WIND TUNNEL STUDY OF STACK GAS DISPERSAL AT LANSING POWER STATION, UNITS 1, 2, 3 and 4

by

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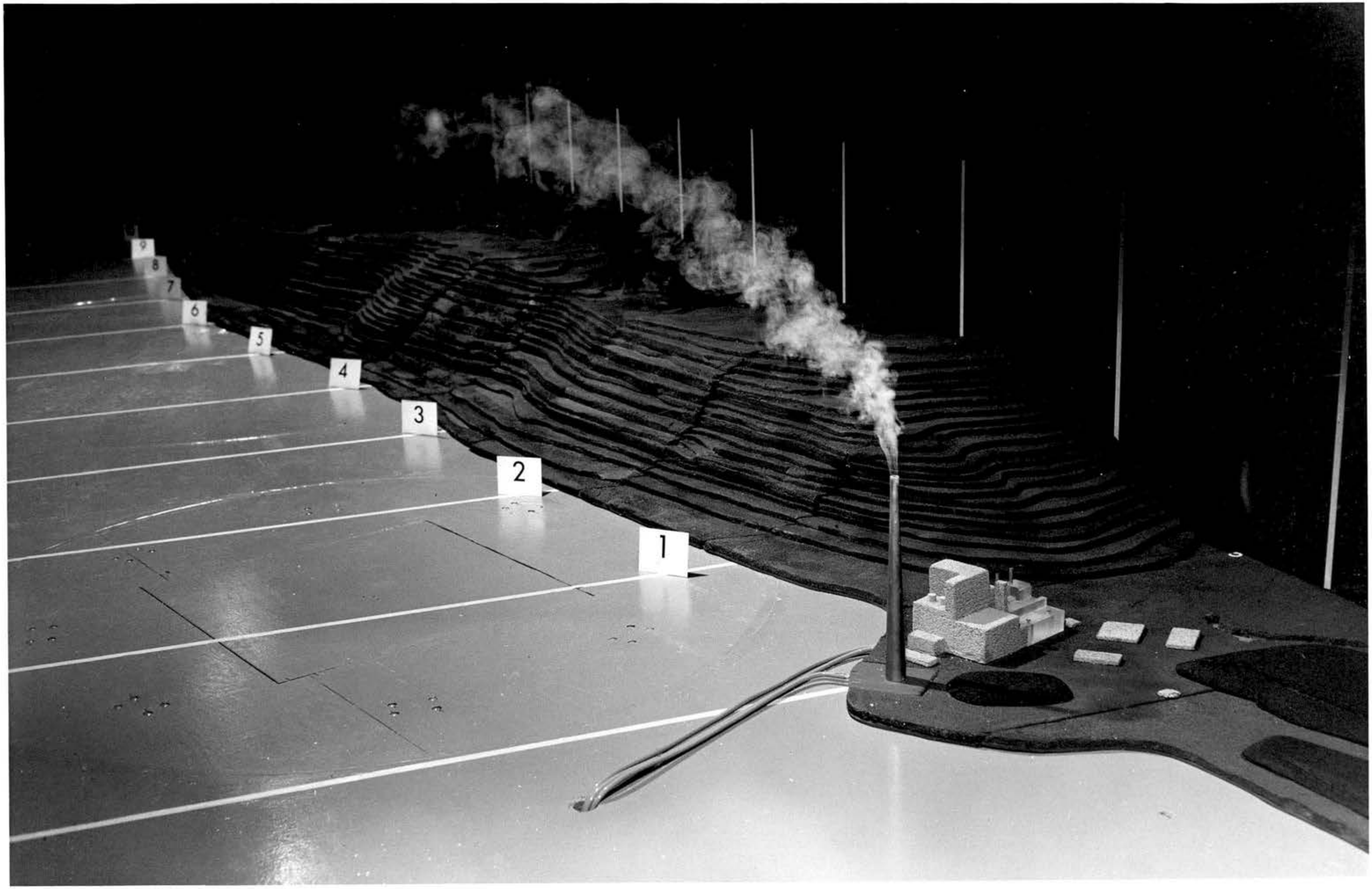


LANSING POWER PLANT MODEL

(Scale 1:400)

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Tests were conducted in the Colorado State University Environmental and Meteorological Wind Tunnel facilities, to study the gaseous plumes released from stacks associated with the Lansing Power Station of the Interstate Power Company. The tests were conducted over a model power plant to scale 1/400 including all significant structures, topography, and roughness elements in the vicinity. Effects of wind orientation, stack height, load, wind velocity, and stratification were established. Data obtained included photographs and color motion pictures of smoke plume trajectories and contaminant concentration downwind of the power plant at ground level sampling positions. On the basis of the experimental measurements reported herein, the following comments may be made:

Neutral Flow:

1) Plumes from Unit 4 do not entrain directly into the building complex cavity for any wind angle, velocity, or load condition studied. Stacks for Units 1-3, being shorter, may entrain for wind velocities 20 ft/sec (13.6 mph) and greater.

2) The rising topography south and west of the plant site intercept plumes released from shorter stacks. A stack height of 500 ft would appear to lift gases emitted from Unit 4 sufficiently such that ground interaction will be noticeable only for the highest wind speeds (>20 ft/sec or >13.6 mph).

3) No significant reduction in ground level concentration for the new stack proposed for unit 4 would be gained for neutral flow situations by increasing the height from 500 to 700 ft.

4) Concentration measurements show that maximum ground-level concentrations will result from Unit 4 at one-half load for NE wind flow over a 300 ft stack. However similar levels for the same stack height may be reached for other wind angles. Ground concentrations for Units 1-3 reach maximum concentrations for full load, existing stacks, for almost any condition evaluated.

Stably Stratified Flow

5) Plumes emitted from Unit 4 stacks of height 500 ft and greater remained aloft in the ground based inversion flow for all wind directions.

6) The highest ground-level concentrations for any Unit 4 stack during the stratified condition is at most one-tenth of the maximum neutral condition.

7) The attempt to model a raised inversion condition was only partially successful. Visualization suggested a mixed layer was formed approximately 300-500 ft deep over the plant site. Unfortunately secondary flows and nonstationarity were also present. In any event the plume buoyancy sufficed to loft the plume above the inversion for all stack heights for the SE wind orientation simulated.

Since specific maximum source levels may vary depending on the source of coal or the load, dimensional prediction tables have been prepared in the manner of Pasquill for the Lansing Power Station configuration. If percent frequency of winds and stability conditions at various wind approach angles are known for the Lansing site, average annual concentrations or 24 hour averages including the effects of wind angle frequency distribution may be calculated in the manner of Turner[52] or Sherlock and Lesher.[44] If one desires the meteorological significant situations such as looping, fanning, fumigation, or trapping one may combine the experimental results developed herein with the expressions suggested by Bierly and Hewson or Slade, Chapter 3, Section 3.5.[47]

LIST OF FIGURES

Figure		Page

Figure		Page

LIST OF TABLES

LIST OF SYMBOLS

Symbol	Definition	
A	Area of the projection of the power station building on a plane transverse to the upstream flow direction	(L^2)
C	Entrainment parameter	(-)
C_p	Specific heat capacity	$(L^2T^{-2}\theta^{-1})$
D	Stack diameter	(L)
Fr	Froude number $\frac{V^2}{g\frac{\Delta\rho}{\rho}D}$	(-)
g	Gravitational constant	(L/T^2)
H	Stack height	(L)
ΔH	Plume rise	(L)
H	Power station effective building height	(L)
k	von Karman constant	(-)
K	Concentration isopleth	(-)
L_{MO}	Monin-Obukhov stability length	(L)
L	Reference length D_s/H_s	
M	Molecular weight	(-)
Q	Source strength	(Curies/T)
Re	Reynolds number $\frac{VL}{\nu}$	(-)
Ri	Richardson number $\frac{g\Delta TH}{T\,V^2}$	(-)
S	Stability parameter $\frac{g}{T}\frac{d\theta}{dz}$	$(1/T^2)$
T	Temperature	(θ)
$\Delta T, \Delta\theta$	Temperature difference across some reference distance or layer	(θ)

Symbol	Definition	
U_*	Friction velocity	(L/T)
V	Mean velocity	(L/T)
x,y,z	General coordinates--downwind, lateral, upwind	(L)
z_o	Surface roughness parameter	(L)

Greek Symbols

χ	Local concentration	(Curies/L^3)
τ	Sampling time	(T)
θ	Potential temperature	(θ)
or	Azimuth angle of upwind direction measured from plant north	(-)
σ	Standard deviation of either plume dispersion or wind angle fluctuations	(L) (-)
ν	Kinematic viscosity	(L^2/T)
δ	Boundary layer thickness	(L)
γ	Specific weight	$M/(T^2L^2)$
ρ	Density	(M/L^3)
Ω	Angular velocity	(1/T)
μ	Dynamic viscosity	M/(TL)
δ	Length scale of boundary layer	(L)

Subscripts

a	Free stream
s	Stack
m	Model
p	Prototype
max	Maximum

CONVERSION TABLE (English to Metric Units)

Multiply units	by	to obtain
inches	2.540	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.02832	cubic meters
feet/second	0.3048	meters/second
miles/hour	0.4470	meters/second
cubic feet/minute	0.02832	cubic meters/minute
cubic feet/minute	0.00047	cubic meter/second

1.0 INTRODUCTION

A wind tunnel study of the Lansing Power Station, Interstate Power Company, Iowa, was motivated by the desire to determine the optimum height and configuration of stacks which would eliminate downwash and reduce the concentration of sulfur dioxide at ground level such that the plant can meet state and federal ambient air quality standards. The power plant is located in Allamakee County, Iowa, approximately three miles southeast of Lansing, Iowa in the Mississippi River valley. Its particular location is such that the ambient wind may carry stack exhaust over the land mass and against the rising river bluffs.

Commercial fossil fuel steam electric generating stations generally require an analysis of the potential behavior of gaseous effluents emitted to the atmosphere as a result of combustion processes. The proposed new design incorporates processes to reduce particulate emissions and ground level concentrations of gaseous chemical effluents to a minimum. Used wisely the atmospheric reservoir permits disposal without damage or nuisance; used without due consideration for its widely varying dispersion capacity, pollutants may at times remain at sufficiently high concentrations near the ground to cause annoyance.

A primary factor in determining whether these gaseous products are to be a nuisance is the stack design. Under certain conditions it may be necessary to make a release in meteorologically unfavorable situations. Hence, it is necessary to design gas exhaust systems such that adequate dispersal of gaseous materials will occur under any realistic meteorological condition.

It has been a traditional design technique to release the various gases through the top of a tall stack located near the power station, where the stack is at least two and one-half times taller than nearby buildings. Calculation of peak and mean ground concentrations of these gases are then based on some semiempirical model which relates the release rate from an elevated point source to the concentration at some point downwind. Mathematical models have been suggested by Sutton, Hay and Pasquill, Roberts and Cramer.[50,37,40,10] These mathematical models require the assumptions of plane homogeneous atmospheric turbulence and constant mean lateral and mean vertical velocities. These assumptions are satisfied for a point release over a flat undisturbed terrain.

In addition, considerable effort has been made to determine the effects of vertical stack velocity and gas buoyancy on the effective stack release height. Recently Carson and Moses[4] have reviewed over 15 plume rise formulas constructed to calculate effective stack heights for conditions where there are no effects from local terrain or buildings. They concluded that no available plume rise equation can be expected to accurately predict short-term plume rise. More recent results produced by Briggs (1969) are more optimistic concerning isolated plumes suggesting error bounds for plume rise of ±20 percent.

Often, it is necessary, due to aesthetics cost, and public relation reasons, to utilize a short to medium height stack. In these cases plume dispersion is sufficiently modified by the presence of the local building structure or ground topography that the only approach available is one of wind tunnel model tests.[33,15]

A number of wind tunnel studies have considered the effects of variations in a single building geometry on plume entrainment and dispersion.[16,49,12,23] These studies have permitted the specification of pertinent scaling criteria for model studies of plume excursions near buildings. Model laws will be discussed in greater detail in Section 2.

Since each arrangement of the power plant and auxiliary buildings or terrain may have separate effects on the generation of mechanical turbulence and mean flow movement, any specific gas dispersion problem will require individual tests. Hence, there exist in the literature descriptions of a variety of different model studies on reactor and industrial plants.[15,24,11,44,19,29,30,32,7] These studies are significant in that their results have been essentially confirmed by either direct prototype measurements or the absence of the gases or dusts the study was directed to remove. References 24, 11, 19, and 29 incorporate such comparisons within their text. Reference 15 has recently been compared with prototype measurements at the National Reactor Testing Station in Southeast Idaho.[12] Agreement of the diffusion concentration results were very satisfactory. Martin[29] favorably compared his wind tunnel study measurements about a model of the Ford Nuclear Reactor at the University of Michigan with prototype measurements. Finally, Munn and Cole[35] have taken diffusion measurements on a power station complex at the National Research Council, Ottawa, Canada, to confirm the general entrainment criteria suggested by the model studies of Davies and Moore.[11]

The purpose of this study is to determine the behavior of plumes created by gases discharged from a proposed new stack for Unit 4 and existing stacks for Units 1-3, of the Interstate Power Company Lansing Power Station (Figs. 1 and 2). Using a 1:400 scale model of the plant in a wind tunnel capable of simulating the appropriate meteorological conditions downwind ground-level stack-gas concentrations were determined by sampling concentrations of tracer gas (Krypton 85) released from the model stacks and overall plume geometry was obtained by photographing smoke plumes created by releasing smoke (titanium oxide) from the model stacks.

The general scope includes determination of how plume behavior is affected by stack height by loading level, wind direction, wind speed and thermal stratification of the atmosphere. A wide range of meteorological conditions can be simulated in the meteorological and environmental wind tunnel of the Fluid Dynamics and Diffusion Laboratory (FDDL) at Colorado State University. The conditions simulated for this study included the adiabatic lapse rate (thermally neutral flow), the ground based inversion, and an elevated inversion (thermally stable flows).

The modeling criteria necessary to simulate atmospheric motions over such a site are presented in Section 2. Details of the model construction and the experimental equipment are described in Section 3. Finally, Sections 4 and 5 discuss the results obtained and their significance.

This report is supplemented by a motion picture (in color) which shows the plume behavior for all stacks for all operating levels, wind directions and meteorological conditions investigated during the course of this study (see Table 11 for motion picture sequences). A set of black-and-white photographs of each plume realization further supplements the material presented in this report.

2.0 SIMULATION OF ATMOSPHERIC MOTION

The use of a wind tunnel for model tests of gas diffusion by the atmosphere is based upon the concept that nondimensional concentration coefficients will be the same at contiguous points in the model and the prototype and will not be a function of the length scale ratio. Concentration coefficients will only be independent of scale if the wind tunnel boundary layer is made similar to the atmospheric boundary layer by satisfying certain similarity criteria. These criteria are obtained by inspectional analysis of physical statements for conservation of mass, momentum and energy. Detailed discussions have been given by Halitsky,[16] Martin[29] and Cermak.[8] Basically the model laws may be divided into requirements for geometric, dynamic, thermic and kinematic similarity. In addition, similarity of upwind flow characteristics and ground boundary conditions must be achieved.

For the Lansing Power Station study, geometric similarity is satisfied by an undistorted model of length ratio 1:400. This scale was chosen to facilitate ease of measurements, provide a boundary layer equivalent to 800-1000 ft for the atmosphere and minimize wind tunnel blockage. (The ratio of projected area to the area of the wind tunnel cross section should not exceed 5 percent. The model of the Lansing Power Station at a scale of 1:400 produced a blockage of 1.0 percent in the MWT and 0.5 percent in the EWT.)

2.1 Modeling the Neutral Atmosphere Case

When interest is focused on the vertical motion of plumes of heated gases emitted from stacks into a thermally neutral atmosphere the following variables are of primary significance:

ρ_a = density of ambient air

$\Delta\gamma$ = $(\rho_a - \rho_s)g$--difference in specific weight of ambient air and stack gas

Ω = local angular velocity component of earth

μ_a = dynamic viscosity of ambient air

V_a = speed of ambient wind at stack height

V_s = speed of stack gas emission

H = stack height

D = stack diameter

δ_a = thickness of planetary boundary layer

z_o = roughness heights for upward surface

Grouping the independent variables into dimensionless parameters with ρ_a, V_a and H as reference variables yields the following parameters upon which the dependent quantities of interest must depend:

$$\frac{V_a}{H\Omega}, \frac{\delta_a}{H}, \frac{z_o}{H}, \frac{D}{H}, \frac{V_a \rho_a H}{\mu_a}, \frac{\rho_s V_s^2}{\rho_a V_a^2}, \frac{\rho_a V_a^2}{\Delta\gamma D}, \frac{\Delta\gamma}{g\rho}$$

The laboratory boundary-layer-thickness parameter δ_a/H was made approximately equal to that for the atmosphere. A value for this ratio of at least 1.5 was established for the highest stacks. Equality of the surface parameter z_o/H for model and prototype was achieved through geometrical scaling of the stacks and upwind roughness. Likewise the stack parameter D/H was equal for model and prototype.

Dynamic similarity is achieved in a strict sense if a Reynolds number $\frac{\rho_a V_a H}{\mu_a}$ and a Rossby number $\frac{V_a}{H\Omega}$ for the model is equal to its counterpart for the atmosphere. The model Rossby number cannot be made equal to the atmospheric value. However, over the short distances considered (up to 15,000 ft), the Coriolis acceleration has little influence upon the flow. Accordingly, the standard practice is to relax the requirement of equal Rossby numbers.[8]

Kinematic similarity requires the scaled equivalence of streamline movement of the air over prototype and model. It has been shown by Golden[15] that flow around geometrically similar sharp-edged buildings at ambient temperatures in a neutrally stratified atmosphere should be dynamically and kinematically similar when the approaching flow is kinematically similar. This approach depends upon producing flows in which the flow characteristics become independent of Reynolds number if a lower limit of the Reynolds number is exceeded. For example, the resistance coefficient for flow in a sufficiently rough pipe as shown in Schlicting (42, p. 521) is constant for a Reynolds number larger than 2×10^4. This implies that surface or drag forces are directly proportional to the mean flow speed squared. In turn, this condition is the necessary condition for mean turbulence statistics such as root-mean square value and correlation coefficient of the turbulence velocity components to be equal for the model and the prototype flow.[16,8]

Golden, as cited by Halitsky,[15,16] found that for flow about a cube for Reynolds numbers above 11,000, there was no change in concentration measurements. The minimum Reynolds number encountered in the present study was 11,000 based on the model scale of 1.0 ft and a minimum velocity of 15 fps. Correlation tests of flow about the Rock of Gibraltar flow over Pt. Arguello, California, and flow over San Nicolas Island, California, may be cited as examples of large Reynolds number flows which have been modeled successfully in a wind tunnel.[14,5,31]

Buildings and building complexes produce nonuniform fields of flow which perturb the regular upstream atmospheric wind profiles. Around each building a boundary layer exists, where the velocity is zero at the surface but increases rapidly to a relatively constant value a short distance from the building wall. Outside of the boundary layer and downstream there exists a region of low velocities and pressures called the cavity. In this region circulations are such that flow may actually reverse with respect to the upstream winds. Surrounding the cavity but extending further downstream is a parabolic region called the wake in which the presence of the building is still evident in terms of deviations of velocity, turbulence, and pressure from conditions found in the upstream atmospheric boundary layer.

The formation of the wake and cavity regions are associated with a phenomena called boundary-layer separation. Under certain conditions the boundary layer actually detaches and enters the flow streaming about the building. This may occur at the corner of a sharp-edged building or on a curved surface if the pressure increases due to a decelerating flow field. The separated boundary layer forms a sheet which completely surrounds the cavity region which contains relatively stagnant fluid. The extent of the cavity region for the Lansing Power Station building may be approximated by $5H \cong 1000$ ft. Based on the measurements of Evans[13] the effect of alternate wind approach angles to an elongated rectangular complex may extend this to $6H \cong 1200$ ft.

The need for scaling of the atmospheric mean wind profile was demonstrated by Jensen.[23] Substitutions of a uniform velocity profile for a logarithmic profile results in threefold variation in the dimensionless pressure coefficient downstream of a model building.

Such variance in the pressure fields indicates a strong effect of the upstream wind profile on the kinematic behavior of the fluid near the building complex. One of the few tunnels currently capable of generating a turbulent boundary layer thick enough for a 1:400 model scale is the Meteorological Wind Tunnel at Colorado State University. Other investigators have attempted to generate logarithmic profiles in short tunnels by inserting special grids upstream of the test section; however, this technique normally creates a nontypical turbulence field which decays rapidly downstream.

The length scale used for scaling the velocity profile is the roughness height z_o.[8] For the Lansing Power Station site typical roughness lengths for land to river motion is assumed to be less than 3 ft, while river to land winds may be typified by a length less than 1/2 in.[51] This means the critical sea to land wind velocities could be modeled in the wind tunnel by a roughness length of less than 1/400 in., or essentially a smooth upstream surface. A turbulent boundary layer approximately 2.5 ft thick was produced by an upstream fetch of 40 ft in the Meteorological Wind Tunnel, and by a tailored vortex grid in the Environmental Wind Tunnel. Considering the sudden change in terrain height, the presence of trees over the hilltops and along the river bluffs, it was decided to simulate the upstream wind profile by a power law exponent of approximately 0.27. This shape profile is characteristic of flow over terrain well covered by numerous obstructions. The irregular river valley terrain quickly modifies this to suit itself by local separation and reattachment over local surface irregularities.

Equality of the parameter $\rho_a V_a^2/(\Delta\gamma D)$ for model and prototype in essence determines the relationship between the atmospheric wind speed and the model wind speed once the geometric scale has been selected (1:400 in this case). Often this criteria results in $(V_a)_m$ being too small to satisfy the minimum Reynolds number requirement. When this happens to the specific weight difference for the model $(\Delta\gamma)_m$ can be made larger than $(\Delta\gamma)_p$ to compensate for the effect of small geometric scale.

Using the lowest stack height (300 ft) and a wind speed of 13.6 mph or 20 ft/sec and a scale of 1:400, the Froude number equality gives

$$\frac{(V_a)_m^{\,2}}{(V_a)_p^{\,2}} = (\frac{1}{400}) \frac{(\Delta\gamma)_m}{(\Delta\gamma)_p}$$

or

$$(V_a)_m = \frac{1}{20} \; [(\Delta\gamma)_M/(\Delta\gamma)_p]^{1/2} \; 20$$

When the specific weight-difference ratio is unity

$$(V_a)_m = 1.00 \text{ ft/sec.}$$

The corresponding model Reynolds number then becomes approximately

$$(\frac{V_a \rho_a H}{\mu_a})_m = \frac{1.0 \times 1}{1.5 \times 10^{-4}}$$

$$= 6700 < 11{,}000.$$

Accordingly the model wind speed would need to be increased to attain the desired minimum Reynolds number.

When the prototype stack gas temperature is 300°F, the foregoing expression for Froude number equality requires that the model stack gas temperature should be approximately 600°F to reach model Reynolds number of 11,000. This temperature is not a practical level for modeling;

however, helium may be used to attain the proper density differences ($\Delta\gamma_m$). The minimum Reynolds number of 11,000 can be obtained if the ratio of specific weight difference is adjusted to 2.24. The permissible minimum wind speed $(V_a)_M$ then becomes 1.50 ft/sec.

By decreasing the density of the plume gas in the model it is thus possible to increase the velocity scale factor and still keep buoyancy scaling at the stack exit. Downstream of the stack exit, however, as the light plume gas mixes with the much denser surrounding air, its buoyancy is depleted at too high a rate to maintain correct scale conditions relative to the prototype plume, for which the density difference ratio between plume and surroundings is less. Yet the above procedure represents the closest approach to correct buoyancy scaling that can be achieved with a model plume which is spreading at the correct rate at the stack exit.

The interaction of the emitted effluent with the wind is governed by the ratio of their respective momenta.[15,16,49,11,29] When the prototype and model plumes have the same density this reduces to a ratio of velocities. When one reduces the plume density there is the problem that its momentum flux relative to that of the surrounding air is too low if the efflux velocity, V_s, is scaled by the same factors as the surrounding air velocity, V_a. This could be corrected by increasing the efflux velocity according to

$$V_{sm} = V_{am} \frac{V_{sp}}{V_{ap}} \sqrt{\frac{\rho_{sp}}{\rho_{sm}}} \sqrt{\frac{\rho_{am}}{\rho_{ap}}} \ .$$

Unfortunately, now one finds repercussions on the rate of mixing of the plume and hence on its rise on the initial phase.

To resolve the stack velocity scaling dilemma a series of smoke tests were made for plume trajectory utilizing different velocity ratio factors. These tests were compared with the predictive equations developed by Hoult.[21] It became apparent that given the Froude number, $\rho_a V_a^2/(\Delta\gamma D)$, is scaled exactly, requiring equality in $\rho_s V_s^2/\rho_a V_a^2$ when $\Delta\gamma/\rho g$ is distorted results in too early a dominance of buoyancy, a raised total trajectory, and an overly optimistic prediction of ground level concentration. On the other hand if one requires equality of only the V_s/V_a ratio the initial stack momentum is too low, the trajectory issuing from the stack exit falls beneath the prototype behavior, and slightly conservative estimate of potential ground concentrations is obtained. A sketch is provided in Fig. 3 to illustrate these points. Since early entrainment was not expected for the new stack produced for Unit 4, Lansing Power Station, the trajectories and mixing ratio associated with the equality of $(V_s/V_a)_p = (V_s/V_a)_m$ was chosen as most suitable.

To summarize the following scaling criteria were applied for the neutral boundary layer situation:

1/ $\mathrm{Re} = \dfrac{\rho_a V_a H}{\mu_a} > 11{,}000$

2/ $\mathrm{Fr} = \dfrac{\rho_a V_a^2}{\Delta\gamma D}$; $(\mathrm{Fr})_m = (\mathrm{Fr})_p$

3/ $R = \dfrac{V_s}{V_a}$; $R_m = R_p$

4/ $(z_o)_m = (z_o)_p$

5/ Similar velocity and turbulence profiles upwind.

Operating conditions for the Lansing Power Station have been supplied by Sargent & Lundy Engineers for the various units. (See Table 1). Meteorological data converted to the form of wind rose patterns (Fig. 4) suggest tests at four primary wind orientations. Modeled wind velocities, stack velocities, and plume densities based upon the selected scaling criteria are tabulated together in Table 2 and Table 3.

2.2 Modeling the Stratified Atmosphere Case

When air follows a trajectory over a cold water surface, the lower layers of the atmosphere are cooled and an inversion develops to a depth of from 100 to 1000 ft. Yang and Meroney found that inversion stratification causes smaller transverse spread in a diffusing plume behind a simple model building.[55] The stratification "freezes" the plume growth in the vertical direction once aerodynamic mixing has subsided. When a tall stack associated with a power plant that is located near the shoreline discharges into the elevated stable layer, the plume initially disperses slowly as it moves downwind. If during the reduced growth of the plume dimensions it contacts a well mixed layer near the ground the plume may descend subsequently more quickly. Such mixed layers may be the result of aerodynamic mixing over rough terrain or the result of solar heating of the ground surface. Thus at some point the mixing layer extends upward to the plume level. At this point material in the plume mixes rapidly downward to cause "fumigation" and high concentrations at ground level.[48,1,25-28,53,9]

When vertical motion of plumes takes place in an atmosphere with thermal stratification, additional requirements must be met to achieve similarity of the atmospheric motion. These requirements have been discussed previously by Cermak,[6] Yamada and Meroney,[51] and SethuRaman and Cermak.[43] Similarity of the stably stratified flow approaching the power plant can be be achieved by requiring equality of the bulk Richardson number

$$Ri = \frac{\Delta T}{\overline{T}} \frac{H}{V_a^2} g$$

for the laboratory flow and the atmosphere. In this expression, $\Delta\overline{T}$ is the difference between mean temperature (potential temperature for the atmosphere) at the surface and at the height H, $\overline{T}$ is the average temperature over the layer of depth H and g is the acceleration due to gravitational attraction.

In order to simulate the phenomenon of a raised inversion resulting from destabilization of the lower surface layer similarity must be attained for heat transfer from the warm land surface to the atmosphere. The Monin-Obukhov length scale

$$L_{MO} = \frac{-U_*^3}{(kg/T)(q/\rho C_p)}$$

for similarity of the atmospheric surface layer provides a good gross parameter when combined with the stack height H to form a dimensionless ratio H/L. In this expression U_* is the shear velocity $(\tau_o/\rho)^{1/2}$, τ_o is the surface shear stress, ρ is the average air density, C_p is the average specific heat for unit mass, q is the surface heat flux and k is the von Kármán constant (0.4). To obtain equality of H/L for the laboratory flow and the atmosphere L must be 400 times smaller for the laboratory flow than for the atmosphere. This is accomplished by testing at a low velocity V_a of about 1 mi/hr (this results in a low value for U_*) and heating the land surface to a high temperature relative to the actual land surface (about 250°F) in order to make q large compared to the atmosphere.

Although one can thus obtain an order of magnitude estimate of laboratory simulation conditions it is expected that the Monin-Obukhov length scale may vary locally. In addition momentum and heat flux information do not appear to be conveniently available for the field or model case.

In order to develop the characteristics of a raised inversion layer a four foot section of the wind tunnel floor upstream of the Lansing Power Plant Model was heated such that ground released smoke sources mixed to an equivalent level of 300 ft. Downstream of this section the floor was neither heated nor cooled but allowed to reach an equilibrium condition on its own.

For a strongly stable stratified flow it is expected that the power-law coefficient for the velocity profile will increase in magnitude. Sutton reports measurements over an English airfield of coefficient values of 0.44, 0.59, 0.63, 0.62 and 0.77 when the temperature change over a 400 ft depth was 2-4, 4-6, 6-8, 8-10 and 10-12°F, respectively.[36] Panofsky, et al., have produced a nomogram from diabatic wind profile measurements for the power-law coefficient variation versus surface roughness, z_o, and stability length parameter, L, which suggests values for strongly stable situations between 0.25 to 0.6.[37]

3.0 TEST APPARATUS

3.1 Wind-Tunnels

The environmental wind tunnel (EWT) shown in Fig. 5 was used for the neutral flow study, and the meteorological wind tunnel (MWT) shown in Fig. 6 was used for the stable stratification study. These wind tunnels, specially designed to study atmospheric flow phenomena, incorporate special features such as adjustable ceilings, rotating turntables, temperature controlled boundary walls, and long test sections to permit adequate reproduction of micrometeorological behavior. Mean wind speeds of 0.2 to 50 ft/sec (0.14 to 40 mi/hr) in the EWT and 0.2 to 130 ft/sec (0.14 to 90 mi/hr) in the MWT can be obtained. In the EWT boundary layers 3 ft thick over the downstream 20 ft can be obtained with the use of the vortex generators at the test section entrance. Boundary-layer thickness up to 4 ft can be developed "naturally" over the downstream 20 ft of the MWT test section. Thermal stratification in the MWT is provided by the heating and cooling systems in the section passage and the test section floor. The flexible test section roof on both the EWT and MWT are adjustable in height to permit the longitudinal pressure gradient to be set at zero.

3.1.1 Test Configuration in the EWT

Vortex generators were installed at the tunnel entrance together with an initial roughness to accelerate the preliminary growth of the modeled boundary layer.

The Lansing Power Station model and terrain (see Section 3.2) were constructed to represent accurately a swath 1200 ft to the right and left of the wind orientation chosen. For the SE and NW wind orientations the model was placed against the side walls of the EWT. This allowed the clear areas on the wind tunnel floor to represent the broad expanse of the Mississippi River. For the SW and NE wind orientations the model was centered in the EWT and topography outside the accurately constructed terrain model to either side was reproduced approximately by temporary canvas and brick construction (Fig. 7). The floor of the tunnel was pierced by 58 taps arranged in sampling arrays to measure ground level concentrations. The false floor was precut in a series of segments to permit orienting the shoreline angle to four cases.

3.1.2 Test Configuration in the MWT

A set of vortex generators were installed 2 ft downwind of the entrance to give the simulated boundary an initial impulse of growth. From 6 to 40 ft a set of 12 roll-bond aluminum panels were placed on the tunnel floor. These panels were connected to the facility refrigeration system and cooled to approximately 32°F. For those cases where a stably stratified approach flow was required the entire tunnel floor length was cooled to 32°F. The air temperature at tunnel centerline was monitored at about 100°F. As mentioned previously in Section 2.2 when a raised inversion was required the first 34 ft of the tunnel was cooled to 32°F, the next 4 ft of floor was heated to develop a mixed layer approximately 300 ft (9 in. in tunnel) deep, and the remaining tunnel floor sections were neither heated nor cooled. An array of ground level sampling tubes permitted concentration measurements downwind to an equivalent field distance of 8,000 ft.

3.2 Model

The model consisted of the power station, the stacks, and the auxilliary buildings constructed from lucite and styrofoam to a linear scale of 1:400. (See Fig. 9). The basic topography was reporduced by fixing terraces of contoured styrofoam to Masonite sheets.

The model and topography were built at a 1/400 scale to dimensions taken from Sargent & Lundy Engineers, supplied drawings. These were topographical maps NK 15-3 LaCrosse, Ferryville Quadrangle; and drawings MS-110, MS-114, MS-115, MA-116, MS-117, MS-121, MS-123, MS-126, MS-127, MS-146, M-1, M-2, M-3, M-4, M-220, M-221, M-222, M-120, M-121, M-122, M-207, M-500, M-501, M-502. Three stacks were constructed for Unit 4--one 700 ft, one 300 ft, and one 300 ft in height. Two sets of stacks were constructed for Units 1-3--one 150 ft and one 190 ft. All connections to the stacks were made by the additions of fittings at the base of each stack.

As a result of the severe entrainment observed as a result of the new boiler building influence on Unit 1-3 stacks a larger model, scale 1/200, was constructed at the request of Sargent & Lundy Engineers. This model was used to determine the influence of a number of alternative stack-height and exit nozzle combinations on the performance of plumes emitted from Unit 1-3 stacks. Stack heights of 150, 190, and 230 ft were examined. Nozzle area ratios of 1:1, 1:0.84, and 1:0.51 were studied for each stack height.

Metered quantities of gas were allowed to flow from each stack to simulate the exit velocity and also account for buoyancy effects due to the temperature difference between the stack gas and the ambient atmosphere. Helium and compressed air were mixed in metered amounts to adjust the specific weight as proposed in Section 2. Fischer-Porter flow rator settings were adjusted for pressure, temperature, and molecular weight effects as necessary. When a visible plume was required the gas was bubbled through titanium tetrachloride before emission. When a traceable plume was required a high pressure mixture of Krypton-85 and air was used in place of the compressed air.

3.3 Flow Visualization Techniques

Smoke was used to define plume behavior over the power plant complex. The smoke was produced by passing the air mixture through a container of titanium tetrachloride located outside the wind tunnel and transported through the tunnel wall by means of a tygon tube terminating at the stack inlet within the model complex. The plume was illuminated with arc-lamp beams. A visible record was obtained by means of pictures taken with a Speed Graphic camera utilizing Polaroid film for immediate examination. Additional still pictures were obtained with a Hasselblad camera. Stills were taken with camera speeds of both 1/30 and 30 seconds--the first to capture characteristic plume excursions on the short time scale, the second to identify mean plume boundaries. A complete series of color motion pictures were also taken with a Bolex motion picture camera mounted on a movable dolly which was traversed the length of the tunnel parallel to the plume trajectory at the average wind speed. Complete sets of these still pictures and motion picture sequences were provided to Sargent & Lundy Engineers, as a separate part of this final report.

3.4 Wind Profiles and Temperature Measurements

A standard pitot-static tube was utilized to measure the up and downstream velocity profiles in the EWT for neutral flow fields. Thermal stratification and low wind velocities precluded use of pitot-static tubes or hot-wire anemometer systems in the MWT. Hence two new systems were utilized to measure velocities under such conditions--first, an eddy shedding device based on the Strouhol shedding frequency of a cylinder in a cross flow,[20] and second, a smoke wire method.

The device requires a "hot-wire" probe positioned in the cylinder wake to measure the eddy shedding frequency. The trace of the anemometer signal was observed on storage oscilloscope and the probe position adjusted so that only the frequency of vortex shedding from one side of this cylinder was counted. The signal appeared in wave form and could be counted by means of constructing Lissajous figures on an oscilloscope. Velocity was determined from Roshko's data relating Strouhol number to Reynolds number. Previous comparison of velocity measurement so measured with the smoke wire technique suggests accuracies to 3 percent.

A smoke wire method has also been utilized to investigate the flow field during thermal stratification. It was perfected for practical use at the Engineering Research Center, Colorado State University. Figure 10 shows a smoke wire with attached instruments for velocity measurements. The advantage of the smoke wire method is an instantaneous visualization of the velocity profile.

The principle of the technique is to follow photographically a white smoke emitted from a wire when light oil is vaporized. In Fig. 10 A is a nichrome wire which is heated electrically, thus vaporizing an oil coating. Oil is dropped down by gravity through an oil outlet B. B is connected to an oil reservoir C and an air bag pushes the oil in the reservoir through the outlet. To measure velocity profiles quantitatively, several auxiliary devices are necessary: a strobe, a strobe delay system, an electronic counter, a trigger circuit, and a camera (see Fig. 10). A trigger circuit is connected to the smoke wire, to a strobe through a delay unit, and to an electronic counter. When a start button on the front pannel of the trigger unit is pushed, a high voltage (~700 volts) is applied to the nichrome wire, vaporizing the oil coating. A white smoke is released instantaneously and is carried along by the ambient wind. A typical time-delay photograph is included in Fig. 10. The actual velocity profile can be reduced from the picture by use of the recorded time difference between the moment of firing the wire and the moment of the strobe picture.

Measurement of temperature was made with a miniature thermistor (Fennal glass coated bead) system constructed by Yellowsprings, Corp. (YSI Model 42 SC). Thermocouples mounted in the MWT aluminum floor were used to monitor boundary temperatures and set electric heater controls. Table 4 lists all the instrumentation and materials employed in this study.

3.5 Gas Tracer Technique

After the flow in a tunnel was stabilized, a mixture of Kr-85 of predetermined concentration was released from model stacks at a required rate (Table 2). Samples of air were withdrawn from the sample points on the wind tunnel floor and analyzed. The flow rate of Kr-85 mixture was controlled by a pressure regulator at the supply cylinder outlet and monitored by Fischer and Porter precision flow meters. Source concentration was from .23 to .48 μc_i/cc of Kr-85, a beta emitter (half lifetime = 10.3 years). The sampling and detection systems are shown in Fig. 11 and described in Ref. 7. A sampling grid of sample points was spaced on the wind tunnel floor (Fig. 12) at suitable locations to establish the plume axis and locate the points of maximum ground-level concentrations.

3.5.1 Analysis of Data

Krypton-85 is a radioactive noble gas with a half life of 10.6 years. The gas decays by emission of beta particles with small amounts of gamma rays. The gas has many advantages over the other tracers used in wind tunnel dispersion studies. It is diluted with air about a million times before use, and as such, has properties very similar to those of air. Its detection procedure is fairly simple and direct.

The procedure for analyzing the concentration data was as follows:

1) Counts of the pulses generated in the G.M. tubes and displayed by the ultra scaler counter were recorded for each sample location

2) These counts were transformed into concentration values by the following steps:□

Cpm - Background (Cpm) = Cpm*

Cpm* x Counting Yield (p Curie/cc/Cpm) = χ($\mu\mu$ Curie/cc)

3) For counts over 1,000 a dead time correction△ had to be applied to the readings, and in this case the correction is,

Cpm - Background = Cpm*

$$\frac{\text{Cpm*}}{1 - 1.77 \times 10^{-6} \times \text{Cpm*}} = \text{Cpm*}$$

Cpm* x Counting Yield = χ(p Curie/cc).

□p Curie: pico curie (10^{-12} curie)

△The time taken for the positive space charge to move sufficiently far from the anode for further pulses to occur.

4) Average concentration values were determined for the known probe position and then displayed at the proper locations.

5) The concentration parameter $\chi \overline{V}/Q$ was then computed at all locations. A sample computation is shown below:

$$q = 600 \text{ cc/min} = 10 \text{ cc/sec}$$

$$Q_{total} = 1.8 \ \mu \text{ Curie/cc} \times 10 \text{ cc/sec}$$

$$= 18.0 \ \mu \text{ Curie/sec}$$

Let $V = 2$ fps $= 60.96$ cm/sec, and $\chi = 80$ p Curie/cc. Then

$$\frac{\chi V}{Q} = \frac{80 \times 10^{-6} \times 60.96}{18} \times 10^{4} = 2.71 \text{ m}^{-2}$$

$$(= .25 \text{ ft}^{-2})$$

6) So far the values of the concentration parameter apply to the model and it is desirable to express these values in terms of the field. At the present time there is no set procedure for accomplishing this transformation. The simplest and most straightforward procedure is to make this transformation using the scaling factor of the model. Since

$$1 \text{ ft}|_m = 400 \text{ ft}|_p \ (= 122 \ ^{m}|_p),$$

one can write

$$\frac{\chi V}{Q}\Big|_p \ (\text{ft}^{-2}) = \frac{1}{400^2} \times \frac{\chi V}{Q}\Big|_m (\text{ft}^{-2})$$

or

$$\frac{\chi V}{Q}\Big|_p \ (\text{m}^{-2}) = \frac{1}{400^{-2}} \times \frac{\chi V}{Q}\Big|_m \ (\text{m}^{-2})$$

or in terms of the above example,

$$\frac{\chi V}{Q}\Big|_p \ (\text{ft}^{-2}) = \frac{1}{400^2} \times .25 = 1.57 \times 10^{-6} \ (\text{ft}^{-2})$$

or

$$\left(\frac{\chi V}{Q}\right|_p \;(m^{-2}) = \frac{1}{400^2} \times 2.71 = 16.94 \times 10^{-6} \;(m^{-2}))$$

This sample scaling of the concentration parameter from model to field appears to give reasonable results.

7) To convert these results to concentration in ppm of SO_2 requires specific information concerning the prototype SO_2 source strength. If the source strength of Unit 4 is say 944.6 gm/sec-SO_2 and the mean wind speed is 22 ft/sec then

$$\chi_p = \frac{\chi V}{Q}\Big|_p \times \frac{Q}{V}\Big|_p = 1.57 \times 10^{-6} \times \left(\frac{944.61/454}{22}\right)$$

$$= 0.148 \times 10^{-6} \; 16/ft^3 - SO_2$$

$$(\text{or } \chi_p = 16.94 \times 10^{-6} \times \left(\frac{944.6}{22 \times 0.30}\right) = 2.42 \times 10^{-3} \; g/m^3$$

$$= 2.42 \times 10^{-3} \; mg/m^3 \times 0.375 \times 10^{-3}$$

$$= .91 \; ppm - SO_2$$

3.5.2 Errors in Concentration Measurements

Where data is obtained with a scaler counter, the apparent activity of a radioactive source is found by subtracting the background rate from the observed sample-plus-background rate. The background rate is measured separately and has an uncertainty of its own due to random radioactive sources.

If the background is present, the standard deviation in the net counting rate σ_{R_s} for a sample is

$$\sigma_{R_s} = \left(\frac{R_{s+b}}{t_s} + \frac{R_b}{t_b}\right)^{1/2}$$

where R_{s+b} is the observed sample-plus-background rate, R_b is the background rate, t_s and t_b are the measurement time for the sample and background, respectively. The standard deviation in the sample rate depends, then, upon both the time for sample measurement and that for background-rate measurement. When R_{s+b} is large in comparison with R_b, a long background measurement is not needed to make the error contribution from the background rate negligible. On the other hand, when R_{s+b} is comparable to R_b, both t_s and t_b must be very long for small values of σ_{R_s}. In the present experiments, an effort was made to keep the probable errors in concentration measurements within 10 percent. For this reason the sample counting time and background counting time were manipulated with this end in view. More detailed information on errors in radioactivity measurements can be found in Yang and Meroney.[55]

3.5.3 Test Results: Concentration Measurements

Since the conventional point-source diffusion equations cannot be used for predicting diffusion near objects which cause the wind to be nonuniform and nonhomogeneous in velocity and turbulence, it is necessary to calculate gaseous concentrations on the basis of experimental data. It is convenient to report dilution results in terms of a nondimensional factor independent of model to prototype scale.

In Refs. 8 and 16 the problem of similarity for diffusion plumes is discussed in detail. It is suggested that concentration measurements be transformed to K-isopleths by the formula

$$K = \frac{\chi}{Q/AV_a}$$

where

χ = sample volume concentration

A = frontally projected area of power plant complex

V_a = mean wind velocity at some references height

Q = gas source release rate

This expression is specifically suitable for measurements within the near-wake and cavity region. Data reported herein, however, represent measurements made at equivalent distances of 8,000 ft from the power plant.

Concentration measurements were made at various downwind distances in the vertical and horizontal planes. Count rates were corrected to concentration in picocuries and compensation was made for Geiger Mueller tube dead time. Since measurements were made at a variety of wind approach angles, wind velocities, and stack positions, the ground level concentration data has been reported in terms of the ratio $V_a\chi/Q$ which has units of length squared. For dispersion in a homogeneous flow this should produce similarity for various V_a and Q values. The significance of all results are discussed in the following section.

When interpreting model diffusion measurements it is important to remember that there can be considerable difference between the instantaneous concentration in a plume and the average concentration due to horizontal meandering. The average dilution factors near a building complex will correlate well with wind tunnel dilution factors since the mechanical turbulence of the wake and cavity region dominate the dispersion. In the wind tunnel a plume does not generally meander due to the absence of large scale eddies. Thus, it is found that field measurements of peak concentrations which effectively eliminate horizontal meandering, should correlate with the wind tunnel data.[18] In order to compare downwind measurements of dispersion to predict average field concentrations it is necessary to use data on peak-to-mean concentration ratio as gathered by Singer, et al. Their data is correlated in terms of the gustiness categories suggested by Pasquill for a variety of terrain conditions.[45] It is possible to determine the frequency of different gustiness categories for a specific site.[46] Direct use of wind tunnel data at points removed from the building cavity region may underestimate the dilution capacity of a site by a factor of 4 unless these adjustments are considered.[29]

An alternate technique has also been suggested by Hino who argues the relationship between the maximum of time-mean ground concentration χ_{max} and the sampling time is $\chi_{max} \sim \tau^{-1/2}$.[18] Field experiments may be compared with wind tunnel data by the formula:

$$(\chi_a)_p = \frac{(\chi_a)_m Q_p V_p^{-1} h_p^{-2}}{Q_m V_m^{-1} h_m^{-2}} \left(\frac{\tau_p}{\tau_m}\right)^{-1/2}$$

where χ_a is the maximum axial concentration, Q discharge rate of gases from a stack, V wind speed, h effective height of stack, τ sampling time, and subscripts p and m represent values for a prototype and model respectively.[18] One may assume that τ_m corresponds to 3 to 5 minutes in the atmosphere for the wind tunnel experiment. Pasquill's suggested values for the standard deviations σ_z and σ_y correspond to 10 minute averages.[52,37] Hence tunnel concentrations could be high by a factor of 1.7 if a 10 minute average is desired, or by a factor of 21.9 if a 24 hour average is desired.

An examination of Singer's results for peak-to-mean concentration ratios suggests the ratio is a function of both stability and boundary surface roughness. Hence for a variation of stratification from unstable to moderately stable the peak/mean concentration ratio may be nearly equal though the sampling time might vary from 30 minutes to 3 minutes respectively and the power law coefficient in Hino's equation above would vary from -0.6 to -0.3. It is not likely that a decisive interpretation of the effects of plume meandering will be available in the near future; hence, the conservative assumption is recommended that the wind tunnel measurements correspond to a 30 minute averaging time and, when correcting results to alter sampling periods, a power law coefficient of -1/2 be utilized. (A 5 minute wind tunnel equivalent sampling time results in 24 hour equivalent concentrations 50 percent smaller.)

4.0 TEST PROGRAM AND RESULTS

4.1 Test Program

The test program consisted of (1) a qualitative study of the flow field around the power plant by visual observation of the smoke plume trajectory released from the stacks; and (2) a quantitative study of gas concentrations produced by the release of Kr-85 from the stacks. The test conditions are summarized in Tables 2 and 3. The test program was accomplished in two parts: Phase A involved neutral stratification and Phase B involved stable stratification.

Angular locations of the approach winds are referred to in terms of angles from a nominal north. Downwind distances refer to lengths as measured from the free standing Unit 4 stack as marked in Fig. 2. Unless otherwise noted, the term wind velocity refers to the velocity in the free stream above the tunnel boundary layer; however, a velocity at any reference height is available by referring to the velocity profiles. (Figs. 11 and 12)

4.2 Phase A: Neutral Stratification

4.2.1 Test Results: Characteristics of Flow

All the experiments were carried out in the EWT over the range of conditions shown in Table 2. The atmospheric boundary layer was modeled to produce a velocity profile equivalent to flow typical of broken terrain. Figure 13 shows the development of the velocity profile over the model for a neutral situation. The profile is conditioned by the building complex as the wind passes over the plant. No comparison of model velocity data with that in the prototype is possible because the latter is not available over a range of height. However, as the model velocity profiles were carefully produced over roughness tailored to reflect the characteristics of the site, it is expected that the prototype flow is adequately represented in the model. The power law exponent for the upstream velocity profile was 0.27.

4.2.2 Test Results: Visualization

The test results consist of photographs and sketches showing the general nature of air flow and diffusion in the vicinity of the power station, (Fig. 16). A general understanding of wake and cavity flows is necessary for an interpretation of the plume behavior (see Ref. 16).

The sequences of photographs shown in Fig. 16 show side views of the behavior of a smoke plume released from Unit 4 at wind angle SE for full load at various wind velocities and stack heights. At low wind speeds the plume lofts high above the separation cavity and aerodynamic wake generated by the power plant complex. The gas behaves as a plume released at an elevated point and is convected well downstream. As the wind speed increases the stack effluent plume is bent over and behaves as though it were released at increasingly lower effective heights. At a sufficiently large free stream velocity the plume intermittently entrains behind the stack itself and the plume may intersect the building wake. For the shortest set of stacks (Units 1-3) at high wind speeds the plume may become completely entrained in the building complex cavity. Entrainment, as utilized herein, will be understood as the presence of any of the gas released from the stack in the power station cavity. A small amount of entrainment usually first occurs under conditions where the gas plume follows the cavity separation streamline to the downstream cavity stagnation point from which it diffuses upstream into the cavity proper. Downwash will be understood as severe entrainment where the plume does not penetrate the separation streamline but rather ventilates directly into the cavity region. A decrease in load from full to one-half has the same effect on the plume behavior as an increase in wind speed. In general lower load aggravates plume behavior; however one must consider the reduced pollutant burden is any assessment of the net significance. Figure 17 displays the effect of change in load for Unit 4, wind angle NW, when the mean effective wind speed is 40 ft/sec.

It is instructive to examine the plume behavior for both instantaneous effluent boundary location and when averaged over a larger time period. Figure 18 depicts the plume outlines when the camera is released after 1/32 and 30 seconds respectively. In an instantaneous sense a plume may contact the ground yet result in rather low ground average concentrations. The longer averaging time tends to emphasize locations beyond which extensive ground contact will occur.

The topography appears to have a minimal effect on plume transport and diffusion for the SE wind direction (toward the city of Lansing). The terrain flattens in the direction of this nearest city and the river widens to include marshy areas and islands. When wind is from the SW sector (directed from the bluffs toward the river) the plumes do not loft as high because of the descending approach stream and recirculation behind the river bluffs. Plumes descended to the ground level nearest the plant for this wind orientation. When wind is from the NW plumes were lifted over the terrain by ascending air. However for the lowest stack heights, Unit 4 (300 ft), Units 1-3 (151, 190 ft) the plumes bathe the river bluffs with fumes. For taller stacks, Unit 4 (500 and 700 ft) the plumes ascended well, only touching the tallest topographical features at high wind speeds. Finally when the wind approached over the river from the NE the plumes often followed terrain features such as small canyons and terrain irregularities. At highest wind speeds all plumes bathe the rising terrain; however, as one can see from the wind rose, Figure 4, this will be very infrequent. One observes in Figure 19 for the 500 ft tall Unit 4 stack the plant plume rises well over all terrain features even for half load at a wind speed of 20 ft/sec. One notes that even this lowest wind speed studied is very infrequent at this location.

Plumes from Unit 1-3 are strongly influenced by the presence of the tall Unit 4 boiler structure nearby. For both 151 and 190 ft stacks plumes are entrained into the building wake and cavity for all wind approach directions. Figure 20 displays the typical appearance of plume entrainment into the structures cavity and wake. Since the behavior of these stacks appeared most significant a larger model was built to a scale of 1/200 to test comparative influence of different combination of stack height and nozzle shape for Units 1-3. See discussion in Section 4.4.

The observed "touchdown" distances evaluated from the flow visualization tests are summarized in Table 5. Touchdown is defined during observation as that point where the plume encounters the ground more than 10 percent of the time. Such an interpretation is necessarily qualitative but different observers do not vary by more than 500 ft. Smoke photographs tend to confirm the initial opinion. Complete sets of instantaneous (speed 1/32 sec) and average (shutter speed 1 sec) still photographs supplement this report. Color motion pictures have been arranged into titled sequences, and the sets available are summarized in Table 9..

4.2.3 Test Results: Concentration Measurements

Turbulent diffusion of gaseous effluent released at two different stack locations were studied. One represented effluents from existing units (1-3) while the second represents the presence of a new stack for Unit 4. Krypton-85 concentrations at ground level and in the vertical were measured at distances equivalent to 1000 ft to 9000 ft downwind.

Twenty-five samples were taken over the model distributed at ground level over the topography in the matrix shown in Fig. 12. Since the stack for Unit 4 was sometimes displaced to the right or left of the concentration grid centerline, coordinates x and y of this stack are recorded for each set of data. All concentration data have been converted to the prototype scale levels as explained in Section 3.5.1. The data is recorded herein in dimensional form as $\chi V/Q$ (m^{-2}) where χ is the concentration over the assumed equivalent averaging time for laboratory measurements, Q is the source strength, and V is the mean wind velocity at stack height (300 ft). The source flow rate and thermal condition assumed for each stack and load condition are summarized in Tables 1, 2 and 3. Data in Table 1 were provided by Sargent & Lundy Engineers.

The results for various sources, loads, wind directions, and wind velocities are presented in Table 10. The coordinates x and y shown in the tables are explained in the definition sketch in Fig. 12. The maximum concentration measured and its respective downwind location for each situation have been gathered together in Table 6.

For full load, Unit 4, maximum concentrations occur at ground level for a 300 ft stack for NW and SE wind directions at a wind speed of 40 ft/sec. Values are $\chi V/Q$ (m^{-2}) = 12.9×10^{-6} and 11.2×10^{-6}

respectively. For one-half load, Unit 4, maximum ground level concentrations will occur for NE wind direction at 60 ft/sec (40.9 mph) and the NW wind direction at 40 and 60 ft/sec. Values are $\chi V/Q$ (m^{-2}) = 73.4×10^{-6}, 38.3×10^{-6}, and 51.9×10^{-6} respectively. The maximum ground concentration at one-half load is approximately four times greater than the maximum concentration at full load when the differences in source strength are not considered. If one assumes one-half the emissions of fumes will occur at one-half load then the worst one-half load case is twice as large as the worst full load case.

An increase in stack height from 300 to 500 ft and then to 700 ft reduce maximum full load ground level concentrations by two and four respectively. However one should observe that for wind speeds less than 20 ft/sec (13.6 mph) no noticeable ground level gases were found out to 9000 ft from the plant site.

Construction of the large Unit 4 boiler adjacent to the short stacks for Units 1-3 definitely increases plume entrainment. Maximum ground level concentrations for plumes emitted from Units 1-3 are from two to six times greater in the presence of the new boiler building. The addition of 40 ft to each stack for Units 1-3 does not suffice to reduce ground level concentrations in this situation. Even with the additional height the stack height to building height ratio is only 1.0; thus the results found are consistent with past experience.

An appendix is included which gives a short discourse on plume calculation techniques pertinent to the cases examined herein. The example case supplied for a 300 ft, Unit 4, stack when compared with laboratory result emphasize the importance of considering topography, exhaust velocity ratio, and stack/building height ratio.

4.3 Phase B: Stable Stratification

4.3.1 Test Results: Characteristics of Flow

All experiments were carried out in the MWT for an approach wind speed of 20 ft/sec (13.6 mph) and a bulk Richardon number of ~1.0. Based on the recommendations of Pasquill and Smith a bulk Richardson number of ~1.0 would correspond to a very stable flow situation. In terms of the Pasquill stability classification this would correspond to an F stability category.[56] The atmospheric boundary layer was modeled to produce a velocity and temperature profile equivalent to flow over a river basin. Figures 14 and 15 show the initial upwind profiles of velocity and temperature. Turbulence was essentially absent as evidenced by the behavior of smoke plumes released over the cooled surface. The profiles are conditioned by the cooled or heated land surface and the presence of the building complex. The power law coefficient for the lower equivalent 200 ft of the modeled boundary layer was 0.88, the slightly less stratified region above fit a coefficient of 0.76. A bulk Richardson number evaluated over the height of 300 ft has the value of $Ri_B \cong 1.0$ which represents a strongly stable condition.

Figures 14 and 15 show the influence of heating the lower surface on the developing flow profile and temperature profile when an inversion condition was modeled for the SE wind orientation. Figures 14 and 15 show developing velocity and temperature profiles for the situation when winds come across the plant site from the bluffs to the SW of the plant. Finally Figs. 14 and 15 display the influence of wind approaching from the NW. No attempt was made to make measurements for flow rising over the bluffs as the wind approached from the NE.

4.3.2 Test Results: Visualization

The test results consist of photographs and movie sequences showing the nature of the air flow and diffusion in the vicinity of the power station. (Fig. 22 to Fig. 24). One should refer to Section 4.2.2 for a discussion on building wake and cavity effects.

The sequence of photographs shown in Figs. 22 and 23 shows side views of the behavior of a smoke plume released from Unit 4 at wind angle SE for full load and one-half load at various stack heights. A decrease in load from full to one-half has the same effect on the initial plume as an increase in wind speed. At no time did it appear plumes intersected the surface over the model for this orientation.

The observed "touchdown" distances evaluated from the flow visualization tests are summarized in Table 7. These distances represent locations where the visual impression is gained that the plume resides greater than 10 percent of the time. Only for the NE wind orientation does any plume emitted from Unit 4 (stack heights 300-700 ft) interact with the ground surface (See Fig. 24). In this case the topography appears to raise sufficiently to intersect the 300 ft and 500 ft plume releases.

4.3.3 Test Results: Concentration Measurements

Twenty-five ground level sampling locations were prepared at distances equivalent to 1,000 ft to 9,000 ft downwind. Measurements of Krypton-85 activity at these locations have been converted to $\chi V/Q$ (m^{-2}) prototype per the earlier discussions. The results for various sources, loads, wind angles and wind velocities are presented in Table 11. The maximum concentration measured and its respective downwind location for each situation have been accumulated into Table 8. For full load, Unit 4, maximum concentrations occurred for a 300 ft stack at NW wind directions 2.21 x 10^{-6} (m^{-2}). A 500 ft stack provided enough additional plume elevation to eliminate measurable levels in the laboratory. For a one-half load situation the 300, 500, and 700 ft stacks develop ground level concentrations of 1.63 x 10^{-6}, 0.06 x 10^{-6}, and 0 (m^{-2}) respectively.

The Appendix titled Dispersion Calculations also contains a critique of current understanding for dispersion situations. Again it is found that the building wake produces a marked increase in ground level concentrations not accounted for in the state-of-the-art calculation procedures.

4.4 Alternative Unit 1, 2 and 3 Stack Configurations

As a result of the increase in model scale it was possible to simultaneously model plume buoyancy and momentum effects. The laboratory settings used are summarized in Table 3. Figures 21a-d reveal that entrainment may occur for almost any given modification to the existing stacks; however, the addition of a style two nozzle (nozzle area reduction of 51 percent) to the 190 ft stacks will decrease or eliminate local high concentrations for anything but the highest wind speeds (>27 mph). For the lower wind speeds (See Fig. 21d) the added momentum provided by the nozzle will loft the plumes above Unit 4 boilers and the cavity structure.

5.0 CONCLUSIONS

The investigation was undertaken to determine the dispersion of exhaust gases released from stacks of the Lansing Power Station operated by the Interstate Power Company, Iowa. The primary aim of the study was to determine the optimum height of stack to utilize a new boiler unit (Unit 4) and determine the effect of building-complex wake on ground-level concentrations of sulfur-dioxide.

On the basis of the experimental measurements reported herein, the following comments may be made:

5.1 Phase A: Neutral Flow

1) Plumes from Unit 4 do not entrain directly into the building complex cavity for any wind angle, velocity, or load condition studied. Stacks for Units 1-3, being shorter, may entrain for wind velocities 20 ft/sec (13.6 mph) and greater.

2) The rising topography south and west of the plant site intercept plumes released from shorter stacks. A stack height of 500 ft would appear to lift gases emitted from Unit 4 sufficiently such that ground interaction will be noticeable only for the highest wind speeds (>20 ft/sec or 13.6 mph).

3) No significant reduction in ground-level concentration for the new stack proposed for Unit 4 would be gained for neutral flow situations by increasing the height from 500 to 700 ft.

4) Concentration measurements show that maximum ground-level concentrations will result from Unit 4 at one-half load for NE wind flow over a 300 ft stack. However similar levels may be reached for other wind angles. Ground concentrations for Units 1-3 reach maximum concentrations for full load, existing stacks, for almost any condition evaluated.

5.2 Phase B: Stable Stratification

5) Plumes emitted from Unit 4 stacks of height 500 ft and greater remained aloft in the stably stratified flow for all wind directions.

6) The highest ground-level concentrations for any Unit 4 stack during the stratified condition is at most one-tenth of the maximum neutral condition.

7) The attempt to model an elevated inversion condition was only partially successful. Visualization suggested a mixed layer was formed approximately 300-500 ft deep over the plant site. Unfortunately secondary flows and nonstationarity were also present. In any event the plume buoyancy sufficed to loft the plume above the inversion for all stack heights for the SE wind orientation simulated.

Since specific maximum source levels may vary depending on the source of coal or the load, dimensional prediction tables have been prepared in the manner of Pasquill for the Lansing Power Station configuration. If percent frequency of winds and stability conditions at various wind approach angles are known for the Lansing site, average annual concentrations or 24 hour averages including the effects of wind angle frequency distribution may be calculated in the manner of Turner[52] or Sherlock and Lesher.[44] If one desires the meteorological significant situations such as looping, fanning, fumigation, or trapping one may combine the experimental results developed herein with the expressions suggested by Bierly and Hewson or Slade, Chapter 3, Section 3.5.[47]

REFERENCES

1. Barrett, R. V. "Use of the Wind Tunnel to Investigate the Influence of Topographical Features on Pollution from a Tall Stack," Chimney Design Symposium, April 9-11th, 1973. Edinburgh, Scotland, 16 p.

2. Barry, P. J., "Estimation of Downwind Concentration of Airborne Effluents Discharged in the Neighborhood of Buildings," Canadian Report AECL-2043, July 1964.

3. Bierly, E. W. and E. W. Hewson, "Some Restrictive Meteorological Conditions to be Considered in the Design of Stacks," Journal of Applied Meteorology, Vol. 1, 1962, pp. 383-390.

4. Carson, J. E., and H. Moses, "Validity of Currently Popular Plume Rise Formulas," USAEC Meteorological Information Meeting, (September 11-14, 1967), Chalk River, Canada, AECL-2787, pp. 1-15.

5. Cermak, J. E., and J. Peterka, "Simulation of Wind Fields Over Point Arguello, California, by Wind-Tunnel Flow Over a Topographical Model, " Final Report, U.S. Navy Contract N 126(61756)34361 A(PMR), Colorado State University, Report No. CER65JEC-JAP64, (December 1965).

6. Cermak, J. E., "Laboratory Simulation of the Atmospheric Boundary Layer," AIAA Jl., Vol. 9, No. 9, pp. 1746-1754, September 1971.

7. Cermak, J. E. and S. K. Nayak, "Wind-Tunnel Model Study of Downwash from Stacks at Maui Electric Company Power Plant, Kahului, Hawaii," Fluid Dynamics and Diffusion Laboratory Report CER72-73JEC-SKN8, Colorado State University, March 1973.

8. Cermak, J. E., "Simulation of Atmospheric Motion by Wind-Tunnel Flows," Colorado State University, Report Number CER66-JEC-VAS-EJP-GJB-HC-RNM-SI17.

9. Collins, G. F., "Predicting Sea Breeze Fumigation from Tall Stacks at Coastal Locations," Nuclear Safety, Vol. 12, No. 2, pp. 110-114, 1971.

10. Cramer, H. E., "A Practical Method for Estimating the Dispersal of Atmospheric Contaminants," Proceedings, First Nat'l Conf. on Appl. Meteor., Amer. Meteor. Soc., C, pp. 33-35. Hartford, Conn., (October 1957).

11. Davies, P. O. A. L., and P. L. Moore, "Experiments on the Behavior of Effluent Emitted from Stacks at or Near the Roof Level of Tall Reactor Buildings," Int. Jour. Air Water Pollution. Vol. 8, pp. 515-533, (1964).

12. Dickson, C. R., G. E. Start and E. H. Markee, Jr., "Aerodynamic Effects of the EBR-II Containment Vessel Complex on Effluent Concentrations," USAEC Meteorological Information Meeting, Chalk River, Canada, AECL-2787, pp. 87-104, (September 11-14, 1967).

13. Evans, B. H., "Natural Air Flow Around Buildings," Research Report 59, Texas Engineering Experiment Station, (1957).

14. Field, J. H., and R. Warden, "A Survey of the Air Currents in the Bay of Gibraltar, 1929-1930," Air Ministry, Geophys, Mem. No. 59, London (1933).

15. Halitsky, J., J. Golden, P. Halpern, and P. Wu, "Wind Tunnel Tests of Gas Diffusion from a Leak in the Shell of a Nuclear Power Reactor and from a Nearby Stack," Geophysical Sciences Laboratory Report No. 63-2, New York University, (April 1963).

16. Halitsky, J., "Gas Diffusion Near Buildings," Geophysical Science Laboratory Report No. 63-3, New York University, (February 1963).

17. Hewson, E. W., "Stack Heights Required to Minimize Ground Concentrations," ASME Transaction, Vol. 77, pp. 1163-1172, 1955.

18. Hino, M. "Maximum Ground-Level Concentration and Sampling Time," Atmospheric Environment, Vol. 2, pp. 149-165, 1968.

19. Hohenleiten, H. L. von and E. Wolf, "Wind Tunnel Tests to Establish Stack Heights for the Riverside Generating Station," Trans ASME Vol. 64, pp. 671-683, (October 1942).

20. Hoot, T. G., Meroney, R. N., and J. A. Peterka, "Wind Tunnel Tests of Negatively Buoyant Plumes," FDDC Report CGR73-74TGH-RNM-JAP13, Colorado State University, October 1973.

21. Hoult, D. P., et al. "A Theory of Plume Rise Compared with Field Observations," M.I.T. Fluid Lab. Pub. 68-2, (PB 179 536), March 1968.

22. Integrated Army Meteorological Wind-Tunnel Research Program, Eleventh Quarterly Progress Report, 22 pages, (1 November 1967 - 31 January 1968).

23. Jensen, M., and N. Frank, "Model-Scale Test in Turbulent Wind, Part I," The Danish Technical Press, Copenhagen, (1963).

24. Kalinske, A. A., "Wind Tunnel Studies of Gas Diffusion in a Typical Japanese Urban District," National Defense Res. Council OSCRD Informal Report No. 10. 3A-48 and 48a, (1945).

25. Lyons, W. A. and H. S. Cole, "Fumigation and Plume Trapping: Aspects of Mesoscale Dispersion on the Shores of Lake Michigan in Summer During Records of Stable Onshore Flow," Conference on Air Pollution Meteorology, Raleigh, North Carolina, April 5-9, pp. 42-47, 1971.

26. Lyons, W. A., "Mesoscale Transport of Pollutants in the Chicago Area as Affected by Land and Lake Breezes," Proceedings 2nd International Clean Air Congress, Washington, D.C., pp. 973-978, 1970.

27. ________ and H. S. Cole, "Fumigation and Plume Trapping on the Shores of Lake Michigan During Stable Onshore Flow", Journal of Applied Meteorology, Vol. 12, No. 4, pp. 494-510, 1973.

28. ________, "Detailed Mesometeorological Studies of Air Pollution Dispersion in the Chicago Lake Breeze," Monthly Weather Review, Vol. 101, No. 5, pp. 387-403, 1973.

29. Martin, J. E., "The Correlation of Wind Tunnel and Field Measurements of Gas Diffusion Using Kr-85 as a Tracer," Ph.D. Thesis, MMPP 272, University of Michigan, (June 1965).

30. Meroney, R. N., J. E. Cermak, and F. H. Chaudhry, "Wind Tunnel Model Study of Shoreham Nuclear Power Station Unit 1, Long Island Lighting Company," Progress Report No. 1, FDDL Report CER68-69RNM-JEC-FHC1, Colorado State University, July 1968.

31. Meroney, R. N., and J. E. Cermak, "Wind Tunnel Modeling of Flow and Diffusion Over San Nicolas Island, California," U. S. Navy Contract N123(61756)50192A(PMR), Colorado State University Report No. CER66-67RNM-JEC44, (September 1967).

32. Meroney, R. N., J. E. Cermak, and F. H. Chaudhry, "Wind Tunnel Model Study of Shoreham Nuclear Power Station Unit 1, Long Island Lighting Company," Progress Report 2, CER68-69RNM-JEC-FHC14, October, 1968.

33. Moses, H., G. H. Strom, and J. E. Carson, "Effects of Meteorological and Engineering Factors on Stack Plume Rise," Nuclear Safety, Vol. 6, No. 1, pp. 1-19, (Fall 1964).

34. Montgomery, T. L., and M. Cain, "Adherence of Sulfur Dioxide Concentrations in the Vicinity of a Steam Plant to Plume Dispersion Models," Journal of APCA, Vol. 17, No. 8, pp. 512-517 (1967).

35. Munn, R. E., A. F. W. Cole, V. A. Sandborn, E. J. Plate, G. J. Binder, H. Chuang, R. N. Meroney, and S. Ito, "Turbulence and Diffusion in the Wake of the Building" Atmospheric Environment, Vol. 1, pp. 34-43, (1967).

36. Olfe, P. B. and R. L. Lee, "Linearized Calculations of Urban Heat Island Convection Effects," Journal of Atmospheric Sciences, Vol. 28, No. 11, pp. 1374-1388, 1971.

37. Pasquill, F., Atmospheric Diffusion, D. Van Nostrand Co., London (1962).

38. Plate, E. and J. E. Cermak, "Micro-Meteorological Wind-Tunnel Facility: Description and Characteristics," Fluid Dynamics and Diffusion Laboratory Report No. CER63EJP-JEC9, Colorado State University (1963).

39. Prophet, D. T., Survey of the Available Information Pertaining to the Transport and Diffusion of Airborne Material Over Ocean and Shoreline Complexes, Technical Report 89(AD-258958), Aerosol Laboratory, Stanford University, June 1961.

40. Roberts, O. F. T., "The Theoretical Scaling of Smoke in a Turbulent Atmosphere," Proc. Roy. Soc., A. 104, p. 640.

41. Roshko, A., "On the Development of Turbulent Wakes from Vortex Steel", NACA Report 1191, 1954.

42. Schlichting, H., Boundary Layer Theory, McGraw Hill, New York, (1960).

43. SethuRaman, S. S. and J. E. Cermak, "Physical Modeling of Flow and Diffusion Over an Urban Heat Island," Proc. 2nd IUTAM-IUGG Symposium on Turbulent Diffusion in Environmental Pollution, Charlottesville, Virginia, 8-14 April 1973.

44. Sherlock, R. H., and E. A. Stalker, "The Control of Gases in the Wake of Smokestacks," Mechanical Engineering Vol. 62, No. 6, pp. 455-458, (June 1940).

45. Singer, I. A., and I. Kazukiko, and G. D. Roman, "Peak to Mean Pollutant Concentration Ratios for Various Terrain and Vegetative Cover," Journal APCA, Vol. 13, No. 1, p. 40, (1963)

46. Singer, I. A., and M. E. Smith, "The Relation of Gustiness to Other Meteorological Parameters," Journ. Meteor. Vol. 10, No. 2, (1953).

47. Slade, D. H., editor, "Meteorology and Atomic Energy-1968", U.S. Atomic Energy Commission. TID-24190, July 1968.

48. Smith, M., editor, "Recommended Guide for the Prediction of the Dispersion of Airborne Effluents," ASME, 1968.

49. Strom, G. H., M. Hackman, and E. J. Kaplin, "Atmospheric Dispersal of Industrial Stack Gases Determined by Concentration Measurements in Scale Model Wind Tunnel Experiments," J. of APCA, Vol. 7, No. 3, pp. 198-204, (November 1957).

50. Sutton, O. G., "The Theoretical Distribution of Airborne Pollution from Factory Chimneys," Quar. J. R. Meteor. Soc. 73, p. 426 (1947).

51. Sutton, O. G., Micrometeorology, McGraw-Hill, 1953.

52. Turner, P. B. "Workbook of Atmospheric Dispersion Estimates," U.S. Dept. of Health, Education and Welfare, Public Health Service, Cincinnati, Ohio, 1969.

53. Vander Hoven, I., "Atmospheric Transport and Diffusion at Coastal Sites," Nuclear Safety, Vol. 8, No. 5, pp. 490-499, 1967.

54. Yamada, T. and R. N. Meroney, "Numerical and Wind Tunnel Simulation of Response of Stratified Shear Layers to Nonhomogeneous Surface Features," Project Themis Tech. Report No. 9, ONR Contract No. N00014-68-A-0493-0001, FDPL Report No. CER70-71TY-RNM62, 1971.

55. Yang, B. T. and R. N. Meroney, "Gaseous Dispersion into Stratified Building Wakes" AEC Report No. COO-2053-3, CER70-71BTY-RNM8, August, 1970.

56. Pasquill, F. and F. B. Smith, "The Physical and Meteorological Basis for the Estimation of the Dispersion," 2nd International Clean Air Congress, Washington, D.C., December 6-11, 1970, Paper ME-20A, 22 p.

APPENDIX: DISPERSION CALCULATIONS

Industrial designers must rely upon generalized dispersion formulae to predict concentrations in the vicinity of pollutant released from tall stacks. Unfortunately one cannot depend upon the accuracy of such relations when nearby buildings are tall enough to cause aerodynamic perturbations upon the theoretical plume behavior. Hence, it is considered good practice to utilize wind tunnel model studies to determine the range of validity of particular formulae and the necessity for correction coefficients for a particular application. It is with these thoughts in mind that the measurements over the Lansing Power Station complex are interpreted. Corrections applied to plume rise near the source may provide a more reliable prediction of contamination at extended distances downstream by means of analytical expressions.[35,38,40,42,43,44]

The latest publications summarizing the "state-of-the-art" for atmospheric diffusion estimates are very similar in detail.[35,44,47] There are some reasons however, to prefer some calculation methods over others; thus some of the relations will be discussed in detail below.

Effective Plume Height

While a smoke plume quickly attains the wind speed in the horizontal direction, its rise is determined by its vertical momentum and buoyancy. Numerous formulae have been published to correlate field measurements of plume rise; none is universally accepted, partially due to observational difficulties, and partially due to the fact that some plumes never really appear to level off.

Although Turner[52] recommends the use of Holland's plume rise formula it may be judged unnecessarily conservative. Stümke recommended the

Holland formula be multiplied by a correction factor of 3.0. In addition more recent dimensional analysis formulae for buoyant sources give consistently good results for all source sizes and distances downwind and take into account atmospheric stability. The formulae below are conservative but not so severely conservative as other formulas. The A.E.C.-1968 monograph by Slade suggests the following expressions: (Eqs. (5.19) and (5.20)):

$$\text{Neutral:} \quad \frac{\Delta H}{D} = 100 \frac{R}{Fr} + 1.5R \qquad \text{(A)}$$

$$\text{Stable with wind:} \quad \frac{\Delta H}{D} = 1.63 \left[\frac{RL^2}{Fr\ Ri}\right]^{1/3} \qquad \text{(B)}$$

where

$$R = \frac{V_s}{V_a}$$

$$L = \frac{H_s}{D_s}$$

$$Fr \cong \frac{V_a^2}{g \frac{\Delta T}{T_s} D_s}$$

$$Ri = \frac{g\ (d\theta/dz)}{T_s\ (V_a^2/H_s^2)}$$

Maximum Ground Concentration

Often the limiting criteria for a particular stack release system is the maximum allowed ground concentration. Since the plume rise formulae recommended above incorporate the effect of atmospheric stability on plume rise it is possible to include their results in expressions which calculate the maximum probable concentration conditions directly. Again the A.E.C. monograph suggests: for plume rise in a neutral or slightly unstable atmosphere (Eq. 5.28):

$$\frac{\chi_{max} V_a D_s^2}{Q} = 0.01 \left(\frac{Fr}{R}\right)^{1/3} \frac{1}{\left(L + \frac{\Delta H}{D_s}\right)^{5/3}} \qquad (C)$$

at an actual velocity associated with

$$\frac{Fr}{R} = \frac{500}{\left(L + \frac{\Delta H}{D_s}\right)} \qquad (D)$$

or

$$V_a = 7.94 \left[\frac{\frac{\Delta T}{T_s} g V_s D_s^2}{H_s + \Delta H}\right]^{1/3} \qquad (E)$$

for a buoyant source in a neutral atmosphere.

Ground Level Concentration Distributions

Correct calculation of ground level dilution profiles depends, of course, on an accurate estimate of the effective stack height. Assuming such information is available the most popular expression is the Gaussian plume formulae:

$$\frac{\chi}{Q} = \frac{1}{\pi \sigma_y \sigma_z V} \exp\left[-\left(\frac{y^2}{2\sigma_y^2} + \frac{h^2}{2\sigma_z^2}\right)\right] \quad \text{where} \quad h = h_s + \Delta h \quad \text{and}$$

where the variance terms σ_y or σ_z are evaluated in terms of downwind distance and the stability condition. Authors such as Sutton, Calder, Pasquill, Smith, and many others have suggested variance coefficient evaluation techniques.[47,48]

Probably the most convenient method currently is that developed by Pasquill where σ_y and σ_z figures have been prepared for simply defined stability categories. See Figs. A.2 and A.3 and Table A.1 from the A.E.C. monograph.[47] Figures 3-2 through 3-9 in Turner's workbook also provide a convenient summary of ground level dilution for various height releases and atmospheric stability conditions.[52]

Typical Concentration Results

Montgomery and Cain have compared the adherence of sulfur dioxide concentrations in the vicinity of a steam plant to plume dispersion models.[34] They concluded that general dispersion models cannot accurately predict specific pollutant concentrations that can be expected to occur at a particular station at a specific time, but they can predict the range of concentrations likely to occur. Dispersion models generally incorporate a conservative bias, hence they also were found to successfully estimate maximum concentrations 93 to 99 percent of the time. Finally, the same mathematical model using different diffusion coefficients may yield very different results, hence the diffusion coefficients should be developed for the model at the particular site of application (if possible).

The influence of building wake and topographical features may be demonstrated by examining a typical calculation for the station considered herein.

Consider, Unit 4, Stack height 300 ft: Neutral flow field;

	D(ft)	V_s(ft/sec)	ΔT°F	R	Fr	$\frac{\chi_{max} V_a}{Q}$ $10^6 (m^{-2})$
Maximum Predicted by Equations C-E Full Load	13.8	100	230	1.48	11.92	9.80
Maximum Predicted for V_a = 40 ft/sec Full Load	13.8	100	230	2.50	11.92	1.58
Maximum Predicted for V_a = 40 ft/sec Half Load	13.8	50	230	1.25	11.92	3.34

The maximum ground level concentration $\chi V_a/Q \times 10^6 (m^{-2})$ measured for full load was 12.9 and for half load was 38.3. One attributes the greater concentrations measured in the laboratory to the stack top and building wake influence when $R < 1.5$ and the rise of the terrain to meet the plume as it flows out of the river valley.

Turner has suggested that estimates based on a Pasquill-Gifford type approach are probably accurate to within a fraction of three assuming the plume rise is correctly estimated. This accuracy is limited to three cases:

(1) for all stabilities for distances of travel out to a few hundred meters.

(2) for neutral to moderately unstable conditions for distances out to a few kilometers; and

(3) unstable conditions in the lower 1000 meters of the atmosphere with a marked inversion above for distances out to 10 kilometers or more.[52]

Based on the work of Briggs one expects plume rise results to be accurate within ±19 percent.[47] However experience is very varied and some calculators have been conservative by a factor of five or optimistic by a factor of nearly two.

For a source which emits at constant rate from hour to hour one may estimate a 24 hour probability of dispersion based on stability wind "rose" data. A stability wind "rose" gives the frequency of occurrence for each wind direction (usually 16 points) of each wind speed class and stability category.

If the effluent is assumed uniformly distributed in each angular sector an appropriate equation for average concentration is then:

$$\frac{\chi(x,\theta)}{Q} = \sum_S \sum_N \{\frac{2\ f\ (\theta,S,N)}{\sqrt{2\pi}\ \sigma_{zs}\ V_N\ (\frac{2\pi x}{16})}\ \exp\ [\frac{1}{2}\ (\frac{h_V}{\sigma_{zs}})^2\ ]\}$$

where $f(\theta,S,N)$ is the frequency during the period of interest that the wind is from the direction θ, for the stability condition, S, and wind speed class N.

$(\sigma_z)_S$ is the vertical dispersion parameter evaluated at the distance x for the stability condition S.

V_N is the representative wind speed for class N.

h_V is the effective height of release for the wind speed V_N.

When stability wind rose information is unavailable a first-order approximation may be made of diurnal concentrations by using the appropriate 24 hour wind rose and assuming all releases occur in neutral stability class, Pasquill D.

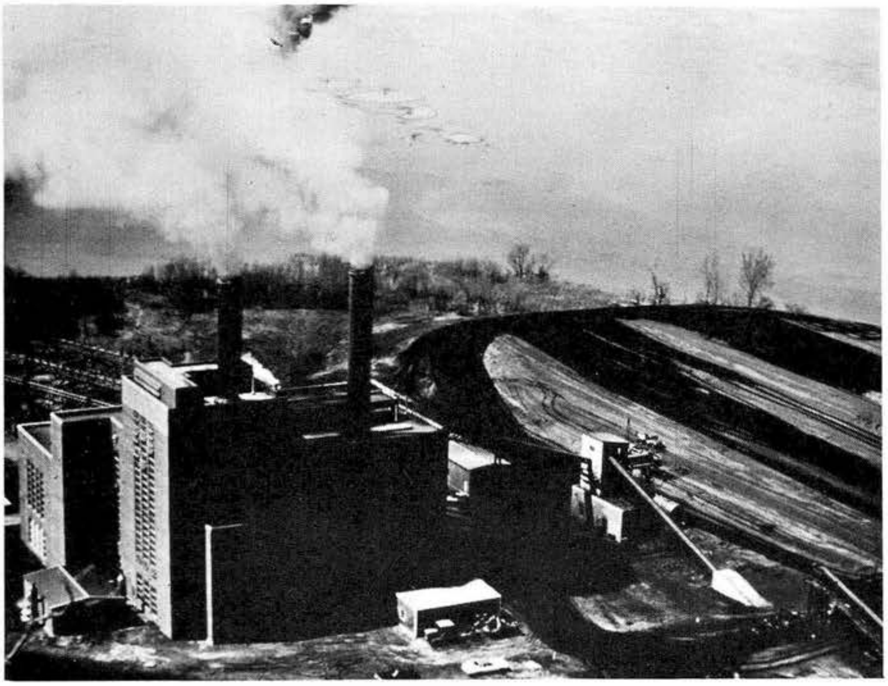


Figure 1a. View of Existing Lansing Power Station Facilities (Looking Up River from 400 ft Hill Behind Site).

Figure 1b. View of Existing Lansing Power Station Facilities (From Above - North Toward Top of Picture).

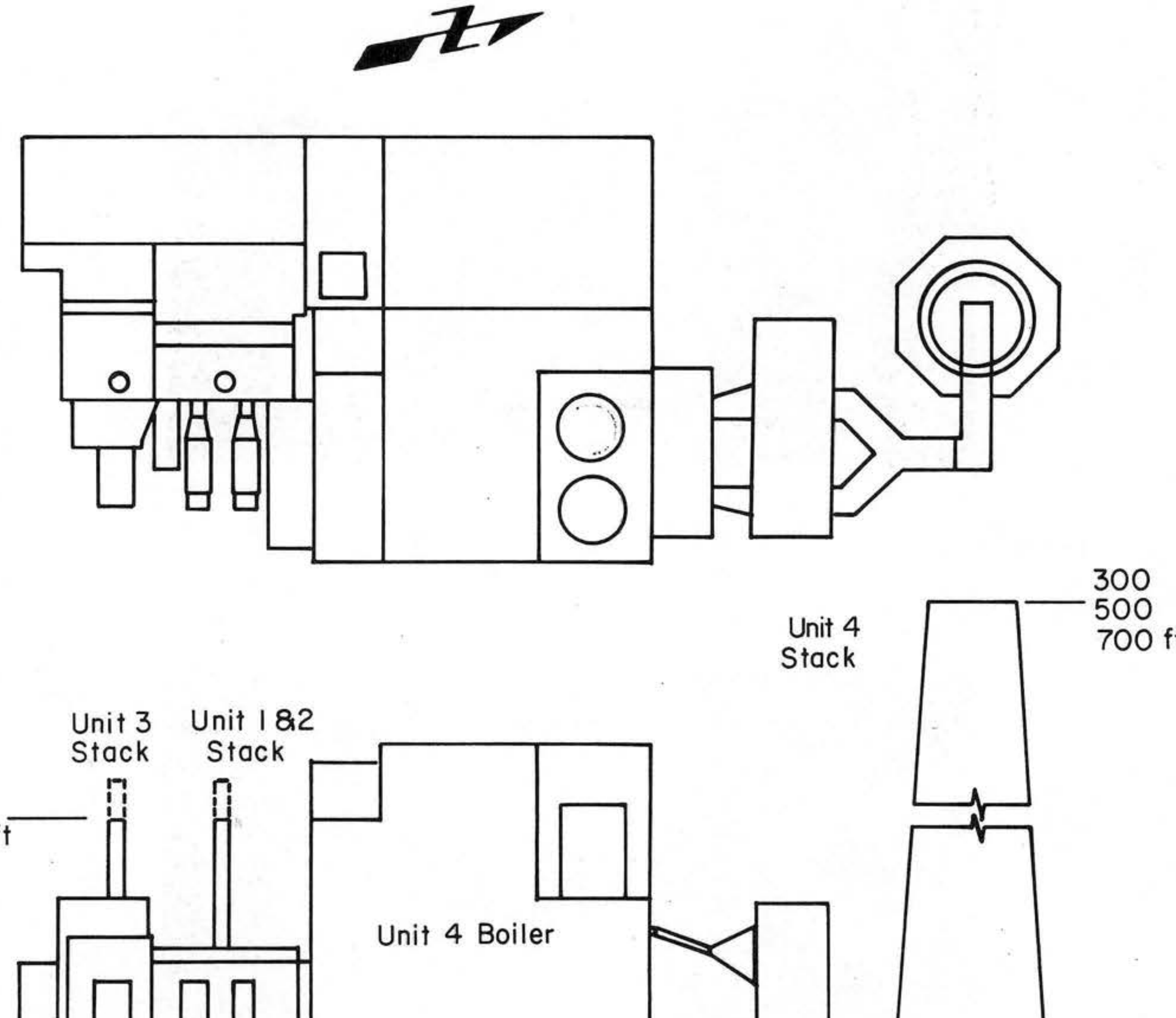


Figure 2. Lansing Power Station, Iowa.

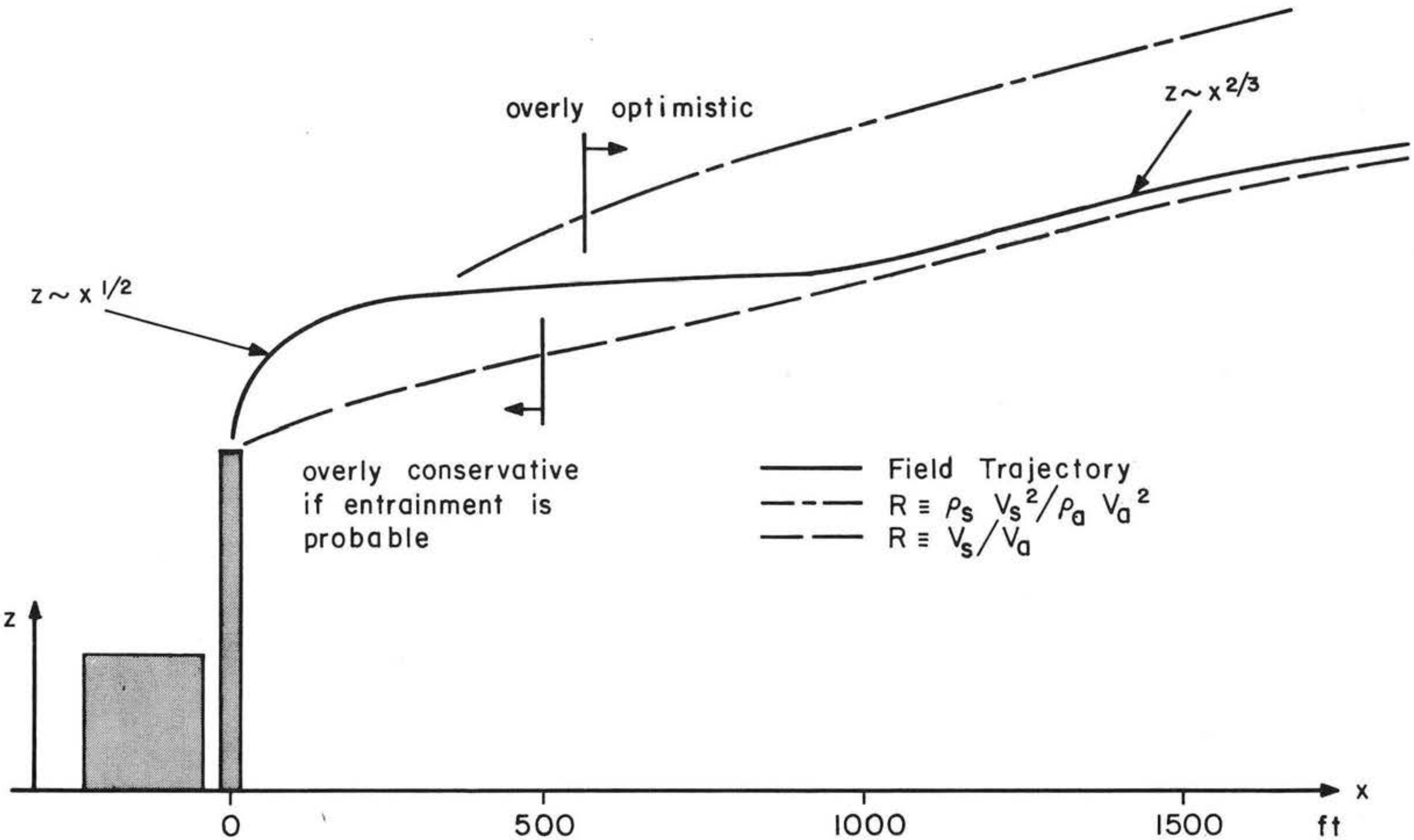


Figure 3. Plume Trajectories for Various Momentum Ratios.

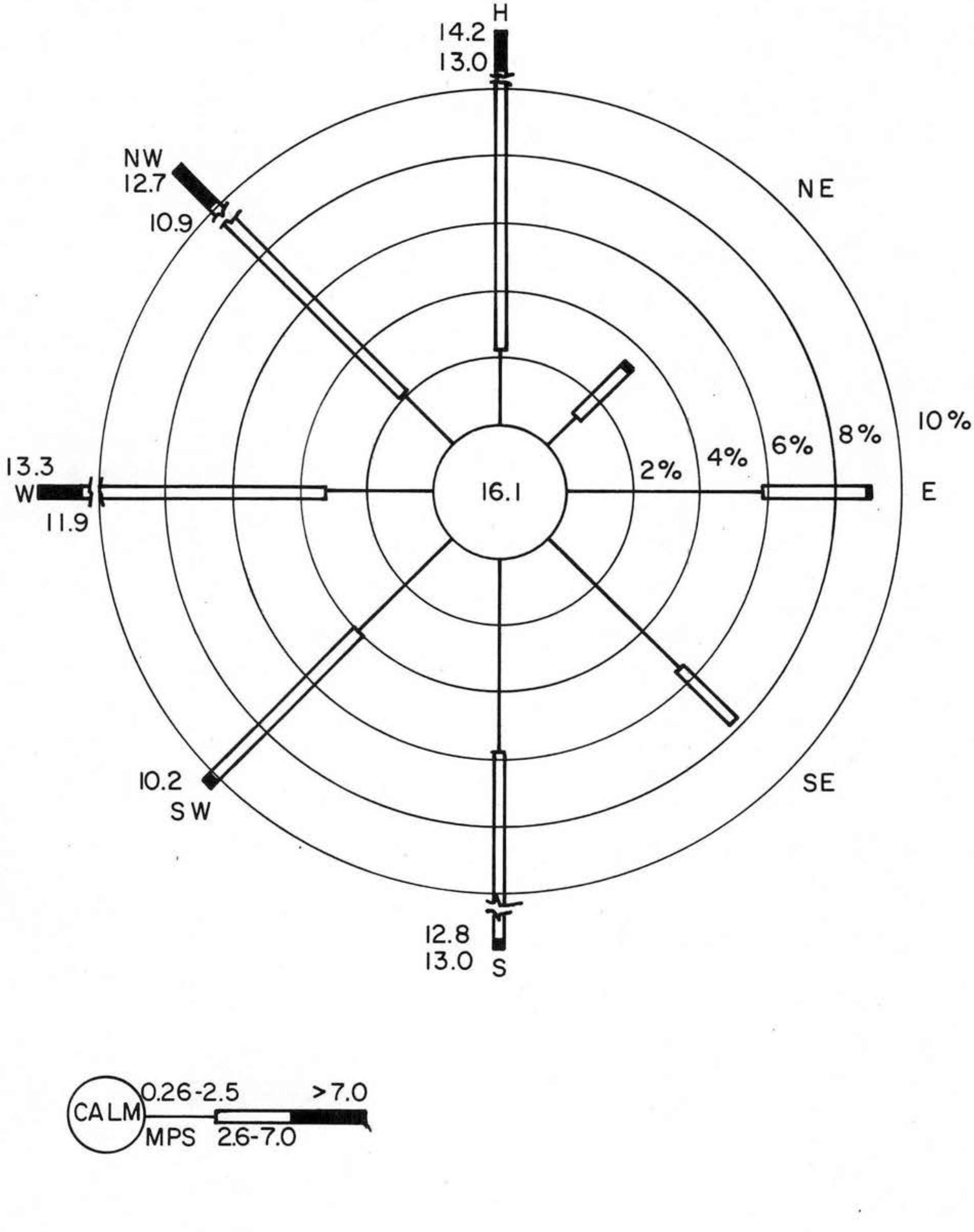


Figure 4. Wind Rose Lansing Station: Period January 1969 through December 1973.

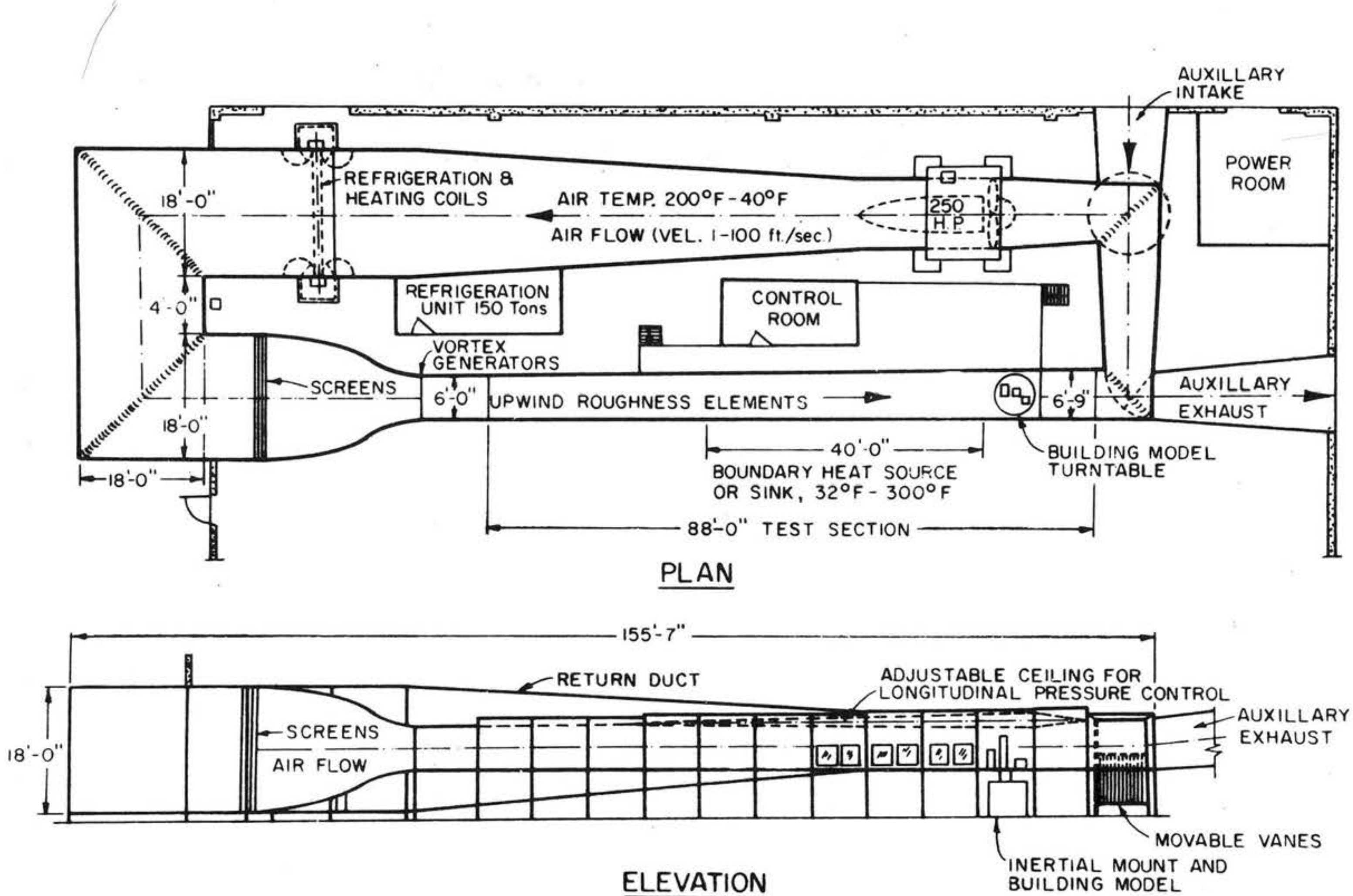


Figure 5. **METEOROLOGICAL WIND TUNNEL (Completed in 1963)**
FLUID DYNAMICS & DIFFUSION LABORATORY
COLORADO STATE UNIVERSITY

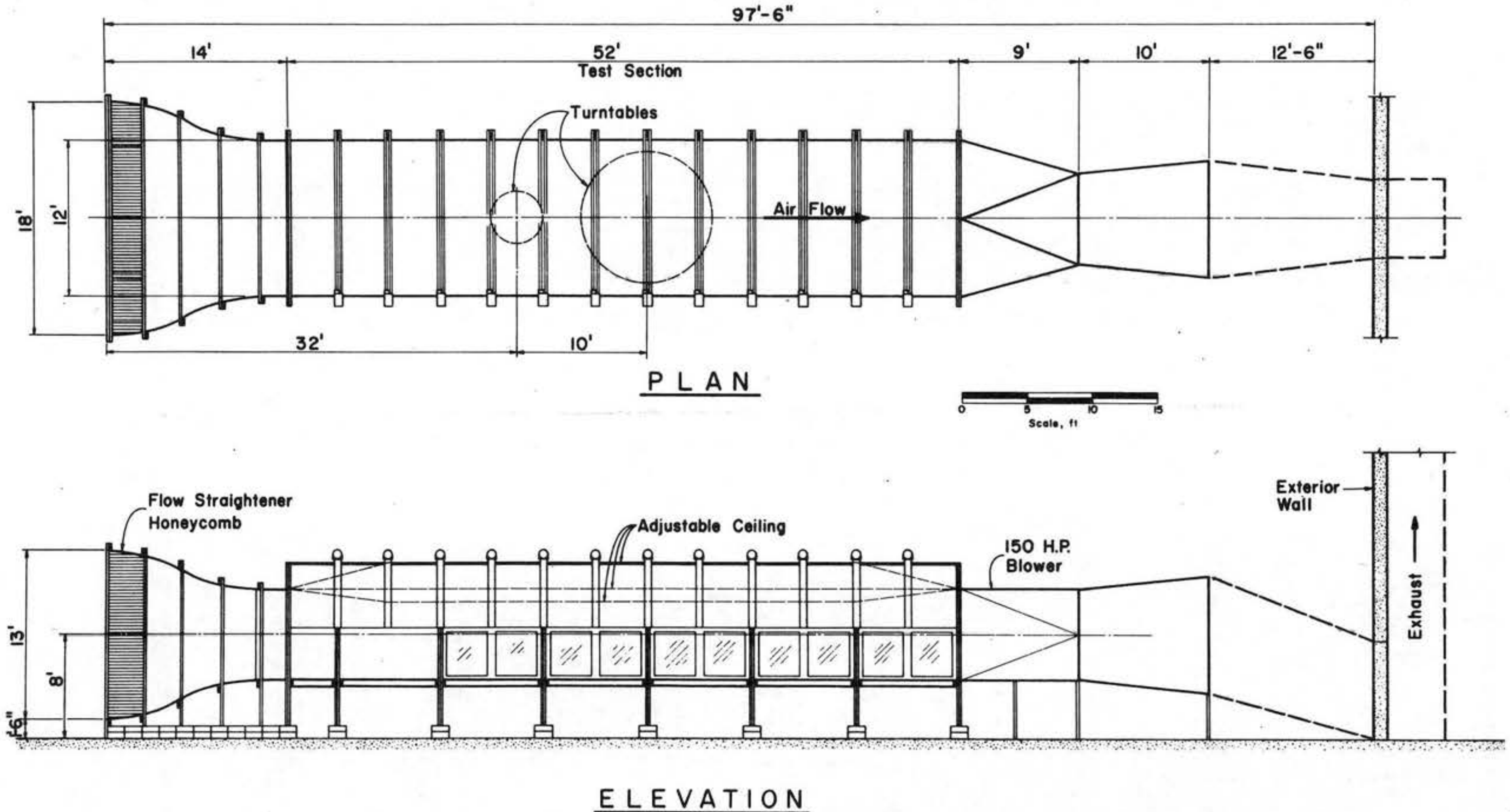


Figure 6. ENVIRONMENTAL WIND TUNNEL
FLUID DYNAMICS & DIFFUSION LABORATORY
COLORADO STATE UNIVERSITY

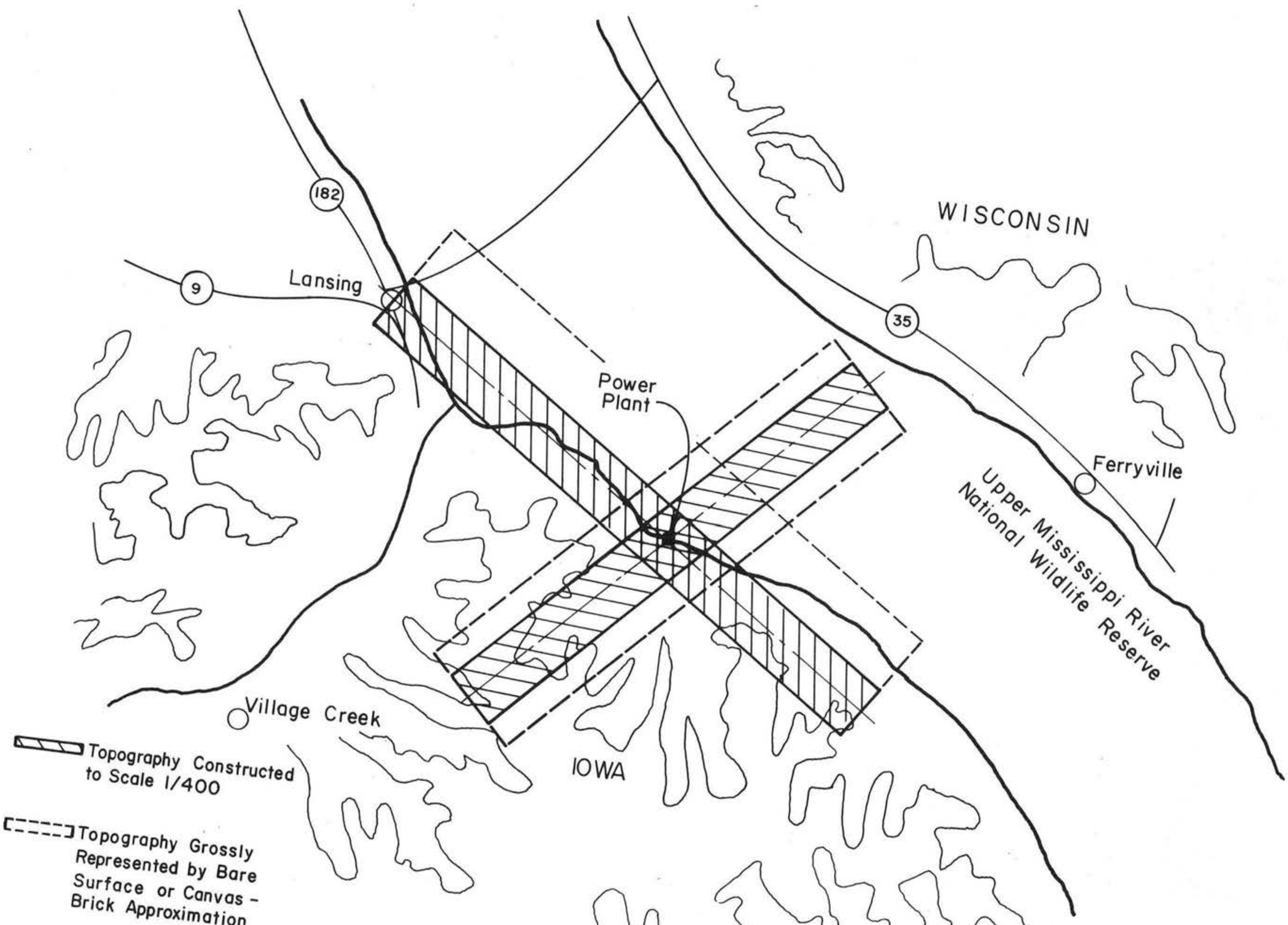


Figure 7. Topographical Map of Areas Modeled.

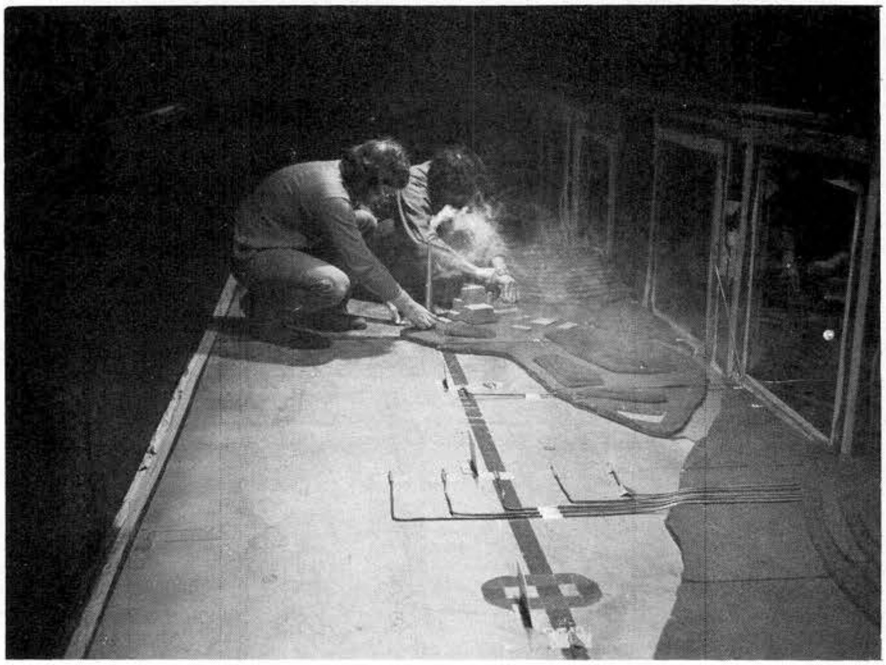


Figure 8a. Model Installed in Meteorological Wind Tunnel, Looking SE.

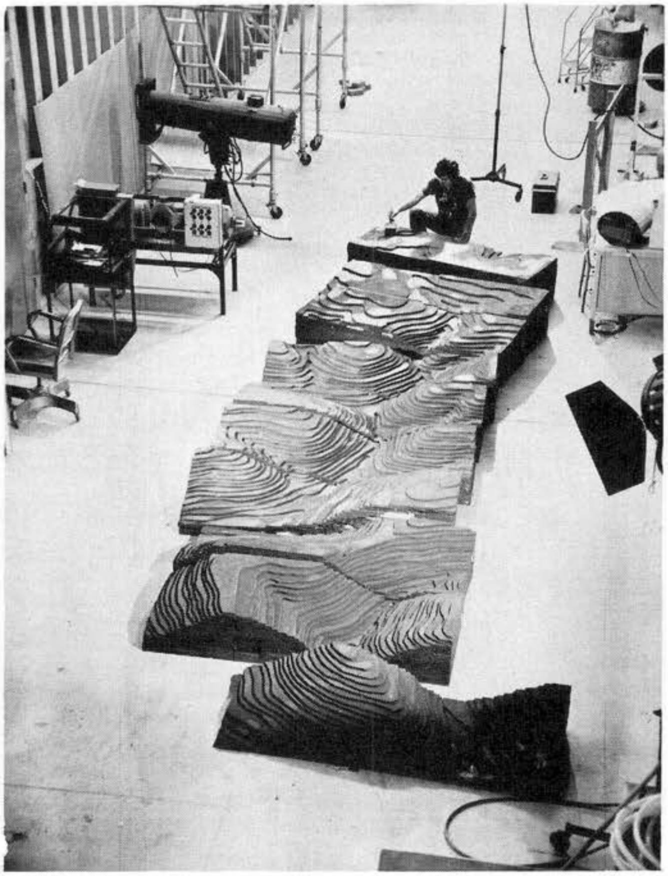


Figure 8b. Model Topography Construction, Looking SW.

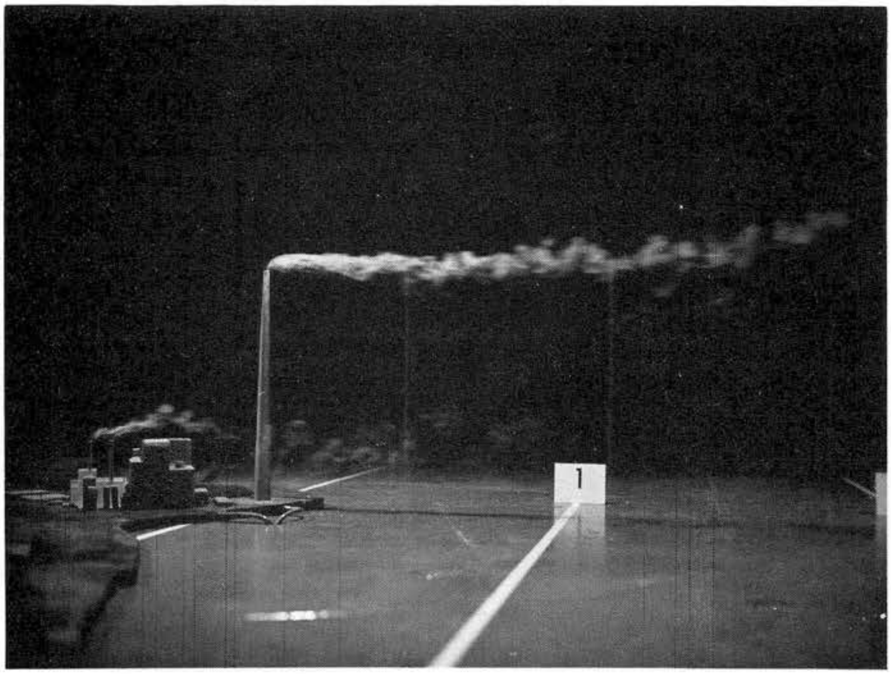


Figure 9a. Flow Visualization, Units 1-3, Stack Height 190 ft, Units 4 Stack Height 700 ft, Flow from SW.

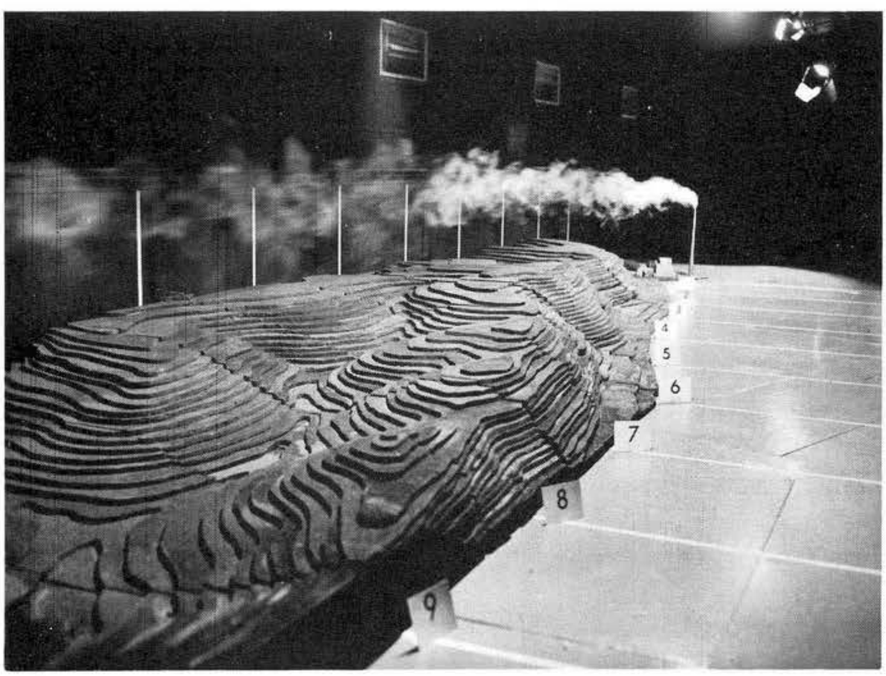
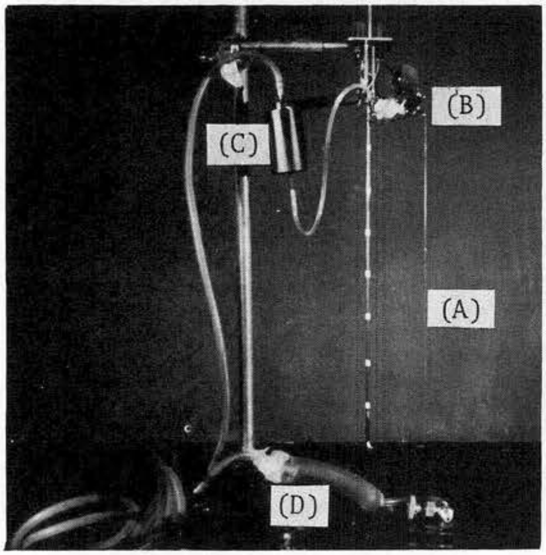
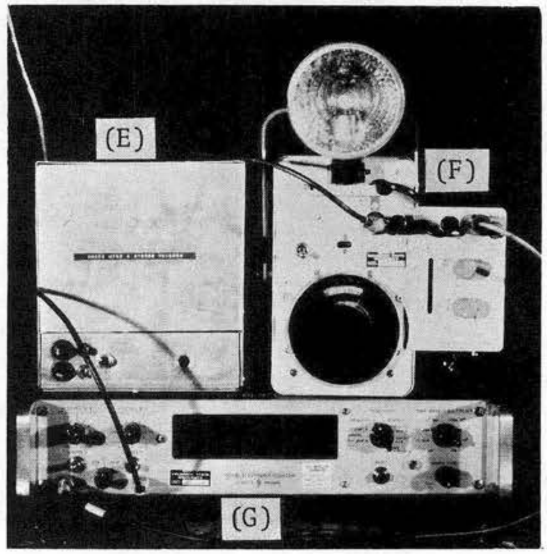


Figure 9b. Flow Visualization, Unit 4, Stack Height 700 ft, Looking to NW.





(A) Nichrome Wire

(B) Oil Outlet

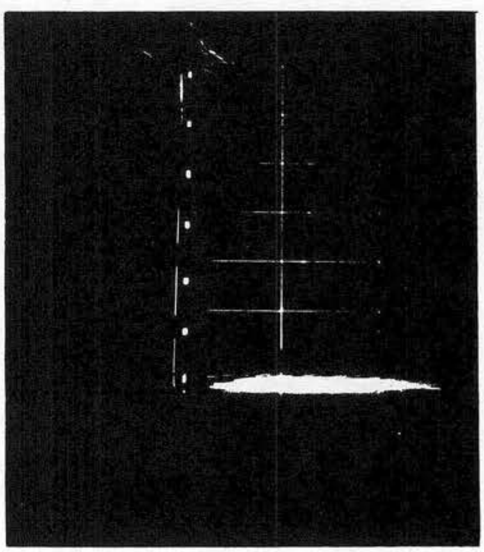
(C) Oil Reservoir

(D) Air Bag

(E) Trigger Circuit

(F) Strobe System

(G) Electronic Counter



A Typical Velocity Profile (Neutral Case)

Figure 10. Smoke Wire and Attached Instruments for Velocity Measurements. A Typical Velocity Profile Is Included.

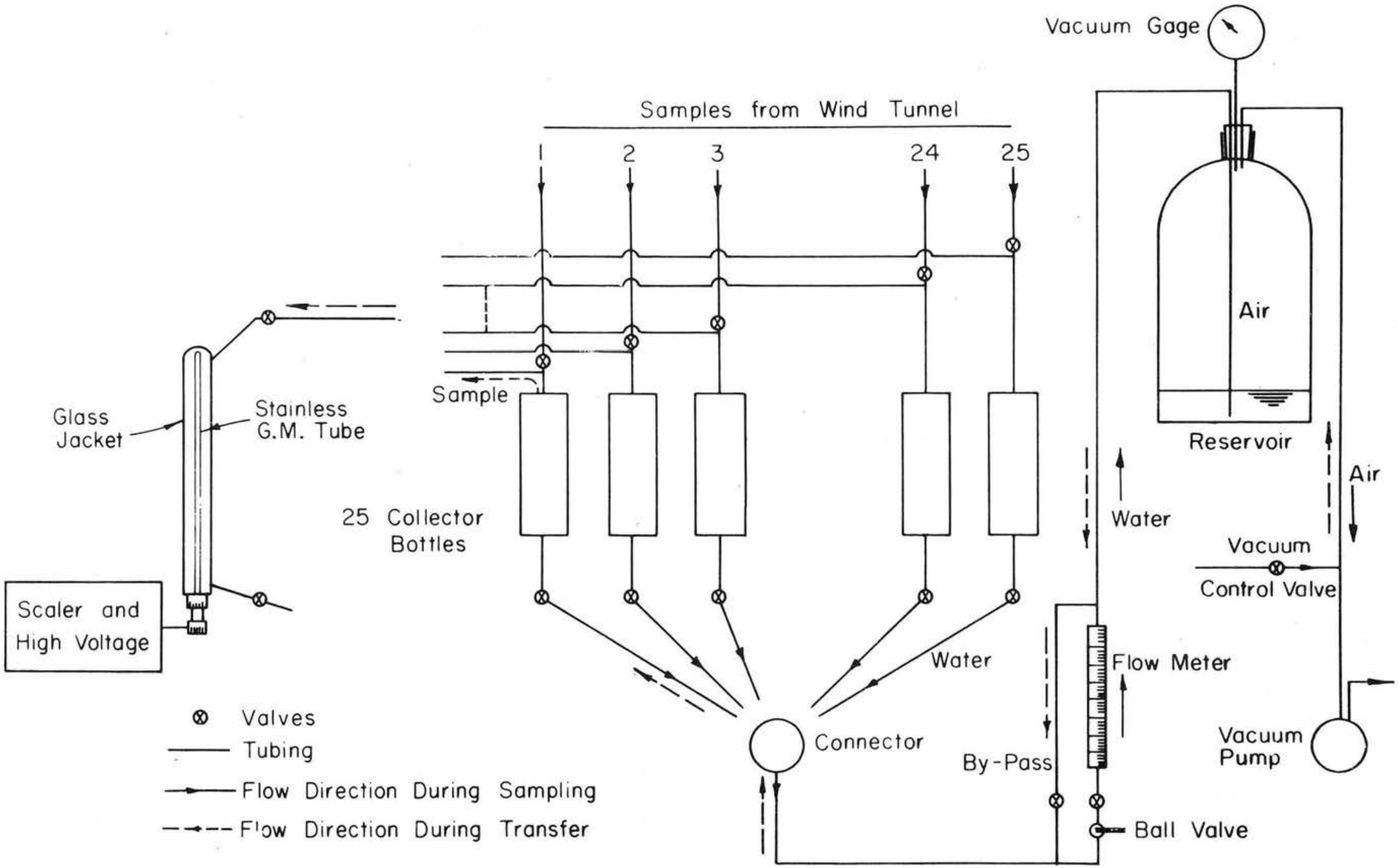


Figure 11. Tracer-Gas Sampling and Analysis System - Schematic.

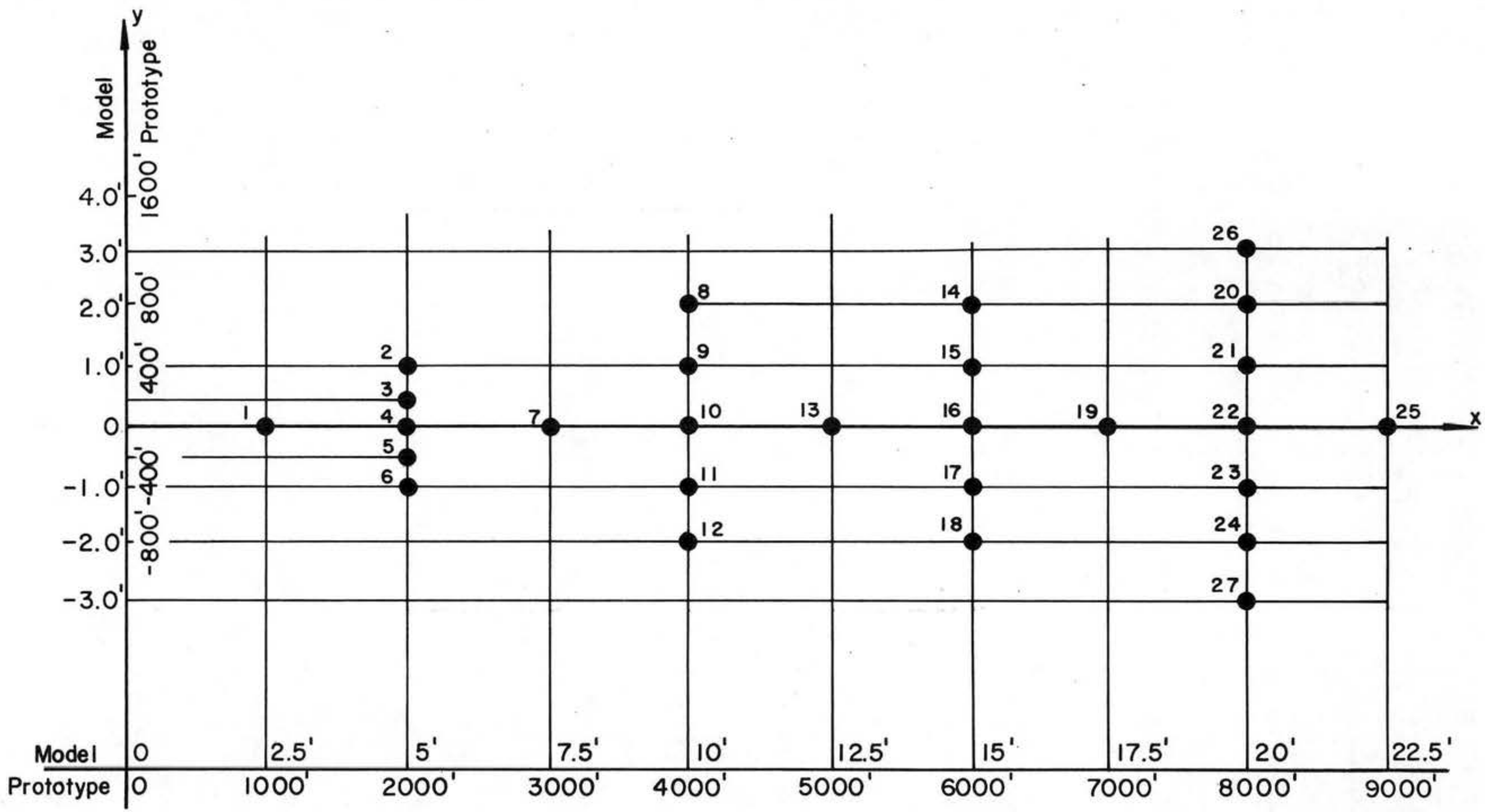


Figure 12. Coordinates for Concentration Measuring Locations.

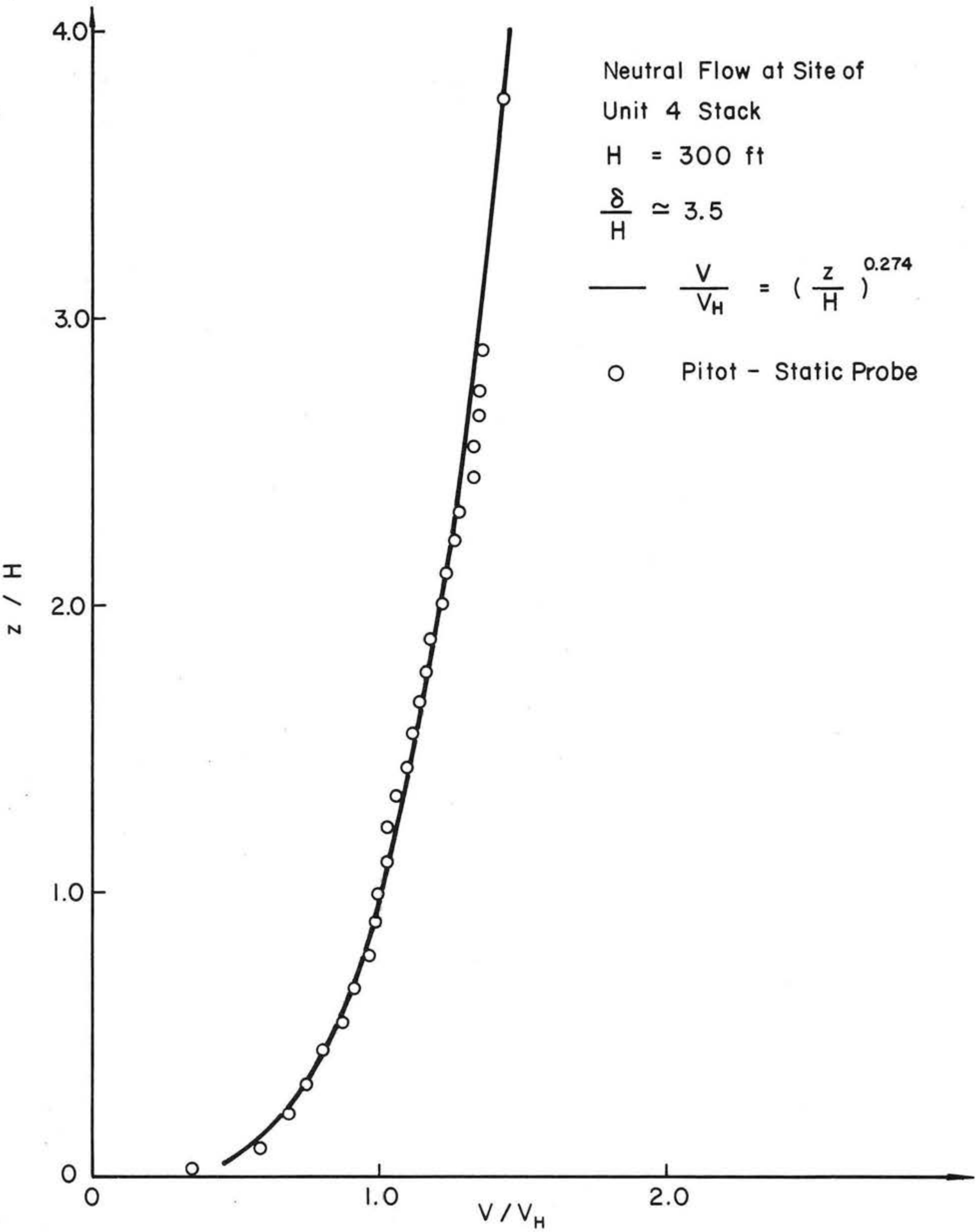


Figure 13. Velocity Profile: Neutral Flow Field.

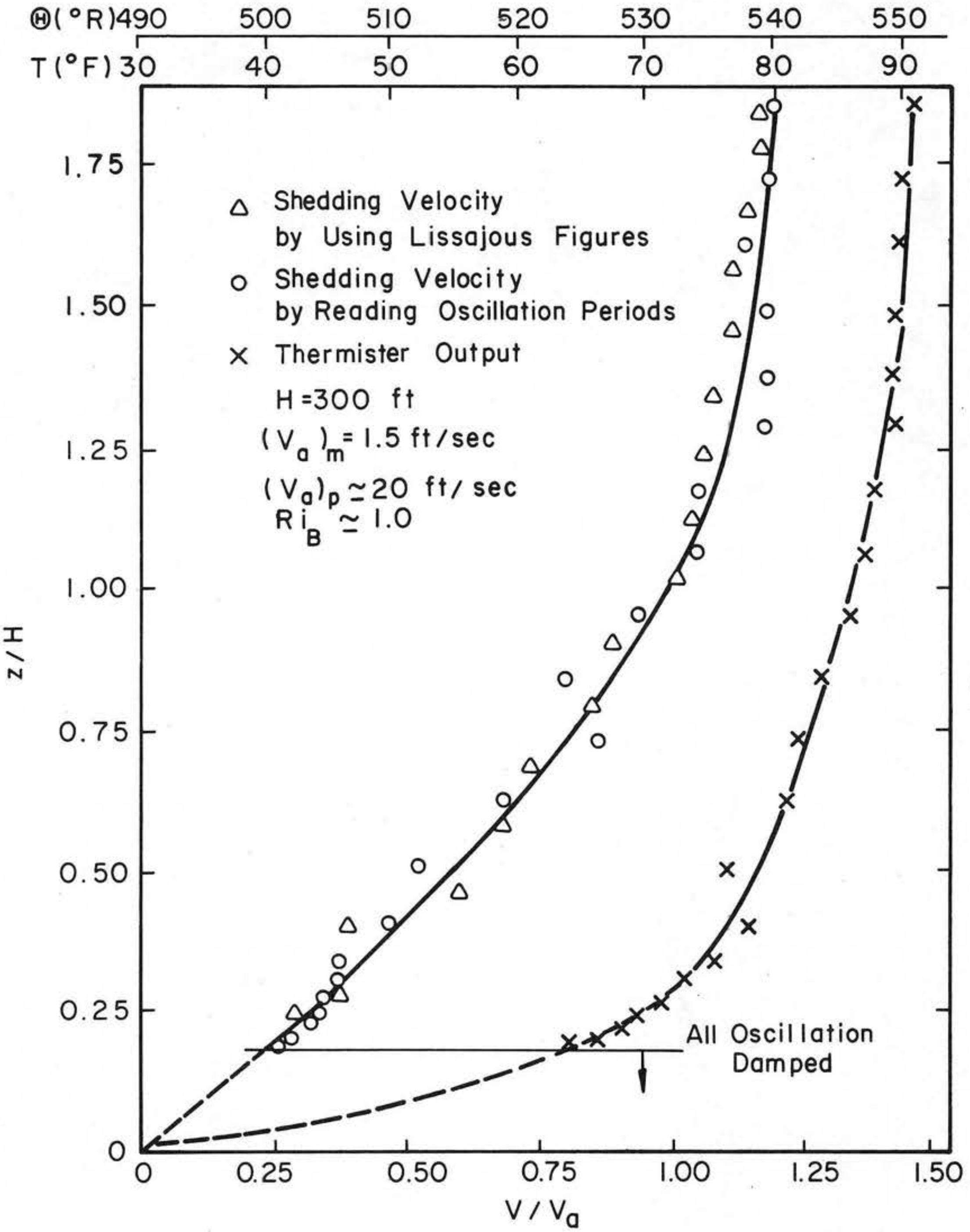


Figure 14a. Velocity Profiles: Stable Stratification, Far Upwind SE, SW, and NE Wind Angles.

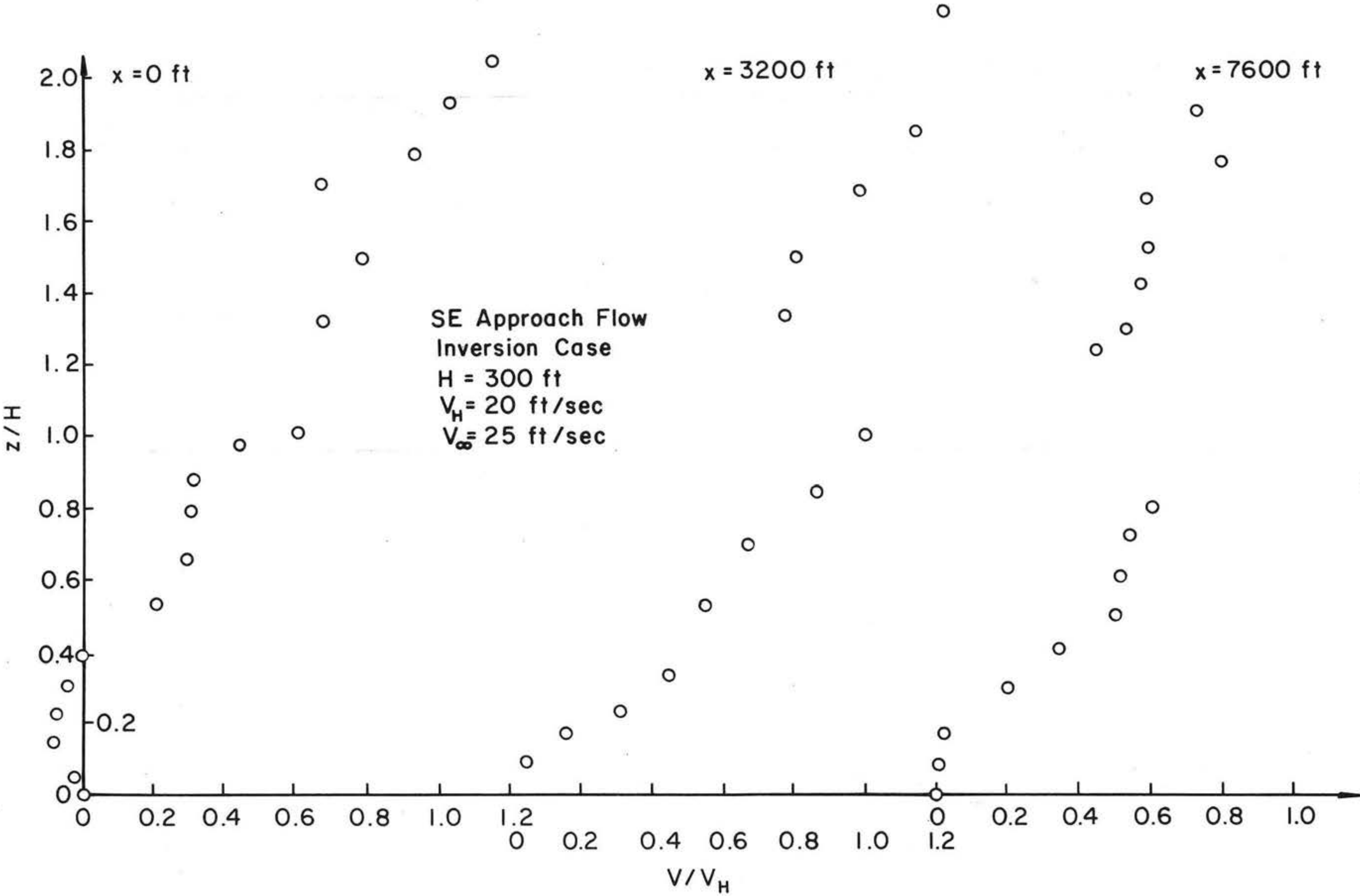


Figure 14b. Velocity Profiles: Inversion Case, SE Approach Flow.

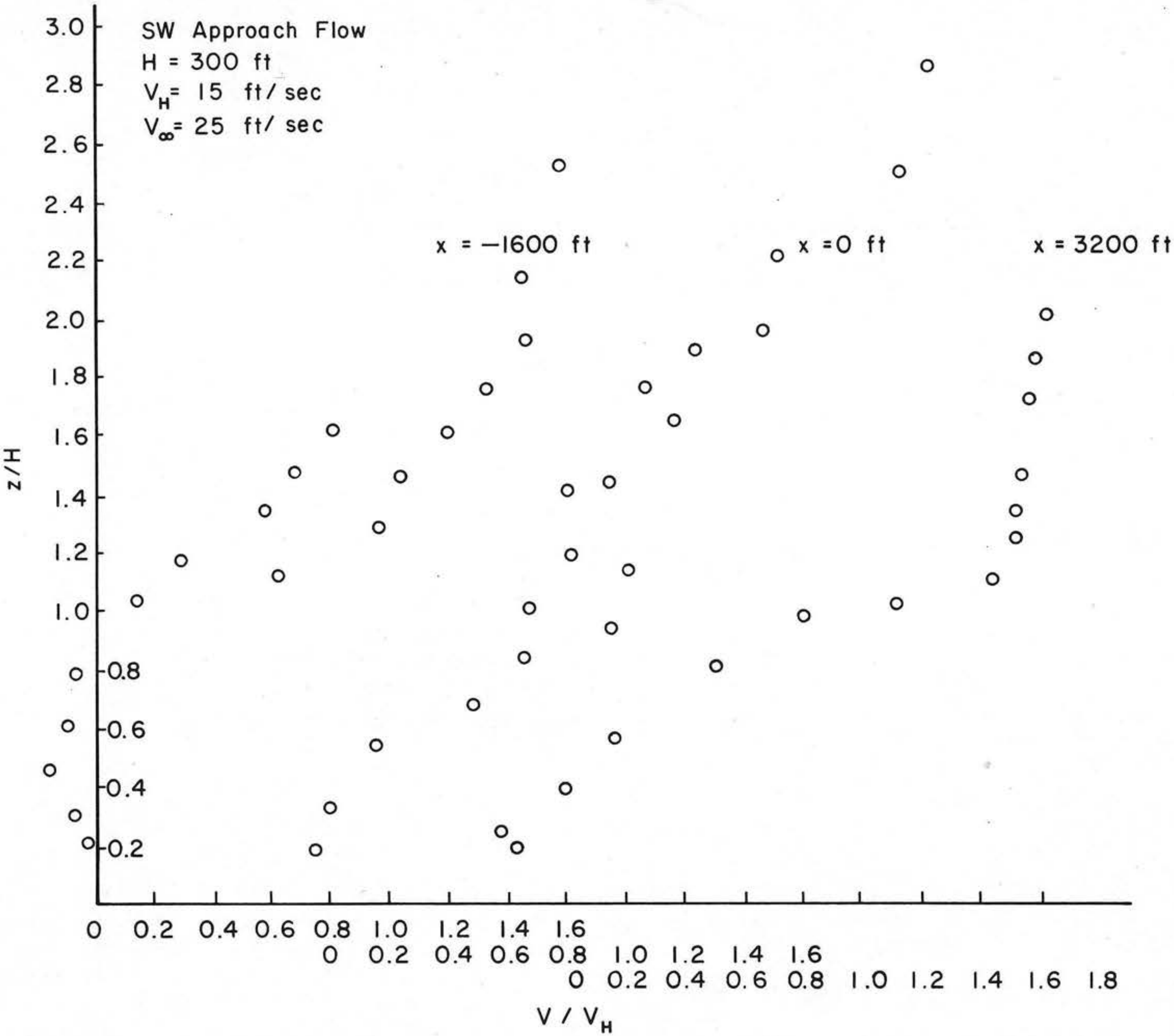


Figure 14c. Velocity Profiles: Stable Case, SW Approach Flow.

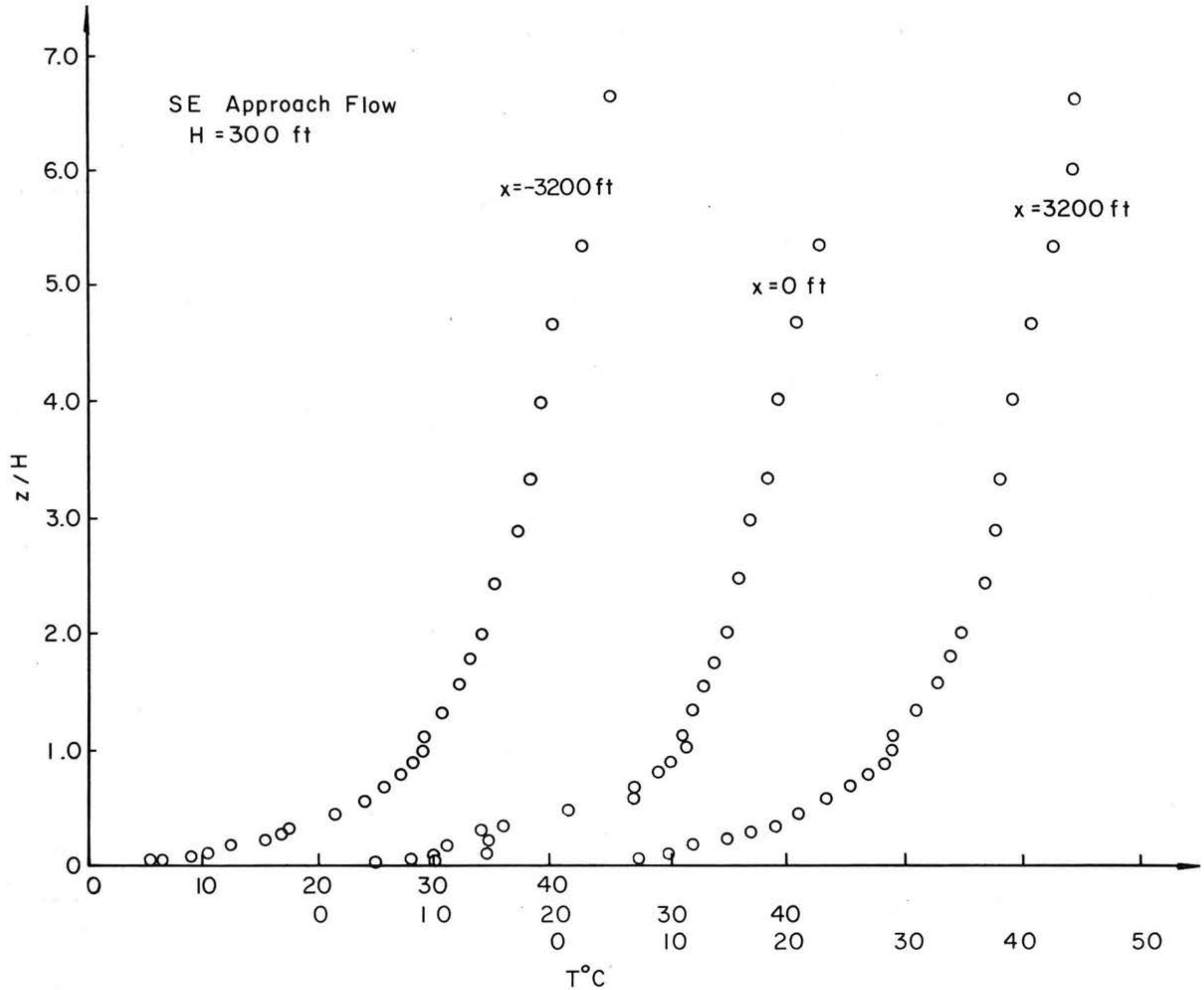


Figure 15a. Temperature Profiles: Stable Case, SE Approach Flow.

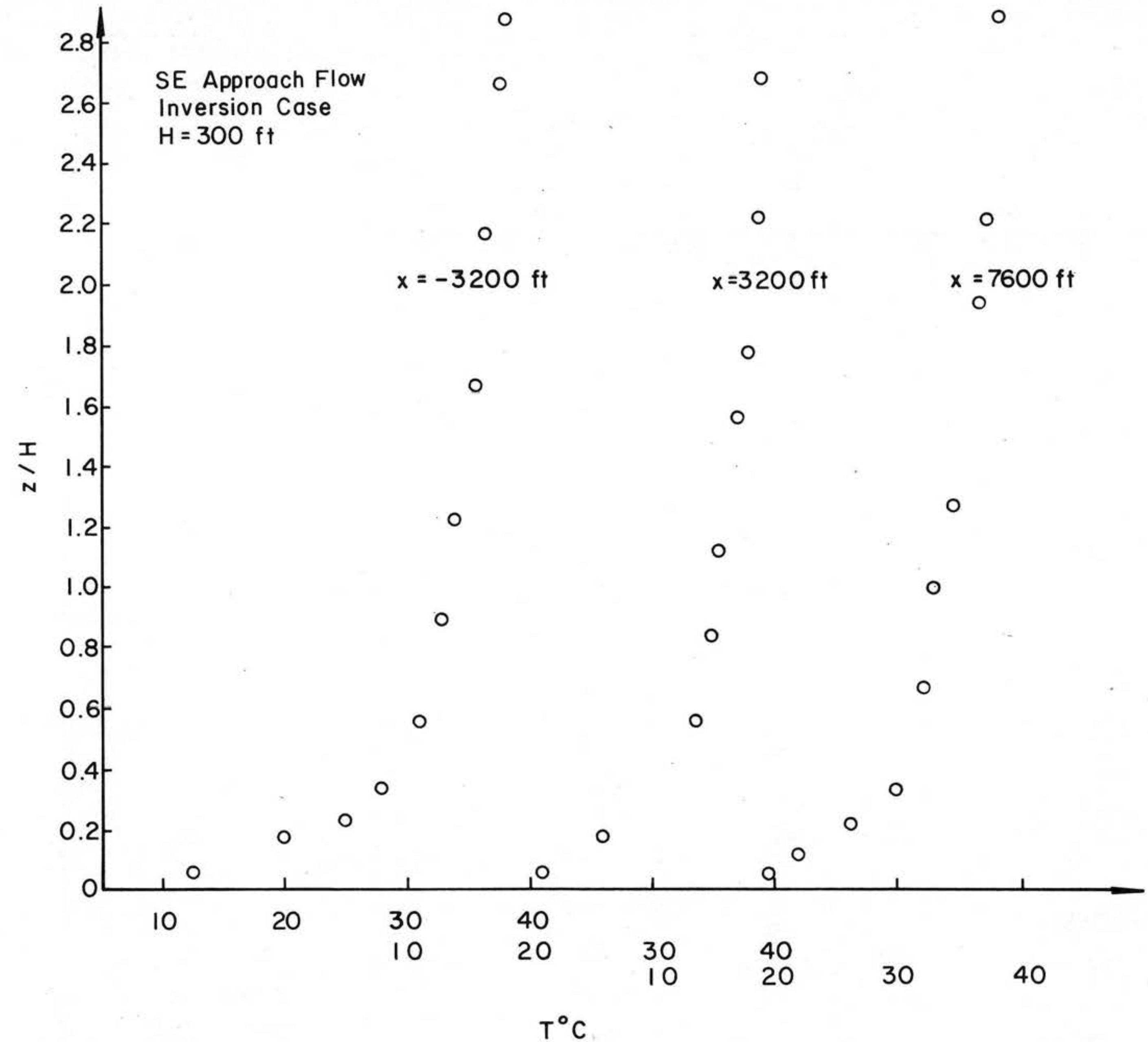


Figure 15b. Temperature Profiles: Inversion Case, SE Approach Flow.

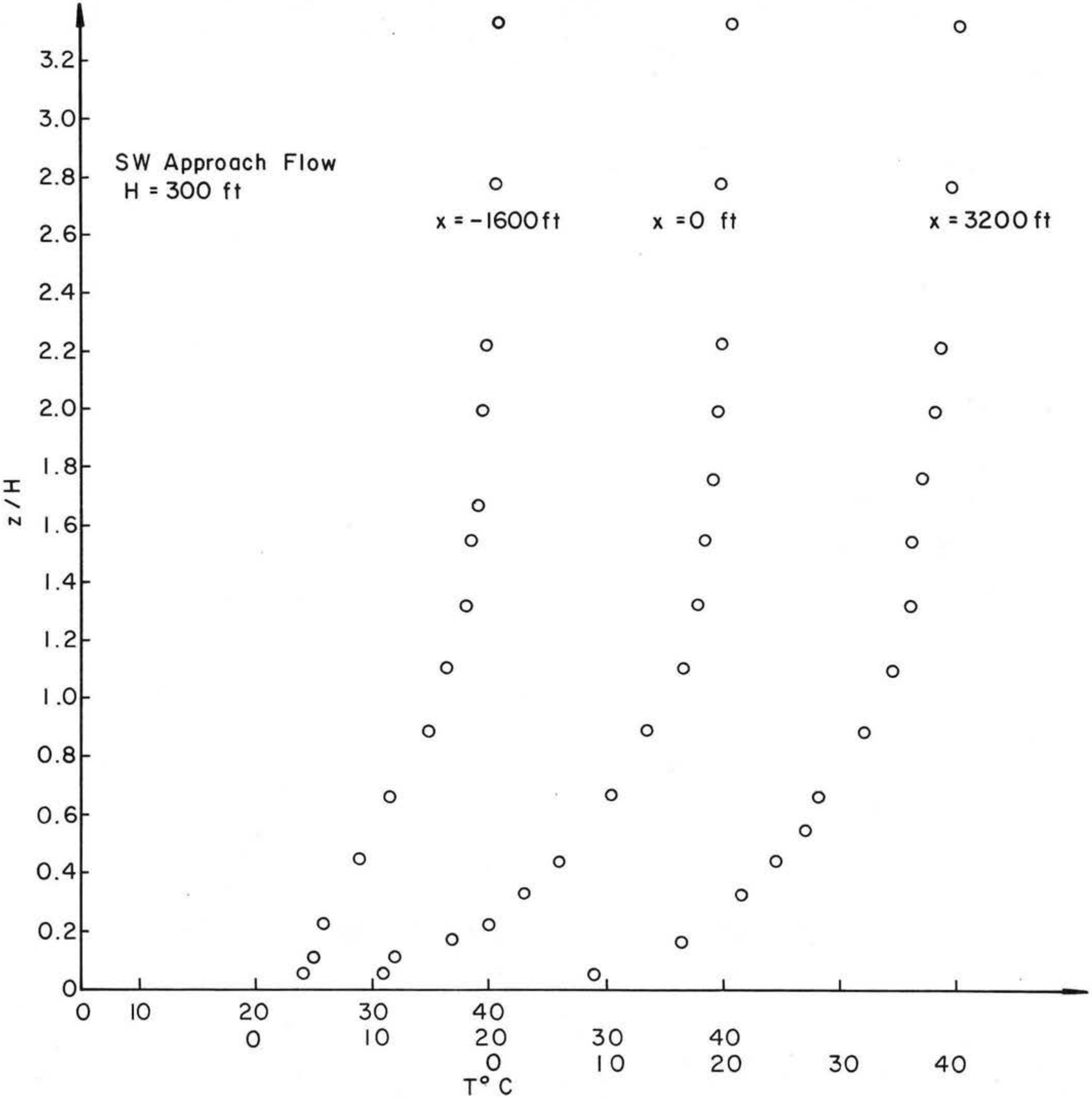


Figure 15c. Temperature Profiles: Stable Case, SW Approach Flow.

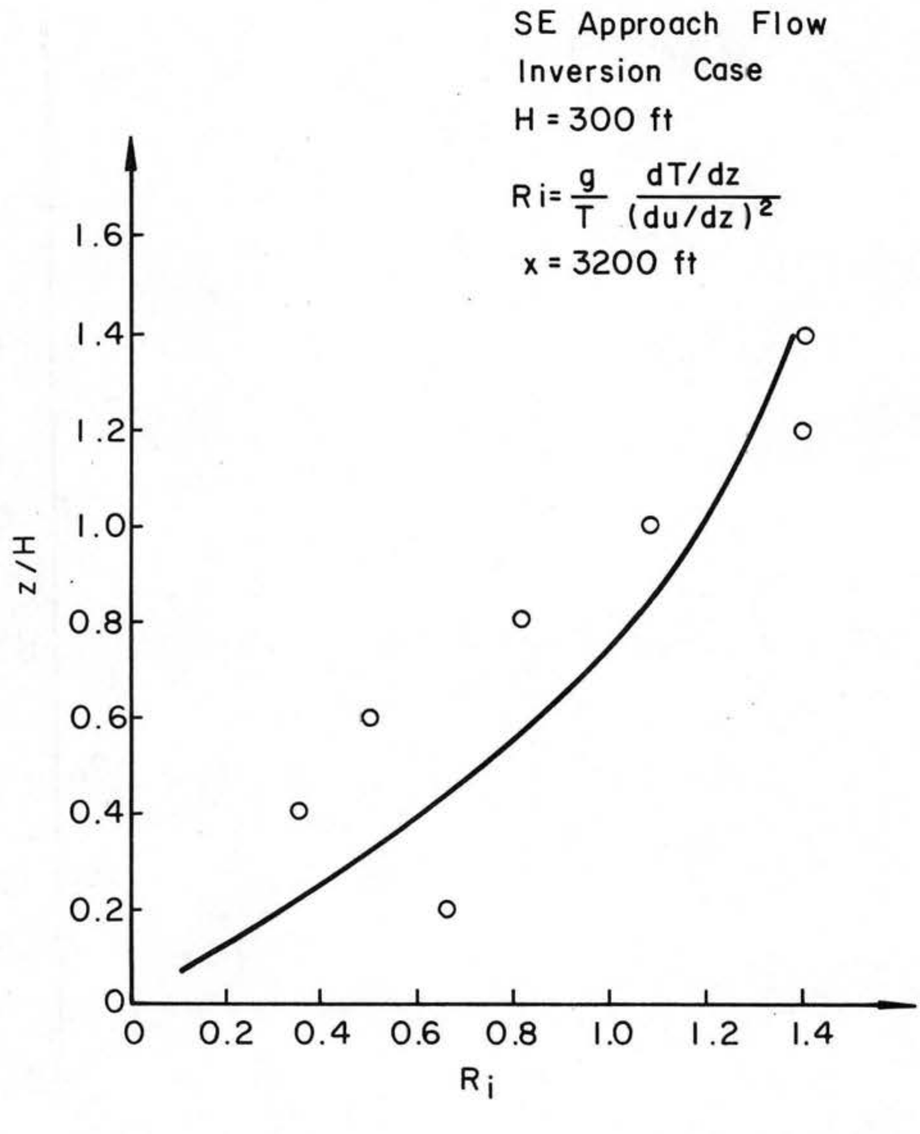


Figure 15d. Richardson Number Profile: Inversion Case, SE Approach Flow.

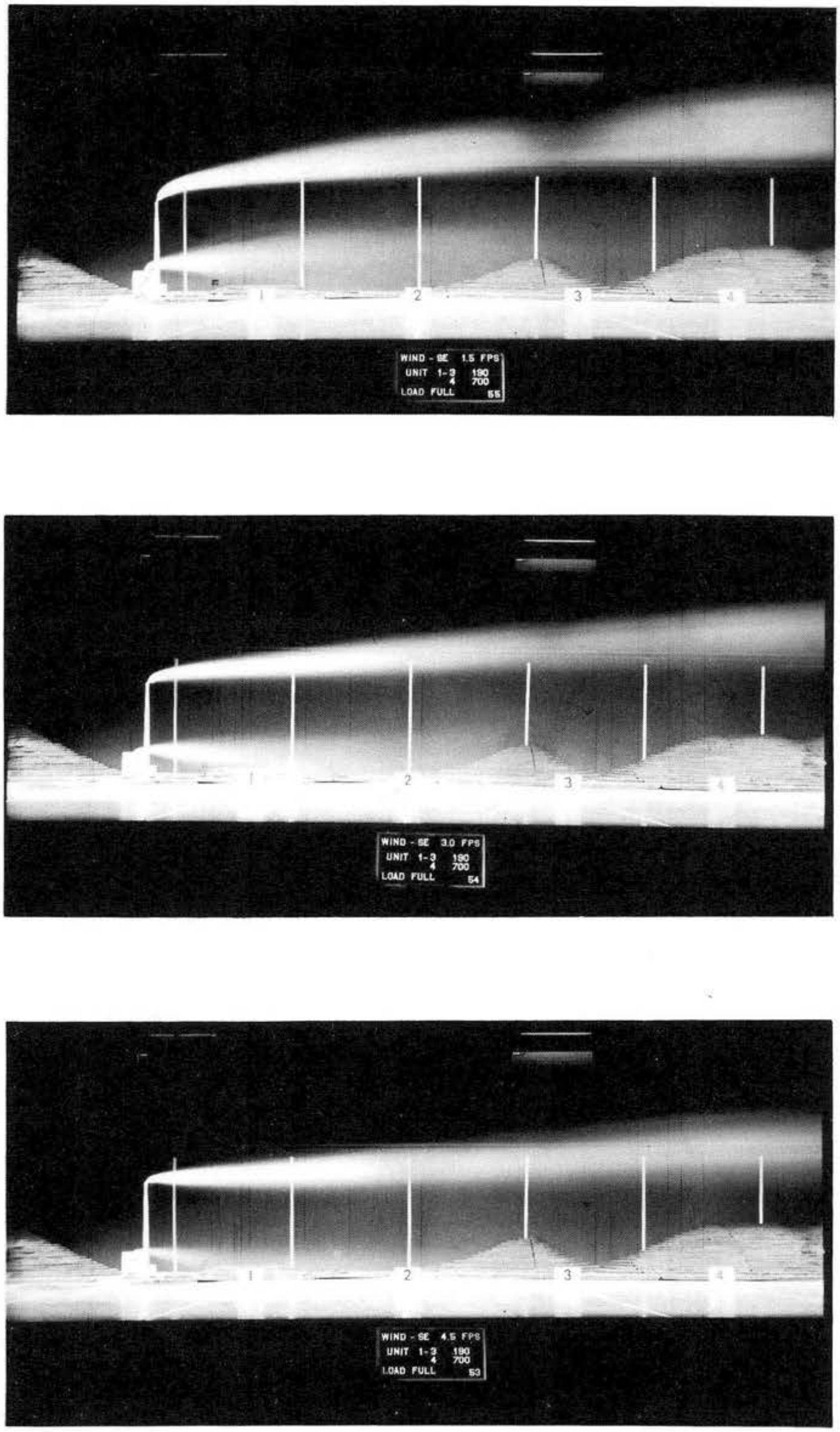


Figure 16a. Flow Visualization Unit 4, 700 ft Stack, Units 1-3, 190 ft Stack; Full load, SE Wind Approach Angle, Wind Speed 20, 40, 60 ft/sec (Long Exposure).

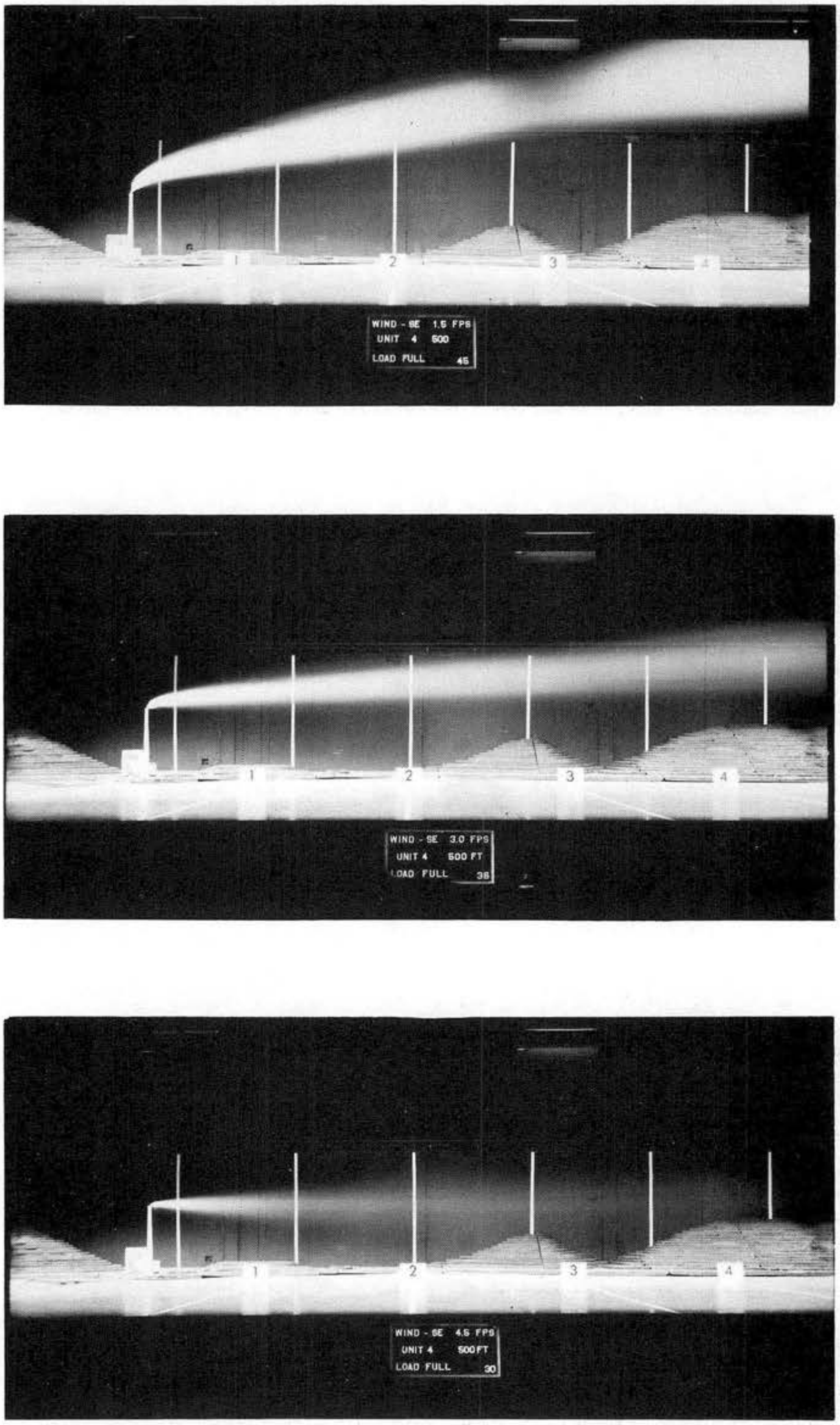
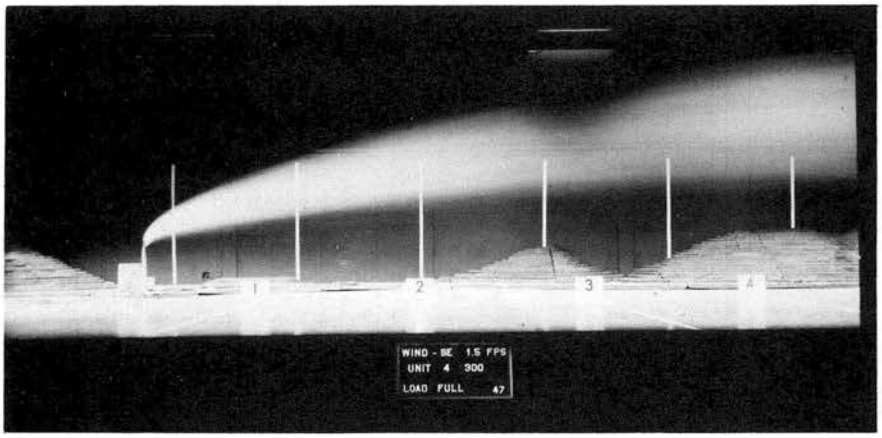
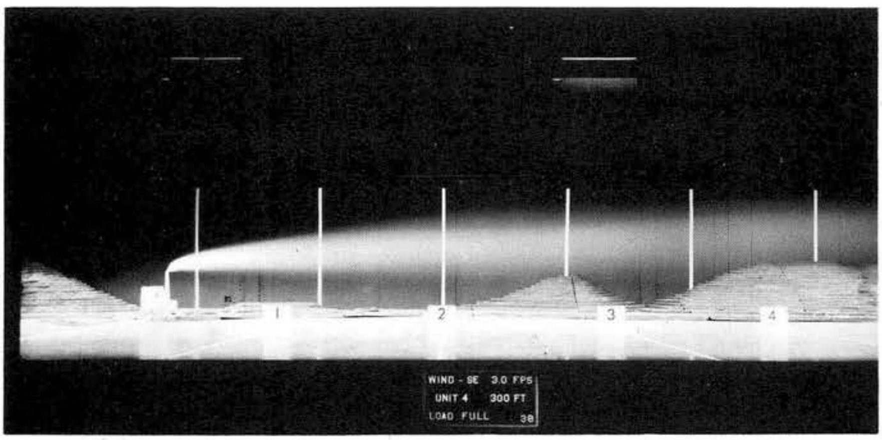


Figure 16b. Flow Visualization Unit 4, Full load, SE Wind Approach Angle, Stack Height 500 ft, Wind Speed 20, 40, 60 ft/sec (Long Exposure).





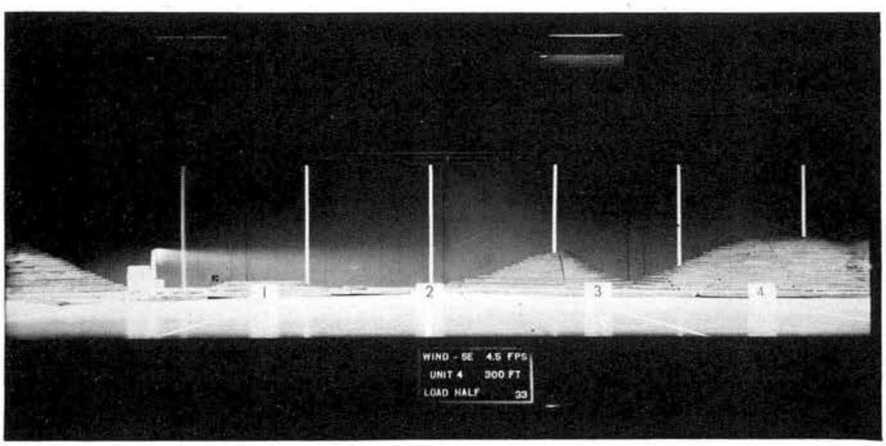
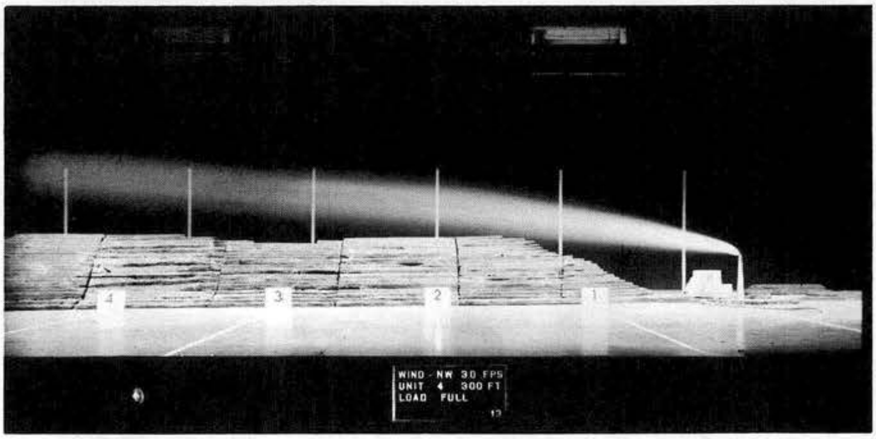


Figure 16c. Flow Visualization Unit 4, Stack Height 300 ft, Full Load, SE Wind Approach Angle, Wind Speed 20, 40, 60 ft/sec (Long Exposure).



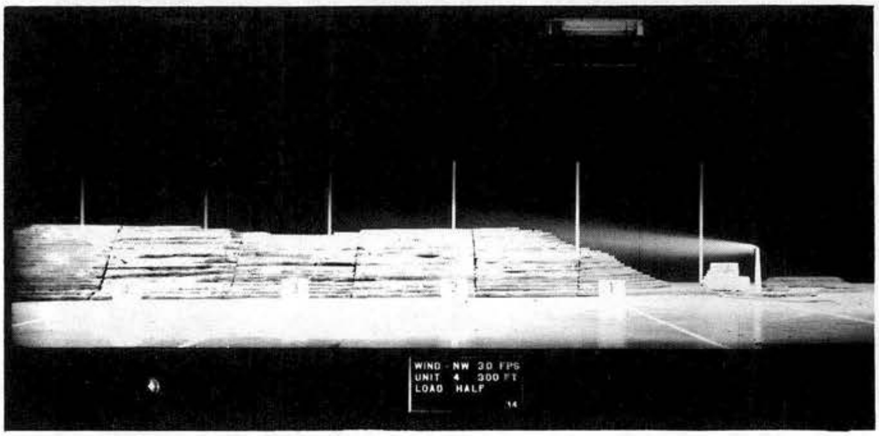


Figure 17. Flow Visualization Unit 4, NW Wind Approach Angle, Wind Speed 40 ft/sec, Stack Height 300 ft, Load: Full and One-Half.

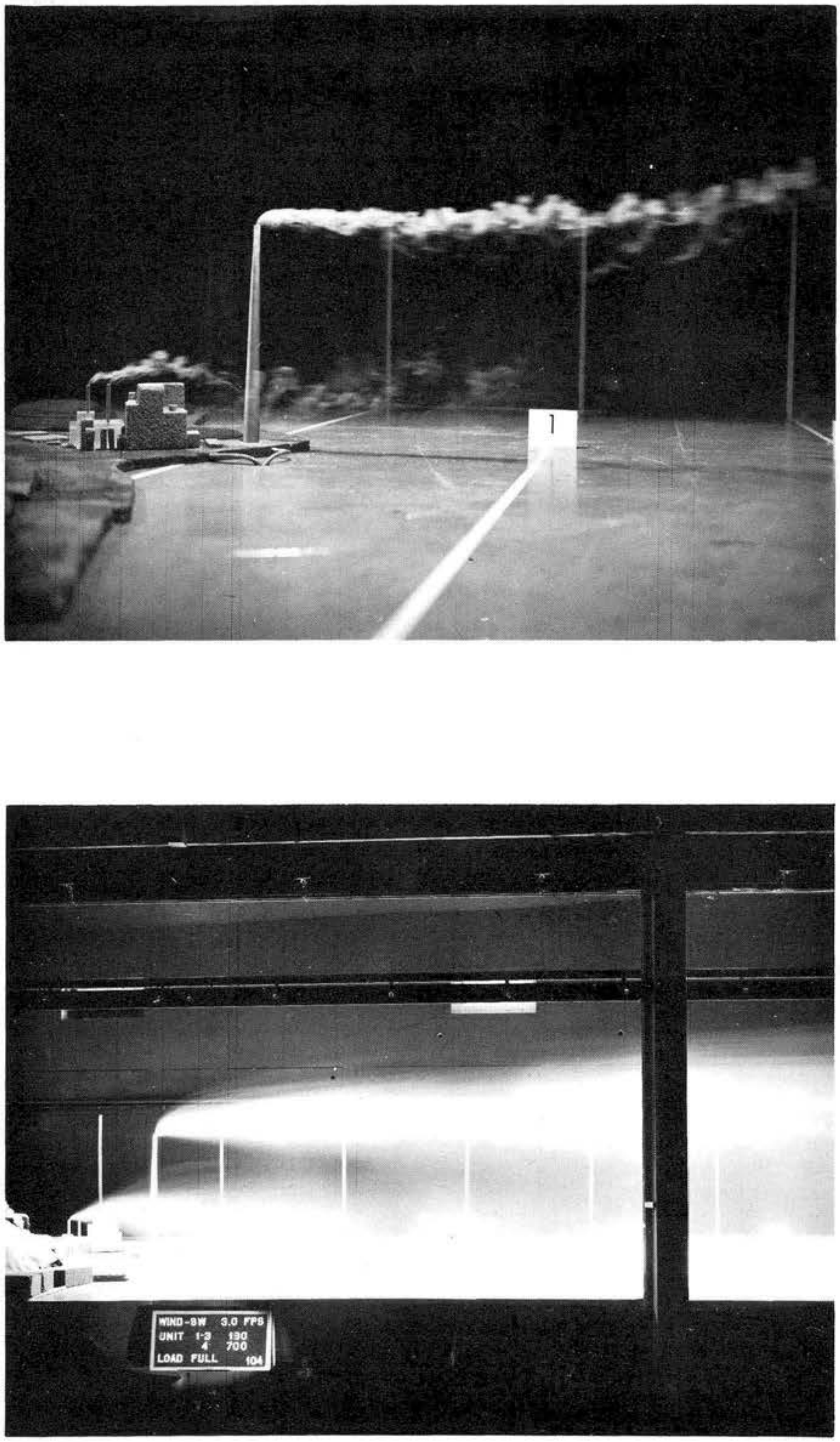


Figure 18. 1/32 and 30 sec Exposures.

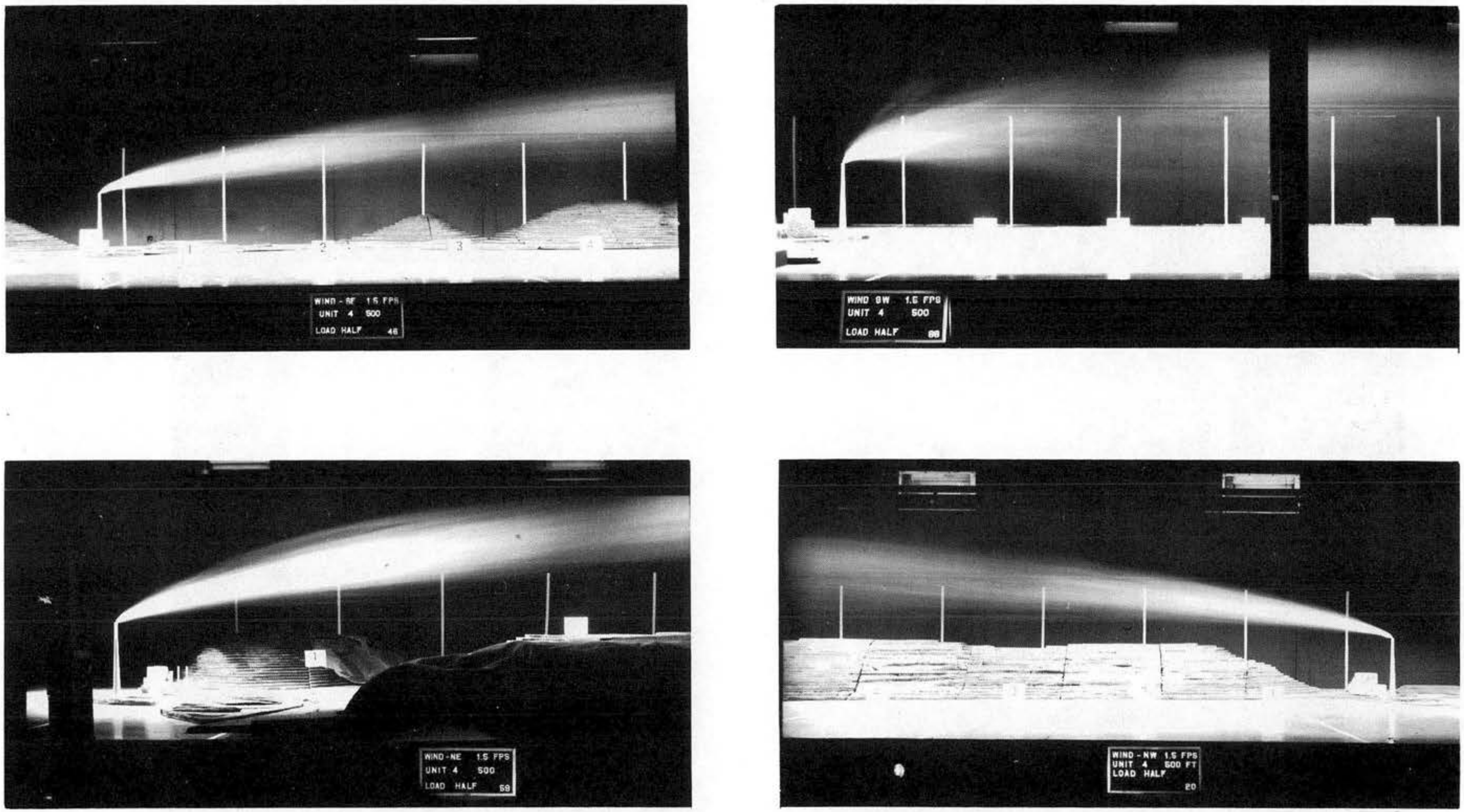


Figure 19. Flow Visualization Unit 4, Stack Height 500 ft, Wind Speed 20 ft/sec, Half Load, Wind Approach Angles SE, SW, NE, and NW.

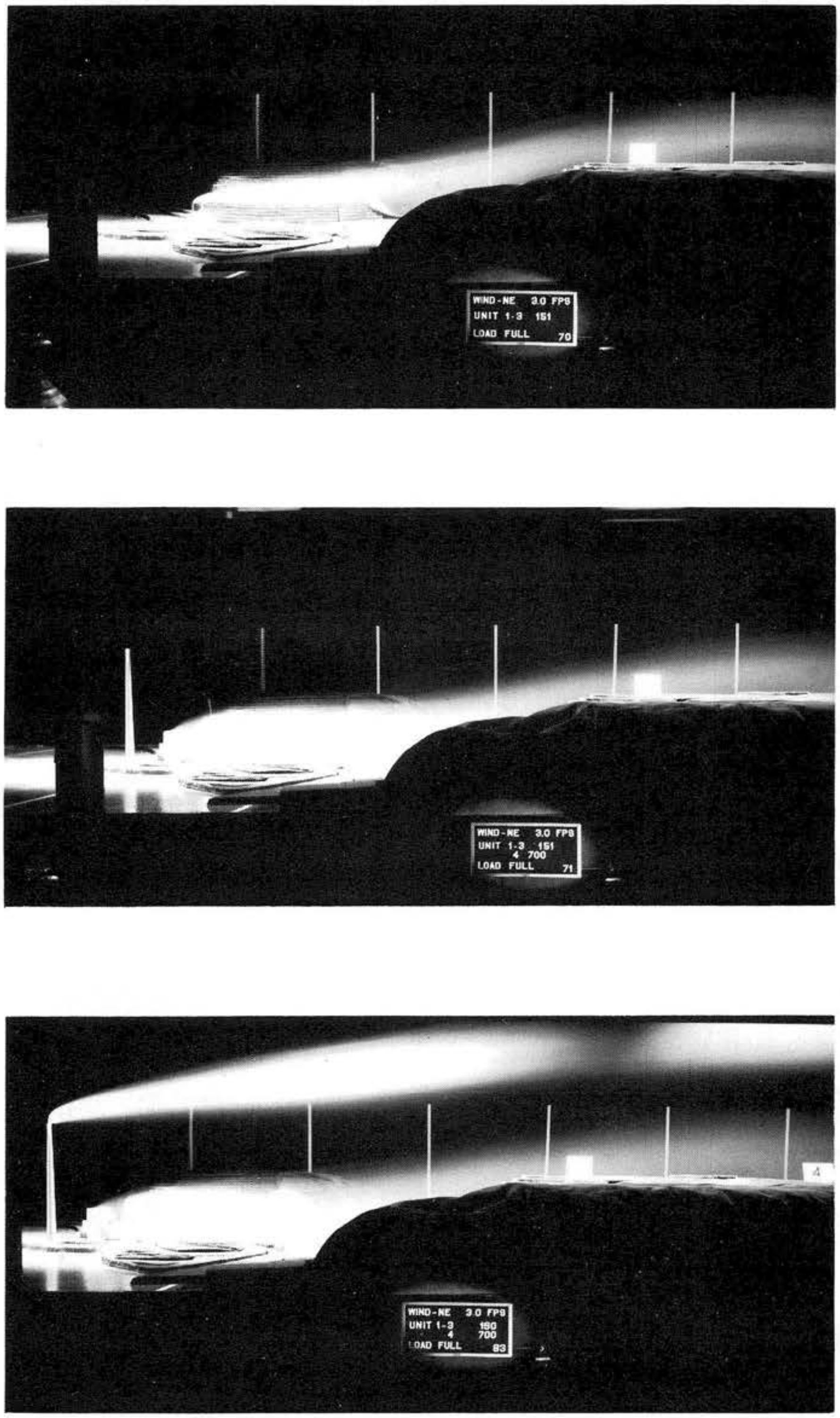


Figure 20. Flow Visualization, Unit 1-3 Alone, Unit 1-3 (151 ft Stack) and Unit 4, Unit 1-3 (190 ft Stack) and Unit 4, NE Wind Approach Angle, Wind Velocity 40 ft/sec, Full Load (Long Exposure).

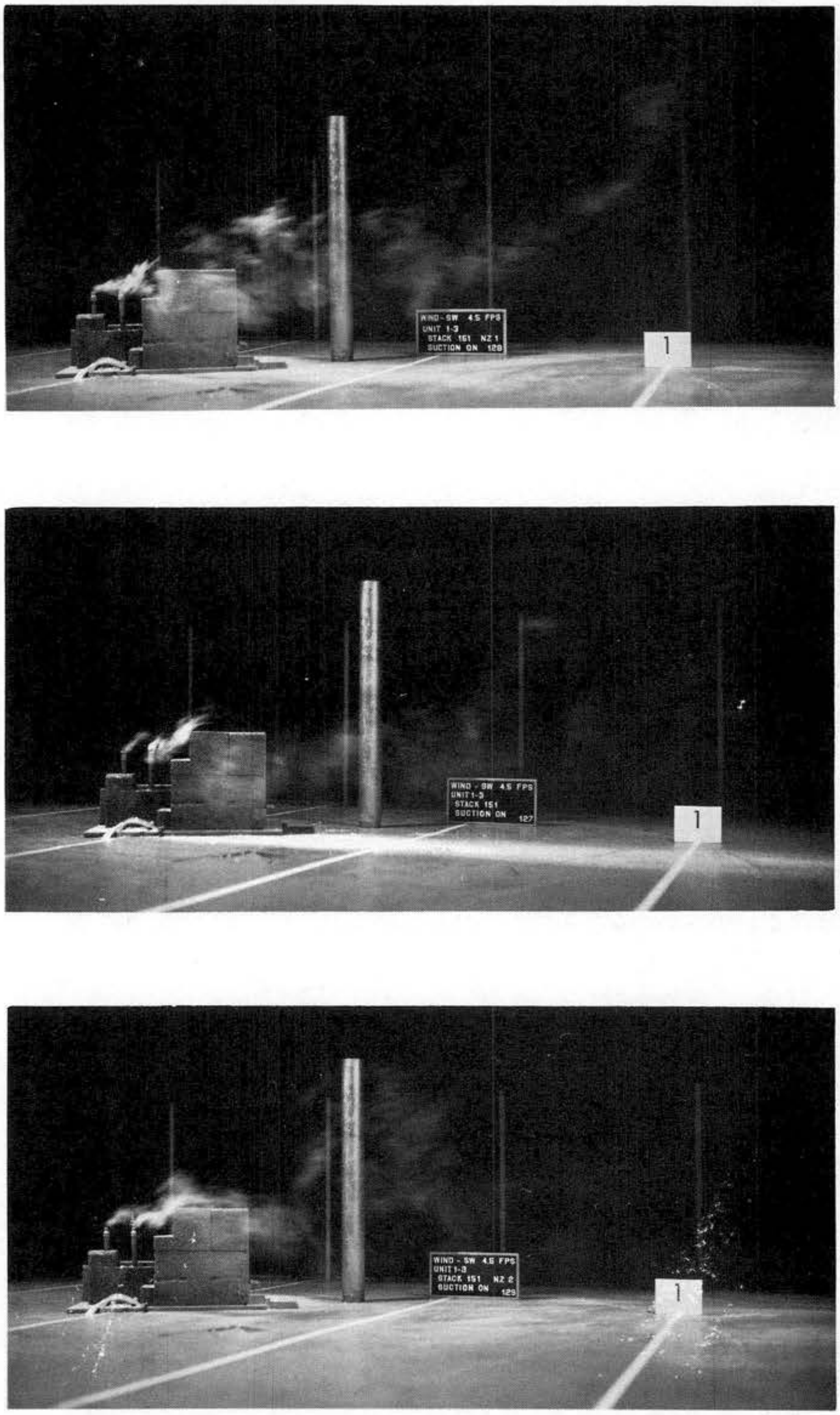


Figure 21a. Flow Visualization 1/200 Model, Units 1-3, NW Wind Approach Angle, Wind Speed 60 ft/sec, Stack Height 151 ft, No Nozzle, Nozzle 1, Nozzle 2.

Figure 21b. Flow Visualization 1/200 Model, Units 1-3, NW Wind Approach Angle, Wind Speed 60 ft/sec, Stack Height 190 ft, No Nozzle, Nozzle 1, Nozzle 2.

Figure 21c. Flow Visualization 1/200 Model Scale, Units 1-3, NW Wind Approach Angle, Wind Speed 60 ft/sec, Stack Height 210 ft and 230 ft.

Figure 21d. Flow Visualization 1/200 Model Scale, Units 1-3, NW Wind Approach Angle, Stack Height 190 ft, Nozzle 2, Wind Speed 20 and 60 ft/sec.

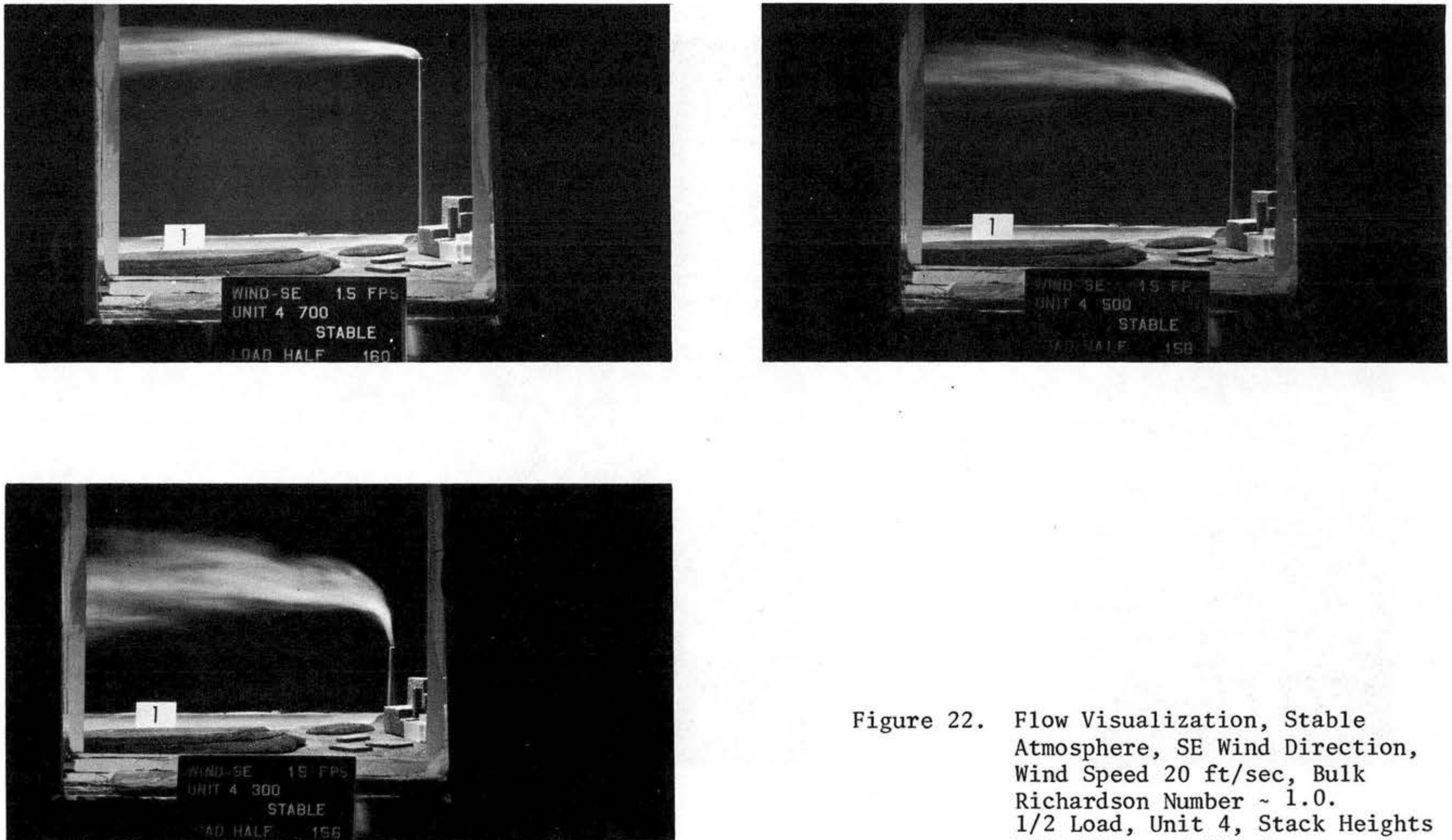
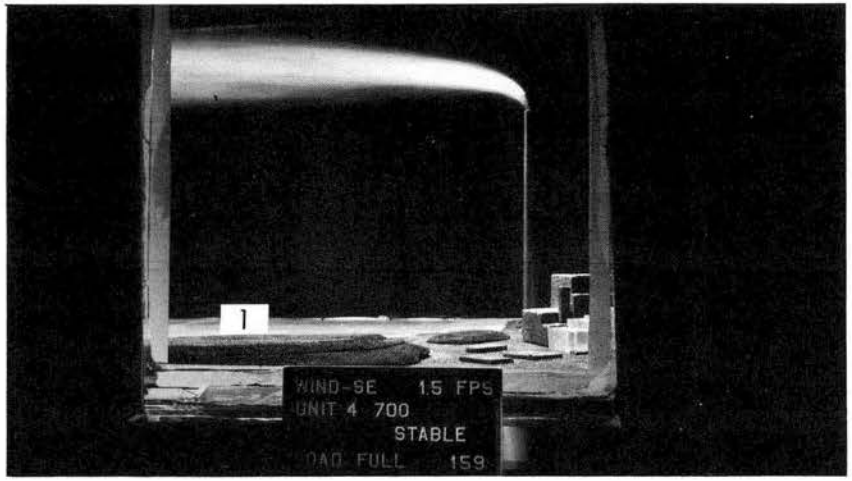
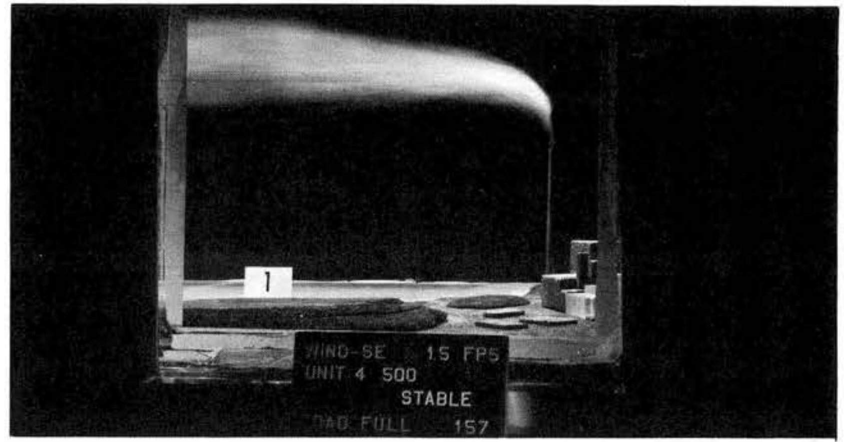


Figure 22. Flow Visualization, Stable Atmosphere, SE Wind Direction, Wind Speed 20 ft/sec, Bulk Richardson Number ~ 1.0. 1/2 Load, Unit 4, Stack Heights 700, 500, and 300 ft.





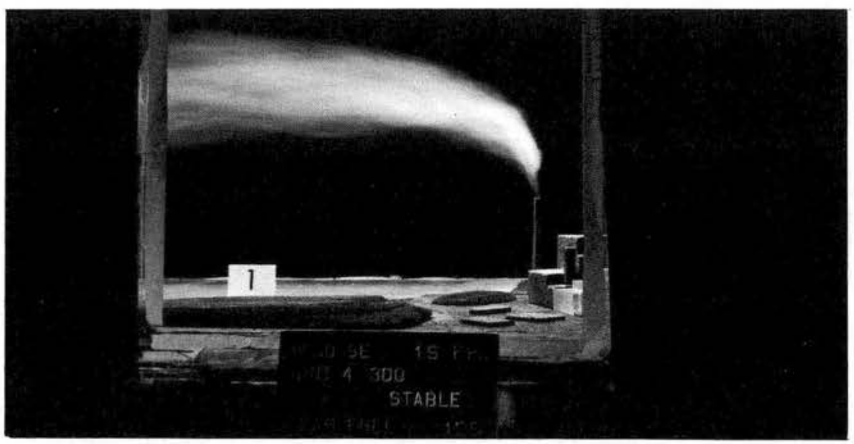


Figure 23. Flow Visualization, Stable Atmosphere, SE Wind Direction, Wind Speed 20 ft/sec, Bulk Richardson Number ~ 1.0, Full Load, Unit 4, Stack Heights 700, 500, and 300 ft.

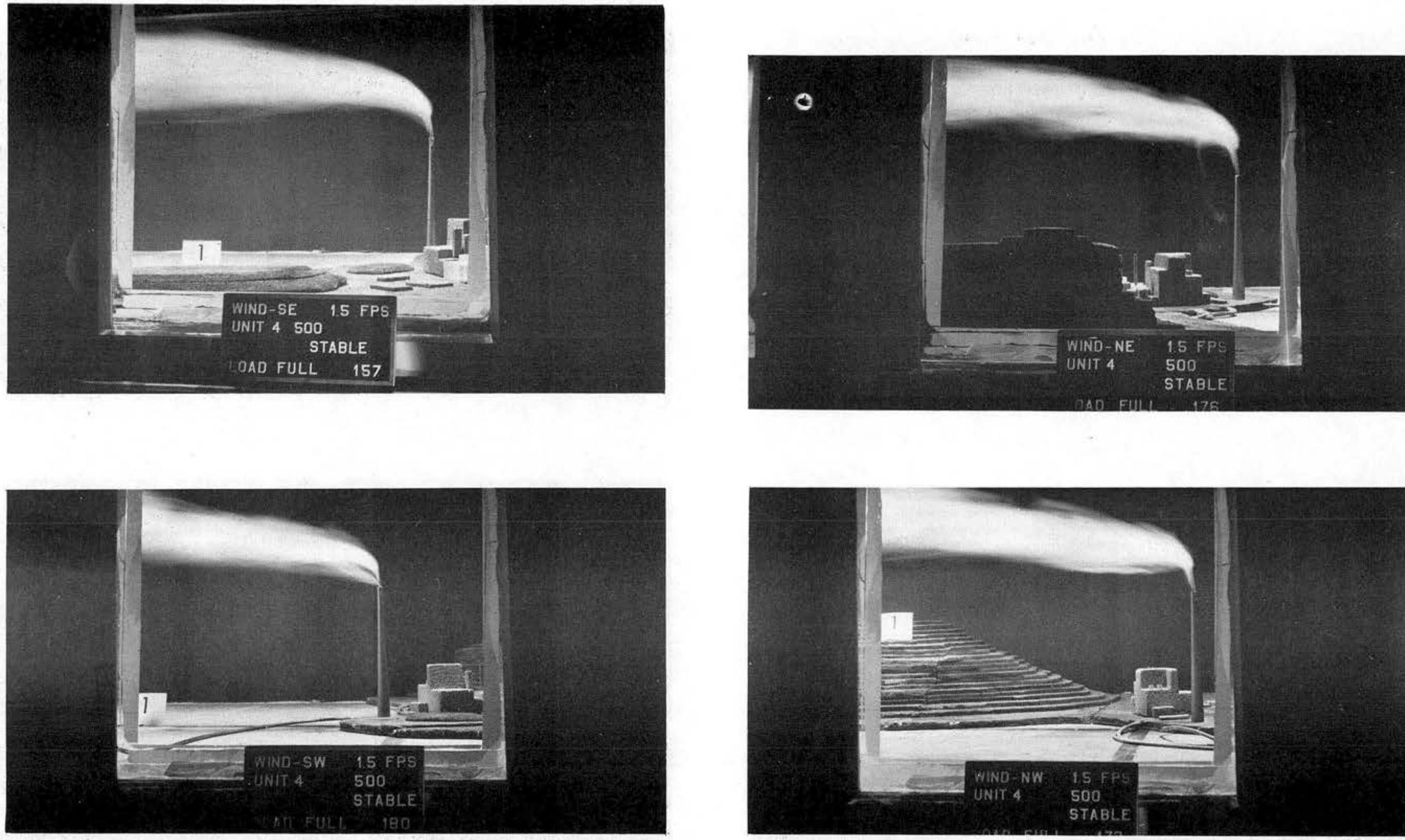


Figure 24. Flow Visualization, Stable Atmosphere, Wind Directions SE, SW, NE, NW, Wind Speed 20 ft/sec, Bulk Richardson Number ~ 1.0, Full Load, Unit 4, Stack Height 500 ft.

Table 1 Prototype Emission Parameters of Lansing Power Plant

Source	Units 1 & 2			Unit 3			Unit 4					
Stack (ft) Diameter	8.0			8.0			13.8					
Area (ft)	50.3			50.3			149.6					
Height (ft)	151, 190			151, 190			300, 500, 700					
Load	100%			100%			100%			50%		
V_s (ft/sec)	52.3 (50 normal)			50.3 (50 normal)			100.0			50.0		
T_s °F	300°F			300°F			300°F			300°F		
V_a (ft/sec)	20	40	60	20	40	60	20	40	60	20	40	60
or in (mph)	13.6	27.3	40.9	13.6	27.3	40.9	13.6	27.3	40.9	13.6	27.3	40.9
$R = V_s/V_a$	2.5	1.25	0.83	2.5	1.25	0.83	5	2.5	1.66	2.5	1.25	.83
$\frac{\Delta\rho}{\rho_a}$ 70°F	0.302			0.302			0.302			0.302		
$Fr_s = \frac{V_s^2}{g\frac{\Delta\rho}{\rho}D}$	32.13			32.13			74.5			18.63		

Table 2 Model Emission Parameters*
Model Scale 1/400

Source	Units 1 & 2	Unit 3	Unit 4	
Stack Diameter (in)	0.25	0.25	0.41	
Area (in^2)	.049	.049	.132	
Height (in)	4.53, 5.7	4.53, 5.7	9, 15, 21	
Load	100	100	100	50
R	2.5 1.25 .83	2.5 1.25 .83	5.0 2.5 1.66	2.5 1.25 .83
V_s (ft/sec)	3.75	3.75	7.5	3.75
Q_s (cfm)	.077	.077	0.412	.206
Fr_s	32.13	32.13	74.5	18.63
$\frac{\Delta\rho}{\rho}$	0.679	0.679	0.679	0.679
x_{He}	0.789	0.789	0.789	0.789
Q_{He} (cfm)	0.061	0.061	0.325	0.162
Q_{air} (cfm)	0.016	0.016	0.087	0.044
*$(Va)_m$	1.5 ft/sec 3.0 ft/sec 4.5 ft/sec			

Table 3 Model Emission Parameters
Model Scale 1/200

Source Nozzle	1-2, 3 1:1	1-2, 3 1:0.84	1-2, 3 1:0.51
Stack Exit Diameter (in.)	0.525	0.480	0.375
Area ($in.^2$)	0.22	0.18	0.11
Height (in.)	9.1,11.4,13.7	9.1,11.4,13.7	9.1,11.4,13.7
Load (%)	100	100	100
R	2.5,1.25,.83	3.05,1.52,1.02	5.0,2.50,1.67
V_s (ft/sec)	3.75	4.58	7.50
Q_s (cfm)	0.34	0.34	0.34
Fr_s	32.13	53.92	185.10
$\frac{\Delta\rho}{\rho}$	0.302	0.302	0.302
χ_{He}	0.350	0.350	0.350
Q_{He} (cfm)	0.12	0.12	0.12
Q_{air} (cfm)	0.22	0.22	0.22

Table 4 Instrumentation and Materials Employed

Camera	movie:	Bolex 16 mm camera lens
	still:	Speed Graphic Camera 4" x 5" & Hasselblad 2" x 3"
Film	movie:	Extachrome - 7242, ASA 125 - Forced developed ASA 500
	still:	Tri-X-Pan-4164 Kodak film, Polaroid
Exposure	movie:	f-1.9, 18 frames per second
	still:	f = 8-11, t = 1/30 sec or 30 sec
Flow meters	1)	Fischer & Porter Co. Precision flow rator No. B4-21-10 float B SVT-45
	2)	Fischer & Porter Co. Percision flow rator No. FP1/4-09-G-G3/4 / 4 / 61
	3)	Fischer & Porter Co. Precision flow rator No. 2F-1/4-20-5/70
Counters		Ultra scaler - model 192A by Nuclear Chicago
Hot-Wire Anemometer		Disa 55D0 constant temperature anemometer
Hot Wire		Pt (80%) Ir (20%) wire, diameter - 0.1 mm
Traversing Mechanism		Made at CSU, with remote control, range 17"
Recorder		Hewlett and Packard X-Y Recorder Model 7035B
Meter		HP Integrating digital voltmeter model 2401C
Sampling Panels	1)	Made at CSU, 25 sample point capacity as shown in Fig.
	2)	Radioactive gas samplers a) Nooo14-68-A-0493-0001-65234 b) Nooo14-68-A-0493-0001-65227
Thermistor		Fennal Glass coated bead #GB33L1, time constant in air ~2 sec
Thermometer		Yellow Springs Corp., YS1 Model 42 SC, Tele - Thermometer, range - 40°C ~150°C.

Table 5 Observed Touchdown Distances (ft) from Flow Visualization Tests (Neutral)

Units (1-3, or 4)	Wind Direction	Stack Height	Full Load (ft/sec) 20	40	60	1/2 Load (ft/sec) 20	40	60
1-3 alone	SE	151	800	400	600			
		190	--	--	--			
	SW	151	2000	500*	300*			
		190	--	--	--			
	NE	151	2200	1200	200*			
		190	--	--	--			
	NW	151	1000	1000	500			
		190	--	--	--			
1-3 (with 4)	SE	151	600	200*	400*			
		190	800	500	500			
	SW	151	1000*	0*	0*			
		190	500*	0*	0*			
	NE	151	0*	0*	0*			
		190	2500	0*	0*			
	NW	151	500*	200*	200*			
		190	1000	500	600			
4	SE	700	+	+	+	+	+	8000
		500	+	8000	7000	+	7000	5000
		300	+	6500	4000	8000	3000	2000
	SW	700	+	7000	4500	+	6000	3500
		500	+	3000	3500	+	2000	2000
		300	3000	1500	1000	2000	1000	1000
	NE	700	+	+	7000	+	+	5500
		500	+	7500	3000	+	7000	2500
		300	+	7000	2700	7000	2500	2000
	NW	700	+	+	>4000	+	5000	>4000
		500	+	>5000	>4000	6000	3000	3500
		300	5000	3000	3500	3000	3000	3500
1-3 (with 4) (200 scale)	SW	151	1000	--	0			
		190	1000	--	0			
		190N	1000	--	800*			
		230	150	--	600*			

\+ No touchdown i.e. (greater than 10,000 ft)

* Entrainment observed

Table 6 Summary of Maximum Ground Level Concentrations (m^{-2}) and Distances (ft) (Neutral)

Units	Wind Direction	Stack Height	Full Load 20	Full Load 40	Full Load 60	1/2 Load 20	1/2 Load 40	1/2 Load 60
1-3	SE	151	3.11 (6000)	43.4 (2000)	59.0 (2000)			
Alone	SW		4.19 (4000)	51.2 (2000)	61.9 (2000)			
	NE		15.60 (7000)	61.1 (4000)	89.8 (2000)			
	NW		21.5 (3000)	51.9 (2000)	81.6 (2000)			
1-3	SE	151	16.8 (2000)	75.6 (2000)	147. (2000)			
with 4	SW		11.7 (2000)	50.5 (2000)	40.3 (2000)			
	NE		22.5 (1000)	283. (1000)	161. (1000)			
	NW		36.5 (2000)	70.4 (2000)	65.5 (2000)			
	SE	190	9.55 (2000)	53.2 (2000)	138. (2000)			
	SW		8.45 (4000)	39.9 (2000)	34. (2000)			
	NE		48.4 (3000)	352. (1000)	187. (1000)			
	NW		20.3 (4000)	56.4 (2000)	65.1 (2000)			
4	SE	700	+	2.29 (8000)	1.30 (8000)	.251 (9000)	11.0 (8000)	6.14 (8000)
	SW		+	3.39 (8000)	1.75 (6000)	+	7.53 (8000)	2.26 (6000)
	NE		+	+	0.106 (9000)	+	+	+
	NW		+	2.21 (4000)	1.16 (9000)	+	2.29 (5000)	5.65 (9000)
	SE	500	+	6.96 (8000)	1.35 (6000)	+	11.1 (6000)	1.34 (8000)
	SW		+	0.94 (6000)	2.95 (6000)	0.488 (9000)	11.9 (6000)	4.82 (4000)
	NE		+	.282 (8000)	4.36 (8000)	+	10.9 (8000)	17.1 (8000)
	NW		+	2.72 (9000)	7.98 (9000)	1.34 (8000)	13.2 (8000)	37.2 (5000)
	SE	300	+	11.2 (8000)	5.06 (6000)	.307 (9000)	20.8 (6000)	12.1 (4000)
	SW		1.56 (7000)	8.35 (6000)	8.66 (2000)	6.01 (9000)	26.6 (3000)	14.7 (2000)
	NE		+	4.84 (8000)	21.20 (8000)	+	19.8 (4000)	73.4 (3000)
	NW		1.07 (9000)	12.9 (6000)	25.3 (5000)	2.27 (9000)	38.3 (3000)	51.9 (4000)

+ zero concentrations

[concentration x 10^6 (m^{-2}); distance (ft)]

Table 7 Observed Touchdown Distances (ft) from Flow Visualization Tests (Stable)

Units	Wind Direction	Stack Height (ft)	Stratification	Full Load	1/2 Load
1-3	SE	151	stable	occasional ~500	
alone	SW	151	"	"	
1-3					
with Unit 4	SE	151	"	~200	
		190	"	~350	
	SW	151	"		
		190	"		
4	SE	300	"	+	+
		500	"	+	+
		700	"	+	+
	SW	300	"	+	+
		500	"	+	+
		700	"	+	+
	NE	300	"	9000	6000
		500	"	8000	8000
		700	"	+	+
	NW	300	"	+	+
		500	"	+	+
		700	"	+	+
4	SE	300	Inversion	+	+
		500	"	+	+
		700	"	+	+

\+ No touchdown (i.e., greater than 10,000 ft)

Table 8 Summary of Maximum Ground Level Concentrations (m^{-2}) and Distances (ft) Stable Stratifications

Units	Wind Direction	Stack Height	Stratification	Full Load	1/2 Load
4	SE	300	Stable	+	+
		500	"	+	+
		700	"	+	+
	SW	300	"	+	+
		500	"	+	+
		700	"	+	+
	NE	300	"	2.21(9000)	1.63(2000)
		500	"	+	0.06(9000)
		700	"	+	+
	NW	300	"	+	+
		500	"	+	+
		700	"	+	+
4	SE	300	Inversion	+	+
		500	"	+	+
		700	"	+	+

\+ Zero ground level concentration measured over extent of model.

Table 9 Summary of Motion Picture Sequences

Summary of Motion Picture Sequences

Run No	Wind Dir	Wind Vel(fps)	Unit No	Unit Ht(ft)	Load %	Run No	Wind Dir	Wind Vel(fps)	Unit No	Unit Ht(ft)	Load %
1	NW	4.5	4	700	100	55	SE	1.5	1-3	190	100
2	NW	4.5	4	700	50				4	700	100
3	NW	4.5	4	500	100	56	NE	1.5	4	700	100
4	NW	4.5	4	500	50	57	NE	1.5	4	700	50
5	NW	4.5	4	500	100	58	NE	1.5	4	500	100
6	NW	4.5	4	300	50	59	NE	1.5	4	500	50
7	NW	4.5	1-3	---	100	61	NE	1.5	4	300	50
8	NW	4.5	1-3	700	100	62	NE	1.5	1-3	151	100
			4		0	63	NE	1.5	1-3	151	100
9	NW	3.0	4	700	100				4	700	0
10	NW	3.0	4	700	50	64	NE	3.0	4	700	100
11	NW	3.0	4	500	100	65	NE	3.0	4	700	50
12	NW	3.0	4	500	50	66	NE	3.0	4	500	100
13	NW	3.0	4	300	100	67	NE	3.0	4	500	50
14	NW	3.0	4	300	50	68	NE	3.0	4	300	100
15	NW	3.0	1-3	---	100	69	NE	3.0	4	300	50
16	NW	3.0	1-3	---	100	70	NE	3.0	1-3	151	100
			4	700	0	71	NE	3.0	1-3	151	100
17	NW	1.5	4	700	100				4	700	0
18	NW	1.5	4	700	50	72	NE	4.5	4	700	100
19	NW	1.5	4	500	100	73	NE	4.5	4	700	50
20	NW	1.5	4	500	50	76	NE	4.5	4	500	100
21	NW	1.5	4	300	100	77	NE	4.5	4	500	50
22	NW	1.5	4	300	50	78	NE	4.5	4	300	100
23	NW	1.5	1-3	---	100	79	NE	4.5	4	300	50
24	NW	1.5	1-3	---	100	80	NE	4.5	1-3	151	100
			4	700	0	81	NE	4.5	1-3	151	100
25	NW	1.5	1-3	---	100				4	700	0
			4	700	100	82	NE	4.5	1-3	190	100
26	NW	3.0	1-3	---	100				4	700	100
			4	700	100	83	NE	3.0	1-3	190	100
27	NW	4.5	1-3	---	100				4	700	100
			4	700	100	84	NE	1.5	1-3	190	100
28	SE	4.5	4	700	100				4	700	100
29	SE	4.5	4	700	50	85	SW	1.5	4	700	100
30	SE	4.5	4	500	100	86	SW	1.5	4	700	50
31	SE	4.5	4	500	50	87	SW	1.5	4	500	100
32	SE	4.5	4	300	100	88	SW	1.5	4	500	50
33	SE	4.5	4	300	50	89	SW	1.5	4	300	100
34	SE	3.0	4	700	100	90	SW	1.5	4	300	50
35	SE	3.0	4	700	50	91	SW	1.5	1-3	151	100
36	SE	3.0	4	500	100	92	SW	1.5	1-3	151	100
37	SE	3.0	4	500	50				4	700	0
38	SE	3.0	4	300	100	93	SW	1.5	1-3	190	100
39	SE	3.0	4	300	50				4	700	0
40	SE	3.0	1-3	---	100	94	SW	1.5	1-3	190	100
41	SE	3.0	1-3	---	100				4	700	100
			4	700	0	95	SW	3.0	4	700	100
42	SE	3.0	1-3	151	100	96	SW	3.0	4	700	50
			4	700	0	97	SW	3.0	4	500	100
43	SE	1.5	4	700	100	98	SW	3.0	4	500	50
44	SE	1.5	4	700	50	99	SW	3.0	4	300	100
45	SE	1.5	4	500	100	103	SW	3.0	1-3	190	100
47	SE	1.5	4	300	100				4	700	0
48	SE	1.5	4	300	50	104	SW	3.0	1-3	190	100
49	SE	1.5	1-3	151	100				4	700	100
50	SE	1.5	1-3	151	100	105	SW	4.5	4	700	100
			4	700	0	106	SW	4.5	4	700	50
51	SE	4.5	1-3	151	100	107	SW	4.5	4	500	100
52	SE	4.5	1-3	151	100	108	SW	4.5	4	500	50
			4	700	0	109	SW	4.5	4	300	100
53	SE	4.5	1-3	190	100	110	SW	4.5	4	300	50
			4	700	100	111	SW	4.5	1-3	151	100
54	SE	3.0	1-3	190	100	114	SW	4.5	1-3	190	100
			4	700	100				4	700	100

Summary of Motion Picture Sequences (Continued)

Run No	Wind Dir	Wind Vel(fps)	Unit No	Unit Ht(ft)	Load %	
115	SW	4.5	1-3	151	100	Suction on
117	SW	4.5	1-3	151	100	Suction on--NZ 1
118	SW	4.5	1-3	151	100	Suction off--NZ 1
119	SW	4.5	1-3	151	100	Suction on--NZ 2
120	SW	4.5	1-3	151	100	Suction off--NZ 2
121	SW	4.5	1-3	190	100	Suction on
122	SW	4.5	1-3	190	100	Suction off
123	SW	4.5	1-3	190	100	Suction on--NZ 1
124	SW	4.5	1-3	190	100	Suction off--NZ 1
125	SW	4.5	1-3	190	100	Suction on--NZ 2
126	SW	4.5	1-3	190	100	Suction off--NZ 2
127	SW	4.5	1-3	151	100	Suction on
128	SW	4.5	1-3	151	100	Suction on--NZ 1
129	SW	4.5	1-3	151	100	Suction on--NZ 2
130	SW	4.5	1-3	190	100	Suction on
131	SW	4.5	1-3	190	100	Suction on--NZ 1
132	SW	4.5	1-3	190	100	Suction on--NZ 2
133	SW	4.5	1-3	210	100	Suction on
134	SW	4.5	1-3	230	100	Suction on
135	SW	4.5	1-3	230	100	Suction on--NZ 2
136	SW	1.5	1-3	150	100	Suction on
137	SW	1.5	1-3	151	100	Suction on--NZ 1
138	SW	1.5	1-3	151	100	Suction on--NZ 2
139	SW	1.5	1-3	190	100	Suction on
140	SW	1.5	1-3	190	100	Suction on--NZ 1
141	SW	1.5	1-3	190	100	Suction on--NZ 2
142	SW	1.5	1-3	210	100	Suction on
143	SW	1.5	1-3	230	100	Suction on
144	SW	1.5	1-3	230	100	Suction on--NZ 2
145	015	1.5	1-3	150	100	Suction on
146	015	1.5	1-3	150	100	Suction on--NZ 2
147	015	1.5	1-3	190	100	Suction on
148	015	1.5	1-3	190	100	Suction on--NZ 2
149	015	1.5	1-3	230	100	Suction on
150	015	1.5	1-3	230	100	Suction on--NZ 2
151	015	4.5	1-3	190	100	Suction on
152	015	4.5	1-3	190	100	Suction on--NZ 2
153	015	4.5	1-3	230	100	Suction on
154	015	4.5	1-3	230	100	Suction on--NZ 2
155	SE	1.5	4	300	100	Stable
156	SE	1.5	4	300	50	Stable
157	SE	1.5	4	500	100	Stable
158	SE	1.5	4	500	50	Stable
159	SE	1.5	4	700	100	Stable
160	SE	1.5	4	700	50	Stable
161	SE	1.5	1-3	151	100	Stable
			4	700	0	Stable
162	SE	1.5	1-3	190	100	Stable
			4	700	0	Stable
163	SE	1.5	1-3	151	100	Stable
164	SE	1.5	4	300	100	Stable-Inversion
165	SE	1.5	4	300	50	Stable-Inversion
166	SE	1.5	4	500	100	Stable-Inversion
167	SE	1.5	4	500	50	Stable-Inversion
168	SE	1.5	4	700	100	Stable-Inversion
169	SE	1.5	4	700	50	Stable-Inversion
170	NW	1.5	4	300	100	Stable
171	NW	1.5	4	300	50	Stable
172	NW	1.5	4	500	100	Stable
174	NE	1.5	4	300	100	Stable
175	NE	1.5	4	300	50	Stable
176	NE	1.5	4	500	100	Stable
177	NE	1.5	4	500	50	Stable
178	SW	1.5	4	300	100	Stable
179	SW	1.5	4	300	50	Stable
180	SW	1.5	4	500	100	Stable
181	SW	1.5	4	500	50	Stable
182	SW	1.5	4	700	100	Stable
183	SW	1.5	4	700	50	Stable
184	SW	1.5	1-3	141	100	Stable
			4	700	0	Stable
185	SW	1.5	1-3	151	100	Stable

Table 10 Ground Level Concentration Results
For Neutral Flow Conditions

Note: if Units 1-3R are indicated this means test was performed with Unit 4 boilers and stacks removed.

Table 10 Locator Table for Individual Concentration Results

Units	Wind Direction	Stack Height	Full Load			1/2 Load		
			20	40	60	20	40	60
1-3 Alone	SE	151	10-1	10-10	10-19			
	SW		10-28	10-34	10-43			
	NE		10-52	10-57	10-66			
	NW		10-75	10-81	10-90			
1-3 with 4	SE	151	10-2	10-11	10-20			
	SW		10-29	10-35	10-44			
	NE		10-53	10-58	10-67			
	NW		10-76	10-82	10-91			
	SE	190	10-3	10-12	10-21			
	SW		10-30	10-36	10-45			
	NE		10-54	10-59	10-68			
	NW		10-77	10-83	10-92			
4	SE	700	10-8	10-17	10-26	10-9	10-18	10-27
	SW		-----	10-41	10-50	-----	10-42	10-51
	NE		-----	10-64	10-73	-----	10-65	10-74
	NW		-----	10-88	10-97	-----	10-89	10-98
	SE	500	10-6	10-15	10-24	10-7	10-16	10-25
	SW		-----	10-39	10-48	10-33	10-40	10-49
	NE		-----	10-62	10-71	-----	10-63	10-72
	NW		-----	10-86	10-95	10-80	10-87	10-96
	SE	300	10-4	10-13	10-22	10-5	10-14	10-23
	SW		10-31	10-37	10-46	10-32	10-38	10-47
	NE		10-55	10-60	10-69	10-56	10-61	10-70
	NW		10-78	10-84	10-93	10-79	10-85	10-94

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3   WIND ANGLE = SE   WIND SPEED (FPS) = 20   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.167E+01		.248E+01		0.	
600											
400				.168E+02		.107E+02		.451E+01		.160E+00	
200				.585E+01							
0			.232E+01	.139E+01	.122E+01	.244E+01	.198E+01	.648E+00	.948E+00	.566E+00	.282E-01
-200				.469E-01							
-400				0.		0.		.310E+00		0.	
-600											
-800						0.		.183E+01		0.	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .168E+02

UNIT 4 LOCATION. X = 325.00 Y = 366.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3R WIND ANGLE = SE WIND SPEED (FPS) = 20 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.330E+00		.144E+01		.299E+01	
600											
400				.519E+00		.610E+00		.311E+01		.245E+01	
200				.169E+00							
0			0.	0.	.469E-01	.114E+01	.256E+01	.164E+01	.986E+00	.105E+01	.164E+01
-200				0.							
-400				0.		0.		.188E-01		.216E+00	
-600											
-800						0.		0.		.354E-01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .311E+01

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3   WIND ANGLE = SE   WIND SPEED (FPS) = 20   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 190

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.884E+00		.483E+00		.108E+01	
600											
400				.955E+01		.162E+01		.610E+00		.573E+00	
200				.166E+01							
0			.422E+00	.236E+00	0.	.118E+00	.160E+00	.130E+00	.178E+00	.601E+00	.127E+01
-200				0.							
-400				0.		0.		0.		.103E+00	
-600											
-800						0.		0.		0.	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .955E+01

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = SE   WIND SPEED (FPS) = 20   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		.106E+00		.266E-01	
600											
400				0.		0.		0.		0.	
200				0.							
0			0.	0.	0.	0.	0.	0.	.141E-01	0.	.106E+00
-200				0.							
-400				0.		0.		0.		0.	
-600											
-800						0.		0.		.257E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .257E+00

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = SE   WIND SPEED (FPS) = 20   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				0.		0.		0.		0.	
200				0.							
0			0.	0.	0.	0.	0.	0.	.558E-01	0.	.307E+00
-200				0.							
-400				0.		0.		0.		.139E+00	
-600											
-800						0.		0.		.700E-01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .307E+00

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = SE   WIND SPEED (FPS) = 20   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200									0.		
1000											
800					0.		.124E+00		0.		
600											
400			0.		0.		0.		0.		
200			0.								
0		0.	0.	0.	0.	0.	0.	0.	.354E-01	0.	
-200			0.								
-400			0.		0.		0.		0.		
-600											
-800					0.		0.		0.		
-1000											
-1200									0.		
-1600											

MAXIMUM CONCENTRATION = .124E+00

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SE WIND SPEED (FPS) = 20 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200									0.		
1000											
800					0.		0.		0.		
600											
400			0.		0.		0.		0.		
200			0.								
0		0.	0.	0.	0.	0.	0.	0.	.875E-01	0.	
-200			0.								
-400			0.		0.		0.		0.		
-600											
-800					0.		0.		.700E-01		
-1000											
-1200									0.		
-1600											

MAXIMUM CONCENTRATION = .875E-01

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SE WIND SPEED (FPS) = 20 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

X = / Y	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				.159E+00		.282E-01		0.		0.	
200				.155E+00							
0			0.	0.	.353E-01	.885E-01	.494E-01	0.	0.	0.	0.
-200				0.							
-400				0.		.705E-02		0.		0.	
-600											
-800						0.		0.		0.	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .159E+00

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SE WIND SPEED (FPS) = 20 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				0.		0.		0.		0.	
200				0.							
0			0.	.175E-01	0.	0.	0.	0.	0.	.875E-01	.251E+00
-200				0.							
-400				0.		0.		0.		.976E-01	
-600											
-800						0.		0.		0.	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .251E+00

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = SE WIND SPEED (FPS) = 40 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.393E+02		.210E+02		.104E+02	
600											
400				.756E+02		.393E+02		.195E+02		.518E+01	
200				.654E+02							
0			.311E+02	.212E+02	.196E+02	.166E+02	.155E+02	.906E+01	.539E+01	.332E+01	.109E+01
-200				.438E+01							
-400				.189E+00		.404E+01		.317E+01		.135E+01	
-600											
-800						0.		.306E+00		.165E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .756E+02

UNIT 4 LOCATION. X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS,   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3R   WIND ANGLE = SE   WIND SPEED (FPS) = 40   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.218E+02		.113E+02		.146E+02	
600											
400				.434E+02		.243E+02		.216E+02		.112E+02	
200				.269E+02							
0			.675E+01	.161E+02	.232E+02	.236E+02	.232E+02	.190E+02	.140E+02	.103E+02	.885E+01
-200				.267E+01							
-400				0.		.113E+02		.893E+01		.588E+01	
-600											
-800						.127E+01		.436E+01		.391E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .434E+02

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS,   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3   WIND ANGLE = SE   WIND SPEED (FPS) = 40   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 190

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.238E+02		.159E+02		.698E+01	
600											
400				.435E+02		.256E+02		.149E+02		.205E+01	
200				.382E+02							
0			.181E+02	.532E+02	.782E+01	.343E+02	.955E+01	.420E+01	.167E+01	.896E+00	.620E+00
-200				.115E+01							
-400				0.		.107E+01		.976E+00		.789E+00	
-600											
-800						0.		0.		0.	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .532E+02

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SE WIND SPEED (FPS) = LOAD = FULL STRATIFICATION = J/NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		.112E+01	
600											
400				0.		0.		.254E+00		.219E+01	
200				0.							
0			0.	.212E+00	.592E+00	.567E+00	.182E+01	.228E+01	.446E+01	.526E+01	.450E+01
-200				.197E+00							
-400				.195E+00		.432E+01		.104E+02		.111E+02	
-600											
-800						.590E+01		.112E+02		.104E+02	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .112E+02

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = SE   WIND SPEED (FPS) = 40   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		.350E+00		.826E+01	
600											
400				0.		0.		.315E+01		.146E+02	
200				0.							
0			0.	.185E+01	.382E+01	.630E+01	.932E+01	.115E+02	.190E+02	.181E+02	.195E+02
-200				.508E+01							
-400				.525E+00		.152E+02		.208E+02		.167E+02	
-600											
-800						.385E+01		.118E+02		.124E+02	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .208E+02

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SE WIND SPEED (FPS) = 40 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		.620E+00	
600											
400				0.		0.		0.		.144E+01	
200				0.							
0			.423E-01	0.	0.	0.	.705E-01	.389E+00	.234E+01	.349E+01	.488E+01
-200				0.							
-400				0.		.987E-01		.361E+01		.536E+01	
-600											
-800						0.		.542E+01		.696E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .696E+01

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SE WIND SPEED (FPS) = LOAD = 1/2 STRATIFICATION = J/NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		.945E+00	
600											
400				0.		0.		.279E+00		.354E+01	
200				0.							
0			0.	0.	.139E+00	.245E+00	.892E+00	.255E+01	.524E+01	.672E+01	.558E+01
-200				0.							
-400				0.		.625E+01		.109E+02		.948E+01	
-600											
-800						0.		.111E+02		.998E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .111E+02

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SE WIND SPEED (FPS) = 40 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				.106E+00		0.		.141E-01		.931E+00	
200				.155E+00							
0			0.	0.	.423E-01	.354E-01	.705E-01	.531E-01	.917E+00	.158E+01	.210E+01
-200				0.							
-400				0.		0.		.606E+00		.229E+01	
-600											
-800						0.		0.		.108E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .229E+01

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SE WIND SPEED (FPS) = 40 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		.175E+00	
600											
400				0.		0.		0.		.290E+01	
200				0.							
0			0.	0.	0.	0.	.167E+00	.140E+01	.541E+01	.746E+01	.974E+01
-200				0.							
-400				0.		0.		.778E+01		.898E+01	
-600											
-800						0.		.704E+01		.110E+02	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .110E+02

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = SE WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.147E+02		.743E+01		.179E+02	
600											
400				.145E+03		.206E+02		.251E+02		.180E+02	
200				.147E+03							
0			.127E+03	.923E+02	.880E+02	.528E+02	.353E+02	.288E+02	.251E+02	.190E+02	.173E+02
-200				.140E+02							
-400				.184E+01		.998E+01		.927E+01		.307E+01	
-600											
-800						0.		.530E+00		.354E-01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .147E+03

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS,   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3B   WIND ANGLE = SE   WIND SPEED (FPS) = 60   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.463E+01		.244E+01		.101E+02	
600											
400				.590E+02		.103E+02		.135E+02		.127E+02	
200				.513E+02							
0			.445E+01	.153E+02	.366E+02	.292E+02	.203E+02	.169E+02	.152E+02	.980E+01	.972E+01
-200				.704E+00							
-400				0.		.245E+01		.566E+01		.400E+01	
-600											
-800						0.		.424E+00		.120E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .590E+02

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = SE WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 190

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.140E+02		.552E+01		.185E+02	
600											
400				.104E+03		.201E+02		.238E+02		.217E+02	
200				.138E+03							
0			.102E+03	.103E+03	.907E+02	.622E+02	.463E+02	.335E+02	.362E+02	.246E+02	.222E+02
-200				.236E+02							
-400				.258E+01		.435E+02		.369E+02		.244E+02	
-600											
-800						0.		.828E+01		.757E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .138E+03

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SE WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		.637E+00	
600											
400				0.		0.		.275E+00		.152E+01	
200				0.							
0			0.	0.	.116E+01	.637E+00	.719E+00	.850E+00	.328E+01	.491E+01	.353E+01
-200				.118E+01							
-400				.372E+00		.417E+01		.506E+01		.470E+01	
-600											
-800						0.		.133E+01		.876E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .505E+01

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = SE   WIND SPEED (FPS) = 60   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		.420E+00	
600											
400				0.		0.		.460E+00		.159E+01	
200				.293E+00							
0			0.	.945E+00	.372E+01	.320E+01	.201E+01	.178E+01	.452E+01	.336E+01	.314E+01
-200				.636E+01							
-400				.577E+00		.121E+02		.745E+01		.439E+01	
-600											
-800						0.		.420E+00		.157E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .121E+02

UNIT 4 LOCATION, X = 326.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SE WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				0.		0.		0.		.635E+00	
200				0.							
0			0.	0.	0.	0.	0.	0.	.169E+00	.558E+00	.123E+01
-200				0.							
-400				0.		0.		.952E+00		.719E+00	
-600											
-800						0.		.135E+01		.797E-01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .135E+01

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SE WIND SPEED (FPS) = 60 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				0.		0.		0.		.418E-01	
200				0.							
0			0.	0.	0.	0.	0.	0.	.585E+00	.630E+00	.376E+00
-200				0.							
-400				0.		0.		0.		.134E+01	
-600											
-800						0.		.787E+00		.420E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .134E+01

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = SE   WIND SPEED (FPS) = 60   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

X = / Y	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				0.		0.		0.		0.	
200				0.							
0			0.	0.	0.	0.	0.	0.	0.	0.	.106E+00
-200				0.							
-400				0.		0.		0.		0.	
-600											
-800						0.		0.		.130E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .130E+01

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SE WIND SPEED (FPS) = 60 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		.472E+00	
600											
400				.247E+01		0.		.585E+00		.585E+00	
200				.142E+01							
0			.155E+01	.157E+01	.335E+00	.105E+01	.155E+01	0.	.130E+01	.320E+01	.514E+01
-200				.502E+00							
-400				0.		.460E+00		.322E+01		.527E+01	
-600											
-800						0.		.394E+01		.614E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .614E+01

UNIT 4 LOCATION, X = 325.00 Y = 366.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = SW WIND SPEED (FPS) = 20 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.700E+01		.407E+01		.373E+01	
600											
400				.117E+02		.418E+01		.209E+01		.111E+01	
200				.915E+01							
0			.969E+01	.327E+01	.685E+00	.483E+00	.310E+00	.153E+00	.507E+00	.177E+00	.310E+00
-200				.310E+00							
-400				0.		.282E-01		0.		0.	
-600											
-800						0.		.354E-01		0.	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .117E+02

UNIT 4 LOCATION. X = -133.33 Y = -183.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3R WIND ANGLE = SW WIND SPEED (FPS) = 20 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.419E+01		.283E+01		.251E+01	
600											
400				.286E+01		.195E+01		.129E+01		.648E+00	
200				.201E+01							
0			.826E+00	.424E+00	.563E+00	.295E+00	.253E+00	0.	0.	.153E+00	.939E-02
-200				.160E+00							
-400				0.		0.		0.		0.	
-600											
-800						0.		0.		0.	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .419E+01

UNIT 4 LOCATION, X = -133.33 Y = -183.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS,   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3   WIND ANGLE = SW   WIND SPEED (FPS) = 20   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 190

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.845E+01		.213E+01		.197E+01	
600											
400				.278E+01		.236E+01		.155E+01		.676E+00	
200				.203E+01							
0			.134E+01	.507E+00	.667E+00	.860E+00	.535E+00	0.	.469E-01	.106E+00	.751E-01
-200				.178E+00							
-400				0.		0.		0.		0.	
-600											
-800						0.		0.		0.	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .845E+01

UNIT 4 LOCATION, X = -133.33 Y = -183.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SW WIND SPEED (FPS) = 20 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

X = / Y	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.119E+01		.119E+01		.752E+00	
600											
400				0.		.395E+00		.938E+00		.147E+01	
200				0.							
0			0.	0.	.240E+00	.443E+00	.677E+00	0.	.156E+01	.128E+01	.134E+01
-200				0.							
-400				.124E+00		.233E+00		.367E+00		.606E+00	
-600											
-800						.301E+00		0.		.487E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .156E+01

UNIT 4 LOCATION. X = -133.33 Y = -183.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = SW   WIND SPEED (FPS) = 20   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.175E+00		.107E+01		.140E+01	
600											
400				0.		.474E+00		.233E+01		.277E+01	
200				0.							
0			0.	0.	0.	.910E+00	.170E+01	0.	.421E+01	.499E+01	.601E+01
-200				0.							
-400				0.		.307E+00		.234E+01		.552E+01	
-600											
-800						0.		.910E+00		.361E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .601E+01

UNIT 4 LOCATION, X = -133.33 Y = -183.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = SW   WIND SPEED (FPS) = 20   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		.105E+00		.175E+00	
600											
400				0.		0.		.307E+00		.279E+00	
200				0.							
0			0.	0.	0.	.875E-01	0.	0.	.209E+00	0.	.488E+00
-200				0.							
-400				0.		0.		0.		.209E+00	
-600											
-800						0.		0.		0.	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .488E+00

UNIT 4 LOCATION. X = -133.33 Y = -183.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 . WIND ANGLE = SW WIND SPEED (FPS) = 40 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										.299E+01	
1000											
800						.347E+01		.457E+01		.590E+01	
600											
400				.919E+00		.744E+01		.962E+01		.543E+01	
200				.848E+01							
0			.197E+02	.276E+02	.259E+02	.214E+02	.156E+02	.118E+02	.101E+02	.781E+01	0.
-200				.505E+02							
-400				.458E+02		.246E+02		.145E+02		.990E+01	
-600											
-800						.191E+02		.146E+02		.995E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .505E+02

UNIT 4 LOCATION. X = -150.00 Y = 216.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3R WIND ANGLE = SW WIND SPEED (FPS) = 40 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										.545E+01	
1000											
800						.462E+01		.733E+01		.821E+01	
600											
400				.127E+01		.102E+02		.113E+02		.851E+01	
200				.111E+02							
0			.241E+02	.456E+02	.311E+02	.255E+02	.193E+02	.243E+02	.120E+02	.988E+01	0.
-200				.512E+02							
-400				.436E+02		.233E+02		.136E+02		.785E+01	
-600											
-800						.132E+02		.131E+02		.731E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .512E+02

UNIT 4 LOCATION, X = -150.00 Y = 216.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = SW WIND SPEED (FPS) = 40 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 190

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										.141E+01	
1000											
800						.174E+01		.229E+01		.370E+01	
600											
400				.141E+00		.321E+01		.665E+01		.423E+01	
200				.250E+01							
0			.872E+01	.120E+02	.132E+02	.109E+02	.128E+02	.901E+01	.889E+01	.684E+01	0.
-200				.280E+02							
-400				.399E+02		.250E+02		.139E+02		.900E+01	
-600											
-800						.188E+02		.148E+02		.941E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .399E+02

UNIT 4 LOCATION. X = -150.00 Y = 216.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SW WIND SPEED (FPS) = 40 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.602E+01		.835E+01		.698E+01	
600											
400				.342E+01		.577E+01		.395E+01		.138E+01	
200				.220E+01							
0			0.	.336E+00	.790E+00	.156E+01	.151E+01	0.	.353E+00	.336E+00	.141E+00
-200				0.							
-400				0.		0.		.846E-01		0.	
-600											
-800						.336E+00		0.		0.	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .835E+01

UNIT 4 LOCATION. X = -133.33 Y = -183.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SW WIND SPEED (FPS) = 40 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.128E+02		.156E+02		.104E+02	
600											
400				.106E+02		.323E+01		.157E+02		.586E+01	
200				.187E+02							
0			.753E+01	.205E+02	.266E+02	.192E+02	.149E+02	0.	.415E+01	.280E+01	.349E+01
-200				.143E+02							
-400				.157E+02		.943E+01		.254E+01		.781E+00	
-600											
-800						0.		0.		.315E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .266E+02

UNIT 4 LOCATION, X = -150.00 Y = 216.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.　　CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4　　WIND ANGLE = SW　　WIND SPEED (FPS) = 40　　LOAD = FULL　　STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200									0.		
1000											
800					0.		.938E+00		.814E+00		
600											
400			0.		0.		.169E+00		.296E+00		
200			0.								
0		0.	0.	0.	0.	0.	0.	.282E-01	0.	0.	
-200			0.								
-400			0.		0.		0.		0.		
-600											
-800					0.		0.		0.		
-1000											
-1200									0.		
-1600											

MAXIMUM CONCENTRATION = .938E+00

UNIT 4 LOCATION, X = -133.33 Y = -183.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SW WIND SPEED (FPS) = 40 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										.110E+02	
1000											
800						.707E+01		.119E+02		.872E+01	
600											
400				.112E+01		.867E+01		.544E+01		.237E+01	
200				.139E+01							
0			0.	.700E-01	.223E+00	.143E+01	.181E+01	.115E+01	.976E+00	.350E-01	0.
-200				.641E+00							
-400				0.		0.		0.		0.	
-600											
-800						0.		0.		.350E-01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .119E+02

UNIT 4 LOCATION, X = -133.33 Y = -183.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SW WIND SPEED (FPS) = 40 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		.266E+00	
600											
400				0.		0.		.324E+00		.635E+00	
200				0.							
0			0.	0.	.564E-01	.230E+00	.310E+00	.868E+00	.213E+01	.184E+01	0.
-200				.564E-01							
-400				0.		.423E-01		.202E+01		.339E+01	
-600											
-800						0.		.159E+01		.319E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .339E+01

UNIT 4 LOCATION, X = -133.33 Y = -183.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = SW   WIND SPEED (FPS) = 40   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.210E+00		0.		.420E+00	
600											
400				.105E+00		0.		.474E+00		.187E+01	
200				0.							
0			0.	0.	.558E-01	.735E+00	.148E+01	.280E+01	.346E+01	.325E+01	0.
-200				.530E+00							
-400				.133E+01		.287E+01		.583E+01		.588E+01	
-600											
-800						.448E+01		.739E+01		.753E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .753E+01

UNIT 4 LOCATION, X = -133.33 Y = -183.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3   WIND ANGLE = SW   WIND SPEED (FPS) = 60   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										.354E-01	
1000											
800						.742E+00		.318E+00		.106E+00	
600											
400				0.		0.		0.		0.	
200				0.							
0			.132E+01	.156E+01	.296E+01	.219E+01	.166E+01	.849E+00	.166E+01	.156E+01	0.
-200				.142E+02							
-400				.403E+02		.175E+02		.986E+01		.592E+01	
-600											
-800						.170E+02		.148E+02		.109E+02	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .403E+02

UNIT 4 LOCATION, X = -150.00 Y = 216.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3R   WIND ANGLE = SW   WIND SPEED (FPS) = 60   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.177E+00		0.		0.	
600											
400				0.		0.		0.		.113E+00	
200				.113E+00							
0			.127E+01	.325E+01	.555E+01	.272E+01	.225E+01	.778E+00	.163E+01	.141E+01	0.
-200				.320E+02							
-400				.619E+02		.282E+02		.161E+02		.803E+01	
-600											
-800						.117E+02		.852E+01		.661E+01	
-1000											
-1200										.228E+01	
-1600											

MAXIMUM CONCENTRATION = .619E+02

UNIT 4 LOCATION, X = -150.00 Y = 216.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = SW WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 190

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										.177E+00	
1000											
800						0.		0.		0.	
600											
400				.354E+00		0.		.563E+00		.310E+00	
200				.253E+00							
0			.149E+01	.248E+01	.400E+01	.223E+01	.273E+01	.152E+01	.262E+01	.990E+00	0.
-200				.131E+02							
-400				.346E+02		.156E+02		.989E+01		.513E+01	
-600											
-800						.163E+02		.134E+02		.944E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .346E+02

UNIT 4 LOCATION, X = -150.00 Y = 216.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SW WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.186E+00		0.		.266E-01	
600											
400				0.		.550E+00		.102E+01		.423E+00	
200				.296E+00							
0			.186E+01	.372E+01	.633E+01	.436E+01	.461E+01	.313E+01	.425E+01	.313E+01	0.
-200				.696E+01							
-400				.866E+01		.807E+01		.739E+01		.580E+01	
-600											
-800						.359E+01		.274E+01		.199E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .866E+01

UNIT 4 LOCATION, X = -150.00 Y = 216.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = SW   WIND SPEED (FPS) = 60   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		.262E+00	
600											
400				.682E+00		.585E+00		.151E+01		.134E+01	
200				.460E+00							
0			.163E+01	.283E+01	.657E+01	.451E+01	.682E+01	.310E+01	.514E+01	.378E+01	0.
-200				.105E+02							
-400				.147E+02		.134E+02		.102E+02		.678E+01	
-600											
-800						.751E+01		.756E+01		.620E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .147E+02

UNIT 4 LOCATION, X = -150.00 Y = 216.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SW WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				0.		0.		0.		.635E-01	
200				0.							
0			.275E+00	0.	.233E+00	.292E+00	.118E+01	.558E+00	.656E+00	.717E+00	0.
-200				.190E+00							
-400				.266E+00		.212E+01		.203E+01		.205E+01	
-600											
-800						.274E+01		.295E+01		.231E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .295E+01

UNIT 4 LOCATION, X = -150.00 Y = 216.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SW WIND SPEED (FPS) = 60 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										.947E+00	
1000											
800						0.		.158E+00		.263E+00	
600											
400				0.		.210E+00		.113E+01		.335E+00	
200				0.							
0			.356E+01	.684E+00	.277E+01	.295E+01	.398E+01	.274E+01	0.	.174E+01	0.
-200				.268E+01							
-400				.389E+01		.482E+01		.440E+01		.470E+01	
-600											
-800						.300E+01		.279E+01		.353E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .482E+01

UNIT 4 LOCATION. X = -150.00 Y = 216.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = SW WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				0.		0.		0.		0.	
200				0.							
0			.465E+00	0.	0.	0.	.846E-01	.372E+00	.465E+00	.345E+00	0.
-200				0.							
-400				0.		.338E+00		.144E+01		.152E+01	
-600											
-800						.876E+00		.175E+01		.154E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .175E+01

UNIT 4 LOCATION, X = -150.00 Y = 216.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = SW   WIND SPEED (FPS) = 60   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				.215E+01		0.		0.		0.	
200				.125E+00							
0			0.	0.	.418E-01	0.	.836E-01	.525E-01	.167E+00	0.	0.
-200				0.							
-400				0.		.113E+01		.226E+01		.460E+00	
-600											
-800						.115E+01		.115E+01		.178E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .226E+01

UNIT 4 LOCATION. X = -150.00 Y = 216.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3R WIND ANGLE = NE WIND SPEED (FPS) = 20 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.284E+01		.172E+01		.482E+01	
600											
400				.589E+00		.778E+01		.498E+01		.979E+01	
200				.113E+01							
0			.413E+00	0.	.368E+01	.119E+02	.551E+01	.115E+02	.156E+02	.114E+02	.999E+01
-200				0.							
-400				0.		.196E+01		.125E+02		.117E+02	
-600											
-800						.354E-01		.962E+01		.119E+02	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .156E+02

UNIT 4 LOCATION, X = 166.67 Y = 141.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = NE WIND SPEED (FPS) = 20 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.586E+01		.298E+01		.749E+01	
600											
400				.155E+02		.136E+02		.771E+01		.117E+02	
200				.153E+02							
0			.225E+02	.331E+01	.589E+01	.577E+01	.495E+01	.120E+02	.121E+02	.139E+02	.108E+02
-200				.111E+01							
-400				0.		.120E+01		.947E+01		.937E+01	
-600											
-800						0.		.397E+01		.850E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .225E+02

UNIT 4 LOCATION, X = 166.67 Y = 141.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = NE WIND SPEED (FPS) = 20 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 190

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.152E+02		.611E+01		.983E+01	
600											
400				.239E+02		.258E+02		.998E+01		.149E+02	
200				.437E+02							
0			.344E+02	.416E+02	.484E+02	.328E+02	.949E+01	.181E+02	.199E+02	.167E+02	.981E+01
-200				.259E+02							
-400				.590E+01		.258E+02		.208E+02		.153E+02	
-600											
-800						.144E+01		.130E+02		.160E+02	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .484E+02

UNIT 4 LOCATION. X = 166.67 Y = 141.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NE   WIND SPEED (FPS) = 20   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				.885E-01		0.		0.		.148E+00	
200				.846E-01							
0			.705E-01	.354E-01	0.	.620E-01	0.	.443E+00	.247E+00	.274E+00	.564E+00
-200				0.							
-400				0.		0.		.705E-01		.472E+00	
-600											
-800						0.		0.		.257E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .564E+00

UNIT 4 LOCATION. X = 166.67 Y = 141.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NE   WIND SPEED (FPS) = 20   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 330

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200									0.		
1000											
800					0.		0.		0.		
600											
400			0.		0.		0.		0.		
200			0.								
0		0.	0.	0.	0.	0.	0.	0.	0.		.139E-01
-200			0.								
-400			0.		0.		0.		0.		
-600											
-800					0.		0.		0.		
-1000											
-1200									0.		
-1600											

MAXIMUM CONCENTRATION = .139E-01

UNIT 4 LOCATION. X = 166.67 Y = 141.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = NE WIND SPEED (FPS) = 40 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.300E+02		.141E+02		.908E+01	
600											
400				.144E+03		.257E+02		.149E+02		.727E+01	
200				.125E+03							
0			.283E+03	.535E+02	.417E+02	.202E+02	.247E+02	.136E+02	.126E+02	.748E+01	.528E+01
-200				.923E+01							
-400				.801E+00		.635E+01		.156E+02		.934E+01	
-600											
-800						.471E+00		.148E+02		.804E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .283E+03

UNIT 4 LOCATION, X = 166.67 Y = 141.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = NE WIND SPEED (FPS) = 40 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.611E+02		.301E+02		.209E+02	
600											
400				.240E+02		.409E+02		.332E+02		.150E+02	
200				.532E+01							
0			.297E+01	.106E+01	.699E+01	.498E+01	.377E+02	.284E+02	.135E+02	.105E+02	.731E+01
-200				.131E+00							
-400				0.		.376E+00		.205E+02		.103E+02	
-600											
-800						.259E+00		.147E+02		.870E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .611E+02

UNIT 4 LOCATION, X = 166.67 Y = 141.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3   WIND ANGLE = NE   WIND SPEED (FPS) = 40   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 190

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.304E+02		.169E+02		.108E+02	
600											
400				.152E+03		.256E+02		.154E+02		.708E+01	
200				.152E+03							
0			.352E+03	.934E+02	.412E+02	.178E+02	.246E+02	.135E+02	.122E+02	.672E+01	.594E+01
-200				.247E+02							
-400				.269E+01		.134E+02		.157E+02		.863E+01	
-600											
-800						.344E+01		.146E+02		.731E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .352E+03

UNIT 4 LOCATION, X = 166.67 Y = 141.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NE WIND SPEED (FPS) = 40 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.885E-01		.212E+00		.956E+00	
600											
400				0.		.776E+00		.183E+00		.202E+01	
200				0.							
0			0.	0.	.592E+00	.159E+01	.240E+00	.154E+01	.323E+01	.374E+01	.269E+01
-200				0.							
-400				0.		.719E+00		.432E+01		.385E+01	
-600											
-800						0.		.761E+00		.484E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .484E+01

UNIT 4 LOCATION, X = 166.67 Y = 141.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NE   WIND SPEED (FPS) = 40   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.168E+01		.980E+00		.339E+01	
600											
400				.592E+01		.812E+01		.354E+01		.848E+01	
200				.346E+01							
0			.173E+02	.266E+01	.121E+02	.198E+02	.438E+01	.770E+01	.151E+02	.128E+02	.154E+02
-200				.613E+00							
-400				0.		.594E+01		.117E+02		.151E+02	
-600											
-800						0.		.476E+01		.117E+02	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .198E+02

UNIT 4 LOCATION. X = 166.67 Y = 141.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NE   WIND SPEED (FPS) = 40   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.531E-01		0.		0.	
600											
400				0.		0.		0.		0.	
200				0.							
0			0.	0.	0.	0.	0.	0.	.705E-01	.230E+00	.226E+00
-200				0.							
-400				0.		0.		0.		.282E+00	
-600											
-800						0.		0.		.177E-01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .282E+00

UNIT 4 LOCATION. X = 166.67 Y = 141.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NE WIND SPEED (FPS) = 40 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		.122E+01		.410E+01	
600											
400				0.		.257E+01		.184E+01		.622E+01	
200				.558E-01							
0			0.	0.	.167E+01	.788E+01	.131E+01	.518E+01	.105E+02	.109E+02	.747E+01
-200				0.							
-400				0.		.212E+01		.817E+01		.104E+02	
-600											
-800						0.		.224E+01		.103E+02	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .109E+02

UNIT 4 LOCATION, X = 166.67 Y = 141.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NE WIND SPEED (FPS) = 40 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200									0.		
1000											
800					0.		0.		0.		
600											
400			0.		0.		0.		0.		
200			0.								
0		0.	0.	0.	0.	0.	0.	0.	0.	0.	
-200			0.								
-400			0.		0.		0.		0.		
-600											
-800					0.		0.		0.		
-1000											
-1200									0.		
-1600											

MAXIMUM CONCENTRATION = 0.

UNIT 4 LOCATION, X = 166.67 Y = 141.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NE WIND SPEED (FPS) = 40 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200									0.		
1000											
800					0.		0.		0.		
600											
400			0.		0.		0.		0.		
200			0.								
0		0.	0.	0.	0.	0.	0.	0.	0.	0.	
-200			0.								
-400			0.		0.		0.		.558E-01		
-600											
-800					0.		0.		0.		
-1000											
-1200									0.		
-1600											

MAXIMUM CONCENTRATION = .558E-01

UNIT 4 LOCATION, X = 166.67 Y = 141.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3   WIND ANGLE = NE   WIND SPEED (FPS) = 60   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.743E+02		.211E+02		.237E+02	
600											
400				.898E+02		.483E+02		.336E+02		.286E+02	
200				.414E+02							
0			0.	.672E+00	.304E+01	.124E+01	.340E+02	.308E+02	.194E+02	.154E+02	.121E+02
-200				0.							
-400				0.		0.		.186E+02		.115E+02	
-600											
-800						0.		.177E+02		.980E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .898E+02

UNIT 4 LOCATION, X = 166.67 Y = 141.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = NE WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.323E+02		.158E+02		.116E+02	
600											
400				.112E+03		.203E+02		.179E+02		.115E+02	
200				.810E+02							
0			.161E+03	.389E+02	.262E+02	.107E+02	.195E+02	.150E+02	.981E+01	.884E+01	.761E+01
-200				.806E+01							
-400				.813E+00		.781E+01		.141E+02		.704E+01	
-600											
-800						.322E+01		.994E+01		.697E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .161E+03

UNIT 4 LOCATION, X = 166.67 Y = 141.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = NE WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 140

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.286E+02		.146E+02		.105E+02	
600											
400				.129E+03		.216E+02		.176E+02		.938E+01	
200				.919E+02							
0			.187E+03	.476E+02	.258E+02	.119E+02	.246E+02	.139E+02	.100E+02	.605E+01	.555E+01
-200				.828E+01							
-400				.117E+01		.282E+01		.119E+02		.733E+01	
-600											
-800						.707E+00		.122E+02		.746E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .187E+03

UNIT 4 LOCATION. X = 166.67 Y = 141.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NE   WIND SPEED (FPS) = 60   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.797E+00		0.		.850E+00	
600											
400				0.		.758E+01		.846E-01		.201E+01	
200				.571E+00							
0			0.	0.	.115E+02	.203E+02	.324E+01	.367E+01	.160E+02	.113E+02	.847E+01
-200				.846E-01							
-400				0.		.389E+01		.173E+02		.194E+02	
-600											
-800						.159E+00		.158E+02		.212E+02	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .212E+02

UNIT 4 LOCATION, X = 166.67 Y = 141.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NE WIND SPEED (FPS) = 60 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.903E+01		.472E+00		.315E+01	
600											
400				.122E+02		.426E+02		.259E+01		.510E+01	
200				.162E+02							
0			.125E+00	.903E+01	.734E+02	.444E+02	.123E+02	.144E+02	.243E+02	.183E+02	.128E+02
-200				.920E+00							
-400				0.		.669E+01		.256E+02		.221E+02	
-600											
-800						.262E+00		.232E+02		.188E+02	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .734E+02

UNIT 4 LOCATION. X = 166.67 Y = 141.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NE WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		.797E-01	
600											
400				0.		0.		0.		.190E+00	
200				0.							
0			0.	0.	0.	.112E+01	0.	.266E+00	.231E+01	.388E+01	.152E+01
-200				0.							
-400				0.		0.		.138E+01		.436E+01	
-600											
-800						0.		.114E+01		.420E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .436E+01

UNIT 4 LOCATION. X = 166.67 Y = 141.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NE WIND SPEED (FPS) = 60 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		.126E+01	
600											
400				0.		.251E+01		0.		.234E+01	
200				0.							
0			0.	0.	.159F+01	.130E+02	.130E+01	.241E+01	.122E+02	.987E+01	.837E+01
-200				0.							
-400				0.		.155E+01		.121E+02		.152E+02	
-600											
-800						0.		.908E+01		.171E+02	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .171E+02

UNIT 4 LOCATION. X = 166.67 Y = 141.67

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NE   WIND SPEED (FPS) = 60   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

```
     X =        250       500      1000      2000      3000      4000      5000      6000      7000      8000      9000
       Y ************************************************************************************************************

     1600


     1200                                                                                           0.

     1000

      800                                                   0.                   .797E-01           0.

      600

      400                                .637E+00           0.                  0.                   .846E-01

      200                                .402E+00

        0                      .184E+01 0.         .190E+00  .266E-01 0.        0.        0.        0.         .106E+00

     -200                               0.

     -400                               0.                  0.                  0.                  0.

     -600

     -800                                                   0.                  0.                  0.

    -1000

    -1200                                                                                           0.


    -1600
```

MAXIMUM CONCENTRATION =   .184E+01

UNIT 4 LOCATION. X =   166.67 Y =   141.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NE WIND SPEED (FPS) = 60 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200									0.		
1000											
800					0.		0.		0.		
600											
400			0.		0.		0.		0.		
200			0.								
0		0.	0.	0.	0.	0.	0.	0.	0.	0.	
-200			0.								
-400			0.		0.		0.		0.		
-600											
-800					0.		0.		0.		
-1000											
-1200									0.		
-1600											

MAXIMUM CONCENTRATION = 0.

UNIT 4 LOCATION, X = 166.67 Y = 141.67

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = NW WIND SPEED (FPS) = 20 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

X = / Y	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.499E+01		.142E+02		.928E+01	
600											
400				.994E+01		.203E+02		.157E+02		.241E+01	
200				.156E+02							
0			.189E+01	.159E+02	.215E+02	.485E+01	.245E+01	.837E+00	.118E+01	.198E+01	.177E+01
-200				.159E+01							
-400				.191E+01		.204E+01		.667E+00		.939E+00	
-600											
-800						.236E-01		0.		.660E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .215E+02

UNIT 4 LOCATION, X = 400.00 Y = 258.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = NW WIND SPEED (FPS) = 20 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.684E+00		.290F+01		.377E+01	
600											
400				.103E+01		.520E+01		.747E+01		.113E+02	
200				.887E+01							
0			.122E+02	.316E+02	.203E+02	.192E+02	.190F+02	.114E+02	.121E+02	.133E+02	.109E+02
-200				.365F+02							
-400				.147F+02		.153E+02		.763E+01		.697E+01	
-600											
-800						.147F+01		.111E+01		.163E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .365F+02

UNIT 4 LOCATION, X = 400.00 Y = 258.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = NW WIND SPEED (FPS) = 20 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 190

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.573E+01		.140E+02		.967E+01	
600											
400				.638E+01		.203E+02		.163E+02		.216E+01	
200				.944E+01							
0			.629E+00	.158E+02	.189E+02	.315E+01	.272E+01	.259E+00	.554E+00	.128E+01	.125E+01
-200				.196E+01							
-400				.354E+00		.826E+00		.188E-01		.441E+00	
-600											
-800						0.		0.		.707E-01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .203E+02

UNIT 4 LOCATION, X = 400.00 Y = 258.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NW WIND SPEED (FPS) = 20 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		.443E-01	
600											
400				0.		.494E-01		.106E+00		.684E+00	
200				0.							
0			0.	0.	.494E-01	0.	.212E+00	.797E-01	.381E+00	.593E+00	.107E+01
-200				0.							
-400				.443E-01		0.		.564E-01		.416E+00	
-600											
-800						0.		0.		.885E-01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .107E+01

UNIT 4 LOCATION, X = 400.00 Y = 258.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NW   WIND SPEED (FPS) = 20   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		.595E+00		.612E+00	
600											
400				.175E+00		.530E+00		.159E+01		.121E+01	
200				.279E-01							
0			0.	.121E+01	.139E+00	.787E+00	.767E+00	.945E+00	.120E+01	.164E+01	.227E+01
-200				0.							
-400				0.		0.		.474E+00		.135E+01	
-600											
-800						0.		0.		.367E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .227E+01

UNIT 4 LOCATION, X = 400.00 Y = 258.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NW   WIND SPEED (FPS) = 20   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				0.		0.		.697E-01		.488E+00	
200				.279E-01							
0			0.	0.	0.	0.	.167E+00	.525E-01	.279E+00	.542E+00	.558E+00	177
-200				.139E-01							
-400				0.		0.		.697E-01		.134E+01	
-600											
-800						0.		0.		.682E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .134E+01

UNIT 4 LOCATION. X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3   WIND ANGLE = NW   WIND SPEED (FPS) = 40   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.592E+01		.124E+02		.124E+02	
600											
400				.774E+01		.279E+02		.376E+01		.169E+02	
200				.255E+02							
0			.102E+02	.494E+02	.450E+02	.274E+02	.256E+02	.192E+02	.143E+02	.113E+02	.947E+01
-200				.519E+02							
-400				.342E+02		.219E+02		.123E+02		.571E+01	
-600											
-800						.646E+01		.278E+01		.210E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .519E+02

UNIT 4 LOCATION. X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = NW WIND SPEED (FPS) = 40 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.164E+02		.142E+02		.142E+02	
600											
400				.619E+02		.332E+02		.153E+02		.127E+02	
200				.704E+02							
0			.309E+02	.597E+02	.403E+02	.252E+02	.196E+02	.123E+02	.992E+01	.918E+01	.532E+01
-200				.382E+02							
-400				.156E+02		.137E+02		.663E+01		.355E+01	
-600											
-800						.236E+01		.189E+01		.156E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .704E+02

UNIT 4 LOCATION. X = 400.00 Y = 258.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3   WIND ANGLE = NW   WIND SPEED (FPS) = 40   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 190

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.745E+01		.172E+02		.941E+01	
600											
400				.177E+02		.270E+02		.204E+02		.207E+02	
200				.359E+02							
0			.161E+02	.514E+02	.493E+02	.329E+02	.340E+02	.206E+02	.171E+02	.113E+02	.123E+02
-200				.564E+02							
-400				.257E+02		.239E+02		.962E+01		.703E+01	
-600											
-800						.314E+01		.292E+01		.309E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .564E+02

UNIT 4 LOCATION, X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NW   WIND SPEED (FPS) = 40   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

X = / Y	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.212E+00		.744E+00		.133E+01	
600											
400				0.		.233E+01		.182E+01		.103E+02	
200				.212E+00							
0			0.	.181E+01	.570E+01	.865E+01	.699E+01	.129E+02	.123E+02	.113E+02	.857E+01
-200				.164E+01							
-400				0.		.104E+02		.123E+02		.113E+02	
-600											
-800						.637E+00		.253E+01		.563E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .129E+02

UNIT 4 LOCATION. X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NW   WIND SPEED (FPS) = 40   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.578E+01		.658E+01		.655E+01	
600											
400				.294E+01		.211E+02		.169E+02		.232E+02	
200				.993E+01							
0			.112E+01	.200E+02	.388E+02	.386E+02	.380E+02	.199E+02	.195E+02	.161E+02	.108E+02
-200				.142E+02							
-400				.385E+00		.150E+02		.616E+01		.485E+01	
-600											
-800						.213E+01		.280E+00		.525E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .388E+02

UNIT 4 LOCATION, X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NW   WIND SPEED (FPS) = 40   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				0.		0.		0.		.145E+01	
200				0.							
0			0.	0.	0.	.106E+01	.874E+00	.106E+01	.159E+01	.161E+01	.272E+01
-200				0.							
-400				0.		.169E+00		.106E+01		.168E+01	
-600											
-800						0.		0.		0.	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .272E+01

UNIT 4 LOCATION, X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NW .   WIND SPEED (FPS) = 40   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				0.		.195E+00		.697E+00		.105E+02	
200				0.							
0			0.	.700E-01	.301E+01	.641E+01	.943E+01	.122E+02	.128E+02	.132E+02	.130E+02
-200				.145E+01							
-400				0.		.736E+01		.932E+01		.122E+02	
-600											
-800						.350E+00		.630E+00		.483E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .132E+02

UNIT 4 LOCATION, X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NW   WIND SPEED (FPS) = 40   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

X = / Y	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.221E+01		0.		0.	
600											
400				0.		.705E-01		.846E-01		0.	
200				0.							
0		0.		.885E-01	.987E-01	.354E-01	0.	.531E-01	0.	0.	.987E-01
-200				.240E+00							
-400				0.		.254E+00		0.		0.	
-600											
-800						0.		0.		0.	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .221E+01

UNIT 4 LOCATION. X = 400.00 Y = 258.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NW   WIND SPEED (FPS) = 40   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		.105E+00		0.	
600											
400				0.		0.		.613E+00		.103E+01	
200				0.							
0			0.	0.	0.	.112E+01	.229E+01	.350E-01	.781E+00	.315E+00	.808E+00
-200				0.							
-400				0.		0.		0.		0.	
-600											
-800						0.		0.		0.	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .229E+01

UNIT 4 LOCATION, X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = NW WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

X = Y	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.207E+02		.240E+02		.212E+02	
600											
400				.655E+02		.389E+02		.296E+02		.181E+02	
200				.614E+02							
0			.489E+02	.505E+02	.430E+02	.268E+02	.257E+02	.185E+02	.170E+02	.154E+02	.101E+02
-200				.279E+02							
-400				.456E+01		.142E+02		.930E+01		.710E+01	
-600											
-800						.134E+01		.117E+01		.202E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .655E+02

UNIT 4 LOCATION. X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3R WIND ANGLE = NW WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 151

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.206E+02		.184E+02		.139E+02	
600											
400				.296E+02		.415E+02		.271E+02		.250E+02	
200				.705E+02							
0			.372E+02	.816E+02	.596E+02	.392E+02	.350E+02	.284E+02	.256E+02	.230E+02	.154E+02
-200				.406E+02							
-400				.845E+01		.262E+02		.167E+02		.139E+02	
-600											
-800						.248E+01		.219E+01		.474E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .816E+02

UNIT 4 LOCATION. X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 1-3 WIND ANGLE = NW WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 190

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.257E+02		.261E+02		.190E+02	
600											
400				.614E+02		.416E+02		.284E+02		.213E+02	
200				.651E+02							
0			.462E+02	.599E+02	.494E+02	.324E+02	.280E+02	.232E+02	.197E+02	.160E+02	.110E+02
-200				.340E+02							
-400				.407E+01		.185E+02		.106E+02		.797E+01	
-600											
-800						.194E+01		.919E+00		.187E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .651E+02

UNIT 4 LOCATION. X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NW   WIND SPEED (FPS) = 60   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.598E+01		.340E+01		.348E+01	
600											
400				.717E+00		.117E+02		.980E+01		.162E+02	
200				.197E+01							
0			0.	.460E+01	0.	.238E+02	.253E+02	.150E+02	.148E+02	.173E+02	.148E+02
-200				.152E+02							
-400				0.		.453E+01		.519E+01		.758E+01	
-600											
-800						.531E+00		.505E+00		.197E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .253E+02

UNIT 4 LOCATION. X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NW   WIND SPEED (FPS) = 60   LOAD = 1/2   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.406E+02		.230E+02		.152E+02	
600											
400				.160E+02		.519E+02		.310E+02		.243E+02	
200				.237E+02							
0			.105E+01	.819E+01	.386E+02	.384E+02	.343E+02	.201E+02	.193E+02	.157E+02	.147E+02
-200				.163E+01							
-400				0.		.795E+01		.711E+01		.761E+01	
-600											
-800						.997E+00		.152E+01		.215E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .519E+02

UNIT 4 LOCATION, X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NW WIND SPEED (FPS) = 60 LOAD = FULL STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.292E+00		.266E+00		.451E+00	
600											
400				0.		.571E+00		.142E+01		.567E+01	
200				0.							
0			0.	.133E+00	.273E+01	.542E+01	.737E+01	.717E+01	.743E+01	.592E+01	.798E+01
-200				.233E+00							
-400				0.		.254E+01		.368E+01		.627E+01	
-600											
-800						.239E+00		.266E-01		.181E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .798E+01

UNIT 4 LOCATION, X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NW WIND SPEED (FPS) = 60 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 500

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.620E+01		.124E+02		.483E+01	
600											
400				0.		.119E+02		.182E+02		.248E+02	
200				.163E+01							
0			.138E+01	.157E+01	.117E+02	.279E+02	.372E+02	.170E+02	.162E+02	.206E+02	.145E+02
-200				.585E+00							
-400				.525E-01		.448E+01		.506E+01		.581E+01	
-600											
-800						.367E+00		.157E+00		.241E+01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .372E+02

UNIT 4 LOCATION. X = 400.00 Y = 258.33

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS.   CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4   WIND ANGLE = NW   WIND SPEED (FPS) = 60   LOAD = FULL   STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				0.		0.		0.		.148E+00	
200				0.							
0			0.	0.	0.	0.	.148E+00	.133E+00	.656E+00	.637E+00	.116E+01
-200				0.							
-400				0.		0.		0.		.613E+00	
-600											
-800						0.		0.		.797E-01	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .116E+01

UNIT 4 LOCATION, X = 400.00 Y = 258.33

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NW WIND SPEED (FPS) = 60 LOAD = 1/2 STRATIFICATION = NEUTRAL

STACK HEIGHT (FT) = 700

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				0.		0.		.836E-01		.226E+01	
200				0.							
0			0.	0.	0.	.472E+00	.794E+00	.115E+01	.268E+01	.515E+01	.565E+01
-200				0.							
-400				0.		0.		.711E+00		.427E+01	
-600											
-800						0.		0.		.735E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .565E+01

UNIT 4 LOCATION, X = 400.00 Y = 258.33

Table 11 Concentration Data for Stable
Flow Conditions

LANSING POWER PLANT. SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NE WIND SPEED (FPS) = 20 LOAD = FULL STRATIFICATION = STABLE

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		.328E+00	
600											
400				0.		.705E-01		.494E-01		.126E+01	
200				0.							
0			0.	0.	0.	.885E-01	0.	.620E-01	.136E+01	.120E+01	.221E+01
-200				0.							
-400				0.		.635E-01		.515E+00		.142E+01	
-600											
-800						0.		.345E+00		.850E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .221E+01

UNIT 4 LOCATION. X = 0.00 Y = 0.00

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS. CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NE WIND SPEED (FPS) = 20 LOAD = 1/2 STRATIFICATION = STABLE

STACK HEIGHT (FT) = 300

Y \ X =	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						.140E+01		.472E+00		.472E+00	
600											
400				.110E+01		.144E+01		.110E+01		.934E+00	
200				.107E+01							
0			.990E+00	.163E+01	.158E+01	.124E+01	.613E+00	.630E+00	.822E+00	.752E+00	.864E+00
-200				.130E+01							
-400				.927E+00		.144E+01		.878E+00		.850E+00	
-600											
-800						.787E+00		.315E+00		.717E+00	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .163E+01

UNIT 4 LOCATION, X = 0.00 Y = 0.00

LANSING POWER PLANT, SARGENT AND LUNDY ENGINEERS, CONCENTRATION = RECIPROCAL METERS SQUARED TIMES 10 POWER6

UNIT NUMBER = 4 WIND ANGLE = NE WIND SPEED (FPS) = 20 LOAD = 1/2 STRATIFICATION = STABLE

STACK HEIGHT (FT) = 500

X = / Y	250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000
1600											
1200										0.	
1000											
800						0.		0.		0.	
600											
400				0.		.418E-01		0.		.418E-01	
200				0.							
0			0.	0.	0.	0.	0.	0.	0.	0.	.558E-01
-200				0.							
-400				0.		0.		0.		.139E-01	
-600											
-800						0.		0.		0.	
-1000											
-1200										0.	
-1600											

MAXIMUM CONCENTRATION = .558E-01

UNIT 4 LOCATION, X = 0.00 Y = 0.00