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AIR QUALITY IMPACT ANALYSIS FOR APPLICATION IN LAND USE AND TRANSPORTATION PLANNING

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AIR QUALITY IMPACT ANALYSIS FOR APPLICATION IN LAND USE AND TRANSPORTATION PLANNING

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Continuing Education in City, Regional, and Environmental Planning
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With the Assistance of the
United States Environmental Protection Agency

Preface

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INTRODUCTORY STATEMENT

Richard H. Thuillier

Good morning! I greatly relish and appreciate the opportunity to welcome you here and to set the tone for this short course in Air Quality Impact Analysis. As we indicated in our brochure, the purpose of this course is to bring a workable air quality analysis approach to the attention of an extended segment of the user community. The desire to do this was stimulated by local requests for assistance, indicating that the copious published material relating to air quality analysis was not imparting a clear message or indicating a discernible direction. The very gratifying and somewhat unexpected attendance here would seem to bear out the existence of a gap between the development and application of techniques. We hope and will certainly attempt to insure that you leave here on Wednesday with an improved albeit imperfect knowledge in this respect.

The story to be told in this course is structured, as is any good story, with a beginning, a middle and an end. In the beginning there was the Clean Air Act, NEPA, CEQA, etc., forming the framework of the legislative and regulatory approach to the attainment and maintenance of a high level of air quality. The bulk of this first day will be devoted to an examination of the setting in which the air quality analysis requirement exists. We will examine the legislation and regulations, particularly as they bear upon land use and transportation. We will discuss the relationship and interaction between the planning and regulatory communities. Finally, we will apprise you of the expectations of agencies currently responsible for setting policy and with the prospects for future evolution of the air quality management process. After the setting is established, we will introduce the very technical business of assessing air quality impact by discussing the nature of the pollutants with which we must deal and the atmospheric processes which transform pollutant emissions into health or welfare related concentrations.

On the second day, we will concern ourselves exclusively with procedures for assessing the impact of land use and transportation projects upon the quality of the air. Since standards have been set in very quantitative terms, it is essential that decision making aimed at achieving or maintaining these standards be provided with information which is also quantitative in nature. Such information should be obtained on a systematic and scientific basis, concern itself with all relevant pollutants and be presented in a form which is readily evaluated in terms of applicable standards. While an exact technique for accomplishing this task may never exist, there does exist a variety of techniques which yield approximate solutions quite suitable for effective decision-making. Our second day will explore the entire state of the art in air quality analysis but will concentrate on simplified methods since adequate and meaningful air quality analysis is the responsibility of the pauper as well as of the prince. Our intent is to provide an alternative to the choice between a costly, esoteric and time consuming analysis and no analysis at all.

We will conclude our story on the third day by discussing appropriate procedures for the written presentation of analysis results. The emphasis will be on environmental impact statements and reports and the discussion will include both quantitative and qualitative aspects of the analysis. A focus for the discussion will be provided via a critique of sample impact reports indicating the faults and merits of some of the impact reporting to date. Our story thus completed, we will view our performance through the looking glass of our audience so that we too can learn from our experience. As in any first effort, we anticipate many wrinkles which will have to be ironed out. We welcome your suggestions in so doing.

Due to the great number of participants, which in all honesty exceeded our greatest expectations, we would like to beg your indulgence in a couple of areas in which our performance will probably fall short of your expectations. We have attempted to provide each of you, free of charge, a small library of the published material which we feel is basic to the process of air quality analysis. This material will be available at the beginning of the session on the second day. Our second request for indulgence concerns audience participation. We ask you to reserve any philosophical discussion for the lunch, coffee break and cocktail hour periods so that we may get through the material we have to present. The speakers will attempt to provide some of their alloted time for questions and answers.

With that, I conclude my introduction, wish you all a profitable experience and return the podium to Dr. Hagevik who will introduce the next speaker. Thank you for your kind attention.

KEYNOTE ADDRESS

AIR QUALITY AND LAND USE

David Morell

Introduction

I would like this morning to set the stage for some of the issues to be covered during the next two days of this seminar by exploring with you three sides of a triangle: one side is Air Quality and the second side Land Use. The third side involves Intergovernmental Relations, the institutional structures which perform the integration, hopefully, of air quality concerns with land use decisions. The challenge of institutionalization to cope with these new issues is particularly important. We face the need to create new institutional structures, or at least to use our existing institutions in new ways. In integrating air quality and land use, a vertical institutional network is required.

Traditionally, the functional federalism of the next fifteen or twenty years has coped with--or tried to cope with--the problems in our metropolitan areas through creation and support of horizontal, area-wide structures. But how do we join land use decisions, traditionally made at city and county levels, with air quality standards, regulations, goals and objectives which traditionally emanate from federal and state levels? Our need is to effect a vertical synthesis of these two activities.

I would like to review some of our activities at the federal Environmental Protection Agency concerning four of the air pollution control programs which affect land use: Transportation Control Plans, Indirect Source Reviews, Air Quality Maintenance Plans, and regulations to prevent Significant Deterioration of air quality in clean-air areas.

Before I go into these programs, however, it seems only fitting that we examine where we've been in EPA relationships with states and cities and counties, through a story--an analogy, if you will--that I think hopefully sets the stage for vastly different relationships in the future. This is the story of the hippopotamus that fell in love with the pigeon; but he didn't know quite what to do to effectuate this relationship. So, he went to see the wise old owl, and he said, "Listen, Mr. Owl, I have a problem; I'm in love with a pigeon and I don't know what to do." The owl, being a wise old owl, scratched his beak, and he thought, and he said finally, "Listen, Hippo, there's only one thing you can do: turn yourself into a pigeon." Well, the Hippo nodded his head, and he thought that sounded like good advice, and he lumbered away down the forest path. As he was walking away it dawned on him, "Well, I was given good advice, to turn myself into a pigeon; but how do I do that?" So he turned around and went back to the wise old owl, and he said, "Look, you told me to turn myself into a pigeon; how do I do that?" And the owl looked him right in the eye and he said, "Listen, Hippopotamus, I only make policy, I don't implement it!"

Well, too often in the past, that's where we've been in EPA relations with State and local governments. Under the mandates of the Clean Air Act of 1970, we have engaged in a good deal of publication of regulations in the Federal Register; we have been making policy. Who's going to implement it? What kind of institutional structures, procedures, commitments, political will, taxing authority and financing are to be involved? We have to move now from regulations--policy, if you will--

such as 38 transportation control plans across this country, including much of California, to a mode of implementation, taking these plans and saying, how do we move from a plan to cleaner air, to a reduction in photo-chemical oxidants in the air here around the Bay Area, or in California's South Coast Air Basin, or in Denver. So this story from the animal kingdom really sets the stage for where I think we want to go together, between the federal government and state and local governments, in terms of institutionalization and implementation of these programs.

One other concept that forms the basis for understanding the relationship between air quality and land use is to view a hierarchy of three objectives in the Clean Air Act in terms of air quality: attainment, maintenance, and preservation. Attainment of what? Attainment of national ambient air quality standards, which have been established for six criteria pollutants. In the areas which are now dirtier than the standards, therefore, we are talking about techniques, technology, land use review, whatever, to attain the standards as expeditiously as possible; under the present mandate of the Clean Air Act, by July 1, 1977, at the latest. Thus one of the main goals, and in many ways the first significant goal of the Clean Air Act, involves attainment of national standards. Once attained, the second goal comes into effect: maintenance. These two goals, however, must and will relate to one another in actual practice. In other words, while you're in an attainment phase, you need to be taking certain actions to insure that you can maintain that air quality, once you get there. We can't suddenly switch from attainment to maintenance on the day when you hit that line, the national standard. Instead we must begin creating a political process, and a decision making process now in the South Coast Air Basin looking toward maintenance of air quality in the 1980's. Therefore, when we talk about an Air Quality Maintenance Plan (AQMP) as needed for maintenance standards, we might as well change the 'M' to Management in some of the very heavily impacted areas like the South Coast Air Basin. This air quality management plan involves the same process and the same procedures as the air quality maintenance plan. The third objective, preservation, is my shorthand for the phrase that is so lengthy in the court orders and the discussions: "prevention of significant deterioration of air quality." Preservation is the objective in areas where the air is cleaner than the standards. Normally, these are rural areas, occasionally elsewhere. What special steps ought to be taken to preserve that air quality? Later I'll describe some of the procedures we are attempting to devise in this area of air quality preservation.

Transportation Control Plans

All four of the programs I named earlier deal in one way or another with the integration of air quality concerns into state and local land use planning and decision making. Transportation control plans are primarily oriented toward the attainment objective. They deal with the pollutants associated with automobiles, and contain a wide variety of measures, some of which have been highly controversial. The plans include measures to influence the pattern of automobile transportation in 38 of our largest metropolitan areas heavily impacted by auto pollution. These measures are designed to shift people over time out of automobiles into buses, fixed rail systems, car pools, bicycles, their own feet, whatever. The volume of auto traffic, its density and congestion and the overall vehicle miles traveled (VMT) are causing the vast majority of the air pollution problems in those cities.

Some measures in the transportation control plans are highly technological, such as the retro-fit of emission control devices on older cars. Inspection and maintenance of automobiles is very important. Although we have had our problems in achieving a cleaner car, the newer ones are certainly much cleaner than the ones made five years ago. Inspection and maintenance programs ensure that the technology we've paid for on the newer cars is at least in working order, rather than allowing these devices to deteriorate. The plans call for improvements to mass transit, and because of the time frames of the Clean Air Act for attainment of standards, we're talking primarily about buses and car pools. There are car pool incentive schemes, moral suasion and cajolling to attempt to attempt to obtain additional car-pooling in lieu of one-man, one-car commuting. Transportation control plans call for increased numbers of buses and improved bus service. One of the ways you improve the attractiveness of the bus is to move it faster than a car. So some plans require exclusive bus lanes, which can move car pools and buses across a bridge, like the Bay Bridge, or down an expressway like the Shirley Highway in Washington, much more rapidly than the congested automobile traffic and thereby might induce somebody to get out of their car and into the bus. We're also working closely with the Department of Transportation on financing for bus system improvements. And we're talking, or at least certainly did talk last year, about a variety of disincentives, because as the buses become available, one is faced with the question of "How do you encourage people who have grown up in an automobile culture, in a suburban bedroom community where all mobility relies on automobile traffic, to use the bus more frequently?" One way, we felt, was through a variety of disincentive measures. One of these was called a parking surcharge, which can be very effective. It didn't receive a very favorable reception here in the state of California, to put it mildly.

The parking surcharge controversy is an excellent example of EPA's desire to have local governments develop programs, policies, plans, techniques of their own that they're committed to. It is also an excellent example of what happens when they don't. Under the Clean Air Act, EPA must promulgate these plans, such as a transportation control plan including the parking surcharge. The local government, or the political constituency, if you will, essentially has two choices: one is to say, "Allright, we don't want the Feds to do that, so we'll do it ourselves, we'll get organized and prepare our own plan." The other alternative is to say, "We don't want the Feds to do that, so we'll call our congressman and object." Well, with the parking surcharge it's fairly clear that the second choice was the one selected. During December and January last winter, there was a great deal of pressure from Congress to rescind the parking surcharge, and on January 15th, EPA did so.

The auto-related air pollution problem is so severe in California in terms of having any chance of approaching the standard by the dates mandated in the Clean Air Act, that major and provocative actions were needed; and these were included in the California plans. For example, in areas where there is already, or where there is projected to be, mass transit availability, such as parts of a central business district, a selective parking surcharge used only against 8-hour parkers, not against shoppers, could be both effective and reasonable. There are ways to do this, applying the surcharge only at certain times of the morning, and only for commuters who are going to park for 8 hours. This could be an essential step toward increasing the load factor on buses. Used broad-scale, as in the California plans, the surcharge would again be a political disaster. But used selectively it is an effective device not only providing a model shift from one-man, one-car into mass transit, or into a carpool as a way to share the cost of the surcharge with your neighbor, but the surcharge would provide the revenue needed to cover the operating deficit on the buses. This subsidy is a very significant issue with which the Congress, DOT, and EPA are still groping, in terms of its implications for incentives for management efficiency of bus systems.

Other components of the management of parking supply continue to be emphasized by EPA in the transportation control plans. New parking-related facilities in areas heavily impacted by auto pollution must undergo pre-construction review to ensure that all reasonable steps have been taken to minimize the new facility's impact on vehicle miles traveled and to ensure that localized carbon monoxide standards are not violated. It is EPA's intention that state and local governments begin to carry out these source-by-source parking management reviews, either through adoption of their own legal requirements or through delegation of EPA's authority. Until this happens, however, EPA is responsible for implementing these review procedures.

Furthermore, EPA is emphasizing development by the affected local jurisdictions of comprehensive Parking Management Plans to provide the analytical framework for these source-by-source reviews. VMT is an areawide problem, which can best be viewed in this context. Although EPA is not by itself going to develop Parking Management Plans, we are encouraging local jurisdictions to do so.

Perhaps that's enough on transportation control plans. They're terribly important. They pose major challenges for implementation by state, regional, county and city officials. They contain a variety of measures which in general are not yet fully integrated with one another. One factor I have realized more and more, and I encourage you all to assess: any single measure by itself isn't going to be enough. Parking surcharge, more buses, inspection and maintenance...what we need is an orchestration of these measures, integrating them so that they support one another, and as a whole take us where we need to go in terms of air quality.

Indirect Source Regulations

Let us turn now to the indirect source regulations. An indirect source is a facility which itself does not pollute, but which attracts or may attract large amounts of automobile traffice: shopping centers, parking lots, stadiums, commercial and industrial facilities, recreational areas, highways, airports. These are facilities that can cause violations of the national standards for carbon monoxide due to automobile congestion in and around the facility, particularly into and out of the parking lot associated with the large regional shopping center, for example. We are requiring the developer to examine features for automobile entrance to and egress from that parking lot. Does it have only two entrances, one on each end; or is there one on each corner, plus in the middle? What's the flow of traffic, and what can be done to avoid congestion? We believe that basically it is congestion that causes localized carbon monoxide violations, and that this design issue can be handled in the planning stages of a shopping center or a commercial facility. The focus is on traffic design to avoid congestion and thereby prevent possible violation of the localized carbon monoxide standards. Large new airports and highways will also be reviewed to ensure their consistency with national standards for photo-chemical oxidants (the VMT issue), as are other parking-related facilities in the transportation control plan areas.

Pre-construction review and issuance of a permit is required for all indirect sources which begin construction on or after January 1, 1975. As of July 1st we in EPA will be available officially to begin to consult with developers on this matter. The applicable regulations in the Federal Register were dated February 25th this year, and a revised set will be issued in early July.

As with parking management, EPA is deeply committed to state and local government implementation of the indirect source regulations. Again, this can occur either through EPA approval of locally-adopted review regulations, or through direct delegation of EPA's review authority under the Clean Air Act.

Air Quality Maintenance Plans

Air Quality Maintenance Plans, or as noted in some areas really Air Quality Management Plans, are a very important element of the overall program. These plans have been little discussed by the concerned public, certainly less than indirect source reviews and parking management. This is somewhat ironic, for in the long run the Air Quality Maintenance Plans may be far more important. Perhaps this difference in emphasis occurs because shopping center owners and developers feel deep and direct concern about what EPA is going to do with their new facilities proposed to start construction next year, whereas an Air Quality Maintenance Plan sounds like a process air quality planners carry out in a corner somewhere, sometime in the future. Air Quality Maintenance Plans broaden the analytical scope of source-by-source pre-construction reviews of indirect sources, parking lots, and single highways in two critical dimensions. Geographically, the plan covers the entire relevant problem shed, or air basin. For example, the entire Bay Area or the entire South Coast Air Basin of California, with parts or all of six counties and scores of component cities would be covered under one air quality management structure. This poses directly the question of institutionalization: "Who is going to prepare and implement an Air Quality Maintenance Plan in the Los Angeles area?" The second dimension being broadened from source-by-source reviews is the temporal one. The Air Quality Maintenance Plan, or management plan, takes today's air quality problem, projects growth over the 1975-85 decade and assesses what that growth is going to mean for air quality. Essentially this process involves looking at two curves: one is the growth curve, of increased emissions; the other is the technological reduction curve, whether through cleaner automobiles or scrubbers or whatever, to reduce pollution per source. Thus there are both a per-source reduction curve and a growth-related aggregate increase curve. For example, one of the problems with automobile pollution is that as we get increasingly cleaner new cars, we also have more cars on the roads. The Air Quality

Maintenance Plan takes today's problem, projects those two curves out, and sees that if there are going to be violations of national air quality standards during the 1975-85 period, then regulations, techniques, devices, procedures, decision making bodies, whatever must be developed to get air quality down to the health-related national standards and keep it there. These plans represent a terribly important air quality management device, replete with implications for institutional procedures.

Prevention of significant deterioration, or "preservation" of air quality, is the fourth air quality program which impacts on land use. EPA was faced with a court order last year which said that in addition to attaining and maintaining national standards of air quality, the federal Environmental Protection Agency in concert with the states had to promulgate regulations to prevent significant deterioration of air quality in areas presently cleaner than the standards. These regulations essentially affect rural areas and deal with developments related to the energy supply situation in this country: power plants, oil refineries, and other essential elements of increasing the supply of energy. Because of the complexity of this issue, EPA decided to innovate. You're supposed to go into the Federal Register with a proposed regulation, review public comments, modify the regulation, and then promulgate a final regulation. In air quality preservation, on September 16, 1973, EPA placed in the Federal Register a proposed regulation which contained four alternatives, and accepted public comments on all four. We have received extension public comment, and we've had a continuing series of discussions within this Administration regarding the role of the federal government in this issue. The Administration had wanted a Clean Air Act amendment which would remove the federal government from the preservation issue and explicitly leave all of it to the states. Administrator Train found himself unable to accept this, and so it was sent up to the Congress not as a proposed amendment but as an issue for Congressional discussion. The Congress is deeply interested in this issue, and several federal agencies are quite interested in it. We're now in the process of getting ready to re-propose one alternative which sets out a national procedural framework for land use and area classification by the states on the basis of air quality and other goals and then for the review of new sources in 19 categories. These exclude the automobile pollutants, but do cover power plants, oil refineries, smelters, and other categories, essentially the "big dirties" of stationary source pollution. The regulation sets out techniques for new source review of these categories against stipulated increments. But the system is sufficiently flexible that at levels below the national standards trade-offs can be made by the states, balancing socio-economic benefits against air quality degradation. At least there is a national framework, which in many ways forms a pretty good model for relating land use to environmental quality. Land use choices in cities, counties, and states have to reflect a broad range of community goals: employment, income, tax-ratable base, as well as environmental goals. As we look back over recent history, it seems clear that the environmental goals tend to have been neglected by most land use decision makers. So these preservation regulations inject them into the system.

Localization of Air Quality Efforts

In many ways, the issue in all four of these programs is how to institutionalize these air quality efforts related to land use at the governmental echelon where these decisions have traditionally been made: in the cities and counties. How do we avoid the federal government making these decisions, instead of the counties and cities. Legislation tends to arrive in the Congress in two sets of relationships: action/reaction (the typical physics principle); and inaction/reaction. The Clean Air Act falls into the second category. The Act of 1967 had a lot of nice words, patted everyone on the back, and very little happened. 1970 came around and the Congress produced a very strong act. Thus inaction led to reaction. However, if we find the federal government--in the person of EPA--attempting to make all land use decisions in this nation, we will then witness an example of action leading to reaction.

How do we institutionalize these measures to adequately preserve and protect air quality--attainment, maintenance, and preservation--through land use decision making, recognizing that as many decisions as possible should continue to be made where they've traditionally been made, in the cities and counties. At the same time we must ensure that two other things occur: First, that these national air quality standards are achieved expeditiously, in all areas, and are maintained in the face of new growth. Second, and equally troublesome, how are these decisions made in the cities and counties while still adequately taking care of the externalities, the fact that air pollution blows all over across jurisdictional boundaries? How do these decisions get made where they have been made, where they ought to be made, and sill insure that they adequately reflect our new environmental air quality concerns?

It might be easier if a city had to live with its own pollution; in this event, the city's constituents might really put pressure on the Mayor for effective actions. But what happens is that much of the air pollution in the Los Angeles area, for example, because of the prevailing winds and the location of mountains--meteorology and topography--pockets in Riverside and San Bernardino Counties. What can the county commissioner in San Bernardino County do about the fact that it's all blowing into his area from Los Angeles County, Orange County, and so on. The problem also exists in the Phoenix metropolitan area, where the city of Phoenix has done relatively little in the way of planning and decision making with respect to photo-chemical oxidant control. The City of Scottsdale on the continguous boundary, with a population of about 90,000, has sponsored effective land use planning for years, particularly because its a tourist center. The tourists come there for sunshine and clean air and a view of the mountains. Scottsdale, similar to Riverside and San Bernardino, is located to the north and east of Phoenix, and the prevailing winds are southwesterly. So the pollution blows into Scottsdale from Phoenix. What do you do? How does the mayor of Scottsdale cope with this? If these decisions are left to the city of Phoenix alone, how do you set parameters and constraints for Phoenix to begin to make decisions that will protect Scottsdale? This is a serious issue. How do you create an institutional structure that can cope with these fragmented jurisdictional boundaries, that can cope with the complexities of metropolitan government and of air pollution that blows across these boundaries?

In conceptualizing this problem, I've found it useful to think of a simple three by two matrix: down the left side, State, Regional, and Local levels of government; across the top, General Purpose Government units and Special Purpose Agencies. The first question to resolve is: "Where should the primary locus of authority or responsibility for relating air quality to land use lie--State level? Regional level? Local level? A general purpose agency? (the governor? the county? the mayor?) Or a special purpose agency? An air pollution control district at a regional level? An air board at the state level?"

Once the decision about where the primary locus of responsibility ought to reside has been made, one is then left with deciding how that institution is to relate to all the others. For example, how will the Bay Area Air Pollution Control District relate to the Association of Bay Area Governments with respect to indirect source regulations? In preparing a parking management plan and an Air Quality Maintenance Plan, how will the City of Los Angeles relate to the County of Los Angeles, and to the Los Angeles Air Pollution Control District, and to the Southern California Association of Governments, and to the air quality task force for the six counties in the South Coast Air Basin? As we move into this institutional issue more and more, these institutional relationships must be determined. Our role as outsiders really is to encourage the responsible, politically accountable decision makers to themselves meet with their colleagues--the county commissioners with the mayor, for example--and determine how their respective institutions are going to relate. I see this as an essential pre-requisite to making the kinds of changes to the system that are critical if these air programs which relate to land use programs are going to be effective.

Air Quality and Land Use Institutional Structures

I want finally to suggest a number of concepts that seem valid and important in terms of thinking through this issue of air quality/land use institutional structures. First, we are focusing primarily on the preventitive rather than the curative mode. The preventitive mode deals solely with new growth, with new facilities. It requires a certain level of technology to be placed on those facilities, such as New Source Performance Standards. It requires review of new shopping centers to insure that they do not produce terrible congestion that violates the standards, rather than an examination of all existing shopping centers to change those which cause undue congestion. Even the preventive mode of dealing with air quality and land use is politically explosive; but imagine going backwards, to the whole universe of existing facilities. The parking surcharge did exactly this, covering existing as well as new facilities. I think it's critical to preclude further obvious violations of air quality standards by doing a good job in the preventive mode, and essentially let technology catch up on the curative side. That's the focus I think we want to have.

Secondly, what we advocate clearly is not "no growth", but instead "managed growth." We see a change from the traditional concept of: "I own the land--I'll do anything I damn please with it--it's my land" to a concept of "All right, what do you want to do with your land, let's review it, let's discuss it--is it responsible in the Environmental Age? Is it responsive to the new environmental ethic or not?" This is managed growth, which requires planning as a pre-requisite to decision making. Or, it might be termed "environmentally responsible new growth."

Another basic theme is that as many decisions as possible should be made at the lowest levels of government, bringing higher only those with externalities or regional impact. Decisions on smaller, localized projects should remain with the cities and counties, introducing new parameters for their decision making. Decisions on projects with major externalities must be brought up the line, through review and appeal processes of various kinds.

Another major point is that we're concerned with emissions of air pollutants, not with growth per se. We want new growth in this country which is non-polluting, or minimally polluting, or polluting as little as possible, rather than no growth. Because we're concerned with the relationship of growth to emissions, pollution abatement technology is a critical factor. As we get better technology on automobiles, or smokestacks, more growth can ensue at the same level of environmental quality or environmental degradation.

Another basic theme calls for general purpose units of government to be involved. Too often over the past 20 years the federal government has relied on creation of special purpose districts to solve critical problems. That may work as long as the primary focus is on technology, but as you begin to get into issues related to land use, the politically accountable officials must be involved: the County Commissioner who stands for election, the Mayor, the Governor. These officials, of course, will rely on their staff people to a great extent, but they must be involved in these air quality/land use decisions. They must know what's going on, and they must be committed early to full participation in relevant decisions. All of us must take the time to insure that this happens before we proceed to implement our programs.

For example, the air quality maintenance planning process is very important, it's not the plan by itself that's important. How many of us have seen zoning plans and beautiful 8-colored zoning maps on the wall, that don't mean a thing? The omnipresent variances have altered the plans every time a developer has come along with a little political leverage. So, it's not the Air Quality Maintenance Plan in which I'm primarily interested, it's the air quality decision making process. And when you're talking about a decision making process, you're talking about the mayor, and the city council; you're talking about the county councillors; you're talking about the governor, and his political aides, and the State legislature, as well as the air pollution director. These politically accountable officials must be involved to relate the technology of air pollution control to all the other things being done. The air quality programs must be integrated with comprehensive planning and zoning, with transportation planning, with sewerage decisions which relate to housing which relate to the use of automobiles. It sounds simple for an ecologist to admit that everything affects everything else. But although it's not simple, as you try to relate air quality to land use, it really is true. The only officials who can make this integration of goals, objectives and techniques are those who are at the apex of the pyramid at each level of government: the governor, county supervisors, the mayor, the city council.

Lastly, to the degree possible, individual source by source decisions should be made in an appropriately broader context. Thus we intend to emphasize the areawide plan rather than the individual source-by-source review, considering the plan part of the overall decision making process. If possible, we should not review the individual shopping center alone as an indirect source, but should consider it within the context of an overall Air Quality Maintenance Plan. Because through the plan rather than by the individual source-by-source review, you can sequence development over time. You can make some trade-offs between this shopping center making air quality a little worse, and additional controls on other existing or new facilities. This allows creation of a balance, and may allow approval of a shopping center which looked at all by itself might have to be disapproved. Too many "no" decisions on proposed facilities are going to place you, me, the mayor, and everybody else in trouble with the developer. We expect some controversy, but if there is too much we will not be able to cope with it. So, we are emphasizing parking management plans or parking resource plans rather than individual parking lot reviews alone. The plan or the planning process must incorporate source-by-source reviews as an integral component. But these reviews will be placed in a broader geographic and temporal context.

Conclusion

In conclusion, EPA's air pollution abatement and control activities are bringing the agency inexorably into the land use arena. This involvement is essential for attainment and maintenance of national air quality standards, and for preservation of clean air. A judicious combination of pollution control technology and more responsible land use decision making in the Environmental Age provides the only effective, long-term solution to the challenge of air pollution. We are committed to effective state and local implementation of these air quality programs which influence patterns of land use, and are working closely with the private development community and with state and local officials to ensure that this occurs.

AIR QUALITY MANAGEMENT AND LAND USE REGULATION

Daniel R. Mandelker

The Clean Air Act and Land Use

In approaching the structural framework that the Clean Air Act has given us for dealing with land use problems we find two major sections of the statute in which land use issues are treated. The first is in those sections of the statute providing for state implementation plans. Here the statute authorizes the inclusion of land use controls in state plans as may be necessary to achieve air quality standards.[1] This provision in the statute is broadly stated, and can be read as an alternative to the more conventional pollution controls over technology and emissions. Just how this authority is to be used by the states is not made clear, however. There are few clues in the statute's legislative history which can tell us how this power in the Clean Air Act is to be carried out; neither has there been much effort in practice to use this authority in the implementation plans that have been prepared. EPA has been proceeding in other directions and has been implementing other sections of the statute dealing with land use controls. Yet the basic land use control power in the statute is in the implementation plan section and the question now is how to make use of this power.

The second set of provisions in the statute that have a land use control potential are the provisions dealing with stationary source performance standards.[2] These provisions require an authority at the state level which, in addition to including the performance standards that are required by the law, also authorizes the review of new stationary sources to determine whether their construction or modification at a proposed location will violate an air quality standard. Presumably this power must also be applied to prevent the degradation of the air in areas in which the quality of the air exceeds the statutory standards, assuming that the nondegradation principle remains in the law. What is novel in the execution of this provision is its present application to indirect as well as direct sources of pollution. As presently interpreted by EPA, the new source performance standards have been extended to indirect as well as direct sources, in order to control motor vehicle emissions that are attributable to the construction of these indirect sources. They have been defined to include major shopping centers, airports, highways, and other large-scale developments. These developments do not pollute directly, but contribute to pollution by attracting automobile traffic that increases or adds to congestion and thus to the build-up of pollution from automobile exhausts.

This extension of new source performance standards control to indirect sources has not so far been found to be outside the authority of the statute, although arguments have been made that EPA has no authority under the law to extend new source performance standards review to cover indirect sources. While litigation to settle the question may be necessary, this extension of the act arguably appears to be within the statutory terms.

A third provision in the Clean Air Act does not relate directly to land use control problems, but bears on these issues indirectly. While plausibly simple in theory, this provision has proved to be considerably more complex in practice. My reference here is to the provision of the law which states, with reference to the primary air quality standards, that an extension for compliance with these standards may be granted by EPA for periods up to two years, but only in cases in which the state has considered all reasonably available alternative means of achieving these standards.[3] The problem here is whether the state in taking into consideration these alternative methods of achieving the primary standards must consider land use controls as one possibility. It happens that the states that have asked for two-year extensions have not considered land use controls as one means of achieving the standards, either because this type of control has not been promoted aggressively enough by EPA or because the exercise of land use controls has met social resistance in some states.

Just how critical is the failure of the Clean Air Act to specify more explicitly the types of alternative methods that must be considered is illustrated by a case just decided by the federal Court of Appeals in the Second Circuit.[4] In this case, New York State applied for and received from EPA an approval of its decision to extend compliance with the statutory air quality standards in Metropolitan New York City. New York State had rejected land use controls as an alternative method for achieving the standards, in part on the ground that these controls would meet social resistance. The federal statute does not explicitly cite social resistance as a reason for not using the land use control approach. Nevertheless, the federal court upheld EPA's approval of the New York extension, holding that it is within the agency's discretion to decide whether or not all reasonably alternative means had been considered, and that the agency does not have to meet an unreasonable burden by finding that all alternatives that might have been used have been considered and rejected. The court also agreed with New York State on the issue of social resistance, holding that some of the proposed alternative land use controls, such as the elimination of all steam plants from New York City, would require too long a time to execute to contribute to compliance with the statutory air quality goal.

This case raises several complex issues in the administration of the Clean Air Act, especially as the air quality goals specified by the statute relate to the types of land use controls that can be helpful in meeting these goals, and to the time frame within which these controls can realistically be helpful. Hopefully EPA will respond to this problem, first by specifying more explicitly the kinds of land use controls that can be helpful in achieving the desired air quality, and next by indicating what time periods should be considered in the execution of these controls. EPA's authority to grant extensions of time for statutory compliance should then be geared to these directions. Perhaps additional Congressional direction will also be needed on this problem.

Complex and Indirect Source Review

Let us turn next to issues of a more specific nature. One of these is the question of complex source review, or what is now known as the review of indirect in contrast to direct pollution sources. This review, as indicated above, considers those sources which do not contribute directly to pollution but which aggravate pollution by attracting additional automobile traffic and increasing traffic congestion. These indirect sources have been divided into publicly built and privately built facilities. Indirect source review of public facilities presents some special problems. Many of these public facilities, in addition to being subject to indirect source review under the air quality program, are also subject to massive statutory controls and review under other federal statutes, as is the case with airport and major highway construction. For example, the federal-aid highway statute contains a wide variety of environmental requirements that must be met in the construction of federally-aided highway projects, including noise standards. Compliance with air quality standards is also required.[5] Federal agencies having direct responsibility for the funding of these major public facilities also exercise considerable power and exert considerable influence on this own, and this power and influence affects the character of programs such as airport and highway construction.

From this wider perspective, the problem is that indirect source review under the Clean Air Act has been approached solely from the perspective of air quality standards. Unfortunately, this approach does not consider important factors such as the effect that indirect source review will have on patterns of land development. In addition, federal agencies having a direct responsibility for public facility programs will not so easily be eased from their positions of responsibility. Direct inter-agency coordination and consultation will probably be needed to work out the complex issues that the application of air quality standards to public facility projects raises, and paper edicts from the Federal Register will not in the long run be enough to resolve these problems.

As far as private indirect sources are concerned, the EPA's authority in this area has been extended to major residential developments as well as to nonresidential uses, the indirect source regulations seem to be relying on two kinds of controls to achieve their objectives.[6] The first of these is design requirements including modifications in the design of parking facilities, which are intended to alleviate major congestion problems. The second set of controls lie in the conditions that may be attached to approval for indirect sources. These conditions, to take one example, may include assurances that the operator of the indirect source will supply his employees with incentives to use mass transit facilities. We shall see later that this kind of condition creates some serious problems of implementation in the context of the Clean Air Act and its state counterparts.

We should also note that the extension of time provisions for compliance with air quality standards do not apply to indirect source review. Review of indirect sources is based on the new source performance standards section of the act, which is mandatory for all state air quality agencies, making indirect source review likewise mandatory. As a consequence, states may not excuse themselves from utilizing indirect source controls on the basis of social resistance, an argument which EPA apparently is authorized to accept with reference to other types of land use controls that may be utilized as part of the state's implementation plan.

This mandatory character of indirect source review forces us to look closely at its implications for urban growth and land development patterns. EPA's indirect source review regulations require a source turndown if interference with the achievement of air quality standards will result. But conditions may be attached to the approval of indirect sources which include elements such as modifications in design features in order to prevent or minimize the impact of the source on the achievement of quality goals. This emphasis on design considerations may cloud the real impact of indirect source review, which is its consequences for major land development patterns. For example, EPA has used a threshold quantitative cutoff point to identify those sources that are subject to indirect source approval. If developers then attempt to evade review by building under the threshold figure, scattered, strip, and dispersed development may result which is inconsistent with area-wide land development objectives. More explicit attention needs to be given to the locational impact of decisions over indirect sources that are taken in the name of air quality, and design factors should enter later. Again, as in the case of public facilities, indirect review of private sources raises complex and interconnected planning and land development problems which need to be answered from more than just the air quality perspective.

From what has been said, and considering in particular the role that other public agencies will play and the major effects that location decisions will have on urban development patterns, it may be expected that the administration of indirect source review may often be politically maneuvered. Moreover, the major decisions applicable to indirect source construction will probably have to be taken at least on a regional scale. An example of both of these possibilities occurred during the preparation of a strategy plan for the city of Melbourne, Australia.

Melbourne is one of the few modern cities in the western world which has an active, growing, and dominant central business district. More than 85 per cent of the workers who come into this district still arrive on public transportation. As the work on the strategy plan proceeded it became clear that there were heavy pressures on foot in the area to create a secondary central business district at a point some distance from the primary CBD. This secondary CBD would not be nearly as well served by the public transportation network as the primary CBD. Planners working on the strategy plan suggested that to approve the secondary CBD would encourage the further suburban spread of shopping areas. By destroying the dominance of the primary CBD with its dependence on the public transportation network, a secondary CBD would also increase motor vehicle use and thus the air pollution that goes with it. For this and other reasons the proposals for a secondary CBD have now been shelved. Essentially, this decision was taken by the political leadership in the state in which Melbourne is located. They have more control of the policy decisions that back up the planning process than do their American counterparts.

But the Melbourne example also illustrates the need for a regional perspective on land development decisions that have an air quality impact. Melbourne planners are in general more sensitive to the need for a major structural framework within which land development and its attendant air quality impacts can be considered. Decisions about proposed secondary business districts clearly affect this overall developmental structure, and such decisions must be made with the regional consequences in mind. A comparable regional framework is absent from EPA's indirect source review, though presumably it can be supplied by the state agencies that are initially authorized to administer the indirect source regulations. There is, however, no statutory mention of a regional input into the administration of the new source review provisions on which indirect source review is based.

Local and Regional Roles Within the Framework of the Clean Air Act

The Clean Air Act is similarly silent on state-regional and on state-local rules in the administration of the act, which must be spelled out if statewide policies are to be effectively translated both at regional and local levels. EPA has authorized the delegation of administrative authority by the states to local governments, but has not specified how state or regional policies in programs such as indirect source review will be monitored or enforced. More attention needs to be given to this problem as well.

The need to provide more clearly for a local and regional role in indirect source review is illustrated by some of the conditions that EPA authorizes for inclusion in indirect source approvals. Recall that one of these conditions requires the developers of indirect sources, such as shopping centers, to provide assurances that their employees will utilize mass transit facilities. The question is how this condition can be enforced. First, this condition cannot be enforced within the traditional land development control framework, and secondly, the regulations do not state how this condition is to be made effective within the intergovernmental framework. In particular, neither the states nor their local governments to which indirect source review may be delegated have any control over mass transit operations, which are usually confided to independent public authorities. What is needed is a framework for regional decision making of the kind that was possible in the Melbourne area, and that will help ensure that mass transit will be the preferred mode of travel.

Another approach to this problem is provided in the Model Land Development Code which is about to be adopted by the American Law Institute. This code provides for state-level review of local government decisions on the siting of major public facilities, such as transportation facilities, but only when the local government decision is unfavorable. The Institute's code thus provides for a review of siting decisions on the transportation facility network, at which point a more effective control may be exercised over the provision of mass transit opportunities. There is no explicit tie to air quality control in this code, however, and its failure to provide for review of local government approvals as well as disapprovals may limit the effectiveness of the state-level review that is authorized. But the Code does deal with the intergovernmental decision making structure within which these decisions are made by specifying clearly the supervisory role of the state reviewing agency and by providing standards for this state-level authority.

NEPA and CEQA

Let us look next at the impact of the federal National Environmental Policy Act on air quality problems, as well as the impact of its state counterparts, such as the California Environmental Quality Act. Under federal guidelines for the implementation of NEPA it is clear that approvals of indirect sources will also require the preparation of an environmental impact statement, and the California law will also be applicable, both to public and to private developments. Moreover, the impact statement prepared under NEPA-like acts requires more than the consideration of air quality, since it must extend to all significant impacts on the human environment. This impact may include the impact of the proposed development on urban and growth patterns. For example, a Federal District Court case in Vermont[7] held recently that one of the impacts to be considered in an environmental impact statement for a state highway was the growth-incuding effect of that highway. California's law also includes growth-inducing effects explicitly as one of the impact to be considered in statements to be prepared under the California statute.

The application of the impact statement requirement to indirect sources may not be too troublesome if the statement is considered only as an informational document and does not have any substantive implications. But it is not clear that this is so. Some federal courts have held that NEPA provides "law to apply", and have held that a reviewing court may reject a project on its merits on the basis of adverse environmental effects disclosed by an impact statement. There is a possibility that the California statute will be interpreted in the same manner. To the extent that the NEPA-like statutes impose on additional environmental and substantive review, these statutes must be considered along with the Clean Air Act as providing substantive policy for the review of indirect sources.

The addition of a new substantive element by way of the impact statement will also produce additional confusions because in most states and at the federal level there is no institutionalized administrative process in which the statement can be considered and a formal decision on its adequacy taken. As a result, the ultimate control over the adequacy of impact statements lies with the courts. Any party having standing to sue may challenge the adequacy of an impact statement in the courts, and the federal courts have so far given standing a liberal interpretation. As a result, decisions taken about indirect sources under EPA regulations may also be brought into court for additional review by way of the impact statement requirement.

I view this result as unfortunate, for it presents some real problems of coordination between the indirect source review procedures and the federal and state environmental policy acts. EPA's regulations, of course, do provide that impact statements must be looked at for information relevant to the indirect source review. I think this approach is correct, but it is not enough. More coordination will be necessary. We simply have too much environmental law floating around, and we haven't hooked it all up.

Conclusion

In summary, the intrusion of air quality controls in the land use field should not be viewed as necessarily threatening to established methods of regulation. Most of the techniques which are contemplated are already available. What is needed are new institutional arrangements to better carry out these programs. Since the major problems arise from the legal fragmentation of environmental legislation in fields other than air quality control, there is a need for better and increased governmental coordination, to the increased use of well-established regional agencies for the largely insular regions like those in California, or to a delegation of approving authority to local governments, subject to very specific substantive criteria in the statutes, which will in turn provide the basis for a higher-level review.

These air quality land use requirements and their implementation will also lead to trial and error experiments. But if we aim especially at achieving and maintaining air quality goals in the long run and over an extended time framework, we will be able to develop a better restructuring of governmental land use mechanisms in which air quality control can play a leading part.

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2. 42 U.S.C. §1857c-5(a)(4) (1970).

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4. Natural Resources Defense Council v. EPA, 494 F.2d 519 (2nd Cir. 1974).

5. See the statutory provisions beginning with 23 U.S.C.A. 109(h) (Supp. 1973).

6. 40 C.F.R. §§52.22(b)(4)(ii); 52.22(b)(9)(ii) (1974).

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INSTITUTIONAL ISSUES IN AIR QUALITY MANAGEMENT

George Hagevik

The papers by David Morell and Daniel Mandelker provide an excellent setting for the subsequent discussion of specific techniques for air quality impact analysis. Before making the transition from the general to the specific, however, it is necessary to examine further a number of the issues raised by both Morell and Mandelker. The thrust of the following comments relates primarily to the question of institutional mechanisms for implementing the Air Quality Act.

Basic Questions

The question that we must ask ourselves is, in the final analysis, what is the purpose of all of EPA's air quality regulations and the actual air quality impact analysis that we are carrying out? Judging by the comments that I have heard at public hearings over the last year there is considerable confusion about the answer to this seemingly straightforward question. I place part of the blame for this development on EPA because, quite frankly, I feel that they have not had a clear idea in their own minds of the purpose of their various air quality management regulations. This criticism needs to be tempered by the realization that the EPA staff has had a very difficult time responding to legislative and court-ordered mandates with exceedingly limited personnel. But in any case, the fact remains that confusion has indeed been fostered in part by the Federal government. Only quite recently have we seen relatively clear and straightforward statements from EPA concerning the role of their various air quality management relations.

This problem seems to be more or less behind us now judging by what I have read lately in the Federal Register and in various EPA documents. Probably the more important criticism now must be laid at the feet of planners and air pollution personnel in state and local government and representatives of various environmental groups. The creative solutions to problems that David Morell would like to see arising from state and local government are more the exception than the rule. To my mind it is now clearly the time for this creative initiative to take place. EPA has finally wholeheartedly embraced the concept that air quality management is really an inter-governmental relations problem and that every level of government has a distinct role to play. For better or worse, the burden of responsibility really lies at the present time with the planners and air pollution control personnel at the state, regional, and local level.

I am afraid that this conclusion is not readily accepted by many environmental groups, who view the court suit as their primary means of having an impact on the air quality management process. This procedure has been very productive in encouraging EPA to play closer attention to the mandate specifically written into the Air Quality Act but the litigation approach now must be complemented by a broader based effort by the environmentalists to work with state and local officials whom they have, by and large, ignored to date.

Because I am somewhat of an optimist by nature, let us assume that these criticisms are really only of historical interest. There is thus one remaining problem that we need to deal with: attempts to use air quality regulations for purposes for which they were not designed. In much the same manner that the environmental impact statement process is sometimes used to delay or defeat projects which might be opposed on other than environmental grounds, air quality regulations are sometimes viewed as a general technique for achieving further governmental control over the land use development decision process. As a planner, I support a strengthened role of government in land use planning, but I think we must resist efforts to use air quality regulations as a means to achieve comprehensive planning goals. Air quality regulations are also sometimes used like the environmental impact statement process whereby projects or plans are delayed or defeated by individuals or groups who oppose projects on environmental grounds while the real basis for their resistance might be of a social or economic nature.

Air Quality Maintenance

It is useful for land use and transportation planners to view air quality regulations as primarily relating to the maintenance of acceptable levels of air quality over the long term. Ignoring for the moment air pollution problems that are of a localized or short term nature, the long term perspective provides us with a useful insight into what information land use and transportation planners need from any air quality impact analysis. What we are talking about here is air quality maintenance. A recent preliminary draft paper by EPA entitled "Uncle Sam as Pollution Regulator," puts air quality maintenance in a proper perspective. Referring to EPA's air quality maintenance regulations, the paper states:

> "In June of 1975, states must submit 10 year growth plans covering any area whose attainment or maintenance of the national ambient air quality standards is in doubt; these plans must show how the area will maintain the standards

> through control of design, and placement of all new sources of air pollution. Air quality maintenance areas will be designated by the states, and will include not only currently polluted areas, but also areas whose present or anticipated growth and development patterns, left unchecked, could lead to future standards violations. The growth plans prepared for these areas will be just that, land use and growth plans consciously tied to air quality considerations. They offer a formal mechanism for state and local governments to make long term reconciliations between air quality and other social and economic goals."

The issues can scarcely be stated more succinctly than they are in this brief paragraph. It is essential, I believe, to understand the air quality maintenance process if one is to play an active role in a Federal environmental program that will have a pervasive influence on State and local governments.

The Air Quality Maintenance Process

To date, EPA's air pollution programs have utilized the State Implementation Plan (SIP) as the technique for attacking existing air pollution problems in specific geographical locations. Because of continued urban growth not only these areas but additional geographical areas with air quality better than the national air quality standards will now have to cope with long range planning. Recognizing the effects of future urban growth of air quality, EPA in 1973 expanded the SIP requirements designed to guarantee attainment of national air quality standards. The maintenance regulations request that all states identify those areas within their boundaries where there is a possibility that air quality standards will be exceeded during the 1975-1985 period, either because of existing air quality problems or because of the potential for degraded air quality due to new urban growth. These areas, to be designated as Air Quality Maintenance Areas (AQMA), are to be covered by an air quality maintenance plan which EPA hopes will be a comprehensive analysis of the air quality problem and contain regulatory measures on air pollutant emissions, including land use and transportation controls, as may be necessary to prevent a violation of the national air quality standards.

It is important to note that it is EPA's position that the air quality maintenance plan will integrate all air quality regulations including indirect source reviews, transportation control plans and stationary source controls. Quite clearly the air quality maintenance plan effort must be integrated with land use and transportation planning to insure a consistent approach with comprehensive planning efforts and to provide a mechanism for recognizing potential environmental problems early on. The development and implementation of this plan will require complicated intergovernmental relationships. State, regional, and local single and multi-purpose governmental agencies will all have to be involved. It is EPA's position that whatever specific agency is assigned responsibility for air quality maintenance as a "lead agency," coordination with all other relevant agencies will be essential to produce effective regulatory programs.

The air quality maintenance plan at the State and area-wide level will form the basis upon which to evaluate all new sources of air pollution. We see here the necessary relation between local plan and project review and the larger air quality maintenance planning process. EPA thus argues that the air quality maintenance planning process will assist communities in managing future growth by effectively integrating air quality constraints into planning and decision making processes at all levels of government. Air quality maintenance will serve to define air quality constraints within which localities can grow while still maintaining national air quality standards. For this reason it is mandatory that the general public have an understanding of the various regulatory measures which are part of the air quality maintenance plan and support their implementation as a part of overall community goals. Similarly, the various land use, transportation, and air pollution agencies must start working with each other in order to guarantee that all plans are consistent with the maintenance plan.

It is EPA's position that a framework for the necessary intergovernmental relations in a particular area will depend upon the institutional frameworks existing in that state or region as well as the traditional relations between the states and localities in the United States with the qualification that, regardless of the particular framework selected, the planning process must involve participation by those who will have ultimate authority for implementation and enforcement of the plan. One might accuse EPA of passing the buck to the States and localities on air quality maintenance since the set of intergovernmental relations that will be necessary will have to be developed by the participants. It seems that after being "burned" on the initial go-around with the transportation control strategies, EPA has realized that they cannot carry the major responsibility in air quality management. After some reflection I would think you would agree that their position is a very reasonable one. In any case EPA will provide technical support to the respective states and localities. For example, in one recent EPA report nineteen different measures which could be useful in maintaining air quality standards are reviewed. These measures range from new source performance standards to fuel conversions to transportation control strategies as well as some more general approaches related to land use planning.[1] One approach which seems to have considerable potential is emission allocation planning.

Emission Allocation Planning

Emission allocation is a maintenance strategy which requires that emissions of pollutants be limited to prescribed levels within an airshed. On the regional (airshed) level a relationship is established between the assimilative capacity of the ambient air in the region and the amount of emissions within the region which would not violate air quality standards. The emission allocation procedure would be administered jointly by air pollution control agencies and land use planning agencies.

The procedure may be applied to all pollutants and to both existing and new point, line, and area sources. Although related to emission density zoning, emission allocation should be viewed as a much more generalized technique concerned with regional air pollution problems that has a focus on the comprehensive land use plan as the basic document from which future levels of air quality are estimated.[2]

The purpose of emission allocation is to utilize land use based emission factors to evaluate the air pollution potential of comprehensive land use plans within a defined region. The land use plans therefore need to be viewed as an accurate representation of the future development that can be expected in the region under study and thus assume a position of importance in estimating future levels of air quality.

The concept of emission allocation procedures is that there should be some relationship established between total air pollutant emissions in a region and the assimilative capacity of the ambient air in the region, and that this relationship should be projected into the future to establish the total amount of emissions that can be allowed at some future point in time. The assumption is made that there is a fairly close relationship between urban growth and increasing levels of air pollution. Thus, if we had a picture of the future levels of land development in a region, one could select the type of air quality maintenance strategies that would be necessary to insure that air quality standards will not be violated. The comprehensive land use plan provides this picture of future development. Thus, emission allocation planning is both an air quality management and land use planning technique.

The recognition of the importance of land use planning as a technique for maintaining air quality standards led the California Legislature in 1972 to direct the California Air Resources Board (ARB) to prepare a report on proposed guidelines for the preparation of an air pollution control element in city and county general plans. In response to this mandate, the ARB let a contract to the consulting firm of Livingston and Blayney to prepare such a report in cooperation with the ARB staff. However, as the study progressed in early 1973, it became apparent that air quality management can be effectively integrated with land use and transportation planning only on an air basin-wide basis. Accordingly, the procedures which the consultant recommended would vest responsibility for allocating air pollutant emission limits within each air basin in the State in a regional agency.

Six steps were proposed in the consultant's report to integrate air quality goals into the land use and transportation planning process under the emission allocation procedures:

1) Compile detailed inventories of air pollution emissions in planning sub-areas of an air basin. The assumption is made that present inventories for counties and the air basin are too generalized for detailed air quality planning.

2) Designate maximum emissions allowable in each planning sub-area to achieve and maintain air quality standards, based on an analysis of present air quality and the assimilative capacity of the air to absorb pollutants and still maintain air quality standards.

3) Project planning sub-area emissions likely to be generated by sources indicated in land use and transportation plans for designated future time periods and compare these emissions with the allowable emission limits.

4) Evaluate and revise land use and transportation plans so that prescribed emissions limits would not be exceeded.

5) Adopt and implement land use and transportation plans which are prepared to meet air quality goals and standards.

6) Monitor public and private development through a refined environmental impact assessment process in which emissions projected directly or indirectly from proposed are accounted for in environmental impact reports.

The key to this process is the concept of allocating air pollutant emissions within an air basin. As long as plans and projects conform to prescribed emission limits air quality standards will be maintained. An appeal process would permit deviation from prescribed limits where technical information is available to ensure that air quality standards will not be exceeded by the proposed deviation.

The designated regional agency in the air basin would compile the planning sub-area emissions inventory and then designate the emissions limits for each planning sub-area. City and county planning agencies would make emissions projections based on their land use and transportation plans, using emission factors provided by the Air Resources Board and the Environmental Protection Agency, and then adjust their plans to meet prescribed emission limits. Transportation planning agencies likewise would make projections of the emissions that would be generated by their proposed plans, and revise them accordingly. A significant amount of interactions between the agencies involved would be necessary before all plans throughout an air basin met the prescribed emissions limits. Appeals to exceed emissions limits would be decided by the designated regional agency. Once the plans had been approved by this agency, the responsibility for implementing them would rest with the cities and counties. However, the designated regional agency would continue to monitor development through the environmental impact assessment process to ensure that emission limits would not be violated.

This general approach to air quality maintenance has a great deal of logic but there are problems with it. Among the many issues which could be raised, I would like to discuss two: (1) the impact of an emission allocation planning strategy on land use and transportation planning, and (2) administrative arrangements. By placing a ceiling on the total amount of air pollutant emissions in a region, while leaving the determination of how to maintain this lid to the appropriate planning and air pollution control agencies, obvious trade-offs between alternatives become possible. For example, hydrocarbons, along with oxides of nitrogen and sunlight, form the basis of photochemical oxidants. An appropriate governmental agency might control hydrocarbons, and maintain emissions within the specified ceiling, by either of two strategies. Either the automobile, which emits significant quantities of hydrocarbons, would be controlled, or hydrocarbon producing stationary sources such as petrochemical complexes, would be restricted.

Clearly the number of potential alternative approaches which could meet emission ceilings for a set of pollutants is very large. The number of reasonably feasible alternatives, however, is much smaller. For example, while vehicle miles could be cut back to some degree in a metropolitan area, massive shifts in automobile use, while desirable, would be difficult to implement. While the emissions from industrial sources can be controlled at the stack through performance standards, the aggregate effects of many installations clustering in one locality may mean that emissions are excessive. In turn, this may mean that there is relatively little that can be done to permit new polluting industries if emissions are near the specified ceiling for the planning area. It should be clear, therefore, that an effective implementation of emission allocation planning would involve some very tough political decisions.

There is no question that the actual implementation of such a procedure could only take place if a number of conditions are met. These include:

1) The availability of a current emissions inventory and land use data. This land use data would be for current land use and for expected future development.

2) The availability of sufficient resources to develop the emission rates and to administer the regulations related to air quality maintenance over time.

3) The availability of sufficient monitoring data to either calculate the emission ceiling of the proportional model or calibrate the dispersion model.

4) A well-developed land use planning capability on the part of municipal and county government.

5) A well-developed procedure for relating project review decisions to land use and transportation plans and the air quality maintenance plan.

A number of other pre-conditions could be listed but I think you have a fair idea of some of the problems that must be addressed before we have an adequate air quality maintenance planning process in operation.

The administrative arrangements for implementing emission allocation planning is a topic that is bound to elicit strong reactions from individuals depending on what type of governmental agency or jurisdiction they represent. For example, municipalities and counties, allocated emission levels by a regional agency, may feel that local autonomy has been diminished. Recalling that total regional emissions are initially determined and then allocated to sub-areas, such as counties and municipalities, an appropriate regional agency must be chosen to make this allocation. In California, the debate centers on whether this agency should be a council of governments (COG), an air pollution control district, or a basin-wide air pollution control coordinating council composed of the air pollution control districts within a given air basin. A second administrative problem centers on the exact determination of the airshed. Generally, an airshed encompasses a geographic area which is meaningful from the perspective of pollutants generated and dispersed as a function of meteorology. This airshed concept is not usually coterminous with political boundaries. However, air quality maintenance areas (AQMAs) to be designated by the States and EPA will be coterminous with the boundaries of municipalities, counties, standard metropolitan statistical areas, and the like. Consider the difficulties of defining the amount of "background" air pollution drifting into an airshed when the decision is being made to relate emissions to ambient air quality concentrations within the airshed.

Air Quality Analysis at the Project Level

In the papers that follow, there is considerable discussion of the localized air quality impact of projects. We know a great deal more about how stable pollutants behave in the vicinity of the emission source than we do about the behavior of the reactive pollutants on the regional scale. Even though the information which follows is exceedingly useful, it needs to be pointed out that the major air pollution problem we face in California is with the reactive pollutants. Procedures for relating emissions to ambient air concentration when photochemical reaction takes place is very complicated and, unfortunately, cannot be given extended discussion in this workshop. Hopefully we do have the building blocks at hand which will allow us to approach the more complicated long-term issues with the proper perspective. Defining your own personal role in air quality management should be something that you should keep in the back of your mind as you read the following papers.

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AIR QUALITY CONSIDERATIONS AND LOCAL LAND USE PLANNING

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While decisions made at state and national levels are of great importance for the growth and development of our urban areas, most land use and transportation decisions are still made at the local level. Cities and counties have a major role to play in relating long-range planning to air quality, a role largely neglected to date by local planners, in part due to the "top-down" approach taken by EPA and acquiesced to by others. The first part of this paper will focus on local planning policies, while the second part will consider Land Use Planning Methodology. Local planning for improved air quality will be considered under three broad categories: growth policies, land use policies and transportation policies.

Growth Policies

Some local governments have no-growth or limited growth policies, some are avowedly expansionist, and many have no explicit aims. Clearly, however, local growth is rapidly coming into the public arena for discussion and policy-making, and bears a close relation to air quality.

In most communities (and certainly in California) the primary source of air pollution is the automobile. Since virtually all development generates traffic, the automobile is the vital link between growth policy and air quality. The main emissions associated with auto traffic, for the foreseeable future, are carbon monoxide, reactive hydrocarbons, nitrogen oxides and (perhaps temporarily) lead; secondary pollutants are photochemical oxidant (smog) and nitrogen dioxide. Of these, carbon monoxide and photochemical oxidant are of greatest concern to local planners--the former very localized in its impact and the latter affecting an area measured in miles and sometimes tens of miles.

It has been suggested that the total amount of a given pollutant permitted in a community should be limited, the "holding capacity" approach, or stated simply, putting a lid on emissions. This would set an upper limit on growth, barring an unexpected breakthrough in source technology. Such a policy would have greater relevance to oxidant than to carbon monoxide, for which a finer-grained control system would be required. For a relatively large and isolated jurisdiction, an oxidant lid (in practice a lid on reactive hydrocarbon emissions) is conceivable. For most cities however, atmospheric transport, lack of control over major highways and technical difficulties in long-range projection make this policy unrealistic. A regional approach has been suggested, but this raises extremely tough technical, institutional, and political problems.

A more promising and widely applicable concept for local planners to consider is linking air quality to the rate of growth, rather than the total amount. This would require the application of time-specific projections based largely on expectations about legally-mandated automobile exhaust controls. The planner would have to know, for example, what emissions and air quality to expect in 1977, 1980, and 1985 for a given growth rate as new, cleaner autos gradually replace older, dirtier ones. While the aforementioned difficulties associated with a "holding capacity" approach would still exist, the short and mid-range time frame would reduce the uncertainties of projection and also enable the local planner to take most or all of the highway network as a given.

Any local growth policy in which air quality is a factor must consider regional and local meteorology and topography. If possible, atmospheric dispersion models now available and becoming available should be employed; in this event, outside expert assistance will usually be necessary. Where cost or other considerations preclude an extensive modeling program, simple models may be used, including the advice and guidance of a knowledgeable meteorologist or air quality expert.

Judgments about meteorological considerations can be valuable even though non-quantitative in nature. Obviously, a numerical growth limitation cannot be based solely on non-quantitative studies. Unless the meteorology is simple and the land is flat, extreme caution must be exercised in accepting statements about the "pollution potential" of an area, much less basing growth controls on such statements; this is true for all pollutants, but particularly where oxidant is concerned. An experienced specialist is needed to make judgments inter-relating meteorology, topography and air quality and frequently, even a specialist cannot do so in the absence of adequate data or without undertaking a detailed study.

Assuming that growth policies are decided on, how are they to be implemented at the local level? Zoning and other land use controls are universally available to local governments; their capabilities and weaknesses are well known. A less common approach involves limiting the timing, location and extent of growth-inducing or growth-enabling public works: highways, sewerage and water facilities. Sometimes these facilities are subject to local control; sometimes they are not. Where local control does exist, it might be used as a mechanism to implement a growth policy based entirely or partially on air quality. It is interesting to note that the lack of highways, sewers or water has been used in some communities as a reason for limiting growth; here, on the other hand, the provision of these facilities is seen as a tool for implementing a growth policy based on other considerations.

A word about New Towns and growth: however desirable they may be for a variety of reasons, a New Town will not serve the cause of air quality in the absence of an effective growth policy in the jurisdiction where the New Town lies. Given the current opposition in many areas to extensive growth, some New Towns are being packaged and sold as an alternative to sprawl and as a means of limiting growth. But approval of a New Town does not per se assure that growth will be limited--it is entirely possible that the opposite will in fact take place, with the New Town being used as a device to promote growth in the face of public resistance. In those areas large enough to contain a New Town, the proposal of such a development should be reason for intensive consideration of the area's attitude towards growth.

Land Use Policies

Except in a very few totally built-up or exclusive communities, some degree of development is bound to occur and land use decisions must be made. Although land use policies will rarely be based on air quality considerations alone, the formation of such policies require a more careful and informed attention to air quality than local governments and planners have so far exercised.

Generally speaking, land uses are related to future air quality by virtue of the automobile. Therefore, local planners need to have some familiarity with traffic generation factors, modal split and trip length frequencies--the tools of transportation planning and traffic analysis. This means that any local planning agency seriously concerned about air quality should have transportation and traffic expertise on its staff or readily available.

Another way to look at land uses is as receptors of pollution, rather than sources. It is possible to make quantitative estimates (for various pollutants) in terms of pollutant exposure units per person in a land use configuration, e.g., the number of parts per million of oxidant, measured during a given time period, times the number of persons exposed to that level of pollution in a particular geographical area. This kind of "exposure index" could be useful in comparing land use alternatives; its application awaits the initiative of local planners.

Land use policies inevitably involve density, and we need more hard thinking about density in an air quality context. There are times when an informed judgment can be made about the density level that will minimize future air pollution, but such judgments cannot be made in the abstract. Judgments can be made only in relation to a specific area, with knowledge of its development patterns and pressures. There is no reason to believe that high density is always better than low density because concentrated development is conducive to mass transit. In the abstract, there is equally good reason to speculate that a low density pattern would in fact minimize air pollution from automobiles. Before venturing a judgment in a particular situation planners should consider such questions as:

1) Will high-density development in one area be "balanced" by non-development somewhere else, or will it tend to induce a higher density overall in the community?

2) Will high-density development produce a localized air pollution problem?

3) Will high-density development in fact be accompanied by mass transit?

4) Who is going to play for the mass transit and when will it be available?

5) Will the number of trips diverted to transit exceed the additional automobile trips produced by the higher density of development?

Most importantly, density and land use in general must be viewed in terms of locational relationships. By reducing auto trip generation and/or trip length, high-density housing located near a transit station may make sense from an air quality standpoint. We can assume that a sports stadium should have ready access to a transit station. And we can recommend that a large residential area should have neighborhood services located within it (which argues against exclusive residential zoning for large areas).

On the other hand, high-density housing located near an employment center may not benefit air quality, nor is a regional shopping center's location on a transit line certain to do so. We should not be too quick to jump from the motherhood statement that "Housing should be located near places of employment" to the conclusion that planning a high-density housing zone in City X adjacent to the industrial center will improve air quality (quite apart from whether or not the industrial center contains large point sources of air pollution). The British New Towns experience may be relevant here--people don't always work where the planners say they should work.

Redevelopment is a special kind of land use planning aimed at rebuilding the core of the older city. By and large, the revitalization of central cities is desirable from an air quality standpoint, because many redevelopment areas are centrally located with respect to existing public transit routes and existing urban centers have high-density, frequently congested patterns which tend to support mass transit as well as discourage high auto ownership. Nevertheless, uncritical acceptance of redevelopment plans overlooks the possibility of localized air pollution problems, and the "halo" generally given to redevelopment by its laudable social purposes is insufficient reason to ignore such problems. Where a redevelopment area provides housing, there should be particular concern about the localized air pollution impact on the future residents.

Among the local land use planning questions arising in an air quality context, none are more puzzling or more tantalizing than those involving open space. At the crudest level, "open space" connotes the absence of development and thus the absence of pollutant emissions. This observation has obvious implications for down wind locations, but since we cannot keep all "upwind" areas free of development, the practical planning value of the observation is limited. Still, the obvious should not be ignored, and a reasonable balance should be struck between open space and development.

If we look at open space as a "sink" for pollution or a cleanser of the air, the question of scale becomes important. Large-scale vegetation is effective in filtering out particulates (thus useful for industrial buffer zones), but much less so with respect to gaseous pollutants. In the case of oxidant formation, pollutant transport occurs largely above ground level, so is little affected by vegetation. On the other hand, vegetation at a receptor site is quite effective in reducing gaseous pollutant levels experienced by persons at the site. Thus, the nature and extent of landscaping at homes, work places, hospitals, schools, and the like are highly relevant. Unfortunately, specific guidelines are hard to come by.

Industrial or stationary pollution sources may be dealt with in a local land use planning framework, but generally require individualized attention. For the most part, decisions on industrial location will depend on the nature of the particular industry proposed, which is not known at the advance planning stage. When a specific proposal is made, detailed diffusion studies may be done, or required of the industrial firm. Buffer zones could be considered at that time. Local air pollution control agencies will enforce source controls and may consider the effects on ambient air quality. In those cases where local planning policy can affect the establishment or expansion of an entire industrial area, a thorough study of local meteorology can be made, comparing alternative locations if possible. Where extensive industrial development is planned, an "emission density" approach could be explored by the locality.

Transportation Policies

In many ways, transportation is a regional problem, but local decisions are also significant from an air quality point of view. Local governments are often instrumental in affecting or modifying state and federal highway decisions. While few counties build expressways, as Santa Clara County does in the Bay Area, almost all cities and counties build or plan arterial streets and often these arterials carry high traffic volumes.

In technical terms, roads can be analyzed as line sources and as area sources. Standard techniques measure the air pollution impact of a road as line source chiefly in terms of carbon monoxide concentrations at roadside and at various distances from the roadside. Pollutant concentrations fall off rapidly, and few line sources will show a significant impact beyond the first few hundred feet from the roadside. Since the analytical techniques are available, it is unfortunate that so far few local planners have taken a hard look at line source impact and tried to use it in policy formulation. Although noise is usually a more serious problem with respect to roads and adjacent land uses, there are situations where air pollution can be viewed as a constraint. Analytical procedures analogous to those now common for noise could be used locally. True, there are no specific standards for roadside air quality other than the federal ambient standards; but this should not preclude planners from proposing setback policies based on what the community considered acceptable health risks from line source pollution.

Area source analysis can be employed where there is a fairly dense network of roads and parking facilities in a local area as in a downtown section or a shopping center. The result of the analysis will show levels of a given pollutant averaged over the local area. These techniques are available, although not as standardized as for line sources, and special expertise is required. For both line and area sources, background concentrations must also be considered.

Another dimension to analyze, though more difficult to quantify, involves the regional effects felt largely in terms of photochemical oxidant. When considering the air quality effects of roads, especially in a general planning context, the planner should be concerned with regional as well as local effects--for most purposes, this means oxidant as well as carbon monoxide.

Clearly traffic flow improvements may result from building new highways and widening existing ones. Assuming no increase in total traffic within a local area, the air quality impact of such improvements should be positive because higher speeds and smoother flow reduce emissions per vehicle/mile (for carbon monoxide and reactive hydrocarbons). However, it is not uncommon for highways to induce or enable growth to take place, either locally or within a broader geographical area. If this is the likely result, it should be reflected in air quality analysis and planning. This means bucking the traditional highway department thesis that highways always follow growth and never cause it, but it is (to switch the metaphor) a bull planners should take by the horns.

In defining planning and air quality relationships, great emphasis has properly been placed on public transit. There is no question about the urgent need in metropolitan areas for alternative forms of transportation, nor is there any question that improving air quality is an important component of that need. Nevertheless, a finer sense of discrimination is necessary with respect to the effects of public transit, not least among planners. Simply stating the desirability or even the imminence of some form of public transportation in a locality is not a substitute for hard thinking and technical analysis.

Plainly put, the role of transit is frequently overstated in planning documents, particularly its prospective effects in reducing air pollution. Whether this hyperbole occurs through an excess of zeal or for other reasons is moot. The fact is that it does occur, as evidenced by many cases of over-optimism both in estimating modal split and in anticipating the advent of public transit.

Just as locational relationships between land uses are crucial for air quality, so is the relation of transit to particular land uses. It is hard to quibble with the idea that a sports stadium should be located near a mass transit stop, or that mass transit should be extended to serve an airport. On the other hand, a transit station near a regional shopping center may be of marginal benefit to air quality, and could even be a net detriment because of the combined effect of auto traffic to the two facilities. Moreover, mass transit may itself be a generator of growth, particularly where highway facilities are improved concurrently with transit construction.

But clearly these caveats do not negate the potential of transit for reducing dependence on the automobile, or at least limiting the growth rate of automotive travel. Nor is the local community's role in transit to be minimized. Mass transit systems are often regional in scope, but many localities maintain extensive bus systems. Even the small community can sometimes institute a bus system, or equally important, do its land use planning with transit in mind. With recent changes in the financing picture, one good test of a locality's commitment to reduced automobile dependence may be the dollars it budgets for road purposes as against public transit. Surely the local planner is relevant here.

Transportation policies for improved air quality can also be related to parking as an implementation tool. Aside from fees and surcharges, parking measures may be divided into two principal categories, regulatory actions and provisions for public parking including off-street parking requirements and off-street parking limitations.

Up until now local zoning ordinances and regulatory actions affecting private development have focused on requiring adequate off-street parking. In many cases the problem was (and is) too little off-street parking rather than too much. It is folly to expect this reality to dissolve today or tomorrow. However, there are situations where requirements can be lessened because of the ready availability and adequacy of public transportation and the compactness of development, as, around mass transit stops and in high-intensity downtown areas. In San Francisco, off-street parking requirements were reduced or eliminated some years ago in much of the downtown core area, pursuant to planning and zoning studies. Obviously the intent was to reduce automobile usage, traffic congestion and air pollution.

The San Francisco downtown experience also illustrates the other side of the regulatory coin--off-street parking limitations. Not only does San Francisco's zoning ordinance reduce parking requirements, it also severely limits the voluntary provision of "accessory" parking. For example, an office building can contain only a small amount of parking in relation to its total floor area. This type of limitation can often be exercised on a case-by-case as well as through a uniform ordinance regulation, since large developments frequently require a special permit from the city. In addition, parking can (and should) be limited in downtown redevelopment projects, which are planned and approved under special legal procedures.

Few cities have the compactness and transit availability that downtown San Francisco has, and the regulatory measures employed there are not readily applicable in most places. In contrast, questions of public parking supply and location are relevant in many jurisdictions. Planning and construction of "fringe" parking facilities next to transit stations, and refusal to build parking garages in the central core area, are two examples of the use of parking as a tool to improve air quality. Nor are such tools confined to large cities. Even a small community can provide parking (either on or off-street) to serve a regional transit stop, or encourage public transportation in lieu of building a parking garage.

The most important thing to realize about parking is that it cannot be treated as a separate subject for planning and regulation, but must be integrated with long-range land use and transportation planning, including transit. Thus, the concept of a "Parking Management Plan" is open to considerable question; the idea that such a plan could be short-range in nature or regional in scope is also somewhat troubling.

Land Use Planning Methodology

It is unlikely that local land use and transportation planning will undergo drastic changes in method solely to accommodate air quality considerations. Nor is it necessary or desirable that this occur. Air quality can, however, be an initial constraint on local planning and a "tuning" factor for plans. There are a number of air quality planning considerations that local planners should be aware of, including basic assumptions, timing factors, General Plan quantification and "VMT" reduction.

All long-range planning involves assumptions about the future. Air quality planning requires numerous assumptions relating not only to future land use and transportation parameters (themselves based on many assumptions about human behavior and technology) but also to those parameters more directly associated with air pollution, including control technology, fuel usage and even meteorological trends.

In the land use transportation area, the most basic assumptions involve growth within the community and external to it. Whether or not an explicit local growth policy exists, it is necessary to project internal growth on a spatially distributed basis in order to engage in meaningful air quality analysis. The simplest projection is an extrapolation of past trends, but the local general planning process should if possible include one or more alternative growth and land use scenarios. The objective is to arrive at a desirable growth level and pattern through a feedback process, using air quality as part of the feedback.

Growth external to the community can often be treated in a less detailed fashion, since most air pollution impacts are local in origin. When dealing with secondary pollutants such as oxidant, however, it may be necessary to pay more attention to external sources. It will often be unfeasible to consider a large number of alternatives for external growth for three reasons: quite a few jurisdictions may be involved; the data may be hard to come by; and the sheer volume and complexity of data handling and manipulation could be a serious problem. Therefore, one or two alternatives for external growth may have to be played off against a greater number of scenarios for growth within the community.

The key assumptions related directly to air pollution are those concerning automobile emission factors. Federal law provides for reduction of up to 90% in emissions of carbon monoxide, reactive hydrocarbons and oxides of nitrogen within a few years. Since old cars have incomplete controls, overall emissions from the total automobile population are expected to diminish year-by-year as old cars are scrapped and new, highly-controlled vehicles replace them. More precisely, the emission factors used for planning purposes should diminish every year, at least for the next decade or so.

Underlying any given set of emission factors are: changes made by Congress or the EPA in auto emission control requirements and deadlines; the relation of car speed to emissions for various pollutants; data on the actual effectiveness of already-existing emission controls as measured by testing of representative cars; the degree of control devices maintenance that can be anticipated in the future; the "vehicle mix" used as the basis for the emission factors (including car age distribution as well as percentage of trucks); and the test cycle or modal configuration on which the emission factors were based, e.g. whether single mode or multi-modal, hot starts vs. cold starts, etc.

In view of the variety of factors mentioned and the controversial nature of many of them, there is ample justification for using alternative emission factor assumptions, or a range of assumptions, for long-range planning purposes. The significance of this approach for air quality projections can hardly be overestimated. Other important assumptions for air quality planning concern transportation planning essentials--trip-making behavior factors like automobile occupancy ratios, trip length and trip generation characteristics, and modal split (the allocation of trips between motor vehicles and public transit). These factors are based on professionally-educated guesses, and on land use assumptions which in turn are based on other guesses.

With respect to stationary sources of air pollution, the matter of future fuel usage is paramount. Assumptions must be made as to the amounts of natural gas, high-sulfur oil, low-sulfur oil and coal that will be burned in electrical power plants and industrial boilers, in various future years. These parameters will determine projected levels of sulfur dioxide. As any casual reader of the newspapers knows, future energy sources are the subject of some uncertainty.

Virtually all assumptions used for projecting the future are based to some degree on "soft" behavioral and policy considerations, however quantitative and "hard" they may appear to be in print. Enough examples have been presented to make the point that most assumptions used in air quality planning are not engraved on stone tablets but are subject to discussion, and if need be, revision. This cannot happen unless all relevant assumptions are clearly defined and set forth--a seemingly obvious principle frequently ignored even in voluminous studies. In many cases, alternative assumptions should be used in air quality planning, and the results under each alternative should be set forth. This latter principle is subject to practical limitations of computational capacity, time and cost.

Development Timing Considerations

There has long been a debate in the land use planning field between those who view the community General Plan as a fairly definite, end-state ideal and those who see long-range planning more in terms of policies and process. In recent years the latter view has tended to prevail. Among other shortcomings, the static, end-state model ignores vital considerations of development timing, which is increasingly recognized as important; indeed, for air quality planning purposes it is crucial.

The "traditional" General Plan, consisting of a colored map with supporting text, gives some idea of what will happen where, but not when or how much. On the other hand, the policies/process plan doesn't always answer even the basic what and where. Air quality planning requires all of these elements--concreteness and specificity are required in terms of magnitudes, spatial distribution and development timing. Thus, policies planning must be accompanied by a more sophisticated, detailed and timephased version of the traditional colored wall map.

To repeat, a General Plan is not well suited to air quality planning purposes without a temporal component. Where will development take place within the next five years? What are the growth pressures during that time period? The question of growth rate is crucial in order to determine air quality levels in early years before auto emission controls reach maximum effectiveness, and the relation between air quality improvement due to auto emission controls and air quality deterioration due to growth in any given time period. Thus, the General Plan should be phased. This is happening anyway in the planning field; air quality considerations could help it to happen faster and in more places.

Failure to view future development in a temporal framework can conceal air pollution problems. While a static, end-state General Plan may be "comprehensive" and spatially balanced, there can be disequilibria during interim time periods before the plan is completely carried out. For example, high-density development may be favored because it will tend to support mass transit; but if the transit is not available for ten years or more, the intense development may cause a serious interim air pollution problem. Concerned professionals might well feel that ten years of breathing polluted air cannot be glassed over as a "short-term" problem (to say nothing of the question of the degree to which the mass transit will actually reduce pollution). To take another example, the General Plan may call for a "balanced" transportation system of highways and transit, but if the highways are constructed first, they may not only cause air pollution problems but also induce development patterns which will destroy the feasibility of transit.

It should be noted that the problems of timing may be more manageable when large-scale development is phased in a specific manner and is under unified control. Thus, a "New Town" _may_ have an advantage in this respect over a like amount of random and piecemeal development.

Quantifying the General Plan

Much has been said about the need to integrate air quality considerations into the land use and transportation planning process. At the present state of the art, the most promising possibility of achieving this integration lies in quantification and analysis of existing and proposed plans as a starting point, rather than attempting to include air quality as an _a priori_ ingredient in the planning process. The approach is an iterative one starting from a plan developed without air quality considerations, quantifying that plan and then taking action as necessary and desired to accommodate air quality. Put in an obvious fashion, a plan must exist before it can be quantified. Efforts have been made to derive generalized "land use emission factors" in order to allow a building-block approach to land use planning with air quality factors included at the outset. Such efforts have not been successful.

Air quality planning methodology leans heavily on the quantification of land use and transportation parameters on a spatially distributed basis. The purpose of projecting emissions may be to compare alternative General Plans, to evaluate a plan in relation to air quality standards, or to impose land use/transportation controls. For each of these purposes, a different degree of detail may be acceptable. At the grossest level, total emissions within the community or planning area, to a rough order of magnitude, might be sufficient for a particular purpose. At the other extreme, emissions on a one-kilometer grid with a relatively high degree of precision might be required. In brief, the method of projecting emissions from a long-range plan depends on the purpose for which such quantification is desired.

An interesting aspect of plan quantification (and of air quality planning in general) is that it tends to put land use and transportation plans "on the spot" by taking them seriously and forcing their proposals to be considered as though they would be implemented. Decisions which are normally clouded over or deferred in General Plans must be "made" for purposes of analysis and evaluation. Nevertheless these decisions will not have been "made" in a real (i.e., political) sense. This discrepancy can have educational value for decision-makers and the public at large.

Although emissions are the initial objective in quantifying a plan, they are not the final result desired in professional air quality planning. Too often an "air quality" analysis stops with emissions and states or implies that the task has been accomplished. There are situations where emissions are an adequate surrogate for air quality, but such a judgment can only be reached after taking into account two paramount facts: 1) the extent to which emissions of specific pollutants are proportional to ambient concentrations of those pollutants at a given location, and 2) the relationship of emissions to air quality standards.

Therefore, plan quantification can be a complex matter requiring the application of meteorological, air monitoring and statistical expertise. While the process can be simplified to some degree, it is not advisable to undertake a serious project without the active assistance or supervision of a group possessing such expertise, such as an air pollution control agency or specialized consulting firm.

"VMT" Reduction

A simple and popular concept for relating air quality to land use/transportation planning is Vehicle Miles Traveled (VMT). Since the automobile is the major source of pollution in most areas, a limitation on automobile travel will lower pollution levels--hence the idea of VMT reduction.

This strategy can be applied in either a short-term or a long-term context. EPA in its Transportation Control Plans has taken the short-term approach, based on the mandate of the Clean Air Act for early attainment of air quality standards. The measures advocated by EPA to reduce VMT have included exclusive bus lanes and ramp metering, greater carpool and bus use, parking surcharges and project review, and even gasoline rationing. Many of these techniques have been evaluated for their possible effectiveness in reducing VMT.

In a long-range planning sense, VMT can be a valuable tool in making rough comparisons of alternative land use and transportation plans, as a parameter useful for plan quantification. However, its use for implementation and control purposes should be approached with extreme caution because of the crude nature of its relationship to air quality. As stated above, emissions are not a direct substitute for air quality. Carrying the process one step further, VMT is not a direct substitute for emissions. One must consider questions involving emission factors, vehicle speeds, spatial distribution and temporal variation. Unless all relevant technical factors have been considered in detail, it is not valid to impose location-specific regulatory controls based on VMT in the name of air quality.

A Personal Perspective

The objective of this paper has been to provide some overall perspective on the fledgling field of air quality/land use planning at the local level, as seen by a professional planner who works for a regional air pollution control district in California. The author has not hesitated to venture opinions based on his professional background and day-to-day experience. There is nothing sacred about these opinions, but they do stem from a fairly unique opportunity to observe and participate in both the air quality and land use sides of the equation. They also stem from a personal conviction that planning for air quality is not just a game to be played, but is an activity worth pursuing seriously (albeit reasonably) in the interests of public health and welfare. With this confessional prelude, a final group of hortatory comments follows, addressed to the local planning community and to anyone else who cares to listen:

a) The cliche has it that air pollution is a regional, not a local problem. The cliche is only partly right. Air pollution is in fact a national, state, regional and local problem--with solutions required at each level of government. In at least two ways, air pollution must be viewed in a local framework: the effects of air pollution are usually felt in a small, localized area around the sources of pollutant emissions; and the long-range solutions dependent on land use planning must be effectuated mainly at the local level.

Conclusion: Don't rely exclusively on higher levels of government --there is much to be done within the local community. Cities (and counties in some places) are not irrelevant.

b) The hard evidence so far, together with the continuing resistence of Detroit to cleaning up the automobile, provides insufficient assurance to prudent professionals that automobile emission controls will be fully effective. A Congressional fiat is no substitute for proven technology and demonstrated enforcement capability.

Conclusion: Land use and transportation planning should be both conservative and flexible--conservative with respect to the public health and welfare and flexible enough to take account of the evidence on emission controls as it comes in, particularly over the next five years.

c) Pollutant emissions are very important, but they should not be confused with air quality. Meaningful planning and implementation for air quality require detailed consideration of meteorology, temporal and spatial variations, air quality standards and if possible, photochemistry.

Conclusion: Don't undertake a serious air quality/land use planning effort without expert technical assistance, including close cooperation with the local or state air pollution control agency. And don't "simplify out" all of the complexities of air quality at the beginning--the community can't balance interests unless those interests are first defined honestly and thoroughly.

d) Ambient air quality standards represent the "best judgment" of the EPA, taking into account the available scientific evidence and allowing for a margin of safety in protecting the public health and welfare. Like all governmental judgments they are political to a degree, but they are not arbitrary and they have the sanction of law. Nevertheless, the air quality standards represent goals to be achieved, and there are unresolved questions concerning how one decides whether those goals have in fact been satisfied. For example, what statistical "confidence limits" are appropriate in predicting future violations of air quality standards? Did Congress intend that air quality standards apply at every point in space? To what extent and over what areas can pollutant concentrations be area-averaged for prediction, planning and control purposes? Should compliance with air quality standards for "attainment" purposes (to 1978) be measured in the same way as compliance for "maintenance" purposes (after 1978)?

Conclusion: While employing the best available methodology and technical expertise, those engaged in planning for air quality should recognize that projected compliance with ambient air quality standards is often a judgmental matter, not an all-or-nothing comparison of two numbers. This is particularly the case in a long-range planning context. While air quality standards cannot be ignored, don't settle for simplistic criteria as to whether a plan "meets" or "does not meet" those standards.

e) Air quality considerations are frequently consistent with other land use planning criteria, but this is not always the case. Several examples on both sides have been given in this paper. Where air quality support can be gained for otherwise desirable plans and projects this should by all means be done, but data should not be strained to achieve this end.

Conclusion: In a general sense, clean air goes hand-in-hand with "good planning", but don't sacrifice analytical integrity to support this statement in a specific case. If a proposal is good for housing or transportation but demonstrably bad for air quality, say so. Where trade-offs are to be made, the politicians should make them not the planners. The primary charge of the professional in air quality planning is to do their best to ensure that first, air quality is not traded off at the expense of the public health and welfare; and second, where trade-offs are justifiable, they are made with full knowledge of the air quality effects, based on technically sound analysis, carried out in an institutional framework that guarantees scientific integrity and broad public exposure.

EMISSIONS ALLOCATIONS: A NEEDED FRAMEWORK FOR RELATING AIR QUALITY CONTENT OF EIRs TO DECISION MAKING

Daniel Lieberman

Introduction

Since the passage of the National Environmental Policy Act of 1969 (NEPA), the California Environmental Quality Act of 1970 (CEQA), and California Assembly Bill 889 in 1972, there has been a continuing sophistication of air quality impact analysis in the reports required by these statutes. Report writers and developers have begun to analyze alternatives and have been able to project and quantify the emissions associated with projects including those from projected automotive traffic.

Some progress has been made in projecting levels of conservative pollutants associated with projects and including forecast background levels for use in decision making. No methodology for relating precursors of oxidant from individual projects to future oxidant levels in the basin seems to be operative. Instead a steadily growing frustration is developing with the utility of the massive amounts of data being accumulated as a guide in decision making. Whether to proceed with projects or to modify projects so as to relate them to future oxidant readings in the atmosphere is a continuous topic of discussion.

Interrelation of the Land Use and Transportation Planning Processes

In August of 1973, in response to California SB 981 (1972) the Air Resources Board transmitted a Report to the Legislature on Guidelines for Relating Air Pollution Control to Land Use and Transportation Planning in the State of California. This report contains as an appendix, a report to the Air Resources Board by Livingston and Blayney, City and Regional Planners, which proposed six steps to integrate air quality goals into the land use and transportation planning processes:

1. Compile detailed inventories of air polluting emissions in planning sub-areas of air basins. The present inventories for counties and air basins are too general for detailed air quality planning.

2. Designate maximum emissions allowable in each planning sub-area to achieve and maintain air quality standards, based on an analysis of present air quality and the environmental capacity of the atmosphere to absorb air pollutants and still maintain air quality standards.

3. Project planning sub-area emissions likely to be generated by sources indicated in land use and transportation plans for designated future time periods, say 1985 and 1995, and compare these emissions with the allowable emissions limits.

4. Evaluate and revise land use and transportation plans so that prescribed emissions limits would not be exceeded.

5. Adopt and implement land use and transportation plans which are prepared to meet air quality goals and standards.

6. Monitor public and private development through a refined environmental impact assessment process in which emissions projected directly or indirectly by projects are accounted for in environmental impact reports.

All of these steps were proposed primarily as an aid to planning. An examination shows the process provides a framework for decision-making with regard to the air quality impact of the EIRs.

Decision making on oxidant precursors does not seem manageable without looking at the cumulative impact of growth and development. Rollback models have related total emissions in an air basin to future air quality. Technical judgment should make us aware that the spatial distribution of precursors of oxidant along a wind trajectory will affect future air quality readings. Analyzing individual projects without being aware of the future cumulative growth or reduction in emissions in a spatial and temporal analysis makes it very difficult if not impossible to provide decisions on whether a project should be approved.

Response to the report has been varied. The question of a governmental mechanism has been a central issue in most comments. Many responses tend to advocate the commentor's organization for carrying out the recommended process but do not question the requirement for a basinwide framework. Questions have also been asked about the technical approaches to carry out the process.

The Emissions Allocation Process

The emissions allocation process is envisioned to work as follows: A rollback model would be used to develop basinwide allowable emissions for each category of pollutant. The rollback model is the methodology used in the State Air Implementation Plan (SIP) for determining allowable emissions. Local existing planning jurisdictions--county, city, and when necessary, special districts--would then be assigned emission limits. The initial allocation would be based on the following formula:

$$\frac{E_m \text{ planning sub-area base year}}{E_m \text{ air basin base year}} = \frac{E_m \text{ allowable in planning sub-area}}{E_m \text{ allowable in air basin (SIP)}}$$

E_m = emissions for each pollutant category

If planning jurisdictions are extremely large, agreements on assignment of limits for sub-areas would be required. Local planners would use existing methods to predict emissions from their plans. This would involve both emissions from mobile sources using projected traffic and appropriate vehicle emission factors, and emissions from stationary sources, point and area. Such land use based emission factors (as described previously) could be related to current emission factors used in developing emission inventories. As sophistication in projecting future emissions develops, new emission factors extablished for forecasting would be utilized. Obviously, there will be uncertainties in many areas as to which stationary industrial sources would be built. It is presumed that in those areas where it was not possible to predict emissions because of an inability to specify the future type of industrial or commercial establishments that would be contained in a geographical area, emissions limitations that correlated with the total emissions of the planning area would be applied by the planners. The projected allowable emissions would provide a basis for comparison in approving or disapproving projects proposed for the area. When the cumulative projected emissions associated with a proposed project and the other projected projects would exceed the limit applied to an area, either the project would be refused a permit or plans would be modified so that the sum total of emissions in the planning area do not exceed the limit of emissions allocated.

This is a technical structure, but it does provide a feasible process for decision-making. In the near future computer photochemical models are expected to be available. These would allow more flexibility in designating emissions allocations and in making tradeoffs between allocations to different areas.

The councils of governments (COGs) are expected to be a portion of the process. The role of the COGs, as flexibility and tradeoffs enter the picture, would be analogous with regard to air limitations as they now are with regard to funding limitations on grants from the federal government. When there is a limited amount of grant money for the development of sewage facilities in a planning area, the COGs act as a mediator between local jurisdictions and comment on grant applications so that an equitable distribution of grant funds is made. The emissions allocations limits to protect the health of the people can be mediated in the same fashion.

Predictions of future emissions and air quality in evaluating the present state of the art are not precise but neither is the result of other long-range planning. The question of energy concerns, the profitability of private enterprise, changes in birth rate, the changing fortunes of the aerospace industry, etc. are unknown factors which the planning process compensates for as more information becomes available.

The emissions allocations framework provides a basis for decision making. Questions have been raised as to interference with achievement of economic and social goals of a region. In the long range timeframe, it would seem that air quality standards which are based on health should not be subject to tradeoffs. Congress has made this decision in the Clean Air Act of 1970. Achievement of health-based standards is a social goal. Economic and other social goals can be achieved using air quality as a constraint.

In addition, if in the initial analysis there is a serious conflict between future air quality and other goals, the regulatory/political process would result in the inclusion of economic and social considerations in setting the allowable basinwide emissions. These tradeoffs can only be realistically made after an initial emissions allocation and a serious effort to develop land use and transportation plans compatible with these allocations have been made.

The California Legislature has mandated consideration of air quality in decision-making in the California Environmental Quality Act. A framework to cope with the cumulative impact of many small projects and to provide a basis for decision-making is necessary. Emissions allocations techniques form that framework. There may be questions about the institutions that allocate emissions, carry out the review and made decisions, but the need is here, the tools are available, and we should be deciding on the institutions to carry out the process or propose an appropriate, effective alternative.

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PANEL DISCUSSION

INTERACTION OF THE PLANNING AND REGULATORY COMMUNITIES

Dan Leiberman, Moderator

There has been a lot of talk this morning about institutions, and I think the question of institutions comes down to what people are doing now. And possibly by listening to some of the people here today, and asking questions, we can get some understanding of where we are now, because in the last two years we have been developing the institutions in the framework of the existing law. The law did not make the institutional constraints clear, but I think that part of what you're interested in is--what do you expect from regulatory agencies and what can you do with planning agencies?

The gentlemen here--John Wise on the left is the Chief of Inter-agencies Activities of EPA Region 9. Milton Feldstein is the Deputy Air Pollution Control Officer in the Bay Area Air Pollution Control District. Bill Rugg is the planning director for the City of San Leandro. Graham Smith is an environmental advisor to Los Angeles' Mayor Bradley.

JOHN WISE: What I plan to focus my remarks on this afternoon is to give an overview of EPA's role in the question of the inter-action of planning and regulatory communities from an air quality perspective. Before I begin I note that David Morell from our Washington office gave a talk this morning and I may be retracking a bit of his thinking, so if I do please bear with me. I do hope to go beyond just a simple enumeration of where EPA is with respect to our individual programs and regulations, and try to weave the interface of the regulations into the planning community. There are three basic issues or subjects which I want to focus on today, which provide a fairly good format for trying to bring together the considerations of regulatory systems under the Clean Air Act, as we seek to attain and maintain national Ambient Air Quality standards, and the traditional role which is played by planners, whether they are state planners, regional planners, local planners, or any other kind of planning fraternity.

First of all, let me give a very brief background sketch on the kind of regulatory system we're dealing with. The Clean Air Act specifies rather broad but at the same time specific mandates on EPA to attain and maintain national Ambient Air Quality standards. Within that general mandate EPA has over the last three years come up with several distinct and somewhat different strategies. The strategies are in and of themselves somewhat single purpose. For example, we have strategies to attain the standards; we have strategies to maintain the standards; and now, we're developing the standards to prevent the significant deterioration of air quality. The point that becomes rather cumbersome in this whole regulatory system, is that we are imposing requirements which in and of themselves are single purpose and tend to be rather cumbersome. Relating those kinds of requirements to the planning community presents a real obstacle. A very major difficulty which we're facing here today is how to relate EPA's single purpose requirements to the broad and more general concerns of the planning community.

Three specific issues which we want to focus on today are the issues of air quality and transportation planning; air quality and the question of facilities siting; and the question of air quality with respect to growth and development.

Let's deal with the first one first: the question of air quality and transportation planning. As most of you know, and I'm sure some of you I see in the audience here are working intimately within this area, the 1973 Federal Aid Highway Act specifies in section 109-J that the projects and plans conceived under federal funding shall be consistant with the goals and objectives of the Clean Air Act. To implement this, the Federal Highway Administration has put together a set of guidelines known as the air quality guidelines which mandate a consistency between transportation planning and transportation projects and the applicable state air implementation plan. This poses an overview requirement that all transportation facilities must henceforth be consistent with the overall goal of attaining and maintaining air quality. EPA has a role to play in all of this, and our role is principally in terms of implementing our own regulatory programs. We serve as a consultant to the Federal Highway Administration in actually implementing these guidelines. In the course of implementation we've begun to run into some very significant aspects of transportation planning and how that planning relates to the more fundamental land-use planning which is going on. I believe it's clear to all of us by now that this is a rather primitive area in terms of relating transportation systems and transportation plans to what is on the ground in terms of land-use planning and land-use decision making. To the extent that the Federal Highway Administration and EPA acting together in implementing the air quality guidelines, are going to come up with an overall constraint which is then imposed on transportation facility planning, we're going to again force the system into consideration of the key elements of transportation and air quality in comprehensive land-use plans. Now, the local planning community, be it state, regional, or local planners, must certainly be aware of this. This is a very major and powerful tool which opens the door towards mutual cooperation and integrating the three distinct areas of air quality, land-use and transportation.

Somewhat related to this is the second issue which I want to discuss, the issue of the siting of key facilities. This of course has been a traditional role which has been played by local general purpose governments in their traditional prerogative of making land-use decisions. These decisions include the location of residential areas, industrial areas, commercial areas by means of a zoning map, but more specifically individual approval through the permit process, determining where specifically a shopping center or an airport may be located.

Again, there are air quality implications which are now being superimposed on that traditional decision-making process. As you probably learned this morning, these take the form of the review and permit authority on the construction of a so-called indirect source (a key facility such as a highway segment with a certain traffic load, an airport, or a major shopping center). These key siting decisions as they're related to air quality then impose an additional constraint on the local planning community. How do you rationalize land-use decisions within the explicit mandates to attain and maintain the air quality standards?

Let's proceed on to the third area I want to talk about, and this is more generalized in scope: the relationship between air quality and the generalized process of growth and development within a community. Here again EPA, in our regulatory wisdom, is coming up with another program, another constraint on the whole system, in that we are now mandating that a new concept of air quality maintenance planning be developed by the state or state designated agencies, to begin to relate to the maintenance of the national Ambient Air Quality standards, over time, specifically over a 10-year period of time. What we're talking about is a continuing planning process really, and when we speak in terms of planning over time we must accomodate the rates of change or growth, if you will, of population, the rates of change of vehicle miles traveled, the economic and social indicators, and we must begin to work these kinds of indicators into the process of maintaining air quality. All of this is going to lead us to the point where the regulatory system finally comes to grips with the local planning community. That to really effectively maintain standards over a long period of time using all available control technologies and control methodologies, including land-use and transportation controls, we must begin to say, okay the regulatory system cannot function by itself. Here at last is an institutional focus where we can begin to put everything together. I'm sure some of the other speakers will build upon this theme that perhaps we're leading to a point where the regulatory system can now step back and say here are the overall requirements--this is what has to be done--and let's put together the local, state, and regional institutions to accomplish that. Following me will be representatives from some of those institutions which will provide you with specific insight on some of these general programs which I've outlined.

MILTON FELDSTEIN: I hope you will forgive me in terms of my remarks which relate more to a technical background than to a planning background. Perhaps there's an oversimplification when one looks at the complex inter-relationships between land-use planning and air-quality, if one looks at it from an engineering or chemical point of view. Recognizing that this is a tremendous over-simplification, I would like to briefly point out some of the aspects of this kind of relationship that is presently going on at the Bay Area Air Pollution Control District. During the morning, and I'm sure for the next day or two, you'll be hearing a lot of information about how one determines the air quality impact of a particular complex source and what kind of specific engineering and technical calculations have to be made. All of this, I think, leads to the concept that we are not dealing with abstractions--we're dealing with specific emissions, we're dealing with emissions primarily, at least in the land use planning aspect, of the so-called indirect or complex source, the emissions which come from the attraction of motor vehicles.

Now it was mentioned earlier that the regulatory process which must be instituted to at least get a handle on a control of these kinds of developments generally occurs through a permit kind of system. The Bay Area Air Pollution Control District (BAAPCD), along with other districts in the State of California, has had a permit system and up until this point in time it has been concerned primarily with stationary source emissions. No one gets excited when one has to apply for a permit for a new refinery or a new chemical plant or a cement plant in terms of the standards and criteria that have to be met, consistent with maintaining and achieving air quality standards.

In the BAAPCD, which developed a permit system only two years ago, this same approach is also true. There are three tests that a new stationary source has to meet when it applies for a permit in relationship to emissions: The first test is that that source has to meet the emissions regulatory requirements that the district has established (we have established emission limits for the five primary contaminants: sulphur oxides, particular matter and so on); each new source has to meet that emission limitation, otherwise, a permit can be denied for that source. The second test is that even though this particular stationary source meets the emission limitations, the emissions must not cause an air quality standard to be exceeded. Even though one meets the particulate rule or the sulphur dioxide rule, the emissions within that limitation cannot cause downwind an air quality standard for that emission to be exceeded. The last test is that even though the emissions meet the regulatory requirements, the permit may be denied if the emissions occur in an area where an air quality standard is already exceeded. So these are the three tests which are applied to stationary sources which apply for permits to construct and operate.

The indirect source rule, which is currently being considered by the Board of Directors of the BAAPCD follows similar reasoning. There are three questions that the Board is considering. I should emphasize that at the present time, these regulations are undergoind public hearing. There were two public hearings held; one in May and one in June, and another one is to be held this coming Thursday, in which input from all diverse views is being received by the Board. I hasten to add that the Board of Directors of the district is the group charged with the responsibility of developing the regulations which, when adopted, become part of the enforcement process of the district as a whole.

The three areas that the Board is currently receiving testimony on relate to the following items: First, what sources should come under private review? What are the cut-off criteria and what size of an indirect source should be reviewed in terms of its impact on air quality? Obviously a single family dwelling is at one end of the scale, and a 10,000 unit residential development is at the extreme other end of the scale. What is the kind of numbers that we're talking about which would bring these sources before the permit section of the district, if you will, in order to determine whether or not that particular project would indeed have an effect on air quality. I'll mention in a moment what the cut-off criteria currently being considered are, so that you may have those in mind.

The second major question which is appearing in public testimony is what is the grandfather, or the grandparent, if you will, type of legislation which would permit ongoing projects (projects which have had substantial investments in time and money and effort) to be excluded from review of these indirect sources?

The third question and here again I feel one of the most serious questions to come in public testimony before the Board, is what are the appeal procedures? What are the social and economic factors that should be considered in the granting or denial of a particular indirect source? This is a problem which has no recognition when one looks unilaterally at the requirements of air quality over any other requirements. The Board of Directors has made it clear that it is our purpose to at least provide a mechanism whereby a review can occur if the air pollution control officer for example denied a particular project on the basis of air quality. Such a review would consider social and economic problems which may result from the building or the denial of the building of that particular project. This essentially then is the kind of approach that a local agency, a regional agency in this case, comprised of the nine counties that surround the Bay Area, is attempting to do, in order to bring under its jurisdiction the review of indirect sources related to their impact on air quality.

I mentioned a moment ago I would briefly mention the kind of sizes that we're talking about now, relative to bringing a source under review. And I must emphasize that this does not mean that any such source that is required to have a permit and be reviewed will automatically be denied. You, as planners, I am sure know the mitigating effects that can occur in developments in terms of reducing vehicle miles traveled, in terms of siting (as was mentioned earlier) so that the impact on air quality would not be directly associated with the particular project that is being built. So the staff has recommended to the Board, and again I must emphasize that this is all preliminary in terms of the testimony that will appear before the Board, that any non-residential indirect source which has a new associated parking area with a capacity of 1000 cars or more be subject to permit review, not be denied, but be subject to permit review. Additionally, any existing facility which adds 500 or more parking places; any facility which induces 1000 or more vehicle trip ends in any one hour period or 5000 or more vehicle trip ends in any 8 hour period; any road or highway with the following anticipated average annual daily traffic volumes with 10 years: for new roads--20,000 or more vehicles per day, for modified roads--an increase of 10,000 vehicles per day; any airport with the following expected aircraft operation within the next 10 years: new airports--50,000 or more commercial operations, modified airports--the same number; and finally any residential development with greater than 1000 units. These have been proposed and I think they follow fairly closely the EPA proposals and they followed the original proposals of the Air Resources Board (ARB) until the ARB decided to delay discussion of this topic.

In terms of those sources which would be required to get a permit to construct and a permit to operate, the permit would be based upon the impact on air quality after making a thorough environmental impact study on air quality emissions relative to that project. In summary, I think then we are now facing in the Bay Area, at least from a local regulatory agency, intense discussions on the part of those who are affected, developers, and those who will be effected, the citizens who feel that air quality should be an important constraint in planning.

I think we have to recognize that there are some problems in terms of assessing the air quality impact of these particular sources. For example, the technology in terms of assessing the impact on oxidant, which is the major air pollutant in the Bay Area, related to the emission of hydrocarbon, is still in a state of infancy. And the thing that concerns me, someone who is inter-twined with these kinds of regulations, is that we know that as soon as a specific project is denied on the basis of its impact on oxidant formation, the procedure will revert to the courts. The courts will make the final decision as to whether or not the technology we had was adequate to deny the permit for a particular source. Be that as it may, I think that indirect source controls are a first step in the necessary long-range planning which you will be discussing for the next two days in terms of bringing all development at least within the constraints of air quality along with other constraints that now exist in long-range planning.

BILL RUGG: I'll have to admit to feeling a little bit like a sacrificial lamb this afternoon--I think they needed someone here who is a local planner from a small community to come up here and raise a little hell--

and I'm about to do that. In fact George said that one of the things my assignment included was to stir people up after lunch. Anyway I'm a registered student like all of you here, and I don't claim to any more expertise any more than any of you have, but I gather that my vantage point as a local land-use planner may be a little bit different. As I recall about a fifth of us here are local planners. So, what I will do is to give you some observations from a guy who's on the firing line most of the time, a guy who meets face to face with the developer who walks in with his plan, and in fact, I double in brass as a developer myself in a way, because in San Leandro we have a combined office--the planning function and the redevelopment function are in the same office--and so I end up half the time trying to beat my own building codes as the redevelopment director at the same time. So I really think I have a fair view of how the poor developer feels when he's confronted not only with EPA but with BCDC, the Seismic Hazards Act, and the Environmental Quality Act--some very large and expensive unknowns before he even gets into the business.

Well, first I'd like to thank both the Sierra Club and EPA for getting us all here today. Because without that 2 x 4 hitting us on the side of the head last fall--the parking surcharge--I don't think our attendance would have been so great. At least, if nothing else, it got our attention. I wanted to say something nice about EPA because I may not say anything nice about EPA during the rest of my remarks. However, there is a real problem--I'd like to get a little information for myself about you--a little bit more than Warren Jones gave us this morning by asking a couple of questions: How many of you here are City Councilmen or members of the Board of Supervisors. One. How many of you are planners from an operating transit district? Not CALTRANS, but an operating transit district. None. Maybe I don't need to go any further on that.

Anyway, my purpose here is to point out some frustrations about what you heard here this morning and about what's been published. I would like to offer six (I've been writing these down during the morning)--I can probably add a few more and I'm sure you can too, but let me lay six different ones on you for argument. Again I say these are frustrations, they do not mean there are not answers to them, they just mean that I do not know what those answers are. I'm before you as a modestly informed planner--I don't proclaim to be an expert--but if I don't know the answers, the chances are that an awful lot of other planners and certainly decision makers don't know them either. So perhaps one of those problems is getting the word out.

Number one, we're talking about land-use planning and air quality, and land-use planning is not a technical problem as is air quality planning; it is a people problem. What we're really talking about in getting to amend our land-use planning techniques, is the changing of habit patterns of people. There is nothing much more difficult in this big wide world than the changing of habit patterns of people. We've got to take people as they are, I think, and try to figure out, perhaps modestly, how to circumvent their prime moving impulses about driving automobiles. That is not going to be easy, and it is not going to be answered by the Federal Register.

Second, are a whole series of things: but one of them, to start off with is that the regulations such as those that Milt Feldstein has just mentioned, are so vague, that I cannot analyze their impact on land-use. I testified against the ARB regulations on indirect sources for that particular reason. I was unable, in reading the regulations as proposed, to tell my community what those would do in terms of land-use planning changes. Now somebody presumably knows this, but I think it is something all of us are going to need to know before we can buy the concept. I don't know, for instance, what specific tests are going to be applied to any indirect source in my community. How do I know in advance? How do I inform the developer? How do I know for the projects that I run? Are they going to be turned down or not turned down or conditioned? What are the specific tests? What land-use patterns are going to emerge? And I thought it was kind of interesting this morning to find out there is a study now going on, now that the regulations have already been adopted, to find out what land-use patterns might emerge. As Ralph Mead said, he's not ready to say that high density is better than low density. Well I'm not either. The point is we don't know what density is the right density and under the circumstances what energy problems are created?

My third frustration I guess, is the large number of apparent control strategies which have been apparently ignored. It was interesting to note that there has been no EIR appear in the federal regulations or the state. I'd like to know what the section might have said that covered what alternatives to the proposed plan are proposed. But who is pushing the transit districts? There are no transit planners here today, apparently. Who is pushing the differential parking fees and the differential bridge tolls and the horsepower tax, the various selective disincentives that could affect specific kinds of trips, not just all trips?

Fourth, there seems to be no money to help with the alternatives. We need additional studies. We need help on more busses, on PRT's, on people movers. We need all kinds of help to provide alternatives to private vehicles. If any of you have applied for grants recently, you are familiar with the fact that there are very few, certainly nothing available that is going to match the problem. But, if our objective is not just to curtail mobility, we've got to provide some alternatives. So far, the regulations we've heard are largely negative, and will tend to curtail mobility. That has to be the result, as far as I can see.

Fifth, there has been a very distinct lack of local input, and I'm not talking about public hearings. As every public local land-use planner knows, by the time he gets to public hearings, it's too late to logic. I'm talking about early work with your friendly local planner, EPA, to devise regulations and strategies that can be implemented by local governments. And the only way I know of that that can be done is to work with local planners early, before the regulations are adopted, not afterwards, or at least not at a public hearing when the large amount of public testimony is for or against, and not what the alternatives might be.

Finally, sixth, we're talking again about a large single-purpose agency, or agencies, trying to solve a single problem without really interacting with all the other problems. Now, if my function here may be a little different, I'd like to end on a positive note. That may not be easy but I'll try.

We do need to have some land-use rules and so far we haven't really got any. As I said we don't seem to know what our best densities are, and what our alternatives are. I'm not even sure we know what our objectives are. Basic to setting up our objective, I think would be the proposition that the solution to this problem should not aggravate other problems. So far in the planning business, our failure to work with the relationships between problems has led to our current preoccupation with drastic single purpose solutions, developed by large single purpose agencies.

The second would be that most of our current plans and our current problem activities tend to seriously discount the future. I don't know how many of you are involved in future research and this kind of thing, but the term discounting has a real connotation here: it simply means that you place less value on a future solution than you do on a current short term solution. Here we're looking at--we've got to solve the air quality problem right now--and what the results of this solution might be in 20 years is discounted at 5% per year. What does that give you? Zero. It is a little like the old story, and I probably shouldn't tell it, but you all know it anyway--about the old bull and the young bull that were standing on top of the hill looking at all of the cows down below. The young bull said let's run down the hill and get a cow. And the old bull said let's walk down the hill and get all the cows--I'm not even sure we can find the cows at this point.

Yet anyway, whatever is our real planning objective? I don't think, from my standpoint, that it's just to improve air quality, because that's something I cannot relate to, and neither can my city council. They don't know how to do that. It's too general. But what is our objective? I think it is to reduce vehicle miles traveled, to put it very simply. Now, that's something that people can at least understand--the lay person can understand what reducing vehicle miles traveled is. It does take a little explanation, but it is possible to explain it. You can go one step further, how do you reduce vehicles miles traveled? Not by reducing mobility, which has some tremendously serious social and economic effects as we've said, but by doing two other things: minimizing the need for mobility, and providing alternative forms of mobility. Now this is where it's at, I think, and here I'm putting up a straw person for you to shoot at--two of them actually. If you don't agree, you're going to say so--but from a land-use planner's standpoint, these two things are understandable, and the planner can sit down and try to figure out what kinds of land-use planning changes can be made in the community that will either in the long run reduce the need for mobility (Ralph Mead alluded to some of those this morning such as locational relationships), but also provide alternative forms of mobility, and I've mentioned some of those too. One of the things that I would like to suggest, and this is why I asked if there were any transit district planners here, is that in reviewing applications from developers, we habitually say, first off, how many parking spaces are you going to provide, Mr. Developer? Secondly, what street widening are we going to hook you for? That's about where it ends. From now on, however, we're going to have to include on our planning review team those transit planners from the operating transit agency, most of which don't exist now. We must ask, how can this development be best served by public transportation--not how much street widening would we get, and how many parking spaces, but what kind of a shuttle system, or can you build a bus shelter, or what can we do to improve the public transit access to that development? These relationships don't exist now; they're the kinds of things we're going to have to work on.

I would end with an appeal to all of you from EPA, and your bosses, who may or may not be out there in the audience, to please get together with your local planners, and your planning directors in particular. Let's try to work out what this jargon that we all use--land-use impact of air quality regulations--really means to the individual city councilman who makes that final decision.

GRAHAM SMITH: I really feel like a visitor today, although Berkeley is my home town. Also, I notice in the program there is a considerable domination of Northern Californians and I feel a little sensitive about being from the air pollution capital of the world. The title of the panel, you know, is Interaction of the Planning and Regulatory Communities, and ever since I went back to school to study planning, I have been profoundly taken with the lack of interaction of the planning and regulatory communities in any kind of planning one may wish to talk about. Kerry Mulligan, who was the head of the State Water Resources Control Board some time ago, said he knew a guy who was planning to sleep with Raquel Welsh for years, but it was the implementation he couldn't figure out. The circumstances we have before us here are compelling some very lively action now, and I think perhaps it's going to start getting very interesting. For planners, we're finding that in the city we're finding it first at the regulatory end, and we're having a little difficulty bringing some of our planners along. Let me illustrate that.

The society today seems to be creating institutions before it knows what to do under those institutions. It knows the outcome, this is a very interesting switch to outcome type of planning rather than input measurement. The Coastal Commissions are a beautiful example; the people had a idea, they wanted some rational thought process applied to the use of the coast, they didn't know what the processes should be and when it came time to start hiring prople for the new Commissions one may seriously question the qualifications. I taught a year of Coastal Planning at U.S.C. and it was hard to get the students to take it seriously because at that time a law didn't exist. In the same sense, in a very comparable fashion, the Clean Air Act was passed. The Feds, very properly I think, tossed the ball to the states and said "You do it--you achieve this outcome--and you do it by this time." The states--in the case of the State of California, and this is some time ago--pretty much scoffed at the standards, and at the deadlines for that matter. I remember Ari Hagen Smith saying that he thought there would be a Boston Tea Party if ever the Feds tried to enforce the act. In the same sense down South, which I think may be more characteristic of the existing institution, the Los Angeles County Air Pollution Control District scoffed, in fact rancorously, and said the whole thing was silly.

Beyond that, there was a separation of course, between the county air pollution control district which has single purpose air pollution control functions, and the city planning departments. Land use has traditionally been a city function, and our city planning department reflects a knowledge only of land use at this time. Correspondingly the Air Pollution Control District only seems to know about reciprocity between hydrocarbons and oxides of nitrogen, and puts no stock in any other techniques. I'm using a little poetry or color here to try and make the point.

What are we doing in Los Angeles in City Planning in relation to air pollution? I want you to understand that we have huge departments, 214 people in our planning department and they've been there a long time and we have a new mayor. We have been a rather sleepy city in the past--now for 11 months--and therefore I do not want to hang the mayor, yet, for some of the things I'm going to say about the way we're approaching the problem. All we do in the City of Los Angeles is review air quality considerations in environmental impact reports. We have a 12 person unit in the planning department reviewing environmental impact reports, and someone there generally reviews what the developer has proposed will be the air quality impact. I would point out that at the same time in the planning department, the people who decide zoning or the granting of sub-division permits and so forth, are going ahead on their own. So there is a good question as to just how much of a role the EIR process plays. Remember we're talking first about air quality considerations. We're now within the City Planning Department, and we've just sort of eliminated air quality considerations under the EIR. So, there is very slight consideration. We have our own department of environmental quality that has one air pollution specialist, and they have discretionary review over EIRs, the very important ones, and so forth. I have yet to see that any of their reviews have played a very significant role in granting or denying approval on a project. So, we're really very far down the line.

I'd like to point out that the Council is supposedly, by charter, the policy making body in the city. There's nothing more that I dread than to go into council to explain the Mayor's position on one or another of the aspects of the Clean Air Act. There are 15 gentlemen who are utterly oblivious--perhaps two or three of them have some sense of the intricacies of the Clean Air Act. My best job I think, was once about a year ago to get across the major provisions of the Act and their relationships in a three hour seminar. We're all learning what the law means, slowly and surely, but the Councilmen have no idea at all and don't have any time to learn. How then, are we going to move to develop something that is concrete both institutionally and substantively in terms of what we want to do. This should be important to every planner here, or anyone in local government. My gut sense now is that EPA did sort of get its ears pinned back in the parking surcharge, going through the other process with the built-in delays from state to local government, and they are going to short-circuit things if they can and go directly to local government. We're all for that and I think that the City of Los Angeles will try to be in the vanguard, to the best of it's ability as a peculiar shaped jurisdiction. The only other jurisdiction in California which is so bizarre is the City of San Jose, which doesn't relate to air pollution at all.

We've been pressing for Regional Air Pollution Control Districts and support AB 1556 in the State Legislature. We will probably come forward with our own parking management plan, we hope, perhaps, by the deadline next January 1st. The Parking Management Plan is a little microcosmic Air Quality Management Plan (AQMP), it is single purpose perhaps, but it sure is land use. The commercial parking business in Los Angeles is a $2,000,000,000.00 a year business. If you just measure the surface area of the parking lots you're dealing with a significant percentage of the land in Los Angeles, let alone locational considerations or the efficiency of traffic flows in and out of parking lots and so forth. We will probably come forward with that. That's the direct, frontal approach. The Bay Area Air Pollution Control District is developing its own guidelines for indirect sources, since for the time being the Air Resources Board seems to have set aside its indirect source review. I spoke on behalf of the Mayor on SB 1543 and proposals of the ARB on indirect source review, and we strongly supported that. What we pointed out was that that proposal was only to bring out an individual indirect source review function, and not to go the whole route as in SB 1543 which set up a planning and allocation framework within which to judge individual projects. We pressed for the whole bit. I'd like to point out that all of this is a real guess. My best sense is that in Los Angeles if we go ahead it will get very hot in the kitchen, but I think we'll be sustained in taking a fairly progressive position, and pushing for these regulations. Other places it may not happen. It may be beaten down again. There's something--I say this with reserve--there's something in knowing that you're right, and in having some faith that the outcome is going to be a positive.

There's one other aspect for planners which should be sort of interesting. We're finding that SCAG, the Southern California Association of Governments, which is a much younger equivalent of ABAG up here, some time ago developed growth policies and adopted them. I think when they adopted them, they were in a sort of never-never-land of going through the paces of stating nice policies--but it did become a plan--a policies plan. And now lo! and behold now that we're talking about a specific transportation proposal, as much as 240 miles of rail rapid transit by some peoples desire, all of a sudden we find that that is in direct conflict with the growth policy dictated by the Southern California Association of Governments. The SCAG has decided now under the transportation bill, the Dedham Bill AB 69, that it does in fact want to be the Regional Agency rather than a token thing and they've all of a sudden gotten tough, and under law they can. It will be very interesting to see what happens there. Some of the outlying counties, the equivalent say of Contra Costa County and the City of Concord here, are very unhappy at the thought that they will not be able to continue to spread in a bedroom community fashion. In the same way, these growth projections and this adopted growth plan, which may have been inadvertently adopted for all I know, are consistently working out at great variants with the individual community plans, even of our own City of Los Angeles. When you start adding up each of our individual community plans you come up with an enormous population growth which is utterly different from what is the official Regional plan now. That battle hasn't been joined, but somewhere in the midst of that battle, if there are some articulate planners who know what they are talking about, who know about air quality and location and growth and so forth, the plan may be resolved rationally. I'd advise everyone here to keep very close touch with old laws on the books of regional agencies and see how they might relate to your individual agency if they ever in fact sprang into life.

DAN LEIBERMAN: One thing that I think we would like to see planners consider is the real cost of strategies relating to transportation. The kind of thing I'm thinking of is a RAND Report a couple of years ago for the San Diego area, which said that mass transit was not cost efficient because it cost too much per pound of pollutant to change the transportation system. A later study in the San Diego area--what's called a radial corridor study--showed that if you want a mass transit alternative, the change in the land use would reduce sewage system costs by $500 million in 20 years, and that the yearly reduction in 20 years of energy utilization was about 20 per cent. So a strategy that might be carried out for clean air should be considered in terms of the secondary social and economic effects, and these are not always negative. In fact they may be positive, so if you do that kind of analysis, what you come back with is, if we want to drive the automobile, and that's the decision made, we should not do it on the basis of considering economic implications, as a mass transit strategy is an economic saving in the long run. Those are the kinds of things that we have not really considered.

The other thing is, from the ARB standpoint, when we see EIRs, and any project which involves federal or state funds will get to the ARB for review, we will look first for adequacy, and second, when it comes to oxidant, whether we can put it in a regional framework. These are very concrete things that you'll have to face when EIR's get to the ARB for review.

Questions

What is an applicable implementation Plan?

JOHN WISE: Under the Clean Air Act EPA has set forth procedures for receiving a document known as a state air implementation plan from the state air pollution control agency, and approving that as the applicable state implementation plan to attain the air quality standards. In the event that parts of that plan are not approvable, then the Clean Air Act specifies that EPA shall provide the implementation plan in its place. Specifically, what has happened to attain the national ambient air quality standards has required that we go beyond the traditional stationary source controls which are, of course, listed and accepted by EPA in the state implementation plan, and go beyond that to the consideration of mobile sources. This has manifest itself in terms of a document known as the transportation control plan, a plan which has been promulgated by EPA as supplementing and actually taking the place of the state air implementation plan for the State of California. With that kind of background the applicable air implementation plan becomes the portion that has been accepted by EPA and the portion that has been promulgated by EPA in a total and comprehensive package. For those transportation agencies who wish that kind of definition, I think that in general it includes the entire array of regulatory activities set forth by the state and approved by EPA. Does that answer the question, Dan?

DAN: Yes, I would point out that in raising this, the disagreement between EPA and ARB. The ARB does not necessarily view EPAs plan as applicable to the state when it is not one that has been adopted by the governor. This is one of the difficulties, and I guess the reason I want to clarify this, is you find that all regulatory agencies are open to discussion, and EIRs go through a very difficult path when they contain federal or state actions. They go usually through a local air regulatory agency, then the state, then EPA, all of which may have different views. So if you are in doubt, the thing to do is to interrogate the agency, and ask them what the view of the situation is.

DAVID R. DIJULIO from the Washington Council of Governments: I have an observation, and then a question. One is that it seems to me that we have to recognize that the automobile provides us an essential role in our society--it gives us something--a bit of mobility that we can't have in any other type of system. But the other side of that coin is that if we're to solve air pollution and noise problems, urban run-off water pollution problems, each of which are linked to the automobile, then there's no way to solve the problem, even the transportation crisis that most of our cities have, without limiting the use of automobiles in certain areas of the cities. I think this group ought to face that sometime here in the next 2 or 3 days. We can talk around and around it but we're going to have to say that we're going to limit the use of automobiles. The question really is to the two gentlemen representing the planning organization. You discussed in your remarks the problems of incorporating air quality in to land use planning, but it seems to me from my point of view that there are some advantages. Air quality has standards based on health effects; it has the power of Congress and regulatory authority behind it. And it can be a tool to be used by local planners to enforce all the other sort of less quantitative regulations or ideas you have about open space, shopping and that type of thing. I wondered if you see the benefits there? Do you see it as a tool to help enforce zoning regulations?

GRAHAM SMITH: I'd like to answer that from our position in L.A. The Mayor has tried to provide leadership to make things happen, and that's precisely the way he has seen it. I mentioned in that brief fast talk that its hard sometimes to get our planners to pick up a book--on city time--and read about air quality and land use, just because of habit perhaps. The Clean Air Act offers an opportunity or a lever where there hasn't been one before. I also believe that the lever is related to the truth of the matter. But I'd like to point out one thing. There has been a lot of talk about VMT reduction, and there are lots of ways to do it. But after the parking surcharge matter, we in L.A. went through the parking surcharge problem and the energy crisis, and we had an incredibly severe situation in L.A. with the energy crisis simultaneously. I came away with the distinct feeling that it would be political suicide even for the strongest political favorite of the public in the nation to propose a disincentive. The state went through a short period, 2 months, under a voluntary gasoline rationing plan and in Los Angeles it was mandatory, where we were cut some 19% over our use in the previous year. What man or woman, if she were mayor, could possibly call for people--on the basis of air quality--to go through the same inconvenience. I would like to advise the Mayor to call for that. The political reality is that it would be suicidal. I'm not down on air quality, I want you to have the sense of the strength of that lever--it's very tenuous. But it's something.

COMMENT: I'd like to echo that. There are some very distinct advantages of course, to combining land use and air quality planning. I'd like to echo the political disaster that befalls anybody that tries to ration gas for the purposes of air quality. Because I think that is going to destroy EPA and destroy all of us along with it. On the other hand, there are going to be things that we as professionals and land use planners are going to want to do in our communities, that will be politically inadvisable for local city councilmen to do in the interests of air quality planning. We are going to need to have either ARB or EPA as support. Now this may be the whipping boy impulse, but nevertheless it is a valuable one and it takes the local politician off the hook in many cases, the cases short of suicide. I don't want to minimize the political importance of having a state or federal grandfather insisting on certain things that we really want to do anyway, but we haven't got the guts to do.

COMMENT: I have an observation to make in response to a point Bill Rugg made. I think its really a very, very important point, particularly since we're talking about the relationship between the regulatory system and the planning community. Bill's point, for those of you who are writing furiously was point #5, that there is a distinct lack of local input into regulatory rule making. What I want to indicate is that EPA as a federal agency is particularly sensitive to this. We recognize the validity in the charge. But there must also be recognized that there are some very significant procedural problems involved here. Maybe I can just enumerate a few of them, and then try to explain what we are trying to do to remedy this problem. Number one is that the Clean Air Act itself, and all of its regulatory provisions, impose time schedules which are to say the least very very near term. Time schedules which don't leave time in fact to do the proper job of involving the public in regulatory rule making. But moreover, in many instances, EPA has been confronted with court orders which substantially accelerate that rulemaking process. So, there's a question of timing involved. There's also a question of national applicability of our standards, or in California, there might be a question of statewide applicability, and for one single federal agency to reach down into every single grassroots of each and every city, county, and planning agency to solicit their views is a monumental task. What EPA is trying to do about it is through a procedure which is in and of itself not very efficient, that procedure is, when we do a regulatory rule making, that first rule making is a proposed rule making, which then appears in the Federal Register, specifically inviting public comments. The commenting period is variable but it is usually a period of 30 days. Subsequently the rule making becomes final, after adjusting for all of the comments received. Now that's kind of a formal process for soliciting public comment, and not many people really read the Federal Register. But nevertheless the procedure is there for those of you diligent enough to search it out and use it. But in the larger sense I believe that Bill's comment is still appropriate. We need to improve the involvement of the public within these regulatory rulemakings.

DAN LEIBERMAN: I think our time is up. I recognize from what I've heard this morning and what I see here, that we are all faced with an evolving problem and I think that there are many people on different sides of the fence, who are struggling together to evolve a solution so that we begin to make decisions that improve air quality without causing reactions that damage the position of air quality in this societal structure.

GENERAL ASPECTS OF AIR POLLUTION

Dario A. Levaggi

Introduction

The addition of an air pollution element in land use planning will have profound effect on air pollution control. The people most intimately involved in this application will obviously have had formal training in areas other than purely technical. The intent of this short paper will be to introduce to planners, public administrators, and the like a rudimentary overview of air pollution with respect to sources, available controls and the present ambient air standards. It is strongly recommended that the attached bibliography be utilized to render more detailed information in specific areas of interest.

The Clean Air Act of 1970 has in essence mandated that a land use planning element be introduced into air pollution control programs. The eventual form and implementation is at present undetermined and somewhat in a state of flux. Considerations are being given in such areas as indirect sources, parking regulations and regional "pollutant" allocation. Any and/or all of these concepts are new arenas of air pollution control which have controversial aspects, but may well hold the key to the eventual solving of urban air pollution problems.

Air Pollution

Air pollution has different meanings to the public at large. To the scientist its meaning is tied to concentration levels, classes of chemicals and intricate meteorological patterns. To the sociologist and economist its meaning is tied to odor episodes, vegetation damage, reduced visibility and public health. Figure 1 illustrates how different the basic air pollution problem is for diverse areas of the world. An already complex problem poses then added complications such as "standardized" ambient air standards for the whole country, country-wide control of contaminant "A" etc.

Stationary Pollutant Sources

Stationary sources include not only industrial complexes but also domestic emissions from fireplaces, heating, cooking, etc. Additional point sources include community waste disposal facilities and agricultural waste disposal in the form of open burning of diseased crops and stubble destruction by incineration.

The following is a brief description of source inventories for the four major pollutant classes from stationary sources:

Sulfur Dioxide: this gaseous pollutant accounts for the greatest tonnage release of any contaminant, and has a long and infamous history. The London crisis of 1952 and the Donora Pennsylvania incident of 1948 accounted for some 4,000 deaths above the normal rate. Sweden in recent years has complained that its northern lakes are increasing in acidity due to transport of acidic sulfur compounds originating from the industrial complexes of Germany and Great Britain. Air pollution knows not of national boundaries!

Major sources of sulfur dioxide occur from the burning of fossil fuels such as coals and heavy oils, both of which

TYPES OF AREA WIDE AIR POLLUTION

	(1)	(2)
Nomenclature	Photochemical	Classical
Location	California	East. USA-Europe
Major Pollutants	O_3 (.1 - .6 ppm)	SO_2 (.2 - 1.0 ppm)
	Part. (visible Reduction)	Part. (300-1000 ugm/m^3)
Relative Humidity	Low	High
Chem. Characteristics	Oxid. Atmos.	Reduc. Atmos.
	Mildly Acidic	Highly Acidic
Health Effects	Yes	Yes
Meteorology	Calm-Inversion	Calm-Inversion
Season	Summer	Winter

Figure 1

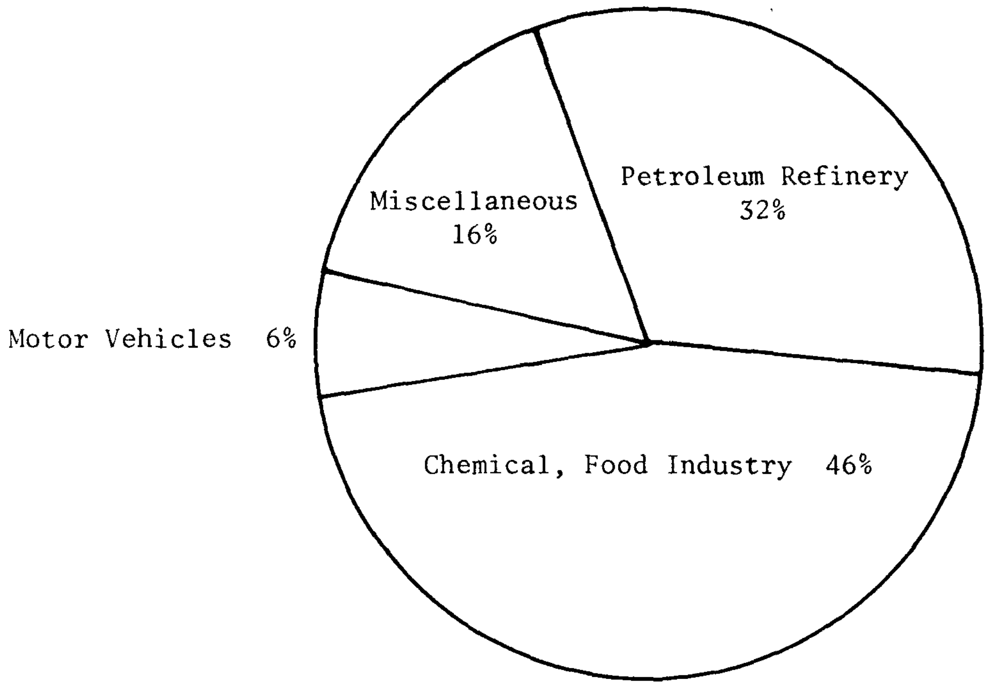
normally contain from .5-5% sulfur by weight. On combustion the primarily organic bound sulfur is converted to gaseous sulfur dioxide. These fuels are burned to generate electrical power, run industrial boilers, propel ships and heat homes and apartments. Figure 2 shows emission data for the San Francisco Bay Area which is typical of a west coast urban area not burning oil or coal but rather natural gas as a primary fuel. An eastern city such as Boston, New York or Chicago would have a distribution considerably different, some 50% or more of the emissions being from power generation facilities. Additionally the tonnage emissions are very much greater in these eastern urban areas.

Great strides have taken place in recent years for sulfur dioxide control. Abatement devices are now available for the petro-chemical industry as well as for power generation plants. Though expensive ($158,000,000 for the Four Corners Power Generation Plan) these control units are slowly being installed country-wide due to regulations being promulgated and the general milieu of the time. The devices employed are called "scrubbers", basically units causing contact between the gaseous emissions and either wet or dry chemicals causing reactions to take place ridding the exit gas of its contained sulfur dioxide.

Oxides of Nitrogen and Carbon Monoxide: Both these contaminant gases are the result of combustion processes. Their distribution in a typical urban area is shown in Figure 3. It is readily seen that both may be considered mainly due to vehicular

BAY AREA AIR POLLUTION CONTROL DISTRICT, 1972

DISTRIBUTION OF EMISSIONS - SO_2



PARTICULATES

1.	Motor Vehicles	24%
2.	Chem. & Food Industry	22%
3.	Metallurgical Industry	18%
4.	Petroleum Refinery	7%
5.	Aircraft	7%
6.	General Combustion	22%

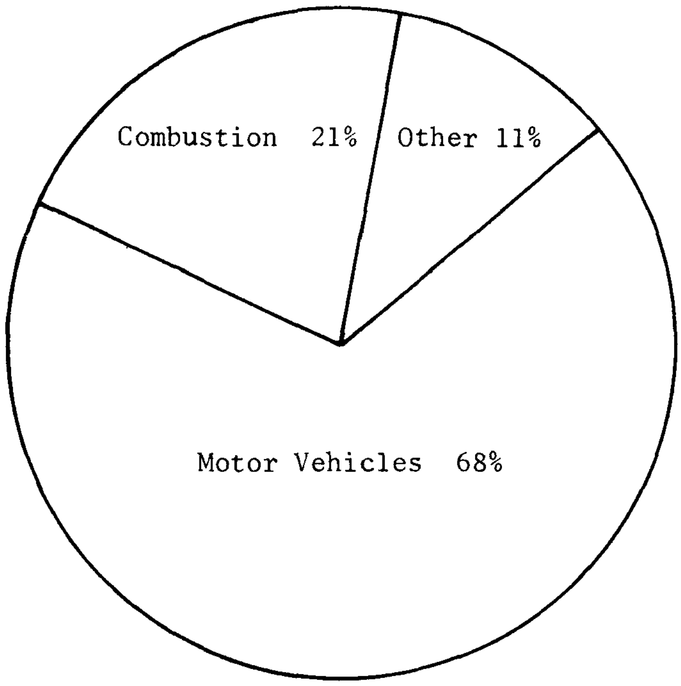
Figure 2.

Figure 3.

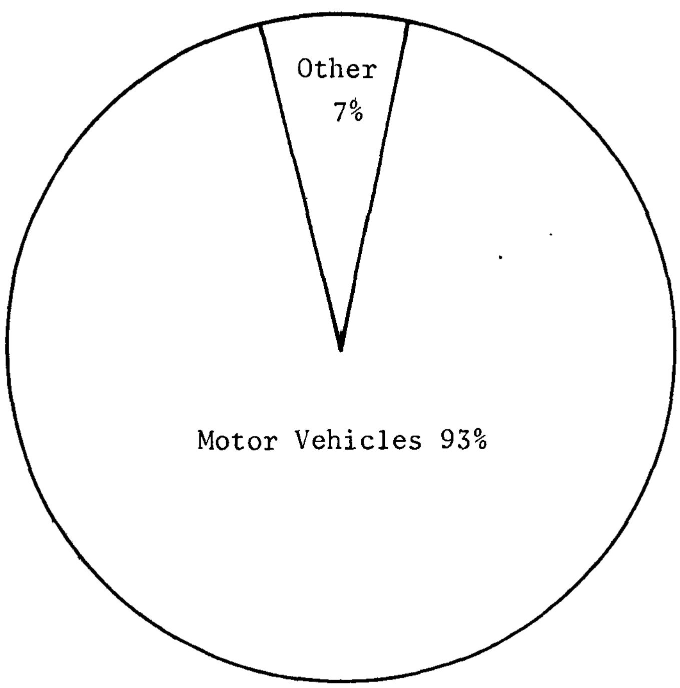
BAY AREA AIR POLLUTION CONTROL DISTRICT 1972

DISTRIBUTION OF EMISSIONS

NO_x



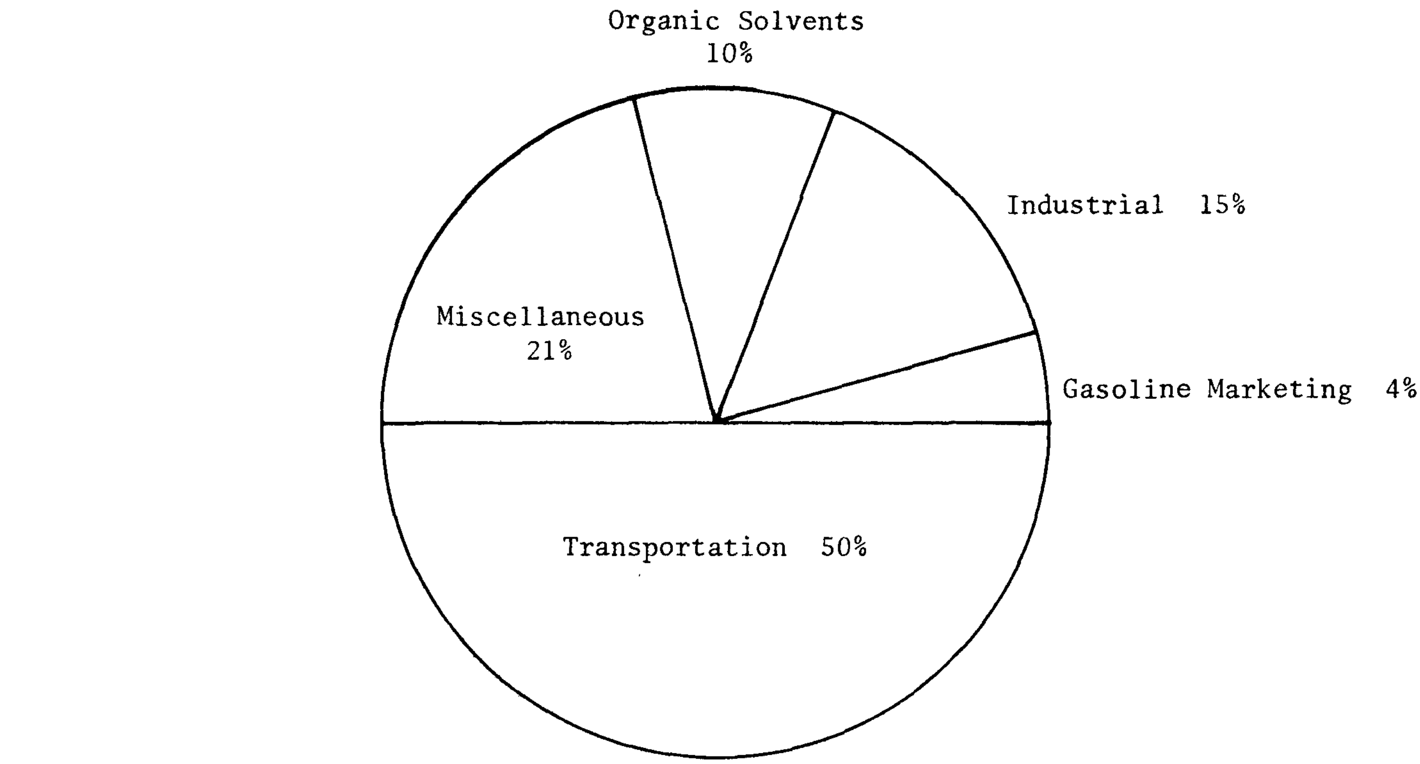
CO



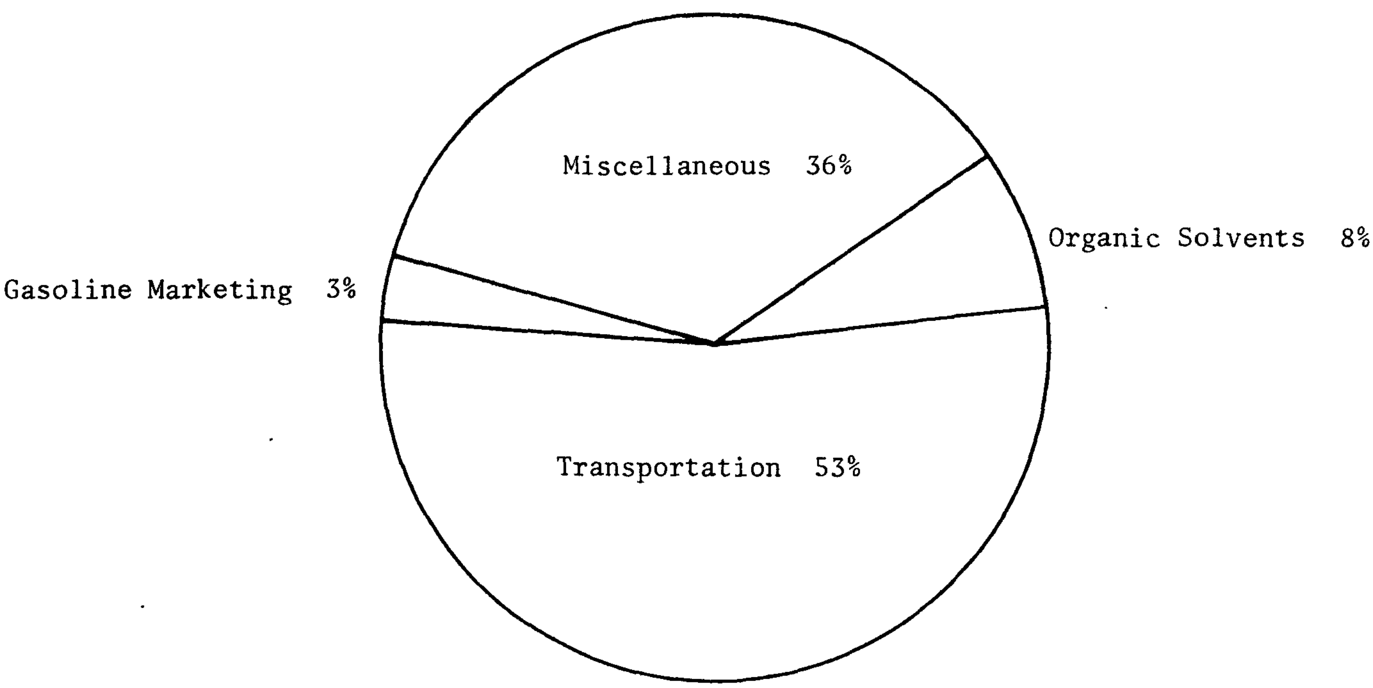
activity, overwhelmingly so in the case of carbon monoxide. These pie distributions are of the Bay Area but the distributions would hold with little change for any urban industrial city in the nation.

Control equipment for stationary sources for these pollutants is nonexistent at this time. There are process changes now taking place in power plants which reduce the output of nitrogen oxides, however, this reduction is only in the order of 30%. For carbon monoxide all that can be stated is that the more complete combustion is, the lower the levels of emission. Since, however, only 7% of all the carbon monoxide is non-vehicular in origin its abatement at stationary sources is of little concern. The oxides of nitrogen are of particular importance due to their participation in the photochemical process. This is the major problem on the west coast, the end result being the formation of ozone, nitrogen dioxide and aerosals. Eye irritation, haze formation and vegetation damage are some of the end effects to the public of this photochemical phenomena commonly called "smog".

Hydrocarbons: the stationary sources of hydrocarbon gases are varied and include as major emission points gasoline marketing, degreasing operations, petroleum refining, incineration, printing, and dry cleaning. Figure 4 shows a national as well as a Bay Area emission distribution. Again, as in the case of nitrogen oxides and carbon monoxide we see that vehicular activity predominates and



NATIONAL EMISSION OF HYDROCARBONS (1968)



BAY AREA AIR POLLUTION CONTROL DISTRICT, 1972

Figure 4.

accounts for approximately 50% of the total emissions.

The importance of hydrocarbon emission is their participation, along with oxides of nitrogen in the presence of sunshine to trigger the photochemical sequence previously described. The hydrocarbon classes which partake in this reaction to the greater extent are the olefin and substituted aromatics portions. Regional and state controls of hydrocarbon stationary sources are now becoming more numerous throughout the country. The pioneering efforts in hydrocarbon control and regulation began in California many years ago due to the high ambient air ozone concentrations in the state, a precursor of which are the hydrocarbons.

The abatement of hydrocarbons may be accomplished by any of the following techniques; incineration, reformulation of solvents, condensation processes, floating roofs for storage tanks and carbon absorption. In addition new developments and regulations are in process in many localities for the control of vehicle tank fillings and underground gasoline storage tanks.

Mobile Pollutant Sources

Transportation sources, essentially the automobiles, contribute the greatest amounts of carbon monoxide (93%), nitrogen oxides (68%) and hydrocarbons (50%+) to the atmosphere. Of all the major primary gaseous contaminants only sulfur dioxide is not associated in a major way with the automobile. What makes these auto emissions so important aside from the sheer quantities involved are: 1) their low level emission points, 2) their containing both oxides of nitrogen and hydrocarbons for the photochemical process and 3) the extremely high local carbon monoxide levels which may occur.

Control of the automobile was started in the State of California in 1966. Figure 5 shows in detail the history of the automotive control programs up to the present time. All 1975 models will contain catalytic devices which will further reduce hydrocarbon emissions greatly, as well as carbon monoxide. These automobiles will use only lead-free gasoline as lead can "poison" the catalyst rendering it ineffective.

Ambient Air Standards

Figure 6 shows the national ambient air standards (AAS) promulgated by the EPA compared with the State of California Standards. The ultimate aim of the Clean Air Act is of course for the entire nation to have at least this quality of air in all urban areas. These ASS were arrived at by numerous committees, hearings, and investigations and are all based on health effects. It should be borne in mind that these standards are intended to protect the most susceptible portions of the public, not the average healthy individual, and may therefore in general be considered conservative.

To say the least these AAS have been controversial, some saying they are too stringent, others that they are too lenient. The medical evidence is on close examination found to be voluminous but contradictory. A recent meeting convened by the National Research Council's Assembly of Life Sciences on the status of knowledge of health effects of air pollution left these tentative conclusions: 1) due to limits of present

Figure 5.

New vehicle standards summary

Increasingly stringent emission standards for new vehicles sold in California have been imposed by State and Federal law.

The summary of regulations is printed below:

Light-duty Vehicles under 6,000 lbs.

YEAR	STANDARD	COLD START TEST	HYDROCARBONS	CARBON MONOXIDE	OXIDES OF NITROGEN
Prior to controls			850 ppm (11 gm/mi)	3.4% (80 gm/mi)	1000 ppm (4 gm/mi)
1966-1967	State	7-mode	275 ppm	1.5%	no std.
1968-1969	State & Federal	7-mode			
		50-100 CID	410 ppm	2.3%	no std.
		101-140 CID	350 ppm	2.0%	no std.
		over 140 CID	275 ppm	1.5%	no std.
1970	State & Federal	7-mode	2.2 gm/mi	23 gm/mi	no std.
1971	State	7-mode	2.2 gm/mi	23 gm/mi	4 gm/mi
	Federal	7-mode	2.2 gm/mi	23 gm/mi	-
1972	State	7-mode	1.5 gm/mi	23 gm/mi	3 gm/mi
		or CVS-1	3.2 gm/mi	39 gm/mi	*3.2 gm/mi
	Federal	CVS-1	3.4 gm/mi	39 gm/mi	-
1973	State	CVS-1	3.2 gm/mi	39 gm/mi	3 gm/mi
	Federal	CVS-1	3.4 gm/mi	39 gm/mi	3 gm/mi
1974	State	CVS-1	3.2 gm/mi	39 gm/mi	2 gm/mi
	Federal	CVS-1	3.4 gm/mi	39 gm/mi	3 gm/mi
1975	State	CVS-1	1 gm/mi	24 gm/mi	1.5 gm/mi
	Federal	CVS-2	0.41 gm/mi	3.4 gm/mi	3 gm/mi
1976	State	CVS-1	1 gm/mi	24 gm/mi	1.5 gm/mi
	Federal	CVS-2	0.41 gm/mi	3.4 gm/mi	0.4 gm/mi

ppm parts per million concentration
gm/mi grams per mile
7-mode is a 137 second driving cycle test.
CVS-1 is a Constant Volume Sample cold start test.
CVS-2 is a Constant Volume Sample cold start test average with a Constant Volume Sample hot start test, both with the Federal 22 minute driving cycle.
The values in parentheses are approximately equivalent values.
* hot seven-mode

FIGURE 6

COMPARISON OF NATIONAL AND CALIFORNIA AMBIENT AIR QUALITY STANDARDS

	National Primary	National Secondary	California
SO_2			
Ann. av.	0.03 ppm	0.02 ppm	--
24-hr av.	0.14	0.10	0.04 ppm
3-hr av.	0.5	0.5	--
1-hr av.	--	--	0.5
CO			
8-hr av.	9 ppm	Same	--
1-hr av.	35 ppm	Same	40 ppm
12-hr av.	--	--	10 ppm
Oxidant			
1-hr av.	0.08 ppm	Same	0.10 ppm
Particulate			
Ann. av.	75 $\mu g/m^3$	60 $\mu g/m^3$	60 $\mu g/m^3$
24-hr av.	260 $\mu g/m^3$	150 $\mu g/m^3$	100 $\mu g/m^3$
NO_2			
Ann. av.	0.05 ppm	Same	--
1-hr av.	--	--	0.25 ppm
HC			
Non-CH_4 "C" (6-9 a.m. av.)	160 $\mu g/m^3$ (0.25 ppm)	Same	

knowledge, it is impossible at this time to establish an ambient air concentration of any pollutant--other than zero--below which it is certain that no human beings will be adversely affected, 2) evidence suggests that the reaction products of a mixture of pollutants may be more significant in impairing health than any primary pollutant alone.

The health effects associated with ozone, sulfur dioxide and nitrogen dioxide are, from epidemiological studies, due to irritations and aggravations to the upper respiratory tract. These effects are more pronounced for persons having histories of chronic asthma, bronchitis and general respiratory illnesses. The carbon monoxide standard is to protect persons with cardiac disease and maintain a level of 2% carboxyhemoglobin or less in individuals. High continuous levels of carbon monoxide may dull senses, cause dizziness and nausea.

Conclusion

I concur with the opinion held by many, that the eventual attainment and maintenance of the Ambient Air Standards cannot be accomplished without sound land use and transportation planning. Stationary and mobile controls are well on the way. The elements now missing in our control program are the forementioned ones of land use and transportation planning. On close examination one finds that many of the problems now faced in air pollution are the sins of the past regarding land use and lack of mass transit systems.

The road to be hoed will be a difficult one, for these elements are those which affect the general public in a most intimate and economic way, and may well result in a change in today's life styles.

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THE ROLE OF METEOROLOGY IN AIR QUALITY

Richard H. Thuillier

Introduction

The quality of the air we breathe depends primarily upon two factors: the type and amount of pollutants emitted from the source complex and the extent to which these pollutants are dispersed in the atmospheric medium. The former is at least partially under the control of man (nature is also a source of pollution) while the latter is almost entirely beyond his control. Before one can assess the impact of a pollutant emitting source, whether it be a stack, a road, a shopping center or a regional transportation system, an understanding of the role of atmospheric processes (meteorology) in dispersing pollutants is required.

Weather Systems and Pollutant Episodes

If we consult the weather section of the daily newspaper, we will usually find a weather "map" which indicates the distribution across the country of "highs", "lows", and "fronts". These features are indicative of motions induced in the atmospheric fluid by the sun's heating of the rough and varied surface of the rotating earth. The weather map, by indicating the patterns of barometric pressure observed at least four times each day by a network of stations, provides, as it were, a snapshot of the disturbed fluid at a particular time of a particular day. If we were to examine the weather maps in successive editions of the newspaper, we would notice that each successive weather map is different from the one before and that certain identifiable features may be seen to move along well defined paths from one location to another. A closer look at the individual weather maps will reveal that associated with certain of the map features we have just described are areas with greatly varying weather such as clear and cloudy areas, calm and windy areas, quiet and stormy areas. Such an examination will also reveal that the direction of the wind is closely associated with the moving map features. Since the dispersing capacity of the atmosphere responds to the type of weather existing at a given place and a given time, we would expect, and do in fact find a great variability in the day to day quality of the air we breathe, even with little or no variability in the rate of emission of pollutants from sources. The variability in weather patterns and associated dispersion of pollutants brings us an occasional episode of several days duration characterized by especially poor air quality, underscored by reduced visibility and a distasteful discoloration of the air. The same variability provides those sparkingly clear days which belie the relentless emission of pollutants from myriad sources. By studying directly the statistical distribution of weather conditions in an area or at a site (climatology) or indirectly the statistical distribution of pollutant concentration values (parts per million) measured by air monitoring stations, the potential or tendency for the development of pollution episodes may be assessed. This potential will vary from place to place and should be of concern to anyone engaged in planning land use or transportation.

Weather Elements and Pollutant Dispersion

The specific way in which the weather features discussed above affect the dispersion of pollutants is by affecting locally or regionally the characteristics of certain weather elements which are in turn directly involved in the pollutant dispersion process. Of these, the most fundamental are the characteristics of air flow and temperature structure.

Air flow characteristics: The direction of air flow is very important from an air pollution standpoint, since it determines the location of receptors relative to the location of sources. Wind direction depends, in a gross sense, upon the orientation of the isobars or lines of equal barometric pressure which delineate the lows and highs on the weather map. It is also influenced to a considerable extent by the presence of topographical features and man-made structures. Topographical features such as canyon walls, valley floors and bodies of water can be heated (by day) or cooled (by night) in a horizontally non-uniform manner due to different surface and slope characteristics, giving rise to local air circulations such as sea breezes and valley winds. Air flow can also be channeled around obstructions such as ranges of hills or large structures. Consequently, wind direction in hilly or mountainous terrain or in urban street canyons may be quite different from that which is indicated by a weather map or the data taken at an airport in nearby but locally flat terrain.

In extensively flat areas such as the central plains of the United States, wind direction information from a single airport station may be quite representative of hundreds or even thousands of square miles surrounding the station. In topographically complex areas, however, stations farther away from a site than the nearest hill may not be representative. Another characteristic of wind direction in complex terrain is a large diurnal (during the day) variability. Local circulations such as sea breezes or valley winds will cause different and frequently opposite directions to occur at different times of the day. In such situations, separate wind roses should be prepared for different times of the day as well as the standard rose for all hours. While wind roses are useful for indicating the relative frequency of various wind directions, it should be borne in mind that for short periods of time, the wind can come from any direction. For this reason, wind direction characteristics of a site may be of little importance in assessing air quality impact of a source relative to a standard which is not to be exceeded more than one hour per year.

The other important characteristic of air flow is the wind speed. While sources emit pollutants at a fairly constant rate, the speed with which a volume of air passes a source will determine the quantity of pollutant the volume receives from the source. Since the concentration or quantity of pollutant per unit volume of air, rather than the rate of emission from the source, is of importance in determining the quality of the air, wind speed and the associated dilution of pollutants at the source is an important meteorological parameter. In addition to the mechanism just described, wind speed has an indirect effect upon dilution by aiding in the production of turbulence in the air. As a general rule, turbulence will increase with an increase in the speed of airflow over the ground. Since increased turbulence leads to increased dilution of pollutants by mixing with cleaner air, wind speed is indirectly associated with this dilution.

Temperature structure and atmospheric stability: Due to the differential heating and cooling of the earth's surface as mentioned above and due, also, to vertical and horizontal movements of air in various layers above the surface, air temperature will vary both horizontally and vertically. When large temperature differences occur horizontally, as mentioned earlier, local air circulations will sometimes occur. Large temperature differences in the vertical will affect the development of turbulence and vertical circulations which are necessary for effective dilution of pollutants from surface sources by mixing with the cleaner air above. In this section we will discuss the relationship between vertical temperature structure and air quality.

On an averaged basis, all over the globe and in the first few miles above the surface, temperature decreases with altitude at the rate of several (usually no more than about five and one-half) degrees Fahrenheit per thousand feet. There are a number of processes, however, that can cause the temperature structure to differ, at a given place and time, from the average condition. Strong heating of the surface of the earth on a hot summer day will cause the air in contact with the ground to reach high temperatures. If the rate of heating near the ground is faster than the rate at which the heat can be transferred to the air higher up, a temperature change of more than five and one-half degrees Fahrenheit per thousand feet may occur near the ground. If the ground is cooled instead of heated, smaller decreases or even increases in temperature with altitude may occur. Departures may occur within discreet layers at any altitude due to different directions of transport at different altitudes. Thus cool marine air may be transported in the lower layers to a site onshore by the action of the seabreeze while the upper layers remain warm on offshore winds. Finally, air which descends from higher to lower altitudes can be heated by compression since atmospheric pressure increases as the surface of the earth is approached.

The rate with which temperature increases or decreases with altitude has a lot to do with the development of atmospheric turbulence which is necessary for dilution of pollutants in the air by mixing. When the temperature in a layer of air decreases rapidly with altitude, turbulence can develop readily and we say that the layer is unstable. When the decrease with altitude is slight or when an increase in temperature with altitude occurs, we say that the layer is stable, since the development of turbulence is inhibited in such cases. Layers in which the temperature increases with altitude are termed inversion layers. Inversion layers are very stable and the development of turbulent conditions in such layers is difficult. Consequently, inversion layers are characterized by a very slow rate of mixing. If a plane or cloud of pollutant gas is emitted into an inversion layer, it will mix very slowly with the surrounding cleaner air and stay fairly concentrated for a long distance downwind of the source. If a plume or cloud of pollutant gas is emitted into an unstable layer adjoining the inversion layer, the gas will be readily mixed by turbulence in the unstable layer but will not readily mix into the inversion layer the boundaries of which act as barriers to the vertical transport of pollutants.

It is quite common in most parts of the world, over the land areas, for stable layers to form near the surface as the result of night-time cooling of the ground in conjunction with one or more of the other processes described earlier. Such a stable layer, or possibly even an inversion layer, may extend several thousands of feet above the ground.

Heating of the ground (by day) or air flow over the rough surface at any time will usually result in the formation of unstable conditions in the air immediately adjacent to the ground. In such situations, when unstable air next to the ground is overlain by more stable air above, pollutants emitted at ground level will be mixed in the unstable air near the ground. The mixing will continue until the pollutants are distributed vertically throughout the unstable layer, but mixing will not proceed into the more stable air above, the base of which acts as a lid. The boundary between the stable and unstable layers is called the mixing height and varies in both space and time. The mixing height is usually greatest in the mid afternoon (several thousand feet) when the surface heating and wind speeds are greatest and least in the early morning (several hundred feet or near zero) when surface cooling and wind speeds are least.

Information on temperature structure in the vertical is obtained by sending up balloons equipped with radio transmitters. As the balloon ascends, information on the temperature structure is transmitted to a receiver on the ground. Statistics on the mixing height characteristics of an area may be obtained from such balloon sounding (radiosonde) data, but as in the case of the winds, care should be exercised in extrapolating such data throughout complex terrain.

Visibility and Air Quality Awareness

One of the most pervasive and persistent indicators of the presence of air pollution is reduced visibility. During pollution episodes, our treasured views of mountain and sky are partially or totally obscured due to the scattering or absorption of light by the particles in the polluted air. The same optical properties of the particles, and certain gases, give rise to a distasteful coloration of the air. If the air were completely free of particles, scattering by the air molecules alone would reduce visibility to about 150 miles. When particles are present, visibility may be reduced to a couple of miles and fog droplets, of course, can reduce visibility to near zero. As it turns out, the amount of light scattering by particles in the air is very highly dependent upon the size of the scattering particles as well as the number of particles present. Particles in the size range from one-tenth to one micron (millionth of a meter) scatter most efficiently while larger and smaller particles scatter less efficiently. When the relative humidity exceeds 70 percent, many types of pollutant particles take on water to form droplets which are larger in size than the original particles. This process can frequently enhance the reduction of visibility when small particles grow to the optimum scattering size. As with all pollutants, the concentration of particulate matter in the air will increase under conditions of light wind and a stable temperature structure. The increase in particle concentration may lead to visibility reduction in and of itself, but high humidity may be an added weather element of concern. In any event, the formation of water droplets in the form of fog or haze is always indicative of the presence of particles in the air. In regions with frequent incidence of high relative humidity, the aesthetic impact of air pollution in the form of visibility reduction will usually be more severe than is the case in the drier regions.

Conclusion

As we have seen in the foregoing discussion, weather elements play an important role in determining the impact of a given air pollutant emission. When analyzing air quality impact, care should be given to obtain meteorological information for the site or area of concern and a professional meteorologist should be consulted in complex situations. It would be well for those engaged in air quality impact analysis on a continuing basis to collect and maintain a library of meteorological and climatological data for their areas of concern, as a ready reference. Sources of such information include the National Weather Service, Air Force, Navy, and some Army bases, air pollution control agencies, universities and colleges and industrial plants, sewage treatment plants and others. A centralized source of weather information from all over the country is the National Climatic Center, Federal Building, Asheville, North Carolina.

THE STATE OF THE ART IN AIR QUALITY MODELING

Warren B. Johnson, Jr. and Richard H. Thuillier[1]

Introduction

Before proceeding with an exposition of the state of the art in air quality modeling, it will be worthwhile to define the terms "modeling" and "state of the art" and to say a few words about the development of the current need for air quality models.

Air quality depends, quite simply, upon the degree to which our air is contaminated by harmful substances. Such substances are emitted from a great variety of sources and mixed with the air. Once the contaminant leaves the source, it is subject over time to increasing dilution as the process of mixing continues. As dilution increases, the degree of contamination decreases and the quality of the air improves. The more highly the parcel is contaminated at the source, the less effective will be the dilution upon the quality of the air. The more sources which contribute to the contamination of the parcel as it moves along, the poorer will be the quality of air in the parcel. Finally, the more vigorous the mixing, the greater the dilution and the better the air quality for a given amount of source contamination.

All of these things are somewhat obvious to us in a qualitative and general sense, but when the source structure and the meteorological conditions become complex, intuition fails and a formal, systematic procedure is required to establish a meaningful relationship between source emissions and air quality through the intervening action of meteorological dilution. Such a procedure is referred to as an air quality model.

The degree to which we may formalize the intricate relationships involved in air quality depends upon our knowledge of the existence and nature of contaminant sources and the atmospheric processes involved in mixing contaminants with and removing them from the air. The rapidity and thoroughness with which we can handle analyses involving vast source complexes and intricate meteorological interactions depends upon the development of efficient data processing facilities and analysis methods. Finally, the ability of the user to comprehend and utilize modeling techniques and incorporate them in the decision making process depends upon the user's technical and fiscal resources and the credibility of the modeling process itself. All of these considerations are intimately involved in determining the state of the art of air quality modeling.

In the early days of air quality control, little need existed for a formalized approach to air quality evaluation. Technological reduction of emissions at the source of curtailment of certain source operations was a direct and cost-effective method of effecting substantial improvement in air quality. The recent introduction of comprehensive and quantitative air quality standards, however, coupled with a rapid increase in the number of sources, has given rise to a need for far greater control than had heretofore been envisioned or achieved. Control costs have increased tremendously as has the political sensitivity of many control decisions. Control effectiveness must therefore be carefully and accurately evaluated and the need for formalized air quality modeling is obvious.

Air Quality Modeling in the Decision Making Process

There are two principal uses to which air quality models may be put. The first of these is to serve as tools for research in gaining a better understanding of the processes involved in the determination of air quality. The second is to serve as tools to aid the decision maker in the day to day effort to hold the line on air quality degradation and in planning for the eventual attainment and maintenance of air quality standards.

In view of the symposium's orientation toward the latter use of modeling, it will be worthwhile to discuss the context or framework of the decision making process vis a vis the use of air quality modeling as outlined in Figure 1. In this context, the specific relationship between emissions and air quality, involving the processes of meteorology, will be referred to as an air quality "simulation" model (AQSM) in order to distinguish it from the more general framework which itself may be thought of as an air quality model of broader context.

When used by itself, the AQSM provides information on a relative though quantitative scale. We may relate conditions of source configuration and meteorology to greater or lesser levels of contamination but we cannot attach any objective significance to those levels. Decision making is better served when the results of the AQSM are coupled with a set of standards against which one can objectively gauge significance. Such standards exist today as promulgated by federal and state government, based directly on health, biological, materials and aesthetic effects.

If the direct effects of contamination levels, as embodied in the standards, were the only item of concern, effective decision making could proceed at this point. This is frequently the case with single

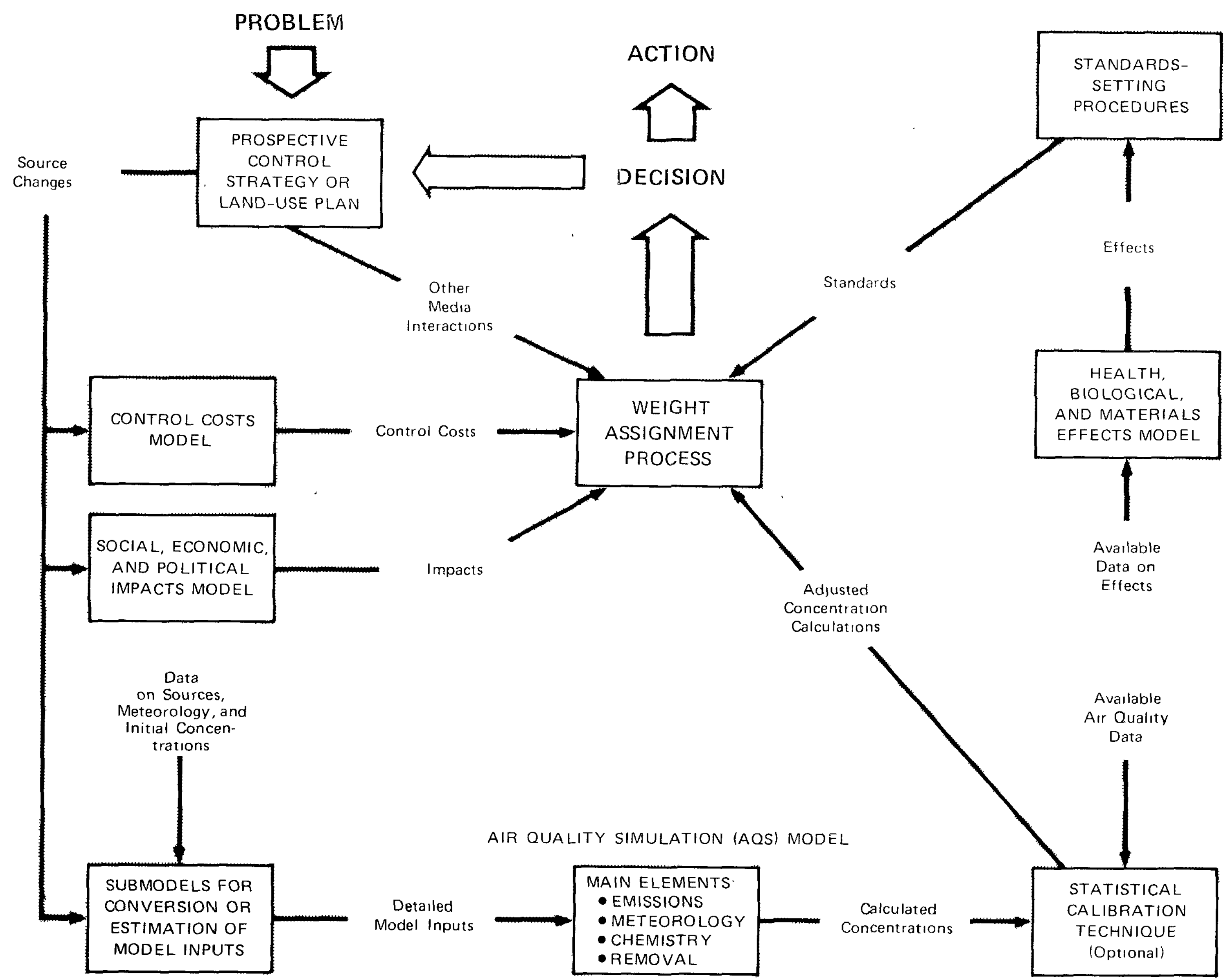

PROBLEM
ACTION
DECISION
STANDARDS-SETTING PROCEDURES
PROSPECTIVE CONTROL STRATEGY OR LAND-USE PLAN
Source Changes
Effects
Standards
Other Media Interactions
CONTROL COSTS MODEL
Control Costs
WEIGHT ASSIGNMENT PROCESS
HEALTH, BIOLOGICAL, AND MATERIALS EFFECTS MODEL
SOCIAL, ECONOMIC, AND POLITICAL IMPACTS MODEL
Impacts
Adjusted Concentration Calculations
Available Data on Effects
Data on Sources, Meteorology, and Initial Concentrations
Available Air Quality Data
AIR QUALITY SIMULATION (AQS) MODEL
SUBMODELS FOR CONVERSION OR ESTIMATION OF MODEL INPUTS
Detailed Model Inputs
MAIN ELEMENTS:
• EMISSIONS
• METEOROLOGY
• CHEMISTRY
• REMOVAL
Calculated Concentrations
STATISTICAL CALIBRATION TECHNIQUE (Optional)

Figure 1.

purpose air pollution control agencies and single purpose legislation such as the Clean Air Act. Realities, however, require that social, economic and political considerations be included.

Basic Modeling Approaches

As mentioned above, the process of air quality modeling is simply a formal, systematic procedure for relating source emissions to air quality. Historically, this procedure has involved a priori approaches based on mathematical physics or the statistical theory of turbulence, a posteriori approaches based on empirical relationships deduced from an analysis of observed data, or a combination of the two approaches. When reviewing the literature, it soon becomes evident that there are just about as many models as there are individuals who are inclined to model. Excellent and detailed summarizations, analyses and bibliographies relating to the gamut of research in air quality modeling are presented by Sutton (1933), Pasquill (1962), Moses (1969), Stern (1970), Eschenroeder et al (1972), Dodge (1972) and Seinfeld et al (1973). All of the modeling approaches described in these reports are reasonable methods for arriving at the relationship between the emission rate of contaminants and resultant air quality. The choice of any one approach depends primarily upon the quality of the input data, the fiscal and technical resources of the user and the nature of the problem to be solved. We shall not devote time to each of the modeling approaches described in the aforementioned summaries but will treat, rather, the basic classes of models with specific references to some typical and widely accepted examples.

Boundary layer models: The most generalized and sophisticated class of models is based on the physical principle of conservation of mass applied to the turbulent layer of air near the surface of the earth. A mathematical equation which may be written in the form of equation (1) describes the balance of physical processes that must be satisfied under the assumption of pollutant mass conservation. In equation (1)

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} + w\frac{\partial C}{\partial z} = \frac{\partial}{\partial x}\left(K_h\frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_h\frac{\partial C}{\partial y}\right) + \frac{\partial}{\partial z}\left(K_v\frac{\partial C}{\partial z}\right) + R + S \quad (1)$$

which is usually referred to as the diffusion equation, C is the concentration (mass per unit volume) of a given contaminant in the air. The first term on the left represents the rate of change of concentration with time; the second term represents the transport of contaminated air by the three components of the mean wind (advection); the first term to the right of the equal sign represents the transport of contaminated air by turbulent motion (diffusion) and the last two terms represent respectively the changes in contaminant concentration due to chemical reactions in the air and the changes due to the contributions from sources and the removal by processes such as deposition and rainout. The equation is valid at a given point in space (x,y.z) and time (t). The quantities K_h and K_v are related to the scale and intensity of turbulence and are derived from the statistical and dimensional theory of turbulence in the boundary layer. The form in which equation (1) appears is termed "Eulerian" which means that the equation is solved for a fixed point in space as the air flows by.

The usual method of solution of equation (1) is by the technique of numerical integration in which the derivatives, which are instantaneous rates of change at a point, are replaced by finite differences, which are average rates of change between two points. The points between which the finite differences are evaluated are arranged on a uniformly spaced grid covering the geographical area in which air quality is to be modeled and the contaminant concentrations are evaluated at discrete points in time at each of the geographical grid points. Since the equation involves only rates of change in concentration with time, concentration values must be provided at each grid point for some initial (starting) time. A high speed computer is used to do the "bookkeeping" involved in keeping track of the many interacting processes taking place on the grid.

An alternative approach to the "Eulerian" is the so called "Lagrangian" approach. In this approach, concentration changes are calculated within a specified parcel of air as it travels along in the flow of air. The form of the equation is essentially the same as equation (1) except that the advection term is absent. Strictly speaking, the Lagrangian approach involves the statistics of the displacements of contaminated parcels in a turbulent flow field along with the mass balance associated with each parcel. In practice, parcels are followed along mean wind trajectories.

Advantages: The boundary layer approach, since it involves physical, deterministic modeling, is potentially the most general of all modeling techniques. Since the diffusion equation is prognostic in form, containing the time derivative of concentration, the approach is applicable to time dependent input such as changing meteorological conditions in evolving air pollution episode situations. Since the rate equations for chemical transformation are similar in form, chemical transformations of pollutant species may be handled in conjunction with advective and turbulent transport to produce a comprehensive transport and air chemistry model. Finally since advective and turbulent transport are contained in separate terms of the equation, the approach can readily handle the light and variable or even the calm conditions of air motion associated with severe pollution episodes.

Disadvantages: The principal disadvantages to the use of boundary layer modeling is one of cost. In order to achieve any useful degree of resolution in space or time, the iterative schemes for solution of the equation in its most general form require large amounts of computer time and core storage. Use of such models is usually limited to agencies with substantial computational facilities. Even with the availability of such facilities, the use of such models for routine operational purposes or for climatological studies involving large numbers of component meteorological regimes is largely precluded by factors of cost. Finally, it should be noted that the accuracy implied in the solution of the physically based diffusion equation can, in reality, be greatly diluted by virtue of the approximate nature of the numerical integration and the high degree of parameterization required to facilitate a solution particularly in the case of sparse or inadequate input data.

Among the examples of boundary layer models we might mention the models of Lamb (1969), Shir and Shieh (1973), MacCracken (1971), Eschenroeder and Martinez (1971), Wayne et al. (1971), and Sklarew et al. (1972). The first three of these are Eulerian grid models, the next two are Lagrangian trajectory models and the last is a hybrid form known as a "particle-in-cell" model which involves the movement of discrete particles, representing given masses of contaminant, through an Eulerian grid. Each of the above models handles the modeling problem in a slightly different way with differing advantages and disadvantages.

Most of them are equipped to handle the full range of reactive and non-reactive species of contaminant.

Chemical sub-models: As mentioned earlier, the boundary layer models are capable of addressing the problem of chemical reactions in the atmosphere. When used for this purpose, a sub-model based on the theory of chemical kinetics is involved. Large numbers of chemical reactions are involved in the transformation of contaminant species which takes place in the atmosphere. Chemical kinetics schemes have been devised to account for varying numbers of these reactions as indicated in Figures 2 and 3. Rate constants for the various reactions are varied within their respective ranges of uncertainty and schemes for lumping similar classes of reacting species are devised with a view toward simulating the atmospheric chemistry as closely as possible with the least number of reaction steps. Almost all of the verification studies for the kinetic sub-models are conducted by comparing the predictions of the model with results obtained by combining contaminants in a laboratory as indicated in Figure 4 for reaction chamber studies but little has been done to validate such schemes in the real atmosphere due to the almost insurmountable complexities involved in such experiments.

Gaussian models: Probably the most widely used of the various modeling approaches is the so called Gaussian plume model. This model assumes that the contaminant plume from a single point source is characterized by a normal (Gaussian) distribution of contaminant concentration about the plume centerline. The spread of the plume with distance downwind of the source is represented by treating the standard deviation of the concentration distribution as an increasing function of

SOME KINETICS SUBMODELS FOR PHOTOCHEMICAL REACTIONS

INVESTIGATORS	NO. OF REACTION STEPS
Eschenroeder and Martinez (1970)	12
Seinfeld et al. (1971)	14
Wayne et al. (1971)	33

Figure 2.

RATE COEFFICIENTS FOR GRC KINETICS MODEL (ESCHENROEDER AND MARTINEZ, 1970)

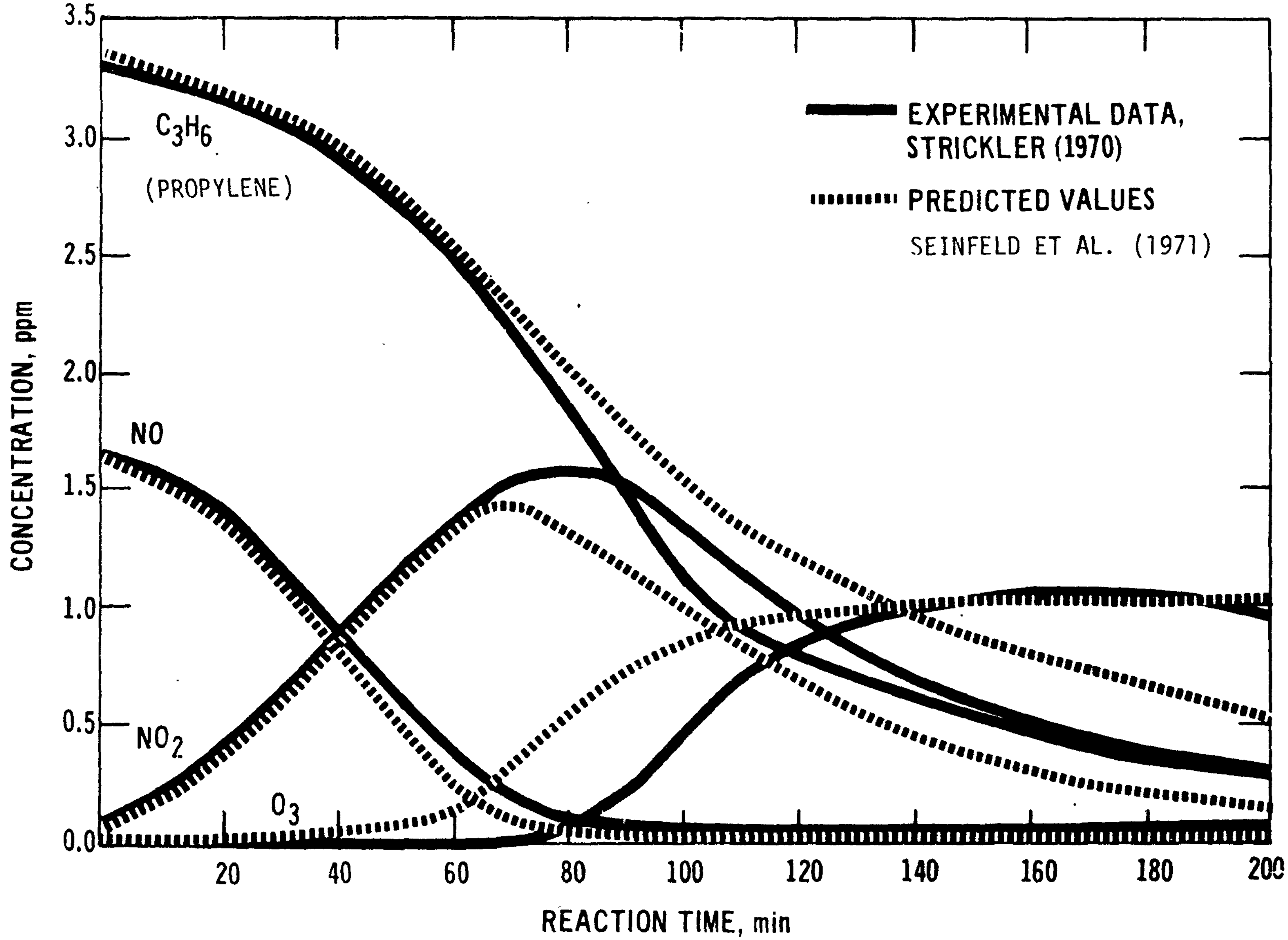
(Stoichiometric inbalances may result from lumped parameter assumptions)

REACTION	MODEL VALUES FROM VALIDATION	NORMAL VALUES FOR PROPYLENE SYSTEM	UNITS
$h\nu + NO_2 \rightarrow NO + O$	0.4	0.4	min^{-1}
$O + O_2 + M \rightarrow O_3 + M$	1.32×10^{-5}	1.32×10^{-5}	$ppm^{-2}min^{-1}$
$O_3 + NO \rightarrow NO_2 + O_2$	40	22-44	$ppm^{-1}min^{-1}$
$O + HC \rightarrow 2RO_2$	6100	6100	$ppm^{-1}min^{-1}$
$OH + HC \rightarrow 2RO_2$	80	244	$ppm^{-1}min^{-1}$
$\dot{R}O_2 + NO \rightarrow NO_2 + 0.5\ OH$	1500	122	$ppm^{-1}min^{-1}$
$RO_w + NO_2 \rightarrow PAN$	6	122	$ppm^{-1}min^{-1}$
$OH + NO \rightarrow HNO_2$*	10	99	$ppm^{-1}min^{-1}$
$OH + NO_2 \rightarrow HNO_3$*	30	300	$ppm^{-1}min^{-1}$
$O_3 + HC \rightarrow RO_2$	0.012	0.009 - 0.012	$ppm^{-1}min^{-1}$
$NO + NO_2 \rightarrow 2HNO_2$**	0.01		
$h\nu + HNO_2 \rightarrow NO + OH$	0.001		

* Rate constant lumps third body concentration

**Water vapor lumped into rate coefficient

Figure 3.



EXPERIMENTAL DATA, STRICKLER (1970)
PREDICTED VALUES
SEINFELD ET AL. (1971)
C_3H_6
(PROPYLENE)
NO
NO_2
O_3
CONCENTRATION, ppm
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
20
40
60
80
100
120
140
160
180
200
REACTION TIME, min

Figure 4.

downwind distance. The algorithm for the Gaussian model takes the generalized form:

$$C = \frac{Q}{2\pi\sigma_y\sigma_z u} \exp\left(-\frac{y^2}{2\sigma_y^2}\right)\left[\exp\left(-\frac{(H-z)^2}{2\sigma_z^2}\right) + \exp\left(-\frac{(H+z)^2}{2\sigma_z^2}\right)\right]$$

where C is contaminant concentration; H is the height of the plume above the ground; u is the wind speed, σ_y and σ_z are the horizontal and vertical standard deviations, respectively of the Gaussian distribution; y and z are, respectively the vertical and crosswind distances from the plume centerline; and e is the base of the natural logarithms. Figure 5 gives a schematic presentation of the spreading plume from an automotive line source and Figure 6 gives a definition of the variation of standard deviation (vertical) with distance for various meteorological conditions on the basis of empirical studies.

Advantages: The principal advantage of the Gaussian approach is the relative simplicity of the modeling algorithm. Properties of the normal distribution have been extensively documented and the solution of the algorithm as a function of space is straightforward. Extensive field investigations have provided considerable data on the concentration standard deviation as a function of downwind distance and broad classes of meteorological conditions. The model can readily be extended to two and three dimensional source configurations by spacial integration of the point source algorithm. Multiple sources can be handled by superposition of point source plumes. Finally, due to the simplicity of the algorithm and its algebraic nature, the Gaussian models are very inexpensive to implement, may be run on desk calculators or by hand and are easily reduced to nomographic solution form.

Disadvantages: The principal disadvantage of Gaussian models is the requisite assumption of "steady state" meteorological conditions. These conditions must prevail for a minimum time period on the order of ten minutes to one hour and up to a time period equal to the furthest downwind distance of concern divided by the wind speed. Curvature of the plume centerline cannot readily be handled. Since most of the empirical data on plume concentration standard deviation has been obtained at locations characterized by relatively flat terrain, use of the models is usually restricted to similarly flat terrain locations. The form of the Gaussian algorithm itself presents a problem since wind speed in the denominator can not approach zero too closely without causing unreasonable results. Therefore, the model is not applicable in calm or very light wind situations. Finally, the method of plume superposition does not lend itself to the consideration of chemical reaction between contaminants from different sources. Some of these disadvantages, specifically those associated with steady state requirements and light wind conditions may be overcome by treating individual contaminant "puffs" in a Lagrangian manner. The added flexibility, however, is offset by a much greater computational burden.

Among the many examples of Gaussian modeling, we may mention the work of Turner (1964, 1969), Miller and Holzworth (1967), Johnson, Ludwig and Moon (1970). The monograph of Turner (1969) is an excellent combination text and workbook which provides a thorough introduction to the use of the Gaussian modeling technique. A simplified version of the Gaussian model which is useful in many urban modeling situations has been presented by Gifford and Hanna (1973) and a number of simplified versions are presented in this symposium in the paper entitled "Simplified

VERTICAL DIFFUSION ACCORDING TO GAUSSIAN FORMULATION

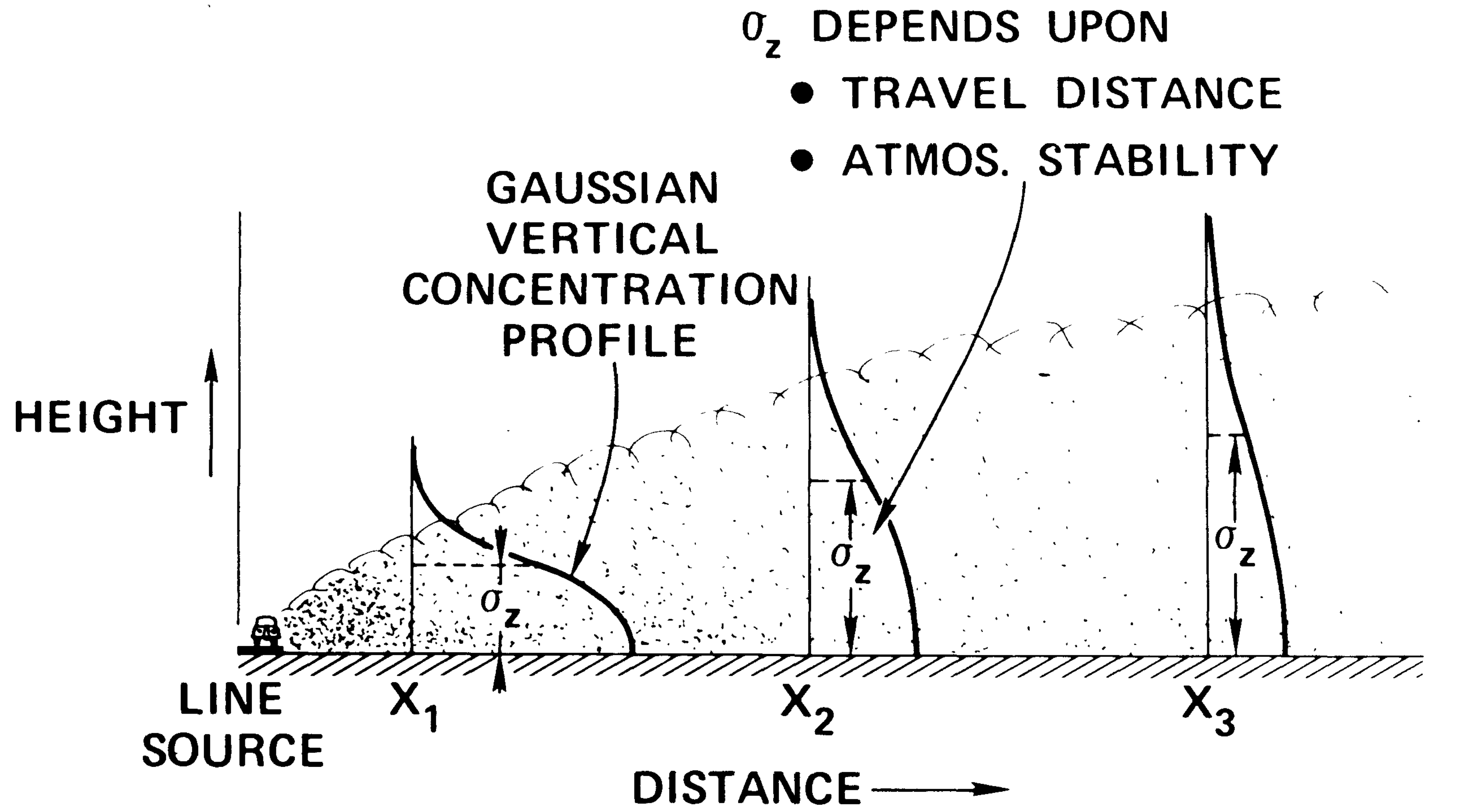
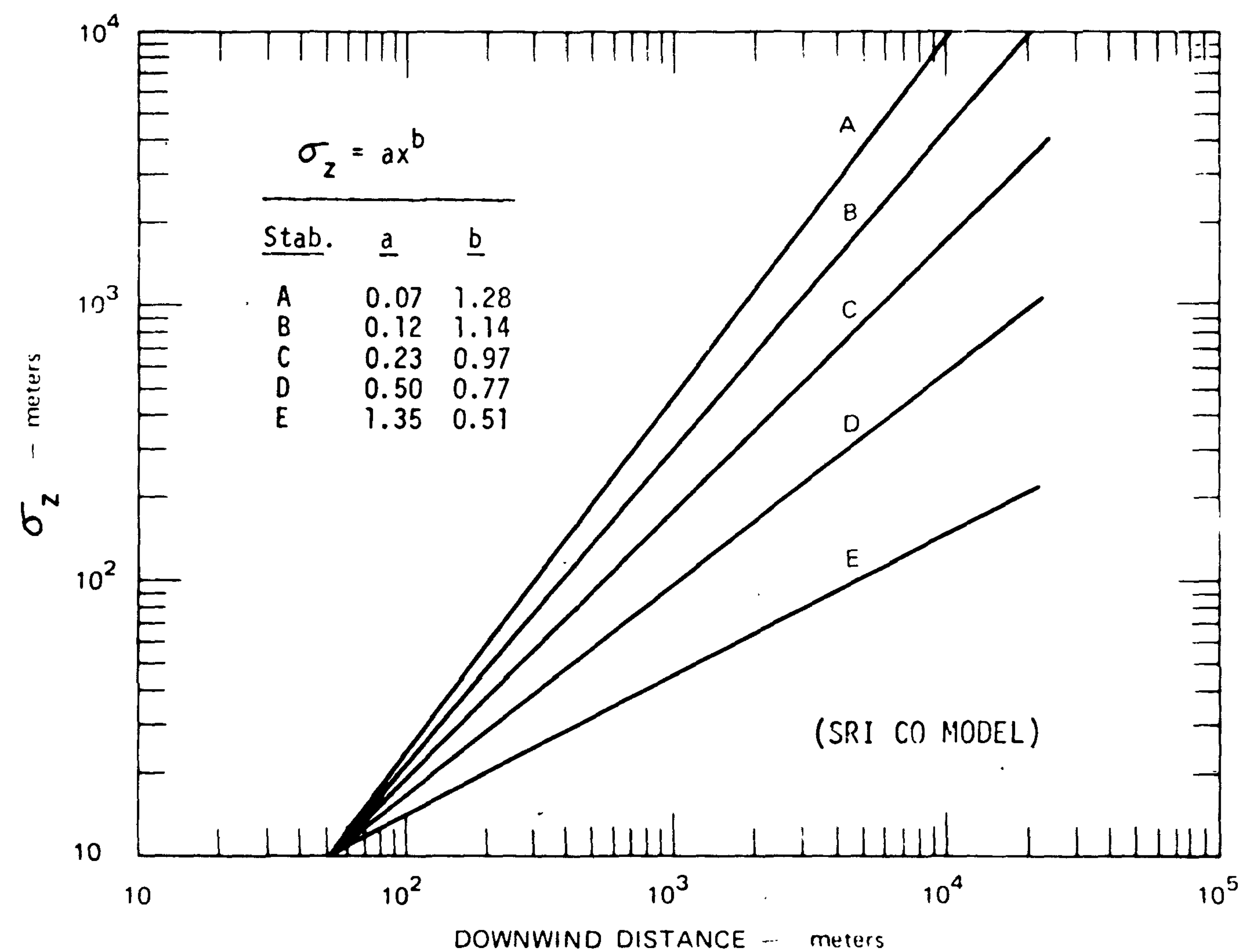


Figure 5.



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VERTICAL DIFFUSION AS A FUNCTION OF TRAVEL DISTANCE AND STABILITY CATEGORY, AS REVISED FOR URBAN CONDITIONS

Figure 6.

Techniques for Air Quality Impact Analysis."

Statistical models: In addition to the Boundary Layer and Gaussian modeling techniques, which are essentially a priori techniques based on physical relationships, there is a third class of models which relies primarily on a posteriori statistical relationships. This modeling approach takes advantage of the information which is contained in existing data sets, involving emissions and concentrations of pollutants with or without meteorological factors.

The principal advantage in the use of statistical models lies in their derivation from observed data, reflecting processes as they actually took place in the atmosphere. They also lend themselves to probabilistic assessments of air quality impact. The principal disadvantage of such models is their inability to handle substantial changes in the amount or geographical distribution of pollutant emissions from the situation which pertained during the data collection. Some of the disadvantages of both the physical and the statistical modeling techniques may be overcome by combining the two approaches. Thus, for example, the annual average pollutant concentration in some future year might be simulated by using a Gaussian or Boundary Layer model. Statistical techniques based on past data might then be used to estimate the frequency with which a one-hour air quality standard will be exceeded during the year.

Some examples of statistical modeling applications are given by Moses (1969), Larsen (1971), Wilting and Van den Berge (1971), and Thuillier (1973). The simple proportional rollback approach which is often used in impact estimations is itself a form of statistical modeling.

Modeling Resolution

One of the most important factors in air quality modeling is the modeling resolution or the scale in space and time on which the modeling is to operate. Some modeling applications might require the estimation of contaminant concentrations occurring on a single street corner and averaged over the period of an hour while other applications might require the annual average contaminant concentration, spatially averaged over an entire city. In addressing the federal and/or state air quality standards, a large variety of averaging times from hourly to annual average must be handled. The desired space and time resolution of the modeling results, coupled with the space and time resolution of available input data and the resources of the user will determine the type of model which will be desirable or suitable for a particular analysis. Fine resolution analyses covering extensive geographical areas and long time intervals tend to be expensive and require considerable modeling sophistication while coarse resolution analyses tend to be simpler and less expensive. In any event, it is never possible to achieve a resolution finer than that of the input emissions or meteorological data. Figures 7 and 8 provide some insights into the interrelationships among uses, users, and resolution of air quality simulation models.

Conclusions and Recommendations

The foregoing has been a brief exposition of air quality modeling as it exists today. No attempt has been made to present the individual modeling techniques in detail since such would be a monumental task out of all proportion in this symposium. The references cited at the end of this paper and throughout the symposium provide a thorough and detailed

ESTIMATES BY HILST OF THE MAXIMUM VARIABILITY OF AIR POLLUTION CONCENTRATIONS ($R = \chi_{max}/\chi_{min}$) (FROM HILST, 1967)

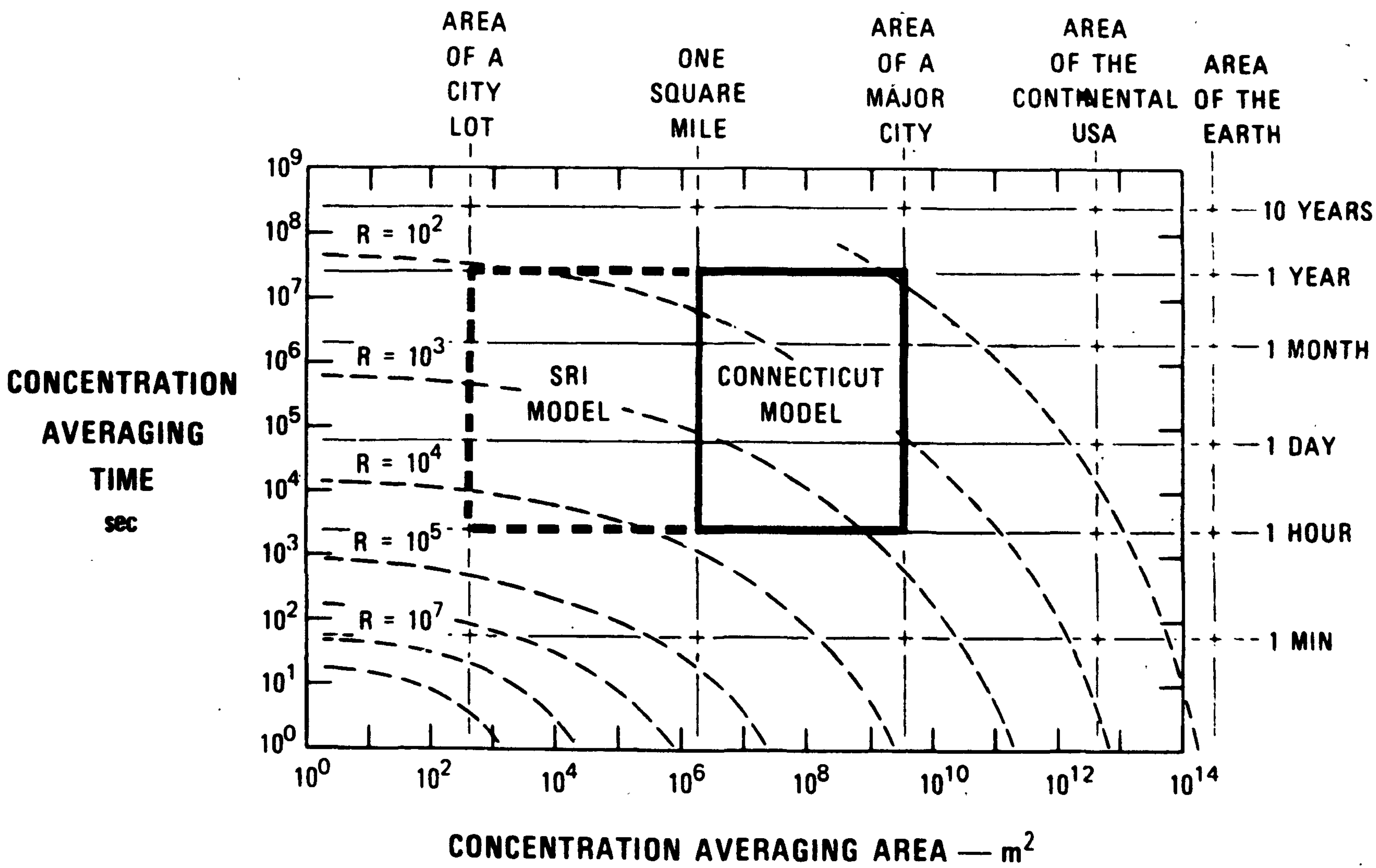

Figure 7.

SPECIFICATION OF MODEL APPLICATIONS
(ORGANIZED AS SUGGESTED BY PACK, 1970)

COMPLETE MATRIX FOR EACH MODEL, AND FOR EACH POLLUTANT, IN TERMS OF:

- Performance needed (design specs.)
- Performance achieved
- Cost per run etc.

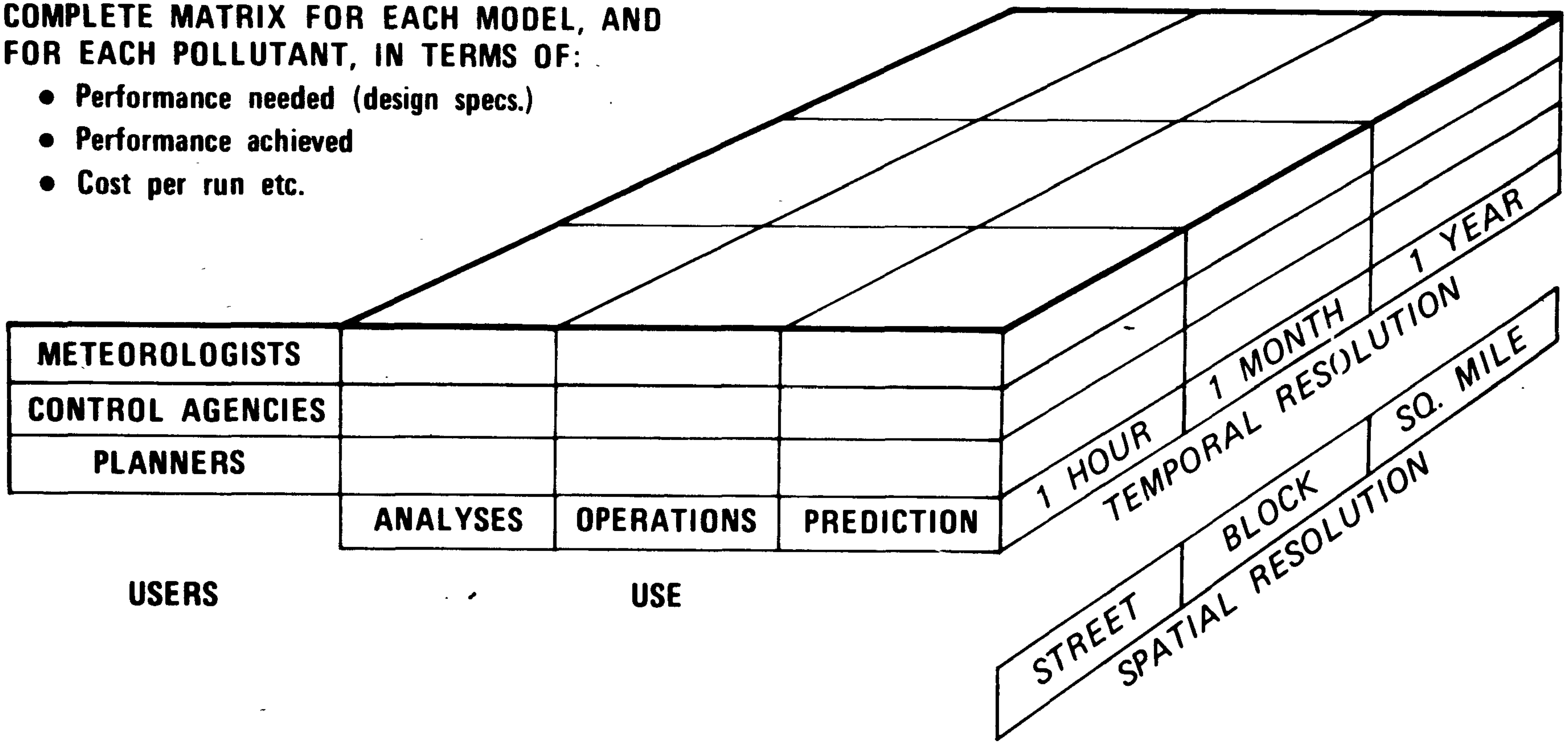

Figure 8.

exposition of the air quality modeling approach and technique. These and similar references should be carefully studied by anyone interested in developing an air quality modeling expertise. For those of limited technical, fiscal and computational resources, the Gaussian approach will serve to provide useful solutions to a great many problems. Even the simplest of modeling techniques, however, can benefit greatly from the insights of an expert in air quality impact analysis and such a person should be consulted whenever possible.

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[1]The presentation on this topic was made at the Symposium by Dr. Johnson who spoke in reference to a number of slides, some of which appear in this paper. Due to a malfunction of the taping procedure, the transcript of Dr. Johnson's talk was lost and no written version of the talk was available. Since a prior and protracted commitment has prevented Dr. Johnson from writing on the subject himself, Mr. Richard Thuillier, Conference Coordinator, has written this paper with Dr. Johnson's permission, using Dr. Johnson's figures.

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AIR POLLUTION EMISSIONS AND EMISSION FACTORS

Howard Harawitz

Introduction

This paper will describe how to estimate the quantity of pollutants emitted into the atmosphere as a result of community development. Together with meteorological data these quantitative estimates of pollutant emissions serve as the input to air pollution models which are used to predict the effect of development on air quality. The models take emission rates from all kinds of human activities and transform those rates into concentrations of contaminants in the atmosphere.

For example, a number representing a quantity of carbon monoxide emitted into the atmosphere would be converted by a model into numbers representing the concentration of carbon monoxide in the air we breathe. The emission rate of carbon monoxide could be expressed as tons-per-day emitted by a source or group of sources. The model would transform the tons-per-day figure into concentrations throughout the modeling area expressed as parts per million.

There are many different kinds of sources of air pollutant emissions, including factories, power plants, dry cleaning establishments, residences, motor vehicles, ships and airplanes. Some of these sources are themselves made up of other sources of air pollution. A factory, for example may contain furnaces, chemical reactors, space heaters and degreasers--all of which are emitters of air contaminants.

Motor vehicles are a most significant and extremely complex pollution source. There are many different kinds of motor vehicles operating in many different modes. There are light and heavy duty trucks and cars, with and without emission controls; there are vehicles accelerating, decelerating and cruising at steady speeds; and there are vehicles idling in parking lots--all contributing different amounts of pollutants to the atmosphere.

Because of these complexities it is not feasible to determine exactly the quantities of pollutants emitted in our existing communities. If it is not possible to determine precisely these existing emissions, how then are we to predict future emissions from communities that do not yet exist? Fortunately, for most planning purposes exact values of these variables are not required. Reasonable estimates, averages and approximations will generally provide enough information so that alternative strategies may be compared, evaluated, and related to air quality standards so that decisions can be made.

It is the purpose of this presentation to familiarize you with ideas and concepts as well as specific methods used in estimating air pollutant emissions for planning purposes.

Pollutant Source Categories

Most agencies divide pollutant sources into the categories of stationary and mobile sources. Stationary sources consist of power plants, refineries, residences, and the like. Mobile sources include automobiles, trucks, trains, ships, and airplanes.

For convenience in the development of an emission inventory for use in modeling, the multiplicity of different kinds of sources can be placed into the following categories:

Point sources

Area sources

Line sources

Mathematically speaking, a point source is a pollutant source the dimensions of which are negligible compared to the area being studied. The term "point source" is most commonly used, however, to specify a single source that emits a relatively high quantity of one or more pollutants. The Bay Area Air Pollution Control District's published Emissions Inventory, for example, lists about 100 specific sources that emit at least 0.1 ton/day of any contaminant. While it is often useful to single out substantial emitters for individual treatment, it is usually more convenient to treat smaller sources like automobiles, houses and small commercial units by aggregating them into area or line sources.

An area source is a collection of small sources, stationary and/or mobile, distributed over some geographical area. The area source boundary might coincide with a jurisdictional boundary, a physical boundary that affects the dispersal of pollutants, or the lines of a convenient geographical grid system.

A line source is a collection of individual sources distributed alone a single line, rather than a geographical area. The most obvious example of a line source is a highway or road. In this case, the individual sources are motor vehicles.

Emission Factors and Emission Rates

An emission factor is used to compute the rate at which a pollutant is released into the atmosphere by a source. For a given pollutant source, the emission rate is equal to an emission factor multiplied by a number expressing the level of activity of that source. Emission rates are expressed in units of mass per unit time, e.g., tons/year, tons/day, kg/day, lbs/hr, or grams/second.

For example, the emission factor for auto body incineration is 1.1 kilogram of carbon monoxide emitted per car body incinerated. (AP-42, 2.2-1) If six car bodies per hour are incinerated and the incinerator operates 8 hours per day, then the daily emissions can be computed as follows:

1.1 kg CO/car x 6 cars/hr x 8 hrs/day = 52.8 kg CO/day.

Emission factors for a great number of different kinds of industrial, and other, activities like furnace operation, cement manufacturing, oil refining, aircraft operations, etc. can be found in the U.S. Environmental Protection Agency publication, Compilation of Air Pollutant Emission Factors (AP-42). It should be pointed out that a great deal of judgment is required in using much of the information contained in that publication because things like process operating conditions and emission control devices must often be taken into account in computing emissions. However, reference to AP-42 in conjunction with conversations with appropriate air pollution control agency personnel can often enable planners to obtain useful approximations.

When emission factors for mobile sources are discussed, we generally mean emission factors for automobiles and trucks, although ships, trains, tractors and airplanes are mobile sources too. It is just that in most communities the highway vehicles account for almost all the emissions from mobile sources. (Emission Factors for motor vehicles are also included in the EPA publication AP-42.).

Computation of emissions from motor vehicles is complex because, as mentioned, the pollutant emission rate from any vehicle depends on its speed, mode of operation (that is, cruising, acceleration, deceleration), presence or absence of air pollution control devices, maintenance, etc. The situation is made even more difficult because of the great variety of vehicles on the road and the variation in traffic conditions during almost any given time period.

To make it possible for air pollution control districts, planners, developers and other interested parties to estimate emissions from motor vehicles, the EPA (and other agencies) have computed average emission factors. These are factors based upon statistical data for the average mix of vehicles on the streets and roads of the United States in a given year. They take into account mileage, emission control devices, deterioration, etc. Because of the changing emission control devices required in different model years, and the gradual replacement of older non-controlled vehicles by newer ones, emission factors are available for the predicted mix that will be on the highways in future years. This permits pollution control agencies, planners and others to estimate the impact of motor vehicles on air quality in future years.

The emission factor data for motor vehicles are derived from a test cycle through which various makes and models of vehicles are run, and their emissions measured. The cycle is presumed to represent some sort of typical everyday driving pattern. There is substantial controversy about whether the Federal Government's, or any other, test cycle is in fact representative of real driving conditions anywhere. The State of California, for example, has its own cycle which it claims is a more realistic representation of California driving patterns. We, in Northern California, wonder if that cycle, based upon Los Angeles driving conditions several years ago, is representative of driving in the San Francisco Bay Area. The average emission factor data in AP-42, as noted, is based upon the vehicle mix for the entire nation. In the absence of other data, or if more elaborate computations are not warranted, these data should be used in estimating motor vehicle pollution.

Because of the required installation of certain pollution control devices in California before they were required elsewhere, special factors should be used. Information for computing these factors is available in the EPA application, An Interim Report on Motor Vehicle Emission Estimation, by Kircher and Armstrong (EPA-450/2-73-003). This report also contains data and instructions for calculation of average emission factors for a vehicle mix that is different from the national average. Some communities, for example, may have a higher proportion of new cars, with tighter emission controls, than the average. For other communities the reverse may be true.

Data on the model year mix for different regions are often available from state motor vehicle bureaus, if one is interested in taking these variations into account in their calculations. The California Air Resources Board and the California Department of Transportation have emission factors for the California vehicle mix, and the Bay Area Air Pollution Control District has factors for the Bay Area mix. The latter factors were obtained using data derived from the California driving cycle and happen to be the ones I use at the moment.

While the compilations of emission factors cited show how to obtain emission factors for vehicles operating at different speeds, none of them list an emission factor for idling emissions, or for speeds below about 10 miles per hour. Factors for these modes are required when evaluating emissions from parking lots, drive-in operations, downtown core city areas, etc. The chart that has been distributed shows how to obtain idling emission factors for the various contaminants. They were derived from information presented in the report, A Study of Emissions From Light Duty Vehicles in Six Cities, prepared for EPA by Automotive Environmental Systems, Inc., March, 1973 (EPA No. APTD-1497).

Computation of Emissions

As previously discussed, emissions data for use as model imput usually must be supplied as emission rates, that is, mass of pollutant emitted per unit time (grams per second, tons per day, etc.). An example was provided earlier showing how to do this for a single stationary pollution source, the car body incinerator. The calculation is somewhat more complicated for mobile sources, but the principle is the same.

The trick is to find a way to treat a mobile source as if it were stationary. One way to do this is to take the emissions averaged over a period of time along the path of a vehicle. The path then becomes the source, and if the path happens to be a road, it usually remains stationary for whatever period one wishes to consider its emissions. Thus, a convenient way to treat motor vehicle emissions in a model is to treat the roadways full of vehicles as line sources. As an example, let's take the following data and compute the average carbon monoxide emissions along a road segment:

Length of road	=	2 miles
Average vehicle speed	=	25 mph
Average hourly traffic	=	200 vehicles per day

Assume that the year is 1974 and the vehicle mix is about the same as the national average. From Figure 1, the emission factor for CO for the 1974 vehicle mix is 56 grams per vehicle-mile. The speed correction factor to be applied can be determined from the figure to be about 0.8. The corrected factor is 56 x 0.8 = 45 grams per vehicle-mile. Then:

45 grams/vehicle-mile x 200 vehicles/hr x 2 miles =
18000 grams/hour, or after conversion of units,
5 grams/second over the 2 miles length.

Some line source models require that emissions be expressed as emission rate per unit length. In the above example, that figure could be obtained by multiplying the emission factor by the average hourly traffic. The result is 7000 grams/hour mile, and could, of course, be converted into whatever units are appropriate for the model in which the data is to be used.

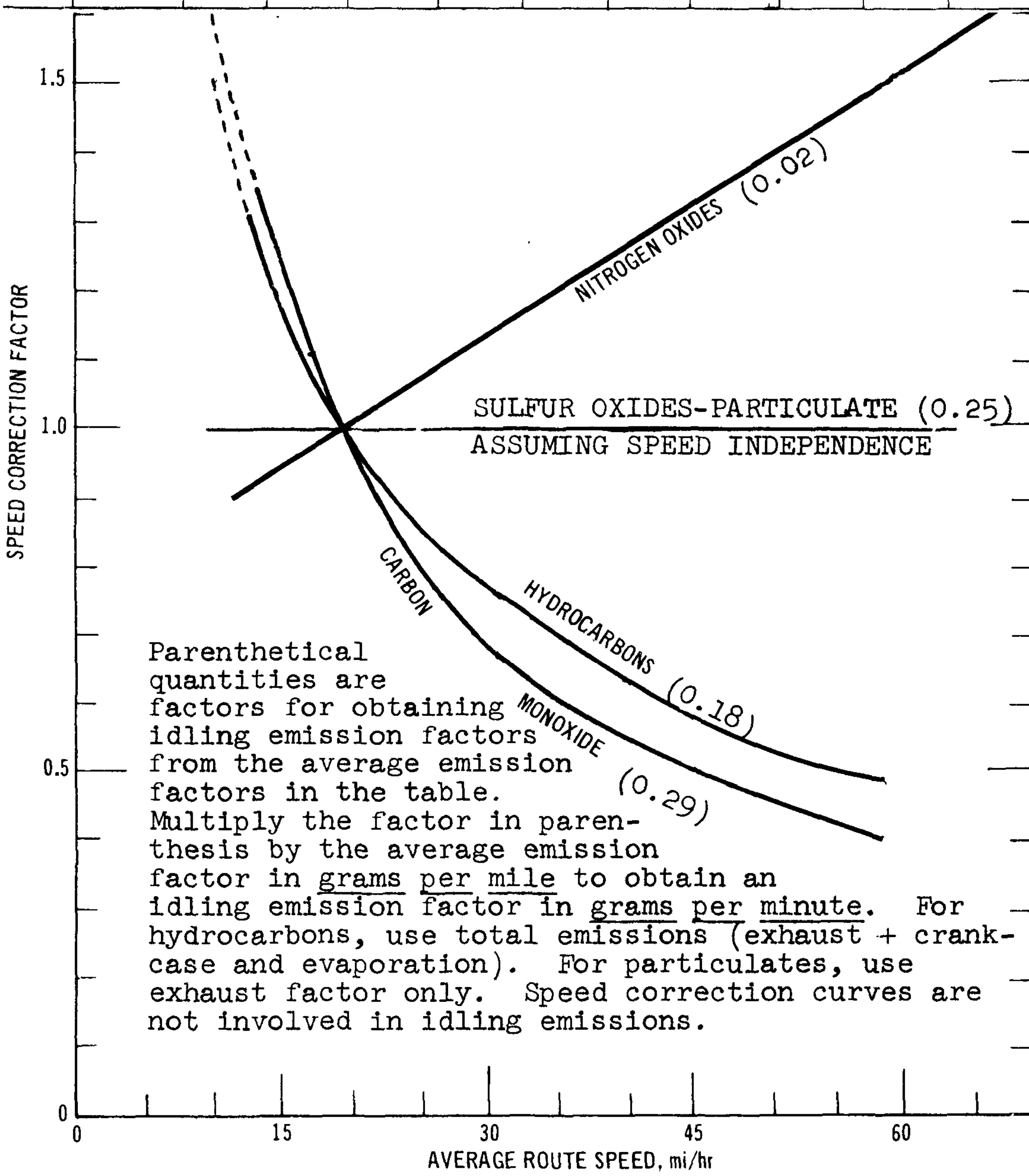
Use of Emissions Data

It was mentioned earlier that an area source is simply a collection of small point sources distributed and averaged over a geographical area. The degree of resolution of most regional air pollution models is at best the order of a square kilometer. That is, most models cannot distinguish between sources that are enclosed within an area smaller than that. Therefore, it is reasonable in many instances to lump groups of small sources together and to treat them as an area source. By doing this, the necessity for obtaining detailed emissions data for each individual source is eliminated and overall average data for the area may be used

Figure 1

AVERAGE EMISSION FACTORS FOR HIGHWAY VEHICLES BASED ON NATIONWIDE STATISTICS

Year	Carbon monoxide		Hydrocarbons: Exhaust		Hydrocarbons: Crankcase and evaporation		Nitrogen oxides (NO_x as NO_2)		Particulates: Exhaust		Particulates: Tire wear		Sulfur oxides (SO_2)	
	g/mi	g/km	g/mi	g/km	g/mi	g/km	g/mi	g/km	g/mi	g/km	g/mi	g/km	g/mi	g/km
1965	89	55	9.2	5.7	5.8	3.6	4.8	3.0	0.38	0.24	0.20	0.12	0.20	0.12
1970	78	48	7.8	4.8	3.9	2.4	5.3	3.3	0.38	0.24	0.20	0.12	0.20	0.12
1971	74	46	7.2	4.5	3.5	2.2	5.4	3.4	0.38	0.24	0.20	0.12	0.20	0.12
1972	68	42	6.6	4.1	2.9	1.8	5.4	3.4	0.38	0.24	0.20	0.12	0.20	0.12
1973	62	39	6.1	3.8	2.4	1.5	5.4	3.4	0.38	0.24	0.20	0.12	0.20	0.12
1974	56	35	5.5	3.4	2.0	1.2	5.2	3.2	0.38	0.24	0.20	0.12	0.20	0.12
1975	50	31	5.0	3.1	1.5	0.93	5.0	3.1	0.38	0.24	0.20	0.12	0.20	0.12
1976	44	27	4.3	2.7	1.3	0.81	4.8	3.0	0.38	0.24	0.20	0.12	0.20	0.12
1977	37	23	3.7	2.3	1.0	0.62	4.3	2.7	0.38	0.24	0.20	0.12	0.20	0.12
1978	31	19	3.2	2.0	0.83	0.52	3.8	2.4	0.38	0.24	0.20	0.12	0.20	0.12
1979	27	17	2.7	1.7	0.67	0.42	3.4	2.1	0.38	0.24	0.20	0.12	0.20	0.12
1980	23	14	2.4	1.5	0.53	0.33	3.1	1.9	0.38	0.24	0.20	0.12	0.20	0.12
1990	12	7.5	1.3	0.81	0.38	0.24	1.8	1.1	0.38	0.24	0.20	0.12	0.20	0.12



to estimate emissions.

This means that one can start with emissions data for a region or county to derive an emission factor that can be used to compute emissions for a much smaller area. For example, since pollution from residences is primarily a result of fuel burned in heating and cooking, if pollutant emissions from domestic fuel consumption are available for a county (as they are for the Bay Area), those figures could be divided by the county population (or number of dwelling units) and a figure for emissions per person (or dwelling unit) can be obtained. This factor can then be used to compute the emissions for any development or sub-area of the county with a specified population. Similarly, if county-wide data for emissions from industrial sources is available, factors could be developed that would express emission rates per unit of industrial area or per person employed. In the absence of more detailed information these factors could be useful in estimating pollutant emissions for some projected industrial development.

REFERENCES CITED

1) The table and curves were taken from Compilation of Emission Factors, EPA publication No. AP-42, April, 1973. The idling emission factors were derived from data presented in A Report by GEOMET Concerning Traffic Behavior in and Around Shopping Centers and Related Shopping Center Characteristics, 1973.

The units of the numbers shown in parenthesis, from which idling emission factors are to be computed, are miles/minute. In order to obtain idling emission factors with proper units (grams/minute) the numbers in parenthesis should be multiplied by the factors in the table with units of grams/mile.

METEOROLOGICAL MODELING INPUT

Richard H. Thuillier

Introduction

As has already been discussed, there are a number of meteorological elements, such as wind speed and direction and atmospheric stability, which are important in determining the extent to which pollutants emitted from sources are dispersed or diluted in the atmospheric medium. A subsequent presentation will discuss the use of mathematical models in relating emissions of air pollutants to the resultant concentrations. Since meteorological factors determine the extent of dispersion, the models, quite obviously, must utilize meteorological information as input. Some of the meteorological elements, such as wind speed, are input directly to the modeling algorithms while others which may be necessary but are not readily obtained, such as atmospheric stability, are "parameterized" before being input to the models. Parameterization means that the element is not input directly to the model but is substituted for by another factor which is related and more readily obtainable.

This presentation will describe the specific types of direct or parameterized meteorological information which are necessary as input to the types of models which will be used. In selecting meteorological input data, and in utilizing the models, the aid of a professional meteorologist or a professional engineer with a background in meteorology is most desirable. Those agencies which expect to be involved on a continuing basis with air quality impact analyses should strongly consider employing a staff person who can engage full time or a good part of the time in developing and utilizing modeling techniques, with appropriate meteorological and emissions inputs, specifically tailored to the needs of the agency or firm. A library of meteorological and climatological data should be assembled to be used as a ready reference to avoid repeated consultation with data source agencies.

Mixing Height Characteristics

Some of the models which will be discussed require the height of the mixing layer which is the unstable layer next to the ground through which pollutants omitted at ground level are vigorously mixed. In general, the mixing height will only be useful when the impact of the source is to be obtained for a receptor site some ten kilometers or more from the source. The reason for this is that the pollutants are mixed relatively slowly up from ground level and must be carried a considerable distance downwind before they will ever reach the top or "lid" of the mixing layer.

As mentioned in the presentation on Meteorology, the height of the mixing layer varies from place to place and from time to time at a given place. Since it is rare that there will be more than one observing station in a region from which statistics on the characteristics of mixing height may be obtained, the place to place variability within a region will be a desirable but unobtainable item of information. In such cases one must assume that the information from that station is representative of the entire region, although it may qualitatively be assumed that parts of the region with appreciably warmer (or colder) temperatures than the location of the observing site will have correspondingly higher (or lower) mixing heights. In any event, since there is a whole spectrum of mixing heights which occur in the course of a year, as many different weather regimes affect the region. One must decide which of these to use as modeling input. One statistic which is quite useful in modeling is the annual average mixing height. Two other statistics of use are the average morning mixing height and the average afternoon mixing height. Finally, the lowest mixing height expected in the course of a year will be useful in worst case analysis applications.

Calculation procedure: Throughout the continental United States, balloon (radiosonde) soundings are made twice a day, between three and six in the morning, approximately, and between three and six in the afternoon, approximately. The temperature of the air as a function of height may be plotted on graph paper as shown in Figure 1. The standard procedure for calculating both the morning (minimum) and afternoon (maximum) mixing depth is to use the balloon sounding. The minimum mixing depth is obtained by adding 5 degrees Centigrade to the minimum (lowest) temperature during the day and drawing a line representing a decrease in temperature of 3 degrees Centigrade per thousand feet of altitude as shown in Figure 1. The point of intersection of this line with the plotted sounding curve indicates the minimum mixing height. The maximum mixing height is obtained using the same procedure but substituting the maximum ground level temperature as shown in the figure. Where the soundings are made at official National Weather Service sites, statistics on mixing height have already been obtained on a climatological basis. These statistics have been summarized in the form of isopleth maps over the contiguous United States in Mixing Heights, Wind Speeds and Differential for Urban Air Pollution Throughout the Contiguous United States.

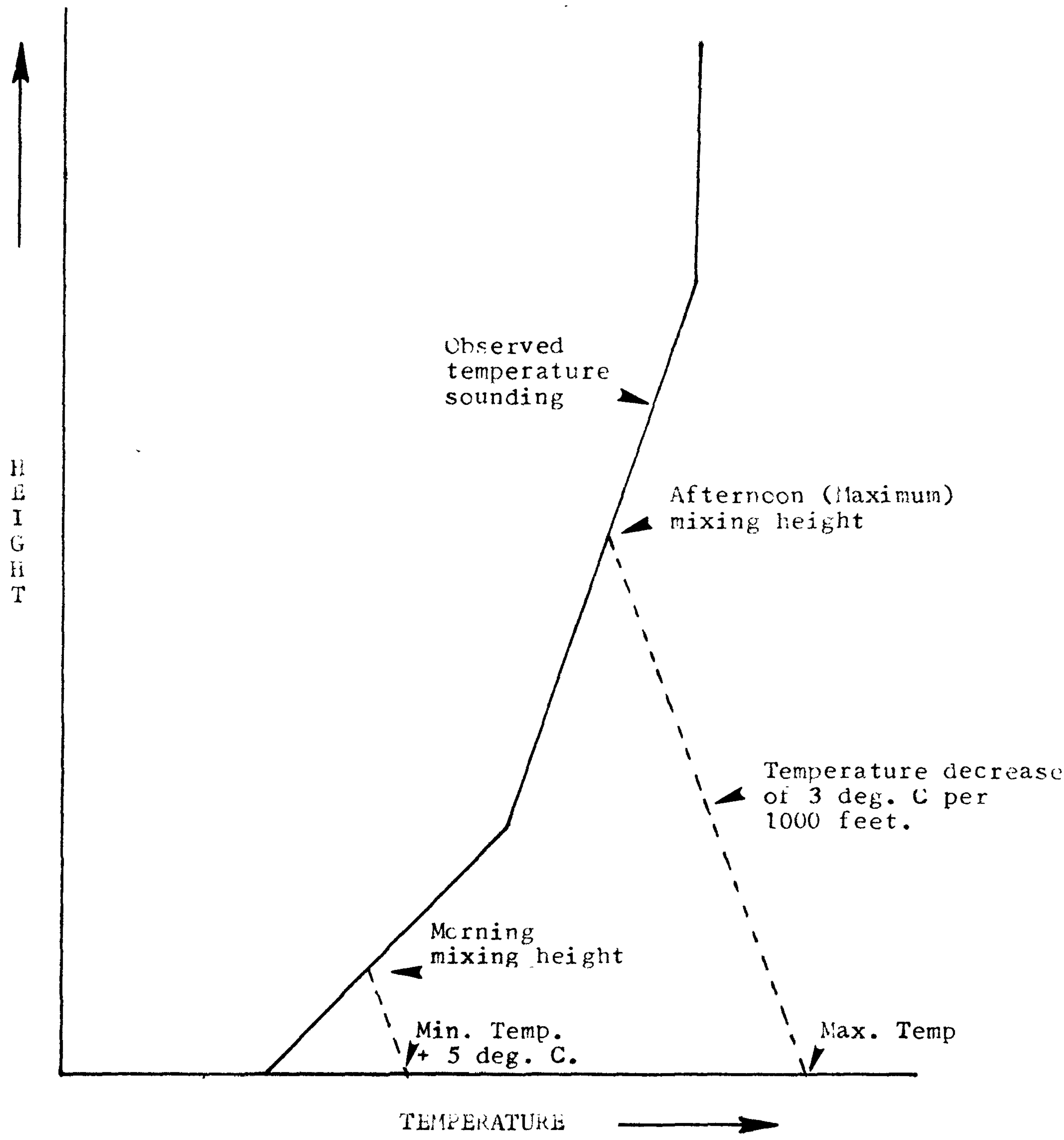


Figure 1. Illustration of mixing height computation

Air Flow Characteristics

As input to dispersion models, two items of information relative to the characteristics of air flow are necessary: the direction and the speed of the wind. For impact analyses in the immediate vicinity of a project, such as a shopping center, wind information should be obtained from an observing site as close to the site as possible, since wind characteristics vary from place to place, particularly in areas with complex terrain. As a general rule of thumb, wind information from a site further away from the project site than the nearest prominent terrain feature should not be used without consulting a professional meteorologist regarding its representativeness. As in the case of mixing height, wind information is profitably obtained on a annual averaged morning, afternoon and worst case basis. In the case of wind direction, we do not usually obtain averages of different directions but rather we obtain the frequency of occurrence of the various directions.

Wind roses: A wind rose may be defined as a comprehensive description of wind characteristics at a site in terms of a fixed number of wind directions observed at a site and the wind speed characteristics associated with each direction. The statistics included in a wind rose consist of the frequency (number of times or percent of the time) with which each direction has been observed to occur and the average wind speed or frequency of occurrence of different wind speeds associated with each direction. Usually, the wind rose also contains information on the frequency of "calms" which is the frequency with which the instrument used to measure the wind ceases to be moved by the flow of air. Caution should be exercised in interpreting the percent of calms, since different instruments will show greater or lesser sensitivity to air motion due to factors such as age, quality or maintenance and type of instrument. Typical airport wind instrumentation, particularly the older models, will cease to record air movement when the speed of the wind drops below 3 or 4 miles per hour. More sensitive, research type instrumentation may respond to wind speeds of 1 mile per hour or less. True calms usually occur only momentarily, if at all, and the usual practice when inputing wind rose information to a model is to distribute the indicated calms by apportioning them to the various wind directions in accordance with either the frequency of occurrence of the individual directions or with the frequency of occurrence of the lowest measureable wind speed range in each of the directions. Strictly speaking, a wind rose is only representative of the site of the measuring instrument although in relatively flat and uniform terrain they may be extrapolated with caution for miles or even tens of miles. A meteorologist should be consulted if possible before such extrapolation is attempted. Figure 2 illustrates a wind rose with sixteeen direction sectors.

Wind patterns: When impact is to be analyzed over an entire region or at a considerable distance from a project site, wind patterns may be more beneficial than wind roses. A wind pattern consists of curved arrows indicating the direction of air flow throughout a region and is obtained by mapping wind direction observations at a given time from all stations in the region and drawing arrows following the indicated flow of the air. Statistics on the frequency of occurrence of each of a number of patterns may be developed in the same way that such statistics are developed for each of a number of wind directions at a site. Unfortunately, wind pattern information is not as readily available as wind rose information. Wind speed can be represented in pattern form by drawing isotachs

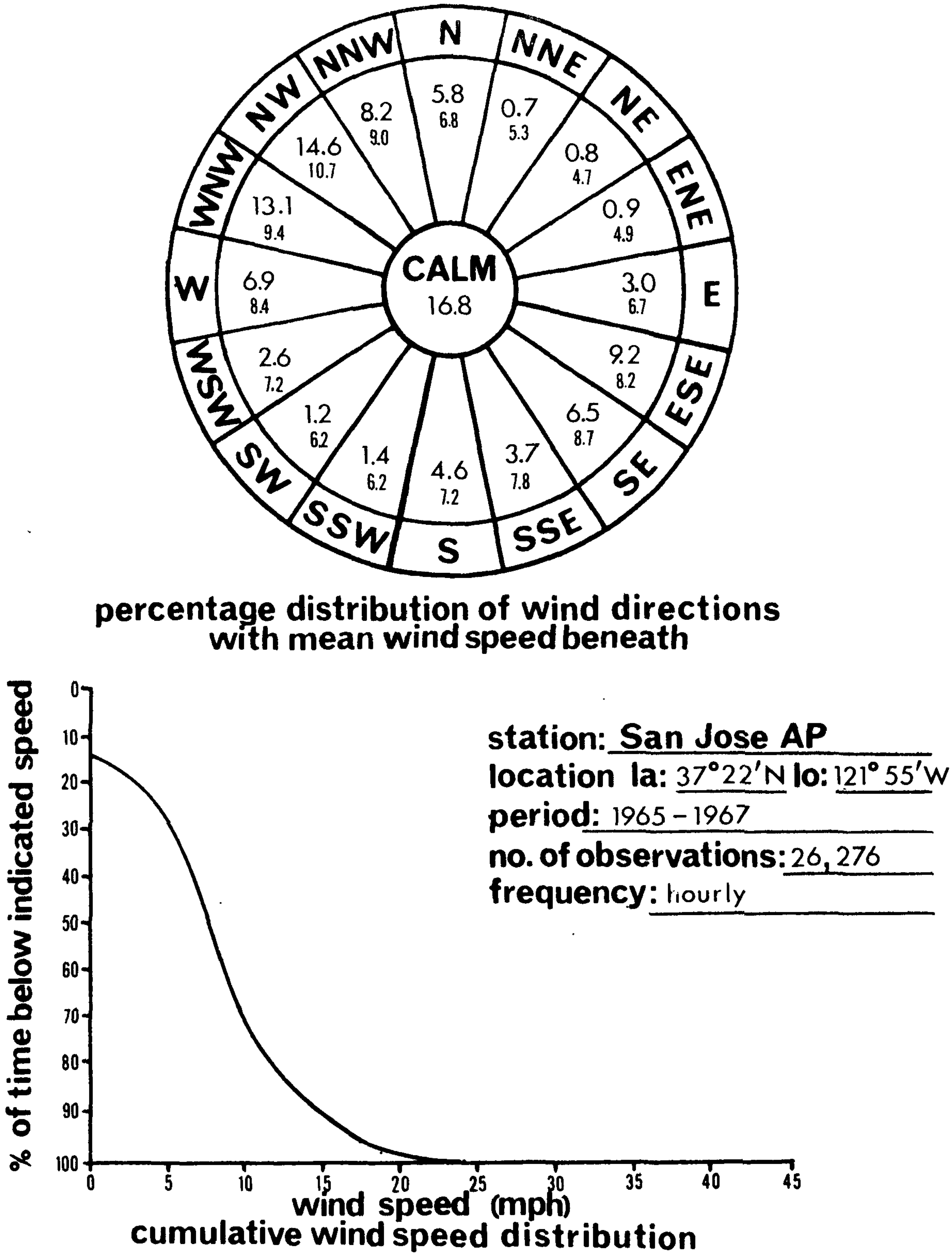


Figure 2. Example of a wind rose consisting of sixteen direction sectors. Large numbers in the sectors indicate the percentage of time that the wind is from the indicated direction in the course of a year. Small numbers are the average wind speeds for the indicated directions. The percentage of calms is in the center.

or lines of equal wind speed on the same map as the direction arrows or flow lines. Figure 3 illustrates a wind pattern for a given region.

Vertical structure: Because of the drag exerted on the air as it flows over the rought surface of the earth, the speed of the wind in the mixing layer is usually lowest at the ground and increases gradually with altitude reaching a maximum or attaining a nearly constant value several hundred feet above the ground. In the case of a city or town with a fairly high density of structures, the same description applies with the average rooftop height substituted for the ground. Below rooftop height, the wind characteristics become very complicated and may differ considerably over distances of tens of feet horizontally and vertically. Above relatively smooth and level ground such as that which exists at an airport site, wind speed my increase by 50 percent between the level of the instrument and the top of the mixing layer. Over a city or town, the increase in wind speed with height above the rooftops may be somewhat greater.

When modeling the impact of a project in the immediate vicinity, the ground level or rooftop wind speeds will usually suffice. When modeling impact regionally or at a considerable distance from a source, it is reasonable to increase the ground level or rooftop wind speeds by some 25 percent to account for the higher average wind speed over the vertical extent of the plume (pollutant cloud). When modeling the impact of elevated sources such as power plant stacks, a wind speed representative of the height of the plume should always be used. Finally, regardless of the application, care should be taken to ascertain that the instruments used to obtain wind data used in an impact analysis are reasonably well maintained and located in an area which is relatively free of nearby

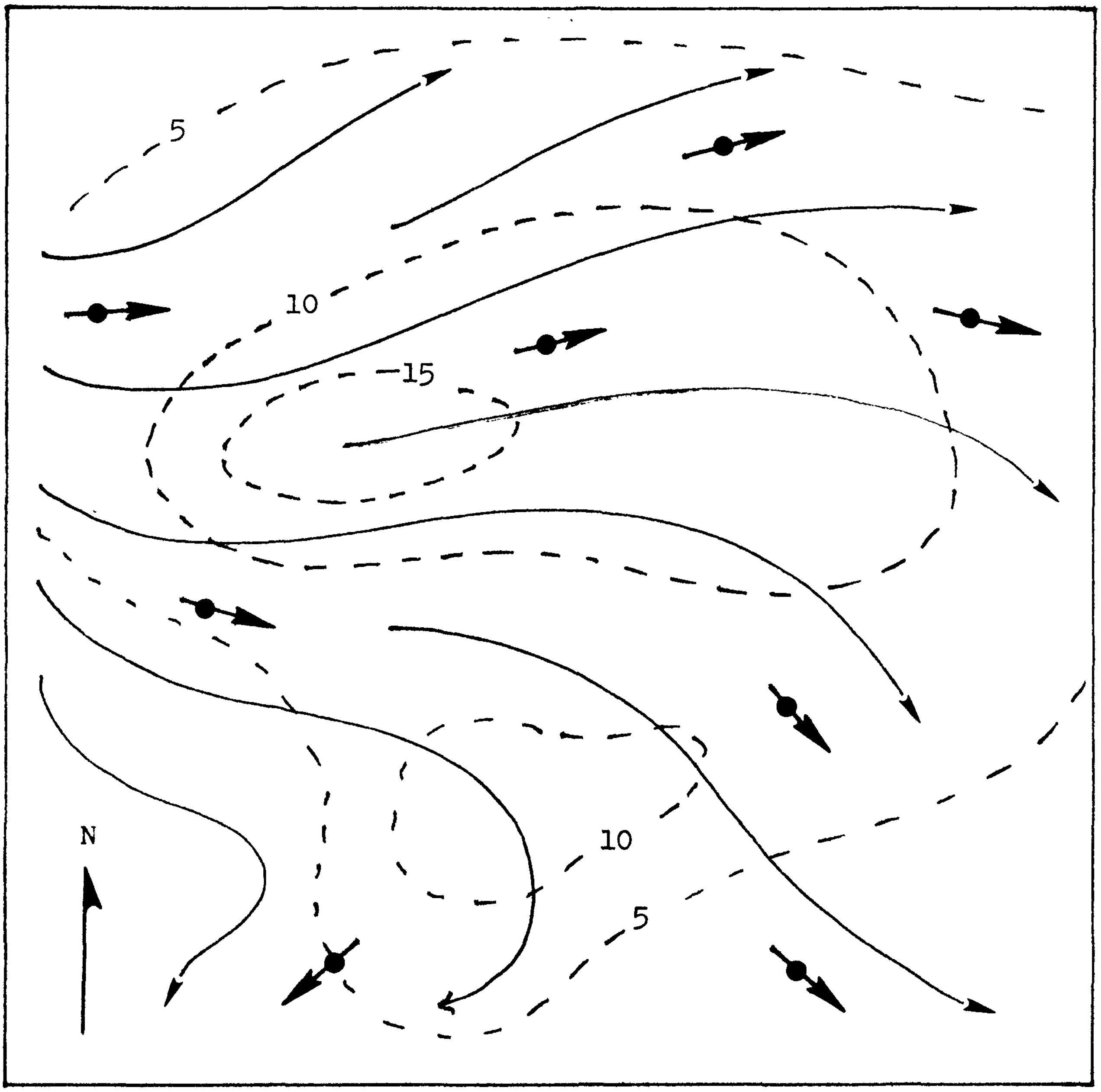


Figure 3. Example of a wind pattern. Short arrows through dots indicate wind observations at stations. Curved arrows indicate the assumed pattern of wind flow based on the observations. Dashed lines are isotachs or lines of equal speed based also on the wind observations. Wind observations are those taken at the same time of day.

obstructions to wind flow. Suspect data should be eliminated from use in the analysis.

Stability Characteristics

As mentioned previously in the meteorology paper, the temperature structure, or stability, of the mixing layer will determine the extent to which the plume emitted from a source is diluted after traveling a given distance. In most cases, it is almost impossible to obtain direct information on the temperature structure in the vicinity of a project site or even for the region as a whole. Moreover, the extent of dilution is partially determined by other factors such as terrain roughness, wind speed and the degree of isolation or solar heating of the ground in conjunction with the temperature structure, the interrelationship of these being somewhat complicated. To get around most of the problems of stability input to air quality models of the type which will be illustrated, an empirical system for relating the rate of plume dilution to readily obtainable information has been devised. This system termed the Pasquill-Gifford approach, after the two researchers involved in its development, relates the spread of a gaussian or normally distributed plume to six categories of stability which are in turned defined in terms of the general weather conditions in the area of concern. Figure 4 provides the description of the stability categories and Figure 5 indicates the relationship between the stability categories and the rate of plume dilution taken as the change in plume standard deviation with distance from the source. The curves in Figure 5 may be fit with straight line segments on the log-log plot which segments are represented by the equation

$$\sigma = aX^b$$

Figure 4.

KEY TO STABILITY CATEGORIES

Surface Wind Speed (at 10 m) m/sec	Insolation			Night	
	Strong	Moderate	Slight	Thinly Overcast or > 4/8 Low Cloud	< 3/8 Cloud
< 2	A	A-B	B	-	-
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
> 6	C	D	D	D	D

The neutral category, D, should be assumed for overcast conditions during day or night

Strong insolation is associated with a sun's elevation of greater than 60 degrees above the horizon. Moderate insolation is associated with an elevation between 30 and 60 degrees and slight insolation is associated with an elevation of less than 30 degrees. Categories have been developed from data gathered in rural locations with relatively smooth terrain and tend to indicate greater stability than that which actually exists in urban locations. In such urban settings, it is common practice to shift toward instability by one category to account for the more unstable conditions associated with highly developed areas.

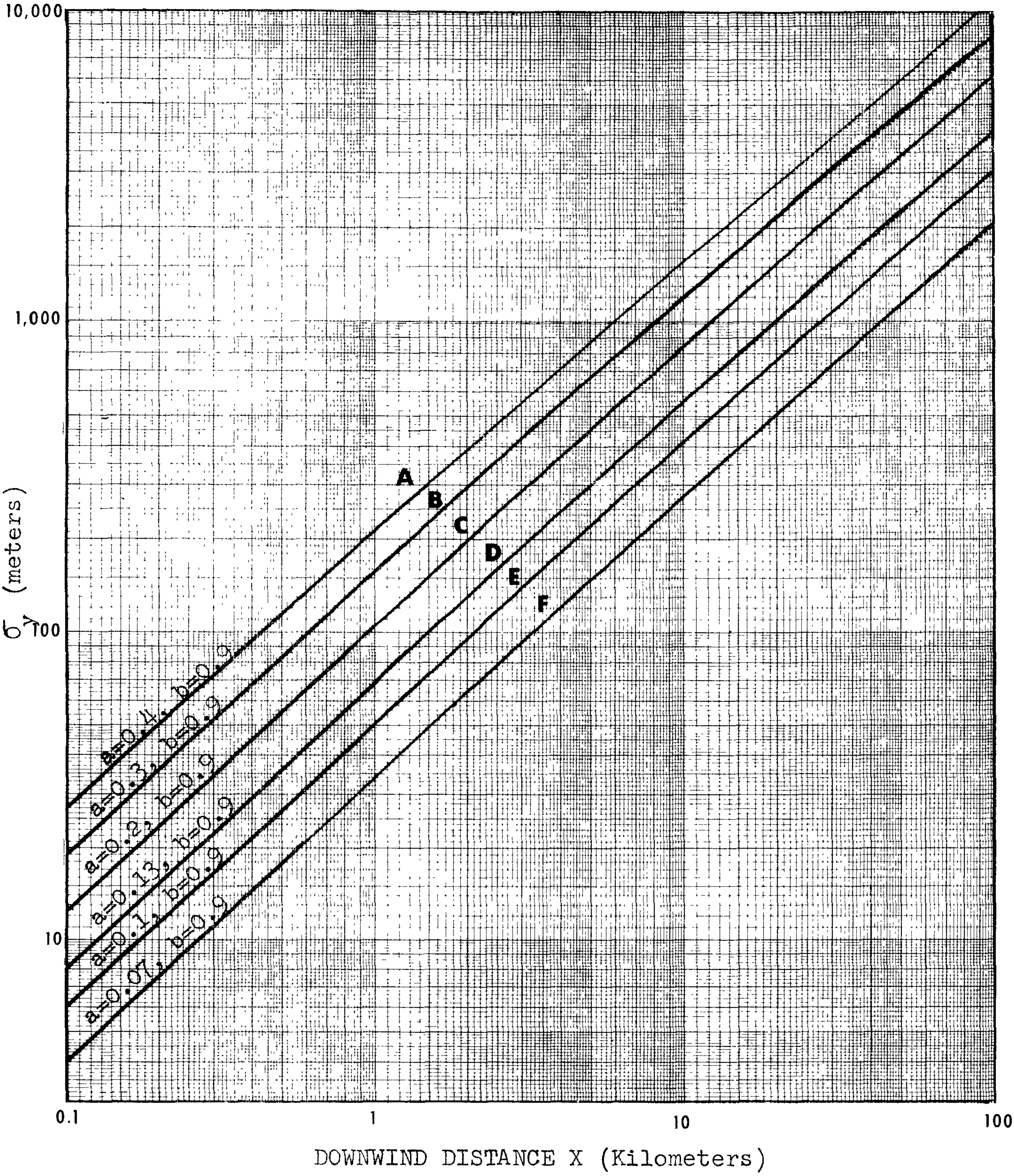


Figure 5a. Variation of horizontal plume concentration standard deviation, σ_y, with downwind distance from a point source. Constants in the fitted function $\sigma_y = aX^b$ are given for the entire range of downwind distance. ([illegible] reference 3)

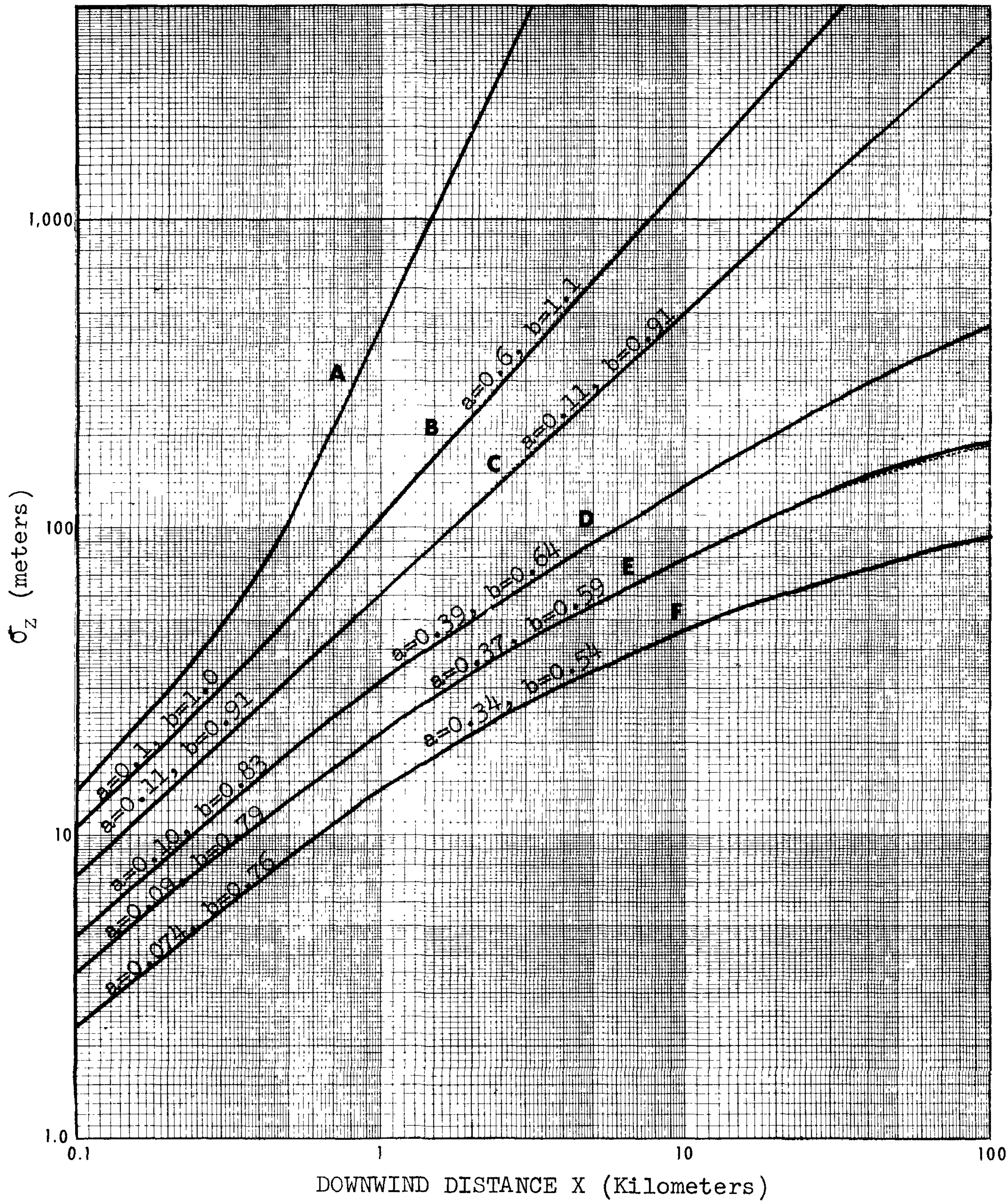


Figure 5b. Variation of vertical plume concentration standard deviation, σ_z, with downwind distance from a point source. Constants in the fitted function $\sigma_z = aX^b$ are given for the less than 1Km and 1-10Km ranges of downwind distance. (After reference 3)

where σ is the plume standard deviation and X is the distance from the source. Figure 5a indicates the characteristics of horizontal plume spread while Figure 5b indicates the characteristics of vertical plume spread. The full six categories of stability are usually found only in rural areas and, indeed, the empirical studies from which the curves and categories were derived were conducted in flat rural areas. When using the system in a relatively urban setting, it is reasonable, based on observations,to select the next most unstable category to the one indicated by the meteorology. Thus an E category might be chosen where an F is indicated. In large cities, the mixing layer rarely becomes more stable than a C or D category and a B or C is usually appropriate as an average condition as opposed to a C or D in a more rural setting. A computer program called the STAR program is available from the National Climatic Center, Asheville, North Carolina, which provides a statistical frequency distribution of the various stability categories for each direction of the wind rose, based on meteorological observations primarily at airport stations. While this information is quite useful, care should be exercised in extrapolating the data to other sites.

Pollutant Level Variability as a Meteorological Paramter

Since the federal and most of the state and local air quality standards are given in terms of a pollutant level which must not be exceeded more than a certain percentage of the time, usually no more than one time per year, it is usually only the extreme situations that we wish to model. Unfortunately it is quite difficult to define the combination of meteorological conditions that lead to the highest concentration of the year or to distinguish those conditions from conditions associated with lower concentrations. When we can define them, it is often difficult to model them since they involve such intractable situations as calm or variable winds. Finally, since the standards involve different averaging times, such as 1, 3, 8 and 24 hours, it is difficult if not impossible to average the meteorology over all the applicable averaging times.

One very handy way to circumvent this problem is to take advantage of a statistical model (reference 2) based on the log-normal distribution function observed to fit most pollutant concentration data. To use this approach, the standard geometric deviation, which describes the annual variability of the data, is obtained as described in the reference for any given averaging time. Pollution data is usually obtained in the form of one-hour averages. Once we know the standard geometric deviation and the frequency of occurrence of any concentration over any averaging annual average concentration (arithmetic mean), standard geometric deviation and the ratio of annual maximum to annual average concentration is given in Table 1.

The principal advantage in using this approach is that the various meteorological regimes leading to the various levels of pollution observed in the course of a year are represented on a statistical basis by the pollutant concentration distribution itself. If we are not concerned about the specific days of the year on which concentration extremes occur, we can estimate those extremes from the distribution function without any knowledge of the extreme meteorological conditions which produced them. If, further, we can assume that the annual variability is related primarily to the climatology of an area, a one time determination of standard

Table 1.

Standard geometric deviation for averaging times of:								Ratio of annual maximum concentration to mean concentration for averaging times of:							
1 sec	5 min	1 hr	3 hr	8 hr	1 day	4 days	1 mo	1 sec	5 min	1 hr	3 hr	8 hr	1 day	4 days	1 mo
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.07	1.06	1.05	1.05	1.04	1.04	1.04	1.03	1.44	1.27	1.20	1.17	1.15	1.12	1.09	1.04
1.14	1.11	1.10	1.09	1.09	1.08	1.07	1.05	2.04	1.59	1.43	1.37	1.31	1.25	1.18	1.08
1.21	1.17	1.15	1.14	1.13	1.12	1.10	1.08	2.83	1.97	1.69	1.57	1.48	1.38	1.27	1.12
1.29	1.23	1.20	1.19	1.17	1.16	1.14	1.10	3.86	2.42	1.97	1.80	1.66	1.52	1.36	1.16
1.36	1.29	1.25	1.23	1.22	1.20	1.17	1.12	5.18	2.93	2.28	2.05	1.86	1.67	1.46	1.20
1.44	1.34	1.30	1.28	1.26	1.24	1.20	1.15	6.85	3.51	2.63	2.31	2.06	1.82	1.56	1.24
1.51	1.40	1.35	1.32	1.30	1.27	1.24	1.17	8.94	4.18	3.00	2.60	2.28	1.98	1.65	1.28
1.59	1.46	1.40	1.37	1.34	1.31	1.27	1.19	11.53	4.93	3.41	2.90	2.51	2.14	1.75	1.31
1.67	1.52	1.45	1.42	1.39	1.35	1.30	1.21	14.69	5.77	3.84	3.22	2.75	2.31	1.85	1.35
1.75	1.58	1.50	1.46	1.43	1.39	1.33	1.24	18.53	6.71	4.32	3.56	3.00	2.48	1.95	1.38
1.83	1.64	1.55	1.51	1.47	1.42	1.36	1.26	23.14	7.76	4.82	3.92	3.26	2.65	2.05	1.42
1.91	1.70	1.60	1.55	1.51	1.46	1.39	1.28	28.65	8.92	5.37	4.30	3.53	2.84	2.15	1.45
1.99	1.76	1.65	1.60	1.55	1.50	1.42	1.30	35.16	10.19	5.95	4.70	3.81	3.02	2.26	1.48
2.08	1.82	1.70	1.64	1.59	1.53	1.45	1.32	42.83	11.58	6.56	5.12	4.10	3.21	2.36	1.52
2.16	1.88	1.75	1.69	1.63	1.57	1.48	1.34	51.78	13.11	7.21	5.55	4.40	3.40	2.46	1.55
2.25	1.94	1.80	1.74	1.68	1.61	1.51	1.36	62.18	14.76	7.90	6.01	4.71	3.60	2.57	1.58
2.34	2.00	1.85	1.78	1.72	1.64	1.54	1.38	74.18	16.56	8.62	6.49	5.03	3.80	2.67	1.61
2.42	2.06	1.90	1.83	1.76	1.68	1.57	1.40	87.96	18.50	9.39	6.98	5.36	4.00	2.77	1.64
2.51	2.12	1.95	1.87	1.80	1.71	1.60	1.42	103.70	20.59	10.19	7.49	5.70	4.21	2.88	1.67
2.60	2.19	2.00	1.92	1.84	1.75	1.63	1.44	121.61	22.83	11.03	8.03	6.04	4.42	2.98	1.70
2.69	2.25	2.05	1.96	1.88	1.78	1.66	1.46	141.88	25.24	11.91	8.58	6.40	4.64	3.09	1.73
2.78	2.31	2.10	2.00	1.92	1.82	1.69	1.47	164.73	27.81	12.83	9.15	6.76	4.85	3.19	1.75
2.87	2.37	2.15	2.05	1.96	1.85	1.72	1.49	190.39	30.55	13.78	9.74	7.14	5.07	3.30	1.78
2.97	2.43	2.20	2.09	2.00	1.89	1.74	1.51	219.09	33.47	14.78	10.34	7.52	5.29	3.40	1.81
3.06	2.50	2.25	2.14	2.04	1.92	1.77	1.53	251.07	36.56	15.81	10.97	7.91	5.52	3.51	1.83
3.15	2.56	2.30	2.18	2.08	1.96	1.80	1.55	286.61	39.84	16.89	11.61	8.30	5.75	3.61	1.86
3.25	2.62	2.35	2.23	2.12	1.99	1.83	1.56	325.94	43.31	18.00	12.27	8.71	5.98	3.72	1.88
3.34	2.69	2.40	2.27	2.16	2.03	1.85	1.58	369.37	46.97	19.15	12.94	9.12	6.21	3.82	1.91
3.44	2.75	2.45	2.32	2.20	2.06	1.88	1.60	417.15	50.82	20.34	13.64	9.54	6.44	3.93	1.93
3.54	2.81	2.50	2.36	2.24	2.09	1.91	1.62	469.60	54.88	21.57	14.35	9.97	6.68	4.03	1.96
3.64	2.88	2.55	2.41	2.27	2.13	1.93	1.63	527.00	59.14	22.84	15.07	10.40	6.92	4.13	1.98
3.74	2.94	2.60	2.45	2.31	2.16	1.96	1.65	589.67	63.60	24.14	15.82	10.84	7.16	4.24	2.00
3.83	3.00	2.65	2.49	2.35	2.19	1.99	1.67	657.92	68.28	25.49	16.58	11.28	7.40	4.34	2.03
3.93	3.07	2.70	2.54	2.39	2.23	2.01	1.68	732.07	73.17	26.87	17.35	11.74	7.64	4.44	2.05
4.04	3.13	2.75	2.58	2.43	2.26	2.04	1.70	812.47	78.28	28.29	18.14	12.20	7.89	4.55	2.07
4.14	3.20	2.80	2.63	2.47	2.29	2.07	1.71	899.45	83.61	29.75	18.95	12.66	8.13	4.65	2.09
4.24	3.26	2.85	2.67	2.51	2.33	2.09	1.73	993.34	89.16	31.24	19.77	13.13	8.38	4.75	2.11
4.34	3.33	2.90	2.71	2.55	2.36	2.12	1.75	1094.51	94.94	32.78	20.60	13.61	8.63	4.86	2.13
4.45	3.39	2.95	2.76	2.59	2.39	2.14	1.76	1203.31	100.94	34.35	21.45	14.09	8.88	4.96	2.16
4.55	3.46	3.00	2.80	2.62	2.42	2.17	1.78	1320.11	107.17	35.95	22.32	14.58	9.13	5.06	2.18
4.66	3.52	3.05	2.84	2.66	2.46	2.20	1.79	1445.27	113.64	37.60	23.20	15.07	9.38	5.16	2.20
4.76	3.59	3.10	2.89	2.70	2.49	2.22	1.81	1579.16	120.34	39.28	24.09	15.57	9.64	5.26	2.22
4.87	3.65	3.15	2.93	2.74	2.52	2.25	1.82	1722.17	127.28	40.99	25.00	16.07	9.89	5.36	2.24
4.97	3.72	3.20	2.98	2.78	2.55	2.27	1.84	1874.68	134.46	42.74	25.92	16.57	10.15	5.46	2.25

To use this table, find the line containing the appropriate standard geometric deviation for any single averaging time (left side). From that line may be obtained either the standard geometric deviation for other averaging times (left side) or the ratio of maximum concentration at various averaging times to the annual averaged concentration (From Reference 2).

geometric deviation will suffice as a "climatological" parameter for use in future years, if based on a number of years of data. This is quite convenient for land use planning applications since we need only model the annual average concentration in future years and apply the climatological standard geometric deviation in order to estimate the frequency of excess of any air quality standard.

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SIMPLIFIED TECHNIQUES FOR AIR QUALITY IMPACT QUANTIFICATION

Richard H. Thuillier

Preface

The formulas presented herein represent adaptations of the basic gaussian plume model which treats the pollutant plume from a point source as though the concentrations in the plume are distributed normally about the centerline. When the input parameters such as wind speed, stability category and emission rate are thoughtfully chosen, preferably with professional consultation, the results should prove adequate as input for many of the day to day decisions related to the air quality impact of projects. Except in instances where emissions and meteorological data of high quality and fine spatial and temporal resolution are available, it is doubtful that more sophisticated techniques will yield results of any greater validity. A summary of formulas is presented in Appendix B.

In utilizing the formulas, the units of the input parameters should be consistent throughout the formulas. The most convenient units to use are micrograms, meters and seconds for mass, length and time, respectively. If these units are used, the concentration values derived from the formulas will be in the units of micrograms per cubic meter, units which are directly comparable to those used in the published ambient air quality standards. While the gaussian plume model has been extensively verified, use of these adaptations in specific situations is best preceeded by a test of the formulas in known situations, if possible. The models may then be adjusted to conform more closely to the local situation. Such adjustment may be accomplished by varying the values of the input parameters within their respective ranges of uncertainty.

The example problems worked out in the course of this presentation have assumed carbon monoxide as the pollutant. The choice of carbon monoxide was made since this pollutant is considered most representative of the surface emitted and relatively inert pollutant type for which these modeling procedures are best suited. The techniques, however, may be applied quite successfully to other pollutants such as suspended particulates, total oxides of nitrogen, hydrocarbons and sulfur dioxide.

In making this presentation, we do not wish to imply that the methodology described will be sufficient in and of itself. Utilization of the methods will be greatly facilitated by background knowledge gained by reading the reference material. In cases where the validity of the assumption is in doubt, competent professional assistance should be obtained. It is strongly recommended that public and private agencies, involved on a continuing basis with the performance or evaluation of air quality analyses, designate a staff person with technical background to develop a familiarity with and competence in the use of these and other techniques of air quality modeling.

Introduction

As the result of provisions in the National Environmental Policy Act and the Clean Air Act and as the result, also, of ensuing legislative, regulatory and judicial action on the federal, state and local level, there exists today a requirement to analyze and report upon the impact on air quality of a large variety of land use and transportation projects.

For the sole purpose of accomplishing this task, a large variety of analysis techniques, usually referred to as air quality "models" have been developed. Some of these models, in attempting to simulate with great fidelity the complex physical and chemical processes involved in the transport, dispersion and transformation of the various pollutant species in the atmosphere, have evolved as sophisticated mathematical systems and require a considerable expenditure of time and money for their application. Other models, highly parameterized and simplified in their mathematics, are applied quite readily at minimal expense.

Studies such as those described in references 1 and 2 have indicated that for reasons probably related to the limited quantity and quality of modeling input data, the added complexity of the sophisticated models is no guarantee of improvement over the more simplified versions. My own experience, over several years of providing guidance for decision making in the area of air quality impact, strongly suggests that many and perhaps most of the decisions relating to air quality impact can be made with confidence on the basis of highly simplified analyses. This is quite fortunate since limitations of time, funding and manpower frequently dictate a choice between a simplified analysis and no analysis at all.

Having made a case for simplified approach to air quality impact analysis, the problem still remains of choosing from the great variety of available techniques. The appropriate choice and effective application of even the simplest techniques requires some familiarity with the atmospheric processes which the "models" seek to represent. For the uninitiated, there is no substitute for competent consultation in this regard. In many cases, however, not even this avenue is open to the harried individual charged with the preparation of an air quality impact report. This being the case, effective techniques, though available, will go unused due to lack of guidance in their application.

All of this would seem to suggest that there is a need for guidance relating to the choice and use of adequate, pertinant and highly cost effective analysis techniques. In the interest of filling this need to some extent, I have put together a set of guidelines for analyzing the impact on air quality of a variety of source types. The methods are those which I, myself, employ routinely as a professional meteorologist and air quality analyst. In providing these guidelines, there is no intent to deny the value or deprecate the use of other approaches. The intent is simply to provide a cost effective and feasible alternative to the virtual neglect of air quality considerations which so often characterizes environmental impact reporting.

Modeling Rationale

In an approach to simplified but meaningful analysis, I have assembled a number of formulas or algorithms and will describe their use within a framework designed to fulfill what I regard as the basic requirements of an adequate impact evaluation. In this regard, the analysis should:

a. Consider the contribution from all sources; local and regional, anthropogenic and natural, project and non-project. The reason, of course, is that the significance of a project's impact must be judged in terms of the setting in which it occurs.

b. Provide a quantitative description of the impact which may readily be compared with applicable federal, state and local air quality standards, for all standard-related pollutants.

c. Estimate the impact in the immediate vicinity of the project site as well as at more distant locations.

d. Estimate the impact on a number of spatial scales reflecting the mobility of receptors over the time periods associated with the air quality standards.

e. Take cognizance of any sensitive receptor sites such as hospitals or playgrounds at locations subject to potentially significant project impact.

Since air quality standards specify an allowable frequency of occurrence (usually once per year) of given pollutant levels when averaged over specified time periods, two basic approaches may be used in the modeling. One approach, which we may call the "worst case" approach, consists of applying the model under the assumption of extreme (adverse) meteorological conditions expected to occur with the same frequency as that specified in a particular standard when averaged over the applicable time period. The other approach, which we may call the "climatological" approach, consists of applying the model under climatologically average meteorological conditions to obtain an average level of air quality and then estimating the extreme, infrequent levels using statistical estimates of pollutant level variability. In attempting the former approach, we face the problem that most models, particularly the simpler versions, perform rather unsatisfactorily in the extreme meteorological situations of interest. In addition, it is quite difficult to determine the combination of meteorological conditions that constitute a worst case, especially over the longer averaging times, a factor which most likely contributes to a common failure in impact reporting to address averaging times other than one hour. The climatological approach seems better suited to the use of simplified modeling and provides information in a statistical form which is particularly well suited to land use planning applications. The analysis approach outlined in this paper will favor the statistical approach, although many of the techniques are applicable in worst case situations as well. Appendix A shows the derivation for most formulae presented.

Analysis Techniques for Non-Project Sources

Anthropogenic background: Pollutant concentrations resulting from sources other than the project in question may be designated as background concentrations (C_b). A convenient approach to calculating C_b is to treat as contributors all sources lying upwind within a sector of the compass rose as indicated in Figure 1. The width of the sector should correspond to the width of available wind rose sectors for the location in question, usually 22.5, 45 or 90 degrees. Within the sector, divisions should be made at convenient distances upwind. Divisions should be made specifically at 10 kilometers and at any upwind distance at which substantial changes in source characteristics occur. The result of this procedure is the delineation of a number of upwind source areas, the contributions of which to C_b will be determined as described below.

In calculating the contribution of source areas greater than 10 kilometers from the receptor site, we may take advantage of the fact that uniform vertical mixing is usually approximated after 10 kilometers or so of pollutant travel. This fact enables us to use the simple formula

$$(C_b)_i = \frac{QL}{AHU} \quad (1)$$

where $(C_b)_i$ is the contribution to C_b from source area i in units of micrograms per cubic meter ($\mu g/m^3$),

Q is the total emission rate in micrograms per second from all sources in area i,

L is the distance from the closest to the farthest upwind boundary of the source area in units of meters,

A is the source area in units of square meters,

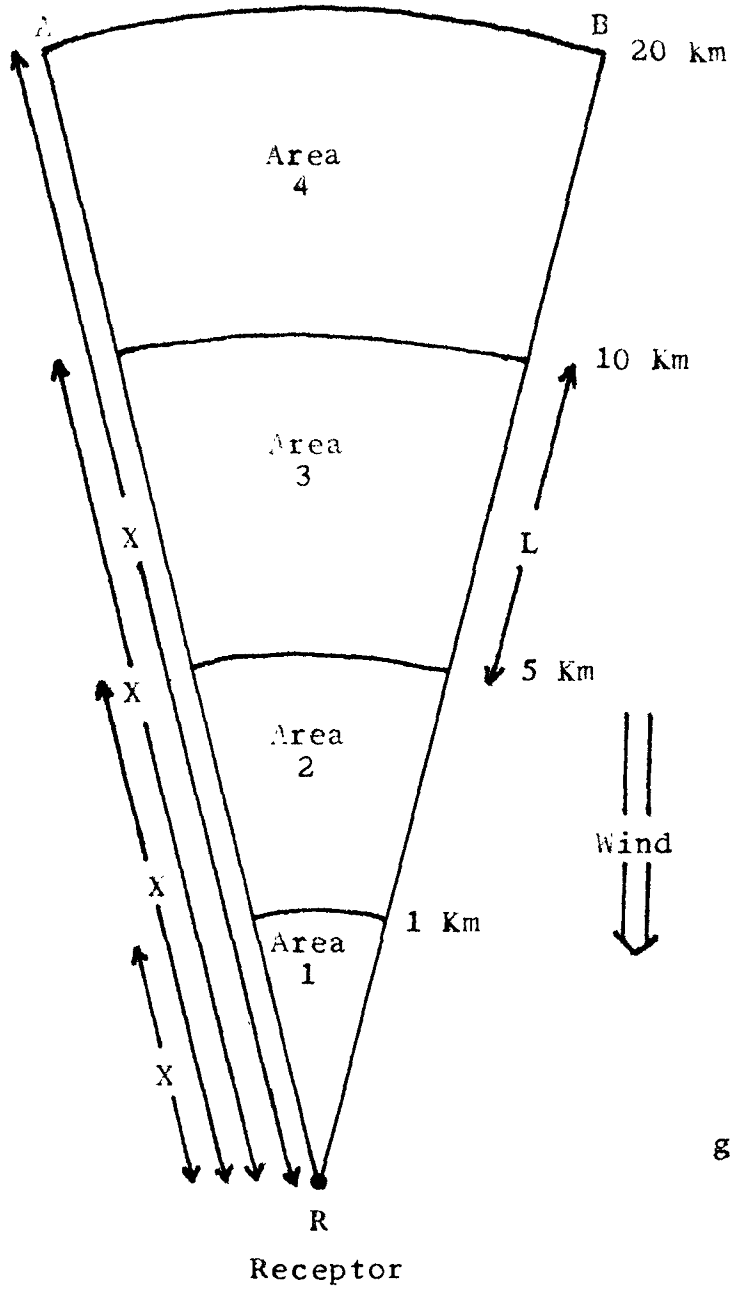
H is the mixing height of the source area in units of meters and

U is the average wind speed in the source area in units of meters per second.

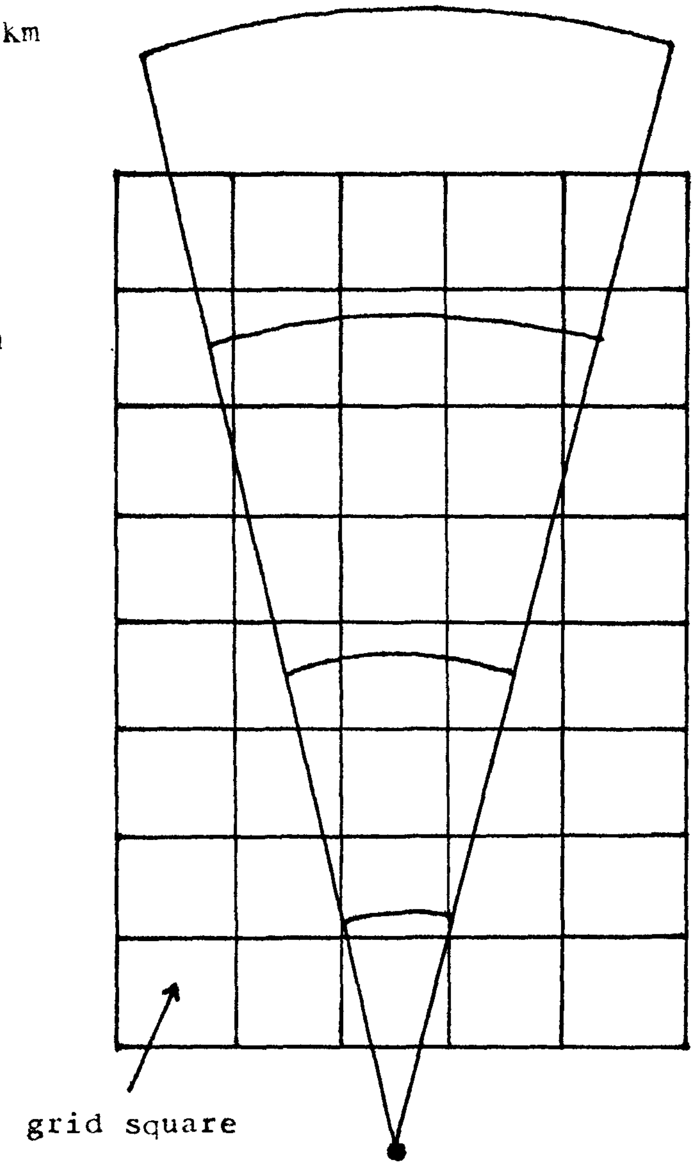
Formula (1) is based on a box model which assumes that pollutants are uniformly mixed in a vertical slab as it moves with the wind.

EXAMPLE 1

In this example, we refer to Figure 1. Large numbers are expressed in floating point or scientific notation as three digit, two decimal place numbers followed by 10 raised to a positive or negative exponent. In this notation, the exponent indicates the number of places to the right (+) or to the left (-) that the decimal point must be moved in order to obtain the number represented by the floating point notation.



1a
Emissions derived for
annular sectors



1b
Emissions derived by
aggregating and apportioning emissions in
individual grid squares

Figure 1. Illustration of the methodology for calculating background concentrations from source areas within a wind rose sector of angular width ϕ. In calculating an annual average concentration, a separate calculation is made for each sector in the wind rose (ϕ usually $22\frac{1}{2}$ or 45 degrees) and the average is taken over all sectors with each sector weighted by its frequency of occurrence. In calculating a short term average concentration when the wind is from a single direction, an angle, ϕ, of $22\frac{1}{2}$ degrees should be used.

Suppose that we want to calculate the contribution of sources in source area 4 (Figure 1a) to the carbon monoxide concentration at receptor point R when the wind is from the direction indicated by the wind rose sector RAB. The geometric area of source area 4 may be obtained by using the formula for the area of an annulus

$$A = \frac{\pi\theta}{360}(X_1 + X_2)(X_2 - X_1) \qquad (2)$$

where θ is the angular width of the wind rose sector in degrees and X_1 and X_2 are the distances from receptor point R to the closest and farthest upwind boundaries, respectively, of source area 4. Using the dimensions indicated in Figure 1a, the source area by formula 2 will be $5.9\text{x}10^7$ square meters. If we assume that the emission rate for carbon monoxide in the source area is one ton/day/km^2 ($6.2\text{x}10^8$ micrograms per second), that the mixing height is 500 meters and that the wind speed is 3 meters per second, formula (1) with $L = 1\text{x}10^4$ meters may be written as

$$(C_b)_4 = \frac{6.20\text{x}10^8\text{x}1\text{x}10^4}{5.9\text{x}10^7\text{x}500\text{x}3} = 70\mu g/m^3$$

While we shall remain consistent in using micrograms per cubic meter throughout, a conversion may readily be made to units of parts per million by volume by using the formula

$$\text{ppm (vol)} = (\mu g/m^3)\text{x}\ \frac{0.024}{m} \qquad (3)$$

where m is the molecular weight of the pollutant in question. Using a molecular weight of 28 for carbon monoxide, the 70 $\mu g/m^3$ obtained above would translate to 0.06ppm.

The lesson to be learned from this example, which uses input data quite typical of an urban area, is that the contribution of distant source areas to the concentration of carbon monoxide at a receptor site is relatively negligible when compared to the concentrations used as the air quality standard, even under adverse meteorological conditions.

In calculating the contributions of source areas less than 10 kilometers from the receptor site, we may no longer, reasonably, take advantage of the uniform mixing assumption. In the case of these more nearby areas, a more reasonable assumption is a gaussian (normal) distribution of concentration in the vertical with the dsitribution standard deviation as an increasing function of distance downwind from the source. With this assumption, the contribution of a nearby source area may be modeled as the sum of contributions from an infinite number of crosswind line sources assumed to comprise the source area. The algorithm for this model takes the form

$$(C_b)_i = \frac{0.8Q}{AU} \left[\frac{X_2^{(1-b)} - X_1^{(1-b)}}{a(1-b)} \right] , \qquad (4)$$

where a and b are the constants in the formula

$$\sigma_z = ax^b , \qquad (5)$$

an empirically derived formula relating the vertical standard deviation of the diffusing line source pollutant plume, σ_z, as a function of downwind distance, x. Definitions of the other parameters in formula (4) have been given earlier. The values of a and b depend upon general meteorological conditions along the path of the diffusing plume as described in reference 3 and may be obtained by fitting straight line segments to the curves in Figure 2. For the stability category C (slightly unstable), which I have found useful as an annual average category, a and b are approximately equal to 0.11 and 0.91 respectively.

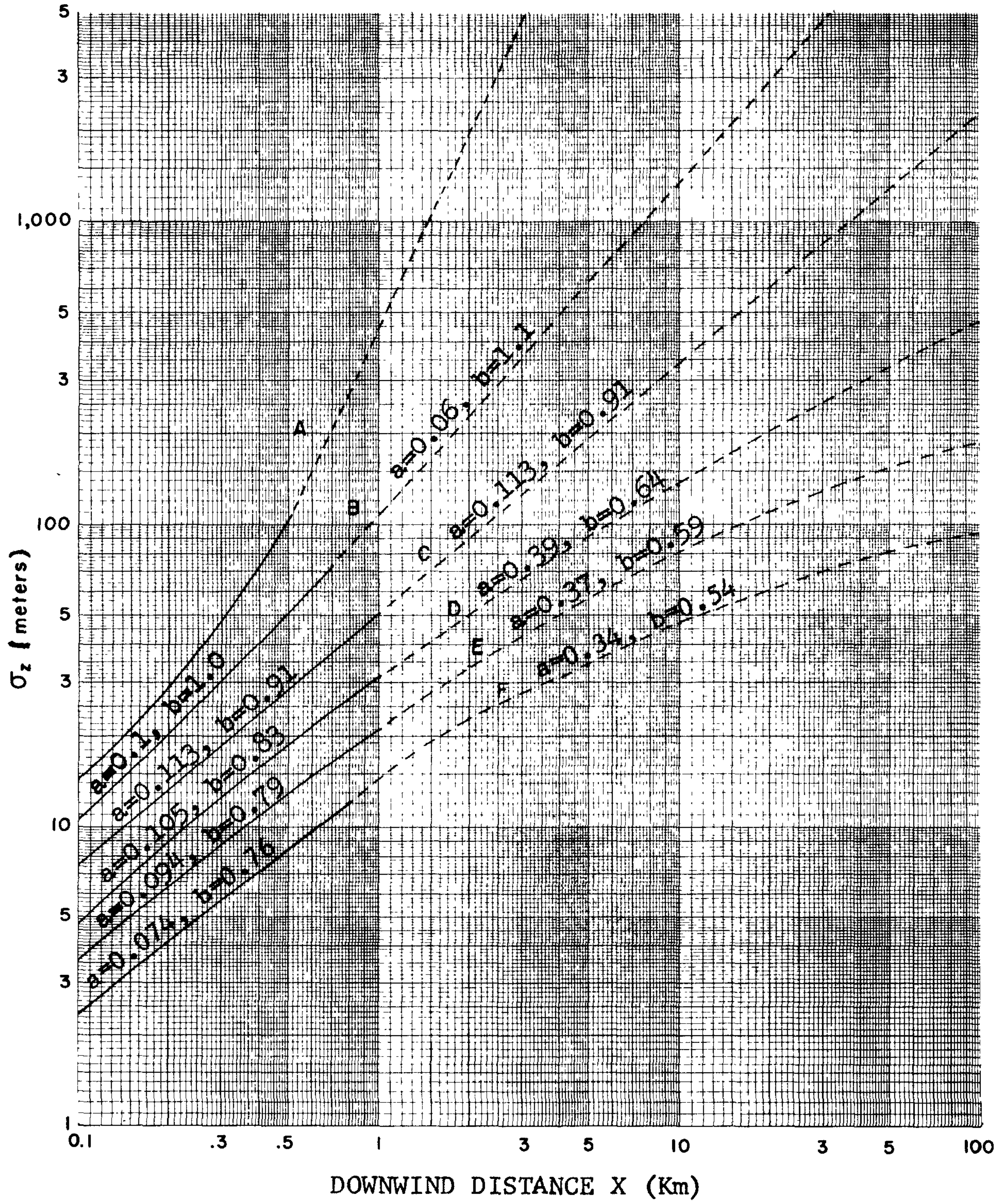


Figure 2. Variation of vertical plume concentration standard deviation σ_z with downwind distance from a point source. Constants in the fitted function $\sigma_z = aX^b$ are given for the less than 1 Km and 1-10Km ranges of downwind distance. (After reference 3)

EXAMPLE 2

Suppose we wish to calculate the contribution of sources in source area 3 (Figure 1a) to the carbon monoxide concentration at receptor point R when the wind is from the direction indicated by the wind rose sector RAB. The geometric area of source area 3 is obtained from formula (2) as 1.47×10^7 square meters. Using the values of a and b given above for stability category C, formula (4) may be written as

$$(C_b)_3 = \frac{0.8 \times 1.54 \times 10^8}{1.47 \times 10^7 \times 3} \left[\frac{10{,}000^{(0.09)} - 5000^{(0.09)}}{0.11(0.09)} \right]$$

where we have assumed a source area emission rate of 1.54×10^8 micrograms per second (1 ton per square kilometer per day) and a wind speed of 3 meters per second. Solution of the above yields

$$(C_b)_3 = 39 \mu g/m^3.$$

Finally, applying the same formulae to source areas 2 and 1, we would obtain 106 and 488 $\mu g/m^3$, respectively, and a total contribution from the wind rose sector (C_b) of 703 $\mu g/m^3$ at receptor point R. This is equivalent to about 0.6 parts per million. If this value seems low, we should recall that it is based on the assumption of a 3 m/sec wind speed, a source emission density of 1 ton/day/km^2 and a C stability category. In central business districts where emission density values of 10 tons/day/km^2 and higher can occur, concentrations 10 times higher as an annual average and 50 times higher during peak traffic and adverse meteorological conditions are not uncommon.

The calculations in examples 1 and 2 illustrate a procedure for obtaining the concentration at a receptor point from upwind, non-project sources. The concentration, as calculated, represents the average concentration over a period of time when the wind can be assumed to remain within the defined wind rose sector and the meteorological conditions can be assumed relatively uniform in space and time (quasi-steady state). If the receptor concentration is desired as an average over a time period involving a number of wind directions and/or meteorological states, the procedure may be carried out separately for each and the receptor concentration taken as the frequency weighted average of the individual calculations. This is commonly done when an annual average is desired by performing and weighting the resultant concentration by the annual frequency of occurrence of the sector wind direction. The weighted sector concentrations can then be added to yield the annual average.

The procedure just described is a very satisfactory one for situations in which the upwind source structure consists of a relatively dense and spatially uniform network of roads, residences, commercial and light industrial establishments and other source types which emit pollutants close to ground level. Large upwind point sources such as industrial stacks, which emit pollutants at substantial elevations, should be modeled separately in accordance with procedures outlined in detail in reference 3. Line sources such as roads, when they are situated within 100 meters of the receptor point, should not be included in the background analysis as described above, but should be modeled separately using techniques to be described below.

Where emissions data is available in the form of average emissions within grid squares, the same procedure may be used after aggregating or apportioning the gridded emissions to approximate the emissions from the polar areas within the wind rose sector. This is illustrated in Figure

1b. An alternative procedure for treating the individual grid squares directly and for treating regional transport in rugged terrain is described in detail in reference 4. A method for estimating the pollutant levels averaged over an entire city is found in reference 5.

Natural background: In addition to the background concentrations arising from non-project anthropogenic sources, consideration must also be given to the background arising from natural sources of pollution. In an urban setting, the background for most pollutants will be dominated by the contribution from anthropogenic sources and the natural background may safely be neglected. About the only exception to this is in the case of suspended particulates. Air with an oceanic trajectory may contain 10 to 15 $\mu g/m^3$ of particulate on the average with an equal amount added over land. To account for this natural background as well as for particulate arising from anthropogenic sources but unaccounted for in emissions inventories, it is reasonable to add from 30 to 40 $\mu g/m^3$ to the background levels of particulate calculated by the methods outlined in the previous section. Additional information on the natural background of both gaseous and particulate pollutants may be found in references 6 and 7.

Use of air monitoring data: In many urban regions, levels of gaseous and particulate air pollution are monitored by air pollution control agencies at a number of air monitoring stations. These stations are normally located in areas where the highest levels of air pollution are expected to occur. When a proposed project is located in the immediate vicinity of an air monitoring station or in an area with similar characteristics of source distribution and meteorology, pollutant concentration statistics obtained at the air monitoring station may be used in place of calculations for the purpose of estimating local background in the base year or year in which the estimate is being made. Background estimates in future years must be made on the basis of projected emissions and the projected effect of emission control strategies. Air monitoring statistics may not be very useful in this regard.

Analysis Techniques for Project-Related Sources

In the previous section, techniques were discussed for obtaining the background concentration in the area where a proposed project is to be located. Concentrations arising from project emissions may be added to the background to obtain the total air quality level in the area or may be compared to the background level to assess the relative contribution of the project to the ambient pollutant level. In order to estimate the impact of the project, whether alone or in concert with other contributing sources, three basic types of analysis are useful:

a. An analysis of the impact spatially averaged over the area of the project site and the immediate surroundings. A one square kilometer area is convenient for this, and in the case of geographically extensive projects, analyses may be made separately for a number of separate areas representing the sites of greatest emission density. The purpose of the spatially averaged analysis is to assess the impact of the project on receptors which move about in the project's vicinity.

b. An analysis of the impact at a substantial distance downwind of the project site. A ten kilometer distance is recommended for this. The purpose of the downwind analysis is to gauge the regionwide significancy of the project by estimating the impact of its emissions on distant receptors. The distance of 10 kilometers is chosen as a typical distance required for concentrations to become thoroughly mixed with the ambient air and hence present a reasonable basis for comparison with the background from other regional sources. In view of the lack of a good definition of "regional impact", it is felt that this approach is an improvement over the common practice in environmental impact reporting of comparing project emissions with total emissions from a region.

c. An analysis of the impact of specific source elements such as roads, parking lots and project power plant stacks, at the sites of sensitive receptors such as schools, hospitals, playgrounds, nursing homes and residences. The purpose of this analysis is to assess the impact of the project emissions on receptors which might reasonably be expected to remain in a confined area for periods of time comparable with the averaging times associated with the air quality standards.

Spatially averaged analysis: If a receptor moves around in the vicinity of a project (such as a shopper might do in the vicinity of a shopping center), the concentration to which the receptor will be exposed will consist of the average of concentrations at all points along the path of travel. Ideally, we would like to obtain the individual point concentrations, weighted by the period of time spent at each point, and average them over an appropriate period related to an air quality standard. Since such an analysis would be quite extensive and since the typical receptor paths and microscale concentration distributions are not readily obtainable, a surrogate technique is suggested. For this technique, the total emissions from all sources within a designated one by one kilometer square (or a circle of one kilometer diameter) are obtained. This includes emissions from roads, parking lots and other sources near ground level but should not include emissions from elevated stacks such as project power plant stacks. The total emissions are divided by the source area to simulate a uniform area-wide emission rate. Finally, the uniform area-wide emissions are modelled on the assumption that the concentration produced by the area averaged emissions will approximate the path averaged concentration produced by the actual emissions. The algorithm for this is a variant of formula (4) and gives the average concentration within a source area treated as an infinite number of cross-wind line sources and takes the form

$$\overline{C} = \frac{0.8Q}{AU}\left[\frac{L^{(1-b)}}{a(1-b)(2-b)}\right] \qquad (6)$$

where L is the alongwind dimension of the source area, that is one kilometer, and the other parameters are as defined earlier. If we use a one kilometer areal dimension as suggested and average meteorological conditions of stability category C (a=0.113 and b=0.91), formula (6) reduces to a simpler form suitable for a quick estimate of annual averaged concentration:

$$\overline{C} \cong 150\,\frac{Q}{AU}\;. \qquad (7)$$

The bar over C in formulas (6) and (7) indicates a spatially averaged concentration, in this case over a 1 Km^2 area.

EXAMPLE 3

Suppose a project is proposed in an area where the average annual wind speed is 3 meters per second and the average emission rate of carbon monoxide from all project related sources within a one square kilometer area is 30×10^6 micrograms per second. Formula (7) may be written as

$$\bar{C} \cong 150 \frac{30x10^6}{1x10^6x3} ,$$

yielding an estimate of 1500 $\mu g/m^3$ (1.2 ppm) as the annual averaged carbon monoxide concentration. If concentration estimates are desired for averaging times other than the annual average, emission rates and meteorological parameters appropriate to the desired averaging time may be used in formula (6), or we may use Table 1.

EXAMPLE 4

Suppose we wish to estimate the impact of the project in example 3 during the peak hour of project activity. For this case assume a 2 meter per second wind speed, an E stability category (a=0.094 and b=0.79) and an emission rate of $300x10^6$ micrograms per second. Formula (6) may be written as

$$\bar{C} = \frac{0.8x300x10^6}{1x10^6x2} \left[\frac{1,000^{(1-0.79)}}{0.094(1-0.79)(2-0.79)} \right]$$

yielding an estimate of 21,431 $\mu g/m^3$ (18 ppm) as the peak hour carbon monoxide concentration under relatively extreme meteorological conditions.

While a source area dimension of one kilometer was used in the examples, the technique may be used with larger areas such as whole cities or towns (reference 5) or with smaller areas such as parking lots. In the case of very large or very small areas, the concentration average obtained may not be representative of the path averaged concentration of mobile receptors. The most reasonable application of the technique is to areas in which a large number of source elements such as road links, parking lots and residences are distributed rather evenly over the source area. Best results are obtained over longer averaging times such as

Table 1.

Standard geometric deviation for averaging times of:								Ratio of annual maximum concentration to mean concentration for averaging times of:							
1 sec	5 min	1 hr	3 hr	8 hr	1 day	4 days	1 mo	1 sec	5 min	1 hr	3 hr	8 hr	1 day	4 days	1 mo
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.07	1.06	1.05	1.05	1.04	1.04	1.04	1.03	1.44	1.27	1.20	1.17	1.15	1.12	1.09	1.04
1.14	1.11	1.10	1.09	1.09	1.08	1.07	1.05	2.04	1.59	1.43	1.37	1.31	1.25	1.18	1.08
1.21	1.17	1.15	1.14	1.13	1.12	1.10	1.08	2.83	1.97	1.69	1.57	1.48	1.38	1.27	1.12
1.29	1.23	1.20	1.19	1.17	1.16	1.14	1.10	3.86	2.42	1.97	1.80	1.66	1.52	1.36	1.16
1.36	1.29	1.25	1.23	1.22	1.20	1.17	1.12	5.18	2.93	2.28	2.05	1.86	1.67	1.46	1.20
1.44	1.34	1.30	1.28	1.26	1.24	1.20	1.15	6.85	3.51	2.63	2.31	2.06	1.82	1.56	1.24
1.51	1.40	1.35	1.32	1.30	1.27	1.24	1.17	8.94	4.18	3.00	2.60	2.28	1.98	1.65	1.28
1.59	1.46	1.40	1.37	1.34	1.31	1.27	1.19	11.53	4.93	3.41	2.90	2.51	2.14	1.75	1.31
1.67	1.52	1.45	1.42	1.39	1.35	1.30	1.21	14.69	5.77	3.84	3.22	2.75	2.31	1.85	1.35
1.75	1.58	1.50	1.46	1.43	1.39	1.33	1.24	18.53	6.71	4.32	3.56	3.00	2.48	1.95	1.38
1.83	1.64	1.55	1.51	1.47	1.42	1.36	1.26	23.14	7.76	4.82	3.92	3.26	2.65	2.05	1.42
1.91	1.70	1.60	1.55	1.51	1.46	1.39	1.28	28.65	8.92	5.37	4.30	3.53	2.84	2.15	1.45
1.99	1.76	1.65	1.60	1.55	1.50	1.42	1.30	35.16	10.19	5.95	4.70	3.81	3.02	2.26	1.48
2.08	1.82	1.70	1.64	1.59	1.53	1.45	1.32	42.83	11.58	6.56	5.12	4.10	3.21	2.36	1.52
2.16	1.88	1.75	1.69	1.63	1.57	1.48	1.34	51.78	13.11	7.21	5.55	4.40	3.40	2.46	1.55
2.25	1.94	1.80	1.74	1.68	1.61	1.51	1.36	62.18	14.76	7.90	6.01	4.71	3.60	2.57	1.58
2.34	2.00	1.85	1.78	1.72	1.64	1.54	1.38	74.18	16.56	8.62	6.49	5.03	3.80	2.67	1.61
2.42	2.06	1.90	1.83	1.76	1.68	1.57	1.40	87.96	18.50	9.39	6.98	5.36	4.00	2.77	1.64
2.51	2.12	1.95	1.87	1.80	1.71	1.60	1.42	103.70	20.59	10.19	7.49	5.70	4.21	2.88	1.67
2.60	2.19	2.00	1.92	1.84	1.75	1.63	1.44	121.61	22.83	11.03	8.03	6.04	4.42	2.98	1.70
2.69	2.25	2.05	1.96	1.88	1.78	1.66	1.46	141.88	25.24	11.91	8.58	6.40	4.64	3.09	1.73
2.78	2.31	2.10	2.00	1.92	1.82	1.69	1.47	164.73	27.81	12.83	9.15	6.76	4.85	3.19	1.75
2.87	2.37	2.15	2.05	1.96	1.85	1.72	1.49	190.39	30.55	13.78	9.74	7.14	5.07	3.30	1.78
2.97	2.43	2.20	2.09	2.00	1.89	1.74	1.51	219.09	33.47	14.78	10.34	7.52	5.29	3.40	1.81
3.06	2.50	2.25	2.14	2.04	1.92	1.77	1.53	251.07	36.56	15.81	10.97	7.91	5.52	3.51	1.83
3.15	2.56	2.30	2.18	2.08	1.96	1.80	1.55	286.61	39.84	16.89	11.61	8.30	5.75	3.61	1.86
3.25	2.62	2.35	2.23	2.12	1.99	1.83	1.56	325.94	43.31	18.00	12.27	8.71	5.98	3.72	1.88
3.34	2.69	2.40	2.27	2.16	2.03	1.85	1.58	369.37	46.97	19.15	12.94	9.12	6.21	3.82	1.91
3.44	2.75	2.45	2.32	2.20	2.06	1.88	1.60	417.15	50.82	20.34	13.64	9.54	6.44	3.93	1.93
3.54	2.81	2.50	2.36	2.24	2.09	1.91	1.62	469.60	54.88	21.57	14.35	9.97	6.68	4.03	1.96
3.64	2.88	2.55	2.41	2.27	2.13	1.93	1.63	527.00	59.14	22.84	15.07	10.40	6.92	4.13	1.98
3.74	2.94	2.60	2.45	2.31	2.16	1.96	1.65	589.67	63.60	24.14	15.82	10.84	7.16	4.24	2.00
3.83	3.00	2.65	2.49	2.35	2.19	1.99	1.67	657.92	68.28	25.49	16.58	11.28	7.40	4.34	2.03
3.93	3.07	2.70	2.54	2.39	2.23	2.01	1.68	732.07	73.17	26.87	17.35	11.74	7.64	4.44	2.05
4.04	3.13	2.75	2.58	2.43	2.26	2.04	1.70	812.47	78.28	28.29	18.14	12.20	7.89	4.55	2.07
4.14	3.20	2.80	2.63	2.47	2.29	2.07	1.71	899.45	83.61	29.75	18.95	12.66	8.13	4.65	2.09
4.24	3.26	2.85	2.67	2.51	2.33	2.09	1.73	993.34	89.16	31.24	19.77	13.13	8.38	4.75	2.11
4.34	3.33	2.90	2.71	2.55	2.36	2.12	1.75	1094.51	94.94	32.78	20.60	13.61	8.63	4.86	2.13
4.45	3.39	2.95	2.76	2.59	2.39	2.14	1.76	1203.31	100.94	34.35	21.45	14.09	8.88	4.96	2.16
4.55	3.46	3.00	2.80	2.62	2.42	2.17	1.78	1320.11	107.17	35.95	22.32	14.58	9.13	5.06	2.18
4.66	3.52	3.05	2.84	2.66	2.46	2.20	1.79	1445.27	113.64	37.60	23.20	15.07	9.38	5.16	2.20
4.76	3.59	3.10	2.89	2.70	2.49	2.22	1.81	1579.16	120.34	39.28	24.09	15.57	9.64	5.26	2.22
4.87	3.65	3.15	2.93	2.74	2.52	2.25	1.82	1722.17	127.28	40.99	25.00	16.07	9.89	5.36	2.24
4.97	3.72	3.20	2.98	2.78	2.55	2.27	1.84	1874.68	134.46	42.74	25.92	16.57	10.15	5.46	2.25

To use this table, find the line containing the appropriate standard geometric deviation for any single averaging time (left side). From that line, we may obtain either the standard geometric deviation for other averaging times (left side) or the ratio of maximum concentration at various averaging times to the annual average concentration. (From Reference 2)

24-hours or 1-year. The technique may be used also with non-project emissions for an estimate of background when upwind emission rates are small compared with those in the area of concern. Wind direction does not enter the calculation.

Downwind regional scale analysis: As one phase of the project impact analysis, it is useful to determine whether the project's emissions will have an appreciable effect outside the immediate vicinity of the project itself. One way to do this is to obtain the concentration of project emitted pollutants after they have travelled a considerable distance downwind. If we define a "considerable distance" as the travel distance required for project pollutants to thoroughly diffuse throughout the vertical extent of the mixing layer, it can be shown that ten kilometers would be a reasonable minimum distance at which to determine the regional scale impact of a project. By treating the project emissions as though they come from a single point (a reasonable assumption at a 10 kilometer distance), the well mixed concentration downwind of the project may be obtained by use of the algorithm

$$\overline{C} = \frac{2.55Q}{HUX_c} \qquad (8)$$

where X_c is the desired downwind distance from the center of the project site. Other parameters in the equation are as previously defined. Formula (8) assumes, in addition to the vertical uniformity of pollutant concentration, that the pollutant is distributed uniformly throughout an angular plume width of 22-1/2 degrees.

EXAMPLE 5

Suppose we wish to estimate the regional impact of the project in example 3 under conditions of a C stability category (a=0.113 and b=0.91) and a northwest wind at 3 meters per second. If we use Formula (8) for our computation and an emission rate ($30x10^6$ μg/sec) as in the example, formula (8) may be written as

$$\overline{C} = \frac{2.55x30x10^6}{500x3x10^4}$$

where X has been taken as 10 kilometers. The calculation yields a concentration of 5.1 $\mu g/m^3$. If the background from all other sources were estimated for the same downwind location, the project impact could be compared for significance. If, for example, the background were calculated as 714 $\mu g/m^3$ as in examples 1 and 2, the project would be found to contribute 5.1/714 or 0.7% to the ambient pollutant level downwind. In a relatively source free area, the same project might assume a greater regional significance. If the regional scale impact is desired as an average over a period of time involving a number of wind directions, a calculation may be made for the wind direction bringing project pollutants to the downwind location in question, and the result weighted by the frequency of occurrence of the applicable wind direction during the desired averaging time. Thus, if the wind is from the northwest ten percent of the time in the course of a year, the regional scale concentration at a point southeast of the project, as an annual average, will be ten percent of the calculated value using a northwest wind since the concentration will be zero for all other wind directions.

Source-specific analysis: The final type of analysis which is useful in quantifying the impact of a project is one which addresses elements in the project source complex. Such elements might consist of individual road links, parking areas, freeway interchanges, project power plant stacks, airport runways, aircraft engine test stands, etc. Whatever the nature of the source, it may usually be categorized as either a point, line or area source, and specific attention should be given to its impact upon sensitive receptors as described above. In this section, we shall outline procedures for the analysis of each of these source categories.

a. Small area sources: In the case of a small area source such as a parking lot, we may wish to analyze the impact within the confines of the source area itself or at some distance downwind of its boundary. In the first case we may use formula (6) to provide an estimate of the average concentration within the area source boundaries under appropriate meteorological conditions. In the second case, we may use formula (4), where X_1 and X_2 are taken as the distances from the receptor point to the closest and farthest boundaries of the source area, when the source area is upwind of the receptor site. If the location of the receptor point is downwind by more than two or three times the crosswind dimension of the area source, but less than 10 kilometers, a better representation is given by the formula

$$C = \frac{2.03 Q X_c^{-(1+b)}}{aU} \qquad (9)$$

where all parameters are as defined earlier. Formula (9) is a variant of formula (8) for distances less than 10 kilometers from the source; X_c is the distance from the receptor to the center of the source area.

EXAMPLE 6

Suppose we wish to estimate the impact of a parking lot's emissions within the confines of the lot, on a picnic area 10 meters from the parking lot boundary and in a residential area 1 kilometer from the boundary. Assume that the parking lot is square, 100 meters on a side. Assume meteorological conditions consisting of a D stability category (a=0.105 and b=0.83), a 2 meter per second wind speed and a parking lot emission rate of 3×10^6 micrograms per second of carbon monoxide in the peak hour. The average concentration of carbon monoxide within the confines of the lot from parking lot sources alone may be estimated using formula (6) as

$$C = \frac{0.8\times3\times10^6}{1\times10^4\times2}\left[\frac{100^{(1-0.83)}}{0.105(1-0.83)(2-0.83)}\right]$$

$$= 12{,}571\ \mu g/m^3 (10\ ppm)$$

The CO concentration 10 meters downwind of the boundary may be estimated, using formula (4) and the same meteorological conditions, as

$$C = \frac{0.8\times3\times10^6}{1\times10^4\times2}\left[\frac{110^{(1-0.83)} - 10^{(1-0.83)}}{0.105(1-0.83)}\right]$$

$$= 5004\ \mu g/m^3\ (4\ ppm)$$

Finally, the CO concentration 1 kilometer downwind of the boundary may be estimated, using formula (9), as

$$C = \frac{2.08\times3\times10^6\times1000^{-(1+0.83)}}{0.105\times3}$$

$$= 62.6\ \mu g/m^3\ (0.05\ ppm)$$

b. Line sources: If we wish to evaluate the impact of a line source such as a road link carrying project traffic, either inside or outside the project boundaries, a line source dispersion model may be used. Based on the findings in reference 8, a suitable algorithm for estimating the pollutant concentration in the vicinity of roads at grade level may be derived in the form:

$$C = \frac{0.25 Q_1 X^{-p}}{U \sin\phi} \qquad (10)$$

where Q_1 is the emission rate per unit length of the line (micrograms per second per meter), ϕ is the angle the wind direction makes with the road, X is the perpendicular distance from the receptor point to the edge of the road and C and U are as defined earlier. The exponent, p, is the function of stability category and may be given values of 0.30, 0.25 and 0.21 for C, D and E stability categories respectively. Formula (10) should not be used for cut or significantly elevated road sections or in cases where the wind direction is within 22-1/2 degrees or less of the road axis. Reference 8 should be consulted for guidance in these cases.

EXAMPLE 7

Suppose a private residence is located with its front windows 10 meters from the edge of a freeway (by the edge of the freeway, we mean the edge of the outside lane). Assume a D stability category (p=0.25), a wind at an angle of 30 degrees to the road at a speed of 2 meters per second and carbon monoxide from traffic emitted at the rate of 8.65×10^4 micrograms per meter of road per second. Formula (10) may be written as

$$C = \frac{0.25 \times 8.65 \times 10^4 \times 10^{-0.25}}{2 \times 0.5}$$

$$= 12{,}161\ \mu g/m^3\ (10\ ppm)$$

Two special cases of the line source situation are worthy of further exposition. One of these is the case of an airport runway which is a line source of finite length and with the wind frequently at a relatively small angle to the line. The pollutant concentration at a point downwind of the end of an active airport runway may be estimated using an algorithm of the form

$$C = \frac{2.04Q_1}{abU}\left[X_1^{-b} - X_2^{-b}\right]^{*} \qquad (11)$$

where X_1 and X_2 are the distances to the closest and farthest ends of the runway, measured from the receptor point, and the other parameters are as defined earlier.

EXAMPLE 8

Suppose the edge of a residential subdivision is located 100 meters downwind of the active runway of a metropolitan airport. Assume a wind speed of 3 meters per second down the runway under conditions of stability category D (a=0.105 and b=0.83). Assume also that aircraft operations on the runway, including taxi, takeoff and landing, utilize 2000 meters of the runway with an emission rate of $5x10^4$ micrograms per second per meter. The concentration at the edge of the subdivision may be estimated by writing formula (11) in the form

$$C = \frac{2.04x5x10^4}{0.105x0.83x3}\left[100^{-0.83} - 2100^{-0.83}\right]$$

$$= 7853\ \mu g/m^3\ (7\ ppm)$$

A second special case of the line source situation is that of the urban street canyon. On the basis of evidence suggesting a helical air

*When using this formula with airport runways, values of X_1 less than 100 meters may yield unreasonable results.

circulation in the urban street canyon, a simple model has been developed as outlined in reference 10. When the wind direction at roof level makes an angle of greater than 30 degrees with the street axis, concentrations of auto emitted pollutants may be estimated separately for the leeward (C_1) and windward (C_W) sides of the street using the formulas

$$C_1 = \frac{7Q_1}{(U+0.5)((x^2+z^2)^{1/2}+2)} \qquad (12)$$

$$C_W = \frac{7Q_1(H-z)}{WH(U+0.5)} \qquad (13)$$

where H is the average building height, W is the width of the street (building to building) and x and z are the horizontal and vertical distances from the receptor to the center of the modeled traffic lane, as indicated in Figure 3. When the wind direction is within 30 degrees or less of the road axis, the concentration at all points is better represented by taking an average of the results of formulas (12) and (13).

EXAMPLE 9

Suppose that carbon monoxide is emitted on a three lane street at the rate of $6\text{x}10^4$ micrograms per meter per second and we wish to estimate the concentration at a second floor window of an apartment house on the leeward side of the street. Assume a rooftop wind of 3 meters per second, perpendicular to the street axis, a street width of 20 meters and an average building height of 30 meters. Assume also that the edge of the apartment building in question is 6 meters from the center of the nearest traffic lane and the window in question is 6 meters above the ground. The concentration at the window resulting from emissions in the nearest lane

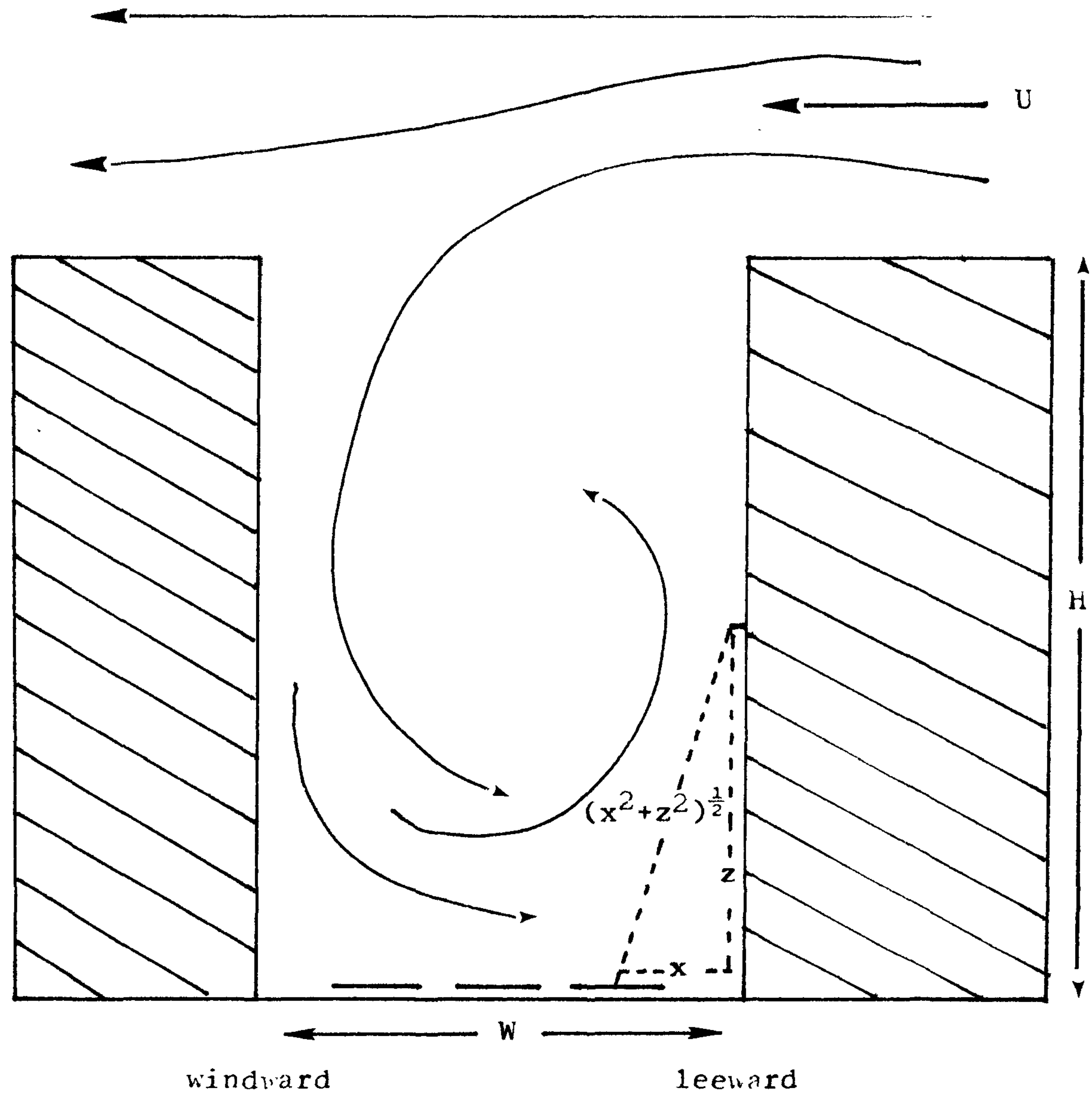


Figure 3. Schematic diagram of conditions in an urban street canyon.

is obtained by writing formula (12) in the form

$$C_1 = \frac{7x2x10^4}{(3+0.5)((3^2+6^2)^{1/2}+2)}$$

$$= 4077\ \mu g/m^3\ (3.4\ ppm)$$

where one-third of the street emissions have been assumed for each lane. The computation should be done separately for each lane, changing the distance, x, each time. The results are then added to obtain the impact from the entire street. If this were done, assuming 4-meter lanes, we would obtain a total of 8.36 ppm at the apartment window. At a similar apartment window on the windward side of the street we would obtain:

$$C_w = \frac{7x2x10^4x24}{20x30x3.5}$$

equal to 1.34 ppm for each of the three lanes or 4.02 ppm from the entire road. This means that under the conditions chosen, leeward concentrations are about twice the windward values.

c. Point sources: Two types of point sources merit discussion here: ground level point sources and elevated point sources. The types of ground level point sources which we normally encounter in impact analysis problems are usually small area sources treated as though their emissions emanated from a point. Such cases may be handled nicely by using either formula (8) or formula (9). In the case of the elevated point sources, the analysis becomes a bit more complex and cannot be reduced adequately to one or two simple algorithms, as has been done with the other source types discussed so far. When a large elevated point source such as a power plant boiler stack exists either on the project site or near enough to affect the project site, its impact should be analyzed. A thorough and lucid description of analysis procedures for point sources is provided in reference 3. As a first approximation, an estimate of the maximum ground level concentration to be expected from an elevated point source may be made by using figures 4 and 5 which are based on the assumption of a B stability category and a 2 meter per second wind speed as a "worst case" for the meteorology.

Concentrations, Averaging Times and
Recurrence Frequencies

The ambient air quality standards promulgated by the federal government and by some state and local jurisdictions require that specified concentrations averaged over specified time periods recur no more than a specified number of times per year (usually once per year). When analyzing the air quality impact of a project, therefore, the analysis must provide information on the specified concentrations, averaging times and recurrence frequencies specified by the standards.

Averaging times: Three approaches are applicable to obtaining the pollutant concentrations at the proper averaging times:

a. Averaged parameter method: In this approach, the analysis procedures described earlier are applied using values for emission rates and meteorological conditions which are considered as a mean over the time period in question. In the case of a road analysis, for example, if we want an 8-hour averaged carbon monoxide concentration, we would obtain the emissions from an 8-hour averaged traffic volume on the road and select a wind direction, wind speed and stability category which we considered to represent an average over the 8-hour period. We would then use formula (10) with the time averaged input parameters to obtain an

Figure 4.

COMPUTATION SHEET

Point source impact computation sheet
(numbers in circles indicate previous entries)

Emission point code number 1 (reference project site plan)

Calculation of plume rise and concentration-source strength ratio

1.	Emission point orifice height above grade.........	20	m
2.	Orifice inside diameter..........................	1	m
3.	Gas exit temperature (at orifice).................	300	°K
4.	Gas exit velocity (at orifice)....................	5	$m\text{-}sec^{-1}$
5.	Temperature difference parameter (1-(288÷ (3))....	0.04	
6.	Buoyancy factor (2.4x(4)x(2)²x(5))..............	0.48	$m^4\text{-}sec^{-3}$
7.	Distance to ground level max. conc. ((1)x15)......	300	m
8.	Plume rise (14.1x(6)$^{1/3}$)........................	11.3	m
9.	Effective stack height ((1)+(8))................	31.3	m
10.	Concentration-source strength ratio (from Fig. 1)	70	$\frac{\mu g/m^3}{gm/sec}$

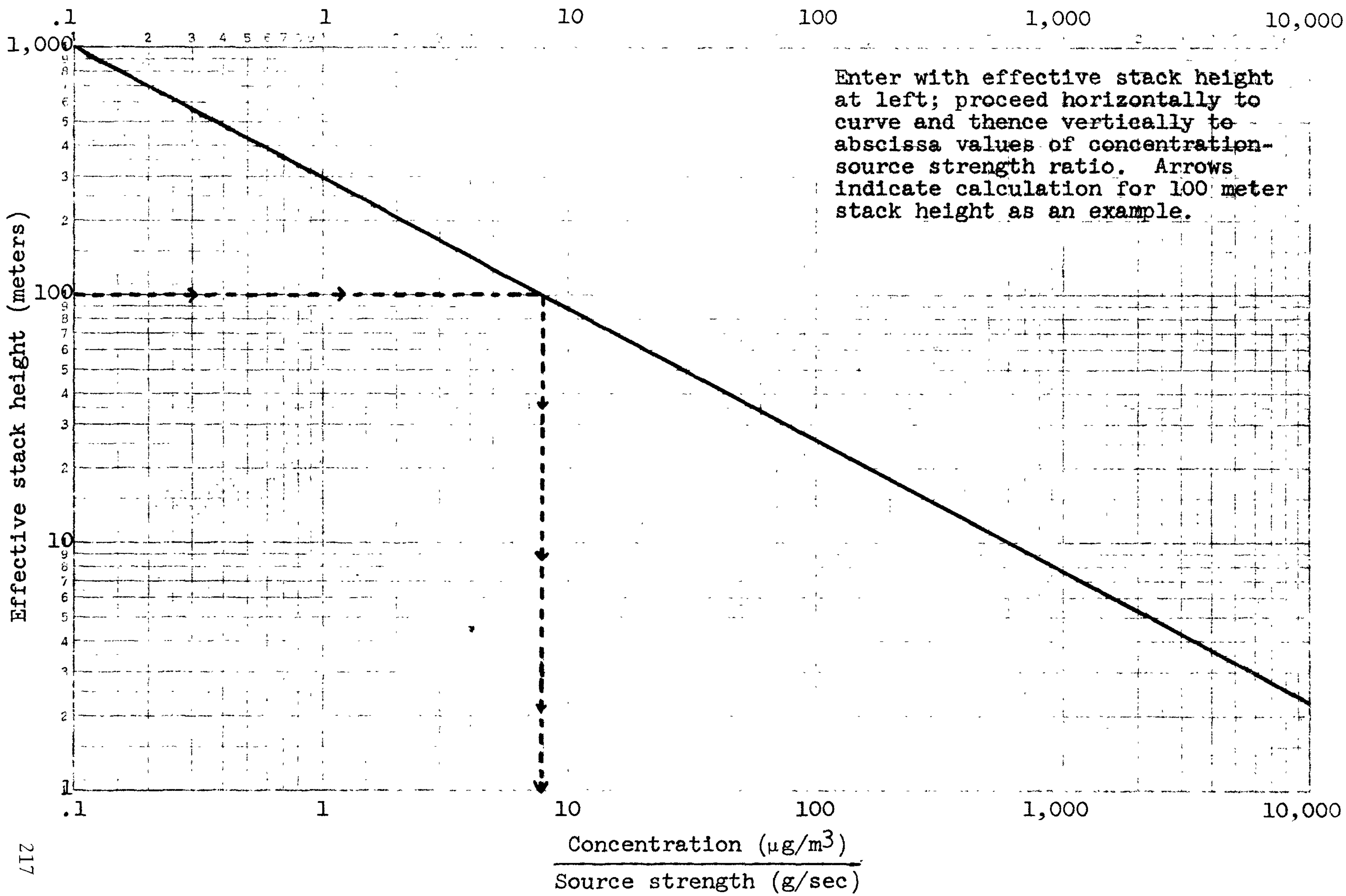
Calculation of maximum ground level impact

Pollutant	Pollutant* source strength gm/sec	Ground level maximum concentration calculated as (10) multiplied by pollutant source strength and in turn multiplied by the averaging time conversion parameter, m. ($\mu g/m^3$) Averaging time conversion parameters 1-hr m=2.0	3-hr m=0.8	8-hr m=0.7	24-hr m=0.6	1-mo m=0.3	1-yr m=0.1
CO	10	1400	560	490	420	210	70
SO_2	60	8400	3360	2940	2520	1260	420
NO_x	0	0	0	0	0	0	0
ORGANICS	0	0	0	0	0	0	0
PARTICULATE	10	1400	560	490	420	210	70

* at maximum capacity

Figure 5

Graphical estimation of concentration-source strength ratio at the point of ground level maximum as a function of effective stack height under adverse meteorological conditions.



estimate of the 8-hour averaged concentration. This method will generally be valid in the absence of large non-uniform variations in the values of the input parameters during the averaging period.

b. Weighted sub-interval method: A second and more precise method is to devide the time period over which the concentration is to be averaged into sub-intervals of time characterized by distinct and different values of emissions and/or meteorological parameters. An analysis can then be performed for each of the component sub-intervals and the resultant concentrations weighted and added to obtain the desired time-averaged concentration. This approach is used when obtaining the annual averaged background concentration at a point by considering the frequency weighted contribution of upwind sources in each individual wind rose sector. Another application would be in obtaining the carbon monoxide concentration from a road source averaged over an 8-hour period spanning peak and off-peak periods.

c. Statistical methods: A third and relatively simple approach makes use of a statistically derived relationship between concentration values at different averaging times as described in reference 9. The relationship is based upon the assumption of a lognormal distribution of pollutant values for all averaging times and requires for its use the standard geometric deviation for one averaging time (see Table 1). In using the table, the procedure would be to perform an analysis of concentration for a specific averaging time for which the best input information is available and then obtain concentration estimates for the other applicable averaging times by applying the ratios indicated in the table.

Recurrence frequency: In addition to obtaining concentrations for appropriate averaging times, we must also find out whether the time averaged concentrations specified in the standards are exceeded, and, if possible, how often. Two approaches are applicable to the recurrence problem:

a. Worst case method: The simplest approach to testing for air quality standard exceedance is to perform an analysis of the impact under conditions of emission and meteorology which are the worst conceivable from an air quality standpoint. If the concentration specified in the standard is not exceeded under such extreme conditions, we can reasonably conclude that the source in question meets the requirements of the standard. If, however, we find that the standard is exceeded, the question of how often still remains to be answered. While the worst case approach seems quite useful on the surface, a number of factors argue against its use. The principal problem with the method is that the meteorological conditions associated with extreme concentrations are often difficult to define, involving, in many cases, subtleties in the microscale effects of structures, terrain features and localized gradients in the meteorological variables. In addition, those meteorological conditions which have generally been associated with elevated pollutant levels, such as stagnant, windless conditions and associated thermally driven local circulations, are usually rather poorly represented by the models.

b. Statistical distribution method: Probably the most useful and most generalized of the simplified approaches to meaningful air quality analysis is to make use of the characteristics of the lognormal frequency distribution for time averaged pollutant concentrations as outlined in reference 9. In such a lognormal distribution, the logarithm of observed pollutant concentrations have a normal or gaussian distribution. We may therefore define a standardized variable or "z-score" in the form

$$z = \frac{\ln X - m}{s} \qquad (14)$$

where m and s are the mean and standard deviation of logarithms of a sample of time averaged pollutant concentrations (e.g., 1-hour averaged carbon monoxide concentrations) and X is a single concentration value in the sample. The quantity z, then, represents the number of standard deviations between the median value and the value X and is associated with the probability of exceeding the value of X. The relationship between z and probability of exceedance may be obtained by referring to any standard set of statistical tables. Formula (14) may be solved for X in the form

$$X = (e^m)(e^s)^z \qquad (15)$$

where e^m and e^s are the geometric mean (GM) and the standard geometric deviation (SGD), respectively, of the distribution of pollutant values, and e is the base of the natural logarithms. If we rewrite Formula (15) in the form

$$X = (MG)(SGD)^z \qquad (16)$$

we can readily see that when pollutant values are distributed lognormally, individual values, X, and the probability of their exceedance (represented by z) are related through the geometric mean and standard geometric deviation of the distribution. Detailed guidance for the application of the lognormal model to air pollution problems is given in reference 9. Use of the model in land use planning situations is discussed in reference

ARITHMETIC MEAN	STANDARD GEOMETRIC DEVIATION 1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
0.1	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.08	0.08	[illegible]
0.2	0.20	0.20	0.20	0.19	0.19	0.18	0.18	0.17	0.17	0.16	0.16
0.3	0.30	0.30	0.30	0.29	0.28	0.28	0.27	0.26	0.25	0.24	0.24
0.4	0.40	0.40	0.39	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.31
0.5	0.50	0.50	0.49	0.48	0.47	0.46	0.45	0.43	0.42	0.41	0.39
0.6	0.60	0.60	0.59	0.58	0.57	0.55	0.54	0.52	0.50	0.49	0.47
0.7	0.70	0.70	0.69	0.68	0.66	0.64	0.63	0.61	0.59	0.57	0.55
0.8	0.80	0.80	0.79	0.77	0.76	0.74	0.72	0.69	0.67	0.65	0.63
0.9	0.90	0.90	0.89	0.87	0.85	0.83	0.81	0.78	0.76	0.73	0.71
1.0	1.00	1.00	0.98	0.97	0.94	0.92	0.90	0.87	0.84	0.81	0.79
1.1	1.10	1.10	1.08	1.06	1.04	1.01	0.98	0.96	0.93	0.90	0.87
1.2	1.20	1.19	1.18	1.16	1.13	1.11	1.07	1.04	1.01	0.98	0.94
1.3	1.30	1.29	1.28	1.26	1.23	1.20	1.16	1.13	1.09	1.06	1.03
1.4	1.40	1.39	1.38	1.35	1.32	1.29	1.25	1.22	1.18	1.14	1.10
1.5	1.50	1.49	1.48	1.45	1.42	1.38	1.34	1.30	1.26	1.22	1.18
1.6	1.60	1.59	1.57	1.55	1.51	1.47	1.43	1.39	1.35	1.30	1.25
1.7	1.70	1.69	1.67	1.64	1.61	1.57	1.52	1.48	1.43	1.38	1.34
1.8	1.80	1.79	1.77	1.74	1.70	1.66	1.61	1.56	1.51	1.46	1.40
1.9	1.90	1.89	1.87	1.84	1.80	1.75	1.70	1.65	1.60	1.55	1.49
2.0	2.00	1.99	1.97	1.93	1.89	1.84	1.79	1.74	1.68	1.63	1.57
2.1	2.10	2.09	2.07	2.03	1.98	1.93	1.88	1.82	1.77	1.71	1.65
2.2	2.20	2.19	2.16	2.13	2.08	2.03	1.97	1.91	1.85	1.79	1.73
2.3	2.30	2.29	2.26	2.22	2.17	2.12	2.06	2.00	1.94	1.87	1.81
2.4	2.40	2.39	2.36	2.32	2.27	2.21	2.15	2.08	2.02	1.95	1.89
2.5	2.50	2.49	2.46	2.42	2.36	2.30	2.24	2.17	2.10	2.03	1.97
2.6	2.60	2.59	2.56	2.51	2.46	2.39	2.33	2.26	2.19	2.12	2.04
2.7	2.70	2.69	2.66	2.61	2.55	2.49	2.42	2.35	2.27	2.20	2.12
2.8	2.80	2.79	2.75	2.71	2.65	2.58	2.51	2.43	2.36	2.28	2.20
2.9	2.90	2.89	2.85	2.80	2.74	2.67	2.60	2.52	2.44	2.36	2.28
3.0	3.00	2.99	2.95	2.90	2.83	2.76	2.69	2.61	2.52	2.44	2.36
3.1	3.10	3.09	3.05	3.00	2.93	2.86	2.78	2.69	2.61	2.52	2.44
3.2	3.20	3.19	3.15	3.09	3.02	2.95	2.87	2.78	2.69	2.60	2.52
3.3	3.30	3.29	3.25	3.19	3.12	3.04	2.95	2.87	2.78	2.69	2.60
3.4	3.40	3.38	3.34	3.28	3.21	3.13	3.04	2.95	2.86	2.77	2.67
3.5	3.50	3.48	3.44	3.38	3.31	3.22	3.13	3.04	2.94	2.85	2.75
3.6	3.60	3.58	3.54	3.48	3.40	3.32	3.22	3.13	3.03	2.93	2.83
3.7	3.70	3.68	3.64	3.57	3.50	3.41	3.31	3.21	3.11	3.01	2.91
3.8	3.80	3.78	3.74	3.67	3.59	3.50	3.40	3.30	3.20	3.09	2.99
3.9	3.90	3.88	3.84	3.77	3.69	3.59	3.49	3.39	3.28	3.17	3.07
4.0	4.00	3.98	3.93	3.86	3.78	3.68	3.58	3.47	3.37	3.26	3.15
4.1	4.10	4.08	4.03	3.96	3.87	3.78	3.67	3.56	3.45	3.34	[illegible]
4.2	4.20	4.18	4.13	4.06	3.97	3.87	3.76	3.65	3.53	[illegible]	[illegible]
4.3	4.30	4.28	4.23	4.15	4.06	3.96	3.85	3.74	3.62	3.50	[illegible]
4.4	4.40	4.36	4.33	4.25	4.16	4.05	3.94	3.82	3.70	3.58	3.46
4.5	4.50	4.48	4.43	4.35	4.25	4.14	4.03	3.91	3.79	3.66	3.54
4.6	4.60	4.58	4.52	4.44	4.35	4.24	4.12	4.00	3.87	3.74	[illegible]
4.7	4.70	4.68	4.62	4.54	4.44	4.33	4.21	4.08	3.95	3.83	[illegible]
4.8	4.80	4.78	4.72	4.64	4.54	4.42	4.30	4.17	4.04	3.91	3.77
4.9	4.90	4.88	4.82	4.73	4.63	4.51	4.39	4.26	4.12	3.99	3.85

Table 2. Relationship between arithmetic mean on the left and geometric mean in the body for various standard geometric deviations. Other values may be obtained by corresponding movement of the decimal point right or left for both arithmetic and geometric mean.

STANDARD GEOMETRIC DEVIATION

ARITHMETIC MEAN	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
5.0	5.00	4.98	4.92	4.83	4.72	4.61	4.48	4.34	4.21	4.07	3.93
5.1	5.10	5.08	5.02	4.93	4.82	4.70	4.57	4.43	4.29	4.15	4.01
5.2	5.20	5.18	5.11	5.02	4.91	4.79	4.66	4.52	4.38	4.23	4.09
5.3	5.30	5.28	5.21	5.12	5.01	4.88	4.75	4.60	4.46	4.31	4.17
5.4	5.40	5.38	5.31	5.22	5.10	4.97	4.84	4.69	4.54	4.39	4.25
5.5	5.50	5.48	5.41	5.31	5.20	5.07	4.92	4.78	4.63	4.48	4.33
5.6	5.60	5.57	5.51	5.41	5.29	5.16	5.01	4.86	4.71	4.56	4.40
5.7	5.70	5.67	5.61	5.51	5.39	5.25	5.10	4.95	4.80	4.64	4.48
5.8	5.80	5.77	5.70	5.60	5.48	5.34	5.19	5.04	4.88	4.72	4.56
5.9	5.90	5.87	5.80	5.70	5.58	5.43	5.28	5.13	4.96	4.80	4.64
6.0	6.00	5.97	5.90	5.80	5.67	5.53	5.37	5.21	5.05	4.88	4.72
6.1	6.10	6.07	6.00	5.89	5.76	5.62	5.46	5.30	5.13	4.96	4.80
6.2	6.20	6.17	6.10	5.99	5.86	5.71	5.55	5.39	5.22	5.05	4.88
6.3	6.30	6.27	6.20	6.09	5.95	5.80	5.64	5.47	5.30	5.13	4.95
6.4	6.40	6.37	6.29	6.18	6.05	5.89	5.73	5.56	5.38	5.21	5.03
6.5	6.50	6.47	6.39	6.28	6.14	5.99	5.82	5.65	5.47	5.29	5.11
6.6	6.60	6.57	6.49	6.38	6.24	6.08	5.91	5.73	5.55	5.37	5.19
6.7	6.70	6.67	6.59	6.47	6.33	6.17	6.00	5.82	5.64	5.45	5.27
6.8	6.80	6.77	6.69	6.57	6.43	6.26	6.09	5.91	5.72	5.53	5.35
6.9	6.90	6.87	6.79	6.67	6.52	6.36	6.18	5.99	5.81	5.62	5.43
7.0	7.00	6.97	6.88	6.76	6.61	6.45	6.27	6.08	5.89	5.70	5.51
7.1	7.10	7.07	6.98	6.86	6.71	6.54	6.36	6.17	5.97	5.78	5.58
7.2	7.20	7.17	7.08	6.96	6.80	6.63	6.45	6.25	6.06	5.86	5.66
7.3	7.30	7.27	7.18	7.05	6.90	6.72	6.54	6.34	6.14	5.94	5.74
7.4	7.40	7.37	7.28	7.15	6.99	6.82	6.63	6.43	6.23	6.02	5.82
7.5	7.50	7.47	7.38	7.25	7.09	6.91	6.72	6.52	6.31	6.10	5.90
7.6	7.60	7.57	7.47	7.34	7.18	7.00	6.81	6.60	6.39	6.19	5.98
7.7	7.70	7.67	7.57	7.44	7.28	7.09	6.89	6.69	6.48	6.27	6.06
7.8	7.80	7.76	7.67	7.54	7.37	7.18	6.98	6.78	6.56	6.35	6.13
7.9	7.90	7.86	7.77	7.63	7.47	7.28	7.07	6.86	6.65	6.43	6.21
8.0	8.00	7.96	7.87	7.73	7.56	7.37	7.16	6.95	6.73	6.51	6.29
8.1	8.10	8.06	7.97	7.83	7.65	7.46	7.25	7.04	6.81	6.59	6.37
8.2	8.20	8.16	8.06	7.92	7.75	7.55	7.34	7.12	6.90	6.67	6.45
8.3	8.30	8.26	8.16	8.02	7.84	7.65	7.43	7.21	6.98	6.75	6.53
8.4	8.40	8.36	8.26	8.12	7.94	7.74	7.52	7.30	7.07	6.84	6.61
8.5	8.50	8.46	8.36	8.21	8.03	7.83	7.61	7.38	7.15	6.92	6.69
8.6	8.60	8.56	8.46	8.31	8.13	7.92	7.70	7.47	7.24	7.00	6.76
8.7	8.70	8.66	8.56	8.41	8.22	8.01	7.79	7.56	7.32	7.08	6.84
8.8	8.80	8.76	8.65	8.50	8.32	8.11	7.88	7.64	7.40	7.16	6.92
8.9	8.90	8.86	8.75	8.60	8.41	8.20	7.97	7.73	7.49	7.24	7.00
9.0	9.00	8.96	8.85	8.70	8.50	8.29	8.06	7.82	7.57	7.32	7.08
9.1	9.10	9.06	8.95	8.79	8.60	8.38	8.15	7.90	7.66	[illegible]	[illegible]
9.2	9.20	9.16	9.05	8.89	8.69	8.47	8.24	7.99	7.74	[illegible]	[illegible]
9.3	9.30	9.26	9.15	8.99	8.79	8.57	8.33	8.08	7.82	7.57	7.31
9.4	9.40	9.36	9.25	9.08	8.88	8.66	8.42	8.17	7.91	7.65	7.39
9.5	9.50	9.46	9.34	9.18	8.98	8.75	8.51	8.25	7.99	7.73	7.47
9.6	9.60	9.56	9.44	9.28	9.07	8.84	8.60	8.34	8.08	7.81	7.55
9.7	9.70	9.66	9.54	9.37	9.17	8.93	8.69	8.43	8.16	7.89	7.63
9.8	9.80	9.76	9.64	9.47	9.26	9.03	8.78	8.51	8.25	7.98	7.71
9.9	9.90	9.86	9.74	9.57	9.36	9.12	8.86	8.60	8.33	8.06	7.79

GEOMETRIC MEAN

4. Relationships between variables are found in Tables 1 and 2.

EXAMPLE 10

Suppose that the 1-hour averaged values of carbon monoxide observed in the course of a year have a geometric mean of 4 ppm and a standard geometric deviation of 2, and suppose we wish to estimate how often the federal 1-hour standard of 35 ppm was exceeded in the course of the year. We may rewrite Formula (16) in the form

$$35 = (4)(2)^z$$

Solving for z, we obtain z=3.1 which equates to a 0.2% exceedance rate. This means that for the given distribution of 1-hour averaged values, the standard value of 35 ppm was exceeded 13 times out of 8700 1-hour periods in the annual sample.

Analysis Techniques for Reactive Pollutant Species

Currently there exist no simplified techniques for handling the problem of chemical transformations in the atmosphere. In fact, even the sophisticated modeling techniques which have been developed are still somewhat experimental and not yet suited to generalized application. The modeling techniques which we have just described are intended for use with the primary pollutant species actually emitted from the sources and do not account in any way for chemical transformations which take place in the atmosphere between source and receptor. Most local impacts tend to be related to primary rather than secondary pollutants. Since there are standards for secondary pollutants such as oxidant and nitrogen dioxide which are formed by such chemical transformations, we must have methods alternative to the techniques we have discussed in order to address ourselves to the impact of projects in terms of these secondary pollutants. In this section we will discuss a few such methods. It is the author's feeling, however, that few projects will be large enough to cause a secondary pollutant impact in and of themselves. Such impacts, when they do occur, tend to be distant from the source.

The substitute standard method: In the case of oxidant, lack of a deterministic relationship between oxidant precursor emissions and oxidant concentrations has led to the promulgation of a substitute or guideline standard for one of the primary pollutants, non-methane hydrocarbons, which is involved in the oxidant producing chemical reactions and is considered by many to be the controlling reagent. One method of handling the oxidant problem, therefore, is to model non-methane hydrocarbon dispersion using the techniques we have described and to compare the resultant concentrations to the substitute standard. The assumption is that compliance with the substitute standard will assure compliance with the oxidant standard as well.

The ratio method: In the case of the oxides of nitrogen, emissions from the source are usually given in terms of total oxides of nitrogen and consist mainly of nitric oxide and a lesser amount of nitrogen dioxide. Chemical transformations in the atmosphere convert much of the nitric oxide to nitrogen dioxide, the rate and amount of conversion depending on a number of factors which are difficult to account for in a straightforward manner. In view of this, there are two ways in which we can attempt to account to some extent for the conversion. One method is to model the dispersion of total oxides of nitrogen using the techniques we have discussed and to assume that the ratio of nitrogen dioxide concentration to that of total oxides of nitrogen is the same as the ratio obtained from data taken at a nearby air monitoring station. Another is to simply assume that the emissions from the source are 100 percent nitrogen dioxide. The latter approach will usually over-estimate the nitrogen dioxide concentration which may be considered as a safety factor favoring air quality.

The proportional trend method: If we are interested only in the comparison between impacts in various future years or between alternative land use strategies in the same and/or future years, a variation of the ratio method may be used. In this case, we simply compare the modeled concentrations of the primary pollutants and assume that the concentrations of the secondary pollutants will be in the same proportion. Thus, if one strategy yields twice the concentration of non-methane hydrocarbons or oxides of nitrogen as does an alternative strategy, we may assume that the concentrations of oxidant or nitrogen dioxide will also be in the proportion of 2 to 1.

Regional Modeling Applications

Throughout this presentation, we have concerned ourselves primarily with the impact of individual projects such as shopping centers or parking lots. The same techniques, however, may be used to model extensive source configurations such as regional land use or transportation plans. In doing this, we simply divide the source area or region into a number of grid squares as described in reference 4 and treat each grid square as an individual area source. The impact of each grid square's emissions upon a given receptor may be modeled using the techniques discussed earlier.

Model Accuracy and Model Tuning

The gaussian modeling techniques which we have described have been found to yield reasonably accurate estimates of concentrations resulting from point and line source emissions on an ensemble averaged basis. That is, if we were to measure the actual concentrations on a large number of days characterized by a given set of emissions and meteorological conditions, we would expect the average of all the observed concentrations to be estimated rather closely by the model. An individual observation, however, might differ significantly from the prediction of the model, typically by a factor of 2. The difference between estimate and observation usually decreases with longer averaging times so that annual averages are typically within 10 to 20 percent of observations if the modeling is carefully done. Spatial averaging also increases the accuracy of the modeling so that a modeled estimate of the concentration averaged over a square kilometer can be expected to agree more closely with the observed concentration than a modeled estimate of concentration at a given point. To be on the safe side, as far as air quality is concerned, in view of the factor of 2 mentioned above, we might at least entertain the possibility that a concentration might occur which is twice that which we estimate with the model or similarly that the frequency of exceeding the standard might be twice that which we expect. In augmenting our modeling estimate, however, we should be careful not to exceed values which have actually been observed in situations similar to those assumed in the model.

Even if the assumptions of the dispersion and statistical models were realized in every detail, we would not expect even the ensemble averages of observation and prediction to be in perfect agreement. Such agreement is precluded by a variety of factors such as instrument accuracy, the inability of monitoring sites to represent spatially averaged concentrations and the fact that certain depletion mechanisms such as chemical and gravitational deposition and chemical transformation have not been and, in fact, could not successfully be included in the models. Since there is no way of successfully separating the error due to these sources from that due to inadequate modeling assumptions, it is logical to deal with the residual error from all sources by means of an empirical or tuning adjustment. This is done by using the model in an area or location for which monitoring data is available and comparing the modeled and observed concentrations under the same conditions of emissions and meteorology. On the assumption that the observation is correct, we may then adjust the modeled estimates by a factor necessary to bring the estimates and observations into agreement. The tuned model may then be used with greater confidence in situations where monitoring data is not available.

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APPENDIX A

A Note on Formula Derivation

The modeling algorithms which we have suggested for use in estimating the air quality impact of projects have been presented without a great deal of information relative to their derivation. It is the purpose of this short appendix to indicate the manner in which the formulas have been obtained for those who might be interested in a more critical assessment of their validity.

Formula (1), the box model formula, is derived by assuming that a column of air with unit area and a height equal to the height of the mixing layer moves across a source area with the speed of the wind. It is further assumed that pollutants emitted into the column as it moves are thoroughly mixed between the lower surface and the top of the mixing layer. With these assumptions, the concentration in the column, when it reaches the downwind edge of the source area, is obtained by multiplying the emission rate into the column (Q/A) by the time the column spends in the source area (L/U) and dividing by the height of the mixing layer (H).

Formulas (4), (6) and (7) are derived on the assumption that the source area has a uniform emission rate and that the area source can be treated as though it were composed of an infinite number of line sources, one next to the other. With this assumption, the concentration at a downwind receptor may be obtained as the sum of the concentrations produced by the individual line sources comprising the uniform area source.

The algorithm for concentration downwind of a ground level line source is given in reference 3, page 40 as

$$C = \frac{2q}{(2\pi)^{1/2} \sigma_z U} \qquad \text{(A-1)}$$

where q is the emission rate per unit length of the line (gm/m-sec) and σ_z is the standard deviation of the plume, in the vertical, at the distance of the receptor. Integration of this formula (A-1) from one end of the area source to the other, after substituting for σ_z using Formula (5), will yield formula (4). Averaging of upwind line source contributions for all receptor points within the area source, via a double integration of formula (A-1) as outlined in reference 5, will yield formula (6). See Figure A-1.

Formulas (8) and (9) are derived on the assumption of a point source plume with uniform concentration across the width of the plume (assessed to be 22-1/2 degrees) and a gaussian distribution in the vertical (reference 3, page 38). Formula (8) makes the further assumption that beyond 10 kilometers, the plume also has a uniform concentration between the ground and the top of the mixing layer. See Figure A-2.

Formula (10) is derived as indicated in reference 8 by treating a street or highway as a line source with the wind at some arbitrary angle ϕ to the road axis. The formula for the concentration downwind of such a line source is simply Formula (A-1) with the sine of the wind angle in the denominator. Formula (10) is a modification of these line source formulas based on the assumption of initial mixing on the road due to the turbulence created by the cars and based also on empirical studies conducted by the California Division of Highways.

AREA SOURCE TREATED AS COMPOSED OF LINE SOURCES

If the source area can be considered to have an emission rate which is uniform, horizontally, and if it is considered, also, to be composed of an infinite number of line source segments, the concentration at a fixed receptor site may be obtained by summing the contributions from each line source segment. In the case of a mobile receptor, the average contribution of the line source segments may be obtained over the approximate travel area of the receptor.

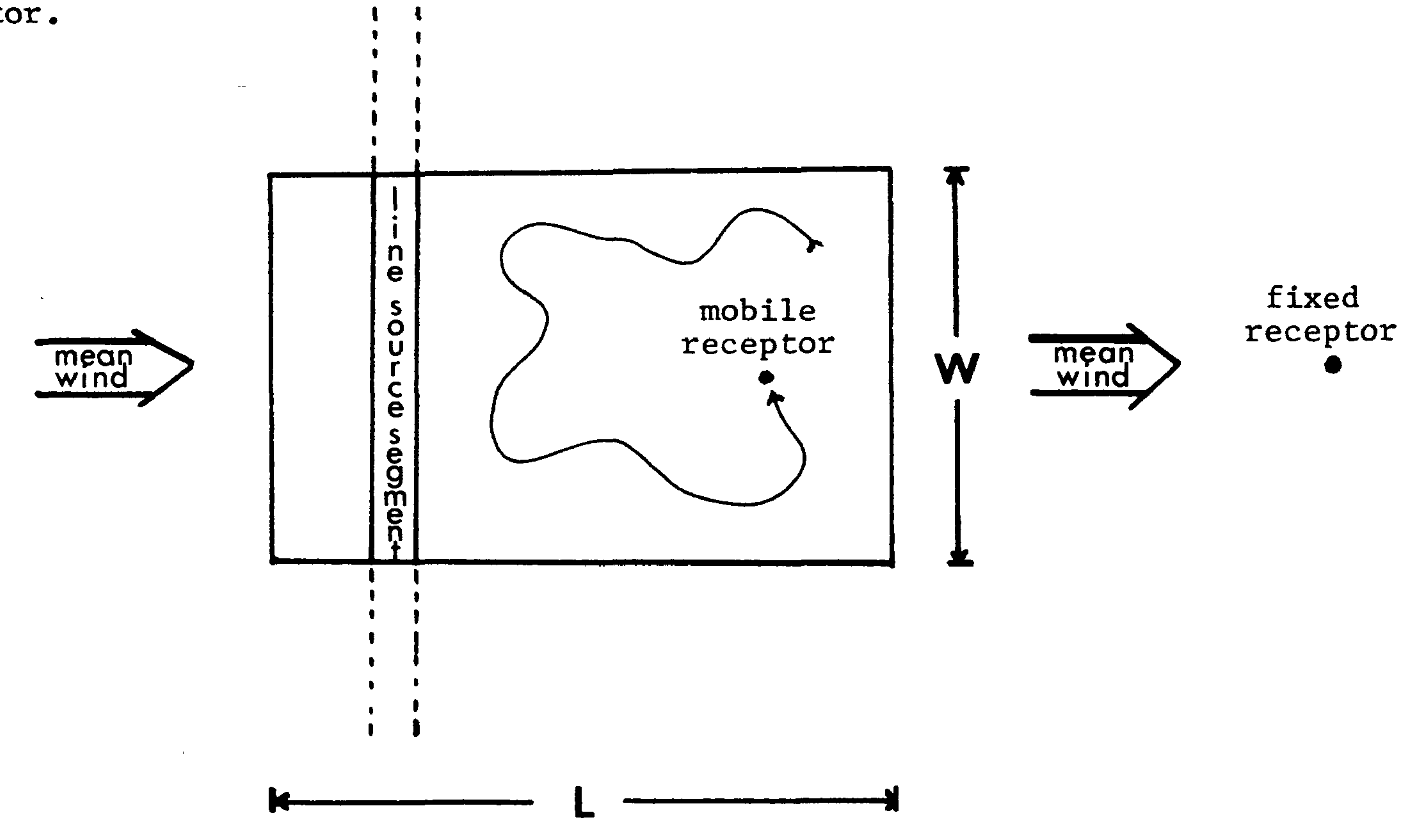

Figure A-1

AREA SOURCE TREATED AS A POINT SOURCE

An area source which is small in dimension compared with the distance to a downwind receptor may be treated as though all emissions emanate from a point at the center of the area source. The plume will have a gaussian distribution of concentration in the vertical until the plume top reaches the base of a stable layer at height H. Beyond this point, the plume will transition to a thoroughly mixed state with uniform distribution of concentration in the vertical. As a rule of thumb, a gaussian plume may be assumed up to ten kilometers with a uniform plume beyond ten kilometers.

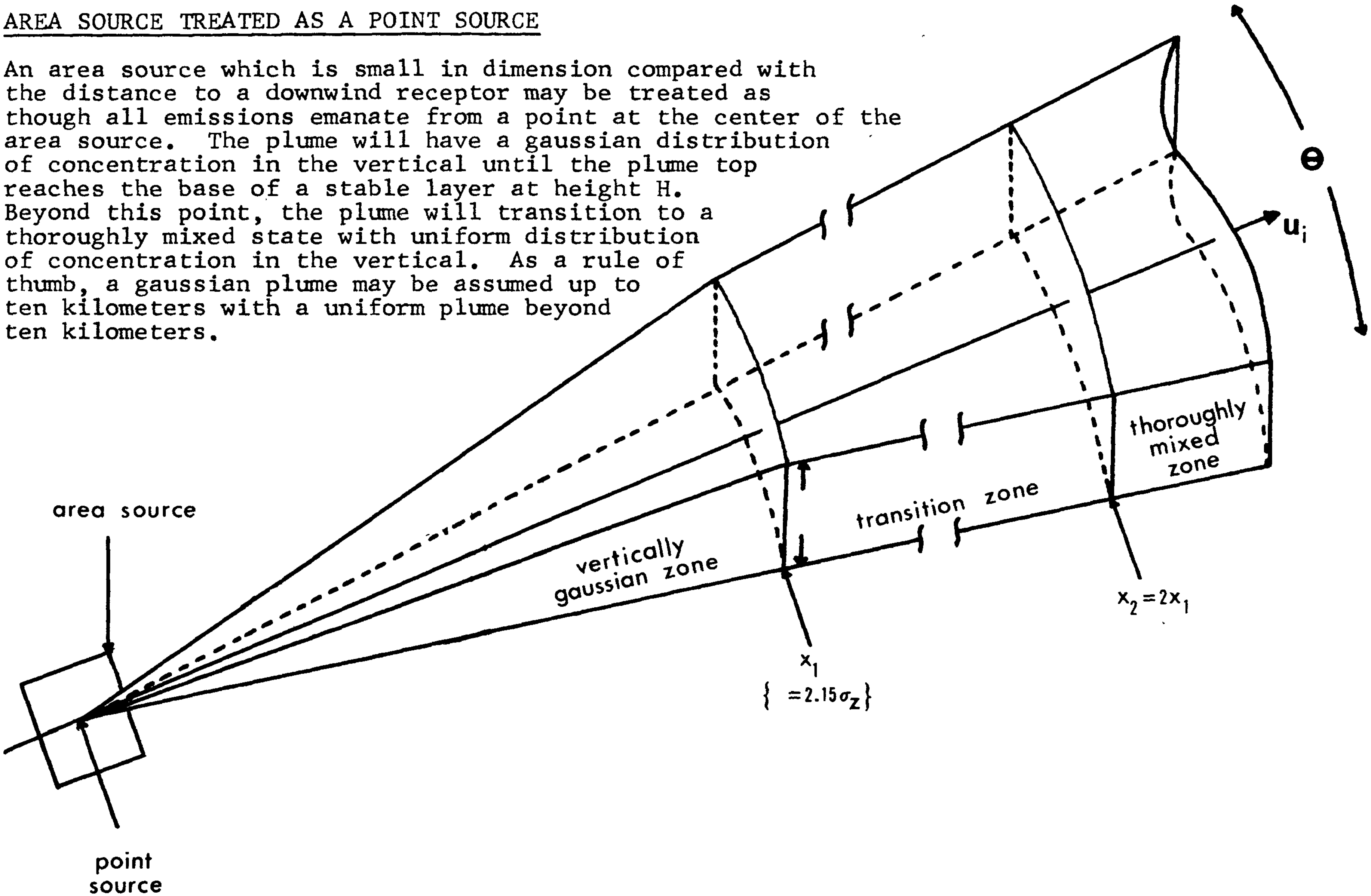

Figure A-2

Formula (11) is obtained by treating a line source as a series of point sources, one next to the other, and summing the impacts of the individual points downwind by integrating formula (9) over the length of the line.

Finally, formulas (12) and (13) are taken from reference 10 where they are given as the result of an empirical study.

The foregoing is but a thumbnail sketch of the derivation of formulas used in our presentation. A thorough familiarity with gaussian modeling obtained by a study of the cited references will aid greatly in an understanding of the reasoning behind the techniques.

APPENDIX B

A Summary of Formulas

The following is a summary of line and area source formulas contained in the foregoing paper. Constants are non-dimensional so that any set of consistent units may be used in the formulas. If micrograms, meters and seconds are used as units, as is suggested in the definition of variables, concentration estimates will be in the units of micrograms per cubic meter, units which are readily comparable with air quality standards.

Formulas may be used for any averaging time (e.g., 1-hour, 8-hour, 24-hour, annual average) provided that meteorological conditions and emission rates are appropriate to the averaging time used. Concentrations for longer averaging times may be calculated as the average of concentrations for a series of shorter averaging times. The use of wind speeds of less than 1 meter per second and extreme (A or F) stabilities will result in questionable results and such use should be avoided. The validity of the parameterization of complex source configurations as points, lines or areas will generally increase with distance from the source.

Summary of simple formulas for the approximation of line and area source impact

AREA SOURCE FORMULAS

A1	$C = \dfrac{QL}{AHU}$	for large area sources with closest boundary more than 10 kilometers from receptor
A2	$C = \dfrac{0.8Q(X_2^{(1-b)} - X_1^{(1-b)})}{AUa(1-b)}$	for large area sources with farthest boundary less than 10 kilometers from receptor
A3	$C = \dfrac{2.55Q}{HUX_c}$	for small area sources with centers more than 10 kilometers from receptor ($X_c > 10$ Km)
A4	$C = \dfrac{2.03QX_c^{-(1+b)}}{aU}$	for small area sources with centers less than 10 kilometers from receptor ($X_c < 10$ Km)
A5	$C = \dfrac{0.8QL^{(1-b)}}{AUa(1-b)(2-b)}$	for average concentration within the boundaries of the area source (mobile receptors)

LINE SOURCE FORMULAS

L1	$C = \dfrac{0.25Q_1X_1^{-p}}{U\sin\emptyset}$	for line sources (roads) with receptors located laterally
L2	$C = \dfrac{2.04Q_1(X_1^{-b} - X_2^{-b})}{abU}$	for line sources (runways) with receptors located longitudinally. Wind parallel.
L3	$C = \dfrac{7Q_1}{(U+0.5)((x^2+z^2)^{1/2} + 2)}$	for leeward side of street canyon (wind angle > 30 deg.) Do separate computation for each lane.
L4	$C = \dfrac{7Q_1(D-Z)}{WD(U+0.5)}$	for windward side of street canyon (wind angle > 30 deg.) Do separate computation for each lane.

Definition of Variables

Q = emission rate of pollutant (micrograms per second)

Q_1 = emission rate per unit length of line (micrograms per meter per second)

U = wind speed (meters per second)

L = Alongwind dimension of area source (meters)

*Note: The constant a has the dimension length (1-b)
Formulae A-3 and A-4 assume a plume width of 22-1/2 degrees

X_1 and X_2 = distance to closest and farthest boundaries of area source with respect to the receptor. (meters)

X_c = distance from receptor to center or small area source (meters)

H = mixing height. (meters)

W and D = width and depth of street canyon (meters)

z = height of receptor above street(meter)

a and b are stability constants

x = distance to center of closest traffic lane

ELEMENTS OF AN ADEQUATE IMPACT PRESENTATION

Ralph A. Mead

Introduction - NEPA and CEQA

The National Environmental Policy Act, and similar laws in many states, require the environmental impact of various public (and in some states private) developments and other actions to be described in detail. The basic intent of such legislation is to require a "full disclosure" of anticipated impacts, and the legislation has been successfully used by environmental groups to halt or delay action in cases where the environmental impact report or statement (EIR) fails to spell out the impact completely. Careful preparation can avoid making the EIR an easy target for litigation and more important, can help focus the attention of the public and the decision makers on the significant impacts.

While it is theoretically possible to prepare an "Air Quality impact analysis" separate from the EIR, it is infinitely more sensible to integrate the two. An EIR will include necessary descriptive and analytical elements, aside from the technical Air Quality analysis, which is essential for any informed judgment about Air Quality impact. The Air Quality analysis may or may not be prepared as a separate document, depending partly on local legal requirements; in substance, however, the two are interwoven. Especially where (as in California) a comprehensive EIR requirement exists for private as well as public projects, the reviewer of an air quality impact analysis should have the benefit of a contemporaneous EIR. (Arguably, certain specialized studies, e.g. flora and fauna, could be kept at a generalized level or omitted for air quality review purposes.)

It is sometimes maintained that individual projects can be analyzed for air quality only in a broader planning context. While there is some merit in this statement, it is nevertheless true that most air quality impacts, especially local ones, can be defined regardless of the breadth of the planning framework. Both viewpoints are important, but the need for a broader context should not be accepted as an excuse for avoiding analysis of major projects.

A great deal of controversy surrounds the question of regulation of indirect sources. While this is a matter of considerable interest, it is not the subject of this paper. Whether and to what extent indirect sources should be regulated depends on a set of judgments about the significance of air quality impacts and the role of air quality in the value system of the people and their representatives. Such judgments are partly technical, partly political and partly legal. It is not necessary to debate these complex questions in order to discuss the elements of an adequate impact presentation, but the readers are invited to pursue them on their own.

Description of Existing Conditions

Three aspects of existing conditions are fundamental: meteorology, air quality and land use-transportation patterns. A description of regional meteorology is important, and it should be concise and relevant. A common failing of EIR's is that there is page after page of meteorological data and comments of little or no significance for air quality, while the succeeding sections on impact are quite sketchy and skimpy. Emphasis should be placed on parameters such as wind speed, inversion height and atmospheric stability which are paramount for air quality. On the local scale, available data should be utilized, but very often such data does not exist on a systematic basis for local areas. The informed judgment of a qualified meteorologist is far better than the guess of a non-meteorologist based on minimal local data. Professional judgment is also essential in evaluating the role of localized topography; superficial judgments in this area are common, due to a lack of understanding of the relationships between topography and meteorology.

Existing and historic air quality data may be obtained from air pollution control agencies and sometimes other sources. Such data, gathered at fixed monitoring stations, is of course subject to qualification and interpretation. Like all statistical data, it is subject to misuse, whether knowingly or unknowingly. The analyst should relate the air quality data to federal and state standards, which require:

a) that these standards be set forth in summary form and

b) that specific relationships be drawn for standard-related pollutants in terms of averaging times.

Monitoring station data must also be adapted to the project site, which can be done in several ways. Reliance may be placed on the opinion of a competent meteorologist familiar with the area. Site monitoring may be performed, although an adequate monitoring program is technically difficult and may be expensive. Air quality modeling is another possibility, again demanding specialized competence, and requiring substantial input data; modeling for the site has the advantage of facilitating comparison of existing air quality with projections for future years.

Existing land use and traffic information in an EIR will normally be found outside of the air quality section. The important consideration for air quality is that this information be comparable in geographical area, scale and level of detail to similar data for future years as discussed below. Particularly important are traffic volumes on major roads and location of sensitive receptors.

Project Description

If an EIR is being prepared concurrently with the air quality analysis, a project description will be available. This description (or one prepared specially for the analysis) must contain information useful for air quality analysis, and should not be accepted uncritically.

Project land uses should be expressed in terms related to their pollutant emissions characteristics. Since automobile emissions are of primary concern, land uses should be given in units amenable to standard trip generation analysis, e.g. gross floor area of commercial space, number and type of dwelling units, number of students, parking area, etc.

Roads to be built as part of the project should be shown in detailed fashion, and parking areas, entrances and exists should be similarly detailed. Circulation and parking patterns are of major importance for automobile emissions; avoidance of congestion within and surrounding the project is an objective for air quality as well as traffic engineering.

Relevant operational characteristics of the project should be described. Hours and days of operation will be of interest, particularly as compared with traffic peaking patterns. For point sources, detailed operational data will be needed, and usually required by the local air pollution control agency.

Any sensitive receptors to be included in the project must be specifically located and described. The term "sensitive receptor" includes any location or facility where health effects are especially pertinent because "sensitive" elements of the population will be present for extended time periods. At a minimum, this would include hospitals, nursing homes, retirement homes, schools, playgrounds, single family homes and family-oriented multiple dwellings.

The phasing and the construction schedule of a project are directly relevant to pollutant emissions because of increasingly effective auto exhaust controls in the years ahead. For a multiphased project this factor can be of crucial importance. For example, assume that an office complex is going to be built in three phases extending over an eight-year period, with the first and largest phase scheduled for completion in 1976. It is quite possible that one or more air quality standards will be exceeded in 1976 and for several years thereafter, while at completion of the entire project in 1982 no standard will be exceeded. If the phasing is inadequately treated in the project description, the air quality analysis will be incomplete and the impact will be mis-stated.

In describing the project, care should also be taken to specify features to be built as part of the project which will facilitate further development by either the project sponsor or other adjacent landowners. Such "directly associated development" may be presumed to have a high probability of occurrence in the eyes of the developer or the locality, or both. For example, a city may require a developer to install oversized water pipes to facilitate development of parcels lying beyond his project area. While the timing of development of those parcels may be uncertain, it is a reasonable assumption that they are expected to be developed; plans may be available or it may otherwise be possible to take account of this development in the air quality analysis.

Project Traffic Study

For almost any sizeable project, a detailed traffic study will be prepared independently of air quality considerations. The traffic study will either be part of the EIR or an essential background document to the EIR (assuming one is required); in any event it will be indispensable for project planning. In the absence of a detailed traffic study it is generally impossible to perform an adequate air quality impact analysis--a rather vital fact sometimes overlooked or ignored.

The requirements of a traffic study for air quality purposes do not differ from those standards in traffic engineering and transportation planning practice, and may be briefly described as follows. First, traffic (trip) generation is typically based on factors derived from specific case studies in the state or region of concern, usually conducted by the state highway department. Such factors will generally be applicable unless the particular project or area can be shown to have special characteristics justifying the use of other factors. Second, traffic distribution procedures, i.e. distribution of trips by geographical zones or sectors, often rely on local, regional, or highway department transportation planning studies, or in the absence of such studies, on standard trip length frequency curves. At this stage of the analysis "modal split" procedures are important (it should be noted that estimates of transit patronage are frequently over-optimistic). Third, the traffic assignment phase relates to assignment of trips to specific roads of "links" of the traffic network, both within the project boundaries and beyond. Assignment is generally made on a least time or shortest path basis.

Finally, the traffic engineer will examine the capacities of access points, roads and intersections affected by the project in relation to the traffic volumes projected for those locations. Average road speeds and levels of service will be predicted. ("Level of service" is a technical traffic term used as an index to the degree of congestion on a road.) Where less than optimal traffic conditions are expected, recommendations for road improvements are made. Such recommendations represent only the opinion of the traffic consultant and, unless incorporated in the project funding program or officially approved by the appropriate governmental agency, cannot be relied on by the air quality analyst to represent reality.

Other Anticipated Local Development

In order for the reviewer, the decision-makers and the general public to arrive at their own assessments of air quality impact, the person or agency preparing the analysis must address the question of expected development in the vicinity of the project at the time of its completion (or maximum impact). In other words, the project will not proceed in a vacuum. The local air quality will be determined not only by the project itself, but also in part by other nearby projects (as well as local and regional activity). The air quality impact of the project can be fairly assessed only if the significance of other anticipated local development is known. The geographical area within which such other development should be described will vary to some extent with the locale and the situation, but a one-quarter to one-half mile radius around the project boundary will normally be appropriate.

Some such projects may already be committed, in terms of official approval and funding. Others may be definitely planned, by public agencies or private developers, for construction within the relevant time period. These two categories--committed and specifically planned projects--can be quantified in air quality terms in many cases. A third less well defined category is "permitted" development, i.e. development permitted pursuant to local zoning and other regulations; ordinarily this category will not require quantification, but it should be described graphically and verbally.

For example, assume that a shopping center under evaluation is due for completion in 1976, and that a large high-density apartment complex approved for construction across the street will also be finished in 1976. To proceed with analysis of the shopping center while ignoring the apartment complex would not be appropriate. Similarly, new sensitive receptors, and new or modified roads, traffic controls and transit improvement, committed or definitely planned in the vicinity within the time period of concern, should be taken into account to the greatest extent possible.

The burden of securing and utilizing this additional information falls on the public or private organization preparing the air quality analysis or EIR. However, the information should be available from local, state, and other public agencies--which are normally contacted for other data. The reviewer in turn can contact these agencies, if necessary, to verify the information. Obviously, the most detailed information on "other anticipated local developments" will be for earlier years; where there is a long time span until project completion, the later data will tend to be sparser and less detailed.

Air Quality Impact Analysis

The core of the presentation is the technical, numerical analysis of air quality impact. The first task is to select an appropriate year or years for which to estimate the project's impact. If construction is to occur within, say, a two year period, the year of completion is the likely choice. If construction will take longer than two years, consideration should be given to selecting more than one analysis year. Desirably, the year of maximum expected impact should be analyzed--this may or may not coincide with the year of completion. Consider for example a project in two phases, the first to be finished in 1977 and the second in 1980. The greater impact will probably occur in 1977 (especially if the first phase is larger) because the effect of improved auto emission controls will be felt less in the earlier year. Regardless of the outcome of the analysis in such a case, the report will be more valid and informative if both years are considered.

The calculation of project impact can take a number of forms. The Research and Planning Section of the Bay Area Air Pollution Control District has evolved a methodology addressed to three levels or scales of impact: roadside, area-averaged and "regional." Aircraft emissions and industrial point sources can be modeled independently and are not discussed here.

For roadside impact, peak and off-peak vehicular emissions are for each road, whether within or beyond the project boundaries, on which project traffic forms a substantial part (say 10%) of total traffic volume. Using a readily available line source model and "adverse-case" meteorology, pollutant concentrations are modeled at roadside and at one or more distances from the road; background concentrations are added. This approach is used chiefly for carbon monoxide.

The area-averaged approach uses total emissions from the project, defined as emissions from all line, point and area sources within one or more (one-kilometer) squares centered on areas of highest source activity. Accepted Gaussian dispersion modeling techniques are used to calculate annual average pollutant concentrations, which may then be converted statistically to any desired averaging time. The result is averaged pollutant concentrations over the one-kilometer square, representing the project's impact on ambient air quality. Background concentrations are added to derive projected ambient air quality. This approach may be used for any non-reactive pollutant.

The regional impact on photochemical oxidant can be approximated by treating total project emissions of hydrocarbons as a point source, diffusing it downwind for ten kilometers, and comparing the resultant concentration to the ambient background concentration of hydrocarbons. While this is not a photochemical modeling process, it does give a general idea of the magnitude of oxidant impact resulting from a single source. It should be observed that over the time and distance required for oxidant formation, this impact is rarely expected to be significant.

After project impact has been calculated, the analyst should calculate the impact of "other anticipated local developments" in the year(s) of concern. Where possible, this consideration should be quantitative; at a minimum, a qualitative assessment is called for. Returning to the previous example (i.e., high-density apartments across from a shopping center under review) the pollutant concentrations resulting from the apartments should be calculated, or if that is impossible, a general idea of the magnitude of the problem should be given so that the reviewer or decision-maker has an understanding of the situation.

Finally, background concentrations should be added to arrive at total ambient air quality. Except in the case of particulates, background is often secondary to localized source concentrations, but can still be important. Projected background concentrations may be extrapolated from existing ambient air quality data or modeled in various ways. The Bay Area Air Pollution Control District uses a projected regional source inventory to provide background distributed over a fine grid. In general, air pollution control agencies are in a good position to supply background concentrations for the near term, or these may be estimated through extrapolation. For the long term, the accuracy of background estimates is subject to greater error, but this is equally true of all long-range projections.

Having calculated project impact and added background concentrations and the effects of "other anticipated local development," the air quality analyst can proceed to the interpretation stage. What does it all mean? At this stage opinions may reasonably differ on some points, but it is the job of the person preparing the impact analysis to set forth his professional judgment. The primary consideration is how the project's impact on air quality relates to federal and state air quality standards, taking non-project sources into account. The key parameter in this respect (obtainable through statistical analysis) is the frequency with which those standards are expected to be exceeded, on a climatological basis. Comparisons "with" and "without" the project are valuable.

For some projects, another valid approach to interpretation little used up to now, is to consider air quality impact in terms of exposure of sensitive receptors. For example, one could attempt to quantify the exposure of sensitive groups in a residential project in terms of an index like person/hours over the oxidant standard. The concept of impact <u>on</u> the project differs from the conventional concept of impact <u>of</u> the project, but it is clearly an appropriate subject for analysis in the sense that <u>without</u> the project this impact would not occur.

Finally, brief mention should be made of impacts during the construction period. Except for large projects in densely built-up areas, construction impacts will generally be tolerable, provided standard relief measures (such as wetting down the site) are used. For the more severe situations, especially where the construction period will be long, an attempt should be made to quantify the impacts, even though emission factors for construction equipment are acknowledged to be less than precise.

<u>Mitigating Circumstances</u>

Having stated the air quality impacts, the analyst can then present information regarding the ways in which those impacts will or could be mitigated. Experience in reviewing EIR's in California indicates that this section of the report is frequently a "mixed bag" (at least where air quality is concerned) consisting of desires, hopes, possibilities, miscellaneous comments and at times, firm data. The following discussion will consider a number of items often claimed to be mitigating circumstances.

Perhaps the most common category of mitigation includes planned and projected actions of national, state or local governments. For example, the air quality benefit anticipated from automobile emission control devices is sometimes set forth in mitigation of adverse impacts. Likewise, the prospect of better public transportation, or road improvements, is said to be a mitigating factor.

Several comments are appropriate with respect to this type of statement. First, some would say that true "mitigating conditions" must be within the control of the developer; if not, the factors at issue should really be a part of the impact analysis proper. Second, the timing involved before the control devices, transit, roads, etc. actually come "on line" should be set forth, rather than simply stating that certain events will (or may) occur at some indefinite future time. Third, just as the impact should be quantified, so should the mitigation. How much will control devices help, in any given year? What will be the "modal split" between transit and cars when transit becomes a reality? (Over-optimism is rampant in EIR's on this subject.) What will be the quantitative effect, on traffic volumes, speeds and patterns, of an anticipated road improvement?

Fourth and perhaps most important, the chances of the claimed mitigating factors ever becoming reality must be soundly appraised. Will promised transit really happen--is the funding there? Will a particular road really be widened within the next five years, or is it a "paper project?" What do real-world studies show about the probable effectiveness of auto emission controls? The degree of "proof" required is a matter of judgment; but if the pollution impacts are likely to be real, the mitigating circumstances must be real as well.

Another "mitigation" statement found in many impact reports is that air pollution will be increased in the vicinity of the project but will be reduced overall in the locality or region. This reduction is usually expressed in terms of "VMT"--Vehicle Miles Traveled. Such a claim, even if valid, would not represent true mitigation but rather a concept of air quality trade-offs, somewhat akin to saying "I'll fix your broken leg if you let me choke you." The localized impact is not mitigated, but is allegedly offset by an improvement somewhere else. The problem here is that "localized" air quality violations are not some second-class form of air pollution--they are health-related effects measured by legally-established air quality standards. One cannot simply wish them away by pointing out reductions occuring elsewhere.

Moreover, the claim of reduced VMT can rarely be sustained. New developments generally cause an overall increase in vehicle travel and air pollution, not a reduction. And the state of the art in "market studies" is such that although traffic attracted to a project can be estimated and distributed fairly well, it is extremely difficult to make defensible estimates of the effects of a project on remote traffic generators.

An example of true mitigation would be a change in proposed operational characteristics of a project, e.g. staggering work hours to lessen congestion and distribute vehicular emissions over a longer time period so as to decrease oxidant potential; or scheduling sports events at times when stadium traffic will not conflict with peak hour freeway traffic. Obviously there should be guarantees that these desirable things will in fact happen.

Design and layout changes can also be legitimate mitigation measures. Redesign of parking areas, internal circulation patterns or entrances and exits is a promising avenue to reduction of pollutant concentrations, especially for carbon monoxide. Building design and placement can have pollution micro-effects, but to determine these effects precisely requires an expensive and detailed study which is rarely justified (wind effects might be a better reason to undertake a study of this nature).

The amount, placement, and character of landscaping should not be ignored, because levels of both particulate and gaseous pollutants experienced at a receptor site can be mitigated by vegetation. Unfortunately, the state of the art does not allow us to quantify these effects reliably.

Finally, construction impacts of major projects may be mitigated if necessary, by such means as ensuring that construction vehicles do not congest nearby highways during peak hours, or even (in rare cases) prohibiting or limiting construction activities on meteorologically adverse days. However, it is a fact that construction impacts tend to be given less weight in decision-making, partly because of the temporary nature of construction activities and partly due to uncertainties regarding equipment emission factors.

Alternative Intensities, Uses, and Sites for the Project

Federal and state environmental impact legislation require a discussion of alternatives to the project. The most important consideration for the preparer of the EIR or similar documents is that the alternatives should be real ones. Little is gained by an extensive treatment of academic alternatives (although at times a brief mention of unreal alternatives may be useful simply in order to dismiss them); rather, a detailed treatment of one or two real possibilities is much to be preferred. Three types of alternatives may be distinguished: different intensities of development, or layouts; different uses for the project site; and different sites for the proposed use.

It is obvious that the air pollution impact of a project will be decreased if the intensity of development is reduced, whether it be a shopping center, sports stadium or residential development. What may not be so obvious is that a reduction in intensity can sometimes bring about a disproportionately large decrease in pollution. For example, if the project would overload a major highway, a relatively small decrease in project size might improve the highway's level of service substantially, causing nearby pollution levels to improve. Because less intense development is frequently desirable for other reasons besides air quality, and is often subject to negotiation under local customs and zoning ordinances, this kind of alternative can be realistic and should be explored and quantified.

The question of altered layout was mentioned under "mitigating circumstances," but is equally pertinent in this section. Through redesign of a project it is sometimes possible to effect substantial reductions in localized pollutant concentrations. This might involve changes in roadways within and serving the project, better parking lot design, additional entrances, exits and the like; or altering the siting of a "sensitive receptor" facility such as a hospital.

Alternative uses for the project site may be limited by zoning, location or economic feasibility. Moreover, in some cases the air quality impact of an alternative use may not differ substantially from what is proposed. But it is certainly conceivable for a realistic alternative use to be demonstrably better (or worse) than the proposed use because of differences in trip generation rate, "model split," or traffic peaking pattern in relation to adjacent highway traffic peaks; or because of the nature of the use as a sensitive receptor. These factors should be quantified and converted into air pollution estimates.

The final type of alternative involves different sites for the proposed use. If realistic alternative sites exist, the analyst can compare these to the project site in terms of potential for public transit, anticipated traffic volumes and congestion levels on adjacent highways, air pollution impact on the proposed use viewed as a sensitive receptor, local meteorology and topography, or growth-inducing effects.

Recent experience in the Bay Area indicates that for large projects such as regional shopping centers and sports arenas, alternative sites are actively considered. For example, a major department store may desire to locate within a general area and will negotiate for several sites simultaneously, but only one will ultimately be selected. In this kind of situation a detailed comparison of the sites is appropriate. Unfortunately practical problems can arise here, because a) additional work is required for a detailed comparison; b) the project proponent sometimes lacks control over data and timing for alternate proposals; c) the alternative site(s) may be located in another jurisdiction, introducing the additional consideration of economic incentives by two or more jurisdictions vying for one facility.

Nevertheless, a comparison of sites can be extremely important and valuable. The challenge to the reviewing agency is to seek complete information about alternate sites despite the problems cited, but without imposing an unfair burden on the project proponent.

Growth-inducing Effects of the Project

The growth-inducing effects of a project are not a part of the air quality impact analysis in the quantitative, location-specific sense used in this paper. Nonetheless these effects may be extremely significant and should be addressed. A three-way classification of projects may be useful here. First, there are projects which in themselves are negligible polluters but which may induce growth, e.g. sewer and water projects. Second, many projects are both polluters in themselves (direct or indirect sources) and inducers of growth, e.g. some highways and industrial plants. Third, other projects have little or no growth-inducing effects, regardless of their own pollution-emitting characteristics.

With respect to the second type of project, the EIR or air quality analysis should treat both the specific air pollution impacts and the more general growth-inducing effects. For the first type, i.e., the "pure" growth-inducing project, only the more general approach to air quality impact is possible.

Each of these contrasting approaches--the general and the specific--has its own validity and its own applications. Statements about growth-inducing effects assume greater meaning within an overall context of planning and growth policy as related to air quality, e.g. an emissions allocation program. The specific project impact analysis which is the main subject of this paper can be carried out more-or-less independently of a growth framework, and is too detailed to handle growth-inducement questions. However, data on growth inducement is still important in a specific project context--and can be handled in a qualitative, judgmental fashion rather than a quantitative, location-specific sense.

With this background in mind, we can proceed to consider some questions about the nature of growth inducement. What kinds of land use are apt to induce growth which affects air quality? Sewer and water facilities, highways and industries have all been mentioned. Generalizations are insufficient however; each case must be examined with respect to location and local development patterns and plans. For example, a major highway connecting an isolated development to an urban area might well be growth-inducing because it would tend to "open up" the intervening land to development which would not otherwise occur. On the other hand, a new highway to improve service in an already developed area might have a minimal effect on growth.

This raises an even more basic question--what kind of "growth" are we talking about? For air quality purposes, population growth with its associated automobile-serviced residential and commercial facilities is of course important, but other parameters of growth are also relevant, including land development patterns and vehicular travel. Locational relationships are also vital. Consider a large residential project proposed for a presently undeveloped area at the edge of the metropolitan region. Questions should be asked (and answered) regarding the project's locational relationships to employment centers, to roads and transit systems and to existing and planned sewer and water facilities.

Will the commuting patterns of the residents result in excessive amounts of vehicle travel? Will densities be too low to support effective bus service or mass transit? Will the project require lengthy utility and road extensions which are themselves growth-inducing? Will the project tend to induce extensive land development in area planned for open space and agricultural use or in an area susceptible to poor air quality conditions? Viewed in light of these questions, even a residential development may in certain circumstances be seen to have substantial growth-inducing effects relevant to air quality.

AIR QUALITY IMPACT ANALYSIS

PANEL DISCUSSION

QUESTION: How do you determine significant impact?

ANSWER: (Ralph Mead, Bay Area Air Pollution Control District) I don't think your environmental impact report can do it in and of itself. At least as far as air quality is concerned, one way to look at it is to look at the total emissions of the project as compared to total emissions in the area in which you're modeling, or considering. At some point, somebody has to pick a number or a percent and say that we feel that that is significant. That's one approach. Another one is to say, does the project in and of itself cause an excess of air quality standards? I'm not suggesting that those are the only tests of significance. There may be cases where something is significant and there is no excess of air quality standards. Perhaps you're putting something where there was no development before, and it's eating up 50% of the way to an excess of air quality standards. I think each professional and each agency is going to have to determine that, and most often on an individual case basis. That's the only way I can answer it.

QUESTION: Who determines significant impact?

ANSWER: (R. Mead) In the first instance, the decision, or the judgment on whether the impact is significant should be made by the preparer of the EIR. In California it will then be submitted to the city (or in some instances prepared by city staff) and the city has to determine whether they agree with that determination. The standards of the person preparing the EIR for what's significant may not agree with what the city reviewer thinks is significant or what is city policy. In turn, that may not agree with what a regional air pollution agency or other agency may consider significant. I'm not trying to evade that question; we don't have any hard and fast rules for what is a significant impact. It requires judgment. We're not discussing specific projects.

(A member of the audience asks that a letter be read by the speaker.)
The following are the comments of the air pollution agency relative to the Draft Environmental Impact Report on the airport expansion as requested by you:

The report indicates the total operations will be reduced from 330,000 passenger airline operations currently to 310,000 by 1985. There may be questions raised on this estimated number of operations. And we suggest that information in the regional airport systems study should be carefully examined in so far as it discusses possible changes in scheduling and the effect of the total number of operations and use of element engines. That's point one. Point two: assuming a maximum of 310,000 operations per year, which is what they say, there will be a decrease in emissions from aircraft by 1985, because of the lower number of operations and the use of cleaner engines. Three: the report indicates--and I would make a point here that again you're talking about certain assumptions, so you have to say whether you're making certain assumptions and the reviewer has to say whether he's basing his judgment on those assumptions, and those assumptions can in some cases be questioned. The report indicates that by 1985, twice as many vehicles will travel to the airport as today, but that automobile emissions will be reduced from

183 tons per day today to 38 tons per day in 1985. This should, or would improve air quality by 1985 given those assumptions. Fourth: the impact of auto emissions on air quality in the intervening years between 1972 and 1985 was not evaluated. That statement is saying, in my opinion, that the Impact Report was inadequate. Fifth: the impact of auto emissions on air quality in surrounding local communities caused by changes in the local traffic resulting from congested routes to the airport was not evaluated for the 1985 period nor for the intervening period of 1972-1985.

I mentioned these points before--what I'm getting at is that we do not always say yes this is significant, or no, this is not significant, as a single statement. First you have to have an adequate impact report before you can determine whether the impact is significant or not significant. And I think that really is the more important point as far as this course is concerned. If there has not been an adequate impact report prepared, it is not possible to determine whether the impact is significant. Then we talk about motor vehicle mixes during those years from '72 to '85 in terms of vehicles being improved and auto exhaust controls inproved over the years. Sixth, the proposed, projected increase in fuel requirements for heating purposes at the airport should be evaluated in terms of the impact on air quality based on fuels which will be available during the period 1972-1985, specifically the use of high sulphur fuel oil for such purposes should be evaluated in terms of air quality effects. You see, what we're saying in this letter, and what we're usually saying, is that we want a better job done, we need a better job done in order to make any kind of judgments at all--let alone about significance. Then we point out that a permit is required if the BTU heat in-put exceeds 10 million BTUs per hour.

And lastly we mention that complex source permits may be coming along from EPA and you'd better think about that, and then we say at the end, it is not clear at this time if complex sources which have had substantial work started prior to the extension of the district's authority to such sources, would be required to obtain a permit. Which means we don't know whether this project or some other project would be grandfathered in (grandpersoned in? grandparented in?), because we don't know what the regulations will say as regards which projects will be grandparented in. This letter is an official letter which is a matter of public record, so, if that's what you wanted.....

QUESTION: I had a question on a different point. I don't see how the air quality impact analysis can be evaluated, in and by itself. For instance, in this case the San Francisco Bay Area economy is dependent upon air travel, or connection in that way with other parts of the world. Wouldn't you have to evaluate the project in relationship to if that airport is not expanded, would it be necessary to build another one in another portion of the Bay Area. If so, what would be the impact of that on air quality?

ANSWER: (Waide Egener) I think this is the point again of using a systems approach, and in this situation we have a broader plan, and that broader plan said--okay, we can accomplish certain environmental objectives and yet fulfill our economic objectives if each airport adheres to certain criteria and standards, so what we're looking for is not a justification of aviation, but a demonstration by whoever is doing the report that the operator or the facility is capable of meeting the criteria and standards which are included in the overall plan.

QUESTION: I believe in this discussion there've been several points that have been alluded to which I think are significant. One is just what is significant, and what is an adequate report? It's been discussed very frequently, but I think it is all in the eyes of the beholder, and that is the real problem that we have right now--what constitutes an adequate report. The man who prepares it thinks it's the best report he ever prepared. The sponsor thinks it's overdone, many times. The local agency may have their own opinion. The regional agency has another opinion, and finally the citizens who might be for or against the particular project have got another opinion, and it's all tossed into one great big mess, if you want to call it that and sometimes it goes on and on--without any real standards of what constitutes an adequate report.

ANSWER: (Herman Volk) I'd just like to say that I think it's possible to read any EIR that's written and make a good case for it not being adequate. I don't think you'll ever get an adequate EIR that suits everybody--it's just not possible. I'd also like to make a point about determining significance of projects, and perhaps I could just point out what we do in our agency when we receive these EIRs. We receive something like 20 to 30 EIRs a month, and we have essentially two people that review them. They are farmed out to other people but essentially it's two people. First of all in the sorting out process, we spend time logging EIRs. We have to make some kind of a preliminary priority determination. We sit down, once a week, and we try to sort them out. Both Ralph and I agree that when you get a freeway project or a highway project, it's potentially a very significant project. It may not be so in all cases, but potentially it's a significant project, and I personally consider all EIRs or EISs for highway projects as significant, particularly if there are a number of miles of new road. Also, widening and interchanges can be significant. There are wastewater treatment EIRs that are really significant. If there's an approval to put in a wastewater treatment facility, it's growth. That's significant. There are shopping centers: I view all regional shopping centers as significant, those are ones with about 250,000 square feet. So a lot of the stuff that we get is significant in our view in terms of what will be emitted as a result of the activity that will be generated by it. On the other hand, you may get a project that is much smaller than the community shopping center, but it's located in a really poor air quality area. It's our view that those should not be overlooked. That's also significant.

We just don't have the time to look at all these EIRs and EISs, unfortunately, and when we do look at these, and I want to make this perfectly clear (I never thought I'd say that...) but it's this, when we look at it--and this is a point that Vivian made, and Ralph made and George made: and that is that the air quality element by itself really doesn't tell you much. You have to look at the traffic part, and the growth inducing aspect, as vague as that is, and as many red flags as that raises every time somebody mentions it; in point of fact it must be considered; also, mitigation measures and alternatives are important. You have to look particularly at the air quality components of each of those related elements, and how they relate. So what that means is that when we get an EIR we read it cover to cover. Now, there are meteorologists who may look at the air quality part and there's a traffic engineer who looks at the traffic, but essentially we review that damn thing cover to cover, and I don't think you can make an adequate review without doing so. And

I think we do a pretty good job of it. And another point is that we planners have been with an air pollution agency now--I've been there for a year, Ralph has been there 3 years. It's a 220 person organization that we're trying to move in our direction, supposedly, and without compromising any goals we may have. You really have to walk on eggshells and you have to weigh everything you say and consider it. And I just get a sense that there's a feeling here that somebody may not be doing an adequate job, and I suggest, I throw the ball back to you, that if you feel an adequate job isn't being done, then say something at this meeting, get up and protest. I think we are all in our own way really doing an adequate job. When I talk to local planners, and I talk to a lot of them, I make known what our concerns are, and they make known what their concerns are to me, and I think we're really talking at the same level and I think we really are moving in the right direction. And it's really difficult to say things perhaps so bluntly as some would like them to be said; of course somebody could always say, okay how do you really know what the impact will be, did you really do a study, is it really adequate, and I guess that's correct.

QUESTION: What happens next in the scenario? You've made comments of informational inadequacy and that generally appies to a draft impact statement...and then they go on with a final--Do you get another crack at it? Would you want another crack at it? What did you do at this stage? Do you ever make a determination once you feel they've done the most complete job they could as to whether it is significantly adverse or not? In other words, do you take a position at a final point?

ANSWER: (Herman Volk) In my opinion we don't take a position on as many projects as we should. Also, I think we really have to follow our comments all the way down the line, and if we really want to get something done we can't just mail a letter in and assume we did our job. To some extent that happens--you know we can only control so much. We're only willing to put--well I guess it's our jobs on the line--to a limited extent. I think there's real need to follow all comments through and one of the points I try to make known to anybody who listens is that we really have to go out there and start talking to people and say we really believe in what we say! We really think there's an adverse air quality impact, and we're serious about it. However, there's a tendancy, perhaps because we're overworked to some extent, to avoid meetings, not to follow things through and to assume they are followed through. To some extent I've been unhappy with the follow-up on reviews. Very often it's not me who follows it through, it's somebody working above me. Hopefully some of that will change, but it's a matter of building up confidence in your ability on the lower staff level, that's the position I'm in.

QUESTION: ...

ANSWER: (Herman Volk) What I'd like to do is critique the EIR that was summarized on the hand-out. (Note: the hand-out describes a project that consists of a 1.2 million square foot regional shopping center in the first phase. Subsequent phases consist of a 1.5 million square foot office complex and many other traffic generators.) I will be specific and I'm focusing on one EIR, but you can relate it to just about any other. First of all, for this specific EIR there were a lot of the standard statements that there would not be an air pollution problem at ultimate development even locally, since all of the controls of motor vehicles would take care of the contaminants. This is a statement which I'm sure you've heard over and over again at this course, but it's something we read continuously in EIRs. You get to the point of saying well, why are you reviewing them if all the controls will take care of everything. It's very upsetting to me to accept that statement, and I've come to the conclusion that I won't accept that statement. But, in this specific EIR ultimate development will take place in 1995, that's some 20 years away, and the EIR did point out that there's an air quality impact of some excess of the standards in 1977. But the next date chosen to analyze was 1995! I submit to you that that is not an adequate way of doing it. Each EIR should consider some interim period when a worst case traffic condition might occur and when there might be a worst combination of emission factors. If you plug it all together you'll probably come up with more excesses of the air quality standard than in 1977. This is really important to keep in mind--I see this all the time. Determine the impact in 1980, for example, if you are dealing with 1977 to 1995. I can't give you a specific interim date, but you should focus on some period that would be a worst case period and you should address yourselves to it. Also, in this particular EIR there was no discussion of emission factors, no discussion of speeds, and no references, but this is really atypical.

Another problem in this particular EIR, and I think it's a problem with many EIRs, is the optimistic, and I would say misleading statement about the kinds of road improvements that will actually be in place, in the time period corresponding to the time frame of the development. This particular project required a new interchange with an interstate road, in order to make the project go. If the interchange is not built, the EIR writer says that traffic would be forced to use narrow streets which would cause the level of service to drop to E, that is, near breakdown conditions. Since cars would be moving at very slow speeds under stop and go conditions, there would be more pollution. Now, the impact of that possibility was not discussed. It was just an assumption, a tacit assumption that the interchange would be in place--and we're dealing with an interstate raod. Additionally, the EIR writers pointed out the State indicated that it was very unlikely that they would build an interchange at that location because it was too close to another interchange. So, what seems to follow from all this is that there is absolutely no guarantee that that interchange will be built, or, that if it is built, it will be built in the time frame corresponding to the development. Again, I see these statements very often in EIRs, and I think it is very important to be wary of them. I don't know what should be accepted in the way of a guarantee, but I would certainly be something more than a statement such as, "It is anticipated that the interchange will be in place."

There's a section entitled "Measures to Mitigate Increased Traffic" which is interesting in itself. There's a discussion of transit, of staggering work hours, discussion of parking costs, and of car pooling. All valid things to try out and test. But there was no discussion concerning what would be needed to implement these mitigation measures and there was no discussion regarding probable traffic impact, although I think there is very little you can do to mitigate the volume of auto traffic that a shopping center generates. I'd be really amazed if you could reduce auto traffic by 10% or by 20%. For suburban shopping centers, it's difficult to reduce auto traffic enough to reduce overall pollution emissions or the amount of road improvements needed. Another mitigation measure that was not discussed, which I think is valid, is the possibility of scaling down the project, although this is not usually talked about. This project consists of a 1,200,000 square foot shopping center, but maybe a 1,000,000 would do. Maybe 900,000. Something on that order. And along with those considerations, there should be some discussion about not permitting development to proceed until the infrastructure is in place, until you have your roads. I don't know if that's reasonable, but it may be in certain cases, and it is something you can keep in the back of your mind and apply it if appropriate because it is important.

CEQA requires a discussion of project alternatives, and that involves consideration of alternative locations. In this particular case, as I recall, there were two alternative locations that were downtown locations; one downtown location was located in the same city as the shopping center site that was studied in detail, while another downtown location was in another city. Now, you know that no proponent, no city would want to say that a shopping center in another city would be better, because of the revenue generated. I think that's a controlling factor and one that I'm glad George mentioned. It's extremely significant because a lot of this is tied up to where the money's coming from, where it's going to, and who's getting it. Also, it seems to me that it makes sense to develop more than one air pollution impact analysis, particularly if you're dealing with a site located outside of a downtown center, and a site in a downtown center. If you're talking about two sites located across the street from each other, it may not make any sense in a regional context, but it may make sense in a local context. However, where there are different urban forms, or other characteristics which differ, I think that those things should be addressed fully in an air quality impact analysis. It's usually not done--it can be expensive to do two impact studies but CEQA calls for it, and I think it should be considered.

The air quality analysis for the 1977 phase, as I indicated, did show excesses of the air quality standard. In this case the excesses were in the 8 hour carbon monoxide standard, and the excesses occurred where homes were located. But there was no indication of the number of homes for example, and no indication of the number of people affected. I think this is a prime consideration--how many people are affected? That wasn't in there. My last point is that the EIR does point out that significant increases in air pollution will occur although they will not necessarily exceed the standard for certain areas. Unfortunately the location where these contaminent increases will occur is where there is a nursing home and an elementary school. Now, there has been a lot of discussion and cavalier attitude about the kinds of things we're doing here, but it seems to me that these are the kinds of sensitive receptors--the people--most sensitive to air pollution and they are often not considered. Older people and younger people, people who have respiratory problems are affected most severely. Now it seems to me that given the uncertainty of the road improvements that I discussed, questions concerning the correct emission factors, and all of the questions about correct deterioration rates and the like, it seems to me that it is prudent to say that the impact analysis should assume that there may be a slowdown in the road improvement program, or that the emission factors won't be applied or will be put off...and see what the impact will be on those 50 or so old people living near that road. Perhaps they shouldn't have been put there, but they are there, and I think that that has to be considered. I think it is extremely serious and I urge you all to keep it in mind, and to require in any EIR a thorough discussion of where hospitals are located, where schools are located, where playgrounds are located, and where they will or are likely to be located. And I think that is a responsibility of the proponent of the project in combination with local planners to locate where those existing and future sensitive receptors are. Sensitive receptors also include you and I--people living in the residential areas. It includes human beings, and that is often not considered for some reason. And I think it should be.

QUESTION: (Waide Egener) I think a project of this sort demonstrates the difficulty of doing, even with the best of intentions, an adequate Environment Import Report at the local level under prevailing circumstances. The question to an air pollution agency would be: Suppose the proponent evaluated a number of alternative locations and the impact of building the facility at those alternate locations at the microscale. That is to say, in the downtown or in the next community right next door or a little way up the road. How is the proponent to know--how is anyone to know--that given the condition of the air quality in that area, none of these sites will be satisfactory. What direction is offered to project proponents by any agency on what kinds of alternatives beyond the immediate area they ought to take into account.

ANSWER: (Herman Volk) A good question. Unfortunately, it's difficult to determine what the impact of a project will be without doing some kind of analysis. And heretofore, before Dick Thuillier's really superb description of what you can do, it was too mind boggling to entertain. Now, after this course, if everybody goes out and spreads the gospel, it may be possible to do a kind of quickie analysis for each one of the sites, and try to come up with some idea of what the impact would be. But before this course I wouldn't know exactly what to tell you; I'm glad I took the course.

QUESTION: (Bill Rugg, Planning Director, San Leandro) I wonder if the panel would play a little game with me. I want to ask each of you to give us three pieces of information--on say, the last project. First, as a staff person, if the indirect source regulations were in effect, would you approve it, or recommend approval, or recommend disapproval. Second, if you recommend approval, what specific conditions of approval would you recommend?

ANSWER: (Herman Volk) With no authority invested in me, I will answer that question. I think what the staff would like me to do is to determine the number of excesses in the air quality standard that would occur, and perhaps state that the excesses are significant or are not significant. And perhaps what they would do, and I really don't know, is to leave it up to the Board itself to determine whether or not it is really significant--the Board being the Board of Directors of the air pollution agency. I don't know if that's really a "cop-out" or not, you'll have to really judge for yourself, but if something will exceed the standard, say two more times, or three more times a year, the question is: is it significant or isn't it significant? I don't know how to make a determination without some kind of maintenance plan, something else to relate it to, and not just hang it on the air quality standard. If you can say it exceeds the standard two times more a year and also is inconsistant with a control strategy or a maintenance strategy, it seems to me that you have better backing.

ANSWER: (Ralph Mead) It seems to me as a staff person that I would generally go along with what Herman said. But I would make a recommendation--not as me individually, but as part of the technical staff in general--I would make a finding or a determination to the air pollution control officer who has the administrative power to make the decision. That finding would include such things as how many times the standard would be exceeded. Now, I would anticipate that if there were indirect source regulations that there would have to be--concurrent with the adoption of those regulations or subsequently before the review of projects--the question of significance would have to be addressed in some either general or specific way. It certainly would be desirable that there be a publicly known position on that, as to whether a certain number of excesses in and of themselves require a turndown. My guess is that it would not--that is the number of excesses alone would not--but that there would be guidelines which would leave the final decision in the judgment of the administrator and would include such factors as how many people would be affected, as well as other factors that have not been discussed here, might even have something to do with VMT (although that's a concept that I abhor and hate to work with. But that's another story, VMT, though it can be a rough guide to magnitude of impact.) The answer I would give--I think it's up to the administrator or decision-making person, given the technical information as to the impact, how many times the standards will be exceeded, where, how many people will be affected and so forth, and there may be other factors as well. There was the whole question that was raised: how do you take social and economic considerations into account? The answer to these questions, of course, is something that I don't have complete control over, nor does anybody else here, and we'll have to wait and see.

ANSWER: (Vivian Brown) I think in view of the fact that I don't think decisions should be made solely on the basis of one factor, be it air quality, water quality or economic growth, that if I were Queen of the region I'd make the decision that the project should go ahead provided that since it is in a corridor that will be developed, prior to the time that development be undertaken of this specific portion of the corridor the staging plan be produced for the entire corridor that would indicate how growth was going to take place and how local transit and internal transit could be provided to alleviate the problems that have been identified. Again, it would be doing it in a context of a plan for the entire area which is one that we've already said should be developed.

ANSWER: (Waide Egener) I'll make it very brief. Since there's been a lot of controversy about indirect source control, I'll just turn the question around and say perhaps as planners for local jurisdictions, if you were reviewing a project for a shopping center in your jurisdiction, and if the Environmental Impact Report that you had prepared technically indicated that the center would produce considerable revenue for your community, would permit you perhaps to lower the tax rate, or at least keep it where it was, but nevertheless it was quite plain from the information that it would have a severe impact on air quality, would you recommend to your council the denial of that shopping center?

QUESTION: (Michael Lake, Planner with the City of Sacramento) I would like to think that I'm something less than an ivory tower planner. As a result, I'd like to be a pragmatist. To do that, however, I'd like to be able to relate air impact to a given set of standards on what was significant, what was adverse, etc. I think I speak as a layman, not as an expert, as many of you people here today are. But I'd like to know if what I propose as mechanism for achieving those standards is possible. Perhaps some of you in the audience would also like to contribute. I'd like to see it done before I leave today, otherwise my three days have been wasted. I would suggest that one of the means of approaching this on a more practical level, would be to relate these standards which we generate for air pollution, in terms of air, quantity of particulate matter, whatever, to a set of standards which would be addressed first of all to the microlevel of a community or a site, whatever, as well as the macro-level, that you use as the mechanism for adoption the legislative body, the control agency, whatever, use it as a sounding board to revive public hearings on it, and thereby, have a given set of practical evaluation measures. We do it everyday in normal living...we're conditioned as human beings to equating a set of values against a given norm. It seems to me it has tremendous possibilities in terms of making our day-to-day functions more practical and efficient, wasting less of our taxpayers' money, etc. Do you want to make any comments on that?

ANSWER: (Herman Volk) I don't know if I understand the question, but I just want to mention something. If you want to relate something to a standard, you could use the federal standards or the state standards, for example--standards which say that if you exceed the CO level more than once a year it's a no-no--don't do it. But you could literally determine whether you do or you don't exceed the standard with a project, and if you do exceed the standard you can say you don't want to approve it. The problem with that is that, in the Bay Area we exceed many of these standards already, so what do you say..do you say, well therefore we're not going to develop? Do we all want that? We kind of go around and say, well let's question the standard again, and this is done. The standards have been questioned ever since they were written. No one has stopped questioning the standards.

QUESTION: (Michael Lake) Yes, I can appreciate that fact very much, however, the general overtone is one that we should use first of all--models--they are a practical vehicle for addressing the whole issue of air quality impact. We should use standards, however imperfect they may be, as a means of getting quantifiable data. Now, it only seems practical to me that you take that one step further--that you have a structure or a mechanism for evaluating what comes out of that. Hopefully, the three days we've spent here we've been trying to learn how to get to that point and evaluate it against standards. Until we do that--we've accomplished nothing.

ANSWER: (Herman Volk) Well, you will be doing that. Perhaps I'm not hitting the mark, but you will be evaluating your results against a standard to determine the number of excesses, and then it's up to the one who makes the decision as to whether or not they want to live with it.

QUESTION: (Michael Lake) Perhaps I have misunderstood some of your general thinking. It appeared to me, however, that you did not have a given set of criteria on which to evaluate what is significant, or what is adverse impact, whatever you want to call it. I would like that criteria.

ANSWER: (Ralph Mead) I just want to say one thing which may or may not answer the question: We have a couple of other considerations here. When the Clean Air Act was passed, I doubt whether anybody thought specifically--including the people passing the Act--and said, "do we really mean we want to stop growth, for example, in a given area if that's what it comes to, in order to, (if that may arguably be proven to be necessary) to prevent any excess of the ambient air quality standards at any point anywhere within that area. I doubt whether that happened. Now, with the indirect source regulations, the EPA is taking that approach, and promulgating the regulations, so we may be faced with having to address exactly that question. It's not an easy question, and if I had to make that kind of determination, I think I would be very hesitant to say that an important project, which might for many reasons be important for the community, should be denied because there was a single, or two, minor excesses of a certain standard at some point. I would be very hesitant to do that.

Responses from Michael Lake: I would concur with you, all I'm suggesting is that in the area of air quality you need to reach a point, and a decision as to the air quality and its impact. Unless we have definable levels, then we aren't there. The total, the economics, all the other variables of course have to be considered.

QUESTION: (Arthur Schwartz) This actually goes back to Bill Rugg's question, and it's really a statement. Somebody once a long time ago said "If you can't stand the heat, get out of the kitchen." The law is fairly specific and court decisions have been very specific. EIR's are supposed to be prepared by qualified experts who can make judgments based on their experience. We can play around with all the numbers we want, and determine how many days a year we might exceed the standard, but in the end the judgment that must be made, and is ultimately made by the decision-making body, the Board of Supervisors, the City Council, is one to approve or disapprove. These people are generally not technical people. They need guidance from the technical people, they need a statement as to whether this project does or does not have a significant impact on the environment. We as consulting engineers, myself with Ecological Impact Studies, have taken the position that we must make those judgments, even if they happen to be subjective. We still have to make them and we have to stand up and be prepared to defend them. We think that every staff member of every jurisdiction and special agency must do the same thing, otherwise they are abrogating their responsibility both to society and under the law. The statements I've heard today about the lack of our ability to make judgments, or the lack of our readiness to make judgments on whether or not something is significant, and to go back instead of playing around with some numbers, one-or-two-days-a-year type of thing, is really very depressing, because this way we will never solve air quality or any other problems.

Response from Person in Audience: I think in trying to set the significance and set the level or reach the levels of criteria that we're looking at today, I think we have to fall back on the one solid thing we have, which is the Act as the gentleman before me started to mention. I'd like to just very quickly review what the Act tells us. The Clean Air Act says that we are to consider land use controls and it specifically mentions those controls. I think that the framers of the Act certainly considered that in some cases you might have to affect land use. I think it very specifically says in its present form that economic and social considerations are not to be taken into account. I repeat, NOT. That is specifically excluded from the Act. The Act further sets air quality standards and required that the administrator of EPA set them, based on health effects. Those standards are set to protect the public health. They are not to be violated; it is as simple as that. I think therein lies the first standard. If a project or a group of projects violates air quality standards, then it has to be modified or it cannot be built. Here are two levels of analysis: one is the immediate and local impact, and the second is the broader, regional impact. The second level that we have to look for significance in is the State Implementation Plan--we went through four years of developing plans to implement those air quality standards and they call for reductions in emissions. If some project is not consis-tant with reducing emissions, then again, I think you have reason to object to that project. The third level is the Air Quality Maintenance Plan. Again, we're required to maintain air standards throughout the future. If the project is inconsistent with plans to maintain air quality standards, there is another reason for refusing the project in the form which is presented. I couldn't agree more with the gentleman before me saying that those on the regulatory side have to stand up and say that the project as presented is inconsistent. It needs to be amended or dropped, and leave it to the planners, the developer who has the interest in changing the project to find an acceptable means of presenting the project. I have one suggestion that we're working on in the Washington area, and it may be of help. Perhaps the planners in the land use, air quality, and transportation fields in conjunction with those in the private development side could set up some basic conditions: Say, in this metropolitan area there is a certain kind of air quality. We'll assume certain things about meteorology, we'll assume certain things about transportation. Then have standards for preparing Environmental Impact Statements. We will review certain things on all EIRs, and then have mutually agreed upon criteria for reviewing those statements. I think that would simplify and solve a lot of the problems that we've been addressing here today. A large portion of this is judgmental, professionally judgmental, and I think we need to come to an agreement of these judgments.

DISCUSSIONS OVER LUNCH

June 26, 1974

GEORGE HAGEVIK: ...we can point out which social disruptions these programs are going to cause. What we see happening now is an attempt to push back the deadline '75 to '77 and give us more lead time. If we have to achieve standards by '75,draconian measures are called for. If we push back the time frame to '85 or '81 or what have you, we dramatically increase our options. Some of these options involve positive programs rather than negative ones; the best example is provision of transit facilities. I think we're going to see in the oversight hearings on the Clean Air Act that Muskie's going to hold in 6 or 7 months hence discussions of moving the dates back. We don't see any significant attempt to change the standards. There might be a possibility that the standards for sulphur oxides might be made more stringent, rather than weakened. The question of the planner from Sacramento was we need a set of operational procedures that we, meaning the planners, had operationalized air quality management, from the land use planning sector. Traditionally, planners have been concerned with health and welfare in their land regulatory programs. We have things like set-back requirements where you have to build your house so many feet back from the roadway. We have building codes which are supposedly health and welfare related. One could argue that the planners traditionally should have been dealing with these kinds of problems. Unfortunately, the mechanisms that the planners have had have not been adequate to deal with these problems. As most of you are aware, one of the major difficulties is the variance procedure. You can have the most beautiful plan, but if the elected officials will allow projects to go through by giving them variances--out the window goes your plan--your grand design. Similarly, with environmental control programs historically you could get a variance. That's much more difficult to get today because we do have these quantitative standards that we're working with. We don't have operational standards for planners at the local level. Other than to say you need a buffer zone here, let's have a set-back requirements of 50 or 60 feet so the carbon monoxide can diffuse a little bit; and change the design of the structure a little bit so that the windows open away from the roadway rather than facing the roadway. We can deal with the micro-design solutions. The problem seems to be is that the problems are regional in nature and require actions, as we've heard earlier, by many more than just one agency. It's difficult to give a set of specific procedures to the planner at the local level. Now in terms of saying yes or no on a project if we accept the Air Quality Act at face value and the regulations at face value, we indeed should turn down these projects just like that. This doesn't seem to be happening because the final decision on these projects rests with elective boards by and large, and that's as it should be. In the final analysis decision, the technician will advise members of the board and they will made decisions as they see fit. Often you might argue it is counter-productive to the air quality objectives; that seems to be a fact of life. That's my interpretation of why you get this ambivalence on the part of people who are involved in the evaluation of impact statements, rather than saying no just like that. Because when they say no it might not be supported higher up.

DAVE HASKINS (attorney): Responding to what you just finished saying, I think that the problem is, not that the staff technicians are saying this is a violation and therefore should not be done--and then their superiors are countermanding their recommendations--the problem is that the technical people are fuzzing it to start with. That is the problem. The political system has made a judgment which may be a hypocritical judgment, but the hypocrisy is only going to be demonstrated if the people who are delegated the responsibility to make the technical decisions, make them straight and make them strong. The discussion we heard this morning showed an unwillingness to take that first step. The political system can make efforts to deal with the unwillingness of the representatives to follow up on what the technical analysis indicates. But what we're not seeing such a statement. For example, during the discussion of the airport expansion, there was a simple statement that certain air quality impacts weren't assessed. In my view, making that simple statement is not adequate. There should have been a critique of the fact that those impacts were not assessed. There should have been a statement by the board charged with the responsibility that--Dammit you had a job to do and you didn't do it and it's wrong that you didn't do it. Here's why it's wrong, and here's what should have been done. That's what you need. You need the first order activity by the technicians that have been delegated the responsibility so that you can see whether the system works or not.

GEORGE HAGEVIK: My response would be a question to you then. That if the system is not operating this way, what recourse does the average citizen then have to the fact that the Act is not being followed? For example, an organization such as yours responds, in the case of significant deterioration, say, by a lawsuit. Is that the only alternative to improve the quality of decisions, or are there other ones?

HASKINS: In an ideal system there are a myriad of alternatives. The way tax structures work, our organization cannot lobby for legislative change because of our tax deductible status. We can bring lawsuits, and we can put the politicians to the test of their often hypocritical gifts to the public. The public starts making a lot of noise about air pollution, and so the politicians get up and pass the Clean Air Act, which says that everything is going to be taken care of, I would rather see a realistic piece of legislation which says they're going to have to be criteria for making balanced decisions, and they should be criteria that reflect the best interests of the public and have the act carried out that way. But if an act is going to be passed which says and gives the public at large the impression that the air pollution is going to be solved, I'm going to make it my organization's business to see that the words of that law are enforced. And if people don't want to obey the law, then the alternative is not to violate the law, but to change it so that it's more responsive to what people really do want. So, yes we would bring a lawsuit. If the technical staff says that the analysis indicates that there's going to be a violation; the law says if there's a violation that the project should not be built. Then if the political board above it goes ahead and recommends building it without making any modifications, then I would urge citizen groups that are upset by that decision to sue, and to enforce the provisions of the law. I might say that there is a false dilemma being presented, and it is that say the image of a needed hospital, or a needed social service that can't be built just because there are one or two days worth of violations. Well that's an avoidable dilemma. The dilemma here is not whether needed social services are going to be able to be provided to the areas that need them, the option is that they have to depend entirely on the automobile. We're talking now about the indirect source related measures. They don't have to depend entirely on the automobile. It may require somewhat greater lead time in constructing them, and it may require--I think that citizen groups and courts might be likely to uphold conditional permits which would permit the start of construction provided that there were enforceable conditions--conditions that would be enforceable in a court of law, that there would be transit improvements to serve those areas. This would mean that the transit improvements would have to be supported by votes of the legislative body, and things like that, before the construction could begin. What you would do then is create a political force working in the legislature to get those transit improvements, because they know they can't start putting those shovels in the ground until the transit legislation is on the books. That's the kind of thing--you have to start building coalitions, and you can do it by making conditions and not by saying flat out--No you cannot build this hospital because it would attract too many people and their cars going to see the doctors. There are modifications, there are alternative control strategies. If you have a hydrocarbon problem, you can look toward more stringent revisions of the hydrocarbon standards. For the emission controls on stationary sources you can look toward improvement of emission control reduction techniques. There are a variety of options and I think that what we are faced with is the question that was put by one of the panel this morning--If you were a planner, would you recommend that a facility that was going to generate a lot of revenue, be turned down. Well, if you don't have some rules when you're going to turn down some of these--if you don't have rules when you're faced with a project that has an employment opportunity or a revenue opportunity, then we might as well go back to the days of slavery and the earliest days of industrial revolution. Because the very same arguments were made then--about the textile mills, about the cotton plantations, about the coal mines--the very same arguments were made, and if you don't have rules--are you going to accept slavery or are you going to refuse it. And if it costs you something are you going to refuse it? If you don't have the standards, you're just wallowing through a marsh that's very frustrating to citizens and very frustrating to me to hear that kind of discussion.

JIM ASHTON (APCD, Las Vegas, Nevada): I just had the opportunity of taking a T.V. course sponsored by the consortium of colleges in that area, and the University of Nevada. In that the question came up this morning as to what defines significant impact. Yet you have right here in the law or in the guidelines that follow it a very well-defined definition, which in essence says that significant impact is anything which interferes with the achievement or maintenance of air quality standards. Nobody on the panel or anybody else brought it up. I would have thought that would have been an adequate answer to the question that came up several times. Also, CEQA in their guidelines gives a significant basis of evaluation for EIRs and EISs. One further source where one can find some general guidelines, would be the Geomet reports that came out, the ones that were done under contract to EPA. They provide some basic information and some fairly good data. However, one must recognize that this data has to be adjusted to the given set of conditions or locations under consideration at a given time. The question came up of somebody putting their job on the line. I think those of us that are in the enforcement activity are getting paid in one sense or the other by the taxpayer's dollar, whether by gifts to the department they're working for or through direct taxation. And I would ask--What in hell are you getting paid for?--if it's not to protect the environment through the group that you're working for? It does not seem out of line at all to make a recommendation if something is going to violate the standard to the deciding board, that it will be in violation. That is a part of what we're getting paid for.

DICK THUILLIER: I'd like to address myself to that particular question. And after sitting up here and watching everybody munch their chicken, it was reassuring to find out that we definitely are all human, and I think the idea here is that in a political system such as we have, we have people having to deal with other people. And we have a very wide divergence of opinion on what is good and what is not good. Basically, as far as getting the provisions of these various pieces of legislation put into effect, we have a stratification I think in terms of decision-makers and their staff. I doubt if there are very many people in this room right now who are in a position to actually turn down a project. I think most of us are in a position of providing information to decision makers who will in turn, turn down the project or not. Now, I think it's the responsibility of the staff people to present the information in the most objective manner possible. And I agree with the gentleman who just spoke, and also with Herman Volk before who did in fact indicate that we could use the ambient air quality standards are our criterian of significance. As a matter of fact, the standards are the only defined criteria for significance that we have. In the case of our own staff, when we submit a recommendation to our air pollution control officer, that recommendation very simply takes a form of stating: This project will cause the air quality standards to be exceeded. Now we could also add: "Therefore, we must recommend that the project be turned down." I don't know that we have to make that specific recommendation because that's fairly clear in the law. However, the particular regulations of the individual control districts frequently will contain their own wording that will enable them to handle some of the trivial situations in the law. The law is meant to be interpreted in some way and I think that's why we have courts. To the degree that the ability exists to interpret laws there are always going to be interpretations made. We run into the problem in the Pollution Control District when we first frame a regulation such as this. Our original regulation stated that in an area where the air quality standards are exceeded, a permit for the project must be denied. But very soon after that regulation was adopted, questions began to come up. I'm going to open up a bottle of ammonia in my area--is that going to be cause for denial of a permit, because standards of the odor regulations for ammonia might be exceeded two feet from the source, or something like that. So, after you come out with the original draft of a regulation, then you start to get feedback on some of the types of projects that could be construed to fall under the wording of the regulation but are obviously not the type of thing you want to stop from being built. Therefore, what has gotten into our regulation now is the term significant--in other words suppose the air quality standard has already been exceeded, but you're going to build a project--say it's a hot-dog stand in that area--do you want to require a permit for a hot-dog stand, and do you want to refuse permission to put that project into effect because it's obviously going to contribute additional pollutants in an area where an air quality standard has already been exceeded. I think that the decision makers and their legal staffs have the prerogative wherein they're able to put their interpretations on some of these regulations, some of the legislation, and they do in fact do that. I think all that we can do as staff people is indicate that the criteria by which we work, which in our case is the air quality standards, are exceeded, and then let the decision-maker put the interpretation on the law. I don't really feel myself that staff people should try to interpret the law. I think they should take the law that is given to them, and they should analyze things with respect to that. In our case, it's the air quality standards, and we can objectively indicate whether the criteria in those regulations are met or whether they are not met. Since we do not have the prerogative to make the final decision I'm not sure that we have the responsibility to try to interpret the law.

BILL RUGG: Dick, let me pursue a little bit more what I started to a few minutes ago. If you take what you just said literally, I think that this is one of the things that those of us in the audience are objecting to. What I would hope that I would see in the staff is that you might report to your Board that--yes, as submitted, such-and-such does exceed such-and-such standard, however, with certain changes in the submission, under certain conditions that you could list, it could be made to fit into the standards. In other words I'm talking about a very distinctly positive view--you and I talked about this a little bit yesterday--where you'd work with the developer or with the applicant to find other ways of doing what wants to be done, but ways that fit into the standards. We looked into that hypothetical airport this morning, and there may be ways that that hypothetical airport may be less injurious than as proposed. I would hope that the staff at the pollution control districts would include a positive input, and some rather distinctly specific work with the proponents. Rather than simply say--yes it does, or no it doesn't meet standards. If you could comment a little bit more on what kind of positive input the pollution control district staffs are willing and able to and are equipped to make, I think this might clear up some of the problems that we've had out here in the audience.

DICK THUILLIER: O.K. Thank you. I think I am addressing myself primarily to the idea of commenting on the significance of the particular project. But certainly the remark that was just made is very valid and very apt in the case of the Bay Area Air Pollution Control District. I'll give you a scenario of what normally goes on when an application for a permit is received in the district. We receive the permit application from the applicant, the impact of the project is evaluated, and let's say we come up with a clear-cut situation that the standards or the District regulations or whatever criteria we're measuring against are exceeded so that a permit must be denied. This has happened in a great number of cases. I might just indicate the type project that will come in: one type of project was a refinery expansion in Richmond. Some of you may be familiar with it. In this case, a project might come in and we would evaluate it and decide that, we're going to have to deny a permit, because the wording of the regulation is very specific in regard to one or more areas of the analysis. The next thing that happens in the scenario is that we notify the applicant that it looks as if we're going to have to deny the permit on the basis of certain criteria and developments in the analysis, and the applicant normally comes into the District and we sit down with them and discuss the problems that are involved. Then in the case of some of the projects modifications can be made. They'll say okay well we'd like to expand this refinery and we think it's very important therefore we're willing to curtail some other aspect of our operations so that the net effect will not run afoul of your requirements. So, go back and re-submit your application with the new data that would result from this modification, and this is done, and we re-evaluate the project. In most cases, in situations where we originally would have to deny a permit, we are able to grant the permit on the basis of the modifications. Now, the other aspect of the question you asked involves the business of getting together with the applicant prior to the submittal of the application so that we can foresee the problems and iron them out ahead of time. And with respect to this aspect I can only say that we are continually having representatives of consulting firms and planning agencies coming in to the district. We're sitting down with these people and talking about upcoming projects and trying to indicate what types of analyses will be involved, what we'll be looking for and where some of the problem areas might arise. So, I would certainly say that what you suggested is certainly the way it should be done, and I think to a great extent the way we do this in our present operations.

BILL RUGG: I think that the next step then Dick, one that presumably you will be getting into either this fall or next winter, would be doing this kind of staff work with indirect source regulations in which you may be making recommendations on land use. This is an area that is quite different from modifications on a refinery. You'd be making recommendations presumably on, Yes, Mr. Developer, what you want to do is fine, but it ought to be someplace else. Or, you've got to extend the BART System, or build a shuttle system or something of this sort. It's a whole new area for air pollution control staff personnel to be working in, and this is the area, of course, that has the land use planners concerned. Certainly, getting in before the application is submitted and working with your staff, is going to be very important. I wonder if you would comment on the ability and willingness and availability of your staff to make recommendations and provide real assistance in land use planning decisions before applications for indirect sources are submitted.

DICK THUILLIER: O.K. Well, first of all, I think that any staff that is going to do this type of thing is going to have to have expertise in a number of areas that usually are not found in air pollution control districts, and this includes both the areas of land-use planning and of transportation planning. In our case, we do have this expertise, but it's embodied in one or two people, and our staff is obviously involved in things other than just sitting down with applicants. So, I think all I can say there is that we have the expertise if we're provided with the type of information that we need to make judgments in that regard, and we can in fact do it. However, frequently, far in advance of a project's coming in for a permit, there is just not the specific type of information available on which to base an analysis, and perhaps to answer your question, I might say that it's usually not very easy to anticipate the problems involved with the permit very much prior to the development of hard information, that accompanies a permit application itself.

LEE SINCLAIR (San Bernardino APCD): As I understand it, in the South Coast Basin of which we're a part (a part of our county is part of the basin), the indirect source regulation will in essence say that the APCD shall review all projects that may have an effect on air quality, and shall deny authority to carry out that project unless the air quality standards are maintained, or words to that effect. My point is that we have a system of reviewing applications and issuing authority to construct and later permits to operate for stationary sources, and under the proposed regulations for indirect sources, I see nothing but to take a very similar approach on them. This would follow the procedure that Dick outlined a little bit ago. I think it's going to boil down to the place that the APCD--or perhaps myself or another engineer as the representative, will review the project and will make a determination that it either does or does not prevent the maintainance and attainment of air quality standards. If it prevents that, we will have to deny the permit. That can be appealed to the Board of Supervisors sitting as the Air Pollution Control Board, or to others, perhaps even taken to court, but we will have no choice than to say, No--if it does not meet those criteria.

DICK THUILLIER: I think I would agree with you there. I think the ideal situation for a single purpose agency such as an air pollution control district is to address itself simply to the air quality standards that are available and make the decision as to whether or not the air quality standards are met. Then pass their decision on to the decision making authority, or in the case of the air pollution control district, if there are clear criteria available, it should simply grant or deny based on the fact that the criteria are or are not met. I think one of the purposes of this course was the fact that the analysis procedures for determining whether or not the criteria are or are not in fact met, was an item of some confusion, particularly among a lot of the non-technical staff people who are involved in the business of evaluating air quality impact. We were hoping to give a suggestion and not give a mandate on how this analysis should be done. A lot of people have come to us and said, Well O.K. you say we should do a quantitative analysis--how do we do it? This course is our response to that. Here are some suggestions as to what you might do, and perhaps the weight of our remarks would consist in the fact that we are an agency that makes requirements, an agency that must be satisfied as far as air quality is concerned and we're saying--this is how an agency that must be satisfied would like to see its input data developed.

JAY BATES (Federal Highway Administration): It looks like the one thing we've been addressing is amendments to the Clean Air Act--I'd like to make one comment to the effect that you do have other federal laws in which established planning procedures, established national goals, and things of this regard also come into play within indirect source reviews and some of these other things. For instance, there's some basic disagreement between the Federal Highway Administration and EPA regarding indirect source regulations which is going to have to be worked out in the future. Some of these things will be worked out, but it's not clear that you can make reviews and permits on certain other facilities which involve other federal laws other than the Clean Air Act.

GEORGE HAGEVIK: I'd like to respond to the point. One example of that problem would be in the Bay Area, where the Metropolitan Transportation Commission (the Regional Transportation Planning Agency) essentially for all practical purposes does give permits on all highway segments proposed. Now, with the promulgation of indirect source regulations we could have two essentially separate agencies giving permits for the same highway. The trouble is--if one agency says yes and the other agency says no--what conflict resolution procedures do we have? At the present time the way it's structured, indirect source regulations would prevail over the two, based on my reading of the respective legislative mandates. But that's not clear, because it hasn't really occurred yet. These problems do exist.

MARVIN HYMAN (Frederickson Engineering Consultants): This is getting back to the critique of the course. In circulating around yesterday, I heard some of the people from planning agencies complaining that the material was too technical and above their head, and we who are in the consulting business feel that yesterday's presentation was very to the point and helped simplify a lot of the correlations that could be used. I'm wondering, is there some better means than presently exists of getting consultants and planning agencies together--the only thing our firm can do right now is to write to every city and county planning agency in the state and say we exist and here are our capabilities, and if you want us we are available. Is there some other means that we can make our presence and capabilities known, and that the planning agencies whether they're city or county or whatever can make their needs known. Maybe there's a list of people who are taking this course that could be made available, and I would like to know if people who are planners here would be offended if consultants started sending them solicitations?

DICK THUILLIER: We certainly intend to provide a list of participants in the course along with the proceedings so that everybody can know by name and address who everybody else is in the course. I really don't know how to answer your question as to how to get these people together. I think the only real way is for the consultants to knock on the door of the planning agencies, and if the planning agencies are seriously interested in hiring consultants they should be going out and looking up consultants and finding out what they can do. When they do get together, I would strongly recommend that both the consultants and the agencies that are hiring them in the air quality area would also make contact with the local regulatory authority, in this case the air pollution control district, so that all three of these people if you will can be sure that they're all talking on the same wave-length, so to speak. It's not going to do a planning agency any good to hire a consultant if the planning agency doesn't know what the consultant should be doing for them to satisfy the pollution control agency. And I think this triangle is very intimately connected here, and I would like to see each planning agency that does hire a consultant have a consultant available that it knows can meet the requirements of the local regulatory agency and can do a good job. The agency should maintain a working relationship with these consultants on a long term basis--and not just go out and quickly hire a consultant at the last minute to do something. If anyone else has any suggestions on that topic we'd sure like to hear them.

ANN RENNER (California Air Resources Board): I just have a few comments by way of a critique. I think that this is a very good first step and I think that we are going to be seeing more of these kinds of workshops as we pull this thing together. One of the things that I hope is as planners we will see air quality as an opportunity rather than as a requirement. There were bills signed by the Governor, just in the last month, I believe, that sets a new requirement for the Environmental Impact Reports and requires some description of energy mitigation measures, so that these things will be tied together to support the goals of air quality rather than just balancing against social and economic considerations.

QUESTION: I still have a technical question, that means away from the political questions. I'd still like to know how you predict the effect of air quality for future years. When you evaluate air quality, you know the future traffic, you know the future emissions, but you still need the future background data for your air quality study. How do you do this? Do you have a formula or a curve to do this?

DICK THUILLIER: Well, the same formulas that are used to calculate background in the base year can be used in future years if you have an estimate of future emissions. This means obtaining an inventory of emissions in the future year, and then applying the same modeling techniques. I think that the main problem in the projection arena is the emissions, because the modeling techniques remain the same, and the atmospheric processes never change.

(Inaudible question)

DICK THUILLIER: No. The background air quality in 1974 is the result of the 1974 emissions distribution throughout the region, and the action of the atmosphere in transporting and dispersing emissions. Now if we go to 1990 we have the same atmospheric processes at work, but the sources are located in different areas perhaps and the amounts of emissions from each source is different. So you simply re-apply the same techniques you used in '74, the same modeling techniques, but you'd use different emissions, a different "Q" to the formula, and that would give you different concentrations in 1990, but the formula would stay the same.

(Inaudible question)

DICK THUILLIER: Yes...I think what you're saying is you can get the projected emissions for your project in 1990 but how do you get the projected emissions from the other sources in the region. The answer is that there are two ways you can do it. One, you can get it from the air pollution control agency or any other agency that's involved in modeling in future years. In the case of the Bay Area Air Pollution Control District we expect in a very short time to have a projected source inventory at least through 1980 for every square kilometer in the nine county bay area. You would simply come to us and say you wanted this for 1990 and we'd give you a computer tape or something with in on. Another alternative would be to go to the Metropolitan Transportation Commission or the Association of Bay Area Governments, the people who are responsible for projecting the parameters that go into determining the emissions inventory (such as traffic assignments, population distributions), and then get somebody who knows how to construct an emissions inventory from these input parameters to construct for you the future emissions. There are very few private individuals or even consultants who would be able to do this type of job on their own without consulting the appropriate agency involved.

(Inaudible question)

DICK THUILLIER: I'd like to respond to that point by saying that many impact statements that I've seen in urbanizing parts of metropolitan areas--by urbanizing I mean out in the suburbs--just assume a zero background because they have no monitoring equipment. The monitoring equipment is around where the hot-spots are, not out in the suburbs which are undergoing rapid development. The real problem is that most planning agencies--for better or for worse--have very imperfect mechanisms for projecting future levels of industrial emissions. One of the Catch 22 aspects of it is that we're projecting growth, but we're having air quality affecting the spatial distribution of growth. For example, in the South Bay Area now, for all practical purposes, we're having air pollution constraints operative on our planning process, because the population forecasts for funding sewage treatment plants are lower in critical air basins. So--you're getting less amount of sewage treatment capacity and slower growth--this is all interacting. So, to get the background for any specific point in a region 15 or 20 years hence is very chancy. You have to guess.

(Inaudible question)

DICK THUILLIER: Let me just make one more point on that. If you can't do this, and in most cases people just don't go through these tremendous background analyses every time they're going to do a project, and especially for the future years, as an approach that's better than just assuming zero background or assuming that it's the same as it is in the base year, you can apply a growth factor based on what projected growth for the region is, say in terms of vehicle miles traveled--VMT will increase by 13% by 1990, but the emission factor will decrease by 50% therefore I have a net decrease of 20%. Now that is a fairly crude way to do it, but it does give you a feeling for whether the background is going to go up or down and approximately how much, and that would be better than doing nothing at all.

(Inaudible question)

DICK THUILLIER: In response to this question of background levels, I think there's a source of technical help that's been alluded to a number of times, but I would like to emphasize it. As we go from the short term control plans to long term air quality maintenance, one of the things that could really provide a basis for evaluating EIRs and making planning decisions would be an area-wide monitoring program where instead of monitoring only trouble spots or or monitoring only pollutants that are easy to monitor and map, which is being done now, some type of systematic area-wide monitoring that would provide an historical data base of the changing pollutant concentrations and would provide a basis for evaluating the EIRs.

(Inaudible question)

DICK THUILLIER: I would agree with you that that would be a very desirable thing to have, but I would just indicate that unfortunately it seems to be a very difficult thing to achieve. We have just now, or are just now are getting to the point where we are going to have our first clean air station in the Bay Area and this means a station that's not in the central business district of a city. And I think there are two reasons why it's basically difficult to field these monitoring programs. One is that the cost tends to be fairly high, and it's not always possible to get the budgeting or to get the grants that you need to put the stations out into the field. The other is that politically or perhaps because of non-contact with the scientific aspects of this air pollution business, its hard to convince people that it's really cost-effective or necessary at all to put an air-monitoring station where there aren't any people around. The idea is that we want to see what's happening where most of the people are--and why do you want to put a station up on the hill up there? So I think what you suggest is very desirable but I don't think it's very easy to do. But it's something that we ought to encourage whenever we have the opportunity to do so.

COMMENT: I'd like to second what you just said about putting out background monitoring stations, because the first background monitoring station that we put out had some of the highest peaks in our area. We havenit figured that one out yet, but we're working on it.

DICK THUILLIER: We run into the same situation. Usually you find when you do put a new station out in an area where it was not thought it would provide any information, you find peaks--in the case of photo-chemical oxidants, that happens quite often, because photo-chemical oxidant impact is never in the source area--it's always down-wind maybe 10 or 15 miles. So, you can have the highest oxidant impact out in rural areas where there aren't any people at all.

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