REGULATION OF INDIRECT SOURCES OF AIR POLLUTION

John J. Roberts, Argonne National Laboratory, Illinois; and
Stephen A. Tamplin and Gary L. Melvin, Division of Air Pollution Control, Illinois Environmental Protection Agency, Springfield

The Division of Air Pollution Control, Illinois Environmental Protection Agency, has conducted an ambient air quality monitoring project focusing on carbon monoxide levels in and around several indirect sources. An analysis of the data indicates that highway types of pollutant emissions have the greatest impact on receptors in the vicinity of indirect sources. This implies that the principal, localized constraint on the siting of indirect sources will be the carbon monoxide generated on public roadways servicing those indirect sources. Clearly, adequate procedures must be developed to link such highway types of emissions to pollutant concentrations. Area-source and line-source models were tested by using the data generated during the monitoring project. Favorable results were achieved by using the line-source model. The proper siting of indirect sources involves the allocation of roadway capacity by the governmental units that are responsible for transportation network design and that work in conjunction with regional planning bodies. A regulatory structure is suggested that emphasizes a regional approach, and an example of an air quality allocation scheme is given. The methodology is applicable to all automotive air pollutants although, in general, localized sensitivity is lost for nitrogen dioxide and photochemical oxidants.

•RECENTLY, it has become increasingly evident that the effective solution of environmental problems must go beyond the confines of a single environmental protection agency. The interrelationships among planning, transportation, and environmental activities have become obvious; the mechanisms for translating these interrelationships into meaningful governmental action have not been so obvious. Recently, the attention of air pollution agencies has been focused on the long-range impact on air quality of transportation plans and indirect sources (facilities that, in and of themselves, may not be a source of air pollution but that, because of induced activities such as the attraction of automobiles, may cause air pollution problems). Therefore, transportation agencies have been directed by the Federal Highway Administration to evaluate regional transportation plans for consistency with state implementation plans for air pollution control (1). Likewise, the U.S. Environmental Protection Agency has directed air pollution agencies to develop regulations governing the air pollution aspects of indirect source development (2) and has (a) established requirements for the development of air quality maintenance area (AQMA) plans designed to ensure the long-term maintenance of the national ambient air quality standards in those areas where, primarily because of growth, one or more of the standards might be exceeded during the 1975-85 period (2); (b) promulgated parking management regulations that are to be implemented as part of comprehensive transportation control programs designed to minimize pollutant emissions from vehicles (3); and (c) developed regulations to prevent the significant deterioration of air quality (4).

As part of a program to accomplish these tasks, a regulatory concept designed to provide a framework within which transportation, regional planning, and environmental matters can receive adequate consideration has been developed. The approach is the outgrowth of discussions between the Division of Air Pollution Control; the Bureau of Environmental Sciences, Illinois Department of Transportation; the Northeastern Illinois Planning Commission; the League of Women Voters, and other organizations cognizant of the complexity of the interrelationships among transportation, regional planning, and the environment.

Pursuant to an order of the U.S. Court of Appeals for the District of Columbia Circuit in the case of Natural Resources Defense Council, Inc., et al. versus the U.S. Environmental Protection Agency (5), EPA has established requirements that states must fulfill in regard to air contaminants associated with indirect sources. Highways, shopping centers, stadiums, and residential, commercial, or industrial developments are examples of indirect sources that may induce sufficient pollution-producing activities to threaten the attainment or maintenance of national clean air standards.

Each state is required to design, as an extension of its implementation plan, a regulatory program (2) to

> ... prevent construction, modification, or operation of a facility, building, structure, or installation or combination thereof, which directly or indirectly results or may result in emissions of any air pollutant in any location which will prevent the attainment or maintenance of a national standard.

The logical regulatory scheme for satisfying this requirement is a permit system. Much concern has been devoted to determining who needs and who does not need to apply for such indirect source permits; however, the more important aspect of the problem, namely, determining standards for the issuance of such permits, has received surprisingly little attention. In fact, many developers in Illinois interpreted early federal guidelines to mean that, if one needs to apply for a permit, one will never receive one.

We will focus on setting standards for the issuance of permits for indirect sources; the criterion of requiring a permit review is relatively unimportant from a clean air standpoint as long as the threshold is set sufficiently low. Setting this threshold then becomes a matter of the associated administrative burden and, in a sense, the degree of fine tuning that one can hope to incorporate in the decision-making process. However, the key to success in anticipating and influencing the design and intensity of the development of indirect sources lies in an appropriate definition of the standards and procedures for issuing the permits.

THE HIGHWAY AS THE KEY ELEMENT

The structure of a regulatory approach to handling indirect sources must be developed with an understanding of the nature of the problem associated with such sources. In the evaluation of the localized impact of indirect sources on ambient carbon monoxide levels, two basic problem areas must be considered:

1. The roadway effect, the impact on air quality of induced vehicular activity on existing or proposed roadways within the region of concern including the indirect source itself; and
2. The area-source effect, the impact on air quality immediately downwind of induced vehicular activity within the zone of the indirect source itself.

Interest was initially focused on the area-source effect, with special attention paid to the size of the parking lot, and on pollution levels in adjacent areas. However, air quality data obtained from a complex source-monitoring project conducted at three shopping centers, a stadium, and a drive-in restaurant in Illinois clearly indicated that pollution levels will generally be highest at receptors subject to roadway types of effects rather than at receptors primarily subject to area-source influences.

The monitoring project data fall into two main categories based on the location of the receptors (i.e., the monitoring instruments):

1. Receptors primarily influenced by roadways (both external to and within the indirect source), and

2. Receptors removed from the immediate vicinity of roadways.

Receptors located in parking lots and not located adjacent to roadways may fall into either category, depending on vehicle activity in the immediate vicinity of the receptor. For example, one of the monitored shopping centers has an in-parking-lot circumferential road with a speed limit of 25 mph (40 km/h). A receptor located near this roadway is often subject to the same influence as a receptor located near a major artery. On the other hand, when the wind is blowing from the receptor toward the roadway, data from such a receptor indicate that it is subject to concentrations more indicative of area sources (i.e., general activity in the parking lot). Data collected during the monitoring of the indirect source were reviewed from the standpoint of comparing these measurements at receptors subject to the roadway effect with simultaneous measurements at a receptor that was primarily subject to area-source influences. The data shown in Figure 1 indicate that the roadway effect is clearly dominant and represents the worst case. The numbers in parentheses represent pairs of observations for which a clear contrast existed between highway and area receptors.

ANALYSIS OF ROADWAY IMPACT

Line-source and area-source models were evaluated by using appropriate data obtained during monitoring of the indirect sources. These data included ambient levels of carbon monoxide, wind speed, wind direction, vehicles entering or leaving the facility, number of vehicles passing on adjacent roadways, average speeds and distances traveled by vehicles within the facility, and other related information. Based on wind direction and receptor location, an appropriate mathematical model (i.e., area- or line-source) was applied to each receptor.

Figure 2 shows the result of using a modeling scheme to estimate concentrations at receptors dominated by roadway types of emissions. This scheme consisted of a combination of a graphical solution to the U.S. EPA HIWAY model and the exponential decay function developed by the General Electric Company (6). The graphical solution to the highway model was used to determine concentrations for receptors located within 33 ft (10 m) of the highway. When receptors were located beyond 33 ft (10 m), the concentration at 33 ft (10 m) was obtained by using a graphical solution to the highway model, and the exponential decay function was applied to that concentration for the remaining distance to the receptors.

Based on the difficulties in precisely describing the atmospheric stability, the traffic-generated turbulence, and the limits on the monitoring devices used in the field study and in estimating pollutant source strength, a fair correlation between calculated and observed concentrations was achieved.

The poor results of the application of the area-source model suggested by the U.S. EPA (2) are shown in Figure 3. For a more successful application of such a model to receptors within indirect sources, the entire formulation on which the abbreviated approach was based should be used with an element size appropriate to the scale involved.

PROBLEM OF ALLOCATION

The observation that the governing, i.e., limiting, aspect of the carbon monoxide problem will be the pollution associated with roadway activities has two immediate consequences:

1. Where such roadway activity occurs within the indirect source, the developer has flexibility to improve the management of the traffic flow and thereby avoid the problem; and
2. Generally, the principal constraint on the siting of an indirect source will be the public roadways over which the induced vehicular traffic travels to reach the indirect source.

Figure 1. Concentrations at highway receptors versus concentrations at area receptors.

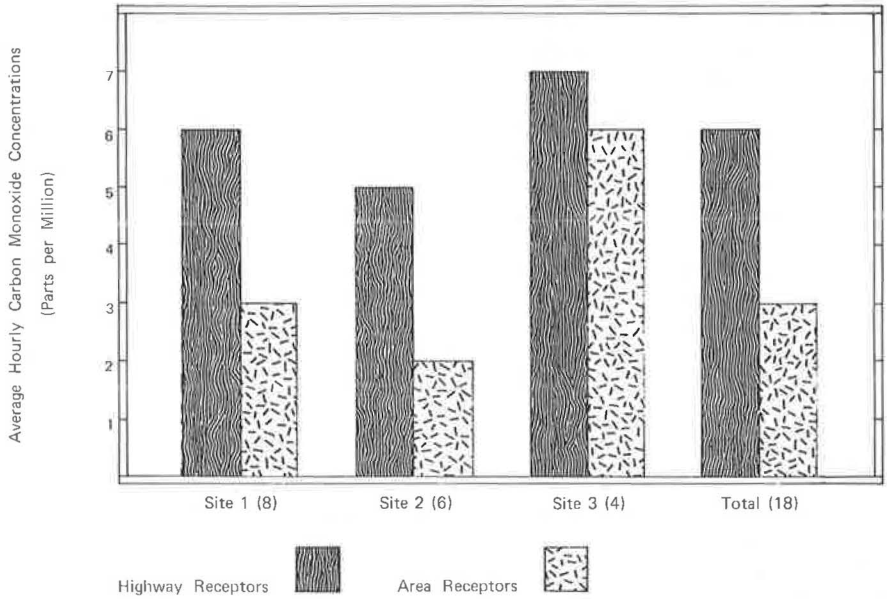
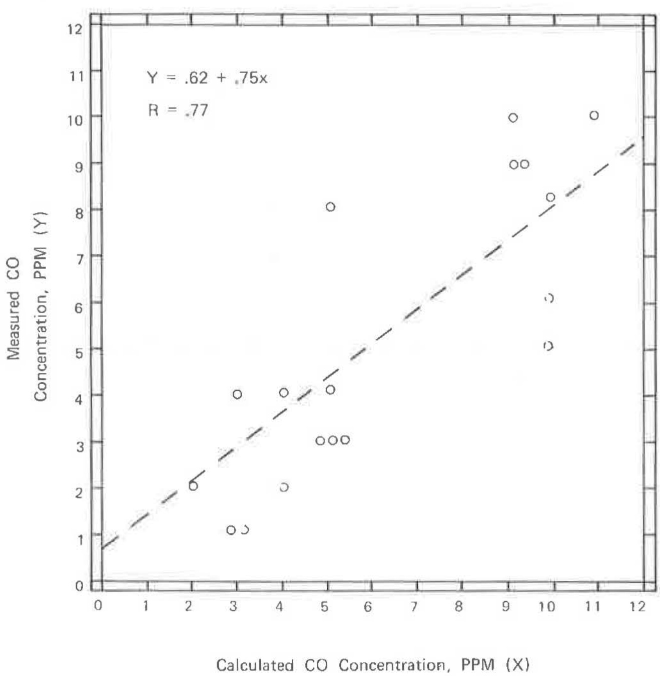


Figure 2. Measured hourly CO concentrations at highway receptors versus concentrations calculated by using modified graphical solution to HIWAY model.



Clearly we must be able to analyze the impact of an individual roadway or network of roadways on air quality if we are to cope with the indirect source problem. Most importantly, it follows from the second consequence that proper handling of the indirect source problem implies controlling the allocation of roadway capacity. This latter conclusion applies, of course, to automotive air pollutants generally, although the effects are often regional in nature (e.g., photochemical oxidants) rather than highly localized. Thus, one is generally concerned with allocation of the network rather than highway-link capacity.

Consider a simple example. A highway is proposed. It must be designed so that at peak activity (which might be the 99th percentile of anticipated demand) clean air standards will not be exceeded. Therefore, associated with the clean air standard is a clean air resource and correspondingly a predetermined, acceptable highway capacity (in terms of vehicles per hour at a reference speed).

The highway when built will immediately have a certain percentage of through traffic satisfying a latent traffic demand. This through traffic consumes a portion of the available clean air resource (i.e., the difference between existing air quality and the applicable air quality standard) that is to be allocated and makes up a portion of the allowable highway capacity corresponding to this available clean air resource.

Evaluating permits so that individual indirect sources can be located along the highway then becomes a process of relating the vehicular traffic induced by the indirect source to the available clean air resource, i.e., the residual highway capacity. Therefore, because the clean air resource is linked directly to highway capacity, we are, in a sense, allocating that capacity as we administer the permit system for indirect sources.

It also follows from this observation that a system that is to effectively handle the indirect source problem must be developed so that it is in accord with whatever governmental system controls the development of a regional transportation network. Although there might be many strategies for controlling growth in a region (e.g., land use planning, energy constraints, and public transit), ultimately they must be viewed in terms of their effect on vehicular traffic so that their principal impact on air pollution levels can be assessed.

STANDARDS FOR ISSUANCE

As mentioned earlier, the most critical aspects of any set of indirect source regulations are the standards and procedures for issuance of associated permits. Such standards, as recommended below, must reflect the nature of the problem (e.g., the roadway dominance), the clean air goals, and the administrative structure by which the regulations will be enforced.

> An indirect source permit shall be granted if and only if the control agency concludes the following:
>
> 1. Public road or highway as indirect source—Construction or modification of a public road or highway will not result in an increase in the ambient air quality levels of any specified air contaminant by more than 80 percent of the difference between ambient air quality standards and the existing ambient air quality levels of any specified air contaminant and will not result in a violation of ambient air quality standards;
> 2. Other than public road or highway as indirect source—Construction or modification of the indirect source, other than a public road or highway, will not result in an increase in the ambient air quality levels of any specified air contaminant by more than 30 percent of the difference between ambient air quality standards and the existing ambient air quality levels of any specified air contaminant and will not result in a violation of ambient air quality standards; or
> 3. Any indirect source—The indirect source has been recommended for permit by an approved regional planning body as conforming with a regional plan approved by the control agency.

The structure inherent in these recommended standards recognizes a shift in the principal responsibility for permit analysis from ad hoc reviews initiated by the control agency to an integration of air pollution criteria as constraints in the regional planning process. The shift also accommodates a broadening of the regulatory perspective from highly localized carbon monoxide problems to regional impacts of pollutants, such as oxidants of nitrogen, hydrocarbons, and photochemicals.

Items 1 and 2 will be examined in greater detail later; however, suffice it to say at this point that they represent a fairly simple scheme for allocating the available clean air resource and the related highway capacity. This allocation scheme is consistent with the concept of emission density zoning (7). The general approach is similar to the proposed nondegradation policy of EPA relating to suspended particulates and sulfur dioxide (4).

Before item 2 becomes operational in any urban area, several steps should take place:

1. A regional planning agency with adequate geographical scope and technical competence should be approved by the control agency for an active role in issuing permits for the indirect source,
2. The regional planning body should have a comprehensive regional plan in sufficient detail to permit the regionwide estimation of pollutant emissions from highways and associated land use activities for the next 10 years, and
3. The comprehensive plan should be analyzed by the control agency and found adequate for the maintenance of national clean air standards.

The approved comprehensive regional plan then becomes a guide against which proposed indirect sources can be measured for conformity and thereby acceptability in relation to clean air standards. A developer with a nonconforming use could apply directly to the control agency under items 1 and 2 but would have to accept the burden of showing that the nonconforming use would not distort the comprehensive plan and lead to a likely violation of ambient air quality standards during the next 10 years. It is felt that this burden, the potentially greater leniency of item 3, and the compatibility of the development of the highway network with the comprehensive regional plan will offer strong incentives for conforming developments and thereby greatly strengthen the ability of regional planning agencies to implement their comprehensive plans. This latter aspect may be the most far-reaching consequence of the nationwide effort to cope with the attainment and long-range maintenance of ambient air quality standards.

Structurally, this regulatory approach is applicable to all automotive air pollutants. Where stationary sources produce significant additional emissions (e.g., NO_x, particulate aerosols), the focus on the highway network must be broadened to consider emissions associated with alternative land use patterns. Unfortunately, attempts to date to correlate air pollution emissions with industrial land use and zoning classifications have been unsuccessful (8). Reliance on regulatory approaches, such as emission density zoning (7, 9), may therefore be necessary to establish an envelope of maximum air quality degradation associated with a given plan for regional development.

EXAMPLE OF ALLOCATION SCHEME IMPLICIT IN ITEMS 1 AND 2

Associated with any existing or proposed highway is a design capacity that can be defined in terms of the maximum number of vehicles per hour that the highway will accommodate at a specified speed. For reasons of cost effectiveness, the design vehicle activity is usually not the absolute maximum hourly activity anticipated on the highway (e.g., the highest hourly traffic volume that might be expected on July 4); instead, it is some lesser figure, such as the 30th highest hour. Whenever the design capacity of the highway, in terms of vehicles per hour, is exceeded, there is generally a substantial decrease in average vehicle speed leading to an ultimate breakdown in traffic flow. This is particularly important from the standpoint of ambient air quality levels attributable to the roadway effect; as traffic volume increases and average vehicular speed drops, hydrocarbon and carbon monoxide emissions increase. This relationship can

Figure 3. Measured hourly CO concentrations at area receptors versus concentrations calculated by using area-source model suggested by EPA.

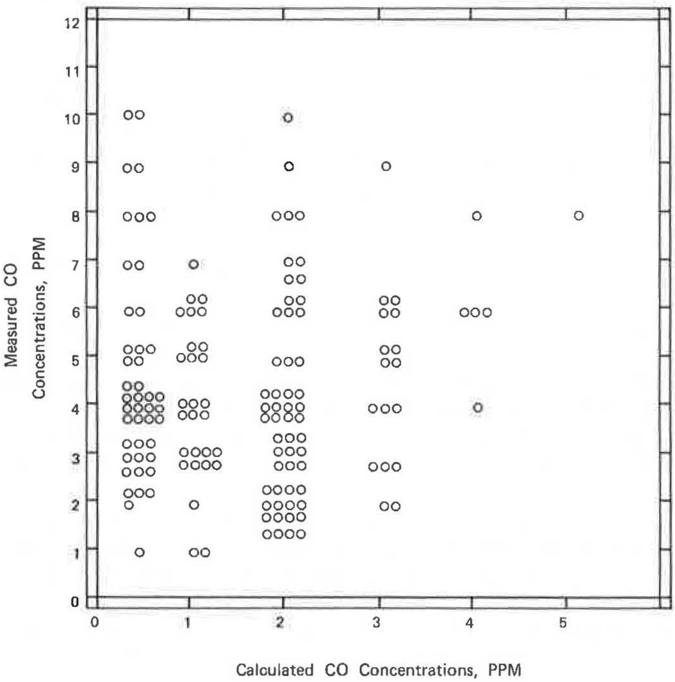
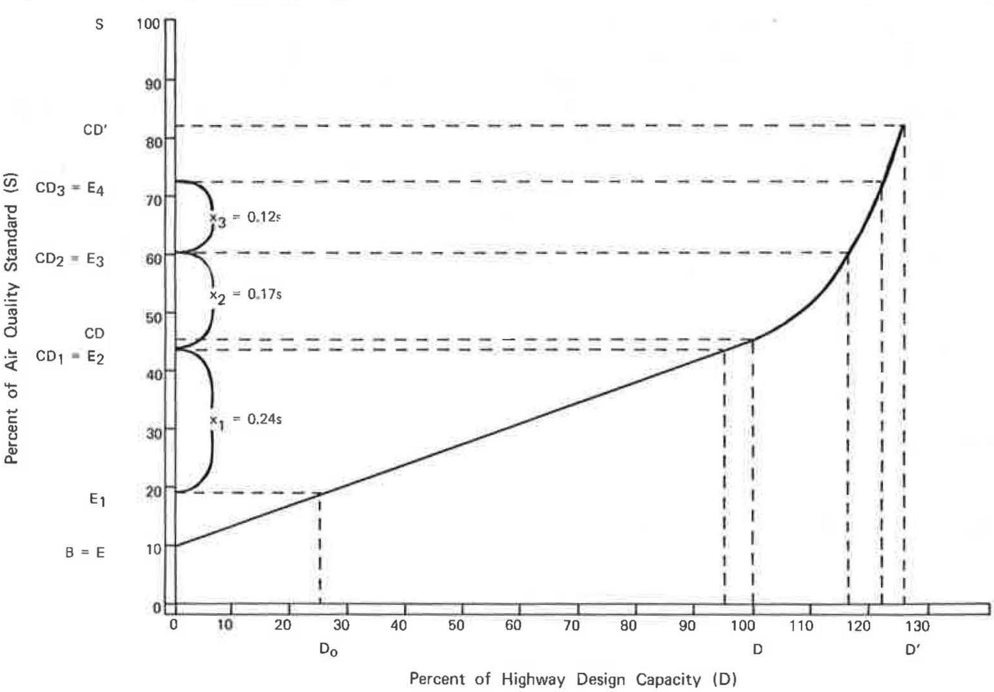


Figure 4. Air quality versus highway traffic.



be illustrated graphically by a curve of air quality versus traffic (Figure 4).

If one assumes some highway design capacity D (i.e., some number of vehicles per hour at a specified average speed), it can be seen that emissions increase linearly with traffic volume as long as the number of vehicles per hour associated with D is not exceeded (obviously this also assumes that these vehicles travel at the design speed). When the design capacity in vehicles per hour is exceeded, however, the curve slopes steeply upward since additional vehicles not only add their own pollution but also slow down existing traffic and thereby greatly increase pollutant emissions.

Consider a hypothetical example for purposes of discussing allocation of the available clean air resource in a particular area and the highway capacity. The notation used in Figure 4 and in our calculations is as follows:

- S = applicable national ambient air quality standard expressed as 100 percent.
- B = background pollutant concentration attributable to sources other than those associated with the proposed highway and associated indirect sources, 10 percent of S for this example.
- E = existing air quality, background concentration plus concentrations attributable to the busiest highway affected by the proposed indirect sources.
- D = design capacity of a proposed highway, representing the maximum number of vehicles per hour for which an assumed design speed of 50 mph (80 km/h) can be maintained.
- D′ = design figure for air quality purposes, the maximum number of vehicles per hour for which an indirect source permit can be issued, which equals the number of vehicles per hour at a specified speed equivalent to an air quality level (for highways) of 0.8 (S - E) in accordance with items 1 and 2. For this example, assume a number of vehicles per hour equivalent to the 99th percentile of maximum anticipated traffic and a likely speed at D′ of 15 mph (24 km/h).
- CD′ = ambient pollutant concentration at D′ = E + 0.8 (S - E).
- CD = ambient pollutant concentration at D.
- X_R = contribution that the proposed public roadway may make to ambient pollution levels, expressed as a percentage of S; S_R = 0.8 (S - E).
- X = contribution that an indirect source, other than a public roadway, may make to ambient pollution levels, expressed as a percentage of S; X = 0.3 (S - E).
- F = speed (1 mile = 1.6 km) correction factor, emissions at 50 mph/emissions at 15 mph = 0.6, for this example.
- V = traffic volume correction factor = vehicles per hour at D/vehicles per hour at D′.

We based the following calculations for a proposed highway subject to the requirements in item 1 on the definitions given above.

$$X_R = 0.8(S - E)$$

If we assume that E = B, then

$$X_R = 0.8(S - B) = 0.8(S - 0.1S) = 0.72S$$

and the ambient pollutant concentration at D′, the design figure for air quality purposes, is

$$CD' = E + 0.8(S - E) = B \pm 0.8(S - B) = B \pm X_R = 0.1S + 0.72S = 0.82S$$

For illustrative purposes, further assume that the traffic volume at D′ is 125 percent of the traffic volume at D; then, the ambient pollutant concentration at D can be determined by proportion as follows:

$$CD = (CD' - E)(V)(F) + E = (0.82S - 0.1S)(100/125)(0.6) + 0.1S = 0.45S$$

Now consider the situation where there is a desire to successively build several indirect sources along a segment of this newly constructed highway. Assume a steady through-traffic volume D_o (independent of local indirect sources) of 25 percent of the traffic volume associated with the highway design capacity D. This assumption establishes a new existing air quality level E_1, where

$$E_1 = 0.25(CD - E) + E = 0.25(CD - B) + B = 0.25(0.45S - 0.1S) + 0.1S = 0.19S$$

Considering a proposed indirect source 1 and applying the 30 percent criterion in item 2 give the allowable contribution or addition to pollution levels as

$$X_1 = 0.3(S - E_1) = 0.3(S - 0.19S) = 0.24S$$

and the resultant ambient pollutant concentration is projected to be

$$CD_1 = X_1 + E_1 = 0.24S + 0.19S = 0.43S$$

In this example, Figure 4 shows that indirect source 1 has brought the traffic level (i.e., $CD_1 = 0.43S$) on the highway segment nearly to the highway capacity design level D (i.e., $CD = 0.45S$). Thus, it appears that either the road segment was designed specifically for this first indirect source or it was grossly underdesigned.

At this point, it should be noted that in practice most indirect sources will not use the full 30 percent allowed by item 2 [i.e., $0.3(S - E)$] if the road segment is adequately designed. As an illustration of the size of a facility that uses the full 30 percent, consider a large suburban shopping center [approximately 1.25 million ft^2 (0.12 million m^2) of floor area] observed during the monitoring of the indirect source conducted by the Division of Air Pollution Control. It is estimated that this facility attracts approximately 4,000 vehicles per hour during its busiest 8 hours, and this traffic flows primarily on two four-lane roads adjacent to the facility (i.e., about 2,000 vehicles per hour per road). When the modified version of the U.S. EPA HIWAY model was used, the 8-hour national ambient air quality standard for carbon monoxide can be expressed in terms of 7,000 vehicles per hour at an average speed of a little over 25 mph (40 km/h). Before this shopping center was built, the existing air quality during the 8-hour period of maximum traffic on the busiest roadway is estimated to have been equivalent to about 500 vehicles per hour. This traffic flow occurred on one of the four-lane roadways adjacent to the facility. Based on the preceding information, application of the 30 percent rule (item 2) would not have prevented the construction of this large shopping center [i.e., $0.3 \times (7{,}000 - 500) \cong 2{,}000$].

The next proposed indirect source to be constructed along the example roadway segment, indirect source 2, must be evaluated in terms of a new existing air quality level E_2, where

$$E_2 = CD_1 = 0.43S$$

Thus, the allowable contribution of indirect source 2 to pollution levels is

$$X_2 = 0.3\,(S - E_2) = 0.3\,(S - 0.43S) = 0.17S$$

and the resultant ambient pollutant concentration is projected to be

$$CD_2 = X_2 + E_2 = 0.17S + 0.43S = 0.60S$$

This situation can be characterized by a rush-hour period during which one might expect peak through traffic on the roadway to overlap peak activity periods at indirect sources 1 and 2. Figure 4 shows that, in our example, an ambient concentration of 0.60S is associated with roadway traffic at about 116 percent of design capacity D, and, correspondingly, a lower average speed, assumed to be 30 mph (48 km/h). It also shows that of this 116 percent, the through traffic D_o accounts for 0.25D, indirect source 1 for 0.70D, and indirect source 2 for 0.21D. In reality, this traffic-load distribution could change if indirect source 2 could adjust its operations so that its peak traffic demand did not coincide with peak roadway traffic or that due to indirect source 1. This would permit a greater amount of vehicular activity at indirect source 2. Additionally, this type of operational adjustment is particularly important as it relates to subsequent development along the affected road segment.

For indirect source 3, the new existing air quality level E_3 is

$$E_3 = CD_2 = 0.60S$$

and the allowable contribution of indirect source 3 to pollution levels is

$$X_3 = 0.3\,(S - E_3) = 0.3\,(S - 0.60S) = 0.12S$$

The resultant ambient pollutant concentration is projected to be

$$CD_3 = X_3 + E_3 = 0.12S + 0.60S = 0.72S$$

From Figure 4, CD_3 is associated with a traffic level of 122 percent of the highway design capacity D; only 6 percent of this load is due to indirect source 3. Obviously, the same types of operational adjustments that were open to indirect source 2 are possibly available to source 3; the potential for increased vehicular activity exists.

There is a point beyond which no more indirect sources that require permits can be permitted. For example, regulations proposed in Illinois require permits only from indirect sources likely to cause increases in carbon monoxide in excess of 10 percent of the national standard S. Thus, since indirect source 4 would only be allowed to contribute 8 percent of the standard [$X_4 = 0.3\,(S - CD_3) = 0.3\,(S - 0.72S)$] to pollution levels, if it applied for a permit (i.e., if its likely contribution was greater than or equal to 10 percent of the standard), it probably would not receive one. This conclusion does not imply that no more indirect sources would be built, however. Many less polluting activities (outside the permit system) could prevail, and off-peak hours could accommodate new, large sources if appropriate operational adjustments were made as previously noted.

However, in essence, we have, for the time being, called a halt to that aspect of regional expansion relying on the highway segment in question. We see therefore an inherent braking mechanism in the proposed regulatory measure that will suffice until a more comprehensive approach based on regional planning concepts can be implemented under item 3 of the recommended standard for issuance.

Note that Figure 4 and associated calculations assume a single functional relationship between vehicular emissions and traffic conditions. In actuality this relationship will strongly depend on the temporal impact of the Federal Motor Vehicle Control Program. The calculations would proceed essentially as outlined except one would use vehicular emission factors appropriate to the likely age distribution of vehicles during the future year under investigation.

RELATIONSHIP OF INDIRECT SOURCE REGULATION TO OTHER PLANNING ACTIVITIES

It is important to recognize that any indirect source regulation is only one of the tools that should be used in the implementation of a comprehensive planning process designed to provide for the rational use of available clean air resources. From an air pollution standpoint, the framework for this comprehensive planning process presently consists of the U.S. EPA planning activity for AQMAs, the proposed federal policy regarding the prevention of significant air quality deterioration, and the FHWA requirement for the environmental review of transportation plans for standard metropolitan statistical areas to ensure that they are consistent with state implementation plans for air pollution control.

The general concept of AQMA planning, if applied to all geographical areas, is broad enough to encompass each of these program elements; however, there are significant institutional and administrative barriers to the successful application of such a concept. Working relationships among environmental agencies, regional planning commissions, and local municipal bodies must be established or clarified; both public and private interest groups must have the opportunity for meaningful input into planning activities; and the environmentally related efforts of all other concerned agencies must be integrated with the entire process. Most assuredly, the question is not whether the necessary decisions will be made but how they will be made. Thus, it is vital that planning factors such as indirect sources regulations be consistent with the overall plan. The approach suggested in this paper is designed to accomplish that end.

ACKNOWLEDGMENT

We would like to thank Earl Bowman, Bureau of Environmental Sciences, Illinois Department of Transportation; Phil Peters, Northeastern Illinois Planning Commission; and Nancy McCrone, League of Women Voters. Conversations with them led to an appreciation of the interrelationships between environmental quality goals and comprehensive regional planning.

REFERENCES

1. Federal Register. Vol. 38, No. 221, Nov. 16, 1973, pp. 31677-31679.
2. Federal Register. Vol. 38, No. 116, June 18, 1973, pp. 15834-15837.
3. Federal Register. Vol. 39, No. 164, Aug. 22, 1974, pp. 30440-30464.
4. Federal Register. Vol. 39, No. 167, Aug. 27, 1974, pp. 31000-31009.
5. Federal Reporter. No. 475, 2nd series, pp. 968-973.
6. Final Report on Study of Air Pollution Aspects of Various Road Configurations. General Electric Company, Sept. 1, 1971.
7. J. J. Roberts and E. J. Cooke. Land Use as an Organizational Basis for Regional Air Resource Management. Proc., 2nd International Clean Air Congress, Wash-

ington, D.C., Dec. 1970, p. 1247.
8. T. Baldwin and A. Kennedy. A Path Analysis Methodology for Predicting Point Source Emissions Using Industrial Land-Use Variables. Proc., Air Pollution Control Association Conference, Denver, June 1974.
9. G. Hagevik. Emission Allocation and Emission Density Zoning: Techniques for Establishing the Baseline for Land Use and Transportation Planning Decisions. Proc., Air Pollution Control Association Conference, Denver, June 1974.