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DIVISION OF STRUCTURES AND ENGINEERING SERVICES

TRANSPORTATION LABORATORY

RESEARCH REPORT

CALINE 2
AN IMPROVED MICROSCALE MODEL FOR THE DIFFUSION OF AIR POLLUTANTS FROM A LINE SOURCE

INTERIM REPORT

CA-DOT-TL-7218-1-76-23

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OFFICE OF TRANSPORTATION LABORATORY

May 1976

FHWA No. DOT-FH-11-7730
TL No. 657218

Mr. C. E. Forbes
Chief Engineer

Dear Sir:

I have approved and now submit for your information this interim research project report titled:

CALINE2 - An Improved Microscale Model for the Diffusion of Air Pollutants from a Line Source

Study made by	Enviro-Chemical Branch
Under the Supervision of	Earl C. Shirley, P.E.
Principal Investigator	Andrew J. Ranzieri, P.E.
Report Prepared by	Charles E. Ward, Jr., P.E.

Very truly yours,

George A. Hill

GEORGE A. HILL
Chief, Office of Transportation Laboratory

Attachment

CEW:lb

[illegible]

ACKNOWLEDGEMENTS

This report has been authored by Charles E. Ward, Jr. under the supervision of Andrew J. Ranzieri.

Acknowledgement is given to Gerald Bemis and Timothy Woody, who assisted in the development of the computer programs and the preparation of data for the verification study.

Special acknowledgement is given to the Translab team devoted to the discipline of applying models to air quality. Nowhere else in California State Government did this level of effort exist, and the creative and dynamic environment vital to the development of such models as CALINE2 would not have existed without it.

This study was conducted under direct contract DOT-FH-11-7730 from the Federal Highway Administration titled "Air Pollution and Roadway Location, Design and Operation", and a California Department of Transportation project with the same title.

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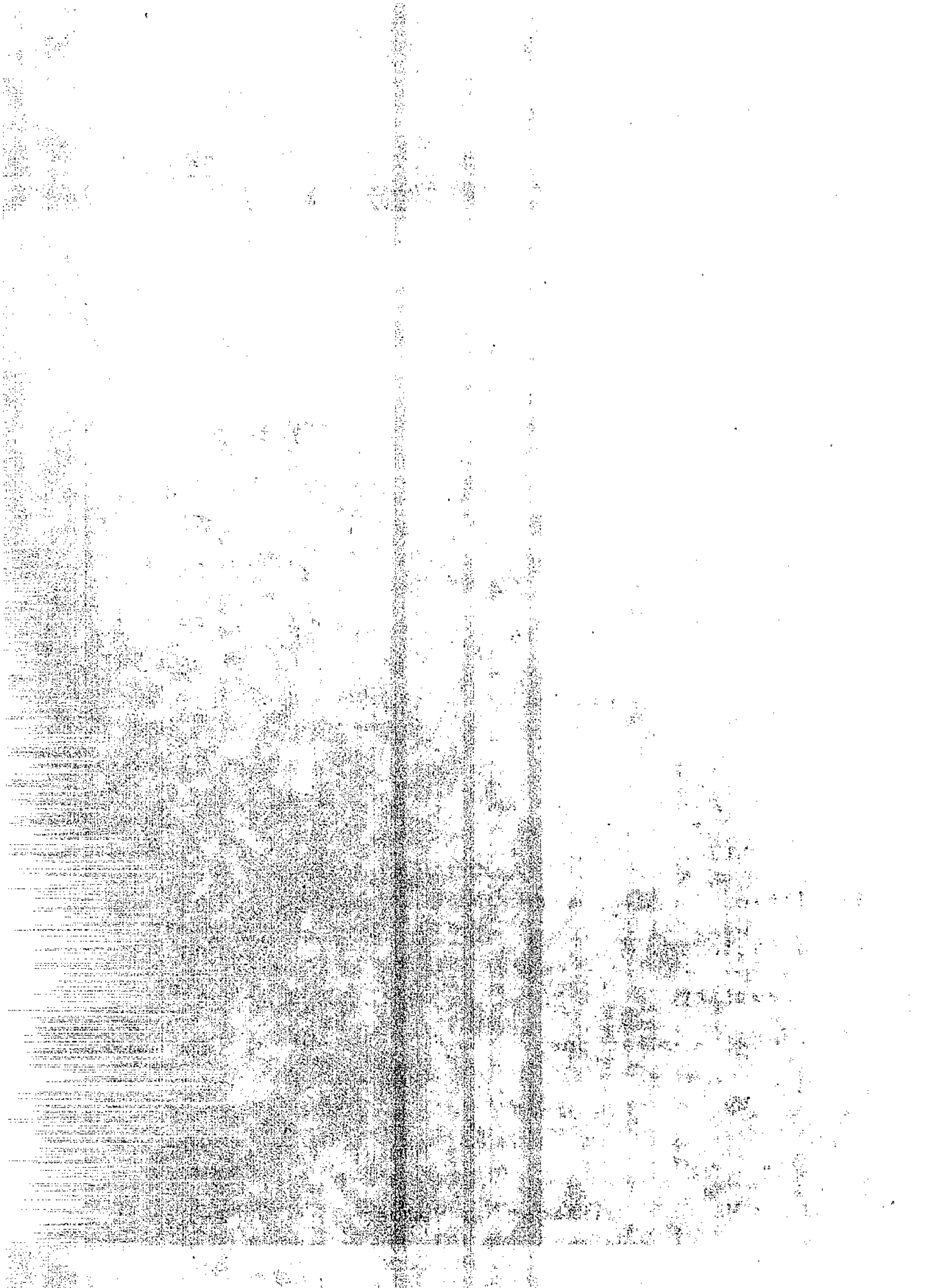

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1 INTRODUCTION

Compliance with the National Environmental Policy Act (NEPA) (1) and the California Environmental Quality Act (CEQA) (2) requires that an air quality assessment be included as part of the Environmental Impact Report prepared for proposed transportation projects. In addition, the Federal-Aid Highway Act (3) and the Clean Air Act of 1970 (4) require air quality analyses for proposed transportation systems.

Transportation agencies must be able to estimate changes in air quality within the highway corridors to comply with these laws and their associated regulations. The highway corridor is defined, in this report, as the region extending from the vehicular source of the pollutants to the downwind point where ambient pollutant levels are again reached. The primary pollutants emitted from motor vehicles are hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x), and particulates. In the last category, lead is the major form of particulates, but with the advent of catalytic converters, sulfate particulates have become an increasing concern. Reactive hydrocarbons (RHC), which are a major proportion of the total vehicular-emitted hydrocarbons, combine in the presence of sunlight with oxides of nitrogen to form secondary pollutants known as photochemical smog.

Photochemical formation of smog is a large-scale phenomenon, and should be analyzed on a regional basis. For a corridor analysis, carbon monoxide is suitable as a tracer pollutant to define air pollutant dispersion because of its relative inertness in the photochemical smog process. Lead and sulfate particulates are not yet considered because of the lack of quantitative data on emission rates and dispersion characteristics.

Line source computer models have been developed over the past few years to simulate the dispersion of carbon monoxide within the highway corridor. The California Department of Transportation (Caltrans) model, CALINE2, has been so named because it is the second major version of the California Line Source Dispersion Model. The first version is described in a Caltrans air quality manual (5).

Included in the present report are a discussion of the Gaussian dispersion theory, the mathematical assumptions of CALINE2, a sensitivity analysis, a comparison of CALINE2 predictions with actual observed data, and computer language listings of CALINE2.

2 CONCLUSIONS AND RECOMMENDATIONS

CALINE2 is a line source model which can be used to obtain estimates of carbon monoxide concentrations as this pollutant is dispersed downwind of the source. It predicts the CO contributed by the source (i.e., above ambient levels), can be used for any wind angle and surface atmospheric stability class, and is applicable to most highway configurations.

Sensitivity analysis of CALINE2 indicates that the wind vector (speed and direction) is the most sensitive input parameter. Traffic volumes and emission factors are important to the model because the calculated CO concentrations are a direct function of these inputs. Because the model is straightforward and fairly simple, all inputs are important, but the inputs concerning highway geometry are relatively less sensitive than the other parameters.

A preliminary verification analysis of CALINE2 using CO data from the Los Angeles area shows that CALINE2 is much improved over earlier versions of the California Line Source Dispersion Model. It also shows that CALINE2 has a good predictive capability for most situations, yielding average correlation coefficients of 0.62 to 0.94 and average standard errors of 1.01 ppm to 1.88 ppm.

It is recommended that CALINE2 be used for assessing the air quality impact of proposed transportation projects. Although CALINE2 is most valid for areas where the surrounding terrain is relatively flat and homogeneous, it can yield approximations of the air quality impact in uneven or heterogeneous terrain, if logical assumptions are made concerning its use. Two such assumptions are: 1) the horizontal advection principle applies to upslope air flow, and 2) uneven terrain can be approximated by an average elevation.

For interchanges, intersections, or freeways with medians wider than 30 feet, each element should be analyzed separately and the superposition approach applied to find the total impact. In heavily-urbanized areas, surface atmospheric stability class "D" is recommended for use as the most stable condition (worst-case) to account for the urban heat island effects. Stability class "F" should be used for other areas. Urban areas add to the atmospheric instability because of an increased consumption of energy, thus releasing additional heat to the atmosphere.

3 IMPLEMENTATION

CALINE2 represents the state-of-the-art of Gaussian line source dispersion modeling. It has been placed on the statewide time-sharing system of Caltrans, called TENET, and on California State's IBM 370/168. It is being used by all Transportation Districts and agencies to assess the impacts of highways upon air quality. However, it should only be used for carbon monoxide and should be limited to the microscale region surrounding the highway.

CALINE2 supersedes any previously-issued versions of the California line source dispersion model. These earlier versions should no longer be used.

4 MATHEMATICAL ASSUMPTIONS

4.1 General Gaussian Assumptions

4.1.1 Gaussian Dispersion

The Gaussian dispersion equations, as described by Turner (6) were developed to describe the dispersion of an inert pollutant from a point source with a constant emission rate. The equations assume that the concentrations of pollutants follow a normal distribution in the horizontal and vertical directions. Figure 4-1 illustrates the dispersion in a typical case, and the coordinate system used.

The general form to describe the Gaussian diffusion equation is:

$$C(x,y,z;H) = \frac{QF}{2\pi\sigma_y\sigma_z\bar{U}}\left[\exp\left\{-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right\}\right]\left[\exp\left\{-\frac{1}{2}\left(\frac{Z+H}{\sigma_z}\right)^2\right\}+\exp\left\{-\frac{1}{2}\left(\frac{Z-H}{\sigma_z}\right)^2\right\}\right] \quad (4.1)$$

where

C = concentration (ppm or $\mu g/m^3$)

x,y,z = receptor location in three dimensional space (meters)

H = effective stack height (meters)

Q = source strength (gms/sec)

σ_y, σ_z = horizontal and vertical dispersion parameters* (meters)

$\bar{U}$ = mean wind speed (meters/sec)

F = conversion factor to change input units to output units.

*σ is the standard deviation of the plume concentration distribution in the appropriate plane. For an explanation of standard deviation, see any standard text on statistics. For instance, Basic Statistical Methods for Engineers and Scientists, by Neville and Kennedy.

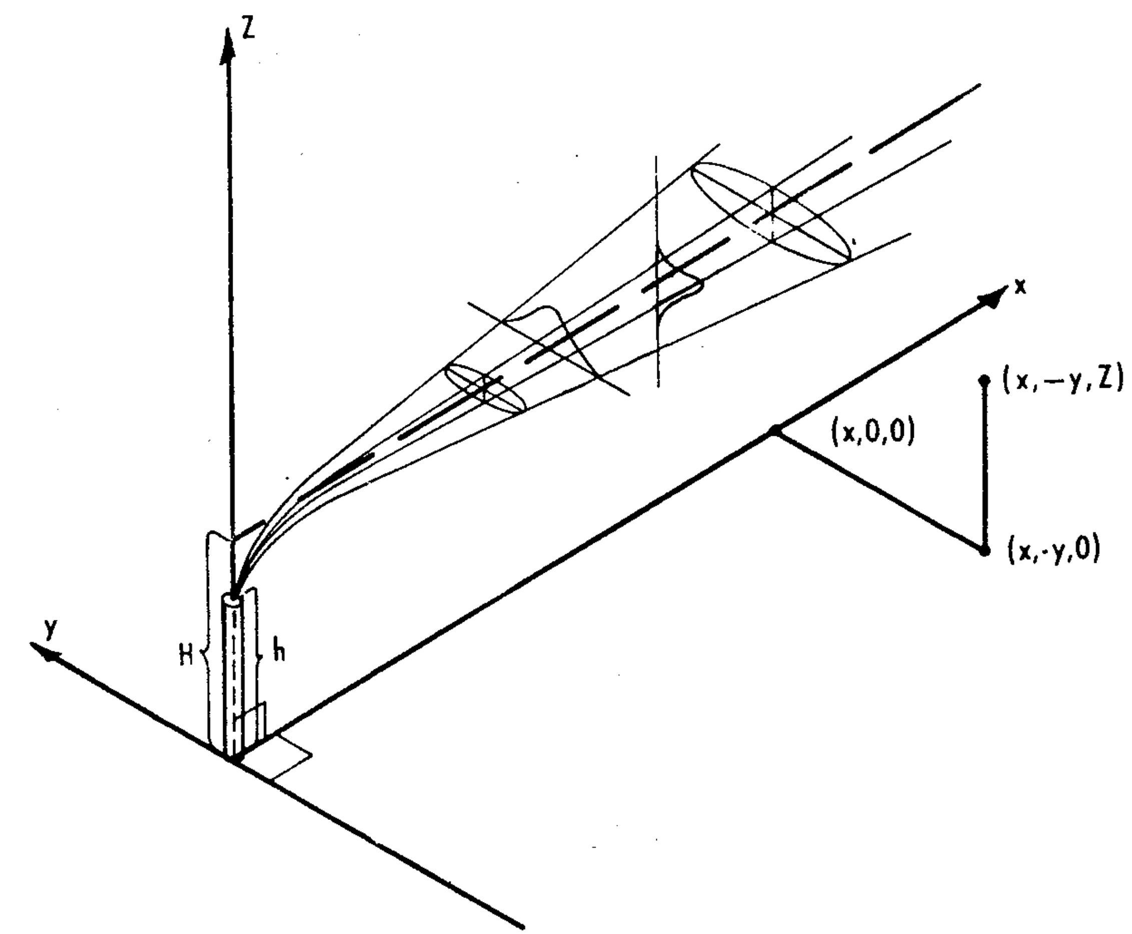


FIG. 4-1 COORDINATE SYSTEM SHOWING GAUSSIAN PLUME DISPERSION IN THE HORIZONTAL AND VERTICAL DIRECTIONS
(After Turner, (6))

The edge of the Gaussian plume is defined as the point in the y-z plane where the pollutant concentration is one tenth that of the centerline. This point is at a distance of 2.15σ from the centerline. Perfect reflection of the plume is assumed when it contacts the ground surface. This assumption is incorporated into equation 4.1 by creating an imaginary point source which is an undersurface mirror of the actual source. The z+H term is related to the vertical dispersion downwind from the actual point source, and the z-H term is related to the vertical dispersion from the imaginary source.

Equation 4.1 only calculates the concentration from the source itself. It does not include the upwind ambient level.

One of the shortcomings of Gaussian dispersion as stated in equation 4.1 is its inability to handle trapping of pollutants by the "lid" of an elevated inversion. However, in the micro-scale (highway corridor) region for which CALINE2 was developed, the vertical dispersion of pollutants from a line source usually does not reach the inversion base height.

The basis of CALINE2 is the modification of equation 4.1 to accommodate a line, rather than a point, source. This modification is described in detail in Section 4.2.

4.1.2 Atmospheric Stability Classes

The surface-layer stability of the atmosphere can be classified into separate stability categories according to meteorological parameters as suggested by Pasquill and modified by Turner (6). Pasquill developed a series of graphs for the dispersion parameters (σ_y and σ_z in equation 4.1), as a function of his stability classes and the downwind distance "x" from the source (see Figures 4-2 and 4-3).

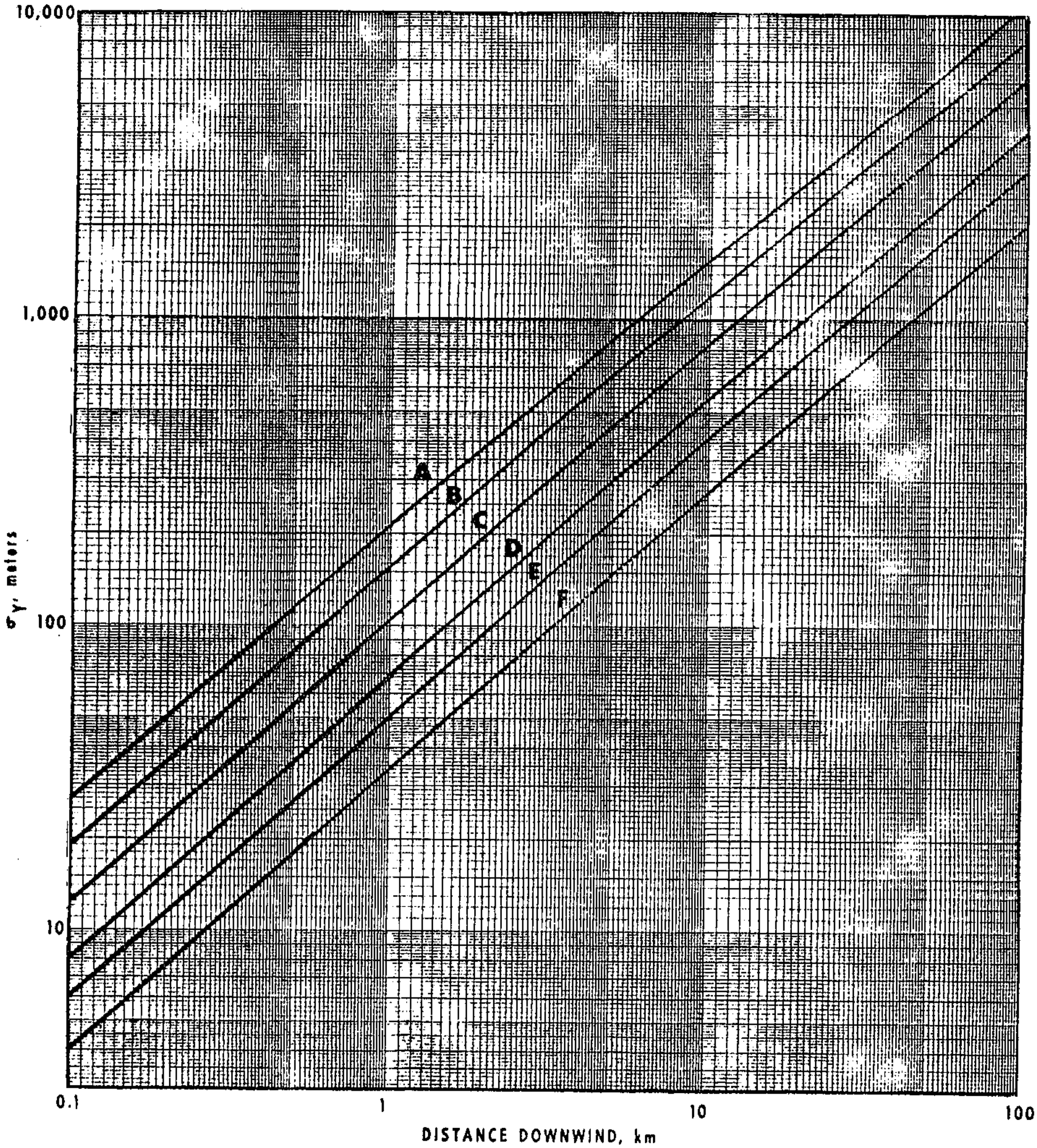


FIG. 4-2 HORIZONTAL DISPERSION COEFFICIENT σ_y AS A FUNCTION OF DOWNWIND DISTANCE FROM THE SOURCE
After Turner, (6)

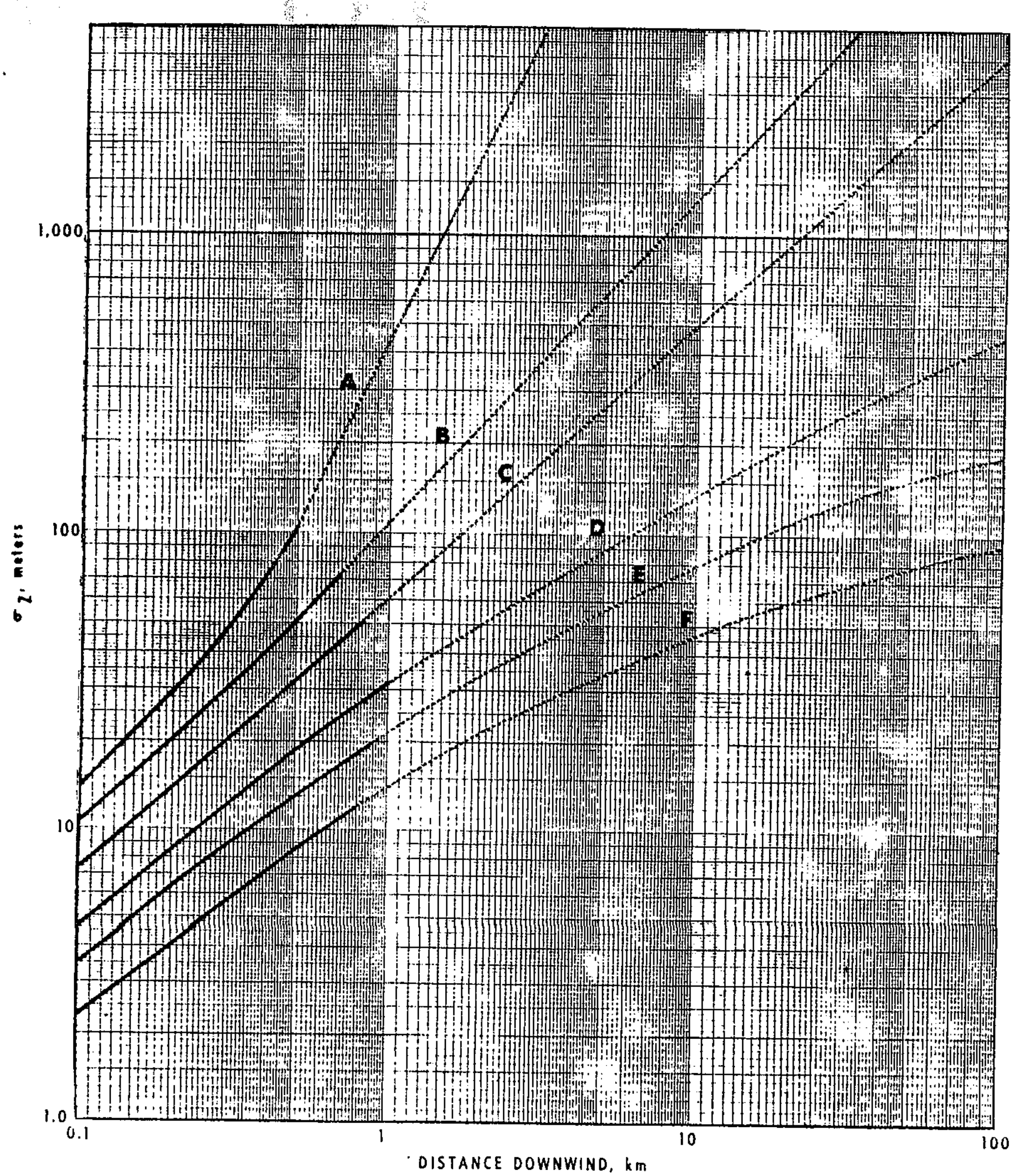


FIG. 4-3 VERTICAL DISPERSION COEFFICIENT σ_z AS A FUNCTION OF DOWNWIND DISTANCE FROM THE SOURCE.

After Turner, (6)

Unfortunately, the Pasquill dispersion parameters shown in the graphs are valid only for downwind distances from 0.1 to 100 km. Many line source impact analyses are concerned with receptors closer to the highway than 0.1 km, especially in the right-of-way range of 15 to 50 meters. Modifications to the dispersion parameter curves to handle these downwind distances less than 0.1 km are discussed in Section 4.2.2.

Additionally, Pasquill's original research was conducted in flat open country in rural areas. It has been found that his stability classes do not adequately describe the atmospheric turbulence encountered in urban areas and rough or forested terrain (6,7). Neither the aerodynamic roughness height nor the unnatural thermal energy imbalance created by man-made surfaces are incorporated in his dispersion parameter graphs. While no attempt has been made to incorporate the higher turbulence encountered in urban areas into the stability parameters in CALINE2, as was done in other Gaussian models (7), stability class "D" (neutral) can be used in urban project analysis to account for this increased instability.

4.1.3 Wind Shear

The wind speed within the atmospheric boundary layer varies from near zero at the ground surface to the geostrophic wind velocity at a height of around 500 meters. This last height figure is highly dependent on surface roughness characteristics and is closer to the ground for flat, even terrain, and higher for central business districts with multi-story buildings (see Figure 4-4).

The Gaussian dispersion equations do not incorporate the wind shear. Rather, they assume a uniform wind flow field with some mean wind velocity, $\bar{u}$, as in Figure 4-5, that is not influenced by surface roughness.

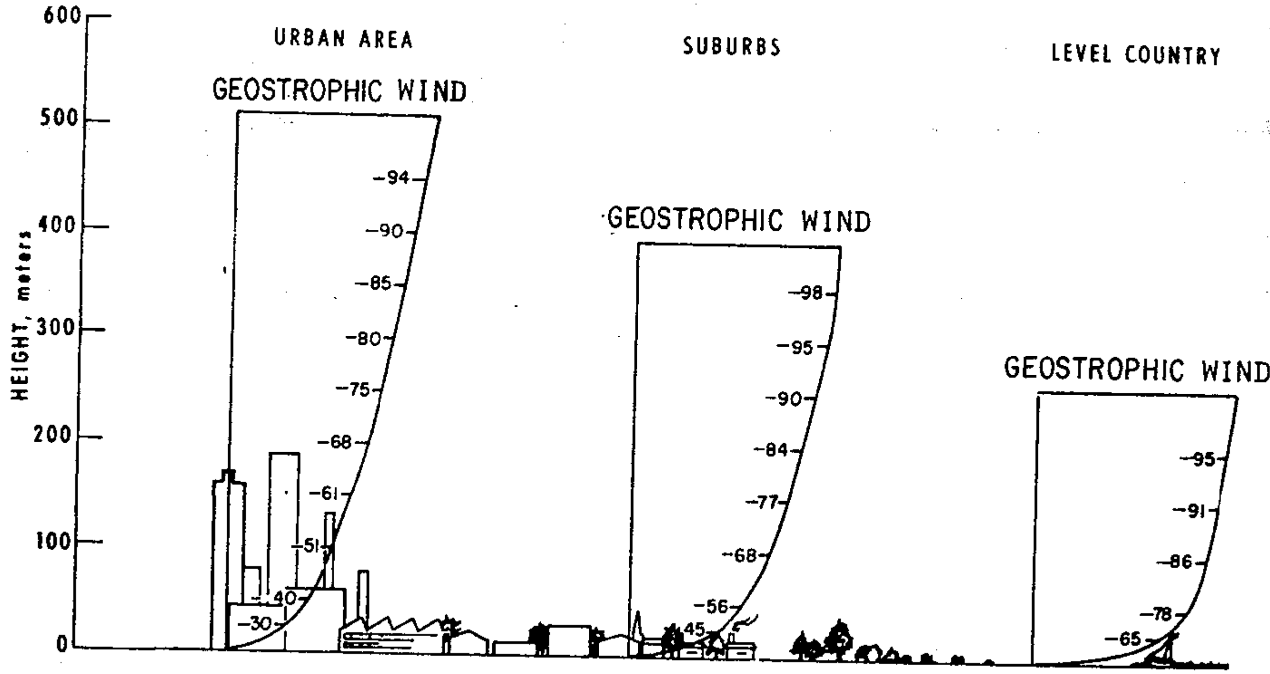


FIG. 4-4 EXAMPLES OF WIND SHEAR WITH DIFFERENT SIZE ROUGHNESS ELEMENTS
(FIGURES ARE PERCENTAGES OF GEOSTROPHIC VELOCITY)
(After Turner, (6))

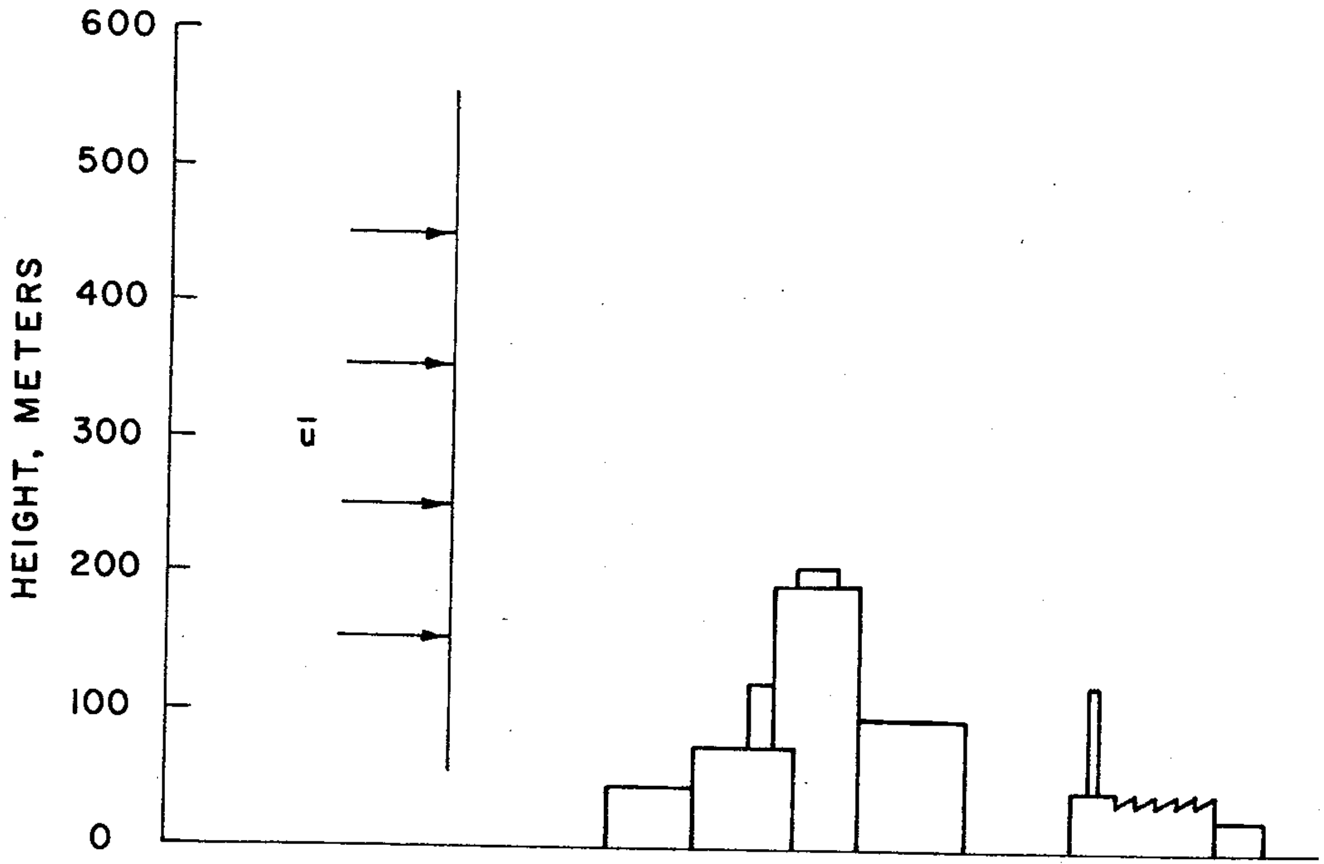


FIG. 4-5 UNIFORM WIND FLOW FIELD

4.1.4 Aerodynamic Eddies

Physical objects in the path of a uniform wind flow field, such as buildings, highway viaducts, or street canyons change the flow and form turbulent eddies. Cavities, areas of divergence, and areas of convergence form, which may disperse or concentrate pollutants, depending on the configuration and interaction of the different eddies. For example, cavities formed in street canyons have been found to allow inadequate dispersion of pollutants under otherwise turbulent atmospheric conditions (8).

Aerodynamic eddies are not included in the Gaussian dispersion theory. Therefore, other means have to be sought to account for these important effects. One such approach is discussed in Section 4.2.6.

4.2 Gaussian Line Source Assumptions

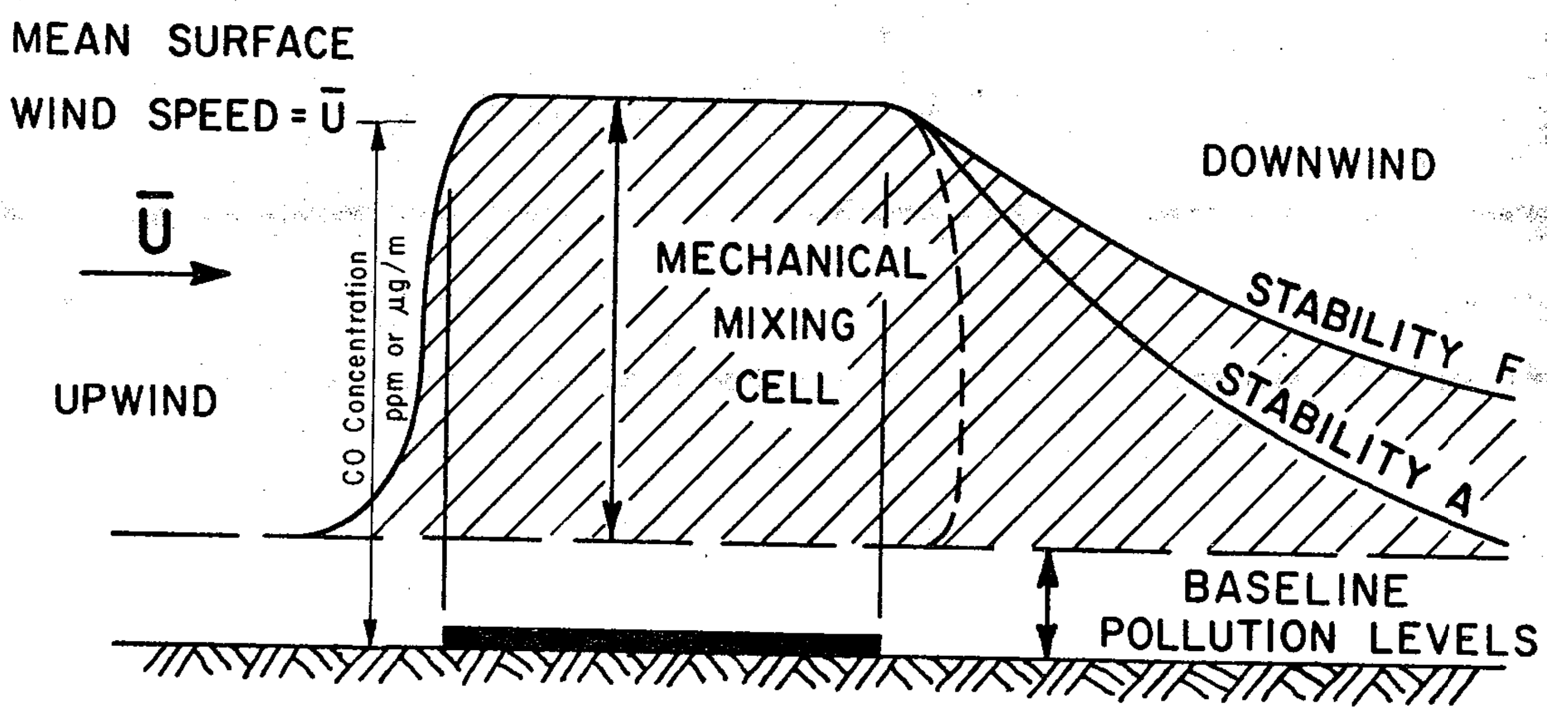
4.2.1 Mixing Cell Concept

It was surmised that the physical movement of the vehicles on a typical line source, a highway, would create a well-mixed region surrounding the highway which would not be affected by surface atmospheric stability. To test this theory, Caltrans conducted a series of smoke plume dispersion tests on an abandoned airport runway north of Sacramento, in 1972 (9). By observing and photographing the initial dispersion of smoke from sources placed in the tailpipes of test vehicles, it was determined that the theory was sufficiently valid. From the plume studies the limits of the mixing cell are approximately equal to the width of the paved surface and twice the height of the vehicle. As a representative average of the vehicle mix, the vertical limit of the mixing cell was set equal to 4 meters. The width of the mixing cell, which is also called the highway width, is determined by adding the width of all the lanes, up to the edge of traveled pavement, plus the median, and an extra distance equal to approximately 3 meters (10 feet) on each side of the highway. This last is to account for the horizontal turbulence created by the mix of heavy duty and light duty vehicles. The same horizontal turbulence is assumed to create a well-mixed region across the median, as long as the median is less than 9.1 meters (30 feet) wide. If the median is greater than 9.1 meters in width, each direction will have to be simulated separately, as discussed in Section 8.

The mixing cell is used as a uniform, well-mixed pollutant source from which the pollutants are then dispersed downwind in a Gaussian manner. Figure 4-6 illustrates this concept. Figure 4-6 also shows how the ambient or baseline pollutant level has been excluded. It is assumed that the concentrations of pollutants within the mixing cell are unaffected by regional meteorological conditions because of the dominating turbulence generated by the moving traffic. The mixing cell can be represented by a tunnel in which the air is thoroughly mixed.

4.2.2 Dispersion Parameter Modifications

In order to determine dispersion parameters for downwind "x" distances less than 0.1 km, the initial dispersion of a line source was set equal to that found at the edge of the mixing cell. Interpolative curves were then drawn between these points and the original Pasquill curves. From the empirical evidence of the smoke study, the initial vertical dispersion parameter was set at 4 meters (see Figure 4-7).



MODEL ESTIMATES ONLY SHADED AREA

TOTAL POLLUTANT CONCENTRATION = BASELINE POLLUTANT LEVELS + POLLUTANTS GENERATED FROM HWYS.

FIG. 4-6 MIXING CELL

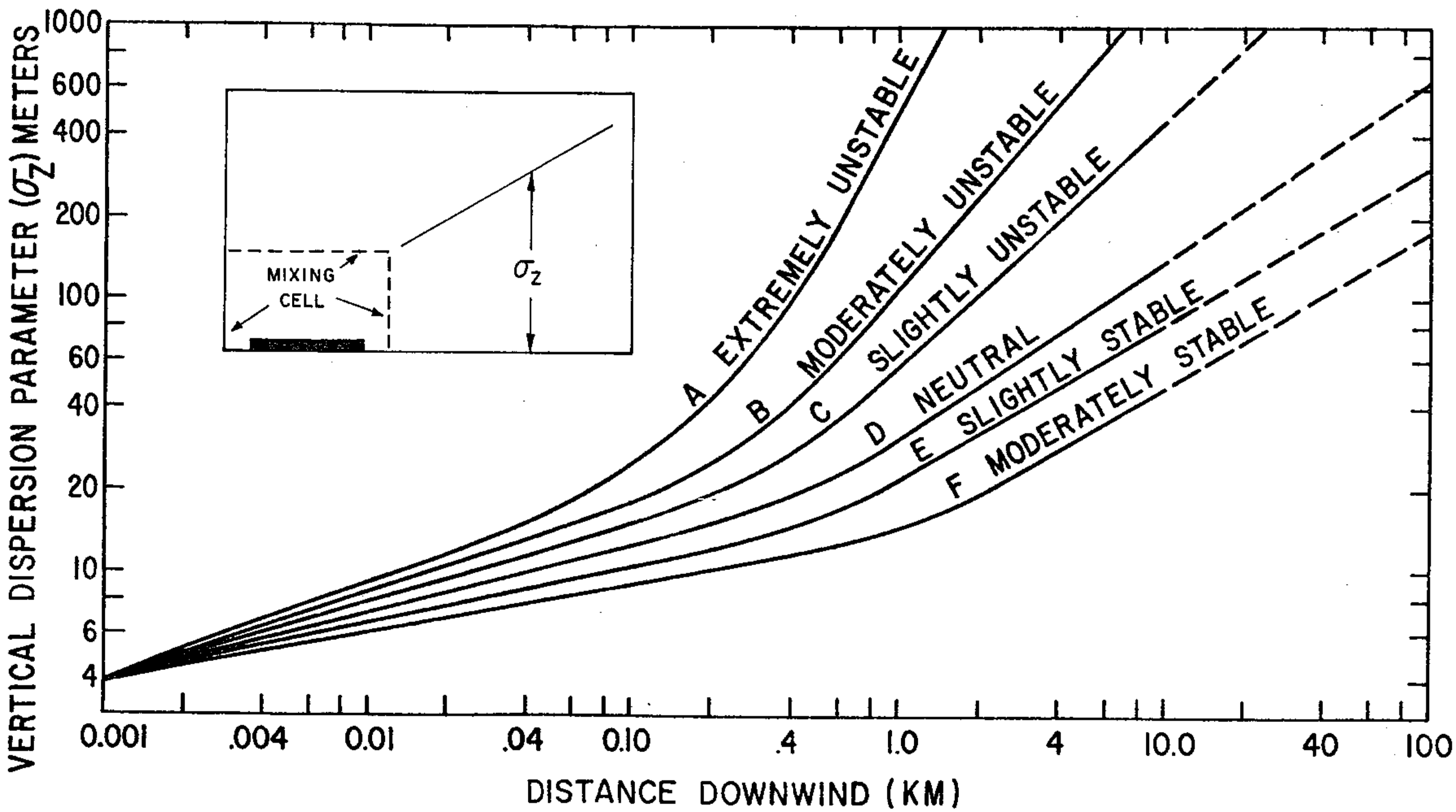


FIG. 4-7 VERTICAL DISPERSION PARAMETERS

To accommodate the individual project's width, the initial horizontal dispersion is found by dividing the highway width by the plume width constant (which equals 4.3)*. The reason for this is more completely explained in Section 4.2.4, and is based on the fact that the horizontal dispersion parameter is only incorporated in the parallel wind equations. A point along an extrapolation of the stability class "A" curve**, as defined by Beaton, et al (10), (see Figure 4-8) is found which corresponds to this initial horizontal dispersion, and the first portions of the other stability class curves are modified to begin at this point. For example, the horizontal dispersion parameter for stability class "F" is assumed linear (on a log-log plot) with downwind distance from the edge of the mixing cell to approximately 1 km, at which point it intersects the previously-established curve as defined by Turner (6). Figure 4-9 illustrates that situation for different highway widths.

---

*Since the edge of the plume is at a distance of 2.15σ from the plume centerline, the plume width is twice this amount, or 4.3σ. Therefore, the plume width constant is 4.3.

**The value of the lower boundary of the curves in Figure 4-8, 8 meters, was determined mathematically from the width of the mixing cell associated with a 6-lane freeway, which was assumed to be the average situation. The mixing cell width was 114 feet, or 34.75 meters. Dividing this value by the plume width constant, 4.3, yields approximately 8 meters. The corresponding downwind value for the vertical dispersion parameter.

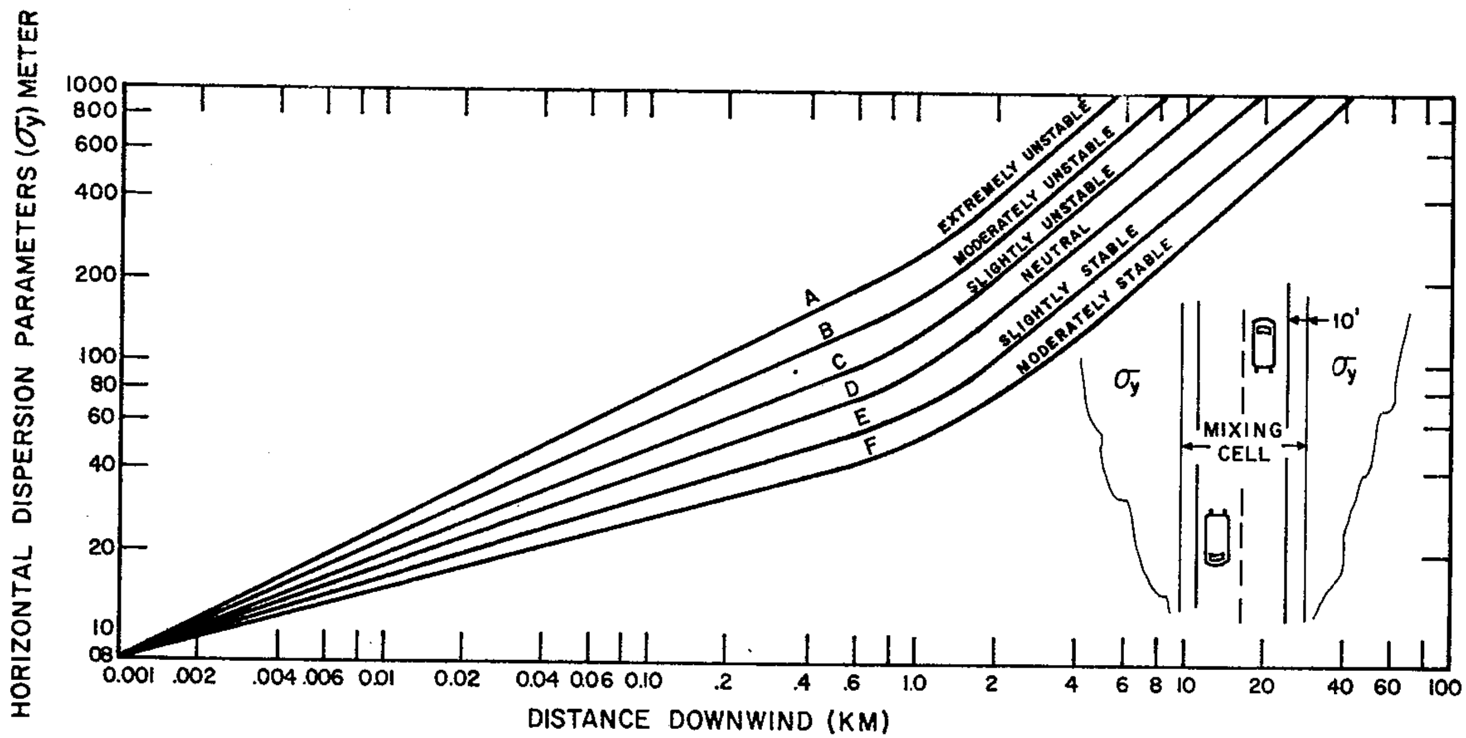


FIG. 4-8 HORIZONTAL DISPERSION PARAMETERS

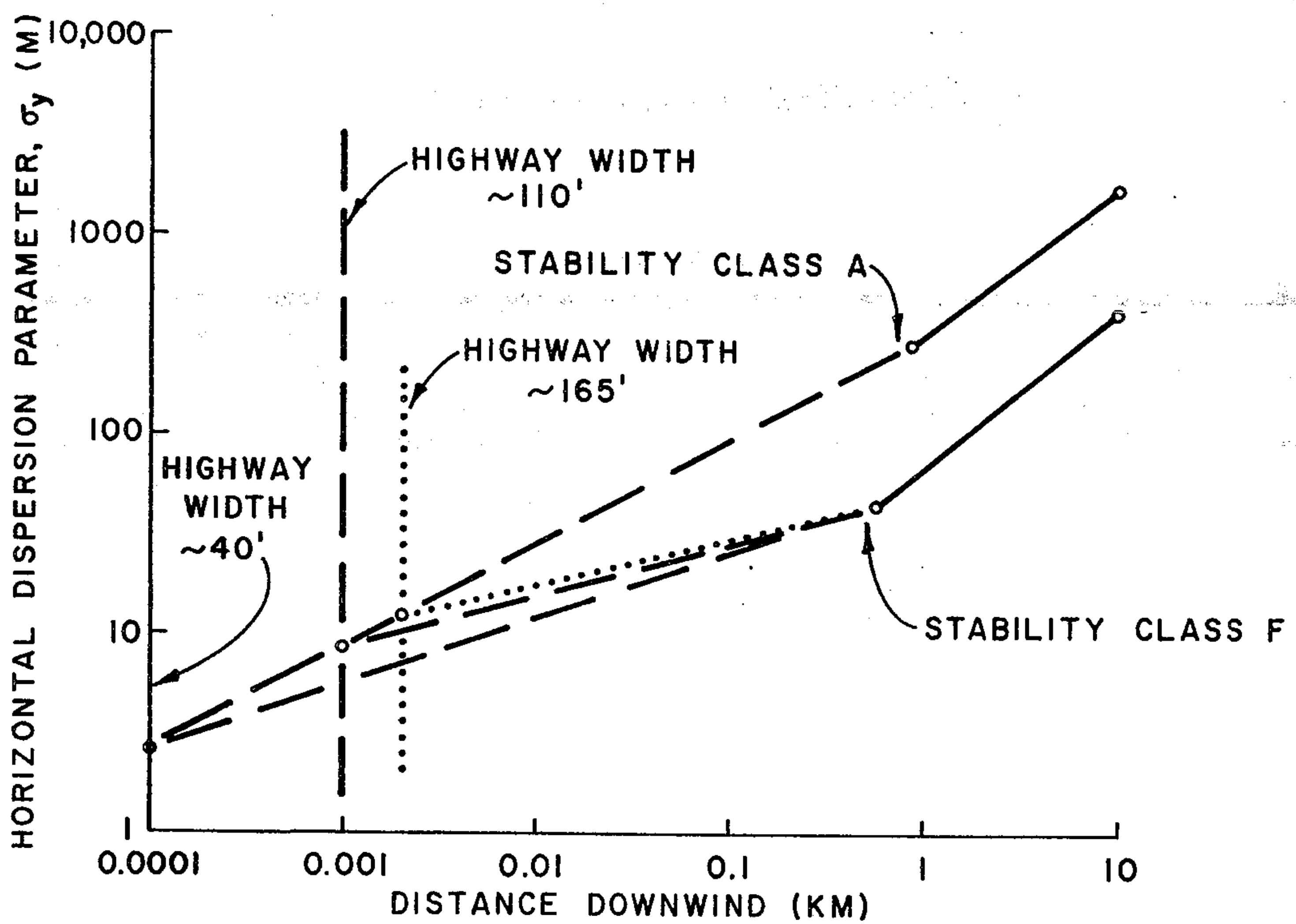


FIG. 4-9 MODIFICATION OF σ_y FOR VARIATIONS IN HIGHWAY WIDTH.

(Highway width includes all lanes, median and 10' on each side of the highway.)

4.2.3 Cross Wind Line Source Equation

The dispersion of pollutants from an infinite line source with a perpendicular wind (90°) can be described by the equation (6):

$$C = \frac{Q_1 F_1}{\sqrt{2\pi}\,\sigma_z \overline{U}} \left[\exp\left\{-\frac{1}{2}\left(\frac{Z+H}{\sigma_z}\right)^2\right\} + \exp\left\{-\frac{1}{2}\left(\frac{Z-H}{\sigma_z}\right)^2\right\}\right] \quad (4.2)$$

where the subscript "1" on C_1, Q_1, and F_1 refers to the crosswind component of the pollutant concentration, line source strength, and conversion factor, respectively.

Q_1 = VPH x EF

VPH = vehicles per hour

EF = emission factor (gms/mile)

H is the height of pavement above ground surface, and the other variables are as previously defined in equation 4.1.

Equation 4.2 is valid as long as the end of the line source is far enough away from the point being analyzed that end effects are unimportant. See Figure 4-10 for a display of the crosswind situation.

4.2.4 Parallel Wind Line Source Equation

When the wind is parallel to the highway alignment (0°), a build-up of pollutants occurs in the downwind mixing cell, because an air parcel continues to amass pollutants as it travels along the highway. When the wind is parallel, the assumption can no longer be made that the highway has no width. The following equation is used to account for these factors:

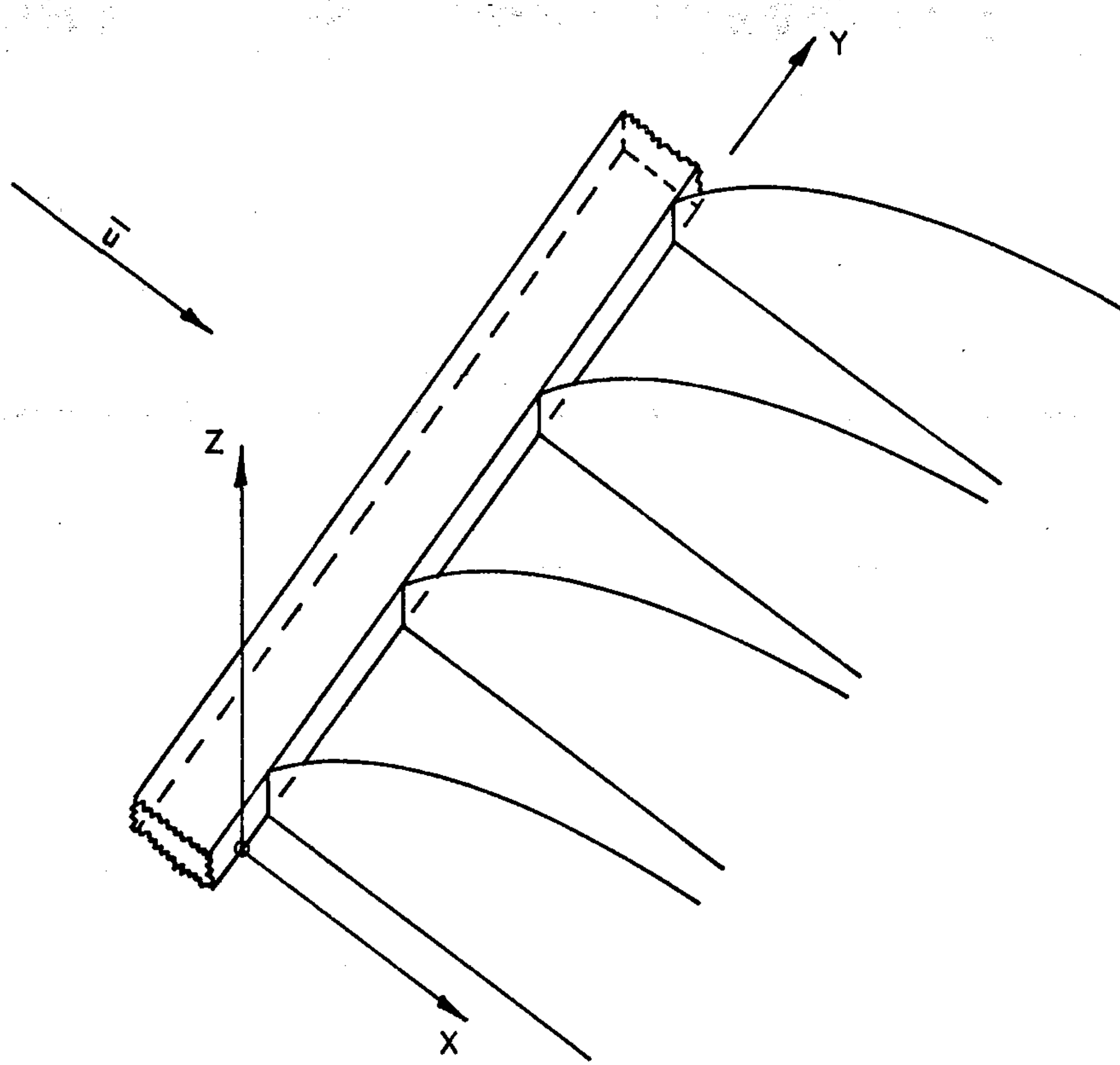


FIG. 4-10 SCHEMATIC SHOWING GENERAL GAUSSIAN DISPERSION OF POLLUTANTS FROM AN INFINITE LINE SOURCE UNDER CROSS WIND CONDITIONS

$$C_2=\sum_{i=1}^{\infty}\frac{Q_2F_2}{2\pi\sigma_{y_i}\sigma_{z_i}\bar{U}}\left[\exp\left\{-\frac{1}{2}\left(y/\sigma_{y_i}\right)^2\right\}\right]\left[\exp\left\{-\frac{1}{2}\left(\frac{Z+H}{\sigma_{z_i}}\right)^2\right\}+\exp\left\{-\frac{1}{2}\left(\frac{Z-H}{\sigma_{z_i}}\right)^2\right\}\right] \quad (4.3)$$

where the subscript "2" on C_2, Q_2, and F_2 refers to the parallel wind component of the pollutant concentration, line source strength, and conversion factor, respectively.

$Q_2 = Q_1 \times W$

W = highway width (meters),

and the other variables are as defined in equations 4.1 and 4.2.

The assumption is made that a highway with a parallel wind can be approximated by the summation of a series of square area sources, each having the same source strength, but a different distance to the receptor. The area sources themselves are approximated by virtual point sources. This last is why equation 4.3 is the same form as equation 4.1 except for the summation. In order to agree with the infinite line theory of the crosswind case, the summation is made over an infinite distance downwind. In actuality, however, the summation need be carried out only to a finite distance, which is dependent on stability class. At this distance, the contribution of pollutant from area sources located farther upwind from the receptor becomes negligible. Since this distance is only dependent on stability class, a scaling factor (see Figure 4-11) for each class can be used to increase the calculated concentration from a short finite parallel wind segment to that for the "infinite" line source. The short finite segment has been determined as 1/2 mile, to allow the incorporation of different highway widths (and thusly, different σ_y curves) with minimal error while shortening the computer time necessary to make the reiterative summation. Figure 4-11 shows the mixing cell CO concentrations as a function of summation length and stability class.

A virtual point source is defined as a point source with the same emission strength as the actual area source, located at a distance downwind of the area source which will yield the same horizontal dispersion parameter as that at the downwind edge of the area source. In order to find the area source's initial horizontal dispersion parameter, the width of the area source (which is the highway width) is divided by the plume width constant 4.3, yielding the σ_y for the downwind edge (6). The virtual distance corresponding to this σ_y is found on the horizontal dispersion curve for the appropriate stability class (see Figure 4-9). The vertical dispersion parameter σ_z is assumed to follow the same virtual distance as σ_y. In other words, the virtual distance determined for σ_y is used to find the appropriate σ_z with the curves in Figure 4-7. See Figure 4-12 for the basic conceptualization of the parallel wind/ virtual point source situation.

The virtual point source should be aligned, theoretically, with the centerline of the area source. However, this would presume that the concentration across the area source would follow a normal distribution, thereby disagreeing with the definition of the mixing cell. The mixing cell definition mandates a constant concentration throughout the area source. Essentially what has to take place to again agree with the mixing cell definition is that the axis of the virtual point source (the x-axis) has to be shifted towards an edge of the mixing cell. By shifting the axis towards the edge nearest the receptor, the normal distribution curve is intersected by the mixing cell edge at a point closer to the distribution's mean, yielding a higher concentration. The higher concentration is then said to be the

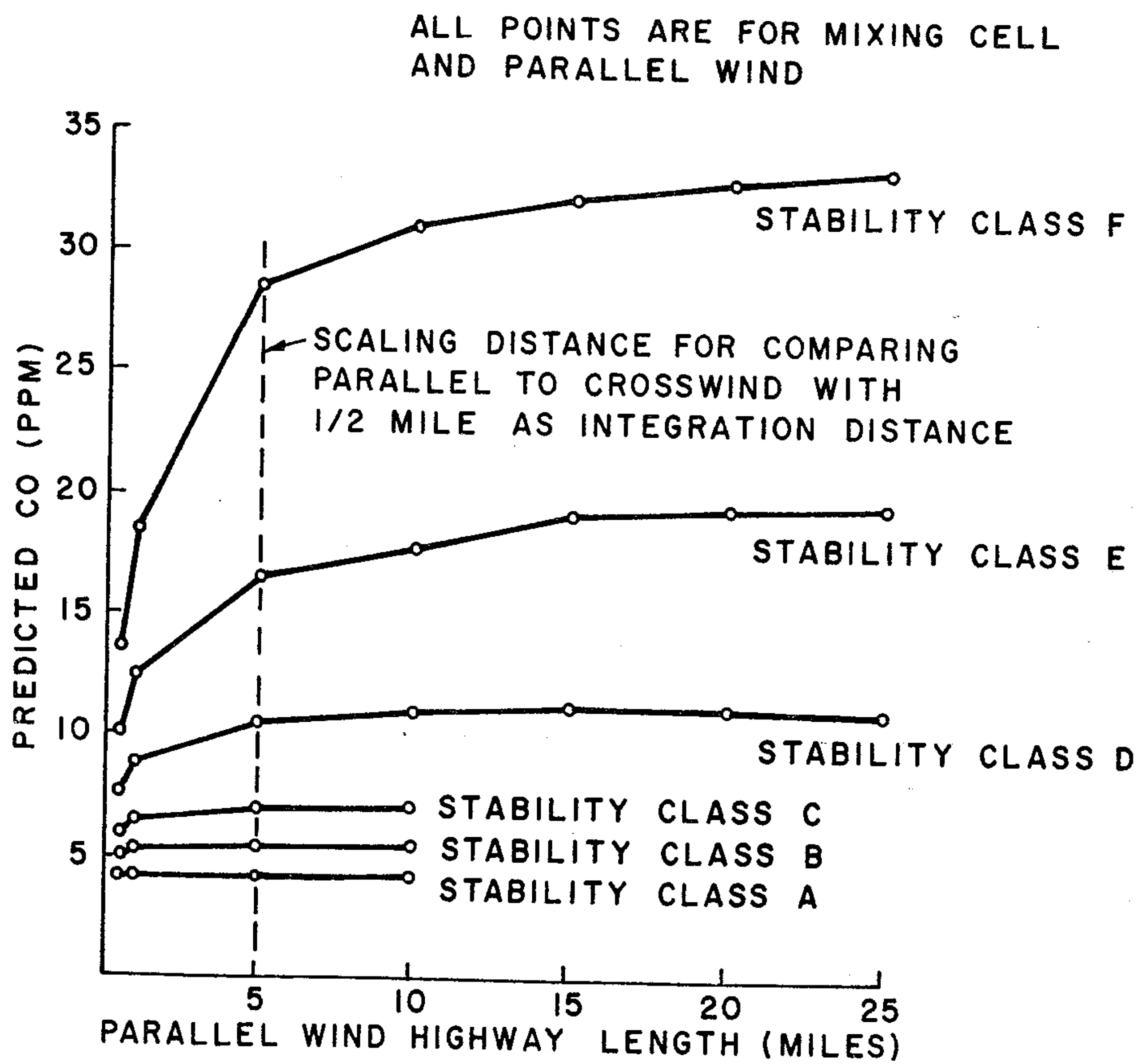


FIG. 4-11 MIXING CELL CONCENTRATIONS AS A FUNCTION OF HIGHWAY LENGTH PARALLEL TO WIND

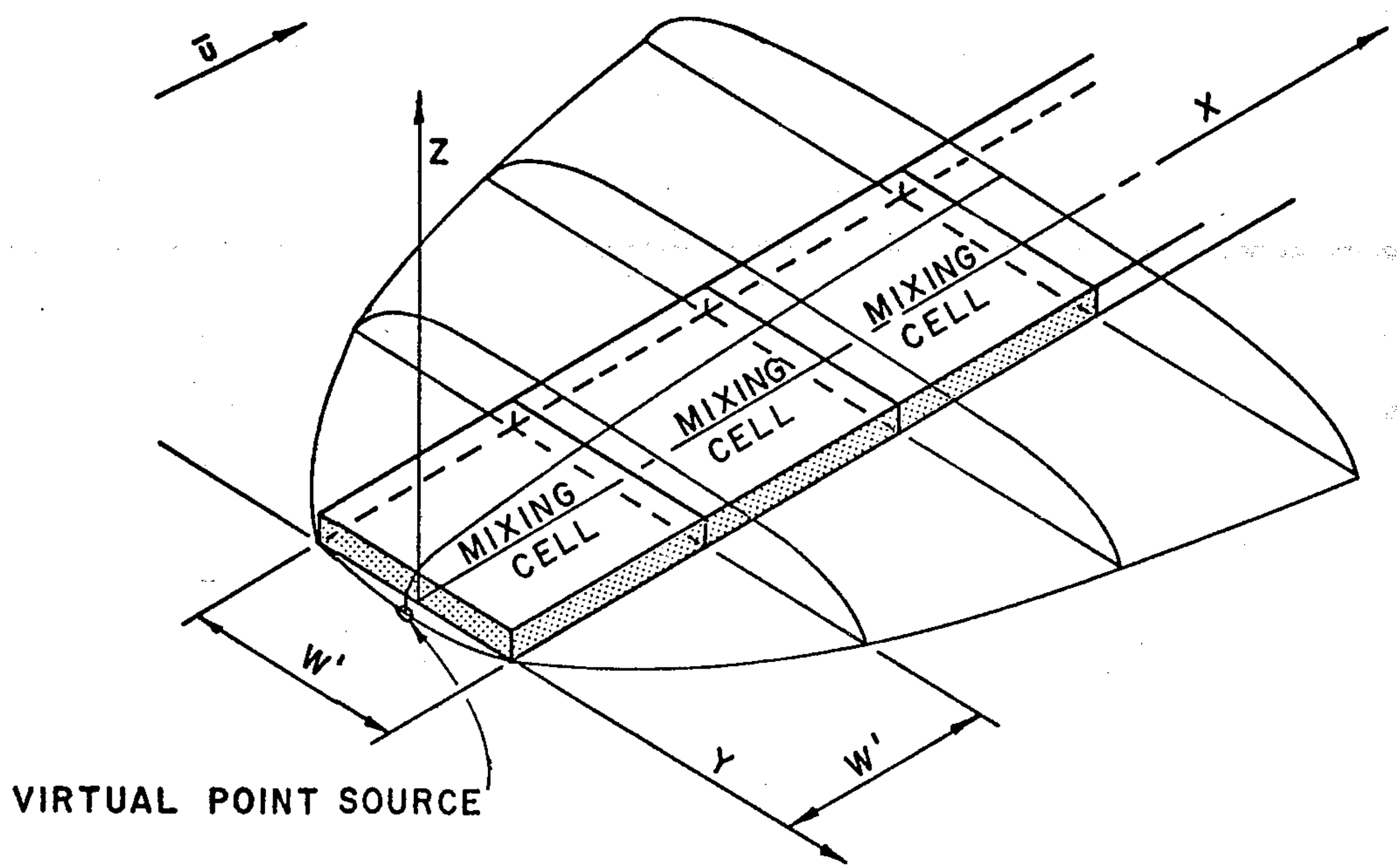


FIG. 4-12 SCHEMATIC SHOWING GENERAL GAUSSIAN DISPERSION OF POLLUTANTS FROM FIRST VIRTUAL POINT SOURCE UNDER PARALLEL WIND CONDITIONS

concentration of the mixing cell, or area source. This shifting of the x-axis artificially imposes the mixing cell definition upon a normal distribution.

The shifting of the x-axis is incorporated in the "y" term of equation 4.3, i.e.,

$$y = y' + s \qquad (4.4)$$

where y' = the horizontal distance from the edge of the mixing cell to the receptor,

s = the distance of the x-axis shift.

The distance "s" is found by solving equation 4.2 and 4.3 (the latter for only the first area source segment) for z, H and the unmodified y set equal to 0 (which is the location of the mixing cell), resulting in equations 4.5 and 4.6.

$$C_1(x,o,o;o) = \frac{2 Q_1 F_1}{\sqrt{2\pi}\, o_z \bar{U}} \qquad (4.5)$$

and

$$C_2(x,o,o;o) = \frac{2 Q_2 F_2}{2\pi\, \sigma_y\, \sigma_z \bar{U}} \qquad (4.6)$$

Neglecting F_1 and F_2 since they are only conversion factors, and remembering that $Q_2 = Q_1 \times W$, it can be seen that equations 4.5 and 4.6 only differ by a factor of $\frac{W}{\sqrt{2\pi}\,\sigma_y}$.

Since the mixing cell concentrations for a crosswind line source and the first area source segment of a parallel wind line source should be the same, for given atmospheric conditions and roadway configuration, a factor of $\frac{\sqrt{2\pi}\,\sigma_y}{W}$ is required in the parallel wind equation (4.6). Because the x-axis has to be shifted, this factor is assumed to be obtained through $\exp\left\{-\frac{1}{2}\left(\frac{S}{\sigma_y}\right)^2\right\}$. Therefore,

$$\exp\left\{-\frac{1}{2}\left(\frac{S}{\sigma_y}\right)^2\right\} = \frac{\sqrt{2\pi}\,\sigma_y}{W} \tag{4.7}$$

and

$$S = \sigma_y \left\{-2\ln\left(\frac{\sqrt{2\pi}\,\sigma_y}{W}\right)\right\}^{1/2} \tag{4.8}$$

For any given values of W and σ_y, "s" approximately equals the σ_y associated with the virtual point source. Therefore, the physical interpretation of the above mathematics is that the shifted x-axis lies between the actual centerline and the mixing cell edge nearest the receptor, at a distance approximately equal to W/4.3 (the σ_y of the virtual point source) from the edge of the mixing cell.

4.2.5 Oblique Wind Line Source Equation

The consideration of a wind blowing at an oblique angle to the highway (0° < angle < 90°), is made easier by the fact that both the crosswind and parallel wind equations are for "infinite" line sources. This similarity allows components of the two "pure" wind angle equations to be added via weighted vectorial coefficients.

As can be seen in Figure 4-13, a wind $\bar{u}$ can be broken down into a crosswind component $\bar{u}\sin\phi$ and a parallel wind component $\bar{u}\cos\phi$. However, the concern with CALINE2 is to find the pollutant <u>concentration</u> resulting from an oblique wind, and not the vector components of the <u>wind</u>. By using the trigonometric

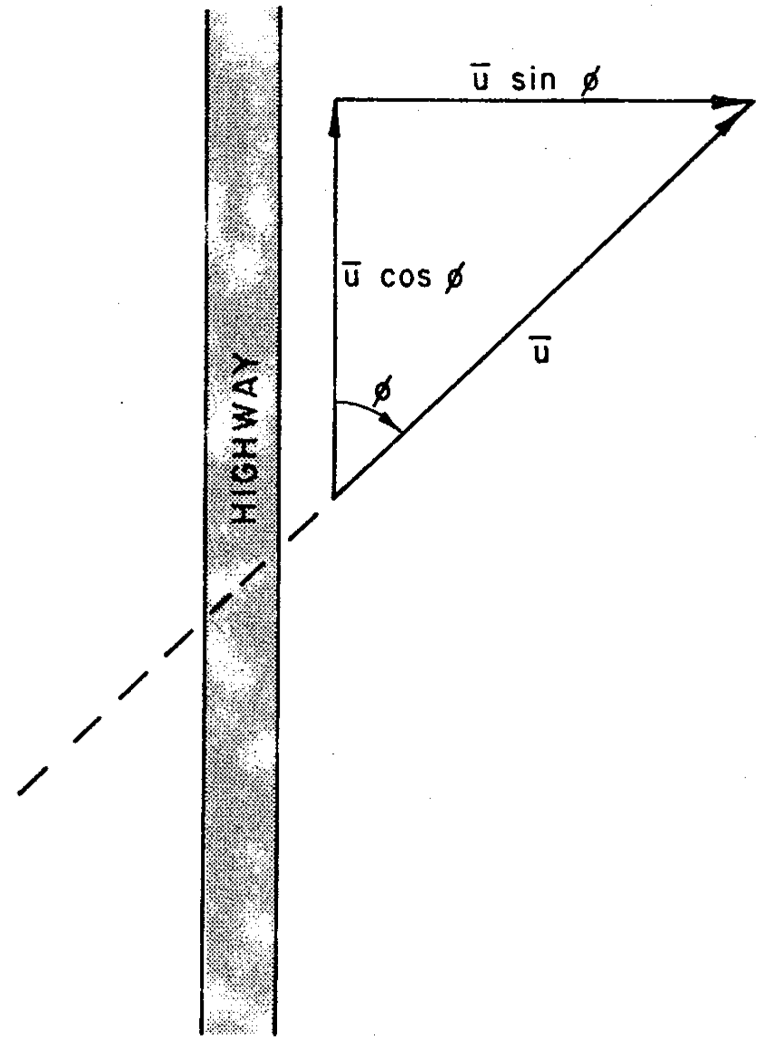


FIG. 4-13 VECTOR COMPONENTS OF AN AVERAGE WIND SPEED WITH AN ANGLE TO THE HIGHWAY OF Φ

identity, $\cos^2\phi + \sin^2\phi = 1$, the concentration from an oblique wind was assumed to be equal to:

$$C_3 = \sin^2\phi \; C_1 + \cos^2\phi \; C_2 \tag{4.9}$$

where the subscript "3" on C_3 refers to the oblique wind pollutant concentrations.
C_1 and C_2 are as defined in equations 4.2 and 4.3,
ϕ is the acute wind angle.

In this case, the trigonometric relationship was used to functionally smooth the sum of the components from each of the "pure" wind angle equations. The preliminary verification study supports this assumption (see Section 7).

4.2.6 Source Height Adjustments

The "H" term in equations 4.2 and 4.3 is used to indicate a highway section that is either depressed in relation to the surrounding terrain, at grade, or raised above the terrain, as in a fill or viaduct section. Highway sections that are other than at grade are difficult to handle in a line source model because the Gaussian theory does not account for aerodynamic eddies, as discussed in Section 4.1.4.

Using the carbon monoxide data gathered in Los Angeles in 1972 (11), which included measured concentrations for two depressed sites up to 24 feet deep, a set of empirical ratios was developed to approximate the nonuniform wind flow through a depressed highway section. By using multiple stepwise linear regression, the variables were determined which had the most correlation with the measured pollutant concentrations directly above the highway at the level of the surrounding terrain (12). The variables considered were traffic volumes, emission factors, wind speed, wind direction, pavement height and Pasquill stability class. From the analysis, regression coefficients were determined which related the most significant variables to the carbon monoxide concentrations.

The empirical equations for depressed sections are categorized by stability class and are:

For stability class A,

$$R = 10^{(-0.18164 + 0.01448H + 1.439 \times 10^{-5} VPH + 7.9 \times 10^{-4} \phi)} \quad (4.10)$$

For stability class B,

$$R = 10^{(0.21754 + 0.01431H - 7.2 \times 10^{-4} \phi - 0.02252\bar{U})} \quad (4.11)$$

For stability classes C-F,

$$R = 10^{(0.02019 + 0.0138H + 4.98 \times 10^{-6} VPH - 5.73 \times 10^{-3} \bar{U})} \quad (4.12)$$

where R = the empirical ratio, and the other variables are as previously defined.

The empirical ratio "R", was derived from the CO concentrations measured at 4 feet, 12 feet, 20 feet, 36 feet, or 44 feet above the highway, divided by the CO concentration at 4 feet. All heights are as measured above the pavement elevation, and not the elevation of the surrounding terrain. Any height above 4 feet had an "R" value less than 1, although the ratio at 12 feet always had a value quite close to 1, reinforcing the concept that a uniform mixing cell exists. There were a few cases where aerodynamic eddies caused some increase of CO concentration with height. These cases were excluded from the analysis and will be subject to future research.

There is only one equation for stability classes C through F (eq. 4.12) because insufficient data were obtained for stability classes E and F due to meteorological conditions. Until further data are gathered, it is assumed that the relationship derived for stability C-D applies to stabilities E and F.

A physical interpretation of the above equations is that an imaginary mixing cell is created at the level of the surrounding terrain which has a smaller source strength than the actual mixing cell on the highway below (see Figure 4-14). Other than the decreased source strength, the imaginary mixing cell has all the characteristics of the original; the same dimensions, the same uniform distribution of pollutants, etc. The pollutants in this imaginary mixing cell are then dispersed in the normal Gaussian manner downwind.

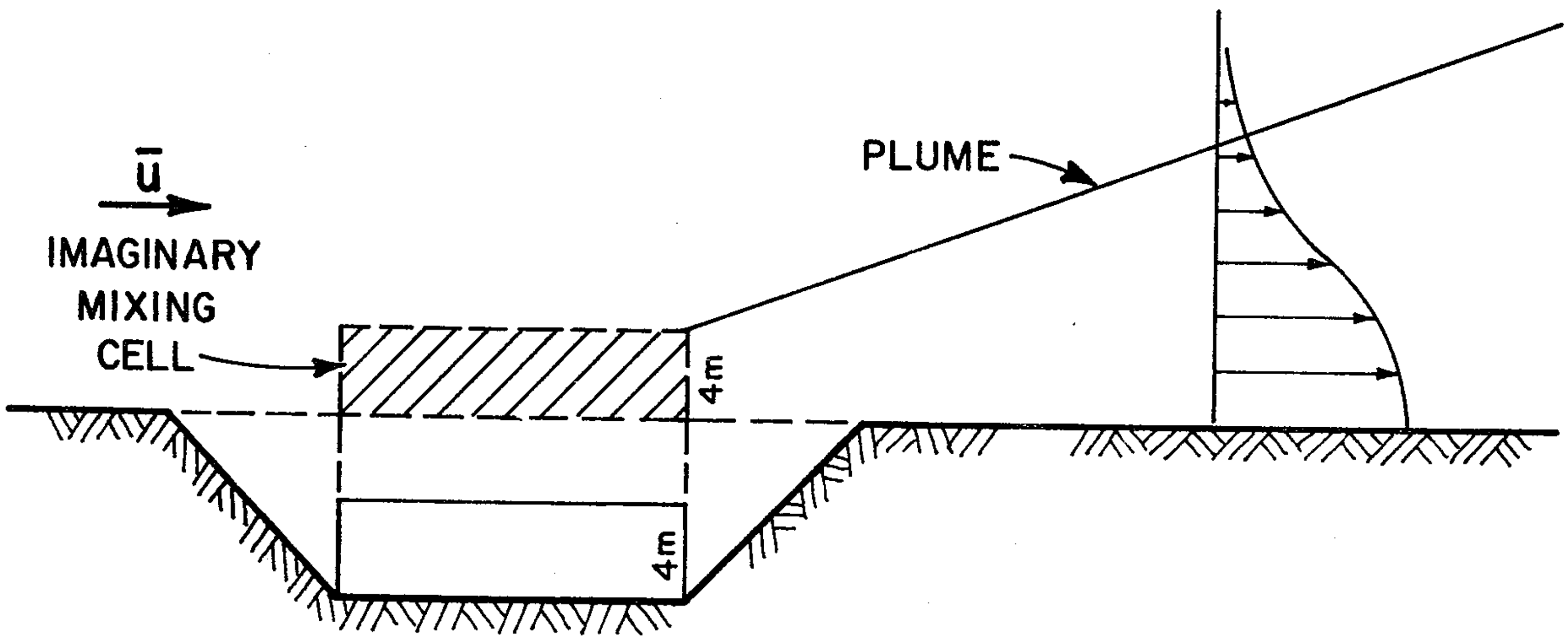


FIG. 4-14 IMAGINARY MIXING CELL FOR DEPRESSED HIGHWAY SECTIONS

At this time, no attempt has been made to develop empirical equations to handle the raised highway section where aerodynamic eddies occur. At present, a raised section is simply considered as an elevated source whose pollutant emissions are dispersed downwind in the same manner as an at-grade line source using the Gaussian equation.

4.3 Summary of Assumptions

1) Gaussian (normal) dispersion of pollutants takes place in horizontal and vertical directions of a plane perpendicular to wind direction.

2) A uniform wind flow field exists, with no vertical wind shear or aerodynamic eddies from uneven surface roughness.

3) No confinement of inert pollutants occurs due to elevated inversion conditions.

4) No chemical reactions or gravitational settling occur that affect the pollutant during the period of analysis.

5) Pollutants generated by the line source do not diffuse upwind.

6) Vehicles using the line source represent a continuous and constant source of emissions.

7) The initial vertical and horizontal dispersions of pollutants within the mixing cell are twice the height of the average vehicle (or 4 meters) and a function of the highway width, respectively.

8) Pollutants are uniformly distributed throughout the mixing cell region regardless of surface atmospheric stability conditions.

9) Perfect plume reflection occurs when the plume intersects the ground surface.

10) Parallel winds cause a buildup of pollutants.

11) A line source having a width "W", can be approximated by a series of square area sources, with "W" length sides, which can in turn be approximated by virtual point sources.

12) A finite highway segment can be approximated by "infinite" line source equations.

13) Pasquill stability classes and modified dispersion parameters adequately describe the turbulence of the atmosphere.

14) Predictions are only made above ambient levels.

5. DATA FORMAT ASSUMPTIONS

5.1 Time Interval

The CALINE2 line source model makes calculations of pollutant dispersion based on hourly averages only. This implies that the output is the concentration of carbon monoxide averaged over one hour. The constraints are that all data upon which the calculations are based, such as the meteorology and traffic volumes, must be hourly values. Obviously, consistency must be maintained in the definition of the hourly average, i.e., if an hour is defined as the period of time between 30 minutes before one hour until 30 minutes before the next, this definition must apply to all variables and not just one.

5.2 Input Data Requirements

As input, CALINE2 requires the following:

1) Traffic volume in vehicles per hour.
2) Average emission factor, in grams per mile.
3) The hour's average wind speed, in miles per hour.*
4) The hour's average wind angle to highway, in degrees.*
7) The hour's surface atmospheric stability class.*
6) Average pavement elevation of the section under consideration, in feet, in relation to the surrounding terrain.
7) The average highway width in feet, including the median (if less than 30 feet), all lanes, and 10 feet on each outer side of the highway.

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*The meteorological data should be as representative of the individual site as possible, which implies that the quidelines set forth in the Meteorology Manual of the Caltrans Air Quality Series (13), should be closely followed. One of the most important of these guidelines is that the meteorological measurements of wind speed and direction be made at 10 meters above the surrounding canopy.

8) Receptor distance in feet, measured normal to the road, from the nearest outside edge of the mixing cell.
9) Receptor height in feet, in relation to the surrounding terrain.

There are three constraints that must be observed when acquiring input data for the model. Since pollutant concentration is inversely proportional to wind speed, a decrease in wind speed causes an hyperbolic increase in the calculated concentration. As the wind speed approaches zero the concentration approaches infinity. The lowest wind speed recommended in Gaussian models is 1 meter per second (approximately 2 mph)(6). A disproportionate increase in concentration occurs if the wind speed is allowed to go below 1 meter per second.

The second constraint is that the empirical ratios for depressed sections were developed for sections 24 feet below grade, as discussed in Section 4.2.6. Since the model is only valid down to 24 feet, it is not recommended that this model be applied to depressed sections greater than 30 feet.*

The final constraint comes from the definitions of the highway corridor and microscale analysis. Beyond the region where inert pollutants, in this case carbon monoxide, return to ambient values, microscale analysis yields to macroscale or regional analysis. Carbon monoxide data from the Los Angeles area (11) have shown that ambient levels are reached at 1000 feet or less away from the freeway. Applying a safety factor of 50%, 1500 feet is defined as the edge of the microscale region. Thus it is not recommended that CALINE2 be applied to receptors farther than 1500 feet from the highway.

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*Based on the author's experience in monitoring CO along roadways, we feel that the empirical ratios for depressed sections can be extrapolated up to 30 feet and still provide reasonable estimates of CO.

6. SENSITIVITY ANALYSIS

6.1 Definition of Sensitivity Analysis

Mathematical computer models are used in the decision-making process because they are capable of describing the complex physical transport and diffusion of air pollutants. They require little time to make the calculations. However, it is sometimes difficult to conceptualize the interactions of a complex numerical model representing a real-world process. Since each small part of the model has to be developed separately, and later interfaced with the other parts, synergistic and nonrealistic situations develop internally when the model is used. Therefore, it becomes necessary to use sensitivity analysis on a complex model in order to determine these inconsistencies and minimize their effects on the model's output.

Essentially, sensitivity analysis involves the perturbation of individual input variables over a wide range of realistic values, yielding variations in output. The resulting variation in output, as a function of the input variable(s), is compared with the real world to insure that the output is what is expected, taking into consideration the assumptions inherent to the model.

Initially, only one input variable at a time should be varied, and the others should be held constant. Then, if time, resources, and the complexity of the model warrant, combinations of variables can be varied simultaneously.

Another function of sensitivity analysis is to determine the input variables to which the model is most sensitive. The implication from such an analysis would be that the more sensitive the model is to a given input, the more effort should be expended to obtain the most correct or representative value for that input.

CALINE2 is a fairly straightforward model in terms of the interactions of the input variables. The sensitivity analysis performed on CALINE2 is, therefore, more of an exercise to demonstrate that the output behaves as one would intuitively expect from the form of the equations. As a model becomes more complex and less intuitively obvious, a properly conducted sensitivity analysis becomes more necessary.

6.2 Sensitivity to Source Strength

The source strength terms in CALINE2 consist of the traffic volume (VPH), the average emission factor (EF), and for parallel winds only, the highway width (W). Since these terms are in the numerators of the line source equations (equations 4.2, 4.3, and 4.5), the calculated pollutant concentrations are directly proportional to them, and the resulting sensitivities are linear.

Figures 6-1 and 6-2 show that for a given change in either VPH or EF, the predicted CO changes correspondingly. In other words, if either VPH or EF is doubled, the predicted CO is doubled.

As can be seen in Figure 6-3, the highway width has an inverse effect on the predicted CO, i.e., as W increases, CO decreases. This effect occurs because W is not only incorporated into the source strength term for parallel winds, but is used to modify the initial segment of the σ_y curve as discussed in Section 4.2.2. It appears reasonable that as the volume of air in the mixing cell increases, while the VPH and EF remain the same, the predicted CO concentration should decrease.

Note that the predicted CO concentrations are shown for only the mixing cell, one wind angle, an at-grade highway, and one stability class. For most of the CALINE2 sensitivities, the sensitivity in the mixing cell (for a given wind angle, etc.)

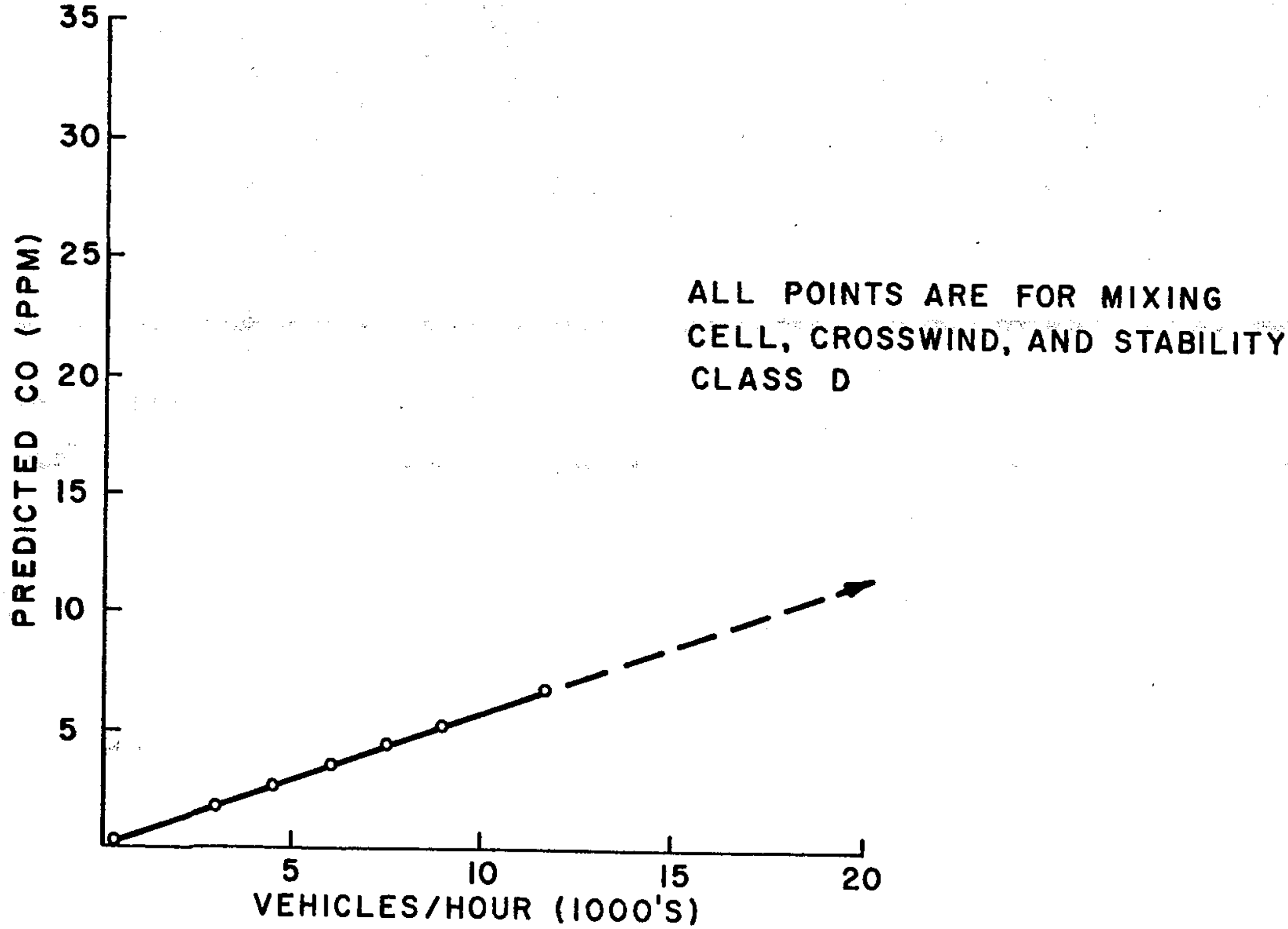


FIG. 6-1 CALINE 2 SENSITIVITY TO VEHICLES PER HOUR

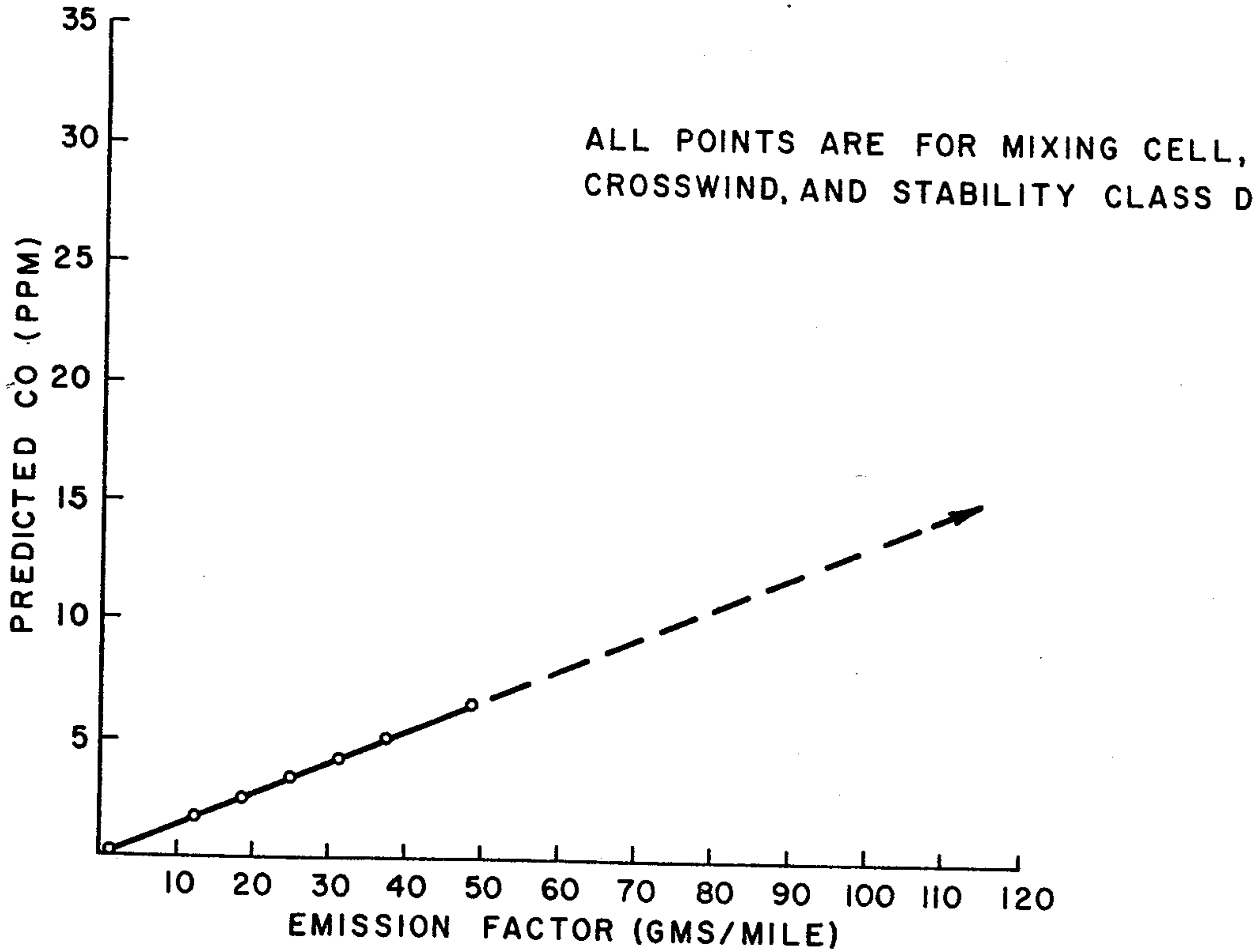


FIG. 6-2 CALINE 2 SENSITIVITY TO EMISSION FACTOR

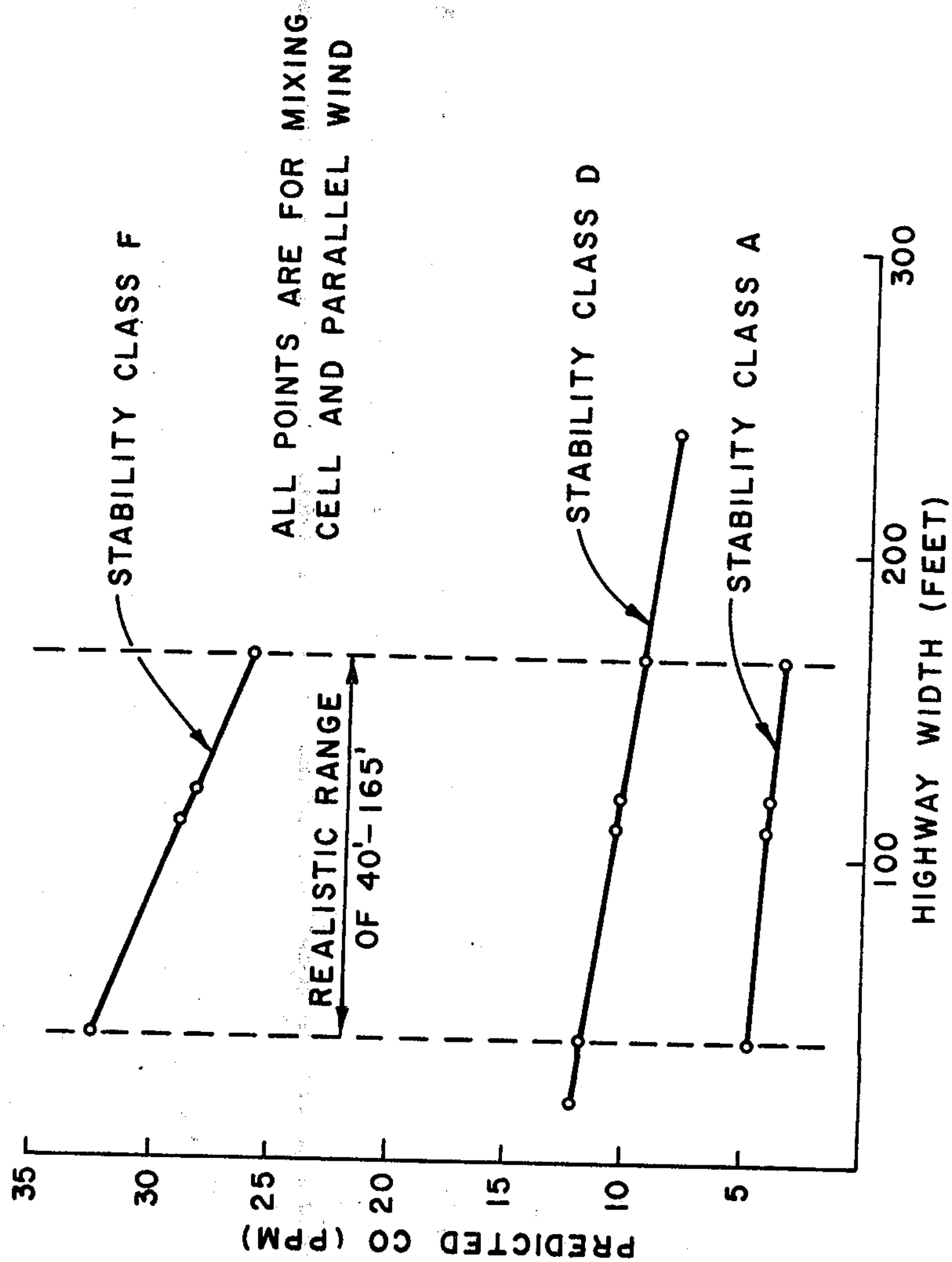


FIG. 6-3 CALINE 2 SENSITIVITY TO HIGHWAY WIDTH

will be similar to the sensitivity at a receptor away from the highway (and for different wind angles, etc.). In the cases where it is not, separate removed receptors' sensitivities (and/or different wind angles, etc.) are shown.

6.3 Sensitivity to Wind Speed

CALINE2's sensitivity to wind speed is shown in Figure 6-4. The hyperbolic increase in predicted CO levels as wind speed decreases (as discussed in Section 5.2) can be seen clearly. The model's limit of 2 mph is indicated by the dashed line. Both cross and parallel wind mixing cells are displayed, and one can see the similarity between the two.

6.4 Sensitivity to Wind Angle

Figure 6-5 is the sensitivity of the mixing cell's concentration to changes in the angle of the wind, for all stability classes. All stability classes have the same mixing cell concentration for an exactly perpendicular ($\phi = 90°$) wind, and they have the greatest difference for an exactly parallel ($\phi = 0°$) wind. Obviously, since stability class "F" is the most stable, the most parallel wind buildup in the mixing cell will occur with this class, and this is what Figure 6-5 shows. On the other hand, stability class "F" will confine the pollutants near the highway under parallel winds because of very little turbulence to spread the plume. For stability class "A" the large degree of turbulence will spread the plume away from the highway. Figure 6-6 depicts this situation for a receptor 400 feet away from the highway, at ground level. In this case, a 90° wind yields the greatest spread in concentrations, as a function of stability class, since the wind is blowing directly towards the receptor, with the most stable air causing the highest pollutant level at the receptor. Note, however, that the scale of predicted CO is greatly reduced

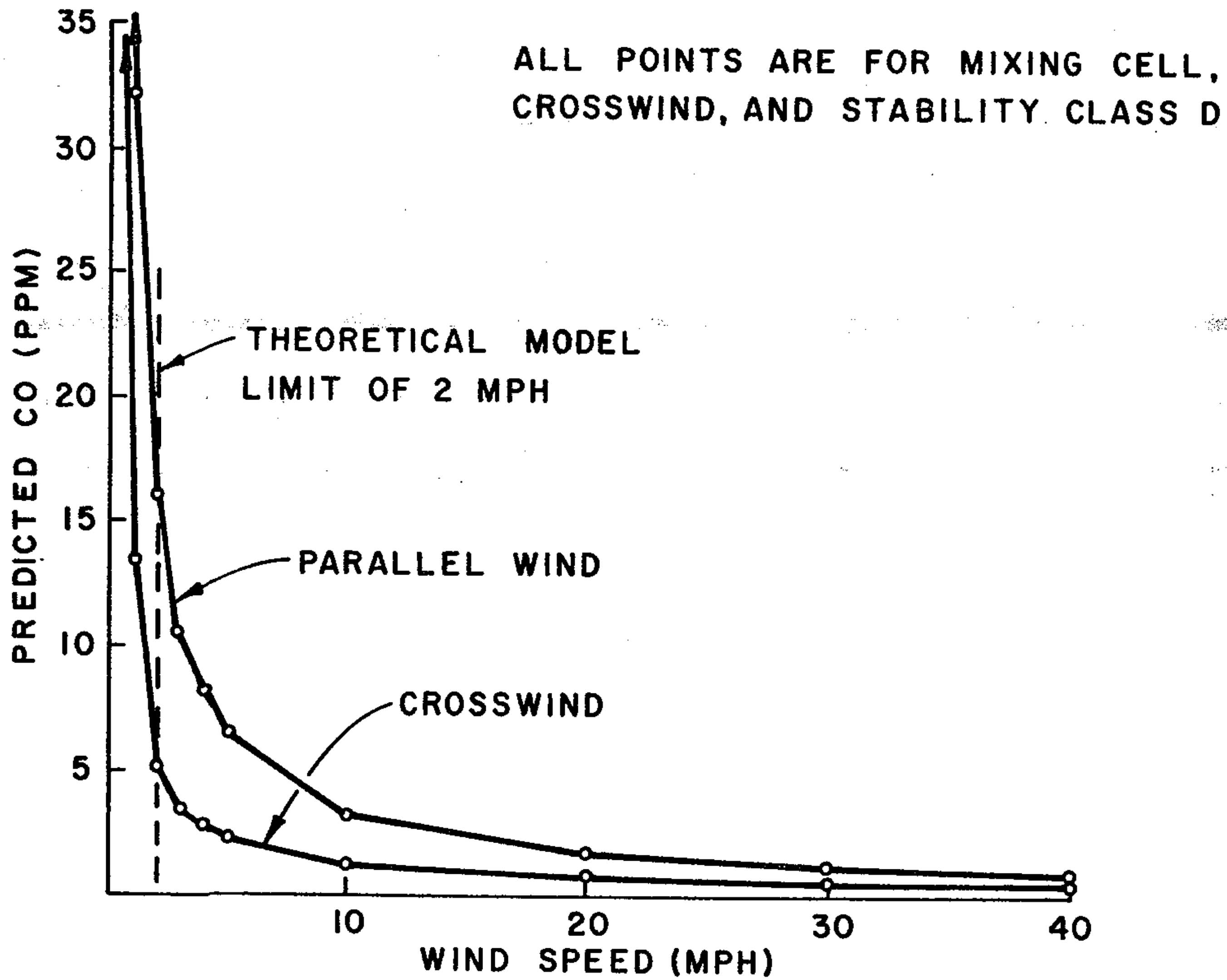


FIG. 6-4 CALINE 2 SENSITIVITY TO WIND SPEED

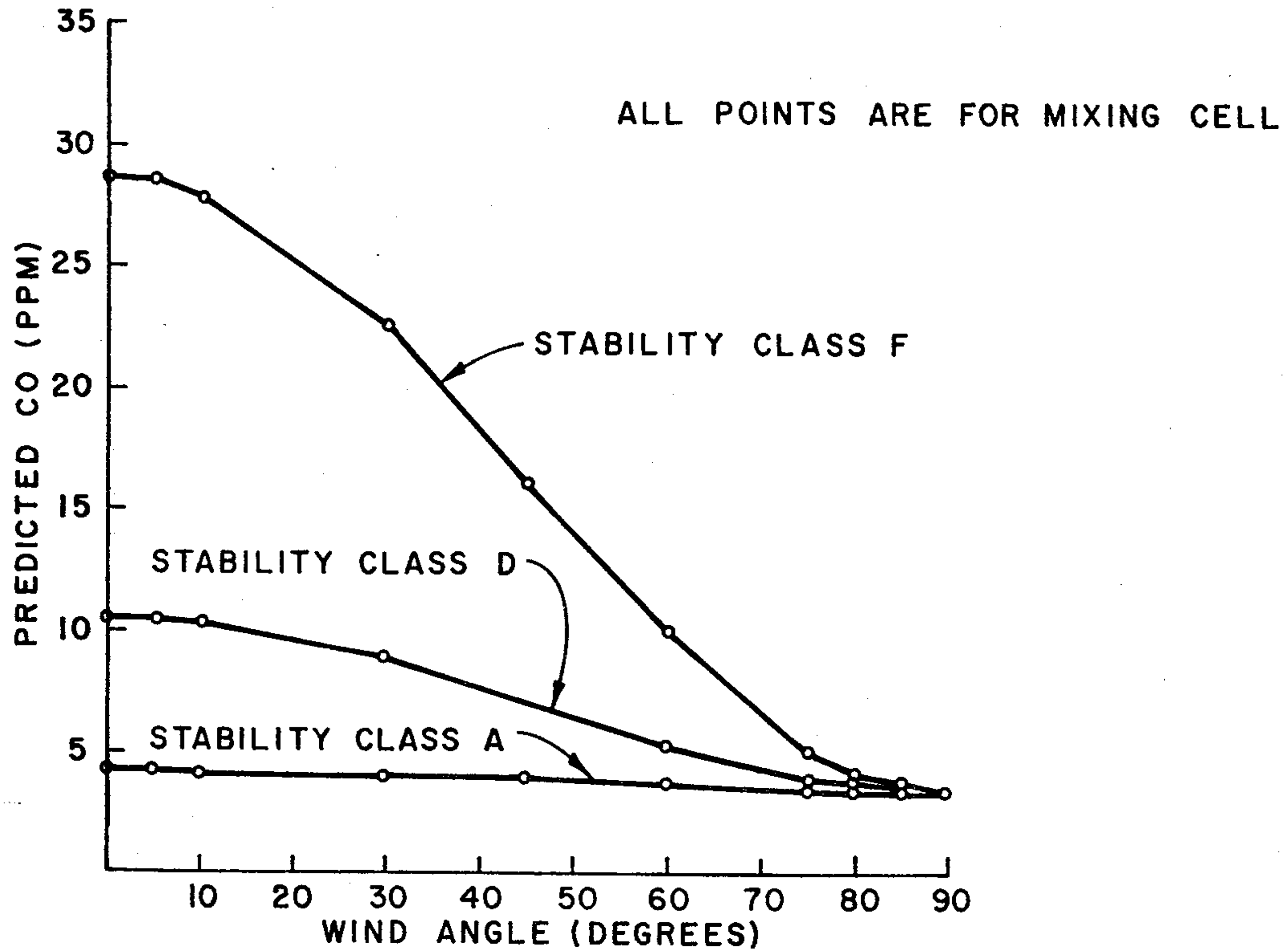


FIG. 6-5 CALINE 2 SENSITIVITY TO WIND ANGLE - MIXING CELL

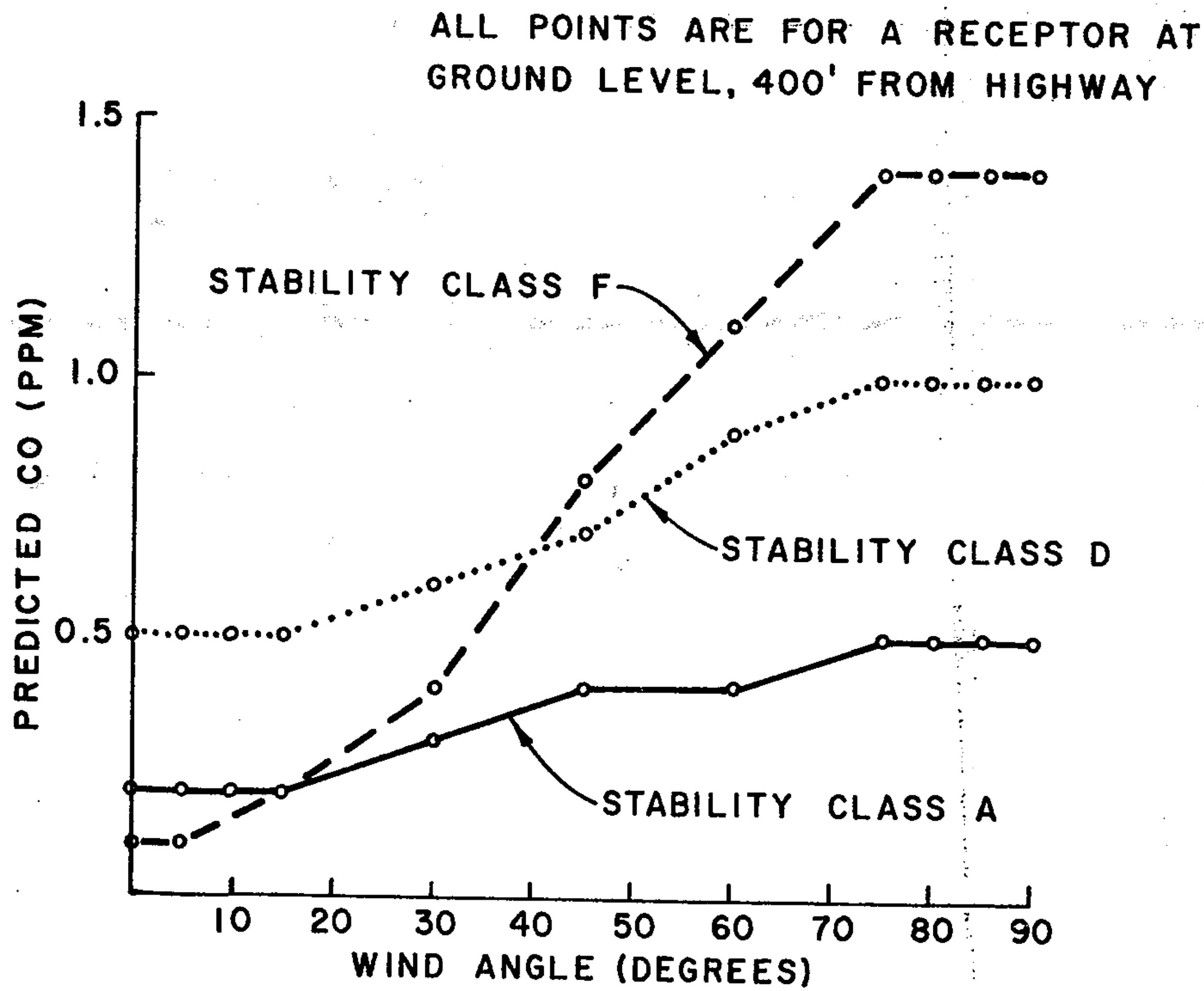


FIG. 6-6 CALINE 2 SENSITIVITY TO WIND ANGLE-OFF HIGHWAY

from Figure 6-5 to Figure 6-6. The uncertainty of the inputs' quality and the Gaussian assumptions result in estimates that are at best accurate to the nearest PPM and not a tenth of a PPM. Therefore, the concentrations shown are in reality all the same, and are very close to ambient. However, for the sensitivity analysis, the calculated values are used to demonstrate the relative importance of input varibles. The curve for stability class "D" in Figure 6-6 should theoretically be located somewhere between those for "A" and "F", for all wind angles. Because of the internal computer precision specified for the sensitivity analysis computor runs, the "D" curve shown in the expanded-scale plot, does not agree with the theory. This lack of agreement is an additional reason why the concentrations shown in Figure 6-6 can be considered to have essentially the same value.

6.5 Sensitivity to Pavement Elevation

CALINE2's sensitivity to pavement elevation is a more difficult analysis to make. The definition of the mixing cell determines that the concentration within the mixing cell will be the same regardless of where the highway is in the relation to the surrounding terrain. Thus, the sensitivity for the input parameter of pavement elevation is shown in Figure 6-7 for a receptor which is parallel to the edge of the mixing cell but at ground level. This implies that the receptor will be above the highway for a depressed section (negative pavement height) and below the highway for a raised section (positive pavement height). As expected, the predicted CO concentration for this receptor decreases as the highway is either lowered or raised from the elevation of the surrounding terrain. Parallel winds cause the decrease to be larger.

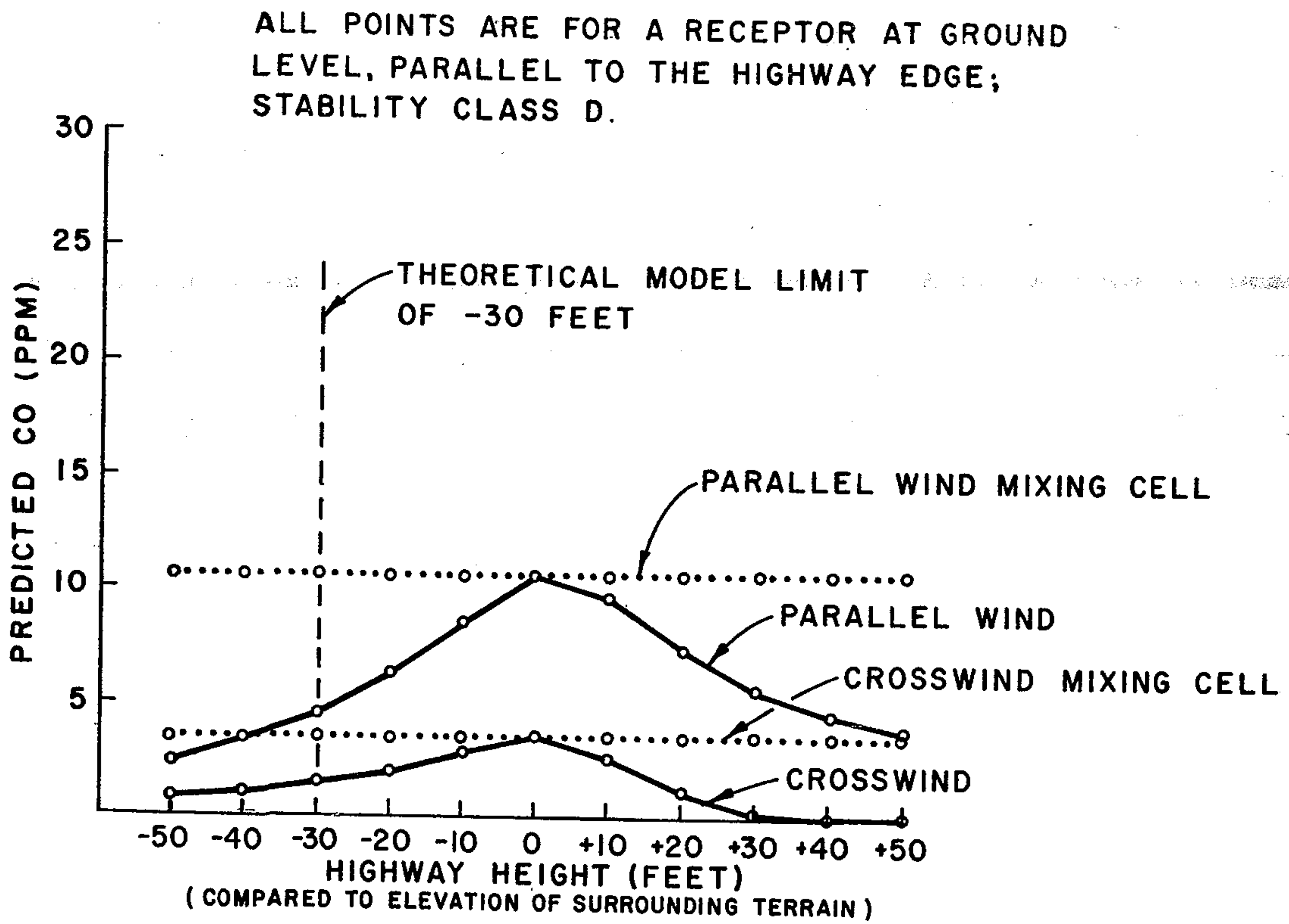


FIG. 6-7 CALINE 2 SENSITIVITY TO HIGHWAY ELEVATION

6.6 Sensitivity to Stability Class

The definition of the mixing cell used in CALINE2 implies its concentration is independent of surface atmospheric stability. This is shown in Figure 6-8 for crosswinds. For parallel winds, an exponential increase in concentrations is evidenced as stability increases, because of the parallel wind buildup.

6.7 Ranking of Sensitive Parameters

From the preceeding sensitivity analysis, the following general ranking can be placed upon the input variables.

CALINE2 is most sensitive to the wind vector because it affects a number of inputs to the model. The direction of the wind vector in relation to the highway is important, since angles approaching 0° cause parallel wind buildup. Stability class as a function of wind speed and is a fairly sensitive input, since "F" stability confines pollutants while "A" allows substantial dispersion. Wind speed itself is important because the calculated concentrations are inversely proportional to it, which means that a halving of the wind speed would cause a doubling of the predicted concentration.

The source strength terms of VPH and EF are as sensitive as the wind vector, although they do not have a multiple influence upon the model. The predicted concentrations are a direct function of VPH and EF, and a change in either term causes a corresponding change in the output.

Pavement height and highway width are important parameters, but are relatively less important to CALINE2 than any of the other inputs.

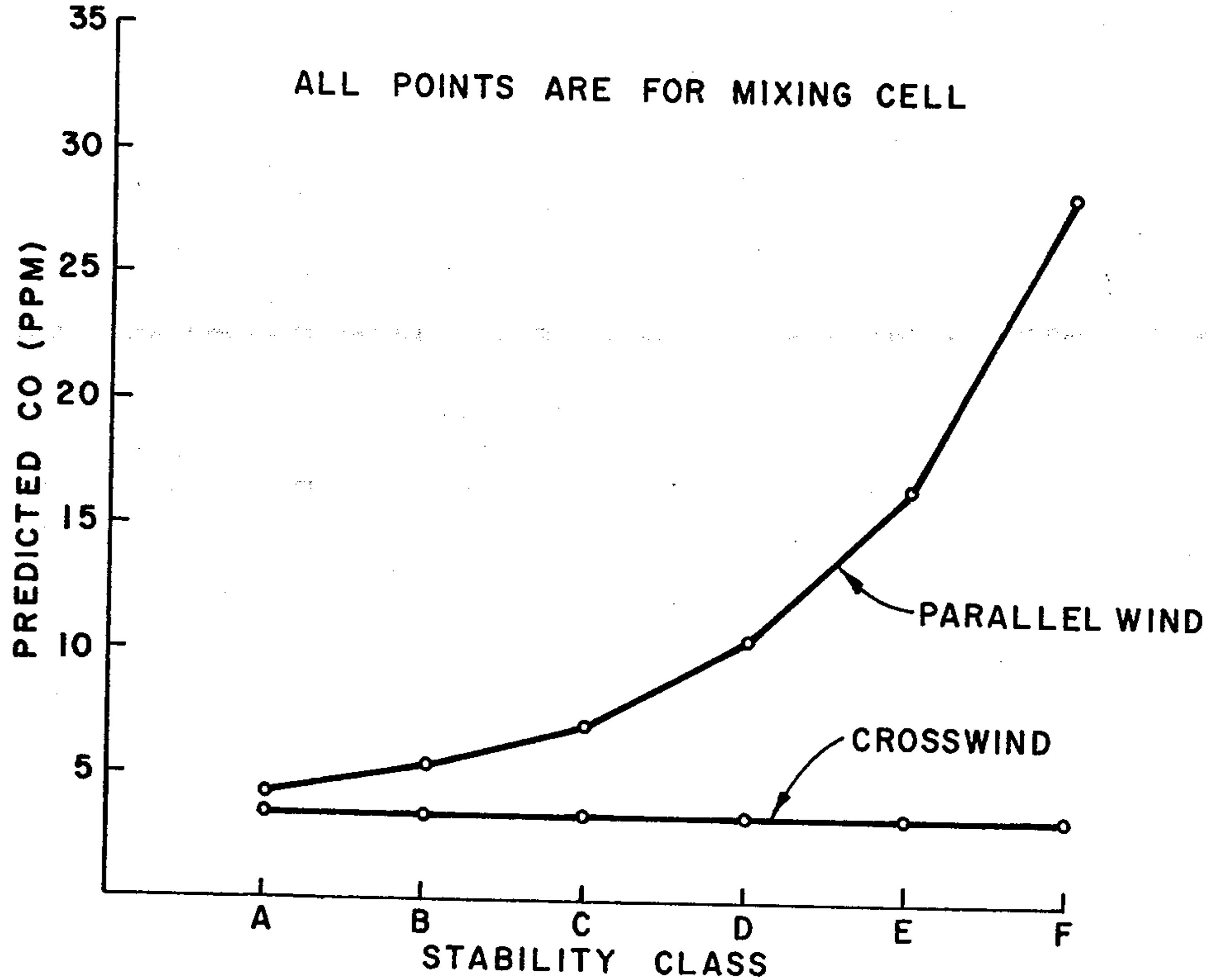


FIG. 6-8 CALINE 2 SENSITIVITY TO STABILITY CLASS

7 CHRONOLOGICAL DEVELOPMENT OF CALIFORNIA LINE SOURCE MODELS

7.1 History

In 1972, the first version of the California Line Source Dispersion Model was developed based on generally-held Gaussian dispersion theories. This first version utilizied a series of graphs which were developed for most wind angles, highway configurations, wind speeds, and stability classes (5). Calculations for CO levels for a proposed project could be obtained manually, using the graphs, although a computer program with the same information (called CAL%DISP) on Caltrans' TENET system could be utilized. The first version had no special routines to approximate the aerodynamic eddy effect encountered in depressed sections, and used a factor of $1/\sin\phi$ to handle oblique wind angles between 12.5° and 90°. Parallel wind concentrations could only be calculated utilizing a "downwind concentration ratio" obtained from a special graph.

To modify the calculated concentrations of the first version to make them more nearly equal to those found in actual field studies, the equations were multiplied by a calibration coefficient. The only field data available at the first testing of the model were from studies completed in New York State (14). These data indicated that the calculated concentrations were low by a factor of 4.24. Therefore, all dispersed values were multiplied by this factor. Immediately thereafter, the data from the preliminary CO bag sampling study in the Los Angeles area (11) became available, and showed that the modified calculations were now high by a factor of 4. The 4.24 factor was consequently divided by 4.24, which effectively returned the model to its original uncalibrated status.

One of the first major modifications to the original model was the derivation of the empirical ratios for depressed sections, which was discussed in Section 4.2.6. This improvement was detailed to the California Transportation Districts in Air Quality Manual Modification Number 1 (12) and was subsequently programmed into CAL%DISP.

The changes resulting in the reformulation of the model into CALINE2 have been accomplished in the last year. Besides being explicitly detailed in this report, the use of CALINE2 and its major assumptions were transmitted to the Districts in Air Quality Manual Modification Number 6 and its Supplement (15,16). Copies of these documents may be obtained from the Transportation Laboratory.

7.2 Comparison of original model and CALINE2

After the publication of Volume IV of the Caltrans Air Quality Manual, and its Appendix, Volume V (5,10), the original California Line Source Dispersion Model received nationwide distribution through either the Federal Highway Administration or the National Technical Information Service. Most agencies that have a copy of the California model have the original one as described in Volumes IV and V. A few have received the Manual Modification detailing the depressed section empirical ratios.

For the benefit of these agencies, Table 7-1 displays the major differences between CALINE2 and the original California Line Source Dispersion Model with the depressed section modification.

Aside from the parallel wind algorithm, the major improvement in CALINE2 is the elimination of the discontinuity at a wind angle of 12.5°.

TABLE 7-1

COMPARISON OF EARLIER AND PRESENT
VERSIONS OF THE CALIFORNIA LINE SOURCE
DISPERSION MODEL

CAL&DISP (Earlier Model)	CALINE2 (Present Model)
1. General Gaussian Assumptions and Limitations are common to both models.	
2. Calibration Coefficients: a) multiplication by 4.24 to agree with early N.Y. CO data, b) divide (a) by 4.24 to agree with early L.A. CO data c) multiplication of original by 0.8 to agree with FHWA CO data.	2. Calibration Coefficients: none have been developed
3. Empirical ratios for depressed sections: Empirical ratio applied to nonmixing cell receptors to artificially lower their concentrations (imaginary mixing cell)	3. Empirical ratios for depressed sections: Same as earlier model
4. Dispersion parameters: a) σ_y curves extrapolated to width of runway (110') used for "Project Smoke"; 1/30.5 used to adjust for different widths b) σ_z curves extrapolated to height of mixing cell (4 meters) as determined from "project smoke"	4. Dispersion parameters: a) σ_y curves dynamically extrapolated to width of project being considered. b) Same as earlier model
5. Crosswind equation: a) $12.5° < \phi \leq 90°$ b) Multiply predicted concentration by $1/SIN\phi$ c) Constants contained in original Gaussian equations incorporated in calibration coefficient	5. Crosswind equation: a) $\phi = 90°$ b) If $0° < \phi < 90°$, modify predicted concentrations in following fashion: $C_3 = C_1 SIN^2\phi + C_2 COS^2\phi$ (see item 6 for C_2) c) Equation reincludes constants contained in original Gaussian equations.

TABLE 7-1 (continued)

CAL%DISP (Earlier Model)	CALINE2 (Present Model)
d) Equation: $C_1 = \frac{4.24 Q_1 \, Fact}{K \sigma_z \bar{U} \, SIN \phi} \left[EXP\left(-\frac{1}{2}\left(\frac{Z+H}{\sigma_z}\right)^2\right) + EXP\left(-\frac{1}{2}\left(\frac{Z-H}{\sigma_z}\right)^2\right) \right]$ Where Fact = conversion factor K = correlation coefficient = 4.24 Other symbols explained in text	d) Equation: $C_1 = \frac{Fact \, Q_1}{\sigma_z \bar{U} \sqrt{2\pi}} \left[EXP\left(-\frac{1}{2}\left(\frac{Z+H}{\sigma_z}\right)^2\right) + EXP\left(-\frac{1}{2}\left(\frac{Z-H}{\sigma_z}\right)^2\right) \right]$
6. Parallel wind equation:	6. Parallel wind equation:
a) $0° \le \phi \le 12.5°$	a) $\phi = 0°$
b) Downwind concentration ratio "A" (buildup factor) obtained from empirical graphs.	b) Same as earlier model except using new dispersion parameters of item 4
c) Constants contained in original Gaussian equations incorporated in calibration coefficient	c) Scaling factor used to make "infinite" line source so C_2 can be compared with and added to C_1 as in item 5b
	d) Equation reincludes constants contained in original Gaussian Equations.
d) Equation: $C_2 = \frac{A \, 4.24 Q_2 \, Fact}{K \sigma_{y_i} \sigma_{z_i} \bar{U}} \left\{ \left[EXP\left(-\frac{1}{2}\left(\frac{Y}{\sigma_{y_i}}\right)^2\right) \right] X \left[EXP\left(-\frac{1}{2}\left(\frac{Z+H}{\sigma_{z_i}}\right)^2\right) + EXP\left(-\frac{1}{2}\left(\frac{Z-H}{\sigma_{z_i}}\right)^2\right) \right] \right\}$	e) Equation: $C_2 = \sum_{i=1}^{n} \frac{Fact \, Q_2}{\sigma_{y_i} \sigma_z \bar{U} \, 2\pi} \left\{ \left[EXP\left(-\frac{1}{2}\left(\frac{Y}{\sigma_{y_i}}\right)^2\right) \right] X \left[EXP\left(-\frac{1}{2}\left(\frac{Z+H}{\sigma_{z_i}}\right)^2\right) + EXP\left(-\frac{1}{2}\left(\frac{Z-H}{\sigma_{z_i}}\right)^2\right) \right] \right\}$
7. Mixing Cell equation:	7. Mixing Cell equation:
a) H = Z = D=0	a) Same as earlier model
b) Depressed section ratio not used	b) " " " "
c) Crosswind mixing cell not required to be equal to one cell of parallel wind segment.	c) Crosswind mixing cell required to be equal to one cell of parallel wind segment.

This angle was the arbitrarily defined division between parallel winds and oblique winds. Since oblique wind dispersion was calculated using the factor $1/\sin\phi$, the concentration grew hyperbolically as ϕ approached 0°. The parallel wind buildup curves of the original model yield concentrations lower than concentrations from an oblique wind of 12.5°. This discontinuity caused the false impression that the worst concentrations occurred at a wind angle of 12.5°. Therefore $\phi = 12.5°$ was defined as one of the "worst case" conditions.

CALINE2, as shown in Sections 4.2.5 and 6.4, yields a smooth, continuous function of calculated concentrations for all wind angles, with the highest concentrations occurring at 0° or 90°, the two extremes, depending on receptor location.

8 PRELIMINARY VERIFICATION

8.1 Interpretation of Results

Caltrans has a contract with the Federal Highway Administration to provide an aerometric data base for the purpose of verifying and calibrating line source models (17). As part of this work, a preliminary data base for hourly averages of carbon monoxide concentrations was obtained using bag sampling procedures in the Los Angeles area in 1972 (11). Three different highway geometries were monitored. They included two depressed sections, an at-grade section and a fill section. Figure 8-1 is a general map of the Los Angeles area showing the location of the sites.

Measurements for this study, at any one site, consisted of as many as 24 sampling points for the integrated one hour CO concentrations, one hour values of surface wind speeds and directions, and one hour traffic counts. The cloud cover and ceiling height were obtained from the U.S. Weather Bureau Station at the Los Angeles International Airport. No measurements of these parameters were made directly at each site. However, cloud cover and ceiling height are generally a large scale phenomenon. Because of the homogeneity of the terrain for the sites on the Surveillance Loop and the close proximity (less than 10 miles) to the Airport, these data were assumed to be representative for all locations. The surface stability classes were determined from an objective system of classifying stabilities from meteorological observations as suggested by Turner (6). Turner's approach considers the cloud cover, ceiling height, wind speed, insolation, time of day, and season of year.

Traffic speeds for the study were derived from measured values of traffic volume and loop occupancy time, using an average vehicle length for each site. The traffic speeds were then used

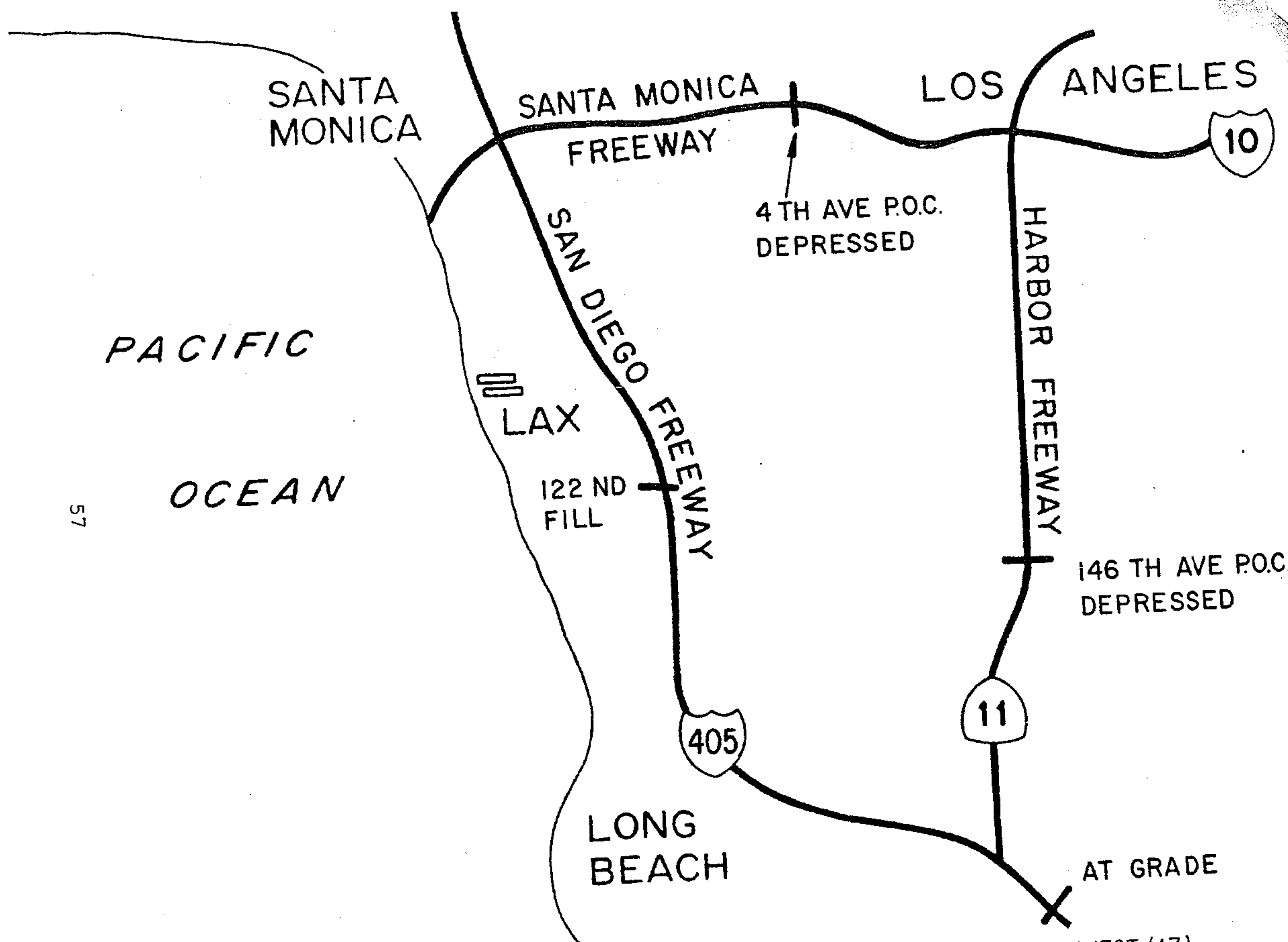


FIG. 8-1 LOCATION OF C O SAMPLING SITES FOR LOS ANGELES RESEARCH PROJECT (17)

to determine the one hour average emission factor based on E.P.A.'s AP-42 (April 1973) with an assumed heavy duty vehicle proportion of 5% (18).

These data from the study, and the highway configuration were used as inputs to CALINE2 to produce simulations which were then compared with the measured CO concentrations. The comparisons were used to determine the predictive capabilities of the model.

Linear regression analysis was used to compare the scatter plot of observed CO concentrations versus predicted CO concentrations. The figures in this section showing the preliminary verification results, contain the regression information for each comparison. This information includes the regression line, the regression equation, the sample size "n", the standard error of the estimate, the correlation coefficient "r", and the F-test value for a 5% level of significance.

The regression line shows how well the model predicts compared to measured concentrations. If the line's slope is less than one, the model overpredicts. If the slope is greater than one, the model underpredicts. If the line is coincident with the 45° line, the model is making near-perfect predictions, depending on the values of the other regression parameters.

Since the model calculates downwind concentrations from the line source only (i.e., above ambient), the upwind (ambient) level was subtracted from the measured mixing cell and downwind concentrations before comparing them to the simulated values.

Included on all the scatter-plot diagrams is the regression information for similar comparisons between the earlier California line source dispersion model, as described in Section 7, and the measured CO concentrations. The regression information and line for the old model are shown for comparison with the same information from CALINE2. The actual scatter-plot for the older model simulations is not shown since it would unnecessarily complicate the diagrams. In all cases, CALINE2 shows an improved prediction capability over the earlier model, and in most cases the improvement is substantial.

The verifications are separated into highway configurations (at-grade, depressed, and fill), wind angles (cross and parallel winds), and on-and off-highway sites to better determine CALINE2's ability to handle each of these situations. Obviously, some of the verifications are questionable because of the small sample size; however, it was felt that they should be included to give a relative indication of CALINE2's abilities. Larger sample sizes could have been obtained by combining all sites and situations, but this would have resulted in data gaps thereby obscuring the model's predictive characteristics for each individual situation.

For instance, the mixing cell generally has higher concentrations than off-highway points. When plotted together, the mixing cell points may form a cluster away from the origin, while the off-highway points cluster close to the origin, leaving a gap between the two clusters. A regression analysis would indicate that there is a good regression between these two clusters, but does not indicate the correlation within each cluster. Therefore, the clusters are broken out into separate categories, as in this analysis.

For all of the regressions, all stability classes have been combined, because there were insufficient data pairs to separate the analyses by stability. The predominant stability classes encountered were those for unstable through neutral surface atmospheric conditions, i.e., classes "A-D". Only a very few cases had stabilities of "E" or "F". Therefore, it is difficult to draw any conclusions about CALINE2's ability to handle stable and very stable atmospheric conditions.

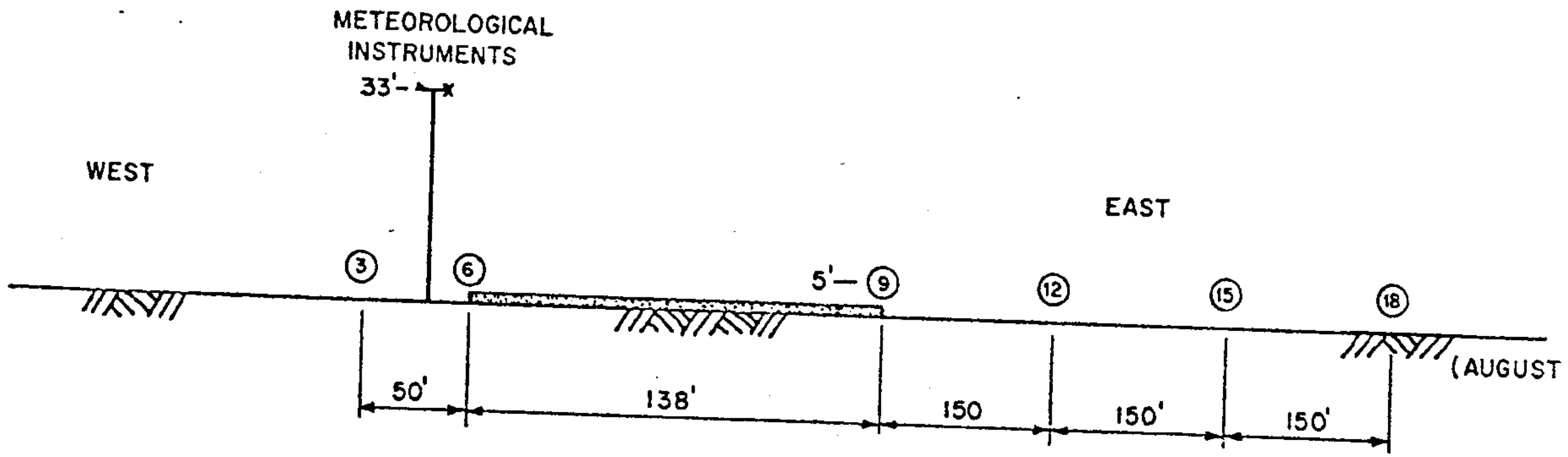
A more extensive verification of CALINE2 is planned utilizing data recently gathered in the Los Angeles area with the Caltrans mobile air quality vans (17). At that time, the analysis will be separated into as many verification categories as possible, including stability classes.

8.2 At-Grade Site

The at-grade site was located at the weigh station on the San Diego Freeway, just southeast of the junction with the Harbor Freeway. Figure 8-2 is a schematic of the site, showing how the probes were placed for the prevailing west wind. Probe number 3 was designed to be used as the upwind sampling intake. Probes 6 and 9 were averaged using weighted factors derived from the traffic flow in each direction, to obtain the "measured" mixing cell concentration.

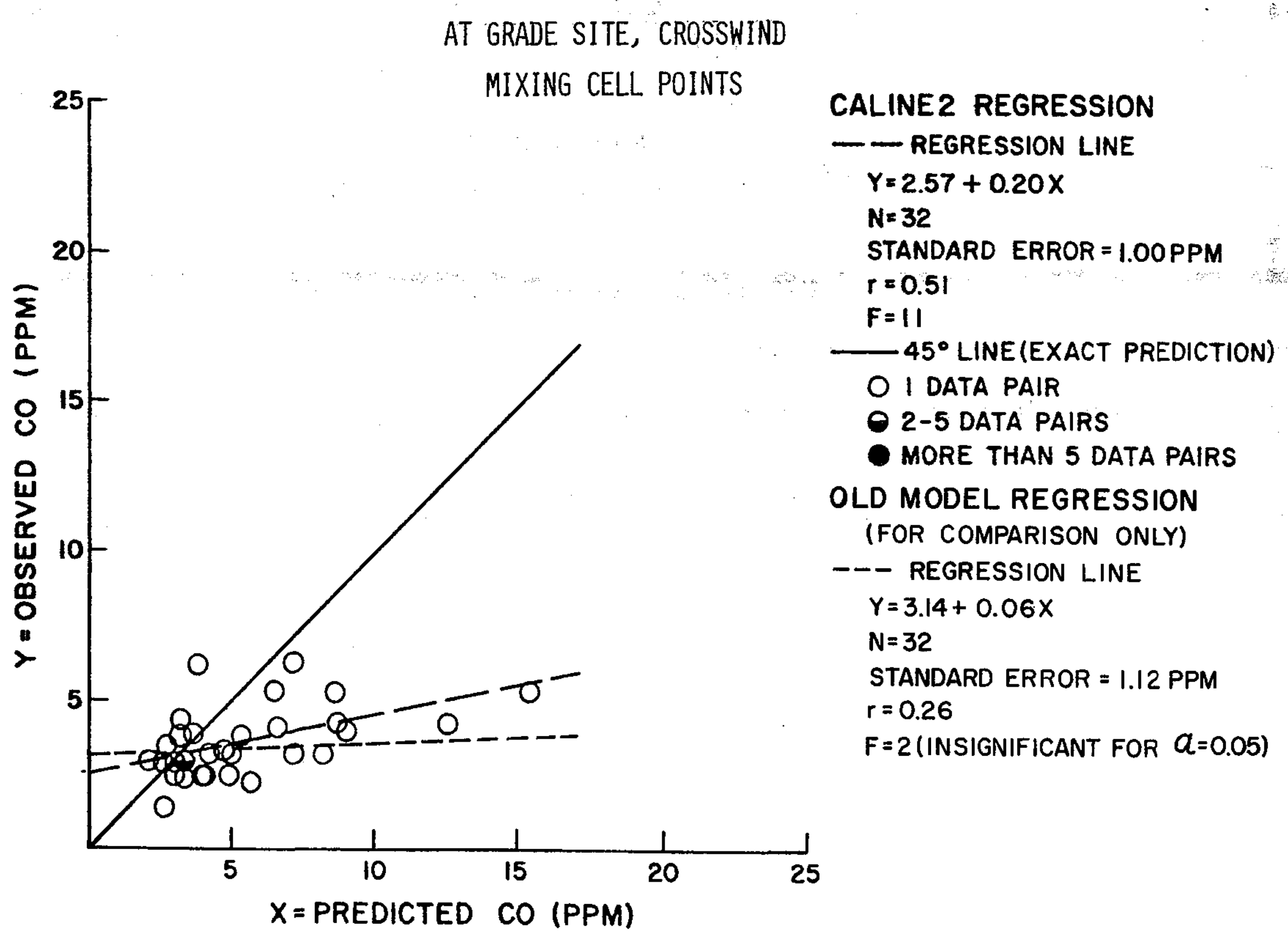
Figures 8-3 through 8-5 depict the crosswind situation for the at-grade site, and show that CALINE2 overpredicts by a factor of 2 for the mixing cell points, does fairly well for off-highway sites, and yields a reasonable correlation for the combined plots. The parallel wind (Figures 8-6 to 8-8) sampling sizes are much smaller, but generally show that CALINE2 is able to handle parallel wind situations reasonably well.

The regression for the crosswind mixing cell may indicate a falsely high overprediction, because of the manner in which the "measured" mixing cell concentrations were obtained. The concentration at probe 6 tended to be much lower than that at probe



① DENOTES PROBE NUMBER

FIG. 8-2 PROBE LOCATIONS, SAN DIEGO FREEWAY AT WEIGH STATION



AT GRADE SITE, CROSSWIND
MIXING CELL POINTS
CALINE2 REGRESSION
—— REGRESSION LINE
Y=2.57 + 0.20X
N=32
STANDARD ERROR = 1.00PPM
r=0.51
F=11
—— 45° LINE (EXACT PREDICTION)
○ 1 DATA PAIR
◒ 2-5 DATA PAIRS
● MORE THAN 5 DATA PAIRS
OLD MODEL REGRESSION
(FOR COMPARISON ONLY)
--- REGRESSION LINE
Y=3.14+ 0.06X
N=32
STANDARD ERROR = 1.12 PPM
r=0.26
F=2 (INSIGNIFICANT FOR α=0.05)
Y = OBSERVED CO (PPM)
X = PREDICTED CO (PPM)
5
10
15
20
25

FIG. 8-3

AT GRADE SITE, CROSSWIND
OFF-HIGHWAY GROUND-LEVEL POINTS

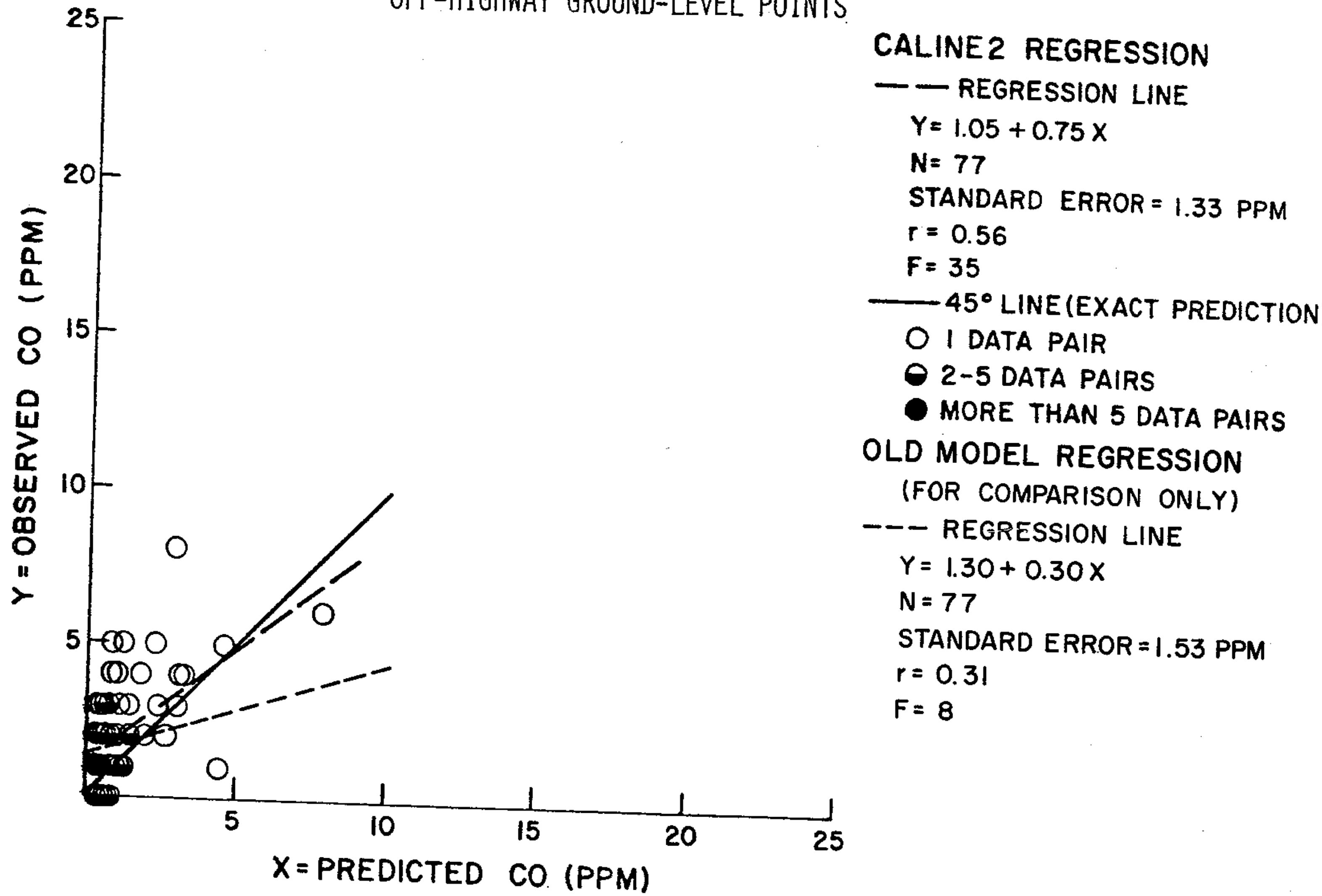


FIG. 8-4

AT GRADE SITE, CROSSWIND

OFF-HIGHWAY GROUND-LEVEL & MIXING CELL POINTS

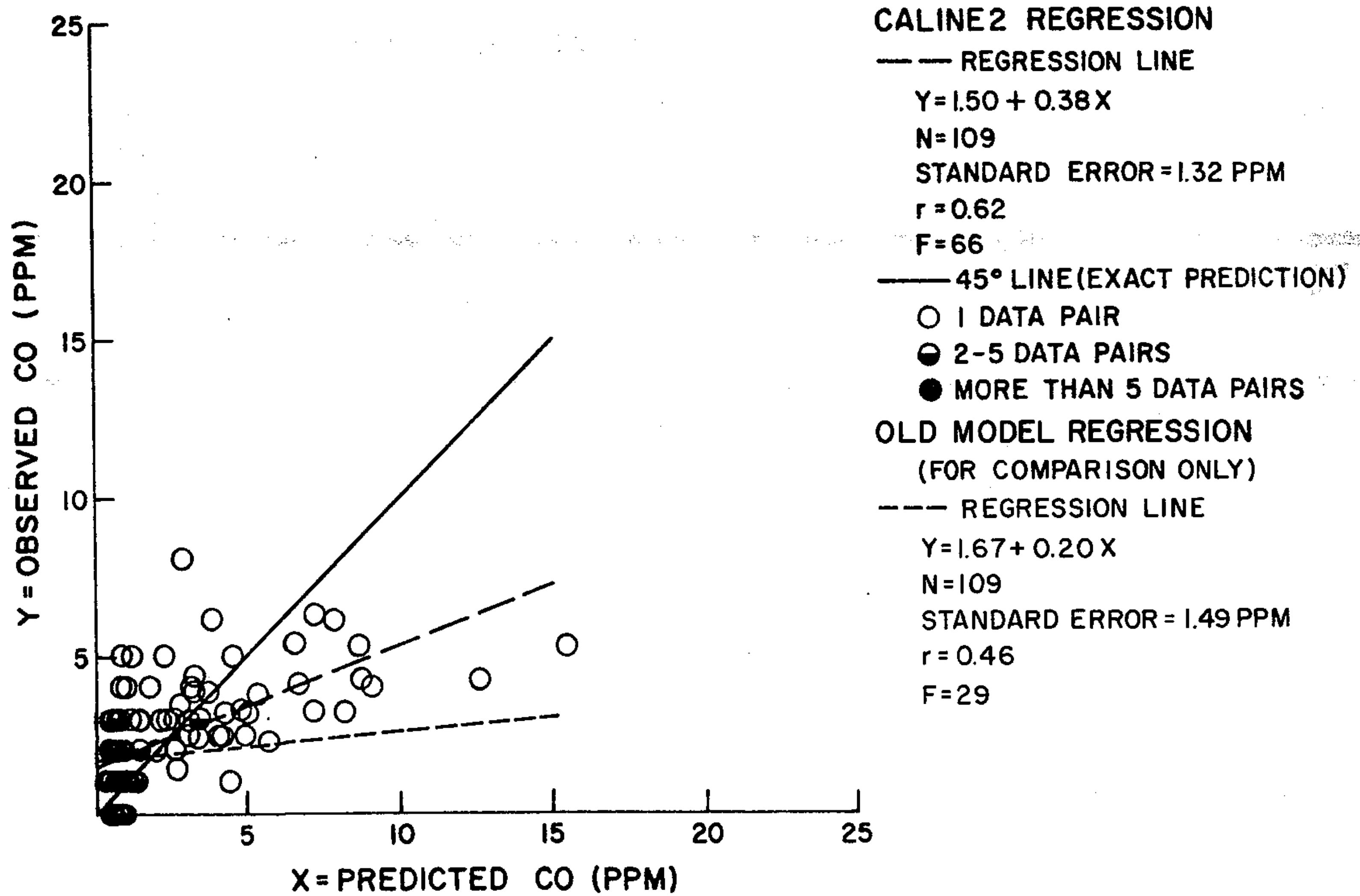


FIG. 8-5

AT GRADE SITE, PARALLEL WIND
MIXING CELL POINTS

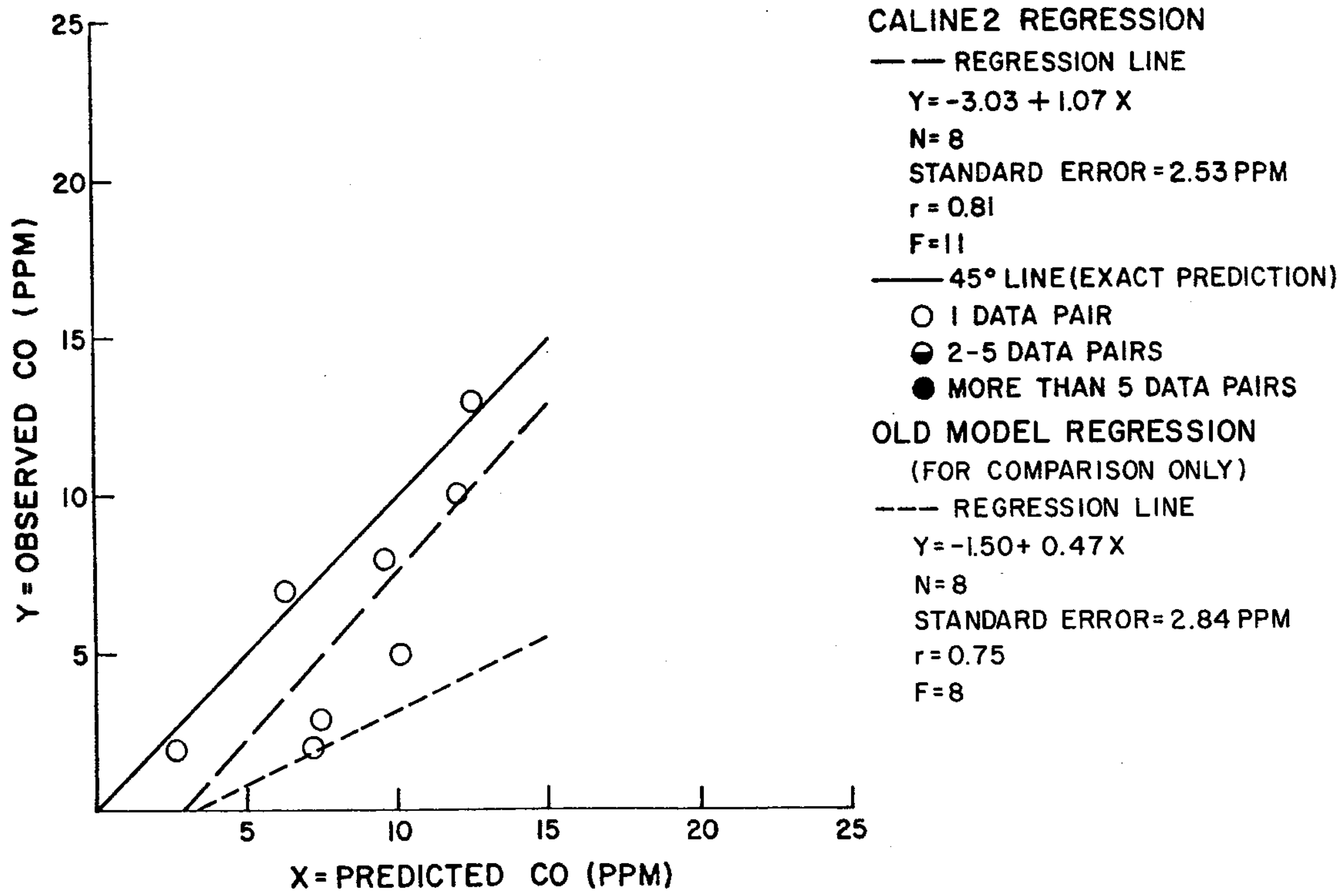


FIG. 8-6

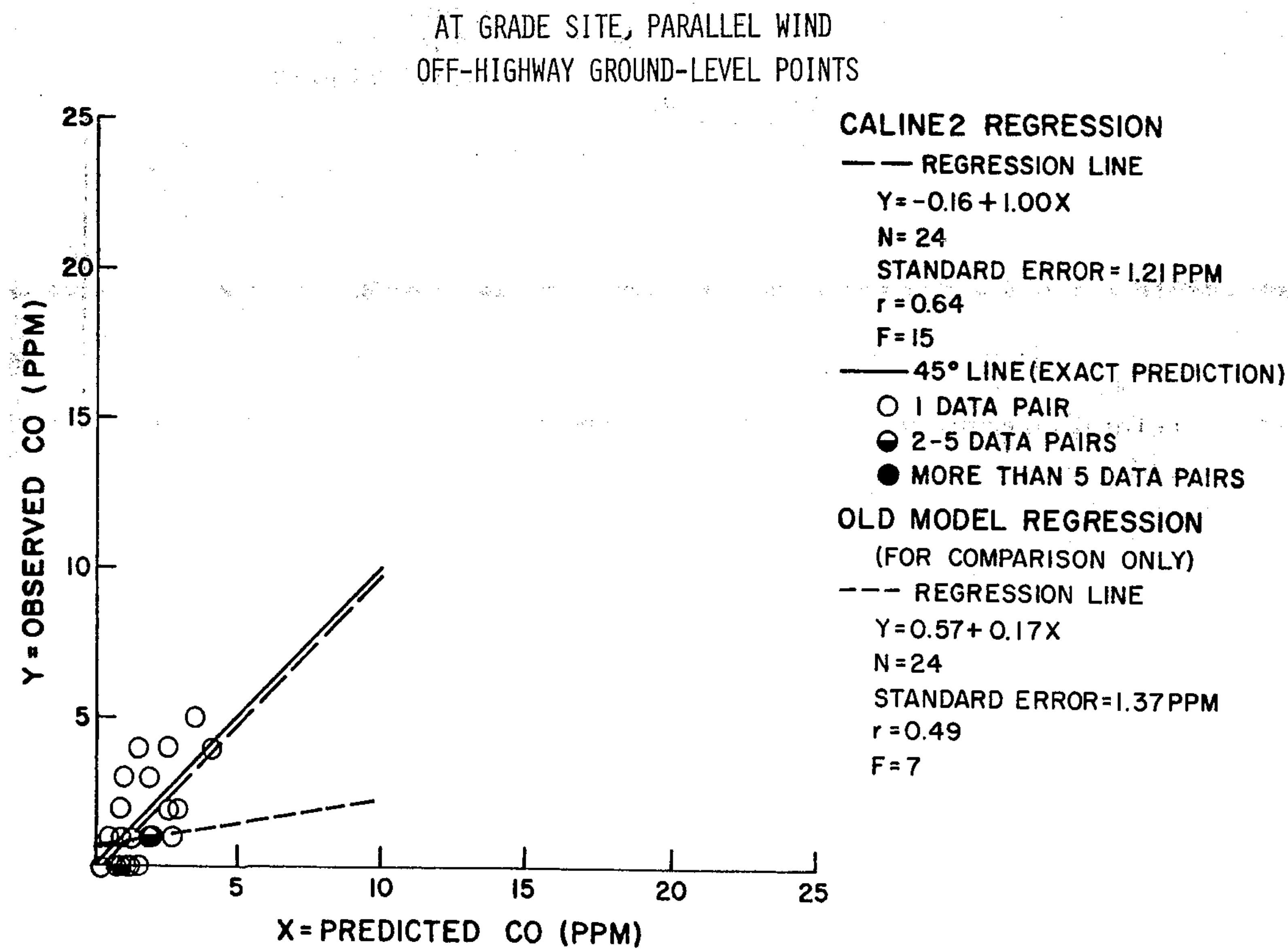

AT GRADE SITE, PARALLEL WIND
OFF-HIGHWAY GROUND-LEVEL POINTS
Y = OBSERVED CO (PPM)
X = PREDICTED CO (PPM)
0
5
10
15
20
25
CALINE2 REGRESSION
REGRESSION LINE
Y = -0.16 + 1.00X
N = 24
STANDARD ERROR = 1.21 PPM
r = 0.64
F = 15
45° LINE (EXACT PREDICTION)
1 DATA PAIR
2-5 DATA PAIRS
MORE THAN 5 DATA PAIRS
OLD MODEL REGRESSION
(FOR COMPARISON ONLY)
REGRESSION LINE
Y = 0.57 + 0.17X
N = 24
STANDARD ERROR = 1.37 PPM
r = 0.49
F = 7

FIG. 8-7

AT GRADE SITE, PARALLEL WIND
OFF-HIGHWAY GROUND-LEVEL & MIXING CELL POINTS

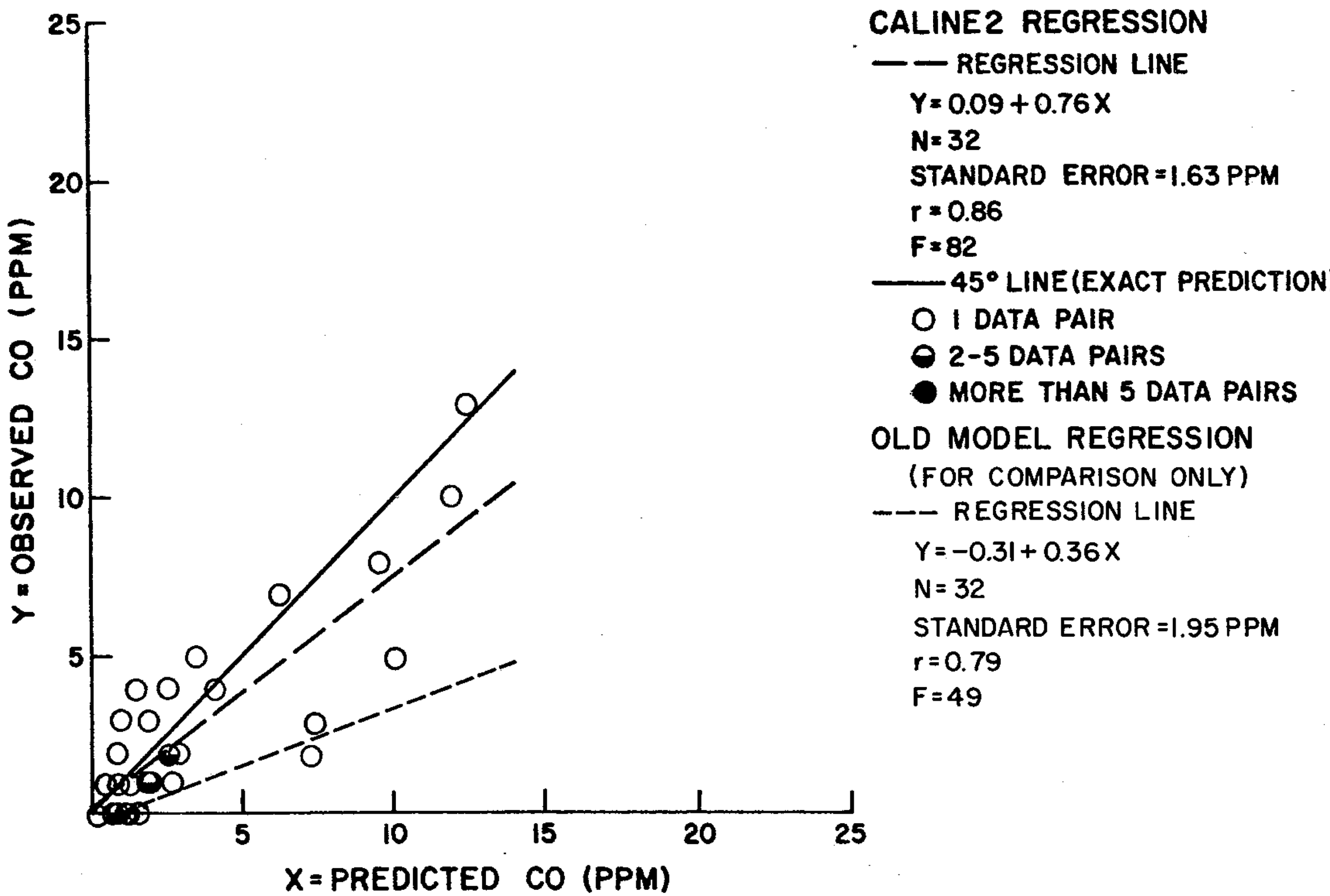


FIG. 8-8

9 under moderate wind speeds, thereby disagreeing with the assumption that a uniform mixing cell exists across the highway's width. Simulations for each traffic direction might yield better correlations, but this task has yet to be undertaken.

8.3 Depressed Sites

The depressed sites were at the 4th Avenue pedestrian overcrossing of the Santa Monica Freeway and the Harbor Freeway at 146th Street. These were true depressed sites, being depressed from the surrounding terrain for noise control or other purposes, and not simple cuts into the sides of hills. Figure 8-9 is the schematic of the Santa Monica site. The probes are equally distributed on either side of the site, because parallel winds were anticipated and it was necessary to maintain maximum flexibility for downwind probe sites. Probes 10 and 11 were averaged to obtain the mixing cell concentration for this site.

Figure 8-10 is the schematic of the Harbor Freeway site, with probes 3 and 4 designed to be used as the upwind intakes. Probes 6 to 10 were averaged via weighted factors in the same manner as the at-grade site, to obtain the "measured" mixing cell concentrations.

As Figures 8-11 through 8-16 demonstrate, CALINE2 appears to be able to handle the depressed section situation quite well, with a slight overprediction. However, one must remember that data from these same sites were used to develop the depressed section ratios discussed in Section 2.2.6. Full verification of the model for this situation must wait until these CO data are available from the Caltrans' research project (17).

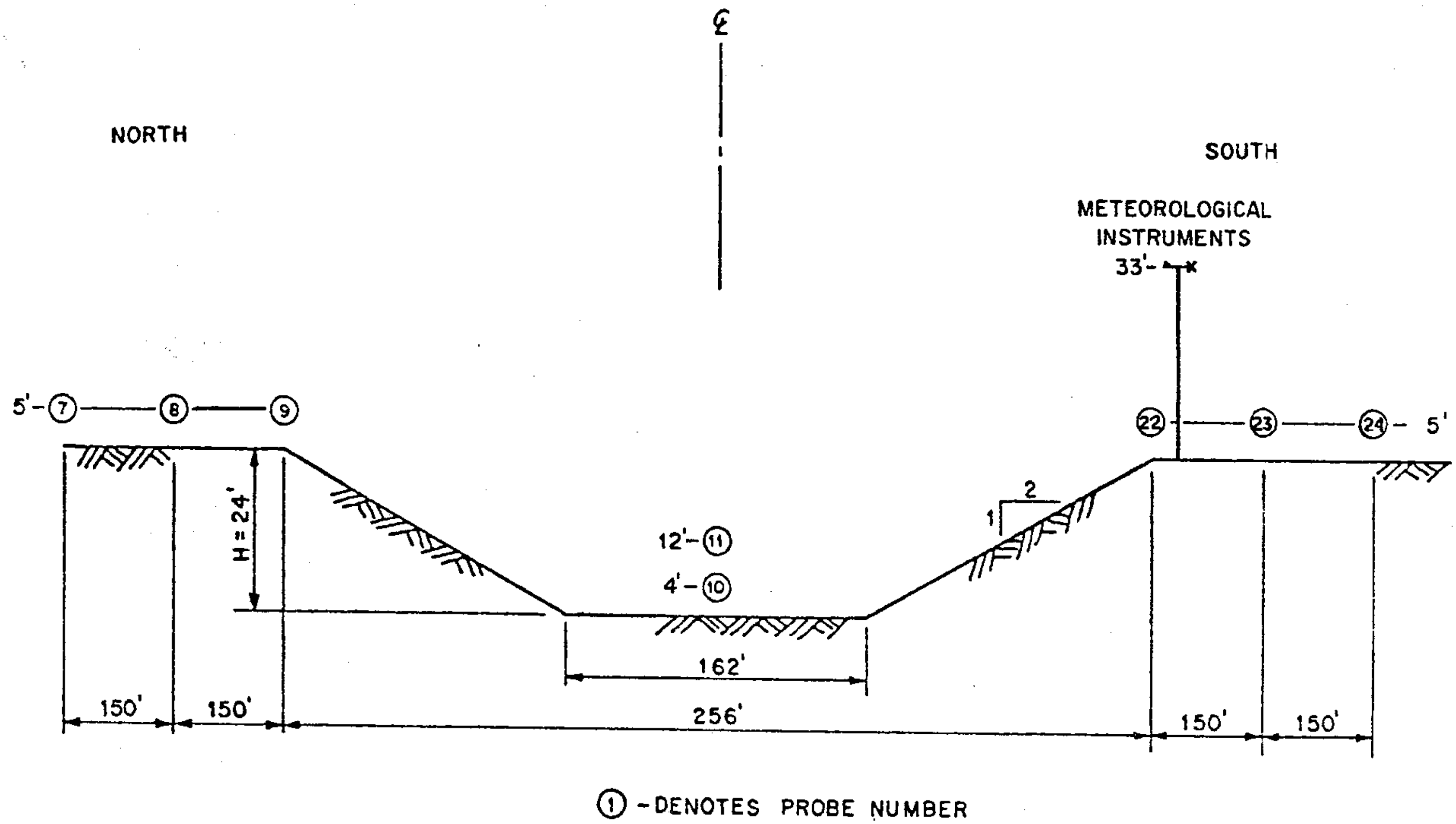
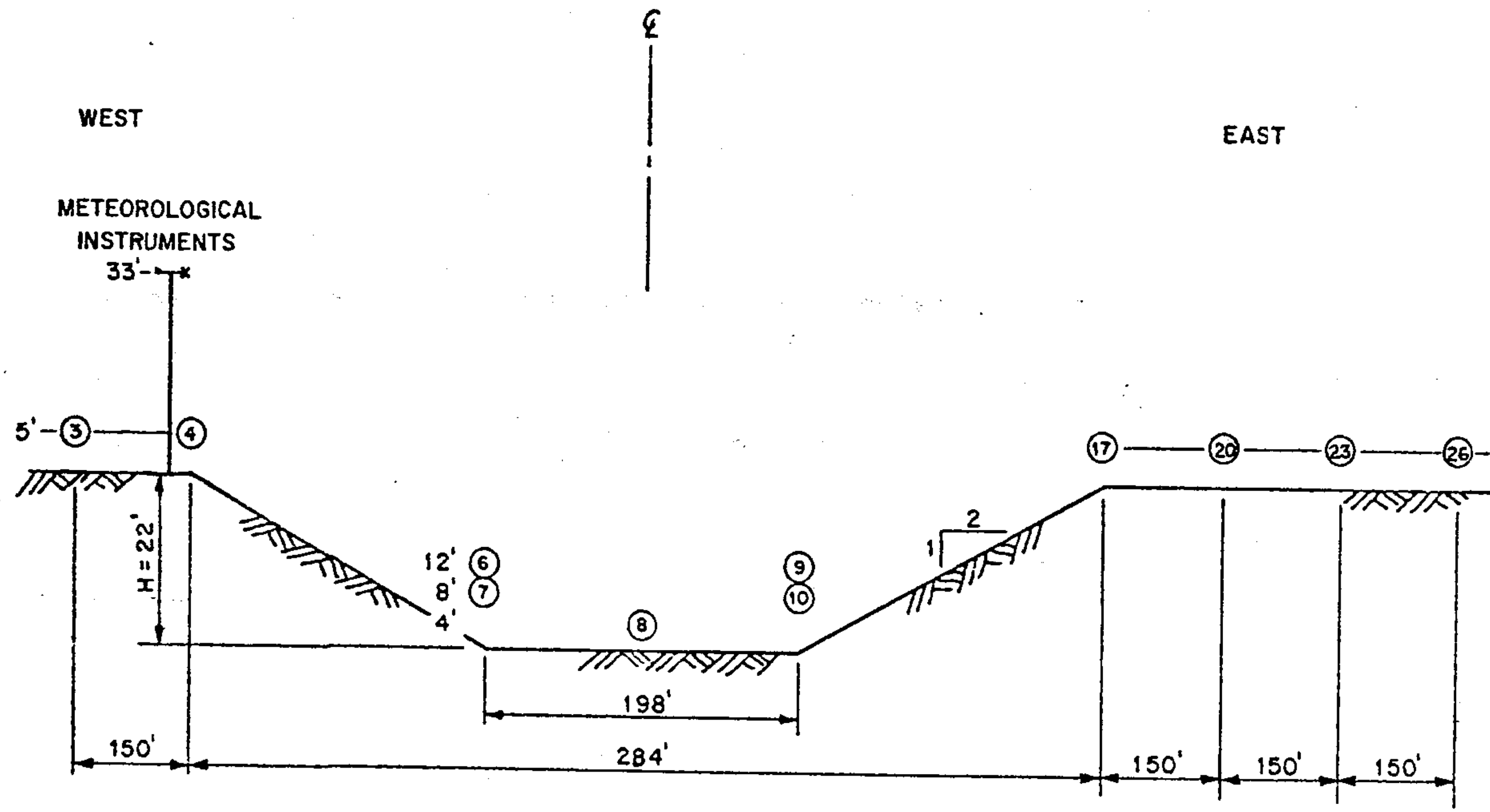


FIG. 8-9 PROBE LOCATIONS, SANTA MONICA FREEWAY
AT 4TH AVE



① -DENOTES PROBE NUMBER

FIG. 8-10 PROBE LOCATIONS, HARBOR FREEWAY
AT 146 TH ST.

DEPRESSED SITES, CROSSWIND
MIXING CELL POINTS

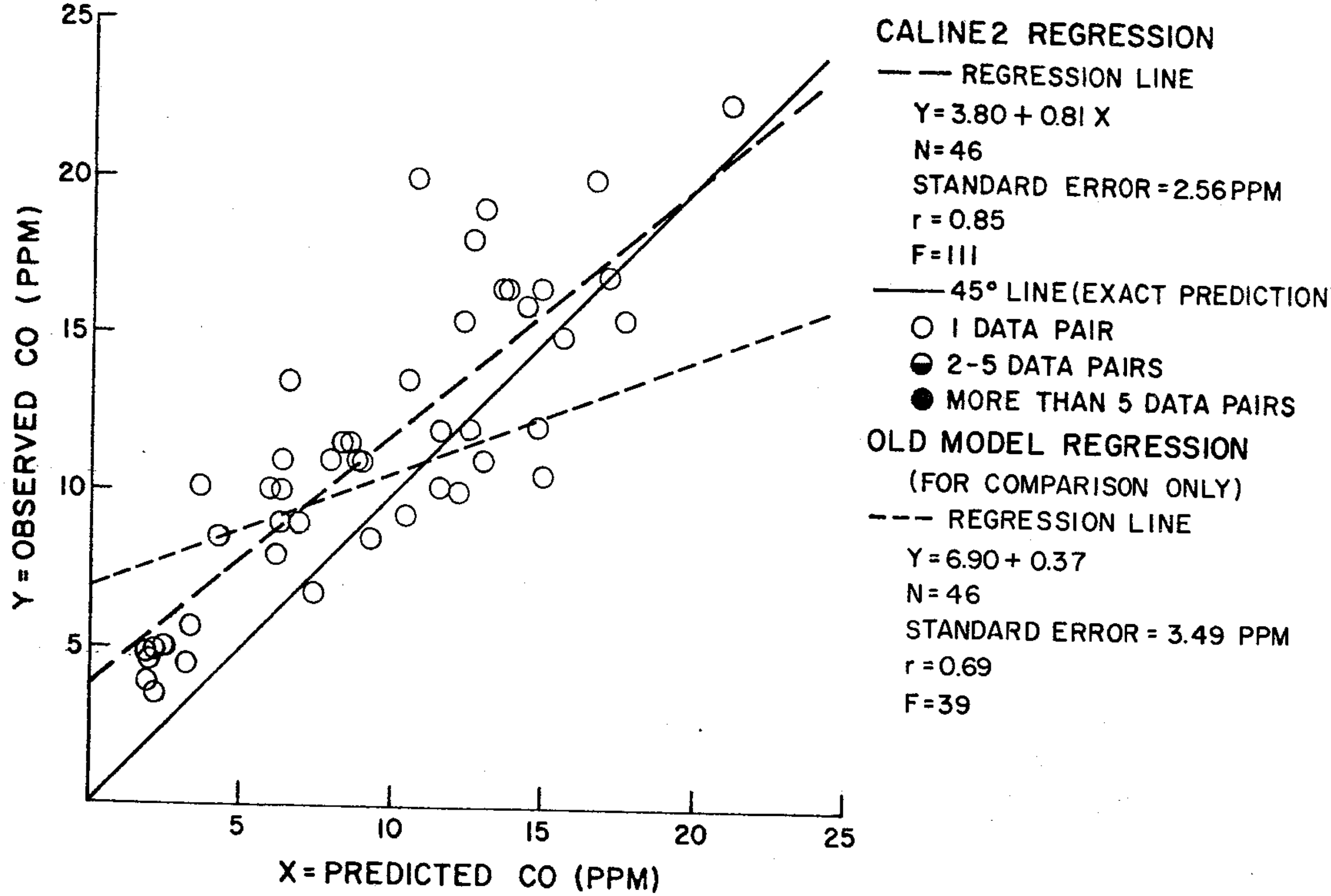


FIG. 8-11

DEPRESSED SITES, CROSSWIND

OFF-HIGHWAY GROUND-LEVEL POINTS

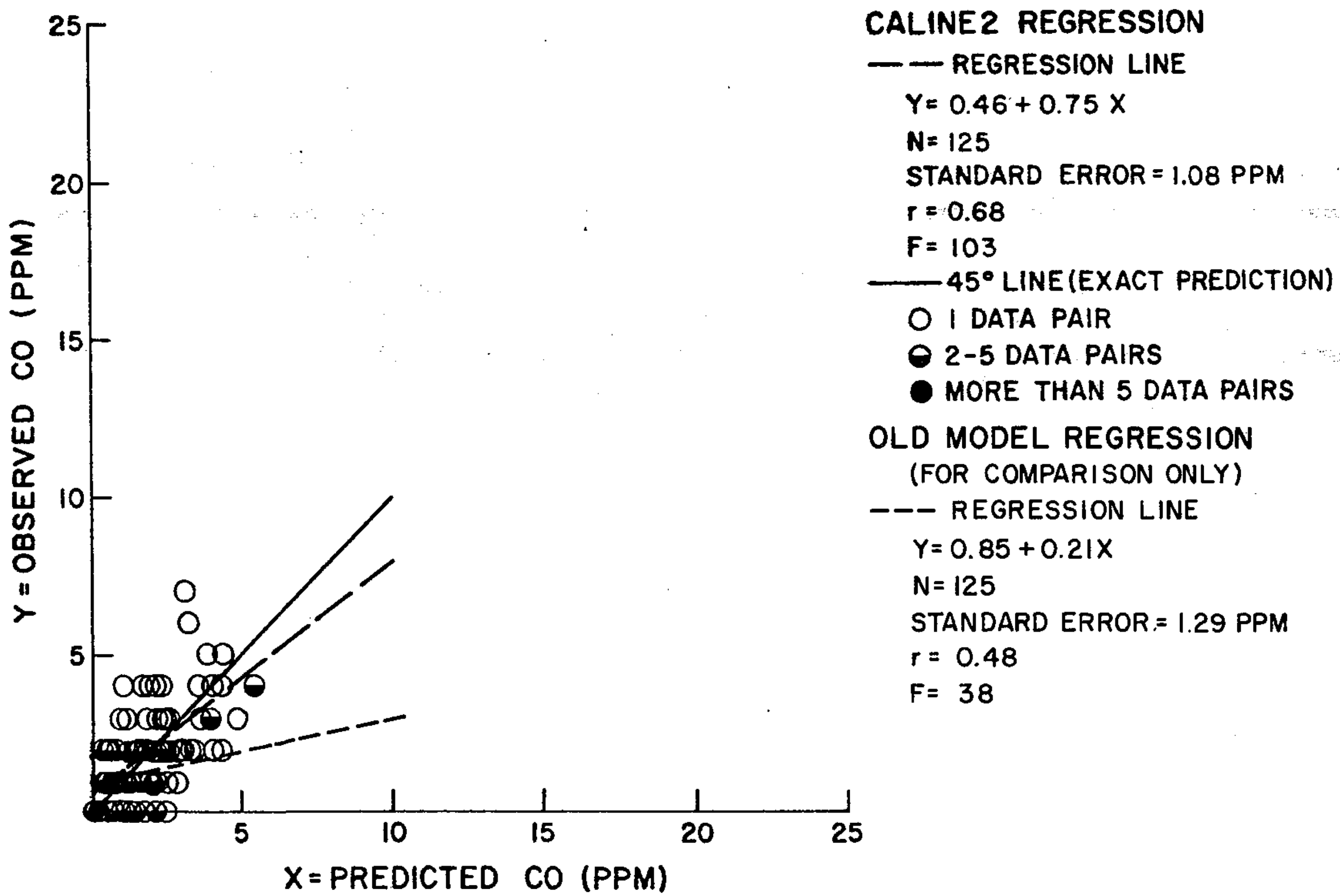


FIG. 8-12

DEPRESSED SITES, CROSSWIND

OFF-HIGHWAY GROUND-LEVEL & MIXING CELL POINTS

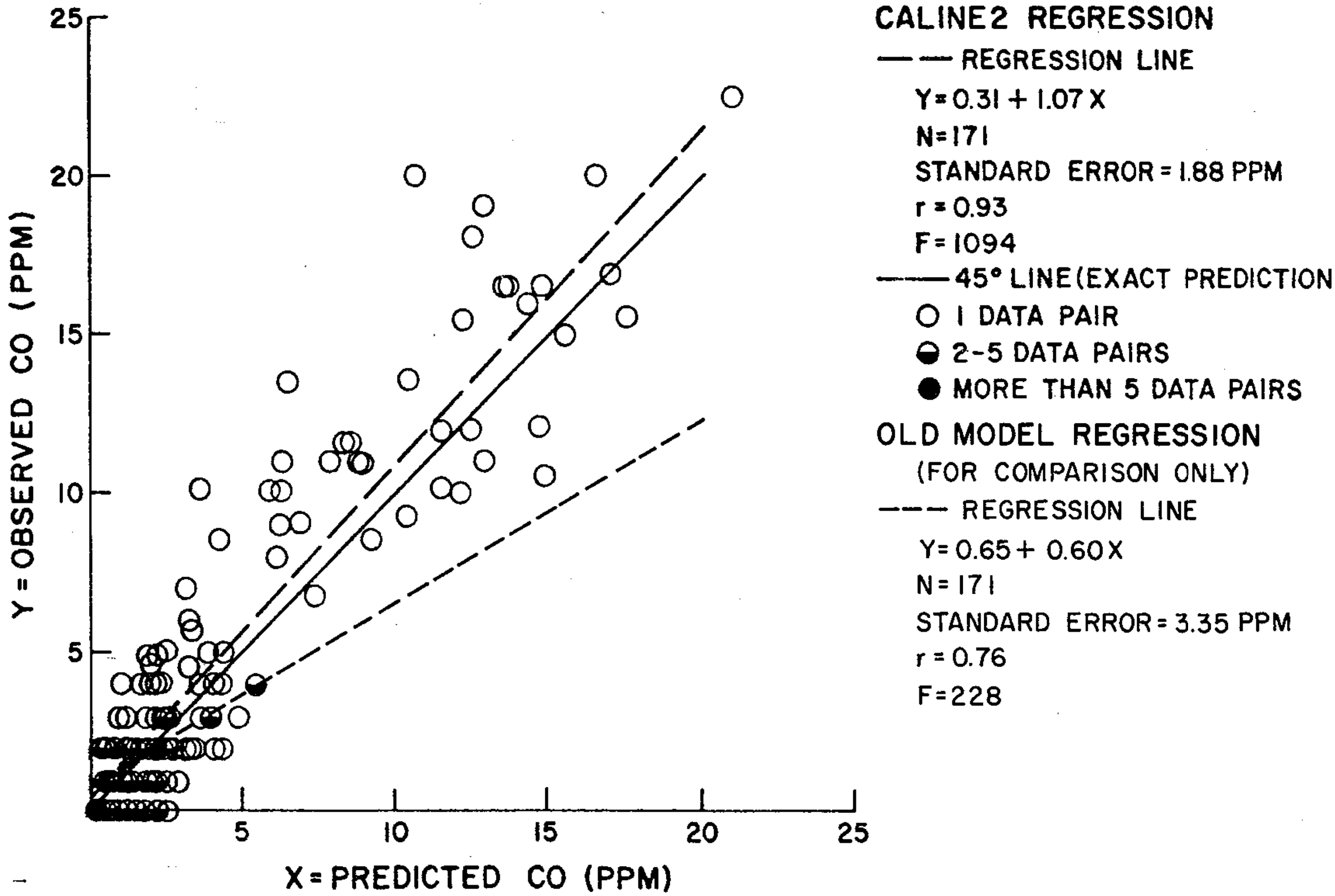


FIG. 8-13

DEPRESSED SITES, PARALLEL WIND

MIXING CELL POINTS

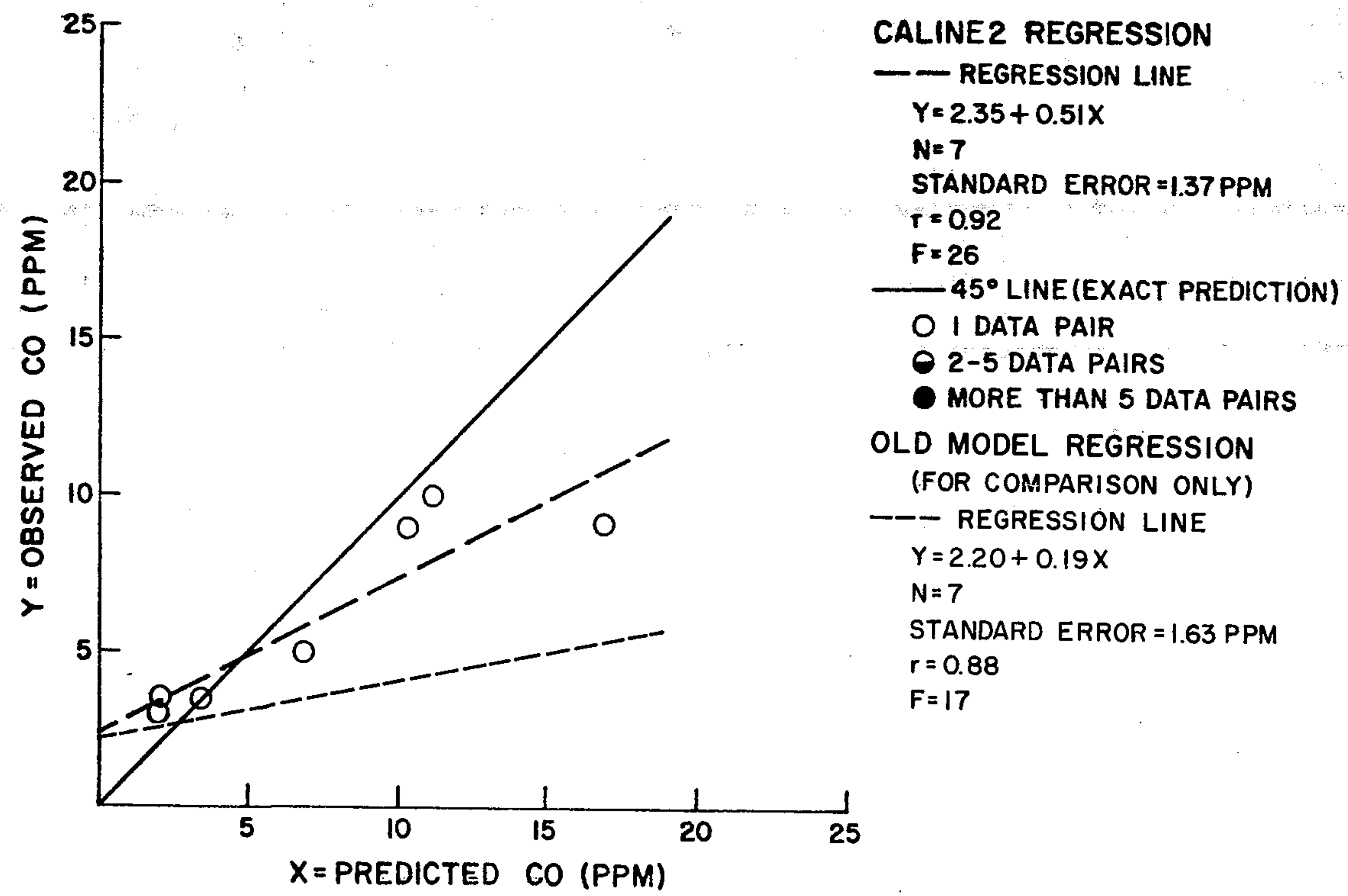


FIG. 8-14

DEPRESSED SITES, PARALLEL WIND

OFF-HIGHWAY GROUND-LEVEL POINTS

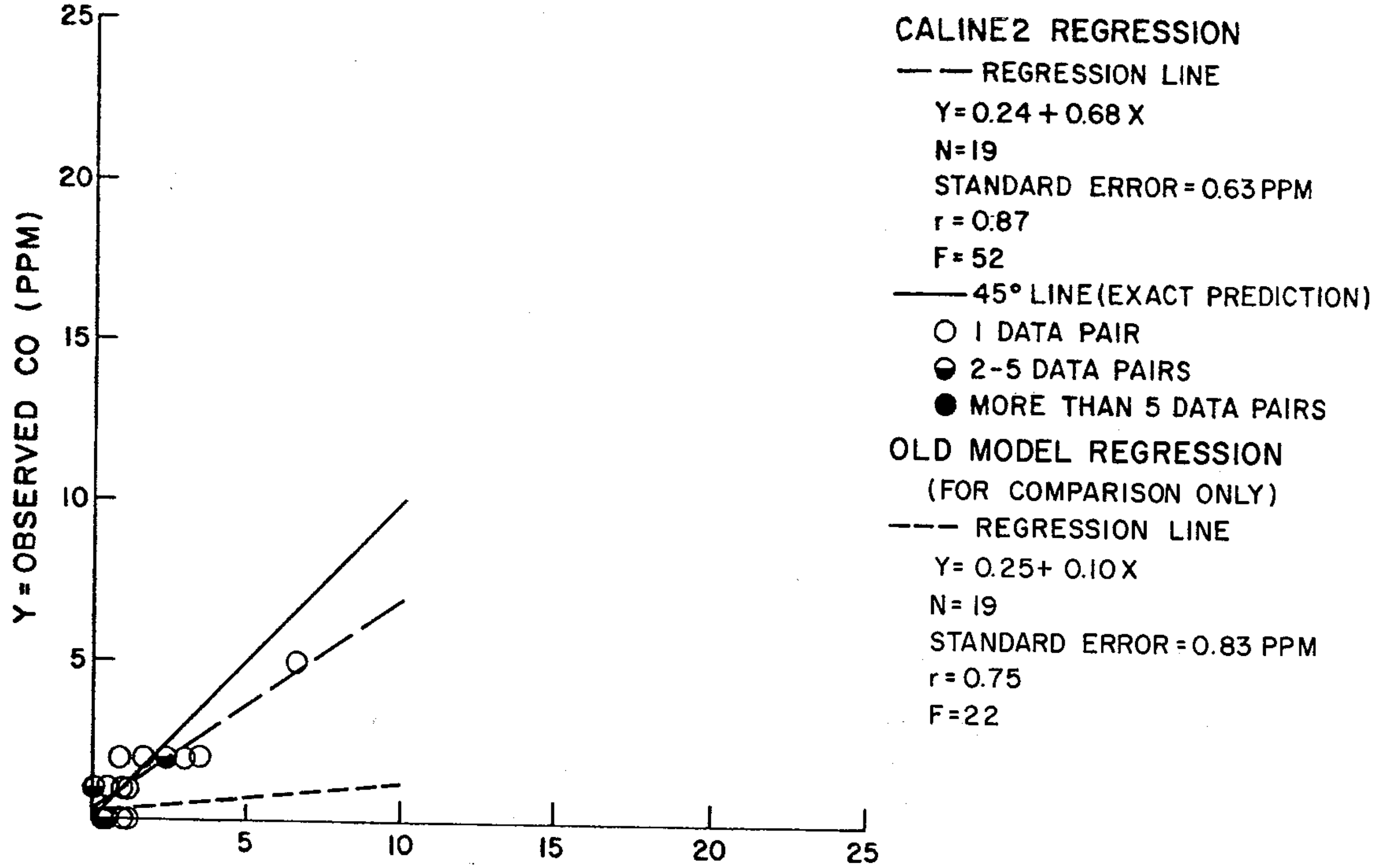


FIG. 8-15

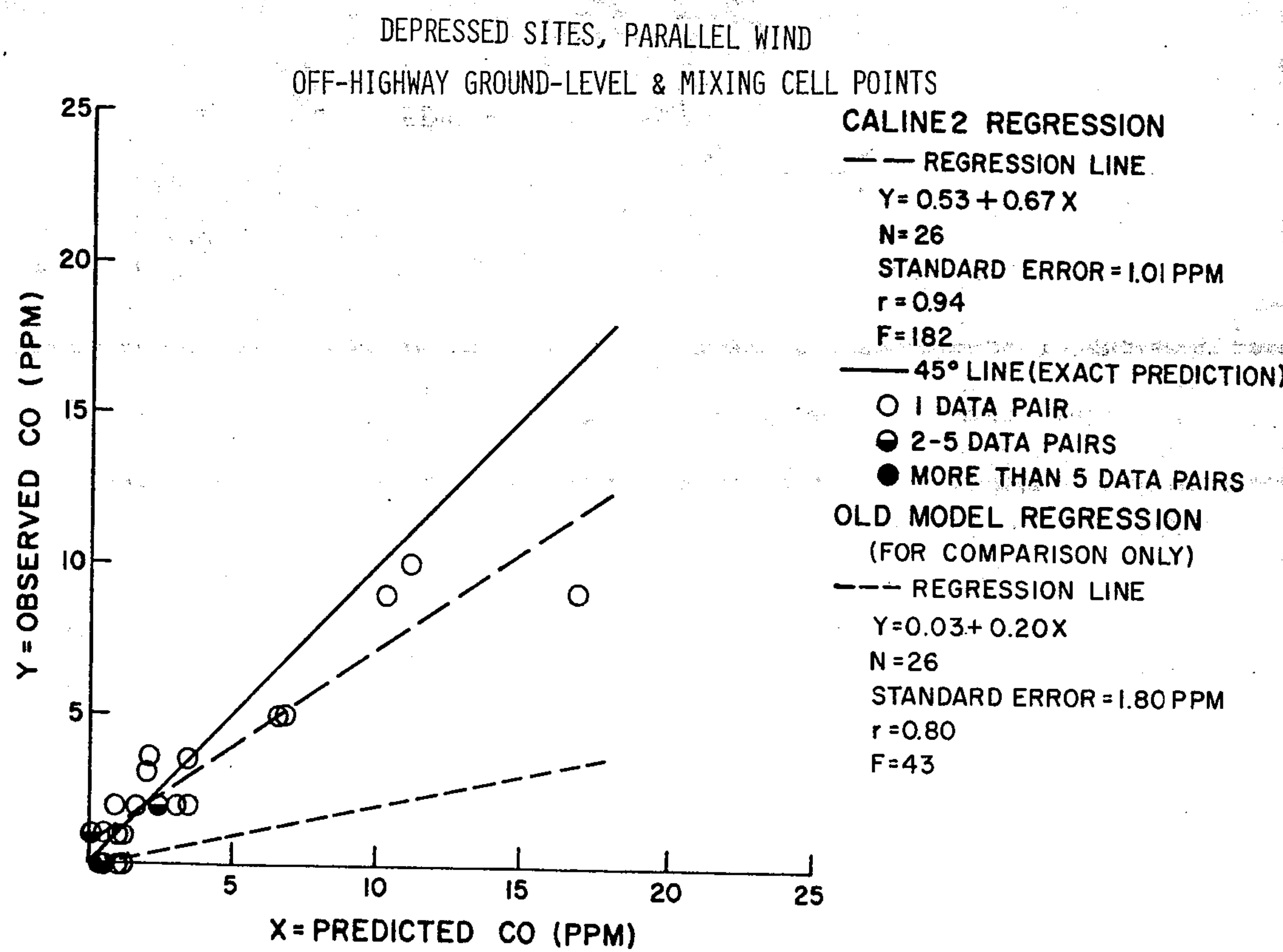
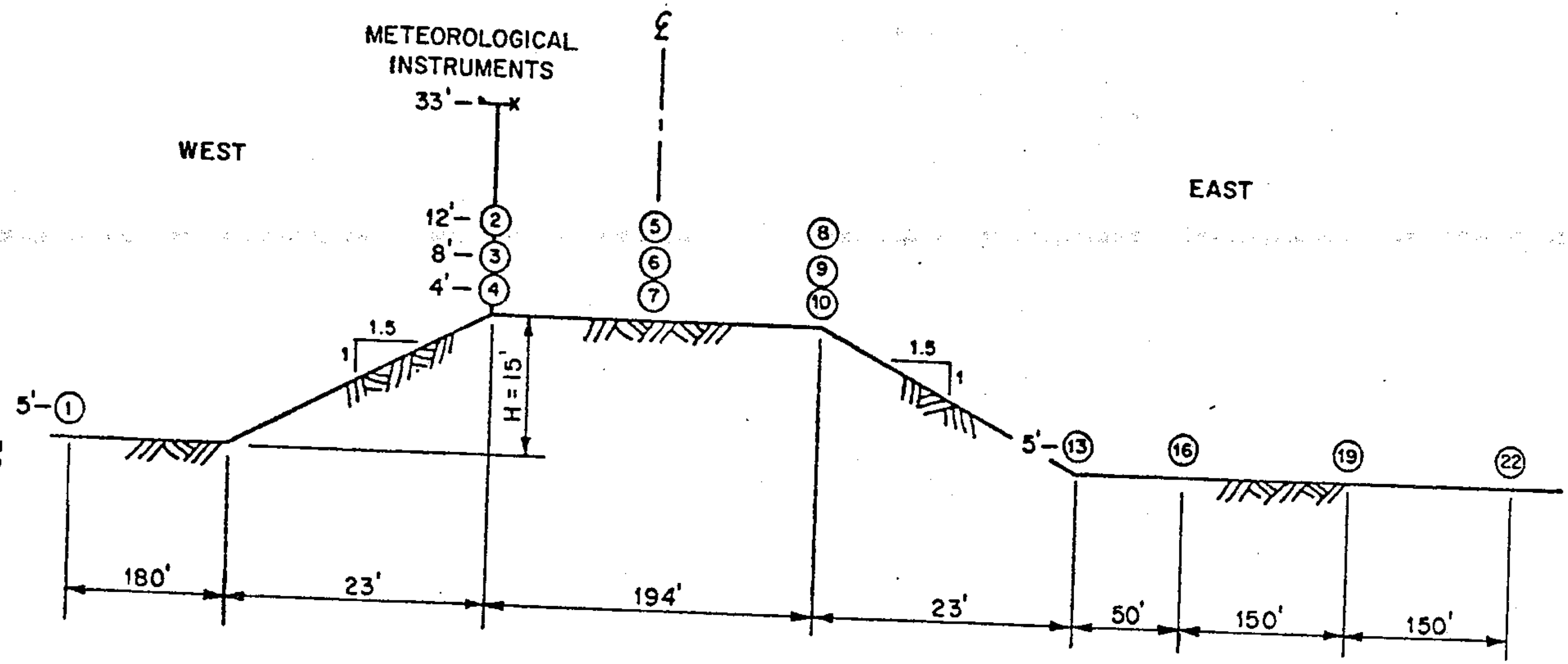

DEPRESSED SITES, PARALLEL WIND
OFF-HIGHWAY GROUND-LEVEL & MIXING CELL POINTS
CALINE2 REGRESSION
REGRESSION LINE
Y=0.53+0.67X
N=26
STANDARD ERROR=1.01 PPM
r=0.94
F=182
45° LINE (EXACT PREDICTION)
1 DATA PAIR
2-5 DATA PAIRS
MORE THAN 5 DATA PAIRS
OLD MODEL REGRESSION
(FOR COMPARISON ONLY)
REGRESSION LINE
Y=0.03+0.20X
N=26
STANDARD ERROR=1.80 PPM
r=0.80
F=43
Y=OBSERVED CO (PPM)
X=PREDICTED CO (PPM)
0
5
10
15
20
25

FIG. 8-16

8.4 Fill Site

The fill site was on the San Diego Freeway at 122nd Street, and is shown schematically in Figure 8-17. Probe 1 was obviously the upwind probe, and probes 2 to 10 were averaged in the same manner as the other sites to obtain the "measured" mixing cell concentrations.

Figures 8-18 through 8-20 show how CALINE2 overpredicts the concentrations resulting from a fill section for a crosswind. There were no parallel wind data for this site. As for the at-grade site, the factor of 2 overprediction for the mixing cell could be a false comparison, since the concentrations for the upwind probes on the edge of the highway (probes 2 to 4) tended to be much lower than those for the probes on the downwind edge (probes 8 to 10).



① – DENOTES PROBE NUMBER

FIG. 8-17 PROBE LOCATIONS, SAN DIEGO FREEWAY AT 122 ND ST.

FILL SITE, CROSSWIND
MIXING CELL POINTS

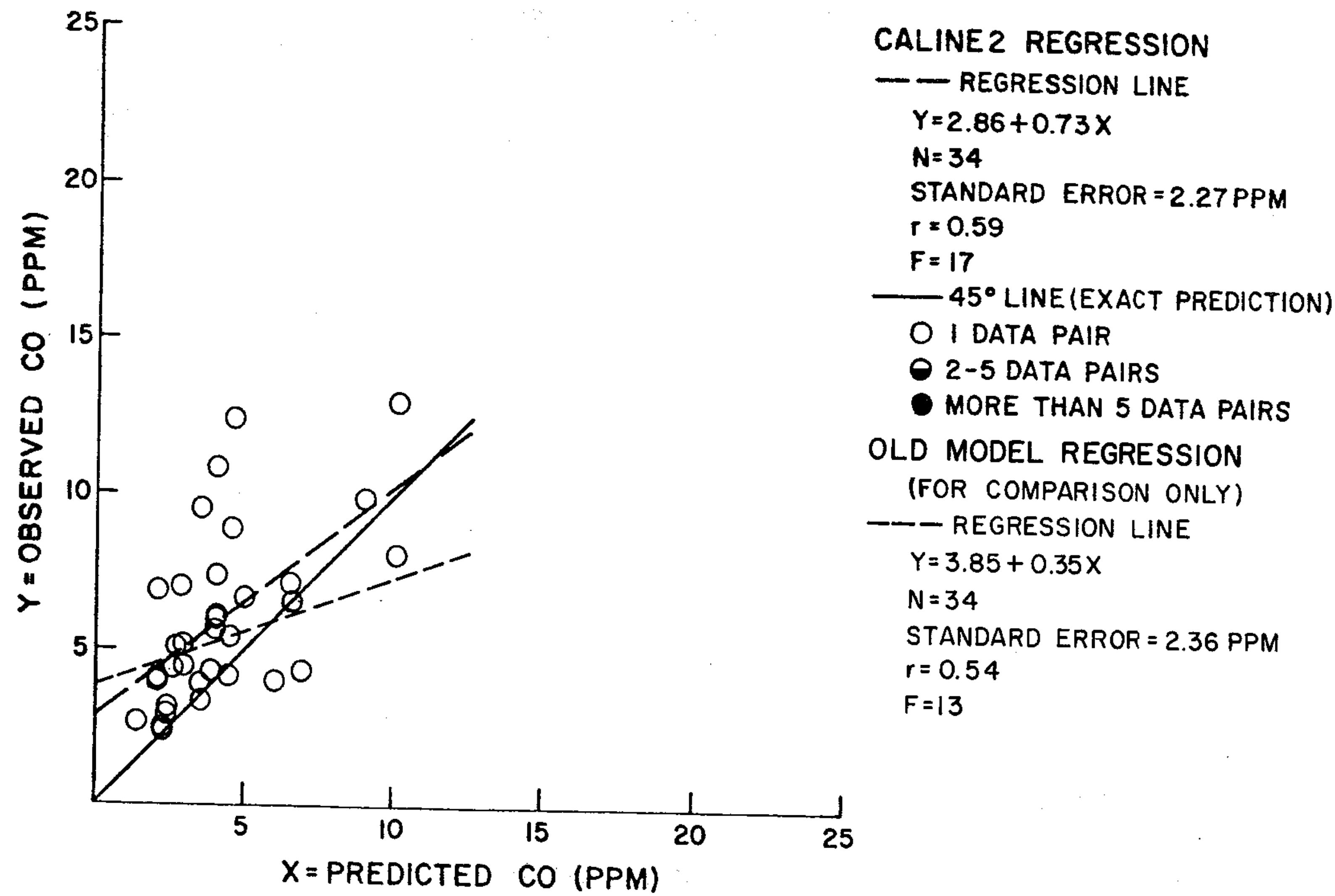


FIG. 8-18

FILL SITE, CROSSWIND

OFF-HIGHWAY GROUND-LEVEL POINTS

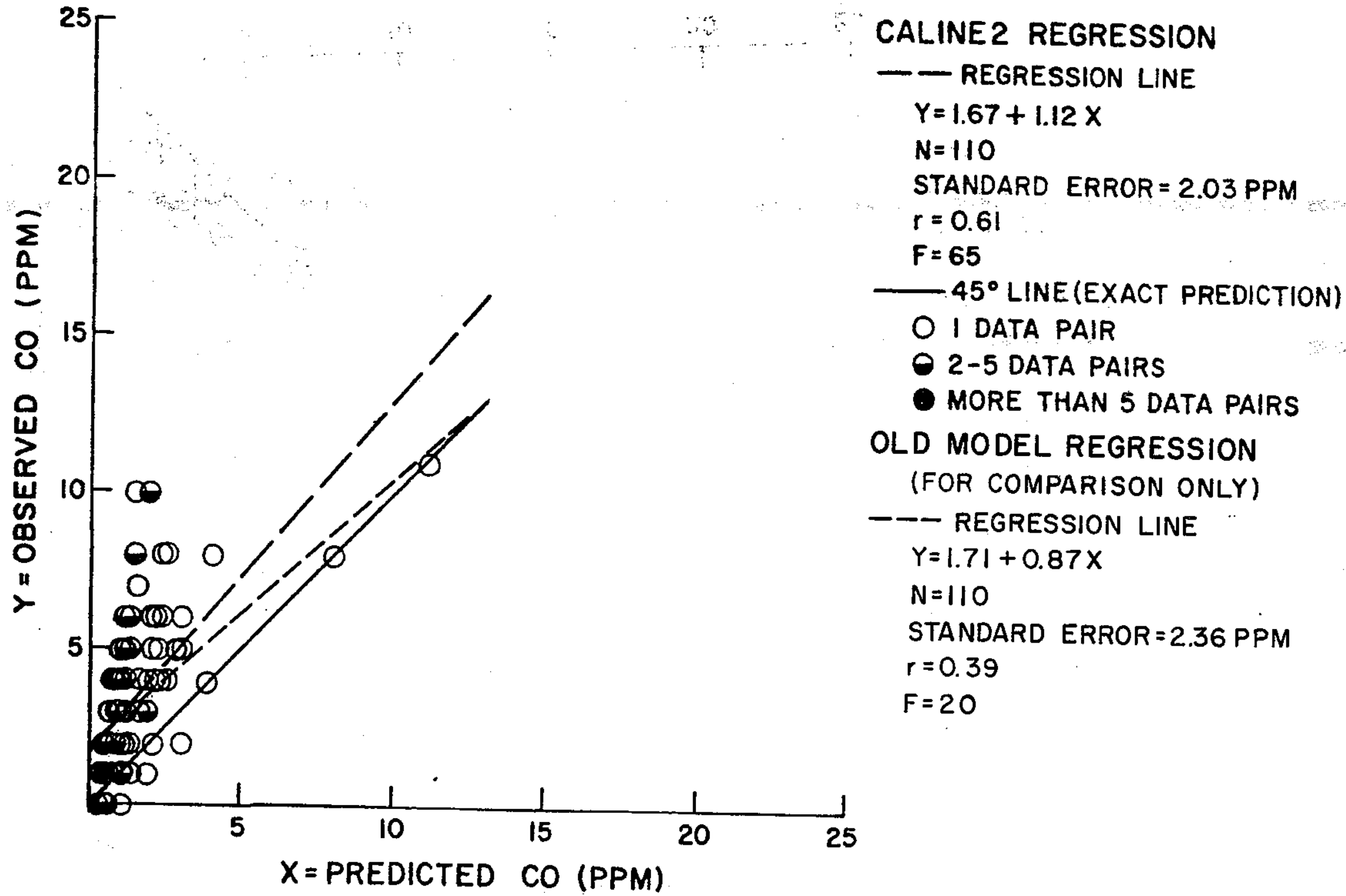


FIG. 8-19

FILL SITE, CROSSWIND

OFF-HIGHWAY GROUND-LEVEL & MIXING CELL POINTS

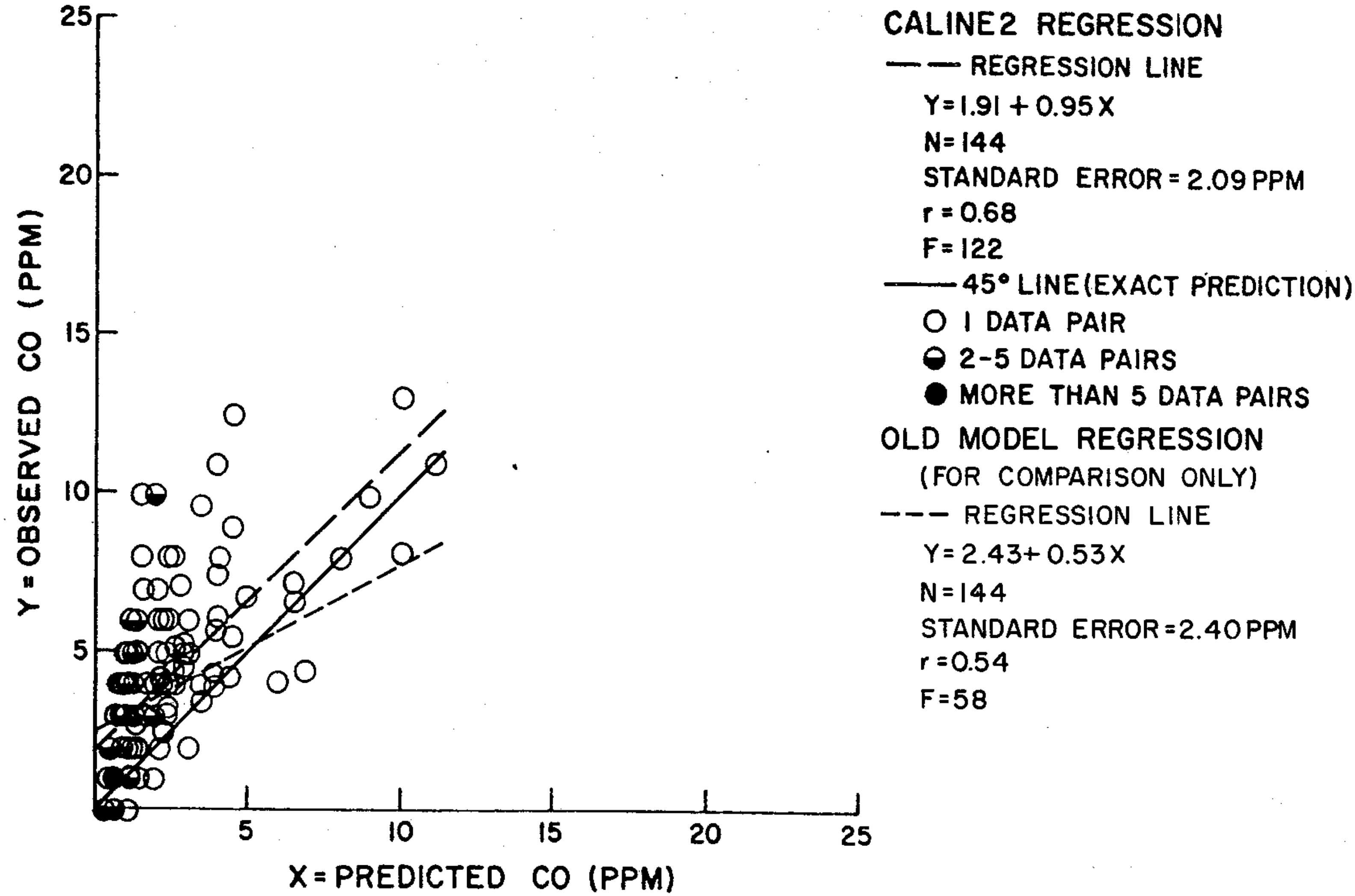


FIG. 8-20

9 APPLICATIONS

9.1 Overall Use of CALINE2

CALINE2 should be used to determine the air quality impact of a proposed highway or other relatively constant linear source of air pollutants. While CALINE2 only calculates the estimated dispersion of carbon monoxide from a line source, this dispersion will give an indication of the atmospheric movement of other pollutants, such as lead and sulfate particulates, and nitric oxides and hydrocarbons.* The model cannot, in its present form, be used to calculate the resultant concentrations of these last pollutants because of the gravitational settling of particulates and chemical reactions. It can, however, yield hourly-average CO estimates which are slightly on the conservative side of actual CO concentrations for most cases, as long as the model's constraints and assumptions are observed.

CALINE2 can be used in the design process of a proposed line source (highway) to determine which configurations would result in the smallest CO concentrations for the site's given meteorology. An analysis can be made of alternative sites (along with alternative configurations) to determine which site's meteorology will disperse the pollutant load most adequately.

Most proposed line source projects will be more than a simple straight line maintaining a constant angle to the prevailing winds and at the same height above or below grade. CALINE2 has

*This assumes that the particulates can be characterized in their transport and diffusion as gases and that there are no chemical reactions of the other pollutants (NO_x, HC).

no internal capability of superposition which would allow the calculation of pollutant contributions from different sections' configurations, but each section's contribution can be simulated on a separate run of the model, and then summed later, either by hand or by another computer program. When the proposed project involves a number of short (less than 1 mile in length) varying segments, or complex situations, such as cloverleaf interchanges, other assumptions/simplifications will have to be made about the project's configurations before the use of CALINE2. These simplifications will result in a greater departure from the real world situation, but the estimated dispersions should still give an approximate indication of the actual dispersion.

Of course, other environmental and design considerations will have to be taken into account in the decision reached on the line source configuration. A line source's environmental siting should not be based on air quality impact alone.

9.2 CALINE2 Simulations

Figure 9-1 depicts the flow of information into the model, the calculations made in the model, and the resulting output. The output can be in $\mu g/m^3$ or ppm, at the user's discretion. Figure 9-2 shows the carbon monoxide concentrations in ppm as calculated by CALINE2 for a crosswind, oblique wind, and parallel wind. The typical situation chosen for these simulations is defined as follows:

VPH = 6000;

emission factor = 25 gms/mile, which is the averaged factor for predominately light duty 1975 vehicles traveling at 55 mph (18);

$\bar{u}$ = 3 mph;

pavement height H = 0 ft;

highway width W = 120 ft;

Pasquill stability class = D, which is indicated to the program by a numerical "4".

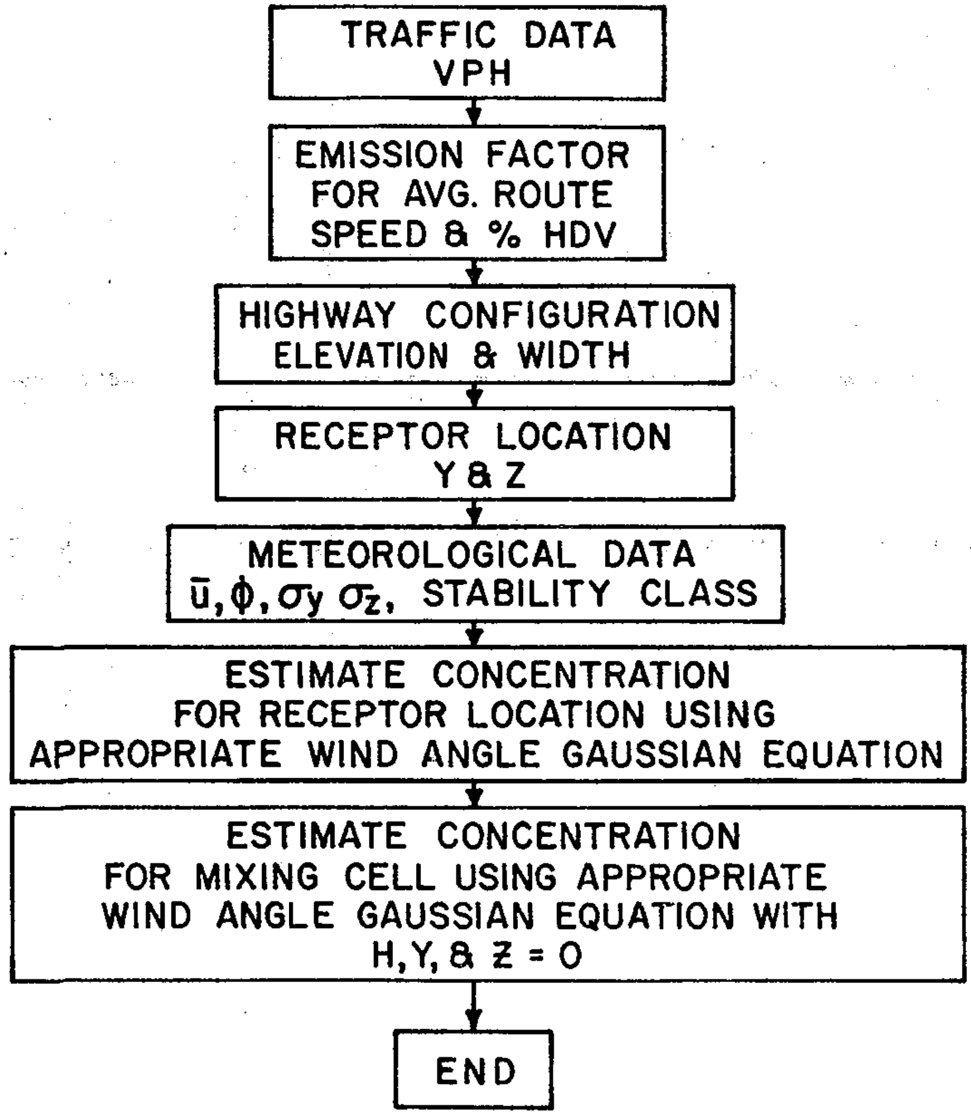


FIG. 9-1 FLOW CHART FOR CALINE 2 MODEL

CALINE2: CALIFORNIA LINE SOURCE DISPERSION MODEL
REVISED JANUARY 1975

CALINE2 SIMULATION WITH CROSS WIND

PREDICTED CO CONCENTRATION (PPM)

VARIABLES	RECEPTOR HEIGHT	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET)					
	(Z FEET)	0	100	200	400	800	1000
VPH= 6000							
EF= 25 GMS/MI							
U= 3 MPH	60	0.0	0.2	0.3	0.4	0.4	0.4
PHI= 90 DEGREES	40	0.0	0.6	0.7	0.7	0.6	0.6
H= 0 FEET	20	1.1	1.2	1.0	0.9	0.8	0.7
CLAS= 4 (D)	10	3.4	1.4	1.2	1.0	0.8	0.8
W= 120 FEET	5	3.4	1.4	1.2	1.0	0.8	0.8

MIXING CELL CONCENTRATION = 3.4 PPM

CALINE2 SIMULATION WITH OBLIQUE WIND

PREDICTED CO CONCENTRATION (PPM)

VARIABLES	RECEPTOR HEIGHT	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET)					
	(Z FEET)	0	100	200	400	800	1000
H= 6000							
EF= 25 GMS/MI							
U= 3 MPH	60	1.5	1.2	0.8	0.4	0.2	0.2
PHI= 45 DEGREES	40	2.1	1.9	1.2	0.5	0.3	0.3
H= 0 FEET	20	4.0	2.5	1.6	0.7	0.4	0.4
CLAS= 4 (D)	10	7.0	2.8	1.7	0.7	0.4	0.4
W= 120 FEET	5	7.0	2.8	1.8	0.7	0.4	0.4

MIXING CELL CONCENTRATION = 7.0 PPM

CALINE2 SIMULATION WITH PARALLEL WIND

PREDICTED CO CONCENTRATION (PPM)

VARIABLES	RECEPTOR HEIGHT	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET)					
	(Z FEET)	0	100	200	400	800	1000
VPH= 6000							
EF= 25 GMS/MI							
U= 3 MPH	60	2.9	2.3	1.4	0.3	0.0	0.0
PHI= 0 DEGREES	40	4.3	3.1	1.8	0.4	0.0	0.0
H= 0 FEET	20	6.9	3.9	2.2	0.4	0.0	0.0
CLAS= 4 (D)	10	10.5	4.2	2.3	0.5	0.0	0.0
W= 120 FEET	5	10.5	4.2	2.3	0.5	0.0	0.0

MIXING CELL CONCENTRATION = 10.5 PPM

FIGURE 9-2 CALINE2 SIMULATIONS

9.3 Worst Case Conditions

Conditions which result in the highest CO concentrations are a complex function of the receptor location, highway configuration, and meteorological conditions. However, from a sensitivity analysis of the CALINE2 model (see Section 6), a number of conditions have been found to yield high CO concentrations for most modeling situations.

1) The lowest wind speed accepted by the model (2 mph).
2) The highest traffic volume (VPH) expected.
3) The highest emission factor expected (usually associated with the lowest route speed and most congested traffic).
4) The most stable atmospheric stability class, usually "D" for urban situations and "E" or "F" for rural situations.

The above are the worst case conditions for any highway configuration or receptor location. One additional factor, the angle of the wind to the highway alignment, needs to be taken into account when analyzing a specific receptor location. Because parallel winds confine the pollutants along the highway corridor, whereas cross winds rapidly disperse them away from the highway, a receptor's highest CO concentration will be affected by differing wind angles, depending upon that receptor's distance from the highway. Receptors closer than 200 feet will have their highest CO concentrations under parallel winds (0°). Receptors farther than 400 feet will have their highest CO concentrations under cross winds (90°). For a receptor between 200 and 400 feet, CALINE2 simulations with both parallel and cross winds will need to be made to determine the worst case. Oblique wind angles yield concentrations somewhere between the extremes of parallel winds and cross winds, so that they need not be considered in a worst case analysis.

9.4 Cost and Availability

CALINE2 requires minimal computer time for simulation runs, especially when used on the large digital computers. On the IBM 370/168, a typical computer run of 42 separate line-source simulations (with 36 receptor sites per simulation) requires 11.5 CPU seconds at an approximate cost of $3.

Generally, therefore, CALINE2 represents a relatively cheap, fast method to obtain reasonable estimates of CO concentrations for a future highway, or other line source.

CALINE2 is currently programmed in FORTRAN on the State of California IBM system 370/168, and in BASIC on Caltrans' TENET timesharing facility.

Appendix B contains a listing and explanations for use of the interactive BASIC program. Appendix C contains the same information for the FORTRAN version, as well as a set of 36 sample runs that demonstrate most of the perturbations of the model. These 36 sample runs can be used to verify that CALINE2 has been programmed correctly into a computer system.

9.5 Graphical CALINE2 Calculations

The "worst-case" conditions described in Section 9.3 were used to develop a series of graphs which could be used to obtain a quick estimate of CO concentrations resulting from a rural highway (19). The graphical method assumes a Pasquill stability class of "F", light wind speeds (2 mph), and ground-level receptors. It accounts for such factors as traffic volume, emission factor, parallel or cross winds, pavement height, and receptor distance. Since the method represents a grosser simplification of the assumptions used for dispersion calculations within CALINE2, the concentrations obtained using this method are more conservative (i.e., higher) than those which would be obtained from actual CALINE2 simulations.

Since the graphical technique described above is only valid for small traffic volumes and rural situations where atmospheric surface stability classes of "F" might actually occur, a second set of graphs was developed for an urban situation (20). This second method incorporates the greater atmospheric instability found in urban areas by assuming a Pasquill stability class of "D". Other than this assumption, the approach is the same as that for the rural situation.

The manual modification detailing the graphical methods is reproduced in Appendix A.

9.6 Future Work

CALINE2 does not yet represent a polished end product, merely an interim tool that can be utilized by transportation planners to obtain estimates of highways' impacts on local air quality. Work remaining to be done includes the following:

1) Fine-tuning calibration and verification with extensive field sampling data which are becoming available (17).

2) Development of a grid or superposition version of the model which will allow the analysis of multiple line sources and modal systems.

3) Evaluation of a possible modification of the model to estimate dispersion of lead and sulfate particulates.

4) Comparison of CALINE2's predictive capabilities with those of other line source models, such as the U.S. Environmental Protection Agency's HIWAY.

The state of the art for air pollution modeling is rapidly changing, and attempts will be made to keep CALINE at the forefront of those changes.

REFERENCES

1. National Environmental Policy Act of 1969 (42 U.S.C.).

2. California Environmental Quality Act (CEQA), 1970.

3. Federal-Aid Highway Act of 1970 (Public Law 91-605).

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APPENDIX A

Air Quality Manual Modification Number 9

AIR QUALITY MANUAL MODIFICATION

Prepared by Charles E. Ward
Transportation Laboratory

October 1975
(Revised May 1976)

Modification Number 9 - A Graphical Method for Estimating Highest Carbon Monoxide Concentrations for Urban Highway Projects, Based on CALINE2

In order to supplement the technique presented in Air Quality Manual Modification Number 7 (1), the staff at the Transportation Laboratory has developed a quick method for estimating the highest CO concentrations which could be expected from a project located in an urban area. The method is essentially the same as that described in Manual Modification Number 7 for rural situations. The major change is that the urban method assumes a Pasquill stability class of "D", rather than the "F" of the rural method, to account for the increased atmospheric instability encountered in urban areas caused by the urban heat island effects. To alleviate any confusion which may result from the introduction of this additional graphical technique, both the rural (stability class "F") and the urban (stability class "D") methods have been incorporated into a single series of charts.

An additional comment needs to be made about an assumption in the rural method. This assumption is that the parallel wind buildup in the mixing cell occurs under "F" stability. "F" stability conditions have only been measured over vegetated rural areas (2). To the author's knowledge, they have not been verified to occur over areas with unnatural surfaces, such as highways. In fact, the mechanical mixing caused by vehicular movement, the additional heat flux from vehicular energy consumption, and the different thermal conductivity and albedo of the pavement probably would increase the local atmospheric instability in the mixing cell. Therefore, parallel wind buildup in the mixing cell would not be a function of "F" stability, but a function of some stability class that allows greater atmospheric dispersion. However, until field verification studies become available to indicate otherwise, "F" stability will be assumed to be the "worst-case" atmospheric dispersion condition for the mixing cell in rural projects with light traffic volumes. At the present time, this assumption will probably yield conservatively high estimates of CO concentrations in rural mixing cells under parallel winds.

Both methods are based on CALINE2 and consist of a series of charts which take into account most of the factors affecting concentrations of carbon monoxide downwind from a line source. They assume light wind speeds (2 mph), and ground-level receptors. They result in "worst case" concentrations and do not require the use of a computer. The resulting concentrations are conservatively high estimates of concentrations which would result from a simulation run of CALINE2. Based on verification studies of CALINE2 from data collected in the Los Angeles area, the CALINE2 simulated concentrations are themselves overestimates of actual CO concentrations.

Although the output from this graphical method is an estimate for a one-hour average CO concentration, the output plus the ambient CO level is compared to the 8-hour standard of 9 ppm. It is assumed that the conditions that would result in the highest 1-hour concentration may exist for 8 hours, in the worst case. If the concentrations from the graphical method plus the ambient (background) level do exceed the 8-hour standard of 9 ppm, a more detailed study using simulation runs of CALINE2 (3, 4) should be undertaken. The frequency of occurrence of predicted concentrations should be analyzed (5) and the 1-hour concentrations should be empirically converted to 8-hour concentrations using Larsen's model (6).

The following are the steps to follow for the graphical method:

1) Obtain an estimate for the highest expected VPH (vehicles per hour) and the largest EF (emission factor in grams per mile, which usually increases with decreasing route speed). Obtain W (highway width, or mechanical mixing cell width from outside of traveled roadway plus 10 feet to outside of traveled roadway plus 10 feet, in feet), H (pavement height, above or below grade, in feet; - 30 feet minimum) and D (perpendicular distance from nearest outside edge of mechanical mixing cell to nearest critical receptor, in feet).

   If the median width is greater than 30 feet, the superposition principle applies. W will be the combined width of all the lanes plus 20 feet (10 feet on each side) in one traffic flow direction, and D will be adjusted for each direction.

2) Obtain the crosswind mixing cell ratio $\frac{VPH \times EF}{10^5}$ using the information in step 1 above. Determine the CO concentration in ppm for the crosswind mixing cell using this ratio and Chart 1.

3) Determine the CO concentration for the parallel wind mixing cell using the ratio $\frac{VPH \times EF \times (1.05-(0.001 \times W))^*}{3.28084 \times 10^4}$ and the appropriate line in Chart 2, for rural or urban projects.

4) Modify (multiply) the mixing cell estimates by the Source Height Adjustment Factor obtained from Chart 3 using the highway height H, for both parallel and crosswinds. These results will be intermediate factors needed to calculate the CO concentrations at the receptors.

5) Modify (multiply) the intermediate factors of Step 4 by the Receptor Distance Adjustment Factor from the appropriate selection of Charts 4, 5, or 6 (for urban projects) or Charts 7, 8, or 9 (for rural projects), by using the perpendicular distance to the receptor D, for both parallel and crosswinds. Charts Nos. 6, 8, and 9 have one curve to be used regardless of pavement height. When using Charts Nos. 4, 5, and 7, the engineer must interpolate between the curves to find the correct adjustment factor for the given pavement height.

The products of the above multiplication will be estimates of the worst-case CO concentrations in PPM for the critical receptor distance. It should be noted that this graphical method is not applicable for an elevated section during a crosswind condition. Whichever of the wind angles yields the highest concentration will be the "worst" wind angle.

6) If the resulting concentration from the "worst" wind angle plus the estimated ambient (background concentration exceeds the 8 hour CO standard of 9 ppm, use CALINE2 to obtain better estimates for use in your environmental analysis as previously discussed.

---

*The factor 1.05-(0.001 x W), was obtained from the sensitivity of the highway width, W(7). As W increases, the predicted CO decreases. The factor's constants are the normalized intercept and slope of the sensitivity line, respectively.

EXAMPLE 1

1. For a rural project:

   VPH = 1000
   EF = 25 gms/mile
   W = 110 feet (4 lanes, 30' median)
   H = -20 feet
   F stability and wind speed of 2 mph assumed
   Estimated ambient CO concentration = 3 ppm

2. Crosswind mixing cell ratio $= \frac{VPH \times EF}{10^5} = \frac{1000 \times 25}{10^5} = 0.25$

   Crosswind mixing cell concentration = 0.8 ppm
   (from Chart 1)

3. Parallel wind mixing cell ratio $= \frac{VPH \times EF \times (1.05 - (0.001) \times W))}{3.28084 \times 10^4} =$

   $\frac{1000 \times 25 \times (1.05 - (0.001 \times 110))}{3.28084 \times 10^4} = 0.7$

   Parallel wind mixing cell concentration = 7.3 ppm
   (from Chart 2, rural projects line)

4. Intermediate factors = 0.8 x 0.56 = 0.4 for crosswind
   (from Chart 3) 7.3 x 0.56 = 4.1 for parallel wind

5. Ground-level receptor concentrations.

D (ft)	Cross Wind (Using Factors from Chart 7)	Parallel Wind (Using Factors from Chart 9)
25	0.4 x 0.83 = 0.3 ppm	4.1 x 0.76 = 3.1 ppm
50	0.4 x 0.74 = 0.3 ppm	4.1 x 0.64 = 2.6 ppm
100	0.4 x 0.66 = 0.3 ppm	4.1 x 0.42 = 1.7 ppm
200	0.4 x 0.57 = 0.2 ppm	4.1 x 0.16 = 0.7 ppm
400	0.4 x 0.52 = 0.2 ppm	4.1 x 0.01 = 0.0 ppm

Parallel winds yield the highest concentrations for receptors 200 feet or less away from the highway. Since the highest predicted CO concentration at a receptor is 3.1 ppm and the ambient CO level is only 3 ppm, CALINE2 simulations should not have to be made in order to make a negative declaration.

EXAMPLE 2

1. For an urban project:

VPH = 10000
EF = 30 gms/mile
W = 130 feet (6 lanes, 20'median)
H = 0 feet
D stability and wind speed of 2 mph assumed
Estimated ambient CO concentration = 10 ppm

2. Crosswind mixing cell ratio = $\frac{VPH \times EF}{10^5} = \frac{10000 \times 30}{10^5} = 3.0$

Crosswind mixing cell concentration = 10 ppm
(from Chart 1)

3. Parallel wind mixing cell ratio = $\frac{VPH \times EF \times (1.05 - 0.001 \times W)}{3.28084 \times 10^4} =$

$\frac{10000 \times 30 \times (1.05 - (0.001 \times 130))}{3.28084 \times 10^4} = 8.4$

Parallel wind mixing cell concentration = 33 ppm
(from Chart 2, urban projects line)

4. Intermediate factors = 10 x 1.0 = 10 for crosswind
(from Chart 3) 33 x 1.0 = 33 for parallel wind

5. Ground-level receptor concentrations.

D (ft)	Cross Wind (Using Factors from Chart 7)	Parallel Wind (Using Factors from Chart 9)
25	10 x 0.60 = 6.0 ppm	33 x 0.67 = 22.1 ppm
50	10 x 0.52 = 5.2 ppm	33 x 0.59 = 19.5 ppm
100	10 x 0.43 = 4.3 ppm	33 x 0.45 = 14.9 ppm
200	10 x 0.36 = 3.6 ppm	33 x 0.25 = 8.3 ppm
400	10 x 0.31 = 3.1 ppm	33 x 0.08 = 2.6 ppm

Parallel winds yield the highest concentrations for receptors 200 feet or less away from the highway for this particular highway configuration. Since the estimated ambient concentration is 10 ppm, CALINE2 should be used to obtain better estimates for CO concentrations as described previously, for all receptors.

EXAMPLE 3

1. For a rural project:

   VPH = 1000
   EF = 40 gms/mile
   W = 50 feet (2-lane highway)
   H = +30 feet

   Same assumptions as for Example 1 (F stability, wind speed is 2 mph), ambient CO = 3 ppm

2. Crosswind conditions are not applicable for elevated roadway sections.

3. Parallel wind mixing cell ratio = $\frac{VPH \times EF \times (1.05 - (0.001 \times w))}{3.28084 \times 10^4}$ =

   $$\frac{1000 \times 40 \times (1.05 - (0.001 \times 50))}{3.28084 \times 10^4} = 1.2$$

   Parallel wind mixing cell concentration = 12 ppm
   (from Chart 2, rural projects line)

4. Intermediate factors = 12.5 x 0.59 = 7.4 for parallel wind
   (from Chart 3)

5. Ground-level receptor concentrations (using factors from Chart 8)

D (ft)	Parallel Wind
25	7.4 x 0.85 = 6.3 ppm
50	7.4 x 0.71 = 5.3 ppm
100	7.4 x 0.49 = 3.6 ppm
200	7.4 x 0.18 = 1.3 ppm
400	7.4 x 0.00 = 0.0 ppm

The highest concentration calculated is 6.3 ppm. Considering that the ambient CO level is 3 ppm, CALINE2 simulations should be made as previously described for the two receptors at 25 and 50 feet.

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Chart I

CROSS WIND MIXING CELL CONCENTRATION

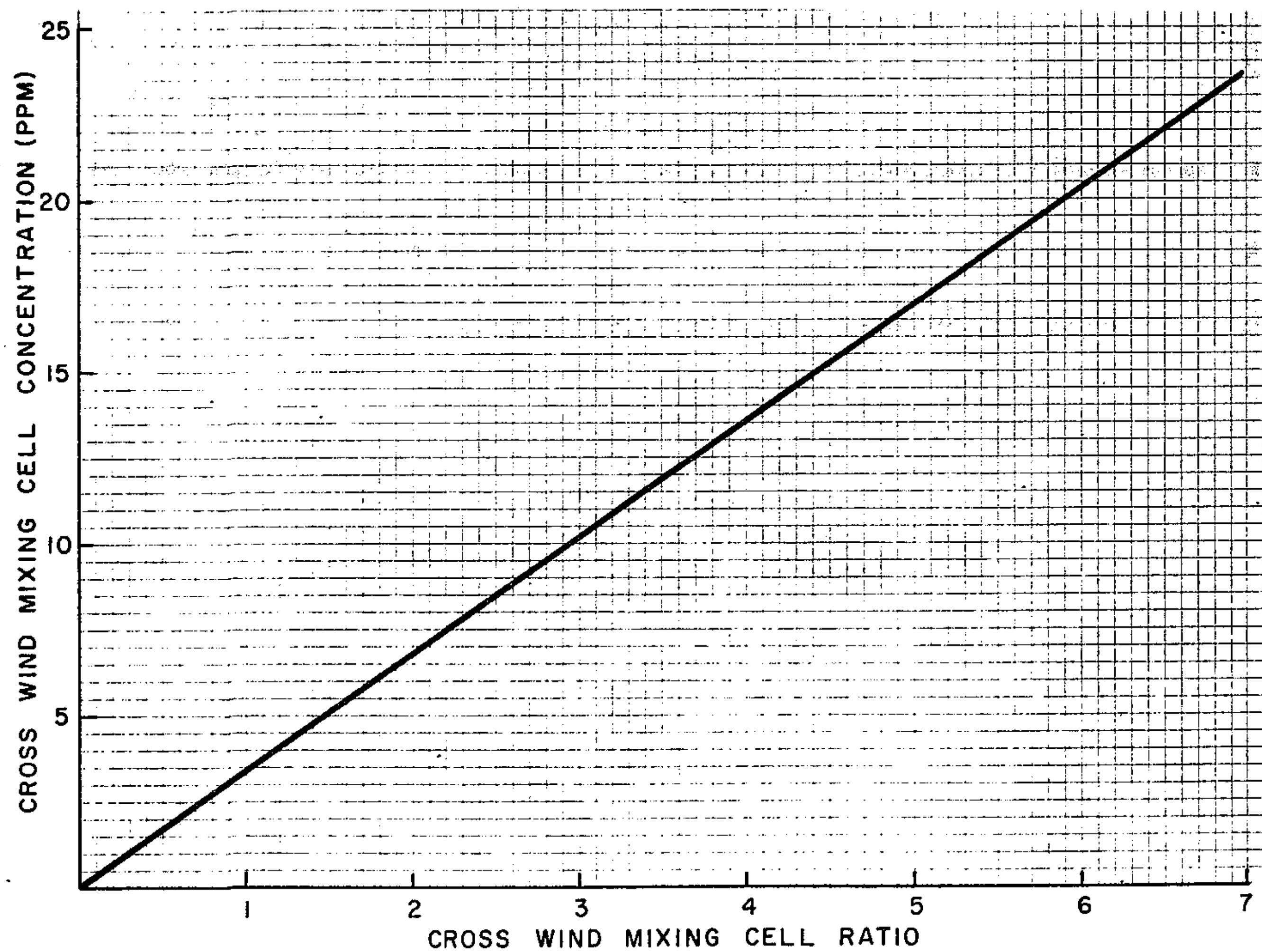


Chart 2

PARALLEL WIND MIXING CELL CONCENTRATION

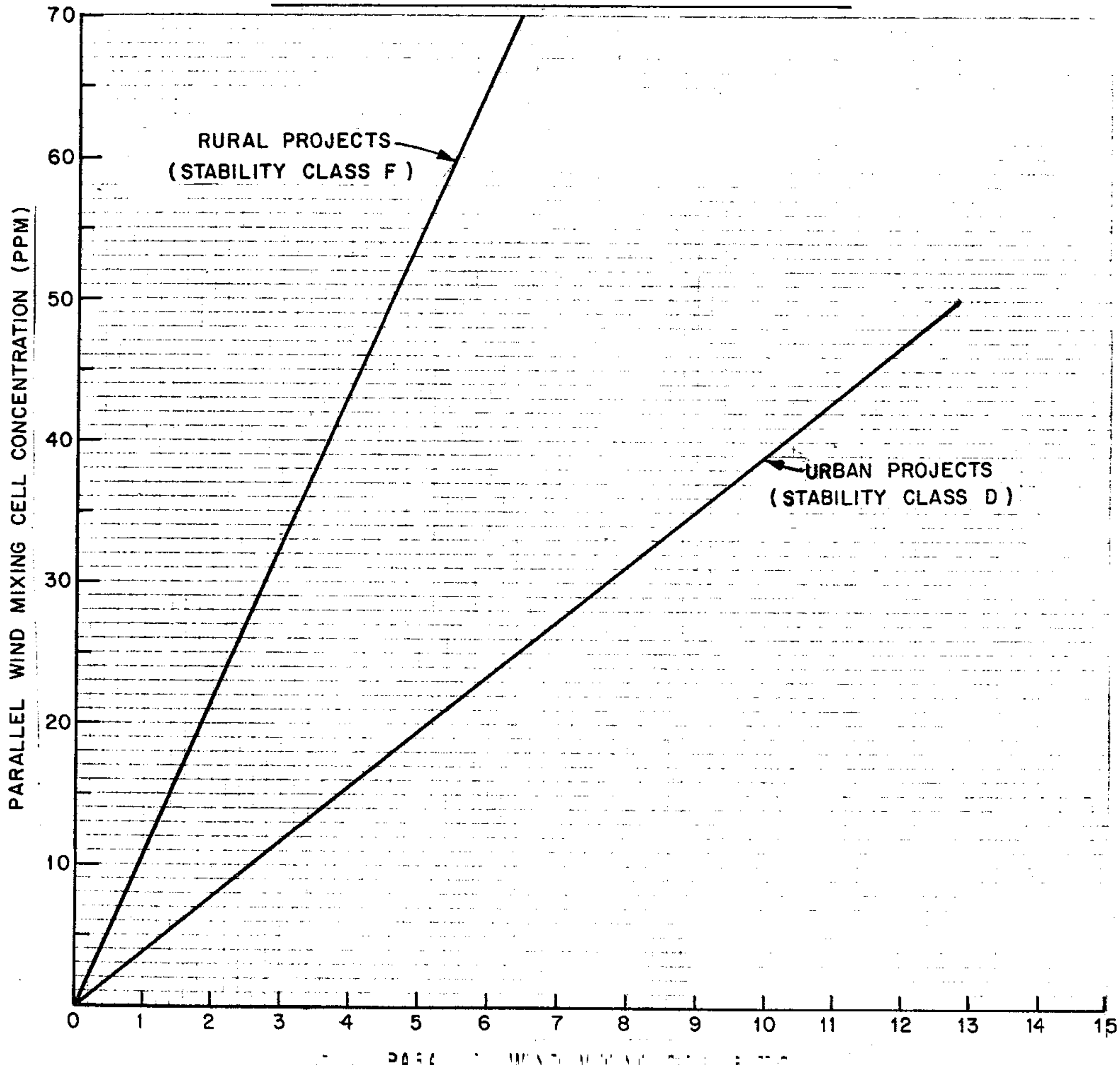


Chart 3

SOURCE HEIGHT ADJUSTMENT FACTOR

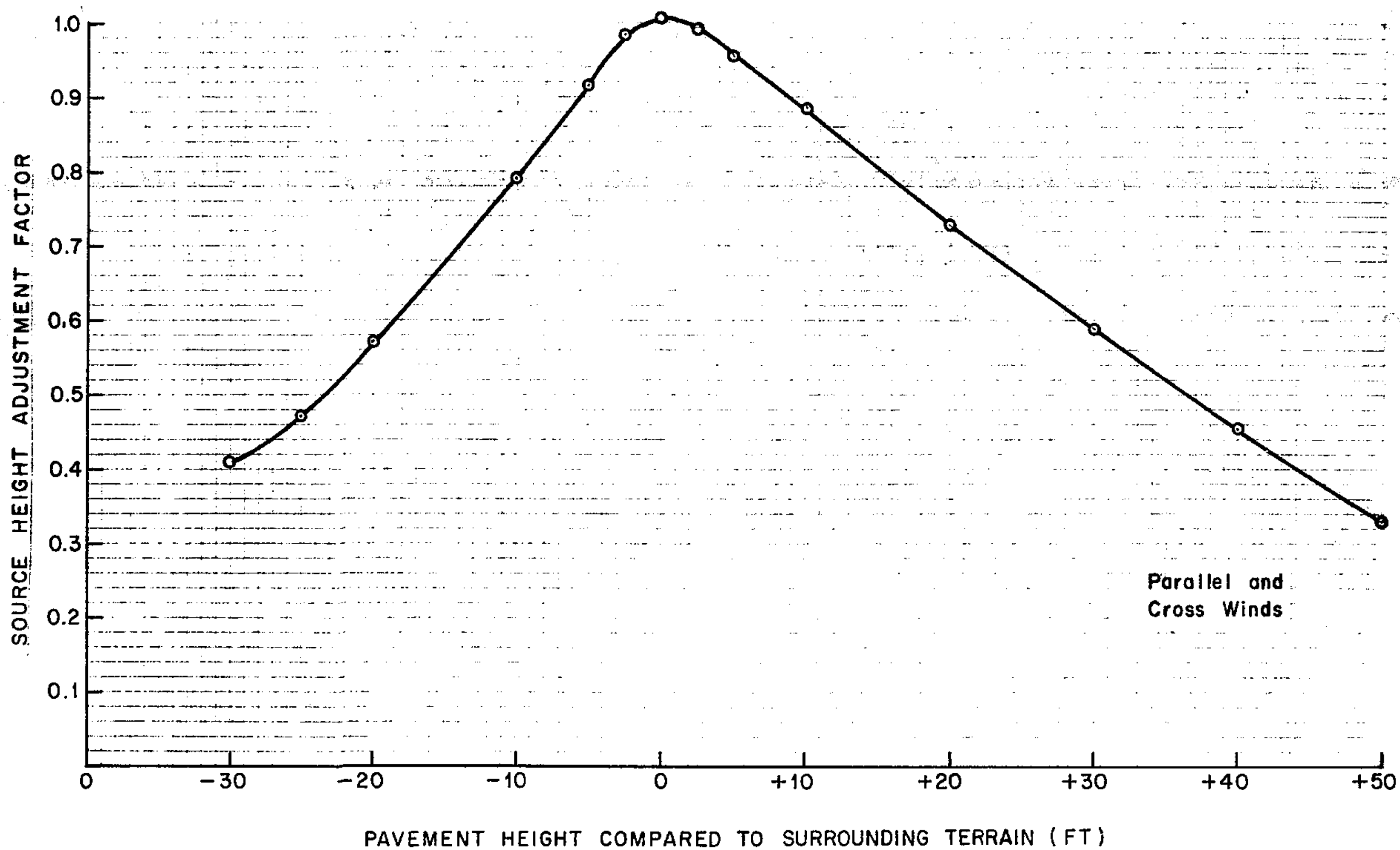


CHART NO. 4

URBAN PROJECTS
STABILITY CLASS D
CROSSWIND
DEPRESSED & AT GRADE SECTIONS

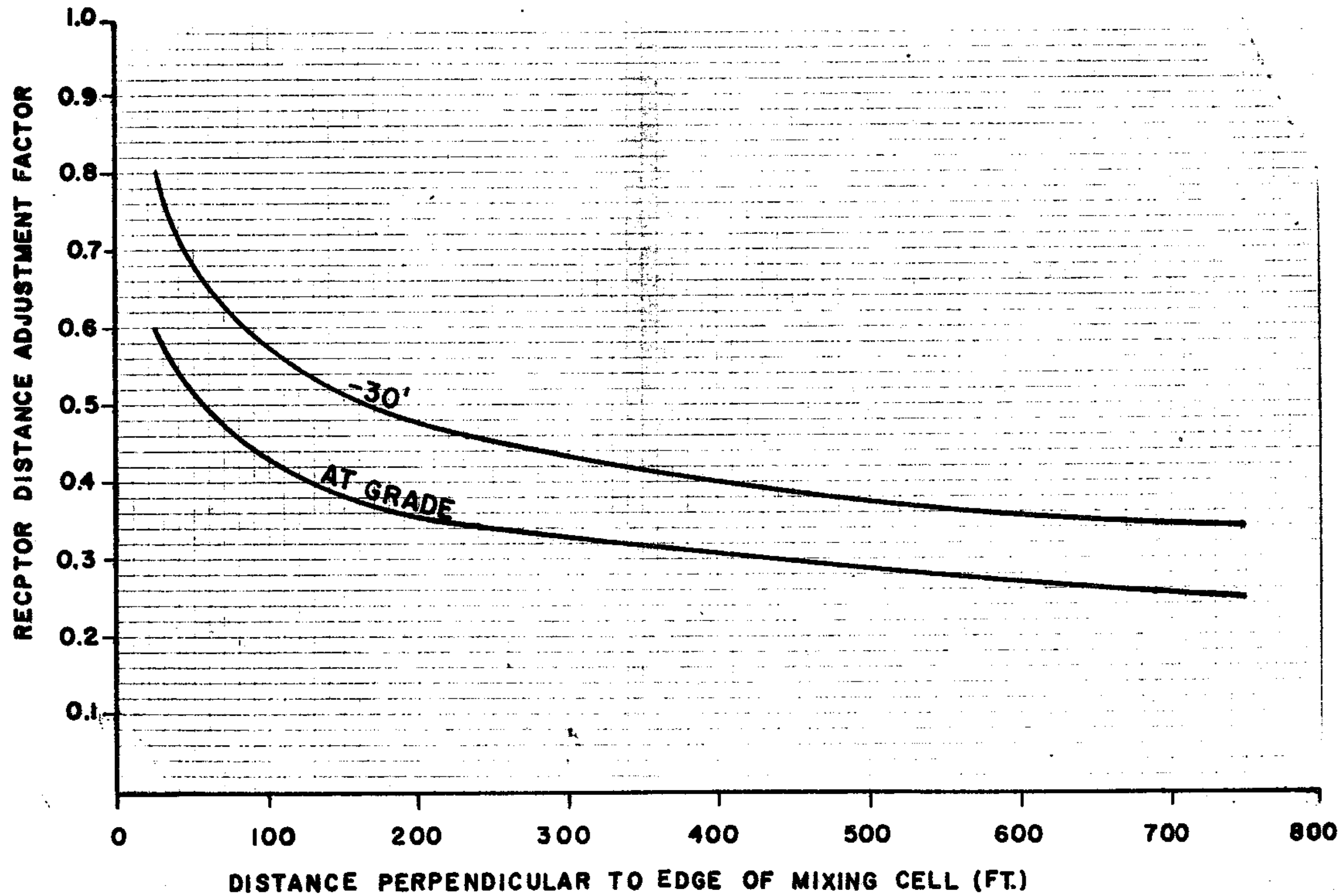


CHART NO. 5

URBAN PROJECTS
STABILITY CLASS D

PARALLEL WIND

ELEVATED SECTIONS

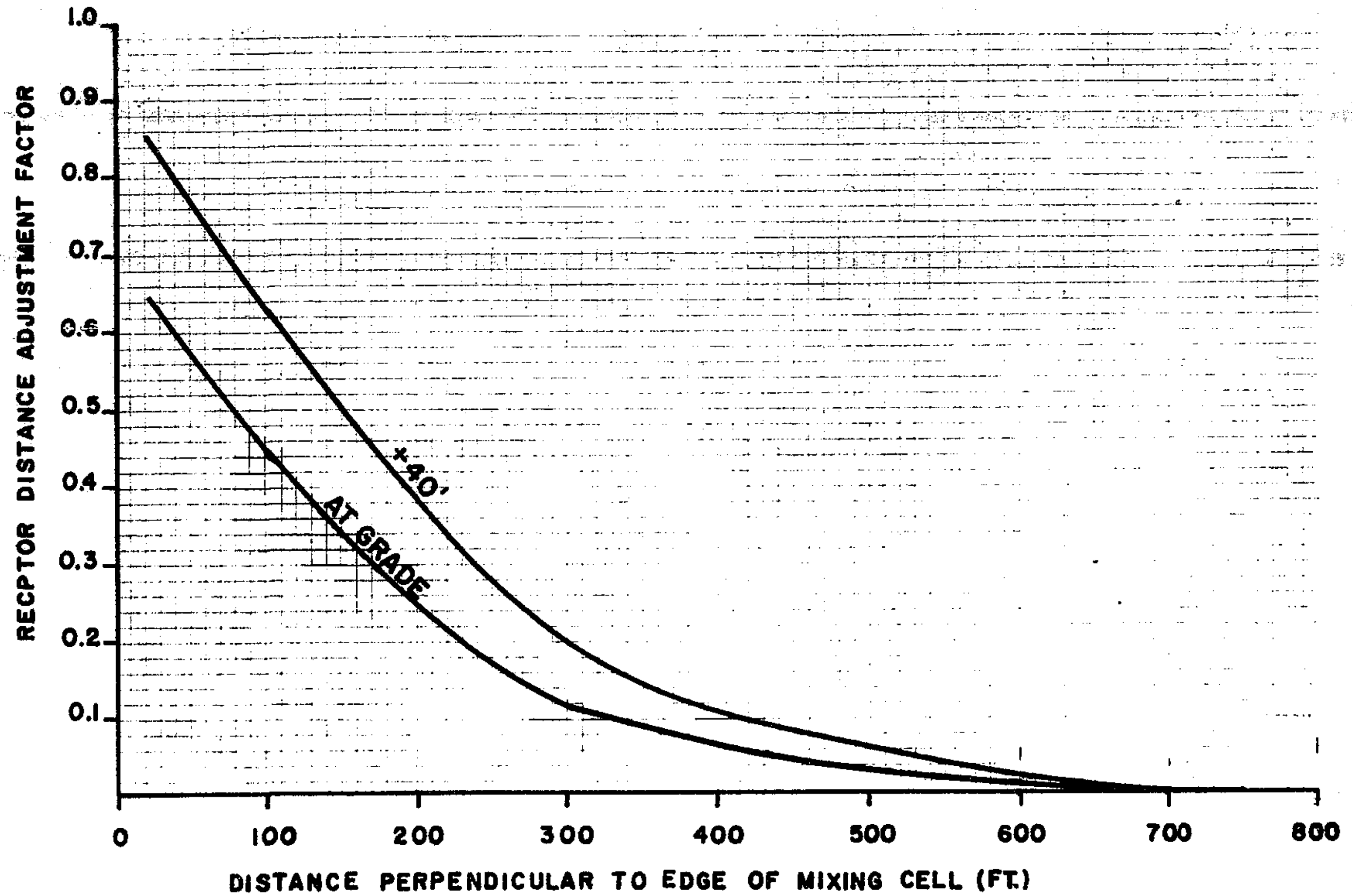


CHART NO. 6

URBAN PROJECTS
STABILITY CLASS D

PARALLEL WIND

DEPRESSED & AT GRADE SECTIONS

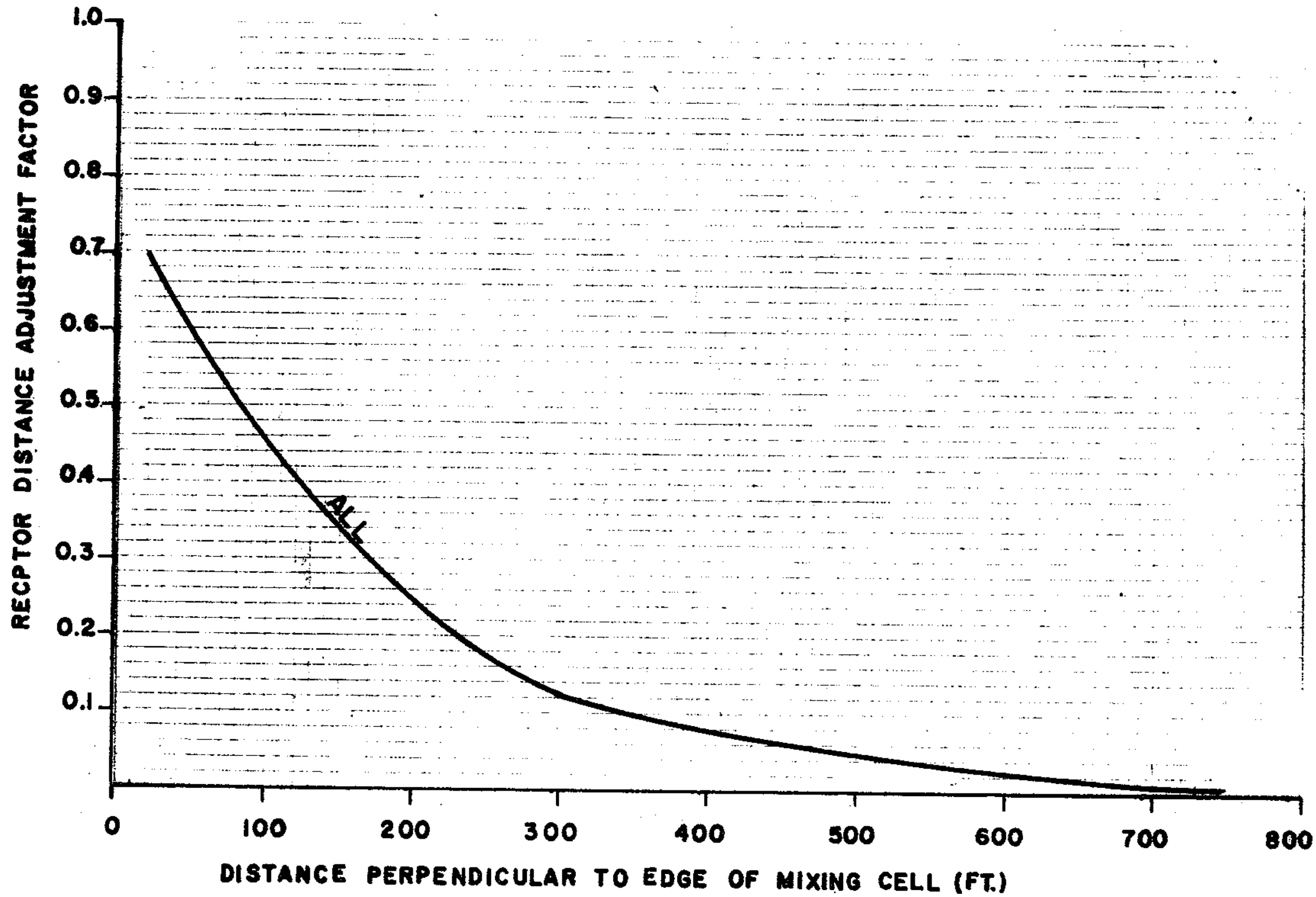


CHART NO. 7

RURAL PROJECTS
STABILITY CLASS F

CROSSWIND

DEPRESSED & AT GRADE SECTIONS

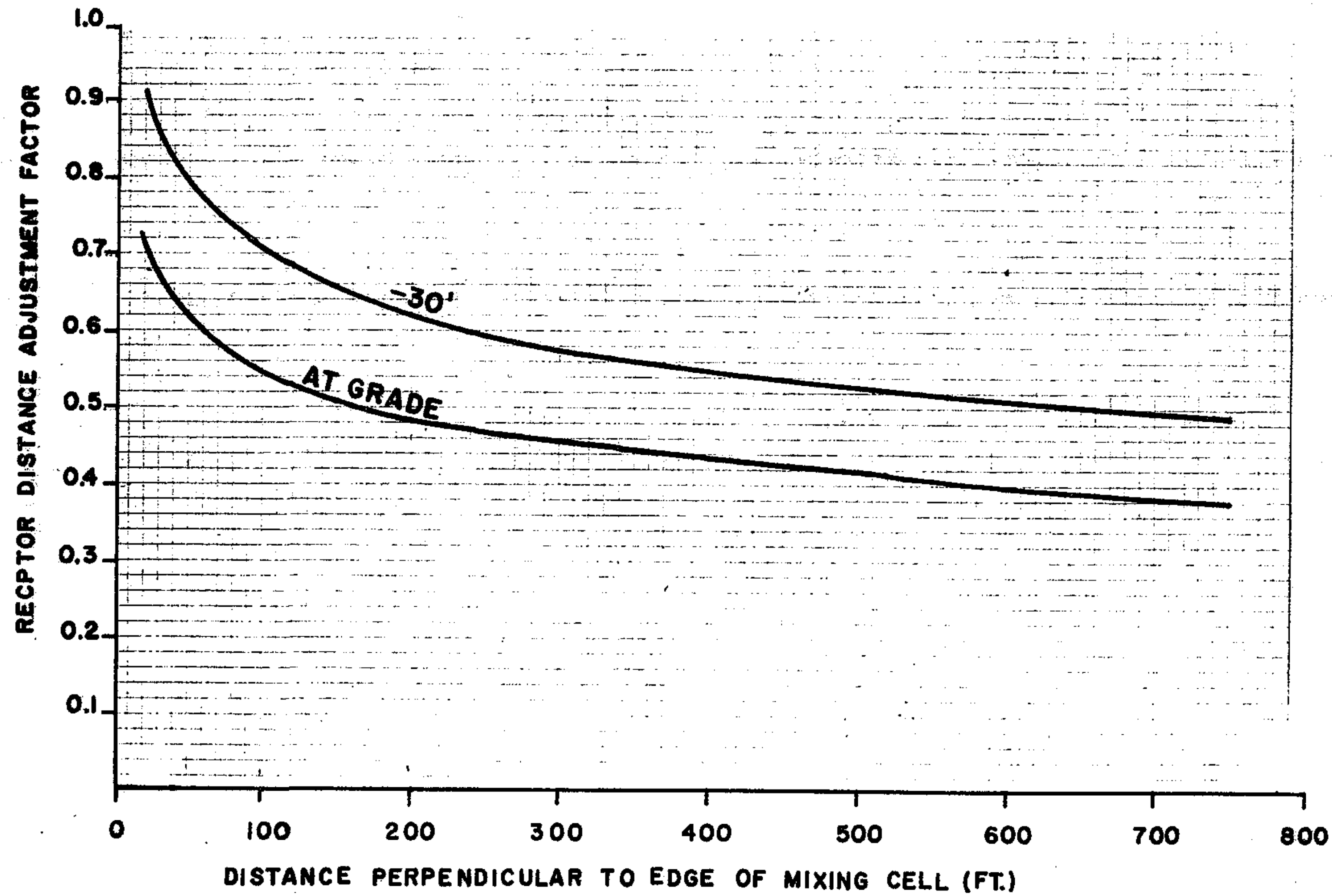


CHART NO. 8

RURAL PROJECTS
STABILITY CLASS F

PARALLEL WIND

ELEVATED SECTIONS

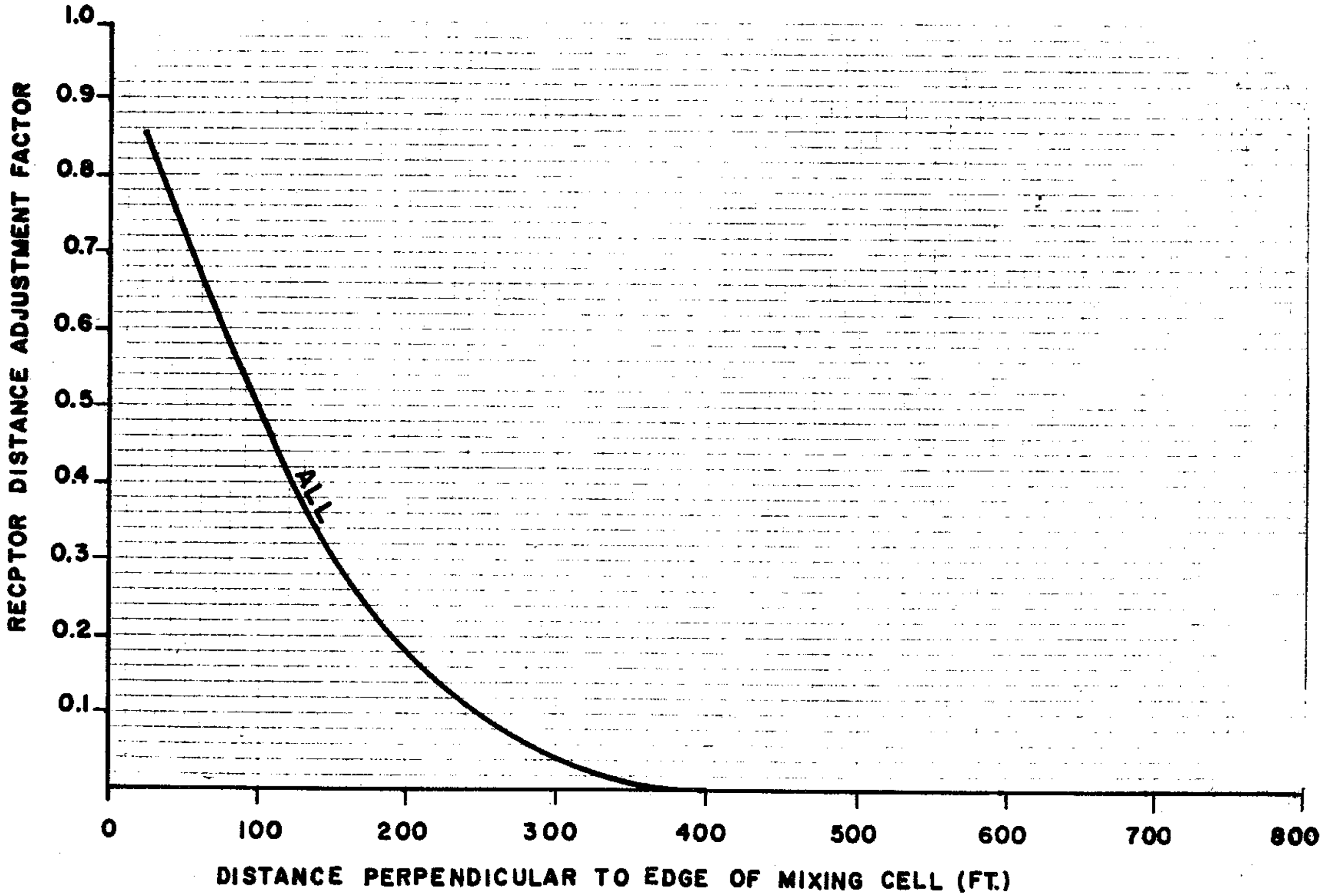
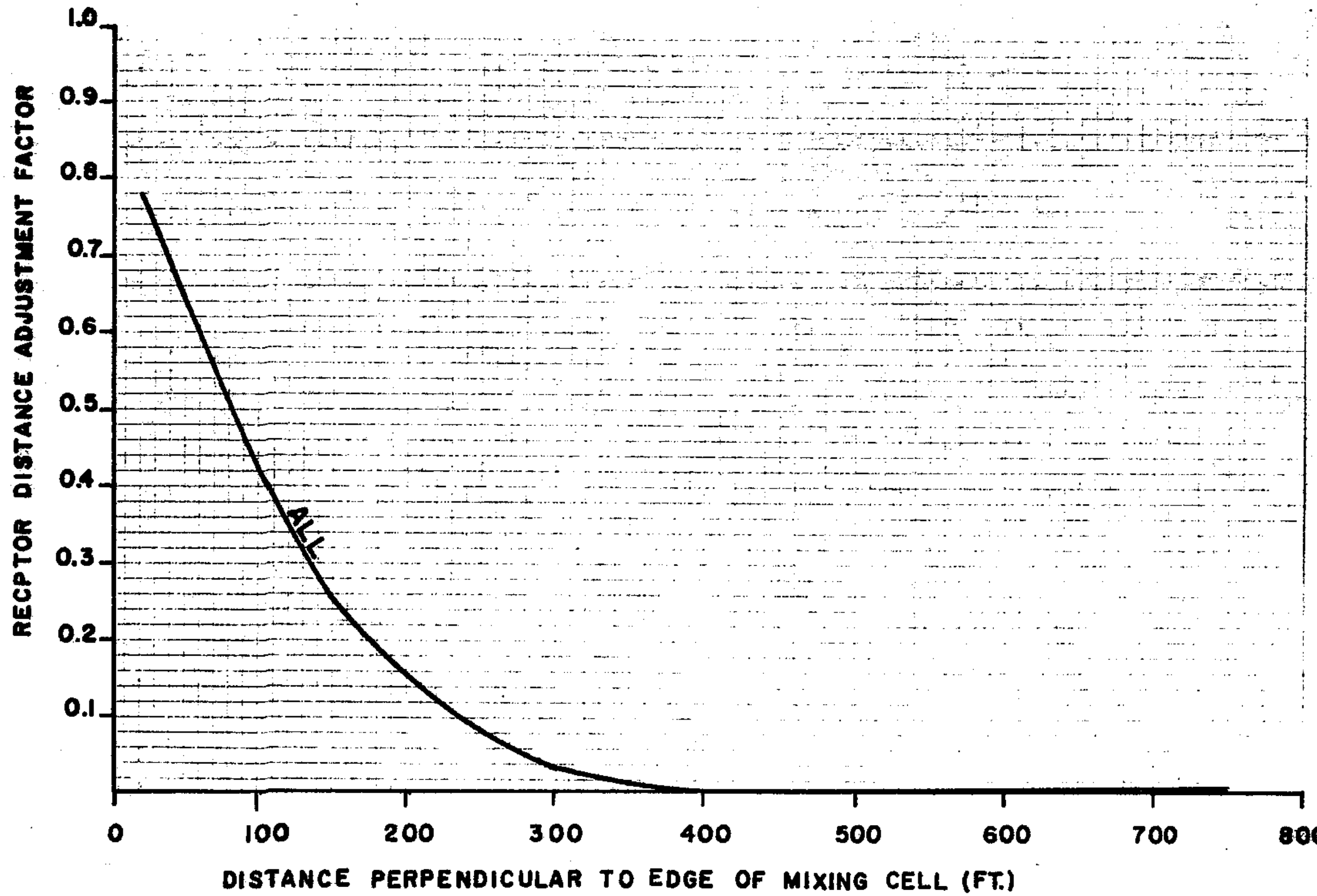


CHART NO. 9

RURAL PROJECTS
STABILITY CLASS F

PARALLEL WIND

DEPRESSED & AT GRADE SECTIONS



APPENDIX B

BASIC Language Listing of CALINE2
and
Examples of Use

```
100 REM **********  PROGRAM CALINEU (UPROGRAMITURKY)  ************

110 REM *****  TIME FUNCTION  *****
120 DEF STRING FNTIME
130 AA=INT(CLOCK/(60*100))
140 BB=ROUND(60*FRACT(CLOCK/(60*100)))
150 IF AA>12 THEN AA=AA-12, AM$='PM'   ELSE AM$='AM'
160 AA$=STR(AA), BB$=STR(BB)
170 IF BB<10 THEN BB$='0' + BB$
180 TME$=TDATE + '    ' + AA$ + ':' + BB$ + ' ' + AM$
190 RETURN TME$
200 END
210 REM *****  END OF 'TIME'   *****

220 PRINT CHAR(12)
230 DIM DMAT(6),ZMAT(6)
240 DIM STB$(6),OUT$(5),OT$(5)
245 RESTORE 260
250 MAT READ STB$
260 DATA "'A'","'B'","'C'","'D'","'E'","'F'"
270 MAT READ OUT$
280 DATA "'    U'","' PHI'","'    H'","'CLAS'","'    W'"
290 MAT READ OT$
300 DATA "'MPH    '","'DEGREES'","'FEET   '","6B","'FEET  '"

310 PGCT=0
320 PRINT IN FORM "/ 20B '***** PROGRAM CALINEU *****'":
330 PRINT IN FORM "/ 5B 'THIS IS AN INTERACTIVE EXAMPLE PROGRAM '
     'FOR CALINE, THE'/5B 'CALIFORNIA LINE SOURCE DISPERSION '
     'MODEL.  THIS PROGRAM UTILIZES'":
340 PRINT IN FORM "5B 'CALINE2, WHICH WAS REVISED IN JANUARY, '
     '1975.'/":
350 PRINT IN FORM "'DO YOU WANT AN INPUT FORMAT EXPLANATION'":
360 INPUT ANS$
370 IF ANS$='NO' THEN 470

380 REM *****      PROGRAM INPUT FORMAT EXPLANATION    *****
390 OPEN '5;LAB;CLINEXP',2,INPUT,RANDOM,OLD
400 FOR IEXP=1 TO TREC(2)
410 INPUT FROM 2 AT IEXP IN FORM "72%": ALN$
420 PRINT ALN$
430 NEXT IEXP
440 CLOSE 2
450 REM *****    END OF PROGRAM INPUT FORMAT EXPLANATION    *****

460 REM *****    INTERACTIVE DATA FROM USER    *****
470 I=0
480 PPMT=TITC=RCPT=DTAT=0
490 PRINT IN FORM "/4B '   *****  ENTER THE NUMBER IN PARENTHESES FOR '
     'YOUR CHOICE  *****' /":
500 PRINT IN FORM " 'PPM(1) OR MICROGRAMS/CUBIC METER(2)'":
510 INPUT PPMT
520 IF PPMT=1 OR PPMT=2 THEN 530 ELSE 500
530 PRINT IN FORM " 'TITLES IN DATAFILE(1), NOW(2), OR LET '
     'PROGRAM TITLE(3)'":
540 INPUT TITC
550 IF TITC=1 OR TITC=2 OR TITC=3 THEN 560 ELSE 530
560 IF TITC#2 THEN 590
570 PRINT IN FORM " 5B 'ENTER TITLE'":
580 INPUT TIT$
```

```
590 RESTORE 600
595 MAT READ DMAT,ZMAT
600 DATA 50,100 150,200,-99,-99,   10,5,-99,-99,-99,-99
610 PRINT IN FORM " 'RECEPTOR MATRIX IN DATAFILE(1), NOW(2), OR USE '
       'INTERNAL MATRIX(3)'":
620 INPUT RCPT
630 IF RCPT=1 OR RCPT=2 OR RCPT=3 THEN 640 ELSE 610
640 IF RCPT#2 THEN 670
650 PRINT IN FORM " 5B 'ENTER RECEPTOR MATRIX, 6 DIST. FIRST, THEN 6 '
       'HEIGHTS,'/5B 'ENTER -99 FOR THOSE NOT DESIRED'/5B 'INPUT?'":
660 MAT INPUT DMAT,ZMAT
670 PRINT IN FORM " 'INPUT DATA IN DATAFILE(1), OR NOW(2)'":
680 INPUT DTAT
690 IF DTAT=1 OR DTAT=2 THEN 700 ELSE 670
700 IF DTAT=1 THEN 750
710 $FN='ENTERED FROM TERMINAL'
720 PRINT IN FORM " 5B 'ENTER VPH,EF,U,PHI,H,CLAS,W'":
730 INPUT VPH,EF,U,PHI,H,CLAS,W
740 GOTO 800
750 PRINT IN FORM " / 'INPUT DATAFILE NAME'":
760 INPUT $FN
770 OPEN $FN,1,INPUT,OLD
780 ON ENDFILE(1) GOTO 1480

790 REM *****   DATA NEEDED TO RUN MODEL   *****
800 IF TITC#1 THEN 820
810 INPUT FROM 1:TIT$
820 IF RCPT#1 THEN 840
830 MAT INPUT FROM 1:DMAT,ZMAT
840 IF DTAT#1 THEN 860
850 INPUT FROM 1: VPH,EF,U,PHI,H,CLAS,W
860 IF INT(I/3)-I/3 # 0 THEN 910
870 PGCT=PGCT+1
880 PRINT CHAR(12)
890 PRINT IN FORM "/ 'PAGE ' 2% 5B 20% 2B 'INPUT=' 22%/
       'CALINE2:  CALIFORNIA LINE SOURCE DISPERSION MODEL,'":
       PGCT,FNTIME,$FN
900 PRINT IN FORM "10B 'REVISED JANUARY, 1975'":
910 I=I+1
920 IF TITC=3 THEN TIT$='C A L I N E 2    R U N    ' + STR(I)
930 ST$="3/"+STR(INT((72-LENGTH(TIT$))/2))+"B "+STR(LENGTH(TIT$))
       +"% //"
940 PRINT IN FORM ST$:TIT$
950 PPM$='PREDICTED CO CONCENTRATION'
960 IF PPMT=1 THEN PPM$=PPM$+' (PPM)'
970 IF PPMT=2 THEN PPM$=PPM$+' (MICROGM/CU M)'
980 PRINT IN FORM "  35B 42% // 5B 'VARIABLES' 11B 'RECEPTOR' 10B
       'DISTANCE PERPENDICULAR'/ 26B 'HEIGHT' 12B 'TO HIGHWAY  '
       '(D FEET)'/": PPM$
990 PRINT IN FORM "5B 'VPH=' 6% 10B '(Z FEET)'": VPH
1000 FOR ID=1 TO 6
1010 IF DMAT(ID)=-99 THEN 1070
1020 IF DMAT(ID)>=0 THEN 1050
1030 PRINT IN FORM "//'RECEPTOR DISTANCE MUST BE >= 0 OR = -99,'/
       'YOURS IS ' 7% /":DMAT(ID)
1040 END
1050 PRINT IN FORM "7%":DMAT(ID)
1060 NEXT ID
1070 PRINT IN FORM "/6B 'EF=' 3%.% ' GMS/MI' ":EF
1080 OUT1(1)=U, OUT1(2)=PHI, OUT1(3)=H, OUT1(4)=CLAS, OUT1(5)=W
```

```
1090 REM *****             RECEPTOR HEIGHT LOOP          *****
1100 IZ1=1, IZ2=6, IZST=1
1110 FOR IZ=1 TO 6
1120 IF ZMAT(IZ)=-99 THEN IZ2=IZ2-1
1130 NEXT IZ
1140 IF ZMAT(2)#-99 AND ZMAT(1)<ZMAT(2) THEN IZ1=IZ2, IZST=-1
1150 IZ=IZ1
1160 FOR J=1 TO 6
1170 T$="3% B"
1180 IF J=4 THEN T$="2% '('" + STB$(CLAS) + "')'"
1190 IF J=5 AND W>=100 THEN T$="4% B"
1200 IF J=6 THEN 1220
1210 PRT$="/ 4B" + OUT$(J) + "'='" + T$ + OT$(J)
1220 IF J=6 THEN PRINT IN FORM "/ 20B":, ELSE
       PRINT IN FORM PRT$:OUT1(J),
1230 IF ZMAT(IZ)=-99 THEN 1360
1240 IF ZMAT(IZ)>=0 THEN 1270
1250 PRINT IN FORM "// 'RECEPTOR HEIGHT MUST BE >= 0 OR = -99,'/
       'YOURS IS ' 7% /":ZMAT(IZ)
1260 END
1270 PRINT IN FORM "8B 2% 3B": ZMAT(IZ),

1280 REM *****          RECEPTOR DISTANCE LOOP          *****
1290 FOR ID=1 TO 6
1300 IF DMAT(ID)=-99 THEN 1360
1310 Z=ZMAT(IZ), D=DMAT(ID)
1320 GOSUB 2000
1330 IF PPMT=1 THEN PRINT IN FORM "5%.%":PPM, ELSE
       PRINT IN FORM "7% ":COMG,
1340 NEXT ID
1350 REM *****        END OF RECEPTOR DISTANCE LOOP     *****

1360 IZ=IZ+IZST
1370 IF IZ <= 0 THEN IZ=6
1380 NEXT J
1390 REM *****        END OF RECEPTOR HEIGHT LOOP      *****

1400 IF PPMT=1 THEN PRINT IN FORM "/30B 'MIXING CELL CONCENTRATION = '
       5%.% ' PPM' /":PPMX
1410 IF PPMT=2 THEN PRINT IN FORM "/23B 'MIXING CELL CONCENTRATION = '
       7% ' MICROGRAMS/CU METER' /":CMIX
1420 IF DTAT=1 THEN 800
1430 PRINT CHAR(12)
1440 PRINT IN FORM "/ 'MORE RUNS'":
1450 INPUT ANS$
1460 IF ANS$='YES' THEN 470
1470 GOTO 1490
1480 PRINT CHAR(12)
1490 PRINT IN FORM "/ 'ANOTHER DATAFILE'":
1500 INPUT ANS$
1510 IF ANS$='YES' THEN 470
1520 END
```

```
2000 REM   *************************************************************
2010 REM   *************************************************************
2020 REM   ***********  SUBROUTINE CALINE - ENTRY LINE 2000  ***********

2030 REM      WRITTEN BY CHUCK WARD - JANUARY 1975

2040 REM      THIS IS A NEW VERSION (CALINE2) OF THE CALIFORNIA LINE
              SOURCE DISPERSION MODEL (FOR PARALLEL & CROSS WIND
              CONDITIONS) ORIGINALLY DEVELOPED BY ANDREW RANZIERI.

2050 REM      THIS SUBROUTINE WILL BE CONTINUOUSLY UPDATED TO REFLECT
              THE LATEST MODELS.

2060 REM      THIS SUBROUTINE IS MEANT TO BE APPENDED TO THE END OF USER
              PROGRAMS.  THEY CAN THEN BE EASILY UPDATED BY DELETING THE
2065 REM      OLD VERSION OF "CALINE" AND APPENDING THE NEW.  IT WILL
              ALWAYS BE STORED AS "5;LAB;CALINE".

2070 REM      IT SHOULD ONLY BE CALLED BY "GOSUB 2000".  IT SHOULD NOT
              BE MODIFIED INTERNALLY WITHOUT FIRST CONTACTING ANDY
              RANZIERI, GERRY BEMIS, OR CHUCK WARD - ATSS 432-4874.

2080 REM   ************       WARNING       ************

2090 REM      USE CAUTION WHEN LABELING VARIABLES IN YOUR CALLING
              PROGRAM SO THAT THE LABELS DO NOT DUPLICATE VARIABLES
              INTERNAL TO THIS SUBROUTINE.

2095 REM      THE FOLLOWING IS A LIST OF THE INTERNAL SUBROUTINE
              VARIABLES (WITH WHAT LOOKS LIKE AN "O" BEING A ZERO):

2097 REM      BN01, BN02, DODW, DOKM, DOM1, DOM2, DOM3, DOM4, DOM5,
              DOM6, DOM7, DWOK, FTRO, FTR2, FTR3, HOMT, ION, K01, MOWT,
2098 REM      NOSG, PHOR, PSO, PSOT, Q0, RODT, ROTO, SGOY, SG1Y, SG2Y,
              SG0Z, SKLO, UOBR, VTOX, WOMT, YOMT, Y2MT, ZOMT.

2100 REM    INPUT PARAMETERS:
              VPH     VEHICLES PER HOUR
              EF      EMISSION FACTOR (GMS/MI)
              U       WIND SPEED (MPH)
              PHI     WIND ANGLE (DEGREES)
2110 REM      H       PAVEMENT HEIGHT (FEET)
              Z       RECEPTOR HEIGHT (FEET)
              D       DISTANCE FROM SOURCE TO RECEPTOR (FEET)
              CLAS    STABILITY CLASS (1-6 = A-F)
2120 REM      W       WIDTH OF HIGHWAY (LANES, MEDIAN, AND 10 FEET ON EACH
                              SIDE OF HIGHWAY, IN FEET)

2140 REM    OUTPUT:
              COMG    POLLUTANT CONCENTRATION (MICROGRAMS PER CUBIC
                      METER) AT DISTANCE "D" &/OR HEIGHT "Z"
2145 REM      PPM     POLLUTANT CONCENTRATION (PARTS PER MILLION)
                      AT DISTANCE "D" &/OR HEIGHT "Z"
2150 REM      CMIX    POLLUTANT CONCENTRATION (MICROGRAMS PER CUBIC
                      METER) IN MIXING CELL
              PPMX    MIXING CELL POLLUTANT CONCENTRATION (PPM)
```

```
2160 REM   ************        NOTE        ************

2170 REM       THIS SUBROUTINE IS DESIGNED TO BE USED ONLY WITH CARBON
               MONOXIDE WHICH HAS A MOLECULAR WEIGHT OF 28.

2175 REM       ALSO, ALL PREDICTED POLLUTANT CONCENTRATIONS ARE ABOVE
               BACKGROUND LEVELS, I.E., THE BACKGROUND LEVELS HAVE TO
               BE ADDED EXTERNALLY.


2180 REM   ************  GENERAL EDITS   ************

2190 IF CLAS>0 AND CLAS<7 THEN 2220    ! STABILITY CLASS MUST BE
                                         A THRU F
2200 PRINT IN FORM "'STABILITY CLASS MUST BE IN RANGE 1 TO 6'
           ' (A TO F)'/'YOUR STABILITY CLASS IS '%%%/":CLAS
2210 END

2220 IF U>=2 THEN 2250    ! WIND SPEED MUST BE GREATER THAN 2 MPH
2230 PRINT IN FORM "'MODEL NOT VALID FOR WIND SPEEDS LESS THAN 2 MPH'/
          'YOUR WIND SPEED IS '%%.%%' MPH'":U
2240 END

2250 IF Z>= 0 THEN 2280    !  NO DEPRESSED RECEPTORS ARE ALLOWED
2260 PRINT IN FORM "'MODEL NOT VALID FOR DEPRESSED RECEPTORS'/
          'YOUR RECEPTOR IS AT '%%%.%%' FEET'":Z
2270 END

2280 IF D>= 0 THEN 2310    !  NO UPWIND RECEPTORS ARE ALLOWED
2290 PRINT "MODEL NOT VALID FOR UPWIND RECEPTORS"
2300 END

2310 IF H>=-30 THEN 2350    ! NO DEPRESSED SECTION < 30 FEET DEEP
2320 PRINT IN FORM "'MODEL NOT VALID FOR DEPRESSED (CUT) SECTIONS '
          'DEEPER THAN 30 FEET'/'YOUR SECTION IS '%%%.%%
          ' FEET DEEP'":-H
2330 END



2340 REM   ************ CHOOSE MODEL ************

2350 MOWT=28                 !  CARBON MONOXIDE MOLECULAR WEIGHT
2360 ZOMT=Z/3.28084          !  CONVERSION FROM FEET TO METERS
2370 IF Z<=5 THEN ZOMT=0      ! IF RECEPTOR HEIGHT IS < 5 FEET, IT IS
                                CONSIDERED TO BE AT GROUND LEVEL
2380 GOSUB 3120     !  RATIO SUBROUTINE FOR DEPRESSED SECTIONS.
                       WILL RETURN VALUE OF 1 IF NOT A DEPRESSED SECTION
2390 HOMT=H/3.28084      ! CONVERSION FROM FEET TO METERS

2400 REM   ***** IF PAVEMENT HEIGHT IS < 0 FEET, IT IS CONSIDERED *****
           ***** TO BE AT GROUND LEVEL. THE RESULT OF THE RATIO   *****
2405 REM   ***** SUBROUTINE IS THEN USED TO ACCOUNT FOR DEPRESSED *****
           ***** SECTIONS.                                        *****

2410 IF H<0 THEN HOMT=0

2420 UOBR=U/2.23714        !  CONVERSION FROM MPH TO METERS PER SECOND
2430 PHOR=RAD(PHI)           !  CONVERSION FROM DEGREES TO RADIANS
```

```
2435 WOMT=W/3.28084          !  CONVERSION FROM FEET TO METERS
2437 DODW=W*ROUND(2640/W)     ! DISTANCE CLOSEST TO 1/2 MILE THAT WILL
                                BE EVENLY DIVISABLE BY WIDTH
2438 COMG=0
2439 K01=0
2440 IF DOM1=VPH AND DOM2=EF AND DOM3=U AND DOM4=PHI AND DOM5=H
       AND DOM6=CLAS AND DOM7=W THEN K01=1
2445 IF K01=1 THEN 2450 ELSE CMIX=0   ! TO SKIP MIX CELL CALC.
2450 IF PHI = 0 THEN 2600    !  BRANCH TO PARALLEL MODEL


2460 REM   ************ CROSS WIND MODEL ***********

2470 REM   ***** THE CROSSWIND MODEL, FOR WIND ANGLES BETWEEN *****
           ***** 0 DEGREES AND 90 DEGREES, ADDS COMPONENTS OF *****
2475 REM   ***** THE "PURE" CROSSWIND AND PARALLEL MODELS VIA *****
           ***** A PERCENTAGE DERIVED FROM THE SQUARE OF      *****
2477 REM   ***** SIN(PHI) (FOR CROSSWIND) AND THE SQUARE OF   *****
           ***** COS(PHI) (FOR PARALLEL WIND)                 *****

2480 Q0 = 1.73E-7*VPH*EF       !  SOURCE STRENGTH
2490 IF K01=1 THEN 2520    ! TO SKIP MIX CELL CALC.
2500 CMIX=(SIN(PHOR)**2)*2.0E6*Q0/(SQRT(2*PI)*4*U0BR)
2510 PPMX=CMIX*0.0245/MOWT
2520 DOKM=D/3280.84             !  CONVERSION FROM FEET TO KILOMETERS

2523 REM *****  IF RECEPTOR DISTANCE IS 0' AND RECEPTOR HEIGHT IS *****
         *****  IN MIXING CELL (UP TO 12' ABOVE HWY), RECEPTOR IS *****
2524 REM *****  GIVEN MIXING CELL CONCENTRATION                   *****

2525 COMG=CMIX
2527 IF D=0 AND ((Z-H)>=0 AND (Z-H)<=12) THEN 2560

2540 GOSUB 3580                 !  OBTAIN SIGMA Z

2545 REM   ***** GAUSSIAN DIFFUSION CONCENTRATION EQUATION FOR *****
           ***** CROSS WINDS (INFINITE LINE SOURCE)            *****

2550 COMG=Q0*1.0E6*(EXP(-.5*((ZOMT+HOMT)/SG0Z)**2)
      +EXP(-.5*((ZOMT-HOMT)/SG0Z)**2))*ROTO*(SIN(PHOR)**2)
      /(SQRT(2*PI)*SG0Z*U0BR)

2560 PPM=COMG*0.0245/MOWT
2580 IF PHI < 90 THEN 2600
2590 RETURN      !  EXIT TO MAIN PROGRAM


2600 REM   ************ PARALLEL WIND MODEL ************

2610 REM   ***** THE PARALLEL WIND MODEL USED HERE IS A COMPLETE  *****
           ***** CHANGE FROM THE PREVIOUS MODEL.  IN THIS MODEL,  *****
2620 REM   ***** THE ROADWAY IS DIVIDED INTO A SERIES OF SQUARE   *****
           ***** AREA SOURCES AT INCREMENTALLY CLOSER DISTANCES   *****
2630 REM   ***** TO THE RECEPTOR.  CONCENTRATIONS FROM EACH AREA  *****
           ***** SOURCE ARE SUMMED AT THE RECEPTOR FOR A          *****
2640 REM   ***** CUMULATIVE CONCENTRATION.                        *****

2660 IF RODT=1 THEN 2700
```

```
2675 REM    ***** SCALE FOR INCREASING PARALLEL CONCENTRATIONS *****
            ***** TO THOSE FOR "INFINITE" LINE SOURCE IS SET    *****
            ***** AT 5 MILES                                    *****

2676 RESTORE 2680
2677 MAT READ SKL0(6)
2680 DATA 1.00,0.94,0.86,0.73,0.61,0.48

2681 REM  ***** FTR0 IS A MATRIX OF DATA USED TO RECALCULATE THE *****
          ***** FIRST SEGMENT OF SIGMA Y CURVES ACCORDING TO     *****
2682 REM  ***** HIGHWAY WIDTH                                    *****

2683 MAT READ FTR0(3,6)
2684 DATA 0.9,0.8,0.8,0.6,0.7,0.6
2685 DATA 242.36,169,120,86.96,65,49
2686 DATA 0.494,0.442,0.392,0.346,0.304,0.263
2689 RODT=1

2700 SG1Y=W0MT/4.3        !  ESTIMATE FOR SIGMA Y TO OBTAIN VIRTUAL DIST.

2710 REM  ***** A VIRTUAL DISTANCE BACK TO A POINT WHICH WOULD   *****
          ***** GIVE NEARLY THE SAME AREA SOURCE MUST BE         *****
2720 REM  ***** DETERMINED.                                      *****

2730 GOSUB 4000       ! TO ADJUST INITIAL SIGMA Y ACCORDING
                        TO ROAD WIDTH
2740 VTOX=BN01         !  VIRTUAL DISTANCE (IN KM)

2750 REM   ***** THE SIGMA Y FOR THE VIRTUAL DISTANCE "VTOX" IS    *****
           ***** KEPT TO MOVE THE X-AXIS INWARD TOWARDS THE        *****
2755 REM   ***** ACTUAL HIGHWAY CENTERLINE, SO THE SIGMA Y OF      *****
           ***** "VTOX" COINCIDES APPROXIMATELY WITH THE EDGE OF   *****
2760 REM   ***** THE HIGHWAY.  THIS ARTIFICIALLY FORCES THE MODEL  *****
           ***** TO ASSUME UNIFORM CONCENTRATION WITHIN THE        *****
2770 REM   ***** MIXING CELL, A CONDITION WHICH WOULD NOT EXIST    *****
           ***** WITH A VIRTUAL POINT SOURCE.                      *****

2780 SG2Y=SG1Y*SQRT(-2*LOG(SG1Y*SQRT(2*PI)/W0MT))

2790 Q0=1.73E-7*VPH*EF*W0MT      !  SOURCE STRENGTH
2800 NOSG=ROUND((D0DW/3.28084)/W0MT)        !  NUMBER OF AREA SOURCES
2805 IF K01=1 THEN 2845     ! TO SKIP MIX CELL CALC.
2810 Z0MT,Y0MT,H0MT=0
2815 DO 2880:3000
2820 CMIX=PS0T+CMIX
2825 PPMX=CMIX*0.0245/M0WT
2830 D0M1=VPH, D0M2=EF, D0M3=U, D0M4=PHI, D0M5=H, D0M6=CLAS,
       D0M7=W
2835 IF H>0 THEN H0MT=H/3.28084
2840 IF Z>5 THEN Z0MT=Z/3.28084

2845 REM *****  IF RECEPTOR DISTANCE IS 0' AND RECEPTOR HEIGHT IS *****
         *****  IN MIXING CELL (UP TO 12' ABOVE HWY), RECEPTOR IS *****
2847 REM *****  GIVEN MIXING CELL CONCENTRATION                   *****

2850 IF D#0 OR ((Z-H)<0 OR (Z-H)>12) THEN 2865
2855 COMG=CMIX
2860 GOTO 3020
```

```
2865 YOMT=D/3.28084
2880 PSOT=0
2890 DWOK=DODW/3280.84 - WOMT/1000    ! CONVERSION FROM FEET TO KM AND
                                        TRANSPOSE AXIS TO "MIDDLE" OF
                                        FIRST CELL (AREA SOURCE)
2900 FOR ION=1 TO NOSG
2910 DOKM=DWOK+VTOX
2920 GOSUB 3190      !  SIGMA Y SUBROUTINE
2930 GOSUB 3580      !  SIGMA Z SUBROUTINE
2940 Y2MT=(YOMT+SG2Y)/SGOY
2950 IF Y2MT>9 THEN Y2MT=9      !  TO PREVENT EXPONENTIAL UNDERFLOW

2955 REM  ***** GAUSSIAN DIFFUSION CONCENTRATION EQUATION FOR *****
          ***** PARALLEL WINDS (MODIFIED POINT SOURCE EQ.)    *****

2960 PSO=(COS(PHOR)**2)*Q0/(2*PI*SGOZ*SGOY*UOBR)*EXP(-.5*Y2MT**2)
       *(EXP(-.5*((ZOMT-HOMT)/SGOZ)**2)+EXP(-.5*((ZOMT+HOMT)/SGOZ)**2))

2970 PSOT=PSOT+PSO      !  SUMMATION OF AREA SOURCE CONCENTRATIONS
2980 DWOK=DWOK-WOMT/1000
2990 NEXT ION
3000 PSOT=PSOT*1.0E6/SKLO(CLAS)
3010 COMG=PSOT*ROTO+COMG
3020 PPM=COMG*0.0245/MOWT
3100 RETURN      !  EXIT TO MAIN PROGRAM


3110 REM  ***** THE FOLLOWING IS THE RATIO SUBROUTINE FOR        *****
          ***** ARTIFICIALLY INCREASING THE MIXING CELL          *****
3115 REM  ***** CONCENTRATION IN A DEPRESSED SECTION.            *****

3120 ROTO=1
3130 IF H>=0 THEN RETURN      !  IF THE HIGHWAY IS NOT DEPRESSED,
                                 RETURN A VALUE OF 1
3140 IF CLAS=1 THEN
       ROTO=10**(-0.18164+0.01448*H+1.439E-5*VPH+7.9E-4*PHI)

3150 IF CLAS=2 THEN
       ROTO=10**(0.21754+0.01431*H-7.2E-4*PHI-0.02252*U)
3160 IF CLAS>2 THEN
       ROTO=10**(0.02019+0.0138*H+4.98E-6*VPH-5.73E-3*U)
3170 IF ROTO>1 THEN ROTO=1
3180 RETURN


3190 REM  ***** THE FOLLOWING IS THE SIGMA SUBROUTINE FOR        *****
          ***** CALCULATING SIGMA Y, THE HORIZONTAL DISPERSION   *****
3195 REM  ***** PARAMETER                                        *****

3200 IF DOKM>= BN01 THEN 3230
3210 SGOY=SG1Y                  !  MIXING CELL DISPERSION PARAMETER
3220 RETURN

3230 ON CLAS GOTO 3250, 3300, 3350, 3400, 3450, 3500

3240 REM  ************ STABILITY CLASS A ************

3250 IF DOKM<.9 THEN SGOY=FTR2*DOKM**FTR3
3260 IF DOKM>=.9 AND DOKM<2.0 THEN SGOY=247.5*DOKM**.692
```

```
3270 IF DOKM>=2.0 THEN SGOY=215.2*DOKM**.898
3280 RETURN

3290 REM   ************ STABILITY CLASS B ************

3300 IF DOKM<.9 THEN SGOY=FTR2*DOKM**FTR3
3310 IF DOKM>=.9 AND DOKM<1.5 THEN SGOY=172*(DOKM)**.707
3320 IF DOKM>=1.5 THEN SGOY=161*(DOKM)**.874
3330 RETURN

3340 REM   ************ STABILITY CLASS C ************

3350 IF DOKM<.8 THEN SGOY=FTR2*DOKM**FTR3
3360 IF DOKM>=.8 AND DOKM<1.5 THEN SGOY=128.4*DOKM**.692
3370 IF DOKM>=1.5 THEN SGOY=121.77*DOKM**.817
3380 RETURN

3390 REM   ************ STABILITY CLASS D ************

3400 IF DOKM<.6 THEN SGOY=FTR2*DOKM**FTR3
3410 IF DOKM>=.6 AND DOKM<1.5 THEN SGOY=98.65*DOKM**.588
3420 IF DOKM>=1.5 THEN SGOY=89.6*DOKM**.826
3430 RETURN

3440 REM   ************ STABILITY CLASS E ************

3450 IF DOKM<.7 THEN SGOY=FTR2*DOKM**FTR3
3460 IF DOKM>=.7 AND DOKM<1.5 THEN SGOY=70*(DOKM)**.494
3470 IF DOKM>=1.5 THEN SGOY=61*(DOKM)**.82
3480 RETURN

3490 REM   ************ STABILITY CLASS F ************

3500 IF DOKM<.6 THEN SGOY=FTR2*DOKM**FTR3
3510 IF DOKM>=.6 AND DOKM<1.5 THEN SGOY=53.5*(DOKM)**.435
3520 IF DOKM>=1.5 AND DOKM<3.0 THEN SGOY=49*(DOKM)**.653
3530 IF DOKM>=3.0 THEN SGOY=38.6*(DOKM)**.876
3540 RETURN


3580 REM   ***** THE FOLLOWING IS THE SIGMA SUBROUTINE FOR          *****
           ***** CALCULATING SIGMA Z, THE VERTICAL DISPERSION       *****
3585 REM   ***** PARAMETER                                          *****

3590 IF DOKM>=0.001 THEN 3620        !  IF DISTANCE FROM THE HIGHWAY IS
                                        > ONE METER
3600 SGOZ=4                          !  MIXING CELL DISPERSION PARAMETER
3610 RETURN
3620 ON CLAS GOTO 3640, 3710, 3780, 3850, 3910, 3960

3630 REM   ************ STABILITY CLASS A ************

3640 IF DOKM<.04 THEN SGOZ=47.4*(DOKM)**.357
3650 IF DOKM>=.04 AND DOKM<.1 THEN SGOZ=91*(DOKM)**.562
3660 IF DOKM>=.1 AND DOKM<.2 THEN SGOZ=148*(DOKM)**.782
3670 IF DOKM>=.2 AND DOKM<.4 THEN SGOZ=300*(DOKM)**1.22
3680 IF DOKM>=.4 THEN SGOZ=489*(DOKM)**1.74
3690 RETURN
```

```
3700 REM  ************ STABILITY CLASS B ************

3710 IF DOKM<.1 THEN SG0Z=34.9*(DOKM)**.314
3720 IF DOKM>=.1 AND DOKM<.2 THEN SG0Z=62*(DOKM)**.565
3730 IF DOKM>=.2 AND DOKM<.4 THEN SG0Z=78*(DOKM)**.71
3740 IF DOKM>=.4 AND DOKM<1.0 THEN SG0Z=105*(DOKM)**1.04
3750 IF DOKM>=1 THEN SG0Z=105*(DOKM)**1.104
3760 RETURN

3770 REM  ************ STABILITY CLASS C ************

3780 IF DOKM<.15 THEN SG0Z=28.4*(DOKM)**.283
3790 IF DOKM>=.15 AND DOKM<.3 THEN SG0Z=45.8*(DOKM)**.536
3800 IF DOKM>=.3 AND DOKM<.6 THEN SG0Z=49*(DOKM)**.594
3810 IF DOKM>=.6 AND DOKM<1.0 THEN SG0Z=58*(DOKM)**.922
3820 IF DOKM>=1.0 THEN SG0Z=58*(DOKM)**.909
3830 RETURN

3840 REM  ************ STABILITY CLASS D ************

3850 IF DOKM<.2 THEN SG0Z=22.4*(DOKM)**.249
3860 IF DOKM>=.2 AND DOKM<.5 THEN SG0Z=26.9*(DOKM)**.36
3870 IF DOKM>=.5 AND DOKM<1.0 THEN SG0Z=31.4*(DOKM)**.534
3880 IF DOKM>=1.0 THEN SG0Z=31.4*(DOKM)**.652
3890 RETURN

3900 REM  ************ STABILITY CLASS E ************

3910 IF DOKM<.3 THEN SG0Z=17.44*DOKM**.213
3920 IF DOKM>=.3 AND DOKM<.7 THEN SG0Z=20.32*DOKM**.340
3930 IF DOKM>=.7 THEN SG0Z=21.98*DOKM**.561
3940 RETURN

3950 REM  ************ STABILITY CLASS F ************

3960 IF DOKM<.5 THEN SG0Z=13.6*(DOKM)**.177
3970 IF DOKM>=.5 AND DOKM< 1.5 THEN SG0Z=14.68*DOKM**.289
3980 IF DOKM>=1.5 THEN SG0Z=13.2*DOKM**.552
3990 RETURN

4000 REM  ***** THE FOLLOWING IS THE FACTOR SUBROUTINE WHICH       *****
          ***** ADJUSTS THE FIRST PORTION OF THE SIGMA Y CURVES    *****
4010 REM  ***** TO COMPENSATE FOR DIFFERENT (FROM 112') HIGHWAY    *****
          ***** WIDTHS                                             *****

4040 REM  ***** THE MINIMUM DISTANCE IN KILOMETERS IS FOUND        *****
          ***** USING AN EXTRAPOLATION OF THE CURRENT SIGMA Y      *****
4050 REM  ***** CURVE FOR STABILITY CLASS A                        *****

4060 BN01=(SG1Y/241.917)**(1/0.4766)

4070 BN02=FTR0(2,CLAS)*FTR0(1,CLAS)**FTR0(3,CLAS)
4080 FTR3=(LOG10(BN02)-LOG10(SG1Y))/(LOG10(FTR0(1,CLAS))-LOG10(BN01))
4090 FTR2=SG1Y/(BN01**FTR3)
4100 RETURN

4450 REM  ************    END OF SUBROUTINE CALINE    ****************
```

"5;LAB;CALINEU" will allow the user to select the output form of the estimated pollutant concentrations, either in parts per million or in micrograms per cubic meter. It will allow the user to specify separate titles for each simulation run, or the program will create the titles. The receptor locations can be supplied by the program or by the user selecting 1 to 36 receptors in a "matrix" format, i.e., each receptor distance will be used in turn with each receptor height. The required input data for each simulation (VPH, emission factor, etc.) can be stored in a file for access by the program or can be input from the terminal during the execution of the program. Titles and receptor locations can also be stored in a file with the input data, or input from the terminal during program execution. "5;LAB;CALINEU" will continue to execute as long as it is fed information or until it encounters an error. More detailed information about "5;LAB;CALINEU" is contained in the attached reproduction of the input format explanation (which can be requested during program execution).

Example runs of "5;LAB;CALINEU" are attached.

In the following TENET BASIC example run of "5;LAB;CALINEU", underlined words and data are those entered by the user.

COPY LINEDATA TO TEL TEXT

6000	25	3	90	0	1	120
6000	25	3	45	0	1	120
6000	25	3	0	0	1	120
6000	25	3	90	0	4	120
6000	25	3	45	0	4	120
6000	25	3	0	0	4	120
6000	25	3	90	0	6	120
6000	25	3	45	0	6	120
6000	25	3	0	0	6	120

```
BASIC
>LINK "5;LAB;CALINEU"
```

```
***** PROGRAM CALINEU *****

     THIS IS AN INTERACTIVE EXAMPLE PROGRAM FOR CALINE, THE
     CALIFORNIA LINE SOURCE DISPERSION MODEL.  THIS PROGRAM UTILIZES
     CALINE2, WHICH WAS REVISED IN JANUARY, 1975.

DO YOU WANT AN INPUT FORMAT EXPLANATION?YES


     *********  PROGRAM CALINEU (UPROGRAMIT)   *********

THIS PROGRAM IS DESIGNED TO ALLOW YOU TO DO THE FOLLOWING:

     1) POLLUTANT OUTPUT TYPE
       A) PPM OF CO
       B) MICROGRAMS PER CUBIC METER OF CO
       C) THE PROGRAM WILL ASK YOU
          "PPM(1) OR MICROGRAMS/CUBIC METER(2)?".
          YOUR RESPONSE WILL BE  1  FOR CHOICE (A) OR  2  FOR CHOICE
          (B).

     2) TITLES OF INDIVIDUAL RUNS
       A) MAXIMUM OF 72 CHARACTERS
       B) MAY BE IN YOUR INPUT DATAFILE AS THE FIRST RECORD OF EACH
          SET (SEE NUMBER (5) BELOW)
       C) MAY BE INPUT BY YOU FROM THE TERMINAL AT THE TIME OF EACH
          RUN
       D) MAY BE SUPPLIED BY THE PROGRAM, IN WHICH CASE IT WILL BE
          "C A L I N E 2    R U N    #", WHERE "#" WILL BE REPLACED
          BY THE RUN NUMBER (SUPPLIED INTERNALLY BY THE PROGRAM)
       E) THE PROGRAM WILL ASK YOU
          "TITLES IN DATAFILE(1), NOW(2), OR LET PROGRAM TITLE(3)?".
          YOUR RESPONSE WILL BE  1  FOR CHOICE (B),  2  FOR CHOICE (C),
          OR  3  FOR CHOICE (D).  IF YOU CHOOSE THE SECOND OPTION,
          THE PROGRAM WILL ASK YOU
          "ENTER TITLE?", AND YOU WILL RESPOND APPROPRIATELY.

     3) RECEPTOR LOCATION MATRIX
       A) 6 RECEPTOR DISTANCES, AND THEN 6 RECEPTOR HEIGHTS (IN FEET)
       B) A  -99  IS REQUIRED FOR EACH RECEPTOR DISTANCE OR HEIGHT
          YOU DO NOT WANT.  FOR INSTANCE, IF YOU ONLY WANT ONE RECEPTOR
          DISTANCE AND HEIGHT THE MATRIX INPUT WILL BE
          DIST,-99,-99,-99,-99,-99,HGT,-99,-99,-99,-99,-99
          WHERE "DIST" & "HGT" ARE REPLACED BY THE DISTANCE AND
          HEIGHT, RESPECTIVELY.
       C) MAY BE IN YOUR INPUT DATAFILE AS THE SECOND RECORD OF EACH
          SET (SEE NUMBER (5) BELOW)
       D) MAY BE INPUT BY YOU FROM THE TERMINAL AT THE TIME OF EACH
          RUN
       E) MAY BE SUPPLIED BY THE PROGRAM, IN WHICH CASE IT WILL BE
          50,100,150,200,-99,-99,10,5,-99,-99,-99,-99
          WHICH INDICATES THAT CO CONCENTRATIONS WILL BE CALCULATED
          AT THE RECEPTOR LOCATIONS (DIST,HGT)  50,10  100,10  150,10
          200,10  50,5  100,5  150,5  200,5
       F) THE PROGRAM WILL ASK YOU
          "RECEPTOR MATRIX IN DATAFILE(1), NOW(2), OR USE INTERNAL
```

MATRIX(3)?".
YOUR RESPONSE WILL BE 1 FOR CHOICE (C), 2 FOR CHOICE (D), OR 3 FOR CHOICE (E). IF YOU CHOOSE THE SECOND OPTION, THE PROGRAM WILL ASK YOU
"ENTER RECEPTOR MATRIX, 6 DIST. FIRST, THEN 6 HEIGHTS, -99 FOR THOSE NOT DESIRED
?", AND YOU WILL RESPOND APPROPRIATELY.

4) INPUT DATA
A) VPH,EF,U,PHI,H,CLAS,W WHERE
VPH= TRAFFIC VOLUME, IN VEHICLES PER HOUR
EF= AVERAGE SPEED-CORRECTED, HEAVY-DUTY-VEHICLE-%-WEIGHTED EMISSION FACTOR, IN GMS/MILE
U= AVERAGE WIND SPEED, IN MPH
PHI= ANGLE OF WIND TO HIGHWAY, IN DECIMAL DEGREES
H= HEIGHT OF PAVEMENT ABOVE OR BELOW GRADE, IN FEET (WITH A MINIMUM LIMIT OF -30')
CLAS= ATMOSPHERIC STABILITY CLASS, IN NUMERIC FORMAT, WITH 1-6 CORRESPONDING TO CLASSES A-F
W= HIGHWAY WIDTH, IN FEET, INCLUDING ALL LANES, THE MEDIAN, AND SHOULDERS
B) MAY BE IN YOUR INPUT DATAFILE AS THE THIRD RECORD OF EACH SET (SEE NUMBER (5) BELOW)
C) MAY BE INPUT BY YOU FROM THE TERMINAL AT THE TIME OF EACH RUN
D) THE PROGRAM WILL ASK YOU
"INPUT DATA IN DATAFILE(1), OR NOW(2)?".
YOUR RESPONSE WILL BE 1 FOR CHOICE (B) OR 2 FOR CHOICE (C). IF YOU CHOOSE THE SECOND OPTION, THE PROGRAM WILL ASK "ENTER VPH,EF,U,PHI,H,CLAS,W?", AND YOU WILL RESPOND APPROPRIATELY. IF YOU CHOOSE THE FIRST OPTION THE PROGRAM WILL ASK YOU
"INPUT DATAFILE NAME?", AND YOU WILL RESPOND WITH THE NAME OF THE FILE IN WHICH YOU STORED YOUR DATA.

5) COMBINATION OF CHOICES
A) ALL DATA IN INPUT DATAFILE.
FIRST RECORD - TITLE
SECOND RECORD - RECEPTOR LOCATION MATRIX
THIRD RECORD - VPH,EF,U,PHI,H,CLAS,W
(A RECORD IS ONE LINE OF DATA)
ONE SET OF THREE RECORDS WILL BE REQUIRED FOR EACH RUN. WITHIN THE SECOND AND THIRD RECORDS, DATA ITEMS MAY BE SEPARATED BY A COMMA, ONE OR MORE BLANKS, OR BOTH.
B) SOME OF THE DATA ENTERED BY YOU FROM THE TERMINAL AT THE TIME OF EACH RUN, AND SOME CONTAINED IN THE INPUT DATAFILE. YOU MAY CHOOSE TO ENTER THE TITLE AND/OR THE RECEPTOR LOCATION MATRIX AT THE TIME OF EACH RUN, AND HAVE THE INPUT DATA STORED IN A FILE. NOTE THAT I SAID "AND/OR" - YOU MAY HAVE EITHER THE TITLE OR THE RECEPTOR LOCATION MATRIX STORED IN THE FILE AND ENTER THE OTHER AT RUN TIME, OR ENTER BOTH AT RUN TIME.
** YOU MAY NOT ENTER THE INPUT DATA AT RUN TIME AND HAVE
** THE TITLE AND/OR THE RECEPTOR LOCATION MATRIX STORED IN
** THE INPUT DATAFILE.
C) ALL DATA ENTERED AT THE TIME OF EACH RUN

6) NUMBER OF RUNS
A) YOU MAY EXECUTE AS MANY RUNS IN ONE GIVEN LINK TO CALINEU AS YOU DESIRE. JUST REMEMBER THAT AS THE NUMBER

```
   OF RUNS INCREASE, ESPECIALLY WITH LARGE RECEPTOR LOCATION
   MATRICES, AND WIND ANGLES < 90 DEGREES. CALINE2 REQUIRES A
   LARGGE AMOUNT OF COMPUTER TIME, AND YOU WILL BE TYING THE
   SYSTEM UP FOR THE REST OF THE TENET USERS.
B) IF YOUR INPUT DATA IS IN A FILE, THE PROGRAM WILL ONLY ASK
   YOU ONCE FOR YOUR TITLE AND RECEPTOR LOCATION MATRIX,
   OR IF YOU WANT TO USE THE INTERNAL INFORMATION, OR IF THEY
   ARE IN THE INPUT DATAFILE; THEN IT WILL CONTINUE TO EXECUTE
   RUNS UNTIL IT REACHES THE END OF YOUR FILE.
C) IF YOU ENTER YOUR INPUT DATA AT RUN TIME, THE PROGRAM
   WILL ASK YOU
   "MORE RUNS?", AND IF YOUR ANSWER IS YES, IT WILL REQUEST
   THE INFORMATION IN ITEMS (1)-(4) FOR EACH RUN.
D) WHEN THE PROGRAM REACHES THE END OF YOUR INPUT DATAFILE
   (FOR OPTION (B)) OR YOUR ANSWER IS NO TO OPTION (C),
   IT WILL ASK YOU
   "ANOTHER DATAFILE?", AND IF YOU HAVE ANOTHER FILE YOU WISH
   EXECUTED, RESPOND APPROPRIATELY.

FOR MORE INFORMATION, SEE AIR QUALITY MANUAL MODIFICATION # 6 AND ITS
SUPPLEMENT.

IF YOU STILL HAVE QUESTIONS, OR ENCOUNTER PROBLEMS, CALL
     CHUCK WARD          AT ATSS  432-4874.



      *****  ENTER THE NUMBER IN PARENTHESES FOR YOUR CHOICE  *****

PPM(1) OR MICROGRAMS/CUBIC METER(2)?1

TITLES IN DATAFILE(1), NOW(2), OR LET PROGRAM TITLE(3)?3

RECEPTOR MATRIX IN DATAFILE(1), NOW(2), OR USE INTERNAL MATRIX(3)?3

INPUT DATA IN DATAFILE(1), OR NOW(2)?1

INPUT DATAFILE NAME?LINEDATA
```

CALINE2: CALIFORNIA LINE SOURCE DISPERSION MODEL, REVISED JANUARY, 1975

C A L I N E 2   R U N   1

PREDICTED CO CONCENTRATION (PPM)

VARIABLES

VPH= 6000
EF= 25.0 GMS/MI
U= 3 MPH
PHI= 90 DEGREES
H= 0 FEET
CLAS= 1(A)
W= 120 FEET

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 50	100	150	200
10	1.2	1.0	.8	.7
5	1.3	1.0	.8	.7

MIXING CELL CONCENTRATION = 3.4 PPM

C A L I N E 2   R U N   2

PREDICTED CO CONCENTRATION (PPM)

VARIABLES

VPH= 6000
EF= 25.0 GMS/MI
U= 3 MPH
PHI= 45 DEGREES
H= 0 FEET
CLAS= 1(A)
W= 120 FEET

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 50	100	150	200
10	1.0	.8	.7	.6
5	1.1	.8	.7	.6

MIXING CELL CONCENTRATION = 3.8 PPM

C A L I N E 2   R U N   3

PREDICTED CO CONCENTRATION (PPM)

VARIABLES

VPH= 6000
EF= 25.0 GMS/MI
U= 3 MPH
PHI= 0 DEGREES
H= 0 FEET
CLAS= 1(A)
W= 120 FEET

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 50	100	150	200
10	.8	.7	.6	.5
5	.8	.7	.6	.5

MIXING CELL CONCENTRATION = 4.2 PPM

CALINE2: CALIFORNIA LINE SOURCE DISPERSION MODEL, REVISED JANUARY, 1975

C A L I N E 2 R U N 4

PREDICTED CO CONCENTRATION (PPM)

VARIABLES

VPH= 6000
EF= 25.0 GMS/MI
U= 3 MPH
PHI= 90 DEGREES
H= 0 FEET
CLAS= 4(D)
W= 120 FEET

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 50	100	150	200
10	1.6	1.4	1.2	1.2
5	1.7	1.4	1.3	1.2

MIXING CELL CONCENTRATION = 3.4 PPM

C A L I N E 2 R U N 5

PREDICTED CO CONCENTRATION (PPM)

VARIABLES

VPH= 6000
EF= 25.0 GMS/MI
U= 3 MPH
PHI= 45 DEGREES
H= 0 FEET
CLAS= 4(D)
W= 120 FEET

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 50	100	150	200
10	3.4	2.8	2.2	1.7
5	3.5	2.8	2.2	1.8

MIXING CELL CONCENTRATION = 7.0 PPM

C A L I N E 2 R U N 6

PREDICTED CO CONCENTRATION (PPM)

VARIABLES

VPH= 6000
EF= 25.0 GMS/MI
U= 3 MPH
PHI= 0 DEGREES
H= 0 FEET
CLAS= 4(D)
W= 120 FEET

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 50	100	150	200
10	5.2	4.2	3.1	2.3
5	5.4	4.2	3.2	2.3

MIXING CELL CONCENTRATION = 10.5 PPM

CALINE2: CALIFORNIA LINE SOURCE DISPERSION MODEL, REVISED JANUARY, 1975

C A L I N E 2 R U N 7

PREDICTED CO CONCENTRATION (PPM)

VARIABLES

VPH= 6000
EF= 25.0 GMS/MI
U= 3 MPH
PHI= 90 DEGREES
H= 0 FEET
CLAS= 6(F)
W= 120 FEET

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 50	100	150	200
10	1.9	1.7	1.6	1.5
5	2.1	1.8	1.7	1.6

MIXING CELL CONCENTRATION = 3.4 PPM

C A L I N E 2 R U N 8

PREDICTED CO CONCENTRATION (PPM)

VARIABLES

VPH= 6000
EF= 25.0 GMS/MI
U= 3 MPH
PHI= 45 DEGREES
H= 0 FEET
CLAS= 6(F)
W= 120 FEET

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 50	100	150	200
10	9.2	6.2	3.9	2.4
5	9.7	6.5	4.1	2.5

MIXING CELL CONCENTRATION = 16.0 PPM

C A L I N E 2 R U N 9

PREDICTED CO CONCENTRATION (PPM)

VARIABLES

VPH= 6000
EF= 25.0 GMS/MI
U= 3 MPH
PHI= 0 DEGREES
H= 0 FEET
CLAS= 6(F)
W= 120 FEET

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 50	100	150	200
10	16.5	10.8	6.2	3.2
5	17.2	11.2	6.4	3.3

MIXING CELL CONCENTRATION = 28.6 PPM

```
ANOTHER DATAFILE?NO
>RUN
```

```
                    ***** PROGRAM CALINEU *****

     THIS IS AN INTERACTIVE EXAMPLE PROGRAM FOR CALINE, THE
     CALIFORNIA LINE SOURCE DISPERSION MODEL.  THIS PROGRAM UTILIZES
     CALINE2, WHICH WAS REVISED IN JANUARY, 1975.

DO YOU WANT AN INPUT FORMAT EXPLANATION?NO


      *****  ENTER THE NUMBER IN PARENTHESES FOR YOUR CHOICE  *****

PPM(1) OR MICROGRAMS/CUBIC METER(2)?1

TITLES IN DATAFILE(1), NOW(2), OR LET PROGRAM TITLE(3)?2

     ENTER TITLE?SAMPLE RUN OF CALINEU

RECEPTOR MATRIX IN DATAFILE(1), NOW(2), OR USE INTERNAL MATRIX(3)?2

     ENTER RECEPTOR MATRIX, 6 DIST. FIRST, THEN 6 HEIGHTS,
     ENTER -99 FOR THOSE NOT DESIRED
     INPUT??50,100,200,-99,-99,-99,5,-99,-99,-99,-99,-99

INPUT DATA IN DATAFILE(1), OR NOW(2)?2

     ENTER VPH,EF,U,PHI,H,CLAS,W?6000,25,3,45,-20,4,120
```

PAGE 1 04/15/75 2:46 PM INPUT=ENTERED FROM TERMINAL
CALINE2: CALIFORNIA LINE SOURCE DISPERSION MODEL,
REVISED JANUARY, 1975

SAMPLE RUN OF CALINEU

PREDICTED CO CONCENTRATION (PPM)

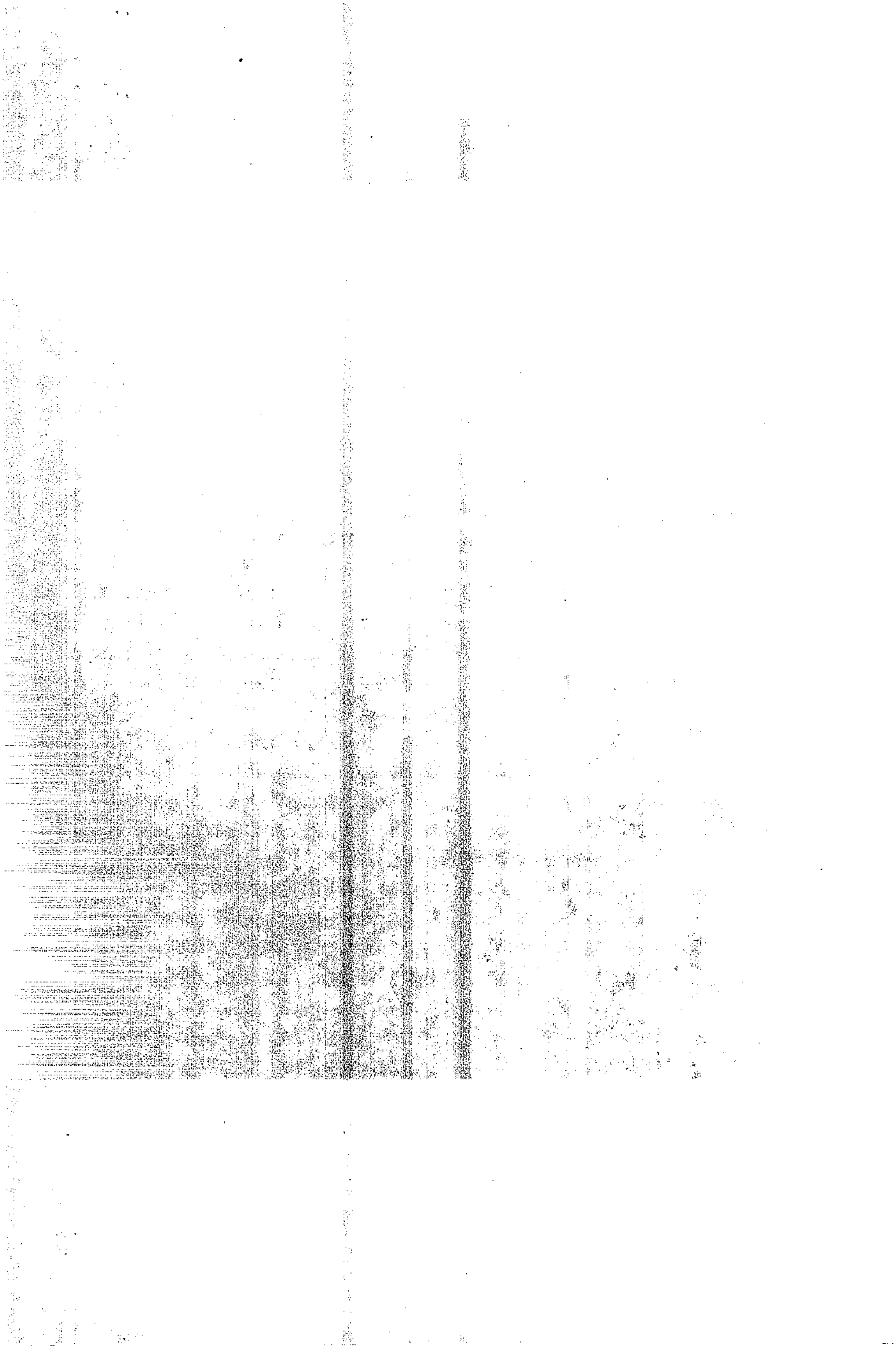
VARIABLES	RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 50	100	200
VPH= 6000				
EF= 25.0 GMS/MI				
U= 3 MPH	5	2.0	1.6	1.0
PHI= 45 DEGREES				
H=-20 FEET				
CLAS= 4(D)				
W= 120 FEET				

MIXING CELL CONCENTRATION = 7.0 PPM

```
MORE RUNS?NO

ANOTHER DATAFILE?NO
>
```

APPENDIX C

FORTRAN Language Listing of CALINE2
and
Examples of Use



```
++WRITE    PRINT,SCALINE2                                              000206
C          DATA SET SCALINE2   AT LEVEL 005 AS OF 11/12/75
C
C         C  A  L  I  N  E 2
C
C
C     THE CALIFORNIA LINE SOURCE DISPERSION MODEL
C
C     DEVELOPED BY THE ENVIRONMENTAL IMPROVEMENT BRANCH, TRANSPORTATION
C     LABORATORY OF CALTRANS.  BASED ON WORK ORIGINALLY PERFORMED BY
C     ANDREW RANZIERI OF THE ENVIRONMENTAL IMPROVEMENT BRANCH AND ON
C     BRUCE TURNER'S "WORKBOOK OF ATMOSPHERIC DISPERSION ESTIMATES".
C     FURTHER MODIFICATIONS MADE BY CHUCK WARD OF THE ENVIRONMENTAL
C     IMPROVEMENT BRANCH.
C
C     WRITTEN BY CHUCK WARD - MARCH 1975
C
C     CALINE2 WAS ORIGINALLY PROGRAMMED ON THE CALTRANS TIME SHARING
C     SYSTEM (TENET) IN JANUARY 1975.
C
C     THE MODEL WILL BE CONTINUOUSLY UPDATED TO REFLECT THE STATE OF
C     THE ART.
C
C     IT SHOULD NOT BE MODIFIED WITHOUT CONTACTING ANDY RANZIERI,
C     GERRY BEMIS, OR CHUCK WARD - 916 444-4874 (ATSS 432-4874).
C
C
C
C     INPUT CARDS:
C    1)   FORM OF OUTPUT AND NUMBER OF SIMULATION RUNS
C             CC    1 = 1, IF POLLUTANT CONCENTRATION IN PARTS PER
C                          MILLION (PPM),
C                     2, IF IN MICROGRAMS PER CUBIC METER
C             CC 3-5 = NUMBER OF SIMULATION RUNS, RIGHT-JUSTIFIED,
C                      EACH RUN WILL REQUIRE ITS OWN SET OF INPUT DATA,
C                      CARDS 2-4
C    2)   TITLE FOR SIMULATION RUN
C    3)   PHYSICAL INPUT DATA
C             CC  1-10 = VEHICLES PER HOUR IN I10 FORMAT,
C                        RIGHT-JUSTIFIED
C             CC 11-15 = EMISSION FACTOR (GMS/MI) IN I5 FORMAT
C             CC 16-20 = WIND SPEED (MPH) IN  I5 FORMAT
C             CC 21-25 = WIND ANGLE TO HIGHWAY (DEGREES)
C                        IN I5 FORMAT
C             CC 26-30 = PAVEMENT HEIGHT (FEET ABOVE OR BELOW GRADE,
C                        -30' IS LOWER LIMIT) IN I5 FORMAT
C             CC  35   = ATMOSPHERIC STABILITY CLASS (1-6 = A-F)
```

```
C                       IN I1 FORMAT
C              CC 36-40 = HIGHWAY WIDTH (FEET), INCLUDING ALL LANES,
C                         MEDIAN (MEDIAN SHOULD BE LESS THEN 30',
C                         OTHERWISE RUN A SIMULATION FOR EACH SIDE AND
C                         ADD RESULTS), AND STANDARD ASSUMED 10'
C                         OUTSIDE SHOULDERS IN I5 FORMAT.
C    4)   RECEPTOR LOCATION MATRIX (MAXIMUM OF 6X6=36 TOTAL RECEPTORS),
C              ENTER 6 DISTANCES PERPENDICULAR TO EDGE OF HIGHWAY (FEET)
C              IN FORMAT 6I5 IN CC 1-30, RIGHT-JUSTIFIED - ONLY POSITIVE
C              DISTANCES ARE ALLOWED, SINCE MODEL CANNOT PREDICT UPWIND.
C              ENTER 6 HEIGHTS ABOVE OR AT GRADE (MODEL CANNOT PREDICT
C              BELOW GRADE) IN FORMAT 6I5 IN CC 36-65, RIGHT-JUSTIFIED
C              IF NOT ALL POINTS ARE DESIRED, ENTER -99 FOR EACH
C              POINT NOT DESIRED.
C
C      PUT AS MANY SETS OF CARDS 2-4 AS NEEDED TO AGREE WITH CARD 1.
C
C
C                    N  O  T  E
C      THIS PROGRAM IS DESIGNED TO BE USED ONLY WITH CARBON MONOXIDE,
C      WHICH HAS A MOLECULAR WEIGHT OF 28, IS ESSENTIALLY INERT, AND
C      HAS NO SIGNIFICANT GRAVITATIONAL SETTLING RATE.  THE PREDICTED
C      CONCENTRATIONS DO NOT INCLUDE BACKGROUND LEVELS.
C
C
C
C
C
C      DIMENSION STATEMENTS AND DATA INITIALIZATION
C
      DIMENSION STAB(6),D(6),Z(6),COCONC(6,6),TITLE(18),DATE(2)
      DIMENSION ID(6),IZ(6)
      COMMON /CALINE/UOBR,HOMT,CLAS,WOMT,ZOMT,DOKM,DODW,SG1Y,BNO1,FTR2,
     1        FTR3,PI
      DATA STAB/'A','B','C','D','E','F'/,IPAGE/0/
      INTEGER VPH,EF,U,PHI,H,CLAS,W,D,Z
      READ(5,1000) NTYPE,NRUN
 1000 FORMAT(I1,I4)
C
C      OBTAIN DATE FOR THIS JOB
      CALL DHDATE(0,DATE)
C
C      SITE LOOP
      DO 900 I=1,NRUN
      READ(5,1002) TITLE
 1002 FORMAT(18A4)
      READ(5,1003) VPH,EF,U,PHI,H,CLAS,W
 1003 FORMAT(I10,4I5,4X,I1,I5)
      READ(5,1004) (D(I1),I1=1,6),(Z(I1),I1=1,6)
 1004 FORMAT(6I5,5X,6I5)
C
      CALL LINE2C(NTYPE,VPH,EF,U,PHI,H,W,D,Z,COMIX,COCONC,IU,
```

```
     1                 IPHI,IH,ICLAS,ID,IZ,NJ,NK)
C       OUTPUT - PRINTING
        IF (INT((I-1)/3.) - (I-1)/3..NE.0.) GO TO 18
        IPAGE=IPAGE+1
        WRITE(6,1015) IPAGE,DATE
 1015   FORMAT(1H1,T6,'PAGE ',I2,T18,2A4/T6,
     1  'CALINE2:  CALIFORNIA LINE SOURCE DISPERSION MODEL, '/T16,
     2  'REVISED JANUARY, 1975')
   18   WRITE(6,1016) TITLE
 1016   FORMAT(1H ,///,18A4)
        IF(NTYPE.EQ.1) WRITE(6,1017)
 1017   FORMAT(1H ,/T36,'PREDICTED CO CONCENTRATION (PPM)'/)
        IF(NTYPE.EQ.2) WRITE(6,1018)
 1018   FORMAT(1H ,/T30,'PREDICTED CO CONCENTRATION (MICROGM/CU M)'/)
        WRITE(6,1019) VPH
 1019   FORMAT(1H ,T6,'VARIABLES',T26,'RECEPTOR',T44,'DISTANCE ',
     1  'PERPENDICULAR'/T27,'HEIGHT',T45,'TO HIGHWAY  (D FEET)'/T6,
     2  'VPH=',I6,T26,'(Z FEET)')
        J1=1
        K1=1
        JSTP=1
        KSTP=1
        IF (D(1).LT.D(NK)) GO TO 20
        K1=NK
        NK=1
        KSTP=-1
   20   WRITE(6,1022) (D(K),K=K1,NK,KSTP)
 1022   FORMAT(1H+,T34,6I7)
        WRITE(6,1024) EF
 1024   FORMAT(1H ,T7,'EF=',I6,' GMS/MI')
        IF (Z(1).GT.Z(NJ)) GO TO 22
        J1=NJ
        NJ=1
        JSTP=-1
   22   DO 855 J2=1,6
        GO TO (24,26,28,30,32,34),J2
   24   WRITE(6,1026) U
 1026   FORMAT(1H ,T8,'U=',I6,' MPH')
        IF (Z(J1)) 850,36,36
   26   WRITE(6,1028) PHI
 1028   FORMAT(1H ,T6,'PHI=',I6,' DEGREES')
        IF (Z(J1)) 850,36,36
   28   WRITE(6,1030) H
 1030   FORMAT(1H ,T8,'H=',I6,' FEET')
        IF (Z(J1)) 850,36,36
   30   WRITE(6,1032) CLAS,STAB(CLAS)
 1032   FORMAT(1H ,T5,'CLAS=',I6,' (',A1,')')
        IF (Z(J1)) 850,36,36
   32   WRITE(6,1034) W
 1034   FORMAT(1H ,T8,'W=',I6,' FEET')
        IF (Z(J1)) 850,36,36
   34   WRITE(6,1036)
```

```
 1036 FORMAT(1H ,25X)
      IF (Z(J1)) 850,36,36
   36 WRITE(6,1038) Z(J1),(COCONC(J1,K),K=K1,NK,KSTP)
 1038 FORMAT(1H+,T26,I5,T34,6F7.1)
  850 J1=J1+JSTP
      IF (J1.EQ.0) J1=6
  855 CONTINUE
      WRITE(6,1040) COMIX
 1040 FORMAT(1H ,T31,'MIXING CELL CONCENTRATION = ',F7.1)
      IF(NTYPE.EQ.1) WRITE(6,1042)
 1042 FORMAT(1H+,T67,' PPM')
      IF(NTYPE.EQ.2) WRITE(6,1044)
 1044 FORMAT(1H+,T67,' MICROGM/CU M')
C
C     GENERAL EDIT WRITE STATEMENTS
      IF (IU.LT.2) WRITE(6,1050) IU
 1050 FORMAT(1H ,/,T5,'YOUR WIND SPEED WAS',I3,' MPH, WHICH IS LESS ',
     1 'THAN THE ALLOWED 2 MPH,',/,T5,'THEREFORE, U WAS CHANGED TO 2 ',
     2 'MPH IN THE ABOVE RUN')
      IF (IPHI.LT.0.OR.IPHI.GT.90) WRITE(6,1052) IPHI,PHI
 1052 FORMAT(1H ,/,T5,'YOUR WIND ANGLE WAS',I4,' DEGREES, WHICH IS ',
     1 'NOT IN THE ALLOWED RANGE',/,T5,'OF 0-90, THEREFORE, ',
     2 'PHI WAS CHANGED TO',I3,' IN THE ABOVE RUN')
      IF (IH.LT.-30) WRITE(6,1054) IH
 1054 FORMAT(1H ,/,T5,'YOUR PAVEMENT HEIGHT WAS',I4,' FT, WHICH IS ',
     1 'LESS THAN THE ALLOWED',/,T5,'-30 FT, THEREFORE, H WAS ',
     2 'CHANGED TO -30 FT IN THE ABOVE RUN')
      IF (ICLAS.LT.1.OR.ICLAS.GT.6) WRITE(6,1056) ICLAS,CLAS
 1056 FORMAT(1H ,/,T5,'YOUR STABILITY CLASS WAS ',I1,' WHICH IS NOT ',
     1 'IN THE ALLOWED RANGE 1-6',/,T5,'(A-F), THEREFORE, CLAS WAS ',
     2 'CHANGED TO ',I1,' IN THE ABOVE RUN')
      DO 860 I1=1,6
      IF (ID(I1).LT.0.OR.ID(I1).GT.1500) WRITE(6,1058) ID(I1),D(I1)
 1058 FORMAT(1H ,/,T5,'YOUR RECEPTOR DISTANCE WAS',I5,' FT ',
     1 'WHICH IS NOT IN THE ALLOWED RANGE',/,T5,'OF 0-1500 FT, ',
     2 'THEREFORE, IT WAS CHANGED TO',I5,' FT IN THE ABOVE RUN')
      IF (IZ(I1).LT.0) WRITE(6,1060) IZ(I1)
 1060 FORMAT(1H ,/,T5,'ONE OF YOUR RECEPTOR HEIGHTS WAS',I3,' FT, ',
     1 'WHICH IS BELOW THE ALLOWED',/,T5,'0 FT, THEREFORE IT WAS ',
     2 'CHANGED TO 0 FT IN THE ABOVE RUN')
  860 CONTINUE
C     END OF OUTPUT
C
  900 CONTINUE
C     END OF SITE LOOP
C
      CALL EXIT
      END
C
C     L I N E 2 C
C
C
```

```
C
C     THIS SUBROUTINE CONTAINS OR CALLS THE COMPUTATIONAL PORTIONS OF
C     THE CALIF. LINE SOURCE CARBON MONIXIDE DISPERSION MODEL.  THE
C     CALLING REQUIREMENTS ARE:
C
C     DIMENSION D(6),Z(6),COCONC(6,6),ID(6),IZ(6)
C     INTEGER VPH,EF,U,PHI,H,CLAS,W,D,Z
C     COMMON /CALINE/UOBR,HOMT,CLAS,WOMT,ZOMT,DOKM,DODW,SG1Y,BN01,FTR2,
C    1            FTR3,PI
C
C
C
C     CALL LINE2C(NTYPE,VPH,EF,U,PHI,H,W,D,Z,COMIX,COCONC,IU,
C    1               IPHI,IH,ICLAS,ID,IZ,NJ,NK)
C
C
C     INPUTS ARE IN INTEGER FORMAT AS FOLLOWS:
C
C         NTYPE = UNITS DESIRED FOR CONCENTRATION PREDICTION OUTPUT.
C                 1 = PPM
C                 2 = MICROGRAMS/CUBIC METER
C         VPH   = VEHICLES PER HOUR
C         EF    = AVERAGE SPEED-CORRECTED, HEAVY-DUTY-VEHICLE-WEIGHTED
C                 EMISSION FACTOR IN GRAMS/MILE.
C         U     = AVERAGE WIND SPEED IN MPH. (CONNOT BE LESS THAN 2 MPH)
C         PHI   = ANGLE OF WIND TO HIGHWAY. (0 TO 90 DEGREES).  ZERO
C                 IS PARALLEL.
C         H     = PAVEMENT HEIGHT, IN FEET. (CANNOT BE LESS THAN  -30')
C                 HEIGHTS ABOVE OR BELOW SURROUNDING GRADE SHOULD ONLY
C                 BE USED WHEN THOSE SECTIONS ARE 1 MILE IN LENGTH OR
C                 LONGER.  OTHERWISE CONSIDER SECTION  AT-GRADE OR THE
C                 AVERAGE PAVEMENT HEIGHT OF THE BOUNDING SECTIONS.
C         CLAS  = ATMOSPHERIC STABILITY CLASS IN NUMERICS. (1-6 = A-F )
C                 CLAS IS FOUND IN THE COMMON BLOCK
C         W     = HIGHWAY WIDTH INCLUDING ALL LANES, MEDIAN, AND
C                 STANDARD ASSUMED 10' OUTSIDE SHOULDERS IN FEET.
C                 (MEDIANS SHOULD BE LESS THAN 30' OR EACH SIDE SHOULD
C                 BE RUN SEPARATELY AND SUMMED AT THE RECEIVER).
C         D     = ARRAY OF 6 RECEPTOR DISTANCES IN FEET MEASURED
C                 PERPENDICULAR TO THE HIGHWAY FROM THE NEAREST
C                 EDGE OF SHOULDER (SHOULDERS ALWAYS ASSUMED TO BE 10')
C                 A -99 VOIDS AN ELEMENT IN THE ARRAY.  NEGATIVE VALUES
C                 ARE NOT ALLOWED.
C         Z     = ARRAY OF 6 RECEPTOR HEIGHTS ABOVE SURROUNDING GRADE
C                 IN FEET.  ENTER -99 TO VOID AN ELEMENT.
C
C     THIS SUBROUTINE USES LABELED COMMON AND SHOULD NOT DISTURB
C     COMMON BLOCKS USED IN THE CALLING PROGRAM.
C
C     OUTPUTS ARE REAL:
C         COMIX = THE MIXING CELL CONCENTRATION IN UNITS SPECIFIED BY
C                 INPUT PARAMETER NTYPE.
```

```
C          COCONC= ARRAY OF CONCENTRATIONS AT THE INTERSECTIONS OF VALID
C                  DISTANCES AND HEIGHTS AS INPUT BY PARAMETERS Z AND D
C                  IN THE ORDER: COCONC(Z,D)
C
C      COUNTERS:
C          NJ     = NUMBER OF HEIGHTS.
C          NK     = NUMBER OF DISTANCES.
C
C      EDIT FLAGS ARE INTEGERS WHICH SHOULD EQUAL CORRESPONDING INPUT
C      PARAMETERS.  IF THEY ARE UNEQUAL THEN AN ERROR WAS FOUND AND A
C      STANDARD FIX-UP PERFORMED.
C
      SUBROUTINE LINE2C(NTYPE,VPH,EF,U,PHI,H,W,D,Z,
     1                  COMIX,COCONC,
     2                  IU,IPHI,IH,ICLAS,ID,IZ,NJ,NK)
      DIMENSION D(6),Z(6),COCONC(6,6),ID(6),IZ(6)
      INTEGER VPH,EF,U,PHI,H,CLAS,W,D,Z
      COMMON /CALINE/UOBR,HOMT,CLAS,WOMT,ZOMT,DOKM,DODW,SGIY,BNO1,FTR2,
     1       FTR3,PI
      DATA MOWT/28/
C     GENERAL EDITS
      ICLAS=2
      IU=3
      IPHI=75
      IH=10
      DO 1 I1=1,6
      ID(I1)=10
      IZ(I1)=10
    1 CONTINUE
      IF (CLAS.GT.0.AND.CLAS.LT.7) GO TO 2
      ICLAS=CLAS
      CLAS=1
      IF (ICLAS.GT.6) CLAS=6
    2 IF (U.GE.2) GO TO 4
      IU=U
      U=2
    4 DO 7 I1=1,6
      IF (D(I1).NE.-99.AND.(D(I1).LT.0.OR.D(I1).GT.1500)) GO TO 5
      IF (Z(I1).LT.0.AND.Z(I1).NE.-99) GO TO 6
      GO TO 7
    5 ID(I1)=D(I1)
      D(I1)=0
      IF (ID(I1).GT.1500) D(I1)=1500
      GO TO 7
    6 IZ(I1)=Z(I1)
      Z(I1)=0
    7 CONTINUE
    8 IF (H.GE.-30) GO TO 10
      IH=H
      H=-30
   10 IF (PHI.LE.90.AND.PHI.GE.0) GO TO 12
      IPHI=PHI
```

```
      PHI=IABS(PHI)
      IF (PHI.GT.90.AND.PHI.LE.180) PHI=180-PHI
      IF (PHI.GT.180.AND.PHI.LE.270) PHI=PHI-180
      IF (PHI.GT.360) PHI=0
      IF (PHI.GT.270) PHI=360-PHI
   12 IF (VPH.GT.0.AND.EF.GT.0.AND.W.GT.0) GO TO 14
      WRITE(6,1012) I
 1012 FORMAT(1H1,'RUN #',I3/'YOU BLEW IT  ONE OF YOUR VARIABLES IS ',
     1 'NEGATIVE OR 0 THAT SHOULD NOT BE.'/'CHECK YOUR VPH, EF, AND ',
     2 'HWY WIDTH TO FIND THE MISTAKE.')
      CALL EXIT
C
C     CONVERSION TO METRIC SYSTEM
   14 HOMT=H/3.28084
      UOBR=U/2.23714
      WOMT=W/3.28084
      PI=3.1415927
      PHOR=PHI*PI/180.
C
C     SOURCE STRENGTH
      QXWND=1.73E-7*VPH*EF
      QPWND=QXWND*WOMT
C
C     IF PAVEMENT HEIGHT (H) IS < 0 FEET, IT IS CONSIDERED TO BE AT
C     GROUND LEVEL.  THE RESULT OF THE RATIO SUBROUTINE (1 IF NOT A
C     DEPRESSED SECTION) IS THEN USED TO ACCOUNT FOR DEPRESSED SECTIONS.
      IF (H.LT.0) HOMT=0.
      ROTO=1.0
      CALL RATIO(H,VPH,PHI,U,ROTO)
C
C     NUMBER OF INTEGRATION STEPS (AREA SOURCES) FOR PARALLEL WIND,
C     BASED ON DISTANCE CLOSEST TO 1/2 MILE THAT WILL BE EVENLY
C     DIVISABLE BY HIGHWAY WIDTH
      DODW=((W*INT(2640./W+0.5))/3.28084)/WOMT
      NSEG=INT(DODW+0.5)
C
C     MIXING CELL CONCENTRATION
      HOMT=0.
      ZOMT=0.
      DOKM=0.
C
C     THE MODEL ADDS COMPONENTS OF THE "PURE" CROSSWIND AND PARALLEL
C     WIND MODELS VIA A PERCENTAGE DERIVED FROM THE SQUARE OF SIN(PHI)
C     AND THE SQUARE OF COS(PHI) (FOR PARALLEL WIND).
      COMIX=(SIN(PHOR)**2)*XWIND(QXWND) +
     1 (COS(PHOR)**2)*PARWND(NSEG,QPWND)
      IF (NTYPE.EQ.1) COMIX=COMIX*0.0245/MOWT
C
C     RECEPTOR HEIGHT LOOP
      IF (H.GT.0) HOMT=H/3.28084
      NJ=6
      DO 800 J=1,6
```

```
      IF (Z(J).EQ.-99) GO TO 790
      ZOMT=Z(J)/3.28084
C
C     IF RECEPTOR HEIGHT IS LESS THAN OR EQUAL TO 5 FEET, IT IS
C     CONSIDERED TO BE AT GROUND LEVEL
      IF (Z(J).LE.5) ZOMT=0.
C
C     RECEPTOR DISTANCE LOOP
      NK=6
      DO 700 K=1,6
      IF (D(K).EQ.-99) GO TO 690
C
C     IF THE RECEPTOR DISTANCE IS 0 AND THE RECEPTOR HEIGHT IS IN THE
C     MIXING CELL (UP TO 12' ABOVE THE HWY) THE RECEPTOR IS GIVEN THE
C     MIXING CELL CONCENTRATION.
      COCONC(J,K)=COMIX
      IF (D(K).EQ.0.AND.((Z(J)-H).GE.0.AND.(Z(J)-H).LE.12)) GO TO 700
      DOKM=D(K)/3280.84
      COCONC(J,K)=((SIN(PHOR)**2)*XWIND(QXWND) +
     1 (COS(PHOR)**2)*PARWND(NSEG,QPWND))*ROTO
      IF (NTYPE.EQ.1) COCONC(J,K)=COCONC(J,K)*0.0245/MOWT
      GO TO 700
  690 NK=NK-1
  700 CONTINUE
      GO TO 800
  790 NJ=NJ-1
  800 CONTINUE
C     END OF RECEPTOR LOOPS
C
      RETURN
      END
C
C     XWIND
C
C     CROSSWIND FUNCTION FOR "PURE" CROSSWIND MODEL
C
C
      FUNCTION XWIND(QXWND)
      COMMON /CALINE/UOBR,HOMT,CLAS,WOMT,ZOMT,DOKM,DODW,SG1Y,BNO1,FTR2,
     1              FTR3,PI
      INTEGER VPH,EF,U,PHI,H,CLAS,W,D,Z
C
      XWIND=QXWND*1.0E6*(EXP(-.5*((ZOMT+HOMT)/SGOZ(1))**2) +
     1 EXP(-.5*((ZOMT-HOMT)/SGOZ(1))**2))/
     2 (SQRT(2.*PI)*SGOZ(1)*UOBR)
C
      RETURN
      END
C
C
C      PARWND
C
```

```
C      PARALLEL WIND FUNCTION FOR THE "PURE" PARALLEL WIND MODEL
C
C      IN THIS MODEL, THE HIGHWAY IS DIVIDED INTO A SERIES OF SQUARE
C      AREA SOURCES (W' X W', WHERE W IS THE HIGHWAY WIDTH).
C      CONCENTRATIONS FROM EACH AREA SOURCE ARE SUMMED AT THE RECEPTOR
C      FOR A CUMULATIVE CONCENTRATION.  FOR EACH AREA SOURCE, A VIRTUAL
C      DISTANCE IS USED TO MOVE THE X-AXIS INWARD TOWARDS THE ACTUAL
C      HIGHWAY CENTERLINE.  THIS ARTIFICIALLY FORCES THE MODEL TO ASSUME
C      UNIFORM CONCENTRATION WITHIN THE MIXING CELL, A CONDITION WHICH
C      WOULD NOT OTHERWISE EXIST WITH A VIRTUAL POINT SOURCE.
C
C
C      THE HIGHWAY LENGTH FOR AREA SOURCE DIVISION IS 1/2 MILE, AND A
C      SCALING FACTOR (WHICH IS A FUNCTION OF STABILITY CLASS) IS USED
C      TO INCREASE CONCENTRATIONS TO THOSE FOR AN "INFINITE" LINE SOURCE
C      OF 5 MILES LENGTH.
C
      FUNCTION PARWND(NSEG,QPWND)
      DIMENSION SCALE(6)
      COMMON /CALINE/UOBR,HOMT,CLAS,WOMT,ZOMT,DOKM,DODW,SG1Y,BNO1,FTR2,
     1       FTR3,PI
      INTEGER VPH,EF,U,PHI,H,CLAS,W,D,Z
      DATA SCALE/1.0,0.94,0.86,0.73,0.61,0.48/
C
      YOMT=DOKM*1000.
C
C      ESTIMATE FOR SIGMA Y TO OBTAIN VIRTUAL DISTANCE
      SG1Y=WOMT/4.3
      CALL WOADJ
C
C     VIRTUAL DISTANCE (IN KILOMETERS)
      VIRTX=BNO1
C
C      X-AXIS ADJUSTMENT
      SG2Y=SG1Y*SQRT(-2.*ALOG(SG1Y*SQRT(2.*PI)/WOMT))
C
C      TRANSPOSE Y-AXIS TO "MIDDLE" OF FIRST AREA SOURCE
      DWOK=(DODW-1.)*WOMT/1000.
C
C     LOOP FOR ADDING AREA SOURCE' CONCENTRATIONS
      CONC=0.
      DO 100 IN=1,NSEG
      DOKM=DWOK+VIRTX
      Y2MT=(YOMT+SG2Y)/SGOY(2)
C
C     TO PREVENT EXPONENTIAL UNDERFLOW
      IF (Y2MT.GT.9.) Y2MT=9.
C
      CONCT=QPWND*EXP(-.5*Y2MT**2)*(EXP(-.5*((ZOMT-HOMT)/SGOZ(2))**2)
     1 + EXP(-.5*((ZOMT+HOMT)/SGOZ(2))**2))/
     2 (2.*PI*SGOZ(2)*SGOY(2)*UOBR)
      CONC=CONC+CONCT
```

```
  100 DWOK=DWOK-WOMT/1000.
C     END OF AREA SOURCE LOOP
C
      PARWND=CONC*1.0E6/SCALE(CLAS)
C
      RETURN
      END
C
C
C
C     SGOY
C
C     THIS IS THE FUNCTION FOR CALCULATING THE HORIZONTAL DESPERSION
C     PARAMETER, SIGMA Y.
C
      FUNCTION SGOY(IDUMB)
C     "IDUMB" IS STRICTLY A DUMMY VARIABLE & IS NOT USED
C
      COMMON /CALINE/UOBR,HOMT,CLAS,WOMT,ZOMT,DOKM,DODW,SG1Y,BNO1,
     1                FTR2,FTR3,PI
      INTEGER VPH,EF,U,PHI,H,CLAS,W,D,Z
C
C     MIXING CELL DISPERSION PARAMETER (DEPENDENT ON HIGHWAY WIDTH)
      IF (DOKM.GE.BNO1) GO TO 100
      SGOY=SG1Y
      RETURN
C
  100 GO TO (110,120,130,140,150,160),CLAS
C
C     STABILITY CLASS A
  110 IF (DOKM.LT..9) SGOY=FTR2*DOKM**FTR3
      IF (DOKM.GE..9.AND.DOKM.LT.2.) SGOY=247.5*DOKM**.692
      IF (DOKM.GE.2.) SGOY=215.2*DOKM**.898
      RETURN
C
C     STABILITY CLASS B
  120 IF (DOKM.LT..9) SGOY=FTR2*DOKM**FTR3
      IF (DOKM.GE..9.AND.DOKM.LT.1.5) SGOY=172.*DOKM**.707
      IF (DOKM.GE.1.5) SGOY=161.*DOKM**.874
      RETURN
C
C     STABILITY CLASS C
  130 IF (DOKM.LT..8) SGOY=FTR2*DOKM**FTR3
      IF (DOKM.GE..8.AND.DOKM.LT.1.5) SGOY=128.4*DOKM**.692
      IF (DOKM.GE.1.5) SGOY=121.77*DOKM**.817
      RETURN
C
C     STABILITY CLASS D
  140 IF (DOKM.LT..6) SGOY=FTR2*DOKM**FTR3
      IF (DOKM.GE..6.AND.DOKM.LT.1.5) SGOY=98.65*DOKM**.588
      IF (DOKM.GE.1.5) SGOY=89.6*DOKM**.826
      RETURN
```

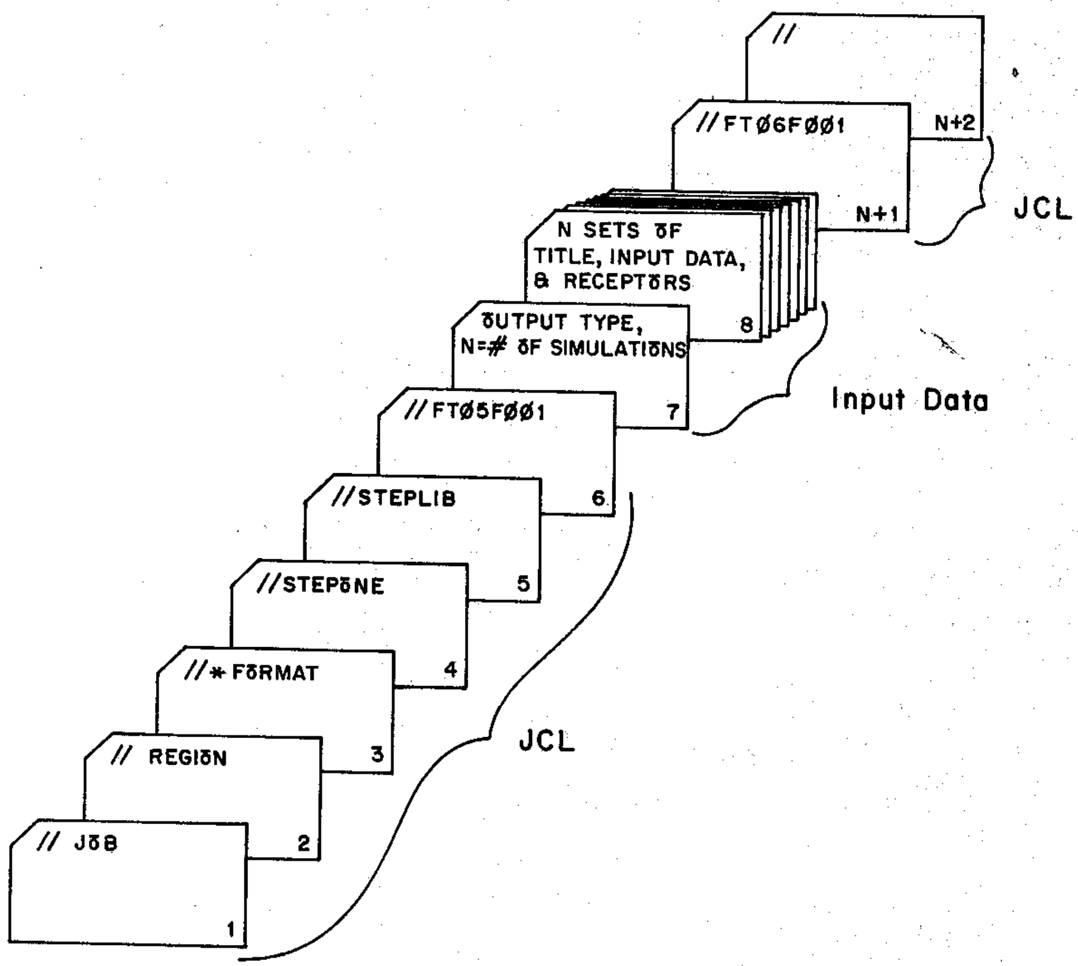
```
C
C      STABILITY CLASS E
  150 IF (DOKM.LT..7) SGOY=FTR2*DOKM**FTR3
      IF (DOKM.GE..7.AND.DOKM.LT.1.5) SGOY=70.*DOKM**.494
      IF (DOKM.GE.1.5) SGOY=61.*DOKM**.82
      RETURN
C
C      STABILITY CLASS F
  160 IF (DOKM.LT..6) SGOY=FTR2*DOKM**FTR3
      IF (DOKM.GE..6.AND.DOKM.LT.1.5) SGOY=53.5*DOKM**.435
      IF (DOKM.GE.1.5.AND.DOKM.LT.3.) SGOY=49.*DOKM**.653
      IF (DOKM.GE.3.0) SGOY=38.6*DOKM**.876
      RETURN
C
      END
C
C
C
C      SGOZ
C
C      THIS IS THE FUNCTION FOR CALCULATING THE VERTICAL DISPERSION
C      PARAMETER, SIGMA Z
C
C
      FUNCTION SGOZ(IDUMB)
C      "IDUMB" IS STRICTLY A DUMMY VARIABLE & IS NOT USED
C
      COMMON /CALINE/UOBR,HOMT,CLAS,WOMT,ZOMT,DOKM,DODW,SG1Y,BNO1,FTR2,
     1                FTR3,PI
      INTEGER VPH,EF,U,PHI,H,CLAS,W,D,Z
C
C      MIXING CELL DISPERSION PARAMETER
      IF (DOKM.GE..001) GO TO 100
      SGOZ=4.
      RETURN
C
  100 GO TO (110,120,130,140,150,160),CLAS
C
C      STABILITY CLASS A
  110 IF (DOKM.LT..04) SGOZ=47.4*DOKM**.357
      IF (DOKM.GE..04.AND.DOKM.LT..1) SGOZ=91.*DOKM**.562
      IF (DOKM.GE..1.AND.DOKM.LT..2) SGOZ=148.*DOKM**.782
      IF (DOKM.GE..2.AND.DOKM.LT..4) SGOZ=300.*DOKM**1.22
      IF (DOKM.GE..4) SGOZ=489.*DOKM**1.74
      RETURN
C
C      STABILITY CLASS B
  120 IF (DOKM.LT..1) SGOZ=34.9*DOKM**.314
      IF (DOKM.GE..1.AND.DOKM.LT..2) SGOZ=62.*DOKM**.565
      IF (DOKM.GE..2.AND.DOKM.LT..4) SGOZ=78.*DOKM**.71
      IF (DOKM.GE..4.AND.DOKM.LT.1.) SGOZ=105.*DOKM**1.04
      IF (DOKM.GE.1.) SGOZ=105.*DOKM**1.104
```

```
      RETURN
C
C     STABILITY CLASS C
  130 IF (DOKM.LT..15) SGOZ=28.4*DOKM**.283
      IF (DOKM.GE..15.AND.DOKM.LT..3) SGOZ=45.8*DOKM**.536
      IF (DOKM.GE..3.AND.DOKM.LT..6) SGOZ=49.*DOKM**.594
      IF (DOKM.GE..6.AND.DOKM.LT.1.) SGOZ=58.*DOKM**.922
      IF (DOKM.GE.1.) SGOZ=58.*DOKM**.909
      RETURN
C
C     STABILITY CLASS D
  140 IF (DOKM.LT..2) SGOZ=22.4*DOKM**.249
      IF (DOKM.GE..2.AND.DOKM.LT..5) SGOZ=26.9*DOKM**.36
      IF (DOKM.GE..5.AND.DOKM.LT.1.) SGOZ=31.4*DOKM**.534
      IF (DOKM.GE.1.) SGOZ=31.4*DOKM**.652
      RETURN
C
C     STABILITY CLASS E
  150 IF (DOKM.LT..3) SGOZ=17.44*DOKM**.213
      IF (DOKM.GE..3.AND.DOKM.LT..7) SGOZ=20.32*DOKM**.340
      IF (DOKM.GE..7) SGOZ=21.98*DOKM**.561
      RETURN
C
C     STABILITY CLASS F
  160 IF (DOKM.LT..5) SGOZ=13.6*DOKM**.177
      IF (DOKM.GE..5.AND.DOKM.LT.1.5) SGOZ=14.68*DOKM**.289
      IF (DOKM.GE.1.5) SGOZ=13.2*DOKM**.552
      RETURN
C
      END
C
C
C
C     RATIO
C
C     SUBROUTINE RATIO - TO ARTIFICIALLY INCREASE THE MIXING CELL
C     CONCENTRATION IN A DEPRESSED SECTION
C
C
      SUBROUTINE RATIO(H,VPH,PHI,U,ROTO)
      COMMON /CALINE/UOBR,HOMT,CLAS,WOMT,ZOMT,DOKM,DODW,SGIY,BNO1,FTR2,
     1              FTR3,PI
      INTEGER VPH,EF,U,PHI,H,CLAS,W,D,Z
C
C     IF THE HIGHWAY IS NOT DEPRESSED, RETURN A VALUE OF 1
      ROTO=1.
      IF (H.GE.0.) RETURN
C
      IF (CLAS.EQ.1)
     1   ROTO=10.**(-0.18164+H*0.01448+VPH*1.439E-5+PHI*7.9E-4)
      IF (CLAS.EQ.2)
     1   ROTO=10.**(0.21754+H*0.01431-PHI*7.2E-4-U*0.02252)
```

```
      IF (CLAS.GT.2)
     1   ROTO=10.**(0.02019+H*0.0138+VPH*4.98E-6-U*5.73E-3)
      IF (ROTO.GT.1.0) ROTO=1.
C
      RETURN
      END
C
C
C
C     WOADJ
C
C     THIS SUBROUTINE ADJUSTS THE FIRST LINEAR SEGMENT OF THE SIGMA Y
C     CURVES TO COMPENSATE FOR DIFFERENT HIGHWAY WIDTHS.  THE MINIMUM
C     DISTANCE IN KILOMETERS IS FOUND USING AN EXTRAPOLATION OF THE
C     STABILITY CLASS "A" SIGMA Y CURVE OF THE OLD CALTRANS MODEL.
C
C
      SUBROUTINE WOADJ
      DIMENSION FACTOR(3,6)
      COMMON /CALINE/UOBR,HOMT,CLAS,WOMT,ZOMT,DOKM,DODW,SG1Y,BNO1,FTR2,
     1              FTR3,PI
      INTEGER VPH,EF,U,PHI,H,CLAS,W,D,Z
      DATA FACTOR/0.9,242.36,0.494,0.8,169.,0.442,0.8,120.,0.392,0.6,
     1 86.96,0.346,0.7,65.,0.304,0.6,49.,0.263/
C
      BNO1=(SG1Y/241.917)**(1/0.4766)
      BNO2=FACTOR(2,CLAS)*(FACTOR(1,CLAS)**FACTOR(3,CLAS))
      FTR3=(ALOG10(BNO2)-ALOG10(SG1Y))/(ALOG10(FACTOR(1,CLAS))-
     1 ALOG10(BNO1))
      FTR2=SG1Y/(BNO1**FTR3)
C
      RETURN
      END
***** ABOVE ACTION SATISFACTORILY COMPLETED *****
```

The following are the input deck and sheets for accessing the FORTRAN program containing CALINE2. Included is an example run of the program.

INPUT DECK FOR CALINE2



JCL CARDS

```
         (1)       (2)            (3)(4)    (5)    (6)    (7)     (8)           (9)                card sequence number
//ENVLIN[ ]  JŌB (T[ ]1ØØP,TR3N,T[   ],[     ][     ][     ][          ]),[          ],      1
//         REGIŌN=1ØØK,CLASS=A                                                              2
                                  (10)             (11)        (12)
//*FŌRMAT  PR,DDNAME=,FŌRMS=DC[  ],CARRIAGE=[ ],DEST=[     ]                                3
//STEPŌNE  EXEC PGM=CALINE2                                                                 4
//STEPLIB  DD DSN=TRANSLIB,DISP=SHR                                                         5
//FT05FØØ1 DD *                                                                             6
                                                                                            7
                                  INPUT DATA CARDS                                          ↓
                                                                                            N
//FTØ6FØØ1 DD SYSŌUT=A                                                                    N+1
//                                                                                        N+2
```

DAS-CS 90-062

(1) - DATA ITEM, SEE NŌTES

Ø - INDICATES A NUMERIC ZERŌ

ō - INDICATES AN ALPHABETIC "O"

NOTES FOR JCL(JOB CONTROL LANGUAGE) CARDS

Card Sequence Number	Item	Item Description
1	1	Optional job identifier, can be left blank
	2	District identification character.*
	3	District identification character.*
	4	MSP code.*
	5	Source code for your job.
	6	Charge code for your job.
	7	Expenditure authorization code for your job.
	8	Special Designation code for your job, may be left blank if you have none.

Note that items 5-8 are not to be separated by commas. Don't forget the ")," after item 8 and if item 8 is left blank or does not require the entire 9-character field, move the ")," to the left so that there are no blanks.

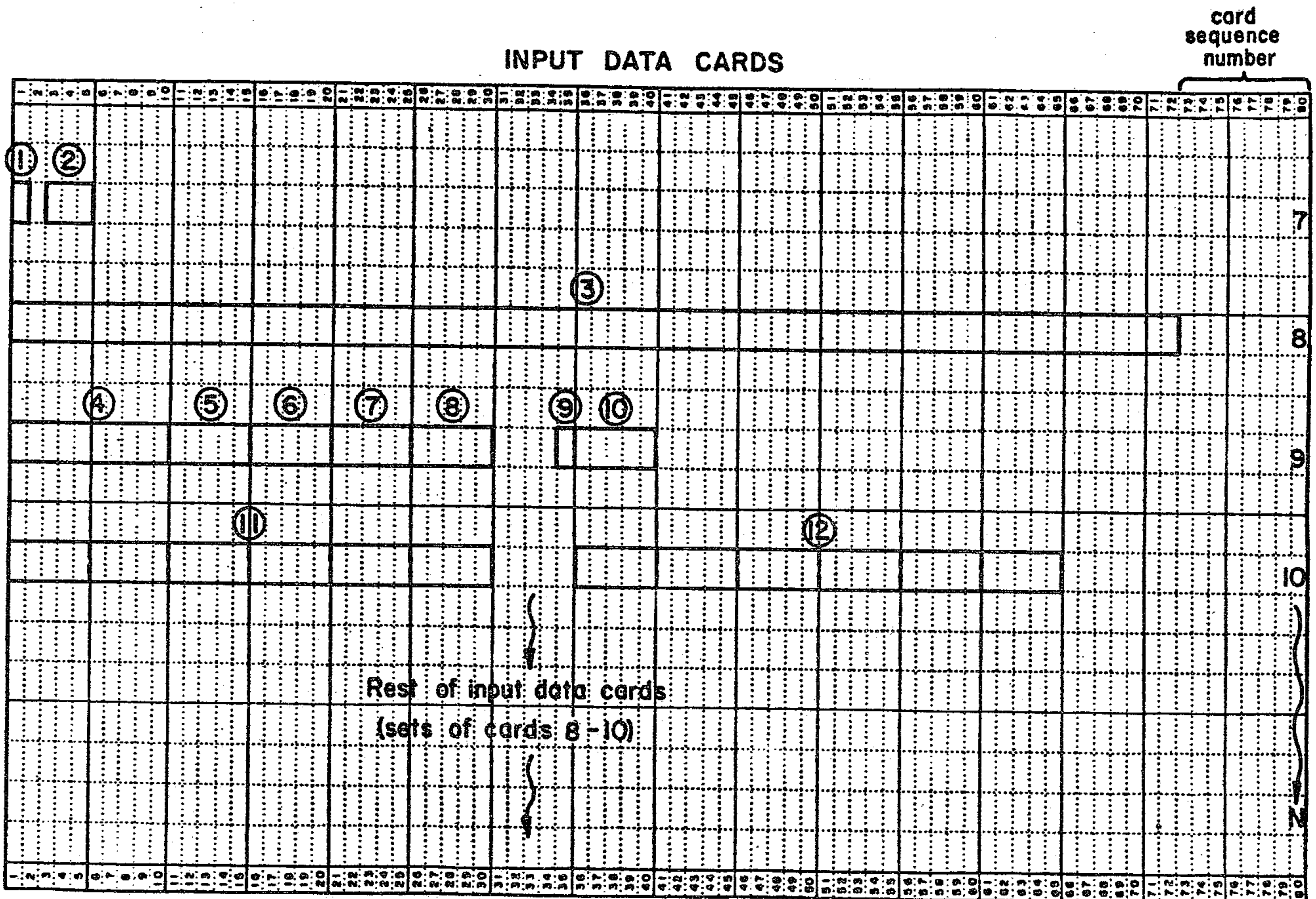
	9	User name, can be any form of your name which will fit in 8 characters or less. If less than 8 characters, move the "," to the left so there are no blanks.
3	10	Output form code, "021" if the output is to come out at your district's remote printer (unless your standard form is different from 14"x8 1/2"). If you desire your output to be printed on 14"x11", route your output to Teale Data Center, and request "061". If you want to put your output directly in a report, or have it in an easily-xeroxable form, route it to Teale, and request "075". See items 11 and 12 for the last two options.
	11	Carriage control code, tells the printer where to expect to page, according to the type of output form requested. For "021" in item 10, this code should be "A". For either "061" or "075", it should be "D".
	12	Destination code, tells the computer where the output is to be printed. Usually of the form "RMT --" where the blanks are replaced by your printer destination code.* This routes the output back to you. If you want it to be printed on the high-speed printers in Sacramento at the Teale Data Center, which is usually the case when your remote printer has a large backlog, or when you request other than standard forms (see items 10 & 11), encode "TDC" and ignore the two remaining blanks. The output will automatically be sent through the State mail or courier system to your EDP section or to the remote printer site, and can be picked up there.

* Contact your EDP (Electronic Data Processing) section for the codes assigned to your District or job.

Cards N+1 and N+2 are to be placed after the end of your input data cards. Don't forget them.

NOTE: The sequence numbers in the last 8 columns of each card are only that; they are for your convenience and for use as reference here, and may or may not be included on your card since the computer will ignore them.

INPUT DATA CARDS



DAS-CS 90-052

① - DATA ITEM, SEE NOTES

NOTES FOR INPUT DATA CARDS

Card Sequence Number	Item	Item Description *
7	1	Form of output 1 = pollutant concentration in parts per million (PPM) 2 = pollutant concentration in micrograms per cubic meter
	2	Number of separate simulation runs
8	3	Title for simulation run. If you want the title centered on the output, center it on the card.
9	4	Vehicles per hour
	5	Average, speed-corrected, heavy-duty-vehicle-weighted emission factor, in grams/mile
	6	Average wind speed, in miles/hour (cannot be less than 2 mph)
	7	Angle of wind to highway, in degrees (must be in the range 0-90°, inclusive)
	8	Pavement height, in feet (cannot be less than -30') note that heights above or below grade (for fill or depressed sections) should be used only when those sections are 1 mile in length or longer, otherwise consider the section to be at-grade, or at the average pavement height of the bounding sections.
	9	Atmospheric stability class, in numeric format (1-6 = A-F)
	10	Highway width, including all lanes, median, and 10' on each side of the highway, in feet (medians should be 30' or less, otherwise simulate each side separately and add concentrations at the receptor site)
10	11	Six receptor distances perpendicular to highway, to nearest foot within each 5-character field. Enter -99 for each distance not desired. (distances cannot be negative, nor greater than 1500', which is the limit of the microscale)

* All inputs are in integer format which, for FORTRAN, means they will have to be right justified withi the field.

Card Sequence Number	Item	Item Description *
10 (cont.)	12	Six receptor heights above grade, to nearest foot within each 5-character field. Enter -99 for each height not desired. Items 11 and 12 will be used together to create a receptor matrix, i.e., each distance will be used in turn with each of the heights. The entire matrix will be output for each simulation run. The matrix can be as small as 1 x 1 (only 1 receptor), and as large as 6 x 6 (36 receptors).

You will need as many sets of cards 2, 3, and 4 as you have separate simulation runs.

*All inputs are in integer format which, for FORTRAN, means they will have to be right justified within the field.

EXAMPLE
JCL CARDS

card sequence number

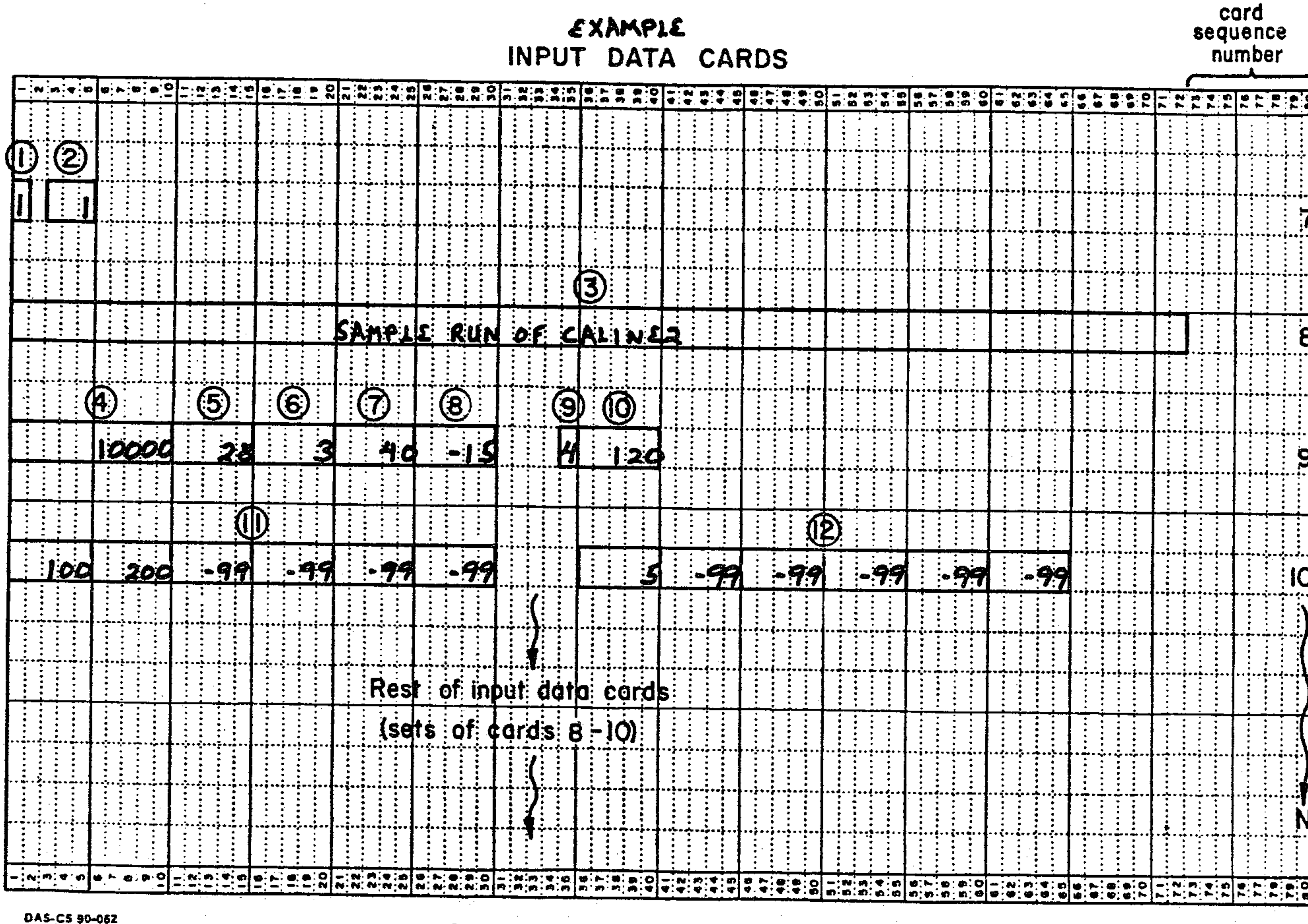
```
//ENVLINE2 JŌB (TM1ØØP,TR3N,TFPMA,197Ø1197Ø1762564GARBAGE    ),CHUKWARD,   1
//         REGIŌN=1ØØK,CLASS=A                                                2

//*FŌRMAT  PR,DDNAME=,FŌRMS=DCØ75,CARRIAGE=D,DEST=10C                         3
//STEPŌNE  EXEC PGM=CALINE2                                                   4
//STEPLIB  DD DSN=TRANSLIB,DISP=SHR                                           5
//FTØ5FØØ1 DD *                                                               6
                                                                              7

                    INPUT DATA CARDS

                                                                              N
//FTØ6FØØ1 DD SYSŌUT=A                                                        N+1
//                                                                            N+2
```

Circled data items: (1) E2, (2) M, (3) F, (4) PMA, (5) 197Ø1, (6) 197Ø1, (7) 762564, (8) GARBAGE, (9) CHUKWARD, (10) Ø75, (11) D, (12) 10C

DAS-CS 90-062

(1) - DATA ITEM, SEE NŌTES
Ø - INDICATES A NUMERIC ZERŌ
Ō - INDICATES AN ALPHABETIC "O"

EXAMPLE
INPUT DATA CARDS



① - DATA ITEM, SEE NOTES

CALINE2: CALIFORNIA LINE SOURCE DISPERSION MODEL,
REVISED JANUARY, 1975

SAMPLE RUN OF CALINE2

PREDICTED CO CONCENTRATION (PPM)

VARIABLES	RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 100	200
VPH= 10000			
EF= 28 GMS/MI	5	4.0	2.4
U= 3 MPH			
PHI= 40 DEGREES			
H= -15 FEET			
CLAS= 4 (D)			
W= 120 FEET			

MIXING CELL CONCENTRATION = 14.1 PPM

36 SAMPLE COMPUTER RUNS

INPUT

CARD COLUMN NUMBERS

```
....*....1....*....2....*....3....*....4....*....5....*....6....*....7.
 1  42
                           SAMPLE CALINE RUN 1
      6000    25     3    90     0     1   120
 0    100    200    400   800  1000               5     10     20     40     60    -99
                           SAMPLE CALINE RUN 2
      6000    25     3    45     0     1   120
 0    100    200    400   800  1000               5     10     20     40     60    -99
                           SAMPLE CALINE RUN 3
      6000    25     3     0     0     1   120
 0    100    200    400   800  1000               5     10     20     40     60    -99
                           SAMPLE CALINE RUN 4
      6000    25     3    90     0     2   120
 0    100    200    400   800  1000               5     10     20     40     60    -99
                           SAMPLE CALINE RUN 5
      6000    25     3    45     0     2   120
 0    100    200    400   800  1000               5     10     20     40     60    -99
                           SAMPLE CALINE RUN 6
      6000    25     3     0     0     2   120
 0    100    200    400   800  1000               5     10     20     40     60    -99
                           SAMPLE CALINE RUN 7
      6000    25     3    90     0     3   120
 0    100    200    400   800  1000               5     10     20     40     60    -99
                           SAMPLE CALINE RUN 8
      6000    25     3    45     0     3   120
 0    100    200    400   800  1000               5     10     20     40     60    -99
                           SAMPLE CALINE RUN 9
      6000    25     3     0     0     3   120
 0    100    200    400   800  1000               5     10     20     40     60    -99
                           SAMPLE CALINE RUN 10
      6000    25     3    90     0     4   120
 0    100    200    400   800  1000               5     10     20     40     60    -99
                           SAMPLE CALINE RUN 11
      6000    25     3    45     0     4   120
 0    100    200    400   800  1000               5     10     20     40     60    -99
                           SAMPLE CALINE RUN 12
      6000    25     3     0     0     4   120
 0    100    200    400   800  1000               5     10     20     40     60    -99
```

ETC.

CALINE2: CALIFORNIA LINE SOURCE DISPERSION MODEL,
REVISED JANUARY, 1975

SAMPLE CALINE RUN 1

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	0.0	0.4	0.4	0.4	0.2	0.2
PHI=	90 DEGREES	40	0.0	0.7	0.6	0.4	0.2	0.2
H=	0 FEET	20	1.1	0.9	0.7	0.5	0.3	0.2
CLAS=	1 (A)	10	3.4	1.0	0.7	0.5	0.3	0.2
W=	120 FEET	5	3.4	1.0	0.7	0.5	0.3	0.2

MIXING CELL CONCENTRATION = 3.4 PPM

SAMPLE CALINE RUN 2

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	0.3	0.4	0.4	0.3	0.1	0.1
PHI=	45 DEGREES	40	0.4	0.6	0.5	0.3	0.1	0.1
H=	0 FEET	20	1.4	0.8	0.6	0.3	0.1	0.1
CLAS=	1 (A)	10	3.8	0.8	0.6	0.3	0.2	0.1
W=	120 FEET	5	3.8	0.8	0.6	0.4	0.2	0.1

MIXING CELL CONCENTRATION = 3.8 PPM

SAMPLE CALINE RUN 3

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	0.6	0.5	0.4	0.2	0.0	0.0
PHI=	0 DEGREES	40	0.7	0.6	0.4	0.2	0.0	0.0
H=	0 FEET	20	1.8	0.6	0.5	0.2	0.0	0.0
CLAS=	1 (A)	10	4.2	0.7	0.5	0.2	0.0	0.0
W=	120 FEET	5	4.2	0.7	0.5	0.2	0.0	0.0

MIXING CELL CONCENTRATION = 4.2 PPM

CALINE2: CALIFORNIA LINE SOURCE DISPERSION MODEL, REVISED JANUARY, 1975

SAMPLE CALINE RUN 4

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	600	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	0.0	0.3	0.4	0.4	0.4	0.3
PHI=	90 DEGREES	40	0.0	0.7	0.7	0.6	0.4	0.4
H=	0 FEET	20	1.1	1.0	0.9	0.7	0.5	0.4
CLAS=	2 (B)	10	3.4	1.1	0.9	0.7	0.5	0.4
W=	120 FEET	5	3.4	1.2	0.9	0.7	0.5	0.4

MIXING CELL CONCENTRATION = 3.4 PPM

SAMPLE CALINE RUN 5

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	0.5	0.6	0.6	0.4	0.2	0.2
PHI=	45 DEGREES	40	0.7	0.9	0.8	0.5	0.2	0.2
H=	0 FEET	20	1.9	1.2	0.9	0.5	0.3	0.2
CLAS=	2 (B)	10	4.3	1.3	0.9	0.6	0.3	0.2
W=	120 FEET	5	4.3	1.3	1.0	0.6	0.3	0.2

MIXING CELL CONCENTRATION = 4.3 PPM

SAMPLE CALINE RUN 6

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	1.1	1.0	0.7	0.4	0.1	0.0
PHI=	0 DEGREES	40	1.4	1.2	0.9	0.4	0.1	0.0
H=	0 FEET	20	2.7	1.3	1.0	0.4	0.1	0.0
CLAS=	2 (B)	10	5.3	1.4	1.0	0.4	0.1	0.0
W=	120 FEET	5	5.3	1.4	1.0	0.4	0.1	0.0

MIXING CELL CONCENTRATION = 5.3 PPM

SAMPLE CALINE RUN 7

PREDICTED CO CONCENTRATION (PPM)

VARIABLES	RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH= 6000							
EF= 25 GMS/MI							
U= 3 MPH	60	0.0	0.3	0.4	0.4	0.4	0.4
PHI= 90 DEGREES	40	0.0	0.7	0.7	0.6	0.5	0.5
H= 0 FEET	20	1.1	1.1	0.9	0.8	0.6	0.5
CLAS= 3 (C)	10	3.4	1.2	1.0	0.8	0.6	0.6
W= 120 FEET	5	3.4	1.3	1.0	0.9	0.6	0.6

MIXING CELL CONCENTRATION = 3.4 PPM

SAMPLE CALINE RUN 8

PREDICTED CO CONCENTRATION (PPM)

VARIABLES	RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH= 6000							
EF= 25 GMS/MI							
U= 3 MPH	60	0.9	0.9	0.7	0.4	0.2	0.2
PHI= 45 DEGREES	40	1.2	1.3	1.0	0.5	0.3	0.2
H= 0 FEET	20	2.6	1.7	1.2	0.6	0.3	0.3
CLAS= 3 (C)	10	5.2	1.8	1.3	0.7	0.3	0.3
W= 120 FEET	5	5.2	1.8	1.3	0.7	0.3	0.3

MIXING CELL CONCENTRATION = 5.2 PPM

SAMPLE CALINE RUN 9

PREDICTED CO CONCENTRATION (PPM)

VARIABLES	RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH= 6000							
EF= 25 GMS/MI							
U= 3 MPH	60	1.8	1.5	1.1	0.4	0.0	0.0
PHI= 0 DEGREES	40	2.4	1.9	1.3	0.4	0.0	0.0
H= 0 FEET	20	4.1	2.2	1.4	0.5	0.0	0.0
CLAS= 3 (C)	10	7.0	2.3	1.5	0.5	0.0	0.0
W= 120 FEET	5	7.0	2.4	1.5	0.5	0.0	0.0

MIXING CELL CONCENTRATION = 7.0 PPM

SAMPLE CALINE RUN 10

PREDICTED CO CONCENTRATION (PPM)

VARIABLES

VPH= 6000
EF= 25 GMS/MI
U= 3 MPH
PHI= 90 DEGREES
H= 0 FEET
CLAS= 4 (D)
W= 120 FEET

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
60	0.0	0.2	0.3	0.4	0.4	0.4
40	0.0	0.6	0.7	0.7	0.6	0.6
20	1.1	1.2	1.0	0.9	0.8	0.7
10	3.4	1.4	1.2	1.0	0.8	0.8
5	3.4	1.4	1.2	1.0	0.8	0.8

MIXING CELL CONCENTRATION = 3.4 PPM

SAMPLE CALINE RUN 11

PREDICTED CO CONCENTRATION (PPM)

VARIABLES

VPH= 6000
EF= 25 GMS/MI
U= 3 MPH
PHI= 45 DEGREES
H= 0 FEET
CLAS= 4 (D)
W= 120 FEET

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
60	1.5	1.2	0.8	0.4	0.2	0.2
40	2.1	1.9	1.2	0.5	0.3	0.3
20	4.0	2.5	1.6	0.7	0.4	0.4
10	7.0	2.8	1.7	0.7	0.4	0.4
5	7.0	2.8	1.8	0.7	0.4	0.4

MIXING CELL CONCENTRATION = 7.0 PPM

SAMPLE CALINE RUN 12

PREDICTED CO CONCENTRATION (PPM)

VARIABLES

VPH= 6000
EF= 25 GMS/MI
U= 3 MPH
PHI= 0 DEGREES
H= 0 FEET
CLAS= 4 (D)
W= 120 FEET

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
60	2.9	2.3	1.4	0.3	0.0	0.0
40	4.3	3.1	1.8	0.4	0.0	0.0
20	6.9	3.9	2.2	0.4	0.0	0.0
10	10.5	4.2	2.3	0.5	0.0	0.0
5	10.5	4.2	2.3	0.5	0.0	0.0

MIXING CELL CONCENTRATION = 10.5 PPM

SAMPLE CALINE RUN 13

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	0.0	0.1	0.2	0.3	0.4	0.4
PHI=	90 DEGREES	40	0.0	0.6	0.6	0.7	0.7	0.7
H=	0 FEET	20	1.1	1.2	1.1	1.0	0.9	0.9
CLAS=	5 (E)	10	3.4	1.5	1.3	1.2	1.0	1.0
W=	120 FEET	5	3.4	1.6	1.4	1.2	1.0	1.0

MIXING CELL CONCENTRATION = 3.4 PPM

SAMPLE CALINE RUN 14

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	2.0	1.5	0.8	0.2	0.2	0.2
PHI=	45 DEGREES	40	3.5	2.6	1.4	0.4	0.3	0.3
H=	0 FEET	20	6.3	3.7	1.9	0.7	0.5	0.5
CLAS=	5 (E)	10	10.0	4.2	2.1	0.7	0.5	0.5
W=	120 FEET	5	10.0	4.3	2.2	0.7	0.5	0.5

MIXING CELL CONCENTRATION = 10.0 PPM

SAMPLE CALINE RUN 15

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	4.1	2.9	1.4	0.2	0.0	0.0
PHI=	0 DEGREES	40	7.0	4.6	2.1	0.2	0.0	0.0
H=	0 FEET	20	11.5	6.3	2.7	0.3	0.0	0.0
CLAS=	5 (E)	10	16.6	6.8	2.9	0.3	0.0	0.0
W=	120 FEET	5	16.6	7.0	3.0	0.3	0.0	0.0

MIXING CELL CONCENTRATION = 16.6 PPM

SAMPLE CALINE RUN 16

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	0.0	0.1	0.1	0.2	0.3	0.3
PHI=	90 DEGREES	40	0.0	0.5	0.6	0.6	0.7	0.7
H=	0 FEET	20	1.1	1.3	1.2	1.2	1.1	1.1
CLAS=	6 (F)	10	3.4	1.7	1.5	1.4	1.2	1.2
W=	120 FEET	5	3.4	1.8	1.6	1.4	1.3	1.2

MIXING CELL CONCENTRATION = 3.4 PPM

SAMPLE CALINE RUN 17

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	2.5	1.5	0.6	0.1	0.1	0.2
PHI=	45 DEGREES	40	5.5	3.3	1.3	0.3	0.3	0.3
H=	0 FEET	20	10.7	5.4	2.1	0.6	0.5	0.5
CLAS=	6 (F)	10	16.0	6.2	2.4	0.7	0.6	0.6
W=	120 FEET	5	16.0	6.5	2.5	0.8	0.6	0.6

MIXING CELL CONCENTRATION = 16.0 PPM

SAMPLE CALINE RUN 18

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	5.1	3.0	1.0	0.0	0.0	0.0
PHI=	0 DEGREES	40	11.0	6.1	2.0	0.1	0.0	0.0
H=	0 FEET	20	20.3	9.6	2.9	0.1	0.0	0.0
CLAS=	6 (F)	10	28.6	10.8	3.2	0.1	0.0	0.0
W=	120 FEET	5	28.6	11.2	3.3	0.1	0.0	0.0

MIXING CELL CONCENTRATION = 28.6 PPM

SAMPLE CALINE RUN 19

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	0.0	0.3	0.3	0.3	0.2	0.1
PHI=	90 DEGREES	40	0.0	0.5	0.4	0.3	0.2	0.1
H=	-10 FEET	20	0.7	0.6	0.5	0.3	0.2	0.1
CLAS=	1 (A)	10	1.7	0.7	0.5	0.3	0.2	0.1
W=	120 FEET	5	2.3	0.7	0.5	0.3	0.2	0.1

MIXING CELL CONCENTRATION = 3.4 PPM

SAMPLE CALINE RUN 20

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
H=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	0.2	0.3	0.3	0.2	0.1	0.1
PHI=	45 DEGREES	40	0.2	0.4	0.3	0.2	0.1	0.1
H=	-10 FEET	20	0.9	0.5	0.4	0.2	0.1	0.1
CLAS=	1 (A)	10	1.8	0.5	0.4	0.2	0.1	0.1
W=	120 FEET	5	2.4	0.5	0.4	0.2	0.1	0.1

MIXING CELL CONCENTRATION = 3.8 PPM

SAMPLE CALINE RUN 21

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	0.3	0.3	0.2	0.1	0.0	0.0
PHI=	0 DEGREES	40	0.4	0.3	0.3	0.1	0.0	0.0
H=	-10 FEET	20	1.0	0.4	0.3	0.1	0.0	0.0
CLAS=	1 (A)	10	1.9	0.4	0.3	0.1	0.0	0.0
W=	120 FEET	5	2.4	0.4	0.3	0.1	0.0	0.0

MIXING CELL CONCENTRATION = 4.2 PPM

CALINE2: CALIFORNIA LINE SOURCE DISPERSION MODEL,
REVISED JANUARY, 1975

SAMPLE CALINE RUN 22

VARIABLES

VPH= 6000
EF= 25 GMS/MI
U= 3 MPH
PHI= 90 DEGREES
H= -20 FEET
CLAS= 2 (B)
W= 120 FEET

PREDICTED CO CONCENTRATION (PPM)

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
60	0.0	0.2	0.3	0.3	0.2	0.2
40	0.0	0.4	0.4	0.4	0.3	0.2
20	0.7	0.6	0.5	0.4	0.3	0.2
10	1.6	0.7	0.6	0.4	0.3	0.3
5	2.1	0.7	0.6	0.5	0.3	0.3

MIXING CELL CONCENTRATION = 3.4 PPM

SAMPLE CALINE RUN 23

VARIABLES

H= 6000
EF= 25 GMS/MI
U= 3 MPH
PHI= 45 DEGREES
H= -20 FEET
CLAS= 2 (B)
W= 120 FEET

PREDICTED CO CONCENTRATION (PPM)

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
60	0.4	0.4	0.4	0.3	0.1	0.1
40	0.5	0.6	0.5	0.3	0.2	0.1
20	1.3	0.8	0.6	0.4	0.2	0.1
10	2.3	0.9	0.6	0.4	0.2	0.1
5	2.9	0.9	0.7	0.4	0.2	0.1

MIXING CELL CONCENTRATION = 4.3 PPM

SAMPLE CALINE RUN 24

VARIABLES

VPH= 6000
EF= 25 GMS/MI
U= 3 MPH
PHI= 0 DEGREES
H= -20 FEET
CLAS= 2 (B)
W= 120 FEET

PREDICTED CO CONCENTRATION (PPM)

RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
60	0.8	0.7	0.5	0.3	0.0	0.0
40	1.0	0.9	0.6	0.3	0.0	0.0
20	2.0	1.0	0.7	0.3	0.0	0.0
10	3.2	1.0	0.7	0.3	0.0	0.0
5	3.9	1.0	0.7	0.3	0.0	0.0

MIXING CELL CONCENTRATION = 5.3 PPM

SAMPLE CALINE RUN 25

PREDICTED CO CONCENTRATION (PPM)

VARIABLES			RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000								
EF=	25	GMS/MI							
U=	3	MPH	60	0.0	0.1	0.1	0.2	0.2	0.2
PHI=	90	DEGREES	40	0.0	0.3	0.3	0.3	0.3	0.3
H=	-30	FEET	20	0.4	0.5	0.4	0.4	0.3	0.3
CLAS=	4	(D)	10	1.1	0.6	0.5	0.4	0.3	0.3
W=	120	FEET	5	1.4	0.6	0.5	0.4	0.3	0.3

MIXING CELL CONCENTRATION = 3.4 PPM

SAMPLE CALINE RUN 26

PREDICTED CO CONCENTRATION (PPM)

VARIABLES			RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
H=	6000								
EF=	25	GMS/MI							
U=	3	MPH	60	0.6	0.5	0.4	0.1	0.1	0.1
PHI=	45	DEGREES	40	0.9	0.8	0.5	0.2	0.1	0.1
H=	-30	FEET	20	1.6	1.1	0.7	0.3	0.2	0.2
CLAS=	4	(D)	10	2.4	1.1	0.7	0.3	0.2	0.2
W=	120	FEET	5	2.9	1.2	0.7	0.3	0.2	0.2

MIXING CELL CONCENTRATION = 7.0 PPM

SAMPLE CALINE RUN 27

PREDICTED CO CONCENTRATION (PPM)

VARIABLES			RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000								
EF=	25	GMS/MI							
U=	3	MPH	60	1.2	0.9	0.6	0.1	0.0	0.0
PHI=	0	DEGREES	40	1.3	1.3	0.8	0.2	0.0	0.0
H=	-30	FEET	20	2.9	1.6	0.9	0.2	0.0	0.0
CLAS=	4	(D)	10	3.8	1.7	0.9	0.2	0.0	0.0
W=	120	FEET	5	4.4	1.8	1.0	0.2	0.0	0.0

MIXING CELL CONCENTRATION = 10.5 PPM

SAMPLE CALINE RUN 28

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	0.0	0.3	0.4	0.4	0.4	0.4
PHI=	90 DEGREES	40	0.5	0.7	0.7	0.7	0.6	0.6
H=	20 FEET	20	3.4	1.0	0.9	0.8	0.7	0.7
CLAS=	4 (D)	10	1.4	1.1	1.0	0.9	0.8	0.7
W=	120 FEET	5	1.1	1.2	1.0	0.9	0.8	0.7

MIXING CELL CONCENTRATION = 3.4 PPM

SAMPLE CALINE RUN 29

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	1.5	1.3	0.9	0.4	0.2	0.2
PHI=	45 DEGREES	40	2.7	1.9	1.2	0.5	0.3	0.3
H=	20 FEET	20	7.0	2.4	1.5	0.6	0.4	0.3
CLAS=	4 (D)	10	4.3	2.5	1.6	0.7	0.4	0.4
W=	120 FEET	5	4.0	2.5	1.6	0.7	0.4	0.4

MIXING CELL CONCENTRATION = 7.0 PPM

SAMPLE CALINE RUN 30

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	3.1	2.3	1.4	0.3	0.0	0.0
PHI=	0 DEGREES	40	4.9	3.1	1.8	0.4	0.0	0.0
H=	20 FEET	20	10.5	3.7	2.1	0.4	0.0	0.0
CLAS=	4 (D)	10	7.2	3.9	2.1	0.4	0.0	0.0
W=	120 FEET	5	6.9	3.9	2.2	0.4	0.0	0.0

MIXING CELL CONCENTRATION = 10.5 PPM

SAMPLE CALINE RUN 31

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	0.0	0.2	0.3	0.4	0.4	0.4
PHI=	90 DEGREES	40	0.0	0.6	0.7	0.7	0.6	0.6
H=	0 FEET	20	1.1	1.2	1.0	0.9	0.8	0.7
CLAS=	4 (D)	10	3.4	1.4	1.2	1.0	0.8	0.8
W=	60 FEET	5	3.4	1.4	1.2	1.0	0.8	0.8

MIXING CELL CONCENTRATION = 3.4 PPM

SAMPLE CALINE RUN 32

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
H=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	1.5	1.3	0.9	0.4	0.2	0.2
PHI=	45 DEGREES	40	2.3	2.0	1.3	0.6	0.3	0.3
H=	0 FEET	20	4.3	2.7	1.7	0.7	0.4	0.4
CLAS=	4 (D)	10	7.4	3.0	1.8	0.8	0.4	0.4
W=	60 FEET	5	7.4	3.1	1.9	0.8	0.4	0.4

MIXING CELL CONCENTRATION = 7.4 PPM

SAMPLE CALINE RUN 33

PREDICTED CO CONCENTRATION (PPM)

VARIABLES		RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH=	6000							
EF=	25 GMS/MI							
U=	3 MPH	60	3.0	2.4	1.5	0.4	0.0	0.0
PHI=	0 DEGREES	40	4.6	3.4	2.0	0.4	0.0	0.0
H=	0 FEET	20	7.5	4.3	2.3	0.5	0.0	0.0
CLAS=	4 (D)	10	11.3	4.6	2.5	0.5	0.0	0.0
W=	60 FEET	5	11.3	4.7	2.5	0.5	0.0	0.0

MIXING CELL CONCENTRATION = 11.3 PPM

SAMPLE CALINE RUN 34

PREDICTED CO CONCENTRATION (PPM)

VARIABLES	RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH= 6000							
EF= 25 GMS/MI							
U= 3 MPH	60	0.0	0.2	0.3	0.4	0.4	0.4
PHI= 90 DEGREES	40	0.0	0.6	0.7	0.7	0.6	0.6
H= 0 FEET	20	1.1	1.2	1.0	0.9	0.8	0.7
CLAS= 4 (D)	10	3.4	1.4	1.2	1.0	0.8	0.8
W= 160 FEET	5	3.4	1.4	1.2	1.0	0.8	0.6

MIXING CELL CONCENTRATION = 3.4 PPM

SAMPLE CALINE RUN 35

PREDICTED CO CONCENTRATION (PPM)

VARIABLES	RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH= 6000							
EF= 25 GMS/MI							
U= 3 MPH	60	1.4	1.2	0.8	0.4	0.2	0.2
PHI= 45 DEGREES	40	2.1	1.8	1.2	0.5	0.3	0.3
H= 0 FEET	20	3.9	2.5	1.6	0.7	0.4	0.4
CLAS= 4 (D)	10	6.5	2.7	1.7	0.7	0.4	0.4
W= 160 FEET	5	6.5	2.7	1.7	0.7	0.4	0.4

MIXING CELL CONCENTRATION = 6.5 PPM

SAMPLE CALINE RUN 36

PREDICTED CO CONCENTRATION (PPM)

VARIABLES	RECEPTOR HEIGHT (Z FEET)	DISTANCE PERPENDICULAR TO HIGHWAY (D FEET) 0	100	200	400	800	1000
VPH= 6000							
EF= 25 GMS/MI							
U= 3 MPH	60	2.9	2.2	1.3	0.3	0.0	0.0
PHI= 0 DEGREES	40	4.2	3.0	1.8	0.4	0.0	0.0
H= 0 FEET	20	6.8	3.7	2.1	0.4	0.0	0.0
CLAS= 4 (D)	10	9.7	4.0	2.2	0.5	0.0	0.0
W= 160 FEET	5	9.7	4.0	2.2	0.5	0.0	0.0

MIXING CELL CONCENTRATION = 9.7 PPM