposed federal actions are located in nonattainment or maintenance areas. Indirect sources may include highways, parking facilities, sports and entertainment facilities, and office buildings. Any applicable indirect source requirements should be identified as early as possible during the NEPA scoping process and described in the NEPA documentation.

The states that require ISR generally establish thresholds for the applicability of ISR. For example, a state may require ISR for all projects that increase total airport throughput at an airport by more than 100,000 passengers per year, add 1,000 new parking spaces, or increase aircraft operations by 1,000 per year. Projects that exceed the thresholds could be required to complete an indirect source analysis and obtain an indirect source permit.[9]

2.3. Regulatory Agencies

There is a wide range of federal, state, and local governmental agencies that are involved in air quality management throughout the U.S. The primary regulatory agencies with jurisdiction in the management of air quality as it pertains to FAA-supported activities are summarized in **Table 2-2** (*Regulatory Agencies*) along with synopses of their roles and responsibilities.

[7] EPA, *General Conformity*, http://www.epa.gov/air/genconform/.
[8] EPA, *Transportation Conformity*, http://www.epa.gov/OMS/stateresources/transconf/.
[9] FAA Order 1050.1 and accompanying Desk Reference, https://www.faa.gov/regulations_policies/orders_notices/.

Table 2-2. Regulatory Agencies

Agency	Roles and Responsibilities
U.S. Environmental Protection Agency (EPA)	Sets national clean air policies under the CAA, establishes emissions standards, promulgates the NAAQS, reviews and approves air quality plans.
Federal Aviation Administration (FAA)	Responsible for implementing NEPA and ensuring CAA compliance as it pertains to aviation actions. Coordinates with EPA on the environmental regulation of aviation equipment and fuels.
Federal Highway Administration (FHWA)	Responsible for the approval of roadway projects under FHWA existing regulations and must examine the environmental impacts of their actions in accordance with NEPA and the Transportation Conformity Rule of the CAA. Assists state and local air quality governance in formulating local transportation plans.
Metropolitan Planning Organizations (MPO)	Local governmental agencies with direct responsibility to prepare air quality-related transportation plans. Also assist in local planning with regard to development of local control strategies for on-road and non-road mobile sources.
State Air Quality Agencies	Implement and enforce air quality programs state-wide including those pertaining to ambient air monitoring, stationary source permitting and smoke management. Also involved in the development of air quality plans in EPA-designated nonattainment or maintenance areas.

3. Sources and Types of Air Emissions

This section discusses the various types of emission sources associated with aviation and the principal types of emissions associated with these sources.

3.1. Emission Sources

A variety of emission sources are associated with aviation, in general, and at airports, in particular. To account for this variation, and for the purpose of this *Handbook*, these emission sources have been grouped in to the following six categories:

- Aircraft[10]
- Auxiliary Power Units
- Ground Support Equipment
- Stationary/Area[11]
- Ground Access Vehicles
- Construction

3.1.1. Aircraft

Aircraft emissions sources are typically associated with the aircraft main engines. The types of aircraft include commercial (air carrier and cargo), air taxi, GA, and military aircraft.

Commercial aircraft are operated on a scheduled basis by civilian international, national, regional, and commuter air carriers but are also operated on an unscheduled basis by civilian charter operators. Cargo aircraft are designed for the commercial transport of freight. Air taxis are non-air carrier commercial operators that fly scheduled service carrying passengers and freight on a limited basis. GA aircraft are privately owned and operated on a non-scheduled basis at a variety of facilities ranging from large commercial airports to small privately-owned airports. Military aircraft are operated by the U.S. Department of Defense (DOD) and include the full spectrum of aircraft types, ranging from high performance jet fighters to large transports to small piston engine training aircraft. Most military aircraft operations occur at DOD-operated air bases, but many operations also take place at joint-use and/or civilian airports.

The aircraft main engine(s) is what propels the aircraft forward and is generally classified as either a gas turbine turbofan, turbojet, or turboprop engine fueled with aviation kerosene (i.e., jet fuel or Jet A) or an internal combustion piston engine fueled with aviation gasoline (commonly known as “Avgas” or 100 octane low-lead “100LL”). Aircraft engines produce emissions from the combustion of fuel which varies depending on aircraft engine type, fuel type, number of

[10] For the purpose of this *Handbook*, rotorcraft and commercial space vehicle are not considered as part of this source category.

[11] The stationary and area sources found at airports are typically categorized as either combustion sources or non-combustion sources. Combustion sources may include boilers and heaters, generators, snowmelters, incinerators, fire training facilities, and aircraft engine testing. Non-combustion sources may include fuel storage tanks, cooling towers, coating and painting operations, de-icing and anti-icing operations, solvent degreasing, salt and sand piles.

engines, power settings, amount of fuel burned, and other variables (e.g., temperature, altitude, etc.).

Computational methods and modeling techniques for assessing aircraft engine emissions are discussed in **Section 6** (*Preparing an Emissions Inventory*) and **Section 7** (*Conducting Dispersion Modeling*). For detailed instructions and guidance on how to compute aircraft engine emissions refer to **Appendix A1** (*Aircraft Emission Inventory for Criteria Pollutants*) of this *Handbook.*

3.1.2. Auxiliary Power Units

Auxiliary Power Units (APUs) are smaller turbine engines that provide power to an aircraft during approach, while taxiing, or positioned at the terminal gate. APUs power the aircraft's instruments, lights, heat and air conditioning, and other equipment and are used for starting the main aircraft’s engines. APUs burn jet fuel and is common on both large commercial and military aircraft and some air taxi and GA aircraft.

APUs typically remain in use while the aircraft is parked and serviced at the gate, unless an alternative source of electricity and preconditioned air is made available. In such cases, APUs are reactivated at least five to ten minutes before the aircraft leaves the gate or parking space. Normally, APUs are turned off after the main engines have been started, prior to takeoff.

Computational methods and modeling techniques for assessing APU emissions are discussed in **Section 6** (*Preparing an Emissions Inventory*) and **Section 7** (*Conducting Dispersion Modeling*). For detailed instruction and guidance on how to compute APU emissions refer to **Appendix A2** *(Auxiliary Power Units Emission Inventory for Criteria Pollutants*).

3.1.3. Ground Support Equipment

Ground Support Equipment (GSE) is a term used to describe the equipment that service aircraft while loading and unloading passengers and freight at an airport. The types of GSE and their use depend on the aircraft type and the designated category of an aircraft operation (e.g., passenger, cargo, etc.). GSE consist of aircraft tugs, air start units, forklifts, tractors, air-conditioning units, ground power units (GPUs), baggage tugs, belt loaders, fuel or hydrant trucks, catering trucks, cabin trucks, deicer trucks, water trucks, lavatory trucks, and cargo loaders, among others.

Air emissions resulting from the operation of GSE vary depending on the number and type of equipment used to service each aircraft, along with the duration of equipment operation per aircraft landing-takeoff (LTO) cycle and the fuel type (e.g., gasoline, diesel, propane, electric, etc.).

Computational methods and modeling techniques for assessing GSE emissions are discussed in **Section 6** (*Preparing an Emissions Inventory*) and **Section 7** (*Conducting Dispersion Modeling*). For detailed instruction and guidance on how to compute GSE emissions refer to **Appendix A3** (*Ground Support Equipment Emission Inventory for Criteria Pollutants*).

3.1.4. Ground Access Vehicles

Ground access vehicles encompass motor vehicles traveling upon on- and off-airport roadways, within airport parking facilities, and idling along terminal curbsides. These include airport passenger vehicles (e.g., private autos, taxis/limos, shuttles, vans, buses, rental cars, etc.);

vehicles transporting airport and tenant employees; and vehicles transporting cargo to and from the airport.

Air emissions associated with these vehicles are a function of traffic volumes and speeds, distances traveled, vehicle operating characteristics, fuel type, and ambient conditions.

Computational methods and modeling techniques for assessing ground access vehicles emissions are discussed in **Section 6** (*Preparing an Emissions Inventory*) and **Section 7** (*Conducting Dispersion Modeling*). For detailed instruction and guidance on how to compute ground access vehicles emissions refer to **Appendix A4** (*Ground Access Vehicle Emission Inventory for Criteria Pollutants*).

3.1.5. Stationary and Area Sources

Stationary and area sources of air emissions at airports consist of both fuel combustion and non-combustion sources. Typical sources include boilers, heaters, generators, snowmelters, incinerators, live-fire training facilities, aircraft engine testing, fuel storage tanks, cooling towers, coating and painting operations, de-icing and anti-icing operations, solvent degreasers and sand/salt piles.

Air emissions associated with fuel combustion are a function of equipment type, equipment size, fuel type, combustion processes and air emission control measures. Non-combustion sources typically emit evaporative emissions (e.g., fuel storage tanks) and/or fugitive dust emissions (e.g., sand and salt piles).

Assessment methods and modeling tools for calculating stationary/area source emissions are discussed in **Section 6** (*Preparing an Emissions Inventory*) and **Section 7** (*Conducting Dispersion Modeling*). For detailed instruction and guidance on how to compute stationary/area emissions refer to **Appendix A5** (*Stationary Sources Emission Inventory for Criteria Pollutants*).

3.1.6. Construction

Construction activities are temporary and variable depending on location, duration, and level of activity and are generally confined to a construction site and access/egress roadways. These emissions occur predominantly from the operation of heavy construction equipment (e.g., backhoes, bulldozers), on- and off-road vehicles used for the transport and delivery of supplies and material (e.g., cement trucks, dump trucks), and on-road vehicles used by construction workers getting to and from a construction site (e.g., cars, pick-up trucks). Construction emissions also include fugitive dust produced from construction materials staging, demolition, and earthwork activities, as well as evaporative emissions from asphalt paving operations.

Assessment methods and models for calculating construction-related emissions are discussed in **Section 6.1.2** (*Airport Construction Emissions).* For detailed instruction and guidance on how to compute construction-related emissions refer to **Appendix A6** (*Construction Emission Inventory for Criteria Pollutants*).

3.1.7. Other Sources

Other sources of air emissions associated with aviation, in general, and airports, in particular that are of emerging interest because of their connection to GHG emissions include the following:

- Electrical Usage – Emissions associated with the onsite generation of electricity using coal, oil, or natural gas;
- Refrigerants – A range of chemicals used for refrigeration and air conditioning that are comprised of substances possessing high global warming characteristics (e.g., Freon, chlorofluorocarbons, etc.); and
- Waste Management – Emissions associated with the solid waste generated and the recycling and solid waste disposal practices employed by the airport.

3.2. Pollutants of Concern

There are a variety of air pollutants associated with aviation-related activities that can potentially have an impact on the environment. This section identifies and discusses these pollutants which consist of EPA's criteria pollutants and their precursors, GHGs, and HAPs.

3.2.1. Criteria Pollutants

As discussed in **Section 2** (*Regulatory Framework*), the EPA has established the NAAQS under the CAA for six common air pollutants known as "criteria pollutants". These air pollutants consist of CO, Pb, NO_2, O_3, PM, and SO_2. The criteria pollutants are generally described in **Table 3-1** (*EPA Criteria Air Pollutants*).

Table 3-1. EPA Criteria Air Pollutants

Pollutant	General Characteristics
Carbon Monoxide (CO)	Carbon monoxide is a colorless, odorless, tasteless gas that is a product of incomplete combustion of organic materials. In the ambient environment, it may temporarily accumulate into localized "hot-spots", especially in calm weather conditions and in the wintertime when CO forms easily and is chemically most stable. In humans, CO can be absorbed by the lungs and react with hemoglobin to reduce the oxygen-carrying capacity of the blood. At elevated concentrations CO can have cardiovascular and central nervous system effects.
Lead (Pb)	Lead is a heavy metal that occurs in the atmosphere as lead oxide aerosol or lead dust. Lead is most commonly associated with emissions from industrial sources including incineration, steel production, smelting, and battery manufacturing. Most avgas (general aviation fuel for piston engines) also contains Pb. Lead is a highly stable compound that accumulates in the environment and in living organisms. In humans, Pb exposures can interfere with the maturation and development of red blood cells, affect liver and kidney functions, and cause nervous system damage.
Nitrogen Dioxide (NO_2)	Nitrogen dioxide is a reddish-brown to dark brown gas with an irritating odor. NO_2, nitric oxide (NO), and the nitrate radical (NO_3) are collectively called oxides of nitrogen (NO_x). These three compounds are interrelated, often changing from one form to another in chemical reactions. The principal man-made source of NO_x is fuel combustion in motor vehicles and power plants with aircraft also contributing. NO_2 emissions from these sources are highest during high-temperature combustion conditions. Reactions of NO_x with other chemicals (such as VOCs) can lead to O_3 formation and acidic precipitation. Additionally, secondary PM can be formed within the atmosphere from precursor gases, such as NO_x, through gas-phase photochemical reactions or through liquid phase reactions in clouds and fog droplets. In humans, NO_2 can be a lung irritant capable of producing pulmonary edema at high concentrations and can lead to other respiratory illnesses such as bronchitis and pneumonia.

Table 3-1. EPA Criteria Air Pollutants

Pollutant	General Characteristics
Ozone (O_3)	Ozone occurs both in the earth's upper atmosphere and at ground level. O_3 occurs naturally in the upper atmosphere, where it forms a protective layer that shields the earth from the sun's harmful ultraviolet rays. Tropospheric, or ground level O_3, is not emitted directly into the air, but is a result of VOCs and NO_x reacting in the presence of sunlight in the atmosphere. Typically, O_3 levels are highest in warm-weather months. VOCs and NO_x are termed "ozone precursors" and their emissions are regulated in order to control the creation of O_3. VOCs, which are a subset of hydrocarbons (HC), are released in industrial processes, mobile sources and from the evaporation of gasoline, solvents and other hydrocarbon-based compounds. In humans, O_3 is a pulmonary irritant that affects the respiratory mucous membranes, other lung tissues, and respiratory functions. Exposure to O_3 at high concentrations can result in symptoms such as tightness in the chest, coughing, and wheezing, and can trigger an attack or exacerbate the symptoms of asthma, bronchitis, and emphysema.
Particulate Matter (PM)	Particulate matter is made up of small solid particles and liquid droplets suspended or settling out of the atmosphere. PM consists of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. PM can be formed from both natural and man-made sources including forest fires and wind erosion over exposed soils (i.e., fugitive dust); the incineration of solid wastes; and as an exhaust product from the internal combustion engine. Of growing concerns are the effects of PM on visibility and the potential impairment to human health by small PM (i.e., ultrafine particle emissions or $PM_{0.1}$). The regulatory standards for PM are segregated by sizes: less than or equal to 10 micrometers (denoted PM_{10}) and less than or equal to 2.5 micrometers (denoted $PM_{2.5}$). • PM_{10} represents the category of particulates categorized as "inhalable coarse" PM (i.e., with an aerodynamic diameter of 10 microns or less). PM_{10} includes solid and liquid material suspended in the atmosphere. Formed as a result of incomplete fuel combustion, industrial processes, or wind erosion, examples of PM_{10} include dust, fog, and fumes. The level of PM_{10} in the atmosphere is largely affected by wind and rainfall conditions. • $PM_{2.5}$ represents the category of particulates categorized as "fine" PM (i.e., with an aerodynamic diameter of 2.5 microns or less). These particles are more characteristically formed from the combustion of fuel, other industrial processes and various industrial processes. PM_{10} and $PM_{2.5}$ are considered a health risk in humans because of their ability to penetrate into the human respiratory system.
Sulfur Dioxide (SO_2)	Sulfur dioxide is a colorless gas also with a strong characteristic odor. SO_2 is emitted into the atmosphere by both natural processes and by man-made sources such as the combustion of sulfur-containing fuels and sulfuric acid manufacturing. When combined with other substances in the air, SO_2 can precipitate out as rain, fog, snow, or dry particles (commonly referred to as "acid rain"). Sulfate particles are a major cause of reduced visibility in many areas of the U.S. In humans, the inhalation of elevated concentrations of SO_2 can cause irritation of the mucous membranes, bronchial damage, and can exacerbate pre-existing respiratory diseases such as asthma, bronchitis, and emphysema.

Source: EPA, *Six Common Air Pollutants*, 2013, http://www.epa.gov/airquality/urbanair/.

3.2.2. Hazardous Air Pollutants

Hazardous air pollutants (HAPs) are pollutants for which there are no NAAQS, but are still regulated under the federal CAA because of their potentially adverse effects on human health and the environment. Also known as "air toxics", these pollutants are comprised of a wide array of organic and inorganic compounds (e.g., formaldehyde, 1 acetaldehyde, benzene, toluene, acrolein, 1,3-Butadiene, xylene, lead, naphthalene, propionaldehyde). In relation to aviation sources, such emissions are present in the exhaust of aircraft, APUs, GSE, and motor vehicle engines and, to a lesser extent, from boilers, fuel facilities, and other stationary sources.

For a detailed discussion on how to assess HAPs associated with aviation refer to **Section 6.2** *(Hazardous Air Pollutants)* and **Appendix B** (*Emissions Inventory for Hazardous Air Pollutants*) of this *Handbook*.

3.2.3. Greenhouse Gases

Greenhouse gases (GHGs) [are pollutants for which there are no NAAQS and] are emitted principally from the combustion of fossil fuels, decomposition of waste materials, and deforestation and are linked to an increase in the earth's average temperature by means of a phenomenon called the "greenhouse effect."

According to the Intergovernmental Panel on Climate Change (IPCC) and Executive Order (EO) 13514[12], the six main GHGs whose emissions are related to human activities (e.g. combustion of fossil fuels, agriculture, land use change) are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6), which are typically reported as carbon dioxide equivalents (CO_{2e}).[13]

GHG emissions associated with aviation are principally in the form of CO_2 and are generated by aircraft, APUs, GSE, motor vehicles and an assortment of stationary sources. For the most part, CO_2 emissions from these sources arise from the combustion of fossil fuels (e.g., jet fuel, Avgas, diesel, gasoline, compressed natural gas [CNG]) and are emitted as by-products contained in the engine exhausts. Other GHGs associated with airport operations include CH_4 and N_2O, water vapor (H_2O), soot, and sulfates - but are emitted by airports to a far lesser extent than CO_2. Emissions of HFCs, PFCs, and SF_6 are most commonly linked with refrigeration, air conditioning, and other coolants.

For a detailed discussion on how to assess GHG associated with aviation refer to **Section 6.3** *(Greenhouse Gases)* and **Appendix C** (*Emissions Inventory for Greenhouse Gases*) of this *Handbook.*

Table 3-2 (*Sources of Air Emissions and Pollutants of Concern at Airports)* provides a summary listing of aviation-related sources of air emissions and the types of pollutants they emit.

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12 DOE, Office of Energy Efficiency & Renewable Energy (EERE), http://energy.gov/eere/femp/articles/executive-order-13514.

13 EPA defines CO_{2e} as a metric measure used to compare the emissions from various GHGs based upon their Global Warming Potential (GWP).

Table 3-2. Sources of Air Emissions and Pollutants of Concern at Airports

Source		Pollutants	Characteristics
Aircraft[1]	Main engine(s)	CO, VOC, NO_x, PM_{10} and $PM_{2.5}$, SO_2, Pb, GHGs (i.e., CO_2, CH_4[1], N_2O), and HAPs[2]	Emitted as the exhaust products of fuel combustion in aircraft engines. The quantities and types can vary based on engine power setting and duration of operation. Emissions are generally assessed based on a typical LTO cycle (i.e., taxi and delay, take-off, climb-out, approach, landing, and taxi to gate). Lead emissions are an exhaust product from aircraft fueled with leaded avgas.
APUs	Turbine engine		Emitted as the exhaust products of fuel combustion of the turbine engine. The quantities and types can vary based on engine power setting and duration of operation. Emissions are generally assessed based on a typical LTO cycle (i.e., taxi and delay, take-off, climb-out, approach, landing, and taxi to gate).
GSE	Combustion engines (e.g., aircraft tugs, air start units, loaders, tractors, fuel or hydrant trucks)		Emitted as the exhaust products of fuel combustion from the operation of service trucks and other equipment servicing the aircraft and the airport. Emissions differ by engine type, fuel type and activity level.
Stationary/ Area	Combustion sources (e.g., boilers, heaters, generators, snowmelters, incinerators, fire training facilities)	CO, VOC, NO_x, PM_{10} and $PM_{2.5}$, SO_2, GHGs (i.e., CO_2, CH_4, N_2O), and HAPs[2]	Results from the combustion of fossil fuels. The combustion sources tend to produce a variety of air pollutants that are released to the atmosphere with combustion gases. The level of emissions of these sources is dependent on type of fuel, usage, and duration of operation.
	Non-combustion sources (e.g., fuel storage tanks, painting operations, de-icing and anti-icing operations, salt/sand storage)	VOC, PM_{10}, $PM_{2.5}$, and HAPs[2]	Emit evaporative emissions from vapor displacement and loss during fuel storage and transfer, and upon application of solvents and coatings. Particulate matter emissions can occur during loading and unloading of the piles and through wind erosion of the pile material.
Ground access vehicles	Passenger vehicles e.g., private autos, taxis/limos, shuttles, vans, buses, rental cars), airport and tenant employee vehicles, airport fleet, and vehicles transporting cargo to and from airport as well as circulating around the airport.	CO, VOC, NO_x, PM_{10} and $PM_{2.5}$, SO_2, GHGs (i.e., CO_2, CH_4, N_2O)	Emitted as the exhaust products of fuel combustion from the operation of passenger, employee and other on-road vehicles approaching, departing, and moving within the airport and its parking facilities. Emissions vary depending on vehicle type (e.g., gasoline, diesel, etc.) and the amount of fuel consumed.
Construction	Combustion sources (e.g.,	CO, VOC, NO_x, PM_{10}	Occur predominantly in the engine

	heavy construction equipment, on-road vehicles and off-road vehicles)	and $PM_{2.5}$, SO_2, GHGs (i.e., CO_2, CH_4, N_2O)	exhaust from the operation of construction equipment (e.g., backhoes, bulldozers, graders, etc.), on-road vehicles (e.g., cars, pick-up trucks, vans, etc.) and off-road vehicles (e.g., cement trucks, dump trucks, etc.). Emissions are based on construction activity schedule, number of vehicles/pieces of equipment, the types of equipment, type of fuel used, and vehicle/equipment utilization rates.
	Non-combustion sources associated with construction activities and operations (e.g., construction materials staging, demolition, and earthworks activities, and asphalt paving operations)	PM_{10}, $PM_{2.5}$ and VOC	Evaporative emissions resulting from asphalt paving operations and fugitive dust emissions are from construction materials staging, demolition, clearing and earthworks activities.
Electrical Usage[3]	The onsite generation of electricity using coal, oil, or natural gas.	GHGs (i.e., CO_2, CH_4, N_2O)	Emissions associated with the onsite generation of electricity using coal, oil, or natural gas.
Refrigerants[3]	Compounds used for refrigeration and air conditioning.	GHGs (i.e., HFCs, PFCs and SF_6)	A range of chemicals comprised of substances possessing high global warming characteristics (e.g., Freon, chloroflorocarbons, etc.).
Waste Management[3]	Solid waste generated and the recycling/waste disposal practices employed by the airport.	GHGs (i.e., CO_2, CH_4, N_2O)	Emissions associated with the recycling/waste disposal practices employed by the airport.

[1] Contributions of CH_4 emissions from commercial aircraft are reported as zero. Years of scientific measurement campaigns conducted at the exhaust exit plane of commercial aircraft gas turbine engines have repeatedly indicated that CH_4 emissions are consumed over the full emission flight envelope [Reference: *Aircraft Emissions of Methane and Nitrous Oxide during the Alternative Aviation Fuel Experiment*, Santoni et al., Environ. Sci. Technol., July 2011, Volume 45, pp. 7075-7082]. As a result, the EPA published that: "…m*ethane is no longer considered to be an emission from aircraft gas turbine engines burning Jet A at higher power settings and is, in fact, consumed in net at these higher powers."* [Reference: EPA, *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines*, May 27, 2009 [EPA-420-R-09-901], http://www.epa.gov/otaq/aviation.htm]. In accordance with the following statements in the *2006 IPCC Guidelines* (IPCC 2006), the FAA does not calculate CH_4 emissions for either the domestic or international bunker commercial aircraft jet fuel emissions inventories. "*Methane (CH_4) may be emitted by gas turbines during idle and by older technology engines, but recent data suggest that little or no CH_4 is emitted by modern engines." "Current scientific understanding does not allow other gases (e.g., N_2O and CH_4) to be included in calculation of cruise emissions*." (IPCC 1999).

[2] Not all HAPs are emitted by these sources. To identify the type of HAP emitted by this source category refer to the FAA/EPA documents: *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines (Version 1.0), May 2009 [EPA-420-R-09-901], http://www.epa.gov/nonroad/aviation/420r09901.pdf;* and *Guidance for Quantifying Speciated Organic Gas Emissions from Airport Sources,* Version 1, September 2, 2009, http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/media/Guidance%20for%20Quantifying%20Speciated%20Organic%20Gas%20Emissions%20from%20Airport%20Sources.pdf.

[3] GHG emissions from these sources are strictly related to the "activities" of these sources, and thus not considered under the stationary/area source category.

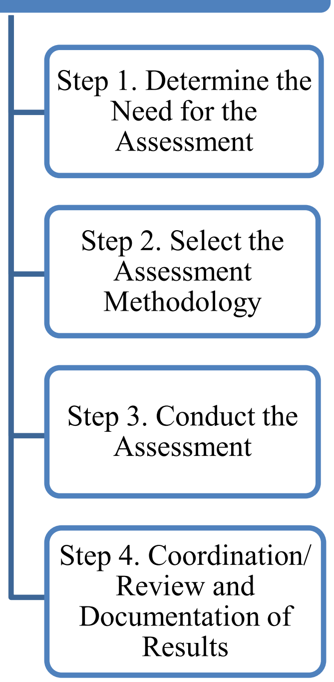
4. Air Quality Assessment Process

As discussed in **Section 1** (*Introduction and Background*), the primary aim of this *Handbook* is to provide guidance in preparing air quality assessments for FAA-supported projects and/or actions. Importantly, the overall premise is that some type of assessment or consideration of air quality is always necessary under NEPA or the CAA - whether it be qualitative or quantitative. Focusing on this principal objective, this section is designed to help *Handbook* users determine what type of air quality assessment is appropriate and to formulate an approach to preparing the assessment.

4.1. The Air Quality Assessment Process

In the most fundamental terms, the air quality assessment process – from conducting an assessment to documenting the results - can be broken down into four steps. As shown in **Figure 4-1** (*Air Quality Assessment Process*) and expanded upon in this section, this process entails the following:

Figure 4-1. Air Quality Assessment Process



Step 1: Determine the Need for the Assessment – The purpose of this initial step is to help determine the overall need and scope for an air quality assessment. It is intended to be broadly applied to all FAA projects based on the project definition as known during the early planning and development stages. As discussed in **Section 4.1.1** *(Step 1: Determine the Need for an Air Quality Assessment),* this step takes into consideration such factors as the FAA's role in the project and the potential significance of the anticipated air quality impacts as well as the "scoping" process (detailed in **Section 9.1**, *Scoping Process*) which is used to identify the most pertinent air quality issues related to a project/action.

Step 2: Select the Assessment Methodology – The purpose of this second step is to determine the type(s) of air quality analyses that are appropriate for the particular project/action. As discussed in **Section 4.1.2** *(Step 2: Select the Assessment Methodology),* the range of analyses comprises a qualitative discussion, emissions inventories of various types and sources of emissions (e.g., operational, construction, etc.), and dispersion modeling (e.g., macroscale and "hot-spot"). In addition, this step can involve agency coordination with the development and application of an "Air Quality Assessment Protocol". The main purpose of the protocol is to document the scope, establish a methodology, and resolve any areas of uncertainty regarding the assessment prior to its undertaking (detailed in **Section 9.2**, *Air Quality Assessment Protocol).*

Step 3: Conduct the Assessment – Once the need and methodology of the air quality assessment has been evaluated and selected, the purpose of this step is to prepare or conduct the air quality assessment. As discussed in **Section 4.1.3** *(Step 3: Conduct the Assessment),* this work may involve selecting the analysis years, identifying the emission types and sources of interest, obtaining and/or developing the necessary input data, and running the appropriate models and/or methodologies.

Step 4: Coordination/Review and Documentation of Results – Once the air quality assessment has been conducted, the purpose of this step is to coordinate and review the analysis with the appropriate agency and to address any comments prior to moving forward with the project/action. Upon completing the coordination/review process, the final step is to properly document the results. As described in **Section 4.1.4** *(Step 4: Document the Results),* this work entails reporting the assessment findings in narrative and other formats that are appropriate, informative and easy to understand to the reviewing agencies and the general public.

Within these four basic steps of the air quality assessment process, there are a number of sub-steps or activities that are typically necessary. The remainder of this *Handbook* section describes the sub-steps to each of the four basic steps.

4.1.1. Step 1: Determine the Need for the Assessment

The initial step in the process is aimed at determining when an air quality assessment is required. As previously discussed, air quality assessments for project/action may be necessary for compliance with the requirements of NEPA, the CAA, and other environmental regulations and directives. In addition, some states and/or local areas have air quality requirements that may also pertain to airports. Therefore, this section provides guidance on determining whether or not an air quality assessment is appropriate. Note that an air quality assessment does not necessarily require creating an emissions inventory or doing dispersion modeling. See Section (4.1.2 ("Step 2: Select the Assessment Methodology") for types of air quality assessments.

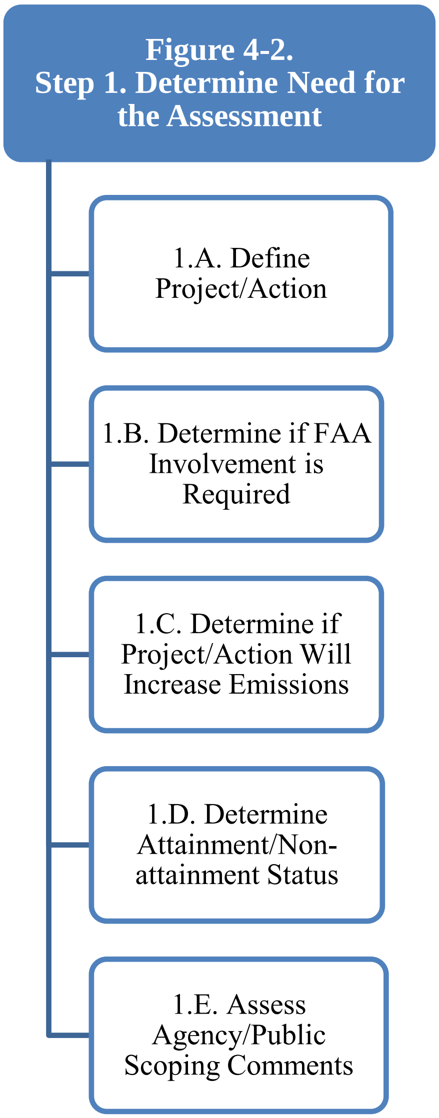


Figure 4-2. Step 1. Determine Need for the Assessment

In most cases, the need to conduct an air quality assessment for FAA-supported projects or actions is project-specific, based largely on the consideration of various factors that, taken together, help to formulate the overall decision-making process. For ease of understanding, several of these factors are identified in **Figure 4-2** (*Determine the Need for the Assessment*) and explained further below. Importantly, this information is intended to be used in conjunction with **Figure 4-3** (*Air Quality Assessment Decision Flow Diagram*) as a means of simplifying the decision-making process.

Step 1.A. Project/Action Definition – The purpose of this step is to define the scope of the proposed project (or action), as well as the alternatives. This basic information provides the necessary knowledge required in subsequent steps to help determine when an air quality assessment is warranted and what type of assessment should be conducted. Such information may comprise (but is not limited to) the proposed changes in the airport layout, supporting facilities and infrastructure, and/or the airport/aircraft operational characteristics. Ideally, the project sponsor's planning process will provide the information and documentation needed to obtain these details.

Step 1.B. Determine FAA's Involvement – This step is to establish whether or not FAA involvement (e.g., approval, funding, permitting, etc.) is associated with the project/action. In those cases where FAA involvement is not required, an air quality assessment for FAA purposes would not be necessary (as there is no FAA action to assess or disclose), but CAA, state/local, and other environmental regulations and directives may still require an air quality assessment. Furthermore, such projects/actions may still be subject to NEPA review, depending on policies and procedures of the project/action sponsor. For example, a proposed roadway interchange or private parking facility located off airport property does not require FAA approval and therefore an air quality assessment for FAA purposes is not warranted, but other directives may require an air quality assessment and/or NEPA review.

This step of the assessment determination process is also to establish if the proposed project/action is being assessed as an environmental impact statement (EIS), environmental assessment (EA), or categorical exclusion (CATEX), using FAA Order 1050.1. If it is classified as a CATEX, further air quality assessment is usually considered unnecessary as there is no significant air quality impact expected. However, the CAA, state/local and other environmental regulations may still require an air quality assessment. Conformity is not determined by NEPA and, depending on where the project is located, may still need to be discussed even if the project is CATEXed. By comparison, an EA or EIS typically includes an air quality assessment commensurate with the project air quality impact to help evaluate and disclose the potential effects on air quality associated with the project.

Step 1.C. Determine if the Project/Action Will Cause or Create a Reasonably Foreseeable Increase in Air Emissions – The principal aim of this step is to determine if the proposed project/action will cause or create a reasonably foreseeable increase in air emissions due to its implementation. Such emissions may be associated with any potentially affected sources described in **Section 3.1** (*Emission Sources*) and/or comprise the pollutants and their precursors described in **Section 3.2** (*Pollutants of Concern*). For the purposes of this determination, a preliminary assessment can be made based upon (i) the project/action definition or operational characteristics identified in **Step 1.A** (*Project/Action Definition*) and/or (ii) prior knowledge and/or experience with similar projects/actions. For projects and actions requiring FAA involvement, a preliminary assessment should involve consultation with appropriate FAA officials and/or review of FAA Order 1050.1.

Examples of projects and actions that will *likely* cause or create a reasonably foreseeable increase in emissions include those that will cause or create an increase in aircraft operations and/or ground access vehicle trips. Other projects such as runway/taxiway improvements, roadway modifications, and/or parking facility expansions, *may* cause or create reasonably foreseeable increases in emissions by changing aircraft and vehicle travel patterns.

By comparison, examples of projects and actions that will not likely cause or create increases in emissions include land acquisition programs or the upgrading of airfield lighting systems.

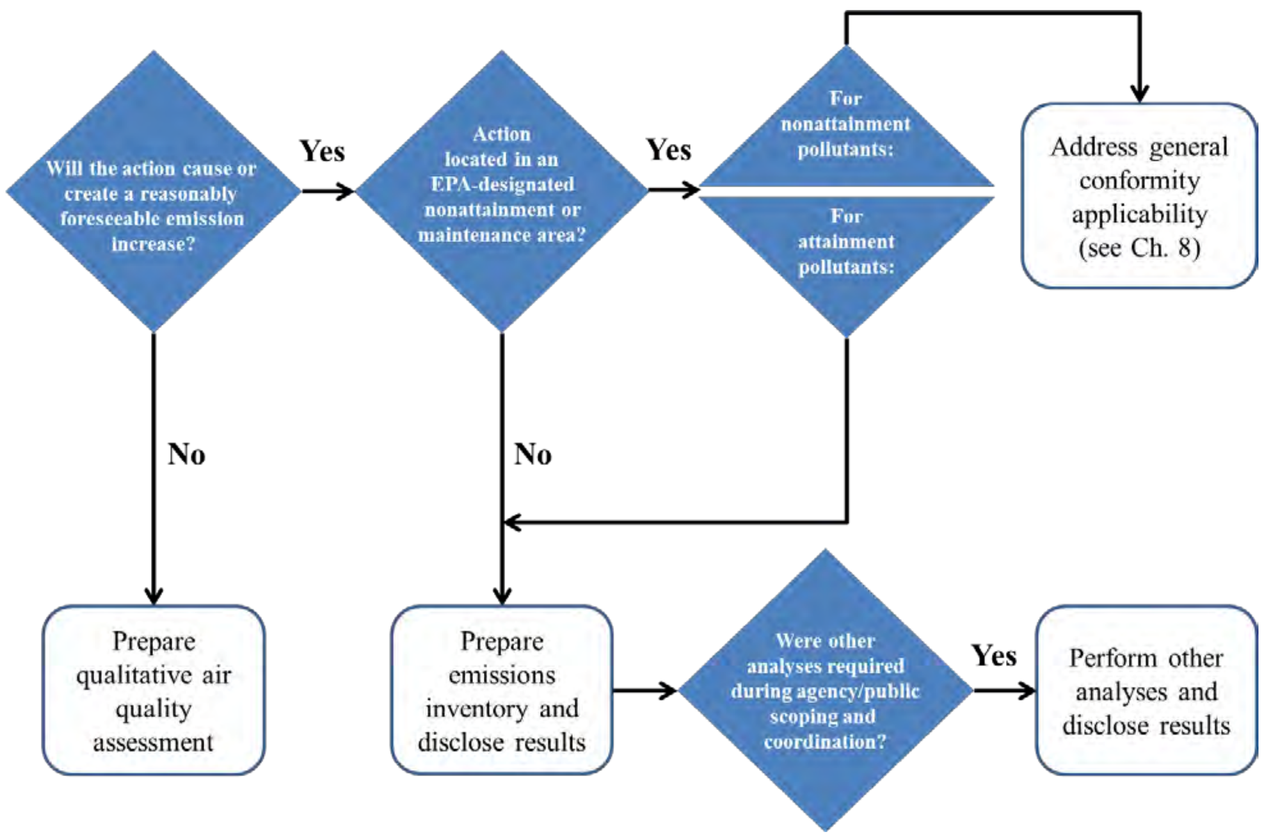
Step 1.D. Determine Attainment/Nonattainment Status – This step of the assessment process is to establish the attainment/nonattainment status of the project/action study area and, if applicable, to identify those pollutants for which the area is designated nonattainment/maintenance (see **Section 2**, *Regulatory Framework,* and **Section 8**, *Conformity,* for further descriptions of attainment/nonattainment areas). This information will aid in ascertaining whether or not the Conformity requirements apply as part of the air quality assessment process.

Step 1.E. Assess Agency/Public Scoping Comments – This last step is intended to evaluate agency/public scoping comments concerning air quality raised during the scoping process, when scoping is conducted (see **Section 9.1**, *Scoping Process*). Scoping is a requirement when preparing an EIS, but is optional in an EA. The response to these comments will depend in large part on the types of comments made combined with the discretion and judgment of the responder. However, some comments may request, or even necessitate, an expanded air quality assessment for a proper response.

By applying the information acquired and/or developed through the course of these preliminary steps, the air quality analyst should have ample justification for deciding what type of an air quality assessment is warranted. Consultation with state or local air quality agencies, EPA regional offices, and FAA (for projects and actions requiring FAA involvement) may still be necessary however.

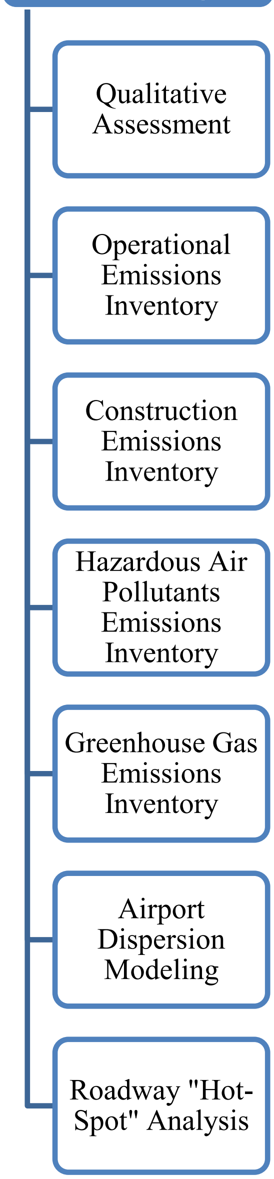
For ease in further determining what type of air quality assessment is appropriate for FAA projects or actions, **Figure 4-3** (*Air Quality Assessment Decision Flow Diagram*) provides a simplified decision tree based upon the information provided and discussed above. As shown, the fundamental decision pathways and terminal nodes are based upon such factors as (i) whether or not the project/action will cause a reasonably foreseeable increase in emissions, (ii) whether it is located in a nonattainment/maintenance area, and (iii) whether additional or other specific analyses have been required during the agency/public scoping and coordination process.

Figure 4-3. Air Quality Assessment Decision Flow Diagram



4.1.2. Step 2: Select the Assessment Methodology

Figure 4-4. Step 2: Select the Assessment Methodology



As shown in **Figure 4-4** (*Select the Assessment Methodology*), there are different types or components of an air quality analysis that can be undertaken depending on project/action type, the change(s) to the emission sources affected, and other relevant factors.

For example, and as discussed further below, in those cases where it has been determined that the project or action will not cause, or create, a reasonably foreseeable increase in emissions, a qualitative assessment is justifiable for disclosure purposes under NEPA.

In the case of an emissions inventory, the assessment methodology is further subdivided based on whether criteria pollutants, GHGs, and/or HAPs are being addressed. Notably, inventories will need to be aggregated for analysis under the Conformity Rule of the CAA. For dispersion modeling, the assessment methodologies are further subdivided based on the scale of the dispersion assessment (i.e., airport-wide dispersion or a roadway hotspot analysis).

For clarity, these various assessment methodologies are further elaborated on as follows:

Qualitative Assessment – As discussed above, a qualitative assessment of air quality impacts is all that is *likely* necessary where it has been determined that the project or action will not cause or create, a reasonably foreseeable increase in air emissions. In this case, an explanation of the conditions and rationale upon which this finding is based along with any supporting data, reasoning and/or justification should be provided. The assessment should explain how or why implementation of the project/action will not cause or create a reasonably foreseeable increase in air emissions.

Operational Emissions Inventory – An operational emissions inventory is designed to quantify the amounts (i.e., mass) of criteria pollutant emissions (and their precursors) associated with operational activity in the proposed project/action. Based upon current and forecasted activity levels coupled with appropriate emission factors, the results provide a measure of the magnitude of the potential air quality impacts and enable useful comparisons of emissions between project alternatives and significance criteria. The results are typically expressed in units of tons/year segregated by pollutant type (e.g., CO, NO_x, etc.), emission source (e.g., aircraft engines, APUs, GSE, etc.), and alternative (e.g., no action and proposed actions) for the specified study period. (See **Section 6.1.1**, *Airport Operations,* and **Appendices A1** through **A5** for more information.)

Construction Emissions Inventory - A construction emissions inventory is designed to quantify the amounts (i.e., mass) of criteria pollutant emissions (and their precursors) associated with the construction of the proposed project/action. Based upon forecasted construction equipment and resource needs, activity levels and appropriate emission factors, the results provide an estimate of the potential air quality impacts and enable useful comparisons between project alternatives and significance criteria. The results are typically expressed in units of tons/year segregated by pollutant type (e.g., CO, $PM_{2.5}$, PM_{10}, etc.), emission source (i.e., construction equipment) and alternative over the construction period. (See **Section 6.1.2**, *Airport Construction Emissions,* and **Appendix A6**, *Construction Emission Inventory for Criteria Pollutants*, for more information.)

Hazardous Air Pollutant (HAPs) Emissions Inventory – HAPs are pollutants for which there are no NAAQS but are regulated and are of concern in connection with the protection of public health and the environment. Similar to the operational emissions inventory of criteria pollutants described previously, the HAPs emissions inventory is designed to quantify the amounts (i.e., mass) of emissions associated with the operation (or implementation) of the proposed project. Again, the results are typically expressed in units of tons/year, segregated by pollutant type (e.g., benzene, formaldehyde, etc.), emission source, and alternative for the study period. (See **Section 6.2**, *Hazardous Air Pollutants,* and **Appendix B**, *Emissions Inventory for Hazardous Air Pollutants*, for more information.)

Greenhouse Gas (GHG) Emissions Inventory – GHGs are also pollutants for which there are no NAAQS but are of concern because of their role in climate change. Similar to the operational and HAPs emissions inventories described previously, the GHG emissions inventory is designed to quantify the amounts (i.e., mass) of these emissions associated with the operation (or implementation) of the proposed project. The results are typically expressed in units of metric tons/year, segregated by emission type (e.g., CO_2, CH_4, etc.), emission source, and alternative for the study period. (See **Section 6.3**, *Greenhouse Gases,* and **Appendix C**, *Emissions Inventory for Greenhouse Gases*, for more information.)

Atmospheric Dispersion Modeling - Dispersion modeling is used to further refine the results of the operational and construction emissions inventory by distributing the emissions across a project/action area both spatially and temporally based upon the operational and physical characteristics of the emission source(s) combined with meteorological and local terrain data. With background levels added to the modeling results, the outcome(s) is/are expressed in the form of concentrations (i.e., micrograms per cubic meter [$\mu g/m^3$] or parts per million [ppm]) of pollutants (e.g., CO, NO_2, PM_{10}, $PM_{2.5}$ etc.) by receptor location for direct comparison to the NAAQS. (See **Section 7.1**, *Atmospheric Dispersion Modeling,* and **Appendix D**, *Atmospheric Dispersion Modeling*, for more information.)

Roadway Dispersion Modeling (i.e., "Hot-Spot" Analysis) – Similar to airport dispersion modeling but on a smaller scale and specific to roadway intersection analysis, hot-spot modeling is designed to assess the effects of motor vehicle traffic emissions on local air quality conditions. Again, with background values added to the modeling results, the outcome(s) is expressed in the form of concentrations (i.e., $\mu g/m^3$ or ppm) of pollutants (i.e., CO, $PM_{2.5}$) for direct comparison to the NAAQS. (See **Section 7.2**, *Roadway Dispersion Modeling,* and **Appendix E**, *Roadway Dispersion Modeling [Hot-Spot Analysis]*, for more information.)

Unfortunately, there is no single, universal criterion for determining what type of analysis is appropriate for FAA-supported projects or actions. However, there are some intended and practical applications of the available analyses that aid in this decision-making process. For example, if it is determined that an emissions inventory of the EPA criteria pollutants (and their precursors) is warranted, it is expected that an inventory of GHGs will also be conducted. In this way, project/action-related criteria pollutants and GHG emissions can be accounted for and disclosed.

As an aid in selecting the appropriate air quality assessment methodology, **Figure 4-5** (*Air Quality Assessment Examples*) identifies the types of air quality analyses (i.e., emissions inventory, dispersion modeling, etc.) that *may* be appropriate for FAA projects and actions. Listed by project/action type, each assessment method is generally symbolized as either *High, Medium or Low* in terms of the *likely* applicability of the analysis to the project/action type.

For example, an air quality assessment for a new airport in a nonattainment area will likely involve operational, HAPs, GHG, and construction emissions inventories as well as dispersion modeling. By comparison, the introduction of new air carrier service at a commercial airport will probably require an operational emissions inventory. New air traffic control procedures above 3,000 feet will likely require no analysis whatsoever.

Importantly, the information provided in this section is not meant to be wholly definitive or all-inclusive in terms of dictating the type(s) of air quality assessment(s) that are required for FAA projects and actions. Rather, the information is provided as a guide in determining which analyses are the most appropriate – by project/action category.

Again, in those cases where the appropriate type of air quality assessment is still uncertain at the conclusion of this process, the appropriate FAA office should be consulted. In other cases, the development and application of an "Air Quality Assessment Protocol" is recommended as it resolves any areas of uncertainty regarding the air quality assessment prior to its undertaking (see **Section 9.2**, *Air Quality Assessment Protocol).*

Figure 4-5. Air Quality Assessment Examples[1,2]

Project/Action Category	Operational Emissions Inventory	HAPs Emissions Inventory	GHG Emissions Inventory	Construction Emissions Inventory	Dispersion Modeling
Project Type					
New Airport	■	■	■	■	◩
New Runway	■	■	■	■	◩
Major Runway Extension	◩	◩	◩	■	◩
New or Expanded Terminal	◩	◩	◩	■	◩
Relocated Terminal	◩	◩	◩	■	◩
Roadway Modifications	◩	◩	◩	■	◩
New or Expanded Cargo Facility	◩	◩	◩	■	◩
New or Expanded Parking	◩	◩	◩	■	◩
New or Expanded Utility Plant	◩	◩	◩	■	◩
New Fuel Storage System	□	◩	□	■	□
New or Modified Taxiway	□	◩	□	■	◩
Runway Safety Area	□	□	□	◩	□

Runway Rehabilitation	☐	☐	☐	☐	☐
Obstruction Removal	☐	☐	☐	☐	☐
Air Traffic Control Tower	☐	☐	☐	◩	☐
Action Type					
Increase in Aircraft Operations	◩	◩	◩	☐	◩
Change in Runway Utilization	◩	◩	◩	☐	◩
Change in Fleet Mix	◩	◩	◩	☐	◩
Increase in Taxi Time/Delay	◩	◩	◩	☐	◩
Increase in Motor Vehicle Trips	◩	◩	◩	☐	◩
Air Traffic Procedures < 3,000 ft	◩	◩	◩	☐	☐
Air Traffic Procedures > 3,000 ft	☐	☐	☐	☐	☐
Land Acquisition	☐	☐	☐	☐	☐
Navigational System	☐	☐	☐	☐	☐

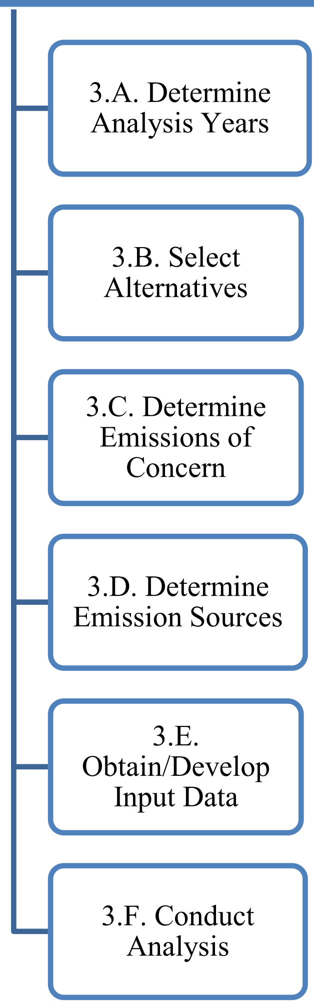
[1]The symbols indicate the relative level of appropriateness of an analysis to a project/action: ■ = High, ◩ = Medium, ☐ = Low

[2]Importantly, the information provided in this figure is not meant to be definitive or all-inclusive in terms of dictating the type(s) of air quality assessments that are required for FAA projects or actions. Rather, the information is provided as a guide in determining which analyses are the most appropriate.

4.1.3. Step 3: Conduct the Assessment

Assuming that the need for a quantitative air quality assessment has been determined under Step 1 (*Determine the Need for the Assessment*) and the method(s) for conducting the assessment have been selected under Step 2 (*Select the Assessment Methodology*), the purpose of this step is to perform the analyses. As shown in **Figure 4-6** (*Conduct the Assessment*) and discussed here, this work generally involves selecting the analysis years, identifying the emission types and emission sources of interest, obtaining and/or developing the necessary input data, and running the appropriate models and/or supplemental analyses.

Figure 4-6. Step 3: Conduct the Assessment



Step 3.A. Determine the Analysis Years – In this step, the years for the air quality analysis are identified and selected. These typically include existing and future-year conditions for the project/action. In many cases, these analysis years are determined by the anticipated impacts of the action. In the case of a General Conformity Determination, the SIP attainment and milestone years are also applicable.

Step 3.B. Select Alternatives for the Analysis – In this step, the project/action alternatives are identified and selected. For future-year conditions, these typically include the no action alternative and the reasonable alternatives analyzed in the NEPA documentation. In the case of a General Conformity Determination, only the preferred alternative is required to be analyzed (see **Section 8**, *Conformity*).

Step 3.C. Determine Emissions of Concern – In this step, the pollutant types that are the subject of the analysis are selected. These may include the criteria pollutants (e.g., CO, $PM_{2.5}$, etc.) and their precursors (e.g., NO_x and VOCs), HAPs (e.g., benzene, formaldehyde, etc.), and/or GHGs (e.g., CO_2, CH_4, etc.). The selection will vary depending on the project/action, location, and the type of analysis conducted.

Step 3.D. Determine the Emission Sources – In this step, the sources of emissions to be included in the air quality assessment are selected. For example, in the case of an operational emissions inventory, these may include aircraft engines, APUs, GSE, and ground access vehicles. For a construction emissions inventory, the sources may include heavy construction equipment and vehicles.

Step 3.E. Obtain/Develop Input Data – In this step, the input data and information necessary to conduct the air quality assessment are obtained and/or developed. These data may include aircraft operational levels and fleet mix data, APU/GSE operating times, roadway traffic volumes, and construction schedules.

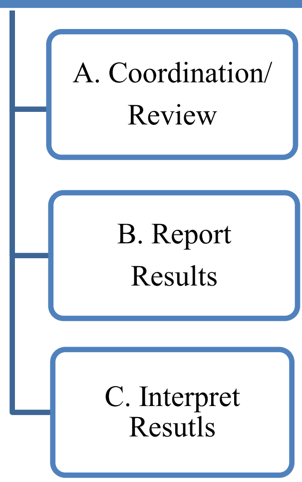
Step 3.F. Conduct the Analyses – In the final step, the selected analyses are completed using the appropriate models and/or supplemental analysis methods.

At the completion of these steps, the analyst has conducted the appropriate analysis and should have the necessary information to document and disclose the potential air quality impacts of the project/action as discussed in the following section.

4.1.4. Step 4: Coordination/Review and Documentation of Results

Once the air quality assessment is completed, the next step is to coordinate and review the analysis with the appropriate agency and to address any comments prior to moving forward with the project/action. Upon completing the coordination/review process, the final step is to document the results in formats that are both appropriate and useful. As shown in **Figure 4-7** (*Document the Results*) and discussed below, this step involves reporting and interpreting the assessment results. The air quality assessment results are reported in the "Environmental Consequences"[14] section of the EA or EIS depending on the level of NEPA review the project/action falls under.

Figure 4-7. Step 4: Coordination/Review and Documentation of Results



Step 4.A. Coordination and Review – Under this step, the analysis is reviewed by the proper agency and comments are addressed and incorporated into analysis prior to documenting final results.

Step 4.B. Report the Results – Under this step, the results of the analysis are assembled and reported. For example, in the case of an emissions inventory the results are typically tabulated by alternative, year, and pollutant type and recorded in units of tons/year for criteria pollutants and HAPs and as metric tons/year for GHGs. In the case of dispersion modeling, the results are also compiled by receptor location and reported in units of $\mu g/m^3$ or ppm.

Step 4.C. Interpret the Results – Under this step, the results of the assessment are interpreted based upon the purpose and outcomes of the analysis and any applicable significance criteria. For example, the purpose of the operational emissions inventory may be to compare emissions between alternatives and/or against the applicable CAA General Conformity Rule *de minimis* thresholds. In the case of dispersion modeling, the results are compared to the NAAQS.

The ensuing sections of the *Handbook* provide detailed guidance on the following topics:

- ***Section 5: Air Quality Assessment Models*** – Describes the various assessment models that are available and recommended to conduct aviation-related air quality assessments.
- ***Section 6: Preparing an Emissions Inventory*** – Describes the recommended methods for preparing aviation-related emission inventories for the criteria pollutants, HAPs, and GHGs.

[14] The Environmental Consequences section of an EA or EIS should focus on significant impacts. If a project/action (or any of its alternatives) has little or no impact in a certain impact category, that should be clearly stated as well.

- ***Section 7: Conducting Dispersion Modeling*** – Describes the recommended methods for conducting atmospheric dispersion modeling for airports and airport-related sources.
- ***Section 8: Conformity*** – Discusses the Conformity regulations of the federal CAA and how they apply to airport projects and actions.
- ***Section 9: Coordination Best Practices*** – Discusses the objectives, benefits, and methods of conducting agency coordination in support of aviation-related air quality assessment processes.

5. Air Quality Assessment Models

This section identifies and offers guidance on the various models and other supporting resources that are available to *Handbook* users for conducting aviation-related air quality analyses. These tools comprise computer models and databases that enable the users to compute emission inventories and conduct dispersion modeling for aviation sources of air emissions based upon appropriate input data and information.

Table 5-1 (*Emissions Inventory and Dispersion Models*) identifies the air quality models available to *Handbook* users for conducting airport air quality analyses associated with aviation-related projects and actions. These analyses include emissions inventories for both airport operation and construction as well as airport and roadway dispersion modeling. The air quality assessment models are further detailed within this section.

Table 5-1. Emissions Inventory and Dispersion Models

Models	Emissions Inventories				Dispersion Modeling	
	Criteria Pollutants		GHG[1]	HAPs	Airport	Roadway (Hot-Spot Analysis)
	Airport Operation	Airport Construction				
EDMS/AEDT	✓		✓	✓	✓	
MOVES	✓	✓	✓	✓		✓
NONROAD		✓				
AERMOD					✓	✓
CAL3QHC						✓

Source: EPA, *Air Quality Models*, http://www.epa.gov/ttn/scram/aqmindex.htm; FAA's, *Emissions and Dispersion Modeling System (EDMS)*, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/, and Aviation Environmental Design Tool (AEDT), http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/aedt/; and EPA's, *MOVES (Motor Vehicle Emission Simulator)*, http://www.epa.gov/otaq/models/moves/index.htm#generalinfo, *NONROAD Model*, http://www.epa.gov/otaq/nonrdmdl.htm#docs, *AERMOD Modeling System*, http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod, and *CAL3QHC/CAL3QHCR Models*, http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#cal3qhc, 2013.

[1] EDMS/AEDT estimate emissions of CO_2 and MOVES estimates emissions of CO_2, N_2O, and CH_4.

5.1. Aviation Environmental Design Tool

The Aviation Environmental Design Tool (AEDT) is developed and distributed by the FAA Office of Environment and Energy (AEE).[15] Essential and up-to-date information regarding AEDT as well as links to AEDT documentation and FAA guidance can be obtained on the official website for AEDT.[16]

AEDT is a new software system that dynamically models aircraft performance to compute emissions, fuel burn, and noise and assess their interdependencies. AEDT has the capability to conduct "full-flight" or "gate-to-gate" analyses of a single airport or a "metroplex", and further assess these facilities and operations on broader regional, nation-wide, and global levels.

[15] FAA, *Aviation Environmental Design Tool* (AEDT), http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/aedt/.

[16] FAA, *AEDT Support Website*, https://aedt.faa.gov/.

AEDT's framework incorporates emissions and dispersion modeling functionality from the FAA's Emissions and Dispersion Modeling System (EDMS). These models are further discussed within this section.

5.1.1. AEDT Development and Architecture

In 2012, AEDT version 2a (i.e., AEDT 2a) replaced the "legacy" regional noise analysis tool, the Noise Integrated Routing System (NIRS).[17] As such, the primary purpose of AEDT 2a was to model the environmental consequences of air traffic airspace and procedure actions being designed and implemented by the FAA's Air Traffic Organization (ATO). AEDT 2a also included the capability to assess CO_2 emissions from aircraft main engines. Of note, AEDT 2a is the required model for air traffic airspace and procedure action NEPA analyses.[18]

AEDT version 2b will replace AEDT 2a and the legacy airport air quality and noise analysis tools - the EDMS and the Integrated Noise Model (INM). AEDT2b will then become FAA's single environmental assessment tool for air quality and noise for all projects, including but not limited to airport and airspace NEPA reviews, General Conformity determinations, Master Planning studies, and Part 150 Noise Compatibility Programs.

The AEDT user interface and underlying software architecture are distinct from that of the EDMS and INM models. AEDT is built on the Microsoft .NET Framework and is capable of running on Microsoft Windows desktop and server operating systems. It is supported by an extensive system of relational databases and an ESRI[19] geospatial capability. Input data are entered into AEDT using the user interface, an XML-based AEDT Standard Input File (ASIF), and/or other EDMS/INM model import tools.

5.1.2. AEDT Usage for Air Quality Assessments

Using AEDT 2b, aviation-related emissions inventories can be computed for the EPA criteria air pollutants (e.g., CO, Pb, NO_2, O_3, PM_{10}, $PM_{2.5}$, and SO_2) and their precursors (e.g., NO_x and VOCs). Sources of airport emissions included in AEDT2b encompass aircraft, APUs, GSE, and an array of stationary sources (e.g., boilers, generators, etc.). For this version, the user utilizes the Motor Vehicle Emission Simulator (EPA's MOVES)[20] model independently of AEDT 2b to obtain the necessary data for computing motor vehicle emissions.

Dispersion modeling can also be conducted within the AEDT interface, based on the results of the emissions inventory and supplemented with meteorological data and the definition of receptor sets. Once the necessary data are inputted to AEDT, AEDT internally calls for the EPA AERMOD modeling system to perform the specified dispersion calculations. The resulting

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17 FAA, *Guidance on Using AEDT 2a to Conduct Environmental Modeling for FAA Air Traffic Airspace and Procedure Actions*, March 2012, http://www.faa.gov/air_traffic/environmental_issues/media/Memo-AEE-400_GuidncMem4_UsingAEDT2a_EnviroModeling_21MAR2012.pdf.

18 77 FR 18297 - *Air Traffic Noise, Fuel Burn, and Emissions Modeling Using the Aviation Environmental Design Tool Version 2a,* http://www.gpo.gov/fdsys/granule/FR-2012-03-27/2012-7354/content-detail.html.

19 ESRI's GIS (geographic information systems) mapping software enables the visualization of geographic data, http://www.esri.com/.

20 EPA, MOVES (Motor Vehicle Emission Simulator), http://www.epa.gov/otaq/models/moves/index.htm#generalinfo.

concentrations are displayed in the AEDT interface via maps of receptor sets and as tabular output.

5.2. Emissions and Dispersion Modeling System

EDMS was originally developed by the FAA in the mid-1980s as a complex source microcomputer model designed to assess the air quality impacts of proposed airport development projects. Since that time, EDMS has been revised and improved numerous times and is designed to assess the air quality impacts of airport emission sources which consist of aircraft, APUs, GSE, ground access vehicles, and stationary sources. EDMS is one of the few air quality assessment tools specifically engineered for the aviation community.[21] It includes the following:

- Emissions inventory and dispersion modeling capabilities;
- The latest aircraft engine emission factors from the International Civil Aviation Organization (ICAO) Engine Exhaust Emissions Data Bank;
- Motor vehicle emission factors from the latest version of the EPA's MOBILE6.2[22] and PART5[23] models (recently replaced with EPA's MOVES model and rendering MOBILE6.2 and PART5 models obsolete);
- GSE emission factors from the latest version of EPA's NONROAD model; and
- Emissions data for the EPA criteria pollutants and speciated organic gas emissions.

In 1998, the FAA identified EDMS as the "required" model to perform air quality analyses for aviation sources.[24] This policy ensures the consistency and quality of aviation-related air quality analyses performed for the FAA. The current EDMS version is 5.1.4.1, released in August of 2013. (EDMS should be used until the release of AEDT 2b and subsequent AEDT updates.)

5.3. MOVES

MOVES is the new emission modeling system developed by EPA's Office of Transportation and Air Quality (OTAQ) that computes emissions for mobile sources.[25] Currently MOVES provides emissions for on-road vehicles including cars, trucks, motorcycles, and buses and estimates exhaust and evaporative emissions as well as brake and tire wear emissions from all types of on-road vehicles for any part of the country, except California.

EPA officially released the MOVES model (i.e., MOVES2010) in March 2010 which replaced the previous on-road MOBILE emissions model (i.e., MOBILE6.2). Presently, MOVES2014 is the latest version of MOVES and incorporates numerous new features and a number of

21 FAA, *Emissions and Dispersion Modeling System (EDMS)*, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/.
22 EPA, *MOBILE6 Vehicle Emission Modeling Software*, http://www.epa.gov/otaq/m6.htm.
23 EPA, *Highway Vehicle Particulate Emission Modeling Software - PART5*, http://www.epa.gov/oms/part5.htm.
24 FAA, *Emissions and Dispersion Modeling System Policy for Airport Air Quality Analysis; Interim Guidance to FAA Orders 1050.1D and 5050.4A,* 18068 Federal Register/Vol. 63, No. 70/Monday, April 13, 1998/Notices, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS%20Requirement%20for%20Airport%20Air%20Quality%20Analysis.pdf.
25 EPA, *MOVES (Motor Vehicle Emission Simulator)*, http://www.epa.gov/otaq/models/moves/index.htm#generalinfo.

performance improvements over the original version, including the capability to compute non-road vehicle emissions. Compared to the previous MOBILE model, MOVES incorporates the latest emissions data, more sophisticated calculation algorithms, increased user flexibility, new software design, and other significant capabilities. Notably, California requires the use of its own motor vehicle emissions model known as EMFAC2011.[26]

MOVES requires various inputs (e.g., vehicle population, vehicle age distribution, vehicle miles travelled [VMT], etc.) and depending on the geographical scale (i.e., national, county, or local) of the assessment, default values may not be appropriate to use. In these cases, state and regional air quality regulatory and transportation planning agencies should be consulted, as these agencies might have more area-specific data. MOVES produces emission factors in grams of pollutant per vehicle mile or grams per idle minute by hour of day or season.

The EPA offers several guidance documents on the MOVES model that may be useful to the users of this *Handbook*.[27,28,29,30,31] The FAA provides a best practices document on the incorporation of MOVES emission factors into EDMS.[32]

5.4. NONROAD

NONROAD is a computerized database developed by the EPA to provide state and local air quality agencies with the ability to create and forecast emission inventories for the nonroad category of emission sources.[33] These include agricultural and construction equipment, all-terrain recreational vehicles, marine equipment, lawn and garden equipment, and a variety of other off-road vehicles and equipment. The required inputs vary by the type of vehicle/equipment for which emission estimates are sought. For airport applications, NONROAD is used primarily for the estimation of emissions from GSE and construction-related equipment. EDMS contains NONROAD and can also be used to compute GSE emissions. Note, however, that EDMS itself does not have functionality to compute construction-related equipment emissions.

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26 CARB, *Mobile Source Emission Inventory -- Current Methods and Data*, http://www.arb.ca.gov/msei/modeling.htm.

27 EPA, *Policy Guidance on the Use of MOVES2010 and Subsequent Minor Revisions for State Implementation Plan Development, Transportation Conformity, and Other Purposes,* April 2012 [EPA-420-B-12-010] http://www.epa.gov/otaq/models/moves/documents/420b12010.pdf.

28 EPA, *Using MOVES to Prepare Emission Inventories in State Implementation Plans and Transportation Conformity: Technical Guidance for MOVES2010, MOVES2010a and MOVES2010b*, April 2012 [EPA-420-B-12-028] http://www.epa.gov/otaq/models/moves/documents/420b12028.pdf.

29 EPA, *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Non-attainment and Maintenance Areas*, December 2010 [EPA-420-B-10-040], http://www.epa.gov/otaq/stateresources/transconf/policy/420b10040.pdf.

30 EPA, *Using MOVES in Project-Level Carbon Monoxide Analyses,* December 2010 [EPA-420-B-10-041], http://www.epa.gov/otaq/stateresources/transconf/policy/420b10041.pdf.

31 EPA, *Using MOVES for Estimating State and Local Inventories of On-Road Greenhouse Gas Emissions and Energy Consumption – Final*, November 2012 [EPA-420-B-12-068], http://www.epa.gov/otaq/stateresources/420b12068.pdf.

32 FAA, *Emissions and Dispersion Modeling System (EDMS),* http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/.

33 EPA, *NONROAD Model*, http://www.epa.gov/otaq/nonrdmdl.htm#docs.

The current version, NONROAD2008[34], is a major update of the NONROAD model. Using appropriate input data, it calculates emission inventories (i.e., tons of pollutant) for all nonroad equipment categories except commercial marine, locomotives, and aircraft. Fuel types include gasoline, diesel, CNG, and liquefied petroleum gas [LPG]. The model estimates exhaust and evaporative HC, CO, NO_x, PM, SO_2, and CO_2 emissions. The user may also select a specific geographic area (i.e., national, state, or county) and time period (i.e., annual, monthly, seasonal, or daily) for the analysis. Of note, California provides its own emissions model, known as OFFROAD[35], to determine emissions from construction activities and GSE.

The EPA offers additional guidance documents on the NONROAD model that may be useful to the users of this *Handbook*.[36,37]

5.5. AERMOD

Developed by the EPA, AERMOD is an atmospheric dispersion model which can simulate point, area, volume, and line sources and has the capability to include simple, intermediate, and complex terrains.[38,39] It also predicts both short-term (1 to 24 hours) and long-term (quarterly or annual) average concentrations. The model can be executed by using the regulatory default options (e.g., stack-tip downwash, elevated terrain effects, calm wind speeds processing routine, missing data processing routine, buoyancy-induced dispersion, and final plume rise), default wind speed profile categories, default potential temperature gradients, and pollutant decay. Lastly, AERMOD has the capability to account for building downwash effects and to employ gas or particle deposition or wet/dry depletion of the plume. AERMOD is commonly executed to yield 1-hour and season average concentrations (in $\mu g/m^3$) at each receptor. These concentrations may be presented as plot files and receptor files showing the results at each receptor for tabular and graphical display.

For a detailed discussion on AERMOD and dispersion modeling refer to **Section 7.1** *(Atmospheric Dispersion Modeling)* and **Appendix D** (*Atmospheric Dispersion Modeling*).

5.6. CAL3QHC

Used for intersection "hot-spot" analyses, CAL3QHC is a computer model developed by the EPA that predicts hourly CO concentrations from both running and idling motor vehicles at

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34 EPA, *User's Guide for the Final NONROAD2005 Model*, December 2005 [EPA420-R-05-013] and EPA NONROAD Model Updates for 2008, April 2009, http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2005/420r05013.pdf.

35 AQMD, *Off-Road Mobile Emission Factors*, http://www.aqmd.gov/ceqa/handbook/offroad/offroad.html.

36 EPA, *Suggested Nationwide Average Fuel Properties*, April 2009 [EPA-420-B-09-018], http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2008/420b09018.pdf.

37 EPA, *Frequently Asked Questions about NONROAD2008*, April 2009 [EPA-420-F-09-021]. http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2008/420f09021.pdf.

38 EPA Preferred/Recommended Models, *AERMOD Modeling System*, http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod.

39 Title 40 CFR Part 51, *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule,* http://www.epa.gov/ttn/scram/guidance/guide/appw_05.pdf.

roadway intersections.[40,41] CAL3QHC combines the CALINE model with a traffic algorithm to estimate delays and queues that occur at signalized intersections. This model is used as a screening model and is the EPA-recommended model for this application.

EPA also developed the CAL3QHCR model, which is a more refined version of CAL3QHC that requires local hourly meteorological data.[42] CAL3QHCR incorporates enhancements to process up to a year of meteorological data and emissions data that vary by day of the week and hour of day. The model has the capability, with the use of various concentration-averaging algorithms, to predict 1-hour, 8-hour, 24-hour, and annual concentrations, compared with only the maximum hourly average computed by CAL3QHC. CAL3QHCR is the EPA-recommended model for PM (i.e., PM_{10} and $PM_{2.5}$) hot-spot modeling for highway and roadway intersection projects/action and also EPA-recommended for CO when a CAL3QHC analysis with conservative assumptions indicates a potential to exceed the NAAQS.

For further information on CAL3QHC/CAL3QHCR model inputs and guidance on how to conduct a CO and PM hot-spot analysis see **Section 7.2** (*Roadway Dispersion Modeling*) and **Appendix E** (*Roadway Dispersion Modeling [Hot-Spot Analysis]*).

40 EPA Preferred/Recommended Models, *CALINE3,* http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#caline3.

41 EPA, *User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections*, November 1992 [EPA-454-R-92-006], http://www.epa.gov/ttn/scram/userg/regmod/cal3qhcug.pdf.

42 EPA Preferred/Recommended Models, *CAL3QHC/CAL3QHCR*, http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#cal3qhc.

6. Preparing an Emissions Inventory

This section addresses the preparation of emissions inventories for three separate categories of emissions: (i) criteria pollutants, (ii) hazardous air pollutants, and (iii) greenhouse gases.

6.1. Criteria Pollutants

6.1.1. Introduction & Background

The purpose of this section is to identify and provide guidance on the various methods that are available to *Handbook* users for assessing air quality conditions associated with aviation-related projects and/or actions with a focus on computing criteria pollutant emissions inventories resulting from airport operational and construction activities.

6.1.2. Existing Guidance

The guidance information listed in **Table 6-1** (*Criteria Pollutant Emissions Inventory Guidance Summary*) underpins the computation of criteria pollutant emissions arising from an airport's operations, as well as from construction activities undertaken to improve airport facilities/operations. Details specific to an emissions source or sources are provided for each listed guidance document.

Table 6-1. Criteria Pollutant Emissions Inventory Guidance Summary

Guidance Document	Emissions Source(s)	Description
EPA, *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, December 1992, [EPA-420-R-92-009]	Aircraft	Provides a framework for how aircraft fleet and activity levels are obtained, as well as a methodology for computing emissions based on static parameters (i.e., not based on flight performance). The method is adjustable to account for local conditions (i.e., the local mixing height) and allows for the application of either aircraft-specific or fleet average emission factors.
	GSE/Construction Equipment	GSE and construction equipment are treated identically in terms of emissions calculation methodology, whereby an inventory is generated using equipment population, annual operating hours, rated horsepower, equipment load factor and emissions factors.
	Ground Access Vehicles	Focuses on inventories of motor vehicle activity for entire fleets over a large geographic domain, is based on fleet-wide vehicle miles of travel, and calls for the definition of local parameters such as emissions control programs and fuel specifications.

Guidance Document	Emissions Source(s)	Description
EPA, *Documentation for Aircraft Component of the National Emissions Inventory Methodology*, January 2011	Aircraft	Advocates the use of EDMS combined with airport-specific LTO data to compute aircraft emissions inventories from commercial operations, retaining EDMS "default" information (e.g., taxi times) in many respects. Also provides an alternate methodology based on "composite" emissions factors and more generalized operational data when airport-specific information is not readily available, calling only for the level of piston and jet LTOs and the segregation of these operations between the air taxi and general aviation categories. Of note, this methodology is not used by FAA practitioners for NEPA.
	GSE/APU	For commercial aircraft operations only, the guidance applies EDMS default parameters to estimate emissions from GSE and APU.
EPA, *Calculating Piston-Engine Aircraft Airport Inventories for Lead for the 2008 National Emissions Inventory,* December 2010, [EPA-420-B-10-044]	Aircraft	Provides a methodology to estimate lead emissions arising from the combustion of leaded Avgas, relying upon the level of piston-engine LTOs, lead content of Avgas, and the level of lead retention in an engine during typical operation.
FAA & EPA, *Technical Data to Support FAA's Advisory Circular on Reducing Emissions from Commercial Aviation*, September 29, 1995	Aircraft, GSE, APU	Outlines calculation methods to estimate emissions from GSE and APU utilization on commercial service aircraft and provides example data parameters and activity inputs to this purpose. Also identifies some considerations related to assessing emissions reduction potential for commercial aircraft, GSE and APU.
FAA, *Use of First Order Approximation (FOA) to Estimate Aircraft Engine Particulate Matter (PM) Emissions in NEPA Documents and Clean Air Act General Conformity Analyses*, May 2005	Aircraft	Consistent with methods outlined by the ICAO, this document identifies how both volatile (i.e., fuel sulfate, fuel organic and lubrication oil organic compounds) and nonvolatile (i.e., soot) PM emissions are quantified from aircraft engines. The FOA version 3a is currently implemented in EDMS/AEDT.
EPA, AP-42, Fifth Edition, *Compilation of Air Pollutant Emission Factors*, *Volume I: Stationary Point and Area Sources*	Stationary Sources, Construction Activities	Emission factor source and methodological guide for combustion and non-combustion stationary source emissions handled by EDMS/AEDT. Also serves as a guide to compute non-exhaust emissions from construction activities such as land disturbance, demolition, travel on unpaved roads, materials handling and other activities undertaken during the construction period.
Jagielski, Kurt D., and Robert J. O'Brien, *Calculation Methods for Criteria Air Pollutant Emission Inventories*, July 1994	Stationary Sources	Provides equivalent/alternative methods and data to AP-42 for the computation of emissions from select stationary sources including generators, engine testing and coating operations.

Guidance Document	Emissions Source(s)	Description
EPA, *Using MOVES to Prepare Emission Inventories in State Implementation Plans and Transportation Conformity: Technical Guidance for MOVES2010, 2010a and 2010b*, April 2012, [EPA-420-B-12-028]	Ground Access Vehicles	Guides a user through the technical aspects of developing, modifying and/or using county-level or larger series of MOVES inputs for emissions calculations, such as inspection/maintenance programs, fuel supply and formulation, and vehicle age distributions.
EPA, *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas*, November 2013, [EPA-420-B-13-053]	Ground Access Vehicles	Guides a user through the project-level components of an emissions analysis of PM_{10} and/or $PM_{2.5}$, such as defining roadway links, link activity, and how to assess and utilize meteorological data for developing emissions rates. This guidance also forms the basis of roadway intersection analyses discussed in **Section 7.2** (*Roadway Dispersion Modeling*).
EPA, *Using MOVES in Project-Level Carbon Monoxide Analyses*, December 2010, [EPA-420-B-10-041]	Ground Access Vehicles	Guides a user through the project-level components of an emissions analysis of CO, such as defining roadway links, link activity, and how to assess and utilize meteorological data for developing emissions rates. This guidance also forms the basis of roadway intersection analyses discussed in **Section 7.2** (*Roadway Dispersion Modeling*).

6.1.3. Airport Operations

6.1.3.1. Airport Operation Emission Inventory Methods

Typical sources and activities addressed in a criteria pollutant emissions inventory of airport operations include aircraft, APU, GSE, stationary sources, and ground access vehicle operations. In general terms, a criteria pollutant emissions inventory is computed by combining pollutant emissions factors with source activity levels; for instance, GSE emissions factors are expressed in pounds of pollutant per horsepower-hour of operation, and are applied to a given GSE's known horsepower and operating schedule.

Using guidance listed on **Table 6-1** (*Criteria Pollutant Emissions Inventory Guidance Summary*) as a foundation, this section discusses considerations that should be made when preparing a criteria pollutant emissions inventory of airport operations, including how the source(s) activity is typically characterized as well as how applicable emissions model(s) such as EDMS and AEDT apply emissions factors or otherwise translate that activity into an emissions estimate. Appendix materials provide additional details on a source category basis (e.g., aircraft, APU, GSE, motor vehicles, and stationary sources). Construction emissions are addressed separately in **Section 6.1.4** (*Airport Construction Emissions*). For additional information on how to populate EDMS/AEDT to compute aircraft, GSE and APU emissions, please refer to **Appendices A1** (*Aircraft Emission Inventory for Criteria Pollutants*), **A2** (*Auxiliary Power Units Emission Inventory for Criteria Pollutants*) and **A3** (*Ground Support Equipment Emission Inventory for Criteria Pollutants*) respectively**. Appendices A4** (*Ground Access Vehicle Emission Inventory for Criteria Pollutants*) and **A5** (*Stationary Sources Emission Inventory for Criteria Pollutants*) offer additional details on stationary source and ground access vehicle calculation methods.

Aircraft

Aircraft emissions for a criteria pollutant emissions inventory are computed in EDMS/AEDT by factoring total aircraft operational activity against a database of aircraft/engine-specific emission factors based on engine manufacturer, model, and aircraft operational mode within the LTO cycle. For the purposes of emissions inventory, an LTO cycle consists of the following operational modes:

- *Approach*: The airborne segment of an aircraft's arrival extending from the start of the flight profile (or the mixing height) to touchdown on the runway;
- *Taxi In*: The landing ground roll segment (from touchdown to the runway exit) of an arriving aircraft, including reverse thrust, and the taxiing from the runway exit to a gate;
- *Startup*: Aircraft main engine startup (for VOC only) occurs at the gate and is considered in EDMS/AEDT for ICAO certified engines only;
- *Taxi Out*: The taxiing from the gate to a runway end;
- *Takeoff*: The portion from the start of the ground roll on the runway, through wheels off, and the airborne portion of the ascent up to cutback during which the aircraft operates at maximum thrust; and
- *Climb Out*: The portion from engine cutback to the end of the flight profile or the mixing height.

EDMS/AEDT calculation of emissions within the LTO relies on two main categories of input: (i) aircraft fleet and operations, and (ii) time within each mode of the LTO cycle.

Aircraft Fleet and Operations

At a minimum, EDMS/AEDT requires definition of an aircraft fleet (i.e., the types of aircraft using the airport and their assigned engines) and a level of operations (i.e., either arrivals/departures/touch-and-go's, or LTO) assigned to each member of the aircraft fleet. EDMS/AEDT can accept varying levels of detail depending on the extent to which aircraft operational parameters at a given airport are available or known. These range from the selection of a generic aircraft fleet with "default" engines selected by EDMS/AEDT, to the identification of specific airframes and engines based on an air carrier's market information, to the modeling of individual flights based on a flight schedules or radar data. Typical sources of data that can be used to identify and define these parameters can be found within **Appendix F** (*Data and Information Sources*).

Times in Mode

EDMS/AEDT functionality currently calculates a performance-based time in mode for the takeoff, approach and climb out (i.e., the aloft) components of the LTO cycle, which is based upon aircraft flight profiles, characteristics of individual aircraft, and meteorological conditions. Users are allowed to modify some of this information, such as aircraft takeoff and landing weights or the local meteorology, allowing for a more site-specific characterization of emissions aloft. Further, EDMS/AEDT currently only consider takeoff, climb out and approach emissions up to the atmospheric "mixing height" for the area, defined as the vertical extent in the atmosphere over which pollutants no longer mix downward to ground level.

For a criteria pollutant emissions inventory, EDMS/AEDT uses static times in mode (TIM) for ground-based aircraft movements (i.e. taxi times) but these times often do not capture airport-specific operating parameters such as ground delay, airfield configuration, ramp locations, variation in aircraft speed, and other important factors. So, users are allowed to modify taxi times on a per-aircraft basis to account for these airport-specific operating conditions. **Appendix F** (*Data and Information Sources*) presents resources available to obtain actual taxi times, simulated taxi times, and to apportion/estimate airfield delay.

Ground Support Equipment (GSE)

GSE criteria pollutant emissions inventories using EDMS/AEDT capture two distinct sets of GSE utilization at an airport: (i) GSE servicing gated aircraft on the apron, and (ii) other activities of the GSE population not tied to gate service operations. An example of a gate service operation is a baggage tractor visiting an aircraft at the apron to drop off baggage; an example of a population activity is a deicing truck driving back and forth to a deicing area during the deicing season.

To compute GSE emissions, EDMS/AEDT applies emissions factors (in grams per horsepower hour [g/hp-hr]) specific to the make/model, year of manufacture, approximate horsepower, and fuel type of a given equipment to annual hours of operation for that equipment. These emissions calculations are further adjusted using the observed horsepower of the equipment and the equipment's average percentage of full throttle (i.e., load factor). EDMS/AEDT offer "default" values for many of these parameters and affords a user to override them to the extent information on an airport's GSE fleet is known.

For GSE population activities, users need only specify the make/model, model year, horsepower, fuel type, and annual hours of operation for a given piece of equipment (or accept EDMS's default information). This approach also applies to the gate service GSE. However, EDMS/AEDT computes annual hours of operation for gate service GSE by considering the number of aircraft LTOs for which GSE service is provided and the total running time of the GSE per LTO.

Calculation steps and input data necessary to compute GSE emissions in EDMS/AEDT are further explained in **Appendix A3** (*Ground Support Equipment Emission Inventory for Criteria Pollutants*).

Auxiliary Power Units (APUs)

When input to EDMS/AEDT, most large commercial and cargo aircraft are automatically assigned a representative make and model of APU if agency/industry documentation indicates that an APU is used on that aircraft.[43, 44] Annual APU emissions are a function of the number of LTOs performed by the equipped aircraft, the time the assigned APU operates per LTO, and the emissions factors assigned to the APU. When assigning APU operating times per LTO, infrastructure considerations such as the availability of fixed electrical ground power and pre-conditioned air, as well as meteorological conditions such as the annual temperature in the area,

[43] FAA & EPA, *Technical Data to Support FAA's Advisory Circular on Reducing Emissions from Commercial Aviation,* September 29, 1995, http://www.epa.gov/oms/regs/nonroad/aviation/faa-ac.pdf.

[44] EPA, Williams, Randall C., Honeywell Engines & Systems. Letter to Bryan Manning, September 29, 2000.

should be considered as these variables factor into the frequency and duration with which an APU is operated (see **Appendix A2**, *Auxiliary Power Units Emission Inventory for Criteria Pollutants*).

Stationary Sources

Currently, EDMS/AEDT can estimate criteria pollutant emissions from the following stationary sources of air emissions, categorized based on whether the emissions occur from fuel combustion or from passive, non-combustion processes such as evaporation or erosion:

- *Combustion Sources* - Boilers and heaters, generators, snowmelters, incinerators, fire training facilities, and aircraft engine testing; and
- *Non-Combustion Sources* - Fuel storage tanks, cooling towers, coating and painting operations, de-icing and anti-icing operations, solvent degreasing, and salt and sand piles.

For combustion-related stationary sources, activity levels in the form of an operating schedule (e.g., annual hours of operation) or a mass of fuel consumed (e.g., annual cubic feet of natural gas) are factored against appropriate emissions factors to derive an emissions inventory. For non-combustion sources, the activity levels required for an emissions calculation relate to a number of factors including (but not limited to) the level of material or fuel moved through or stored within the device, the dimensions and size of the device, and the application area over which a substance is applied.

Appendix A5 (*Stationary Sources Emission Inventory for Criteria Pollutants*) contains detailed data input requirements and calculation steps used to compute emissions from all of the combustion and non-combustion stationary sources identified in this section.

Ground Access Vehicles

Motor vehicle criteria pollutant emissions inventories typically focus on three distinct types of activities: (i) vehicles traversing airport roadways; (ii) vehicles accessing parking facilities; and (iii) vehicles accessing the terminal curbside areas for passenger pickup and drop-off.

The EPA's Motor Vehicle Emissions Simulator (MOVES) is the current federally-approved tool to compute motor vehicle emissions rates representative of the types of activities specified above. Using locally developed data on vehicle types, fuel types, vehicle ages, inspection and maintenance programs and other factors, MOVES will generate emissions rates in grams of pollutant per vehicle mile of travel (g/VMT) or grams per vehicle hour of operation (g/hour) against which airport motor vehicle activities can be applied. See **Appendix A4 (***Ground Access Vehicle Emission Inventory for Criteria Pollutants*) and **Appendix E** (*Roadway Dispersion Modeling [Hot-Spot Analysis]*) for further details on how best to execute the MOVES for specific applications.

In order to utilize MOVES emission rate information to estimate roadway emissions, a total VMT must first be calculated for each type of vehicle using the airport (e.g., separate VMT for all passenger cars, all diesel shuttles, CNG buses, etc.), which is a function of the traffic volumes for a given type of vehicle and its travel distance. By factoring a vehicle type's VMT against its corresponding emissions factor in g/VMT, a total mass of pollutant is obtained.

Travel-based VMT must also be computed for parking and curbside activities and converted to a total mass of pollutant(s). However, the majority of the motor vehicle emissions attributable to parking and curbside activities are caused by vehicle idling. So, in addition to computing a VMT for the parking and curbside areas, an emissions inventory must also derive or estimate the total number of hours spent at idling for each vehicle type and for each parking facility/curbside area, and apply the appropriate g/hour emissions rate to produce a total mass of pollutant. By summing the travel emissions based on VMT and the idling emissions based on hours of operation, a total emissions inventory of roadway, parking and curbside motor vehicle activities is obtained.

6.1.3.2. Airport Operation Emission Inventory Results

Once the assessment is complete, an operational criteria pollutant emissions inventory is typically documented using the example template shown in **Table 6-2**, *Operational Emissions Inventory Results*, which summarizes the total emissions, in tons of pollutant per year of operation[45], by emissions source. This example also highlights how emissions should be summarized for NEPA assessments, whereby a project alternative subject to NEPA analysis is compared against the No Action alternative to assess the level of emissions increase (or decrease) that would occur. Refer to **Section 8** (*Conformity*) for details on how to relate this emissions increase (or decrease) to CAA compliance.

Table 6-2. Operational Emissions Inventory Results

Source	Proposed Action (tons/year)					
	CO	VOC	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Aircraft	718	146	482	59.7	7.3	7.3
APUs	22.8	1.6	12.7	2.2	2.2	2.2
GSE	81.8	6.3	51.0	0.4	5.9	5.7
Stationary Sources	3.6	0.2	4.3	0.1	5.9	5.7
Motor Vehicles	261	6.2	35.1	0.8	2.6	1.2
Total Proposed Action	**1,087**	**160**	**585**	**63.1**	**78.2**	**76.6**
Total No Action	**1,018**	**154**	**536**	**58.9**	**76.6**	**75.3**
Net Increase (project-related)	**69**	**6**	**49**	**4.2**	**1.6**	**1.3**

Example

6.1.4. Airport Construction Emissions

Although comparatively short-term in duration, construction-related air emissions can have an impact on both local air quality conditions and on the regional airshed. Moreover, construction emissions are classifiable as "direct" sources of emissions under the CAA General Conformity Rule (see **Section 8.1**, *General Conformity*). As a result, these emissions must be quantified, and in some cases mitigated, in nonattainment/maintenance areas in order to meet the requirements of the General Conformity Rule. In attainment areas, construction-related emissions can be reported for disclosure purposes under NEPA.

This section provides recommended approaches for assessing construction emissions associated with FAA projects/actions. **Appendix A6** (*Construction Emission Inventory for Criteria Pollutants*) provides additional information on these emissions including emission inventory methods and equations, data sources and other supporting materials.

6.1.4.1. Construction Emission Inventory Methods

[45] For conformity analyses the various inventories (i.e., operations, construction) need to be converted into tons per year.

Construction-related emissions are primarily associated with the exhaust from heavy equipment (e.g., backhoes, bulldozers, graders, etc.), delivery trucks (e.g., cement trucks, dump trucks, etc.), and construction worker vehicles traveling to, from and moving around the site as well as fugitive dust from site preparation, land clearing, material handling, and demolition activities. Construction emissions also evolve from the storage/transportation of raw materials, the disposal of construction debris and the production of asphalt or concrete. These emissions are temporary in nature (i.e., during the construction period only) and generally confined to the construction site and the access/egress roadways. Other types of fugitive emissions (e.g., asphalt off-gassing, etc.) occur in construction but are relatively insignificant and included on a case-by-case basis.

Typically, emissions from construction activities are estimated based on the construction activity schedule for the project, the number and types of vehicles/pieces of equipment needed, the types of fuel used, and the vehicle/equipment utilization rates.

Emission factors for on-road vehicles (e.g., passenger cars, pickup trucks, haul trucks, etc.) can be obtained from the EPA MOVES[46] emissions model. The emission factors should be developed in accordance with appropriate state or local regulatory guidelines. For on-road vehicles, the anticipated VMT should be determined or estimated to compute emissions.

Emission factors for off-road equipment (e.g., dump trucks, dozers, graders, etc.) can be obtained from the EPA NONROAD2008a[47] emissions model. For off-road equipment, the expected equipment size, hours of operation, and load factors are required or need to be estimated.

Fugitive dust emissions can be computed from emission factors contained within EPA's *Compilation of Air Pollution Emission Factors* (i.e., AP-42).[48] These factors are combined with project-specific values representing areas of disturbance, volumes of materials processed and/or dust control measure efficiencies.

6.1.4.2. Construction Emission Inventory Results

For consistency with the operational emissions inventory and for direct comparison to the General Conformity Rule *de minimis* levels, construction emissions inventory results should also be reported in tons per year. **Table 6-3** (*Construction Emissions Inventory Results)* provides a sample format for reporting these emissions. For simplification, total values are shown for each pollutant, construction year and alternative evaluated.

Table 6-3. Construction Emissions Inventory Results

Alternative	Pollutant	Construction Year (tons per year)			
		Year 1	Year 2	Year 3	Year 4
Alternative A	CO	1.08	15.9	11.4	12.2
Alternative B		1.23	12.6	20.1	22.2
Alternative A	VOC	0.23	3.02	2.28	2.39

46 EPA, *Motor Vehicle Emissions Simulator (MOVES*), http://www.epa.gov/otaq/models/moves/.

47 EPA, *User's Guide for the Final NONROAD2005 Model*, December 2005 [EPA 420-R-05-013] and EPA NONROAD Model Updates for 2008, April 2009, http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2005/420r05013.pdf.

48 EPA, *Emissions Factors & AP 42, Compilation of Air Pollutant Emission Factors*, http://www.epa.gov/ttnchie1/ap42/.

Alternative B		0.26	2.49	4.01	4.48
Alternative A	**NO_x**	1.31	28.7	19.5	21.5
Alternative B		1.66	21.5	35.8	38.8
Alternative A	**SO_x**	0.03	0.64	0.44	0.49
Alternative B		0.04	0.48	0.82	0.90
Alternative A	**PM_{10}**	0.17	2.45	1.79	1.91
Alternative B		0.19	1.97	3.19	3.56
Alternative A	**$PM_{2.5}$**	0.17	2.38	1.73	1.86
Alternative B		0.19	1.91	3.09	3.45

6.2. Hazardous Air Pollutants

Hazardous air pollutants (HAPs) are pollutants for which there are no NAAQS, but are still regulated under the federal CAA because of their potentially adverse effects on human health and the environment. Also known as "air toxics", these pollutants are comprised of a wide array of organic and inorganic compounds (e.g., formaldehyde, 1 acetaldehyde, benzene, toluene, acrolein, 1,3-Butadiene, xylene, lead, naphthalene, propionaldehyde.). Such emissions are present in the exhaust of aircraft, GSE/APUs, and motor vehicle engines and, to a lesser extent, from boilers, fuel facilities, and other stationary sources. **Section 3** (*Sources and Types of Emissions*) identifies and generally describes these emissions as they pertain to aviation.

This section addresses the available guidance and approaches for assessing HAPs in connection with FAA projects/actions. **Appendix B** (*Emissions Inventory for Hazardous Air Pollutants*) provides additional information on these emissions including emission inventory methods, data sources and other supporting materials.

6.2.1. Introduction & Background

The EPA has identified 187 air pollutants that are considered to be HAPs and therefore subject to the requirements of Section 112 (*Hazardous Air Pollutants*)[49] of the CAA. From this list of 187 HAPs, 40 have been further designated by the EPA as having the greatest potential health threat to the general public and are known as "Section 112(k) HAPs."[50] The major categories of HAPs in this group include volatile and semi-volatile organic compounds (i.e., VOCs, SVOCs) and heavy metals.

Importantly, neither airports nor aircraft are specifically included among the source types identified in Section 112 of the CAA nor do they meet the definitions of the source types (i.e., "major stationary", "area", or "mobile sources") that are specifically covered under this rule. Rather, all emissions from aircraft engines are currently regulated under Part B (*Aircraft*

[49] CAA, Title I, Part A, *Section 112 – Hazardous Air Pollutants*, http://www.epa.gov/air/caa/title1.html; EPA, *Introduction to CAA and Section 112 (Air Toxics)*, http://www.epa.gov/ttn/atw/overview.html; and United States Code (USC), Title 42, Chapter 85, *Section 7412 – Hazardous Air Pollutants*, http://www.gpo.gov/fdsys/pkg/USCODE-2009-title42/pdf/USCODE-2009-title42-chap85-subchapI-partA-sec7412.pdf.

[50] EPA, *Section 112(k) - Urban Air Toxics Program Development of Air Emissions Inventory*, http://www.epa.gov/ttnatw01/urban/112kfac.html.

Emission Standards)[51] of the CAA. Therefore, although aircraft HAPs are not specifically regulated under the CAA, they are indirectly controlled as elements of total unburned hydrocarbons (HC) and PM.

In a related matter, the EPA has identified 21 HAPs that are designated as Mobile Source Air Toxics (MSATs)[52] to signify those HAPs that are emitted by motor vehicles and non-road engines (e.g., farm and construction equipment, heavy industrial vehicles, GSE, etc.). These pollutants include VOCs and heavy metals that are commonly associated with the combustion of gasoline and diesel fuels - including those emitted by aviation-related motor vehicles and GSE.

Other sources of HAPs associated with airports are similarly regulated under Section 112 of the CAA if their emissions exceed established thresholds and they meet the definition of a major stationary or area source. These may include aircraft repair and maintenance facilities, engine test cells, central heating plants, painting operations, and other airport support services that generate air emissions.

6.2.2. FAA Guidance

In 2003, the FAA undertook a review of publicly available information pertaining to the relationship(s) between aircraft and airport-related activities and the emissions of HAPs. This initial body of work focused on those emissions specifically identified by the EPA as HAPs and was prepared in response to the rising interest by various federal, state and local governmental agencies and the general public in connection with these pollutants. Referred to as the *FAA Resource Document for HAPs*, this initial report was entitled and is described as follows:

- *Select Resource Materials and Annotated Bibliography on the Topic of Hazardous Air Pollutants (HAPs) Associated With Aircraft, Airports and Aviation.*[53]

  Among the key findings from this initial publication was the need for a more unified approach and technical guidelines for evaluating HAPs emissions for aviation-related sources. Other topics include HAP types and sources, agency regulations, and air monitoring data associated with airports and aviation.

In response to this need for more information, in 2009 the EPA and the FAA developed organic gas (OG) speciation profiles and best practices for use in HAPs emission inventories of aircraft equipped with turbofan, turbojet, and turboprop engines fueled with kerosene-based jet-A fuel. The development of these profiles and guidance was the combined work of both agencies, taking into account the most recent data and information available. Referred to as the *Speciated Organic Gas Emissions from Aircraft Guidance*, this document is entitled and described as follows:

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[51] CAA, Title II, *Part B – Aircraft Emission Standards (Sections 231 – 234)*, http://www.epa.gov/air/caa/title2.html, and USC, Title 42, Chapter 85, Subchapter II, *Part B – Aircraft Emission Standards (Sections 7571 – 7574)*, http://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/pdf/USCODE-2010-title42-chap85-subchapII-partB.pdf.

[52] EPA, *Mobile Source Air Toxics*, http://www.epa.gov/otaq/toxics.htm.

[53] FAA, *Select Resource Materials and Annotated Bibliography on the Topic of Hazardous Air Pollutants (HAPs) Associated With Aircraft, Airports and Aviation,* Technical Directive Memorandum D01-010, July 1, 2003, http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/media/HAPs_rpt.pdf.

- *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines.*[54]

  The aircraft-related speciation profile developed from this initiative was used to update the OG profile for aircraft in the EPA SPECIATE database – the agency's multi-sector repository for such data. In this application, a *speciation profile* is the amount of OGs emitted based on the amount of VOCs emitted by an emission source.

Again in 2009, the FAA also published a document providing an approach to, and technical guidance for, preparing speciated OG emission inventories for airport sources including aircraft, APUs, GSE, motor vehicles, and stationary sources. Referred to as the *Speciated Organic Gas Emissions from Airports Guidance*, this document is entitled and described as follows:

- *Guidance for Quantifying Speciated Organic Gas Emissions from Airport Sources.*[55]

  This guidance is intended to help ensure that OG/HAPs emission inventories prepared in support of environmental documents prepared by, or on behalf of, the FAA under NEPA are done so consistently. Importantly, it points out that emission inventories of aviation-related OGs; which include the OGs identified by the EPA to be HAPs and the OGs listed in the EPA's Integrated Risk Information System (IRIS)[56], are not required by current EPA regulations.[57] However, in those cases where it is necessary to prepare such an aviation-related HAP inventory, the inventory must be prepared following this guidance and using EDMS/AEDT.

The FAA also recognized that the need to prepare an emissions inventory of OGs/HAPS is not widely instituted nor uniformly applied in connection with FAA projects/actions. To address this discrepancy, FAA has provided a flow chart in the *Speciated Organic Gas Emissions from Airports Guidance* document that can be used to determine when an emission inventory of OGs/HAPs should be prepared.

If an EA or EIS is not required to assess a proposed project/action, then preparation of a HAPs emissions inventory is not warranted. In other words only those proposed projects/actions evaluated through an EA or EIS should consider including a HAP emissions inventory. Furthermore, considerations are given as to (i) whether the project/action is considered "major" (e.g., new airport, new runway, major runway extension, etc.); (ii) whether or not it is located in a nonattainment/maintenance area; and/or (iii) whether a criteria air pollutant emissions inventory is also prepared. In those cases where the magnitude of the project is uncertain, a HAP emissions inventory may also be prepared when called for during agency scoping or based on consultation with the appropriate FAA office.

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[54] FAA and EPA, *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines (Version 1.0)*, May 2009 [EPA-420-R-09-901], http://www.epa.gov/nonroad/aviation/420r09901.pdf.

[55] FAA, *Guidance for Quantifying Speciated Organic Gas Emissions from Airport Sources,* Version 1, September 2, 2009, http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/media/Guidance%20for%20Quantifying%20Speciated%20Organic%20Gas%20Emissions%20from%20Airport%20Sources.pdf.

[56] Integrated Risk Information System (IRIS), http://www.epa.gov/iris/.

[57] For a detailed discussion of the relationship of HAPs and OG, along with other "groups" of OG, refer to Section 1.5.1 of FAA's *Guidance for Quantifying Speciated Organic Gas Emissions from Airport Sources*, Version 1, September 2, 2009.

6.2.3. HAPs Emission Inventory Methods

Again, it is important to acknowledge that there are currently no federal regulatory guidelines specific to HAPs emissions from aircraft engines, specifically, and airports, in general. While the methodology discussed in this *Handbook* is useful for disclosure, reporting, and comparative purposes, it does not provide results that are directly comparable to any regulatory threshold or air quality standards.

It is also important to note that other than an emissions inventory, a HAPs assessment prepared for the FAA must not include any other type of analysis including, but not limited to, atmospheric dispersion modeling, toxicity weighting, or human health risk analyses. These types of assessments require a more complete understanding of the reactions of HAPs in the atmosphere and downstream plume evolution as well as human exposure patterns. Because the science of these relationships with respect to aviation-related HAPs is still evolving, the corresponding level of understanding is also currently limited.

As stated previously, in cases where it is necessary to prepare such an aviation-related HAP inventory, the inventory must be prepared following the *Speciated Organic Gas Emissions from Airports Guidance* and using EDMS/AEDT. In this application, EDMS/AEDT applies speciation factors to quantify individual HAP compounds. These factors estimate the quantities of individual HAPs based on the total emissions of VOCs. Notably, the EPA MOVES emission factor model should be used to develop individual HAP speciation data for motor vehicles.

Presently, EDMS/AEDT calculates emissions for 394 different OGs. Of these, 45 are classified as HAPs by the EPA while the other 349 are considered to be non-toxic compounds. These 45 HAPs are listed in **Table 6-4** (*Potential HAPs to be Included in an Airport Emissions Inventory*).

Table 6-4. Potential HAPs to be Included in an Airport Emissions Inventory

Hazardous Air Pollutants			
1,1,1-Trichloroethane	Cyclohexane	Methyl alcohol	Phenol (carbolic acid)
1,3-Butadiene	Dichloromethane	Methyl chloride	Phthalic anhydride
2,2,4 Trimethylpentane	Thyl acetate	Methyl ethyl ketone	Propionaldehyde
2-Methylnaphthalene	Ethyl ether	Methyl tert butyl ether	Styrene
Acetaldehyde	Ethylbenzene	m-xylene	Toluene
Acetone	Ethylene bromide	Naphthalene	Trichloroethylene
Acrolein (2-propenal)	Ethylene glycol	n-Butyl alcohol	Trichlorotrifluoroethan
Benzaldehyde	Formaldehyde	n-Heptane	Vinyl acetate
Benzene	Isomers of xylene	n-Hexane	
Butyl cellosolve	Isopropylbenzene	o-Xylene	
Chlorobenzene	m & p-Xylene	Perchloroethylene	
Source: FAA, Guidance for Quantifying Speciated Organic Gas Emissions from Airport Sources, September 2, 2009, http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/media/Guidance%20for%20Quantifying%20Speciated%20Organic%20Gas%20Emissions%20from%20Airport%20Sources.pdf.			

Importantly, the type(s) and number of HAPs reported in an aviation-related emissions inventory will depend on the type of airport sources that are evaluated and, in some case, the type of fuel and other emission characteristics of the individual source(s) involved.

For most airport emission inventories, formaldehyde occurs in the greatest amounts followed by acetaldehyde, acrolein, and 1,3-butadiene. These compounds are emitted in the exhaust of aircraft, APUs, GSE, and motor vehicle engines and, to a lesser extent, from boilers, fuel facilities, and other stationary sources at an airport. Compounds such as benzene, ethylbenzene, naphthalene, toluene, hexane, styrene, and xylene also occur, but in far lesser amounts.

Appendix B (*Emissions Inventory for Hazardous Air Pollutants*) provides additional information on computing these aviation-related emissions including the emission inventory methods, data sources and other supporting materials.

6.2.4. HAPs Emission Inventory Results

As discussed previously, for NEPA-related HAPs emission inventories, the emphasis is on "disclosing" the incremental change in HAPs emissions with the proposed project (and alternatives) compared to the no-action alternative. For consistency, HAPs emission inventories should also be reported in tons per year. **Table 6-5** (*HAPs Emissions Inventory Results*) provides a sample format for reporting HAP emissions. For simplification, total values are shown for each species of HAPs evaluated and comprise emissions from aircraft, APUs, GSE, motor vehicles, stationary sources, and fuel storage facilities.

Table 6-5. HAPs Emissions Inventory Results

Pollutant	HAPs Emissions Inventory (tons per year)					
	No Action		Alternative A		Alternative B	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
1,3-butadiene	3.92	4.58	3.93	4.45	3.80	4.58
2,2,4-trimethylpentane	0.28	0.23	0.28	0.23	0.28	0.23
2-methylnaphthalene	0.43	0.51	0.44	0.50	0.42	0.51
Acetaldehyde	9.92	11.6	9.95	11.3	9.61	11.6
Acetone	0.88	1.02	0.88	0.99	0.85	1.02
Acrolein	5.27	6.18	5.29	6.01	5.08	6.18
Benzaldehyde	1.03	1.20	1.03	1.17	0.99	1.20
Benzene	7.23	8.14	7.24	8.00	7.21	8.22
Chlorobenzene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyclohexane	0.02	0.02	0.03	0.03	0.03	0.03
Ethylbenzene	0.85	0.94	0.85	0.92	0.83	0.93
Formaldehyde	27.7	32.4	27.8	31.5	26.8	32.4
Isopropylbenzene (cumene)	0.03	0.04	0.03	0.04	0.03	0.04
M & P-xylene	1.92	2.19	1.92	2.17	1.90	2.19
Methyl alcohol	3.80	4.47	3.81	4.34	3.66	4.47
M-xylene	0.34	0.29	0.34	0.29	0.34	0.3
Naphthalene	1.23	1.44	1.23	1.40	1.18	1.44
N-heptane	0.49	0.52	0.50	0.52	0.49	0.52
N-hexane	0.77	0.78	0.77	0.78	0.77	0.78
O-xylene	1.08	1.18	1.08	1.17	1.06	1.18

Phenol (carbolic acid)	1.54	1.81	1.54	1.75	1.48	1.80
Propionaldehyde	1.62	1.90	1.63	1.84	1.57	1.89
Styrene	0.68	0.79	0.68	0.77	0.65	0.79
Toluene	3.32	3.64	3.33	3.60	3.28	3.64

It is again noteworthy that the HAPs emission inventory results are not compared to the NAAQS or any other significance criteria. Rather, the information is provided for informational purposes as a means of disclosing the project's potential effects on HAPs.

6.3. Greenhouse Gases

Greenhouse gases (GHGs) are another category of pollutants for which there are no NAAQS but are of concern because of their climate-changing potential. **Section 3** (*Sources and Types of Air Emissions*) identifies and generally describes these emissions as they pertain to aviation. These include gases such as CO_2, CH_4, and N_2O as by-products of fuel combustion in aircraft, APU, GSE, and motor vehicle engines as well as emissions of HFCs, PFCs, and SF_6 linked with refrigeration and air conditioning.

This section addresses the available guidance and approaches for assessing these emissions in connection with FAA projects/actions. **Appendix C** (*Emissions Inventory for Greenhouse Gases*) provides additional information on these aviation-related GHGs including emission inventory methods, data sources and other supporting materials.

6.3.1. Introduction & Background

There is presently a broad scientific consensus that human activities, primarily in the form of GHGs, are contributing to changes in the earth's atmosphere. These GHGs, brought about principally by the combustion of fossil fuels, decomposition of waste materials, and deforestation, cause an increase in the earth's average temperature – a phenomenon which is referred to as the "greenhouse effect" or "global climate change."

As a result, the scientific community is continuing its efforts to better understand the impact of aviation emissions on the global atmosphere. In particular, the FAA is leading and participating in a number of initiatives intended to clarify the role that aviation plays in GHG emissions and climate. For example, the FAA, with support from the U.S. Global Change Research Program (GCRP)[58] and its participating federal agencies (i.e., NASA, NOAA, EPA, and DOE)[59], has developed the Aviation Climate Change Research Initiative (ACCRI)[60] in an effort to advance scientific understanding of regional and global climate impacts of aircraft emissions, with quantified uncertainties for current and projected aviation scenarios under changing atmospheric

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58 U.S. Global Change Research Program, http://www.globalchange.gov/about.

59 National Aeronautics and Space Administration (NASA) at http://www.nasa.gov/, National Oceanic and Atmospheric Administration (NOAA) at http://www.noaa.gov/, and Department of Energy (DOE) at http://energy.gov/.

60 FAA, *Aviation Climate Change Research Initiative*, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/science_integrated_modeling/accri/.

conditions.[61] The FAA also funded the Partnership for Air Transportation Noise & Emissions Reduction (PARTNER) and subsequently the Center of Excellence for alternative jet fuels and environment (ASCENT) research initiatives to quantify the effects of aircraft exhaust and contrails on global and U.S. climate and atmospheric composition. Similar research topics are being examined at the international level by the ICAO.[62]

In terms of U.S. contributions, the U.S. Government Accountability Office (GAO) reports that "*domestic aviation contributes about 3 percent of total carbon dioxide emissions, according to EPA data*," compared with other industrial sources, including the remainder of the transportation sector (20 percent) and power generation (41 percent).[63] The ICAO also estimates that GHG emissions from aircraft account for roughly three percent of all anthropogenic GHG emissions globally.[64]

Importantly, actions are underway within the U.S. and by other nations to reduce aviation's contribution of GHGs through such measures as new aircraft technologies to reduce emissions and improve fuel efficiency, renewable alternative fuels with lower carbon footprints, more efficient air traffic management, market-based measures, and environmental regulations including an aircraft CO_2 standard.

6.3.2. FAA NEPA Guidance

Presently, FAA's principal guidance for assessing and reporting upon climate change and GHGs for NEPA documents is described below; however, subsequent revisions should be consulted as they become available.

- *Federal Greenhouse Gas Accounting and Reporting Guidance.*[65]

  Prepared by the CEQ, this Guidance presently serves as the FAA's protocol for assessing and reporting upon GHGs in NEPA documents. From this, the FAA recommends the following with respect to the documentation of GHGs in NEPA documents:

  - If GHGs and climate are not relevant to the proposed action and alternative(s) (i.e., because there would be no GHG emissions), this should be briefly noted and no further analysis is required.
  - Where the proposed action or alternative(s) would not result in a net increase in GHG emissions (as indicated by quantitative data or proxy measures such as

[61] Nathan Brown, et. al. *The U.S. Strategy for Tackling Aviation Climate Impacts*, 2010, 27th International Congress of the Aeronautical Sciences.

[62] Lourdes Q. Maurice and David S. Lee. Chapter 5: *Aviation Impacts on Climate. Final Report of the International Civil Aviation Organization (ICAO) Committee on Aviation and Environmental Protection (CAEP) Workshop*, October 29th - November 2nd 2007, Montreal.

[63] GAO, *Aviation and Climate Change. GAO Report to Congressional Committees*, June 2009 [GAO-09-554]; http://www.gao.gov/new.items/d09554.pdf.

[64] ICAO, Alan Melrose, *European ATM and Climate Adaptation: A Scoping Study*, in ICAO Environmental Report 2010, http://www.icao.int/environmental-protection/Documents/EnvironmentReport-2010/ICAO_EnvReport10-Ch6_en.pdf.

[65] Council on Environmental Quality, *National Environmental Policy Act (NEPA) Draft Guidance, "Consideration of the Effects of Climate Change and Greenhouse Gas Emissions."*, 75 Federal Register 8046, 2010, https://federalregister.gov/a/2010-3532

reduction in fuel burn, delay, or flight operations), a brief statement describing the factual basis for this conclusion is sufficient.

- Where the proposed action or alternative(s) would result in an increase in GHG emissions, the emissions should be assessed either qualitatively or quantitatively as described below.

Moreover, the guidance points out there are currently no federal requirements for reporting GHG emissions from aviation sources as well as no significance thresholds. Therefore, the FAA recommends the following with respect to assessing and reporting GHGs in NEPA documents:

- When there is reason to quantify emissions, GHG emission inventories should be reported in metric tons of carbon dioxide equivalents (MT CO_{2e}).[66]
- GHG emissions should be based on fuel burn, energy usage and/or activity levels developed from FAA-approved tools.
- CO_{2e} should be computed for time periods that are reasonably foreseeable using the same analytical timeframes used for the NEPA analyses.
- CO_{2e} results should be documented in a separate section of the NEPA document distinct from air quality, under a heading labeled "Climate".
- CO_{2e} emissions should be reported in a table or similar format that compares the project/action and/or alternatives to the no-action alternative (i.e., the incremental change) within the same timeframe.
- For an air traffic action, the CO_{2e} should be computed based on the fuel content and the assessment boundary shall be the same as the study area.
- For an airport action, the GHG assessment should include the same emission sources that would typically be included in an air quality analysis – with a particular focus on those emission sources affected by the project/action.
- For aircraft, the altitude up to which GHG emissions would be quantified should be 3,000 feet. For non-aircraft sources, GHGs should be determined from fuel burn, energy usage, and/or activity levels.

Therefore, in those cases where the project/action would not increase GHG emissions, this finding should be stated and no further explanation is required. In those cases where GHGs are shown to increase with the project/action and quantification is warranted, **Section 6.3.4** (*GHG Emission Inventory Methods*) provides recommended methodologies.

Finally, in those cases where GHG emissions are not quantified (i.e., because other air emissions and/or fuel burn are not quantified), FAA suggests that the potential impacts can be expressed semi-qualitatively. For example, given that all U.S. aviation represents less than three percent of U.S.-based GHG emissions, then it can be concluded by proportion, that the percent contribution

[66] EPA defines CO_{2e} as a metric measure used to compare the emissions from various GHGs based upon their GWP. CO_{2e} are commonly expressed as "metric tons of carbon dioxide equivalents ($MTCO_{2e}$)." The CO_{2e} for a gas is derived by multiplying the tons of the gas by the associated GWP.

of the project/action contribution to this overall total is also a very small fraction of the U.S. total.

If necessary, the FAA program office or AEE can be consulted regarding how to conduct the GHG assessment and discuss the results. It should also be noted that there may be state or local requirements that could dictate additional documentation.

6.3.3. Methodology

In general, airport-related GHG emissions inventory procedures are intended to accomplish the following:

- Identify and characterize the types and sources of GHGs to include in an airport emissions inventory.
- Apply appropriate and consistent methods for computing airport GHG emission inventories.
- Help airports track and manage GHG emissions over time taking into account issues pertaining to ownership, control and location.
- Aid in the integration of airport GHG inventories into larger regional, national and global inventories.
- Clarify the specific makeup and percent contribution of airport-generated GHGs, by source and emission type.

Typically, aviation-related GHG emissions are also translated into Scopes based upon their origin and ownership. Consistent with international reporting protocols, these Scopes are defined as follows:

- *Scope 1/Direct* – GHG emissions from sources that are owned by the reporting entity (i.e., airport operator). These include on-airport owned stationary sources (e.g., boilers, generators, snowmelters, etc.) and airport-owned GSE and fleet motor vehicles.
- *Scope 2/Indirect* – GHG emissions associated with the generation of electricity purchased and consumed by the reporting entity.
- *Scope 3/Indirect* – GHG emissions that are associated with the activities of the reporting entity, but are associated with sources that are owned by others. These include aircraft-related emissions and emissions from airport tenant's activities as well as ground transportation to and from the airport by the public.

Furthermore, GHG emissions are categorized by the degrees of control that an airport operator may have over them. These categories are defined as follows:

- *Category 1* – GHG emissions from sources that are controlled by the reporting entity. In the case of an airport operator these include Scope 1 emissions but can also include some Scope 2 and Scope 3 sources over which the entity can exert some control. Examples of the latter can include on-airport motor vehicles and tenant electrical use.
- *Category 2* – This category comprises Scope 3 emissions associated with sources owned and controlled by airlines and airport tenants. Examples include aircraft, APUs, most GSE, electrical consumption, and other stationary sources controlled by tenants.

- *Category 3* – This category generally comprises Scope 3 emissions associated with public sources associated with the airport. Examples include automobiles, taxis, limousines, buses, and shuttle vans traveling to and from the airport.

It should be mentioned that with the adoption of these Scope and Category definitions, the *Scope 3* and *Category 2/3* groupings represent by far the largest emissions for airport operators because they include all aircraft-related emissions and emissions from all tenant activities as well as the public's travel to and from the airport. In other words, the overall percentage of GHG emissions owned and controlled by the airport is typically very small.

Again, for NEPA GHG emission reporting, the focus is on the project/action-related effects. In other words, the analyst should identify and disclose the incremental change in GHG emissions with the proposed project (and alternatives) compared to the no-action alternative within the same timeframe.

6.3.4. GHG Emission Inventory Methods

As discussed in **Section 3** (*Sources and Types of Air Emissions*), the primary sources of GHG emissions that are typical of most airports that service both commercial and GA operations include aircraft, APUs, GSE, an assortment of stationary sources, and motor vehicles (operating on the airport's internal roadways, parking facilities and terminal curbsides, and off-airport roadways). For the most part, emissions from these sources arise from the combustion of fossil fuels (e.g., jet fuel, Avgas, diesel, gasoline, CNG, etc.) and are emitted as by-products contained in the engine exhaust.

Because GHG emissions are primarily a function of fossil fuel use, most of the emission calculations for each source are based on estimating or obtaining fuel use (or activity) data and then applying the appropriate GHG emission factor (i.e., pounds per gallon or grams per mile traveled), as follows:

GHG emissions = (Fuel Use or Activity Level) x (Emission Factor)

For example, when calculating aircraft-related GHG emissions, fuel use can be obtained from airport fuel throughput data for jet fuel and Avgas or computed from EDMS/AEDT for those operational modes within the LTO cycle (i.e., taxi/idle, take-off, approach, and climbout). Importantly, GHG emissions beyond the study area (i.e., cruise mode) are typically not included in a NEPA analysis. For APU GHG emissions, fuel use can be obtained from manufacturer fuel flow rates. These data can then be converted to GHG emissions using appropriate emission factors for each fuel type (e.g., jet fuel, avgas, etc.).

GHGs from GSE can be computed from fuel use and/or operational time from the EPA NONROAD model (or airport records) and then combined with fuel-specific emission factors (e.g., gasoline, diesel, CNG, etc.).

Similarly, the EPA MOVES model provides GHG emission factors for a variety of motor vehicle types and operating speeds. These emission factors are typically reported in grams per mile traveled and can be combined with aviation-related motor vehicle traffic volumes to determine GHG emissions.

GHG emissions from stationary sources are also largely based on fuel throughput data combined with emission factors for each fuel type (e.g., diesel, natural gas, etc.).

GHG emissions associated with the onsite generation of electricity using coal, oil, natural gas, etc. may be included in an aviation-related GHG emissions inventory. Typically, these values are based on aviation-related electrical usage and emission factors from local utilities or from the EPA eGRID[67] system.

The GHG emissions associated with refrigeration and heating and air-conditioning systems as well as the GHG emissions from recycling of solid waste associated with an airport are likewise occasionally included. These values are based mostly on product-specific material-balancing methods and emission factors which take into account the use and disposal of these materials.

Notably, GHG emissions associated with the entire "supply chains" or full "life cycles" (e.g., production, consumption and/or disposal of goods and materials such as paper, plastic and waste products, foodstuffs, building materials, etc.) by either airport facilities or its tenants are typically not included in an aviation-related GHG emissions inventory.

Moreover, the storage of fuel (e.g., jet fuel, Avgas, gasoline, and diesel) is a potential source of evaporative hydrocarbon emissions, but does not produce the type of HCs that contribute directly to global climate change.

Due to the fact that CO_2, CH_4, and N_2O are by-products of fuel combustion, they are also the predominant GHGs associated with most airports. Emissions of HFCs, PFCs, and SF_6 linked with refrigeration, air conditioning, and other coolants also occur, but at far lesser amounts. However, in all cases, the estimated GHGs should be converted to CO_{2e} values using Global Warming Potentials (GWPs).[68,69]

Table 6-6 (*GHG Emission Inventory Methods*) provides a summary listing and **Appendix C** (*Emissions Inventory for Greenhouse Gases*) provides further guidance on the computation of GHG emissions associated with aviation including the emission inventory methods, data sources, and other supporting materials.

Table 6-6. GHG Emission Inventory Methods

Source	Method
Aircraft Engines	Fuel use rates within the study area based on EDMS/AEDT combined with fuel-specific emission factors.
APUs	Fuel use rates from EDMS/AEDT combined with fuel-specific emission factors.
GSE	Fuel use or fuel use rates from NONROAD combined with fuel-specific model emission factors.
Ground Access Vehicles	Fuel use or VMT combined with emission factors from MOVES model.
Stationary Sources	Fuel use combined with fuel-specific emission factors.
Electric Usage	Kilowatt hours combined with emission factors from local utility and/or eGRID system.
Refrigeration, Heating, Air	Material balancing accounting for charging, use and disposal

67 EPA, *Emissions & Generation Resource Integrated Database (eGRID)*, http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

68 GWPs are a relative measure of how much heat a GHG traps in the atmosphere when compared CO_2.

69 EPA, *Global Warming Potentials of Ozone-Depleting Substances (ODS) Substitutes*, http://www.epa.gov/ozone/geninfo/gwps.html.

Conditioning	combined with appropriate emission factors.
Solid Waste Recycling	Material amounts combined with WARM model emission factors.

6.3.5. GHG Emission Inventory Results

As discussed above, the FAA NEPA Guidance is a resource document for reporting the results of aviation-related GHG emissions inventories. It is recommended that GHG emission inventories should be reported in MT CO_{2e}.

For NEPA-related GHG emission inventories, the emphasis is on "disclosing" the incremental change in GHG emissions with the proposed project (and alternatives) compared to the no-action alternative. **Table 6-7** (*GHG Emissions Summary for NEPA Documents*) provides a sample format for reporting GHG emissions in this fashion.

Table 6-7. GHG Emissions Summary for NEPA Documents

Alternative	GHG Emissions (MT CO_{2e})	Difference from No Action (MT CO_{2e})	% Difference from No Action
No Action	3,910,933	--	--
Alternative A	3,928,321	17,388	0.44
Alternative B	3,929,648	18,715	0.48

In the case where the purpose of the aviation-related GHG emissions inventory is to translate the emissions into categories, or Scopes, based upon their ownership and control, **Table 6-8** (*GHG Emissions Summary by Source, Category, and Scope*) provides a sample format for reporting the results in this manner.

Table 6-8. GHG Emissions Summary by Source, Category, and Scope

Source/Category	Scope	GHG Emissions (MT CO_{2e})	
		2020	2025
Category 1: Airport Owned/Controlled			
Stationary Sources - Combustion	1	3,435	3,435
Stationary Sources - Refrigerants	1	675	675
Fleet Vehicles	1	3,572	4,191
Electrical Consumption	2	7,281	7,281
On-airport Roadways	3	27,385	32,134
Parking Ramps/Lots	3	3,708	4,184
Total - Airport Owned/Controlled		**46,054**	**51,899**
Category 2: Tenant Owned/Controlled			
Aircraft (Ground-based)	3	204,053	243,432
Aircraft (Ground to 3,000 feet)	3	252,473	276,820
Aircraft - Engine Startup	3	3,187	3,461
APUs	3	22,417	25,180
Subtotal – Aircraft		*482,130*	*548,893*
GSE	3	33,482	37,912
Stationary Sources - Combustion	3	22,037	22,037

Electrical Consumption	3	91,446	91,446
Total - Tenant Owned/Controlled		**629,095**	**700,288**
Category 3: Passenger Owned/Controlled			
Off-Airport Roadways (Aviation-related only)	3	57,769	68,497
Total - Passenger Owned/Controlled		**57,769**	**68,497**
Grand Total		686,910	820,684
Note: Totals may differ from sum due to rounding.			

It is noteworthy that the GHG emission inventory results are not compared to the NAAQS nor any other significant criteria. Rather, the information is provided for informational purposes as a means of disclosing the project's potential effects on GHGs and climate change.

7. Conducting Dispersion Modeling for Criteria Air Pollutants

This section addresses two types of atmospheric dispersion modeling conducted in support of FAA projects/actions: (i) atmospheric dispersion modeling for airports and (ii) roadway dispersion modeling.

7.1. Atmospheric Dispersion Modeling for Airports

This section discusses the recommended guidance and approaches for conducting and reporting atmospheric dispersion modeling of aviation-related emissions in connection with FAA projects/actions. **Appendix D** (*Atmospheric Dispersion Modeling*) provides additional information on dispersion modeling methods, data requirements, and other supporting materials.

7.1.1. Introduction & Background

In general terms, dispersion modeling is the process by which the dispersal of atmospheric pollutants are simulated and assessed under the effects of meteorological, terrain and other influencing factors. Computer models such as the American Meteorological Society/EPA Regulatory Model (AERMOD) have been developed and used for this purpose. The results of this modeling allow for the prediction of pollutant concentrations at or near an emission source(s) and enable the comparison of these results to the NAAQS.

7.1.2. EPA Guidance

EPA's principal guidance of conducting dispersion modeling and assessing the air quality impacts on nearby receptors is entitled and described as follows:

- *Appendix W to Part 51 - Guideline on Air Quality Models*[70]

  This guidance contains recommendations and supporting information on the selection and applications of air quality models, determining background concentrations and the use of meteorological data. This guidance also specifies dispersion models required to be used for SIPs revisions and for New Source Review (NSR) and Prevention of Significant Deterioration (PSD) programs.

Notably, dispersion modeling requirements and methodologies may vary by purpose and/or locale, thus state and regional air quality regulatory agencies should be consulted on the methodology, assumptions, and data sources utilized.

However, as discussed previously in **Section 5** (*Air Quality Assessment Models*), the FAA's EDMS is the required model for performing air quality assessments of aviation-related sources in support of FAA projects/actions until EDMS is replaced by AEDT2b.[71] Coupled with

[70] Appendix W to Part 51 – *Guideline on Air Quality Models*, http://www.ecfr.gov/cgi-bin/text-idx?SID=e6a5b817b94abf58460f48c032d9a39c&node=40:2.0.1.1.2.23.11.5.37&rgn=div9.

[71] FAA, *Emissions and Dispersion Modeling System Policy for Airport Air Quality Analysis; Interim Guidance to FAA Orders 1050.1D and 5050.4A*, 18068 Federal Register/Vol. 63, No. 70/Monday, April 13, 1998/Notices,

AERMOD, EDMS computes spatially- and temporally-allocated emissions associated with airports and estimates the resulting pollutant concentrations.

In brief, AERMOD can simulate emission sources as point, area, volume, and line sources over simple, intermediate, and complex terrains. It also has the capability to predict both maximum short-term (i.e., 1 to 24 hours) and average long-term (i.e., quarterly or annual) concentrations. As discussed in **Appendix D** (*Airport Dispersion Modeling*), AERMOD contains supplemental modules, including AERMET[72], AERMAP[73], and AERSURFACE[74] for the processing of meteorological and terrain data.

EPA's principal guidance for using AERMOD are entitled and described as follows:

- *User's Guide for the AERMOD* - Addresses the regulatory application of AERMOD for assessing criteria pollutants under the CAA.[75]
- *AERMOD Implementation Guide* - Provides information on the recommended use of AERMOD and addresses specific topics such as meteorological data processing, terrain processing, urban environment applications, and source release characteristics. [76]
- *AERMOD: Description of Model Formulation* - Provides a comprehensive and detailed description of the technical formulation of AERMOD and its preprocessors.[77]
- *AERSURFACE User's Guide* – Aids in the determination of land surface characteristics based on land use cover, soil moisture, and seasonal conditions for use in AERMET.[78]
- *User's Guide for the AERMOD Meteorological Preprocessor (AERMET)* - Provides a methodology to process and organize meteorological data into a format suitable for use by the AERMOD.[79]
- *User's Guide for the AERMOD Terrain Preprocessor (AERMAP)* - Provides a physical relationship between terrain features and the behavior of air pollution plumes. [80]

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http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS%20Requirement%20for%20Airport%20Air%20Quality%20Analysis.pdf.

72 EPA, Preferred/Recommended Models, *AERMET – Version 12345*, http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm#aermet.

73 EPA, Preferred/Recommended Models, *AERMAP – Version 11103*, http://www.epa.gov/ttn/scram/dispersion_related.htm#aermap.

74 EPA, Preferred/Recommended Models, *AERSURFACE – Version 13016*, http://www.epa.gov/ttn/scram/dispersion_related.htm#aersurface.

75 EPA, *User's Guide for the AMS/EPA Regulatory Model - AERMOD*, September 2004 [EPA-454-b-03-001], http://www.epa.gov/scram001/7thconf/aermod/aermodugb.pdf

76 EPA, *AERMOD Implementation Guide*, Last Revised: March 19, 2009, http://www.epa.gov/scram001/7thconf/aermod/aermod_implmtn_guide_19March2009.pdf

77 EPA, *AERMOD: Description of Model Formulation*, September 2004, [EPA-454-R-03-004], http://www.epa.gov/scram001/7thconf/aermod/aermod_mfd.pdf

78 EPA, *AERSURFACE User's Guide*, January 2008 (Revised 01/16/2013) [EPA-454/B-08-001], http://www.epa.gov/scram001/7thconf/aermod/aersurface_userguide.pdf

79 EPA, *User's Guide for the AERMOD Meteorological Preprocessor (AERMET)*, November 2004 [EPA-454-B-03-002], http://www.epa.gov/scram001/7thconf/aermod/aermetugb.pdf.

80 EPA, *User's Guide for the AERMOD Terrain Preprocessor (AERMAP)*, October 2004 [EPA-454-B-03-003], http://www.epa.gov/ttn/scram/dispersion_related.htm#aermap.

7.1.3. Dispersion Modeling Methods

Typically, the first step in dispersion modeling is to compile detailed information on the emission sources being modeled. This information includes the source emission rates (including temporal variations), release characteristics, location coordinates, and source layout. For an airport, these emission source data may take the form of an aircraft fleet mix, runway and taxiway locations, gate assignments, stack height, and airport operational profiles (see **Appendix D**, *Airport Dispersion Modeling*, for more information).

Second, representative meteorological information is required, typically obtainable from publicly-available databases; this data includes wind speed, wind direction, and atmospheric stability (i.e., surface roughness, albedo, and Bowen Ratio). For those locations with variable terrain, local topographic data may also be required. Receptors are similarly identified and located as representing the locations where pollutant concentrations are computed.

Finally, appropriate background concentrations are added to the computed concentrations to represent the contributions from all other emission sources within the study area. Special consideration should be given to the estimation of NO_2 concentrations to account for the conversion of nitric oxide (NO) to NO_2 (see **Appendix D**, *Airport Dispersion Modeling*, for more information).

For clarity, this multi-step process of setting up and running a dispersion model such as AERMOD for aviation-related sources is summarized as follows:

- *Select model options* - Model options include averaging periods, pollutant types, urban vs. rural setting, receptor layout, and data output format.
- *Select emission source characteristics* - Develop source release conditions for point, area, line, and volume sources including emission rate, stack height and diameter, exhaust temperature and exit velocity, source length and width, and volume height above ground level. Also, source locations are to be provided to create a spatial relationship between sources and receptors.
- *Select meteorological data* - Develop meteorological data such as wind speed, wind direction, turbulence indices, temperature, and relative humidity using the AERMET processor and surface/upper air data from the nearest representative monitoring station.
- *Select terrain data* - Digital elevation data is used to determine elevations for sources and receptors using AERMAP and account for wind and plume behavior associated with terrain features.
- *Select receptor site locations* - The locations at which concentrations are estimated are known as receptors. Generally receptors are located where the general public is likely to have continuous access.
- *Determine background concentrations* - Background concentrations are typically obtained from a representative background monitoring site not affected by the modeled emission source(s).
- *Tabulate results* - Representative background concentrations should be added to the model predicted concentrations.

For airport applications, the typical AERMOD input requirements and their corresponding data parameters are listed in **Table 7-1** (*AERMOD Model Inputs and Data Requirements*).

Table 7-1. AERMOD Model Inputs and Data Requirements

Model Inputs	Data Parameters
Model Options	• Averaging time • Pollutants • Urban versus rural
Emission Source Release Parameters	• Location coordinates • Area dimensions • Roadway link length and width • Stack height • Stack diameter • Exit temperature • Exit velocity
Meteorological Data	• Surface/upper air conditions • Wind speed and direction • Ambient temperature • Mixing height • Surface roughness, albedo, Bowen ratio
Spatial Allocation	• Runway coordinates • Runway utilization • Taxiways and taxipaths • Gate assignments • Airport capacity and configuration
Temporal Profiles	• Quarter hour • Daily • Monthly
Topography Data	• Source and receptor elevations
Building Downwash	• Building height and dimensions • Stationary source locations
Receptor Locations	• Location coordinates • Flagpole height
NO to NO_2 Conversion	• In-stack emission ratio • Ozone concentrations • Initial ozone concentration
Background Concentrations	• Nearby ambient monitoring data
Source: EPA Preferred/Recommended Models, *AERMOD Modeling System*, http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod.	

When dispersion modeling is conducted at airports for the EPA criteria pollutants, CO, NO_2, PM_{10}, and $PM_{2.5}$ are most commonly evaluated. Characteristically, CO levels are typically elevated in areas of high motor vehicle traffic such as the main terminal area access/egress roadways, curbsides and parking facilities. By comparison, NO_2 concentrations are also more likely to be highest near the runway ends where aircraft engine thrust settings are at their highest.

PM_{10} and $PM_{2.5}$ levels are generally more ubiquitous across the airport but similarly elevated near areas of high activity levels and/or emission sources within close proximity to each other.

Dispersion modeling of SO_2 and Pb are much less frequently conducted due to their expected low ambient levels. Elevated Pb concentrations are not usually associated with commercial airports but may be found near airports with significant Avgas usage. Ozone is a regional pollutant resulting from the combined effects of VOCs and NO_x in the presence of sunlight and thus not conducive to dispersion modeling on a local scale.

7.1.4. Dispersion Modeling Results

Normally for airport applications, the output of the dispersion model is the maximum or average concentration(s) of a pollutant (or set of pollutants) at each receptor analyzed and over a specified time period (i.e., 1-, 3-, 8-, 24-hour to annual). These time periods typically correspond to the same pollutant-specific time periods stipulated as part of the NAAQS.

For NEPA purposes, the reporting is primarily intended to disclose the differences in pollutant concentrations between the project alternatives (i.e., action vs. no-action) and to demonstrate that there are no expected violations of the NAAQS. For the purposes of General Conformity, the principal intent is aimed at showing that the project/action will not cause or contribute to a violation of any NAAQS nor delay the attainment of any NAAQS. **Table 7-2** (*Dispersion Modeling Results*) provides a sample format for reporting dispersion modeling results in support of FAA projects/actions. As shown, the results are typically presented in $\mu g/m^3$, although they can also be reported as ppm.[81] In most cases, the concentrations are reported with the background values added for easy comparison to the NAAQS. In this example, the reported values represent the highest concentrations of all the receptors analyzed.

It is important to note that in some instances the background values may be near or exceed the NAAQS by themselves and the effects of the project's/action's contribution is minimal by comparison. In these cases, it should be clearly documented in the results that the project/action is not the cause of the predicted violation(s).

[81] If results reported in micrograms per cubic meter ($\mu g/m^3$), temperature and pressure should be specified at 25 degrees C (°C) and 1 atmosphere since values change with temperature and pressure. In contrast, results in parts per million do not change with temperature and pressure.

Table 7-2. Dispersion Modeling Results

Pollutant	Averaging Period	NAAQS	Modeling Year ($\mu g/m^3$)			
			2015		2020	
			No Action	Proposed Action	No Action	Proposed Action
NO_2	1-hour	188	123	142	120	150
	Annual	100	78.5	78.8	77.3	80.8
CO	1-hour	40,000	19,800	19,900	20,800	20,000
	8-hour	10,000	8,000	8,400	7,200	8,200
SO_2	1-hour	196	51	48	50	47
	3-hour	1,300	473	416	474	415
PM_{10}	24-hour	150	54.6	54.5	55.2	54.1
$PM_{2.5}$	24-hour	35	29.5	29.7	29.8	29.3
	Annual	12	9.7	9.6	9.6	9.5
Note: Results include background concentrations. $\mu g/m^3$= micrograms per cubic meter.						

7.2. Roadway Dispersion Modeling

This section addresses the current available guidance and approaches for assessing emissions from roadway intersections in connection with FAA projects/actions. **Appendix E**, *Roadway Dispersion Modeling (Hot-Spot Analysis)*, provides additional information on dispersion modeling methods, data requirements, and other supporting materials.

7.2.1. Introduction & Background

A roadway intersection analysis, also known as a "hot-spot" analysis[82] may be warranted for aviation-related projects/actions that have the potential to adversely affect the air quality in the vicinities of roadways both on and off the airport. Such an analysis would help ensure that the project-related traffic emissions would not cause or contribute to violations of the NAAQS.

The main pollutants of concern in a hot-spot analysis are CO, PM_{10}, and $PM_{2.5}$. At airports, these emissions arise from motor vehicles (e.g., cars, trucks, vans, buses, etc.) traveling and idling along terminal curbsides and on- and off-airport roadways. For this analysis, the pollutant concentrations would be analyzed at each applicable intersection(s), combined with a background concentration, and then compared to the appropriate NAAQS.

7.2.2. CAA and NEPA Guidance

[82] A hot-spot analysis is defined in 40 CFR 93.101 as "…*an estimation of likely future localized CO, PM10, and/or PM2.5 pollutant concentrations and a comparison of those concentrations to the NAAQS. Hot-spot analysis assesses impacts on a scale smaller than the entire nonattainment or maintenance area, including, for example, congested roadway intersections and highways or transit terminals, and uses an air quality dispersion model to determine the effects of emissions on air quality to the NAAQS*."

The CAA has established procedures and limitations for evaluating transportation projects in areas within the U.S. designated as nonattainment or maintenance[83] with respect to the NAAQS. The specific procedures, often referred to as Transportation Conformity regulations (see **Section 8**, *Conformity),* require assessment of potential air quality impacts of all regionally significant planned and programmed transportation projects. The transportation conformity regulations for localized CO and PM hot-spot analyses are codified within 40 CFR Part 93, Subpart A[84].

In addition to the conformity regulation requirements, NEPA also requires environmental review of actions that have the potential to affect the environment (see **Section 2**, *Regulatory Framework*). Specifically, on-road transportation projects using federal-aid funds and/or requiring Federal Highway Administration (FHWA) or the Federal Transit Administration (FTA) approval actions must be evaluated for the potential impacts the actions will have on the natural and human environment. Air quality is one of several elements within the human environment to be considered. The NEPA requirements in regard to project-level FHWA/FTA air quality analyses are outlined in 23 CFR Part 771.[85]

The major difference between the project-level air quality requirements under the CAA and those under the NEPA is that CAA hot-spot requirements apply to projects within specifically identified areas (i.e., nonattainment/maintenance areas), whereas NEPA applies to federally-funded projects irrespective of location.

When conducting a hot-spot analysis for the purposes of complying with NEPA or transportation conformity, the EPA-preferred/recommended dispersion and emission models[86] are the CAL3QHC/CAL3QHCR and AERMOD, and MOVES/EMFAC (see **Section 5**, *Air Quality Assessment Models*), respectively.

CO Project-level Analyses

NEPA air quality analyses have typically focused on CO as the primary indicator for vehicular air quality impacts. A CO project-level hot-spot analysis is performed to ensure that new or worsened violations of the NAAQS will not occur as a result of a project/action. Presently, EPA in coordination with FHWA and FTA, has provided the following guidance documents for assessing CO hot-spot analysis for both project-level air quality requirements under the CAA and the NEPA:

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83 The attainment designations mean that criteria pollutant levels are either below or meet the NAAQS. The maintenance designation signifies that violations of the NAAQS have occurred in the past but that the area is currently in attainment.

84 Title 40 CFR Part 93, Subpart A - *Conformity to State or Federal Implementation Plans of Transportation Plans, Programs, and Projects Developed, Funded or Approved Under Title 23 U.S.C. or the Federal Transit Laws,* http://www.epa.gov/air/genconform/documents/20100324rule.pdf.

85 FHWA and FTA, Title 23 CFR Part 771 – *Environmental Impact and Related Procedures,* Effective: April 23, 2009, http://www.fta.dot.gov/documents/NEPA_reg_clean.pdf.

86 Appendix W to Part 51 – *Guideline on Air Quality Models*, http://www.ecfr.gov/cgi-bin/text-idx?SID=e6a5b817b94abf58460f48c032d9a39c&node=40:2.0.1.1.2.23.11.5.37&rgn=div9 describes EPA's recommended models. Also see EPA's Technology Transfer Network Support Center for Regulatory Atmospheric Modeling at http://www.epa.gov/ttn/scram/, EPA's *MOVES (Motor Vehicle Emission Simulator)* at http://www.epa.gov/otaq/models/moves/, and the *EMFAC model issued by the California Air Resources Board* at http://www.dot.ca.gov/hq/env/air/pages/emfac.htm.

- *Guideline for Modeling Carbon Monoxide from Roadway Intersections*[87]

  This guidance provides the methodology for estimating the air quality impacts associated with vehicular traffic at intersection(s) to determine if such impacts may exceed the NAAQS for CO.

- *Using MOVES in Project-Level Carbon Monoxide Analyses*[88]

  This guidance supersedes the emission factor sections from the 1992 CO Guidelines to reflect the use of the MOVES emissions model for project-level CO analyses. In particular, this guidance describes how to use the MOVES emissions model to estimate CO emissions from transportation projects, including roadway intersections, highways, transit projects, parking lots and intermodal terminals. This guidance can be applied when using MOVES to complete any project-level quantitative CO analysis, including hot-spot analyses for transportation conformity determinations, modeling project-level emissions for SIP development, and completing analyses pursuant to NEPA.

PM Project-level Analyses

PM (i.e., PM_{10} and $PM_{2.5}$) hot-spot analyses are required for projects of local air quality concern, which include certain highway and transit projects that involve significant levels of diesel vehicle traffic and any other project identified in the PM SIP as a localized air quality concern. Presently, the principal guidance document for assessing PM hot-spot analysis issued by EPA (in coordination with DOT) is the following:

- *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas*[89]

  This guidance describes how to complete quantitative hot-spot analyses for certain highway and transit projects in PM_{10} and $PM_{2.5}$ nonattainment and maintenance areas. In addition, this guidance describes transportation conformity requirements for hot-spot analyses, and provides technical guidance on estimating project emissions with EPA's MOVES model, California's EMFAC model, and other methods.

7.2.3. Roadway Dispersion Modeling Methods

This section provides a general overview of the process for conducting a quantitative CO and/or PM hot-spot analysis. Differences between the two modeling methods (i.e., CO and PM) are mentioned but further detailed in **Appendix D**, *Airport Dispersion Modeling*, and documented in the aforementioned EPA technical guidance documents.

87 EPA, *Guideline for Modeling Carbon Monoxide from Roadway Intersections*, http://www.epa.gov/scram001/guidance/guide/coguide.pdf.

88 EPA, *Using MOVES in Project-Level Carbon Monoxide Analyses,* December 2010 [EPA-420-B-10-041], http://www.epa.gov/oms/stateresources/transconf/policy/420b10041.pdf

89 EPA, *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Non-attainment and Maintenance Areas,* November 2013 [EPA-420-B-13-053], http://www.epa.gov/otaq/stateresources/transconf/policy/420b13053-sec.pdf.

- Determine whether project/action is in need of a quantitative hot-spot analysis. A hot-spot analysis is required only for projects of local air quality concern. The following describes the types of projects/actions that might require a hot-spot analysis for CO, PM_{10} and $PM_{2.5}$, respectively:
  - As stated in 40 CFR 93.123(a)(1) a quantitative CO hot-spot analysis should be considered for the following types of projects:

    "(i) For projects in or affecting locations, areas, or categories of sites which are identified in the applicable implementation plan as sites of violation or possible violation;(ii) For projects affecting intersections that are at Level-of-Service (LOS)[90] D, E, or F, or those that will change to LOS D, E, or F because of increased traffic volumes related to the project; (iii) For any project affecting one or more of the top three intersections in the nonattainment or maintenance area with highest traffic volumes, as identified in the applicable implementation plan; and (iv) For any project affecting one or more of the top three intersections in the nonattainment or maintenance area with the worst level of service, as identified in the applicable implementation plan."

    Furthermore, 40 CFR 93.123(a)(2) states:

    "...In cases other than those described above, the demonstrations required by § 93.116 may be based on either:(i) Quantitative methods that represent reasonable and common professional practice; or (ii) A qualitative consideration of local factors, if this can provide a clear demonstration that the requirements of § 93.116 are met."
  - 40 CFR 93.123(b)(1) defines the projects of *air quality concern* that require a quantitative PM_{10} and $PM_{2.5}$ hot-spot analysis as:

    "(i) New highway projects that have a significant number of diesel vehicles, and expanded highway projects that have a significant increase in the number of diesel vehicles; (ii) Projects affecting intersections that are at LOS D, E, or F with a significant number of diesel vehicles, or those that will change to LOS D, E, or F because of increased traffic volumes from a significant number of diesel vehicles related to the project; (iii) New bus and rail terminals and transfer points that have a significant number of diesel vehicles congregating at a single location; (iv) Expanded bus and rail terminals and transfer points that significantly increase the number of diesel vehicles congregating at a single location; and (v) Projects in or affecting locations, areas, or categories of sites which are identified in the PM_{10} or $PM_{2.5}$

[90] LOS is defined in terms of the average total vehicle delay of all movements through an intersection. Vehicle delay is a method of quantifying several intangible factors, including driver discomfort, frustration, and lost travel time. Specifically, LOS criteria are stated in terms of average delay per vehicle during a specified time period (for example, the PM peak hour). Vehicle delay is a complex measure based on many variables, including signal phasing (i.e., progression of movements through the intersection), signal cycle length, and traffic volumes with respect to intersection capacity.

> *applicable implementation plan or implementation plan submission, as appropriate, as sites of violation or possible violation."*
>
> Furthermore, 40 CFR 93.123(b)(2) states:
>
> *"Where quantitative analysis methods are not available, the demonstration required by § 93.116 for projects described above must be based on a qualitative consideration of local factors."*

Roadway dispersion modeling may be required based on other special considerations or indications, thus state and regional air quality regulatory and transportation planning agencies should be consulted.

If it is determined that a quantitative hot-spot analysis is not warranted because the project/action does not meet the listed criteria for CO, PM_{10}, and $PM_{2.5}$, than a qualitative analysis should still be considered to provide a clear demonstration that the requirements of 40 CFR 93.116 are met. If it is determined that a quantitative hot-spot analysis is needed, the following steps should be considered:

- *Determine approach*:
  - Select scenarios (i.e., no-action, project/action) and analysis year(s) for emissions and air quality modeling.
  - Select critical intersection(s) based on highest traffic volumes, worst LOS and significant number of diesel vehicles generated by proposed project/action.[91]
- *Obtain project specific-data*:
  - Obtain traffic volumes, speeds and signal operating conditions for selected peak time periods (i.e., morning, noon, and evening). For PM_{10} and $PM_{2.5}$, more detailed data is necessary (i.e., hourly traffic data).
  - Obtain roadway configurations and geometry of critical intersections for selected scenarios.
  - Obtain model input data (i.e., meteorological) specific to project site.
- *Estimate on-road motor vehicle emissions*:[92]
  - Estimate emissions using EPA's MOVES model. Additionally, for PM_{10} and $PM_{2.5}$ hot-spot analyses emissions from road dust,[93,94] construction[95], and additional sources should be accounted for when applicable.

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[91] Typically those intersections with the highest traffic volumes and lowest LOS ratings are considered and selected for modeling. LOS ratings measure the operating conditions at the intersection and how these conditions affect traffic volume, signal timing, and related congestion delays. There are six LOS rankings: LOS A through LOS F. LOS A is the highest ranking relating to delays of less than 10 seconds per vehicle. LOS F is the lowest, describing operations with delays greater than 80 seconds per vehicle.

[92] Exhaust, brake wear, and tire wear emissions from on-road vehicles are always to be included in a project's $PM_{2.5}$ or PM_{10} hot-spot analysis. See Sections 4 and 5 for how to quantify these emissions using MOVES (outside California) or EMFAC (within California).

[93] Re-entrained road dust must be considered in $PM_{2.5}$ hot-spot analyses only if EPA or the state air agency has made a finding that such emissions are a significant contributor to the $PM_{2.5}$ air quality problem in a given nonattainment or maintenance area (40 CFR 93.102(b)(3) and 93.119(f)(8)). See the July 1, 2004 final conformity rule (69 FR 40004).

- *Select receptor site locations*:
  - The locations at which concentrations are estimated are known as receptors. Generally receptors are located along the roadway where the general public is likely to have continuous access.
- *Select dispersion models and calculate concentrations at selected intersection(s)*:[96]
  - For quantitative hot-spot analyses the EPA-recommended models for CO and PM_{10} and $PM_{2.5}$ are CAL3QHC and AERMOD/CAL3QHCR, respectively. CAL3QHCR is recommended for CO when a CAL3QHC analysis with conservative assumptions indicates a potential to exceed the NAAQS.
- *Determine background concentrations*:
  - Background concentrations are typically obtained from a representative background monitoring site not affected by the intersection(s) of interest.
- *Tabulate results*:
  - Representative background concentrations should be added to the predicted worst-case project-level concentration and compared to the NAAQS. If project does not conform, consider mitigation or control measure(s).

7.2.4. Roadway Dispersion Modeling Results

The last step of the process for conducting a quantitative CO and/or PM_{10} and $PM_{2.5}$ hot-spot analysis is to document the analysis and results. For both project-level air quality requirements under the CAA and those under the NEPA, it is always necessary to complete emissions and air quality modeling on the project/action and compare the resulting values to the relevant NAAQS. **Table 7-3** (*CO Intersection Hot-Spot Results*) and **Table 7-4** (*PM Intersection Hot-Spot Results*) provide a sample format for reporting CO, PM_{10}, and $PM_{2.5}$ impacts of roadway traffic from a hot-spot analysis, respectively. As shown, CO results are typically presented in ppm and PM_{10} and $PM_{2.5}$ results in $\mu g/m^3$ and all results include background concentrations.

[94] Re-entrained road dust must be included in all PM_{10} hot-spot analyses. Because road dust is a significant component of PM_{10} inventories, EPA has historically required road dust emissions to be included in all conformity analyses of direct PM_{10} emissions – including hot-spot analyses. See the March 2006 final rule (71 FR 12496-98).

[95] Emissions from construction-related activities are not required to be included in PM hotspot analyses if such emissions are considered temporary as defined in 40 CFR 93.123(c)(5) (i.e., emissions which occur only during the construction phase and last five years or less at any individual site).

[96] Appendix W to Part 51 – *Guideline on Air Quality Models*, http://www.ecfr.gov/cgi-bin/text-idx?SID=e6a5b817b94abf58460f48c032d9a39c&node=40:2.0.1.1.2.23.11.5.37&rgn=div9, describes both AERMOD and CAL3QHC/CAL3QHCR as being appropriate for modeling line sources.

Table 7-3. CO Intersection Hot-Spot Results

Intersection	Averaging Period	NAAQS	CO Modeling Year (ppm)				NAAQS Exceeded?
			Year 1		Year 2		
			No Action	Proposed Action	No Action	Proposed Action	
1	1-hour	35	2.2	2.2	2.2	2.2	No
	8-hour	9	1.5	1.5	1.5	1.5	No
2	1-hour	35	2.3	2.2	2.1	2.1	No
	8-hour	9	1.6	1.5	1.4	1.4	No
3	1-hour	35	2.6	2.6	2.5	2.5	No
	8-hour	9	1.8	1.8	1.7	1.7	No

Note: 1-hour and 8-hour results include background concentrations. Concentrations are for the receptor with highest concentration for each scenario. ppm = parts per million.

Table 7-4. PM Intersection Hot-Spot Results

Intersection	Pollutant	Averaging Period	NAAQS	PM Modeling Year ($\mu g/m^3$)				NAAQS Exceeded?
				Year 1		Year 2		
				No Action	Proposed Action	No Action	Proposed Action	
1	$PM_{2.5}$	Annual	12	5	6	5	6	No
		24-hour	35	8	9	8	9	No
	PM_{10}	24-hour	150	22	23	22	23	No
2	$PM_{2.5}$	Annual	12	5	5	5	5	No
		24-hour	35	5	5	5	5	No
	PM_{10}	24-hour	150	15	17	18	20	No

Note: $PM_{2.5}$ and PM_{10} results include background concentrations. Concentrations are for the receptor with highest concentration for each scenario. $\mu g/m^3$ = micrograms per cubic meter.

8. Conformity

As discussed in **Section 2** (*Regulatory Framework*), the Conformity Rule of the federal CAA ensures that federally-funded, permitted, or supported actions occurring in EPA-designated nonattainment and maintenance areas are accounted for within, and do not in any way interfere with, the approved SIP. Of note, the CAA Conformity Rule does not apply to attainment areas. With a focus on FAA actions and General Conformity, this section provides further guidance on this requirement.[97]

8.1. General Conformity

General Conformity covers most aspects of airport activities funded by federal agencies. In summary, the purpose of the General Conformity Rule is to:

- Ensure that federal activities do not cause or contribute to new violations of the NAAQS;
- Ensure that actions do not increase the frequency or severity of any existing violation of the NAAQS; and
- Ensure that attainment of the NAAQS is not delayed.

The General Conformity process begins with an "applicability analysis" whereby the federal agency (or agencies) with jurisdiction over the action determines how and to what degree General Conformity applies. If General Conformity applies, the agency must prepare a General Conformity Determination outlining the process by which the subject action is assessed, whether or not the action conforms to an approved SIP(s), whether offsetting is required, and any other necessary actions. Then federal, state, and local air quality control governance, as well as the general public, are engaged in a formal "public review process" of the agency's determination.

These three elements – (i) Applicability Analysis, (ii) Preparing a General Conformity Determination, and (iii) Interagency and Public Review Process – are each presented in greater detail as follows.

Although General Conformity is a separate requirement from NEPA, the two processes share aspects and are often combined. When a Conformity Determination is required, it is generally disclosed in the NEPA document and included as an appendix. Notably, if a Determination is required, the FAA may not finalize a NEPA document (i.e., issue the Finding of No Significant Impact), or sign the Record of Decision, until the Conformity Determination is completed.

8.1.1. Applicability Analysis

When preparing a General Conformity applicability analysis, the FAA considers a range of factors to determine if the rule applies to a project or action. In some cases (but not necessarily all), these considerations are made in consultation with other federal, state and local air quality agencies. These factors include the following

- If the action will occur in a nonattainment or maintenance area(s);

[97] EPA, *General Conformity*, http://www.epa.gov/air/genconform/index.html.

- If specific exemptions allowed in the General Conformity Rule apply;
- If the action, or portions thereof, are included on the federal agency's list of "presumed to conform activities" (see Section 8.1.1.3);
- If total direct and indirect air emissions associated with the action are above or below the General Conformity *de minimis* levels; and
- If an EPA-approved SIP has an emissions budget against which the emissions associated with the action could be compared (i.e., a facility-wide emissions budget) and whether or not the budget is inclusive of the action.

If an action is not exempt or presumed to conform, or found to cause emissions above applicable *de minimis levels* in any nonattainment or maintenance area, the agency must prepare a General Conformity Determination prior to taking the action.

Best practices for each item of determination in an applicability analysis are discussed below.

8.1.1.1. Nonattainment/Maintenance Status for the Purposes of General Conformity

The EPA's *Green Book* is a publicly available resource for identifying whether or not an action occurs in a current or historical nonattainment or maintenance area for any NAAQS-regulated pollutant(s).[98] It identifies both current and historical nonattainment or maintenance areas for each county within each U.S. state (as well as the U.S. territories of Guam and Puerto Rico).

Some nonattainment and maintenance areas include an entire county or counties, whereas others only encompass a portion of a county (i.e., "partial"). For partial counties within nonattainment or maintenance areas, the location of an action within the exact jurisdictional boundaries of the area should be verified with either EPA or the state/local air quality control agency prior to ascribing any General Conformity applicability. Situations may arise where an action will occur at a facility whose footprint is only partially contained within a nonattainment or maintenance area. Conversely, emissions associated with an action can sometimes span multiple nonattainment areas or portions thereof.

Interagency coordination is also beneficial for actions occurring in maintenance areas that have a federally enforceable maintenance plan, as the duration and characteristics of these plans can vary. Further, per the "anti-backsliding" regulations of the CAA, areas designated nonattainment or maintenance of a NAAQS that has since been revoked (i.e., 1-hour O_3) may still hold a continuing program responsibility to enforce the applicable plan, or components thereof.[99] In these instances, interagency coordination involving EPA and state/local air quality governance can be beneficial in reaching accordance in how General Conformity should be addressed for an action.

8.1.1.2. Conformity Exemptions

[98] EPA, *The Green Book Nonattainment Areas for Criteria Pollutants,* July 2013, http://www.epa.gov/oar/oaqps/greenbk/index.html.

[99] Codified at 40 CFR 51.900, the anti-backsliding provisions of the CAA prevent the rescission of measures or requirements applicable to areas in which a NAAQS is revoked or relaxed by the EPA, such that select requirements continue to apply to an area after revocation or relaxation of the NAAQS in question (i.e., the 1-hour O_3 NAAQS), if the requirements were applied in the area based on the area's prior designation.

The General Conformity regulations make allowances by exemption for instances where emissions associated with an action are not "reasonably foreseeable", are not expected to increase emissions, will affect an increase that is of *de minimis* impact, or are to be implemented as part of a conforming land management plan. When determining General Conformity applicability for an action the regulations should be consulted to determine if the action falls under exemption, in full or in part.

8.1.1.3. Presumed to Conform

In addition to the General Conformity exemptions allowed under the CAA, federal agencies have the prerogative to establish a listing of additional activities that are presumed to conform. The FAA has established such a listing of presumed to conform activities.[100] FAA-supported actions or portions thereof appearing on the presumed to conform listing can be discounted when assessing General Conformity applicability and the actions are not subject to the requirements of a formal General Conformity Determination.

8.1.1.4. *De minimis* Thresholds

Federally-supported actions (or portions thereof) that do not fall under CAA exemption or are not listed on FAA's approved presumed to conform list must then undergo a *de minimis* comparison to identify whether a formal General Conformity Determination is required.

The *de minimis* thresholds represent emission quantities of a NAAQS-regulated pollutant or its applicable precursors, in tons per year, over which an action in a nonattainment or maintenance area may cause or contribute to a new or continued violation of the NAAQS. Established *de minimis* thresholds can vary by pollutant, by the severity of nonattainment, and in some cases by geographic location. For instance, *de minimis* thresholds established for O_3 relate to emissions of its precursor pollutants NO_x and VOC, the specific thresholds of which vary based on the severity of the O_3 nonattainment status as well as whether or not the action is located within an Ozone Transport Region (OTR).[101]

Current *de minimis* thresholds established are summarized in **Table 8-1** (*De minimis Thresholds in Nonattainment Areas*) for nonattainment areas and in **Table 8-2** (*De minimis Thresholds in Maintenance Areas*) for maintenance areas.

[100] FAA, *Federal Presumed To Conform Actions, Under General Conformity*, Federal Register / Vol. 72, No. 145 / Monday, July 30, 2007 / Notices, http://www.faa.gov/airports/resources/publications/federal_register_notices/media/environmental_72fr41576.pdf.

[101] The Ozone Transport Region (OTR) is an area of the contiguous U.S. where O_3 is thought to be transported long distances and across state and local jurisdictional boundaries. In this way, O_3 emissions from one area can significantly impact O_3 concentrations in an area substantially downwind. The current OTR comprises the following states: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Washington D.C., and Virginia.

Table 8-1. *De minimis* Thresholds in Nonattainment Areas

Criteria Pollutant	Nonattainment Status		*De Minimis* Threshold (Tons/Year)								
			CO	NH_3	NO_2	NO_x	Pb	$PM_{2.5}$	PM_{10}	SO_2	VOC
CO	All		100	-	--	-	-	-	-	-	-
NO_2	All		-	-	100	-	-	-	-	-	-
O_3	Marginal and Moderate	Outside OTR	-	-	-	100	-	-	-	-	100
		Inside OTR	-	-	-	100	-	-	-	-	50
	Serious		-	-	-	50	-	-	-	-	50
	Severe		-	-	-	25	-	-	-	-	25
	Extreme		-	-	-	10	-	-	-	-	10
Pb	All		-	-	-	-	25	-	-	-	-
$PM_{2.5}$[1]	All		-	100	-	100	-	100	-	100	100
PM_{10}	Moderate		-	-	-	-	-	-	100	-	-
	Serious		-	-	-	-	-	-	70	-	-
SO_2	All		-	-	-	-	-	-	-	100	-

Source: 40 CFR 93.153(b)(1).
Notes: OTR = Ozone Transport Region.
[1] NO_x is evaluated as a $PM_{2.5}$ precursor unless federal/state/local regulation deems it is not significant to $PM_{2.5}$ nonattainment in an area(s). VOC and NH_3 are only evaluated as $PM_{2.5}$ precursors if federal/state/local regulation deems it is significant to $PM_{2.5}$ nonattainment in an area(s).

Table 8-2. *De minimis* Thresholds in Maintenance Areas

Criteria Pollutant		*De Minimis* Threshold (tons/year)								
		CO	NH_3	NO_2	NO_x	Pb	$PM_{2.5}$	PM_{10}	SO_2	VOC
CO		100	-	-	-	-	-	-	-	-
NO_2		-	-	100	-	-	-	-	-	-
O_3	Outside OTR	-	-	-	100	-	-	-	-	100
	Inside OTR	-	-	-	100	-	-	-	-	50
Pb		-	-	-	-	25	-	-	-	-
$PM_{2.5}$[1]		-	100	-	100	-	100	-	100	100
PM_{10}		-	-	-	-	-	-	100	-	-
SO_2		-	-	-	-	-	-	-	100	-

Source: 40 CFR 93.153(b)(2).
Notes: OTR = Ozone Transport Region.
[1] NO_x is evaluated as a $PM_{2.5}$ precursor unless federal/state/local regulation deems it is not significant to $PM_{2.5}$ nonattainment in an area(s). VOC and NH_3 are only evaluated as $PM_{2.5}$ precursors if federal/state/local regulation deems it is significant to $PM_{2.5}$ nonattainment in an area(s).

Once the appropriate *de minimis* thresholds are identified (**Table 8-1**, *De minimis Thresholds in Nonattainment Areas*, and/or **Table 8-2,** *De minimis Thresholds in Maintenance Areas*), the *de minimis* comparison is accomplished as follows:

- **Step 1**: **Select Appropriate Comparison Year(s)**

  The selection of years for which a *de minimis* comparison should be conducted must be selected with discretion to ensure that General Conformity requirements are fully addressed. These years include the following:

  - The attainment year specified in the approved SIP, or the latest attainment year possible under the CAA;
  - The last year for which emissions are projected in a maintenance plan;
  - The year during which the total direct and indirect emissions from the action is expected to be greatest on an annual basis; and
  - Any year for which the approved SIP contains an emissions budget.

  Of note, the comparison years required for General Conformity may or may not be aligned with timeframes utilized in the NEPA document for an air quality impact assessment. As such, it is advantageous for both the NEPA and General Conformity processes to be considered during project scoping and planning such that all requirements can be satisfied as needed.

- **Step 2**: **Prepare Emissions Inventories**

  Compute an inventory of all "reasonably foreseeable direct and indirect emissions" associated with the action once implemented (i.e., the proposed action emissions).[102] Also inventory emissions that would occur irrespective of the action (i.e., the no action emissions). Subtract the no action emissions from the proposed action emissions to determine the net increase associated with the action's operation.

  For actions involving construction activities, prepare an emissions inventory for each year of planned construction, including all reasonably foreseeable direct and indirect emissions (e.g., on-site equipment and off-site haul trucks).

- **Step 3**: **Identify Emissions Reductions Measures**

  Features of an action that by design have an emissions reducing effect are called "design measures" and are typically accounted for in the emissions inventories of the action prepared in **Step 2**. For instance, if an action includes installing additional terminal gates, and these gates are equipped with gate electrification infrastructure, the resulting emissions benefit of defrayed APU usage would then by virtue be included in the emissions inventory.

[102] Reasonably foreseeable emissions include all quantifiable emissions from an action that are known at the time of the General Conformity evaluation. Direct emissions from an action are those that caused by the action and occur in the same time and place. Indirect emissions represent emissions caused by the action that occur in a different time and place but are under the practical control of the agency.

Emissions reduction credits, including certified Airport Emission Reduction Credits (AERCs) obtained through airport participation in the FAA Voluntary Airport Low Emissions (VALE) program[103] can be similarly discounted as design measures from the net emissions associated with the action. If this discounting produces net emissions that are below *de minimis*, the need for a formal General Conformity Determination is circumvented.

- **Step 4**: **Compare Net Emissions to Appropriate *De Minimis* Threshold(s)**

  If after completing **Steps 1** through **3** the net emissions associated with an action exceed an applicable *de minimis* threshold(s), the federal agency must prepare a formal General Conformity Determination for the action.

8.1.1.5. Facility-Wide Emissions Budgets

Provisions of the General Conformity Rule also allow airports to prepare and submit a "facility-wide emissions budget" for inclusion in the EPA-approved SIP for a nonattainment or maintenance area. The budget is established for a set time period and specifies either annual or seasonal quantities of emissions that must not be exceeded.

A drawback of the facility-wide emissions budget is the requirement for periodic reporting or compliance monitoring to ensure that the "budget" is not exceeded. However, if emissions associated with an action (i.e., total proposed action emissions) are within an airport's approved budget, that action is presumed to conform for the purposes of General Conformity. So, a formal General Conformity Determination would not need to be prepared even if the action's net increase in emissions exceeds an applicable *de minimis* threshold(s).

In instances where a facility has an approved budget but a portion of the action's emissions exceed the approved budget, the federal agency can use the budget to demonstrate General Conformity and only the portion in excess would be subject to a General Conformity Determination. Also, if an area SIP includes a category for airport related or general construction emissions, an approved budget could be used to exempt construction emissions from further Conformity analysis.

8.1.2. Preparing a General Conformity Determination

Conducting an applicability analysis outlined in **Section 8.1.1** (*Applicability Analysis*) will define the need for a General Conformity Determination. If required, a General Conformity Determination must show that, for each year an action's emissions exceed applicable *de minimis* thresholds for a pollutant or its precursors (see **Table 8-1**, *De minimis Thresholds in Nonattainment Areas,* and **Table 8-2**, *De minimis Thresholds in Maintenance Areas*), the following apply:

- The total direct and indirect emissions from the action are specifically identified and accounted in the applicable federally-approved SIP. (Portions of an action's emissions attributable to motor vehicles, as determined by the local MPO, must also be specifically identified in a conforming transportation plan); or,

[103] FAA, *Voluntary Airport Low Emissions Program (VALE)*, http://www.faa.gov/airports/environmental/vale/.

- All direct and indirect emissions (not just the portion exceeding *de minimis* threshold(s) are fully offset such that there is no net increase in emissions of the pollutant or its precursors; or,
- The action will not cause or contribute to a new NAAQS violation in the area based on area-wide or local air quality modeling, and it will not increase the frequency or severity of any existing violation; or
- State/local air quality governance agrees to revise the SIP to accommodate the action's emissions.

These four demonstration points are further explained as follows.

8.1.2.1. Identifying Emissions in the SIP

Through consultation, the federal agency must identify the approved SIP and isolate the action's emissions within the approved SIP budget for years that the direct and indirect emissions of the action are subject to a General Conformity Determination. It is preferable that this comparison be done at the facility level (i.e., the SIP budget should specifically identify an airport and its sources for a given year). However, this approach is not always possible and often it is the case that only a category-specific comparison can be made (i.e., Airport's aircraft emissions are compared to the SIP aircraft budget for the entire nonattainment area). For each year requiring a Conformity Determination, it must be demonstrated that the action's emissions are within the applicable SIP budget line or category.

In the case of motor vehicles, a motor vehicle emissions budget in the approved SIP can only be used for comparison purposes if the action is specifically identified in a conforming Transportation Plan as determined by the local MPO. If the action is not specifically included in this fashion, the motor vehicle emissions predicted from the action must be shown to conform in a manner that does not utilize the SIP motor vehicle emissions budget. These instances require close coordination with the MPO to ensure the action's emissions could then be accommodated.

If identifying an action's emissions in the SIP is the selected General Conformity strategy, Conformity would be demonstrated by securing statements of concurrence from the state/local air agency, the MPO, and in some cases the EPA regional authority, that the action's emissions are contained within the SIP and that the action conforms per the General Conformity Rule.

8.1.2.2. Emissions Mitigation and Offsetting

As mentioned, an action's direct and indirect emissions must be fully offset to zero if emissions mitigation and offsetting are used as a General Conformity strategy. In the case of O_3 and PM, a state agency can approve offsets or mitigation measures of different precursors of the same pollutant only if such trades are allowed by local regulation, are technically justified, and have a demonstrated environmental benefit. For instance, if an action causes a reduction in emissions of the O_3 precursor VOC, these reductions could be used, with approval, to offset an action's increase in NO_x emissions (also an O_3 precursor).

In terms of timing, the General Conformity Rule generally requires that emissions reductions from an offset or mitigation measures used to demonstrate conformity must occur during the same calendar year as the emissions subject to Conformity. However, exceptions to this rule are allowed on State authority on a case-by-case basis. Such allowances must also not cause or exacerbate a violation of the NAAQS nor impeded an area's attainment strategy in any way.

8.1.2.3. Air Quality Modeling for CO and PM

Under General Conformity, the state agency responsible for preparing the SIP can allow either an area-wide or local-scale dispersion assessment of CO or PM as a means of demonstrating General Conformity. The results of the air quality modeling must show that the action does not cause or contribute to any new violation of any NAAQS in any area and does not increase the frequency or severity in any area.

8.1.2.4. Commitment to Revise the SIP

If direct and indirect emissions attributable to an action cannot be identified in an approved SIP, cannot be demonstrated via air quality modeling that a violation or exacerbation of the NAAQS would not be incurred, and/or cannot be mitigated or offset to zero, the only remaining option to demonstrate General Conformity is to petition the state Governor (or their designee) to revise the SIP. The Governor or their designee (i.e., the air agency) must then submit a commitment to EPA providing the following:

- A specific schedule for adoption and submittal of a revision to the SIP which would achieve the needed emission reductions prior to the time emissions from the federal action would occur;
- Identification of specific measures for incorporation into the SIP which would result in a level of emissions which, together with all other emissions in the nonattainment or maintenance area, would not exceed any emissions budget specified in the applicable SIP;
- A demonstration that all existing applicable SIP requirements are being implemented in the area for the pollutants affected by the federal action, and that local authority to implement additional requirements has been fully pursued;
- A determination that the responsible federal agencies have required all reasonable mitigation measures associated with their action; and
- Written documentation including all air quality analyses supporting the conformity determination.

Generally speaking, a SIP including the commitments above must be submitted to EPA for approval within 18 months of the Conformity Determination and the agency cannot undertake the action prior to final approval of the SIP revision by EPA.

8.1.3. Interagency and Public Review

When a Draft General Conformity Determination is prepared, public and agency involvement is required. The Draft must be advertised via public notice in a daily newspaper of local circulation and air quality stakeholders (including EPA, state/local air quality government, and the general public) are allowed to provide comment for a 30-day period. The General Conformity Rule allows for this comment period to run concurrent with any other public involvement, including

NEPA review. Upon finalization, a federal agency must make available comments and responses received/rendered on the Draft within 30 days of issuing the Final Conformity Determination.

8.1.4. FAA Guidance

As a means of adding clarity to the General Conformity process, the FAA (in cooperation with the EPA) has published guidance on the topic. This document is entitled and summarized as follows:

- *General Conformity Guidance for Airports: Questions and Answers.*[104]

  Using a question and answer format, this document provides information on the General Conformity Rule, its interpretation and application as it pertains to airport projects/actions.

8.2. Transportation Conformity

Another component of the Conformity Rule is called Transportation Conformity. Transportation Conformity applies to "regionally-significant" highway or transit projects that are developed, funded, or approved by the FHWA or FTA in nonattainment and maintenance areas.[105] A "regionally significant" project is a transportation project serving regional transportation needs and would normally be included in the modeling of a metropolitan area's transportation network.

In the case of an airport, these regionally-significant roadway or transit projects outside the airport boundary will likely require Transportation Conformity analysis. This is most directly accomplished by demonstrating that these projects are included in the regional emissions analysis for a transportation plan or TIP.

[104] EPA, *General Conformity Guidance for Airports: Questions and Answers,* September 25, 2002, http://www.epa.gov/ttn/caaa/conform/airport_qa.pdf.

[105] EPA, *Transportation Conformity,* http://www.epa.gov/OMS/stateresources/transconf/.

9. Coordination Best Practices

This section discusses the opportunities, objectives, and methods of conducting agency coordination in support of the airport air quality assessment process. Such coordination between the FAA, the reviewing agencies and other stakeholders will help foster a common understanding towards meeting the goals of the assessment and help to avoid unnecessary delays and setbacks. For the purposes of this discussion, three common methods for conducting this coordination are addressed: (i) the Scoping Process, (ii) the Air Quality Assessment Protocol, and (iii) the Coordination and Review Process.

9.1. Scoping Process

Under NEPA, "scoping" is an early and open process for determining the scope of issues to be addressed in an EIS and identifying the significant issues related to a project/action. Typically, the responsible FAA official (or representative) takes the lead in the scoping process, inviting the participation of affected federal, state and local agencies and any other interested persons. Although there is no standard approach to public scoping, it is also traditional that scoping facilitate public participation in the process. If appropriate, a scoping meeting(s) is/are held to collect this feedback from agencies and the public. Consultation with appropriate agencies having jurisdiction by regulation or special expertise is usually initiated at this point as well.

Scoping serves the additional purpose of identifying those environmental impact categories that do not require detailed analysis and for such things as setting the temporal/geographic boundaries for those that do require an assessment.

In the case of air quality, scoping provides an opportunity for reviewing agencies and the public to submit comments and provide suggestions on the overall scope of the assessment, including the analysis methods, the endpoints, and any other particular concerns or expectations among the respondents.

9.2. Air Quality Assessment Protocol

Another useful means of enhancing agency coordination is the development and application of an "Air Quality Assessment Protocol". The overall purpose of the protocol is to document the scope, establish the endpoints, and resolve any areas of uncertainty regarding the assessment prior to its undertaking. An example of the contents of such a protocol follows:

- *Project Description* - This section provides a general overview of the purpose and scope of the project/action, including the alternatives.
- *Regulatory Setting* - This section provides information pertaining to regulatory conditions in the project area. For example, information on attainment/nonattainment designations, SIPs, and applicable regulatory criteria and/or thresholds that will be applied to the results of the air quality assessment can be included.
- *Air Quality Assessment* - This section describes the overall approach, specific methodologies and models, data sources and assumptions, and other supporting information that will be used in conducting the air quality assessment.

- *Presentation of Results* - This section describes how the results of the assessment will be presented including the endpoints of the technical analyses.
- *Supplemental Information* - This material includes (but is not necessarily limited to) information pertaining to General and Transportation Conformity, HAPs and GHGs, and any other technical information to be collected and/or developed in support of the air quality assessment.

Once the protocol document has been reviewed and agreed upon by the various stakeholders, acknowledgements of acceptability should be developed and the work completed.

9.3. Coordination and Review Process

Agency coordination and review process is the final step to address any comments or concerns prior to documenting the results and moving forward with the project/action.

References

This section contains a listing of the guidance, regulations, manuals, and other documents referred to in this *Handbook*.

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- Clean Air Act Public Law 88-206, http://www.epw.senate.gov/envlaws/cleanair.pdf.
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Glossary

This section discusses basic terms and definitions used in assessing the air quality impacts from airport actions.

Above Ground Level (AGL) - Height above ground elevation.

Affected Environment - The section of an environmental document (i.e., Environmental Impact Statement or Environmental Assessment) which describes the resource categories (e.g., air, water, flora, fauna, historic sites, etc.) that are affected or potentially affected by the proposed action and any alternative.

Air Quality - Ambient pollutant concentrations and their temporal and spatial distribution.

Air Quality Database - A collection of information on the ambient air quality that existed within an area during a particular time period. This data is usually collected and published by the State Air Pollution Control Agency.

Air Quality Model - An algorithmic relationship between pollutant emissions and pollutant concentrations used in the prediction of a project's pollutant impact.

Air Quality Monitor - A device for measuring pollutant concentrations. One such device is a Non-Dispersed Infrared Analyzer used to record carbon monoxide concentrations.

Air Quality Standard - A legal requirement for air quality, usually expressed in terms of maximum allowable pollutant concentration, averaged over a specified interval.

Ambient Concentrations - Initial concentration sensed/measured at a monitoring/ sampling site.

Ambient Monitoring - Systematic measurements of characteristics (e.g., pollutant concentration and wind velocity) of the air at a fixed location.

Area Source - In air quality modeling the agglomeration of many sources that have low emission rates spread over a large area that are too numerous to treat individually. An example of this type of source would be a parking lot.

Atmospheric Stability - The resistance to or enhancement of vertical air movement related to vertical temperature profile.

Attainment Area - An area that meets NAAQS for a particular pollutant.

Auxiliary Power Units (APUs) - On-board engines that supply power to an aircraft while taxing and parked at the gate when the main engines are off.

Averaging Time - A period over which measurements of air quality parameters are taken. Air quality standards are specified for averaging times of one, three, eight and twenty four hours, as well as one year.

Aviation Environmental Design Tool (AEDT) - A software system that dynamically models aircraft performance in space and time to produce fuel burn, emissions and noise.

Background Concentration - Pollutant concentrations due to (i) natural sources, (ii) nearby sources other than the one(s) currently under consideration and (iii) unidentified sources.

Calm - For purpose of air quality modeling, calm is used to define the situation when the wind is indeterminate with regard to speed or direction.

Carbon Dioxide (CO_2) - The most prevalent GHG emitted when burning carbon-based fuels.

Carbon Monoxide (CO) - A colorless, odorless, toxic gas produced by the incomplete combustion of organic materials used as fuels. CO is emitted as a byproduct of essentially all combustion. Idling and low speed mobile source operations, such as aircraft taxiing are the most prevalent CO emission sources commonly found at airports.

Categorical Exclusion (CATEX) - Categories of actions that do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect. See 40 C.F.R. Section 1508.4. Note: A categorically excluded action is NOT eligible to be categorically excluded if extraordinary circumstances exist that may cause a significant environmental effect. Extraordinary circumstances are set out in EPA’s NEPA rule at 40 C.F.R. Section 6.204(b).

Clean Air Act (CAA) - The Federal law regulating air quality. The first CAA, passed in 1967, required that air quality criteria necessary to protect the public health and welfare be developed. Since 1967, there have been several revisions to the CAA. The CAA Amendments (CAAA) of 1990 represent the fifth major effort to address clean air legislation.

Clean Air Act Amendments of 1990 (CAAA) - The CAAA of 1990 represent the fifth major effort to address clean air legislation. Revisions include significant strengthening of CAA, especially by adding detailed requirements for Federal actions to conform to State Implementation Plans (SIP), expanding the list of hazardous air pollutants from eight to 189, and strengthening the operating permit program.

Code of Federal Regulations (CFR) - An annual codification of the general and permanent rules published in the Federal Register (FR) by the executive departments and agencies of the federal government of the U.S.

Conformity - The act of meeting Section 176(c)(l) of the CAAA that requires Federal actions to conform to the SIP for air quality. The action may not increase the severity of an existing violation nor can it delay attainment of any standards.

Construction Emissions - Emissions generated by construction activities and/or equipment that may have substantial temporary impact on local air quality.

Control - The ability to regulate, in some way, the emissions from a Federal action. The ability to regulate can be demonstrated directly through the use of emissions control equipment on a boiler or indirectly through the implementation of regulation or conditions in the nature of activity that must be established in permits of approvals or by design of the action. An example of indirect control is limiting vehicle emissions by controlling the size of a parking facility.

Control Strategy - A combination of limiting measures designed to achieve the aggregate reduction of emissions.

Cooperating Agency - A cooperating agency may be any Federal agency that has jurisdiction by law or special expertise with respect to any potential environment impact involved in a proposal for legislation or Federal action that significantly affects the quality of the human environment. A cooperating agency may also be a state or local agency of similar qualifications or, when the effects influence a reservation, an Indian Tribe. By agreement with the lead agency, an Indian Tribe may become a cooperating agency.

Criteria Pollutants - The six pollutants listed in the CAA that are regulated by the EPA through the NAAQS because of their health and/or environmental effects. They are: nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), particulate matter (PM) which is segregated into two size ranges: equal to or less than 10 microns in diameter (PM_{10}) and equal to or less than 2.5 microns in diameter ($PM_{2.5}$), and lead (Pb).

***De minimis* -** So small as to be negligible or insignificant. If an action has *de minimis* emissions (Conformity Rule 40 CFR 93.153c), then a conformity determination pursuant to the CAA of 1990 is not required.

Direct Effect - An effect that is caused by the implementation and/or operation of an action that occurs at the same time and place. These type of effects are also often referred to as primary effects.

Direct Emissions - Direct emissions are those caused by or initiated by the implementation and/or operation of an action, and that occur at the same time and place as the action.

Dispersion - The process by which atmospheric pollutants disseminate due to wind and vertical stability.

Emission Factor - The rate at which pollutants are emitted into the atmosphere by one source or a combination of sources.

Emission Inventory - A complete list of sources and rates of pollutant emissions within a specific area and time interval.

Emissions and Dispersion Modeling System (EDMS) - A model designed to assess the air quality impacts of airport emission sources, particularly aviation sources, which consist of: aircraft, APUs, GSE, ground access vehicles, and stationary sources.

Environmental Assessment (EA) - A concise public document that provides sufficient data, evidence, and analysis to determine if Federal agency should prepare an EIS for an action or issue a FONSI. An EA is not necessary in cases where the Federal agency has decided to prepare an EIS. An EA can be prepared at any time to aid agency decision making.

Environmental Impact Statement (EIS) - An EIS is a detailed, concise public document required for major Federal actions likely to have significant effects on the human environment. The document may be directly prepared, without first doing an EA, if the action will have significant environmental impacts. An EIS provides the public and decision makers with clear, written documentation of potential significant environmental effects of the proposed action, and reasonable alternatives including the no action alternative.

Federal Action - Actions with effects that may be major and potentially subject to Federal control and responsibility. Federal actions tend to fall into four categories: adoption of official policy, adoption of formal plans, adoption of programs and approval of projects, whether approved by permit or other regulatory decision. See 40 CFR 1508.16 for additional information.

Finding of No Significant Impact (FONSI) - A FONSI is a document which briefly presents evidence of why Federal agency has determined that a proposed action, not otherwise categorically excluded, will not have a significant impact on the environment. The FONSI justifies why the preparation of an EIS is unnecessary. The FONSI must include the EA or be attached to the EA, or a summary of it, and reference any other associated environmental documents. The FONSI should state all mitigation that will be undertaken, if any.

Fluorinated Gases - There are three main categories of fluorinated gases -hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). These are synthetic, powerful greenhouse gases (GHGs) that have no natural sources and only come from human-related activities and are emitted through a variety of industrial processes.

Fugitive Dust - Dust discharged to the atmosphere in an unconfined flow stream such as that from unpaved road, storage piles and heavy construction operations.

General Aviation (GA) - The operation of civilian aircraft for purposes other than commercial passenger transport, including personal, business, and instructional flying.

General Conformity Rule - Rule that ensures that Federal actions comply with the NAAQS. In order to meet this CAA requirement, a Federal agency must demonstrate that every action that it undertakes, approves, permits or supports will conform to the appropriate SIP.

Greenhouse Effect - Trapping and build-up of heat in the atmosphere (troposphere) near the earth’s surface. Some of the heat flowing back toward space from the earth's surface is absorbed by water vapor, carbon dioxide, ozone, and several other gases in the atmosphere and then reradiated back toward the earth’s surface. If the atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere will gradually increase.

Greenhouse Gases (GHGs) - Gases that trap heat in the atmosphere. The most prevalent GHGs are CO_2, methane (CH_4), and nitrous oxide (N_2O), and fluorinated gases.

Ground Access Vehicle - Encompass motor vehicles traveling on- and off-airport roadways, within airport parking facilities, and idling along terminal curbsides (e.g., private autos, taxis/limos, shuttles, vans, buses, rental cars, etc.). Ground access vehicles exclude those GSE used for servicing the aircraft and airport.

Ground Power Unit (GPU) - Provides electrical power to aircraft during ground time.

Ground Support Equipment (GSE) - On-site airport vehicles and equipment designed to service aircraft while parked at the gate or when operating in the terminal area (e.g., baggage tugs, belt loaders, etc.).

Hazardous Air Pollutants (HAPs) - Under the federal CAA and its amendments, the EPA has initially identified 188 air pollutants that meet the definition and are regulated under Section 112 (*Toxic Air Pollutants*) of the act. These include a wide variety of organic and inorganic chemicals and compounds.

Heavy Metals - Metallic elements of relatively high density, or of high relative atomic weights; (e.g. mercury, chromium, cadmium, arsenic, and lead).

Hot-Spot Analysis - an estimation of likely future localized CO, PM_{10}, and/or $PM_{2.5}$ pollutant concentrations and a comparison of those concentrations to the NAAQS.

Hydrocarbons (HC) - Total hydrocarbons excluding CH_4 and ethane. These gases represent unburned and wasted fuel. They come from incomplete combustion of gasoline and from evaporation of petroleum fuels.

Indirect Control - Control of air quality by altering activities that influence the rate and distribution of emissions (e.g., traffic patterns, land use). Indirect control contrasts with direct control at the source of emissions (e.g., devices on automobiles or smoke stacks).

Indirect Effect - Effects that are caused by the implementation and/or operation of an action, that occur later in time or are further removed by distance from the action, but which are still reasonable foreseeable. Often referred to as secondary effects.

Indirect Emissions - Indirect emissions are those caused by the implementation and/or operation of an action, are reasonably foreseeable, but which occur later in time and/or are farther removed in distance from the action itself. Under General Conformity, indirect emissions are further limited to those indirect emissions that the responsible Federal agency can "practicably control and will maintain control over due to a continuing program responsibility of the Federal agency."

Indirect Source - Any structure or installation which attracts an activity which creates emission of pollutants. For example, a shopping center, an airport or a stadium.

Integrated Noise Model (INM) - A computer model that evaluates aircraft noise impacts in the vicinity of airports.

Inventory - See "Emission Inventory".

Inversion - A thermal gradient created by warm air situated above cooler air. An inversion suppresses turbulent mixing and thus limits the upward dispersion of polluted air.

Landing and Takeoff (LTO) - LTO refers to an aircraft's landing and takeoff cycle. One aircraft LTO is equivalent to two aircraft operations (one landing and one takeoff). The standard L TO cycle begins when the aircraft crosses into the mixing zone as it approaches the airport on its descent from cruising altitude, lands and taxis to the gate. The cycle continues as the aircraft taxis back out to the runway for takeoff and climbout as its heads out of the mixing zone and back up to cruising altitude. The five specific operating modes in a standard LTO are: approach, taxi/idle-in, taxi/idle-out, takeoff, and climbout. Most aircraft go through this sequence during a complete standard operating cycle.

Lead (Pb) - A heavy metal that, when ingested or inhaled, affects the blood forming organs, kidneys and the nervous system. The chief source of this pollutant at airports is the combustion of leaded aviation gasoline in piston-engine aircraft.

Lead Agency - The agency preparing or having taken primary responsibility for preparing the EIS.

Level-of-Service (LOS) - LOS ratings measure the operating conditions at the intersection and how these conditions affect traffic volume, signal timing, and related congestion delays. There are six LOS rankings: LOS A through LOS F. LOS A is the highest ranking relating to delays of less than 10 seconds per vehicle. LOS F is the lowest, describing operations with delays greater than 80 seconds per vehicle.

Line Source - In air quality modeling a long, narrow source of emissions such as roadway or runway.

Maintenance Area - Any geographic area of the U.S. previously designated nonattainment pursuant the CAA Amendments of 1990 and subsequently redesignated to attainment.

Methane (CH_4) - Methane is the second most prevalent GHG, emitted from industry, agriculture, and waste management activities.

Microscale - Small scale analysis involving distances up to approximately one kilometer and averaging times up to several tens of minutes.

Mitigation - This term is defined in 40 CFR 1508.20. It includes: (i) avoiding the impact altogether by not taking a certain action or parts of an action or finding a new site; (ii) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (iii) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (iv) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (v) compensating for the impact by replacing or providing substitute resources or environments.

Mixing Height - The height of the completely mixed portion of atmosphere that begins at the earth's surface and extends to a few thousand feet overhead where the atmosphere becomes fairly stable. See also "inversion".

Mobile Source - A moving vehicle that emits pollutants. Such sources include airplanes, automobiles, trucks and ground support equipment.

Mobile Source Air Toxics (MSATs) - Mobile source air toxics are compounds emitted from highway vehicles and nonroad equipment which are known or suspected to cause cancer or other serious health and environmental effects. Mobile sources are responsible for direct emissions of air toxics and contribute to precursor emissions which react to form secondary pollutants. Examples of mobile source air toxics include benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, polycyclic organic matter (POM), naphthalene, and diesel PM.

Modal Emissions Factors - Vehicular emissions factors for individual modes of operation. For aircraft, these modes are takeoff, climbout, approach and taxi.

Model - A quantitative or mathematical representation or simulation which attempts to describe the characteristics or relationships of physical events.

Monitoring Site - A location of a measurement device in a monitoring network.

NAAQS Assessment - For the purpose of this *Handbook*, this refers to the use of an air quality model to predict ambient concentrations of air pollutants and the comparison of these results to the NAAQS.

National Ambient Air Quality Standard (NAAQS) - Air Quality standards established by the EPA to protect human health (primary standards) and to protect property and aesthetics (secondary standards).

National Environmental Policy Act (NEPA) - An Act established "…to declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality." [42 USC § 4321 - *Congressional declaration of purpose*]

Nitric oxide (NO) – Also known as nitrogen monoxide, is a by-product of combustion of substances in the air, as in automobile engines, fossil fuel power plants, and is produced naturally during the electrical discharges of lightning in thunderstorms.

Nitrogen Dioxide (NO_2) - The two most prevalent oxides of nitrogen (NO_x) are nitrogen dioxide (NO_2) and nitric oxide (NO). Both are toxic gases with NO_2 being a highly reactive oxidant and corrosive. NO_2 is an odorless gas that acts mainly as an irritant affecting the mucosa of the eyes, nose, throat, and respiratory tract. Extremely high-dose exposure (as in a building fire) to NO_2 may result in pulmonary edema and diffuse lung injury.

Nitrogen Oxides (NO_x) - A poisonous and highly reactive gas produced when fuel is burned at high temperatures causing some of the abundant nitrogen in the air to bum also. At airports this pollutant is emitted by automobiles, aircraft engines, electric power plants and other combustion equipment. Takeoff and climbout are the significant NO_2 producing modes of aircraft operation.

Noise Integrated Routing System (NIRS) - A noise-assessment program designed to provide an analysis of air traffic changes over broad areas. It is intended to work in conjunction with other Air Traffic modeling systems that provide the source of routes, events, and Air Traffic procedures such as altitude restrictions.

Nonattainment Area - Any geographic area of the U.S. that is in violation of any NAAQS and therefore has been designated as nonattainment under the CAA.

Non-methane OG (NMOG) - As implied, NMOGs include all organic compounds except CH_4 which is the most common OG and a greenhouse gas that is sometimes excluded from the assessment/analysis of organic compounds.

NONROAD Model - Model that estimates air pollutants from non-road engines, equipment, and vehicles.

Notice of Intent (NOI) - A brief notice placed in the *Federal Register* by the Federal agency noting that the agency will prepare an EIS. The NOI describes the proposed action and possible alternatives, details the proposed scoping process (i.e., location and time of meetings), and provides the name and address of a point of contact within the Federal agency to answer questions about the proposed action and the EIS.

Ozone (O_3) - A colorless, toxic gas formed by the photochemical reactions in the atmosphere of VOCs with the oxides of nitrogen. Ozone commonly is referred as "Smog". Ozone is not emitted directly by any airport.

Particulate Matter (PM) - Also known as “particle pollution”, is made up of a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope. Particle pollution includes "inhalable coarse particles," with diameters larger than 2.5 micrometers and smaller than 10 micrometers (PM_{10}) and "fine particles," with diameters that are 2.5 micrometers and smaller (i.e., $PM_{2.5}$).

Plume - The spreading pollutants emitted by a fixed source such as a smokestack or an exhaust and released into the atmosphere.

PM_{10} - a criteria pollutant for which there are NAAQS and represents the category of particulates categorized as “coarse” PM (i.e., with an aerodynamic diameter of 10 microns or less). PM_{10} includes solid and liquid material suspended in the atmosphere formed as a result of incomplete combustion.

$PM_{2.5}$ - a criteria pollutant for which there are NAAQS and represents the category of particulates categorized as "fine" PM (i.e., with an aerodynamic diameter of 2.5 microns or less). These particles are considered a health risk because of their ability to penetrate deep into the human respiratory system. Aircraft are the primary source of $PM_{2.5}$ emissions at airport.

Point Source - In air quality modeling a pollutant source that is fixed to the ground and that releases pollutants through a relatively small area. Common stationary sources at airport include boilers, heaters, incinerators and fuel storage tanks.

ppb - Parts per billion (10^9) by volume

ppm - Parts per million (10^6) by volume.

Precursor - A chemical compound that leads to the formation of a pollutant. HC and NO_x, are precursors of photochemical oxidants.

Preferred Model - A refined model that is recommended for a specific type of regulatory application.

Prevention of Significant Deterioration (PSD) Area - A geographic area that contains air which is relatively clean and not in violation of NAAQS. The emissions in these area are regulated to prevent degradation of its air quality.

Primary Pollutant - Chemical contaminants which are released directly to the atmosphere by a source.

Primary Standard - A NAAQS set to protect human health.

Receptor - A location at which ambient air quality is measured or estimated.

Record of Decision (ROD) - The decision document, prepared after the EIS, that states what the decision is, identifies all alternative considered by the lead agency in reaching its decision, and states whether all practicable means to avoid or minimize environmental harm have been adopted, and if not, why not.

Scoping - An early and open process (that invites the participation of affected Federal, state and local agencies, any affected Indian tribe, the proponent of the action and other interested persons) that determines the issues to be addressed in an environmental document and identifies relevant and/or significant issues related to a proposed action.

Screening Technique - A relatively simple analysis technique to determine if a given source is likely to pose a threat to air quality. Concentration estimates from screening techniques are conservative.

Secondary Pollutant - Atmospheric contaminants formed in the atmosphere as a result of such chemical reactions as hydrolysis, oxidation and photochemistry.

Secondary Standard - A NAAQS set to protect human welfare.

Semi-volatile Organic Compounds (SVOCs) - an organic compound which has a boiling point higher than water and which may vaporize when exposed to temperatures above room temperature. Semi-volatile organic compounds include phenols and polynuclear aromatic hydrocarbons (PAH).

Simple Terrain - An area where terrain features are all lower in elevation than the top of the stack of the source.

Simulation Model - A mathematical description of a real physical and/or chemical process. The responses of the model to input parameter variations are analogous to those of the real processes.

Smog - A common term for ground-level ozone.

Stability - A property of the atmosphere which determines the amount of vertical mixing.

State Implementation Plan (SIP) - The strategy to be used by a state to control air pollution in order that the NAAQS will be met. EPA regulations require that each state devise such a plan or the EPA will impose its own plan for that state.

Stationary Source - A source of pollutants which is immobile. Such sources include power plants, individual heater, incinerators, fuel tanks, Aircraft Rescue and Firefighting (ARFF) training, facilities and solvent degreasers, among others.

Sulfur Dioxide (SO_2) - This is a corrosive and poisonous gas produced mainly from the burning of sulfur containing fuel.

Thrust - A measure of the power generated by turbine engines. Thrust is measured in pounds (force) or kiloNewtons (kN). 1kN = 4,450 lb.

Total Organic Gas (TOG) – Defined by the California Air Resources Board (CARB) as compounds of carbon, excluding CO, CO_2, carbonic acid, metallic carbides or carbonates, and ammonium carbonate. TOG includes all organic gas compounds emitted to the atmosphere, including the low reactivity compounds (e.g., methane, ethane, various chlorinated fluorocarbons, acetone, perchloroethylene, volatile methyl siloxanes, and oxygenated OG).

Transportation Implementation Plan (TIP) - A plan that analyzes the current transportation system, near-term transportation projects and provides an option of probable costs to implement solutions.

Turbulence - Unsteady and irregular motions of air in the atmosphere.

Vehicle Miles Traveled (VMT) - The sum of distances traveled by all motor vehicles in a specified region. VMT is equal to the total number of vehicle trips multiplied by the trip distance (measured in miles). This sum is used in computing an emission inventory for motor vehicles.

Volatile Organic Compounds (VOCs) - VOCs are created when fuels or organic waste materials are burned. Most HCs are presumed to be VOCs in the regulatory context, unless otherwise specified by the EPA.

Acronyms and Abbreviations

AAS	Airport Safety and Standards
ACCRI	Aviation Climate Change Research Initiative
ACRP	Airport Cooperative Research Panel
AEDT	Aviation Environmental Design Tool
AEE	FAA Office of Environment and Energy
AERCs	Airport Emission Reduction Credits
AFS	Airport Flight Standards Service
AGC	Office of the Chief Counsel
AGL	Above Ground Level
AIM	Aeronautical Information Manual
AIP	Airport Improvement Program
ALP	Airport Layout Plan
APE	Area of Potential Effects
APL	Office of Policy, International Affairs, and Environment
APP	Airport Planning and Programming
APU	Auxiliary Power Unit
ARP	Office of the Associate Administrator for Airports
ASIF	AEDT Standard Input File
ATO	Air Traffic Organization
AVS	Aviation Safety
CAA	Clean Air Act
CAAA	Clean Air Act Amendments of 1990
CATEX	Categorical Exclusion
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CH_4	Methane
CNG	Compressed Natural Gas
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_{2e}	Carbon dioxide equivalent
DOD	Department of Defense

DOE	Department of Energy
DOT	Department of Transportation
EA	Environmental Assessment
EDMS	Emissions and Dispersion Modeling System
EERE	DOE Office of Energy Efficiency & Renewable Energy
EIAP	Environmental Impact Analysis Process
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FONSI/ROD	Finding of No Significant Impact/Record of Decision
FTA	Federal Transit Administration
GA	General Aviation
GAO	General Accounting Office
GCRP	Global Change Research Program
GHGs	Greenhouse Gases
GPU	Ground Power Units
GSE	Ground Support Equipment
GWP	Global Warming Potential
H_2O	Water Vapor
HAPs	Hazardous Air Pollutants
HC	Hydrocarbons
HFCs	Hydrofluorocarbon
ICAO	International Civil Aviation Organization
INM	Integrated Noise Model
IPCC	Intergovernmental Panel on Climate Change
IRIS	Integrated Risk Information System
ISR	Indirect Source Review
LOB/SOs	Lines of Business and Staff Offices
LOS	Level-of-Service
LPG	Liquefied petroleum gas
LTO	Landing-takeoff cycle

MOU	Memorandum of Understanding
MOVES	Motor Vehicle Emissions Simulator
MPO	Metropolitan Planning Organization
MT CO_2	Metric tons of CO_2
MT CO_{2e}	Metric tons of CO_2 equivalent
MWC	Municipal Waste Combustors
N_2O	Nitrous Oxide
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NCDC	National Climatic Data Center
NEPA	National Environmental Policy Act
NIRS	Noise Integrated Routing System
NO	Nitric oxide
NO_2	Nitrogen Dioxide
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NO_x	Nitrogen Oxide
O_3	Ozone
OFEE	Office of the Federal Environmental Executive
OTAQ	EPA Office of Transportation and Air Quality
OTR	Ozone Transport Region
PARTNER	Partnership for Air Transportation Noise & Emissions Reduction
Pb	Lead
PCA	Preconditioned air
PFCs	Perfluorocarbons
PM	Particulate Matter
PM_{10}	Particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of 2.5 microns or less
RFP	Reasonable Further Progress Plans
ROD	Record of Decision
ROP	Rate of Progress
SF_6	Sulfur hexafluoride

SIP	State Implementation Plan
SO_2	Sulfur Dioxide
TDS	Total Dissolved Solids
TIM	Times-in-mode
TIP	Transportation Implementation Plan
TOG	Total Organic Gas
TRB	Transportation Research Board
$\mu g/m^3$	Micrograms per cubic meter
VALE	Voluntary Airport Low Emissions
VMT	Vehicle Miles Travelled
VOCs	Volatile Organic Compounds

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APPENDIX A1 - Aircraft Emissions Inventory for Criteria Pollutants

A1.1 Overview

This appendix discusses the recommended emissions inventory methodologies, models, and data sources for computing criteria pollutant emissions from aircraft engines. **Section 3** (*Sources and Types of Air Emissions*) of the *Handbook* provides a description of the types of criteria pollutants most commonly associated with aircraft engines and **Section 6.1** (*Preparing an Emissions Inventory – Criteria Pollutants*) provides a discussion of the available guidance for preparing and reporting a criteria pollutant emissions inventory for Federal Aviation Administration (FAA) projects/actions.

For this discussion, three overall approaches, or methods, are addressed and are referred to as the (i) Environmental Protection Agency (EPA), (ii) Emissions and Dispersion Modeling System (EDMS), and (iii) Aviation Environmental Design Tool (AEDT) methods. First, some common terms and concepts are discussed that apply to all three methods.

As summarized in **Table A1-1** (*Aircraft Uses Categorization*), for emission inventory applications, aircraft are typically categorized by their general use as commercial (including air carrier and cargo), air taxi, general aviation (GA), or military.

Table A1-1. Aircraft Uses Categorization

Aircraft Use	Description
Commercial	Includes aircraft used for scheduled service transporting passengers, freight, or both.
Air Taxi	Includes aircraft that fly scheduled service carrying passengers and/or freight but usually are smaller aircraft and operate on a more limited basis.
General Aviation (GA)	Includes most other non-military aircraft used for recreational flying, personal transportation, business travel (usually on an unscheduled basis) and various other activities.
Military	Covers a wide range of aircraft sizes, uses, and operating missions. While they often are similar to civil aircraft, they are handled separately because they typically operate exclusively out of military air bases and frequently have distinctive flight profiles.
Source EPA, *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, December 1992, [EPA-420-R-92-009].	

Aircraft engines produce emissions from the combustion of fuel and these emissions vary depending on aircraft engine type, fuel type, number of engines, power settings, and amount of fuel burned. The criteria pollutants (and their precursors) of primary significance include volatile organic compounds (VOCs), carbon monoxide (CO), oxides of nitrogen (NO_x), sulfur dioxide (SO_2), and particulates (PM).

When computing aircraft engine emissions, it is customary to simulate aircraft activity patterns within the traditional landing and takeoff (LTO) cycle. An LTO cycle consists of the following operational modes:

- *Taxi/idle* includes the time an aircraft taxis between the runway and a terminal, and all ground-based delay incurred through the aircraft taxi route. The taxi/idle-delay mode includes the landing roll, which is the movement of an aircraft from touchdown through deceleration to taxi speed or full stop.

- *Approach* begins when an aircraft descends below the atmospheric mixing height and ends when an aircraft touches down on a runway.
- *Takeoff* begins when full power is applied to an aircraft and ends when an aircraft reaches approximately 500 to 1,000 feet.
- *Climb out* begins when an aircraft powers back from the takeoff mode and ascends above the atmospheric mixing height.

Engine startup operations are also often included in the LTO cycle to account for VOC emissions that occur during this mode occurring within the terminal gate area prior to the aircraft departure.

Similarly, a Touch-and-Go (TGO) cycle consists of the approach mode, followed immediately by the takeoff and climb out modes. TGO operations are generally performed for training purposes, usually occur at military bases or smaller civilian airports, and generally have a flight profile that starts and ends at a much lower altitude than a regular LTO cycle.

Importantly, aircraft emissions vary by operational mode because at power settings other than cruise, engine performance and emission levels are less than optimal. For example, when aircraft are idling, CO and VOC emissions are highest. Alternatively, during take-off and climbout, CO and VOC emissions decrease and NO_x emissions increase significantly.

A1.2 EPA Methodology

This methodology for calculating aircraft engine emissions provides insight into the basic framework and application used by EDMS/AEDT and is adapted from EPA's *Procedures for Emission Inventory Preparation, Volume IV*.[1]

Following this approach, engine emissions are computed for one complete LTO cycle of each aircraft type. Within the LTO cycle, emissions are mainly a function of the number of operations (i.e., arrivals and departures); the aircraft fleet characteristics (i.e., aircraft type, number of engines, and take-off weight); the aircraft engine operating features (i.e., fuel flow rates and emission factors); and the time the aircraft spends in each of the operating modes (i.e., takeoff, climb out, approach, and taxi/idle), also known as the Time-In-Mode (TIM).

For this approach, **Equation A1-1** (*Emission Calculation for Each Aircraft Type for One LTO*) is used to compute NO_x, CO, and VOC emissions for each aircraft/engine combination and is repeated for each aircraft/engine type and LTO TIM. If an aircraft has multiple engines, then the equation is multiplied by the number of engines used on that specific aircraft type.

[1] EPA, *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, December 1992 [EPA-420-R-92-009], http://www.epa.gov/otaq/models/nonrdmdl/r92009.pdf.

$$E_{ij} = \frac{1}{1,000} \times NE_j \times \sum_k [TIM_{jk} \times FF_{jk} \times EF_{ijk}]$$

Where:

E_{ij} = total emissions of pollutant i, expressed in pounds, produced by aircraft type j for one LTO cycle

NEj = number of engines used on aircraft type j

TIM_{jk} = time in mode for mode k, expressed in minutes, for aircraft type j

FF_{jk} = fuel flow for mode k, expressed in pounds per minute, for each engine used on aircraft type j

EF_{ijk} = emission factor for pollutant i, expressed in pounds of pollutant per one thousand pounds of fuel, in mode k for aircraft type j

i = pollutant type (e.g., NOx, CO, or VOC)

j = aircraft type (e.g., 737-900)

k = mode (i.e., idle, approach, climbout, or takeoff)

Equation A1-1. Emission Calculation for Each Aircraft Type for One LTO

Total aircraft emissions are then estimated by applying **Equation A1-2** (*Emission Calculation for All Aircraft*), which multiples the aircraft emissions per LTO for a given aircraft type.

Notably, not all aircraft operations follow the standard LTO cycle. Thus, this method can be adjusted for the non-standard conditions. For example, in the case of a TGO, the taxi/idle mode is eliminated, the approach and climbout modes shortened, and a "return flight" mode is added (to allow the plane to turn around and repeat the procedure). To calculate the emissions from a TGO, the taxi/idle mode should be eliminated from the calculations. Rather than reducing the approach and climbout times and then adding additional time for circling the airfield, the full approach and climbout times should be used (assuming this will account for the additional flight

$$E_i = \sum_j [E_{ij} \times LTO_j]$$

Where:

E_i = total emissions of pollutant i, expressed in pounds, produced by all aircraft operating in the region of interest

E_{ij} = total emissions of pollutant i, expressed in pounds, produced by aircraft type j for one LTO cycle

LTO_j = total number of LTO cycles for aircraft type j (where j covers the range of aircraft operating in the area) during the inventory period

i = pollutant type (e.g., NOx, CO, or VOC)

j = aircraft type (e.g., 737-900)

Equation A1-2. Emission Calculation for All Aircraft

time within the mixing zone[2]).

Lead emissions are associated with leaded aviation fuel used in GA piston-driven aircraft. Lead emissions per LTO are calculated using **Equation A1-3** (*Lead Emission Calculation*). [3]

For additional details on EPA's lead emission calculation procedures refer to *Calculating Piston-Engine Aircraft Airport Inventories for Lead for the 2008 National Emissions Inventory.*[4]

$$\boldsymbol{E_{Pb} = LTO \times 3.46 \times 2.12 \times \frac{1}{907,180} \times 0.95}$$

Where:

E_{Pb} = total Pb emissions (in short tons) produced by all piston engine aircraft,
LTO = total number of LTO cycles for all piston engine aircraft, and
3.46 = assumed gallons of avgas consumed per LTO cycle
2.12 = assumed grams of lead per gallon of avgas
$\frac{1}{907,180}$ = number of short tons per gram
0.95 = fraction of lead emitted from the total avgas lead content.

Equation A1-3. Lead Emission Calculation

The method for estimating PM emissions from aircraft engines is based on the *First Order Approximation* procedure described in the FAA's policy memorandum on the topic.[5] This method takes into account non-volatile PM, volatile sulfate PM, and volatile organic PM. For additional details on estimating PM emissions refer to the International Civil Aviation Organization (ICAO's) *Airport Air Quality Manual.* [6]

A1.3 EDMS/AEDT Methodology

As discussed in **Section 5** (*Air Quality Assessment Models*), AEDT 2b (upon release) will become the model required by the FAA to assess air quality impacts of proposed airport developments. Until AEDT 2b is released, EDMS is the model required for use to assess such impacts.[7,8,9] EDMS and AEDT are designed to assess the air quality impacts of airport emission

2 The time spent in the approach and climbout modes of the landing/take-off cycle is directly related to the height of the "mixing zone." The mixing zone is the layer of the earth's atmosphere where air is completely mixed and pollutants emitted anywhere within the layer will be carried down to the ground level. The height of the mixing zone for a given location typically varies by season and time of day.

3 EPA, *Documentation for Aircraft Component of the National Emissions Inventory Methodology*, January 2011 available at: http://www.epa.gov/ttnchie1/net/2008_nei/aircraft_report_final.pdf.

4 EPA, *Calculating Piston-Engine Aircraft Airport Inventories for Lead for the 2008 National Emissions Inventory*, December 2010, [EPA-420-B-10-044], http://www.epa.gov/otaq/regs/nonroad/aviation/420b10044.pdf.

5 FAA, *Use of First Order Approximation (FOA) to estimate aircraft engine particulate matter (PM) emissions in NEPA Documents and Clean Air Act General Conformity Analyses*, May 24, 2005

6 ICAO, *Airport Air Quality Manual*, First Edition 2011 [DOC 9889].

7 Until AEDT 2b is released, EDMS is available from the FAA at the following website: http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/.

8 FAA, DOT, *Emissions and Dispersion Modeling System Policy for Airport Air Quality Analysis*; Interim Guidance to FAA Orders 1050.1D and 5050.4A [Docket No. 29194].

sources, particularly aviation sources, such as aircraft as well as auxiliary power units (APUs), and ground support equipment (GSE) (see **Appendices A2** (*Auxiliary Power Units Emissions Inventory for Criteria Pollutants*) and **A3** (*Ground Support Equipment Emissions Inventory for Criteria Pollutants*) for more information on computing emissions from APUs and GSE).

As discussed, aircraft emissions inventories prepared using EDMS/AEDT are mainly a function of the number of aircraft operations, fleet mix, TIM and aircraft engine operating features (i.e., fuel flow rates and emission factors).

A1.3.1 Aircraft Operations

In this application, aircraft operational data are subdivided among four operational use categories: 1) air carrier (including cargo), 2) air taxi/commuter, 3) GA, and 4) military. The types and number of aircraft within each of these aircraft categories can vary widely and are rather airport-specific. These operational data for most airports under current and historical conditions can be obtained from the referenced sources listed in **Table A1-2** (*Aircraft Operational Input Data Sources*) or may be obtained from the airlines.

Table A1-2. Aircraft Operational Input Data Sources

Data Source	Description
Terminal Area Forecast (TAF)	Forecasts aviation activity at active airports in the National Plan of Integrated Airport Systems (NPIAS). This information can be accessed at the following website: http://aspm.faa.gov/main/taf.asp.
The Operations Network (OPSNET)	Provides airport activity level (per air carrier, air taxi, general aviation, and military). This data source contains proprietary information and requires an FAA registered user name and password. After acquiring a login from FAA, this information can be accessed at the following website: https://aspm.faa.gov/opsnet/sys/Default.asp.
Air Carrier Statistics Database (T-100 database)	Earliest data year is 1990. Periods of data available for a month, a quarter, and a year. Form 41/T-100 records are available for all of the airports in FAA's NPIAS and 313 additional air transportation facilities. The T-100 database does not capture every aircraft operations at the airport; only those that have been reported. The T-100 database can be accessed at the following website: http://www.transtats.bts.gov/tables.asp?db_id=111&DB_Name=.
Airport IQ5010™ Airport Master Records and Reports	The *Based Aircraft & Operations* section of these reports provides operational data; this information can also be used to develop a general fleet mix. This information can be accessed at the following website: http://www.gcr1.com/5010web/.
Airport Noise & Operations Monitoring System (ANOMS)	Reports aircraft operations, including aircraft type (such as passenger, cargo, general aviation and other); however, airports are not required to have an ANOMS so systems are in limited use.
JP Airline Fleets	Provides airport activity level. The information is proprietary and can be purchased at the following website: http://www.buchair.com/JPAF.htm.

[9] AEDT Version 2b will replace the legacy airport air quality and noise analysis tools - the Emissions and Dispersion Modeling System (EDMS) and the Integrated Noise Model (INM), see **Section 5** (*Air Quality Assessment Models*) of the *Handbook*. The website for AEDT is http://aedt.faa.gov/.

Data Source	Description
Traffic Flow Management System Counts (TFMSC) database	Records aircraft operations at a facility that are either detected under Instrumental Flight Rules (IFR) by Air Traffic Control (ATC), or for which pilots have filed a flight plan, only a subset of the military and GA operational activity is available via TFMSC. After acquiring a login from FAA, this information can be accessed at the following website: https://aspm.faa.gov/tfms/sys/.
Source: FAA; BUCHair USA Inc., 2013; Airport IQ5010, 2013; Bureau of Transportation Statistics (BTS), 2013; and ACRP Report 84, *Guidebook for Preparing Airport Emissions Inventories for State Implementation Plans*, 2013.	

In those cases where the data sources listed in **Table A1-2** (*Aircraft Operational Input Data Sources*) are unavailable, a recent airport study, an airport's Form 5010 Airport Master Record (ARM), or an Airport System Plan (ASP) prepared by a state/local transportation agency may contain these data. Other recommended data sources include a current Airport Master Plan (AMP), a Federal Aviation Regulations (FAR) Part 150 Noise Study, or an Environmental Impact Statement/Assessment (EIS/EA) for the airport, if available and up-to-date.

Future year airport operational data may also be obtained from a recent airport study and/or the Terminal Area Forecast (TAF) for National Plan of Integrated Airport Systems (NPIAS) airports (with and without an Air Traffic Control Tower [ATCT]) and from an ASP or the FAA Aerospace Forecast for all other airports as well as from the reference sources listed in **Table A1-2** (*Aircraft Operational Input Data Sources*).

A1.3.2 Fleet Mix

Aircraft type and engine data may be obtained from a number of aviation industry publications listed in **Table A1-3** (*Fleet Mix Input Data Sources*).

Table A1-3. Fleet Mix Input Data Sources

Data Source	Description
JP Airline Fleets	Provides comprehensive aircraft information (including current registration, type, serial number, previous identity, date of manufacture, date of delivery, engine type and number, maximum take-off weight, configuration, fleet number, name, etc.). The information is proprietary and can be purchased at the following website: http://www.buchair.com/JPAF.htm.
OAG Absolute Aviation Advantage	Provides flight schedules, flight status and aviation data for over 900 airlines and over 4,000 airports. Proprietary source; can be ordered at the following website: http://www.oag.com/Global.
Airport Noise & Operations Monitoring System (ANOMS)	Provides tail number, aircraft type, runway usage, airline, operation type (i.e., arrival and departure), and the destination/origin for aircraft operations. The ANOMS does not capture every aircraft operation at an airport. Airports are not required to have an ANOMS so systems are in limited use.
Air Carrier Statistics Database (T-100 database)	Earliest data year is 1990. Periods of data available for a month, a quarter, and a year. Form 41/T-100 records are available for all of the airports in FAA's NPIAS and 313 additional air transportation facilities. This database is better suited for deriving fleet mix than operational data. This database can be accessed at the following website: http://www.transtats.bts.gov/tables.asp?db_id=111&DB_Name=.

Data Source	Description
Source: Federal Aviation Administration (FAA); OAG Absolute Aviation Advantage, 2013; BUCHair USA Inc., 2013; Airport IQ5010, 2013; and Bureau of Transportation Statistics (BTS), 2013.	

Aircraft type and engine combinations data can also be acquired from airline(s)/tenant(s) surveys of their fleets. However, while this approach would yield highly accurate results, the data is rarely available. Airline financial reports may also report these aircraft and engines information.

When unavailable, aircraft engine assignments can be based on EDMS/AEDT default values. **Table A1-4** (*Example of EDMS/AEDT Aircraft Fleet Mix*) is an example of an aircraft fleet mix / engine combination derived from the EDMS default database.

Table A1-4. Example of EDMS/AEDT Aircraft Fleet Mix

Category	Model	Engine
Air Carrier	Airbus A320-200 Series	V2527-A5
	Boeing 767-200 Series	CF6-80A
	Airbus A319-100 Series	CFM56-5B6/P
Air Taxi/Commuter	Saab 340-A	CT7-5A2
	Bombardier CRJ-100	CF34-3A1 LEC II
	Gulfstream G500	BR700-710A1-10
General Aviation (GA)	Cessna 750 Citation X	AE3007C Type 2
	Bombardier Learjet 25	CJ610-6
	Piper PA-31 Navajo	TIO-540-J2B2
Military	Boeing F/A-18 Hornet	F404-GE-400
	Northrop F-5E/F Tiger II	J85-GE-21
	T-38 Talon	J85-GE-5H (w/AB)
Source: EDMS v5.1.3; for further information on EDMS, see: http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/.		

Future year aircraft fleet mix data may be obtainable from an Airport Master Plan Study and/or the FAA Aerospace Forecast for the airport.

A1.3.3 Time-in-mode

Time-in-mode (TIM) data required by EDMS/AEDT includes the time an aircraft spends in each of the four operating modes (i.e., takeoff, climb out, approach, and taxi/idle) discussed previously. EDMS/AEDT calculates performance-based TIMs using flight profile data that are based on the airframe, engine, aircraft weight, and approach angle.

Potential sources of airport-specific taxi/idle times include aircraft operators, airport operators and/or on-site measurements. Other data sources may include airport master plans, airport operational models (i.e. SIMMOD) and the databases shown in **Table A1-5** (*Taxi Time Input Data Sources*).

Table A1-5. Taxi Time Input Data Sources

Data Source	Description
Aviation System Performance Metrics (ASPM)	Provides detailed data on flights to and from the ASPM airports; and all flights by the ASPM carriers, including flights by those carriers to international and domestic non-ASPM airports. All IFR traffic and some Visual Flight Rules (VFR) traffic are included. ASPM also includes airport weather, runway configuration, and arrival and departure rates. This combination of data provides a robust picture of air traffic activity for airports and air carriers. This information is proprietary and requires an FAA registered user name and password. After acquiring a login from FAA, this information can be accessed at the following website: https://aspm.faa.gov/aspm/entryASPM.asp?lite=y.
Bureau of Transportation Statistics (BTS) On-Time Statistics	Provides aircraft statistics, including taxi in and taxi-out data for specific airlines at 287 airports. Annual data available beginning with the year 1995. This information can be accessed at the following website: http://apps.bts.gov/xml/ontimesummarystatistics/src/dstat/OntimeSummaryDepatures.xml.
Source: FAA; and BTS, 2013.	

A1.3.4 Emission Factors

EDMS/AEDT contains a database of aircraft engine emission factors for CO, NO_x, PM, SO_2, and VOCs based on engine make and model for each of the four engine operating modes (i.e., taxi/idle, takeoff, climb out, and approach). These emission factors are based on the ICAO Engine Exhaust Emissions Databank[10], manufacturer data, and for older aircraft, data contained in EPA's AP-42, Volume II, Section 1.[11]

Notably, EDMS/AEDT estimates aircraft main engine PM emissions only for aircraft with ICAO certified engines using the First Order Approximation FOA3/FOA3a methodology (see **Section A1.2**, *EPA Methodology*).

EDMS/AEDT does not report Pb emissions directly, but many users calculate Pb emissions as a post-processing step to running EDMS/AEDT. Thus, one should use EDMS's/AEDT's fuel consumption information (only for GA aircraft piston engines that use Avgas) coupled with assumptions of how much Pb is in the fuel and how much Pb remains in the engine (see **Equation A1-4**, *Lead Emission Calculation*).

Generally, aircraft engine emission factors are expressed as grams of pollutant emitted per kilogram of fuel burned or pounds of pollutant per 1000 pounds of fuel consumed. When these are multiplied by the fuel flow rates in kilograms per second or pounds per second, emission rates in grams-per-second or pounds-per-second, respectively, are produced.

[10] ICAO's Aircraft Engine Exhaust Emissions Databank available at the following website: http://easa.europa.eu/document-library/icao-aircraft-engine-emissions-databank.

[11] EPA's *AP-42, Volume II: Mobile Sources* is no longer maintained and has been superseded by more recent EPA publications, refer to http://www.epa.gov/otaq/ap42.htm for additional information.

For additional details on EDMS' data inputs refer to FAA, *Emissions and Dispersion Modeling System (EDMS) User's Manual.*[12] For further detail on AEDT, please visit the AEDT website.[13]

[12] FAA, *Emissions and Dispersion Modeling System (EDMS) User's Manual*, June 2013 [FAA-AEE-07-01 (Rev. 10 – 06/07/13)], http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS_5.1.4_User_Manual.pdf.

[13] Aviation Environmental Design Tool. http://aedt.faa.gov/.

APPENDIX A2 - Auxiliary Power Units Emissions Inventory for Criteria Pollutants

A2.1 Overview

This appendix details the methodology for computing emissions from auxiliary power units (APUs). APUs consist of small turbine engines used by many commercial jet aircraft to start the main engine(s); provide electrical power to aircraft radios, lights, and other equipment; and to power the onboard air conditioning (heating and cooling) systems. There are different models and series of APUs to meet the needs of various aircraft and generally APUs are not common on smaller aircraft.

APUs operating practices largely are determined by individual airlines and vary considerably among aircraft types and airlines. When an aircraft arrives at a terminal gate, the pilot has the option of shutting off power to the main jet engine(s) and operating the on-board APU. Some airlines start the APU when the aircraft is on approach and keep it on during the entire taxi-in phase as a precaution to insure its availability if needed for engine restart. Typically APUs are turned on while taxiing to the gate or parking apron and remain in use while the aircraft is parked. Alternately, an aircraft can receive 400 Hertz (Hz) gate power and pre-conditioned air (PCA) from ground power unit (GPU) and air conditioning (A/C) equipment from connections at the gate. On departure, the APU is used to start the main engines. Once the main engine(s) are started APU can also provide the electric power and ventilation to the aircraft. Again, some airlines prefer to keep the APU running during taxi-out as a back-up.

A2.2 Methodology

APU engines burn jet fuel and create exhaust emissions similar to aircraft engines. APU emissions include hydrocarbons (HC), carbon monoxide (CO), nitrogen oxide (NO_x), and sulfur dioxide (SO_2). The methodology for calculating emissions from APUs is similar to that of an aircraft engine operating in one power setting only. The methodology is adapted from EPA's *Procedures for Emission Inventory Preparation, Volume IV*[14].

APU emissions are estimated for one complete landing-takeoff (LTO) cycle (i.e., during arrival and departure) of each aircraft type and are based on emission factors, fuel flow for the aircraft's specific APU model and the amount of APU usage during the course of the LTO cycle. **Equation A2-1** (*APU Emissions from a Single LTO*) can be used to estimate emissions from a single APU. If a particular aircraft has multiple APUs, then the equation must be multiplied by the number of APUs on the aircraft. Using **Equation A2-1** (*APU Emissions from a Single LTO*), APU emissions per LTO can be calculated for multiple aircraft types and any period of time (i.e., day, month, and year).

[14] EPA, *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, December 1992 [EPA-420-R-92-009], http://www.epa.gov/otaq/models/nonrdmdl/r92009.pdf.

$$E_{ij} = \frac{1}{1000} \times T \times FF_j \times EF_{ij}$$

Where:

E_{ij} = emissions of pollutant i, expressed in pounds, produced by the APU model installed on aircraft type j for one LTO cycle

T = operating time per LTO cycle, expressed in minutes

FF_j = fuel flow, for each APU used on aircraft type j, expressed in pounds per minute

EF_{ij} = emission factor for pollutant i, expressed in pounds of pollutant per one thousand pounds of fuel, for each APU used on aircraft type j

i = pollutant type (e.g., HC, CO, NO_x, SO_2, etc.)

j = aircraft type (e.g., B-737, MD-11, etc.)

Equation A2-1. APU Emissions from a Single LTO

Total APU emissions are estimated by applying **Equation A2-2** (*Total APU Emissions*), which multiples the APU emissions per LTO for a given aircraft type and operating time (determined using **Equation A2-1**, *APU Emissions from a Single LTO*) by the number of corresponding LTOs, then sums the emissions over all aircraft types.

$$ET_i = \sum_j [E_{ij} \times LTO_j]$$

Where:

ET_i = total APU emissions of pollutant i, expressed in pounds, produced by all aircraft types in question

E_{ij} = emissions of pollutant i, expressed in pounds, produced by the APU model installed on aircraft type j for one LTO cycle

LTO_j = number of landing and takeoff cycles for aircraft type j during the inventory period

Equation A2-2. Total APU Emissions

A2.2.1 Data Inputs

The data inputs required to estimate APU emissions and the likely sources of obtaining this information are listed in **Table A2-1** (*Data Inputs for Estimating Emissions from APU*).

Table A2-1. Data Inputs for Estimating Emissions from APU

Data Inputs	Description	Source
Model	The particular APU model that is installed on an aircraft must be determined to select the emission factors used in calculating the emissions.	Individual aircraft operators at airports are potential sources of site-specific APU model information. If site-specific information is not available, FAA's EDMS/AEDT lists APU models commonly found on

Data Inputs	Description	Source
		aircraft should be used.
Emission Factors and Fuel Flow	Emission factors and fuel flow vary by APU model. APU emission factors generally are in pounds of pollutant per 1000 pounds of fuel consumed. APU fuel flow typically is in pounds per minute of usage.	Potential sources of additional emission factors and fuel flow data are APU engine manufacturers. Where data are unavailable for a specific APU, data for an alternative unit of the same or similar horsepower should be used. Otherwise default emission factors and fuel flows within FAA's EDMS/AEDT can be used.
Operating Time	The APU operating time for the aircraft arrival/departure must be known to calculate emissions. This includes time the APU operates while parked at a gate or parking space, during aircraft or APU maintenance, and during aircraft taxi. APU operating time varies by arrival/departure, aircraft, operator, and airport.	Potential sources of site-specific APU operating time data are individual aircraft operators at airports or in-the-field measurements. If no information is available, EDMS/AEDT default values of 13 minutes per arrival and 13 minutes per departure can be used. If gate infrastructure is available, then a value of 3.5 minutes per arrival and 3.5 minutes per departure can be used.
Source: FAA, *Emissions and Dispersion Modeling System (EDMS) User's Manual*, [FAA-AEE-07-01 (Rev. 10 – 06/07/13)], June 2013, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS_5.1.4_User_Manual.pdf.		

A2.3 Computing APU Emissions with EDMS/AEDT

EDMS/AEDT assigns a default APU based on aircraft/engine assignments and also includes criteria pollutant emission factors corresponding to the horsepower for each unit. The user can specify the number of minutes the APU will operate during both arrivals and departures. EDMS's/AEDT's default values are 13 minutes for each operating cycle (i.e., during arrival and departure), which represents the operating time without PCA/400 Hz.

As previously mentioned, in the absence of an APU a combination of 400 Hz electric power and PCA can be supplied to the aircraft using a fixed system at each gate to allow for normal operation. Fixed systems usually generate little or no emissions at the airport and therefore are not included into EDMS/AEDT. Operating times of 3.5 minutes for each operating cycle (i.e., during arrival and departure) represents the operating time with PCA/400 Hz.

APPENDIX A3 - Ground Support Equipment Emissions Inventory for Criteria Pollutants

A3.1 Overview

This appendix discusses the methodologies for computing emissions from ground support equipment (GSE). GSE is a term used to describe the vehicles that service aircraft after arrival and before departure (i.e., while aircraft are unloading and loading passengers and/or freight). Emissions from these sources are based on the number and type of equipment used to service each aircraft along with the amount of time the equipment is in use per aircraft landing-takeoff (LTO) cycle and the equipment fuel type.

There are a wide variety of GSE that service aircraft; a list of the most common GSE types, along with a brief description, follows:

- *Air Start Units* — Provide large volumes of compressed air to an aircraft's main engines for starting. Air start units are also called air compressors.
- *Air Conditioning Units* — Provide conditioned air to ventilate and cool parked aircraft.
- *Aircraft Tugs/Tractors* — Tow aircraft in the terminal gate area or on the tarmac. They also tow aircraft to and from hangers for maintenance. These are broken into two categories: tugs/tractors for narrow body aircraft and tugs/tractors for wide body aircraft.
- *Baggage Tugs/Tractors* — Equipment used at airports to haul baggage between the aircraft and the terminal.
- *Belt Loaders* — Mobile conveyor belts used at airports to move baggage between the ground and the aircraft hold.
- *Buses* — Shuttle personnel between facility locations.
- *Cargo Moving Equipment* — Variety of types of equipment employed to move baggage and other cargo around the facility and to and from aircraft. This category includes forklifts, lifts, and cargo loaders.
- *Deicers* — Vehicles used to transport, heat, and spray deicing fluid.
- *Ground Heaters* — Mobile units that provide heated air to heat the parked aircraft.
- *Ground Power Unit (GPU)* — Mobile ground-based generator units that supply aircraft with electricity while they are parked at the facility. GPUs also are called generators.
- *Light Carts* — Mobile carts that provide light.
- *Other* — Small miscellaneous types of equipment commonly found at facilities such as compressors, scrubbers, sweepers, and specialized units.
- *Pickups* — Move personnel and equipment around the facility.

- *Service Vehicles* — Vehicles that are specially modified to service aircraft at facilities. This category includes fuel trucks, hydrant trucks, maintenance trucks, service trucks, lavatory trucks, and bobtail tractors (a truck body that has been modified to tow trailers and equipment).
- *Vans* — Move personnel and equipment around the facility.
- *Vehicles* — Move personnel around the facility.

In addition, there is also a wide variety of GSE that service an airport. This equipment may be assigned to various departments of the facility including administration, emergency response, police department, operations, engineering and construction, automotive, mechanical maintenance, and landscaping/gardening. The types of equipment servicing an airport vary from cars and pick-ups to generators.

A3.2 Methodology

GSE emissions can be calculated using a total GSE population-based approach (i.e., an accounting of all the equipment and vehicles on the airport) or using an aircraft LTO approach (i.e., based on the type and number of GSE servicing each aircraft type for an LTO). GSE emissions include hydrocarbons (HC), carbon monoxide (CO), nitrogen oxide (NO_x), particulate matter (PM_{10} and $PM_{2.5}$), and sulfur dioxide (SO_2).

For aircraft GSE, exhaust emissions from each GSE type are calculated using site-specific GSE type and usage information combined with non-site-specific inputs (e.g., brake horsepower, load factor, emissions factors). Emissions from each GSE type are summed to obtain the total emissions inventory. This methodology can be used to calculate emissions from an individual type of equipment for one LTO of a given aircraft type or for the entire inventory period independent of aircraft type.

If the equipment usage is based on the time required to service one LTO of an aircraft type, the activity for each aircraft type is applied to the GSE emissions per LTO calculated to obtain the total inventory emissions for GSE. This approach is very flexible since emissions can be calculated for as many or as few aircraft and LTOs as desired and for any inventory period. If total usage hours for the inventory period (i.e., hours per year) are used, it is not necessary to apply aircraft activity to the resulting emissions. For computing emissions for aircraft GSE, the preferable method is the “aircraft LTO approach” which is based on the type and number of GSE servicing each aircraft type for an LTO.

For airport GSE, GSE types and corresponding usage required for the entire inventory period are needed. **Table A3-1** (*Example of EDMS/AEDT Default GSE Usage Assignments*) lists EDMS/AEDT default usage data for specific types of GSE to service one LTO of an aircraft type (i.e., Boeing 767-200 Series).

Table A3-1. Example of EDMS/AEDT Default GSE Usage Assignments

GSE Type	Departure (minutes)	Arrival (minutes)
Air Start	7.00	0.00
Aircraft Tractor	8.00	0.00
Baggage Tractor	60.00	60.00

GSE Type	Departure (minutes)	Arrival (minutes)
Belt Loader	18.00	17.00
Catering Truck	10.00	10.00
Hydrant Truck	20.00	0.00
Lavatory Truck	0.00	25.00
Service Truck	8.00	7.00

Source: EDMS, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/.
Notes: Default GSE usage shown is for a typical Boeing 767-200 Series aircraft servicing one LTO.

The GSE type and usage information is then combined with the remaining inputs to the emissions calculation to obtain total GSE emissions for the given inventory period. In general, only limited calculation input data is readily available for airport GSE. Emissions from airport GSE and aircraft GSE are then summed to obtain the total GSE emissions inventory.

While GSE are commonly fueled by gasoline or diesel, many different types of GSE are commercially available that operate on alternative fuels or electricity. Examples of alternative fuels are compressed natural gas (CNG), liquefied natural gas (LNG), and liquefied petroleum gas (LPG); also commonly known as propane. Different fuels have different emission characteristics for the same piece of equipment. Use of electric GSE produces no emissions because the emissions associated with electric GSE occur at the power plant rather than at the point where the equipment is used (i.e., the airport). Therefore, for the purpose of an emission inventory associated with airport activities emissions from electric GSE are zero.

The factors that determine the quantity of pollutant emitted from GSE are the brake horsepower (BHP), load factor[15], usage, and emission factor. From this, **Equation A3-1** (*Conventional and Alternative Fuel GSE Emission Calculation*) can be used to calculate the emissions from an individual type of equipment for one LTO of a given aircraft type or for the entire inventory

$$E_{it} = (BHP_t \times LF_t \times U_t \times EF_{it}) \times CF$$

Where:

E_{it} = emissions of pollutant i, expressed in pounds, produced by GSE type t

BHP_t = average rated brake horsepower (BHP) of the engine for equipment type t

LF_t = load factor for equipment type t

U_t = hours of use for equipment type t (e.g., to service one LTO of an aircraft type or for the entire inventory period)

EF_{it} = emission factor for pollutant i, expressed in grams per BHP-hour (g/BHP-hr), which is specific to a given engine size and fuel type

i = pollutant type (e.g., CO, VOC, etc.)

t = equipment type (e.g., baggage tug, belt loader, etc.)

CF = factor to convert grams to pounds (i.e., 0.0022046)

Equation A3-1. Conventional and Alternative Fuel GSE Emission Calculation

[15] Load factors are values that represent the ratio of the average energy demand of the equipment (the load) to the maximum (peak load) of the equipment.

period independent of aircraft type based on the period the equipment usage.

A3.2.1 Data Inputs

The data inputs required to estimate GSE emissions and the likely sources of obtaining this information are listed in **Table A3-2** (*Data Inputs for Estimating Emissions from GSE*).

Table A3-2. Data Inputs for Estimating Emissions from GSE

Data Inputs	Conventional and Alternative Fuel	
	Description	**Source**
Equipment Type	Refers to the equipment (e.g., baggage tug) and fuel (e.g., diesel) type.	Site-specific GSE type information can be obtained from a variety of sources including (but not limited to) the airport, the airlines, the equipment/vehicle owner/operator, and in-the-field surveys. If site-specific data is not available, default GSE equipment per aircraft type is provided in the FAA's EDMS/AEDT model.
Usage (hours per LTO or hours per year)	Refers to the hours of use for a specific equipment type either to service one LTO of a specific aircraft type or for the entire inventory period.	Site-specific GSE usage information can be obtained from a variety of sources including (but not limited to) the airport, the airlines, the equipment/vehicle owner/operator, and in-the-field surveys. If site-specific data is not available, default aircraft and airport GSE usage data is provided in the FAA's EDMS/AEDT model.
Size (horsepower)	Brake horsepower (BHP) refers to the average rated brake horsepower of an equipment type's engine.	Site-specific GSE horsepower information can be obtained from a variety of sources including (but not limited to) the airport, the airlines, the equipment/vehicle owner/operator, and in-the-field surveys. If site-specific data is not available, default aircraft and airport GSE horsepower data is provided in the FAA's EDMS/AEDT or EPA's NONROAD models. Default data also may be available from equipment manufacturers.
Load Factor	Refers to the average operational horsepower output of the engine divided by its rated horsepower.	Site-specific GSE load factor information can be obtained from a variety of sources including (but not limited to) the airport, the airlines, the equipment/vehicle owner/operator, and in-the-field surveys. If site-specific data is not available, default aircraft and airport GSE load factor data is provided in the FAA's EDMS/AEDT or EPA's NONROAD models. Default data also may be available from equipment manufacturers.
Emission Factor	Emission factors are expressed in grams per horsepower-hour, which is specific to a given engine size and fuel type.	Default emission factors for both aircraft and airport GSE in provided in FAA's EDMS/AEDT model or may be estimated using EPA's NONROAD model.

Source: TRB, ACRP Report 78, *Airport Ground Support Equipment (GSE): Emission Reduction Strategies, Inventory, and Tutorial*, 2012; FAA, *Emissions and Dispersion Modeling System (EDMS) User's Manual,* [FAA-AEE-07-01 (Rev. 10 – 06/07/13)], June 2013, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS_5.1.4_User_Manual.pdf; and EPA, *User's Guide for the Final NONROAD2005 Model*, December 2005, [EPA-420-R-05-013],

Data Inputs	Conventional and Alternative Fuel	
	Description	Source
http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2005/420r05013.pdf.		

A3.3 Computing GSE Emissions with EDMS/AEDT

EDMS/AEDT has the capabilities to compute GSE emissions. GSE emissions inventories using EDMS/AEDT are set to capture GSE utilization at an airport for two activities: (i) GSE servicing aircraft (e.g., a baggage tractor visiting an aircraft at the apron to drop off baggage), and (ii) GSE population not tied to gate service operations (e.g., a deicing truck driving back and forth to a deicing area during the deicing season).

Within EDMS/AEDT, GSE usage is dependent upon the size of aircraft being serviced (e.g., small, narrow body, and wide body) as well as the operational purpose of the aircraft (e.g., passenger air carrier, cargo air carrier, etc.). In EDMS/AEDT, GSE emissions generated by LTO cycle are the product of the emission factor, horsepower, load factor and operating time. For annual emissions this result is multiplied by the number of yearly LTO cycles for the aircraft to which the equipment is assigned. Alternatively, for a population GSE, the annual GSE emissions are the product of the emission factor for the given pollutant, horsepower, load factor, annual usage and population.

EDMS/AEDT offers default values for many of the parameters mentioned (e.g., horsepower, load factor, etc.). EDMS/AEDT also allows the user to override default data to the extent more site-specific GSE fleet information is available. Therefore, it is ideal to gather site-specific GSE data from the airport, the airlines, the equipment/vehicle owner/operator, or by performing in-the-field surveys.

APPENDIX A4 - Ground Access Vehicles Emissions Inventory for Criteria Pollutants

A4.1 Overview

Ground access vehicles[16] include airport passenger vehicles (e.g., private autos, taxis, limousines, shuttles, vans, buses, rental cars, etc.), vehicles transporting airport and tenant employees, airport fleet (e.g., buses, shuttles, etc.), and vehicles transporting cargo to and from the airport as well as circulating around the airport. This appendix details the methodology for computing emissions from ground access vehicles associated with airport activities.

A4.2 Methodology

Ground access vehicle emissions are typically associated with three different types of airport activities: (i) vehicles traveling on- and off-airport roadways, (ii) vehicles traveling and idling within airport parking facilities; and (iii) vehicles accessing and idling at terminal curbside areas associated with passenger pickup and drop-off.

A4.2.1 On- and Off-Airport Roadways

Emissions from motor vehicles traveling on- and off-airport roadways are primarily a function of vehicle-miles-travelled (VMT) within a specific roadway segment by a specific type of vehicle (e.g., passenger cars, diesel shuttles, compressed natural gas [CNG] buses, etc.). VMT are then factored against a series of pollutant emissions rates for that type of vehicle, in grams per VMT, to compute emissions. This approach is also employed for the component of parking and curbside activities associated with vehicle travel (as opposed to vehicle idling). Emissions from ground access vehicles traveling on- and off-airport roadways may be estimated by applying **Equation A4-1** (*Total Pollutant Emissions from Traveling Motor Vehicles*).

$$\boldsymbol{E_{Travel} = CF \times \sum_{j} [VMT_j \times ER_j]}$$

Where:

E_{Travel} = total traveling motor vehicle emissions of a pollutant (i.e., CO, SO_2, PM_{10}, $PM_{2.5}$, NO_x, or VOC), for a given time period, expressed in pounds.

CF = factor to convert grams to pounds (i.e., 0.0022046)

VMT_j = vehicle-miles-travelled on a roadway segment by vehicle type j (e.g., Honda Civic) for a given time period, expressed in miles.

ER_j = emissions rate of pollutant considering speed and vehicle type j, expressed in grams of pollutant per mile.

j = vehicle type (e.g., Honda Civic).

Equation A4-1. Total Pollutant Emissions from Traveling Motor Vehicles

[16] Ground access vehicles exclude those ground support equipment (GSE) used for servicing aircraft and airports.

A4.2.2 Parking Facilities

Parking emissions are a compound function of how many vehicles are entering and exiting airport parking facilities (i.e., garages and surface lots), the distance they travel to access and egress the parking area, and any idling time incurred as the vehicles queue either in waiting for a space or to enter or exit. The travel-based component of the parking emissions can be estimated by applying **Equation A4-1** (*Total Pollutant Emissions from Travelling Motor Vehicles*). The idling-based component of the parking emissions may be quantified by applying **Equation A4-2** (*Total Pollutant Emissions from Motor Vehicles Idling*). Emissions should be estimated for each on-site and/or off-site parking facility associated with the airport. A typical idle time is 1.5 minutes and a typical travel distance is equivalent to twice the diagonal of the parking area.

$$\boldsymbol{E_{Idling} = CF \times \sum_{j} \left[AADT_j \times IT_j \times ER_j \right]}$$

Where:

E_{Idling} = total idling motor vehicle emissions of pollutant (i.e., CO, SO_2, PM_{10}, $PM_{2.5}$, NO_x, or VOC), for a given time period, expressed in pounds.

CF = factor to convert grams to pounds (i.e., 0.0022046)

$AADT_j$ = average annual daily traffic counts by vehicle type j for the parking facility.

IT_j = idling time, expressed in minutes per vehicle type j.

ER_j = emissions rate of pollutant from idling considering speed of vehicle type j, expressed in grams per minute.

j = vehicle type (e.g., Honda Civic).

Equation A4-2. Total Pollutant Emissions from Motor Vehicles Idling

A4.2.3 Terminal Curbside Areas

Emissions from the terminal curbside areas are based on the number of vehicles traveling to these areas, the distance of the curbside area and the amount of idling time incurred as these vehicles pickup and drop-off passengers. The approaches discussed previously for roadways and parking facilities may be applied to estimate motor vehicle emissions from terminal curbside areas. Therefore, the travel- and idling-based components of these emissions may be quantified by applying **Equation A4-1** (*Total Pollutant Emissions from Traveling Motor Vehicles*) and **Equation A4-2** (*Total Pollutant Emissions from Motor Vehicles Idling*), respectively. A typical idle time ranges from 1.5 to 6.0 minutes depending on vehicle type and a typical travel distance is equivalent to length of the terminal curbside holding area.

Total emissions from roadway, parking and curbside motor vehicle activities may be obtained by summing the travel emissions based on VMT and the idling emissions based on hours of operation, as shown by **Equation A4-3** (*Total Pollutant Emissions from Motor Vehicles*).

$$E_{Total} = E_{Idling} + E_{Travel}$$

Where:

E_{Total} = total motor vehicle emissions of pollutant (i.e., CO, SO_2, PM_{10}, $PM_{2.5}$, NO_x, or VOC), for a given time period, expressed in pounds.

E_{Idling} = total idling motor vehicle emissions of pollutant (i.e., CO, SO_2, PM_{10}, $PM_{2.5}$, NO_x, or VOC), for a given time period, expressed in pounds.

E_{Travel} = total traveling motor vehicle emissions of pollutant (i.e., CO, SO2, PM_{10}, $PM_{2.5}$, NO_x, or VOC), for a given time period, expressed in pounds.

Equation A4-3. Total Pollutant Emissions from Motor Vehicles

A4.2.4 Data Inputs

The data inputs required to estimate traveling and idling emissions from motor vehicles and possible sources of obtaining this information are listed in **Table A4-1** (*Data Inputs for Estimating Emissions from Motor Vehicles*).

Table A4-1. Data Inputs for Estimating Emissions from Motor Vehicles

Data Inputs	Description	Source
Vehicle-Miles-Travelled (VMT)	VMT is equal to the total number of vehicle trips multiplied by the trip distance (measured in miles).	Information on VMT may be obtained from the airport operator. If available, the airport's most recent traffic study that includes traffic volumes (e.g., AADT), speeds, mileage, ridership, and vehicle mix data is the most optimal source.
Idling Time	The amount of time a vehicle is stationary, typically expressed in minutes per vehicle.	This information can be initiated by requesting the airport to conduct a survey of the motor vehicles idling along terminal curbside areas and within parking areas of the airport. However, if this information is unavailable a default idling time of 1.5 minutes is typically used.
Emission Rate	Emission are expressed in grams of pollutant per mile travelled (g/VMT) or grams per vehicle hour of operation (g/hour).	Emission rates are estimated using EPA's MOVES or California's EMFAC. See **Section 5** (*Air Quality Assessment Models*) of *Handbook*.
Source: EPA MOVES, http://www.epa.gov/otaq/models/moves/index.htm; and CARB's EMFAC, http://www.arb.ca.gov/msei/modeling.htm.		

A4.3 Models Used to Compute Ground Access Vehicle Emissions

As discussed in **Section 5** (*Air Quality Assessment Models*) of the *Handbook,* the EPA's Motor Vehicle Emissions Simulator (MOVES), version 2014 is the current EPA-approved model used to compute motor vehicle emissions rates representative of various types of vehicles and activities. MOVES covers a broad range of pollutants and allows multiple scale analyses (i.e., national, county, or local). To execute MOVES, input data such as: vehicle population, vehicle age distribution, vehicle VMT, speed, etc., is needed. The user may apply MOVES' national default data; however, depending on the scale and type of project, these values may not be representative of the study area and may not be appropriate. Therefore, state and regional air quality regulatory and transportation planning agencies should be consulted, as these agencies might assist the user with more localized, site-specific data. For further information, on MOVES, refer to EPA's *User Guide for MOVES2014*[17] or any subsequent guidance.

In addition, it should be noted that if the project is located in California the EPA-approved emission model is the EMFAC. EMFAC is California's model for estimating emissions from on-road vehicles issued by the California Air Resources Board (CARB). For further information, on EMFAC and the latest model version, refer to CARB's *EMFAC2011 Overview*[18].

In the current version of EDMS (version 5.1.4.1), vehicle emission rates still need to be computed using EPA's MOVES and populated into EDMS, as the current EDMS uses MOBILE6.2, which has been replaced by MOVES. For further information on how to do this, refer to the FAA's *Best Practice Document for using EDMS with EPA MOVES*[19]. Alternatively, ground access vehicle activity can be excluded from the EDMS study and modeled solely in MOVES. AEDT does not use MOBILE6.2 or MOVES, so users using AEDT should model ground access vehicles in MOVES.

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17 EPA, *Motor Vehicle Emissions Simulator (MOVES) User Guide for MOVES2014*, July 2014 [EPA-420-B-14-055], http://www.epa.gov/otaq/models/moves/documents/420b14055.pdf.

18 CARB, *EMFAC2011 Overview*, September 19, 2011 (Updated January 2013), http://www.arb.ca.gov/msei/emfac2011-release-document-final-updated-0712v03.pdf.

19 Federal Aviation Administration, *The Usage of the U.S. Environmental Protection Agency's (USEPA) Motor Vehicle Emission Simulator (MOVES) with the Federal Aviation Administration's (FAA) Emissions and Dispersion Modeling System (EDMS).* March 2014. http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS-MOVES_Best_Practice.pdf.

APPENDIX A5 - Stationary Source Emissions Inventory for Criteria Pollutants

A5.1 Overview

This appendix discusses the methodology for computing emissions from stationary and area sources at airports, which consist of both combustion and non-combustion sources. The stationary and area sources typically found at airports are listed and are discussed in detail throughout this appendix.

Combustion Sources

- Boilers and Heaters
- Generators
- Snowmelters
- Incinerators
- Fire Training Facilities
- Aircraft Engine Testing

Non-Combustion Sources

- Fuel Storage Tanks
- Cooling Towers
- Coating and Painting Operations
- De-icing and Anti-icing Operations
- Solvent Degreasing
- Salt and Sand Piles

Site-specific data is necessary for determining emissions from stationary and area sources. This information can be obtained from multiple sources such as the airport operator, the individual airport tenants and/or the state/local air quality regulatory agency.

EDMS/AEDT has the capabilities to compute stationary source emissions associated with airports. However, the main focus of this appendix is to address the calculation steps and equations needed to compute an emission inventory for criteria pollutants for each of the sources listed.

A5.2 Combustion Sources

Emissions from combustion sources (e.g., boilers, heaters, generators, etc.) derive from the burning of fossil fuels such as coal, fuel oil, and natural gas. The pollutants emitted by these sources include CO, SO_2, PM_{10}, $PM_{2.5}$, VOC, and NO_x.

A5.2.1 Boilers and Heaters

Airports operate boilers and heaters to fulfill much of their heating and power generation requirements. These stationary combustion sources burn several different fuel types, most commonly distillate fuel oil, residual fuel oil, diesel fuel, natural gas, and occasionally jet fuel. Emissions from these sources are dependent on the type of fuel burned, usage rates, and duration of operation. Specific information on the type of equipment, the type of fuel burned, and the control equipment for each boiler or heater should be obtained from the airport operator and/or the equipment manufacturer. Information on fuel composition (i.e., sulfur and ash content) may be obtained from the fuel supplier.

A5.2.1.1 Methodology

Emissions from boilers and heaters are estimated based on the amount and type of fuel burned by those sources over the time period being analyzed. Emissions for each pollutant are calculated by multiplying the fuel consumption rate by the emission factor specific to each pollutant. This technique is repeated for each boiler or heater in order to obtain total emissions for these stationary combustion sources.

Total pollutant emissions from boilers and heaters may be estimated by applying **Equation A5-1** (*Total Pollutant Emissions for Boilers and Heaters*).

$$E = F \times EF$$

Where:

E = total emissions of pollutant from the stationary source for a given time period, expressed in pounds.

F = total amount of fuel consumption for a given time period; liquid fuels should be expressed in terms of thousand gallons, natural gas as million cubic feet, and coal as tons.

EF = emission factor of pollutant (i.e., CO, SO_2, PM_{10}, $PM_{2.5}$, NO_x, or VOC), expressed in pounds per thousand gallons (for liquid fuels), million cubic feet (for natural gas), or ton of fuel (for coal).

Equation A5-1. Total Pollutant Emissions for Boilers and Heaters

As shown in **Equation A5-1** (*Total Pollutant Emissions for Boilers and Heaters*), the total fuel consumption is multiplied by the emission factor to estimate emissions from the boiler or heater. The accuracy of this methodology depends upon the ability to determine an appropriate emission factor for each pollutant. The following section describes how to obtain EPA-approved emission factors for each combustion source.

A5.2.1.2 Emission Factors

EPA provides emission factors for a wide range of boilers, but provides little emission information specific to heaters. Therefore, for the purpose of airport emissions inventories it can be assumed that the emission factors provided for boilers are applicable to heaters of a comparable size and fuel type.

Emission factors for most stationary combustion sources found at airports are found within Chapter 1, *External Combustion Sources,* of EPA's *Compilation of Air Pollution Emissions Factors* (i.e., AP-42)[20]. These emission factors take into consideration several elements that have a significant impact on pollutant emissions, including: fuel type, fuel sulfur content, fuel ash content, boiler size, boiler type, and pollution control equipment. The emission factors are calculated by obtaining the uncontrolled emission factor based on fuel type, boiler size and boiler

20 EPA, AP-42, Fifth Edition, *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources,* http://www.epa.gov/ttnchie1/ap42/.

type, and correcting for the reduction of pollutants by any air pollution control equipment in operation.

In addition, the SO_2 emission factors are reflective of the fuel sulfur content of the fuel, which may be obtained from the fuel supplier and/or the airport operator. PM emission factors are reflective of the fuel ash content of the fuel. This may be obtained from the fuel supplier, airport operator, or may be taken from calculation of default ash content of fuels as described in Chapter 1.3, *Fuel Oil Combustion* of EPA's AP-42[21].

The methodology for obtaining the appropriate emission factors is expressed by **Equation A5-2** (*Emission Factors for Boilers and Heaters*).

$$EF = UEF \times (1 - CF/100) \times FM$$

Where:

EF = emission factor of pollutant (i.e., CO, SO_2, PM_{10}, $PM_{2.5}$, NO_x, or VOC), expressed in pounds per thousand gallons (for liquid fuels), million cubic feet (for natural gas), or ton of fuel (for coal).

UEF = uncontrolled emission factor of pollutant, expressed in pounds per thousand gallons (for liquid fuels), million cubic feet (for natural gas), or ton of fuel (for coal).

CF = air pollution control factor, expressed as a percentage.

FM = fuel modifier (fuel weight percent sulfur for SO_2 emission factor; fuel weight percent ash for PM emission factor; ignore for other pollutants).

Equation A5-2. Emission Factors for Boilers and Heaters

A5.2.2 Generators

Generators at airports typically are fixed in place and located throughout the airport to provide supplementary or emergency power. These generators are likely powered by gasoline or diesel-fueled reciprocating internal combustion engines.

A5.2.2.1 Methodology

There are two methodologies to calculate emissions from generators: (i) EPA's AP-42 method, which calculates emissions based on the capacity rating (in horsepower) of generator engines, and (ii) the U.S. Air Force's method, which calculates emissions based on the amount of fuel consumed.

Data inputs required for the emissions calculation for both methodologies (e.g., capacity of generator engine, time of generator usage, type and quantity of fuel burned, and air pollution control factor) for each generator should be obtained from the airport operator, the equipment manufacturer, and/or the fuel supplier.

[21] EPA, AP-42, Chapter 1.3, *Fuel Oil Combustion*, http://www.epa.gov/ttnchie1/ap42/ch01/final/c01s03.pdf.

EPA's AP-42 method for estimating pollutant emissions is based on the generator capacity, generator usage rate, and pollutant emission factors. Emissions are calculated by multiplying the power capacity of each generator by the number of hours the generator was operated and by the emission factor for each specific pollutant and by the air pollution control factor. Air pollution control methods for generators include steam injection, water injection, and selective catalytic reduction for NO_x control.

Total pollutant emissions from a generator using EPA's AP-42 method may be estimated by applying **Equation A5-3** (*Total Pollutant Emissions for Generators - EPA's AP-42 Method*).

$$E = GC \times T \times UEF \times (1 - CF/100)$$

Where:

E = total emissions of pollutant from the emergency generator for a given time period, expressed in pounds.

GC = generator power capacity rating, expressed in horsepower or kilowatts.

T = time generator was operated during inventory time period, expressed in hours.

UEF = uncontrolled emission factor of pollutant (i.e., CO, SO_2, PM_{10}, $PM_{2.5}$, NO_x, or VOC), expressed in pounds per horsepower-hour (if the generator power capacity rating GC is expressed in horsepower) or pounds per kilowatt-hour (if the generator power capacity rating GC is expressed in kilowatts) of power output.

CF = air pollution control factor, expressed as a percentage.

Equation A5-3. Total Pollutant Emissions for Generators (EPA's AP-42 Method)

U.S. Air Force's method for estimating pollutant emissions is based on the quantity of fuel burned and pollutant emission factors. Emissions are calculated by multiplying the quantity of fuel burned by the emission factor for each specific pollutant and by the air pollution control factor. Again air pollution control methods for generators include steam injection, water injection, and selective catalytic reduction for NO_x control.

Total pollutant emissions from a generator may be estimated by applying **Equation A5-4** (*Total Pollutant Emissions for Generators – U.S. air Force's Method*).

$$E = F \times UEF \times (1 - CF/100)$$

Where:

E = total emissions of pollutant from the emergency generator for a given time period, expressed in pounds.

F = total quantity of fuel burned, expressed in thousands of gallons of fuel or million cubic feet for natural gas, for a given time period.

UEF = uncontrolled emission factor of pollutant (i.e., CO, SO_2, PM_{10}, $PM_{2.5}$, NO_x, or VOC), expressed in pounds per thousand gallons of fuel or million cubic feet for natural gas.

CF = air pollution control factor, expressed as a percentage.

Equation A5-4. Total Pollutant Emissions for Generators (U.S. Air Force's Method)

A5.2.2.2 Emission Factors

The uncontrolled emission factors for **Equation A5-3** (*Total Pollutant Emissions for Generators - EPA's AP-42 Method*) for gasoline and diesel engines are given in Chapter 3.3, *Gasoline and Diesel Industrial Engines*[22], of EPA's AP-42. These emission factors can be used for engines that have a rated power of up to 250 horsepower (hp) for gasoline engines and up to 600 hp for diesel engines. Diesel engines greater than 600 hp are covered in Chapter 3.4, *Large Stationary Diesel and All Stationary Dual-fuel Engines*[23], of EPA's AP-42.

The uncontrolled emission factors for **Equation A5-4** (*Total Pollutant Emissions for Generators – U.S. Air Force's Method*) for generators powered by reciprocating engines are given in **Table A5-1** (*Uncontrolled Emission Factors for Generators*). These emission factors are also the default values used in EDMS/AEDT. Note that for SO_2, the percent of sulfur in the fuel must be obtained to calculate the emission factor. The type of fuel and sulfur content should be available from the fuel supplier and/or the airport operator.

Table A5-1. Uncontrolled Emission Factors for Generators

Fuel	Emission Factors[1]				
	CO	PM_{10}	NO_x	SO_2[2]	VOC
Distillate Oil (Diesel)	130	32.0	604	141(S)	49.3
Kerosene/Naphtha (Jet Fuel)	102	32.0	469	128(S)	32.1
Gasoline (Mogas)	7,128	6.2	185	123(S)	344
Natural Gas (pounds/million cubic feet)	430	10.0	3,400	840(S)	82.9
LPG (Propane or Butane)	129	5.0	139	91(S)	83.0
Residual/Crude Oil	102	30.8	469	152(S)	32.1

Source: *Emissions and Dispersion Modeling System (EDMS) User's Manual,* FAA-AEE-07-01 (Rev. 10 – 06/07/13), June 2013, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS_5.1.4_User_Manual.pdf; and Jagielski, Kurt D., and Robert J. O'Brien, *Calculation Methods for Criteria Air Pollutant Emission Inventories*, July 1994.
Notes:
[1] Emission factors are expressed in pounds per thousand gallons for fuel and pounds per million cubic feet for natural gas.
[2] (S) signifies the fuel sulfur content, expressed as weight percent sulfur, which is multiplied by the coefficient given to obtain the emission factor for SO_2.

A5.2.3 Snowmelters

Snowmelters at airports are used to remove snow from airfield surfaces. They are portable and stationary sources that are typically powered by gasoline or diesel-fuel or natural gas. Emissions are dependent on type of fuel and the amount of fuel being burned over the time period being analyzed.

[22] EPA, AP-42, Chapter 3.3, *Gasoline and Diesel Industrial Engines*, http://www.epa.gov/ttnchie1/ap42/ch03/final/c03s03.pdf.
[23] EPA, AP-42, Chapter 3.4, *Large Stationary Diesel and All Stationary Dual-fuel Engines*, http://www.epa.gov/ttnchie1/ap42/ch03/final/c03s04.pdf.

A5.2.3.1 Methodology

Pollutant emissions from snowmelters are calculated by multiplying the fuel consumption rate by the emission factor specific to each pollutant. Specific information on type of equipment and fuel should be obtained from the airport operator.

Total pollutant emissions from a snowmelter may be estimated by applying **Equation A5-5** (*Total Pollutant Emissions for Snowmelters*).

$$E = F \times EF$$

Where:

E = total emissions of pollutant from the snowmelter for a given time period, expressed in pounds.

F = total quantity of fuel burned, expressed in thousands of gallons of fuel or million cubic feet for natural gas, for a given time period.

EF = emission factor of pollutant (i.e., CO, SO_2, PM_{10}, $PM_{2.5}$, NO_x, or VOC), expressed in pounds per thousand gallons of fuel or million cubic feet for natural gas.

Equation A5-5. Total Pollutant Emissions for Snowmelters

A5.2.3.2 Emission Factors

Emission factors for each pollutant for sources such as snowmelters may be found within Chapter 1, *External Combustion Sources*[24]*,* of EPA's AP-42.

A5.2.4 Incinerators

Incinerators at airports are likely small industrial or commercial combustors for the disposal of food wastes (e.g., from international flights) or other refuse. Large municipal waste combustors (MWC) are unlikely to be operated at airports. Emissions are dependent on the total mass of waste burned for a given time period.

A5.2.4.1 Methodology

Pollutant emissions from incinerators are calculated by multiplying the mass of waste burned by the emission factor for each specific pollutant multiplied by the air pollution control factor. Emissions from incinerators are sometimes controlled by scrubbers or gas-fired afterburners. Information on equipment and control efficiency should be obtained from the airport operator.

Total pollutant emissions from an incinerator may be estimated by applying **Equation A5-6** (*Total Pollutant Emissions for Incinerators*).

A5.2.4.2 Emission Factors

Uncontrolled emission factors based on the type of incinerator are given in Chapter 2.1, *Refuse Combustion*[25], of EPA's AP-42. Uncontrolled emission factors for PM, SO_2, CO, VOC, and NO_x

24 EPA, AP-42, Chapter 1, *External Combustion Sources,* http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s00.pdf.

are provided. EPA provides emission factors for two types of industrial/commercial incinerators: multiple chamber and single chamber. The type of incinerator design should be obtained from the airport operator.

A5.2.5 Fire Training Facilities

Many major airports operate on-site aircraft rescue and firefighting (ARFF) training facilities. In these specialized training facilities, fuel is burned in a pit or a mockup of an aircraft to simulate emergency situations that may occur on airport grounds. Fire training activities are a periodic

$$E = F \times UEF \times (1 - CF/100)$$

Where:

E = total emissions of pollutant from the incinerator for a given time period, expressed either in pounds or tons (e.g., pounds per year).

F = total mass of waste burned for a given time period, expressed in tons.

UEF = uncontrolled emission factor of pollutant (i.e., CO, SO_2, PM_{10}, $PM_{2.5}$, NO_x, or VOC), expressed in pounds per ton of waste burned.

CF = air pollution control factor, expressed as a percentage.

Equation A5-6. Total Pollutant Emissions for Incinerators

source of emissions. The amount of fuel burned (e.g., Jet-A, propane, diesel, and tekflame fuels) and time of burning depends upon the particular training exercise being performed and type of equipment in use. The number of training fire events is also used in the calculation.

Air pollutants from the burning of training fires at airports include PM_{10}, $PM_{2.5}$, CO, NO_x, SO_2, and VOC. Emission factors for these pollutants depend upon the type of fuel burned, and are estimated based on measured emissions from the uncontrolled burning of each fuel. Using these emission factors, total pollutant emissions from a training fire can be calculated using the following methodology.

A5.2.5.1 Methodology

Emissions from training fires at airports are estimated by determining the quantity of fuel burned in each fire and multiplying by the emission factors to calculate the total pollutant emissions to the atmosphere for each simulated fire event. The total number of fire training events per year is then used to determine the total annual emissions.

Total emissions from one training fire may be estimated by applying **Equation A5-7** (*Total Pollutant Emissions for Training Fires*).

[25] EPA, AP-42, Chapter 2.1, *Refuse Combustion,* http://www.epa.gov/ttnchie1/ap42/ch02/final/c02s01.pdf.

$$E = QF \times EF$$

Where:

E = total emissions of pollutant from training fires, expressed in pounds.

QF = quantity of fuel burned in training fire (thousands of gallons).

EF = emission factor of pollutant (i.e., CO, SO_2, PM_{10}, $PM_{2.5}$, NO_x, or VOC), expressed in pounds per thousand gallons of fuel burned.

Equation A5-7. Total Pollutant Emissions for Training Fires

A5.2.5.2 Emission Factors

Table A5-2 (*Emission Factors for Uncontrolled Burning in Training Fires*) provides emission factors for each of the fuels commonly burned in ARFF training facilities. These emission factors are also the default values used within EDMS/AEDT.

Table A5-2. Emission Factors for Uncontrolled Burning in Training Fires

Fuel	Emission Factors[1]				
	CO	PM_{10}	NO_x	SO_2	VOC
JP-4	3,584	960	26.9	3.8	128
JP-5	124	96.6	2.6	14.9	198
JP-8	4,487	1,014	33.6	6.8	135
Propane	34.8	117	6.4	0.02	31.8
Tekflame	68.3	33.3	3.7	0.04	49.6

Source: *Emissions and Dispersion Modeling System (EDMS) User's Manual,* FAA-AEE-07-01 (Rev. 10 – 06/07/13), June 2013, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS_5.1.4_User_Manual.pdf; and Jagielski, Kurt D., and Robert J. O'Brien, *Calculation Methods for Criteria Air Pollutant Emission Inventories*, July 1994.
Notes: [1] Emission factors are expressed in pounds of pollutant per thousand gallons of fuel burned.

A5.2.6 Aircraft Engine Testing

Aircraft engine testing is performed at some airports as part of regular aircraft maintenance cycles. In general, testing at commercial airports is limited to uninstalled engines in enclosed test cells. These tests are often performed following overhaul or repair of the engine to determine air worthiness, engine safety performance and fuel efficiency. During the test, the engine is mounted in a special enclosed cell that restricts noise but allows air to flow through at speeds simulating aircraft flight. Engine thrust and other essential performance parameters are measured as the engine is taken through a sequence of power settings. Aircraft engine testing is also performed for installed engines within hush houses.

A5.2.6.1 Methodology

Pollutant emissions from aircraft engine testing are computed for each engine being tested at different operational modes. During testing, the engine is taken through a sequence of power levels simulating actual flight conditions. Knowledge of the test operating times and fuel flow rates for each of these modes and conditions allows the calculation of emissions from each testing mode.

The methodology for calculating overall emissions from aircraft engine testing is expressed by **Equation A5-8** (*Total Pollutant Emissions for Aircraft Engine Testing*).

$$E = N \times TT_{Mode} \times FF_{Mode}/1{,}000 \times EF$$

Where:

E = total emissions of pollutant.

N = Number of test cycles performed.

TT_{MODE} = *average test time for a specific testing mode, expressed in minutes.*

FF_{MODE} = *fuel flow rate while in a specific testing mode, expressed in pounds per minute.*

EF = emission factor of pollutant (i.e., CO, SO_2, PM_{10}, $PM_{2.5}$, NO_x, *or VOC), expressed in pounds per thousand pounds of fuel burned.*

Equation A5-8. Total Pollutant Emissions for Aircraft Engine Testing

Data inputs required to execute **Equation A5-8** (*Total Pollutant Emissions for Aircraft Engine Testing*) and their respective sources are listed in the following sections.

A5.2.6.2 Testing Data

Maintenance personnel should be consulted to determine the typical number of test cycles performed upon each aircraft. In addition, aircraft engine test time for each testing mode varies with the engine type, goals of the test, and equipment used. Therefore, site-specific information on test times should be obtained from the maintenance personnel performing the testing.

A5.2.6.3 Engine Fuel Flow

The default average fuel consumption rate, in pounds per minute, of an engine in each operational mode, is provided in Chapter 5 of EPA's *Procedures for Emission Inventory Preparation, Volume IV: Mobile Source,*[26] and in the ICAO's *Engine Exhaust Emissions Databank*[27]. For military aircraft, the EPA's *Procedures for Emission Inventory Preparation, Volume IV: Mobile Source* should be used. These engine fuel flow default values are adapted within EDMS/AEDT.

A5.2.6.4 Emission Factors

Emission factors for an aircraft engine are listed by operating mode, generally, in pounds of pollutant per thousand pounds of fuel consumed. Average emission factor data for engines by operating mode are included in EDMS/AEDT and have been adapted from EPA's *Procedures*

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[26] EPA, *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, Chapter 5, EPA420-R-92-009, December 1992, http://www.epa.gov/otaq/models/nonrdmdl/r92009.pdf.

[27] ICAO, *Aircraft Engine Emissions Databank*, http://easa.europa.eu/environment/edb/aircraft-engine-emissions.php.

for Emission Inventory Preparation, Volume IV, Chapter 5 (for both civil and military aircraft engines) and the ICAO's *Engine Exhaust Emissions Databank* (for civil aircraft engines only).

A5.2.6.5 Engine Type

Potential sources of site-specific data on engine types being tested include airline maintenance, and sampling. If site-specific engine data for commercial airlines is not available but the aircraft operator is known, then an appropriate default engine can be chosen based on the operator's national fleet. Airline fleet data, including aircraft engine model, is published in Bucher & Co.'s JP Airline-Fleets International. If the aircraft operator is not known, default, typical aircraft-engine data is provided in Chapter 5 of EPA's *Procedures for Emission Inventory Preparation, IV: Mobile Source*. For military aircraft, site-specific information on engine types being tested may be obtained from the maintenance personnel performing the testing. Default military aircraft engine data is also listed in the EPA's *Procedures for Emission Inventory Preparation, IV: Mobile Source*.

A5.3 Non-Combustion Sources

Typical non-combustion stationary and area sources (e.g., fuel tanks, cooling towers, etc.) found at airports are described in the following sections. The methodologies used to calculate emissions from these sources varies depending on the type of source and the pollutant specific to that source.

A5.3.1 Fuel Storage Tanks

Many airports have fuel farms where large quantities of jet fuel, avgas, gasoline and other fuel types are stored in tanks. Fuel storage and handling activities represent sources of evaporative hydrocarbon emissions. Emissions from these sources occur from "breathing losses" (or "standing losses") and "working losses" (or "withdrawal losses").

Breathing losses are the result of the natural expansion and contraction of the fuel caused by changes in ambient temperature and the resultant evaporative emissions escaping from the fuel storage tanks.

Working losses are the combined losses from filling and emptying the storage tanks. Filling causes increased pressure in the tank, thus expelling vapors from the tank. Emptying losses occur when air drawn into the storage tank during fuel removal becomes saturated with hydrocarbon vapors, expands, thus exceeding the vapor space capacity, and is expelled out of the tank. Working losses also occur during the refueling of aircraft and fuel trucks. The level of emissions depend on the type of storage device, the type and amount of fuel stored, transfer and refueling methods, efficiency of vapor recovery and atmospheric conditions (i.e., temperature and relative humidity).

Table A5-3 (*Evaporative Emission Losses of Fuel Storage Tanks*) summarizes the fuel storage tanks commonly found at airports and the various ways evaporative emissions escape from these sources.

Table A5-3. Evaporative Emission Losses of Fuel Storage Tanks

Tank Type[1]	Evaporative Emission Losses
Horizontal	Potential evaporative emission sources for above-ground horizontal tanks are the same as those for fixed-roof tanks. Emissions from underground storage tanks are mainly associated with changes in the liquid level in the tank. Losses due to changes in temperature or barometric pressure are minimal for underground tanks because the surrounding earth limits the diurnal temperature change and changes in the barometric pressure would result in only small losses.
Vertical Fixed Roof[2]	*Breathing losses* are expelled via vents during temperature and pressure-induced expansions and contractions. *Working losses* are evaporative losses produced during filling and emptying operations. As the tank is filled, the vapor pressure within it exceeds the relief pressure and vapors are expelled from the tank. During fuel removal, air drawn into the tank to replace the liquid becomes saturated with organic vapor and expands, thereby exceeding the capacity of the vapor space and exiting through the pressure-vacuum relief valve.
Internal Floating Roof[3]	*Rim seal, deck fitting, and deck seam losses* occur in internal floating roof tanks due to slight imbalances in internal and external pressure. *Withdrawal losses* are similar to those for external floating roof tanks with one major difference--wind is not a predominant factor affecting rim seal losses.
External Floating Roof[3]	*Standing storage losses* emanate from roof fittings and rim seals--which occupy the space between the edge of the floating roof and the tank wall. Some breathing losses also occur. Most of these losses are wind-induced. *Withdrawal losses* occur during removal operations, fuel remains attached to the tank wall and evaporates as the fuel level, and thus the floating roof, is lowered.
Domed External Floating Roof[4]	This type of tank is very similar to an internal floating roof tank with a welded deck and a self-supporting fixed roof. As with the internal floating roof tanks, the function of the fixed roof is not to act as a vapor barrier, but to block the wind. Like the internal floating roof tanks, these tanks are freely vented by circulation vents at the top of the fixed roof. The deck fittings and rim seals, however, are basically identical to those on external floating roof tanks.

Source: *Emissions and Dispersion Modeling System (EDMS) User's Manual*, FAA-AEE-07-01 (Rev. 10 – 06/07/13), June 2013, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS_5.1.4_User_Manual.pdf, and Chapter 7, *Organic Liquid Storage Tanks,* of EPA's AP-42, http://www.epa.gov/ttnchie1/ap42/ch07/.

Notes:

[1] Tanks listed are typically above ground storage tanks, except for horizontal fixed roof tanks which can be constructed for both above-ground and underground service.

[2] In general, fixed-roof tanks tend to be older and result in the greatest atmospheric emissions. The presence of a volume of vapor space above the level of liquid in the tank promotes evaporation of the fuel hydrocarbons and their subsequent release to the atmosphere through the breather valve.

[3] Tanks equipped with a floating roof are able to reduce evaporative emissions by eliminating the vapor space between the liquid level in the tank and the tank roof. However, some emissions do occur through various seals and

Tank Type[1]	Evaporative Emission Losses
openings and because fuel clings to the tank walls as the liquid level and roof are lowered. [4] Domed external floating roof tanks usually result from retrofitting an external floating roof tank with a fixed roof.	

A5.3.1.1 Methodology

Evaporative emissions from fuel storage tanks at airports can be estimated using FAA's EDMS/AEDT or EPA's TANKS program. Both models are based on the emission estimation procedures detailed in Chapter 7, *Liquid Storage Tanks,* of EPA's *AP-42*[28].

The general methodology for calculating storage tank evaporative emissions is expressed by **Equation A5-9** (*Evaporative Emissions for Storage Tanks*).

$$E_{HC} = EB + EW$$

Where:

E_{HC} = total hydrocarbon emissions from a single tank over a given time period.

EB = breathing emissions from the tank.

EW = working emissions from the tank.

Equation A5-9. Evaporative Emissions for Storage Tanks

The methodologies for calculating breathing emissions and working emissions is different for each tank type (e.g., fixed, horizontal, floating, etc.) and is dependent on data inputs, such as physical tank dimensions, fuel type being stored, meteorological data, fuel throughput, and other tank-specific characteristics that are further detailed in Chapter 7.1, *Organic Liquid Storage Tanks*[29], of EPA's AP-42. An overview of these data inputs and the likely sources of obtaining this information are given in **Table A5-4** (*Data Inputs for Fuel Storage Tanks*).

Table A5-4. Data Inputs for Fuel Storage Tanks

Data Inputs	Description	Source
Tank Type	Refer to **Table A5-3** (*Evaporative Emission Losses of Fuel Storage Tanks*).	Information may be obtained from the airport operator, fueling contractor, or by visual inspection of the tank(s).
Tank Dimensions	Tank dimensions (e.g., shell diameter, and height) are necessary to calculate emission losses.	Information may be obtained from the airport operator, fueling contractor, or by visual inspection of the tank(s).
Fuel Type	Specification of the type of fuel stored in	Information is given in Section 7.1, *Organic*

[28] EPA, AP-42, Chapter 7, *Organic Liquid Storage Tanks,* http://www.epa.gov/ttnchie1/ap42/ch07/.
[29] EPA, AP-42, Chapter 7.1, *Organic Liquid Storage Tanks*, http://www.epa.gov/ttn/chief/ap42/ch07/final/c07s01.pdf.

Data Inputs	Description	Source
	the tank allows the use of default values for vapor pressure and density. Fuel vapor pressure and density for each storage tank are required to calculate emission losses.	*Liquid Storage Tanks*, of EPA's AP-42 and included in FAA's EDMS/AEDT and in EPA's TANKS program.
Meteorological Data	Data such as average wind speed, average daily ambient temperature range, average daily solar insulation, and average atmospheric pressure values are each required for the emission calculation.	Information is included in EPA's TANKS program which contains a database of the necessary climatic information for over 250 cities in the U.S., so that only the closest nearby city needs to be specified by the user.
Fuel Throughput	Annual fuel throughput is necessary to calculate emission losses. Annual throughput is expresses in gallons per year.	Information should be obtained from the airport operator and/or fueling contractor.
Tank-specific characteristics	These characteristics include one or more of the following: type of seals, breather vent settings, tank paint color, number of vacuum breakers, number of columns, effective column diameter, deck fitting types, and deck seam length.	This information may be obtained from the airport operator, fueling contractor, tank manufacturer, or by visual inspection of the tank(s). Default values are given in Chapter 7, *Liquid Storage Tanks*, of EPA's AP-42 and are incorporated into FAA's EDMS/AEDT and EPA's TANKS program.
Source: *Emissions and Dispersion Modeling System (EDMS) User's Manual*, FAA-AEE-07-01 (Rev. 10 – 06/07/13), June 2013, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS_5.1.4_User_Manual.pdf, and Chapter 7, *Organic Liquid Storage Tanks,* of EPA's AP-42, http://www.epa.gov/ttnchie1/ap42/ch07/.		

A5.3.2 Cooling Towers

Some airports are likely to have a power generating facility associated with its activities, which in turn might also have cooling towers. Cooling towers are heat exchangers that are used to dissipate large heat loads to the atmosphere. Although cooling towers can be classified several ways, the primary classification is dry or wet towers, and some hybrid wet-dry combinations exist. Dry-cooling towers use air instead of water to cool the steam exiting a turbine. Wet, or evaporative, cooling towers rely on the latent heat of water evaporation to exchange heat between the process and the air passing through the cooling tower. In hybrid wet-dry systems, both wet and dry components are included in the system, and they can be used separately or simultaneously for either water conservation or plume abatement purposes.

Cooling towers may range in size from ones used for small air conditioning to large power plant cooling towers. Air pollution control equipment such as drift eliminators are typically used in cooling towers. These capture water droplets entrapped in the air stream that otherwise would be lost to the atmosphere. Because the drift droplets generally contain the same chemical impurities as the water circulating through the tower, these impurities can be converted to airborne emissions. Drift droplets may evaporate before being deposited in the area surrounding the tower, and they can produce PM_{10} emissions. PM_{10} emissions are generated when the drift droplets evaporate and leave fine particulate matter formed by crystallization of dissolved solids.[30]

VOC emissions typically result from the leakage from process heat exchangers that service hydrocarbon process streams as well as from chemical treatment with VOC containing material added to the circulating water. VOC emissions are expected from cooling towers used in refineries and chemical plants, where the circulating water is used to cool down the process stream. Thus, VOC emissions from airport cooling towers are uncommon.

A5.3.2.1 Methodology

Typically PM emissions from airport cooling towers are PM_{10} and are the result of the total dissolved solids (TDS) in the circulating water which are carried out with the water that is entrained in the air being discharged from the cooling tower. PM_{10} emissions from cooling towers are calculated using the methodology presented in Chapter 13.4, *Wet Cooling Towers*[31], of EPA's AP-42. The AP-42 method assumes that all TDS emitted in "drift" particles (liquid water entrained in the air stream and carried out of the tower through the induced draft fan stack) are PM_{10}; however, this method is overly conservative for wet cooling towers with medium to high TDS levels.

The general methodology for calculating PM_{10} from wet cooling towers is expressed by **Equation A5-10** (*Particulate Matter Emissions for Cooling Towers*).

$$E_{PM} = CWFR \times TDS/10^6 \times DR/100 \times 60 \times 8.34$$

Where:

E_{PM} = total particulate matter emissions from a single cooling tower over a given time period, expressed in pounds per hour.

CWFR = circulating water flow rate, expressed in gallons per minute.

TDS = total dissolved solids concentration, expressed in parts per million (ppm).*

DR = drift rate, expressed as a percentage of the cooling tower water CWFR.

60 = conversion factor from minutes to hours.

8.34 = pounds of water per gallon of water.

**ppm is defined as one part of the pollutant to one million parts of solution. In other words, one ppm is equal to $1/10^6$. The equation includes the $1/10^6$ factor (e.g. 12,000 ppm / 10^6 = 0.012). Depending on the media, ppm can be on a volume or mass basis.*

Equation A5-10. Particulate Matter Emissions for Cooling Towers

30 EPA, AP-42, Chapter 13.4, *Wet Cooling Towers*, http://www.epa.gov/ttnchie1/ap42/ch13/final/c13s04.pdf.

31 EPA, AP-42, Chapter 13.4, *Wet Cooling Towers*, http://www.epa.gov/ttnchie1/ap42/ch13/final/c13s04.pdf.

As shown in **Equation A5-10** (*Particulate Matter Emissions for Cooling Towers*), to estimate PM_{10} emissions from wet cooling towers, three data inputs are required: (i) drift rate[32] (may range from 0.0006 to 0.02 percent), (ii) circulating water flow rate, and (iii) total dissolved solids concentrations (approximately 12,000 ppm). These data inputs and the likely sources of obtaining this information are listed in **Table A5-5** (*Data Inputs for Cooling Towers*).

Table A5-5. Data Inputs for Cooling Towers

Data Inputs	Description	Source
Drift Rate (DR)	DR is the emitted percentage of the circulating water from the cooling tower that is entrained in the exhaust air stream and emitted from the cooling tower.	This information may be obtained from the airport operator or equipment manufacturer.
Circulating Water Flow Rate (CWFR)	CWFR is the quantity of water pumped from the tower basin to the equipment to be cooled, usually expressed as gallons per minute (gpm).	This information may be obtained from the airport operator or equipment manufacturer. If this information is unavailable, default values provided in Chapter 13.4, *Wet Cooling Towers*, of EPA's AP-42, may be used.
Total Dissolved Solids (TDS) Concentration	TDS are the sum of the organic and inorganic materials dissolved in water.	This information may be obtained from the airport operator or equipment manufacturer. If this information is unavailable, statistics for TDS content in circulating water are given in Chapter 13.4, *Wet Cooling Towers*, of EPA's AP-42, may be used.

Source: EPA, AP-42, Chapter 13.4, *Wet Cooling Towers*, http://www.epa.gov/ttnchie1/ap42/ch13/final/c13s04.pdf.

A5.3.3 Coating and Painting Operations

A variety of coating and painting operations are performed at airports. Roadway and runway maintenance requires the occasional application of paint, and some aircraft maintenance facilities may include aircraft painting. These operations usually result in evaporative emissions from the various coatings and solvents usage.

A5.3.3.1 Methodology

Coating/painting operations emit VOC to the atmosphere through evaporation of the paint vehicle, thinner, or solvent used to facilitate the application of the coatings. The main factor affecting VOC emissions from painting operations is the volatile content of the coatings. Most, if not all, of the volatile portion of the coating evaporates during or following application. To reduce these emissions, paint manufacturers have reduced the VOC content of coatings in recent years. In addition, air pollution control equipment, such as activated carbon adsorption of VOC emissions or destruction of VOC in an afterburner, is available for use in some applications.

[32] For cooling towers equipped with very high efficiency drift eliminators, drift rates are in the order of 0.0006 percent.

VOC emissions from coating/painting operations at airports can be estimated using FAA's EDMS/AEDT and the methodology is based on **Equation A5-11** (*Hydrocarbon Emissions for Painting Operations*).

$$E_{VOC} = \sum_{i} [Q_i \times VOC_i \times (1 - CF/100)]$$

Where:

E_{VOC} = total volatile hydrocarbon emissions from painting operations, expressed in pounds.

Q_i = total quantity of coating type i used in time period being studied, expressed in gallons.

VOC_i = VOC content for coating type i, expressed in pound of VOC per gallon.

CF = air pollution control factor, expressed as a percentage.

Equation A5-11. Hydrocarbon Emissions for Painting Operations

VOC emissions from coating/painting operations are calculated for each type of coating used in painting, by multiplying the quantity of coating used by the VOC content. If air pollution control equipment is in use, then the VOC emissions estimate is reduced to reflect the benefits of the air pollution control.

As shown in **Equation A5-11** (*Hydrocarbon Emissions for Painting Operations*), to estimate the VOC emissions from coating/painting operations, four data inputs are required: (i) the type of coating used, (ii) the quantity of coating used, (iii) an uncontrolled emission factor, and (iv) an air pollution control factor (if applicable). An overview of these data inputs and the likely sources of obtaining this information are given in **Table A5-6** (*Data Inputs for Coating and Painting Operations*).

Table A5-6. Data Inputs for Coating and Painting Operations

Data Inputs	Description	Source
Type of Coating	Coatings include paint (water based), paint (solvent based), varnish and shellac, lacquer, enamel, primer, thinner, and adhesive.	The airport operator, maintenance department, aircraft operator, should be able to provide information on the type of coatings used.
Quantity of Coating	The quantity of each type of coating used should be expressed in gallons.	Information on the quantity of coating used should be obtained from the airport maintenance department.
VOC Content (by volume)	Volatile content is expressed in terms of pounds per gallon of solvent or VOCs.	Information typically comes from the Material Safety Data Sheets (MSDS) or the coating manufacturers. If this information is unavailable, default values from **Table A5-7** (*VOC Content of Common Surface Coatings*) may be used.

Data Inputs	Description	Source
Control Equipment	Air pollution control equipment such as activated carbon adsorption or afterburner destruction of the vapors is sometimes used in painting operations.	Information on the demonstrated effectiveness of these control methods should be obtained from the airport maintenance section, or equipment manufacturers.

Default emission factors for the VOC content (by volume) of common surface coatings are listed in **Table A5-7** (*VOC Content of Common Surface Coatings*). These emission factors are also embedded into FAA's EDMS/AEDT.

Table A5-7. VOC Content of Common Surface Coatings

Surface Coating	VOC Content (pound/gallon)
Paint (Solvent Base)	5.6
Paint (Water Base)	1.3
Enamel	3.5
Lacquer	6.1
Primer	6.6
Varnish/Shellac	3.3
Thinner	7.36
Adhesive	4.4

Source: *Emissions and Dispersion Modeling System (EDMS) User's Manual*, FAA-AEE-07-01 (Rev. 10 – 06/07/13), June 2013, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS_5.1.4_User_Manual.pdf, and Jagielski, Kurt D., and Robert J. O'Brien, Calculation Methods for Criteria Air Pollutant Emission Inventories, July 1994.

A5.3.4 De-icing and Anti-icing Operations

The purpose of airport de-icing and anti-icing operations is to ensure safe aircraft departures, landings, and travel on airport grounds. Deicing operations remove snow and ice accumulations from aircraft and airfield surfaces. Anti-icing operations prevent snow and ice from accumulating on aircraft and airfield surfaces, either before accumulation can take place or after a surface has been cleared by deicing operations. Aircraft de-icers and anti-icers typically contain water and propylene glycol or ethylene glycol which emit evaporative emissions upon application.

A5.3.4.1 Methodology

VOC emissions result from the application of deicing fluid to both aircraft and runways. As stated previously, common aircraft deicing fluids are a mixture of water and propylene glycol or ethylene glycol. These chemicals are slightly volatile and a small fraction of the chemical is likely to evaporate after the deicing fluid is applied. Other chemicals present in runway deicing fluids include urea and other organic and inorganic salts, most of which are unlikely to contribute to VOC emissions.

A methodology for estimating VOC emissions from aircraft and runway deicing operations based on emission factors from independent sources is presented in this section. Because of the different practices for deicing of runways and aircraft, these two operations are considered separately and have two different emission factors. The mass of organic chemical consumed (commonly propylene glycol or ethylene glycol) is determined by multiplying the volume of deicing fluid consumed by the density of the fluid and by the concentration of the chemical in the fluid. The calculated mass of organic chemical consumed is multiplied by an emission factor to determine the VOC emissions from the application of the deicing fluid. This methodology is expressed by **Equation A5-12** (*VOC Emissions for Deicing Operations*).

$$E_{VOC} = Q_f \times D \times (C/100) \times EF$$

Where:

E_{VOC} = annual HC emissions from deicing operations (i.e., runway or aircraft deicing), expressed in pounds.

Q_f = quantity of deicing fluid used per year per deicing operation, expressed in gallons.

D = density of deicing fluid, expressed in pounds per gallon.

C = concentration of chemical present in deicing fluid (i.e., propylene glycol, ethylene glycol, or other organic compound) for specific type of deicing operation, expressed in percent by weight.

EF = emission factor of chemical used in deicing operation, expressed in pounds of HC emissions per pound of chemical consumed.

Equation A5-12. VOC Emissions for Deicing Operations

Quantities of deicing fluid should be expressed in gallons and separated into fluid used for aircraft and runway deicing. This information may be obtained from the airport operator or deicing contractor. Density of deicing fluid may be obtained from maintenance, fluid manufacturer, or by calculation. The density should be expressed as pounds per gallon of fluid. To estimate the density of the deicing fluid, **Equation A5-13** (*Density of Deicing Fluid*) should be applied. The equation is performed for each component, and results are totaled to obtain the total density.

The concentration of each component in the deicing fluid (including water) should be obtained from the airport operator, deicing contractor, or fluid manufacturer. Therefore, if a solution is given as 48 percent propylene glycol, then the remainder of the solution (52 percent) is assumed to be water.

$$D = D_w \times (C/100) \times SG$$

Where:

D = density of deicing fluid, expressed in pounds per gallon.

D_w = density of water, expressed as 8.345 pounds per gallon.

C = concentration of component in deicing fluid (i.e., water, ethylene glycol, propylene glycol, urea, polymer additives, etc.), expressed as a percent.

SG = specific gravity of component in deicing fluid; specific gravity is a dimensionless ratio of the weight of the chemical to the weight of water.

Equation A5-13. Density of Deicing Fluid

Specific gravity for common deicing fluid components is given in **Table A5-8** (*Specific Gravity of Common Deicing Fluid Components*).

Table A5-8. Specific Gravity of Common Deicing Fluid Components

Fluid Component	Specific Gravity
Water	1.000
Ethylene Glycol	1.119
Propylene Glycol	1.036
Urea	1.323
Source: CRC Handbook of Chemistry and Physics.	

Concentration of chemical in deicing fluid (by weight) should be obtained from MSDS sheets, deicing contractor, or fluid manufacturer. Common solutions are 50 percent propylene glycol in water or 50 percent ethylene glycol in water. In many cases, different chemical formulations are used for runway and aircraft deicing.

A5.3.4.2 Emission Factors

Emission factors for an ethylene glycol solution applied to a runway and to aircraft have been calculated. An emission factor of 0.0067 pounds VOC emissions per pound of ethylene glycol and propylene glycol applied should be used for runway and taxiway surface deicing, and an emission factor of 0.00011 pounds VOC emissions per pound of ethylene glycol and propylene glycol applied should be used for aircraft deicing.[33] One should be careful to note that emissions are given per pound of ethylene glycol rather than per pound of deicing fluid, which also contains water. **Equation A5-13** (*Density of Deicing Fluid*) takes this into account by employing a concentration factor. The emission factors given for ethylene glycol solutions may also be

[33] Garska, Dan, Union Carbide Corporation. Letter to Terrence J. Godar, Virginia Department of Environmental Quality, dated August 22, 1995.

applied to propylene glycol, which is somewhat less volatile than ethylene glycol. These emission factors are also embedded into FAA's EDMS/AEDT.

A5.3.5 Solvent Degreasing

Solvent degreasing units are regularly used for aircraft and ground vehicle maintenance, paint stripping and other miscellaneous activities utilizing organic solvents. Solvent degreasers use organic solvents to remove fats, oils, grease, wax or soil from various metal, glass or plastic items. There are two types of solvent degreasers commonly used: cold cleaning and open-top vapor degreasers. Cold cleaning operations use alcohol, ketones and petroleum distillates as solvents for parts cleaning through immersion, brushing, spraying or flushing. Open-top vapor systems are boiling degreasers that clean by the condensation of solvent on the surface of parts being cleaned. Each of these operations causes VOC emissions due to evaporation of the solvent.

A5.3.5.1 Methodology

The use of organic solvents such as chlorinated hydrocarbons, petroleum distillates, ketones and alcohol results in the evaporation of VOC, which are subsequently either disposed of as waste liquids or released to the atmosphere. If water-based alkaline wash systems are used for degreasing, no evaporation of VOC occurs.

The methodology for estimating evaporative VOC emissions from the operation of solvent degreasers is based on the assumption that all solvent consumed by a solvent degreasing unit is either disposed of as waste liquid or released to the atmosphere as VOC emissions. The emissions to the atmosphere, therefore are estimated by calculating the difference between the volume of solvent consumed and the volume of solvent disposed as liquid, and multiplying this difference by the density of the solvent. This methodology is expressed by **Equation A5-14** (*Hydrocarbon Emission for Solvent Degreasers*) which computes the VOC emission for one solvent degreaser.

$$E_{VOC} = D \times (QC - QD)$$

Where:

E_{VOC} = hydrocarbon emissions from solvent degreasing unit, expressed in pounds.

QC = quantity of solvent consumed in solvent degreaser in a given time period, expressed as gallons.

QD = quantity of solvent disposed of as liquid in given time period, expressed as gallons.

D = density of solvent, expressed as pounds per gallon.

Equation A5-14. Hydrocarbon Emission for Solvent Degreasers

The quantity of solvent consumed and disposed of (expressed in gallons) should be available from the operator of the solvent degreaser. If no records on solvent disposal are available, then it should be assumed that 100 percent of the solvent consumed by the solvent degreaser is released to the atmosphere as VOC emissions. The density of solvent, expressed as pounds per gallon, should also be available from the operator of the solvent degreaser or the solvent manufacturer. If this information is unavailable the values listed in **Table A5-9** (*Specific Gravity of Common Degreasing Solvents*) may be used.

Table A5-9. Specific Gravity of Common Degreasing Solvents

Solvent	Density (pound/gallon)
Acetone	6.604
Alcohol (ethyl)	6.604
Alcohol (methyl)	6.751
Carbon Tetrachloride	13.315
Chloroform	12.432
Ether	6.136
Isopropyl Alcohol	6.555
Methylene Chloride	11.070
Perchloro-ethylene	13.541
Stoddard Solvent	6.497
1,1,1-Trichloroethane	11.174
Trichloro- ethylene	12.219
Turpentine	7.259
Water	8.345
Source: CRC Handbook of Chemistry and Physics.	

A5.3.6 Salt and Sand Piles

Many airports store salt and sand piles on-site for use in maintaining roads and runways during inclement weather. Fugitive dust emissions occur at several points in the storage cycle, such as material loading onto the pile, disturbances by strong wind currents, and unloading from the pile.

The methodology for estimating emissions from material storage piles is provided in Chapter 13.2.4, *Aggregate Handling and Storage Piles*[34], and Chapter 13.2.5, *Industrial Wind Erosion*[35], of EPA's AP-42, and are associated with two main activities: (i) batch loading and unloading of material, and (ii) wind erosion of the piles, respectively.

A5.3.6.1 Methodology - Loading and Unloading of Material Piles

The major source of PM emissions during "loading and unloading" of piles occurs as material is dropped from a loader onto the pile or into a truck. The methodology for calculating the PM emission factor for these events is provided in Chapter 13.2.4, *Aggregate Handling and Storage Piles*[36], of EPA's AP-42, and is based on mean wind speed, material moisture content, and cutoff

[34] EPA, AP-42, Chapter 13.2.4, *Aggregate Handling and Storage Piles*, http://www.epa.gov/ttnchie1/ap42/ch13/final/c13s0204.pdf.
[35] EPA, AP-42, Chapter 13.2.5, *Industrial Wind Erosion* http://www.epa.gov/ttnchie1/ap42/ch13/final/c13s0205.pdf.
[36] EPA, AP-42, Chapter 13.2.4, *Aggregate Handling and Storage Piles*, http://www.epa.gov/ttnchie1/ap42/ch13/final/c13s0204.pdf.

$$E_{PM} = 2 \times TH \times EF$$

Where:

E_{PM} = total particulate emissions from pile loading and unloading, expressed in pounds.

2 = factor representing number of drops material undergoes; once during loading and once during unloading.

TH = total throughput of material stored in pile in a given time period, expressed as tons.

EF = emission factor, given as pounds of particulate matter emitted per ton of material undergoing drop operation.

Equation A5-15. Particulate Matter Emission from Loading and Unloading of Material Piles

particle size (e.g., 10µm if PM_{10} is desired). Once the PM emission factor is estimated, it can then be multiplied by the quantity of material transferred to or from the pile during the desired time period, to obtain the total PM emissions in pounds. This is expressed by **Equation A5-15** (*Particulate Matter Emission from Loading and Unloading of Material Piles*).

The data inputs required to estimate PM emissions during loading and unloading of material piles and the likely sources of obtaining this information are summarized in **Table A5-10** (*Data Inputs for Loading and Unloading of Materials*).

Table A5-10. Data Inputs for Loading and Unloading of Materials

Data Inputs	Source
Mean Wind Speed	Only one figure for the mean wind speed at the airport is required. This may be obtained from the National Climatic Data Center at the following website: http://www.ncdc.noaa.gov/ or from the weather station on site. The mean wind speed should be expressed in meters per seconds (m/s).
Material Moisture Content	This information can be obtained by direct sampling of the piles, or from the maintenance operator of the pile. If data is unavailable, Chapter 13.2.4, Aggregate Handling and Storage Piles, of EPA's AP-42 provides information on the moisture content of material types by industry. The moisture content of the material of the pile should be expressed in percentages.
Quantity of Material Loaded and Unloaded	This information should be obtained from the maintenance operations department. Because the methodology takes into account both loading and unloading of the pile, the desired information is the material "throughput" for each pile. The throughput should be expressed in tons per a given time period.
Source: Chapter 13.2.4, *Aggregate Handling and Storage Piles*, of EPA's AP-42, http://www.epa.gov/ttnchie1/ap42/ch13/final/c13s0204.pdf.	

A5.3.6.2 Methodology - Wind Erosion

The second major source of PM emissions from sand and salt piles is *wind erosion* of the piles. A detailed methodology for calculating wind erosion emissions is given in Chapter 13.2.5, *Industrial Wind Erosion*[37], of EPA's AP-42. The methodology calculates the PM emissions generated by wind erosion of open storage piles by applying an "erosion potential function" to each surface of the pile. Because the methodology is too complex to be reduced into a single equation, this section mainly focuses on the critical data inputs needed to compute these emissions.

The data inputs required to estimate PM emissions from wind erosion of storage piles are summarized in **Table A5-11** (*Data Inputs for Wind Erosion*).

Table A5-11. Data Inputs for Wind Erosion

Data Inputs	Description	Source
Quantity of Material Stored in Pile	The quantity should be expressed in tons used/stored per a given time period.	This information should be obtained from the maintenance operator of the pile.
Moisture Content of Stored Material	The moisture content of the material of the pile is typically expressed in percentages (%).	This information can be obtained by direct sampling of the piles, or from the maintenance operator of the pile. If data is unavailable, Chapter 13.2.5 of EPA's AP-42 provides information on the moisture content of material types by industry.
Silt Content of Stored Material	Silt content is a measure of the percentage of material that passes through a No. 200 sieve.	This can be obtained by direct sampling of the pile or the maintenance operator of the pile. If data is unavailable, Chapter 13.2.5 of EPA's AP-42 provides the silt content of a sand pile stored at a municipal landfill: 2.6%. This value may be used as a default if silt content of piles located on the site is not available.
Frequency of Loading/Unloading Events	Wind erosion is a factor of the number of times the surface of the pile is disturbed through loading or unloading events in a given time period.	Information on the frequency of loading and unloading events should be obtained from the maintenance operator of the pile.
Percentage of Pile Surface Disturbed in Loading/Unloading Events	An estimate of the percentage of the pile surface disturbed in each event must be calculated.	This information is based on the material throughput rate and pile size, or if possible, from information supplied by the maintenance operator of the pile. Chapter 13.2.5 of EPA's AP-42 describes the specific informational requirements needed for these calculations.
Physical Dimensions of the Pile	Required dimensions include overall pile shape description (flat, conical, or oval flat- topped), as well as pile height and diameter, expressed in meters.	This information is available through direct observation or from the maintenance operator of the pile.

37 EPA, AP-42, *Chapter 13.2.5, Industrial Wind Erosion*, http://www.epa.gov/ttnchie1/ap42/ch13/final/c13s0205.pdf.

Data Inputs	Description	Source
Threshold Friction Velocity of the Stored Material	The threshold friction velocity is the wind velocity at which wind shear stress is great enough to cause particles to be released from the material surface.	This information can be obtained by sampling of the pile surface according to the method described in the Chapter 13.2.5 of EPA's AP-42 or by applying the default parameters provided within the same chapter. However, threshold friction velocity is not given for either sand or salt. A default figure of 1.02 meters per second (m/s), measured for overburden material at a coal mine, may be used if no other source of information is available
Surface Roughness Height of Stored Material (cm)	The surface roughness height is a measure of the resistance to wind flow near the surface of the material caused by unevenness or roughness of the material.	For some materials, default parameters based on material type are provided in Chapter 13.2.5 of EPA's AP-42. As with threshold friction velocity, surface roughness height is not explicitly given for sand or salt. A default value of 0.3 centimeters (cm) may be used, based on a measured value for overburden material at a coal mine.
Wind Speed	Required information is the "fastest mile" of wind recorded daily for the time period being investigated. The fastest mile is the highest measured wind speed, expressed in miles per hour (miles/hour), at which air is measured by an anemometer to travel one mile.	This data is available for most airport weather stations. The data is available from the following website: http://www.ncdc.noaa.gov/IPS/lcd/lcd.html
Source: *Emissions and Dispersion Modeling System (EDMS) User's Manual*, FAA-AEE-07-01 (Rev. 10 – 06/07/13), June 2013, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS_5.1.4_User_Manual.pdf, EPA, AP-42, Chapter 13.2.4, *Aggregate Handling and Storage Piles*, http://www.epa.gov/ttnchie1/ap42/ch13/final/c13s0204.pdf, and Chapter 13.2.5, *Industrial Wind Erosion*, http://www.epa.gov/ttnchie1/ap42/ch13/final/c13s0205.pdf.		

EDMS/AEDT has the capability to estimate dust emissions generated by wind erosion of open storage piles for multiple types of materials such as: coal, sand, clay, clay/dirt mix, and fly ash. However, EDMS/AEDT does not account for the emissions generated from the process of loading and unloading the material piles. The data inputs detailed in **Table A5-11** (*Data Inputs for Wind Erosion*) are the default values embedded into EDMS/AEDT to calculate wind erosion, which are adapted from Chapter 13.2.5, *Industrial Wind Erosion*[38], of EPA's AP-42. EDMS/AEDT assumes that PM_{10} emissions equal $PM_{2.5}$.

[38] EPA, AP-42, Chapter 13.2.5, Industrial Wind Erosion, http://www.epa.gov/ttnchie1/ap42/ch13/final/c13s0205.pdf.

APPENDIX A6 - Construction Emissions Inventory for Criteria Pollutants

A6.1 Overview

Construction-related emissions are primarily associated with the exhaust from heavy equipment (e.g., backhoes, bulldozers, graders, etc.), delivery trucks (e.g., cement trucks, dump trucks, etc.) and construction worker vehicles getting to and from the project site; dust from site preparation, land clearing, material handling, and equipment movement on unpaved areas, wind erosion; and demolition activities. These emissions are temporary in nature (i.e., during the construction period only) and generally confined to the construction site and the access/egress roadways. Construction activities also involve the storage/transportation of raw materials, the disposal of construction debris and the production of asphalt or concrete.

While the understanding of emissions from various airport sources is improving, the methodology for calculating construction emissions remains highly variable. The FAA's EDMS/AEDT currently does not explicitly account for construction emissions, and few resources offer guidance for estimating such emissions.

A6.2 Methodology

Emissions from construction activities are estimated based on the projected construction activity schedule, the number of vehicles/pieces of equipment, the types of equipment/type of fuel used, vehicle/equipment utilization rates, and the year(s) in which construction occurs. Emissions of CO, VOC, NO_x, SO_2, PM_{10}, and $PM_{2.5}$ should be evaluated. The following section details the calculation steps, methods and other considerations for estimating emissions from construction activities.

A6.2.1 Construction Equipment Schedule

Data regarding the number of pieces and types of construction equipment to be used, the deployment schedule of equipment (monthly and annually), and the approximate daily operating time (including power level or usage factor) should be estimated for each individual construction project based on a schedule of construction activity. The estimates should be provided by project phase and subcomponent. These data can be estimated using *RS Means Productivity Standards for Construction*[39] and FAA's Advisory Circular 150-5320-6D, *Airport Pavement Design and Evaluation*[40], provided the quantity of construction materials likely to be involved in the construction is known.

The construction equipment schedule specifies which vehicles/equipment are anticipated, when the vehicles/equipment will be used, the number of units, and how many hours it will be used. Along with vehicle/equipment usage, the construction schedule should also estimate manpower. If unavailable, manpower can be estimated based on the number of pieces of equipment times 125 percent. Typical construction is anticipated to occur six days per week and ten hours per day.

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[39] R S Means Company, *Means Productivity Standards for Construction*, Third Edition, August 1994.

[40] FAA's Advisory Circular 150-5320-6D, *Airport Pavement Design and Evaluation*, September 30, 2009, http://www.faa.gov/documentLibrary/media/Advisory_Circular/150_5320_6e.pdf.

A6.2.2 On-road Vehicles

As previously discussed, emission factors for light-duty vehicles (i.e. passenger cars, pickup trucks, shuttle, and haul trucks) can be obtained from the EPA MOVES2014[41] or subsequent emissions models. The emission factors should be developed in accordance with model parameters utilized by the appropriate state or local regulatory agency. For on-road vehicles, the anticipated VMT should be estimated to determine annual emissions. **Equation A6-1** (*On-road Construction Vehicle Emissions*) should be used to obtain annual emission rates for on-road vehicles:

Emission Rate (tons/year) for on-road vehicles *= Emission Factor (grams/mile) x miles per day x # of days/year x (1 pound/453.59 grams) x (1 ton/2,000 pounds)*

Equation A6-1. On-road Construction Vehicle Emissions

For example, on-road trucks can be assumed to travel a roundtrip distance of 100 miles or a distance based on project-specific conditions. On-road trucks may include delivery trucks, material haul trucks, and concrete trucks. On-road vehicles, utilized for the purposes of security, escorting and project management, including construction worker vehicles getting to and from the site can be assumed to travel a roundtrip distance of 40 miles or a distance based on site-specific conditions.

A6.2.3 Off-road Equipment

Emission factors for heavy-duty equipment (e.g., dump trucks, dozers, graders, etc.) can be obtained from the EPA NONROAD2008a[42] emissions model. For off-road equipment, the expected equipment size, hours of operation, and load factor should be estimated to determine annual emissions. **Equation A6-2** (*Off-road Construction Equipment Emissions*) is used to obtain emission estimates for off-road construction equipment:

Equipment Emission Rate (tons/year) *= Full Throttle Emission Factor (grams/hp-hour) x size (hp) x hours per year x Load Factor x Usage Factor x (1 pound/453.59 grams) x (1 ton/2,000 pounds)*

Equation A6-2. Off-road Construction Equipment Emissions

NONROAD requires input of the maximum, average, and minimum ambient temperature. The 30-year normal should be entered based on National Climatic Data Center (NCDC) data.[43] For the off-road equipment SO_2, PM_{10}, and $PM_{2.5}$ emission factors, diesel sulfur content should be assigned based on EPA's *Suggested Nationwide Average Fuel Properties* based on EPA mandated 15 parts per million (ultra-low sulfur diesel fuel) regulations, effective June 2010.[44]

41 EPA, *Motor Vehicle Emissions Simulator (MOVES) User Guide for MOVES2014*, July 2014 [EPA-420-B-14-055], http://www.epa.gov/otaq/models/moves/documents/420b14055.pdf.

42 EPA, *User's Guide for the Final NONROAD2005 Model*, December 2005 and EPA NONROAD Model Updates for 2008, April 2009, http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2005/420r05013.pdf.

43 NCDC 1981-2010 Climate Normals, http://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/climate-normals/1981-2010-normals-data.

44 EPA, Suggested Nationwide Average Fuel Properties, April 2009, http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2008/420b09018.pdf.

Once emission factors are determined, the equipment size (in horsepower) is assigned to each construction equipment type based on site-specific information or based on the most frequently utilized equipment within the country in which the project is located as derived from NONROAD2008a. Emission factors and horsepower for each equipment type are then applied to the anticipated equipment work output (i.e., horsepower-hours of expected equipment use). Lastly the usage factor and load factor are applied. **Table A6-1** (*Example of Construction Equipment Data*) presents example construction equipment data such as horsepower, load factor, and usage factor.

A usage factor accounts for the percentage of daily operation and a load factor accounting for the average throttle setting relative to full throttle rating is used and based on data within the NONROAD model. For example, a usage factor of 0.75 equates to 7.5 hours of operation (based on a ten hour work day) and a load factor of 0.62 equates to 62 percent of full throttle rating during operation.

Table A6-1. Example of Construction Equipment Data

Equipment	Horsepower	Load Factor	Usage Factor
Backhoes	100	0.21	0.55
Small Compressors (185 cfm)	40	0.43	0.39
Medium Compressors (300 cfm)	75	0.43	0.39
Large Compressors (1,600 cfm)	100	0.43	0.39
Small Generators	40	0.43	0.16
Medium Generators	175	0.43	0.16
Large Generators	300	0.43	0.16
Crane (45-ton)	175	0.43	0.48
Crane (100-ton)	300	0.43	0.48
Tugboat	600	0.21	0.02
Light Towers	25	0.43	0.26
Excavators	175	0.59	0.53
Dozers	175	0.59	0.45
Graders	300	0.59	0.46
Pavers	175	0.59	0.39
Rollers	100	0.59	0.37
Sweepers	175	0.43	0.59
Mobile Mixers	6	0.43	0.13
Milling Machines	75	0.43	0.46

Table A6-1. Example of Construction Equipment Data

Equipment	Horsepower	Load Factor	Usage Factor

Source: EPA, NONROAD2008b, 2013, http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2005/420r05013.pdf.
Note: cfm = cubic feet per minute.

A6.2.4 Fugitive Emissions

The construction emissions inventories for fugitive dust sources should be calculated using emission factors within EPA's AP-42, *Compilation of Air Pollutant Emission Factors,*[45] and other publications. Fugitive dust emissions can result from the following activities: grading, moving soil, and digging, loading/unloading of trucks, movement of trucks on unpaved surfaces, and wind erosion of stockpiles. A fugitive dust emission factor of 1.2 tons per acre disturbed per month during construction should be used, consistent with AP-42, assuming that 25 percent of the construction project area would be disturbed per construction month. $PM_{2.5}$ is assumed to be 10 percent of PM_{10}. A dust control efficiency of 75 percent due to daily watering and other measures can also be estimated. **Equations A6-3** (*Fugitive Dust Construction PM_{10} Emissions*) and **A6-4** (*Fugitive Dust Construction $PM_{2.5}$ Emissions*) are used to obtain emission estimates for fugitive dust sources:

Fugitive Dust PM_{10} Emission Rate (tons/year) = Total Area Disturbed (acre) x 0.25 x 1.2 tons/acre Disturbed/Month x 12 month/year x (1-0.75) control efficiency

Equation A6-3. Fugitive Dust Construction PM_{10} Emissions

Fugitive Dust $PM_{2.5}$ Emission Rate (tons/year) = Fugitive Dust PM_{10} Emission Rate (tons/year) x 0.10 $PM_{2.5}$ to PM_{10} ratio

Equation A6-4. Fugitive Dust Construction $PM_{2.5}$ Emissions

Evaporative VOC emissions associated with the application of hot mix asphalt on areas requiring paving (e.g., roadways, parking lots, and taxiways) should be estimated using raw materials quantities, as well as an emission factor of 0.053 tons of VOC per acre of asphalt material laid.[46]

If the acreage of asphalt placed is known, than the area can be determined based on the amount of asphalt used and the assumption of six inches of thickness. **Equation A6-5** (*Fugitive Asphalt VOC Construction Emissions*) is used to obtain fugitive asphalt VOC emission estimates:

Asphalt VOC Emission Rate (tons/year) = 0.053 tons/acre of asphalt placed x acres of asphalt placed per year

Equation A6-5. Fugitive Asphalt VOC Construction Emissions

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[45] EPA, AP-42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, http://www.epa.gov/ttnchie1/ap42/.

[46] EPA, *Emission Inventory Improvement Program*, Asphalt Paving, Chapter 17, Volume III, April 2001, http://www.epa.gov/ttn/chief/eiip/techreport/volume03/iii17_apr2001.pdf.

A6.2.5 Emission Reduction Measures

Incorporating the basic measures within the FAA's Advisory Circular 150/5370 – 10F, *Standards for Specifying Construction of Airports*[47], can provide a means for reducing construction emissions related to fugitive dust and combustion exhaust.

[47] FAA, Advisory Circular 150/5370 – 10F, Standards for Specifying Construction of Airports, September 30, 2011, http://www.faa.gov/documentLibrary/media/Advisory_Circular/150_5370_10F.pdf.

APPENDIX B - Emissions Inventory for Hazardous Air Pollutants

B.1 Overview

This appendix discusses the recommended methodologies for computing emissions of organic compounds (OGs) for FAA projects/actions. **Section 6.2** (*Hazardous Air Pollutants*) of the *Handbook* provides a discussion of the available guidance for preparing and reporting these HAPs. In summary, the guidance states the following:

- Where it is necessary to prepare a HAPs assessment, the inventory must be prepared following the FAA *Guidance for Quantifying Speciated Organic Gas Emissions from Airport Sources*[48] and using EDMS/AEDT. This applies to emission sources such as aircraft, APUs, GSE, and stationary sources. Motor vehicle HAPs are computed using the EPA MOVES or California's EMFAC (with SPECIATE).
- There are currently no federal regulations specifically pertaining to HAPs emissions from aircraft engines or airports. While the assessment methodology discussed is useful for disclosure, reporting, and comparative purposes, it does not provide results that are directly comparable to any regulatory or enforceable ambient air quality standards or emission thresholds.
- Other than an emissions inventory, the FAA documentation must not include any other type of HAPs assessment including, but not limited to, dispersion modeling, toxicity weighting, or health risk analyses. These types of assessments require a more complete understanding of the reactions of HAPs in the atmosphere and downstream plume evolution as well as human exposure patterns. Because the science of these relationships with respect to aircraft- and airport-related HAPs is still evolving, the corresponding level of understanding is also currently limited.

B.2 Emission Sources

For the purpose of this *Handbook* and consistent with the assessment methodology for the EPA "criteria" pollutants (see **Appendix A**), HAP emission sources are grouped into the following categories:

- Aircraft (see **Appendix A1**, *Aircraft Emission Inventory for Criteria Pollutant*);
- Auxiliary Power Units (APUs)/Ground Support Equipment (GSE) (see **Appendix A2**, *Auxiliary Power Units Emissions Inventory for Criteria Pollutant*, and **Appendix A3** *Ground Support Equipment Emissions Inventory for Criteria Pollutant*);
- Ground Access Vehicles (see **Appendix A4**, *Ground Access Vehicles Emissions Inventory for Criteria Pollutant*); and

48 FAA Guidance for Quantifying Speciated Organic Gas Emissions from Airport Sources, http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/media/Guidance%20for%20Quantifying%20Speciated%20Organic%20Gas%20Emissions%20from%20Airport%20Sources.pdf.

- Stationary Sources (see **Appendix A5**, *Stationary Source Emissions Inventory for Criteria Pollutant*).

B.2.1 Aircraft

As described in **Section 6.2** (*Hazardous Air Pollutants*) of the *Handbook*, a revised speciation profile to identify most of the individual HAP species from aircraft equipped with turbofan, turbojet, and turboprop engines was developed and documented within the FAA *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines*[49].

This profile was based on recent field measurement campaigns and is considered representative of today's modern aircraft engines. The new profile (i.e., SPECIATE Profile No. 5565), incorporated into the EPA's SPECIATE (Version 4.3) Database[50] was a replacement for all prior speciation profiles identified for aircraft and is the preferred profile that should be used to characterize HAP emissions from aircraft equipped with turbofan, turbojet and turboprop engines.

B.2.1.1 Methodology

The operational data that are of primary importance for the preparation of an emissions inventory of HAPs for commercial, military, general aviation, and air taxi aircraft that are equipped with turbofan, turbojet, and turboprop engines include the following:

- The number of aircraft operations (i.e., landings and takeoffs) by aircraft type,
- The type and number of aircraft engines, and
- Times-in-mode for each of the aircraft operational modes (i.e., approach, taxi-in, taxi-out, idle (delay), takeoff, and climbout) within the atmospheric mixing zone.[51,52]

For each unique aircraft/engine combination, *Handbook* users should first prepare an emissions inventory for total hydrocarbons (THC), total organic gases (TOG)[53], volatile organic compounds

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49 FAA & EPA, *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines (Version 1.0),* May 2009 [EPA-420-R-09-901], http://www.epa.gov/nonroad/aviation/420r09901.pdf.

50 SPECIATE 4.3, http://www.epa.gov/ttn/chief/software/speciate/index.html, September 2011.

51 The time spent in the approach and climbout modes of the landing/take-off cycle is directly related to the height of the "mixing zone." The mixing zone is the layer of the earth's atmosphere where air is completely mixed and pollutants emitted anywhere within the layer will be carried down to the ground level. The height of the mixing zone for a given location typically varies by season and time of day.

52 Aircraft also emit organic gases during "start-up". These emissions may be addressed through future research and included in updates to EDMS/AEDT (including updates to the speciation profile at the time such an update is appropriate).

53 Total Organic Gases (TOG) is defined by the California Air Resources Board (CARB) as compounds of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate. TOG includes all organic gas compounds emitted to the atmosphere, including the low reactivity compounds (e.g., methane, ethane, various chlorinated fluorocarbons, acetone, perchloroethylene, volatile methyl siloxanes, and oxygenated organic gases.

(VOC)[54], or non-methane organic gases (NMOG)[55] emissions. The HAP emissions are then estimated based on appropriate conversion factors and HAP speciation profiles. These inventories can be prepared using either the FAA's EDMS/AEDT model or by manual calculation using the EDMS/AEDT database or ICAO's Engine Exhaust Emissions Databank.[56]

B.2.1.2 Example of Aircraft HAP Emission Calculations

For demonstrative purposes, the following example shows how to compute THC/HAPs emissions using ICAO data. THC are computed based on the amount of fuel consumed by an aircraft in each of the aircraft operational modes combined with engine-specific THC emission factors (specific to each aircraft operational mode). Speciation factors are then used to convert THC to HAPs.

In this case, emission calculations for an Airbus A320-100 equipped with two CFM56-5A1 turbofan engines are presented. It is also assumed that the A320-100 performs 1,000 operations (500 landing-takeoff cycles) annually. Based on the configuration of the airport and field surveys, each aircraft has an average combined taxi/idle (delay) time of 26 minutes per landing-takeoff cycle (a taxi in time of 7 minutes and a taxi-out time, including delay, of 19 minutes). These example aircraft operational data are summarized in **Table B-2** (*Example Aircraft Operational Data*).

Table B-2. Example Aircraft Operational Data

Aircraft	Engine	Number of Engines	Number of Operations	Taxi Time (minutes)	
				In	Out
Airbus A320-100	CFM56-5A1	2	1,000	7	19

Source: EPA and FAA, *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turboject, and Turboprop Engines*, May 27, 2009, http://www.epa.gov/otaq/regs/nonroad/aviation/420r09901.pdf.

The fuel flow rates and THC emission factors for the CFM56-5A1 are provided in **Table B-3** (*Example Fuel Flow Rates/Emission Factors*).

Table B-3. Example Fuel Flow Rates/Emission Factors

Data	Aircraft Operational Mode			
	Takeoff	Climbout	Approach	Idle

54 Volatile Organic Compounds (VOCs) are defined by EPA as any compound of carbon that participates in atmospheric photochemical reactions. For aircraft, this is further defined as exhaust TOG corrected to exclude the mass of methane, ethane, and acetone and to fully account for the mass of formaldehyde and acetaldehyde per EPA definition of VOC, http://www.epa.gov/ttn/naaqs/ozone/ozonetech/def_voc.htm.

55 Non-Methane Organic Gases (NMOGs) include all organic compounds except methane which is the most common organic gases and a greenhouse gas that is sometimes excluded from the analysis of organic compounds.

56 The ICAO Engine Exhaust Emissions Databank, http://easa.europa.eu/document-library/icao-aircraft-engine-emissions-databank.

Table B-3. Example Fuel Flow Rates/Emission Factors

Data	Aircraft Operational Mode			
	Takeoff	Climbout	Approach	Idle
Fuel Flow Rate (kilograms/second)	1.051	0.862	0.291	0.101
THC Emission Factors (grams/kilogram of fuel)	0.230	0.230	0.400	1.40
Source: EPA and FAA, *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines*, May 27, 2009, http://www.epa.gov/otaq/regs/nonroad/aviation/420r09901.pdf.				

Using the aircraft operational data (i.e., number of arrivals, number of departures, times-in-mode) and the engine data (i.e., fuel flow rates and THC emission indices), the THC emissions, by aircraft operational mode, are calculated and then summed for each mode, as shown in **Equations B-1** (*Fuel Consumption by Aircraft Operational Mode*) and **B-2** (*THC Emissions by Aircraft Operational Mode*).

Total Fuel Consumption/Engine for Operational Mode (kilograms [kg]) *= Fuel Flow Rate for Operational Mode (kilograms per second [kg/sec]) x Time-in-Mode (seconds [sec])*

Equation B-2. Fuel Consumption by Aircraft Operational Mode

THC Emissions by Mode (kg) *= Total Fuel Consumption for Operational Mode (kg) x THC Emission Factors (grams [g]/kg of fuel) x Number of Engines x Number of Operations x kg/1000 g*

Equation B-2. THC Emissions by Aircraft Operational Mode

As contained in **Table B-4** (*Example THC Estimate*), 278 kilograms of THC emissions are estimated to be emitted by the Airbus A320-100 following this approach. Notably, the level of THC varies substantially depending on the aircraft operational mode with emissions being the highest during the taxi in and taxi out modes and the lowest during approach, takeoff, and climbout.

Table B-4. Example THC Estimate

Fuel Flow Rate (per Engine)		Time in Mode (min)	Fuel Consumption (kg)	THC Emission Indices (g/kg of Fuel)	Number of		THC (kg)
Mode	Rate (kg/sec)				Engines	Operations	
Approach	0.291	4.12	71.935	0.40	2	500	28.77
Taxi In	0.101	7.00	42.562	1.40	2	500	59.45
Taxi Out	0.101	19.00	115.254	1.40	2	500	161.36

Table B-4. Example THC Estimate

Fuel Flow Rate (per Engine)		Time in Mode (min)	Fuel Consumption (kg)	THC Emission Indices (g/kg of Fuel)	Number of		THC (kg)
Mode	**Rate (kg/sec)**				**Engines**	**Operations**	
Takeoff	1.051	1.51	95.221	0.23	2	500	21.90
Climbout	0.862	0.53	27.412	0.23	2	500	6.30
						Total	278

Source: EPA and FAA, *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines*, May 27, 2009, http://www.epa.gov/otaq/regs/nonroad/aviation/420r09901.pdf.

Unlike emissions from other transportation sources, international certification standards require that HAP emissions from newly certified aircraft engines be reported in units of methane equivalency. Thus, for HAP emissions, the methane equivalency[57] is converted to TOG according to the average molecular weight of the specific profile. The factors for converting THC to TOG, VOC to TOG and factors to/from the other groups of organic compounds (such as Non-Methane Organic Gases - NMOG and Non-Methane Hydrocarbons - NMHC) are provided in **Table B-5** (*Conversion Factors*).

Table B-5. Conversion Factors

THC to TOG	VOC to TOG	THC to NMHC	THC to VOC	NMOG to TOG	TOG to VOC	TOG to NMHC
1.16	1.01	1.16	1.15	1.00	0.99	1.00

Source: EPA and FAA, *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines*, May 27, 2009, http://www.epa.gov/otaq/regs/nonroad/aviation/420r09901.pdf
Note:
[1] For the purpose of reporting, application, and comparison, the units for the compounds in this table are referenced as follows: THC measured as methane equivalent (following Procedures in the Emissions Certification of Aircraft Engines, Annex 16, Volume II, International Civil Aviation Organization, TOG as TOG, VOC as VOC, and NMOG as NMOG.

This conversion from THC to TOG emissions is shown in **Equation B-3** (*Conversion to TOG Emissions*).

TOG Emissions (kg) *= THC Emissions (kg) x THC to TOG Conversion Factor*

Equation B-3. Conversion to TOG Emissions

[57] ICAO, *Procedures in the Emissions Certification of Aircraft Engines*, Annex 16, Volume II, www.icao.int.

For this example, and as shown in **Table B-5** (*Conversion Factors*), the THC to TOG conversion factor is 1.16. Therefore, the amount of TOG emitted by the A320 aircraft is an estimated 322 kilograms (or 278 kilograms times 1.16).

To speciate the TOG emissions, the HAP speciation profile (i.e., the percentage of TOG emissions associated with a particular HAP) is obtained. To then derive the emission rates for an individual HAP, the mass fraction profile is multiplied by the total amount of TOG emission. The calculation for obtaining the estimated emission rate for an individual HAP (i.e., benzene, formaldehyde) is provided in **Equation B-4** (*Aircraft HAP Emissions Using TOG*).

$$\textbf{HAP}_i\ \textbf{Emissions (kg)} = \text{TOG Emissions (kg)} \times \text{Speciation Profile}_i\ \text{(mass fraction)}$$

Where:

i = HAP of interest

Equation B-4. Aircraft HAP Emissions Using TOG

For demonstration purposes, **Table B-6** (*Example HAP Emission Estimates*) provides the emission estimate for the A320 aircraft example for three individual HAPs. As shown, the computed emission totals for ethylene, formaldehyde, and toluene emissions are approximately 43, 34, and 2 kilograms, respectively.

Table B-6. Example HAP Emission Estimates

Aircraft Type	Engine Type/Number	TOG (kg)	HAP	Speciation Profile (mass fraction)	HAP Emissions (kg)
A320-100	CFM-56 / 2	278	Ethylene	0.15459	43.0
			Formaldehyde	0.12308	34.2
			Toluene	0.00642	1.78

Source: *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines*, May 27, 2009, http://www.epa.gov/otaq/regs/nonroad/aviation/420r09901.pdf.

B.2.2 Auxiliary Power Units

For large commercial and cargo aircraft, APUs generate on-board electricity and air conditioning (A/C) while an airplane is taxiing or parked at the gate. In some cases, GPUs are used. APUs and GPUs are traditionally powered with jet fuel and diesel fuel, respectively. At many modern airports, gate furnished electricity and air conditioning are used to supplement and/or replace usage of APUs/GPUs.

B.2.2.1 Methodology

With one exception, the procedure for calculating HAP emissions for an APU is the same as the procedure used to compute HAP emissions for an aircraft engine, described in the previous section. For APUs however, the amount of fuel consumed is based on the run time of an APU prior to main engines start up on departure and the run time after the aircraft engines are shut down on arrival and, if available, connected to ground power at an airport. Notably, if ground power and pre-conditioned air is not available, an APU may be used the entire time an aircraft is at an airport's gate.

B.2.2.2 Conversion Factors

The required input data for obtaining an estimate of HAP emission for an APU includes: (i) the fuel flow rate for the specific APU model, (ii) the APU run time (for a complete landing-takeoff cycle), (iii) a THC emission index specific to the APU model, (iv) a factor that converts the estimated level of THC to TOG, and (v) a HAPs speciation profile. **Equation B-5** (*HAP Emissions – APU*) demonstrates how to derive HAP emissions for an APU.

$$A \times B \times D \times F \times H \times 1/1000 = I$$

Where:

A = Fuel flow rate (kg/sec)

B = Time in operation (sec)

D = THC emission index (g/kg fuel consumed)

F = THC to TOG conversion factor (unitless)

H= Speciation profile for HAP of interest (mass fraction)

1/1000 = Converstion factor from grams to kilograms

I= Mass of HAP of interest (kg)

Equation B-5. HAP Emissions - APU

B.2.3 Ground Support Equipment

GSE provide service to aircraft while at an airport terminal and are generally classified as either "on-road" vehicles or trucks (e.g., an airline employee shuttle bus) and other similar vehicles or "non-road" vehicles/equipment such as tugs, tractors, loaders, etc. The fleet of GSE utilized at an airport, their operating times and fuel types (gasoline or diesel) varies by aircraft type (commercial, commuter, GA, military), by airline, and by airport.

B.2.3.1 Methodology

GSE emissions are calculated either using a total GSE population-based approach (i.e., an accounting of all the equipment and vehicles on the airport) or using an aircraft LTO approach (i.e., based on the type and number of GSE servicing each aircraft type for an LTO) (see **Appendix A.3**, *Ground Support Equipment Emissions Inventory for Criteria Pollutants*).

B.2.3.2 Emission Factors

For GSE, the input data used determine the amount of HAP emission include: (i) the brake horsepower of the equipment, (ii) the load factor, (iii) equipment usage (equipment operating time), (iv) THC emission indices, (v) a THC to TOG conversion factor specific to the equipment fuel type, and (vi) a HAPs speciation profile that is also specific to the fuel type.

Equation B-6 (*HAP Emissions – GSE*) can be used to calculate the HAP emissions from an individual piece (or type) of equipment. The THC to TOG conversion factors (as used in EDMS/AEDT) for diesel, gasoline, CNG, and LPG equipment are 1.07, 1.043, 1.002, and 1.0995, respectively.

$$I = L \times M/100 \times B \times D \times F \times H \times 1/60 \times 1/1000$$

Where:

I = Mass of THC of interest, expressed in kilograms (kg)

L = Average rated brake horsepower

M = Load factor, expressed as a percentage

B = Time in operation, expressed as minutes

D = THC emissions index, expressed in grams per horsepower-hour (g/hp-hr)

F = THC to TOG conversion factor (unitless)

H= Speciation profile for HAP of interest (mass fraction)

1/60 = Conversion factor from minutes to hours

1/1000 = Conversion factor from grams to kilograms

Equation B-6. HAP Emissions - GSE

B.2.4 Ground Access Vehicles

On-site ground access vehicles are the various fleets of public and privately-owned motor vehicles traveling on airport roadways, and in parking lots and parking garages by passengers, employees, commercial vehicles and cargo carriers. These fleets typically include cars, vans, taxis, shuttles, buses and trucks. Ground access vehicles emissions vary by vehicle and fuel type (gasoline or diesel), travel distance, operating speed, and ambient temperature.

Outside airport property, these ground access vehicles operate on the local and regional roadway networks while traveling to and from an airport and are difficult to distinguish from background (i.e., non-airport) traffic.

B.2.4.1 Methodology

The EPA has identified 21 HAPs that are designated as Mobile Source Air Toxics (MSATs) to signify those HAPs that are emitted by motor vehicles.[58] MOVES is currently the best tool for estimating these motor vehicle emissions of MSATs.[59]

The MOVES output is expressed in units of grams/vehicle-mile and can be segregated by vehicle and fuel type (e.g., light duty gasoline, heavy duty diesel, etc.) or combined into a composite value representative of the entire Ground access vehicle fleet.

[58] EPA, *Mobile Source Air Toxics*, http://www.epa.gov/otaq/toxics.htm.

[59] Information regarding MOVES, including software and user's guide can be found at the following websites: http://www.epa.gov/otaq/models/moves/index.htm#generalinfo.

B.2.4.2 Emission Factors

The MOVES emission rates, when coupled with estimates of travel activity (vehicle-miles-traveled or VMT), provide estimates of the mass of HAP as shown in **Equation B-7** (*HAP Emissions - Ground Access Vehicles*).

$$I = D \times N \times 1/1000$$

Where:

I = Mass of HAP of interest (kg)

D = HAP emission index, expressed in grams per mile (g/mi)

N = Vehicle-miles-traveled, expressed as miles (mi)

1/1000 = Conversion factor from grams to kilograms

Equation B-7. HAP Emissions - Ground Access Vehicles

B.2.5 Stationary Combustion Sources

Potential stationary combustion sources of HAPs at airports include boilers/space heaters, generators, incinerators, fire training facilities, and aircraft engine testing. The data required to prepare a HAP emission inventory for these sources include: (i) the amount of fuel consumed over a given time period, (ii) a THC emission index, (iii) a THC-to-TOG conversion factor, and (iv) a HAPs speciation profile. In nearly all cases, the types and amounts of HAP emitted by these sources depend on the type and quantity of the fuel used, operating times, and the existence of emission control equipment.

Equation B-8 (*HAP Emissions - Stationary Combustion Sources*) provides a methodology to estimate of HAP emissions for an individual stationary combustion source. EDMS/AEDT provides THC to TOG conversion factors for various equipment and fuel.

$$I = C \times D \times F \times H$$

Where:

I = Mass of HAP of interest, expressed in pounds (lbs)

C = Total fuel consumed, expresses in gallons (for liquid fuels), million cubic feet (for natural gas), or tons (for coal)

D = THC emission index, expressed in pounds per gallon (lbs/gal) for liquid fuels, pounds per million cubic feet (lbs/10^6 cf) for natural gas, or pounds per ton (lbs /ton) for coal

F = THC to TOG conversion factor (unitless)

Equation B-8. HAP Emissions - Stationary Combustion Sources

B.2.6 Fuel Storage Tanks

HAP emissions from fuel storage tanks vary by fuel type and vapor pressure; containment vessel, emission control device, fuel throughput volumes, and local meteorological conditions.

Fuel storage and the handling of jet and diesel fuel does not produce significant HAP emissions because these fuels have a relatively low vapor pressure and the emissions remain well confined within the containment vessels and the distribution system. However, HAP emissions from aviation gasoline and motor gasoline storage can be more significant as their vapor pressures are higher than that of jet and diesel fuel.

To estimate HAP emissions from storage tanks, the data required include: (i) an estimate of the standing storage and working THC emissions[60], (ii) a THC-to-TOG conversion factor, and (iii) a speciation profile.

The general methodology for calculating storage tank HAP emissions is expressed in **Equation B-9** (*HAP Emissions - Fuel Storage Tanks*).

$$I = (O + P) \times F \times H$$

Where:

I = Mass of HAP of interest, expressed in pounds (lbs)

O = Standing storage THC emissions, expressed in pounds (lbs)

P = Working storage THC emissions, expressed in pounds (lbs)

F = THC to TOG conversion factor (unitless)

H = Speciation profile for HAP of interest (mass fraction)

Equation B-9. HAP Emissions - Fuel Storage Tanks

B.2.7 Coating and Painting Operations

Emissions of VOC from coating and painting activities (use of enamel, primer, varnish, adhesive, etc.) vary depending on the type and the amount of materials used and the type of emission control measure. **Equation B-10** (*HAP Emissions - Coating/Painting Operations*) provides the general method of calculating HAP emissions from these sources.

$$I = Q \times R \times S/100 \times F \times H$$

Where:

I = Mass of HAP of interest, expressed in pounds (lbs)

Q = Quantity of coating/paint, expressed in gallons

R = VOC content, expressed in pounds of VOC per gallons (lbs VOC/gallons)

S = Air pollutant control factor, expressed as a percentage

F = VOC to TOG conversion factor (unitless)

H = Speciation profile for HAP of interest (mass fraction)

Equation B-10. HAP Emissions - Coating/Painting Operations

[60] Estimates of standing storage and working HC emissions may be obtained from EDMS/AEDT, the EPA's TANKS program, and/or using methodologies described in *Section 7.1 of Volume I of Compilation of Air Pollutant Emission Factors*. Information specific to the type of tank (i.e., fixed or floating roof) may be obtained from the airport operator, fueling contractor, or by visual inspection.

B.2.8 Deicing Activities

The amount of HAP emissions from deicing activities varies depending on the specific chemical present in the deicing fluid (i.e., propylene glycol, ethylene glycol, or other organic compound) and the amount of fluid used. **Equation B-11** (*HAP Emissions – Deicing*) provides the methodology for deriving and speciating VOC emissions from deicing activities (aircraft or runway).

$$I = Q \times T \times U/100 \times D \times F \times H$$

Where:

I = Mass of HAP of interest, expressed in pounds (lbs)

Q = Quantity of deicing fluid, expressed in gallons

T = Density of deicing fluid, expressed in pounds per gallon (lbs/gallon)

U = Concentration of deicing chemical expressed as percent by weight

D = VOC emission index, expressed as pounds of VOC per pound of chemical consumed

F = VOC to TOG conversion factor (unitless)

H = Speciation profile for HAP of interest (mass fraction)

Equation B-11. HAP Emissions - Deicing

B.2.9 Solvent Degreasers

Emissions of VOC that result from the use of organic solvents are estimated by calculating the difference between the volume of solvent consumed and the liquid volume disposed, and then multiplying this difference by the density of the solvent. The resultant VOC emissions are then speciated for individual HAP emissions as shown in **Equation B-12** (*HAP Emissions - Solvent Degreaser*).

$$I = (Q - V) \times T \times D \times F \times H$$

Where:

I = Mass of HAP of interest expressed as pounds (lbs)

Q = Quantity of solvent consumed, expressed in gallons

V = Quantify of solvent disposed of, expressed in gallons

T = Density of solvent, expressed in pounds per gallon (lbs/gallon)

D = VOC emission index, expressed as pounds of VOC per pound of chemical consumed

F = VOC to TOG conversion factor (unitless)

H = Speciation profile for HAP of interest (mass fraction)

Equation B-12. HAP Emissions - Solvent Degreaser

APPENDIX C - Emissions Inventory for Greenhouse Gases

C.1 Overview

This appendix discusses the methodologies for computing greenhouse gas (GHG) emissions from aircraft engines, auxiliary power units (APU), ground support equipment (GSE), ground access vehicles, stationary sources (such as boilers, generators, and fire training), and other miscellaneous activities such as electrical usage, waste management, and refrigerant usage. See **Section 3** (*Sources and Types of Air Emissions*) for a description of GHGs associated with aviation and **Section 6.3** (*Preparing an Emissions Inventory – Greenhouse Gases*) for a discussion of available guidance for preparing and reporting a GHG assessment for FAA projects/actions.

The six primary GHG pollutants which should be considered for a GHG emissions inventory are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

For the most part, GHG emissions should be determined based on the estimated/actual fuel usage (e.g., gallons, cubic feet, etc.) and an appropriate emission factor (e.g., pounds per gallon). The types of sources from which GHG emissions should be calculated using the fuel usage approach include aircraft, APU, GSE, and stationary sources. In the case of motor vehicles, GHG emissions should be based on the estimated/actual activity levels (e.g., vehicle miles travel) or estimated/actual fuel usage (e.g., gallons, cubic feet, etc.) and an approved emission factor (e.g., grams per mile, pounds per gallon). GHG emissions from electrical usage, refrigerant usage, and waste management should also be accounted for within the inventory.

In all cases, the GHG emission inventory results should be converted to CO_2 equivalent (CO_{2e}) values using the Global Warming Potential (GWP)[61] values of 1 for CO_2, 34 for CH_4, and 298 for N_2O (based on a 100 year period) as presented in the IPCC's Fifth Assessment Report.[62]

C.2 Methodology

The following sections discuss the methodologies for computing GHG emissions from aircraft, APUs, GSE, ground access vehicles, stationary sources, electrical usage, waste management, and refrigerant usage.

C.2.1 Aircraft

The following section discusses the methodology for computing GHG emissions from aircraft engines within the landing and take-off (LTO) cycle. As noted previously, the LTO cycle includes the take-off, climbout, approach, and taxi/idle operating modes.

[61] GWPs are a relative measure of how much heat a GHG traps in the atmosphere when compared CO_2.
[62] IPCC, Fifth Assessment report (AR5), http://www.ipcc.ch/.

C.2.1.1 Aircraft within LTO Cycle

In general, the computation and data inputs for computing GHGs from aircraft fuel usage are similar to that used to compute aircraft criteria pollutants (see **Appendix A1**, *Aircraft Emissions Inventory for Criteria Pollutants*). As such, the EDMS/AEDT fuel usage (in kilograms) is based on the aircraft/engine assignment, the time-in-mode, the number of operations, the number of engines, and the International Civil Aviation Organization (ICAO) fuel flow rate (in kilograms per second). In addition, GHG emissions within the LTO should also be based on an atmospheric mixing height. The aircraft engine fuel usage calculation is shown in **Equation C-1** (*Aircraft*

Fuel Usage (kilograms) *= Fuel Flow Rate (kilograms per second) x Time-in-Mode (minutes) x 60 (seconds per minute) x number of operations x number of engines*

Equation C-1. Aircraft Fuel Usage in Kilograms

Fuel Usage in Kilograms). This calculation is repeated for each operating mode and aircraft/engine combination using EDMS/AEDT.

The EDMS/AEDT -computed fuel usage rates (in kilograms) should then be summed for turbine engines, other non-piston aircraft and for piston-powered aircraft. This total fuel usage should then be converted to gallons using **Equation C-2** (*Aircraft Fuel Usage in Gallons*) and the density of the fuel. A density of 6.84 pounds per gallon should be used for Jet A and 6.00 pounds per gallon should be used for avgas. The total fuel usage of Jet A and avgas (in gallons) for each operating mode (i.e., take-off, climbout, approach, and taxi/idle) is then determined.

Once the aircraft fuel usage (in gallons) for Jet A and avgas are determined, the appropriate emissions factors (shown in **Table C-1**, *GHG Emission Factors for Aircraft Fuel*) are then applied to determine the CO_2, CH_4, and N_2O emissions (in metric tons).

Jet A Fuel Usage (gallons) *= Jet A Fuel Usage (kilograms) x 2.20462 pounds per kilogram / 6.84 pounds per gallon*

Avgas Fuel Usage (gallons) *= Avgas Fuel Usage (kilograms) x 2.20462 pounds per kilogram / 6.00 pounds per gallon*

Equation C-2. Aircraft Fuel Usage in Gallons

Table C-1. GHG Emission Factors for Aircraft Fuel

Fuel	CO_2	N_2O	CH_4[63]	Units	Density
Jet A - LTO	21.098	0.000683	0.0	lb/gallon	6.84
Jet A – startup mode			0.000595		
Avgas – LTO/startup modes	18.342	0.000243	0.0155	lb/gallon	6.00
Source: Department of Energy, Energy Information Administration, 2012, Voluntary Reporting of Greenhouse Gases Emissions.					

Importantly, the total CO_2, CH_4, and N_2O emissions should then be adjusted to account for their GWP with a result of CO_{2e} (in metric tons). **Equation C-3** (*CO_{2e} Emission Calculation for Turbine Aircraft*) provides an example for Jet A usage during LTO.

CO_2 (metric tons) *= Fuel Usage (gallons) x 21.098 pounds CO_2 per gallon x short ton per 2,000 pound x 0.907185 metric ton per short ton*

N_2O (metric tons) *= Fuel Usage (gallons) x 0.000683 pounds N_2O per gallon x short ton per 2,000 pound x 0.907185 metric ton per short ton*

CO_{2e} (in metric tons) = CO_2 + N_2O x 298

Equation C-3. CO_{2e} Emission Calculation for Turbine Aircraft during LTO (Jet A)

C.2.1.2 Aircraft within Engine Startup Mode

The following section discusses the methodology for computing GHG emissions from aircraft engine startup. The startup mode is only applied to aircraft with engines represented in the ICAO Engine Exhaust Emissions Databank[64] (e.g. the startup mode is not applied to piston engines) and should be estimated based on an engine startup fuel flow rate,[65] as used by EDMS/AEDT.

63 LTO contributions of CH_4 emissions from aircraft gas turbine engines burning Jet A are reported as zero. Years of scientific measurement campaigns conducted at the exhaust exit plane of commercial aircraft gas turbine engines have repeatedly indicated that CH_4 emissions are consumed over the full emission flight envelope [Reference: *Aircraft Emissions of Methane and Nitrous Oxide during the Alternative Aviation Fuel Experiment*, Santoni et al., Environ. Sci. Technol., July 2011, Volume 45, pp. 7075-7082]. As a result, the EPA published that: "…m*ethane is no longer considered to be an emission from aircraft gas turbine engines burning Jet A at higher power settings and is, in fact, consumed in net at these higher powers."* [Reference: EPA, *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines*, May 27, 2009 [EPA-420-R-09-901], http://www.epa.gov/otaq/aviation.htm]. In accordance with the following statements in the *2006 IPCC Guidelines* (IPCC 2006), the FAA does not calculate CH_4 emissions for either the domestic or international bunker commercial aircraft jet fuel emissions inventories. *"Methane (CH_4) may be emitted by gas turbines during idle and by older technology engines, but recent data suggest that little or no CH_4 is emitted by modern engines." "Current scientific understanding does not allow other gases (e.g., N_2O and CH_4) to be included in calculation of cruise emissions."* (IPCC 1999).

64 ICAO's Aircraft Engine Exhaust Emissions Databank available at the following website: http://easa.europa.eu/document-library/icao-aircraft-engine-emissions-databank.

65 ICAO/CAEP Working Group 3, May 5, 2006, Engine Starting Emissions.

Fuel Usage (gallons) *= (463.4 pounds per hour x 1 hour per 3600 seconds x 2 seconds x number of engines in the ICAO Engine Exhaust Emissions Databank / 6.84 pounds per gallon) + (829 pounds per hour x 1 hour per 3600 seconds) x 40 seconds x number of engines in the ICAO Engine Exhaust Emissions Databank / 6.84 pounds per gallon)*

Where:

463.4 pounds per hour and 2 seconds is fuel flow rate and duration, respectively, for the first phase of startup.

829 pounds per hour and 40 seconds is fuel flow rate and duration, respectively, for the second phase of startup.

Equation C-4. Aircraft Engine Startup Jet A Fuel Usage

Aircraft engine startup mode is divided into two fractions: (1) the raw fuel released prior to ignition, and (2) the products of incomplete combustion during the acceleration to idle power. The latter fraction contributes the most fuel usage. **Equation C-4** (*Aircraft Engine Startup Jet A Fuel Usage*) presents the fuel usage calculations of Jet A from both fractions in gallons. During the first phase, 463.4 pounds per hour and 2 seconds is fuel flow rate and duration, respectively. During the second phase, 829 pounds per hour and 40 seconds is fuel flow rate and duration, respectively. The other input data is the number of engines.

Once the engine startup fuel usage (in gallons) is determined, **Table C-1** (*GHG Emission Factors for Aircraft Fuel*) and **Equation C-5** (*CO_{2e} Emission Calculation for Turbine Aircraft during Startup*) should be used to determine the CO_2, CH_4, and N_2O emissions, which should then be adjusted to account for GWP with a result of CO_{2e} (in metric tons). **Equation C-5** (*CO_{2e} Emission Calculation for Turbine Aircraft during Startup*) provides an example for Jet A.

CO_2 (metric tons) *= Fuel Usage (gallons) x 21.098 pounds CO_2 per gallon x short ton per 2,000 pound x 0.907185 metric ton per short ton*

CH_4 (metric tons) *= Fuel Usage (gallons) x 0.000595 pounds CH_4 per gallon x short ton per 2,000 pound x 0.907185 metric ton per short ton*

N_2O (metric tons) *= Fuel Usage (gallons) x 0.000683 pounds N_2O per gallon x short ton per 2,000 pound x 0.907185 metric ton per short ton*

CO_{2e} (in metric tons) = CO_2 + CH_4 x 34 + N_2O x 298

Equation C-5. CO_{2e} Emission Calculation for Turbine Aircraft during Startup (Jet A)

C.2.2 Auxiliary Power Units

The following section discusses the methodology for computing GHG emissions from aircraft APUs. APUs consist of small turbine engines used by many commercial jet aircraft to start the main engines, provide electrical power to aircraft electronics, and to power the onboard air conditioning (heating and cooling) systems.

Again, the computation and data inputs of APU fuel usage for computing GHGs is similar to that uses for computing APU criteria pollutants (see **Appendix A2**, *Auxiliary Power Units Emissions Inventory for Criteria Pollutant*). As discussed, EDMS/AEDT contains a database of aircraft and APU assignments as well as fuel flow rates (typically ranging from 50 to 860 pounds per hour) for the designated APU. However, EDMS/AEDT does not report this fuel usage.

Therefore, APU fuel usage should be estimated based on the APU assignment, the fuel flow rate, the operating time, the number of operations, and fuel density. APU operating times (arrival plus departure) typically range from 7 to 26 minutes depending on gate infrastructure and airport operations. **Table C-2** (*APU Fuel Usage Rates*) presents the APU fuel flow rates for the 38 units within EDMS/AEDT.

Table C-2. APU Fuel Usage Rates

Description	Fuel Usage (pounds/hour)
APU 131-9	255
APU GTC 85	235
APU GTC85-72 (200HP)	210
APU GTCP 331 (143 HP)	268
APU GTCP 331-350	453
APU GTCP 36 (80HP)	221
APU GTCP 36-100	146
APU GTCP 36-150[]	149
APU GTCP 36-150[RR]	183
APU GTCP 36-300 (80HP)	221
APU GTCP 36-4A	134
APU GTCP 660 (300 HP)	767
APU GTCP 85 (200 HP)	235
APU GTCP100-544 (400 HP)	413
APU GTCP30-300	282
APU GTCP30-54	69.0
APU GTCP331-200ER (143 HP)	268
APU GTCP331-500 (143 HP)	536
APU GTCP85 (200 HP)	235
APU GTCP85-129 (200 HP)	235
APU GTCP85-98 (200 HP)	235
APU GTCP95-2 (300 HP)	293

Table C-2. APU Fuel Usage Rates

Description	Fuel Usage (pounds/hour)
APU PW901A	863
APU ST-6	440
APU T-62T-27 (100 HP)	102
APU T-62T-47C1	235
APU TSCP 700 (142 HP)	463
APU TSCP700-4B (142 HP)	463
APU WR27-1	140
APU GTCP 165-9(135 HP)	100
APU GTCP 165-1A(128 HP)	95.1
APU GTCP 331-250	106
APU 85-180(177 HP)	132
APU T62T27(65 HP)	48.3
Source: FAA's EDMS, 2013.	

Equation C-6 (*Fuel Usage for APU*) shows the calculation for computing APU fuel usage in gallons.

Fuel Usage (gallons) *= Fuel Flow Rate (pounds per hour) x Operating Time (minutes) x number of operations x 1 hour per 60 minutes / 6.84 pounds per gallon*

Equation C-6. Fuel Usage for APU

Once the APU fuel usage (in gallons) is determined, the emission factor for Jet A – startup mode in **Table C-1** (*GHG Emission Factors for Aircraft Fuel*) should be used to determine the CO_2, CH_4, and N_2O emissions, which should then be adjusted to account for GWP using **Equation C-5** (*CO_{2e} Emission Calculation for Turbine Aircraft during Startup*) with a result of CO_{2e} (in metric tons).

C.2.3 Ground Support Equipment

The following section discusses the methodologies for computing GHG emissions associated with GSE. GSE include aircraft tugs, baggage tugs, fuel trucks, food trucks, cargo trailers, water trucks, lavatory trucks, cabin service, belt loaders, and cargo loaders.

Some airports collect GSE fuel usage data within its recordkeeping system (often through a fuel consortium or fixed based operator). These records provide the most accurate accounting of GSE fuel usage. However, at some airports, fuel use records are not available or reliable. For these conditions, GSE fuel usage should be estimated based on the fuel flow rates (in grams per horsepower-hour) within EPA's NONROAD model. Again, the computation and data inputs of GSE fuel usage for computing GHGs are similar to those used to compute GSE criteria pollutants (see **Appendix A3**, *Ground Support Equipment Emissions Inventory for Criteria Pollutants*).

As such, the fuel flow rates should be combined with the GSE assignments (by aircraft), the operating time (i.e., within the LTO cycle), the horsepower, the load factor, the number of operations, and fuel density to determine the fuel usage. **Equation C-7** (*Gasoline Fuel Usage for GSE – Within LTO Cycle*) shows the calculation of the gasoline GSE fuel usage in gallons within an LTO cycle. GSE typically use diesel, gasoline, propane (LPG), or compressed natural gas (CNG).

Fuel Usage (gallons) *= Fuel Flow Rate (grams per horsepower-hour) x horsepower x Operating Time (minutes) x load factor x number of operations x 1 hour per 60 minutes / 453.592 grams per pound / 6.20 pounds per gallon*

Equation C-7. Gasoline Fuel Usage for GSE – Within LTO Cycle

Fuel Usage (gallons) *= Fuel Flow Rate (grams per horsepower-hour) x horsepower x Hours of Operation (hour) x load factor / 453.592 gram per pound / 6.20 pounds per gallon*

Equation C-8. Gasoline Fuel Usage for GSE – Population-based

Notably, some GSE do not specifically support the aircraft LTO cycle (e.g., sweepers, deicers, etc.) but are instead operated when needed. These GSE are known as population-based GSE and fuel usage for this equipment is based on the annual hours of operation. **Equation C-8** (*Gasoline Fuel Usage for GSE – Population-based*) shows the calculation of the population-based gasoline GSE fuel usage for these GSE in gallons.

Once the GSE fuel usage (in gallons) is determined (via fuel records or NONROAD estimates), the appropriate emissions factors (shown in **Table C-3**, *GHG Emission Factors for GSE*) can be applied to determine the CO_2, CH_4, and N_2O emissions (in metric tons).

Table C-3. GHG Emission Factors for GSE

Fuel	CO_2	N_2O	CH_4	Units	Density
Diesel	22.377	0.00057	0.00128	lb/gallon	7.10
Gasoline	19.643	0.00049	0.00110	lb/gallon	6.20
LPG	12.669	0.00000023	0.000003	lb/gallon	4.24
CNG	120.372	0.0002	0.0002	lb/1000 feet^3	0.042
Source: Department of Energy, Energy Information Administration, 2012, Voluntary Reporting of Greenhouse Gases Emissions.					

The CO_2, CH_4, and N_2O emissions should then be adjusted to account for GWP with a result of CO_{2e} (in metric tons). **Equation C-9** (*CO_{2e} Emission Calculation of Gasoline GSE*) provides an example for gasoline GSE.

$$CO_2 \text{ (metric tons)} = \text{Fuel Usage (gallons)} \times 19.643 \text{ pounds } CO_2 \text{ per gallon} \times \text{short ton per 2,000 pound} \times 0.907185 \text{ metric ton per short ton}$$

$$CH_4 \text{ (metric tons)} = \text{Fuel Usage (gallons)} \times 0.000003 \text{ pounds } CH_4 \text{ per gallon} \times \text{short ton per 2,000 pound} \times 0.907185 \text{ metric ton per short ton}$$

$$N_2O \text{ (metric tons)} = \text{Fuel Usage (gallons)} \times 0.00000023 \text{ pounds } N_2O \text{ per gallon} \times \text{short ton per 2,000 pound} \times 0.907185 \text{ metric ton per short ton}$$

$$CO_{2e} \text{ (in metric tons)} = CO_2 + CH_4 \times 34 + N_2O \times 298$$

Equation C-9. CO_{2e} Emission Calculation of Gasoline GSE

C.2.4 Ground Access Vehicles

The following section discusses the methodologies for computing GHG emissions from ground access vehicles. Ground access vehicles[66] encompass airport passenger vehicles (e.g., private autos, taxis, limousines, shuttles, vans, buses, rental cars, etc.), vehicles transporting airport and tenant employees, airport fleet (e.g., buses, shuttles, etc.), and vehicles transporting cargo to and from airport as well as circulating around the airport.

Emissions from ground access vehicles are generally a function of traffic volumes, distances traveled, vehicle operating characteristics, and fuel type. They are also typically associated with three different types of vehicles trip types: (i) those traveling within on- and off-airport roadways, (ii) those traveling within airport parking facilities; and (iii) those accessing terminal curbside areas associated with passenger pickup and drop-off.

In general, the computation and data inputs for computing motor vehicle GHG emissions are similar to those used for computing motor vehicle criteria pollutants (see **Appendix A4**, *Ground Access Vehicles Emissions Inventory for Criteria Pollutants*). As discussed, some airports monitor and collect information on the overall movement of traffic through the use of automatic vehicle identification (AVI) systems. Other airports track fuel usage for some types of vehicle operations (e.g., parking shuttle buses, rental car shuttles, airport fleet vehicles). Traffic volumes can also be estimated based on passenger surveys and enplanement data.

From these data, the ground access vehicle usage (either in miles traveled or fuel usage) can be determined. The EPA's MOVES model is then used to estimate fuel consumption rates (in gallons per mile) and CO_2, CH_4, and N_2O emission factors (in grams per mile) based on the vehicle fleet mix.

[66] Ground access vehicles exclude those ground support equipment (GSE) used for servicing aircraft and airport.

Equation C-10 shows the calculation of the motor vehicle CO_{2e} emissions as a function of vehicle miles traveled. This calculation can be made for each vehicle type or for a composite vehicle fleet mix.

CO_2 (metric tons) = *VMT (miles) x CO_2 Emission Factor (grams per mile) x 1 short ton/2,000 pound x 0.907185 metric tons/short tons*

CH_4 (metric tons) = *VMT (miles) x CH_4 Emission Factor (grams per mile) x 1 short ton/2,000 pound x 0.907185 metric tons/short tons*

N_2O (metric tons) = *VMT (miles) x N_2O Emission Factor (grams per mile) x 1 short ton/2,000 pound x 0.907185 metric tons/short tons*

CO_{2e} (in metric tons) = $CO_2 + CH_4 \times 34 + N_2O \times 298$

Equation C-10. CO_{2e} Emission Calculation for Motor Vehicles

If vehicle fuel usage is known (via airport records), then the CO_{2e} emissions should be calculated as a function of the fuel-based emission factors (shown in **Table C-3**, *GHG Emission Factors for GSE*). These emission factors should then be applied to determine the CO_2, CH_4, and N_2O emissions (in metric tons), as shown for an example diesel bus in **Equation C-11**, (*CO_{2e} Emission Calculation of Diesel Bus*).

CO_2 (metric tons) = *Fuel Usage (gallons) x 22.377 pounds CO_2 per gallon x short ton per 2,000 pound x 0.907185 metric ton per short ton*

CH_4 (metric tons) = *Fuel Usage (gallons) x 0.00128 pounds CH_4 per gallon x short ton per 2,000 pound x 0.907185 metric ton per short ton*

N_2O (metric tons) = *Fuel Usage (gallons) x 0.00057 pounds N_2O per gallon x short ton per 2,000 pound x 0.907185 metric ton per short ton*

CO_{2e} (in metric tons) = $CO_2 + CH_4 \times 34 + N_2O \times 298$

Equation C-11. CO_{2e} Emission Calculation of Diesel Bus

C.2.5 Stationary Sources

The following section discusses the methodologies for computing GHG emissions from stationary sources. Stationary sources at an airport which emit GHG emissions include boilers, generators, snowmelters, and fire training facilities. Storage of fuel (i.e., jet fuel, avgas, gasoline, and diesel) is a potential source of evaporative hydrocarbon emissions, but does not produce the types of hydrocarbons that contribute directly to climate change.

Typically, stationary source fuel usage can be obtained from fuel purchase records, storage tank throughput, or other records. If fuel usage records are not available, the fuel usage should be estimated based on the hours of operation and hourly fuel flow rates for each source from manufacturer data.

Once the stationary source fuel usage (in gallons or cubic feet) is determined (via fuel records or estimated via manufacturer specifications), the appropriate emissions factors (shown in **Table C-4**, *GHG Emission Factors for Stationary Sources*) can be applied to determine the CO_2, CH_4, and N_2O emissions (in metric tons).

Table C-4. GHG Emission Factors for Stationary Sources

Fuel	CO_2	N_2O	CH_4	Units
Natural Gas	120.372	0.0002	0.0002	lb/1000cf
No 2 Oil	22.384	0.0001928	0.000534	lb/gallon
No 6 Oil	26.033	0.0002081	0.0002245	lb/gallon
Diesel	22.377	0.00057	0.00128	lb/gallon
Gasoline	19.643	0.00049	0.00110	lb/gallon
Tekflame	12.669	0.00000023	0.000003	lb/gallon
Source: Department of Energy, Energy Information Administration, 2012, Voluntary Reporting of Greenhouse Gases Emissions.				

The CO_2, CH_4, and N_2O emissions should then be adjusted to account for GWP with a result of CO_{2e} (in metric tons). **Equation C-12** (*CO_{2e} Emission Calculation for Boiler using Natural Gas*) provides an example for natural gas usage within a boiler.

CO_2 (metric tons) *= Fuel Usage (cubic feet) x 120.372 pounds CO_2 per cubic feet x short ton per 2,000 pound x 0.907185 metric ton per short ton*

CH_4 (metric tons) *= Fuel Usage (cubic feet) x 0.000534 pounds CH_4 per cubic feet x short ton per 2,000 pound x 0.907185 metric ton per short ton*

N_2O (metric tons) *= Fuel Usage (cubic feet) x 0.0002 pounds N_2O per cubic feet x short ton per 2,000 pound x 0.907185 metric ton per short ton*

CO_{2e} (in metric tons) = CO_2 + CH_4 x 34 + N_2O x 298

Equation C-12. CO_{2e} Emission Calculation for Boiler using Natural Gas

C.2.6 Electrical Usage

The following section discusses the methodologies for computing GHG emissions from electrical consumption at airports. With electricity usage generally reported in kilowatt hours (kWh), emission factors (in pounds per MWh or pounds per GWh) from local utility providers, Emissions & Generation Resource Integrated Database (eGRID)[67], or U.S. Energy Information Administration (EIA) for specific regions of the country should be used to calculate GHG emissions. These emission factors are a function of the type of fuel/process used to generate the electricity in a particular region. Once the electrical consumption is determined, the appropriate emissions factors can be applied to determine the CO_2, CH_4, and N_2O emissions.

[67] EPA, *Emissions & Generation Resource Integrated Database* (eGRID), http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

The CO_2, CH_4, and N_2O emissions are again adjusted to account for GWP with a result of CO_{2e} (in metric tons). **Equation C-13** (*CO_{2e} Emission Calculation for Pacific Northwest Electrical Consumption*) provides an example for electrical consumption in the Pacific Northwest.

CO_2 (metric tons) *= Electrical Consumption (kWh) x 819.21 pounds CO_2 per MWh x short ton per 2,000 pound x 0.907185 metric ton per short ton x 0.001 MWh per kWh*

CH_4 (metric tons) *= Electrical Consumption (kWh) x 15.29 pounds CH_4 per GWh x short ton per 2,000 pound x 0.907185 metric ton per short ton x 0.000001 GWh per kWh*

N_2O (metric tons) *= Electrical Consumption (kWh) x 12.50 pounds N_2O per GWh x short ton per 2,000 pound x 0.907185 metric ton per short ton x 0.000001 GWh per kWh*

CO_{2e} (in metric tons) = Electrical CO_2 + Electrical CH_4 x 34 + Electrical N_2O x 298

Equation C-13. CO_{2e} Emission Calculation for Pacific Northwest Electrical Consumption

C.2.7 Waste Management

Most airports have implemented waste management activities designed to recycle various forms of waste. These activities produce GHG emission reductions when contrasted with activities that do not recycle (i.e., divert waste from landfills).

GHG emissions related to the waste management practices should be estimated using EPA's Waste Reduction Model (WARM)[68]. WARM is available both as a Web-based calculator and as a Microsoft Excel spreadsheet. WARM calculates and totals GHG emissions of baseline and alternative waste management practices—source reduction, recycling, combustion, composting, and landfilling. The model calculates emissions in metric tons of CO_{2e} for 26 materials and 8 mixed material categories (e.g., construction and demolition waste, aluminum cans, glass, plastic, paper, wood, and metals, etc.) commonly found in municipal solid waste (MSW). The emission factors represent the GHG emissions associated with managing one short ton of MSW in a specified manner.

WARM also provides several options for landfill emissions modeling, including whether or not landfill gases are recovered. Emissions from the transportation of the waste to the landfill are also incorporated into WARM. Default transportation distances of 20 miles can be used if site-specific data is unavailable.

For each material type, the amount of material recycled, landfilled, composted, and/or combusted is input into WARM. GHG savings are then be calculated by comparing the emissions associated with the alternative scenario with the emissions associated with the baseline scenario.

C.2.8 Refrigerant Usage

The following section discusses the methodologies for computing GHG emissions from refrigerant usage at airports. At airports, refrigeration usage can be composed of air conditioning and heat pumps, chillers, fire extinguishers, and storage refrigeration.

[68] EPA, *Waste Reduction Model (WARM)*, Version 13, June 2013, http://epa.gov/epawaste/conserve/tools/warm/index.html.

GHG emissions associated with refrigerant usage at an airport should be based on the methodology established by *The Climate Registry, General Reporting Protocol*[69]. The method for computing GHG emissions from refrigerants is based on material balancing, which takes into account the charging, operating, and disposal of refrigerants. *The Climate Registry, General Reporting Protocol* contains a screening method to establish significance of GHG emissions and quantification approaches to quantify GHG emissions. One can choose a quantification approach based on data availability, purpose of quantification, and the level of accuracy required.

The screening method is intended for entities that do not own or operate a significant amount of equipment that use HFCs or PFCs, but may own or operate equipment that use refrigerants. Typically the GHG emissions from these sources represent a small percentage of an emission inventory at an airport and thus, a screening method can be used to conservatively estimate these emissions.

The screening approach requires data including the number of units, the type of refrigerant used, the total refrigerant charge for each type of equipment, and the annual leakage rate. This information should be available from the facility as it is often required reported for Refrigerant Management Plans. *The Climate Registry, General Reporting Protocol* provides default values for equipment charge, equipment lifetime, assembly/installation emission factors, annual leakage rate, and recycling efficiency. This approach is used only as a screening method since default emission factors can be highly uncertain. The HFC and PFC emissions should then be adjusted to account for GWP with a result of CO_{2e} (in metric tons). These gases have high GWP ranging from 140 to 11,700 times that of CO_2. **Equation C-14,** (*CO_{2e} Emission Calculation for Refrigerant Usage*), provides an example for refrigerant usage.

The quantification approach requires information on the quantity of refrigerant used to fill new equipment during installation, the quantity of refrigerant used to service equipment, the quantity of refrigerant recovered from retiring equipment, and the full and proper charges of new and retiring equipment. The approach tracks emissions from equipment manufacturing, operation, servicing, and disposal.

Emissions (metric tons) = *Capacity charge x % of capacity/year + Refrigerant Added – Refrigerant Recovered*

CO_{2e} Emissions (metric tons) = Emissions (metric tons) x GWP

Equation C-14. CO_{2e} Emission Calculation for Refrigerant Usage

69 Climate Registry, General Reporting Protocol, Version 2.0, *Accurate, Transparent, and Consistent Measurement of Greenhouse Gases Across North America*, March 2013, http://www.theclimateregistry.org/downloads/2013/03/TCR_GRP_Version_2.0.pdf.

APPENDIX D - Atmospheric Dispersion Modeling

D.1 Overview

This appendix discusses the methodology, typical input data, and endpoints associated with atmospheric dispersion modeling of airport-related sources. **Section 7.1** (*Atmospheric Dispersion Modeling for Airports*) discusses the available guidance for preparing and reporting the results of dispersion modeling for FAA projects/actions.

D.2 Dispersion Modeling Data

The fundamental concepts and elements of air dispersion modeling include the following:

- Model identification and options
- Emission source release characteristics
- Meteorological data
- Spatial allocation
- Temporal profiles
- Topography data
- Building downwash
- Receptor locations
- NO_x to NO_2 conversion
- Background concentrations

These concepts and elements are discussed individually in the following sections.

D.2.1 Model Identification and Options

AERMOD is a steady-state Gaussian dispersion model recommended by the EPA for short-range (i.e., up to 50 kilometers) dispersion of air pollutant emissions from point, area, line, and volumes sources over simple, intermediate, and complex terrain.[70] As such, AERMOD serves as dispersion modeling component for the FAA's EDMS/AEDT.

The model predicts both short- (i.e., 1-, 3, 8, 24-hour) and long-term (i.e., annual) average concentrations (in microgram per cubic meter or $\mu g/m^3$) at each receptor. These concentrations may be presented as plot files and receptor files providing the results for both tabular and graphical display.

AERMOD is typically executed using the regulatory default options (e.g., stack-tip downwash, buoyancy-induced dispersion, and final plume rise), default wind speed profile categories, default potential temperature gradients, and no pollutant decay. AERMOD also has the capability to account for building downwash effects[71] and to employ gas or particle deposition or wet/dry depletion of the plume.[72]

70 EPA, Preferred/Recommended Models, http://www.epa.gov/scram001/dispersion_prefrec.htm.

71 The term *building downwash* describes the effect that wind flowing over or around a structure(s) has on plumes released from nearby sources (such as stacks). Essentially, structure(s) create a cavity of recirculating winds in the area near the structure(s), and these cavities cause increased vertical dispersion of plumes emitted from

The selection of the appropriate dispersion coefficients depends on the land use within three kilometers (km) of the source. The land use typing is based on the classification method defined by Auer[73]; using pertinent U.S. Geological Survey (USGS) 1:24,000 scale (7.5 minute) topographic maps of the area. If the Auer land use types of heavy industrial, light-to-moderate industrial, commercial, and compact residential account for 50 percent or more of the total area, the EPA *Guideline on Air Quality Models*[74] recommends using urban dispersion coefficients; otherwise, the appropriate rural coefficients are to be used. Generally, airports are located in urban areas; however, the immediate area is often characterized by large areas of pavement, low buildings, and open space. Thus, rural coefficients may be most appropriate for most airports.

D.2.2 Emission Source Release Characteristics

Dispersion models require several types of data for each emission source to simulate the emission release characteristics. Depending on the source category (e.g., taxiway, roadways, stationary sources), AERMOD constructs point, area, line, or volume sources. Point (or stationary) sources, with buoyant plumes due to thermal energy and momentum, are used to model stacks from boilers, turbines, generators, and cooling towers. Area sources are used to model emissions from aircraft gate aprons (i.e., aircraft at startup, GSE operations, and APU activity), aircraft taxiing, queuing, accelerating on the runway, and in climb-out and approach modes. Roadways are classified as line sources or series of area sources. Volume sources are used to model any source that has an area and height element such as fuel storage facilities.

Depending on the source type, some additional information about the source is required to model the dispersion of the emissions. This additional information includes the following:

- Source layout, including location and height;
- For stack emissions, parameters including location, stack gas temperature, exit velocity, stack diameter and stack height above ground;
- For mobile sources, link length and width; and
- For area sources, coordinates defining the shape and height above ground.

EDMS/AEDT spatially allocates APU and GSE emissions to a defined aircraft apron. These operations can be designated as an area source with a height of 1.5 meters and an initial vertical distribution of 3 meters.

Each parking garage should be treated as one area source per garage level, which is stacked to simulate a parking garage. The number of levels in each garage and the average separation between levels (e.g., approximately 4 meters or 13 feet) is based on site-specific information and

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sources on or near the structure(s). Building downwash often leads to elevated concentrations downwind of affected sources.

72 *Dry deposition* is the removal of gaseous or particulate material from the pollution plume by contact with the ground surface or vegetation (or even water surfaces) through transfer processes such as absorption and gravitational sedimentation. *Wet deposition* is the removal of pollution plume components by the action of rain.

73 Auer, August H., 1978: *Correlation of Land Use and Cover with Meteorological Anomalies*. J. Appl. Meteor., 17, 636–643 http://journals.ametsoc.org/doi/pdf/10.1175/1520-0450%281978%29017%3C0636%3ACOLUAC%3E2.0.CO%3B2

74 Appendix W to Part 51 – *Guideline on Air Quality Models*, http://www.ecfr.gov/cgi-bin/text-idx?SID=e6a5b817b94abf58460f48c032d9a39c&node=40:2.0.1.1.2.23.11.5.37&rgn=div9.

is accounted for in the dispersion modeling analysis. The x and y coordinates, which define the size of the area source, may be based on aerial photographs and maps. The initial vertical dispersion parameter is specified as three meters.

The stationary source locations can be based on the facility permits, aerial photographs and maps. Stack release parameters such as: height, diameter, temperature and velocity can also be based on permits, site visits, default data, and engineering judgment.

Roadways similarly require the specification of x, y coordinates with associated elevations, widths, and release heights for each roadway. The roadway coordinates locate the roadway spatially within the network and provide information on roadway dimensions. The default width is 20 meters (65.6 feet); however, roadway-specific widths can be determined based on site visits, aerial photographs and maps. The initial vertical dispersion parameter is specified as three meters and the height is the distance above the ground elevation at which emissions are released. A roadway may be defined as a series of connected line segments identified by their endpoints or as an area source derived from the segments and the width.

EDMS/AEDT also requires a number of data to simulate the distribution of emissions associated with aircraft. These data include temporal profiles, runway utilization, taxipaths, and airport capacity and configurations – all of which are discussed further below.

D.2.3 Meteorological Data

The fundamental meteorological parameters included in an air dispersion modeling analysis include the following:

- Wind speed and wind direction;
- Mixing height;
- Surface roughness length, albedo, and Bowen ratio; and

AERMOD contains a meteorological data preprocessor, AERMET[75] that accepts surface meteorological data, upper air soundings, and data from on-site instrument towers (optional) such as a SODAR. Atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length, and surface heat flux are then calculated based on these hourly data.

The AERMET output files contain meteorological parameters such as wind speed, wind direction, temperature, precipitation, relative humidity, atmospheric pressure, and a number of parameters defining the turbulence and stability of the atmosphere.

A wide range of meteorological data is collected at most airports and these data are available from the National Climatic Data Center (NCDC) in a digital format ready for use by AERMET. Typically, for airport dispersion modeling, five years of meteorological data are first analyzed in AERMET and, from this, a "worst-case" meteorological year is determined and used.

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[75] EPA, *User's Guide for the AERMOD Meteorological Preprocessor (AERMET)*, November 2004, http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm#aermet.

D.2.3.1 Wind Speed and Direction

AERMOD assumes that wind speed is constant from one direction for a given time period being modeled, usually one hour. Wind speeds are usually measured by an anemometer at a height of 20 feet. These measurements may or may not be corrected by the air quality analyst to account for increasing wind speed with height.

For those time periods in which the wind speed is given as zero or "calm", dispersion models will generally assign a minimum wind speed. If a wind speed of zero is specified, AERMOD computes an infinite concentration of the pollutant at the source, with no dispersion. In reality, diffusion of pollutants into the surrounding atmosphere would take place in calm conditions.

Atmospheric stability is related to the turbulence of the atmosphere and is determined by a combination of wind speed, cloud cover, and solar radiation.

In unstable atmospheric conditions, high turbulence and associated vertical mixing produce a peak ground-level pollutant concentration near the emission source. In stable atmospheric conditions, a low level of vertical mixing results in low ground-level steady-state concentrations near the source. In most cases, the most unstable atmospheric conditions occur during daylight hours, with low wind speeds and high solar radiation. The most stable atmospheric conditions occur at night, during times of low wind speeds and clear skies.

D.2.3.2 Mixing Height

The term "atmospheric mixing height" generally describes the height above ground level (AGL) where most air pollutants are generated and where atmospheric mixing occurs. Within the atmosphere, this height (expressed in meters or feet AGL) is determined by an assortment of factors including air temperature, humidity, solar radiation, wind speed, and topographic features on the ground (i.e., valleys, mountains, vegetative cover, reflective and impervious surfaces, water bodies, etc.). The atmospheric mixing height is dynamic and moves up or down both spatially and temporally throughout the day, season, and year with corresponding changes in these abovementioned factors. The height of this mixing layer generally ranges between 1,000 and 6,000 feet AGL.

The presence of a stable layer above the mixing layer has the effect of restricting vertical diffusion of pollutants. This "lidding" effect requires a modification for it to remain accurate at distances greater than several kilometers downwind of the emission source. For applications such as airports, however, where the pollutant of concern is not likely to be transported at high concentration very far from the source, mixing depth effects on downwind pollutant concentrations may be ignored without too much loss of accuracy.

The EPA has established guidelines for the determination of atmospheric mixing heights used for computing an emission inventory and for conducting atmospheric dispersion modeling. In Section 5.2.2 (*Mixing Height Determination*) of the *Guideline on Air Quality Models*[76], the following preamble discusses the application of mixing heights as it applies to aircraft emissions:

[76] Appendix W to Part 51 – *Guideline on Air Quality Models*, http://www.ecfr.gov/cgi-bin/text-idx?SID=e6a5b817b94abf58460f48c032d9a39c&node=40:2.0.1.1.2.23.11.5.37&rgn=div9.

> *"The height of the mixing zone…is significant primarily when calculating NO_x emissions rather than hydrocarbons or CO. If NO_x emissions are an important component of the inventory, site-specific data must be gathered on mixing heights. If NO_x emissions are unimportant, mixing height will have little effect on the results and the default value of 3,000 feet can be used for more generalized results."*

The EPA *Guideline on Air Quality Models* also identifies four options for establishing the mixing height based on the type and amount of data available as well as its application. These options are summarized below:

- *NCDC Data*: These data are site-specific and based upon the most recent set of "real-world" measurement data near an airport.
- *Support Center for Regulatory Air Models (SCRAM) Data*: These data are available from the EPA Office of Air Quality Planning and Standards SCRAM Bulletin Board. Although these data are based on NCDC measurements, they were collected during the late 1980's and early 1990's and are not the most recent available.
- EPA's *Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States*: This 1972 publication (also called the "Holzworth" report) contains data and graphs depicting mixing heights for mean annual morning and mean summer afternoon conditions across the U.S., by season (i.e., winter, summer, etc.).[77]
- *3,000 feet Mixing Height:* This value is recommended by EPA when no site-specific data is available and is the "default" value contained in EDMS/AEDT.[78,79]

D.2.3.3 Surface Roughness Length, Albedo, Bowen Ratio

AERSURFACE[80] should be used to assess the land use cover and determine the appropriate surface roughness length[81], Bowen ratio[82], and albedo[83] based on land use cover, soil moisture, and seasonal conditions.

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77 EPA, Mixing Heights, *Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States*, 1972 (also called the "Holzworth" report), http://nepis.epa.gov/Exe/ZyNET.exe/20013CDS.TXT?ZyActionD=ZyDocument&Client=EPA&Index=Prior+to+1976&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C70thru75%5CTxt%5C00000005%5C20013CDS.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL.

78 EPA, *Procedures for Emission Inventory Preparation*, Volume IV, Chapter 5, Section 5.2.2, December, 1992, EPA-420-R-92-009], http://www.epa.gov/otaq/models/nonrdmdl/r92009.pdf.

79 More recent regulatory update also mentions checking the STIP/TIP if mixing height is provided (EPA 40 CFR 93.153).

80 AERSURFACE is a tool that processes land cover data to determine the surface characteristics for use in AERMET.

81 The roughness length is approximately one-tenth of the height of the surface roughness elements. For example, short grass of height 0.01 m has a roughness length of approximately 0.001 m. Surfaces are rougher if they have more protrusions. Forests have much larger roughness lengths than tundra, for example. Roughness length is an

The surface roughness length, in meters, is a measure of the near-surface wind resistance. For informational purposes, **Table D-1** (*Surface Roughness Lengths (m) for Various Land Uses*) provides typical surface roughness lengths for a variety of land uses. As shown, typical values range from 0.0001 meters over water to 1.00 meters within an urban environment. A typical airport environment has a surface roughness length of 0.10 meters.

Table D-1. Surface Roughness Lengths (m) for Various Land Uses

Surface Type	Winter	Spring	Summer	Autumn
Water	0.0001	0.0001	0.0001	0.0001
Deciduous Forest	0.50	1.00	1.30	0.80
Coniferous Forest	1.30	1.30	1.30	1.30
Swamp	0.05	0.20	0.20	0.20
Cultivated Land	0.01	0.03	0.20	0.05
Grassland	0.001	0.05	0.10	0.01
Urban	1.00	1.00	1.00	1.00
Desert Scrubland	0.15	0.30	0.30	0.30
Source: EPA, *User's Guide for the AERMOD Meteorological Preprocessor (AERMET)*, November 2004, http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm#aermet.				

The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. Typical values range from 0.10 for thick deciduous forests to 0.90 for fresh snow. **Table D-2** (*Albedo for Various Land Uses*) provides typical albedo for a variety of land uses. A typical airport environment has an albedo of 0.20.

Table D-2. Albedo for Various Land Uses

Surface Type	Winter	Spring	Summer	Autumn
Water	0.20	0.12	0.10	0.14
Deciduous Forest	0.50	0.12	0.12	0.12
Coniferous Forest	0.35	0.12	0.12	0.12
Swamp	0.30	0.12	0.14	0.16
Cultivated Land	0.60	0.14	0.20	0.18
Grassland	0.60	0.18	0.18	0.20

important concept in urban meteorology as the building of tall structures, such as skyscrapers, has an effect on roughness length and wind patterns

82 The Bowen ratio is used to describe the type of heat transfer in a water body. The Bowen ratio is the mathematical method generally used to calculate heat lost (or gained) in a substance; it is the ratio of energy fluxes from one state to another by sensible and latent heating respectively.

83 The ratio of reflected radiation from the surface to incident radiation upon it or reflecting power of a surface.

Table D-2. Albedo for Various Land Uses

Surface Type	Winter	Spring	Summer	Autumn
Urban	0.35	0.14	0.16	0.18
Desert Scrubland	0.45	0.30	0.28	0.28
Source: EPA, *User's Guide for the AERMOD Meteorological Preprocessor (AERMET)*, November 2004, http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm#aermet.				

The Bowen ratio, an indicator of surface moisture, is the ratio of the sensible heat flux to the latent heat flux. Although the Bowen ratio can have significant diurnal variation, it is used to determine the planetary boundary layer parameters for convective conditions **Table D-3** (*Bowen Ratio for Various Land Uses*) provides typical Bowen Ratio for a variety of land uses and moisture conditions. A typical airport environment has a Bowen Ratio of 2.0 but it varies by season and surface moisture conditions.

Table D-3. Bowen Ratio for Various Land Uses

Surface Type	Winter	Spring	Summer	Autumn
Dry Conditions				
Water	2.0	0.1	0.1	0.1
Deciduous Forest	2.0	1.5	0.6	2.0
Coniferous Forest	2.0	1.5	0.6	1.5
Swamp	2.0	0.2	0.2	0.2
Cultivated Land	2.0	1.0	1.5	2.0
Grassland	2.0	1.0	2.0	2.0
Urban	2.0	2.0	4.0	4.0
Desert Scrubland	10.0	5.0	6.0	10.0
Average Conditions				
Water	1.5	0.1	0.1	0.1
Deciduous Forest	1.5	0.7	0.3	1.0
Coniferous Forest	1.5	0.7	0.3	0.8
Swamp	1.5	0.1	0.1	0.1
Cultivated Land	1.5	0.3	0.5	0.7
Grassland	1.5	0.4	0.8	1.0
Urban	1.5	1.0	2.0	2.0
Desert Scrubland	6.0	3.0	4.0	6.0
Wet Conditions				
Water	0.3	0.1	0.1	0.1
Deciduous Forest	0.5	0.3	0.2	0.4

Table D-3. Bowen Ratio for Various Land Uses

Surface Type	Winter	Spring	Summer	Autumn
Coniferous Forest	0.3	0.3	0.2	0.3
Swamp	0.5	0.1	0.1	0.1
Cultivated Land	0.5	0.2	0.3	0.4
Grassland	0.5	0.3	0.4	0.5
Urban	0.5	0.5	1.0	1.0
Desert Scrubland	2.0	1.0	1.5	2.0
Source: EPA, User's Guide for the AERMOD Meteorological Preprocessor (AERMET), November 2004, http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm#aermet.				

D.2.4 Airport Capacity and Configurations

For dispersion modeling, EDMS/AEDT requires the capacity of runway use configurations as inputs to the Delay and Sequence Module. Configurations represent specific wind flows, cloud ceiling, and visibility conditions. For such configurations, the airfield capacity should be established (i.e., the number of departures during which the hourly arrivals are at maximum and the number of arrivals during which the hourly departures are at maximum). The FAA's Aviation System Performance Metrics (ASPM) database can be used to establish the hourly capacity of an airport.[84]

D.2.5 Spatial Allocation

EDMS/AEDT and AERMOD incorporates specific details on source location (i.e., airport layout and roadway network) and activity variation to develop a spatial representation of each emission source. The locations of emission sources and receptors should be represented in the Universal Transverse Mercator (UTM) coordinate system and the analysis should be centered on the airport reference point.[85] Emission source locations can be determined using airport layout plans, aerial photographs, drawings, maps, available databases, and/or site visits. The location of runway endpoints can be obtained from AEDT or the FAA's Airport Master Record.[86]

Other spatial allocation parameters included in an air dispersion modeling analysis include the following:

- Runway utilization
- Taxipaths
- Apron/Gate Assignments

The percent of time the various runways are used for departures/arrivals are developed to distribute the aircraft operations to each runway endpoint. To accommodate EDMS/AEDT and AERMOD, the runway utilization is developed by aircraft size (i.e., small, large and heavy) for each airfield configuration.

84 FAA, *Aviation System Performance Metrics*, https://aspm.faa.gov/aspm/entryASPM.asp.
85 The airport reference point is a point of an airport located at the geometric center of all the usable runways.
86 Airport IQ 5010, Airport Master Records and Reports, http://www.gcr1.com/5010web/.

Taxipaths (i.e., the arrival path from the end of the landing roll to the terminal and the departure path from the terminal to the runway end) are also designated based on field observations, airport procedures, and/or airfield simulation modeling and included in the dispersion modeling analysis. In this manner, a taxipath is a series of taxiways from runway end to aircraft servicing location. Within these taxipaths, aircraft speeds can be designated as 5 knots within the terminal areas, 10 knots within taxiways with tight turns, 15 knots for most remaining taxiways, and 35 knots for high speeds runway exits. The EDMS/AEDT default value is 15 knots.

Apron/gate areas define the locations of aircraft operations such as unloading and loading of cargo and passengers. Thus, these locations also represent activities associated with APU, GSE and other supporting operations.

D.2.6 Temporal Profiles

Temporal (or operational) profiles are used to describe the relationship of one time period to another (i.e., the relationship of the activity during 1-hour to the activity during a twenty-four hour period). In EDMS/AEDT, these temporal profiles are used to represent varying levels of activity as a fraction of a peak period (a scale of zero to one: unless values denoted as fraction of peak values).

Notably, distinct temporal profiles can be developed for air carrier, cargo, commuter, general aviation, and military aircraft operations during arrival and departure conditions for each quarter hour of the day, day of the week, and month based on ASPM data.

D.2.7 Topographical Data

The terrain in the vicinity of airports is usually flat because of the requirement for a level runway, approach and climbout area. Some sources, such as training fires, stacks, and painting operations, produce emission in the form of a buoyant plume. In such cases, topography may play a role in altering the downwind dispersion of the plume and should be included in the dispersion analysis.

AERMOD includes a terrain preprocessor, AERMAP[87], which provides a physical relationship between terrain features and the behavior of air pollution plumes. AERMAP processes USGS Digital Elevation Model (DEM) data and creates a file of elevation and hill-height scaling factors. AERMAP generates location and height data for each receptor and source location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting flow around hills.

D.2.8 Building Downwash

Building downwash describes the effect that wind flowing over or around a structure(s) has on plumes released from nearby sources (such as stacks). Essentially, structure(s) create a cavity of recirculating winds in the area near the structure(s), and these cavities cause increased vertical dispersion of plumes emitted from sources on or near the structure(s). Building downwash often leads to elevated concentrations downwind of affected sources.

[87] EPA, *User's Guide for the AERMOD Terrain Preprocessor (AERMAP)*, October 2004, http://www.epa.gov/scram001/dispersion_related.htm.

Airport buildings affect the emitted point source plumes by essentially serving as obstacles to those sources, and therefore have a significant impact on concentrations resulting from stationary source emissions. Buildings have no effect on the concentrations estimated from volume and area sources such as aircraft, APU, GSE, roadways, and parking facilities. Secondly, given the nature of the airport environment, buildings tend to be short and thus the downwash effect tends to be subdued. AERMOD includes the PRIME plume rise and building downwash model which considers the position of the stack relative to the buildings, streamline deflection near the building, and vertical wind speed shear and velocity deficit effects on plume rise. EDMS/AEDT allows users to include building locations and dimensions and applies the effects of building downwash on AERMOD "point" sources only. Airport projects with significant stationary sources and large/tall buildings should consider conducting a building downwash analysis in consultation with regulatory agencies.

D.2.9 Receptor Locations

The locations at which concentrations are estimated are known as "receptors". EPA's *Guideline on Air Quality Models*[88] provides guidance on the selection of receptor sites and recommends that receptor sites be placed to estimate the highest potential concentrations.

Receptors are defined as those areas in which pollutant concentrations are to be calculated. If an overall view of pollutant concentration on and off the site is desired, then a grid of receptors should be defined. For many applications, however, only those locations defined as "sensitive" (i.e., where the public is likely to come into contact with emissions) may be modeled in order to reduce the model computational requirements[89]. For a complex emissions scenario such as an airport, reducing the number of receptors may be necessary for this reason.

Nevertheless, pollutant concentrations should be predicted at a sufficient number of receptor locations to identify the maximum concentrations. Because EDMS/AEDT and AERMOD is designed to handle only a moderate number of receptors, a strategy must be developed to help limit the run time of the model while optimizing the results. Overall, the dispersion analysis should include about 50 receptors, selected as follows:

- *Boundary receptors* – Boundary receptors should be located in areas along the airport boundary at a spacing of approximately 10 degrees (a total of 36 receptors).
- *Sensitive receptors* – Sensitive receptors include schools, parks, residential areas, health/day-care centers located in the vicinity of the airport based on land use maps.
- *Worst-case receptors* – Worst-case receptors should be selected in close proximity to air emissions sources such as near runway ends, terminal area access/egress roads, and off-

88 Appendix W to Part 51 – Guideline on Air Quality Models, http://www.ecfr.gov/cgi-bin/text-idx?SID=e6a5b817b94abf58460f48c032d9a39c&node=40:2.0.1.1.2.23.11.5.37&rgn=div9.

89 Some receptors are considered more sensitive to air pollutants than others, because of preexisting health problems, proximity to the emissions source, or duration of exposure to air pollutants. Land uses such as primary and secondary schools, hospitals, and convalescent homes are considered to be relatively sensitive to poor air quality because the very young, the old, and the infirm are more susceptible to respiratory infections and other air quality related health problems than the general public. Residential areas are also considered sensitive to poor air quality because people in residential areas are often at home for extended periods. Recreational land uses are moderately sensitive to air pollution, because vigorous exercise associated with recreation places a high demand on respiratory system function.

site roadway intersections. These receptors represent sites where the pollutant concentrations are expected to be the highest and the public has access.

- *Additional receptors* – Locations such as Class I Wilderness areas and nearby air monitoring sites.

Receptors should be placed at a flagpole height of six feet or 1.8 meters (typical breathing height).

D.2.10 NO_x to NO_2 Conversion

Dispersion modeling predicts nitrogen oxide (NO_x) concentrations, while NAAQS are associated with nitrogen dioxide (NO_2) concentrations. The combustion process typically forms several types of NO_x. For modeling purposes, the NO_x emissions are typically assumed to be nitric oxide (NO) and NO_2. However, after the flue gas exits the stack, additional NO is created as the exhaust mixes with the surrounding air.

Oxidation by ozone (O_3) is typically the main reaction for NO_2 formation, especially in rural areas. While the reaction rate is essentially instantaneous, the total amount of NO_2 conversion is limited by how quickly the plume entrains surrounding air. Therefore, the amount of NO_2 within the NO_x plume increases as the plume travels and disperses downwind of the stack. The final plume NO_x-to-NO_2 ratio will equal the existing ambient NO_x-to-NO_2 ratio. Therefore, once the ambient NO_x-to-NO_2 ratio is established, the predicted NO_2 impact can be determined by multiplying the modeled NO_x concentration by the NO_x-to-NO_2 ambient ratio.

When the rates of these two reactions are equal, NO, NO_2, and O_3 are said to be in a "photo-stationary state". Emissions of NO_x in the form of NO rapidly lead to reductions in O_3 concentrations and concomitant increases in NO_2 concentrations. The maximum concentration of NO_2 that can be formed as a result is limited by the availability of O_3 (and to a smaller extent, peroxy radicals). Further downwind, O_3 levels can recover and exceed background values via additional photochemical reactions involving VOCs.

While AERMOD is generally considered a non-chemistry model, it offers three methods for modeling NO_2 formation from NO_x emissions: (i) the Ambient Ratio Method (ARM), (ii) the Ozone Limiting Method (OLM), and (iii) the Plume Volume Molar Ratio Method (PVMRM). Moreover, EPA's *Guideline on Air Quality Models*[90], recommends a three-tiered screening approach to estimate ambient concentrations of NO_2:

- Tier 1 – assumes complete (i.e., 100 percent) conversion of all emitted NO_x to NO_2 – essentially, treating NO_x as a non-reactive pollutant (similar to CO). EDMS/AEDT implement the Tier 1 approach when used with AERMOD.
- Tier 2 – the ARM multiplies Tier 1 results by empirically-derived ambient NO_2/NO_x ratio, with 0.75 as the default ratio for annual impacts and 0.80 as the default ratio for 1-hour impacts. Site-specific ambient NO_2/NO_x ratios derived from appropriate ambient monitoring data may also be considered as detailed screening methods on a case-by-case basis, with proper justification. ARM2 incorporates a variable ambient ratio that is a function of model predicted 1-hr NO_x concentration, based on an analysis of hourly

[90] Appendix W to Part 51 – Guideline on Air Quality Models, http://www.ecfr.gov/cgi-bin/text-idx?SID=e6a5b817b94abf58460f48c032d9a39c&node=40:2.0.1.1.2.23.11.5.37&rgn=div9.

ambient NO_x monitoring data from approximately 580 stations over the period 2001 through 2010. With AERMOD version 13350, the ARM is the default Tier 2 method and ARM2 is a non-default Beta option.

- Tier 3 – performs a detailed analysis on a case-by-case basis by employing the OLM or PVMRM. Tier 3 requires information such as in stack NO_2/NO_x ratio and ambient ozone concentrations.

Generally, at lower NO_x concentrations, PVMRM predicts NO_2/NO_x ratios closest to observations. At highest NO_x concentrations, all three methods are similar, and overestimate the NO_2/NO_x ratio when compared to observations. All methods over predict NO_2 by factors ranging from approximately 1.2 to 2.[91]

Prior to the April 2010 revision of the NO_2 NAAQS, most facilities were able to demonstrate compliance with the NAAQS using the Tier 1 and 2 screening methods. However, with the additional stringency of the new 1-hour NO_2 NAAQS, the need for facilities to use a Tier 3 approach has increased. EPA has issued guidance indicating that the three-tiered approach is generally applicable for the 1-hour NO_2 NAAQS, and also clarified that the OLM and PVMRM, included as non-default options in the AERMOD dispersion model, are currently considered to be detailed screening methods under Tier 3.[92]

The use of the Tier 3 PVMRM and OLM options in AERMOD requires the specification of an in-stack ratio (ISR) of NO_2/NO_x for each source. The EPA guidance emphasized the importance of these in-stack ratios for the 1-hour NO_2 NAAQS, recommending that in-stack ratios used with either the OLM or PVMRM options be justified based on the specific application (i.e., there is no "default" in-stack NO_2/NO_x ratio for either OLM or PVMRM). Additional EPA guidance allowed for a default ISR of 0.5 in the absence of more appropriate source-specific information.[93] However, the recommended default ISR may still be too conservative for many applications such that there remains a significant need for a widely available and well-documented database of ISRs.

For modeling purposes, the NO_x emissions are typically assumed to be 50 percent (by volume) nitric oxide (NO), and 50 percent NO_2. However, for aircraft, the NO_2 fraction of NO_x decreases with power from approximately 90 percent at the lowest power setting (i.e., 4 percent rated thrust or taxi/idle) to 10 percent at higher power settings (65 to 100 percent rated thrust or climbout and takeoff).[94] This has two important ramifications for downwind NO_2:

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91 *Ambient Ratio Method Version 2 (ARM2) for AERMOD 1-hour NO_2 NAAQS Analyses*, March 19, 2013 and *Ambient Ratio Method 2 (ARM2) for use with AERMOD for 1-hour NO2 Modeling*, September 20, 2013.

92 EPA, *Applicability of Appendix W Modeling Guidance for the 1-Hour NO_2 National Ambient Air Quality Standard*, June 28, 2010, http://www.epa.gov/ttn/scram/guidance/clarification/ClarificationMemo_AppendixW_Hourly-NO2-NAAQS_FINAL_06-28-2010.pdf.

93 EPA, *Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-Hour NO_2 National Ambient Air Quality Standard*, March 1, 2011, http://www.epa.gov/ttn/scram/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf.

94 Wood et al., (2008). *Speciation and Chemical Evolution of Nitrogen Oxides in Aircraft Exhaust near Airports*. Environmental Science Technology 42: 1884-1891, Wood et al., 2010.

- The maximum possible NO_2 concentrations are not limited by the ambient O_3 concentration; and
- O_3 can actually be elevated in a plume for which the NO_2/NO_x ratio is high enough. (This has been observed in isolated aircraft engine exhaust plumes.[95])

Thus, when conducting an OLM and/or PVMRM analysis, the hourly ozone concentrations from a nearby monitoring station during the same period as the meteorological data is also required.

D.2.11 Background Concentrations

The dispersion modeling performed for the air quality analysis cannot represent all pollutant sources in proximity to the airport that contribute to total pollutant levels. Therefore, background concentrations are developed to reflect the emissions from nearby sources. When background concentrations are added to the airport dispersion modeling results, the results represent total pollutant concentrations at the receptor sites.

Ambient concentrations from a nearby monitoring station should be used to develop background concentrations. The ambient monitoring station data should be representative of sources not associated with the airport, if possible, and ideally located upwind.

According to the EPA's *Guideline on Air Quality Models*:

> "*Background concentrations are an essential part of the total air quality concentration to be considered in determining source impacts. Background air quality includes pollutant concentrations due to: (1) natural sources; (2) nearby sources other than the ones currently under consideration; and (3) unidentified sources. Typically, air quality data should be used to establish background concentrations in the vicinity(s) of the sources under consideration. The monitoring network used for background concentrations should conform to the same quality assurance and other requirements as those networks established for PSD purposes. An appropriate data validation procedure should be applied to the data prior to use. If the source is not isolated, it may be necessary to use a multi-source model to establish the impact of nearby sources. Background concentrations should be determined for each critical (concentration) averaging time*."

For annual standards, the recommended background is typically based on the annual average value. Using the average *second-high* monitored value for a short-term standard is conservative, but not a requirement. If a background based on second-high values is believed to be too high, technical analysis is allowed to show that the second-high value, for example, could not reasonably be assumed to occur at the same time/place as the modeled concentrations. Alternatively, a variable background field could be used if there is sufficient data to generate one.

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[95] Wood et al., (2008). *Speciation and Chemical Evolution of Nitrogen Oxides in Aircraft Exhaust near Airports*. Environmental Science Technology 42: 1884-1891, Wood et al., 2010.

APPENDIX E - Roadway Dispersion Modeling (Hot-Spot Analysis)

E.1 Overview

This appendix discusses the methodology for conducting a project-level roadway intersection "hot-spot" analysis in connection with FAA projects/actions. This consists of computing emissions and conducting dispersion modeling of motor vehicles traveling and idling along terminal curbsides and on- and off- airport roadway(s). EPA identifies CO, PM_{10}, and $PM_{2.5}$ as the primary pollutants of concern in hot-spot analyses as increased concentrations of these pollutants are generally expected in places where large numbers of motor vehicles (especially diesel vehicles for PM_{10} and $PM_{2.5}$) are present.

Generally described, a hot-spot analysis computes and compares the pollutant concentrations of the proposed action (i.e., Build scenario) to the pollutant concentrations without the action (i.e., No-Build scenario) to ensure that new or worsened violations of the NAAQS will not occur as a result of the proposed action.

As discussed in **Section 7.2** (*Roadway Dispersion Modeling*) of the *Handbook*, **Table E-1** (*Summary of Criteria for Evaluating a Project-level CO and PM Hot-spot Analyses*) summarizes the overall criteria for evaluating whether a project-level CO and PM hot-spot analysis is warranted.

Table E-1. Summary of Criteria for Evaluating a Project-level CO and PM Hot-spot Analyses

Criteria for Evaluating Project	Pollutants		Comments
	CO	PM (PM_{10} and $PM_{2.5}$)	
Regulatory Basis[1]	Transportation Conformity Rule under CAA Environmental review under NEPA	Transportation Conformity Rule under CAA Environmental review under NEPA	CAA: 40 Code of Federal Regulations (CFR) 93.116 and 93.123 NEPA: 23 CFR Part 771
Applicable Guidance[2,3]	EPA *Guideline for Modeling CO*	EPA *Guidance for Quantitative PM Hot-Spot Analyses*	See footnote
Criteria Defining Analysis Approach	Analysis required for projects of air quality concern	Analysis required for projects of air quality concern	Interagency consultation should be used to ensure proper level of analysis
1. Type of projects that require analysis	Projects affecting one or more of the top three intersections with highest traffic volumes and projects affecting one or more of the top three intersections with the worst level of service	New highways with a significant number of diesel vehicles and expanded highway with a significant increase in diesel vehicles	CO: Top intersections defined in State Implementation Plan (SIP) PM: Includes highway improvements that connect to a major freight, bus or intermodal terminal
Annual Average Daily Traffic (AADT) Volume	Top three highest traffic volumes; top three worst Level-of-Service (LOS)	New highway: Greater than 125,000 (example) Expanded highway: Not	PM: Explained in 71 Federal Register (FR) 12491

Criteria for Evaluating Project	Pollutants		Comments
	CO	PM (PM_{10} and $PM_{2.5}$)	
		applicable	
Percent Diesel Traffic	Not applicable	New highway: 8% or more (example) Expanded highway: Significant increase (not defined)	PM: Explained in 71 FR 12491 Significant increase: Discuss through interagency consultation
2. Type of projects that require analysis	Projects affecting intersections that are at LOS D, E, or F or that will change to LOS D, E, or F.	Projects affecting intersections that are at LOS D, E, or F with a significant number of diesel vehicles or that will change to LOS D, E, or F.	PM: Focused on intersections with a significant number of diesel vehicles
AADT Volume	Defined by LOS	Defined by LOS	LOS is defined in terms of the average total vehicle delay of all movements through an intersection.
Percent Diesel Traffic	Not applicable	Not defined	
3. Type of projects that require analysis	Projects in or affecting locations, areas, or categories of sites which are identified in the applicable implementation plan	Projects in or affecting locations, areas, or categories of sites which are identified in the PM_{10} or $PM_{2.5}$ applicable implementation plan	
AADT Volume	May be defined in SIP	May be defined in SIP	
Percent Diesel Traffic	May be defined in SIP	May be defined in SIP	
Additional Considerations			
Models	Emission Models: EPA's MOVES or California's EMFAC Dispersion Models: EPA's CAL3QHC	Emission Models: EPA's MOVES or California's EMFAC Dispersion Models: EPA's CAL3QHCR and AERMOD	Appendix W to 40 CFR Part 51 describes EPA's recommended models
Receptor Sensitivity	At least three meters from the edge of the travel lane	Receptors should be sited as near as five meters from a source (e.g., the edge of a traffic lane or a source in a terminal)	CO and PM: Per EPA's modeling guidance
Background Concentration	Discussed in EPA Guidance; generally ranges between 2.5 and 5 parts per million (ppm)	Considered through the use of existing monitors in the nonattainment or maintenance area	Discuss through interagency consultation; should reflect local condition
Definition of Project Boundary	The area substantially affected by the project.	The area substantially affected by the project.	Explained in 58 FR 62212
Analysis Methods	Quantitative if meet above requirements, otherwise, analysis may be qualitative	Quantitative if meet above requirements, otherwise, analysis may be qualitative	If quantitative hot-spot analysis is not warranted, than a qualitative analysis should be considered to

Criteria for Evaluating Project	Pollutants		Comments
	CO	PM (PM_{10} and $PM_{2.5}$)	
			provide a clear demonstration that the requirements of 40 CFR 93.116 are met.
Analysis Year	Year(s) of peak emissions during the time frame of the transportation plan	Year(s) of peak emissions during the time frame of the transportation plan	Explained in 69 FR 40056

Source: http://www.fhwa.dot.gov/resourcecenter/teams/airquality/plc_hotspotanalysis.cfm.
Notes:
[1] The major difference between the project-level air quality requirements under the CAA and those under the NEPA is that CAA hot-spot requirements apply to projects within specifically identified areas (i.e., nonattainment/maintenance areas), whereas NEPA applies to federally-funded projects irrespective of location.
[2] CO: EPA, *User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections,* November 1992 [EPA-454-R-92-006], http://www.epa.gov/ttn/scram/userg/regmod/cal3qhcug.pdf, and *Using MOVES in Project-Level Carbon Monoxide Analyses,* December 2010 [EPA-420-B-10-041], http://www.epa.gov/otaq/stateresources/transconf/policy/420b10041.pdf.
[3] PM: EPA, *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Non-attainment and Maintenance Areas,* November 2013 [EPA-420-B-13-053], http://www.epa.gov/otaq/stateresources/transconf/policy/420b13053-sec.pdf.

E.2 Methodology

Once the airport-related project/action has been determined to be of *local air quality concern* (see **Section 7.2** (*Roadway Dispersion Modeling*) of *the Handbook* and above **Table E-1**, *Summary of Criteria for Evaluating a Project-level CO and PM Hot-spot Analyses*), the following steps should be undertaken to complete a CO and/or PM hot-spot analysis:

- Determine Analysis Year(s)
- Select Critical Roadway Intersection(s)
- Obtain Project Data
- Estimate On-Road Vehicle Emissions
- Select Receptor Site Locations
- Select Dispersion Models
- Estimate Background Data

E.2.1 Determine Analysis Year(s)

Typically CO concentrations are predicted for existing conditions, for the future proposed action (i.e., Build scenario) and the future without the proposed action (i.e., No-Build scenario). Build and No-build scenarios are based on existing/anticipated peak-hour traffic volumes and speeds. These two scenarios are compared to see how the proposed action will affect CO concentrations throughout the project and whether concentrations may be in violation of the CO NAAQS.

Similarly, a PM hot-spot analysis compares the air quality concentrations for the No-Build and Build scenarios. These concentrations are determined by calculating a design value which is a statistic that describes a future air quality concentration in the project area that can be compared to a particular NAAQS. It is customary to complete emissions and air quality modeling on the Build scenario and compare the resulting design values to the PM NAAQS; however, it is not always necessary to conduct emissions and air quality modeling for the No-Build scenario.[96]

In addition, depending on the type and length of the project, multiple analysis years may need to be completed. Selecting appropriate analysis year(s) should be considered through the process established by each area's interagency consultation procedures as stated in 40 CFR 93.105(c)(1)(i).

E.2.2 Select Critical Roadway Intersections

As a general rule, a hot-spot analysis should be focused on those project areas where the general public has continuous access and where the maximum project-related pollutant concentrations are likely to be expected. For airport-related projects and actions this could be in the vicinities of roadway intersections both on and off the airport (i.e., critical intersections).

Intersections are selected based on Level-of-Service (LOS), traffic volumes, delays, and the percentage of diesel vehicles. LOS measures the operating conditions in the intersection and how these conditions affect traffic flow and delay. **Table E-2** (*Level of Service Criteria for Signalized Intersections*) and **Table E-3** (*Level of Service Criteria for Un-signalized Intersections*) provide the LOS criteria for both signalized and un-signalized roadway intersections, respectively.

Table E-2. Level of Service Criteria for Signalized Intersections

LOS	Average Control Delay (seconds per vehicle)	Description
A	≤10	Very low control delay 10 or less seconds per vehicle; progression is very favorable; most vehicles arrive during green signal; most vehicles do not stop. Short cycle lengths may also contribute to low delay.
B	>10 and ≤ 20	Control delay greater than 10 and up to 20 seconds per vehicle; progression is good and/or cycle lengths are short. More vehicles stop than for LOS A, causing higher levels of average delay.
C	>20 and ≤ 35	Control delay greater than 20 and up to 35 seconds per vehicle; progression is fair and/or cycle lengths are longer. Individual cycle failures may begin to appear at this level. The number of vehicles stopping is significant, though many vehicles still pass through without stopping.
D	>35 and ≤ 55	Control delay greater than 35 and up to 55 seconds per vehicle; progression is unfavorable, cycle lengths are long, or has a high flow rate to capacity ratio. Many vehicles stop, and the proportion of vehicles not stopping diminishes. Individual cycle failures are obvious.
E	>55 and ≤ 80	Control delay greater than 55 and up to 80 seconds per vehicle; progression is poor, cycle lengths are long, and has a high flow rate to capacity ratio. Individual cycle failures are frequent occurrences.

[96] EPA, *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Non-attainment and Maintenance Areas*, November 2013 [EPA-420-B-13-053], http://www.epa.gov/otaq/stateresources/transconf/policy/420b13053-sec.pdf.

LOS	Average Control Delay (seconds per vehicle)	Description
F	>80	Control delay greater than 80 seconds per vehicle; progression is very poor, cycle lengths are long. Many individual cycle failures. Arrival flow rates exceed the capacity of the intersection. This level is considered unacceptable to most drivers.
Source: Highway Capacity Manual (Transportation Research Board, Special Report 209, 2000).		

Table E-3. Level of Service Criteria for Un-signalized Intersections

LOS	Average Control Delay (seconds per vehicle)	Description
A	≤10	Very low control delay 10 or less seconds per vehicle. All drivers find freedom of operation. Very rarely more than one vehicle in queue.
B	>10 and ≤ 15	Control delay greater than 10 and up to 15 seconds per vehicle. Some drivers begin to consider the delay troublesome. Seldom there is more than one vehicle in queue.
C	>15 and ≤ 25	Control delay greater than 15 and up to 25 seconds per vehicle. Most drivers feel restricted, but tolerably so. Often there is more than one vehicle in queue.
D	>25 and ≤ 35	Control delay greater than 25 and up to 35 seconds per vehicle. Drivers feel restricted. Most often, there is more than one vehicle in queue.
E	>35 and ≤ 50	Control delay greater than 35 and up to 50 seconds per vehicle. Drivers find delays approaching intolerable levels. There is frequently more than one vehicle in queue. This level denotes a state in which the demand is close or equal to the probable maximum number of vehicles that can be accommodated by the movement.
F	>50	Control delay in excess of 50 seconds per vehicle. Very constrained flow. Represents an intersection failure situation that is caused by geometric and/or operational constraints external to the intersection.
Source: Highway Capacity Manual (Transportation Research Board, Special Report 209, 2000).		

Based on EPA guidance (i.e., 40 CFR 93.123) intersections that are at a LOS of D, E, or F or that will deteriorate to LOS D, E, or F with the proposed action, should be modeled for CO concentrations. Intersections that are at LOS D, E, or F with a significant number of diesel vehicles or that will change to LOS D, E, or F with the proposed action, should be modeled for PM_{10} and/or $PM_{2.5}$ concentrations.

Typically the top three critical intersections are selected based on the abovementioned criteria (i.e., significant number of diesel vehicles and worst LOS) and highest traffic volumes.

E.2.3 Obtain Project Data

It is recommended to obtain project-specific data when computing a hot-spot analysis. These data include peak traffic data (i.e., traffic volumes, traffic speeds, signal timing and type of intersection control), and roadway configurations and geometry (i.e., layout of intersections delineating approaches and departures, number of lanes, roadway width, and number of turning movements). For PM_{10} and $PM_{2.5}$ more detailed data (i.e., hourly traffic data) is necessary. This data is needed for all scenarios (i.e., Build and No-Build) and analysis year(s). A "Traffic Impact Analysis" of the project study area is the best source for this information.

E.2.4 Estimate On-Road Vehicle Emissions

The two EPA-approved on-road vehicle emissions' models for quantitative CO and PM hot-spot analyses are MOVES and California's EMFAC. Information pertaining to these models is summarized in **Table E-4** (*EPA-Approved On-Road Emissions Models for Quantitative CO and PM Hot-Spot Analyses*) below as well as detailed in **Section 5** (*Air Quality Assessment Models*) of the *Handbook*. Furthermore, the steps for using MOVES and California's EMFAC to generate emission factors necessary to complete project-level CO and PM hot-spot analyses are discussed in this section and illustrated in **Figures E-1** through **E-3**.

Table E-4: EPA-Approved On-Road Emissions Models for Quantitative CO and PM Hot-Spot Analyses

Emissions Model	Geographic Applicability	Federal Register Notice of Approval (date signed)
MOVES	All states other than California	Official Release of the MOVES2010 and EMFAC2007 Motor Vehicle Emissions Models for Transportation Conformity Hot-Spot Analyses and Availability of Modeling Guidance (December 20, 2010) MOVES2014 is the latest version of MOVES. EPA will be publishing a Federal Register notice of availability in the near future to approve MOVES2014 for official purposes.
EMFAC2011	California only	Official Release of EMFAC2011 Motor Vehicle Emission Factor Model for Use in the State of California (March 6, 2013)
Source: EPA's website at http://www.epa.gov/otaq/stateresources/transconf/projectlevel-hotspot.htm and http://www.epa.gov/otaq/models/moves/index.htm as well as CARB's website at http://www.arb.ca.gov/msei/modeling.htm for latest updates and model revisions. For further information on latest MOVES model refer to: http://www.epa.gov/otaq/models/moves/.		

E.2.4.1 CO Emissions Modeling

MOVES requires multiple inputs (e.g., vehicle population, vehicle age distribution, vehicle miles travelled [VMT], etc.) and depending on the geographical scale (i.e., national, county, or local) of the project, default values may not be appropriate to use. Thus state and regional air quality regulatory and transportation planning agencies should be consulted to request the most recent MOVES inputs of the project's geographical area. **Figure E-1** (*Steps for Using MOVES in Project-Level CO Analysis)* illustrates the steps for using MOVES in a project-level CO analysis).

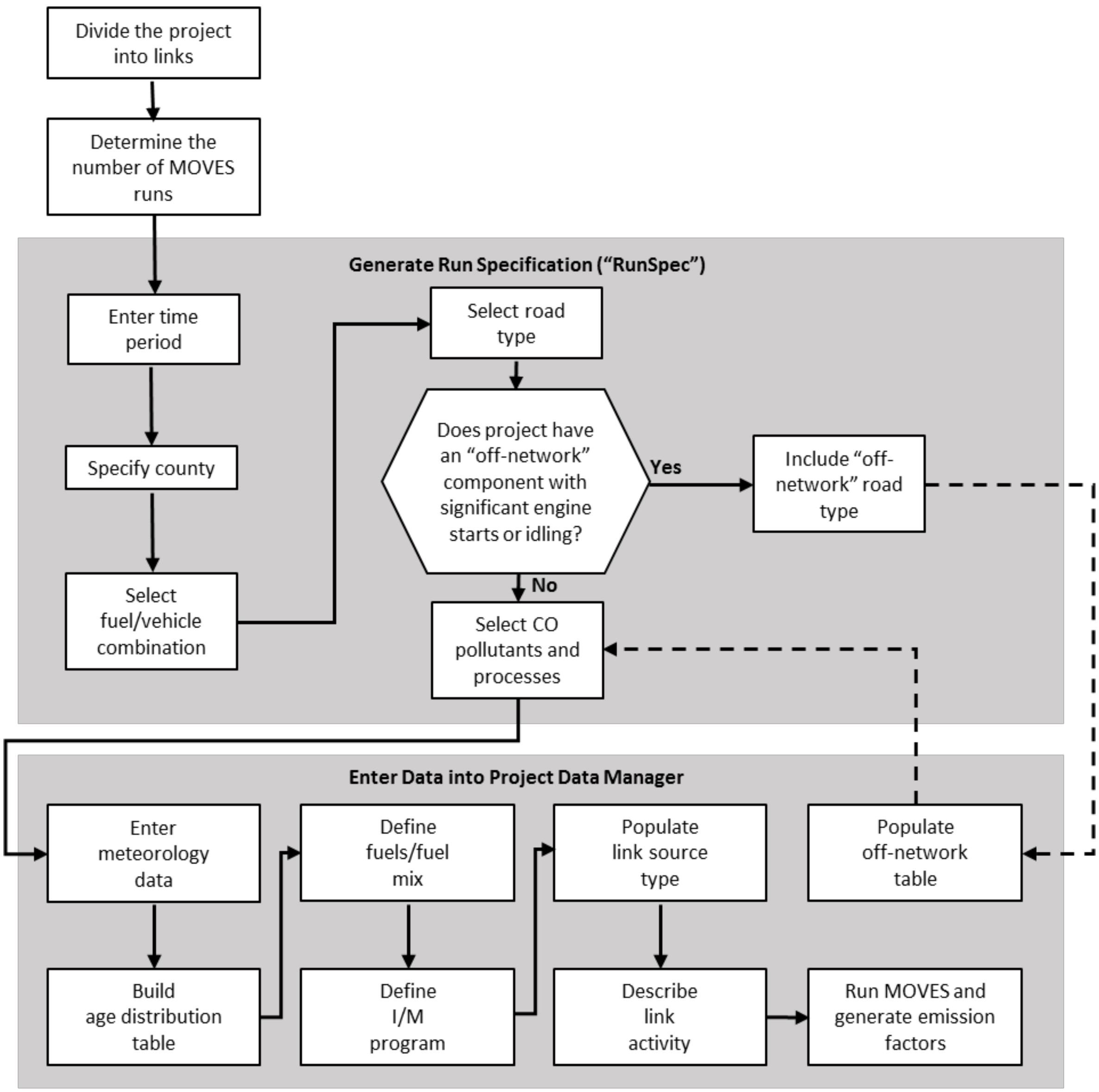
In 1997, EPA approved the *CO Protocol*[97] for use as an alternative hot-spot analysis method in California. This protocol is strongly recommended for CO hot-spot analysis in California;

[97] California DOT, *Transportation Project-Level Carbon Monoxide Protocol (CO Protocol),* http://www.dot.ca.gov/hq/env/air/pages/coprot.htm.

however, CO hot-spot modeling based on EPA's standard CO modeling guidance[98] is acceptable if EMFAC is used to generate emission factors instead of MOVES models.

For further guidance on conducting a CO hot-spot analysis and on the appropriate inputs to MOVES and EMFAC to generate the emission factors necessary to complete the analysis, refer to EPA's *Using MOVES in Project-Level Carbon Monoxide Analyses*[99], and the California *CO Protocol* mentioned previously.

Figure E-1. Steps for Using MOVES in Project-Level CO Analysis



Source: *EPA, Using MOVES in Project-Level Carbon Monoxide* Analyses, December 2010 [EPA-420-B-10-041].

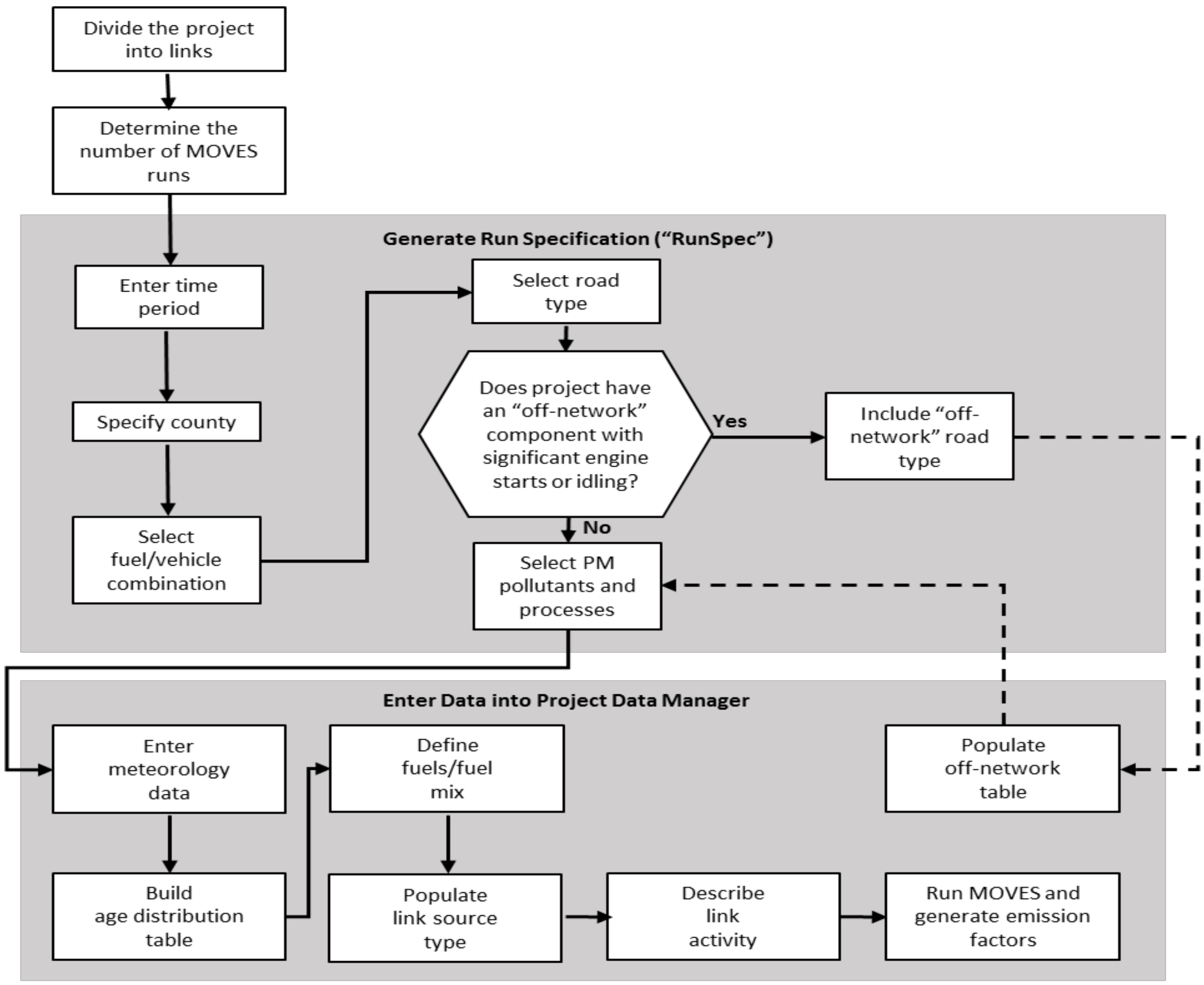
98 EPA, *Guideline for Modeling Carbon Monoxide from Roadway Intersection*, November 1992 [EPA-454/R-92-005], http://www.epa.gov/scram001/guidance/guide/coguide.pdf.

99 EPA, *Using MOVES in Project-Level Carbon Monoxide Analyses*, December 2010 [EPA-420-B-10-041], http://www.epa.gov/oms/stateresources/transconf/policy/420b10041.pdf.

E.2.4.2 PM Emissions Modeling

MOVES is the EPA-approved model to estimate PM exhaust, brake wear, and tire wear emissions for PM hot-spot analyses outside of California. **Figure E-2** (*Steps for Using MOVES in a Quantitative PM Hot-spot Analysis*) provides the necessary steps for applying the MOVES model for project-level PM hot-spot analyses.

Figure E-2. Steps for Using MOVES in a Quantitative PM Hot-spot Analysis



Source: EPA, *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Non-attainment and Maintenance Areas*, November 2013 [EPA-420-B-1013-040053].

Additionally, for PM_{10} and $PM_{2.5}$ hot-spot analyses emissions from road dust,[100,101] construction[102], and additional sources should be accounted for when applicable.

MOVES includes a default database of meteorology, fleet, activity, fuel, and control program data for the entire U.S., which comes from a variety of sources which are not necessarily the most accurate or up-to-date information available at the local level for a particular project. EPA's *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} nonattainment and Maintenance Areas*[103], provides guidance on when it is appropriate to use MOVES' default databases for a PM hot-spot analysis, as well as when available local data must be used also defined in 40 CFR 93.110 and 93.123(c).

The EMFAC model issued by the CARB is approved by EPA for developing on-road motor vehicle emission inventories and hot-spot analyses in California. EMFAC produces composite emission factors for an average day of a month (January to December), a season (summer and winter), or an annual average, for specific California geographic areas by air basin, district, and county as well as the statewide level. EMFAC can produce $PM_{2.5}$ and PM_{10} emission rates for three exhaust emission processes (running, starting, and idle), tire wear, and brake wear.[104] **Figure E-3** (*Steps for Using EMFAC in a Quantitative PM Hot-spot Analysis*) illustrates the steps to using EMFAC to complete a PM hot-spot analysis.

100 Re-entrained road dust must be considered in $PM_{2.5}$ hot-spot analyses only if EPA or the state air agency has made a finding that such emissions are a significant contributor to the $PM_{2.5}$ air quality problem in a given nonattainment or maintenance area (40 CFR 93.102(b)(3) and 93.119(f)(8)). See the July 1, 2004 final conformity rule (69 FR 40004).

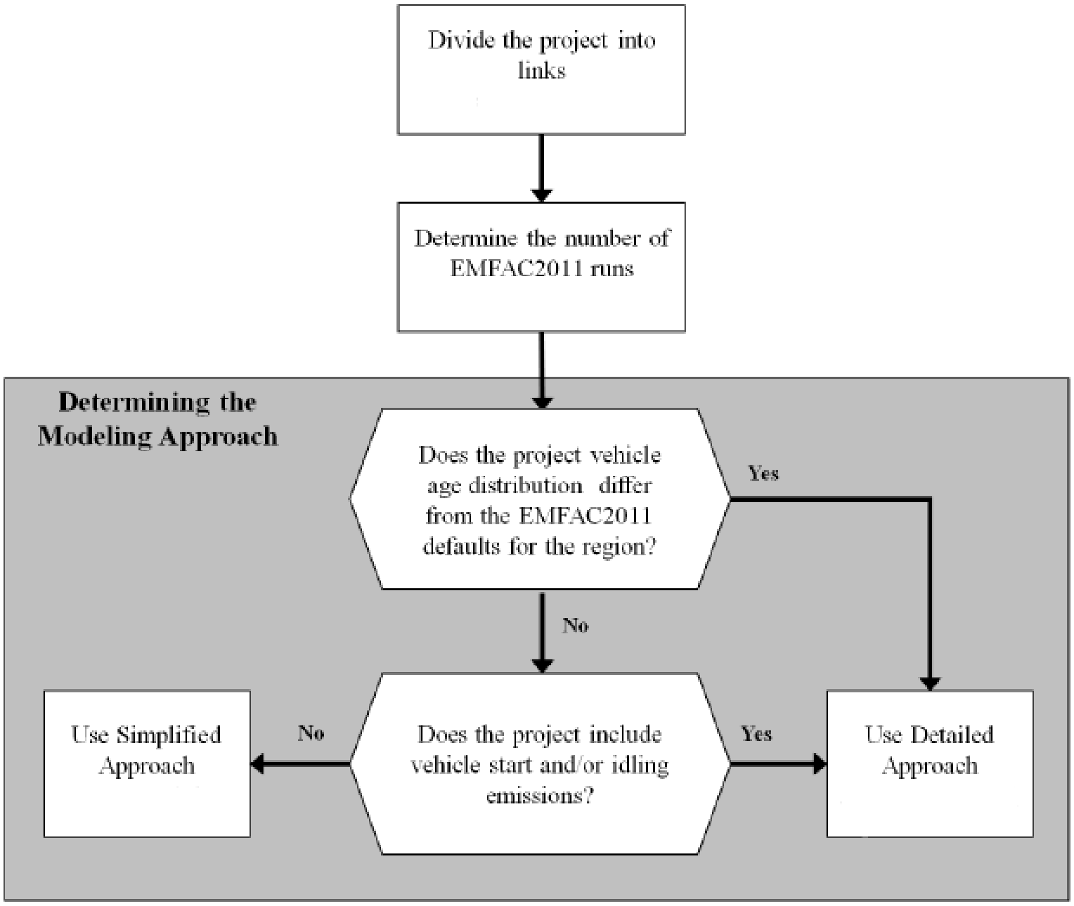
101 Re-entrained road dust must be included in all PM_{10} hot-spot analyses. Because road dust is a significant component of PM_{10} inventories, EPA has historically required road dust emissions to be included in all conformity analyses of direct PM_{10} emissions – including hot-spot analyses. See the March 2006 final rule (71 FR 12496-98).

102 Emissions from construction-related activities are not required to be included in PM hotspot analyses if such emissions are considered temporary as defined in 40 CFR 93.123(c)(5) (i.e., emissions which occur only during the construction phase and last five years or less at any individual site).

103 EPA, *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Non-attainment and Maintenance Areas*, November 2013 [EPA-420-B-13-053], http://www.epa.gov/otaq/stateresources/transconf/policy/420b13053-sec.pdf.

104 EPA, *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Non-attainment and Maintenance Areas,* November 2013 [EPA-420-B-13-053], http://www.epa.gov/otaq/stateresources/transconf/policy/420b13053-sec.pdf.

Figure E-3. Steps for Using EMFAC in a Quantitative PM Hot-spot Analysis



Source: EPA, *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Non-attainment and Maintenance Areas*, November 2013 [EPA-420-B-1013-040053].

E.2.5 Select Receptor Site Locations

The locations at which concentrations are estimated are known as "receptors". EPA's *Guideline on Air Quality Models*[105] provides guidance on the selection of receptor sites and recommends that receptor sites be placed to estimate the highest potential concentrations.

When completing a CO hot-spot analysis, receptors should be placed at each approach on both sides of the roadway where traffic queues develop (i.e., at least three meters from each of the traveled roadways which make-up the intersection). Other examples of reasonable receptor sites include the following:

- Sidewalks to which the general public has access on a continuous basis;
- A vacant lot near an intersection, where the general public would have continuous access;
- Portions of a nearby parking lot to which pedestrians have continuous access;
- In the vicinity of parking lot entrances and exits, provided a nearby area contains a public sidewalk, residences, or structures to which the general public is likely to have continuous access; and
- Property lines of residences, hospitals, rest homes, schools, playgrounds, and the entrances and ground-level air intakes to all other buildings.

For further guidance on the selection of receptor locations for CO hot-spot analyses, refer to EPA's *Guideline for Modeling Carbon Monoxide from Roadway Intersection*[106].

Additionally, the selection of receptor sites for PM hot-spot analyses should be determined on a case-by-case basis taking into account project-specific factors that may influence areas of expected high concentrations, such as prevailing wind directions, monitor locations, topography, and other factors. Typically, receptors should be sited as near as five meters from a source (e.g., the edge of a traffic lane or a source in a terminal. For further guidance on the selection of receptor locations for PM hot-spot analyses refer to EPA's *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in* $PM_{2.5}$ *and* PM_{10} *Nonattainment and Maintenance Areas* mentioned above.

EPA recommends that receptors should be positioned to represent concentrations near-ground level, generally at a height of 1.8 meters (approximately 6 feet) above grade. Receptors should also be placed at higher elevations (if needed) to represent concentrations at different heights along multi-story buildings, such as apartment or office buildings.

Finally, when completing air quality modeling for Build and No-Build scenarios, receptors should be placed in the same locations in both scenarios so that direct comparisons can be made between the concentrations calculated at each receptor.

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105 *Appendix W to Part 51 – Guideline on Air Quality Models*, http://www.ecfr.gov/cgi-bin/text-idx?SID=e6a5b817b94abf58460f48c032d9a39c&node=40:2.0.1.1.2.23.11.5.37&rgn=div9.

106 EPA, *Guideline for Modeling Carbon Monoxide from Roadway Intersections*, http://www.epa.gov/scram001/guidance/guide/coguide.pdf.

E.2.6 Select Dispersion Models

CAL3QHC and CAL3QHCR are the two EPA-approved mobile source dispersion models used to predict CO and PM (i.e., PM_{10} and $PM_{2.5}$) concentrations, respectively, at sensitive receptor locations adjacent to highway and roadway intersections[107]. Information on EPA's recommended models is detailed in EPA's *Guideline on Air Quality Models* mentioned above.

The CAL3QHC model is an effective tool for predicting hourly CO emissions due to motor vehicles operating under free-flow conditions and from idling vehicles under stop-and-go conditions (or queuing conditions) near signalized intersections. The model's inputs include roadway geometries, traffic data, receptor locations, meteorological conditions, and vehicular emission rates (estimated using either EPA's MOVES or California's EMFAC). Additionally, it incorporates intersection-specific parameters and detailed signal information (e.g., signal timing and intersection lane assignments) to predict 1-hour and 8-hour CO concentrations at near-by sensitive receptors.

The CAL3QHCR is the refined, yet independent version of CAL3QHC that has the capability to predict 1-hour, 8-hour, 24-hour, and annual concentrations, with the use of a full year of hourly meteorological and traffic data; thus CAL3QHCR is better suited for PM hot-spot analyses. Notably, when using the CAL3QHCR for PM hot-spot analysis for highway and roadway intersection projects, its queuing algorithm should not be used.[108] CAL3QHCR should be used for CO when a CAL3QHC analysis with conservative assumptions indicates a potential to exceed the NAAQS.

Additionally, EPA has also approved AERMOD as a recommended air quality model for completing PM hot-spot analyses for different types of transportation projects (e.g., parking facilities). Refer to EPA's *Transportation Conformity Guidance for Quantitative Hot-Spot Analyses in* $PM_{2.5}$ *and* PM_{10} *Nonattainment and Maintenance Areas* mentioned above, for complete information on selecting an appropriate air quality model.

The CAL3QHC and CAL3QHCR model inputs and their respective parameters are provided in **Table E-5** (*CAL3QHC and CAL3QHCR Model Input Data*) and further discussed in this section.

Table E-5. CAL3QHC and CAL3QHCR Model Input Data

Model Inputs	Parameters	Units
Roadway Geometry	• Free flow link coordinates (x, y, z) • Queue link coordinates (x, y, z) • Mixing zone width • Link Height	• Meters or feet
Traffic Data[1]	• Traffic Volume	• Vehicle per hour

[107] EPA's Technology Transfer Network (TTN) Support Center for Regulatory Atmospheric Modeling website at: http://www.epa.gov/scram001/dispersion_prefrec.htm for latest model guidance, updates and revisions.

[108] EPA, *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in* $PM_{2.5}$ *and* PM_{10} *Non-attainment and Maintenance Areas,* November 2013 [EPA-420-B-13-053], http://www.epa.gov/otaq/stateresources/transconf/policy/420b13053-sec.pdf.

Model Inputs	Parameters	Units
	• Traffic Speed • Average Signal Cycle Length • Average Red Time Length • Clearance Lost Time • Saturation Flow Rate (optional) • Signal type (optional) • Arrival rate (optional)	• Miles per hour • Seconds • Seconds • Seconds • Vehicle per hour • Pre-timed, actuated, or semi-actuated • Worst, below average, average, above average, best progression
Receptor Location	• Receptor coordinates (x, y, z)	• Meters or feet
Meteorological Conditions[1]	• Averaging Time • Surface Roughness coefficient • Settling Velocity • Deposition Velocity • Wind Speed • Stability Class • Mixing Height	• Minutes • Centimeters • Centimeters per second • Centimeters per second • meters per second • 1 to 6 = A to F • meters
Vehicular Emission Rates[2]	• Composite Running Emission Factor • Idle Emission Factor	• Gram per vehicle-mile • Gram per vehicle-hour

Source: EPA, *User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections*, November 1992 [EPA-454-R-92-006], http://www.epa.gov/ttn/scram/userg/regmod/cal3qhcug.pdf, and *User's guide to Cal3qhc version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections (Revised)*, September 1995, [EPA-454/R-92-006R], http://www.epa.gov/scram001/userg/regmod/cal3qhcug.pdf.

Note:

[1] The CAL3QHCR model uses a two-tiered approach. Tier I, a full year of hourly meteorological (MET) data are entered into CAL3QHCR in place of the one hour of meteorological data that are commonly entered into CAL3QHC. One hour of emissions, traffic volume, and signalization (ETS) data are also entered as is done when using CAL3QHC. In Tier II, the same MET data as used in the Tier I approach are entered into the model. The ETS data however, are more detailed and reflect traffic conditions for each hour of a week.

[2] The latest versions of EPA's MOVES or California's EMFAC should be used to estimate vehicular emission rates used as inputs to CAL3QHC and CAL3QHCR.

E.2.6.1 Roadway Geometry

Roadway geometry is the geometric dimensions of each intersection such as lane configuration, roadway widths, and roadway links. The position of these elements (such as *free-flow* and *queue* links) should be specified by using an x, y, and z coordinate system typically using the center of the intersection as the origin point with a coordinate of (0, 0).

Each free-flow link is placed on each lane group that serves different directions and has different characteristics such as traffic volume, emission factor, width and height. Each free-flow link begins in the center of the intersection and is aligned with the respective approach either in the x- or the y-directions and is positioned in the middle of each lane group. Three meters should be added to either side of each free-flow link to account for the dispersion of the plume generated by the wake of moving vehicles, known as the "mixing zone". A link height of 0 meters is typically applied; however, the model accepts link heights no greater than 10 meters and no less than -10 meters. Queue links are defined as a straight segment of roadway with a constant width and emission source strength on which vehicles are idling for a specified period of time. The queue link is placed at the point where queuing begins at the intersection. A mixing zone width is not needed for queue links since vehicles are not moving and no turbulence is generated. **Figure**

E-4 (*Example of Roadway Geometry*)[109] illustrates example roadway geometry for a two-way intersection (units in feet).

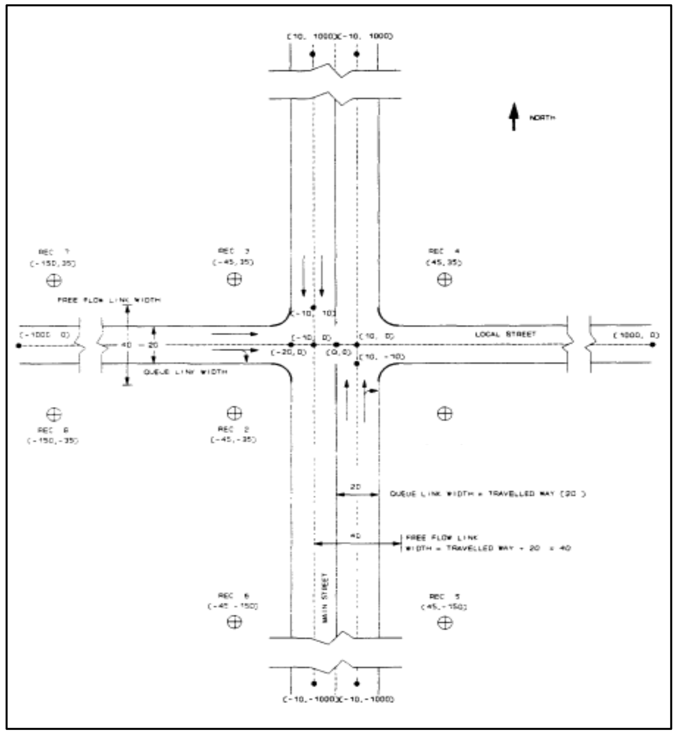

Figure E-4. Example Roadway Geometry

E.2.6.2 Traffic Data

Typically, total traffic volumes, turning movements, saturation flow rates, total signal length, control type, and red/yellow/green time are detailed in Highway Capacity Model (HCM's) SYNCHRO traffic data reports. This information is required for each scenario (e.g., existing, no-build, and build), time period (e.g., AM and PM peak hours) and analysis year(s). This will allow the air quality analyst to accurately represent all free-flow and turning lane geometry for the CAL3QHC and/or CAL3QHCR dispersion model. For PM, hourly traffic data is neccessary.

E.2.6.3 Meteorological Data

Local meteorological conditions must be specified when conducting a hot-spot analysis. The typical meteorological inputs into CAL3QHC are summarized in **Table E-6** (*Typical Meteorological Inputs*). However, site-specific data for these parameters supersedes any default value.

Table E-6. Typical Meteorological Inputs

Solvent	Typical Values
Averaging Time	30 min to 60 min
Surface Roughness coefficient	3 cm to 400 cm
Settling Velocity	0 cm/s
Deposition Velocity	0 cm/s
Wind Speed	1 m/s
Stability Class	Urban = D(4) and Rural = E(5)]
Mixing Height	1000 m
Source: EPA, *Addendum to The User's Guide to CAL3QHCR Version 2.0 (CAL3QHCR User's Guide)* by Peter A. Eckhoff and Thomas N. Braverman, September 1995, http://www.epa.gov/scram001/userg/regmod/cal3qhcrug.pdf.	

[109] Figure excerpted from EPA's *User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections*, November 1992 [EPA-454-R-92-006], http://www.epa.gov/ttn/scram/userg/regmod/cal3qhcug.pdf.

As previously mentioned, the CAL3QHCR model uses a full year of hourly meteorological data. Use of representative meteorological data that has been collected on-site is preferred; however, if on-site data is not available, National Weather Service (NWS)[110] data, representative of the area being modeled, is acceptable. If NWS data is used, the model must be run for five consecutive meteorological years.[111]

E.2.6.4 Vehicular Emission Rates

Vehicular emission rates are estimated for queuing and idling vehicles using the EPA-approved models: MOVES and California's EMFAC. Emission rates for each idling and queuing link are input into the CAL3QHC/R model as gram per vehicle-mile and gram per vehicle-hour, respectively. Refer back to **Section E.2.4** (*Estimate On-Road Vehicle Emissions*) for the steps on how to generate emission factors with MOVES and California's EMFAC models.

E.2.7 Estimate Background Data

Once the project-level emissions and dispersion modeling analysis is complete and pollutant concentrations associated with the project have been computed, representative background concentrations should be added to the predicted worst-case project-level concentration (for both CO and PM). Background concentrations are typically obtained from a background monitoring site not affected by the intersection(s) of interest. EPA's AirData provides background monitoring data at different monitoring locations collected across the U. S. for the seven criteria pollutants.[112]

The evaluation and selection of monitoring data for use in a particular analysis must follow the process defined in each area's interagency consultation procedures. Background monitored data should also be adjusted for future-year conditions. Methods used to compute future background concentrations for CO and PM hot-spot analyses are detailed in EPA's *Guideline for Modeling Carbon Monoxide from Roadway Intersection*, and EPA's *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas*, respectively, mentioned above.

[110] National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS) at http://www.weather.gov/.

[111] EPA, *Addendum to The User's Guide to CAL3QHC Version 2.0 (CAL3QHC User's Guide)* by Peter A. Eckhoff and Thomas N. Braverman, September 1995, http://www.epa.gov/scram001/userg/regmod/cal3qhcrug.pdf.

[112] EPA's AirData can be accessed from the following website: http://www.epa.gov/airdata/ad_rep_mon.html.

APPENDIX F - Data and Information Sources

This appendix lists the data and information sources that can be consulted when developing an emission inventory, dispersion modeling, roadway intersection and/or air quality monitoring analysis for a proposed airport project or action.

Analysis Type	Source Type	Parameter	Data Source	Description
Emission Inventory	Aircraft	Operational Data	Terminal Area Forecast (TAF)	Forecasts aviation activity at active airports in the National Plan of Integrated Airport System (NPIAS). This information can be accessed at the following website: http://aspm.faa.gov/main/taf.asp.
			The Operations Network (OPSNET)	Provides airport activity level (per air carrier, air taxi, general aviation, and military). This data source contains proprietary information and requires an FAA registered user name and password. After acquiring a login from FAA, this information can be accessed at the following website: https://aspm.faa.gov/opsnet/sys/Default.asp.
			Air Carrier Statistics Database (T-100 database)	Earliest data year is 1990. Periods of data available for a month, a quarter, and a year. Form 41/T-100 records are available for all of the airports in FAA's NPIAS and 313 additional air transportation facilities. The T-100 database does not capture every aircraft operations at the airport; only those that have been reported. The T-100 database can be accessed at the following website: http://www.transtats.bts.gov/tables.asp?db_id=111&DB_Name=.
			Airport IQ5010™ Airport Master Records and Reports	The *Based Aircraft & Operations* section of these reports provides operational data; this information can also be used to develop a general fleet mix. This information can be accessed at the following website: http://www.gcr1.com/5010web/.
			Airport Noise & Operations Monitoring System (ANOMS)	Reports aircraft operations, including aircraft type (such as passenger, cargo, general aviation and other); however, airports are not required to have an ANOMS so systems are in limited use.

Analysis Type	Source Type	Parameter	Data Source	Description
			JP Airline Fleets	Provides airport activity level. The information is proprietary and can be purchased at the following website: http://www.buchair.com/JPAF.htm.
			Traffic Flow Management System Counts (TFMSC) database	Records aircraft operations at a facility that are either detected under Instrumental Flight Rules (IFR) by Air Traffic Control (ATC), or for which pilots have filed a flight plan, only a subset of the military and GA operational activity is available via TFMSC. After acquiring a login from FAA, this information can be accessed at the following website: https://aspm.faa.gov/tfms/sys/.
		Fleet Mix	Airline Information	Can be initiated through request that the airline/tenant perform a survey of the engines deployed on the aircraft operating at the airport. While this approach would have the highest fidelity, the data is rarely available. Airline financial reports (i.e., K1s) may also report aircraft and engines.
			JP Airline Fleets	Provides comprehensive aircraft information (including current registration, type, serial number, previous identity, date of manufacture, date of delivery, engine type and number, maximum take-off weight, configuration, fleet number, name, etc.). The information is proprietary and can be purchased at the following website: http://www.buchair.com/JPAF.htm.
			OAG Absolute Aviation Advantage	Provides flight schedules, flight status and aviation data for over 900 airlines and over 4,000 airports. Proprietary source; can be ordered at the following website: http://www.oag.com/Global.
			Emissions and Dispersion Modeling System (EDMS)/Aviation Environmental Design Tool (AEDT)	Requires knowledge of the computer model. Default values, which are based on common aircraft/engine assignments for the U.S. aircraft fleet, may be assigned. AEDT 2b and subsequent versions will replace EDMS and will be available at the following website: http://aedt.faa.gov/. Until replaced by AEDT 2b, EDMS is available from the FAA at the following website: http://www.faa.gov/about/office_org/headquarters_offices/apl/research/m

Analysis Type	Source Type	Parameter	Data Source	Description
				odels/edms_model/.
			Airport Noise Monitoring System (ANOMS)	Provides tail number, aircraft type, runway usage, airline, operation type (i.e., arrival and departure), and the destination/origin for aircraft operations. The ANOMS does not capture every aircraft operations at an airport. Airports are not required to have an ANOMS so systems are in limited use.
			Air Carrier Statistics Database (T-100 database)	Earliest data year is 1990. Periods of data available for a month, a quarter, and a year. Form 41/T-100 records are available for all of the airports in FAA's NPIAS and 313 additional air transportation facilities. This database is best suited for deriving fleet mix than operational data. This database can be accessed at the following website: http://www.transtats.bts.gov/tables.asp?db_id=111&DB_Name=.
		Time-in-mode (TIM)	EDMS/AEDT	Includes default data for each TIM. Requires knowledge of the computer model. AEDT 2b and subsequent versions will replace EDMS and will be available at the following website: http://aedt.faa.gov/ Until replacement by AEDT 2b, EDMS is available from the FAA at the following website: http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/.
			Aviation System Performance Metrics (ASPM)	Provides detailed data on flights to and from the ASPM airports; and all flights by the ASPM carriers, including flights by those carriers to international and domestic non-ASPM airports. All IFR traffic and some Visual Flight Rules (VFR) traffic are included. ASPM also includes airport weather, runway configuration, and arrival and departure rates. This combination of data provides a robust picture of air traffic activity for airports and air carriers. This information is proprietary and requires an FAA registered user name and password. After acquiring a login from FAA, this information can be accessed at the following website:

Analysis Type	Source Type	Parameter	Data Source	Description
				https://aspm.faa.gov/aspm/entryASPM.asp?lite=y.
			Bureau of Transportation Statistics (BTS)	Provides aircraft statistics, including taxi in and taxi-out data for specific airlines at 287 airports. Annual data available beginning with the year 1995. This information can be accessed at the following website: http://apps.bts.gov/xml/ontimesummarystatistics/src/dstat/OntimeSummaryDepatures.xml.
	Stationary	Operational Data	Operating Permits (Title V operating permits)	Legally enforceable documents that permitting authorities (i.e., federal, regional, state and/or local air agencies) issue to major stationary air pollution sources after the source has begun to operate. Under Title V of the Clean Air Act (CAA), any source that emits or has the potential to emit 100 tons per year or more of any criteria air pollutant is a *major source* and must obtain a Title V operating permit. This information may be limited as not all stationary sources at airports fall under this category.
		Emission Factors	Emissions & Generation Resource Integrated Database (eGRID)	This is a comprehensive source of data on the environmental characteristics of almost all electric power generated in the U.S., which emissions rates; net generation; resource mix; and many other attributes. This information can be accessed at the following website: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html
			AP-42	Emission factors are available from the EPA document *Compilation of Air Pollution Emissions Factors (i.e., AP-42)*, that can be accessed at the following website: http://www.epa.gov/ttnchie1/ap42/.
			Energy Information Administration (EIA)	Greenhouse gas (GHG) emission factors and global warming potentials (GWPs) are available from the *Voluntary Reporting of Greenhouse Gases Program*. This information can be accessed at the following website: http://www.eia.gov/survey/form/eia_1605/emission_factors.html.
			EDMS/AEDT	Includes default data for emission factors for stationary sources

Analysis Type	Source Type	Parameter	Data Source	Description
				(including, boilers, heaters, emergency generators, etc.). Requires knowledge of the computer model. AEDT 2b and subsequent versions will replace EDMS and will be available at the following website: http://aedt.faa.gov/ Until replacement by AEDT 2b, EDMS is available from the FAA at the following website: http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/.
	Ground Access Vehicles	Traffic Data	Relevant Airport Traffic Study	If available, most recent airport traffic study that includes traffic volumes, speeds, mileage, ridership, and vehicle mix data is the most optimal source.
		Vehicle-miles-travelled (VMT)	Automatic Vehicle Identification (AVI)	This system identifies, monitors, tracks, and collects data on vehicle movements, enabling better management of a variety of airside and landside vehicle activities. This information may be limited as not all airports have this tracking system in place.
		Emission Factors (On-Road)	MOVES	Although a full range of default data is available in MOVES, the allocation of the default data down to the county level is based on a generalized algorithm and is not the most recent nor best available local data. Requires knowledge of the computer model. Model is available from the EPA at the following website: http://www.epa.gov/otaq/models/moves/index.htm
			EMFAC	EMFAC is California's model for estimating emissions from on-road vehicles operating in California. EMFAC was issued by CARB but is also EPA-approved. The model is available from the CARB at the following website: http://www.arb.ca.gov/msei/modeling.htm.
		Emission Factors (Off-Road)	NONROAD	Requires knowledge of the computer model. Model is available from the EPA at the following website: http://www.epa.gov/otaq/nonrdmdl.htm.

Analysis Type	Source Type	Parameter	Data Source	Description
		Emission Factors (Fugitive Dust)	AP-42	Emission factors are available from the EPA document *Compilation of Air Pollution Emissions Factors (i.e., AP-42)*, that can be accessed at the following website: http://www.epa.gov/ttnchie1/ap42/.
		Emission Factors (Evaporative Emissions)	National Association of Clean Air Agencies (NACAA, formerly STAPPA/ALAPCO)	Emission factors are available from the EPA document *Evaluation of Emissions from Paving Asphalts*, EPA-600/R-94-135, August 1994, that can be accessed at the following website: http://nepis.epa.gov/Exe/ZyNET.exe/P1006G50.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1991+Thru+1994&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C91thru94%5CTxt%5C00000022%5CP1006G50.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL.
Dispersion Modeling	All sources	Model	EDMS/AEDT	The FAA requires the use of the EDMS for air quality analyses of airport emission sources. EDMS allows dispersion analysis for both aviation and non-aviation sources at airports. AEDT 2b and subsequent versions will replace EDMS and will be available at the following website: http://aedt.faa.gov/ Until replacement by AEDT 2b, EDMS is available from the FAA at the following website: http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/.
			AERMOD	AERMOD is integrated into EDMS/AEDT; it generates input files to be processed by AERMOD. Model is available from the EPA at the following website:

Analysis Type	Source Type	Parameter	Data Source	Description
				http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod.
		Meteorological	AERMET	AERMET is a meteorological data preprocessor for AERMOD. AERMET processes commercially available or custom on-site met data and creates two files: a surface data file and a profile data file. Information on the AERMET processor is available from the EPA at the following website: http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm#aermet.
			National Climate Data Center (NCDC)	Climate and historical data and information is available from this source. The data are site-specific and based upon the most recent set of "real-world" measurement data near an airport. This information is available at the following website: http://www.ncdc.noaa.gov/cdo-web/
		Mixing Height	EPA	*EPA's Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States*. This 1972 publication (also called the "Holzworth" report) contains data and graphs depicting mixing heights for mean annual morning and mean summer afternoon conditions across the U.S., by season (e.g., winter, summer, etc.). This document can be accessed at the following website: http://nepis.epa.gov/Exe/ZyNET.exe/20013CDS.TXT?ZyActionD=ZyDocument&Client=EPA&Index=Prior+to+1976&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C70thru75%5CTxt%5C00000005%5C20013CDS.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

Analysis Type	Source Type	Parameter	Data Source	Description
		Terrain Data	AERMAP	AERMAP is a terrain preprocessor for AERMOD. AERMAP processes commercially available digital elevation data and creates a file suitable for use within an AERMOD control file. Information on AERMAP is available from the EPA at the following website: http://www.epa.gov/ttn/scram/dispersion_related.htm#aermap.
			Digital Elevation model (DEM) Data/National Elevation Dataset (NED)	Elevation data needed to process AERMAP. AERMAP has been revised to support processing of terrain elevations from the NED developed by the U.S. Geological Survey (USGS); however, it still has the capabilities to support terrain elevations in the original DEM format. These data sets can be accessed at the following website, respectively: http://ned.usgs.gov/ and http://ngdc.noaa.gov/mgg/dem/.
		Background Data	Air Data	Earliest data year is 1980. Background monitoring data collected across the U.S. at different monitoring locations for the seven criteria pollutants can be accessed from the EPA at the following website: http://www.epa.gov/airdata/ad_rep_mon.html.
Roadway Intersection Analysis	Mobile Sources	Traffic and Geometry Data	Traffic Impact Analysis of signalized intersections	A traffic analysis of signalized intersections within study area, including roadway geometry, traffic volumes, speeds, Highway Capacity Manual (HCM) Synchro sheets (red/yellow/green timing/delays), level-of-service (LOS), is the most optimal source.
		Model	CAL3QHC/ CAL3QHCR	CAL3QHC is a computer based model that predicts carbon monoxide (CO) or other inert pollutant concentrations from motor vehicles at roadway intersections. The model includes the CALINE-3 line source dispersion model and a traffic algorithm for estimating vehicular queue lengths at signalized intersections. CAL3QHCR is a more refined version based on CAL3QHC that requires local meteorological data. Models can be accessed from the EPA at the following website: http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#cal3qhc.
		Emission	MOVES or EMFAC	Requires knowledge of the computer models. MOVES is available from

Analysis Type	Source Type	Parameter	Data Source	Description
		Factors		the EPA at the following website: http://www.epa.gov/otaq/models/moves/index.htm. EMFAC is available from the CARB at the following website: http://www.arb.ca.gov/msei/modeling.htm.
		Background Data	Air Data	Earliest data year is 1980. Background monitoring data collected across the U.S. at different monitoring locations for the seven criteria pollutants can be accessed from EPA at the following website: http://www.epa.gov/airdata/ad_rep_mon.html.
Air Quality Monitoring			Air Data	Access to air quality data collected at outdoor monitors across the U.S., Puerto Rico, and the U.S. Virgin Islands. The data comes primarily from EPA's AQS (Air Quality System) database. The data can be: 1) downloaded into a file, 2) generated as one of AirData's standard reports, 3) graphically displayed using one of the visualization tools, and 4) viewing via interactive map. This information can be accessed from EPA at the following website: http://www.epa.gov/airdata/.
Source: Environmental Protection Agency (EPA), 2013, www.epa.gov; Federal Aviation Administration (FAA), 2013, www.faa.gov; California Air Resource Board (CARB), 2013, www.arb.ca.gov; National Oceanic and Atmospheric Administration (NOAA), 2013, www.noaa.gov; OAG, 2013; and Energy Information Administration (EIA), 2013, www.eia.gov.				