ANALYSIS OF AIR QUALITY EFFECTS
TANGUISSON POWER PLANT

For: Guam Power Authority

By: R.W. Beck and Associates

Date: February 1980

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FOR

GUAM POWER AUTHORITY

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February 25, 1980

Mr. Frank G. Blaz
Acting General Manager
Guam Power Authority
Post Office Box 2977
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Dear Mr. Blaz:

Pursuant to the terms of our employment by the Guam Power Authority, we have enclosed our report entitled Tanguisson Power Plant - Analysis of Air Quality Effects. This report contains descriptions of the existing situation and our analytical approach, discussions of results, comparisons with previous work, conclusions, and recommendations regarding the potential for air quality effects related to operation of the Tanguisson Power Plant.

We gratefully acknowledge the cooperation of the Guam Power Authority staff in this endeavor.

Respectfully submitted,

R.W. BECK AND ASSOCIATES

RW Beck and Associates

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1. INTRODUCTION

The Tanguisson Power Plant, which consists of two oil-fired steam electrical generating units originally rated at 26.5 MW (gross) each, is located on the western shore of Guam approximately two miles north of Tumon Bay (Figure 1-1). The plant was constructed in 1970 on the beach area approximately 20 feet above mean sea level adjacent to a bluff which extends to a mean height of about 300 feet msl. It is the only source of sulphur dioxide in the area. The U.S. Navy owns Unit 1 and Guam Power Authority (GPA) owns Unit 2. GPA operates both units. Each unit has a 131-foot stack and neither unit is equipped with specific emission control equipment.

Tanguisson Power Plant was determined to have the potential for violation of the National Ambient Air Quality Standards (NAAQS) for sulphur dioxide (SO_2) on the basis of a theoretical modeling study for which supportive monitoring data were not available. Three control strategies were proposed for the Tanguisson Power Plant by the Guam Environmental Protection Agency (GEPA) on the basis of modeled violations. GEPA requested GPA to select one of the proposed control strategies for Tanguisson for inclusion in the Guam State Implementation Plan (SIP).

Two recent studies (since 1975) related to analysis of the air quality in the vicinity of the Tanguisson Power Plant have been performed by consultants engaged by the U.S. Environmental Protection Agency, Region IX (EPA). The first was reported by PEDCo - Environmental Specialists, Inc. (PEDCo) in 1975 in "Analysis of SO_2 Emission Control Alternatives for the Cabras Power Plant, Guam Power Authority". The second study was described in "Preliminary Results of SO_2 Dispersion Modeling - Guam SIP Non-attainment Program" by Engineering-Science (ES) in 1979. A final report had not been issued by ES as of 1 February 1980.

The PEDCo work, as the title indicates, is primarily concerned with Cabras Power Plant but contains a great deal of information concerning the other Guam power facilities. In particular, it contains operating data for the Tanguisson Power Plant as well as monitoring data and some discussion of possible SO_2 impacts attributable to Tanguisson. Between 1972 and 1974 one episode of SO_2 concentrations in excess of NAAQS was recorded. The PEDCo report also contains useful summaries of previous modeling efforts by EPA and the Naval Civil Engineering Laboratory (NCEL) at the Cabras and Piti Power Plants. No modeling of the Tanguisson Power Plant was included in the PEDCo study.

The ES work was initiated by EPA to provide technical information for evaluating the SO_2 non-attainment status of Guam and for preparing the non-attainment plan revision for Guam. The report contains brief descriptions of modeling efforts for Cabras, Piti, and the Inductance Barge as well as for Tanguisson Power Plant. Analyses employing several models are presented for Tanguisson along with the analytic assumptions and input data used. Results are, in most cases, related to NAAQS. In addition to the preliminary report, ES transmitted recommendations for control strategies for Tanguisson Power Plant and the Inductance Power Barge to GEPA and EPA in a letter dated 15 August 1979 (T. A. Peters to J. B. Branch). The three possible control strategies listed for Tanguisson were: 1) reduce maximum operation to 20 percent of capacity; 2) use fuel with less than 0.65 percent sulphur content; or 3) increase the stack heights to 250 feet.

GPA has serious reservations concerning the potential for violation of the National Ambient Air Quality Standards due to operation of the Tanguisson Power Plant. They initiated the work described in this report to examine that potential and to evaluate the methods and results of related previous air quality studies. The approach to this assignment was first to assess the physical, meteorological, and operational parameters affecting the air quality around Tanguisson. Available models were then examined and appropriate ones were selected for use in accordance with recommendations set forth in the EPA modeling guidelines. Next, the selected models were used to simulate plant operation under several scenarios of expected worst case conditions. Comparisons were then made between the methods and results of the current and previous Tanguisson studies. Various input parameters and the model assumptions were examined to determine the applicability and reliability of the modeling results. Finally, conclusions were reached and recommendations were made based on the results of the study.

R. W. Beck and Associates, as a result of this study and subsequent engineering analyses, concluded that the available data base is currently insufficient either to determine if a control strategy is necessary or to evaluate potential control strategies. A program of air quality and meteorological monitoring was recommended to acquire the data needed to make informed decisions regarding the potential for air quality effects related to operation of the Tanguisson Power Plant.

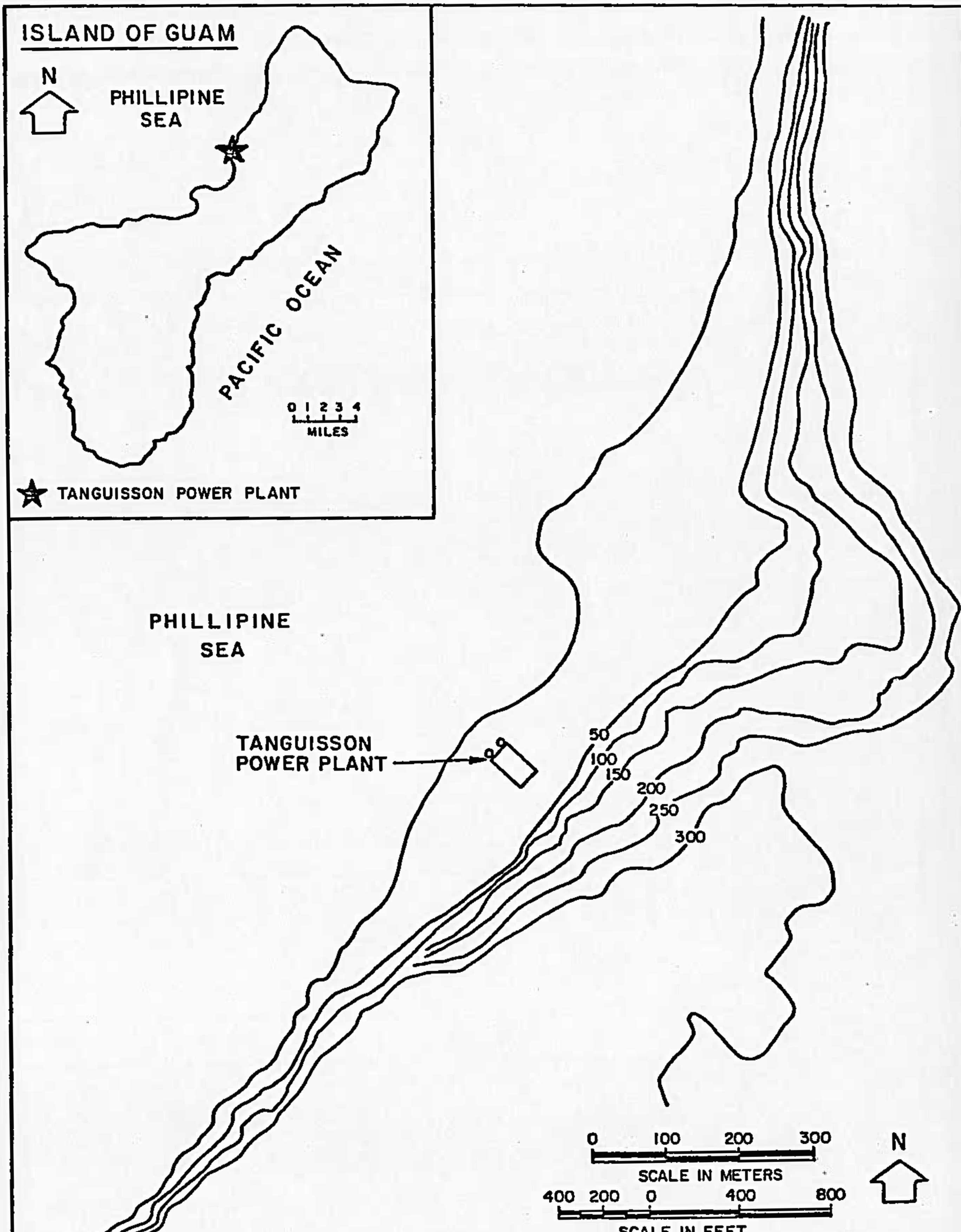


FIGURE 1-1

VICINITY OF TANGUISSON POWER PLANT
50 FOOT CONTOUR LINES

2. DESCRIPTION OF STUDY AREA, PLANT OPERATION, AND METEOROLOGY

2.1 Study Area

Guam lies at approximately 13.5° north and 145° east between the Phillipine Sea to the west and the Pacific Ocean to the east. It is the largest of the Mariana Islands. The northern portion of the island is a plateau of limestone origin which rises directly from the sea or from small beaches to an elevation of 300-600 feet. The Southern part of the island is comprised of several mountain peaks of volcanic origin. The two ends are connected by a relatively low-lying region generally less than 200 feet above sea level.

The climate of Guam is dominated by trade winds. Temperature and humidity are relatively constant. Seasonal changes are related to wind and precipitation variations. There is a four month dry season (January through April) and a four month rainy season (mid-July through mid-november). The trade winds are dominant throughout the year, but are most consistent during the dry season. Wind speeds of 15 to 25 mph are common. Typhoons strike the island with a frequency of 1 in 8 years and pass near enough to cause severe weather about once in three years.

Tanguisson Power Plant is located on one of the narrow beach areas on the northern part of the island on the west coast about two miles north of Tumon Bay. As is typical on the northern end of the island, the land rises steeply to a plateau approximately 300 feet above sea level immediately to the east of the plant (Figure 1-1). The general topography and plant location are indicated in Figure 2-1.

2.2 Plant Operation

The Guam Power Authority operates both oil-fired steam electric generating units at Tanguisson Power Plant. Both units were expected to be of 26.5 MW (gross) capacity, however, the Navy derated Unit 1 to 24 MW due to actual construction data. The units are also no longer operated according to their design criteria.

Some of the relevant design and actual operating parameters at full load for the Tanguisson Units are indicated below. These data, along with the SO_2 emission rate (2062 pounds of SO_2 per hour for both units at full load and 3.14 percent sulphur oil), are often referred to as an emissions inventory.

Parameter	Design	Actual*
Flue gas temperature (°F)	310	350
Flue gas flow (cfs)	1662	2100
Flue gas exit velocity (fps)	99.4	127.3

*Approximated from analysis of actual operating data for November and December 1979.

The amount of excess air and, therefore, exit gas temperature and volume flow are actually higher than the design values for the units. This operating modification was initiated to reduce corrosion in the air preheater by maintaining mean temperatures above the dew point, thereby avoiding condensation and subsequent sulphuric acid formation on the preheater baskets. As an incidental result of the changes, the effluent plume rises faster and to a greater ultimate height than for the design operating conditions.

2.3 Meteorology

Sound meteorological data are essential to the proper predictive modeling of air quality impacts due to plant operation because wind speed, direction, and atmospheric stability significantly affect the distribution of the effluent plume. The data set used in this study was taken from the National Weather Service (NWS) station and U.S. Naval Air Station (NAS) on Guam. The NWS station is approximately 3.2 km east-northeast of Tanguisson Power Plant (13^{o} 33' N, 144^{o} 50' E) on the plateau area typical of the northern area of the island. Upper air sounding data are collected at that location twice each day. A five-year period of hourly surface data from 1967 through 1971 from NAS was obtained from the National Climatic Center in Ashville, North Carolina. Data from NAS (13^{o} 29' N, 144^{o} 48' E), 5.5 km south of Tanguisson, were identified as the best available data to represent conditions at Tanguisson.

The meteorology on Guam is strongly influenced by the prevailing easterly trade winds. The overall average wind speed is 3.9 m/sec (8.8 mph) while the average wind speed for winds from the east is 4.4 m/sec (9.9 mph). The following table presents the frequency distribution for surface wind direction (the direction <u>from which</u> the wind blows) for the time period 1968 to 1972.

Wind Direction (from)	Frequency of Occurrence (%)
N	1.9
NNE	3.1
NE	8.6
ENE	21.2
E	35.9
ESE	10.7
SE	5.2
SSE	3.8
S	3.2
SSW	1.1
SW	0.7
WSW	0.9
W	1.3
WNW	0.7
NW	0.7
NNW	1.0

Relative to the Tanguisson Plant, the wind blows out to sea about 90 percent of the time. During the remaining 10 percent, the wind blows in a direction which could cause emission from the plant to impact on land.

The NWS and NAS weather data were processed by the EPA computer model CRS, a subroutine of the EPA diffusion model CRSTER. That analysis provided hourly diffusion meteorology including mixing heights and stability estimates from atmospheric soundings and surface meteorology. In addition, a search was made of the CRS output to find and print out hourly periods when the wind blew toward nearby elevated terrain (from 70 to 200 azumith degrees) and the atmosphere was stable (stability classes 5 and 6). Such worst case conditions, on-shore winds and stable atmosphere, were expected to have a high potential for causing impacts on ground-level air quality due to Tanguisson Power Plant operation.

A summary of the hours of stable air flow toward land follows. Only wind speeds in excess of 1 meter per second were considered in order to exclude calms. During calm periods, wind direction is not meaningfully recorded because the threshold velocity of the sensing equipment is not exceeded.

Year	Number of hours	Percentage of year
1967	71	0.8
1968	112	1.3
1969	23	0.3
1970	79	0.9
1971	148	1.7
Mean	87	1.0

The CRS analysis of the NWS and NAS data indicated substantial variation in wind direction associated with the previously described on-shore winds. That variability is demonstrated in the following sector analysis of shoreward stable winds.

Year	ENE	E	ESE	SE	SSE	S	SSW
1967	11	16	6	7	11	13	7
1968	24	15	8	14	20	16	15
1969	1	6	3	3	1	5	4
1970	13	15	4	2	7	21	17
1971	4	20	10	11	17	40	50
Mean	10.6	14.4	6.2	7.4	11.2	19.0	18.6

Shoreward winds were also variable in velocity, ranging from 0 to 4.6 meters per second under stable conditions. Approximately 36 percent of the time stable conditions of class 6 were computed by CRS during on-shore winds in the 1967-1971 period. The remainder were of class 5.

The recorded (NAS and NWS) meteorological data and calaculated (by CRS) diffusion meteorology were reviewed by a Certified Consulting Meteorologist to evaluate the unpredictable interactions expected between the unusual terrain and trade wind climate. The review received from Mr. Loren W. Crow (Appendix A) indicated that it was unlikely that the data from the inland stations were completely representative of the Tanguisson site. Although the data were probably the best available, there were several predictable inaccuracies to be expected.

Localized differences in wind direction and atmospheric stability between the Tanguisson site and the inland monitoring stations can be expected on a regular basis. At the coastal site a consistent easterly flow of air could be expected at night when the majority of variable westerly, stable flows were recorded inland. Sea breezes and terrain conditions can be predicted to cause local direction changes even during dominating trade winds. Significantly persistent west to east winds on Guam are often associated with nearby typhoon centers and would, therefore, normally be associated with neutral stability.

Mr. Crow's analysis indicates that the CRS subroutine may overestimate the atmospheric stability on Guam. Data indicate that class 6 stability is unlikely on the island, yet CRS estimated about 36 percent of the hours of shoreward winds were class 6. Errors in the CRS analysis were found during night time hours during rain storms when stable atmosphere was designated. Such conditions should actually have been calculated as neutral. These errors are probably due to the analytic assumptions of CRS regarding the relationship between stability and wind speed, cloud cover, and time of day. Such assumptions may be inappropriate for an island setting with persistent trade winds.

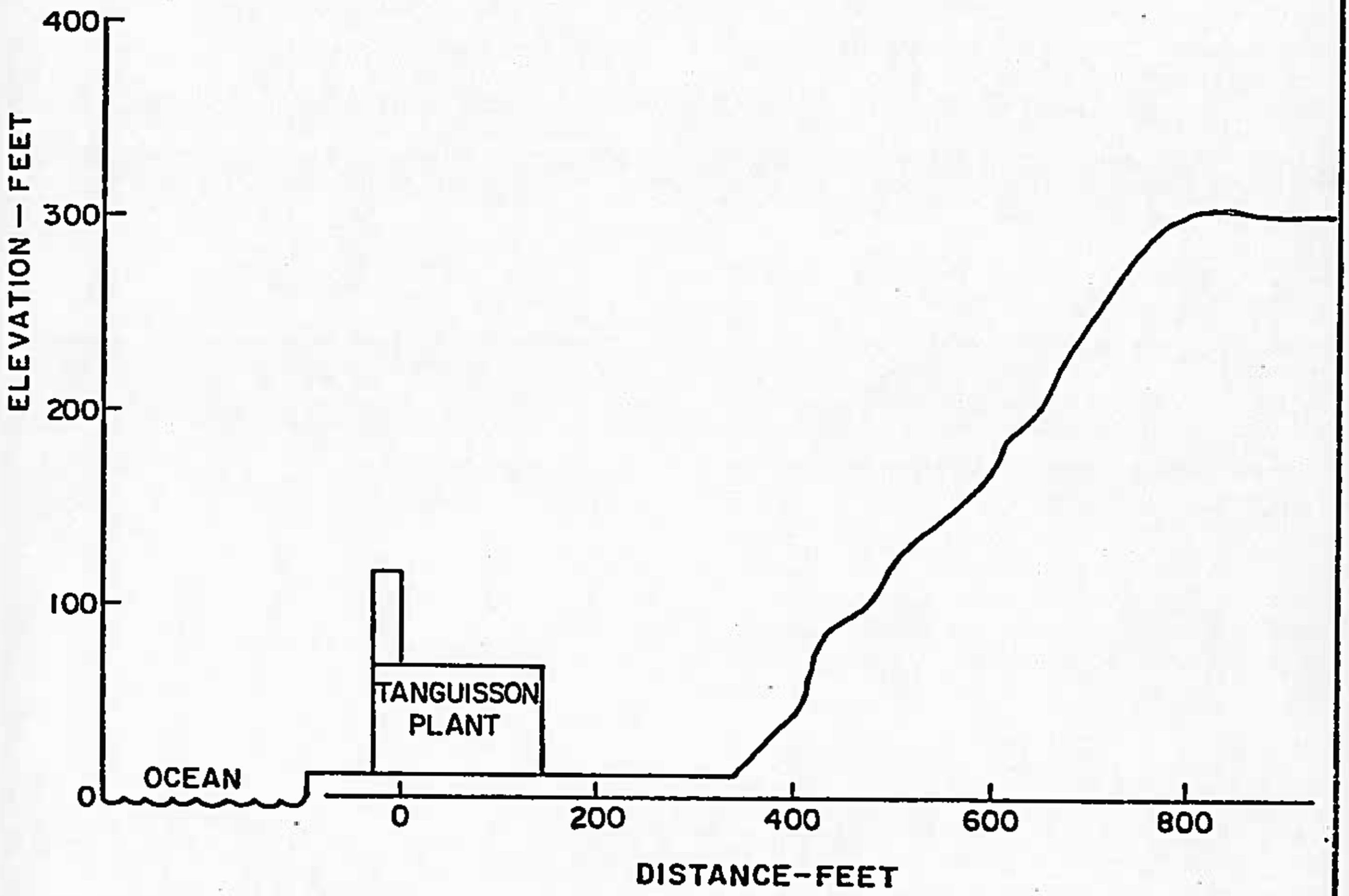


FIGURE 2-1
TANGUISSON PLANT AND TERRAIN PROFILE TO SOUTHEAST

3. MODELING METHODS

3.1 Model Selection

Air quality models are computer programs which are used to predict ground level pollutant concentrations resulting from individual source emissions. At best, computer models represent only approximations of pollutant dispersion phenomena under limited meteorological, topographical, and source-specific conditions. Nevertheless, models have become standardized techniques for regulatory agencies in determining whether NAAQS might be violated. For existing sources they are used when air quality monitoring data are not available. Models are used extensively in new source review to determine probable compliance with applicable regulations.

There are a variety of models available for specific situations, a number of which have been approved by the EPA. Factors which determine which model to use in a given circumstance include the source emissions inventory, the available meteorological data, the topographic complexities, and air quality standards to be satisfied (short-term/long-term).

The meteorological and topographic features at the Tanguisson Power Plant site are complex and are not well represented by any available, EPA-approved model. The meteorology is trade wind dominated and is also influenced by the presence of the ocean. The topography is dominated by the high ridge just inland from the power plant which is more than twice the height of the stacks. Both of these factors will strongly influence plume behavior and the dispersion of SO_2. They are also important factors in determining the applicability of specific computer models.

3.2 CRSTER Model

A standard computer model for a single point source with a detailed meteorological data base (hourly observations) is the CRSTER Model (Guldberg et. al. 1977). Although it is not strictly applicable to complex meteorological and terrain situations, CRSTER is useful for predicting impacts under unstable or neutral atmospheric conditions in such terrain. The model is Gaussian-based and thus also provides a quantitative standard for comparison with other Gaussian-based modeling results such as those from PTMTP presented by ES. PTMTP is a short-term Gaussian model which is usually used in areas of flat or gently rolling terrain. The results of CRSTER and PTMTP are directly comparable under neutral or unstable conditions. The CRSTER results can also be compared with terrain-specific modeling results to isolate the effects of topographic features.

The CRSTER Model is designed to calculate the contributions from multiple elevated stack emissions at a single plant location to ambient air quality levels, defined in the same time scales as the NAAQS. The program calculates concentrations for an entire year and prints out the highest and second-highest 1-hour, 3-hour and 24-hour, as well as annual mean concentrations at a set of 180 receptors surrounding the plant. The

CRSTER is based on a modified form of the Gaussian plume equation which uses empirical dispersion coefficients and includes adjustments for plume rise, limited mixing height and gentle elevated terrain. Pollutant concentrations are computed from measured hourly values of wind speed and direction, and estimated hourly values of atmospheric stability and mixing height. The CRSTER Model was used for short-term and long-term concentration predictions using five years of hourly meteorological observations.

3.3 Valley Model

The Valley Model is an EPA-approved screening model designated for use in certain complex terrain situations. It was used in this study to determine whether or not the potential for violating the NAAQS exists during worst case meteorological conditions at the Tanguisson Power Plant.

When the winds blow from the ocean towards the ridge, the air flow, and thus the plume trajectory, can be complicated. During neutral and unstable conditions there is a strong likelihood that the air and the plume are carried up and over the ridge, without any significant plume interaction with the land. This condition is simulated by CRSTER. However, during stable conditions the wind flow is more uncertain. Because of the stable temperature gradient, the air below the cliff will only rise over the ridge if there is sufficient kinetic energy (high wind speed) to overcome the potential energy (temperature) gradient. If the wind speeds are low under stable conditions, there is a possibility of the wind turning parallel to the ridge below the cliff. The vertical buoyancy and momentum dominated flow from the stack itself will also affect the pollutant dispersion. All of these factors will influence the plume trajectory and the resulting ground-level impacts.

There are several state-of-the art models (e.g., CRAMER Model, IMPACT Model) which could realistically represent the air flow for the complex terrain situations at Tanguisson. However, U.S. EPA modeling guidelines (EPA 1977b) require that such models be verified with air quality data for site specific application. Since continuous data are not available at the Tanguisson site, these models are inapplicable under the EPA guidelines. In a case such as this, the guidelines require application of the Valley Model (EPA 1977a). However, the Valley Model is not intended to be a predictive model for quantifying impacts. Rather it is to be used as a conservative screening technique (EPA 1976). Using this approach, if the results of the Valley Model show no potential for exceeding NAAQS, then no further modeling is necessary since it is considered a conservative model. However, if potential violations are indicated, then monitoring or site-verified modeling is required by the guidelines since Valley is not a predictive model.

The Valley Model is a Gaussian model which simulates short- and long-term pollutant concentrations for receptors on flat or elevated three-dimensional terrain. The model assumes that for neutral and unstable conditions, a plume approaching a hill will rise over it, and not come any closer to the receptor than it would if it were flowing over level terrain. This is consistent with the CRSTER formulation for neutral and unstable conditions. For stable conditions, the Valley Model assumes that the plume flows toward the elevated terrain until the center line comes within 10 m of the receptors. The model calculates ground level concentrations based on the assumption that the plume center line is always 10 m from the ground after initial impact using a polar coordinate grid. It cannot use detailed, hourly wind data. Rather, meteorological assumptions must be made from the data and input into the model for each hour. For annual calculations, the model accepts star-type meteorological data. The model was used to simulate 24- and 1- hour impacts by direct input of meteorology for this study. Episodes of terrain interaction at the Tanguisson site are expected to be short-term because of the prevailing trade winds.

3.4 Downwash Model

Another concern raised in previous studies was the potential for downwash of the plume caused by air flowing down from the ridge causing the plume to impact on the beach or the ocean. There are no satisfactory models for this situation. Most available downwash models are intended for application to stacks with adjacent buildings which can create a recirculation cavity and force stack emissions to the ground very quickly. Tanguisson does not present such a situation. Huber et. al. (1967) indicated that the size and shape of the turbulent cavity downwind of a ridge were substantially affected by upwind terrain and angle of downslope. The crest of the ridge is about 800 feet horizontally from the stacks and not immediately adjacent. Furthermore, the ridge is relatively flat for some distance on top and does not slope downward on the other side as most models would assume. While some information is available regarding the flow of air over ridge-like structures (Huber et. al. 1967), no EPA approved model has been released.

3.5 Analytical Approach

The approach used in this study was to examine the physical conditions of the situation, apply the selected modeling techniques, and analyze the results in a manner consistent with the objectives of the study. Those objectives were to determine, if possible, the potential for violation of NAAQS at Tanguisson Power Plant and to examine the results of previous studies.

The physical conditions described in Section 2 were examined to determine potential worst case combinations of weather, terrain, and operating parameters. Various combinations were then selected for testing with appropriate models. The terrain configuration nearest the plant, as described in Section 2.1, was selected as most severe. Several levels of plant operation were examined to test the effect of such variations on potential impacts. 1969 meteorology was selected, on the basis of persistent wind direction, as the worst case meteorology for CRSTER runs. On-shore winds with stable atmospheric conditions were examined in Valley Model runs.

The results of such tests were qualified with regard to the likelihood of occurrence of the modeled circumstance, the applicability of the model used, and the designated function of the model. Evaluations were made with respect to appropriate air quality standards, and comparisons were drawn with previous work. Where possible, such comparisons included an analysis of possible reasons for differences in results.

4. RESULTS AND DISCUSSION

4.1 Introduction

It is cautioned that the predictions of the CRSTER and Valley Models discussed in this section are intended only for qualitative evaluation and are not necessarily representative of actual air quality conditions. As indicated in Section 3.1, the meteorological and topographic features of the Tanguisson site are complex and are not well-represented by any available EPA-approved air dispersion models. The proximities of the ocean to the west and the high ridge to the east will significantly influence plume behaviour.

4.2 Analysis of Model Applicability

The applicability of a theoretical model to specific conditions is based on how closely the real situation meets the restrictions of the theoretical model. Since models are by definition simplifications of the actual case, they must, inherently, include some assumptions and limits for application. The reliability of the simulation decreases as the restrictions for application of the model are exceeded. The assumptions and limits of air quality models are generally related to characteristics of the source, meteorological conditions, and the topography of the study area.

Two models were determined to have at least limited applicability to the analysis of SO_2 impacts from Tanguisson Power Plant. CRSTER is an EPA-approved, Gaussian model which provides fairly reliable results over both short- and long-term simulations, utilizes a detailed meteorology base, and appears appropriate for limited use at Tanguisson except under stable atmospheric conditions. When stable conditions occur, terrain effects become important. For such cases the Valley Model was applied as a conservative screening device even though some of its assumptions and limitations were exceeded. The Valley Model results are expected to be affected for several reasons.

The Valley Model was originally intended by EPA for use as a screening technique. Although it is sometimes used as an analytical simulation, it was proposed as a conservative tool to determine whether monitoring or site-specific modeling was necessary in terrain-affected situations. The limits of error, as observed by EPA for Valley and applied to a typical simulation at Tanguisson (Figure 4-1), are large.

The use of the Valley Model for the Tanguisson Power Plant is further complicated because some of the model assumptions and limitations do not fit the Tanguisson situation. Quantitative predictions of the model, therefore, may be overly conservative for a number of reasons. The model was developed to predict ground level pollutant concentrations on three-dimensional elevated terrains such as individual hills. The model is not considered applicable to two-dimensional terrain conditions such as the long ridge at Tanguisson. The model assumes that the plume essentially impacts directly on the terrain if the plume rise is not above the terrain. While this type of flow could occur for a three-dimensional hill, it is considered unlikely for a two-dimensional ridge.

The Valley Model also assumes a sloping plume. It allows the plume to impinge on nearby terrain before it reaches its ultimate height. This is a questionable assumption, especially in a two-dimensional terrain situation. The Valley Model uses the Briggs plume rise formula. This is a standard plume model and is generally applicable in flat and uniform terrain with an expected accuracy for determining plume height of $\pm$ 10 percent; that error may increase to $\pm$ 40 percent if there is either a large water body nearby or if there is an abrupt change in the adjacent topography (Briggs 1969). Since both conditions are present at Tanguisson, the plume rise calculation, an essential component of the Valley Model, must be regarded as questionable.

The easterly trade winds carry the Tanguisson plume out to sea approximately 90 percent of the time. Air flowing westward over the nearby ridge could, under certain circumstances, create a turbulent downwash during which the plume could be carried down to ground (sea) level intermittently. While several downwash models are available, none is considered applicable to the Tanguisson site (Section 3.4). It is felt that no meaningful assessment of the downwash potential can be made with currently available simulations.

4.3 Applicable Standards

The primary reason for conducting this study was the requirement by EPA that GPA adopt one of three control strategies for SO_2 as recommended by ES. The need for the control strategies was based on Subsection 172(a)(1) of the Clean Air Act which requires that each State Implementation Plan (SIP) demonstrate attainment of each NAAQS primary standard by December 31, 1982. The focus of this study is on the National Standards, including the 3-hour secondary standard, rather than the potentially more stringent standards which are part of the Guam SIP. The secondary NAAQS (3-hour) was also evaluated although it is not required by Section 172(a)(1).

Following are the NAAQS for SO_2.

Time Period	NAAQS ($\mu g/m^3$)	
Annual	80	(primary)
24-hour	365 (1)	(primary)
3-hour	1300 (1)	(secondary)

(1) Not to be exceeded more than once per year.

The Guam air quality standards are as follows:

Time Period	Guam AQS ($\mu g/m^3$)
Annual	60
24-hour	365 (1)
4-hour	650 (1)
1-hour	1300 (1)

(1) Not to be exceeded more than once per year.

The Tanguisson Plant must ultimately demonstrate compliance with the Guam standards. However, it is felt that this can be done better with monitoring data than on the basis of potentially inaccurate modeling results.

4.4 CRSTER Model Results

The CRSTER Model was applied to Tanguisson Units 1 and 2 at full load in the flat terrain mode using five years of hourly meteorological data. Results of the analysis for 1969, the worst year, are shown as isopleths of ground-level SO_2 concentration in Figures 4-2 through 4-6. The worst annual, 24-hour, and 3-hour impacts are indicated as well as second maximum 24- and 3-hour impacts since single excursions are permitted for those standards (Section 4.3). The dominating influence of the easterly trade winds are apparent in the annual and 24-hour average figures with the highest concentrations occurring over the ocean to the west.

The highest SO_2 impacts predicted by CRSTER are shown in the table below along with NAAQS and the ES results.

Time Period	CRSTER Impacts $\mu g/m^3$	ES PTMTP $\mu g/m^3$	NAAQS $\mu g/m^3$
Annual	36	-	80
24-hour	209 (1)	110	365
3-hour	578 (1)	400	1300

(1) Second highest maximum.

The CRSTER short-term predictions are slightly higher than the ES-PTMTP results, primarily because of differences in meteorology. None of the results indicate a potential violation of NAAQS.

4.5 Valley Model Results

The EPA Valley Model was applied to the Tanguisson Plant for stable, on-shore wind conditions to determine the potential for impacts on the ridge adjacent to the site. Meteorological data were selected using the preprocessing CRS algorithm of the CRSTER model. Five years of data were screened for conditions of stable meteorology (stability classes 5 and 6) to determine the frequency of occurrence of adverse conditions (Section 2.3). Runs were made to determine 3-hour and 24-hour concentrations using actual operating conditions at full load and most severe meteorology from the worst case year, 1971. The results of the runs are presented below with the ES results for purposes of comparison only.

Time Period	ES Results	RWB Results	NAAQS
24-hour	1,800	734	365
3-hour	12,600*	3151	1300

* Modeled on PTMTP, all others from the Valley Model.

If the Valley Model results had indicated concentrations less than air quality standards, then no further work would be required under EPA guidelines. Since the simulated SO_2 concentrations exceed the standards, the conclusion is only that the potential for violation exists. The guidelines suggest that the appropriate course of action is to monitor air quality and/or apply a site specific model to determine if, in fact, violations are likely to occur (EPA 1977a). Since application of such models requires unavailable site-specific data, the logical conclusion is to monitor at the site.

It is important to note that the Valley Model analysis is based on the worst year's meteorology for stable conditions from a 5-year record. Many fewer and less severe potential violations of the secondary (3-hour) standard were indicated during the other four years; in fact, none was expected during 1969. Valley Model screening for the primary standard (24-hour) showed no violations in 1967, 1969, and 1970 and only one violation in 1968. More violations were modeled in 1971, the worst case year for stable conditions, than in all of the other four years combined, indicating that 1971 was an unusual year.

The difference in magnitude of the 3-hour impacts between the ES and RWB studies is due to the modeling techniques employed. ES used a flatland PTMTP simulation and raised the receptors to the heights corresponding to the nearby terrain. Such a technique is extremely conservative because it effectively allows the air and plume to flow through the terrain. RWB used the Valley Model which, although not completely appropriate for the situation, provides conservative estimates of the potential for violations.

The Valley Model results of the RWB study and of the ES study for 24-hour concentrations are of different magnitude. ES estimated 1800 $\mu g/m^3$ without determining the occurrence interval of such concentrations since their estimate was based on the hypothetical default meteorological conditions of the Valley Model. RWB estimated a potential worst case violation of 734 $\mu g/m^3$ based on five years of real meteorology. Several other differences in input data also contributed to the differences between the two modeled values.

4.6 Valley Model Differences

Several possible sources of discrepancy were noted between ES and RWB Valley Model application. Major differences are outlined in the following text.

4.6.1 Meteorology

Meteorological inputs are recognized as the greatest potential source of error in modeling dispersion phenomenon under stable conditions in complex terrain (EPA 1977a). Appropriate site-specific data are, therefore, assumed essential in producing a representative simulation. It is unlikely that the best source of data, the nearby National Weather Service station, provides an accurate representation of the conditions of Taguisson Power Plant. Such data is considered necessary for complete analysis by the Valley Model. In a case like Tanguisson where the conditions are also highly variable and short-term (Section 2.3), accurate wind speed, direction, and stability data becomes even more essential.

These variables have a substantial effect on simulation of SO_2 concentrations. The effect of wind direction is obvious in determining whether the plume would be carried toward elevated terrain or not. The relative influence of wind speed on the magnitude and location of possible SO_2 impacts from Tanguisson are indicated in Figure 4-7. Minor changes in wind velocity could cause extreme variations in near-field (0.5-1.5 km) areas on the bluff east of Tanguisson Power Plant. Variations in stability have the greatest potential effect (Figure 4-8) in both the near- and far-field.

In the ES study, default conditions of the Valley Model were used. Those conditions include consistent wind direction, velocity, and extreme stability conditions. Such meteorology was never recorded during the 1968-1971 period as demonstrated in the comparison of the Valley Model default data and actual worst case data (1968-1971) below. Note that any potential impact associated with the actual data would be allowed under NAAQS as an excursion with the next most adverse condition during that year being registered as a potential violation.

	Valley Default		Actual Meteorology	
Hour	Stability (1-6)	Wind Speed (m/s)	Stability (1-6)	Wind Speed (m/s)
1	6	2.5	5	3.1
2	6	2.5	6	3.1
3	6	2.5	6	3.1
4	6	2.5	5	2.1
5	6	2.5	5	2.1
6	6	2.5	-	-

4.6.2 Emission Inventory

The emission inventory is another source of error. The Valley Model User's Guide warns against using emissions and source data without thoroughly testing the reliability and representativeness of that data. Differences between the design operating conditions used by ES in the Valley Model and actual operating conditions were found to be potentially extreme in the near field (Figure 4-9). Actual operating conditions provide a basis for much greater plume rise (Section 2.2) and less potential interaction with the ridge. This is demonstrated to result in lower potential ground level concentrations.

Valley is intended for use with average emission rates, yet variations in emission rates may be correlated with potential adverse impacts. The effect of operating level on potential impacts was examined by modeling maximum and minimum operation for both units with adverse wind direction and stable conditions (Figure 4-10). The maximum likelihood for impact occurred in the near field at minimum plant load (10 MW). Maximum load produced greater effects downwind. The lower load indicated greater potential for impact in Valley simulations because of reduced plume rise. However, as previously discussed, the Valley plume rise equations are subject to question.

4.6.3 Terrain

The physical dimensions of the bluff adjacent to the plant at the nearest point are critical to the Valley Model analysis. The parameters used by ES and RWB differ by wide margins. ES used a bluff crest height of 350 feet at a distance of 600 feet from the stacks. RWB measurements indicate an actual bluff height of 300 feet at a distance of 800 feet. Both of the ES measurements would tend to increase impact estimates.

4.7 Downwash Modeling

There are three possible cases of downwash at Tanguisson. These include stack, building, and terrain downwash. Stack downwash generally results from low plume exit velocities. This phenomenon can occur when wind speeds are greater than 1.5 times the stack exit velocity. The plume is then pushed into a wake on the downwind side of the stack. Since the exit velocity of the Tanguisson Units is 38 meters per second, the potential for significant stack-plume downwash is very low.

Building downwash occurs when a source is located in the lee of a building. The potential for a plume to be brought to the ground quickly can be high if the plume release height is less than 2.5 building heights. However, the plume can escape the cavity provided it has adequate exit velocity and thermal buoyancy. Briggs (1969) has proposed the following equation to calculate the initial plume rise due to plume momentum (exit velocity):

$$h = 2D\ (V_s/U - 1.5)$$

Where h is the initial plume rise, D is the stack diameter, V_s is the plume exit velocity, and U is the wind speed.

For the Tanguisson Power Plant, the stack height is approximately twice the building height. However, Equation (1) results in sufficient initial plume rise for the exhaust gases to escape the building downwash cavity. According to Equation (1), the wind speed must be greater than 7.6 m/s (7 mph) for the plume rise to be significantly affected by the building cavity. Although there may be some plume rise reduction at wind speeds greater than 7.6 m/s, Briggs' indication that plume heat buoyancy should also be considered in the positioning of the final effective plume height makes this event even less likely. Considering all variables, it is unlikely that building aerodynamic downwash will occur at Tanguisson Power Plant.

The most potentially serious downwash condition at the Tanguisson Power Plant results when winds approach from the east and move downward off the elevated terrain and flow toward the ocean to the west. This condition will occur often since the predominant trade winds flow in that direction. The Tanguisson plume release height of 151 feet msl is less than the terrain height of approximately 300 feet and, therefore, this terrain downwash condition will be far more likely than the two downwash conditions previously discussed.

A survey was conducted of the literature related to terrain downwash simulation. No applicable analytical model for describing potential Tanguisson impacts under the prevailing conditions was found. EPA wind tunnel tests for placement of sources in the lee of mountain ridges (Huber et al 1967) seem, however, to be useful to describe the Tanguisson situation.

Most downwash models simulate downwind cavities caused by air flowing up, over, and around a three-dimensional object (power plant building, etc.). Field and fluid flow experiments have shown that dispersion is enhanced in the downwind cavity due to mechanical turbulence created by the object.

In their recent review of Tanguisson air impacts under such terrain downwash conditions, Engineering-Science employed a model similar to that described above which treats the elevated terrain to the east of the plant as a three-dimensional obstacle over which the air must flow. This analytical method has been developed by A. H. Huber and W. H. Snyder at Research Triangle Park (RTP), North Carolina. Application of this model by ES resulted in a modeled 3-hour impact (1 point) of 1600 $\mu g/m^3$ during neutral (Class 4) conditions and wind speeds from 5 to 15 meters per second. No estimates of 24-hour impacts were made.

Application of such a model for Tanguisson Power Plant is inappropriate. The air flow is not obstructed by the elevated terrain at Tanguisson but rather flows horizontally until it approaches the edge of the elevated terrain. The downwind downwash cavity so formed is expected to be greatly different from that modeled as a rectangular obstacle (Huber et. al. 1976). Figure 4-11 indicates the offshore air flow over the Tanguisson Power Plant and the type of associated potential downwash cavities resulting from the two previously mentioned analyses. With the obstacle technique, the plume has less chance to escape the cavity due to momentum and buoyancy than with the ridge concept. The difference in potential to exit the cavity is proportional to the variation in distance from the top of the stack to the cavity surface (Ze in Figure 4-11).

Very conservative modeling by Engineering-Science indicated that impacts in the ocean were only slightly above standards and were of much lower magnitude than potential impacts during stable air flow toward the elevated terrain to the east. ES predicted concentrations at the water surface of 1600 $\mu g/m^3$ compared to the 3-hour secondary standard of 1300 $\mu g/m^3$. Since a more realistic cavity would be closer to the stack height and the plume would, therefore, be more likely to escape that cavity; downwash concentrations were expected to be less than those predicted by application of the building model.

4.8 Control Strategies

A control strategy should be necessary for the Tanguisson Power Plant only if violation of the NAAQS is demonstrated through monitoring or predictive modeling. As previously discussed, Valley Model results are applicable only if accurate input data are available and if the existing conditions are within the defined limitations of the model. Neither of these criteria is met. The available meteorological data, while sufficiently detailed, is probably not representative of that at the plant site. Meteorological data is recognized as the most important of the required input data sets for modeling purposes. In addition, several aspects related to the physical location of the Tanguisson Power Plant have also been demonstrated to be outside the scope of application of the Valley Model. Thus, a great deal of uncertainty is expected to be associated with any control strategy identified on the basis of Valley Model results.

The control strategies recommended to GPA were apparently based on a Valley Model analysis. That analysis has been shown to incorporate several inconsistencies beyond the general problems of such Valley Model use previously outlined. Model inputs were different from actual operating, meteorological, and terrain conditions, further compounding the inaccuracies associated with control measures based on the ES Valley Modeling. The proposed limit for sulphur in fuel and the proposed minimum stack height are probably both extremely conservative. In addition, reduction in load would reduce plume rise and might increase SO_2 impacts at ground level on the bluff under stable on-shore winds.

Based on this evaluation, the control measures recommended by ES for Tanguisson Power Plant are inappropriate. No reliable data base is available upon which to determine whether or not a control strategy is required; or, if required, what that control strategy might be. This demonstrates the need for developing a sufficient data base so that responsible decisions can be made.

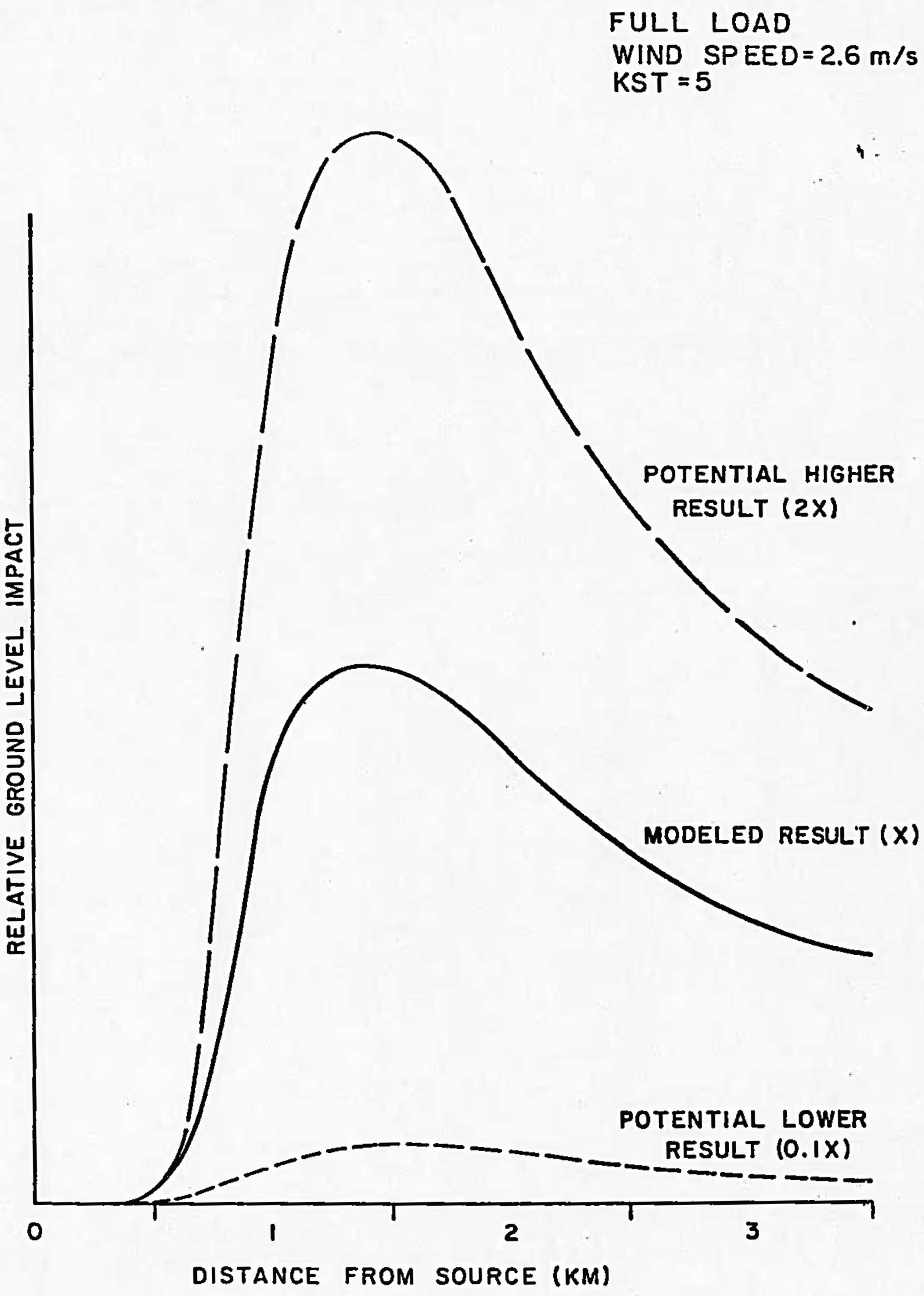


FIGURE 4-1

OBSERVED ERROR LIMITS FROM ACTUAL APPLICATIONS OF THE VALLEY MODEL

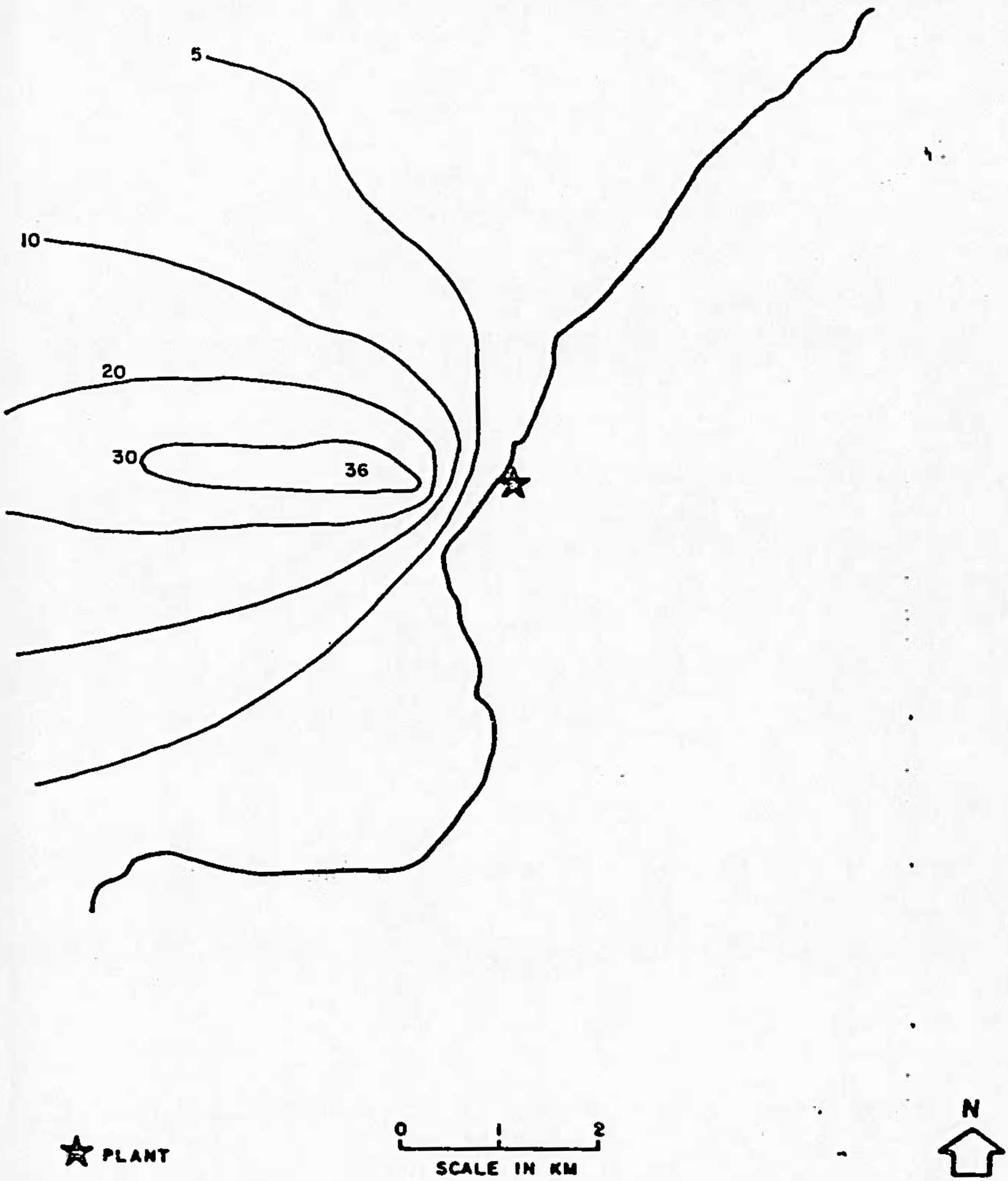


FIGURE 4-2

ANNUAL AVERAGE SO_2 IMPACT DISTRIBUTION AROUND THE TANGUISSON PLANT UNITS 1 & 2 AS DETERMINED BY THE EPA CRSTER MODEL AND 1969 METEOROLOGY

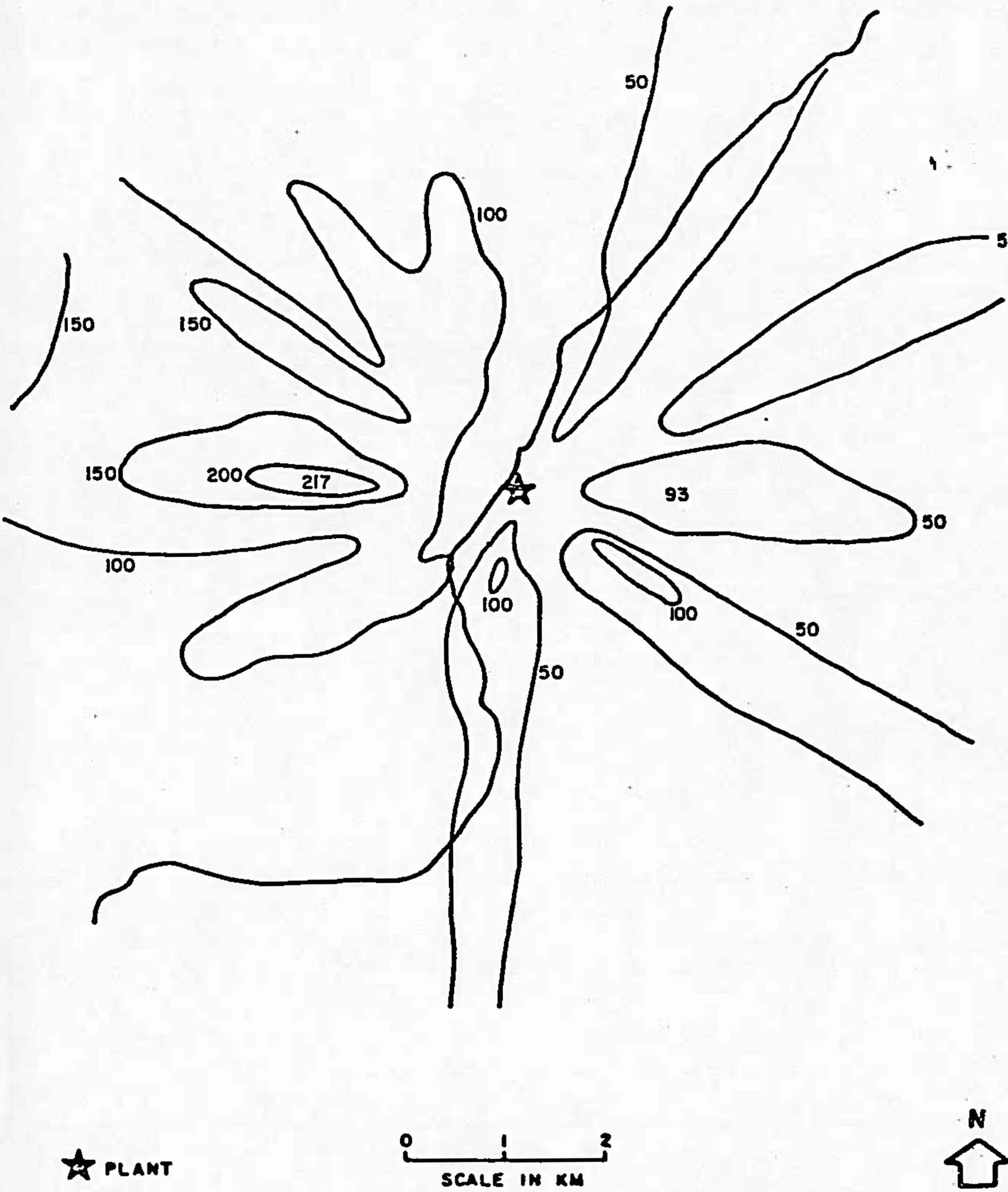


FIGURE 4-3

HIGHEST 24-HOUR SO_2 IMPACT DISTRIBUTION AROUND THE TANGUISSON PLANT UNITS 1 & 2 AS DETERMINED BY THE EPA CRSTER MODEL AND 1969 METEOROLOGY

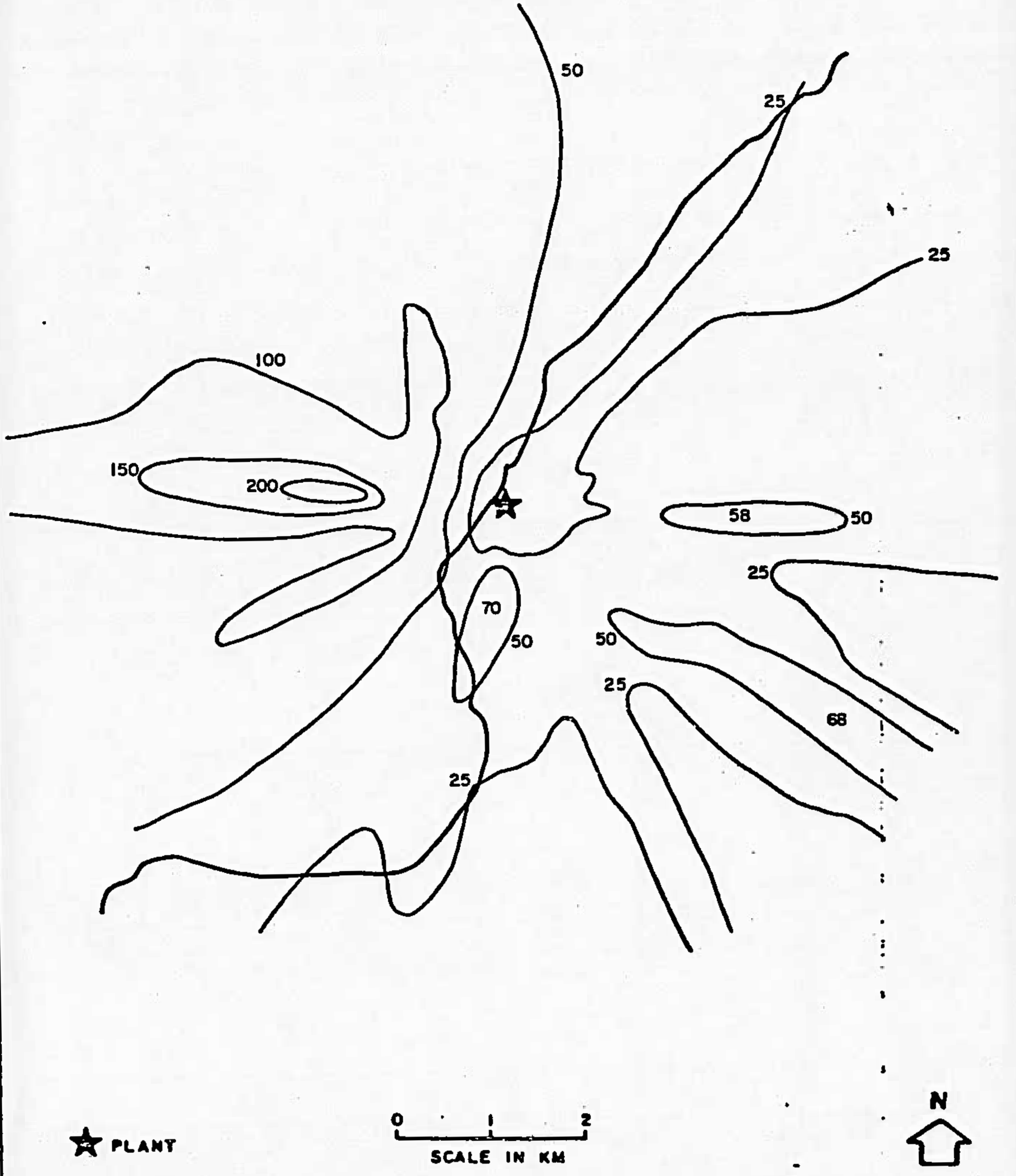


FIGURE 4-4

SECOND HIGHEST 24-HOUR SO_2 IMPACT DISTRIBUTION AROUND THE TANGUISSON PLANT UNITS 1 & 2 AS DETERMINED BY THE EPA CRSTER MODEL AND 1969 METEOROLOGY

FIGURE 4-5

HIGHEST 3-HOUR SO_2 IMPACT DISTRIBUTION AROUND THE TANGUISSON PLANT UNITS 1 & 2 AS DETERMINED BY THE EPA CRSTER MODEL AND 1969 METEOROLOGY

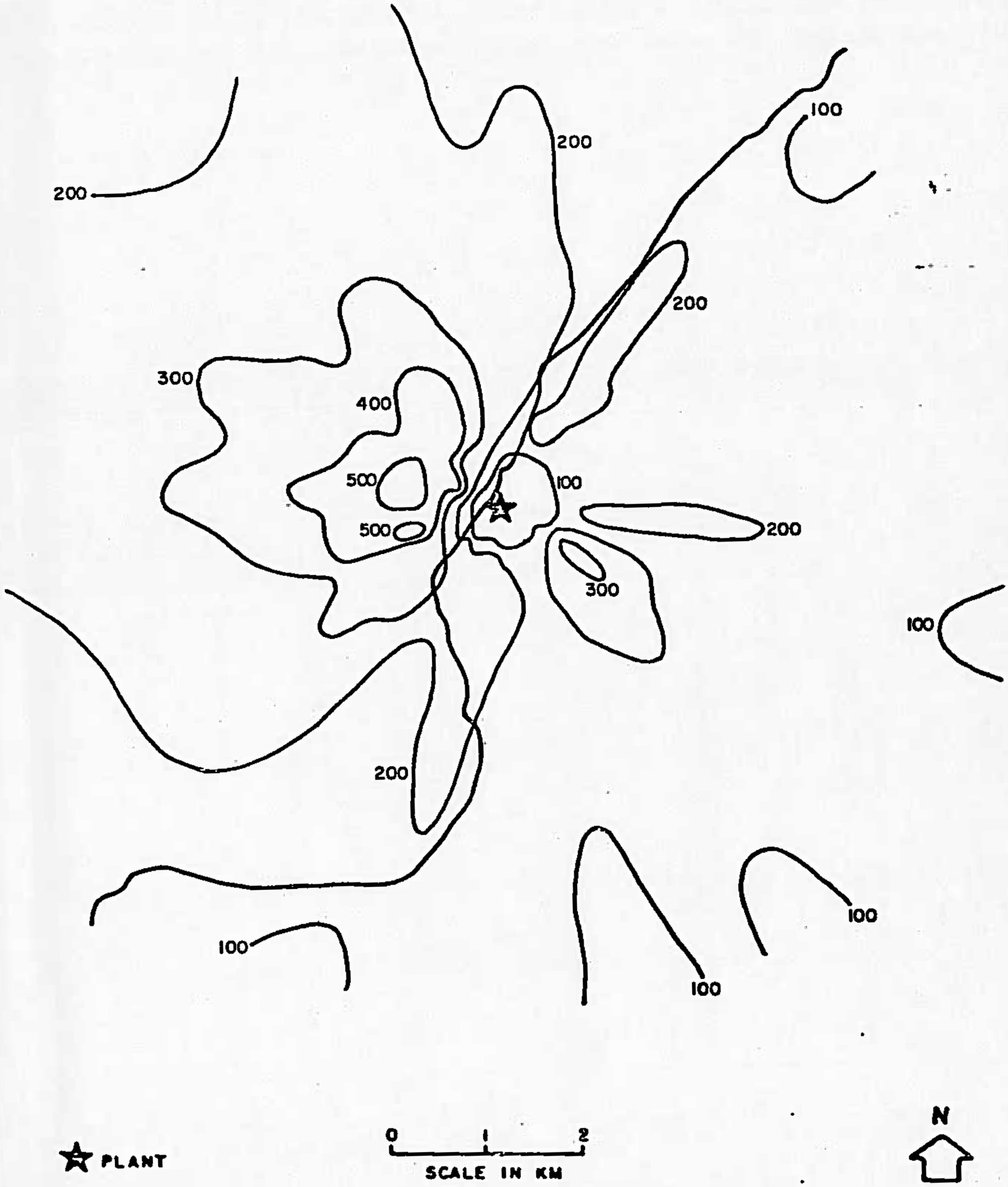


FIGURE 4-6

SECOND HIGHEST 3-HOUR SO_2 IMPACT DISTRIBUTION AROUND THE TANGUISSON PLANT UNITS 1 & 2 AS DETERMINED BY THE EPA CRSTER MODEL AND 1969 METEOROLOGY

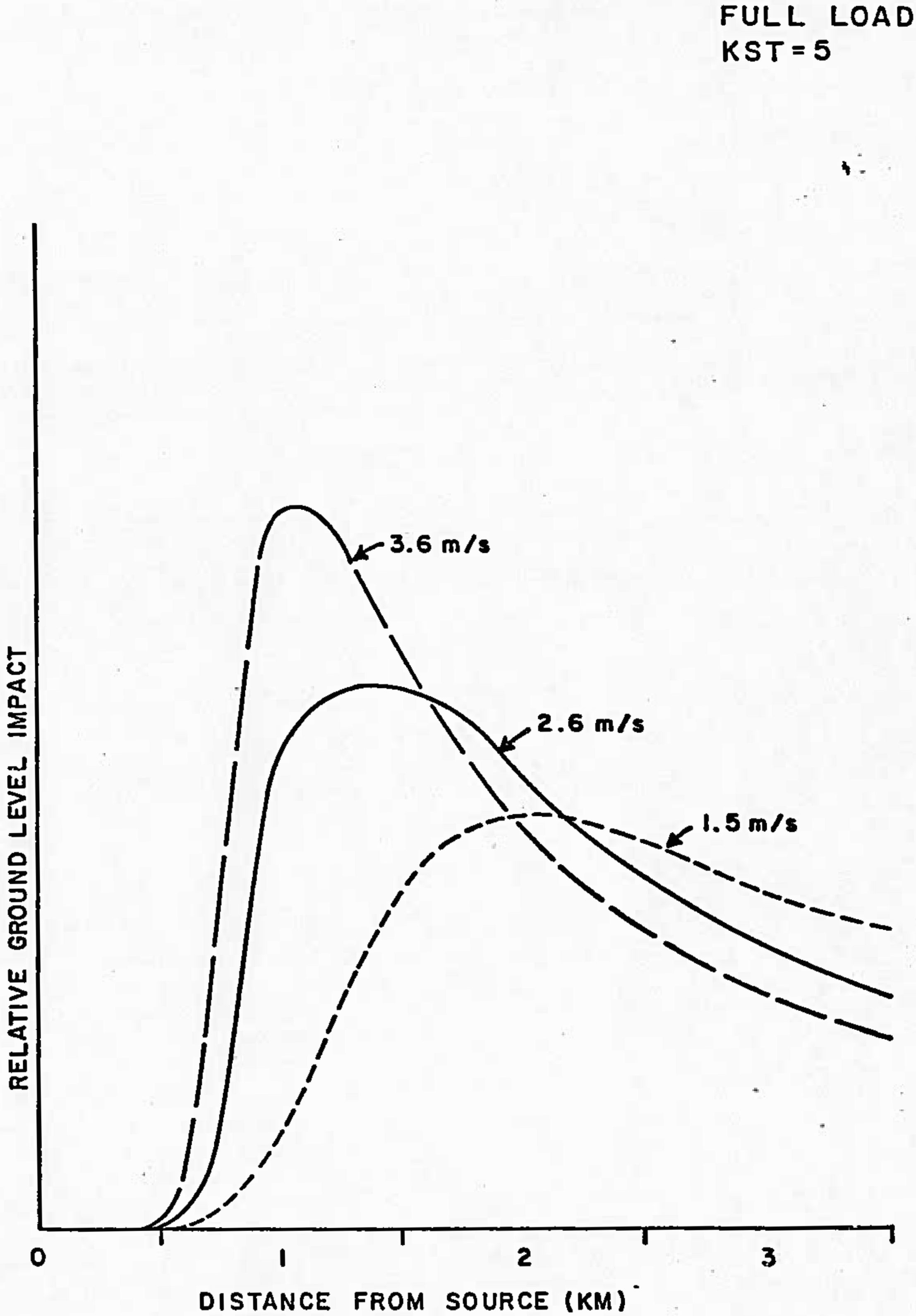


FIGURE 4-7

EFFECT OF WIND SPEED ON POTENTIAL SO_2 IMPACTS FROM TANGUISSION POWER PLANT AS PREDICTED BY VALLEY MODEL

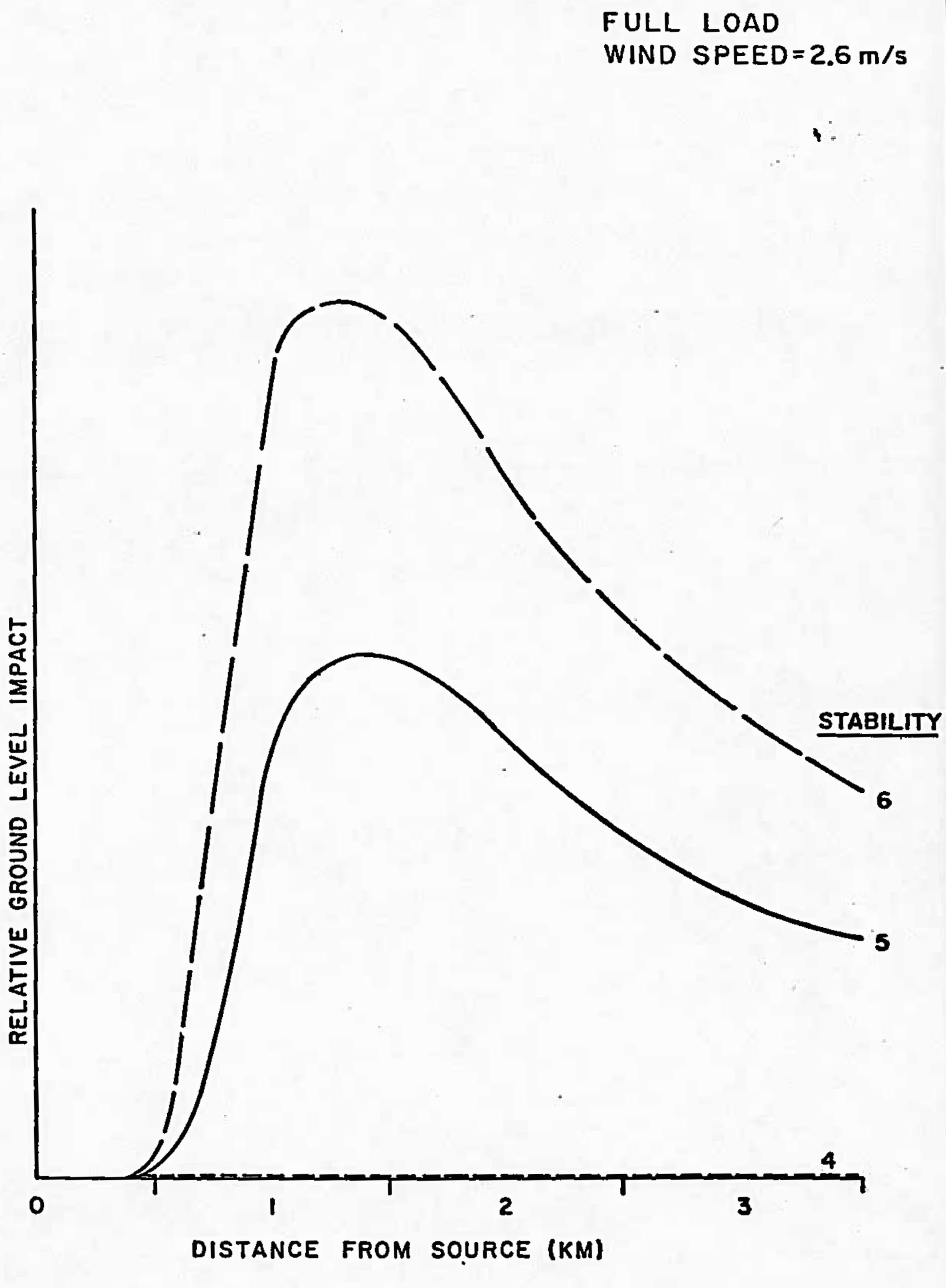


FIGURE 4-8

EFFECT OF ATMOSPHERIC STABILITY ON POTENTIAL SO_2 IMPACTS FROM TANGUISSON POWER PLANT AS PREDICTED BY VALLEY MODEL

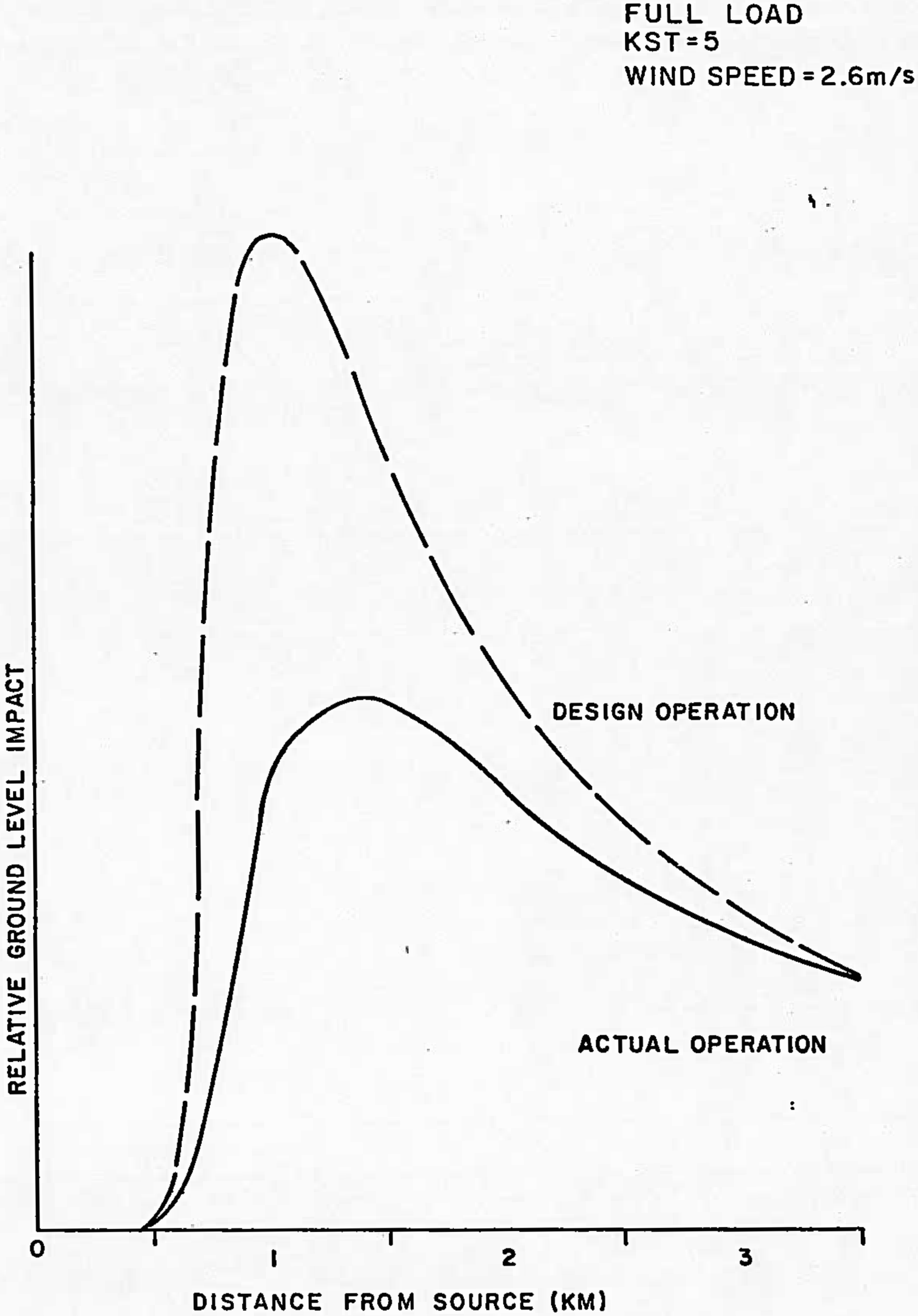


FIGURE 4-9

EFFECT OF OPERATING CONDITIONS ON POTENTIAL SO_2 IMPACTS FROM TANGUISSON POWER PLANT AS PREDICTED BY VALLEY MODEL

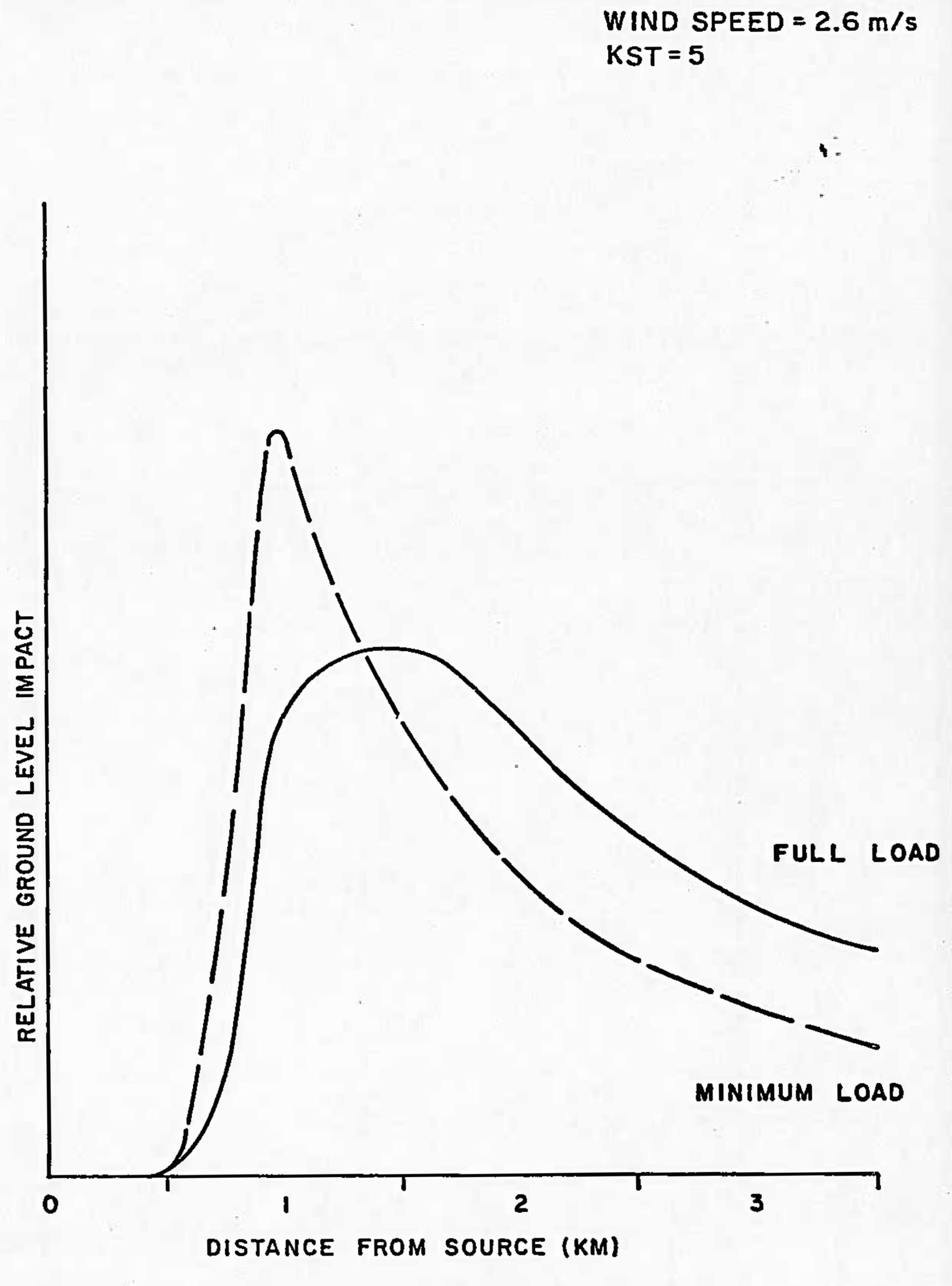


FIGURE 4-10

EFFECT OF PLANT LOAD ON POTENTIAL SO_2 IMPACTS FROM TANGUISSION POWER PLANT AS PREDICTED BY VALLEY MODEL

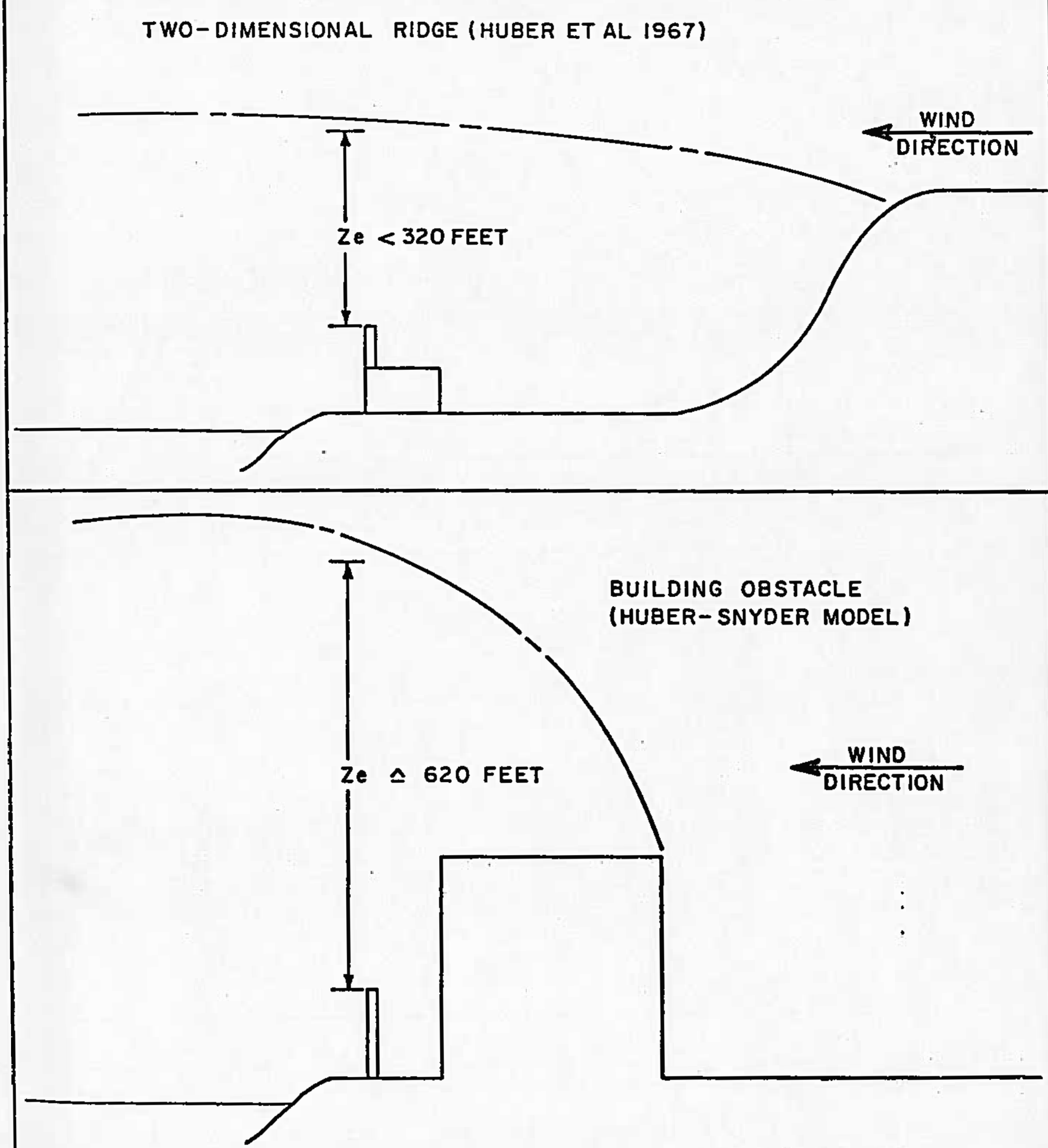


FIGURE 4-11

TWO-ESTIMATES OF THE POTENTIAL TURBULANT CAVITY AFFECTING TANGUISSON STATION DURING EAST TO WEST WINDS SHOWING THE VERTICAL DISTANCE (Ze) A PLUME MUST TRAVEL TO ESCAPE THE TURBULENT CAVITY.

5. CONCLUSIONS AND RECOMMENDATIONS

A number of conclusions were reached as a result of analysis of the unique situation of the Tanguisson Power Plant, examination of previous studies, and investigation of potential modeling techniques. These conclusions and brief summaries of supporting information are listed below in Subsection 5.1. Recommendations based on these conclusions and the underlying engineering analysis, and consistent with applicable EPA guidelines, are set forth in a similar format in Subsection 5.2.

5.1 Conclusions

(1) VALLEY MODEL RESULTS INDICATE THE NEED FOR FURTHER STUDY OF THE POTENTIAL FOR VIOLATION OF NATIONAL AMBIENT AIR QUALITY STANDARDS AT TANGUISSON ESPECIALLY UNDER STABLE CONDITIONS.

The Valley Model is not considered a predictive model, but a conservative screening technique. Its purpose is to identify those situations in which a violation of National Ambient Air Quality Standards is unlikely. Where the Valley Model fails to indicate a low probability for violation, as at Tanguisson, the results are not considered to be an indication of violation but only that further study is required.

(2) THE POTENTIAL FOR VIOLATION OF NATIONAL AMBIENT AIR QUALITY STANDARDS AT TANGUISSON IS NOT AS SERIOUS AS INDICATED BY THE ENGINEERING-SCIENCE STUDY.

Since the Valley Model is not considered a predictive model, it should not be used to quantify SO_2 impacts, conclude that violations are actually taking place, or recommend control strategies . Futhermore, as a result of application of Valley as a screening tool, R. W. Beck and Associates are of the opinion that there are several deficencies in the Environmental-Science analyses. Specifically, inappropriate input data were used for meteorology, source parameters, and terrain conditions. As a result, the Environmental-Science predictions of maximum SO_2 impacts are several times higher than those based on more accurate input data.

(3) THE CONTROL STATEGIES PROPOSED FOR TANGUISSON POWER PLANT ARE CURRENTLY UNJUSTIFIED.

In view of Conclusions 1 and 2 above, the indications that control strategies must be implemented are considered to be without foundation.

(4) MODELING INDICATES LOW PROBABILITIES FOR VIOLATION OF NATIONAL AMBIENT AIR QUALITY STANDARDS BY TANGUISSON POWER PLANT UNDER NEUTRAL OR UNSTABLE CONDITIONS.

Analyses of both Engineering-Science and R. W. Beck and Associates appropriate for neutral or unstable conditions indicated that, under worst case conditions, SO_2 concentrations at ground level would not exceed National Ambient Air Quality Standards. R. W. Beck and Associates used CRSTER (an EPA-approved predictive model) and real-time meteorology from 1967 (the worst case year for unstable or neutral conditions between 1967 and 1971) to test possible violation of the 3-hour, 24-hour, and annual SO_2 standards.

(5) NO CURRENTLY AVAILABLE MODEL IS FULLY APPROPRIATE FOR APPLICATION AT TANGUISSON

Because of the unique meteorology and terrain conditions, there is no satisfactory model available to predict SO_2 impacts in the vicinity of the Tanguisson Power Plant especially under stable atmospheric conditions. Although more sophisticated models for complex terrain are available, such models should be used in conjunction with site-specific monitoring data.

(6) THE PROPER COURSE OF ACTION FOR EVALUATING THE NEED AND, IF NECESSARY, THE TYPE OF SO_2 CONTROL STRATEGIES FOR TANGUISSON POWER PLANT IS TO MONITOR AIR QUALITY AND METEOROLOGY AND THEN TO REMODEL IF REQUIRED.

As noted, suitable models are not available to predict the potential impacts of Tanguisson Power Plant under what are expected to be worst case conditions (on-shore winds and stable atmosphere). The frequency of occurrence of such conditions is unknown because of the lack of site-specific meteorology. Actual air quality (SO_2) and meteorological data bases should be acquired in order to provide the needed information to make responsible decisions regarding control strategies. Depending on analysis of the acquired data base, remodeling employing that new data might be used to assess the effectiveness of proposed control strategies. This approach is consistent with EPA air quality modeling guidelines.

5.2 Recommendations

(1) IT IS RECOMMENDED THAT, ON THE BASIS OF ENGINEERING ANALYSIS, NONE OF THE PROPOSED CONTROL MEASURES BE SELECTED FOR USE AT TANGUISSON POWER PLANT AT THIS TIME.

The current data base is insufficient to assess the need for control strategies at Tanguisson and is insufficient to accurately evaluate any potential methods of emission control.

(2) IT IS RECOMMENDED THAT A RELIABLE PROGRAM OF AIR QUALITY AND METEOROLOGICAL MONITORING BE INITIATED.

An air quality monitoring program should be instituted consisting of as many as four continuous SO_2 monitors located as indicated in Figure 5-1 for a period of one year. Two meteorological monitoring towers (10-meter) with continous wind speed, temperature, and direction monitors should be erected at the locations indicated in Figure 5-1. A quality control program should be undertaken and quarterly data summaries should be made.

(3) IT IS RECOMMENDED THAT, AT THE END OF THE MONITORING PERIOD, THE NEED FOR CONTROL MEASURES BE ASSESSED AND (IF NEEDED) THE EFFECTIVENESS OF VARIOUS CONTROL STRATEGIES BE EVALUATED.

After an adequate data base is established, the potential for SO_2 violations due to Tanguisson Power Plant should be determined by direct evidence or by remodeling. If emission control measures are required, site-specific simulations should be prepared to test the effectiveness of various alternatives.

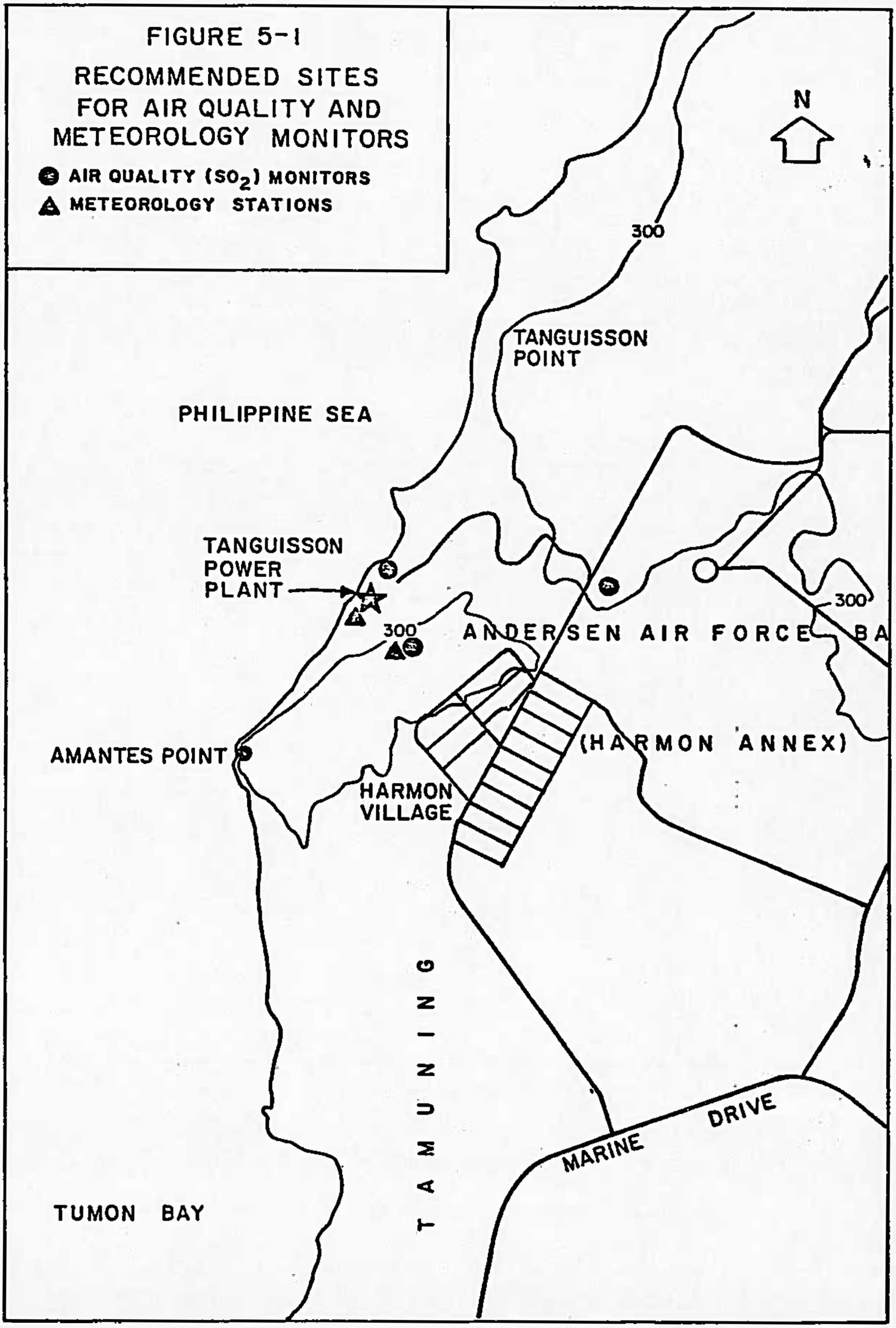


FIGURE 5-1
RECOMMENDED SITES FOR AIR QUALITY AND METEOROLOGY MONITORS

APPENDIX A

Loren W. Crow CERTIFIED CONSULTING METEOROLOGIST

Phone (303) 722-8665 or 756 3971
2422 South Downing Street
Denver, Colorado 80210

February 11, 1980

Mr. John Moldovan
R. W. Beck and Associates
660 Bannock Street
Denver, Colorado 80204

Dear Mr. Moldovan:

This letter will summarize my findings after a quick review of the data you have assembled for an impact analysis of a small oil-fired power plant on the NCS Beach near Amantes Point on the Island of Guam. (See enclosed map.)

While it is fortunate that you have an extended hourly weather record made at the US Naval Air Station (NAS) approximately three miles south of the plant, the representativeness of data at that station cannot be directly transposed to the power plant site, especially for short time periods. The twice-per-day upper air soundings (1000 and 2200 local time) are made at the National Weather Service station located two miles northeast of the plant. (See US Weather Bureau location in extreme upper right corner of map).

During nighttime hours weather observations made at the NAS would not be representative of typical air flow along the coastline near the power plant site. While stable conditions prevail during night and early morning hours, the NAS will record light wind speeds and highly variable directions. During the same hours it is my opinion that air flow at the power plant site would almost always be from some easterly component. The east toward west flow near the power plant site would be generated by downslope air flow from the top edge of the bluff in the arc from near Amantes Point to Tanguisson Point. The very immediate downslope flow from the southeast in the first 200 meters from the plant would tend to insure a boundary condition of colder air near the ground as compared with any air emitted from the power plant. A wind measurement on the bluff to the south or south-southwest of the plant would more correctly reflect air flow in the immediate vicinity of typical effective plume height for the power plant.

At both locations, the NAS and the power plant, the arc of direction range with wind speeds 2 meters per second or less generally will cover at least 67.5° over a three hour time period.

A second period of notable difference between air flow patterns likely at the NAS as compared with the power plant occurs during the warmest part of the day. While continued east or northeast air flow prevails at the NAS, the local influence of the nearby terrain will tend to permit some intermittent portions of the plume to mix with the air along the upper portion of the cliff to the south and southwest of the power plant. However, stability at this time of day will either be neutral or unstable. It is not expected that a continuous plume path near effective stack height will move toward any one point on the cliff for any extended period of time. During the hours from 1200 through 1500 on days with light wind speeds within the general northeast trade wind condition, there will be a strong tendency for sea breeze patterns to develop locally in the immediate vicinity of the power plant. Such an air flow will move air from the ocean toward the land with a rise in the air above the bluff and a return flow back toward the west or southwest at elevations between 600 and 1500 feet MSL. Penetration of west to east flow of any sea breeze patterns is much less frequent at the NAS than at the power plant.

There is a low frequency of occurrence for west to east flow along the entire island of Guam. Such air flow occurs when typhoon centers move from east to west to the north of the island. At least one instance of such air flow can be expected each year. However, air flow from the west related to typhoon motion would generally be expected to stay in a neutral condition most of the time. When typhoons move close enough to produce heavy precipitation and/or strong winds, the neutral condition is assured.

The full range of stability categories from one through seven probably is not satisfied in the Guam area. The oceanic air mass which moves across Guam is almost constantly in the slightly unstable mode. During more than half of the nighttime hours convective cloud activity can be observed from any high point on Guam. Stability classes from 2 through 5 (B through E), will most likely satisfy the full range of stability conditions in the Guam area. In the present EPA CRSTER model, nighttime hours have been improperly assigned a stability of 5 or 6 when in fact a moderate to heavy rain was being recorded at the Naval Air Station. These same hours should be treated as neutral.

The uniqueness of the small power plant near the 300-foot bluff deserves some local SO_2 measurements with corresponding wind recording equipment. On the map I have indicated a small box where a high quality SO_2 monitor should be placed. Immediately to the right the letter "W" indicates where a wind measuring unit 10 meters above the ground should be located. That wind unit should be at least 100 meters toward the south-southeast from the edge of the bluff and not more than 200 meters back from the edge of the bluff. I would also recommend the location of at least seven sulfation plate measuring devices, one located coincident with the SO_2 unit and six others located to the right and left along the top edge of the bluff indicated by the red dots on the map. The two to the east of the power plant can help verify the questionable frequency and duration of west to east flow near the power plant. The sulfation plate readings would indicate whether or not the SO_2 measuring unit is located near the highest impacted sector.

I would also recommend a concerted effort to collect photographs of plume activity from a point approximately two and one-half km to the northeast. The minimum effort would require a 35 mm camera used to take five photographs per day between the hours of 0800 and 1600. The plume emanating from the small power plant at the NCS beach should be easily identified in such photographs. Still a better photographic record could be made with a time-lapse camera having a zoom lens focused on the power plant plume. Such a camera should also be located two and one-half km to the northeast. The time interval setting for the time-lapse camera should be approximately every 8 to 10 seconds to collect a very good record of the plume activity during daylight hours. A starting time near sunrise may be necessary to portray the typical flow pattern for early morning stable conditions.

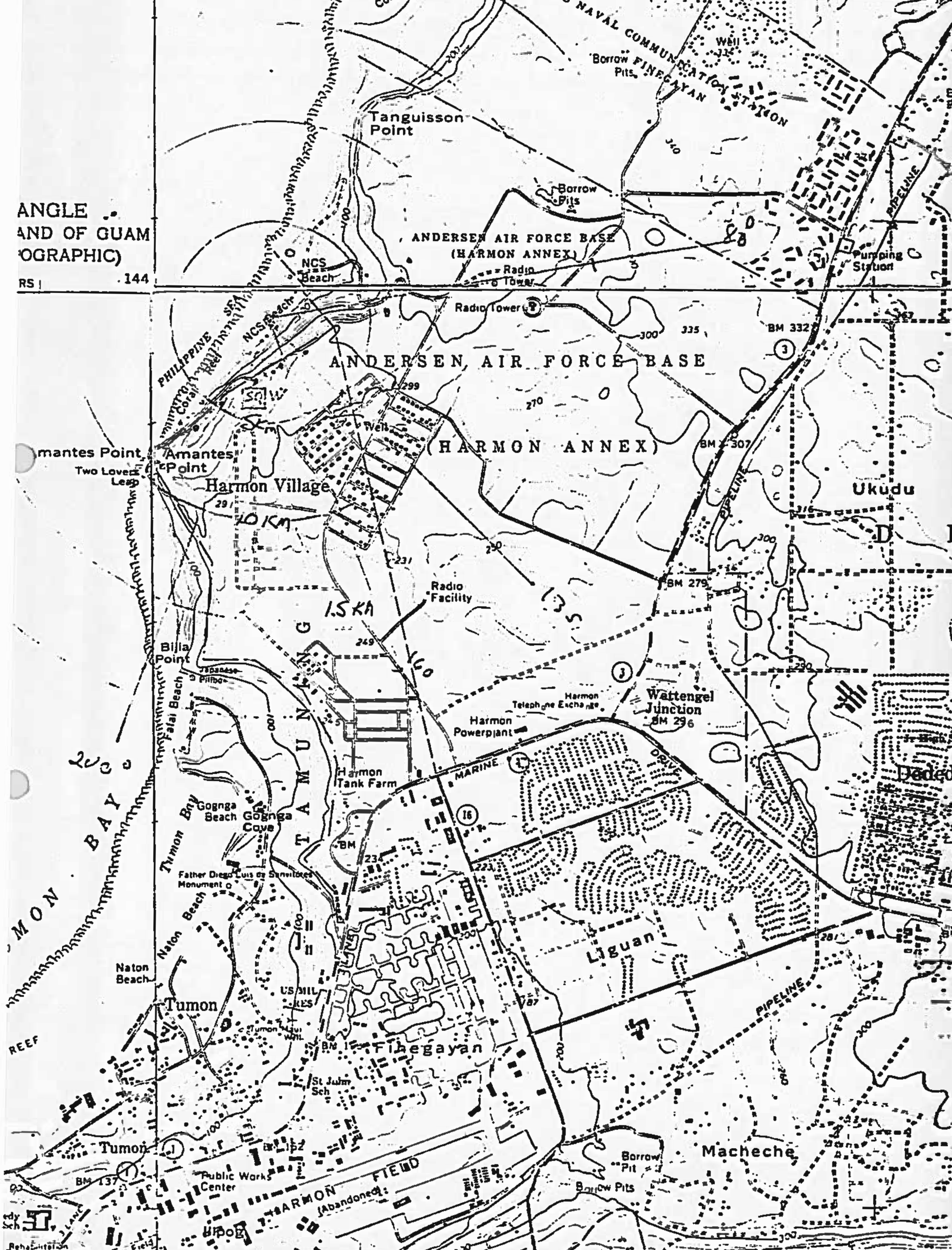
Daily atmospheric cycles of air motion occur regularly throughout the year on Guam. Therefore, it should not be necessary to collect a full year's record to determine appropriate recurring diffusion transport patterns. A monitoring program of three-month duration should be sufficient to identify potential problems.

Sincerely yours,

Loren W. Crow

Loren W. Crow
Certified Consulting Meteorologist

LWC:dd



ANGLE
AND OF GUAM
OGRAPHIC)
RS
144
NAVAL COMMUNICATION STATION
FINEGAYAN
Well
Borrow Pits
Tanguisson Point
Borrow Pits
ANDERSEN AIR FORCE BASE
(HARMON ANNEX)
Radio Tower
NCS Beach
Pumping Station
Radio Tower
BM 332
PHILIPPINE SEA
NCS Beach
Coral Reef
ANDERSEN AIR FORCE BASE
Well
(HARMON ANNEX)
BM 307
Amantes Point
Amantes Point
Two Lovers Leap
Harmon Village
Ukudu
PIPELINE
10 KM
BM 279
Radio Facility
1.5 KM
135
Bijia Point
Japanese Pillbox
Falai Beach
Harmon Telephone Exchange
Wattengel Junction
BM 296
Harmon Powerplant
MARINE DRIVE
TAMUNING
Harmon Tank Farm
200
Gognga Beach
Gognga Cove
Tumon Bay
TUMON BAY
Father Diego Luis de Sanvitores Monument
Naton Beach
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Liguan
US MIL RES
Tumon
PIPELINE
REEF
Finegayan
St John Sch
Macheche
Tumon
Borrow Pit
BM 137
Public Works Center
HARMON FIELD
(Abandoned)
Borrow Pits
Upog

References

Briggs, G. A. Plume Rise. U. S. Atomic Energy Commission. 1969.

Engineering-Science. Preliminary Results of SO_2 Dispersion Modeling, Guam SIP Non-Attainment Program. Arcadia, California. July 1979.

Guldberg, et al, p. 3-1. "User's Manual for Single Source (CRSTER) Model". Publication No. EPA-450/2-77-013 (NTIS PB 271360). Research Triangle Park, North Carolina. July 1977.

Huber, Alan H. An Evaluation of Obstacle Wake Effects on Plume Dispersion. Paper presented at American Meteorological Society, Fourth Symposium on Turbulence, Diffusion and Air Pollution. January 15-18, 1979. Reno, Nevada.

Huber, A. H., W. H. Snyder, Roger S. Thompson, Robert E. Lawson, Jr. Stack Placement in the Lee of a Mountain Ridge. A Wind Tunnel Study. Research Triangle Park, North Carolina. September 1976. (NTIS: PB-259 877.

Huber, Alan H. and William H. Snyder. Building Wake Effects on Short Stack Effluents. (Mimeograph) U. S. Environmental Protection Agency. Research Triangle Park, North Carolina. No date.

National Climatic Center. Local Climatological Data, Annual Summary with Comparative Data. Guam, Pacific. Asheville, North Carolina. 1976.

PEDCo-Environmental Specialists, Inc. Analysis of SO_2 Emissions Control Alternatives for the Cabras Power Plant, Guam Power Authority. Prepared for the U. S. Environmental Protection Agency, Region IX, San Francisco, California. May 13, 1975.

Specialists' Conference on the EPA Modeling Guideline. Report to the U.S. EPA. Chicago, Illinois. February 22-24, 1977.

United States Environmental Protection Agency. Complex Terrain Models. W. C. Barber, Office of Air Quality Planning and Standards to David D. Hawkins, Assistant Adminstrator for Air, Noise, and Radiation (Mimeograph) June 5, 1979.

Interim Guideline on Air Quality Models. OAQPS No. 1.2-080. Research Triangle Park, North Carolina. October 1977.

Valley Model User's Guide. EPA-450/2-77-018. Research Triangle Park, North Carolina. September 1977.

User's Manual for Single Source (CRSTER) Model. Publication No. EPA-450/2-77-013 (NTIS PB 271360). Research Triangle Park, North Carolina. July 1977.