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THE BALANCE SHEET TECHNIQUE

Volume I: The Balance Sheet Analysis Technique for Preconstruction Review of Airports and Highways

by

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Draft Report

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THE BALANCE SHEET ANALYSIS TECHNIQUE FOR PRECONSTRUCTION REVIEW OF AIRPORT AND HIGHWAY PROJECTS

1. INTRODUCTION

1.1 PURPOSE AND HISTORY OF THE TECHNIQUE

This report describes and applies a technique to enable state air pollution control agencies to review proposed air carrier airport projects for their impact on photochemical oxidant levels. The balance sheet approach relies on the specification of the maximum allowable emissions of oxidant precursors, hydrocarbons (HC) and oxides of nitrogen (NO_x), from the region for the planning horizon. The airport project is judged acceptable if its emissions plus the other emissions in the region remain below this maximum desired level. If they do not, then the balancing process begins. The airport must lessen its own projected emission levels (an internal trade-off) or other emission sources that can reduce their projected emissions must be identified, so as to keep the regional emission totals under the desired levels. This technique was first proposed by Region II of the EPA in the context of the review of the New York-New Jersey highway system plan, but the full analysis has not yet been completed. This technique will be applied to four test cases, two airports and two highways. Some of the experiences of Region II is incorporated into the discussion of the highway test cases. This technique is distinct from the 'offset policy' (40 FR 55524) published by U.S. EPA, which applies only in non-attainment areas, with regard to location of new or modified sources. The balance sheet is applicable in all regions, and herein is applied only in the context of airport and highways.

In the case of airports, the technique is intended for project-by-project review. This is in sharp contrast to its use in highway review, where a single highway project is reviewed in the context of the 5 or 10 year highway system plan. The system plan is initially reviewed for consistency with the regional air quality plans, vastly simplifying the review of each project as it comes up. As only a few regions have more than one major air carrier airport, the system planning concept holds little value for review of airport projects. The major differences in application of the technique to systems or to projects come after the need for balancing is determined. The trade-offs available for system level review are characterized by fewer constraints since this stage is, by definition, an early planning stage. In project level review, the airport operator is closer to actual construction and the available airport trade-offs are more heavily constrained. These differences, although significant to the control strategy employed, do not influence the application of the balance sheet approach since the comparison against desired emission levels is the crux of the technique and is unchanged in either application. However, as airport planning becomes more regionally and nationally coordinated, and locally integrated with highway and transit planning, the air pollution control agency should take the opportunity to review projects in the earliest stages of planning in the context of the overall transportation system. Relief of airside congestion via an improved system of regional airports is a relatively new concept in airport planning that holds promise for air quality improvements. Better coordination with ground transportation facilities, as well as alterations to the terminal and parking layout, can ease the landside auto traffic congestion and also lead to an improved air quality picture.

1.2 OVERVIEW OF THE TECHNIQUE

Preconstruction review of airport projects requires information from the airport operator and from the reviewing agency. In general the airport must supply all the data necessary for analysis of the emissions from the airport and the growth induced by the project. The reviewing agency must supply the regional emissions inventory and the desired regional emission levels. The first step is to determine whether the proposed airport project meets the federally-determined criteria for review: an expected growth, over ten years, of 1.6 million annual passengers or 50,000 annual operations. The criteria are related to the expected growth in auto traffic. If the airport meets one of these criteria then the analysis proceeds. In most cases, the regional emissions data will be available from the ongoing air quality planning process. With the aid of the models listed in Section 2.2, the airport's emissions can all be computed from the basic airport activity forecasts of operations and passengers. With this emission data, the decision process sketched on Fig. 1.1 is begun. The technique allows for incorporation of the detailed base year airport emissions inventory produced for this review into the regional inventory through the use of the correction term. The detailed airport inventory now in the regional inventory supplies the regional desired emission levels for the forecast period (10 years). When

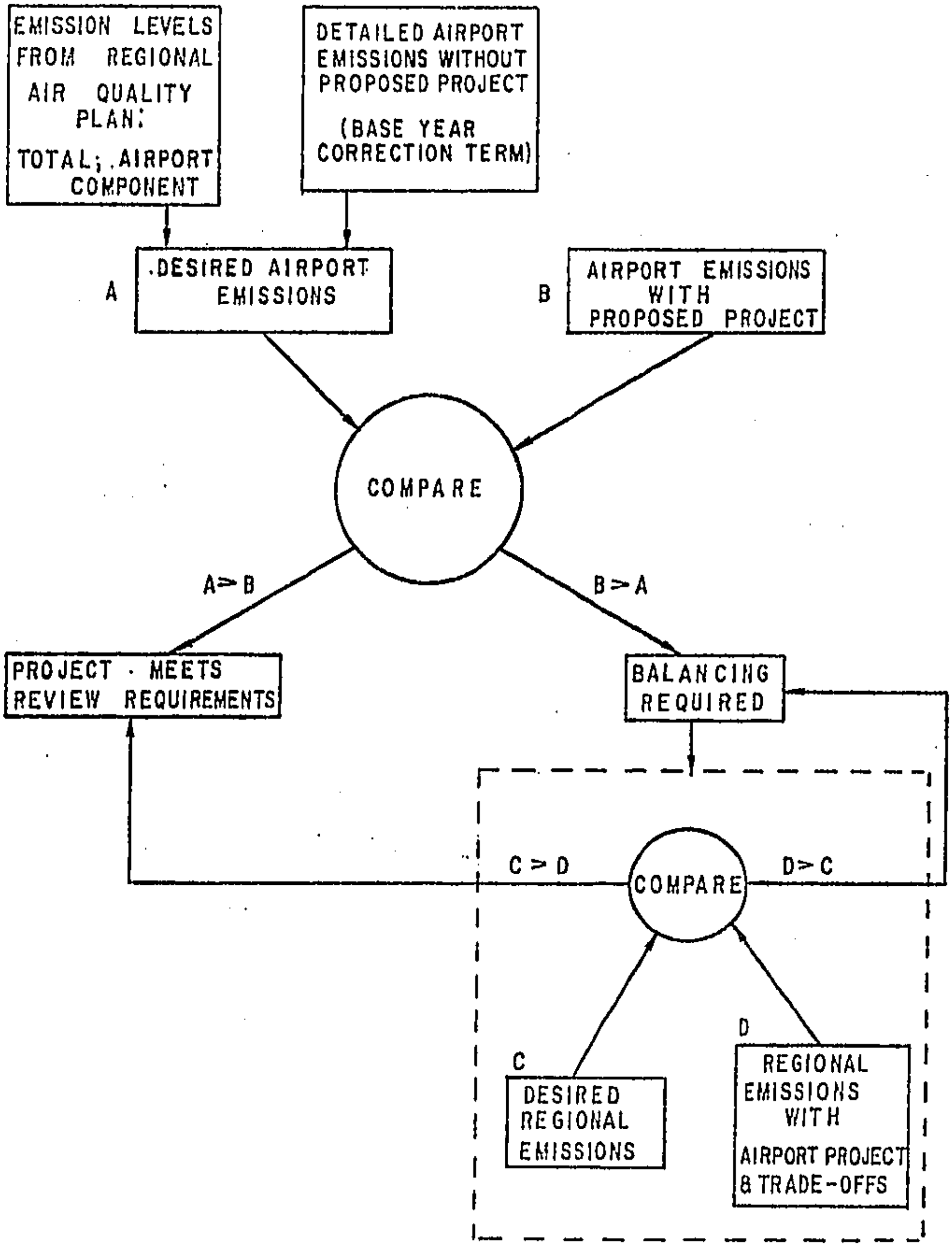

Fig.1.1. Decision Points in the Balance Sheet Analysis Technique

the desired emission levels are determined, the regional emission totals with the airport project (B on Fig. 1.1) can be compared to the desired levels (A) and a judgment made as to the acceptability of the project as proposed. If the emissions are too high, trade-offs can be made, either internal to the airport or with other pollutant sources in the region. On final balance, the projected regional emission totals must be at or below the desired levels.

This review technique is meaningful only in the context of proportional reduction modeling, using HC or HC/NO_x emission data. Simulation models use more information than emission totals to determine the resulting air quality. Thus such models should be used directly to test an emission reduction strategy. It is not necessary to carefully balance the trade-offs, since other factors considered by simulation models may dominate in producing a significant change in air quality in the region.

In general, it is expected that most reviews will take place in large metropolitan areas with extensive transportation and air quality data bases. As a result, the level of complexity of the computations should pose no problem. All computations can be done by hand, or with the aid of computerized models, at the discretion of the airport and the reviewing agency. The technique is highly adaptable to the many different local situations regarding the kinds of emissions data available.

1.3 DESCRIPTION OF REPORT

In the next section, the balance sheet technique is described in detail. In the first subsection, the many alternatives for each aspect of the preconstruction review technique are described and recommendations made for each. In particular the issue of the appropriate size for the study or analysis region for the review is presented in detail. The general procedures for forecasting emissions from the airport and induced growth sources are outlined in Section 2.2, along with a summary of the available emissions for each source. In Section 2.3, the concept of the desired emission level is explained, and the method of determining this level in conjunction with existing air quality planning procedures is demonstrated. Additionally, the three methods for determining required changes in precursor emissions levels to attain and maintain the oxidant air quality standard are reviewed in the context of the balance sheet analysis technique. The last subsection highlights the elements of the critical comparisons to determine the need for emissions trade-offs. A detailed overview of the complete analysis technique is provided followed by a suggested procedure for updating.

Section 3. presents the results of two test cases, one new airport and one modified airport. Using data from actual situations, the balance sheet technique is applied. Conclusions regarding its usefulness in reviewing airport projects are presented in Section 3.3. In the next chapter, Section 4., the difficulty of application of the technique to highway projects is explained in the context of two urban highway test cases. General conclusions are presented in the last section. The two appendices present the detailed tables supporting the results in the airport test cases in Section 3. Appendix A, in particular, contains all the data and describes the procedures to do a hand calculation of emissions from a large new airport.

There is a second volume to this report containing the results of several surveys and analyses relating to the impact of the balance sheet analysis technique on state reviewing agencies and on airports. A survey of airports potentially subject to review under the criteria utilized in Volume I is presented, along with a survey of state experience with indirect source review regulations. An analysis of the resources (person power, etc.) that would be required of state agencies if this regulation were in force is presented. Finally, a brief summary of the issues we have outlined as a result of this study regarding indirect source review follows in Section 5 of the second volume.

1.4 DEFINITION OF TERMS

Analysis Region - The area, containing the project under review, defined for the purpose of this review; an emissions inventory and forecast must be available for the entire analysis region and all pollutant sources within the region may be considered for emission trade-offs. The Air Quality Maintenance Area (AQMA), Air Quality Control Region (AQCR) or Metropolitan Planning Organization (MPO) urbanized area are recommended as suitable analysis regions.

Balance Sheet Analysis Technique - A technique intended to be useful in the preconstruction review of airport and highway projects for their impact on regional oxidant air quality. It must be used in conjunction with proportional reduction modeling at the regional level. The technique is the subject of this report. The technique allows for emission trade-offs in the event that a proposed project causes the regional emissions total to exceed the desired emissions level for the region. The trade-offs may be internal or external. In a non-attainment area, trade-offs must be made as prescribed by EPA's recent 'offset policy'.

Compliance Emission Level - That level of total regional emissions, above which it is assumed that the region will violate the oxidant National Ambient Air Quality Standard (NAAQS), and below which it is assumed that it will be in compliance with the NAAQS. The compliance emissions level is determined in the context of proportional reduction models, like Appendix J, at the regional level.

Desired Emission Levels - Those levels of regional emissions projected by the state air pollution control agency in the SIP for attainment and maintenance of the NAAQS over the planning period. The desired level may be above the compliance level in a non-attainment region during the period of time prior to projected compliance. It may be below the compliance level in regions never expected to or soon expected to violate the NAAQS.

External Trade-Offs - In the event that the proposed project would cause an increase in the regional emission levels so as to exceed the desired emission level, a reduction to balance that increase may be provided at a source other than the source under review, yet within the analysis region. Such external trade-offs will generally require revisions to the SIP.

Internal Trade-offs - In the event that the proposed project would cause an increase in the regional emission levels so as to exceed the desired emission level, a reduction to balance that increase may be found at the source under review. By revising the proposed project or changing other aspects of the facility's operation so as to reduce emissions, the internal trade-off may meet the requirements of this review. These internal trade-offs would be effected by a conditional construction permit.

Offset Policy - A recently published (Federal Register, 40(246) 55524; 55558) U.S. EPA policy regarding the location of new or modified sources in non-attainment areas. This policy affects a balance sheet review of a project in a non-attainment area in this way: the size of trade-off, if one is required, must be greater than, not just equal to, the excess emissions (beyond the desired regional emissions level) projected as a result of the project. If future research called for under this policy identified regions specifically defined as the regions in which HC offsets can be made, these new regions would most likely serve as the analysis region for reviews of projects in non-attainment areas.

Permit Process - In this instance, the permit process means the application by an airport or highway operator to a reviewing agency to construct a particular project. The project is reviewed using the balance sheet if appropriate. A permit, possibly a conditional permit, is issued by the reviewing agency, if the project will not cause regional emissions to exceed the desired levels set in the regional air quality plan. Internal or external trade-offs may be required before the permit can be issued.

Reviewing Agency - Most likely, the state or local air pollution control agency will perform reviews, as part of the new and indirect source review procedures required in the SIP.

Trade-offs - In the balance sheet technique, the reduction in emissions in the analysis region that balances the excess in regional emissions projected as a result of the proposed project. Depending on the U.S. EPA policy in effect in the region where the review is taking place, the trade-off amount may be less than, equal to, or greater than the excess amount projected as a result of the project.

2. DESCRIPTION OF THE BALANCE SHEET ANALYSIS TECHNIQUE

2.1 DEVELOPMENT OF TECHNIQUE-REVIEW CRITERIA

2.1.1 Alternative Criteria

There are several criteria for the review of airport projects with alternative standards for each criterion. These criteria include the size of the analysis region, the scope of the reviews, the size of airport projects requiring review and the time period for the analysis. The specification of the criteria determines which projects will be reviewed, which will require trade-offs and what trade-offs will be available. Each criterion can take several possible forms. The alternative specifications for each criterion are presented here, documenting how the balance sheet technique was developed.

The techniques for the review of an airport project for its impact on photochemical oxidant levels are limited by the nature of oxidant chemistry. The choice of the size of the analysis region, in particular, is influenced by the oxidant formation process. Unlike carbon monoxide (CO) whose effects are highly localized, oxidant precursor emissions may come from almost anywhere in a large region, according to current theory. The highest oxidant levels may be found in the afternoon, while the emissions that fed the oxidant formation may have been emitted in the morning, or the oxidant may have travelled several miles from the area of its initial formation. As a result, the area for analysis of oxidant air quality must be fairly large. For transportation systems, which emit a significant fraction of the precursor pollutants in a region, this means that an area much larger than the immediate zone near the facility must be considered. For an airport, this means that the effect of its emission must be determined in conjunction with the emissions from sources throughout the region. This further implies that, in the context of control strategies, emission trade-offs are possible. The trading of emissions is possible only because oxidants are an area wide pollutant; this could not occur with a local pollutant like CO, where the source of any violation is in the immediate vicinity. If an airport project would cause a region to exceed the desired emission level, then the possibility for trade-offs within the airport and in the analysis region must be explored. Since there are several regions that meet the general criterion of large size, the choice of precisely which region to use for analysis is further discussed in Section 2.1.2.

The scope of the preconstruction review can include either one project alone or the transportation or airport system of which it is a part. In the review of highways, the system plan review concept is quite useful. In a given region there is a highway network for which improvements are planned at specified intervals. The entire plan can be reviewed for air quality impacts and each construction project reviewed for consistency with the overall plan at the time it is scheduled. As long as the system-wide emissions stay below the desired level, the emissions due to each project are not of prime concern. With the current situation for airport planning, this concept cannot be used. As there is generally only one large air carrier airport per air quality region and the master planning is done for only one facility, project level review is all that is feasible. Although there are differences in the application of the balance sheet technique between the system and the project level reviews, these differences are not crucial to the use of the essential aspect of the technique: the comparison against desired emission levels. The major differences lie in the nature of the trade-offs available if balancing is deemed necessary as a result of that critical comparison. The trade-offs available in the system level review have fewer limitations than in the project review because the system level review comes at a very early stage in planning. Construction is anticipated much sooner by the airport operator when a specific project is submitted for review, so fewer project-level options for emission reduction are available. There will be some minor differences in the initial data for the review, but the forecast emissions are required in either type of review. The updating also changes somewhat for system review as compared to project review. In system review, the updating consists of the review of each specific construction project. Any changes in the system plan are monitored in this way. When a new system plan is proposed, a new indirect source review using the balance sheet would be undertaken by the air pollution control agency. For project-by-project review, however, updating consists of periodic monitoring of the actual traffic levels, for comparison against the forecasts. Given the state of airport planning, it is necessary to carry out project level reviews. Should there be more national and regional airport planning or incorporation of airports into local transportation plans, the preconstruction reviews could take place during this step of system plan development.

The selection criteria for the preconstruction review of airport projects were determined by the U.S. EPA[1] on the basis of the amount of automobile traffic generated by the increase in air traffic. The selection criteria are an increase of 1.6 million annual passengers or 50,000 annual operations within the ten years after the project is opened. These criteria select only the busiest airports in the country; of the 31 expecting construction and growth of that scale[2], the least busy one ranks 46th out of 514 on the list of annual air carrier passenger enplanements for fiscal year 1974[3]. Thus these criteria are effective in identifying large scale improvements at major airports that might cause a problem in the attainment or maintenance of the oxidant air quality standards.

One other consideration is pertinent to the development of the reviewing technique. Since a good regional emissions inventory and forecast is necessary to complete the review, it is useful to coordinate with AQMA and AQCR planning as described in Section 2.3. These inventories are all on an annual basis, however. Since oxidant is a seasonal problem in most areas, the most useful inventory for this type of analysis is a summer inventory. Analysis can proceed on an annual basis but would be more accurate is only summer data were used. Peak day analysis is necessary for a complete review; as inventories do not usually have these data, the airport peaking information can only be used to check the variation in traffic and the effectiveness of controls for all daily traffic levels. This type of review is useful for evaluation of episode control strategies that might be required in the region.

The review technique must, therefore, cover a large area, account for all emission sources in that area, coordinate with existing plans and be done at the project level. In the context of proportional reduction modeling for the region, annual emissions must be computed for the region, and peak daily plus annual emissions for the airport. Seasonal emissions could be used where available.

2.1.2 Size of the Analysis Region

2.1.2.1 Introduction

The review of an indirect source of oxidant precursor emissions requires that a region size be chosen for the purpose of designating relevant emission sources for undertaking air quality analysis and for considering potential trade-offs among sources. The choice of a specific region size is complicated by the nature of the oxidant formation process, by the transport of oxidant precursors during the process, and by meteorological and topographical conditions at each project site.

The formation of photochemical oxidants results from chemical reactions in the presence of sunlight, between non-methane hydrocarbons (NMHC) and nitrogen oxides. The sources of the organic compounds include automobile and truck exhausts, aircraft, vaporization of stored hydrocarbons, solvent evaporation, open burning, and industrial operations. Nitrogen oxides, particularly NO, are emitted by fuel combustion sources such as electric power generation units, space heaters, and automobile, diesel and jet engines.

The difficulty in specifying a region size for the purpose of evaluating the oxidant impact of an emission source results from the following aspects of oxidant formation.

- Oxidant precursors do not all react at the same rate;
- The ratio of hydrocarbons to nitrogen oxides as well as absolute concentration is important in the ozone formation process;
- Meteorological conditions affect the rate of oxidant formation and determine the area of maximum oxidant concentration;
- Transport of oxidants and their precursor compounds has been verified to 50 miles downwind of urban areas and in many cases oxidant levels have been found to exceed ambient air quality standards more often in rural than in nearby urban areas; and
- In certain areas (Los Angeles) the oxidant problem can be attributed almost entirely to local emissions while in other areas the oxidant problem in one area may be the result of emission from a distant area.

Thus, while a specific region size may be reasonable for one project site, it may have little relationship to the oxidant problem at another site.

2.1.2.2 Region Size Specification

The choice of a specific region size for the analysis of the oxidant impact of a proposed project involves trade-offs among several factors, including data requirements, detail and reliability of forecasts, the relative significance of airport emissions in the region, model costs, and the number of trade-off options that may be considered when a desired emission level is exceeded. The options for region size and the implications of each option are detailed below.

The Airport and the Area Within Three Miles of the Airport Center.

The advantages of this region size are the small data requirements; the fact that this size region will include the majority of the growth induced by the airport project;[4] and the ease of determining what emission sources are available for trade-offs. The disadvantages are that this size region may have little relationship to the oxidant formation and transport process, and thus many relevant emission sources could be ignored. This size region also limits the number of trade-offs that may be made in the region to a small number of sources.

Environmental Protection Agency Specified Region - AQMA or AQCR.

The primary advantages of these regions, the Air Quality Maintenance Area (AQMA) and the Air Quality Control Region (AQCR), are the probable availability of air quality and emission data and the likelihood that a State Implementation Plan (SIP) or maintenance plan exists for the region. Such a plan would probably contain extensive regional emission data and may possibly give the allowable levels for the airport. The availability of this data would allow air quality analysis to be undertaken using available data. This size region also allows one to consider a large number of trade-off options if the project exceeds its desired emission level. This larger size is also a disadvantage in that the emissions from the airport project can become such a small percentage of the area's total emissions that it is difficult to deal with in trade-off considerations. This type of region may also have little relationship with the area which is affected by the airport project. Possibly irrelevant emission sources could be considered in trade-offs with the airport and sources which do contribute to the same oxidant problem as the airport could be excluded.

Other Predefined Regions (County, SMSA, State, or Metropolitan Planning Organization Designated Urbanized Area).

The advantages of each of these regions are the probable availability of transportation, land use and possibly air quality data based on these regions, and the fact that these regions have political sanction and are recognized by other planning agencies. The air quality data available for such a region will most likely not be as extensive as that available for an EPA defined region. However, transportation, industrial and other data which are organized for this region, especially in the case of the Standard Metropolitan Statistical Area (SMSA), can be utilized to obtain emission data for the region. The disadvantages are the same as those discussed for the EPA designated regions. The region may have little relationship to the area of impact of the airport project emissions and the area may be so large as to make the airport a very small percentage of the region's total emissions.

Region Determined From Point of Maximum Impact

An alternative method of determining the region size is to use a trajectory model to find the area on which the airport emissions will have the maximum impact and to find which other emission sources also contribute to this impact. This type of region would be advantageous in that it would consider the area most affected by the airport's emission. The disadvantages are that data requirements are large and the available data could require much manipulation; a model must be run to find the size of the region and then another technique would have to be employed to determine the desired emission level. The early stage of the development of these models might prove a disadvantage in using it for reviews in the next year or so.

2.1.2.3 Recommendations

All the options presented here for the analysis region are valid; considerations of convenience lead to a recommendation for one type however. The EPA specified regions, AQCR and AQMA, have distinct advantages with respect to data availability, the existing oxidant models and administrative ease. The large size of these regions is logical in view of what is currently known about the chemistry of oxidant formation. The recommendation of the EPA regions is tied to the project-by-project review expected for airports. For highway projects, where system plan review becomes a part of the process, the region specified for highway planning by the Metropolitan Planning Organization (MPO) is a likely choice. It also is a large region, the basis for highway related data, and a geographic subset of the two EPA-specified regions. In fact, the application of the balance sheet technique itself is not limited by the region size. Rather, it is the regional air quality model that is critical in determining whether the balance sheet technique is applicable. The need for this kind of balancing is precluded by the use of simulation models, since they account for more factors than just the amount of emissions such as meteorology, dispersion and chemistry.

2.2 EMISSION PROJECTION PROCEDURES

The calculation of the NO_x and HC emissions produced by the airport over the 10 year planning horizon is a crucial step in the Balance Sheet analysis. The calculations must be done for two situations: with and without the proposed project. Additionally the computations must be done for the first, fifth, and tenth years of the project, on an annual and peak daily basis. The emissions are computed for each source in the analysis region, both on and off airport. The emissions of HC and NO_x computed for the appropriate time periods, by source, with and without project, constitute the basic information for the Balance Sheet reviewing technique. These figures are contrasted with the desired emission levels discussed in Section 2.3, to provide a basis for a decision on the acceptability of the project from an oxidant air quality perspective using the balance sheet technique. A summary of the methods available to complete these computations of projected emissions is presented.

2.2.1 Basic Activity Data

Unless actual emission test data are used, emissions are calculated simply as the product of the numerical measure of the activity (e.g., operations/day) and the emission factor or rate (e.g., grams of HC/operation). Both these values change over time, due to increased activity, use of different equipment and the more stringent emission limits mandated for new equipment in the next ten years.

The most essential data items for the emission forecasts are the measures of airport activity -- annual air carrier aircraft operations and total annual passengers (enplanements plus deplanements). In addition, the automobile vehicle miles of travel (VMT) due to the airport must be supplied. All the above data must be provided for all combinations of the following conditions:

- First, fifth, and tenth years of the project; and
- With and without the project being built.

The forecasts of activity must be supplied by the airport on the permit application. These basic data, plus a few detailed breakdowns noted later, supply all that is needed to specify airport activity levels for the simplest models. In conjunction with emission factors and a particular computational model, the airport emissions can be computed.

Off-airport emissions (beyond the airport fence, up to the border of the analysis region) require further data. Local and state planning agencies and air pollution control agencies are the best sources for this information. In some cases, an emission inventory for NO_x and HC sources will be available for the forecast period directly from these agencies in the form of the Air Quality Maintenance Area Plan, expected to be available by 1978 for most areas. In other cases, the State Implementation Plan (SIP) will contain the necessary inventories. In any event, to apply the balance sheet technique it is necessary to have a regional emissions inventory for HC and in some cases NO_2.

In summary there are three categories of activities, and their associated emissions, of interest. Each will be discussed in turn, along with a discussion of computation techniques. They are:

1) on the airport;
2) off-airport: project-induced development; and
3) off-airport: other development.

2.2.2 On-Airport Sources of Air Pollution

2.2.2.1 Airport Sources of HC and NO_x Emissions

An airport has many activities taking place within its borders in addition to the movement of traffic. These activities are all directly related to the movement of passengers and air freight, and are sources of HC and NO_x emissions. The airport sources are as follows:

1) Aircraft engines;
2) Ground service vehicles and equipment;
3) Access traffic (auto, taxi, bus, truck);
4) Engine tests;
5) Heating and air conditioning;
6) Fuel handling and storage; and
7) Miscellaneous -- painting, degreasing, incinerating.

Each of these sources is considered separately because of its unique emission rate and because it is a candidate for emission trade-offs later on. Ground service vehicle fuel use can be related to the number of aircraft operations; the emissions are calculated from the fuel use using EPA emission factors for similar vehicles. Heating and air conditioning fuel use can be directly specified by the airport operator, as can the extent of engine testing, the amount of fuel storage and miscellaneous maintenance functions such as paint bake ovens and degreasing operations. Access traffic can be related to passenger movements, and the emissions determined by the appropriate emission factors. In general, the data describing the activity levels for each of these sources are supplied by the airport commission or operator. The data sources are discussed in more detail below.

2.2.2.2 Description of Models for Emissions Computation and the Data Required

At this step in the analysis, what is needed is the emissions produced from each airport source for each forecast year - one, five and ten years after the project is completed, and possibly for the base year of the air quality plan. There are several ways to compute these emissions. The choice among them depends on the detail of the available airport activity data and on the intended use of the results. That is, more detail is required to justify the emission reductions expected from a control strategy like aircraft towing than to establish baseline emissions. Computational models of concern have the capability of computing the emissions from one or more airport sources, given the activity level of the source. In addition, some of the models can derive the level of one activity, say for the ground service vehicles, and the emissions from them, given another parameter such as aircraft types and numbers of operations based on factors from other airports. This lessens the need for data collection at the airport under review.

Some of these computational models can calculate pollutant concentration contours based on dispersion models. This capability of a model is irrelevant to this particular analysis; only the emissions are of consequence in the balance sheet. In effect, all these models are doing is setting up the emission computations so that the whole process may be easily replicated for the different years, with and without the project, and for the testing of emission reduction strategies at the airport should it prove necessary. The computations can always be done by hand; the computerized models offer specification of more details in the airport's operation or the ability to analyze more emission reduction strategies.

The models presented in Table 2.. generally include average data based on particular airports. Any model selected can be examined for its applicability to the airport under review. For example, the emission factors for the LTO cycles may need alteration if the airport has its own data on the actual time spent in each mode of operation (taxi, idle, climb-out, etc.), or the airport may have estimates of the relationship between auto traffic volumes and air passenger volumes that are specific to its operation. Such airport specific data can be incorporated whenever available; however, the average factors are available. The emission factors incorporated into a model are also subject to scrutiny. The latest emission factors applicable to the equipment in use at the airport are necessary. Schedules for replacement of engines with newer, cleaner ones can also be accounted for in the emissions computation. The nature of the computations for each source is discussed below.

Aircraft Engines

The computation of aircraft engine emissions is very important since nearly 70% of the airport's HC emissions and 75-80% of the NO_x emissions[5,6] are due to aircraft. The simplest method is to multiply the number of landing and take-off cycles (LTOs) by the cycle emission rate. The U.S. EPA has published average LTO emission factors for each type of aircraft in its publication AP-42 (see table for reference), based on typical cycle parameters (taxi time, take-off time, etc.) and measured engine emission rates. The airport could determine an LTO cycle emission factor specific to its operations by measuring (or estimating for forecasts) actual cycle parameters, since the EPA-determined LTO cycle has some limitations. It is based on data from studies done in 1968 and 1971 and applies primarily to large metropolitan airports. The taxi-idle time, in particular, may be too long compared to the actual conditions at many airports.

The new engine emission standards set forth by the FAA[7] must also be taken into account. Each year after 1980 a greater percentage of the fleet will have engines meeting these standards. The emissions computations should reflect the different emission rates and the changing portion of the fleet meeting the new requirements.

TABLE 2.1 Emissions Forecasting for Airport Sources of HC and NO_2

Airport Source	Data Required[a]	Sources of Data[b]	Model	
			Hand Computation	Computerized
1) Aircraft engines	<u>BASIC</u>			
	• Types of aircraft • % of fleet meeting new emission standards • Aircraft emission factors	FAA activity tabulations Airport EPA, FAA (1)	Air Pollution Impact Methodology (APIM) (2)	
	<u>ADDITIONAL</u>			
	• Airport layout • Speed and acceleration parameters for take-off and landing	Airport (3)		Airport Vicinity Air Pollution (AVAP) Model (4,5) GEOMET Model (6)
	• Diurnal aircraft activity patterns	<u>Official Airline Guide</u> Airport anticipated departures FAA summaries		
	• Assignment of taxiway paths and terminal parking	Airport		
	<u>ADDITIONAL</u>			
	• Commercial aircraft emission characteristics to replace military	(1)		Air Quality Assessment
	• Modal emission factors	(1)		Model (AQAM) (7,8)
2) Ground service vehicles	<u>BASIC</u>			
	• Number and types of vehicles • Regulations governing future emissions • Service times of vehicles by plane type • Fuel consumption rates • Emission factors in terms of fuel consumed (In absence of actual data, rates from heavy-duty trucks can be used.)	Airport EPA (2) (4) (9)	APIM (2)	AVAP (4,5) AQAM (7,8)

TABLE 2.1 Emissions Forecasting for Airport Sources of HC and NO_2 (Cont.)

Airport Source	Data Required[a]	Sources of Data[b]	Model	
			Hand Computation	Computerized
3) Access traffic	BASIC			
	• Number and types of vehicles	Highway department forecasts	APIM (2)	AVAP (4,5)
	• Manner in which vehicles are operated (speed, hot or cold starts, etc.)	(11) or (9)		AQAM (7,8)
	• Emission factors per gallon of fuel	(9)		GEOMET (6)
	• Age distribution of vehicles	(11) or (9)		
	• Regulations governing future emissions	EPA		
	• VMT, or to compute VMT (2):	VMT forecast		
	• Air Passenger Related Visitor Ratios by Hour	(2)		
	• Employee Arrivals and Departures by Hour	(2)		
	• Casual Visitor Arrivals and Departures by Hour	(2)		
	ALTERNATIVE			
	• Design of airport	Airport	EPA Guidelines (10)	
	• Either 1, 2, or 3, as follows:			
	1) Average daily trip generation rate	EPA estimates (10)		
	For HC: Peak 6 AM-9AM			
	Peak daily			
	For NO_2: Annual average daily			
	2) Peak and average number of passengers visitors, employees or estimates	Airport (10)		
	Fraction of through passengers (vs. originating or terminating)	Airport		
	Fraction of passengers using mass transit	Airport		
	Number of buses	Airport		
	3) Annual number of LTO cycles	Airport		
	Seating capacity per LTO cycle	EPA estimates (10)		
	Number of airport employees	Airport		

TABLE 2.1 Emissions Forecasting for Airport Sources of HC and NO$_2$ (Cont.)

Airport Source	Data Required[a]	Sources of Data[b]	Model	
			Hand Computation	Computerized
4) Engine testing and maintenance	BASIC			
	• Number and types of engines tested	Airport	APIM (2)	AVAP (4,5) AQAM (7,8)
	• Time at each power setting	Airport		
	• Emission rates for engines	(1)		
5) Heating and air conditioning plants	BASIC			
	• Size of buildings	Airport	APIM (2)	
	• Fuel used	Airport		
	• Fuel requirements	Airport		
	• Emission factors from fuels	(1)		
	• State regulations for fuel	EPA		
	ADDITIONAL			
	• Average temperature to determine heating needs	National Weather Service		AVAP (4,5) GEOMET (6)
	ADDITIONAL			
	• % Sulphur and % Ash, where applicable	Airport		AQAM (7,8)
	• Emission control devices in use	Airport		
6) Fuel handling and storage	BASIC			
	• Type of tank	Airport	APIM (2)	
	• Fuel stored	Airport		
	• Fuel requirements	Airport		
	• Emission factors for storage tanks	(1)		
	ADDITIONAL			
	• Number of tanks	Airport		AVAP (4,5)
	• Capacity of tanks	Airport		AQAM (7,8)
	• Annual throughput	Airport		
	• Vapor pressure	American Petroleum Institute (12,13)		GEOMET (6)

TABLE 2.1 Emissions Forecasting for Airport Sources of HC and NO_2 (Cont.)

Airport Source	Data Required[a]	Sources of Data[b]	Model	
			Hand Computation	Computerized
7) Miscellaneous				
Combustion Sources	• Emission factors	(1)	EPA Guidelines (10)	
Maintenance facilities	• Location on airport	Airport		AVAP (4,5)
Refuse Incinerators	• Refuse burned • Method of combustion • Design of incinerator	Airport Airport Airport		AQAM (7,8)

[a] It is assumed that annual operations and passenger movements for the first, fifth and tenth years are available.

[b] When "Airport" is listed as source, the data are available from engineering or planning studies done for the project.

REFERENCES FOR TABLE 2.1.

1. Compilation of Air Pollutant Emission Factors, Second Edition, U.S. EPA, Report No. AP-42, Research Triangle Park, N.C., March, 1975.

2. J.E. Norco, R.R. Cirillo, T.E. Baldwin, J.W. Gudenas, An Air Pollution Impact Methodology for Airports - Phase I, Argonne National Laboratory, U.S. EPA, Report No. APTD-1470, Research Triangle Park, N.C., January, 1973.

3. M. Platt, et al., The Potential Impact of Aircraft Emissions Upon Air Quality, Northern Research and Engineering Corp., Report No. 1167-1, Cambridge, Mass., December, 1971.

4. D.M. Rote, I.T. Wang, L.E. Wangen, R.W. Hecht, R.R. Cirillo, J. Pratapas, Airport Vicinity Air Pollution Study, Argonne National Laboratory, prepared for U.S. Department of Transportation, FAA, Report No. FAA-RD-73-113, Washington, D.C., December, 1973.

5. I.T. Wang, L.A. Conley, D.M. Rote, Airport Vicinity Air Pollution Model - User Guide, Argonne National Laboratory.

6. S.D. Thayer, D.J. Peltan, G.H. Stodskleu, B.D. Weaver, Model Verification-Aircraft Emissions Impact on Air Quality, GEOMET, Inc., Report No. EF-262, Rockville, Md., July 31, 1973.

7. D.M. Rote, L.E. Wangen, A Generalized Air Quality Assessment Model for Air Force Operations, Argonne National Laboratory, Air Force Weapons Laboratory, Report No. AFWL-TR-74-304, Kirkland Air Force Base, N.M., February, 1975.

8. L.E. Wangen, et al., Argonne National Laboratory, A Generalized Air Quality Assessment Model for Air Force Operations - An Operator's Guide, October, 1973.

9. Supplement 5 to Compilation of Air Pollutant Emission Factors, U.S. EPA, Report No. AP-42, Research Triangle Park, N.C., April, 1975.

10. Guidelines for Air Quality Maintenance Planning and Analysis Volume 9: Evaluating Indirect Sources, U.S. EPA, Report No. EPA-450/4-75-001, Research Triangle Park, N.C., January, 1975.

11. Local (metropolitan area or state) data from Transportation Study or air pollution control agency.

12. "API Bulletin on Evaporation Loss from Floating-Roof Tanks," American Petroleum Institute, API Bull. 2517, February, 1962.

13. "API Bulletin on Evaporation Loss from Fixed-Roof Tanks," American Petroleum Institute, API Bull. 2518, June, 1962.

All of the factors mentioned above can be accommodated by the hand computation methods referenced in the table. The models listed as computer models add a degree of precision to the emission computations: the exact specification of the operation of the aircraft throughout a take-off or landing. The effect of active runways crossing each other or a taxiway that crosses an active runway can be accounted as the aircraft operations are simulated. To gain this precision in emissions computations, more precise aircraft activity must be supplied, including assignment of taxiway path and terminal parking, airport layout and diurnal traffic patterns.

Ground Service Vehicles

The emissions due to ground service vehicles can be computed several ways. For vehicles whose use is tied to aircraft arrivals and departures the computation of emissions can be based on average service time per aircraft operation. Airport-specific data can be collected, or average values can be used (references 2 and 4 on Table 2.1). Multiplying the average service times by the number of operations (stratified by aircraft type) yields vehicle-hours per day. A fuel consumption rate in gallons/vehicle-hour, determined from the assumed or observed values of miles/hour divided by miles/gallon, converts this to gallons of fuel/day. This is multiplied by an emission factor expressed in grams of pollutant per gallon of fuel to yield daily emissions in grams. When average data for vehicle service times are used, the airport need supply only the operations by aircraft type. The emission factors (gm/gal) used in the computations should reflect the latest EPA emission factors and match the types of vehicles in use in the airport. The models in the table include emission factors in grams/gallon based on data available when the models were published several years ago.

Emissions due to ground service vehicle activity that is not related to aircraft operations but occurs on a daily basis can be computed in the same fashion as automobile emissions. That is, given the distance travelled per day, and the emission factor in grams per kilometer or mile (adjusted by average speed), the daily emissions due to such activity are the product of the distance per vehicle and the emission factor, multiplied by the number of vehicles.

In both cases, schedules for replacement of older vehicles with new ones are of interest, if the new vehicles have different emission characteristics.

The emission computations need to be sufficiently detailed to distinguish vehicles by fuel type (gasoline or diesel fuel) and by emission characteristics if new engines are expected to be different from those now in use with respect to emissions.

Access Traffic

Automobile access traffic within the airport bounds is also a large source of the emissions at the airport, accounting for 12% of the HC at one airport[5]. Since automobile pollutant emission factors are in terms of emissions/mile or kilometer at a certain speed for each type of vehicle by age, the necessary access traffic data are vehicle miles of travel (VMT), by speed for each vehicle type (auto, bus, truck) and the vehicle age distribution. Average regional characteristics can be applied for the vehicle type distribution and the age distribution. The speeds and VMT have to be measured or estimated, however, for the airport. There are many ways to do this, as indicated on the table. The first source for auto traffic forecasts is the local transportation planning agency. They may have already forecast daily vehicle trips to the airport, without the project, in which case the agency could assist in the preparation of with-project forecasts. Otherwise, the number of vehicle trips can be determined using the air passenger traffic as a basis. Both the APIM document and Volume 9 of the EPA Guidelines (see table for references) provide estimating techniques based on passenger movements. The number of vehicle-trips is converted to vehicle miles of travel inside the airport by assuming an average trip length inside the airport. The product of vehicle-trips and trip length is VMT. Vehicle speeds are also necessary for determination of emissions since emission rates vary with speed. If there are both high and low speed zones in the airport, the VMT must be broken down according to the various speeds. EPA emission factors from the latest version of AP-42 (reference 8 on the table) can then be applied. As for the previous two emission sources, expected or legally mandated schedules for lower emissions from new vehicles are to be included in the access traffic emission estimates.

Evaporative and crankcase HC emissions need also be treated for a complete accounting of vehicular emissions. The computation technique is very simple and it relies on the emission factors in Supplement 5 of AP-42.

Engine Tests

Engine test emissions are computed from the estimated amount of aircraft engine testing (number of engines and time in each mode of operation) and the modal engine emission factors found in AP-42 (see table). The amount of engine testing varies from airport to airport depending on the extent of airline maintenance facilities, so this activity needs to be estimated for each airport project. The experience of several airports regarding the amount of testing can be found in several of the references mentioned in the table.

Heating and Air Conditioning

Heating and air conditioning plants are considered stationary sources of emissions. The determination of emissions depends on the amount and type of fuel used. Emission factors are available from AP-42 (See table for reference) by fuel type, expressed in mass of pollutant/amount of fuel used. When computed annually, only the total annual fuel use is relevant. Peak day emission computations require information on the typical day's fuel usage during the season in which the peak day occurs.

If expected fuel usage is not known, it can be estimated from the building floor area using techniques outlined in APIM (see table).

Fuel Handling and Storage

Fuel handling and storage can account for about 10% of HC emissions at an airport[5,6]. The emissions are due to evaporation of fuel held in tanks and of fuel moving through the distribution system on the way from storage to vehicles. The important variables in computing the emissions are the type of fuel storage tanks, type of fuel (jet fuel, other aviation fuel) and amount of fuel used, which can all be determined by the airport operator. The basic computational procedure is to multiply the amount of fuel used per day or year by an emission factor expressed in grams per 1000 gallons or liters of fuel. The emission factors for this computation can be found in AP-42 and APIM (see table for references).

Miscellaneous Sources

Various point sources of pollutant emissions fall into this category. The kind of sources varies from airport to airport, but typically includes refuse incineration, painting, degreasing operations and other maintenance

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functions. These sources are all treated in the EPA's emission handbook, report number AP-42, and should be handled individually for emission computations. These sources are not generally that significant, but are included in the analysis because of the variance from airport to airport. For example, airports with extensive aircraft maintenance facilities would have more sources under this grouping and possibly more emissions than the typical airport.

2.2.3 Off-Airport Sources of Air Pollution

The emission sources covered in this section are those beyond the airport fence but within the study region. They can be further distinguished as: 1) new emissions sources due to growth induced by the airport project; 2) other regional emission sources. Emissions from the latter are used unchanged from the projections in the regional air quality plan in the first steps of the analysis, over the forecast period. If balancing of emissions is required then these sources are candidates for trade-offs that change the forecast emission values. The sources for the regional emissions inventory are discussed in more detail in connection with the determination of the desired emissions level in Section 2.3.2. If the study region does not coincide with the air quality region, it may be necessary to employ the subcounty allocation techniques outlined in Volume 13 of the Guidelines for Air Quality Maintenance Area Planning and Analysis[8].

The first group of sources is assumed to change in the with and without project scenarios. These are the new emission sources that locate near the airport because of the airport project. The location of these new land uses near the airport is usually considered an economic benefit of the airport's expansion. This induced growth is, however, an additional source of oxidant precursor emissions which are attributable to the airport project. The first step in the determination of the emissions due to the induced growth is the identification of the induced growth. It is essential to identify only the net increases in the analysis region since some part of the development near an airport constitutes the relocation of existing sources to be closer to the airport. There is not one standard projection technique, although economists and land use planners can provide reasonable estimates of growth due to a project using estimation techniques tailored to the local area. For air quality purposes, the growth needs to be specified in terms of the process activity (manufacturing), square footage of buildings to yield heating needs (commercial) and amount of vehicle miles of travel generated (all growth). These are the factors that yield emission estimates because the emission factors are always expressed as pollutants per unit of activity. Manufacturing processes can be specifically identified in emissions handbooks; emissions are computed based on the size of the facility. The space heating and cooling needs of commercial establishments are the primary determinants of their emissions. Some sources are characterized mainly by the travel generated, such as warehouses and truck terminals, although all the induced growth will add new vehicle- or person-trips. This discussion of land use forecasting techniques is necessarily brief, relying heavily on the use of existing techniques. Identification of this growth is important in the analysis, but a critical review of available techniques is a study in itself.

The local land use planning agency can be of help in identifying the amount and timing of the growth. It is expected that the influence of the airport project will not be felt beyond a distance three to four miles from the airport center[4], so the induced growth region can be limited to this size. Once the sources are identified in this region, the EPA emission factors handbook (see Table 3.1) can be used for the applicable emission factor for each manufacturing and commercial source.

For vehicle-miles of travel, the local transportation planning agency may be helpful. In addition to determining the VMT in the region due to air travellers, it is also necessary to compute the VMT due to all of the induced growth. Traditional techniques that determine a trip generation rate and an average trip length from each source (whose product is VMT) are applicable here. The usual economic projection of number of employees can be useful in this computation. The truck traffic is also included as induced growth and should be separated from auto traffic for purposes of emissions computation.

The total of the emissions due to the net induced growth, in each project year, is added to the on-airport emissions to produce the grand total of emissions due to the airport project.

2.2.4 Time Period For Analysis

The structure for the emissions computations is now specified, except for the time period. The HC emissions must be computed on an annual totals basis, in conjunction with the emission inventory. Major control strategies for the airport emissions are based on this annual total. However, peak day, or peak summer day if different, emissions must also be computed for the project. Since congestion can cause a more than proportional increase in emissions for the traffic at the airport, it may be necessary to provide an additional strategy for episode control on such days. The airport may have to be prepared for worst case meteorological days, regardless of whether they are peak air traffic days.

The NO_x emissions are required only in two cases: where the area is designated for non-attainment of the NO_x standard, and where the model used to analyze the regional emissions requires NO_x data for its use. In these cases, the annual and peak day NO_x emissions must be supplied. Again, these totals for both NO_x and HC are required for the first, fifth, and tenth years of the project's operation. The annual computations should be done for the without-project scenario in the project years and in the base year of the air quality plan.

The emissions computations are made on a 10 year basis for several reasons. One is that air quality planning and transportation planning both utilize 10 year planning periods for many analyses; these reviews would be consistent then with the general structure of both agencies. The ten year period is intended to cover most of the effects of these major additions to capacity in the airport or highway system, while fitting into the existing long term planning structure. The twenty year period required, with some exceptions, in AQMA planning (see Federal Register, 5-3-76) is too long for purposes of analyzing the effects of one project. The desired emission levels determined for the region as part of the State Implementation Plans will reflect the long range framework.

2.3 DETERMINATION OF DESIRED EMISSIONS LEVELS

2.3.1 Introduction and Assumptions

After determining the study region and projecting emissions throughout the study period, the desired emissions levels for the region must be found. These levels represent maximum emission levels above which oxidant problems would be expected. If emissions from the study project were to cause these desired levels to be exceeded, trade-offs within the project or between the project and other source categories would be necessary to keep the total regional emissions at or below the desired levels. The following discussion presents several methods for determining desired emissions levels for HC and NO_x, consistent with air quality planning efforts expected to be completed by mid 1978. Where such planning is not required, other modeling techniques are presented.

Two assumptions have been made in this discussion. First, it is assumed that the local oxidant plume mechanism holds. This mechanism assumes that a source's emissions cause oxidants in the immediate vicinity of the source. Most current models and control theory are based on this assumption. However, recent findings of high ozone levels in rural areas, apparently resulting from long range transport of precursors from urban areas[9], have cast doubt on the validity of the local plume mechanism in some circumstances. The existing state-of-the-art is such, however, that only the local problem can be treated at this time.

Second, it is assumed that the emission changes, both direct and indirect, attributable to the project have not already been considered in detail in an existing air quality plan. If the air quality impacts of the project and its induced development have already been assessed, there is no need to redo the work unless there are difficulties with the existing plan.

Employing the balance sheet approach implies that no attempt will be made to simulate the air quality changes resulting from the project. If the overall control strategy was developed using a computerized simulation model, the balance sheet is unnecessary; the emissions from the project and any desired trade-offs can be used as input and the resulting estimated air quality simulated. When simpler methods such as rollback, Appendix J, or smog chamber methods have been used in the regional analysis, the results are given in terms of either the regional desired emission levels or an emission reduction.

The balance sheet provides a means of determining whether the regional emissions ceilings will be violated by the study project and a means of trading off emissions between sources to keep the ceiling from being exceeded.

2.3.2 Methods of Determining Desired Emissions Levels

A Recent Air Quality Plan Exists

The selected study region may already have been analyzed for a State Implementation Plan (SIP), Transportation Control Plan (TCP), or Air Quality Maintenance Area (AQMA) analysis or plan. The original SIPs from 1972 are generally outdated; TCPs treated only the central business districts of urban areas. Neither of these is thus likely to provide a firm basis for estimating desired emission levels. However, 25 out of 31 airport projects expected to require Indirect Source Review (ISR) are located in areas requiring either SIP revisions or AQMA analyses or plans for oxidants. SIP revisions, which will probably be the first AQMA plan in regions where both are required, are due in July, 1977, with land use and transportation provisions due in July, 1978. AQMA analyses were due in July, 1976, (as of October, 1976, some had not yet been submitted)[10] and the AQMA plans will generally be required within 2-3 years. Whenever possible, computations of desired emissions levels should be based on these plans to insure consistency among programs and reduce the amount of work required. The ISR will be a project-specific review in addition to the broader based air quality planning contained in the more general AQMA plan or SIP. As used in this section "plan" refers to the general AQMA plan or SIP; "study" or "ISR" refers to the project specific review. Both the general plan and the specific review are required by EPA regulations.

Two cases arise when a recent analysis exists:

- the air quality planning and study regions will be the same, or
- the study region will be a subregion of the planning region.

The desired emission levels in the plan will normally need some adjustment: in both cases because of the level of detail in the ISR and additionally in the second case because only part of the planning region is being studied. The existing plan should contain an emission inventory for the planning region and estimates of desired emission levels of HC and NO_x if the analysis technique employed considered NO_x. The baseline emissions for the airport in the plan and in the ISR can be compared to determine any required corrections to the emission levels given in the plan.

The level of detail used in estimating airport emission levels in the plan will generally be based on aircraft LTOs and hence will be less than that involved in conducting an ISR. In doing the detailed project emissions calculations for the ISR, it would not be unexpected to find that the baseline emissions levels assumed for the airport in the plan are different from those estimated on the basis of a fully detailed calculation using the methods of Sec. 2.2. When the detailed estimates of baseline emissions agree with the estimates used in plan development, no problem arises and the desired emission levels in the plan need not be modified. However, when the detailed calculations indicate that the emissions levels used in plan development are not accurate, there are two possible courses of action.

First, the desired emissions levels from the plan can be retained without adjustment. Such a course, however, would place unnecessarily stringent restrictions on the project if the detailed baseline emission estimates are greater than the emissions assumed when the plan was developed and, more importantly, violates the principle of the rollback models in the context of which a balance sheet approach applies. These models give a required percentage reduction <u>regardless of absolute emissions levels</u>. Hence, the second and preferred course of action is to change the emission levels in the plan to reflect the more detailed baseline emission estimates generated during the review. The plan specifies some required percentage reduction in emissions, R. This percentage is based on air quality data only, not on the magnitude of emissions. The plan may also have assumed a regional growth factor (gf) in calculating R. (e.g., the growth factor would be 1.02 if emission were expected to increase 2% over the planning horizon). The compliance emission level (CEL) in the plan is:

$$CEL = (gf) \times \left(\begin{array}{l}\text{Total}\\ \text{Baseline}\\ \text{Regional}\\ \text{Emissions}\end{array}\right) \times (1 - R/100)$$

$$= (gf) \times \left(\begin{array}{l}\text{Baseline}\\ \text{Airport}\\ \text{Emissions}\\ \text{in Plan}\end{array} + \begin{array}{l}\text{Other}\\ \text{Emissions}\end{array}\right) \times (1 - R/100)$$

During the ISR process, a more detailed treatment of the airport's emissions in the base year might show them to be different from those assumed in the plan. The percentage reduction R based on measured air quality would still be applicable, and a new compliance emission level (CEL') based on the more detailed inventory would be:

$$CEL' = (gf) \times \left(\begin{array}{l}\text{Detailed}\\ \text{Baseline}\\ \text{Airport}\\ \text{Emissions}\end{array} + \begin{array}{l}\text{Other}\\ \text{Emissions}\end{array}\right) \times (1 - R/100).$$

$$\text{Thus, } CEL' = CEL \text{ (in plan)} + (gf) \times \left(\begin{array}{l}\text{Detailed}\\ \text{Baseline}\\ \text{Airport}\\ \text{Emissions}\end{array} - \begin{array}{l}\text{Baseline}\\ \text{Airport}\\ \text{Emissions}\\ \text{in Plan}\end{array}\right) \times (1 - R/100).$$

When Appendix J has been used in the plan, $(gf) = 1$. This corrected compliance emission level (CEL') would be used as the regional desired emission level for all planning years beyond the compliance year projected in the plan. Between the detailed baseline emissions in the air quality plan base year and the compliance emissions level in the compliance year, the desired emission level can be obtained by linear interpolation if no intermediate levels have been given in the plan. When intermediate emission totals have been specified, they should be increased by an amount calculated by assuming that the difference between the detailed baseline airport emissions and the baseline airport emissions in the plan will decrease linearly over time. The rate of decrease is given by the requirement that the difference be reduced by the required percentage R between the baseline and compliance years. Use of this technique for adjusting the allowable emissions specified in the plan will result in regional desired emission levels consistent with air quality goals and reflecting the more detailed project-specific emissions inventory.

Two additional points need to be made about this correction term. First, an upward correction in the plan's regional emission level to give the desired emissions level does not mean that the region can absorb increased emissions. The correction simply accounts for emissions not included in the baseline inventory and although the compliance emissions level has been adjusted upward, the critical implication is that an additional emissions reduction equal to the unaccounted emissions reduced by R must be found. Second, the correction really applies to the entire region. However, for purposes of determining whether balancing is required, it is convenient to add the change to the airport emissions in the plan and call this the desired airport emissions.

In practice, the situation is frequently somewhat more complicated because Project Year 1, the earliest year for which a detailed airport inventory has been generated, is likely to be later than the baseline year in the air quality plan, the year upon which the required reduction R is based. The adjustment procedure requires the amount of emissions that were present in the air quality plan's base year but which were not accounted for in the plan's inventory. To produce a precise estimate of the unaccounted emissions in the base year, two corrections must be applied to the unaccounted emissions in Project Year 1:

1) The growth in the airport sources causing the unaccounted emissions must be discounted in moving from Project Year 1 backward in time to the air quality plan's base year and

2) Care must be taken to subtract out the emissions of any sources (such as new storage tanks) which began operation between the air quality plan base year and the opening year of the proposed project.

If both of these factors are taken into account a reliable estimate of unaccounted emissions in the base year should be obtained and the procedure described earlier can be applied.

Similar problems occur when the study region is a subregion of the air quality planning region. In this case there is the additional necessity of disaggregating the regional levels to find the fraction constituting the desired emission levels in the study subregion. This estimate is best accomplished by summing the emissions of sources located in the study subregion from the plan. For sources located only by county in the plan,

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the use of the subcounty allocation procedures in Volume 13 of the AQMA guidelines[11] is recommended. The same corrections as discussed above must be applied to reflect the more detailed estimates of airport emissions.

A Recent Air Quality Plan Does Not Exist

When a recent analysis does not exist, recourse must be made to the original SIPs. All AQCRs have been designated either Priority I or Priority III for NO_x, HC and O_x. Priority I AQCRs are required to have rather detailed emissions inventories, oxidant air quality data, and a SIP for standard attainment upon which estimates of desired emission levels could be based. This SIP was probably developed in 1972 and the state air pollution control agency or EPA Regional Office should be consulted prior to using desired emission levels based on such a plan, to ascertain whether any modifications are being contemplated. If the original plan is still considered reliable, its emission level estimates may be used as described above to estimate desired emission levels.

Priority III regions have greater potential for causing difficulty. There are no federal requirements that oxidant air quality be monitored in Priority III areas. Such data are necessary to estimate desired emission levels using proportional models. Data may, however, be available from the state, EPA Regional Office, or in EPA's Storage and Retrieval of Aerometric Data (SAROAD) system which can be accessed at the EPA Regional Office. If no oxidant air quality data is available, a short-term monitoring program covering June through August of one year should provide sufficient data for a review. Area source emission data may also be incomplete for Priority III AQCRs. EPA's National Emission Data System (NEDS) contains estimates of emissions for areas where incomplete data are available. However, states should be checked first for updated inventories. In such cases, trade-offs are limited to the sources given in the inventory. These should, however, include all large point sources of HC and NO_x, the major problem being the timeliness of the data.

2.3.3 Photochemical Oxidant Modeling Techniques

Three types of procedures exist for estimating desired emission levels. The first are the proportional models which give desired emission levels directly or, equivalently, required emissions reductions. Second are the statistical-empirical models. The third are the simulation models that estimate air quality based on emissions, thus eliminating the need for a balance sheet but requiring an emission inventory. All three types are described below beginning with the proportional models. This discussion of the modeling techniques available is included to provide a complete picture of the options available, even though the balance sheet technique is applicable only in conjunction with proportional reduction models. The discussion of statistical-empirical and simulation models is somewhat brief for this reason.

2.3.3.1 Proportional Models

Appendix J[12]

The method most widely used to determine desired emissions levels is the so-called Appendix J method.[13] This method is based upon observations of non-methane hydrocarbons (NMHC) between 6 A.M. and 9 A.M. and the highest corresponding 1-hour oxidant concentrations during the day in several U.S. cities. A curve is drawn through the maximum oxidant values found at each NMHC level, producing a relationship between NMHC and maximum oxidant levels. This "upper-limit curve" can be combined with the familiar simple rollback model discussed below to give the percentage reduction R in NMHC emissions needed to attain the oxidant standard. Assuming no oxidant background, the technique has been used by EPA and presented in Appendix J of the regulations for preparation of SIPs (40 CFR 51). Use of the technique is simple. The highest recorded oxidant value in the study area is picked and the Appendix J curve is used to obtain the percentage reduction in NMHC levels required to attain the standard (see Fig. 2.1.). The NMHC emissions in the study region are calculated for the year the maximum oxidant concentration was measured. The percentage reduction, R, is then applied to the emissions total, yielding the desired NMHC emission level in the region. This level cannot be exceeded if the oxidant air quality standard is to be met. It is possible, of course, that R be negative, that is, that emissions can increase in the region.

It is also possible to construct an upper-limit curve from data for a particular region rather than using the EPA curve based on aggregate data from several cities. The result would be a curve similar to the Appendix J curve but reflecting the local hydrocarbon mix and meteorology and hence better suited to review of sources in the region where the upper-limit curve was developed.

There are several limitations to the Appendix J method:

- The upper-limit curve is empirical and does not necessarily have predictive value;
- The method disregards NO_x and, in particular, the NO_x/HC ratio which have been found to be important in oxidant production;
- The portions of the curve for high and low oxidant values have only a small amount of data (This may not be true for location-specific curves.);
- These curves are not necessarily valid at locations other than where they were derived and location-specific curves do exhibit variations;
- Oxidant transport is neglected; and
- The use of rollback to determine required emission reductions introduces the limitations enumerated below.

Rollback

This method makes use of the simple rollback equation

$$R = \frac{(gf)C_{max} - \text{Standard}}{(gf)\ C_{max} - \text{Background}} \times 100$$

to give the percentage emission reduction R. In this equation C_{max} and Standard are the maximum observed ambient concentration and the ambient standard, respectively. The Background is typically taken as zero for oxidants; gf is a growth factor. Using the maximum measured one-hour oxidant value in the study region for C_{max}, R is taken to be the required reduction in NMHC emission levels. This is equivalent to assuming that oxidant levels are directly proportional to NMHC emission levels. Results in smog chambers indicate that this is not a totally unjustified assumption. In the Appendix J method, the proportionality was obtained from the much criticized upper-limit curve. This method results in lesser control requirements than Appendix J. A good discussion of the limitations of simple rollback has been given by deNevers and Morris.[14] The major limitations are:

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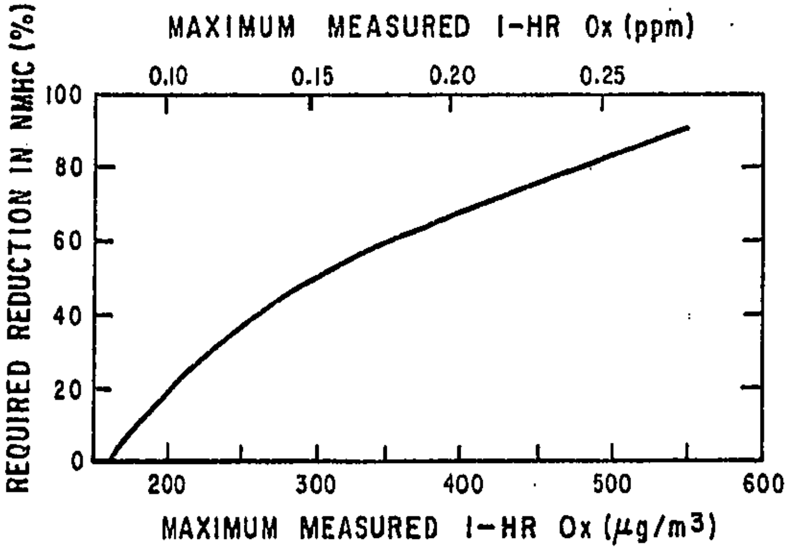

Fig. 2.1. Appendix J Relationship for Oxidant Analysis Considering NMHC Only

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- It cannot be validated experimentally;
- It assumes all sources reduce emissions in the same proportion;
- The true C_{max} value must be known;
- The meteorological pattern is assumed to be the same at all times; and
- Background levels of oxidants are assumed to be zero.

In addition, de Nevers and Morris discuss four modifications to simple rollback that make the method somewhat more sensitive to emission patterns and meteorology. They take into account successively:

- Emission rates specific to different source categories;
- Emission heights representative of each source category (Emission height is normally ignored in oxidant modeling.);
- A limited set of source-receptor distance ranges; and
- The frequency with which the wind direction lies in different directions.

Since the oxidant standard is a one-hour standard, the last modification could be ignored. The first modification could be useful in treating trade-offs between source categories. It consists essentially of keeping the overall emissions inventory by category so that the various categories may be rolled back by different amounts to achieve the desired emission level.

Smog Chamber Methods[13,15]

Simple rollback assumes a simple proportionality between hydrocarbon precursors in place of the upper-limit curve relationship of Appendix J. Oxidant-precursor relationships derived in smog chambers can also be used in a rollback technique to obtain the desired emission levels. In the smog chamber various mixtures of NO_x and NMHC are irradiated and the maximum one-hour ozone concentration (the standard measure of oxidant levels) is found. The results can be plotted as isopleths of O_3 concentration on a graph such as that shown in Fig. 2.2. The shaded areas in this figure represent NO_x/NMHC ratios which were not found to cause one-hour ozone values in excess of the standard, 0.08 ppm.

These isopleths can also be plotted based on simulations of the chemistry. A model of the chemistry is developed based on smog chamber results. Then the model is adjusted to account for the differences between the chamber and atmosphere and isopleths similar to Fig. 2.2 are plotted based on the adjusted model.

The simplest application of these data identifies the 6 to 9 A.M. ambient NMHC and NO_x levels with chamber concentrations, and the annual maximum (or second highest) O_3 concentration with the chamber isopleth corresponding to the observed NMHC/NO_x ratio. The chamber isopleth value is then rolled back by the same proportion as required to bring the observed C_{max} to the standard. The isopleth so determined can be used with an estimate of expected NO_x reductions to calculate the desired NMHC emission level.

Dimitriades[13] has proposed another method of using the smog chamber data to determine the desired emission levels:

1. The 6 to 9 A.M. ambient NO_x/NMHC and the annual maximum one-hour O_3 concentration are used to determine the chamber counterparts of the ambient situation. This point is found on the figure as the intersection of the C_{max} oxidant isopleth and a line with a slope equal to the ambient NMHC/NO_x ratio. (Figure 2.2 shows such a point (A) for NMHC/NO_x = 5 and C_{max} = 0.40 ppm O_3.
2. The NO_x value is reduced to account for expected NO_x control (Point B).
3. NMHC control is calculated to bring the ratio into the shaded area (Point C).

This method has the advantage of being simple to use and of taking NO_x levels into account. It does not, however, give a unique answer without an assumption about NO_x levels. It could provide a basis for trade-offs between NO_x and NMHC.

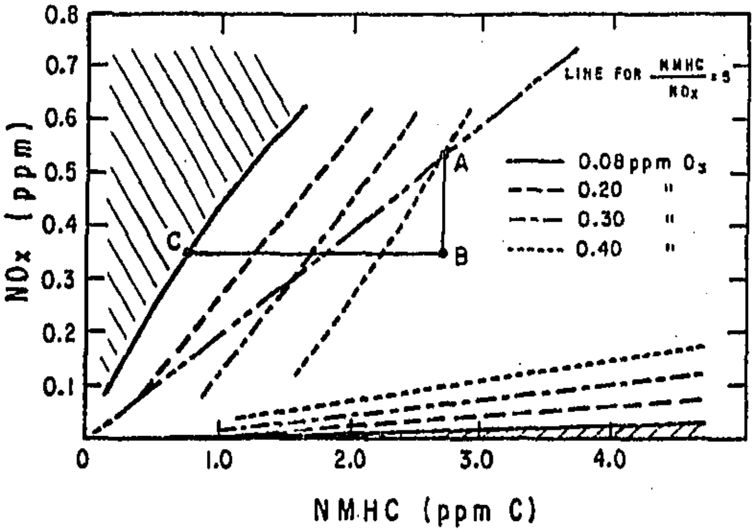

Fig. 2.2. Smog Chamber Method for Oxidant Analysis Taking Account of NMHC and NO_x

Three-hour NO_x levels could be estimated from existing ambient data and the expected effects of existing control programs like the federal motor vehicle control program. The major limitations of the smog chamber methods, in addition to the rollback assumptions, are:

- The chamber atmospheres may not accurately reflect the chemistry that occurs in the real atmosphere (models that are adjusted to simulate atmospheric chemistry minimize this problem);
- The ozone concentrations and initial reactant concentrations in the chamber obey a cause and effect relationship, unlike the real world where transport occurs and ozone concentrations at one location are related to NMHC concentrations observed earlier in the day at another location; and

- The data relate only to oxidant concentrations as a function of precursor concentrations, not to the frequency with which the standard level is exceeded. The NAAQS for oxidants is expressed in terms of the number of hours per year in which the standard level may be exceeded.

2.3.3.2 Statistical-Empirical Models

These models derive relationships between observed oxidant levels and precursor and/or meteorological variables by statistical methods. For example, oxidant values might be predicted based on yesterday's C_{max} and today's 6 to 9 A.M. NMHC/NO_x ratio. These models generally lack spatial resolution and require a significant amount of data for their development. If the data exist, however, model development or application is relatively straightforward and inexpensive. One model incorporating spatial resolution has been developed for San Diego. This model and various other statistical techniques that have been used and some of the models that have been developed are described by Myrabo, Wilson, and Trijonis[16] but are too numerous and location-specific to be described here.

Two classes of models are available: models for short-term (episode) prediction and long-term models for control strategy development, which are of interest here. The long-term models suffer from two disadvantages:

- It is not clear that the model applies when conditions are radically altered as when a control strategy is implemented;
- A sufficient quantity of aerometric data is frequently not available to give good precision or to allow for spatial resolution in model development.

2.3.3.3 Simulation Models

Reactive Environmental Simulation Model (REM)[17]

REM is a large computer model that computes oxidant concentrations in a moving column of air with a base of fixed area. The elevation of the column base follows the local topography and the elevation of the top follows the mixing height. This moving column is treated as a smog chamber in which emissions are allowed to react. The treatment of the photochemistry is the most extensive of any of the models discussed here. The column moves along a path determined by averaging all available wind data.

The data requirements of REM are fairly simple. They can be found in Record, Patterson, Bryant, and Castaline.[17] REM uses a 25 x 25 grid element

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network. Stationary source emissions and vehicle miles of travel (VMT) must be allocated to each grid element. REM has certain features specific to Los Angeles which can be easily removed from the computer code. It has been tested only in Los Angeles.

The following additional point should be made about REM:

- As a trajectory model, which follows a single air parcel through time as it moves under the influence of the wind, it is best suited to project rather than system review;
- REM's treatments of transport, diffusion, and vehicular emissions are weak; and
- It requires fewer inputs, has far less extensive data requirements, and has a simpler code than either the DIFKIN or SAI models, which are discussed below.

Diffusion Kinetics Model (DIFKIN)[17]

This model is also a trajectory model and hence most applicable to project level analysis. DIFKIN treats vertical dispersion in contrast to the REM model which assumes uniform mixing. It has been applied in Los Angeles, San Francisco, and Denver. It performed adequately only in the first two cities.

In general, however, it predicts ozone levels better then REM does. In terms of data, DIFKIN requires an extensive set of data, particularly for calculation of vehicular emissions. Several other points should be made about DIFKIN:

- The computer code must be modified for areas other than Los Angeles;
- Calculated concentrations are extremely sensitive to initial concentrations of pollutants; and
- The treatment of dispersion and advection is better than REMs but could still introduce errors by a factor of two or more when compared with observed values.

Urban Air Shed Photochemical Simulation Model (SAI)[17]

SAI is the most sophisticated model discussed here. Concentrations are predicted for all elements of 25 x 25 array and hence it is more suitable for system analyses than REM or DIFKIN. Several features of SAI are peculiar to Los Angeles and computer code modification is required for application in other areas. It has been validated in Los Angeles and a very limited comparison made with the other two models. Values predicted by SAI correlated with observations slightly better than did REM's values while DIFKIN's predicted values correlated better than SAI's. Emissions data requirements for SAI are similar to those of DIFKIN; meteorological data requirements are similar to those of REM. Several other points should also be noted:

- SAI is expensive and runs for about an hour on an IBM 370/155. It does, however, give concentrations in all grid elements in contrast to the trajectory models;
- The required information is more detailed than with the other models; and
- SAI treats transport and diffusion in more detail than the other models and is better able to accommodate topographic features and changes in initial and boundary conditions.

Observations

After examining the common models described in this subsection and discussing oxidant modeling with EPA staff members it must be noted that:

- EPA has recommended the Appendix J method for most situations but will allow other models to be used;
- EPA is currently working on revisions to Appendix J that would account for NO_x as well as hydrocarbons;
- Appendix J, linear rollback, and SAI appear to be the models most generally being used in SIP and AQMA planning at this time;
- No single method presently represents a generally accepted model. Some authorities recommend comparing the results of models in assessing control strategies; and
- The problem of determining the oxidant impact of a specific source has received scant attention; the major emphasis has been on regional modeling without attempting to isolate source-specific contributions to oxidant concentrations.

2.3.4 Summary and Conclusions

Various methods of assigning desired emissions levels of NMHC and NO_x to a study region have been described. It was noted that most airport projects will be located in areas where AQMA planning or SIP revisions are already underway. Even in these cases, however, the plans will probably lack the level of detail required for indirect source review and adjustments to the desired emissions levels specified in the plan will need to be made.

In cases where the existing analysis is inadequate or outdated, some form of modeling must be used to estimate the desired emissions levels. The available techniques divide into three broad categories: those based on proportional models requiring only hand calculation, statistical models, and those that simulate air quality requiring use of a computer. Only the first lead directly to desired emission levels and are reasonable within the context of a balance sheet approach. Several conclusions were reached:

- Oxidant modeling is in a developmental stage. Better models should become available within the next 5 years;
- The computer models were either developed for a specific location (statistical-empirical models) or have features specific to Los Angeles (photochemical simulation models) which can be removed by altering the computer code;
- Smog chamber methods have a good chance of accounting for both NO_x and NMHC;
- Although a desired emissions level could be determined by adding all the input emissions to a simulation model, this procedure violates the purpose of such models -- the simulation of air quality given emissions. The balance sheet is not recommended in such cases; the project's effects on air quality should be simulated by multiple runs of the model; and
- The balance sheet is recommended as an analysis tool in cases where a simulation model is not currently available and where resources do not permit such a model to be implemented within the time available for the review.

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2.4 ACCOUNTING PROCEDURES

All of the elements for the balance sheet analysis are now prepared: regional total and airport desired emission levels and projected airport emissions with and without the project. Given these computations the comparison between forecast and desired emissions can be made, which determines the need for trade-offs. These elements are now combined into a review and decision-making process.

2.4.1 The Decision to Require Balancing

As illustrated in Figure 2.3, the essential decision is a comparison between the emissions projected for the airport with the project and the emissions allowed to the airport by the SIP or Air Quality Maintenance Area plan. If in any year (first, fifth or tenth) the airport emissions (B on Fig. 2.3) exceed the desired airport emission level (A), the balancing analysis proceeds. If the airport emissions with the project (B) are less than the desired level (A), then the project meets the review requirements and no balancing is needed.

The desired airport emissions are based on the regional air quality plan but corrected for any discrepancies with the air quality plan in the base year, relying on a more detailed computation of emissions from the airport sources. As mentioned in Section 2.3, it is expected that the airport emissions specified in the regional air quality plan will account only for aircraft LTOs; a more accurate determination of emissions for all airport emission sources may yield a higher emissions total than the value in the plan. A correction term can be determined from the base year (i.e., the year of the best available inventory) of the plan. This term is used to adjust the airport emissions specified in the plan for each project year - one, five and ten. For purposes of determining whether balancing is necessary, the adjustment is made only on the airport total because the other regional emissions are considered unchanged. The initial comparison, then, is between airport emission totals only. However, if balancing occurs, further comparisons are made between regional emission totals because the other regional sources can be part of the trade-offs. As shown in the figure, balancing requires a comparison between the desired regional emission levels (C on Fig. 2.3) and the

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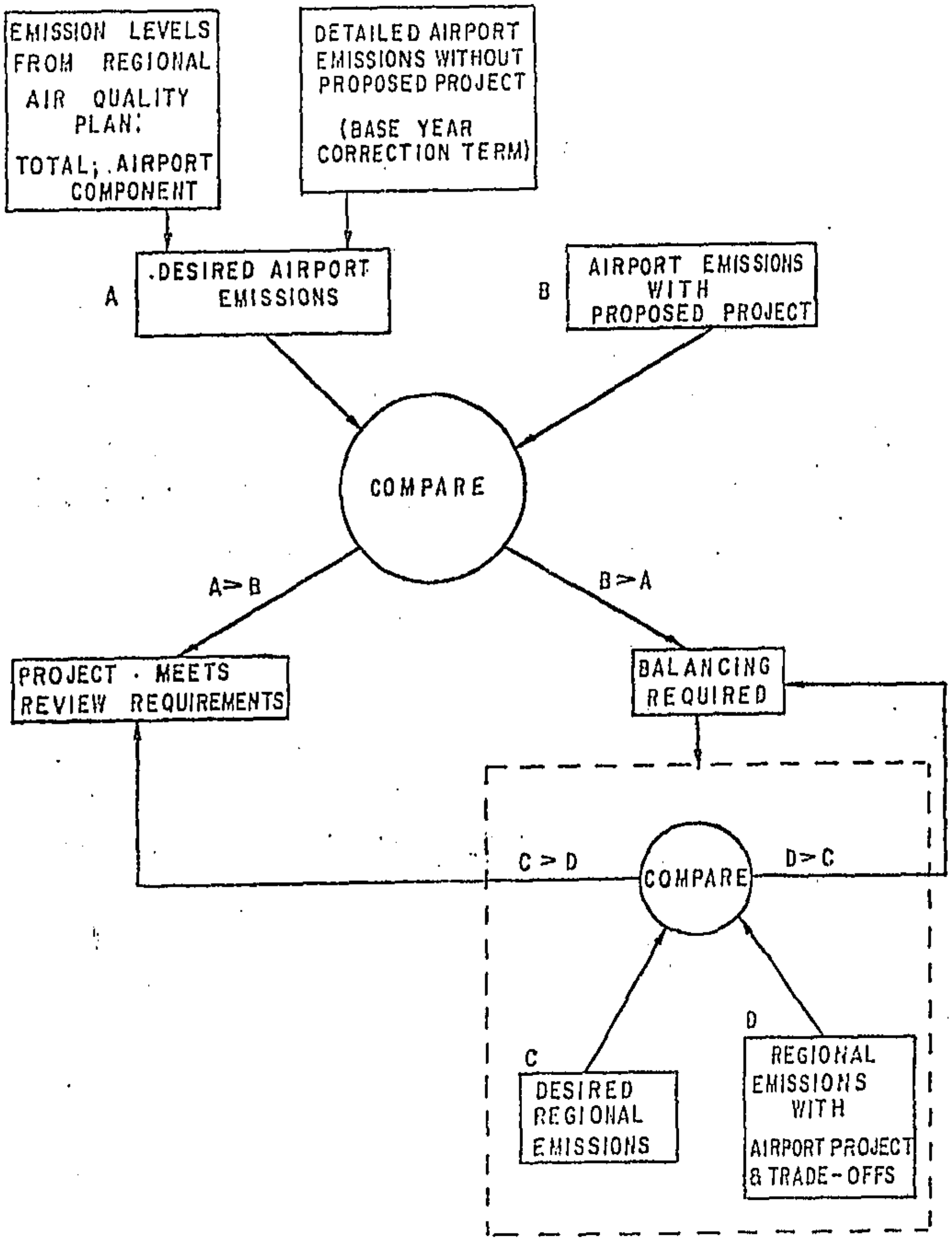

Fig. 2.3. Decision Points in the Balance Sheet Analysis Technique

regional emissions total that results from the airport project and the trade-offs made among the various regional emissions sources to balance the proposed increase in emissions due to the airport (D on Fig.2.3.). The trade-offs are made until the projected emissions from the region (D), accounting for all trade-offs, are less than the desired regional emissions in every project year (C).

There are several policies regarding the attainment/maintenance status of the study region that can affect the balancing decision. Three types of regional status will be considered: "clean air" areas, maintenance-only areas, non-attainment areas. Clean air areas are those regions that do not now have any violations of the air quality standards, nor are they expected to have any over the next several years. Maintenance-only areas are those regions that do not now have any violations of the air quality standard, but are projected to violate a standard; such areas must have a maintenance plan that demonstrates the steps taken to prevent those expected future violations. Non-attainment areas are those regions currently in violation of an air quality standard. These areas have plans for both attainment and maintenance of the standards. Of prime concern in this memorandum is the status of a region with respect to the oxidant standards.

For clean air areas, there are three policy options that affect balancing. The first, now in effect, limits emission growth only to that value which would cause a violation of the standards, the compliance emission level. In terms of the proportional reduction technique for oxidant air quality analysis, the required reduction, R, is negative. If the project brings the region an emissions increase greater than R, then balancing is required. Two other related policy options similar to the policy for TSP and SO_2 now being considered in the Congress, are possible for oxidants, however. A level of increase less than +R is set for the region and emissions growth is limited by this amount. The emissions ceiling is a value less than the compliance emission level. The amount of increase could be set to zero, or no increase is allowed over present emissions. These two policies are referred to as policies of non-degradation of air quality. Under the latter policy, any projected increase in emissions would have to be balanced by decreases elsewhere in the region or the project could not

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be begun. Under the former policy, trade-offs would be necessary if the lowered ceiling for emissions in the region was exceeded because of the project's projected emissions. In some cases, then, a less-than-equal trade-off against the proposed increase in emissions would satisfy the review requirements.

In maintenance-only areas, balancing is required when the forecast emissions exceed the desired level. However, in the years before the compliance emission level is expected to be reached according to the maintenance plan, the tradeoffs can be less-than-equal. That is, the compliance emission level can never be exceeded, but the upward path toward the compliance level can be surpassed. At the compliance emission level, all trade-offs must be at least equal so that the compliance emission level is never exceeded.

In the non-attainment areas, several policies are open. The least restrictive in terms of balancing is to require balancing when the forecast with-project emissions exceed the desired airport emissions level but to allow equal trade-offs to maintain the level specified in the maintenance plan. Another policy (known as the 'offset policy') would require greater-than-equal trade-offs if an emission source is built or modified in the region. That is, an otherwise unanticipated emission reduction must result from the proposed project for all project years[18]. Another way to view it is that the desired airport emissions level gets a little lower in a non-attainment area when a project is proposed. Further, all trade-offs would be required to be clearly enforceable by their inclusion in the SIP, as revisions to that plan. States might choose to be even more restrictive in emission control and specify no-growth in emission sources as their policy, disallowing any trade-offs. Sources would be actively discouraged from locating in the region, or from modifying existing sources so as to increase emissions. None of these policies is yet in force, but they are under consideration by the EPA. They are presented here to illustrate how each policy option effects the balance sheet review technique.

In other than clean air areas, certain options are open to the reviewing agency in balancing. In the event that some or all of the emission sources required to reduce emissions by the compliance year are ahead of schedule, that cushion may be used in trade-off. Of course, the compliance emission level and the compliance year remain unchanged.

2.4.2 Organization of the Balance Sheet

Figure 2.4 presents an outline of the essential information that a balance sheet analysis might include. The overall flow of the analysis is indicated by presenting the key information at each step. Not all of the necessary computations leading to the key figures are specified here; they were described in the preceeding sections of this memorandum and would have to be provided in an actual analysis. The figure is intended to be generic in nature, rather than a recommended form for an ISR review.

The first item, I on Fig. 2.4 collects all the identifying information for the project, including the year of project completion, applicable air quality region data and whether the project is being reviewed under the National Environmental Policy Act (NEPA) of 1969. This helps coordinate reviews; in additon, the record of computations and the data may be in the EIS. The second item (II) demonstrates whether the proposed project qualifies for preconstruction review as an indirect source of air pollution. The criteria were derived by the U.S. EPA[19] to select out major projects likely to make a significant contribution to air quality problems. The criteria are stated in terms of airport activity levels - passenger movements or aircraft operations - that lead to large amounts of automobile traffic. It has been demonstrated that these criteria do include only large airports expecting significant increases in traffic.[20]

Item III presents a summary of the emissions data, as outlined in A, B, and C; some of the traffic levels used to compute the emissions are covered in D. These numbers are the results of the analysis described in Section 2.2 of this memorandum. Documentation for these numbers is necessary since the assumptions for the computations and the emission factors used can vary. The emission sources are arranged in A, B, and C to highlight the airport sources available for balancing, should it prove necessary later. The traffic levels in D are only those for the tenth year of the project, to show the ultimate size of the airport with and without the project. Information is organized for both annual totals and the peak day. The annual totals for emissions are directly comparable with

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BALANCE SHEET

Preconstruction Review of Airport Projects

I. PROJECT IDENTIFICATION

A. Name of Project:

B. Sponsoring Agency:

C. Project Completion Date:

D. Air Quality Regions: AQCR#__________

AQMA __________Yes __________No

Pollutants: __________

SIP Revisions __________Yes __________No

Pollutants: __________

Area: __________

E. Brief Description of Proposed Project:

F. Is an Environmental Impact Statement, pursuant to NEPA (1969), prepared for this project? __________Yes __________No

Is the EIS being submitted as data record?

II. SELECTION CRITERIA

Either A or B is sufficient to require review.

A. Expected increase in total annual passengers of 1.6 million over the ten year period.

Increase: __________million annual passengers.

B. Expected increase in annual operations of 50,000 over the ten year period.

Increase: __________annual operations.

Review Required? __________Yes __________No

Fig. 2.4

Overview of Balance Sheet Analysis

III. AIRPORT SOURCES - EMISSION INVENTORY AND AIRPORT ACTIVITY

A. With Project HC, tons/year

Airport Sources					Induced Growth			
Project Year	Air-Craft	Access Traffic	Non-Aircraft	On Airport Total	Auto Traffic	Commercial	Industrial	GRAND TOTAL
1								
5								
10								

B. With Project Peak Day HC Emissions, tons

Airport Sources					Induced Growth			
Project Year	Air-Craft	Access Traffic	Non-Aircraft	On Airport Total	Auto Traffic	Commercial	Industrial	GRAND TOTAL
1								
5								
10								

C. Without Project HC, tons/year

Airport Sources					Induced Growth			
Project Year	Air-Craft	Access Traffic	Non-Aircraft	On Airport Total	Auto Traffic	Commercial	Industrial	GRAND TOTAL
1								
5								
10								
Air Quality Plan Base Year								

Note: If it is required by the model used for analysis, the same information must be provided for NO_x emissions.

Fig. 2.4 (cont.)

Overview of Balance Sheet Analysis

D. Airport Activity Measures

	With Project		Without Project	
For Project Year 10	Aircraft Operations	Total Passengers	Aircraft Operations	Total Passengers
Annual				
Peak Day				

IV. ANALYSIS REGION

A. Describe the region used:

AQMA (name) ____________
AQCR (number) __________
MPO (name) ____________
Other region ___________

B. Name of plan, and enforcement agency, governing emissions:

AQMA __________
SIP ___________
Other _________

Fig. 2.4 (cont.)
Overview of Balance Sheet Analysis

V. DESIRED EMISSION LEVELS

A. Annual HC Emissions From Air Quality Plan, Without Proposed Project

Time	Year	Desired Regional Emissions	Airport Emissions from Plan	Desired Airport Emissions*
Air Quality Plan Base Year				
Project Year 1				
5				
10				

*Based on Air Quality Plan Base Year emissions only.

B. Discuss in detail the methods and data sources used to produce the numbers in A above. Of particular importance are the methods used to bring the inventories to the same year and the data used to adjust the desired emissions for the airport. Present all computations, assumptions and judgments.

VI. COMPARISON

A.

Time Period	[1] Desired Airport Emissions, from Plan	[2] Forecast Airport Emissions, With the Project
Project Year 1		
5		
10		

B. If [2] is greater than [1] for any year, balancing is required.

Fig. 2.4 (cont.)

Overview of Balance Sheet Analysis

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VII. TRADE-OFF ANALYSIS

A. Attainment Region: ______________

Non-Attainment Region: __________

(for O_x and NO_x)

B. Internal Trade-off

1. Describe emission reduction strategy proposed for the airport, specifying the source affected (e.g., aircraft, taxiing, access traffic).
2. Demonstrate the emission reductions that are expected (data, computations, effectiveness).

C. Induced Growth Area Trade-offs

1. Identify the sources expected to reduce emissions.
2. Describe the emission reduction strategy.
3. Demonstrate the emission reductions thar are expected (data, computations, effectiveness).

D. Transportation System Trade-offs

1. Identify the sources expected to reduce emissions.
2. Describe the emission reduction strategy.
3. Demonstrate the emission reductions that are expected (data, computations, effectiveness).

E. Other Regional Emission Sources

1. Identify the sources expected to reduce emissions.
2. Describe the emission reduction strategy.
3. Demonstrate the emission reductions that are expected (data, computations, effectiveness).

F. Sum all expected changes in emission and adjust the Expected Regional Emissions to reflect the new emissions forecast. Compare it to the Desired Regional Emission Level. If the Expected is less than the Desired, the balancing is complete. If not, revise the list of emission reduction strategies and proceed through the balancing again.

Fig. 2.4 (cont.)

Overview of Balance Sheet Analysis

the annual totals in the regional air quality plan. The peak day figures provide information for oxidant episode control strategies required in the region. They also provide information on how the airport design works with very high traffic levels, airside and landside. The without-project emission totals are the emissions that result from the activity that would take place at the airport over the forecast period if the project were not built. In addition, the emissions for the base year of the air quality plan are computed. These are the detailed airport emissions used to adjust the emissions specified in the plan for the airport.

It may be that the emissions computed in this table (C) for the project years may not agree with the desired airport emissions level determined by the reviewing agency. The methods used by the airport and the reviewing agency to determine these without-project emission levels may not be the same. This is a point in the balance sheet analysis where coordination between the two groups is crucial. Difficulties in agreeing upon the baseline emissions for comparison lead to more disputes further along the analysis.

Starting with Item IV, the next steps in the balance sheet analysis are done by the reviewing agency. Up to this point, the airport supplied the information. It is essential to maintain coordination between the airport and the reviewing agency since, in the event trade-offs are required, the reviewing agency may need to examine the potential for emission trade-offs within the airport bounds. Then the airport will come back into the analysis procedure to demonstrate whatever the potential emission reductions are. Item IV specifies the analysis region to be used for the balance sheet. The candidates for analysis region were described in Section 2.1.2. The Air Quality Maintenance Area (AQMA), if applicable, or the Air Quality Control Region (AQCR), are recommended for airports because of their compatibility with existing administration, their large size, and the data available for them. It is crucial to thoroughly explain the choice of the analysis region and how it fits into the regional air quality planning process. The applicable air quality plan is also described here, in preparation for the determination of the desired emission level.

Item V-A on Fig. 2.4 outlines the information needed for the desired airport and regional emissions levels, also described in Section 2.3 The desired regional emissions level is first determined from the air quality plan for that plan's base year. The base year refers to the year of the best, most recent inventory. The airport portion of that regional total is separated out. Then for that base year, any corrections are made to the amount shown in the plan, based on the detailed airport emissions described in Item III-C of the figure. If a percentage reduction, R, was applied to the regional emissions, it is applied to this new, more detailed calculation of airport emissions also (See Section 2.3.2). Using linear interpolation where necessary, the desired airport emissions for each project year are then determined. It is this set of emission levels to which the projected airport emissions are compared in Item VI, Comparisons. Item V-B presents the relevant issues in computing the desired airport emissions. This is a difficult, but important step, since the comparison depends partially on the result of this step. In addition, the regional emissions inventory will be used again if there are trade-offs to be made.

The comparison outlined in Item VI was shown schematically in Fig. 2.3. The first column [1] comes directly from the last column of Item V. The second column [2] is from the TOTAL column of the annual, with-project emissions table found in Item III-A. If, for any of the project years, the value in [2] is greater than that in [1], balancing is required. The policies discussed above in Section 2.4.1 become relevant at this point. Whether trade-offs are allowed at all, or less-than-equal, greater-than-equal or exactly equal trade-offs can be made is determined by the type of air quality region in which the airport project is located (clean air, maintenance-only, non-attainment) and the local and national policies in effect for each type of region. The task now at hand is to find one or more sources, somewhere in the region, that can reduce their emissions by an amount equal to (or possibly greater than) the increase projected by the airport. The possible sources can be classified as belonging to: 1) the airport, 2) the induced growth in the region, 3) the regional transportation system, and 4) other regional emission sources. This breakdown is used because it distinguishes airport-controlled sources from the others, and acknowledges the close relationship, logically and administratively, between the airport and the rest of the regional transportation system. A successful trade-off strategy could include components from any one or all of the four categories. The strategies available in each case are, of course, very different. In non-attainment areas it may be required to institute the trade-offs as revisions to the SIP. In the tradeoff analysis (Item VII), strategies for reduction of projected regional emissions are designed and tested against the desired regional emissions level in each project year. The review requirements are met when the projected emissions for the region come in below the desired level.

2.4.3 Trade-Off Possibilities

Trade-offs can come from anywhere in the study region. There are some sets of emission sources that are more likely to yield trade-offs or are easier to control from the airport's point of view. The possible sources are presented here in groups determined by administrative control and potential for trade-off.

On-airport Trade-offs

The first set of trade-off possibilities are found on the airport. These have the advantage of being directly under the control of the airport operator. All of the sources at the airport are candidates for trade-off. The use of larger, fuller planes can cut down aircraft emissions for the same level of passenger traffic. At some airports, the runway and taxiway layout is such that planes have to wait in queues to cross active runways before proceeding to the terminal area. A change in the layout can bring a large reduction in emissions of aircraft by lessening the amount of time spent idling. Other aircraft-related strategies include controls on the number of flights each hour and using tow vehicles instead of using aircraft engines for taxiing. This latter strategy yielded a 33.5% reduction in the HC emissions at one airport.[21] Fuel tanks can be converted to floating roof tanks to reduce their emissions. The pattern of access traffic can be examined for bottlenecks or extra route mileage; the potential for additional mass transit routes to the airport from various points in the region can be exploited.

The heating plant might be further controlled to reduce its emissions. The airport operator must be able to demonstrate the emission reductions expected as a result of implementation of any of these strategies by using any of the emissions forecasting techniques mentioned in Section 2.2. Demonstration of the emission reductions due to runway or taxiway layout or aircraft towing requires detailed computations like those used to figure emissions in a simulation model however. The simple LTO based methods cannot trace the effects of these emission reduction strategies.

Induced Growth Region

As an airport increases its capacity, a certain amount of the increase in activity near the airport can be attributed to the airport's increase. This area of influence cannot be exactly defined but is usually taken to be no larger than a 3-4 mile radius centered on the airport itself.[22] The additional activity due to the airport growth can be classed into highway traffic, commercial (hotels, rental cars, etc.), or industrial (truck terminals, manufacturing, etc.). The highway traffic increase includes the vehicle-miles of travel (VMT) due to airport users as well as the VMT due to the commercial and industrial growth. Although the airport operator does not directly control this growth, the airport can influence it with the aid of local land use and transportation planning agencies. Local zoning and state enforced emission restrictions are two tools for controlling which uses locate near the airport and what emissions they will produce. For new point sources locating in this induced growth region, there are two ways to control emissions: one is to forbid or actively discourage their location in this area and the other is to specifically limit emissions from each source on a case-by-case basis. The legal implications of the latter are not clear, so that option should be carefully examined. The vehicular traffic in the induced growth region is also a source for potential trade-offs. Reduction in the number of vehicles through increased use of high-occupancy vehicles, including traffic flow manipulation to give such vehicles preferential treatment, is one way to reduce emissions due to vehicles. Another is to examine routing of traffic through the area for directness - e.g., minimizing the road distance from the freeway interchange to the truck terminal or hotel complex. Improvements to traffic flow in the area, including intersection modifications to increase capacity and lessen the stop-start characteristic of the traffic in the area, are other means to lessen HC emissions , which decrease with increasing speed.

Transportation System Trade-offs

The airport is a part, both conceptually and administratively, of the regional transportation system. An airport is a point of interface of air and ground transportation systems. It is logical to link these systems in the emission trade-off analysis because of these interconnections. As one example, the primary mode of ground transportation available in the busiest corridors of travel to the airport will influence the amount of vehicular emissions due to the airport access traffic. If the airport is accessible exclusively by auto and not by any high-occupancy transit mode, emissions are greater than if there were an excellent mass transit access system to the airport. There are other trade-off possibilities that lie within the ground transportation system. Emission reductions can be generated by regional automobile inspection programs, requiring maintenance that keeps auto emissions lower. Emission benefits expected from the Federal Motor Vehicle Control Program[23] can be used as trade-offs if these reductions brought the regional emissions totals lower than the compliance level. Manipulations of the ground transportation ranging from improved level of service on mass transit systems to intersection flow improvements and selective improvement of freeway links can provide emission benefits over the existing plans, which can be used as trade-offs.

Entire Region

The entire analysis region is available for trade-offs. The subsets listed above provide some advantages in the process, but in some regions it may be just as easy to consider trade-offs with the point sources in the region. (The transportation system is the principal area source for oxidant precursor emissions, so point sources remain). Controlling a source category as yet uncontrolled, or further controlling a category that is, are the basic strategies for reductions. Tank farms, power plants and chemical manufacturing plants are hydrocarbon sources that might be considered for further emission reductions. If a community particularly desires the airport growth, this type of trade-off might be necessary to accomodate that preference.

Conclusions

In considering all of the tradeoff possibilities open to the reviewing agency and the community in a balance sheet analysis for preconstruction review of an airport project, certain of them appear more fruitful than others. The first step is always to examine the airport for emission reductions within its bounds. The major advantage to the airport in this instance is that the control of the emission sources lies with the airport. Since the airport already has some concern for the nature of nearby land uses because of flight safety and noise exposure reduction, the inclusion of the induced growth region in the trade-off analysis is the next logical step. Moving out of the sphere of the airport operator's direct control, the transportation system for the region is the next likely set of trade-offs. The airport is connected to the regional transportation system in such a way that trade-offs can be built into the system planning process. The transportation system is also a particularly large source of HC and NO_x emissions and of proportionately large reductions. The least likely source of trade-offs appears to be other regional point sources. Without strong community or state support these reduction strategies are the most difficult to enforce. Opposition from the sources already controlled might delay implementation of these strategies.

2.4.4 Updating

Since air quality review is an ongoing process, it is necessary for the reviewing agency to monitor the regional air quality periodically and to examine the emission sources specified in the trade-offs to ensure that the reduction strategies are implemented as specified during the original balancing of emissions. The requirements for measurement of regional air quality are specified in various EPA requirements for attainment and maintenance of the National Ambient Air Quality Standards (NAAQS). These measurements are the primary indicators of air quality; if the oxidant standard is violated after the compliance year, for example, either the emission control strategy for the region was not effective and needs to be revised or the emission sources are not controlling emissions to the

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levels forecast. The first problem can be alleviated by more sophisticated and accurate modeling and forecasting of air quality based on emissions and meteorology, requiring monitoring of air quality as the indicator of success in attaining and maintaining concentrations at or below those specified in the NAAQS, and a revised emission control plan. The second situation is somewhat different, however. It is toward this situation that the updating requirements described here are aimed, although the information is also useful for designing a new strategy in the instance the plan is insufficient to bring the region into compliance with the NAAQS and keep it there. Two sets of updating requirements are described here, one to match the needs of non-attainment and maintenance areas, and one for clean air areas. If the analysis region becomes a non-attainment or maintenance area during the ten year period, the stricter set of requirements would apply.

For non-attainment and maintenance areas, yearly information on air traffic levels including passenger movements and aircraft operations by aircraft type should be supplied to the reviewing agency. Additionally, descriptions (or maps where appropriate) of the current physical plan of the airport would assist in the continuing review process. This information allows the reviewing agency to monitor the progress of staged development at the airport. In addition, counts of vehicular traffic volume on the airport - the access traffic - are needed to verify the expected traffic levels. Close tallies of induced growth in the region near the airport should also be kept. This task could be done most simply by the reviewing agency because many of these sources may need permits. The local zoning boards and building departments can be consulted for permits issued in that region. The reviewing agency also monitors the other trade-off categories. If the reviewing agency sees a problem in meeting the forecast emission levels at any time, further analysis and demonstration of effectiveness of the possibly revised emission reduction strategies at the airport may be required by the reviewing agency.

In clean air areas, such frequent updating and review is not necessary. Instead the same set of information - passenger movements and aircraft operations by aircraft type, access traffic counts, maps of the layout with up-to-date versions of all runways, taxiways, roads and other facilities - is reviewed after each five year period. Alternatively, the reviewing agency may choose to review the airport at the same time the review of the region to determine the need for a maintenance plan takes place since this review occurs at five year intervals. Monitoring of the induced growth again falls to the reviewing agency, relying on the local construction permitting authorities for records and on the state or local department of transportation for on and off-airport traffic counts. Trade-offs made with other regional emission sources are also monitored by the reviewing agency. In clean air areas under a non-degradation policy, should it be in effect, it is suggested to choose the more stringent requirements of yearly review. Under this policy, the region is very close to its desired level and five years in between reviews allows for extensive emission growth if the original strategies are not followed.

3. AIRPORT TEST CASES

3.1 NEW AIRPORT TEST CASE

3.1.1 Description of Proposed Project

This test case demonstrates the use of the balancing technique for a proposed new airport in an oxidant non-attainment area. The data for the region and the airport are based on actual air quality and aircraft activity data but have been modified for purposes of illustration. The analysis follows the technique described in Section 2; the discussion will focus on the data sources and the comparison of the desired with the actual emission levels.

The project under review is a proposed new major air carrier airport to be built on the outskirts of the urban area of the Modern City Air Quality Maintenance Area (AQMA) that will replace the present airport. The present airport, Oldfield Airport, is too small for forecast traffic and has no room for expansion, as it is located in a highly developed section of the urban area. The proposed Neway Airport would be built in phases, opening in project year 1 to accommodate principally general aviation and charter traffic. By the fifth year the transition of scheduled commercial traffic to the new airport would be essentially complete, and by the tenth year only a small amount of general aviation traffic would remain at Oldfield Airport. The character of the traffic at Neway Airport would also be changing over the ten year analysis time period. Scheduled air carrier traffic would be added by the fifth year, and in the tenth year there would be almost exclusively scheduled commercial and charter traffic with an emphasis on long haul flights. A summary of the air traffic forecasts for both airports is presented in Table 3.1.

Table 3.1. Aircraft Activity and Passenger Movements with Proposed New Airport[a]

Project Year	1	5	10
Neway Airport Air Carrier Operations[b]	0	54,800	148,700
Passengers Air Carrier[b]	0	3,131,000	13,704,000
Oldfield Airport Air Carrier Operations[b]	45,000	13,000	0

[a] Source: Modern City Airport Commission

[b] Excludes charter.

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It can be seen by examination of Table 3.1 that the Neway Airport is subject to preconstruction review for its impact on oxidant levels, since the increase in air carrier operations over the ten year period is 148,700; additionally, the level of annual passenger movements increases by 13.7 million over the same time. When compared with the criteria of an increase of 50,000 annual operations or 1.6 million annual passengers over ten years, the proposed project is subject to review based on either criterion.

The site of the proposed airport is quite large. The airport commission assembled a parcel 11.5 km (7.2 miles) long and 4.8 km (3.0 miles) wide to allow for the phased development of the airport and to minimize the noise exposure. The size of the site affects the length of the ground access trips and the associated emissions. Other plans for the airport site include extension of a commuter rail line from Modern City to each terminal, and connections to the three major roadways passing near the site. The terminal buildings will be built in phases, with additions scheduled to open at each analysis year. Other facilities - mail handling, cargo, airline maintenance - will be added as needed, generally following the passenger terminal construction phases. Activity levels for these facilities have been incorporated into the airport activity forecasts assuming growth parallel to that of the passenger traffic.

3.1.2 Emissions Due to the Proposed Project

The airport commission let a contract to suggest alternative designs for the airport terminal and runways and produce related activity data for design and environmental impact evaluation purposes. This report is the source of most of the airport data needed to compute the hydrocarbon emissions due to the proposed new airport in each of the years required. Where specific data were not available from the consultant's report, average figures from other airports were used.

The fully detailed computations of the emissions from each airport source are presented in Appendix A. A summary of the emission totals is presented in Table 3.2. The entries are the emissions due to the new airport (Neway) only, operated in the manner described in the consultant's report. The emissions due to the Oldfield Airport are not of concern here; they will be discussed in the context of the regional desired emission levels.

Table 3.2. Detailed Airport Hydrocarbon Emission Inventory For Proposed Project - Neway Airport

	Emissions (10^3 kg/year)		
	Project Year		
Category	1	5	10
Aircraft	149.6	933.9	1885.8
Access Traffic	31.2	93.2	108.1
Ground Service Vehicles	7.1	57.4	176.6
Fuel Storage & Handling	3.4	12.9	32.4
Heating & Cooling	0.2	1.0	3.3
Engine Tests	0	6.9	27.5
On-Airport Total	191.5	1105.3	2233.7
Induced Growth			
Air Passenger Traffic	0	9.4	46.9
Employee Traffic	19.7	94.2	91.5
New Workplaces	0.1	0.9	2.1
Manufacturing Processes	0.2	1.8	4.2
Induced Growth Total	20.0	106.3	144.7
NEWAY AIRPORT TOTAL	214.7	1211.6	2378.4

Only hydrocarbon emissions are presented here although the nitrogen oxide emissions totals can be found in Appendix A. The AQMA in which Neway Airport is to be located used the Appendix J method for determining the required emission reductions in the region; that method relies only on hydrocarbon emission totals. The aircraft are the largest single source of hydrocarbon emissions at the airport in every year. The aircraft emission factors were assumed to be the same in every year so the increase is proportional to the growth in traffic. The new FAA engine emission standards were not considered appropriate for this airport since it is expected to open before any noticeable fleet changeover to the cleaner engines will occur. Of course, if changeover begins before the ten year period is up at the airport emissions should then be recomputed to see if the actual value is less than the forecast. The state air pollution control agency can use this information in an update of the regional plan.

The aircraft emissions represent 71% of the total due to the proposed project in Project Year 1, 77% in year 5 and 79% in year 10. Access traffic, the on-site travel by air passengers, visitors and employees, reduces its relative contribution to total emissions by a factor of three over the ten year time period, from 15% to 5% of the total airport HC emissions. Although the number of person trips increases dramatically, several factors work against this increase: 1) more stringent emission controls reduce the composite HC emission factor by 80% (see Appendix A); 2) the share of trips going by transit increases sharply; 3) the vehicle load factor (persons/vehicle/trip) increases for air passengers between Project Years 1 and 10. The emissions due to induced growth, primarily due to VMT increases, are 9.4% of the total in Year 1, and fall to 6.1% by the tenth year in spite of a sevenfold increase in the magnitude of the emissions. The emissions due to aircraft increase by a factor of twelve, however, dominating the airport emissions growth.

Ground service vehicles become a more significant emission source as the airport shifts to more larger aircraft requiring more service time. No emission controls are assumed for ground service vehicles. Fuel storage and handling remains a fairly constant percentage of the total; although the quantity of jet fuel used increases by a factor of 24, the emissions increase only by a factor of 10. In the first year, 63% of the fuel storage emissions are due to the aviation gas used for general aviation which represents only 1/24 of the amount of jet fuel used in that year. Again, the large growth in aircraft emissions overshadow the emissions growth from this category. Heating and cooling is a relatively small source of emissions. Engine testing becomes nearly as large a source of emissions as fuel handling by Project Year 10, as the airlines are expected to have extensive maintenance facilities at Neway by then. In the first year, however, no testing is expected to occur. Other emissions from maintenance facilities were not itemized because (1) they are expected to be negligible in contrast to aircraft and (2) it is difficult to determine at this early planning stage the exact nature of these facilities.

3.1.3 Regional Air Quality Plan

An attainment and maintenance plan has been prepared for the Modern City AQMA. The plan contains a base year inventory and forecasts hydrocarbon emissions for future years. The state air pollution control agency used a proportional reduction technique (Appendix J) to determine the total regional emissions level required to comply with the NAAQS for oxidants. Their analysis showed that a 21.86% reduction in total regional hydrocarbon emissions was required between the air quality plan base year and the compliance year. The state accounted for New Source Performance Standards, the Federal Motor Vehicle Control Program and adopted several regulations requiring retrofit of existing emission sources to effect the required reductions. The final result of the state agency's planning effort is given in Table 3.3

In this particular instance it happened that the plan's compliance year coincided with the tenth year of the proposed new airport's operations. Thus, the forecasts from the air quality plan need no interpolation to match the analysis years for the airport project, because they were made at five year intervals. Year 1 of the project was selected as the base year for determining any corrections to maximum emission levels specified in the plan. This is allowable since the present Oldfield airport has experienced smooth linear growth in emissions between the plan's inventory year and the opening year of the proposed project (Project Year 1).

The inventory is broken down into thirteen categories; only two, automotive and aircraft, are of concern initially. The emissions specified for aircraft are based on the present Oldfield Airport only. In the regional

Table 3.3 Summary of the Hydrocarbon Emission Inventory From Air Quality Region Plan

	Emissions (10^3 kg/year)		
	Project Year		
Category	1	5	10
Gasoline Handling & Storage			
Bulk Storage	2252	2384	2490
Terminal Loading	848	901	927
Service Station Storage	159	159	185
Service Station Pumps	371	397	397
Power Plants	1695	980	1060
Refuse	270	270	270
Diesel and Shipping	3179	3258	3576
Industrial and Process Heating	2093	2119	2172
Drycleaning	260	260	260
Other Solvents	10278	10437	10702
Miscellaneous Gasoline Engines	1007	1060	1139
Aircraft	949	1144	1386
Total Automotive	56252	43139	37643
TOTAL	79613	66508	62207
			Compliance Emission Level

plan, emissions were assumed to grow proportionately with the air traffic; no change in engine emission characteristics was anticipated. The only other category of emissions due to the airport that was considered in the regional plan is access traffic. The automobile and bus trips to the Oldfield Airport were included in the regional vehicle-miles of travel forecast.

The category of airport induced growth is also included in the regional plan. It is, of course, not categorized in that way; the region's growth forecasts included the effects of airport growth in the commercial and industrial sectors. It is useful to point out here that it is not necessary to total up separately the growth effects of the without-project scenario as long as the induced growth tabulated for the with-project scenario is net growth. In this test case, for example, the economic benefits of the proposed project (Neway Airport) were computed by the consultant to the airport commission. These benefits, including new jobs in the region, were presented as a net increase in jobs, accounting for the relocation of some commercial establishments and industrial facilities as the focus of air traffic moved from Oldfied to Neway Airport. The majority of emissions due to induced growth can be related to the number of jobs created in the region near the airport, so the figures supplied in that consultant's report allowed a computation of the emissions due to the net increase in commercial and industrial activity.

As several on-airport sources of hydrocarbon emissions are not included in this inventory for the region, it is necessary to correct the base year inventory by including these sources. The correction amount for the base year, Project Year 1, is determined by adding together the emissions from Oldfield Airport sources not now in the inventory, as shown in Table 3.4. In this instance, the correction amount is relatively small: 81 x 10^3kg/yr against a regional total of 79,613 x 10^3kg/yr in the original inventory. Its inclusion is still important from the airport operator's viewpoint, however, because the allowable regional emissions will be slightly increased, mitigating the effects of growth.

It is then necessary to apply the reduction percentage, R, to the correction term for the compliance year, Project Year 10. As noted above, the value of R over the ten year period is 21.86%. The amount added to the

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Table 3.4. Detailed Airport Emission Inventory in Base Year Without Project

Category	HC Emissions (10^3 kg/yr)
Aircraft	949
Airport Non-Aircraft Already in Inventory	
- Access Traffic	100
Airport Non-Aircraft Not in Inventory	
- Ground Service Vehicles	60
- Fuel Storage & Handling	11
- Heating & Cooling	1.5
- Engine Tests	8.2
Induced Growth [a]	0
TOTAL	1130
TOTAL NOT IN INVENTORY	81

[a] Growth induced by Oldfield Airport is included in regional growth projections; only the net increase due to the proposed project will be considered in the analysis.

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regional desired emission level to include the previously unaccounted emission sources, in the tenth year, is determined by

$$\begin{aligned} A_{10} &= \text{(Base Year Correction) } (1-R/100) \\ &= (81 \times 10^3 \text{ kg/yr}) (1-0.2186) \\ &= 63.3 \times 10^3 \text{ kg/yr.} \end{aligned}$$

The value of the correction term for Project Year 5 is found by simple linear interpolation between years 1 and 10. These results are summarized in Table 3.5. The numbers in the column headed "Total from Plan" are the regional emission totals from Table 3.3. These plan-specified values are increased by the increment in the next column, which was computed above. The figures in the last column, headed "Desired Emission Level"; represent the total desired emission level for hydrocarbons for the region, corrected for several previously overlooked airport emission sources. These are the totals that cannot be exceeded by the region (Modern City AQMA) if the new airport is built. The desired emission level for PY 10 should guarantee the attainment of the oxidant NAAQS if Appendix J is valid in the region.

3.1.4 The Decision to Require Balancing

The regional desired emission level can be compared to the emissions that would result if Neway Airport were completed. Table 3.2 presented the hydrocarbon emission inventory for Neway Airport. In Table 3.6, those data plus the emissions from Oldfield while Neway is in operation - the with project scenario - are presented. The first item, "Remainder of Region", is the sum of all the emission categories on Table 3.3 except aircraft. This is unchanged as a result of the project. Included in this total are the emissions due to access traffic that would occur if the project were <u>not</u> built. Thus the "Airport Non-Aircraft" category includes all non-aircraft airport emissions due to Neway Airport, including for access traffic only those emissions due to access traffic in excess of levels previously expected for Oldfield. The fraction of the access traffic indicated on Table 3.2 that is considered new traffic in Project Years 1, 5 and 10 is 0%,8.1% and 34.6% respectively. These numbers were derived by comparing the number of vehicle trips expected under the with (Neway) versus the without (Oldfield only) project scenarios. Although the passenger traffic increase

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Table 3.5. Modification of Desired Emission Level for Each Project Year

Project Year	Total From Plan	Increment[a]	Desired Emission Level
1	79613	81.0	79694
5	66508	$\frac{81 + 63.3}{2}$[b]	66580
10	62207	63.3	62270

[a] Accounts for existing emissions not included in original state plan and found in this analysis using a more detailed airport emissions inventory.

[b] Linear interpolation

Table 3.6. Regional Hydrocarbon Emission Inventory Including the Proposed New Airport

	Emissions (10^3 kg/year)		
	Project Year		
Category	1	5	10
Remainder of Region[a]	78664	65364	60821
Aircraft			
Oldfield Airport	753	210	18
Neway Airport	150	934	1886
Airport Non-Aircraft[b]			
Oldfield Airport	65	19	0
Neway Airport	31	240	460
TOTAL	79663	66767	63185
Desired Emission Level	79694	66580	62270
Excess Emissions	-31	187	915

[a] Includes all source categories in regional inventory (Table 3.3) except aircraft.

[b] Includes all induced growth, ground service vehicles, fuel storage, heating, engine tests; includes new auto access trip emissions for each year (0%, 64.8%, and 73.5%, respectively, of the amounts shown on Table 3.2 for Access Traffic).

is actually greater than that for Years 5 and 10, a significant fraction of passengers are expected to use the new rapid rail connection to the airport. However, new trips alone do not account for all of the difference in access traffic emissions; in PY5, for example, only 8.1% of the emissions are from new trips, while 64.8% of the emissions on Table 3.2 are due to Neway. The greater length of the trips on the Neway Airport site, compared to the Oldfield site, must also be taken into account. For the number of trips already expected to be made by air travelers, the on-site trip length more than doubles. Thus in Project Year 5, 55.5×10^3 kg of HC emissions are due to Neway, in excess of the 37.7×10^3 kg forecast for Oldfield without the new airport being built. In Project Year 10, 75.5×10^3 kg of HC emissions are due to Neway. The emissions shown for aircraft reflect the split between the two airports as described earlier. The total for Neway aircraft emissions is taken from Table 3.2. The totals for Oldfield Airport were computed separately, reflecting the transition to a general aviation airport over the ten years. In the first year, the total emissions due to aircraft are less than the amount that would occur if the project were not built; this is due to the relieving of congestion at Oldfield because of the shifting of some traffic to Neway.

The comparison between the total regional emissions expected with the project being built and the desired emission level from the regional air quality plan can now be made for each project analysis year. The desired emission levels, computed on Table 3.5, are projected to be exceeded in Project Years 5 and 10. Emission reduction strategies must be found, starting by Project Year 5, to offset these proposed increases due to the new airport, or a permit cannot be granted.

3.1.5 Balancing and Trade-Offs

As shown in Table 3.6, the proposed project causes the regional emissions total to exceed the desired emissions level in Project Years 5 and 10. Following the balance sheet technique, it is necessary to find emission trade-offs equal to or greater than the expected excess emissions, either from the airport or somewhere else in the region, for those years. The first place to look is at the airport sources. In the fifth year, the most significant source is aircraft, followed by on-airport access traffic and new traffic outside the airport due to new air passengers and employees in the area (see Table 3.2). The aircraft emissions are affected by the engine characteristics - not changeable until the fleet changes over - and by operating characteristics such as taxiing time. The latter is not a very promising area, as the Neway Airport is laid out to minimize the taxi time for large jets. The auto traffic emissions from all three sources can be affected only by eliminating traffic, since the Federal Motor Vehicle Control Program has already been taken into account. As a significant mode split to commuter rail is included in the auto traffic estimates, this path also is not promising.

So in this instance, the off-airport sources for emission trade-offs look more promising. By examining the regional air quality plan, several strategies appear relevant. The first, sufficient to negate the excess emissions of Project Year 5, involves dry cleaning solvents. Currently, reactive hydrocarbon solvents are used. The use of non-reactive hydrocarbon solvents can essentially eliminate all the emissions now expected from dry cleaning, 260×10^3 kg/year. For Project Year 10, this strategy alone is not adequate, since the excess emissions total 915×10^3 kg/year. Examining the inventory leads to several conclusions: 1) automotive, gasoline handling and storage are already controlled to the maximum practicable level in the plan; 2) power plants cannot be controlled further; and 3) except for solvents the other sources are relatively small and it is difficult to find control strategies. Thus, the category of Other Solvents has the greatest potential for this AQMA. Detailed examination of the source-by-source inventory yields the fact that just about 9% of the solvent emissions are due to surface coating facilities (painting, varnishing, etc.). Requiring the use of activated carbon adsorbers at these facilities could be 90% effective in reducing hydrocarbon emissions. Requiring the adsorbers on surface coating facilities would yield a trade-off of 867×10^3 kg/year. The two strategies added together - use of non-reactive dry cleaning solvents and control of surface coating emissions - yield an emission trade-off large enough to balance the expected excess emissions in Project Year 10. These results are presented in Table 3.7.

In determining these strategies for emission trade-offs, it is essential to have detailed knowledge of exactly what is included in the regional air quality plan. The nature of the pollutant sources and the

Table 3.7. Strategy for Trade-offs

Project Year	Excess Emissions (10^3 kg/year)	Trade-offs (10^3 kg/year)	
1	None		
5	187	260	Use of non-reactive solvents in drycleaning.
10	915	260	Use of non-reactive solvents in dry cleaning.
		867	Use of activated carbon adsorbers in surface coating facilities.

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strategies already used in the regional plan varies from one air quality region to another. This test case also demonstrates the significance of the traffic induced by the airport as an emission source. Even where a commuter train is available, auto traffic levels are still high. Especially in the later analysis years, as other emission sources in the region are controlled so as to slow or reverse growth in emissions, the airport as a whole begins to grow in significance as a regional source of hydrocarbon emissions. In this case, the airport grows from 1.2% to 3.8% of the regional total. Aircraft accounted for 85% of the on-airport increase between Project Years 5 and 10, while induced auto traffic accounted for 90.6% of the increase in induced growth. For years beyond the compliance year (Project Year 10), the new aircraft engine emission standards will be important in keeping the region below the compliance emission level.

3.2 MODIFIED AIRPORT TEST CASE

3.2.1 Description of Proposed Project

This test case demonstrates the application of the balance sheet technique for a proposed modification to an existing airport in an oxidant nonattainment area. The data for the airport and for the region are based on actual aircraft activity and air quality data but have been modified for purposes of illustration. The discussion will focus on the balancing decision in this application of the technique to a proposed modification of an existing airport, following the procedure of Section 2.

The Metro Airport in the Green Apple Air Quality Maintenance Area (AQMA) is anticipating a large increase in traffic within the next several years. To accommodate this growth, the airport commission feels that a new jet runway is needed. There is adequate space at this airport to build a runway. A long runway is needed (12,000') since much of the growth in traffic will come in the form of more large jet operations. It is felt that the terminal and parking facilities are adequate to handle the passenger load since the terminal building was expanded a few years ago in anticipation of more rapid growth than has actually occurred in the interim. The traffic forecasts for the ten-year analysis period, beginning with the opening of the runway to traffic, are presented in Table 3.8.

Table 3.8. Forecast Aircraft Activity at Metro Airport

Project Year	1	5	10
Air Carrier Operations (10^3)	483	577	671
Air Carrier Passenger Enplanements (10^6)	15	20	25

Given the 188 x 10^3 increase in air carrier operations, and the 20 million increase in passenger movements (enplanements and deplanements), it can be seen that this project is subject to review under the criteria. An increase of 50,000 annual air carrier operations <u>or</u> 1.6 million annual passengers is sufficient to qualify for pre-construction review.

3.2.2 Emissions Due to the Proposed Project

Metro Airport proposed a simulation model of its current operations. The model simulated aircraft operations in detail for a typical day, computing the aircraft and ground service vehicle emissions of HC and NO_x hour by hour. Five other on-site sources of emissions were included, using detailed data collected for current activities to determine the emissions from these sources (access traffic, fuel storage and handling, engine tests, heating, miscellaneous). Starting from this finely calibrated simulation, the airport had little difficulty in forecasting emissions for the higher levels of traffic expected when the new runway is completed. All the activity levels were based on aircraft operations and passenger movements, using relationships (e.g., visitor/passenger ratios, access vehicle load factors) derived from current patterns. The induced growth sources were forecast for the analysis period using relationships between aircraft and passenger activity levels and regional employment developed specifically for Metro Airport. Studies of current land use patterns provided an excellent data base for these relationships. As Metro Airport is already a very busy airport, it is felt that the land use patterns in the region are fairly settled; no major intra-regional shifts will occur. Rather, growth attracted to the region because of the airport will locate in the same pattern as existing land uses. The new hotels will be built near the existing ones and so on.

The summary of the HC emissions expected at Metro Airport if the project is completed is presented in Table 3.9. The details of these computations may be found in Appendix B, including references to the simulation model used. The AQMA in which Metro Airport is located used the Appendix J method for determining the required emission reductions for attainment of the oxidant air quality standard; for this reason, only the hydrocarbon emission inventory is included in Table 3.9. The NO_x inventory is included in Appendix B, however.

The computations of aircraft HC emissions assumed that the entire fleet will meet the new engine emission standards proposed by FAA,[7] in Project Year 10. In Project Year 1, all of the fleet is expected to use current engines, as characterized in U.S. EPA's Report AP-42.[24] By Project Year 5, roughly half of the fleet will be composed of aircraft having the newer, cleaner engines. This assumption on the part of the airport is a crucial one in this

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Table 3.9. Detailed Metro Airport Hydrocarbon Emission Inventory With Proposed Project

	Emissions (10^3 kg/year)		
	Project Year		
Category	1	5	10
Aircraft	1520.3	1533.2	1546.0
Access Traffic	196.1	204.6	213.2
Ground Service Vehicles	306.8	369.4	432.1
Fuel Storage and Handling	397.7	470.6	543.4
Heating and Cooling	0.8	0.8	0.8
Engine Tests	36.1	21.6	7.0
Miscellaneous	6.7	8.1	9.5
On-Airport Total	2464.5	2608.3	2752.0
Induced Growth			
Air Passenger Traffic	59.2	82.2	131.3
Employee Traffic	138.0	152.6	160.4
New Workplaces	0.1	0.9	2.1
Manufacturing Processes	0.2	1.8	4.2
Induced Growth Total	197.5	237.5	369.9
TOTAL DUE TO AIRPORT WITH PROJECT	2662.0	2845.8	3121.9

analysis. Aircraft are responsible for 57.1% of the emissions in Project Year 1, yet they drop to less than 50% of the total in Project Year 10, accounting for only 5.6% of the overall increase in airport emissions over that time period. Given the 39% increase in jet aircraft operations, only the assumption of clean engines in Project Year 10 keeps the total airport emission growth so low (17.3%). If the fleet changeover does not occur at the rate projected by Metro Airport, considerable recalculation and reconsideration would be called for. The potential error in the emissions forecast due to an underestimating of aircraft emissions is at minimum 570 x 10^3 kg in the tenth year, or nearly 20% of the airport total in that year.

Ground service vehicles are another large source of HC emissions. The emissions increase 41% over the analysis period, growing from 11.5% to 13.8% of the airport total. Thus the increase in emissions is parallel with the 40% increase in jet operations, since the emission factors for ground service vehicles are assumed not to change over the ten years. The relative share of the airport total increases for ground service vehicles as aircraft emissions reduce their share of the total.

The on-site access traffic is also a relatively large source of HC emissions. These emissions increase very little (1.7%) over the ten years. Although vehicle miles of travel increases proportional to the passenger movements, the composite emission factors for automobiles are lowering each year tending to negate the effect of the increased VMT. As a result, access traffic emissions become a less significant source from project year 1 to year 10 (7.4% to 6.8%). Fuel storage and handling is the other major HC emission source on the airport site. As fuel needs are directly proportional to aircraft operations and the fuel emission factors are constant over the ten years, fuel emissions increase nearly 37% over the analysis period. Their share of the airport total also increases, from 14.9% to 17.4%, again because aircraft emissions are nearly constant and emissions from fuel are increasing.

The remaining on-airport sources of HC emissions account for less than 2% of the total in any year. The heating needs are not expected to change since the terminal size will not change. The engine test emissions actually decrease over the analysis period, even though the number of engine tests will increase along with operations, because of the new clean engines which will be tested in Year 10. The miscellaneous sources include refuse incineration and various airline maintenance facilities that contribute from 0.2-0.3% of the annual total.

Induced growth increases its share of the airport total from 7.4% to 11.9% over the ten years. The emissions increase 87% over that time. The growth is due mainly to the vehicle miles of travel due to new air passengers and employees at new off-site jobs. The airport's importance in the region's economy is demonstrated by the growth attracted to the region on its account.

3.2.3 Regional Air Quality Plan

Green Apple AQMA has prepared an attainment and maintenance plan for the oxidant air quality standard, as it is a non-attainment area for oxidants. There is available an inventory of HC emissions for the base year of the plan with forecasts until five years beyond the projected compliance year. A summary of the plan is presented in Table 3.10. This plan called for a reduction of 7.64% in HC emissions between the plan's base year and the compliance year. The region is fairly close to compliance at the start of the airport's ten-year analysis period, as indicated by the relatively low percentage reduction needed to achieve the oxidant NAAQS. Note that the years are indicated in terms of the proposed project's analysis years. The compliance year for the AQMA happens to occur in the third year of operation of the proposed new runway. The year five years before compliance (3 years before the project) is the baseline year for the air quality plan. Project Year 1 will be used as the baseline for any corrections to the inventory, however.

In the regional air quality plan, the airport was expected to grow by 25% over the ten years, since its physical facilities limited its growth. With the proposed runway, however, operations growth of 40% is expected. The new engine emission standards were expected to be in effect. These assumptions led to the amounts noted in Table 3.10 for aircraft emissions. The on-airport categories of heating and cooling and access traffic were also included in the regional plan, in the appropriate source categories.

As the project's analysis years do not match the plan's analysis time frame, it is necessary to interpolate the requirements of the plan to match the project's analysis years. In Table 3.11, the interpolation is shown.

Table 3.10. Summary of Hydrocarbon Emission Inventory From Regional Air Quality Plan

	Emissions (10^3 kg/year)		
	Project Year		
Category	3 years before project	3 (Compliance Year)	8
Gasoline Handling & Storage			
Bulk Storage	2252	2384	2384
Terminal Loading	848	901	901
Service Station Storage	159	159	159
Service Station Pumps	371	397	397
Power Plants	1695	980	980
Refuse	270	270	270
Diesel and Shipping	3179	3258	3258
Industrial and Process Heating	2093	2119	2119
Drycleaning	260	260	260
Other Solvents	10278	10437	10437
Miscellaneous Gasoline Engines	1007	1060	1060
Aircraft	1534	1474	1474
Total Automotive	46252	41139	41139
TOTAL	70198	64838	64788
		Compliance Emissions Level	

Table 3.11. Interpolation to Compute Plan Requirements in Project Years 1, 5, 10

	HC Emissions (10^3 kg/year)			
	Project Year			
Category	-3	1	3	5[b]
Rest of region[a]	22412	22300	22225	22225
Automotive	46252	43184	41139	41139
Aircraft	1534	1498	1474	1474
TOTAL	70198	66982	64838	64838

[a] Categories "Gasoline Handling and Storage" through "Miscellaneous Gasoline Engines" on Table 3.10.

[b] Since compliance is reached in Project Year 3 and forecast in the plan to Project Year 8, the plan requirements for Project Year 10 are assumed to be the same as those indicated for Project Year 5.

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The data from the plan, in the columns headed Project Year -3 and Project Year 3, are taken from Table 3.10. The data for Project Year 1 is a simple linear interpolation between them. Project Year 5 repeats the requirements of Project Year 3, since compliance was forecast out to Project Year 8. Project Year 10 is assumed to be the same as Year 5, since the regional plan stops at Year 8.

In Table 3.12, the HC emission inventory for Metro Airport for Project Year 1 without the runway being built is provided. It is necessary to compute these emissions since the regional air quality plan does not include all of the relevant sources, as noted above. In the table, all of the HC emissions estimated from each of the on-airport sources are listed in the first column. The next two columns distinguish the emission source categories that were included in the plan from those that were not. The total from the third column, 730 x 10^3 kg/yr, represents the total amount of emissions not accounted for in the original emissions inventory.

This amount (730 metric tons) must now be included in the regional emissions, and reduced by R = 7.64%, the required regional emission reduction. The reduced amount is added to the compliance year emission level, yielding the corrected compliance emission level. The results of these computations are presented in Table 3.13 for the airport project's analysis years and for the regional air quality plan's compliance year. The same amount is added to the plan's totals for Years 5 and 10 as for the compliance year, since compliance is forecast beyond the compliance year. The totals in the third column represent the emission levels that cannot be exceeded in each year if the plan is to be adhered to and the oxidant NAAQS to be met.

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Table 3.12. Detailed Airport Emission Inventory for Base Year[a] (without project)

	(10^3 kg/year)		
Category	Actual Hydrocarbon Emissions	HC Emissions in Plan	Extra Emissions Due to Detailed Inventory
Aircraft	1498.4	1498.4	0
Heating and Cooling	0.8	0.8	0
Access Traffic	166.7	166.7	0
Ground Service Vehicles	302.4	0	302.4
Engine Tests	35.6	0	35.6
Fuel Storage and Handling	392.0	0	392.0
Induced Growth[b]	0	0	0
Airport Total	2395.9	1665.9	730.0

[a] Project Year 1

[b] Included elsewhere in the regional inventory.

Table 3.13. Modification of Desired Emission Level for Each Project Year

Project Year	Total from Plan	Increment	Desired Emission Level
1	66982	730.0	67712
3 (Compliance year in plan)	64838	674.2	65512.2
5	64838	674.2	65512.2
10	64838	674.2	65512.2

3.2.4 The Decision to Require Balancing

Given the desired emission level for the region for each analysis year, it can now be determined whether these desired totals will be exceeded at any time as a result of the airport modification. In Table 3.14, the emission inventory for the region with the project is presented year by year. Only the airport sources are broken out, since they are the only ones that have changed at this point in the analysis. The Aircraft and Airport Non-Aircraft categories include only those emissions not already counted in the Remainder of Region category. That is, no aircraft emissions are included in the Remainder of the Region; they are all counted in Aircraft. The heating and access traffic emissions already in the Remainder of the Region category are not in the Airport Non-Aircraft category. Referring to Table 3.9, the Airport Non-Aircraft category includes all the source categories except aircraft, heating and cooling, and 85% of the access traffic emissions.

The totals shown in Table 3.14 represent the emissions that would occur in the region if the project were built and no other changes in emissions occurred. These totals when compared with the desired emission level in each year yield the excess emissions. In this test case, there are excess emissions in every analysis year. If the project is to be built, then reductions in HC emissions must be found in the region to offset these proposed increases.

3.2.5 Balancing and Trade-offs

Emission reductions greater than the excess amounts shown in Table 3.14 must be found from some source of HC emissions in the region. The first place to examine in this case is the airport itself. There are several aspects of the airport's design and operation which lend themselves to improvements that would reduce emissions. Metro Airport is poorly laid out from the perspective of minimizing taxi and idle time. Thus a strategy to reduce aircraft emissions by lessening idle and taxi emissions could be fruitful. Towing aircraft, in place of taxiing, meets this need. The simulation model was used to determine the maximum emission reduction possible by complete conversion to towing. In the first year, a reduction of over 1300 x 10^3 kg/yr is possible. But a reduction of only 266 x 10^3 kg/yr is needed in that year. The airport might then introduce towing slowly, requiring one-third of the operations to use it. By the fifth year, however, all operations will need to use

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Table 3.14. Hydrocarbon Emission Inventory Including the Proposed Airport Modification

	Emissions (10^3 kg/year)		
	Project Year		
Category	1	5	10
Remainder of Region[a]	65484	63364	63364
Aircraft	1520	1533	1546
Airport Non-Aircraft[b]	974	1138	1434
TOTAL	67978	66035	66344
Desired Emission Level	67712	65512	65512
Excess Emissions	266	523	832

[a] Sum of first two categories on Table 3.11.

[b] Includes induced growth; excludes airport emission amounts already in "Remainder of Region" (i.e., heating at airport, access traffic at without-project levels).

towing to achieve sufficient reduction in emissions to trade-off against the proposed increase of 523 x 10^3 kg/yr. In the tenth year, the effect of the lowered engine emission standards is such that only 60% of the necessary emission offset can be found through the use of towing for all operations. An additional strategy is required in this year. Even though jet fuel (JP-5) is not very volatile, a large reduction in emissions can be achieved by using floating roof instead of fixed roof tanks for storage. The new floating roof tanks eliminate just about 75% of the emissions of a fixed roof tank. This strategy then would yield a reduction of 346 x 10^3 kg/yr in HC emissions. The two strategies together, towing and the use of floating roof tanks, will create a large enough reduction to trade-off against the increase due to the higher traffic levels. These strategies are summarized on Table 3.15; details of the towing strategy are presented in Appendix B.

This test case illustrated the large effect that on-airport strategies can have. Again, the need for careful computations is emphasized. Detailed knowledge of the airport's operation is essential in identifying on-airport emission reduction strategies.

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Table 3.15. Strategy for Trade-offs

Project Year	Excess Emissions (10^3 kg/year)	Trade-offs (10^3 kg/year)	
1	266	442.5	Use of tow vehicles in place of aircraft taxiing (for one third of the operations)
5	523	579.6	Use of tow vehicles in place of aircraft taxiing
10	832	495.5	Use of tow vehicles in place of aircraft taxiing
		346.4[a]	Use of floating roof tanks for jet fuel storage

[a] 85% of fuel storage emissions due to jet fuel; 75% emission reduction due to new tanks.

3.3 CONCLUSIONS

There are several issues brought out by these test cases, using the balance sheet analysis technique for a proposed new airport. They include:

1) The need for a firm understanding of the growth assumptions included in the regional air quality plan and in particular just what rates are assumed for various source categories.

2) The importance of an accurate accounting of the emissions from induced growth sources since induced growth, conservatively estimated in these test cases, contributes 5-10% of the airport total.

3) The problem of double counting airport sources when computing the base year correction term.

4) The importance of having a line-by-line inventory for the air quality region in defining trade-off strategies.

The application of the technique was straight-forward. The problems arose generally in the need for a strict accounting of emissions and correspondingly good data regarding the regional air quality plan and the airport emissions inventory. The mismatch of analysis years between the air quality plan and the project poses no problems - only additional computation to determine the air quality plan's requirements for the project years. The computation of any corrections to the inventory deserves careful attention, however. In doing the test cases it became clear 1) that the inclusion of previously uncounted emissions from airport sources must be added in the air quality plan base year, and 2) that the additional amount must be reduced by the regional emission reduction percentage, R. If growth in airport emissions has been linear between the air quality plan base year and project year 1, then the project year inventory for the without-project scenario could be used. However, the correction amount must still be reduced by R in the compliance year, even though the time between project year 1 and the compliance year is less than the time between the air quality plan base year and the compliance year. The amount of the reduction specified by a proportional reduction method such as Appendix J is independent of the period of time chosen by the air pollution control agency to effect that reduction and as such the full reduction must be made.

4. HIGHWAY TEST CASES

4.1 TEST CASE 1 - SHORELINE FREEWAY CONNECTION

4.1.1 Description of Proposed Project

For this test case, a major link in the downtown portion of the highway network of a medium sized metropolitan area is proposed for construction. A 4.1 mile segment, 6 lanes for most of its length, will connect two freeways. This link in the highway network passes through the central area of the city. A sketch of the proposed construction and the study area is included in Fig. 4.1. The study area was defined by the highway planners as that area which would contain the traffic increases or decreases brought about by this new freeway segment.

The traffic changes that might be brought about by the completion of this freeway link can be measured either in terms of the additional capacity using average daily traffic (ADT) or in terms of the additional trip mileage using vehicle miles of travel (VMT) as a measure. The traffic levels with and without the project were forecast using a traffic assignment model. A traffic assignment model assigns the trips from the trip interchange matrix to a particular network of freeways and arterials using either a capacity-restrained or free assignment algorithm. The trip interchange matrix was itself generated from other planning models. The matrix contains the number of trips between every pair of zones in the region under study. The zone is the basic element in the highway demand modeling process, since all measures of activity are specified for each zone. Zones are smaller in area in densely populated portions of the study area, and become very large (4 sq mi) as the population thins out. In this particular test case, the entire study area is densely populated, as only the central portion of the urban area is included in it.

To analyze the effects of the new link on the network, several runs of the assignment model were made. First, the ADT and VMT were determined for the situation in which the proposed link is not completed - the no-build or do-nothing alternative. The, using the same trip interchange matrix, the ADT and VMT were determined for several with-project alternatives. The alternatives differ mainly in the exact path of the roadway (with no significant differences in length) and the number of interchanges along the new link.

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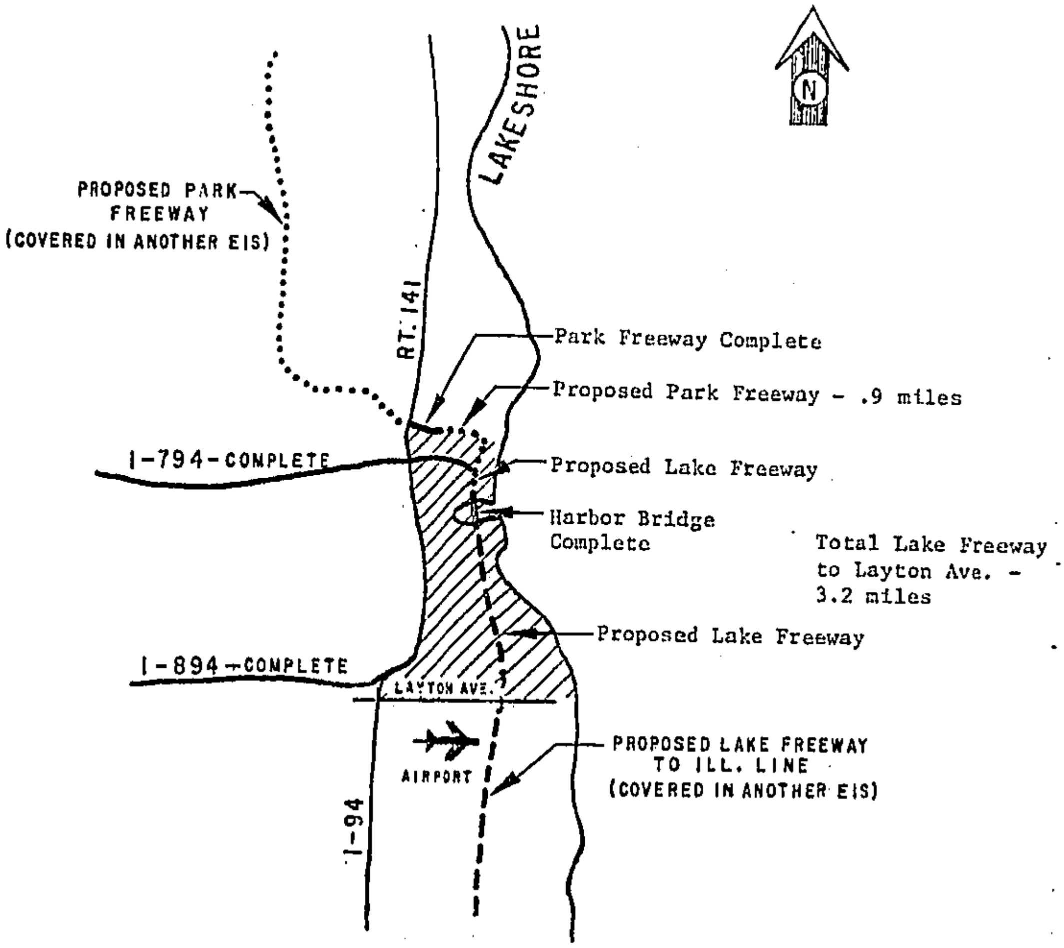

Fig. 4.1. Highway Test Case 1 - Schematic of Proposed Highway Link

Only one alternative is presented here. The results of these traffic assignments are presented in Table 4.1.

Table 4.1. Test Case 1 - Highway Traffic Measures

	ADT			VMT[c]		
Project Year	1	5	10	1	5	10
Option						
No Build						
Screenline 1[a]	0	0	0	1,691,124	2,113,905	2,325,292
Screenline 2[b]	20,960	26,200	28,820			
Build						
Screenline 1[a]	0	68,300	75,130	1,752,182	2,190,352	2,409,383
Screenline 2[b]	20,960	69,700	76,670			

[a] South of bridge on Fig. 4.1

[b] At bridge on Fig. 4.1

[c] For entire study area on Fig. 4.1

By inspection of Table 4.1, it can be seen that the proposed project is subject to preconstruction review under the criterion of a 50,000 increase in ADT over ten years, starting from the opening date of the project (Project Year 1 on the table). Note that the ADT for Project Year 1 is the same for the build and no-build options. The starting point for the growth forecasts is taken to be the no-build traffic levels, since by the end of even the first year of the project a large increase in traffic over the no-build option will occur.

Some discussion of the source of these ADT and VMT estimates is appropriate. The transportation forecasting tools used in the study are tailored for highway capacity purposes, not impact analysis. The demand for trips was forecast for one year—project year 5 in this case. The fraction of trips by highway, as well as the trip interchange matrix, were then calculated using standard models. The traffic assignment using the existing network indicated deficiencies in this "no-build" network. Various "build" strategies were examined by inputting the same set of highway trips to the assignment model but with an improved network. As the project start-up date is five years before the year of the point forecasts assumptions of growth before and after the forecast year were made: 0.8 of PY5 in PY1, and 1.1 of PY5 in PY10.

The differences in VMT must be very small as a result of this process, regardless of the size of ADT changes in any corridor. The additon of capacity serves the forecast traffic; increases in VMT (3.6% in this case) result from serving all the forecast trips by lifting the capacity limitation and, to a smaller extent, result from trips shifted into the proposed roads from other roadways. This method of analysis is adequate for highway capacity purposes because it does successfully identify the places in the network where additional capacity will be needed. Certain deficiencies in this method can be identified for impact analysis purposes, however, especially including the inability of the existing standardized transportation planning package to predict travel due to growth induced by the additon of the highway link.

4.1.2 Emissions Due to Project

The determination of HC emissions due to the proposed highway project relies on the results of the traffic assignment model (VMT and average speeds), using the emission factors of EPA's Supplement 5. The emissions of concern are those due to traffic on the proposed roadway and any other traffic increases in the study area, during the ten year analysis period. It is essential to capture all VMT increases and speed changes that result from the proposed project, including induced traffic. The study area indicated on Fig. 4.1 includes all segments of the network which are expected to show any VMT changes or speed changes as a result of the project, according to the transpotation planners. Using current transportation planning methods it is difficult, however, to identify increases in VMT due to development attracted to the area on account of the facility. It is probable that the VMT used is an underestimate of what will occur.

A summary of the HC emissions for the build and no-build options is presented in Table 4.2.

Table 4.2. HC Emissions for Study Area for Test Case 1 (10^3 kg)

	Project Year			
	1		10	
	Daily	Annual	Daily	Annual
No Build	6.72	2452	7.88	2878
Build[a]	6.90	2518	8.11	2961

[a] Assuming traffic increases in opening year.

It must first be pointed out that the analysis that produced these emission totals presumed an increase in traffic in the first year of the project, accounting for the difference in emissions for the two situations in the first year. This is in contrast to Table 4.1, where this increase was not included in the ADT figures (although it was included in the VMT) to demonstrate the computation of the ADT change in determining whether the project is subject to review.

If it is assumed that the project was not included in the regional air quality plan, but that the VMT, and therefore emissions, growth without the project were included, then the difference between the with and without project scenarios is the main concern. In the tenth year, the increase in annual HC emissions due to the project is 2.9% of the no-build scenario, or 83 x 10^3 kg annually.

Compared to regional annual HC emissions on the order of 40,000 x 10^3 kg (see Tables 3.3 and 3.10), this difference is inconsequential. The small increase is a direct consequence of the small increase in VMT due to the project. The emissions increase of 2.9% is less than the 3.6% increase in VMT because of the decreasing automobile emission factors over the analysis period and also due to higher speeds on some roadways.

A regional emissions analysis is not in order, given the small change in emissions. However, a discussion of the sensitivity of the HC emissions forecast to possible errors in the VMT forecast is in order as current transportation planning methods are constrained in certain aspects crucial to air quality impact analysis.

4.1.3 Sensitivity of HC Emission Forecasts to VMT Forecasts

If the VMT forecast for this project is indeed correct then it appears that no balancing analysis need be done. Let us examine, however, the effect of errors in the increased VMT, due to the project, on HC emission forecasts.

Focusing on the tenth project year, the relevant data are summarized in Table 4.3 below.

Table 4.3. Project Year 10 Data for Highway Test Case 1

	No Build	Build
ADT		
Screenline 1	0	75,130
Screenline 2	28,820	76,670
VMT (10^3 mi)	2,325.29	2,409.38
HC Emissions (10^3 kg/year)	2,878	2,961
%VMT due to project	-	3.6%

If no significant downward change in the distribution of speeds is assumed to occur and various magnitudes of error in the forecast of VMT due to the project are selected, the following is the effect on the absolute increase in HC emissions in the study area:

Increase in VMT Due to Project	Increase in HC Emissions (10^3 kg/yr)
3.6%	83 (Actual forecast)
7.2%	188
36.0%	1012

An error of a factor of 10 in the forecast of vehicle miles travelled, a relatively small error with respect to the highway capacities, yields a significant change in the emissions picture. An increase of a thousand metric tons of HC emissions is not to be ignored, from an air quality perspective.

4.2 TEST CASE 2 - URBAN INTERSTATE CONNECTION

4.2.1 Description of Proposed Project

The second proposed highway construction project is the completion of a major interstate highway through an urban area. The proposed link will be 10-15 miles long, depending on the selection of the best route location, with six lanes for most of its length. A sketch of the proposed project (Fig. 4.2) illustrates the two possible paths through the urban area (they are labeled 2 and 7).

The effect of this proposed link was modeled by the transportation planners in the same manner as the first highway test case. That is, the various route location alternatives were input to the traffic assignment model, using the same trip interchange matrix in each case. The alternatives numbered 2 and 7 seem to the transportation planners to be more desirable on several counts than the others proposed; so this review focuses on those two alternatives. Both go through heavily developed urban areas. The study region includes all roadways whose traffic speed or volume would be affected by the new route. A summary of the traffic levels with and without the project is presented in Table 4.4.

Table 4.4. Test Case 2 - Highway Traffic Measures

	ADT		VMT (10^6 miles)	
	Project Year		Project Year	
	1	10	1	10
No-Build	24,000	31,000	24.0	29.9
Alternative 2	54,000	68,000	24.4	30.5
Alternative 7	97,000	127,000	24.6	30.7

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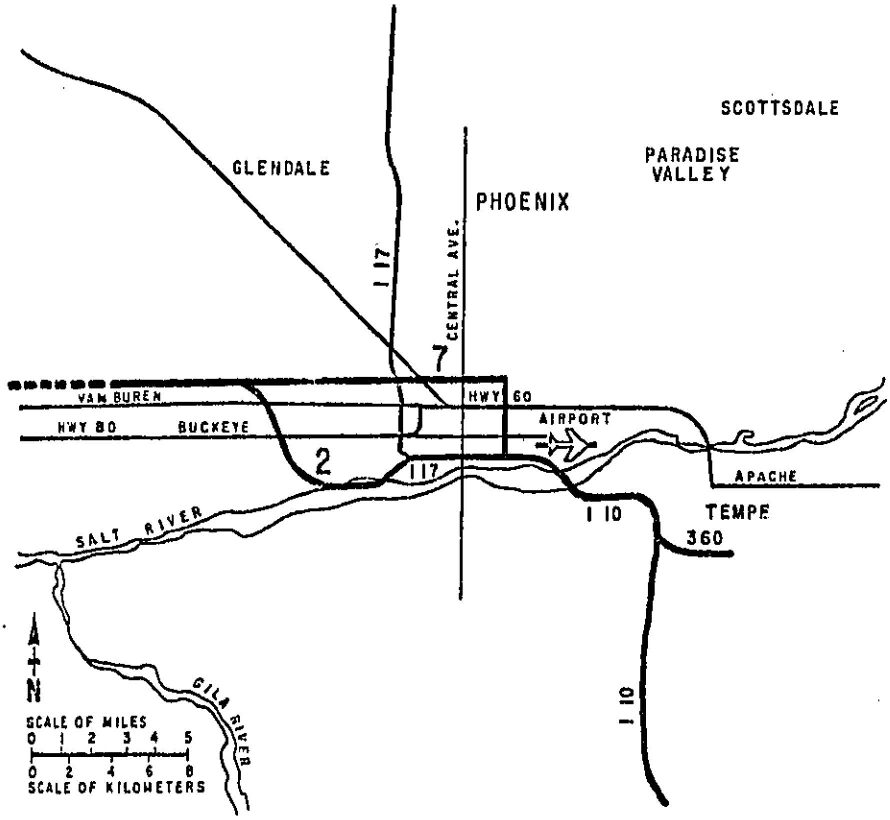

Fig. 4.2. Highway Test Case 2 - Schematic of Proposed Construction

This project qualifies for review as an indirect source, as seen by the increase in ADT of 103,000, under Alternative 7 over the ten years. The increase in ADT shown for the first project year for the two build options is reflective of the linear growth assumptions over a twenty-year period that are the basis for these forecasts (Project Year 1 is the tenth planning year).

4.2.2 Emissions Due to Project

The emissions due to this project were forecast for all the options mentioned above using emission factors from Supplement 5 of AP-42. Emissions were computed from each link in the network, adjusting for the speed on each link. The results of these computations are found in Table 4.5.

Table 4.5. Tenth Year HC Emissions for Highway Test Case 2
(10^3 kg)

	Daily	Annual
No Build	41.9	15,293
Alternative 2	42.1	15,366
Alternative 7	42.2	15,403

The difference, in the tenth year, between the build and no-build alternatives is, at worst, 110 tons per year. For a project of this scope, it is an almost negligible increase in emissions as a result of the project. The small magnitude of the difference in emissions directly corresponds to the small increase in VMT due to the project. The situation is very similar to that of the previous test case. In fact, a similar analysis of the sensitivity of the change in forecast emissions to small changes in the VMT forecast can be done here also. If the percent increase due to the project (Alternative 7), compared to no-build, were 27%, instead of 2.7%, the forecast tenth year VMT would be 38.0 x 10^3 miles. The emissions, assuming the same average emission factor as the analysis of alternative 7, would increase nearly 25%, or 2700 tons annually, over the without project scenario. This would be a significant increase in regional emissions although the change in traffic levels for the region is not as severe with respect to system capacity.

4.3 SUMMARY AND CONCLUSIONS

The assembly of the data and the pursuant analysis for the two highway test cases has been enlightening. The analysis differs from the airport test cases in several ways, including the number of emission sources considered (traffic only vs. seven airport sources), the level of analysis (system and project level), the detail of the without-project forecasts (greater for highways), and the forecasting techniques used for system usage (demand). Although the highway test cases provided more detail in the without project forecasts, the constraints of the highway planning process were more binding. The major effect on traffic levels of a new facility is not captured by current methods. The induced growth in traffic (also called the development traffic, mentioned in an FHWA publication[28]) is not forecast by the existing methods, since facility improvements are not fed back into the land use plan and then allowed to affect trip-making characteristics. The highway test cases have demonstrated this insensitivity very clearly. The forecast impact of a major facility in each of two urban areas is about 2% of the regions traffic. Because of the expected effect on the Federal Motor Vehicle Control Program on future auto engines, the emissions increase is less, on the order of 1%, in the tenth year of the analysis period. If 1% emission increases are in fact all that do result from such large scale highway projects, then the role of project-by-project review must be relegated to that of an updating procedure for the consistency review of the highway system plan under Section 109j of the highway act. If the actual growth is higher, and there is reason to suspect that it might be, the project-by-project review is extremely important from an air quality perspective.

Work underway in U.S. EPA Region II underlines the severity of this problem. The EPA Regional Office is beginning the system level consistnecy determination in a form compatible with balance sheet analysis. That is, each of the proposed projects for the next 10 years is identified on the system plan, and VMT changes are identified for each project. The data from the state being reviewed does not, however, reflect any significant VMT increases as a result of any of the proposed projects. They are using standard techniques for transportation planning. This situation is basically the same as that found in the test cases. One of the reasons to suspect underprediction is the comparison with the

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effect of airport projects. Highway traffic to and from an airport is only a part of the airport's contribution to emissions and only a part of the traffic in the region; increases in auto traffic due only to the airport, however, are more significant from an emissions viewpoint, than those due to large highway projects seem to be. The new airport test case, for example, generated about 200 metric tons annually over the no-project scenario due to auto traffic alone in the tenth year, and presuming no facility changes except connections to the main roads from the new airport, compared to 80 and 110 metric ton increases expected from the large highway facility construction projects.

A thorough review of the transportation planning process and the existence, of lack thereof, of trends of underprediction of traffic levels after major facilities are constructed, is beyond the scope of this contract. The analysis that was performed did point to several probelems of using traditional transportation planning techniques for impact analysis. Had we been able to carry out the regional analysis for the highway projects, the application would have been straightforward. The primary difficulty lies in the requirement for an analysis tool that is sensitive to the traffic changes caused by highway facility construction so that air quality impacts may be more accurately forecast. The balance sheet itself is fairly simple to compute. It is essentially a comparison between emissions forecast for the air quality plan at one point in time, and the emissions expected including a particular project not previously in the forecast. Or, if a system consistency plan has been completed, the balance sheet review is a way to insure that the system plan is proceeding as projected, using the detailed data available at the time of project programming.

5. CONCLUSIONS AND SUMMARY

5.1 APPLICABILITY OF THE TECHNIQUE

Based on the two test cases, the balance sheet analysis technique is applicable to airport project review. The technique applies equally well to the cases of the new airport and the modification of an existing airport. The importance of accurate accounting of emissions, both due to the airport and in the entire analysis region, is not to be understated. Both test cases brought out the significance of double-counting, a problem encountered if the regional inventory is not well documented or if careful attention is not paid to what is included or excluded from the various categories detailed in that inventory.

The regional oxidant modelling technique used in conjunction with a balance sheet review must be a proportional reduction technique. This type of emission balancing presumes equality of all sources in the analysis region, in that a 50 ton annual reduction of any source is expected to have the same effect on regional air quality as an equal reduction of any other source in the analysis region. This is an assumption of the use of the emission trade-offs in the defined analysis region for the balance sheet review. The simulation models that have been developed for oxidant formation do not require this assumption. These models follow the emissions from various sources, tracing the interactions between source emissions located on a grid and meteorological conditions to determine the spatial distribution of oxidant levels throughout the region. As a result, such simulation models will not mesh with a balance sheet analysis. Instead, the proposed reduction strategies, and the project itself without the reduction strategies, should be input to the model directly to see the effect on regional air quality.

In the case of highway projects, the test cases demonstrated that the technique itself can be applied successfully in the highway context, either in the context of consistency planning at the system level or looking only at projects individually, although it is not recommended at this juncture to use the balance sheet until problems stemming from the transportation models are resolved. In the context of system level consistency plans, the balance sheet review of each project serves as an updating procedure, checking off each proposed project as it is programmed and assuring that effect of airport projects. Highway traffic to and from an airport is only a part of the airport's contribution to emissions and only a part of the traffic in the region; increases in auto traffic due only to the airport, however, are more significant from an emissions viewpoint, than those due to large highway projects seem to be. The new airport test case, for example, generated about 200 metric tons annually over the no-project scenario due to auto traffic alone.in the tenth year, and presuming no facility changes except connections to the main roads from the new airport, compared to 80 and 110 metric ton increases expected from the large highway facility construction projects.

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5.2 LIMITATIONS OF THE TECHNIQUE

The primary limitation of this technique is that it should not be used when simulation models have been used for regional oxidant air quality. It is flexible in many respects, in that it is basically an accounting technique designed to fit in with current air quality planning practices for oxidants. In the case of highway projects, the balance sheet technique might appear to be limited; the real limitations are in the transportation planning process, however. That planning process is not well-suited to the needs of air quality forecasting. Given an excess amount of emissions, above and beyond the level forecast in the air quality plan, the balancing process can take place. If the transportation forecasting techniques are insensitive to change in the variables that affect HC emissions, then no internal emission trade-offs can be identified, and the initial highway emission forecasts are themselves suspect.

In general, the balance sheet technique is limited by the quality of the data used in the review. The regional emission inventory should be a rich source of data; if it is not, however, the review using the balance sheet will not be adequate. The emissions forecast for the airport must be thorough and detailed; if it is not, the effect of the project cannot be ascertained.

Additionally, the technique itself does not point out effective trade-off strategies, nor does it indicate when it might be worthwhile to ignore small amounts of excess emissions. The work done in organizing the regional emissions inventory may help guide the reviewing agency in defining reduction strategies for trade-offs, but the review technique does not provide them. In short, it is an accounting tool that leaves the exercise of judgement to the reviewers. This accounting tool is useful for identifying the effect of a project on regional emission levels and pointing

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out the need for trade-offs to balance projected increases in emissions. The limitations of the balance sheet technique regarding its insensitivity to the size of the trade-off must also be recognized. As an accounting technique, it must be used in conjunction with a set of policies regarding the significance of the size of the emission trade-offs. The highway test cases emphasize this point. Although the technique can be applied to the test cases, it was not applied in either case because of the judgement that the predicted increases in emissions due to the projects were not significant within the range of accuracy of the models that produced the results. What was warranted for those highway test cases was a discussion of the models that produced the results, since it appears that they are inherently insensitive to changes in the variables affecting emission burden calculations. The need to work on the regional level for hydrocarbon emissions is also clearly stated. Used in the context of regional air quality plans based on proportional reduction models, the balance sheet analysis technique shows promise as a useful method by state or regional reviewing agencies.

Appendix A - Test Case 1, Neway Airport

This appendix explains the methods used to calculate hydrocarbon (HC) and nitrogen oxides (NO_x) emissions from the Neway Airport, Test Case 1. As there were insufficient data to use a simulation model, the calculations were made using the method outlined in An Air Pollution Impact Methodology for Airports - Phase I[4] (APIM), a hand calculation procedure. Forecasts of emissions from each of the six major on-airport categories - aircraft, access traffic, ground service vehicles, fuel handling and storage, heating plants, and engine tests - are made first for Project Year 1 (PY1), the year the airport opens, and then for the next five and ten years (PY5 and PY10). Except where noted, most of the data used are from a consultant's report on the proposed new airport, using conversion factors when necessary. Many of the emission factors are available from the Compilation of Air Pollutant Emission Factors, Report Number AP-42[24], published by the Environmental Protection Agency (EPA) and Supplement 5[25] to the same report. When the factors are not available from either of these sources, they can be computed by the methods explained later in this Appendix. Occasionally, data are incomplete and must be estimated from observations or experience at other airports. The APIM report is the source for the data regarding other airports.

A.1 EMISSIONS FROM AIRPORT SOURCES

Since the biggest source of HC emissions at an airport is aircraft, most of the data required pertains to aircraft type and activity. Exactly what aircraft operate from the airport and the number of flights made by each type of aircraft are the first pieces of information that are necessary. Table A.1 lists the aircraft classes operating at Neway Airport with an example of the aircraft or type of aircraft included in each class. The number of seats available and number and type of engines for each class are also included. These classes represent kinds of service that will be available at this airport; they may vary at other airports. Other necessary information is the number of operations and number of landing and take-off (LTO) cycles. The number of average daily operations by aircraft type is shown on Table A.2. The number of LTO cycles is derived by dividing the

Table A.1. Aircraft Classification, Number of Seats and Engine Characteristics

Class	Model or Type	Number of Seats	Number of Engines	Type of Engines
General Aviation Piston	Local Aircraft	-	1	Lycoming 0-320
General Aviation Business (non-jet)	Business Air Taxi	10	2	Lycoming 0-320 TPE 331
General Aviation I	Government	20	2	TPE 331
General Aviation II	Commuter	30-70	2	JT 8 D
Medium Range Jet I	DC-9 B-737	70-95	2	JT 8 D
Medium Range Jet II	B-727-100 B-727-200	95-125	3	JT 8 D
Long Range Jet I	B-707 DC-8	125	4	JT 3 D
Long Range Jet II	A-300-B	200	4 2	JT 3 D (PY1) GE CF-6 (PY5, PY10)
Jumbo Jet I	DC-10 L-1011	250	3	GE CF-6
Jumbo Jet II	B-747	350-500	4	JT 9 D
Cargo	Cargo	-	4 4	JT 3 D (PY1, PY5) JT 9 D (PY10)

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Table A.2. Average Daily Operations by Aircraft Class

Class[a]	Project Year 1	Project Year 5	Project Year 10
GA Piston	326.0	304.1	-
GA Business (non-jet)	173.1	242.1	293.6
GA I	32.4	33.7	36.4
GA II	-	28.4	59.2
MR Jet I	7.2	57.0	76.4
MR Jet II	2.5	54.5	94.5
LR Jet I	8.0	46.2	65.4
LR Jet II	-	-	46.1
JJ I	5.9	-	44.5
JJ II	-	36.2	109.0
Cargo	-[b]	-[b]	47.1
TOTAL	555.1	802.2	872.2

[a] GA = General Aviation; MR = Medium Range; LR = Long Range; JJ = Jumbo Jet

[b] Included in LR Jet I traffic.

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number of operations by two. Table A.3 breaks down the operations by type of service category, including domestic and overseas air carrier, cargo, business jet, and local and itinerant general aviation flights.

Once the type of operating aircraft and the number of LTO cycles are known, the emissions can be calculated by applying the appropriate emission factors. Table A.4 contains the emission factors by operational mode for each aircraft class. The basic factors for each engine type are from Report AP-42 mentioned above. These factors, in kilograms per hour per engine, are then multiplied by the number of engines per aircraft to produce a factor in kilograms per hour per aircraft for both HC and NO_x for taxi-idle, take-off, climbout and approach modes. EPA's report AP-42 also contains typical times in mode for an LTO cycle by aircraft class for the same modes used in Table A.4. By taking the sum of the products of the factors for each operating mode in Table A.4 multiplied by the times-in-mode for the corresponding aircraft class on Table A.5, a single LTO cycle emission factor of kilograms per aircraft for HC and NO_x is obtained for each class (Table A.5). Tables A.6 and A.7 contain the annual and daily emissions for HC and NO_x respectively for project years 1, 5 and 10. Daily emissions are simply the products of the emission factors from Table A.5 and the number of daily LTO cycles for each aircraft class. Annual emissions are daily emissions multipled by 365.

The second largest source of HC emissions is access traffic. The data needed to compute the emissions from this source are the vehicle-miles traveled per year (VMT), average speeds and the emission factor by year and vehicle class calculated from Supplement 5. In this case, the VMT is supplied in the consultant's report on the proposed project. If the consultant does not supply the data, the estimating procedure outlined in APIM can be used. Figuring the emission factor, however, is a complex procedure. The number and type of vehicles driven must be known, as well as the age distribution of each type. Supplement 5 also takes into account the speeds driven and the fraction of cold starts. A separate factor for evaporative emissions of HC is also included. By weighting the emission factors provided in Supplement 5 by the age and type distributions forecast by the airport, and applying a speed correction factor also found in

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Table A.3. Annual Aircraft Operations by Flight Category at Neway Airport

	Project Year		
Flight Category	1	5	10
Air Carrier[a]			
Domestic	2,600	49,200	128,200
Overseas	3,250	13,206	31,000
Total Air Carrier	5,850	62,406	159,200
Cargo	2,720	8,400	17,200
Business Jet	3,750	11,100	21,300
General Aviation			
Local	119,000	111,000	0
Itinerant	71,250	100,000	120,700
Total General Aviation	190,250	211,000	120,700
Total Annual Operations	202,570	292,906	318,400

[a] Including charter flights as follows:

Domestic	2,600	2,600	2,500
Overseas	3,250	5,000	8,000
Total Charter	5,850	7,600	10,500

Table A.4. Modal Emission Factors by Aircraft Type
(kg/hr/aircraft)

Class[a]	Number Engines	HC Taxi-Idle	HC Takeoff	HC Climbout	HC Approach	NO_x Taxi-Idle	NO_x Takeoff	NO_x Climbout	NO_x Approach
GA Piston	1	0.161	0.676	0.594	0.225	0.006	0.097	0.170	0.023
GA Business (non-jet)	2	0.560	0.701	0.618	0.334	0.439	1.747	1.67	0.790
GA I	2	0.798	0.050	0.048	0.218	0.866	3.30	3.00	1.534
GA II	2	7.42	0.706	0.836	1.588	2.64	179.6	118.8	28.0
MR Jet I	2	7.42	0.706	0.836	1.588	2.64	179.6	118.8	28.0
MR Jet II	3	11.13	1.059	1.254	2.382	3.96	269.4	178.2	42.0
LR Jet I	4	178.8	8.44	8.92	14.24	2.596	268.4	174.4	39.56
LR Jet II-PY1	4	178.8	8.44	8.92	14.24	2.596	268.4	174.4	39.56
PY5, PY10	2	14.0	1.18	1.18	1.72	3.26	490.0	302.0	157.0
JJ I	3	21.0	1.77	1.77	2.58	4.89	735.0	453.0	235.5
JJ II	4	49.6	5.36	4.80	5.44	11.00	1308.0	832.0	98.0
Cargo-PY1,PY5	4	178.8	8.44	8.92	14.24	2.596	268.4	174.4	39.56
PY10	4	49.6	5.36	4.80	5.44	11.00	1308.0	832.0	98.0

[a] GA = General Aviation; MR = Medium Range; LR = Long Range; JJ = Jumbo Jet

Table A.5. LTO Cycle Emission Factors
(kg/aircraft)

Class[a]	EPA Typical Time in Mode, minutes				Emission Factors per LTO Cycle	
	Taxi-Idle	Takeoff	Climbout	Approach	HC	NO_x
GA Piston	16.00	0.30	4.98	6.00	0.1181	0.0185
GA Business (non-jet)	21.00	0.40	3.74	5.25	0.2684	0.3385
GA I	26.00	0.50	2.50	4.50	0.3646	0.6428
GA II	26.00	0.70	2.20	4.00	3.360	9.462
MR Jet I	26.00	0.70	2.20	4.00	3.360	9.462
MR Jet II	26.00	0.70	2.20	4.00	5.040	14.19
LR Jet I	26.00	0.70	2.20	4.00	78.85	13.29
LR Jet II - PY1	26.00	0.70	2.20	4.00	78.85	13.29
PY5, PY10	26.00	0.70	2.20	4.00	6.238	28.67
JJ I	26.00	0.70	2.20	4.00	9.358	43.00
JJ II	26.00	0.70	2.20	4.00	22.09	57.07
Cargo - PY1, PY5	26.00	0.70	2.20	4.00	78.85	13.29
PY 10	26.00	0.70	2.20	4.00	22.09	57.07

[a] GA = General Aviation; MR = Medium Range; LR = Long Range; JJ = Jumbo Jet

Table A.6. Daily and Annual HC Emissions by Aircraft Class

Class[a]	Project Year 1			Project Year 5			Project Year 10		
	Daily Number of LTO Cycles	Emissions (kg) Daily	Emissions (kg) Annual	Daily Number of LTO Cycles	Emissions (kg) Daily	Emissions (kg) Annual	Daily Number of LTO Cycles	Emissions (kg) Daily	Emissions (kg) Annual
GA Piston	163.0	19.25	7,026	152.05	17.96	6,554	0	0	0
GA Business (non-jet)	86.55	23.23	8,479	121.05	32.49	11,859	146.8	39.40	14,381
GA I	16.2	5.907	2,156	16.85	6.144	2,242	18.2	6.636	2,422
GA II	0	0	0	14.2	47.71	17,415	29.6	99.46	36,301
MR Jet I	3.6	12.10	4,415	28.5	95.76	34,952	38.2	128.4	46,848
MR Jet II	1.25	6.30	2,300	27.25	137.3	50,129	47.25	238.1	86,921
LR Jet I	4.0	315.4	115,121	23.1	1821.0	664,824	32.7	2578.0	941,114
LR Jet II	0	0		0	0	0	23.05	143.8	52,482
JJ I	2.95	27.61	10,076	0	0	0	22.25	208.2	75,999
JJ II	0	0	0	18.1	399.8	145,938	54.5	1204.0	439,425
Cargo	b	b	b	b	b	b	23.55	520.2	189,880
TOTAL	277.55	409.8	149,573	401.1	2558.2	933,913	436.1	5166.2	1,885,773

[a] GA = General Aviation; MR = Medium Range; LR = Long Range; JJ = Jumbo Jet

[b] Included in LR Jet I traffic.

Table A.7. Daily and Annual NO_x Emissions by Aircraft Class

	Project Year 1			Project Year 5			Project Year 10		
	Daily Number	Emissions (kg)		Daily Number	Emissions (kg)		Daily Number	Emissions (kg)	
Class[a]	of LTO Cycles	Daily	Annual	of LTO Cycles	Daily	Annual	of LTO Cycles	Daily	Annual
GA Piston	163.0	3.016	1,101	152.05	2.813	1,027	0	0	0
GA Business (non-jet)	86.55	29.30	10,693	121.05	40.98	14,956	146.8	49.69	18,138
GA I	16.2	10.41	3,801	16.85	10.83	3,953	18.2	11.70	4,270
GA II	0	0	0	14.2	134.4	49,042	29.6	280.1	102,227
MR Jet I	3.6	34.06	12,433	28.5	269.7	98,428	38.2	361.4	131,929
MR Jet II	1.25	17.74	6,474	27.25	386.7	141,137	47.25	670.5	244,724
LR Jet I	4.0	53.16	19,403	23.1	307.0	112,055	32.7	434.6	158,623
LR Jet II	0	0	0	0	0	0	23.05	660.8	241,208
JJ I	2.95	126.9	46,300	0	0	0	22.25	956.8	349,214
JJ II	0	0	0	18.1	1033.0	377,033	54.5	3110.0	1,135,265
Cargo	b	b	b	b	b	b	23.55	1344.0	490,559
TOTAL	277.55	274.6	100,205	401.1	2185.4	797,631	436.1	7879.6	2,876,157

[a] GA = General Aviation; MR = Medium Range; LR = Long Range; JJ = Jumbo Jet

[b] Included in LR Jet I traffic.

Supplement 5, one composite emission factor for each vehicle class for each calendar year can be computed. New standards for automobiles and gasoline engines are included where applicable. Table A.8 gives the annual VMT, emission factors, and total emissions for the four vehicle classes to be operating at the Neway airport for the project years considered. The total emissions are obtained by multiplying the VMT by the composite emission factor. Note that the factor is different for each class of vehicle and also for each project year.

The access traffic emissions calculated above represent the total emissions forecast for the "with project" scenario - that is, emissions from Oldfield and Neway airports combined. A portion of these emissions are contributed by "new" air passengers and visitors. These people represent the increase in traffic brought about by the construction of Neway Airport, or the net increase in traffic over what was forecast for Oldfield without Neway being built. To figure the emissions due only to this new traffic, data showing the difference in VMT between the with and without project scenarios must be assembled. Table A.9 shows the percent of new passengers who will originate or terminate (O and T) at Neway and also the mode of ground transportation chosen. In Project Year 1, all passengers start and end their trips at Neway because there are only charter and general aviation flights. As the airport grows, general aviation decreases and air carrier service dominates the operations. As for ground transportation, automobile trips always account for the largest portion of the total person trips. However, with the construction of the railroad terminal and its service, the percent of travel by auto and bus decreases. This transportation mode split is taken into account when figuring the access traffic at the new airport. Given the total number of vehicle trips forecast without the project in the consultant's report, the percent of the total vehicle trips forecast for Neway Airport made by new passengers or visitors can be determined by comparing the number of with-project trips to the number of without-project trips. In Project Year 5, the new passengers and visitors account for 8.1% of the total trips forecast and for 36.4% in Project Year 10. Applying these percents to the total HC emissions from access traffic on Table A.8 produces the HC emissions due to the trips made by new passengers and visitors at Neway Airport only, as shown on Table A.9. One more fact

Table A.8. Annual VMT, Emission Factors and Emissions from Access Traffic

	HC								
	Project Year 1			Project Year 5			Project Year 10		
Vehicle Class	VMT (10^3 mi/yr)	Factor (gm/mi)	Emissions (10^3 kg)	VMT (10^3 mi/yr)	Factor (gm/mi)	Emissions (10^3 kg)	VMT (10^3 mi/yr)	Factor (gm/mi)	Emissions (10^3 kg)
Autos	5433.	5.417		28,830	3.033	87.441	75,980	1.253	95.202
Gas Trucks	54.97	23.57	1.296	254	16.50	4.191	762	11.60	8.839
Diesel Vehicles	34.41	3.257	0.112	159	3.257	0.518	477	3.257	1.554
Buses, Limo, Etc.	37.90	8.335	0.315	160	6.568	1.051	466	5.343	2.490
TOTAL	5560.28		31.154	29,403		93.201	77,685		108.085

	NO_x								
	Project Year 1			Project Year 5			Project Year 10		
Vehicle Class	VMT (10^3 mi/yr)	Factor (gm/mi)	Emissions (10^3 kg)	VMT (10^3 mi/yr)	Factor (gm/mi)	Emissions (10^3 kg)	VMT (10^3 mi/yr)	Factor (gm/mi)	Emissions (10^3 kg)
Autos	5433.	4.142	22.503	28,830	2.175	62.705	75,980	0.784	59.568
Gas Trucks	54.97	10.95	0.602	254	12.14	3.084	762	13.04	9.936
Diesel Vehicles	34.41	25.13	0.865	159	25.13	3.996	477	25.13	11.987
Buses, Limo, Etc.	37.90	21.58	0.818	160	21.88	3.501	466	22.11	10.303
TOTAL	5560.28		24.788	29,403		73.286	77,685		91.[illegible]

Table A.9. Portion of Annual HC Emissions due to Construction of Neway Airport

Data	Project Year		
	1	5	10
Total Annual New Passengers	800,000	4,606,000	16,181,000
% O and T	100	82.2	71.1
Number of passengers	800,000	3,786,132	11,504,691
Ground Transportation Mode Split at Neway			
% of passengers using:			
Auto	85.0	72.9	69.7
Rail	0	13.7	17.5
Bus	15.0	13.4	12.8
HC Emissions due to trips made by new passengers and visitors (10^3 kg)	-	7.5	33.9
HC Emissions due to increased length of trips at Neway over Oldfield (10^3 kg)	-	48.0	41.6
Portion of total access traffic HC emissions attributed strictly to Neway (10^3 kg)	-	55.5	75.5

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must be taken into account in determining the portion of the access traffic emissions due only to the building of Neway Airport. The difference between the total access traffic emissions at Neway (Table A.8) and the emissions due to "new" automobile trips is greater than the emissions forecast without the project. That is because the trips forecast for Oldfield without the project are only 3.0 miles long, compared with a 6.8 mile average on-site trip at Neway. Multiplying the difference in emission totals by the ratio of trip lengths (0.44) yields the forecast Oldfield - only access traffic emissions; the complement is the emissions due to longer trips at Neway, which amount is shown in Table A.9. These increased trip length emissions added to the new passenger and visitor trip emissions yields the portion of the total on-site access traffic HC emissions contributed only by Neway Airport.

Another major source of HC and NO_x emissions is ground service vehicles. The emissions from this source are directly related to aircraft activity. Emissions are figured by multiplying the emission factor found in EPA's AP-42 by the ground service vehicle time per LTO cycle. Since some of the service vehicles are diesel-powered, factors for both gasoline and diesel engines are used. To figure the service time per LTO cycle, a table of data collected at other airports is used, specifying the number of vehicle-minutes required for each type of ground service vehicle to service each aircraft class. Times are given for jet aircraft only. Since the same emission factor is used for each vehicle, by adding the service times of all vehicles a total number of vehicle-minutes per class is established. Then the product of total service-minutes per class and the number of annual LTOs per class is the total service hours per year. This fugure multiplied by the appropriate emission factor yields the annual emissions. The emission factor is based on gasoline and diesel truck emission factors from AP-42, assuming 6 mpg and 10 mph, as described in the APIM publication. Tables A.10 and A.11 summarize the HC and NO_x emissions from ground service vehicles.

Table A.10. Annual HC Emissions from Ground Service Vehicles[a]

Class[b]	Emission Factor (gm/hr)[c]	Total Service Time per LTO Cycle (Vehicle-hours)	Project Year 1		Project Year 5		Project Year 10	
			Vehicle hrs per year	Emissions (10^3 kg)	Vehicle hrs per year	Emissions (10^3 kg)	Vehicle hrs per year	Emissions (10^3 kg)
MR Jet I	372.7	3.083	4051	1.51	32,071	11.95	42,986	16.02
MR Jet II	372.7	2.950	1346	0.502	29,341	10.94	50,876	18.96
LR Jet I	372.7	4.533	6618	2.47	38,220	14.25	54,104	20.16
	49.27[d]	0.200	292	0.014	1,686	0.083	2,387	0.118
			6910	2.484	39,906	14.333	56,491	20.278
LR Jet II	372.7	4.533	0		0		38,137	14.21
	49.27[d]	0.200					1,683	0.083
							39,820	14.293
JJ I	372.7	6.600	7107	2.65	0		53,600	19.98
JJ II	372.7	8.200	0		54,173	20.19	233,604	87.06
	49.27[d]	0.033			218	0.011	940	0.046
					54,391	20.201	234,544	87.106
TOTAL			19,414	7.146	155,709	57.424	478,317	176.637

[a] Assumed use only by jet aircraft including cargo.

[b] MR = Medium Range; LR = Long Range; JJ = Jumbo Jet.

[c] Gasoline engines except where noted.

[d] Diesel fueled vehicles.

Table A.11. Annual NO_x Emissions from Ground Service Vehicles[a]

Class[b]	Emission Factor (gm/hr)[c]	Service Time per LTO Cycle (Vehicle-hours)	Project Year 1		Project Year 5		Project Year 10	
			Vehicle-hrs per year	Emissions (10^3 kg)	Vehicle-hrs per year	Emissions (10^3 kg)	Vehicle-hrs per year	Emissions (10^3 kg)
MR Jet I	95.19	3.083	4051	0.386	32,071	3.05	42,986	4.09
MR Jet II	95.19	2.950	1346	0.128	29,341	2.79	50,876	4.84
LR Jet I	95.19	4.533	6618	0.630	38,220	3.64	54,104	5.15
	257.8[d]	0.200	292	0.075	1,686	0.435	2,387	0.615
			6910	0.705	39,906	4.075	56,491	5.765
LR Jet II	95.19	4.533	0		0		38,137	3.63
	257.8[d]	0.200					1,683	0.434
							39,820	4.064
JJ I	95.19	6.600	7107	0.677	0		53,600	5.10
JJ II	95.19	8.200	0		54,173	5.16	233,604	22.24
	257.8[d]	0.033			218	0.056	940.1	0.242
					54,391	5.216	234,544.1	22.482
TOTAL			19,414	1.896	155,709	15.131	478,317.1	46.341

[a] Assumed use only by jet aircraft including cargo.

[b] MR = Medium Range; LR = Long Range; JJ = Jumbo Jet.

[c] Gasoline engines except where noted.

[d] Diesel fueled vehicles.

Fuel handling and storage represents another source of HC emissions. The fuel is broken down into two categories - jet fuel (JP-5) and aviation gas. The vapors emitted during refueling or handling of the fuel are the working loss, while the vapors emitted during storage are called breathing losses. It is assumed that all storage tanks are fixed-roof tanks since there is very little evaporation from JP-5. Additionally, New Source Performance Standards do not require floating-roof tanks for JP-5.[26] To calculate the emissions first the annual fuel use per LTO cycle must be available. In this test case, the consultant did not provide the information, so experience from existing airports was used to estimate the average amount of fuel used. Once this figure has been established for both jet and general aviation fuel it is multiplied by the average number of LTOs per year to calculate the annual fuel use as shown on Table A.12. The emission factors, when applied to these annual fuel use figures, will produce the working loss emissions of the fuel. To account for the breathing loss, the average daily fuel storage must be established. Since airports store more than a one-day fuel supply, this figure must be more than merely the average daily fuel use. The assumption for this test case is that the airport will store the amount of fuel needed for five days while still using a full day's requirement each day. The refilling schedule is such that the average daily fuel storage is 3.2 times the average daily amount of fuel used. There are four emission factors to be used when calculating fuel handling and storage emissions. The working loss and breathing loss factors for commercial jet fuel are taken from an EPA publication, Revision of Evaporative Hydrocarbon Emission Factors[27]. For general aviation fuel the emissions for both working loss and breathing loss from fixed-roof tanks are taken from EPA Report AP-42. Table A.13 shows the emission factors used and then the total HC emissions for each type of fuel for each project year. The emissions from working losses of jet and general aviation fuel are arrived at by multiplying the annual fuel use by the appropriate emission factors. In the case of jet fuel, however, the product was then doubled to account for underestimation of fuel used and also for any emissions resulting from filling the aircraft tanks. To arrive at total emissions from breathing loss of both fuels, the appropriate emission factor was applied to the

Table A.12. Annual and Average Daily Fuel Use

	Average Fuel Used Per LTO		Annual Fuel Use					
			Commercial Jet Fuel		General Aviation Gas		Total Fuel	
Project Year	Commercial Jet Fuel (liters)	Aviation Gas (liters)	No. of LTOs	Fuel (10^6l)	No. of LTOs	Fuel (10^6l)	No. of LTOs	Fuel (10^6l)
1	10,220.6	18.9	4,285	43.80	97,021	1.83	101,306	45.63
5	10,220.6	18.9	35,403	361.84	111,017	2.10	146,420	363.94
10	12,113.3	18.9	88,200	1068.40	70,977	1.34	159,177	1069.74

	Average Daily Fuel Use (10^6l)					
	Commercial Jet Fuel		General Aviation Gas		Total	
	1 Day Use	Average Daily Storage	1 Day	Average Daily Storage	1 Day	Average Daily Storage
1	0.12	0.384	0.0050	0.016	0.125	0.40
5	0.991	3.171	0.0058	0.0186	0.997	3.190
10	2.927	9.366	0.0037	0.0118	2.931	9.378

Table A.13. HC Emission Factors and Annual Emissions from Fuel Handling and Storage

Source of Emissions	Emission Factors	HC Emissions (10^3kg)		
		Project Year 1	Project Year 5	Project Year 10
Commercial Jet Fuel				
Working Loss[a]	0.0032 kg/10^3l	0.284	2.316	6.838
Breathing Loss	0.007 kg/10^3l/day	0.981	8.099	23.929
Total Commercial Jet		1.265	10.415	30.767
General Aviation Fuel				
Working Loss	1.1 kg/10^3l	2.013	2.310	1.470
Breathing Loss	0.026 kg/10^3l/day	0.152	0.177	0.112
Total General Aviation		2.165	2.487	1.582
Total All Fuel		3.430	12.902	32.349

[a] Emissions have been doubled to account for underestimation of fuel used and any emissions resulting from filling of aircraft tanks.

average daily storage figure computed earlier (Table A.12). The fuel handling and storage emissions from ground service vehicle fuel were also computed but were found to be negligible so are not included in the case study.

Another source of HC and NO_x emissions is the heating plant on the airport site. Knowing the size of the building, the energy required to heat it can be determined by applying an average factor of 219×10^3 Btu/sq.ft./year, based on other airports in similar climates. This conversion yields the amount of Btus required to heat the area in one year. For this test case, the consultant's report stated that No. 6 fuel oil is the only feasible fuel. Dividing the yearly energy requirement by the average heating capacity of 144,000 Btu/gallon, yields the average fuel use. Applying the emission factors from EPA's Report AP-42 to the yearly fuel use will produce the emissions of HC and NO_x by the heating plant. This procedure is summarized on Table A.14.

The final emission source considered for the Neway airport is jet engine testing. Based on information from other airports an assumed number of tests per 500 LTOs for all engines was used. The distribution of types of engines to be tested is assumed to be in the same ratio as the aircraft operations for the corresponding aircraft types in each year (see Table A.15). Engine tests are assumed to use the idle and approach modes, for 0.3125 hour and 0.1042 hour respectively. The number of engine tests per year is computed by multiplying the assumed number of tests per 500 LTOs by the number of LTOs per engine per year and then dividing by 500. This product is the activity level used to figure emissions. The emission factors are composed of two sums. The first sum is the percentage of use of each engine multiplied by the emission factor for the idle mode for each respective engine (see Table A.4); this sum is then multiplied by the time in idle mode, which is assumed to be the same for all engines. The same procedure is followed for the approach mode. The idle and approach products are added to produce a composite emission factor. This is done for both HC and NO_x and for both Project Years 5 and 10 since the distribution of engine use changed for each year. It is assumed that no engine testing would occur in the first year. Finally, the calculated emission factors are multiplied by the number of engine tests per year to obtain the total emissions shown on Table A.15.

Table A.14. Data and Annual Emissions from the Heating Source

Data	Project Year 1	Project Year 5	Project Year 10
Size of Building (sq. ft.)	127,100	513,400	1,617,400
Energy Required to Heat Building (10^9 Btu/yr)	27.835	112.435	354,211
Average Fuel Use per Year (10^6 l/yr)	0.731	2.956	9.312
Emission Factors[a]:	HC = 0.35 kg/10^3 l NO_x = 4.8 kg/10^3 l		
HC Emissions (10^3 kg)	0.256	1.035	3.259
NO_x Emissions (10^3 kg)	3.509	14.189	44.70

[a] Reference 24.

Table A.15. Data and Annual Emissions from Engine Testing Source [a]

	Distribution of Engines to be Tested (%)		No. of Jet LTOs per Year		No. of Engine Tests per Year[b]		Total Emissions (10^3 kg)[c]			
							HC		NO_x	
Engine	PY 5	PY 10	PY 5	PY 10	PY 5	PY 10	PY 5	PY 10	PY 5	PY 10
JT 8 D	57.6	35.4	20,392	31,223	815.7	2372.9	3.98	9.73	1.40	8.46
JT 3 D	23.8	13.5	8,426	11,907	337.0	904.9	1.64	3.71	0.580	3.23
JT 9 D	18.6	32.3	6,585	28,489	263.4	2165.2	1.28	8.88	0.453	7.72
GE CF 6	0	18.8	0	16,581	0	1260.2	0	5.17	0	4.49
TOTAL			35,403	88,200	1416.1	6703.2	6.90	27.49	2.433	23.90

[a] It is assumed that no engine testing will take place in project year 1.

[b] Assumed number of engine tests per 500 LTOs - PY 5: 20; PY 10: 38.

[c] Composite Emission Factors:

HC (kg/engine test)		NO_x (kg/engine test)	
PY 5	PY 10	PY 5	PY 10
4.875	4.102	1.72	3.565

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Since there were no miscellaneous sources of emissions for this test case, the total emissions for the on-airport sources is simply the sum of emissions from each of the six sources as shown on Table A.16. The procedures followed here are applicable to any new airport, given the necessary data from the airport planning documents or environmental impact report. When no simulation model is available or the data is insufficient, this is one method of hand calculating on-airport emissions. The remaining source of emissions due to the airport, induced growth sources, is discussed below.

Table A.16. Annual Emissions Due to On-Airport Sources

	HC Emissions (10^3kg)			NO_x Emissions (10^3kg)		
Source	PY 1	PY 5	PY 10	PY 1	PY 5	PY 10
Aircraft	149.6	933.9	1885.8	100.2	797.6	2876.2
Access Traffic	31.2	93.2	108.1	24.8	73.3	91.8
Ground Service Vehicles	7.1	57.4	176.6	1.9	15.1	46.3
Fuel Handling and Storage	3.4	12.9	32.4	0	0	0
Heating Plant	0.26	1.0	3.3	3.5	14.2	44.7
Engine Tests	0	6.9	27.5	0	2.4	23.9
Total due to on-airport sources	191.56	1105.3	2233.7	130.4	902.6	3082.9

A.2 EMISSIONS DUE TO INDUCED GROWTH

The construction of Neway Airport will result in increased activity near the airport site in the surrounding region. There will be more auto travel by the new passengers and visitors to the airport, and by new employees at off-site jobs. These people will produce a dramatic increase in VMT resulting in a higher level of hydrocarbon emissions. In addition to traffic, new industrial and commercial concerns will appear and cause increased HC emissions from their heating plants; industrial concerns may also produce emissions due to their manufacturing processes. The activity included in this analysis of induced growth represents net increases due to the building of the airport. It is recognized that many activities will shift in the region to be closer to the new airport. These shifts are not considered in the computations - only the net growth.

To calculate the vehicular emissions from new passengers and visitors, forecasts of trips from the airport commission's or consultant's reports must be utilized. Table A.17 outlines the procedure followed in this case. First the forecasts for Oldfield are compared with the total number of passengers forecast for both airports, Oldfield plus Neway. When considering only Oldfield, it is as if the project were non-existent (without project). Adding Neway airport forecasts to those from the existing airport produces the with-project scenario. The total number of passengers is given to show the increase expected over the 10-year analysis period. The number of visitors is expected to increase in the same ratio as the local passengers. It is assumed that all originating and terminating (O and T) passengers use local ground transportation to and from the airport, and that through passengers make no use of ground access travel modes. By applying the appropriate O and T air passenger or visitor load factor to the number of person-trips, the number of new vehicle-trips is produced. To arrive at the annual VMT, the number of new vehicle-trips is multiplied by the average trip length of 10.0 miles or 16 km. Once the VMT is known it is simply a matter of applying the composite emission factor from Table A.8 to obtain annual emissions. The final HC emission figure on Table A.17 is the amount of HC emissions produced by the off-site portion of trips to the airport due to the new project. There is also an increase in the number of airport employees, but only their travel on-site is considered. It is

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Table A.17. Data and Annual HC Emissions from Off-Site Portion of New Air Passenger Related Trips

	Annual Passengers (10^6 people)		
Data	PY 1	PY 5	PY 10
Oldfield only (without new project)			
Total passengers	3.3	4.0	5.5
Local O and T passengers[a]	2.8	3.2	4.7
Visitors	1.4	1.6	2.4
Oldfield plus Neway Airport (with project)			
Total passengers	3.3	4.6	16.2
Local O and T passengers[a]	2.8	3.7	11.5
Visitors	1.4	1.9	5.8
% increase in total number of local passengers and visitors due to proposed project	0%	14%	59%
Fraction of trips by auto		72%	70%
New Air Passenger Related Trips[b] (10^6 trips)		0.36	4.76
New Visitor Trips (10^6 trips)		0.3	3.4
Total New Person-Trips by Auto (10^6 trips)		0.66	8.16
Emissions Computations			
Air Passenger Vehicle Load Factor		1.9	2.0
Visitor Load Factor		2.5	2.5
New Vehicle Trips		309,474.0	3,740,000.0
Average Trip Length (mi)		10.0	10.0
Annual VMT		3,094,740.0	37,400,000.0
Composite HC emission factor (gm/mi)		3.033	1.253
Annual HC Emissions (10^3 kg)		9.4	46.9

[a] Originating and Terminating Passengers

[b] Mode split for auto trips is applied to these trips.

[c] All visitor trips are assumed to be by auto.

assumed that these new employees were previously driving to other jobs in the region, so no new off-site emissions are considered for these trips. This is a conservative estimate of the airport's effect on emissions, since some of the on-site jobs might be in excess of what was forecast without the project for the region. The activity included in this analysis of induced growth represents net increases due to the building of the airport. It is recognized that many activities will shift in the region to be closer to the new airport. These shifts are not considered in the computation - only the net growth.

While the new on-site airport employees' off-site travel is not considered to increase regional emissions, travel by new off-site employees does increase the total. These are the people who are employed by the new industrial or commercial concerns brought about by the airport project. The number of new employees expected in the region was forecast in the consultant's report and is shown on Table A.18. By applying a load factor of 1.2 employees per trip and multiplying by the assumed trip length, the VMT per new off-site employee is calculated. As was done previously, multiplying the VMT by the composite auto emission factor from Table A.8 produces the total amount of HC emissions generated by new off-site employment (Table A.18). Note that even though employment rises in the fifth to tenth years, the amount of emissions decreases because of the lower emission factor.

The heating and cooling of these new commercial or industrial concerns is another component of the emissions due to induced growth. The number of annual emissions is calculated the same way for off-site buildings as it was earlier for the on-site plant. Again, No. 6 fuel oil is assumed to be the only feasible fuel, with a heat content of 144,000 Btus per gallon of oil. Applying an average factor of 219 x 10^3 Btu/sq.ft./yr to the number of square feet of building space to be heated produces the number of Btus necessary to heat the space. Converting the number of gallons needed to liters and multiplying by the emission factor which is in kg/10^3l yields the annual HC emissions from the heating plant. Emissions due to cooling were estimated as 30% of those due to heating. This procedure is summarized on Table A.19.

Table A.18. Traffic and HC Emissions Generated by New Employees Working at Off-Site Jobs

Data	Project Year 1	 5	 10
Number of new employees at off-site jobs	2200	17,900	42,200
Assumed trip length for each new employee (mi/day)	5.5	5.7	5.7
Annual VMT due to new employees (10^3 mi)	3650	31,025	73,000
Total HC emissions generated by off-site employment (10^3 kg)	19.7	94.2	91.5

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Table A.19. Data and Annual HC Emissions from Heating and Cooling Plants for New Commercial and Industrial Concerns Due to Induced Growth of Region

Data	Project Year 1	5	10
Sq. Ft. of Building Space to be Heated	40,000	340,000	800,000
Annual Heating Needs (10^9 Btu)	8.76	74.5	175.2
Quantity of No. 6 Fuel Oil			
(10^3 gal)	60.8	517.1	1216.7
(10^3 l)	230.2	1957.4	4605.7
HC Emission Factor for No. 6 Fuel Oil (kg/10^3 l)	0.35	0.35	0.35
HC Emissions from Heating and Cooling (kg)	104.7[a]	890.6[a]	2095.6[a]

[a] Emissions from heating plant multiplied by 1.3 to account for cooling also.

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There were no specific data for estimating the emissions contributed by the manufacturing processes expected to be attracted to the area, so a pollutant load equal to twice the heating and cooling emissions is used. There are other small sources, but the activities listed above are the major off-site contributors of emissions. These activities and the amount of emissions contributed by each are summarized on Table A.20. Clearly, new off-site employment accounts for the largest portion of HC emissions. These emissions are all due to the net growth in the region brought about by the construction of Neway Airport.

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Table A.20. Annual HC Emissions Due to Net Regional Induced Growth

Activity	HC Emissions (10^3 kg) Project Year 1	 5	 10
Air Passenger-Related Travel	0	9.4	46.9
Off-Site Employment	19.7	94.2	91.5
Heating and Cooling	0.1	0.9	2.1
Manufacturing Processes	0.2	1.8	4.2
Total Off-Site Emissions	20.0	106.3	144.7

Appendix B - Test Case 2, Metro Airport

For this test case, it is assumed that an airport is already in existence; however, it has insufficient capacity to meet forecast air travel demands. To help alleviate the problem, a new jet runway is proposed. The emission calculations are based on the assumption that the runway is opened for operation in project year one (PY 1) and continues in use throughout project years five and ten (PY 5 and PY 10). The Argonne Airport Vicinity Air Pollution (AVAP) [6] simulation model was used to calculate hydrocarbon (HC) and nitrogen oxides (NO_x) emissions. The data used in the model are from the airport forecasts of activity with the new runway. The major on-airport emission sources are the same as in Test Case 1 - aircraft, ground service vehicles, access traffic, engine tests, heating and cooling, and fuel handling and storage. In addition, emissions from maintenance facilities and refuse incinerators are included as miscellaneous sources, since these data were included in the forecasts.

B.1 EMISSIONS FROM AIRPORT SOURCES

As expected, the largest contributor of on-airport emissions is aircraft. To calculate annual emissions the number of annual operations must be known. Since this test case assumes an existing airport, the number of operations from previous years was used to calibrate the model and forecast the number of operations for Project Years 1 and 10. With data from Project Year 1 and Project Year 10, linear interpolation can be applied to produce data for Project Year 5. It is assumed in all instances that the amount of emissions increases or decreases linearly within the ten-year period addressed here. The annual number of operations for Project Years 1, 5 and 10 are shown on Table B.1 listed by type of aircraft operating at the airport. The model uses the number of operations combined with the emission factor for each type of aricraft to determine total emissions. The emission factors for Project Year 1 are those given in the <u>Compilation of Air Pollutant Emission Factors,</u> Report AP-42[24], published by the U.S. Environmental Protection Agency (EPA). The factors for Project Year 10, however, are ones which will meet the Federal Aviation Administration's (FAA) new engine emission standards[7]. The factors are given by operating mode for each engine. Tables B.2 and B.3 list the factors used in the model by aircraft type. That is, the modal emission factor for a specific aircraft is the engine

Table B.1. Annual Operations by Aircraft Type

Aircraft	Project Year		
	1	5	10
DC-9	190,560	226,145	261,730
B-727	126,720	150,384	174,047
Be-99	8,640	10,253	11,867
YS-11	2,880	3,417	3,955
B-737	16,800	19,937	23,074
B-747	44,160	52,407	60,653
L-1011	29,760	35,317	40,874
DC-10	60,000	71,204	82,408
General Aviation - jet	12,366	18,549	24,732
General Aviation - piston	8,834	13,251	17,668
Total jet	483,246	577,360	671,473
Total non-jet	17,474	23,504	29,535
TOTAL	500,720	600,864	701,008

Table B.2. Modal Emission Factors by Aircraft Type – Project Year 1
(kg/hr/aircraft)

			HC Factors by Mode					NO_x Factors by Mode				
Aircraft[a]	Engine	No. of Engines	Taxi-Idle	Climb-Engine Check	Runway Roll	Approach	Landing	Taxi-Idle	Climb-Engine Check	Runway Roll	Approach	Landing
DC-9	JT8D	2	7.42	0.836	0.706	1.588	4,876	2.64	118.8	179.6	28,0	49.16
B-727	JT8D	3	11.13	1.254	1.059	2.382	7.314	3.96	178.2	269.4	42,0	73.74
Be-99	0302	2	0.322	1.188	1.352	0.450	0,5896	0.012	0.34	0.194	0.046	0.0611
YS-11	56A7	2	5.86	0.432	0.390	0.470	3,684	1.96	19.24	20.8	7,06	7.298
B-737	JT8D	2	7.42	0.836	0.706	1.588	4.876	2.64	118.8	179.6	28.0	49.16
B-747	JT9D	4	49.6	4.8	5.36	5.44	31.916	11.0	832.0	1308.0	98.0	336.2
L-1011	CF6	3	21.0	1.77	1.77	2.58	13,437	4.89	453.0	453.0	235.5	149.34
DC-10	CF6	3	21.0	1.77	1.77	2.58	13.437	4.89	453.0	453.0	235.5	149.34
GA-jet	J610	2	14.3	0.72	0.72	1.14	9.936	0.78	52.4	52,4	11.86	14.942
GA-piston	0302	1	0.161	0.594	0.594	0.225	0.2752	0.006	0.17	0.17	0.023	0.0481

[a] GA = General Aviation

Table B.3. Modal Emission Factors by Aircraft Type - Project Year 10
(kg/hr/aircraft)

			HC Factors by Mode					NO_x Factors by Mode				
Aircraft[a]	Engine	No. of Engines	Taxi-Idle	Climb-Engine Check	Runway Roll	Approach	Landing	Taxi-Idle	Climb-Engine Check	Runway Roll	Approach	Landing
DC-9	JT8D	2	2.20	0.248	0.208	0.470	1.445	1.04	47.0	71.0	11.06	19.43
B-727	JT8D	3	3.30	0.372	0.312	0.705	2.168	1.56	70.5	106.5	16.59	29.15
Be-99	0302	2	3.66	0.308	0.308	0.448	2.342	2.32	215.6	349.8	11.2	87.14
YS-11	56A7	2	3.06	0.226	0.204	0.246	19.24	1.96	19.24	20.8	7.06	7.298
B-737	JT8D	2	2.20	0.248	0.208	0.470	1.445	1.04	47.0	71.0	11.06	19.43
B-747	JT9D	4	50.0	1.34	1.48	1.52	30.6	4.44	336.0	528.4	39.56	135.8
L-1011	CF6	3	10.38	0.87	0.87	1.275	6.642	1.95	180.3	180.3	93.6	59.43
DC-10	CF6	3	10.38	0.87	0.87	1.275	6.642	1.95	180.3	180.3	93.6	59.43
GA-jet	J610	2	0.82	0.042	0.042	0.066	0.5126	0.16	10.68	10.68	2.42	3.046
GA-piston	0302	1	1.83	0.154	0.154	0.224	1.171	1.16	107.8	107.8	5.6	27.46

[a] GA=General Aviation

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emission factor from AP-42 multiplied by the number of engines on the aircraft. Table B.4 shows the annual amount of HC and NO_x emissions calculated by the model for each type of aircraft for Project Years 1, 5 and 10. The emissions are shown for jet and non-jet aircraft. Included as non-jet aircraft are the Be-99 and the general aviation-piston type aircraft. The number of operations increases over the ten-year period for all aircraft types; however, in most cases the amount of NO_x emissions decreases. Only the non-jet aircraft are forecast to increase NO_x emissions significantly. In the case of hydrocarbons, the total amount of emissions increases slightly; this is due mainly to the B-747 aircraft's higher emissions and also to the L-1011 aircraft and increased emissions from non-jet aircraft.

Another major source of emissions is ground service vehicles. Since the amount of emissions is directly related to the type of aircraft to be serviced, the service times and number of service vehicles used in the model are based on actual counts. The type of service vehicles and length of service time for each of these vehicles is used to estimate a total ground service vehicle emission rate per aircraft. The emission rates used in the model are shown on Table B.5 for both gasoline and diesel fueled vehicles. The amount of HC and NO_x emission from ground service vehicles is listed on Table B.6 by aircraft type. No servicing times were allowed for any general aviation or non-jet aircraft.

Access traffic emissions are calculated in the model by using forecast VMT for all road segments on the site. The length of the road segments was defined over continuous segments having the same average speed along the roadway. Eight different types were identified, at speeds of 10, 20, 25, 27, 35, 40, 45 and 55 miles per hour. The VMT for six vehicle classes was estimated and then multiplied by the appropriate emission factors from EPA's Report AP-42 to arrive at the annual access traffic emissions. The six classes considered are: 1) passenger cars, 2) light-duty trucks, 3) heavy-duty gas trucks--6000-16,000 pounds, 4) heavy-duty gas trucks--16,001-33,000 pounds, 5) heavy-duty gas trucks greater than 33,000 pounds, and 6) heavy-duty diesel vehicles. These VMT figures are found on Table B.7. Annual HC and NO_x emissions due to access traffic, and the remaining on-site sources, are summarized on Table B.8.

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Table B.4. Annual Aircraft Emissions by Type

Aircraft[a]	HC Emissions (10^3 kg) PY1	PY5	PY10	NO_x Emissions (10^3 kg) PY1	PY5	PY10
DC-9	280.2	255.8	231.3	678.5	528.0	377.6
B-727	329.1	305.3	281.4	695.6	510.9	326.2
Be-99	0.7	2.6	4.7	0.1	33.2	66.4
YS-11	2.2	2.1	1.9	2.7	3.3	3.8
B-737	24.4	22.6	20.8	57.0	44.4	31.8
B-747	460.4	550.6	640.7	967.3	758.7	550.0
L-1011	158.5	162.0	165.5	471.2	367.6	263.9
DC-10	234.2	210.6	187.0	1089.8	810.6	531.3
GA-jet	30.1	19.5	8.8	19.2	12.5	5.8
GA-piston	0.5	2.2	3.9	<.1	21.3	42.6
Total jet	1519.1	1528.5	1537.4	3981.4	3036.0	2090.4
Total non-jet	1.2	4.8	8.6	0.1	54.5	109.0
TOTAL	1520.3	1533.3	1546.0	3981.5	3090.5	2199.4

[a] GA=General Aviation

Table B.5. Emission Factors for Ground Service Vehicles
(kg per operation)

Aircraft Type[a]	Gasoline-Fueled Vehicles		Diesel-Fueled Vehicles	
	HC Factor	NO_x Factor	HC Factor	NO_x Factor
DC-9	0.800	0.200	0.038	0.420
B-727	1.08	0.280	0.038	0.420
Be-99[b]	-	-	-	-
YS-11	0.760	0.180	0.026	0.280
B-737	0.820	0.200	0.032	0.354
B-747	2.86	0.700	0.038	0.420
L-1011	2.32	0.560	0.030	0.326
DC-10	1.60	0.400	0.030	0.326
GA-jet[b]	-	-	-	-
GA-piston[b]	-	-	-	-

[a] GA=General Aviation

[b] No ground service vehicles are used for these aircraft

Table B.6. Annual Emissions from Ground Service Vehicles by Aircraft Serviced

Aircraft[a]	HC Emissions (10^3 kg) PY1	PY5	PY10	NO_x Emissions (10^3 kg) PY1	PY5	PY10
DC-9	79.8	96.1	112.4	59.1	71.2	83.2
B-727	70.8	85.3	99.7	44.3	53.4	62.5
Be-99	0	0	0	0	0	0
YS-11	1.1	1.3	1.6	0.7	0.8	0.9
B-737	7.2	8.6	10.1	4.6	5.5	6.5
B-747	64.0	77.1	90.1	24.7	29.8	34.8
L-1011	35.0	42.1	49.3	13.2	15.9	18.6
DC-10	48.9	58.9	68.9	21.8	26.2	30.7
GA-jet	0	0	0	0	0	0
GA-piston	0	0	0	0	0	0
TOTAL	306.8	369.4	432.1	168.4	202.8	237.2

[a] GA=General Aviation

Table B.7. Annual VMT at Metro Airport During Project Year 1 (10^3 miles)

Average Speed on Roadway	Passenger Car	Light-Duty Gas Truck	Heavy-Duty Gas Truck 6000-16,000 lb	Heavy-Duty Gas Truck 16,001-33,000 lb	Heavy-Duty Gas Truck >33,000 lb	Heavy-Duty Diesel Vehicles	Total VMT
10	2595.5	21.8	65.8	7.6	4.6	10.6	2705.9
20	1030.9	28.8	121.4	11.3	6.2	17.1	1215.7
25	689.0	13.4	38.6	5.6	3.5	8.8	758.9
27	3716.1	77.7	191.0	32.1	19.3	46.3	4082.5
35	1458.7	0	98.2	0	0	1.6	1558.5
40	7471.2	345.7	364.0	143.6	85.9	209.7	8620.1
45	414.5	0	28.0	0	0	0.4	442.9
55	1327.3	0	89.4	0	0	1.4	1418.1
TOTAL	18,703.2	487.4	996.4	200.2	119.5	295.9	20,802.6

Annual VMT at Metro Airport During Project Year 10 (10^3 miles)

Average Speed on Roadway	Passenger Car	Light-Duty Gas Truck	Heavy-Duty Gas Truck 6000-16,000 lb	Heavy-Duty Gas Truck 16,001-33,000 lb	Heavy-Duty Gas Truck >33,000 lb	Heavy-Duty Diesel Vehicles	Total VMT
10	3515.8	26.0	93.6	10.8	6.5	16.8	3669.5
20	1466.6	41.0	172.8	16.0	8.7	24.4	1729.5
25	979.5	19.0	55.1	8.0	5.0	12.5	1079.1
27	5232.8	110.1	271.7	45.6	27.4	66.9	5804.5
35	2075.1	0	139.6	0	0	1.8	2216.5
40	12,047.3	491.9	517.9	204.5	122.2	298.4	13,682.2
45	589.6	0	39.9	0	0	0.6	630.1
55	1879.2	0	127.2	0	0	2.0	2008.4
TOTAL	27,835.9	688.0	1417.8	284.9	169.8	423.4	30,819.8

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Table B.8. Annual On-Airport Emissions (10^3 kg/yr)

Source	HC Emissions			NO_x Emissions		
	PY1	PY5	PY10	PY1	PY5	PY10
Aircraft	1520.3	1533.2	1546.0	3981.5	3090.4	2199.4
Ground Service Vehicles	306.8	369.4	432.1	168.4	202.8	237.2
Access Traffic	196.1	204.6	213.2	88.3	85.4	82.4
Engine Test	36.1	21.6	7.0	199.6	162.2	124.8
Heating and Cooling	0.8	0.8	0.8	9.4	9.4	9.4
Fuel Handling and Storage	397.7	470.6	543.4	0	0	0
Miscellaneous	6.7	8.1	9.5	2.3	2.3	2.3
TOTAL	2464.5	2608.3	2752.0	4449.5	3552.5	2655.5

The data used to calculate the emissions from the remaining sources are based on collected information for a base year and then forecast for project years 1 and 10. Again, linear interpolation was used to arrive at project year 5 emissions. For example, the number of engines tested is based on the current ratio of engine tests to the aircraft operations at Metro Airport. While the number of operations, and therefore aircraft, is forecast to increase, the emissions from engine testing are expected to decrease because of the changeover to new engines expected to meet the new engine emission standards promulgated by the Federal Aviation Administration (FAA). The heating and cooling plant emissions are based on existing data and assumed to stay approximately the same since there is no change proposed for the size of the terminal.

The information required to calculate fuel handling and storage emissions was also given for a base year. The size, location and type of the tanks was known. Only fixed-roof tanks are used at Metro Airport. From this information, forecasts of future fuel storage and handling needs were made and future emissions were computed.

As mentioned above, data from two miscellaneous sources were also forecast and emissions calculated from maintenance facilities and from refuse incinerators. In all cases, emission factors from EPA's AP-42 were used when available.

B.2 EMISSIONS DUE TO INDUCED GROWTH

The modification to Metro Airport also attracts growth in the area surrounding the airport. The major activities affected are the increased air passenger and visitor auto trips to and from the airport site and auto traffic from new employees in jobs away from the airport. Both of these activities increase the regional hydrocarbon emission levels. Two smaller contributors are the emissions from the heating and cooling of these new work places and also emissions from the manufacturing processes. Data on the forecasted increase of this induced growth was given, so the amount of HC emissions can be computed. The figures on Table B.9 represent emissions from the four largest source activities affected by the project. (That is, activities which are a direct result of the net growth of the area surrounding the airport.) By adding these totals to the total on-site emissions, the "with-project" scenario is complete.

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Table B.9. Annual HC Emissions from Induced Growth

	HC Emissions (10^3 kg)		
Activity	PY1	PY5	PY10
Air Passenger and Visitor Auto Traffic To and From Metro	59.2	82.2	131.3
New Off-Site Employee Auto Traffic	138.0	152.6	160.4
Heating and Cooling of New Workplaces	0.1	0.9	2.1
Manufacturing Processes	0.2	1.8	4.2
TOTAL	197.5	237.5	298.0

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B.3 ON-SITE EMISSION REDUCTION STRATEGY

To help decrease on-site airport emissions, a test case was run using the AVAP model. It was assumed that instead of taxiing to the runway, each aircraft would be towed by a ground vehicle. To simulate this strategy the emission factor for the taxi-idle mode was decreased to account only for emissions from the idle mode. The modified emission factors, assumed the same for all years, are shown on Table B.10. Applying these new factors to the aircraft operations produces the new emissions by aircraft type listed on Table B.11. Table B.12 summarizes the total on-airport emissions using the towing strategy. This strategy, used for all aircraft, can produce a decrease in aircraft HC emissions of 44%, 38%, and 32% in project years 1, 5, and 10, respectively. Total airport emissions decreased 27% in project year 1, 22% in project year 5 and 18% in project year 10 as a result of this towing strategy.

Table B.10. Emission Factors for Taxi-Idle Mode for Aircraft Towing Strategy (kg/hr/aircraft)

	All Project Years	
Aircraft[a]	HC	NO_x
DC-9	0.602	0.264
B-727	0.903	0.396
Be-99	0.602	0.264
YS-11	0.602	0.264
B-737	0.602	0.264
B-747	1.204	0.528
L-1011	0.903	0.396
DC-10	0.903	0.396
GA-jet	0.602	0.264
GA-piston	0.301	0.132

[a] GA=General Aviation

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Table B.11. Annual Emissions by Aircraft Type for Aircraft Towing Strategy (10^3 kg)

	HC Emissions			NO_x Emissions		
Aircraft[a]	PY1	PY5	PY10	PY1	PY5	PY10
DC-9	163.6	178.3	192.9	637.7	498.3	358.8
B-727	212.6	231.5	250.4	654.8	482.9	311.1
Be-99	0.9	1.3	1.7	0.3	32.2	64.1
YS-11	0.9	0.9	1.0	2.4	2.9	3.4
B-737	14.7	16.1	17.5	53.6	41.9	30.2
B-747	246.8	292.2	337.6	920.9	723.4	526.0
L-1011	100.6	113.8	127.0	458.0	357.8	257.6
DC-10	107.3	110.0	112.7	1061.4	790.2	518.9
GA-jet	8,5	8.4	8.3	18.4	12.2	6.0
GA-piston	0.7	1.1	1.4	0.2	20.6	40.9
Total jet	855.0	951.2	1047.4	3807.2	2909.6	2012.0
Total non-jet	1.6	2,4	3.1	0.5	52.8	105.0
TOTAL	856.6	953.6	1050.5	3807.7	2962.4	2117.0

[a] GA=General Aviation

Table B.12. Annual On-Airport Emissions With Aircraft Towing Strategy (10^3 kg)

	HC Emissions			NO_x Emissions		
Source	PY1	PY5	PY10	PY1	PY5	PY10
Aircraft with Towing	856.6	953.6	1050.5	3807.7	2962.4	2117.0
Ground Service Vehicles	306.8	369.4	432.1	168.4	202.8	237.2
Access Traffic	196.1	204.6	213.2	88.3	85.4	82.4
Engine Test	36.1	21.6	7.0	199.6	162.2	124.8
Heating and Cooling	0.8	0.8	0.8	9.4	9.4	9.4
Fuel Handling and Storage	397.7	470.6	543.4	0	0	0
Miscellaneous	6.7	8.1	9.5	2.3	2.3	2.3
TOTAL	1800.8	2028.7	2256.5	4275.7	3424.5	2573.1

REFERENCES

1. Federal Register, 39 (132): 25292-25301, July 9, 1974.

2. Sarah LaBelle, Michael Harbour, Dorathea Seymour, "Airport Construction Projects, 1977-1987," Technical Memorandum - 1, Argonne National Laboratory, prepared for U.S. Environmental Protection Agency, Washington, D.C., July, 1976.

3. Terminal Area Forecasts, 1977-1987, U. S. Department of Transportation, Federal Aviation Administration, Office of Aviation Policy, FAA-AVP-75-5, Washington, D.C., January, 1976.

4. J. E. Norco, R. R. Cirillo, T. E. Baldwin, J. W. Gudenas, An Air Pollution Impact Methodology for Airports - Phase I, U.S. Environmental Protection Agency, Office of Air and Water Programs, Report No. APTA-1470, Research Triangle Park, N.C., January, 1973, Chap. 4.

5. R. R. Cirillo, J. F. Tschanz, J. E. Camaioni, "An Evaluation of Strategies for Airport Air Pollution Control," Argonne National Laboratory, Report No. ANL/ES-45, Argonne, Illinois, March, 1975, p. 47.

6. D. M. Rote, I. T. Wang, L. E. Wangen, R. W. Hecht, R. R. Cirillo, J. Pratapas, "Airport Vicinity Air Pollution Study," Argonne National Laboratory, prepared for U.S. DOT, Federal Aviation Administration, Report No. FAA-RD-73-113, Washington, D.C., December, 1973, Appendix A-4.

7. "Control of Air Pollution from Aircraft and Aircraft Engines," Federal Register, 38 (136): 19088-19103, Part II, July 17, 1973.

8. Guidelines for Air Quality Maintenance Planning and Analysis, Volume 13: Allocating Projected Emissions to Subcounty Areas, U.S. Environmental Protection Agency, Report No. EPA-450/4-74-014, November, 1974.

9. R. M. Angus and E. L. Martinez, Rural Oxidant and Oxidant Transport in Assessing Transportation - Related Air Quality Impacts, Proc. of the Conference on the State of the Art of Assessing Transportation - Related Air Quality Impacts, Washington, D.C., Oct. 22-24, 1975. Transportation Research Board Special Report 167, National Academy of Sciences, Washington, D.C. pp. 63-73, 1976. Referred to as TRB SR 167.

10. Various references, Federal Register, 41: 27999 through 40558.

11. Guidelines, op. cit.

12. This discussion is based largely on B. Dimitriades, Chemistry, TRB SR 167, op. cit., pp. 8-20.

13. 40 CFR 51.

14. N. de Nevers and R. Morris, Rollback Modeling - Basic and Modified, paper No. 73-139 presented at Air Pollution Control Association meeting, Chicago, June 24-28, 1973.

15. B. Dimitriades, "Effects of Hydrocarbons and Nitrogen Oxides on Photochemical Smog Formation", *Env. Sci. and Tech. 6* (3), 253-260, March, 1972.

16. L. N. Myrabo, K. R. Wilson, and J. C. Trijonis, *Survey of Statistical Models for Oxidant Air Quality Prediction*, TRC 167, *op.cit.*, pp. 46-62.

17. F. A. Record, R. M. Patterson, D. A. Bryant, and A. H. Castaline, *Photochemical Oxidant Modeling Volume I - Techniques Applicable to Highway System Evaluation*, U.S. Environmental Protection Agency Report No. EPA-450/3-75-069-a, July, 1975.

18. "Review of New Sources and Modifications" and "Requirements for Preparation, Adaptation, and Submittal of Implementation Plans", *Federal Register*, *41* (246), p. 55558 and p. 55524, respectively, December 21, 1976.

19. *Federal Register*, *39* (132): 25292-25301, July 9, 1974.

20. Sarah LaBelle, *et. al.*, *op. cit.*

21. R. R. Cirillo, *et. al.*, *op.cit.*, Table 25.

22. J. E. Norco, *et. al.*, *op. cit.*

23. 40 CFR 85.

24. *Compilation of Air Pollution Emission Factors*, Second Edition, U.S. EPA, Report No. AP-42, Research Triangle Park, N.C. March, 1975.

25. Supplement 5 to *Compilation of Air Pollutant Emission Factors*, U.S. EPA, Report No. AP-42, Research Triangle Park, N.C., April, 1975.

26. *Federal Register Vol. 39*, (47), p. 9308, March 8, 1974, and (75), p. 13776, April 17, 1974 and (116), p. 20790, June 14, 1974.

27. C. E. Burklin, R. L. Honerkamp, Revision of Evaporative Hydrocarbon Emission Factors, Office of Air and Waste Management, U.S. EPA Report No. EPA-450/3-76-039, August, 1976.

28. S. Zimmerman, M. West, T. Kozlowski, *Urban Highways as Traffic Generators*, U.S. DOT, Federal Highway Administration, Washington, D.C., August, 1974.

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