EPA-910/9-86-147
December 1986

COMPARISON OF AIR QUALITY MODEL ESTIMATES WITH MEASURED SO_2 CONCENTRATIONS NEAR MARCH POINT, WASHINGTON

Prepared by

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EPA Contract No. 68-02-3886

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1.0 INTRODUCTION

TRC Environmental Consultants, Inc. was retained by the Environmental Protection Agency to investigate the performance of the SHORTZ and ISCST air quality models in predicting sulfur dioxide concentrations in the vicinity of March Point, Washington. The March Point area, located just to the east of Anacortes, Washington is the site for two oil refineries and limited other industrial development. TRC's role was to utilize the air quality models to predict sulfur dioxide concentrations for a study period running from May through November, 1985. The predicted concentrations were then to be compared with the measured concentrations to evaluate model performance.

1.1 Background

The three industrial concerns of the March Point area in this investigation, Texaco, Shell and Allied Chemical, in cooperation with the Northwest Air Pollution Authority (NWAPA), the Washington State Department of Ecology and the U.S. Environmental Protection Agency (EPA), began a program to monitor sulfur dioxide concentrations in the vicinity of the March Point refineries several years ago. In the early 1980's, sulfur dioxide concentrations collected by Allied Chemical in the March Point area showed violations of the local five-minute and one-hour standards. In 1984, the EPA conducted an evaluation of the sulfur dioxide concentrations in the March Point to determine 1) the source contributions to the measured values, 2) the concentrations at locations other than the air quality monitoring stations, and 3) recommendations for siting of new air quality monitors in areas of high concentration.

The EPA study was based on the use of air quality modeling techniques to predict ambient concentrations of sulfur dioxide. The principal air quality model used in the evaluation of the sulfur dioxide concentrations was the SHORTZ Model, developed by the H. E. Cramer Company for the EPA. The SHORTZ Model is the model recommended by the EPA for use with sulfur dioxide emissions from buoyant sources located in urban areas of complex terrain, defined as the presence of terrain heights above the stack height. The terrain to the south of the March Point area includes terrain heights above stack height.

Based on EPA recommendations, the State Department of Ecology and the NWAPA established three temporary monitors for sulfur dioxide in the area to the south of the March Point industrial area. A test period established as May, 1985 through November, 1985 was used to collect data for model validation. The data collected at the three monitors would be used to test the model accuracy, and ultimately to select permanent agency-operated sulfur dioxide monitoring station locations.

1.2 Purpose of the Current Study

The current study is the performance of air quality modeling for comparison with the measured concentrations during the test period of May, 1985 through November, 1985. Ultimately the results of the study will be used to determine if the SHORTZ Model or an alternative, the ISCST Model is an accurate tool for the siting of air quality monitors in locations similar to the March Point setting, and, if possible, to select permanent monitor sites for the sulfur dioxide monitoring in the March Point area.

1.3 Organization of the Current Document

The current report documents all the proceedings of the TRC investigation of the air quality model performance for the March Point area. Section 2.0 describes the methodology of the current study, including a brief description of the SHORTZ and ISCST air quality models, a discussion of the meteorological, emission, and other inputs used by the models, and a discussion of the key decisions in running the models (e.g., the determination of stack-tip downwash using computation of the Froude Number). Section 3.0 discusses the results of the direct modeling of the cases selected by the Department of Ecology. Section 4.0 discusses the sensitivity analysis, which describes how the model results vary depending on values selected for the input parameters. Finally, Section 5.0 discusses the conclusions of the study. Appendix A presents sample computer printouts for the SHORTZ and ISCST runs.

2.0 METHODOLOGY

2.1 The SHORTZ Model

The SHORTZ air quality model was developed by the H. E. Cramer specifically for simulating air quality impacts from multiple source developments in complex terrain. For the purposes of the current air quality modeling, complex terrain is defined as the presence of terrain elevations in the area to be modeled that are higher than the stack heights of the emission sources. For the current study there are a total of 20 sources of emission, with emission heights above sea level varying from 52 to 82 meters above sea level. Terrain elevations of over 90 meters above sea level are located to the south of the refineries within a distance of 2-3 kilometers. As a result, the area is judged to be complex terrain. The Guideline on Air Quality Models, a document published by the EPA, provides guidance on the appropriate air quality models to use for certain applications, and the SHORTZ Model is recommended for urbanized or industrialized areas of complex terrain for sources such as the three industrial facilities on March Point. The SHORTZ Model has been used in numerous previous air quality studies in Western Washington-- most notably the evaluation of the ASARCO Tacoma copper smelter.

The SHORTZ air quality model is well documented in the "User's Instructions for the SHORTZ and LONGZ Computer Programs, Volumes I and II", published by the EPA (EPA-903/9-82-004). No attempt will be made to describe the SHORTZ Model here. The major model inputs can be grouped in four general classes:

- o emission information,

- meteorological data,
- receptor locations, and
- other information.

Each of these data requirements will be discussed in the following sections.

2.2 The ISCST Model

The Industrial Source Complex Short-Term (ISCST) Model was also developed by the H. E. Cramer Company for regulatory use. The ISCST Model is well documented in the User's Guide for the Industrial Source Complex Dispersion Model (EPA-450/4-86-005) and will not be discussed in detail. It is very similar in many regards to the SHORTZ Model, but differs in a few key areas. Primarily, the differences concern the treatment or ability to treat the effects of terrain on plume dispersion. The SHORTZ Model was specifically designed to treat rough terrain settings, defined as the presence of terrain heights above the stack height in the area. The ISCST Model specifically cannot treat rough terrain settings. In fact, the ISCST Model does not allow the specification of terrain heights above stack level. The ISCST Model can, however, treat rolling terrain with heights below stack height.

The other principal difference between ISCST and SHORTZ concerns the treatment for downwash. The ISCST Model is designed to treat the complex effects of building wake downwash on plume dispersion. The SHORTZ Model, although having a treatment for stack-tip downwash, is not designed to treat the effects of building wakes. For the current project, building wakes are not considered to have a significant effect on plume dispersion.

2.3 Emission Information

Both models require that each source be identified with a specific source identification number. The information which must be provided for each source includes the emission rate in grams per second, the source location, the stack height, the elevation of the stack base, and a number of stack parameters such as the emission temperature, the volume of the stack gases emitted and the stack radius. Sources can also be grouped and the results printed out in terms of a group's contribution at each receptor to the total impact.

For the current project, there are three industrial facilities being modeled: the Texaco oil refinery, the Shell oil refinery and the Allied Chemical plant. Emissions at an oil refinery are not constant, but rather vary from day to day depending on the sulfur in the feed stock, the operating conditions, or the shutting down of certain sources for maintenance. For determining the air quality models' performance during the test period, it was necessary to determine the emission conditions for each source during the test period. The Department of Ecology reviewed the air quality data for the entire test period and selected certain periods for modeling. They then obtained emission data from the industrial facilities for those periods. The runs of the both models were accomplished by adjusting the input parameters to reflect actual conditions for each of the periods to be modeled.

A total of 20 different periods were selected by the Department of Ecology and modeled in the current study. Ten of these periods were one-hour episodes, while the remaining 10 were three-hour episodes. Table 2-1 depicts the input values used for each of the major parameters for each stack of concern in the current study.

Table 2-1

Emission Rates Used In the Air Quality Modeling

Constant Parameters:

Source	UTM-X	UTM-Y	Stack Ht. (m)	Base Elev. (m)	Stack Radius (m)
Allied Chem.:					
101	532722	5369522	30.5	30	0.61
Texaco:					
201	532661	5368539	52.0	30	1.41
Shell:					
301	531961	5371117	37.0	14	0.88
302	531945	5371117	40.0	14	0.88
303	531923	5371117	46.0	14	0.99
304	531897	5371117	46.0	14	0.72
305	532029	5371120	40.0	14	0.84
306	532178	5371115	54.0	14	1.45
307	532170	5371132	53.0	14	1.14
308	531833	5371030	40.0	14	0.69
309	531845	5371030	40.0	14	0.45
310	532125	5371190	38.0	14	0.87
311	532125	5371202	38.0	14	0.87
312	531932	5370843	52.0	20	0.76
313	531924	5370843	52.0	20	0.84
314	531915	5370843	52.0	20	0.84
315	531875	5370845	52.0	20	1.37
316	531887	5370845	52.0	20	1.37
317	531906	5370843	52.0	20	0.76
318	531898	5370843	52.0	20	0.69

Variable Parameters:

Source	Emission Rate (g/sec)	Stack Temp. (°K)	Volume Flow (m3/sec)
May 22, 1985 (Cases 1, 11 and 12)			
Allied Chem:			
101	2.68	350	11.94
Texaco:			
201	175.40	545	77.10
Shell:			
301	8.95	601	11.76
302	11.72	486	10.19
303	10.46	584	13.54

Table 2-1
(continued)

Source	Emission Rate (g/sec)	Stack Temp. (°K)	Volume Flow (m3/sec)
304	3.78	523	3.79
305	9.07	515	8.54
306	78.37	497	51.01
307	64.64	526	44.70
308	5.29	610	5.75
309	1.26	615	1.38
310	17.01	466	13.31
311	19.91	472	15.45
312	5.80	626	7.12
313	5.42	481	4.04
314	1.89	441	1.51
315	19.53	508	17.98
316	19.53	513	18.16
317	2.14	475	1.57
318	0.63	715	0.92
June 20, 1985 (Case 2)			
Allied Chem:			
101	3.76	350	11.94
Texaco:			
201	195.60	545	77.10
Shell:			
301	5.80	593	12.81
302	6.43	513	11.51
303	14.24	614	21.93
304	1.51	548	3.39
305	4.28	509	8.46
306	44.86	493	46.39
307	37.84	516	40.52
308	2.52	600	5.43
309	0.63	605	1.44
310	18.90	478	17.96
311	13.61	472	12.88
312	3.91	669	10.18
313	2.02	506	4.14
314	0.76	460	1.42
315	9.70	505	18.39
316	9.70	511	18.61
317	1.13	481	1.95
318	1.13	810	4.23

Table 2-1
(continued)

June 24, 1985 (Cases 3 and 13)

Allied Chem:

Source	Emission Rate (g/sec)	Stack Temp. (°K)	Volume Flow (m3/sec)
101	4.43	350	11.94
Texaco:			
201	195.60	545	77.10
Shell:			
301	6.30	594	11.75
302	7.69	522	12.54
303	8.06	606	18.23
304	1.76	539	3.18
305	4.41	505	7.96
306	50.90	498	52.40
307	41.58	523	44.82
308	2.52	575	4.68
309	0.76	605	1.48
310	9.58	475	11.39
311	6.80	466	8.49
312	4.66	681	10.04
313	2.52	524	4.31
314	0.63	451	1.04
315	10.08	499	16.61
316	10.08	500	16.64
317	1.26	485	1.95
318	1.01	690	3.34

August 15, 1985 (Cases 4 and 14)

Source	Emission Rate (g/sec)	Stack Temp. (°K)	Volume Flow (m3/sec)
Allied Chem:			
101	4.03	350	11.94
Texaco:			
201	181.80	545	77.10
Shell:			
301	3.91	523	7.25
302	4.28	480	7.58
303	7.43	571	12.85
304	1.13	473	1.40
305	4.79	451	5.67
306	53.05	497	50.88
307	43.09	523	43.67
308	0.38	586	0.50
309	0.00	615	1.38
310	13.86	480	13.21
311	11.59	486	11.23

Table 2-1
(continued)

Source	Emission Rate (g/sec)	Stack Temp. (°K)	Volume Flow (m3/sec)
312	4.91	612	6.64
313	1.51	478	1.80
314	1.76	477	1.98
315	11.09	478	12.23
316	11.09	496	12.69
317	1.39	473	1.58
318	2.27	810	4.79
September 27, 1985 (Cases 5, 6, 15, 16 and 17)			
Allied Chem:			
101	4.70	350	11.94
Texaco:			
201	0.00	NA	NA
Shell:			
301	0.00	NA	NA
302	11.34	501	11.19
303	14.36	614	17.75
304	1.51	493	1.41
305	5.92	469	5.53
306	80.39	505	55.87
307	65.90	526	47.57
308	3.40	561	3.73
309	1.13	598	1.40
310	16.00	475	14.92
311	16.00	489	14.88
312	7.81	641	11.24
313	2.539	483	2.02
314	1.51	463	1.44
315	11.97	480	11.18
316	11.97	490	11.41
317	1.89	491	1.94
318	3.15	810	8.47
October 5, 1985 (Case 7)			
Allied Chem:			
101	3.22	350	11.94
Texaco:			
201	0.00	NA	NA
Shell:			
301	0.00	NA	NA
302	8.57	484	10.65

Table 2-1
(continued)

Source	Emission Rate (g/sec)	Stack Temp. (°K)	Volume Flow (m3/sec)
303	14.74	626	21.16
304	1.01	481	1.22
305	5.04	465	5.67
306	92.36	503	52.37
307	76.73	523	44.92
308	2.77	579	3.93
309	0.76	581	1.16
310	15.88	478	15.79
311	19.66	489	19.67
312	5.29	634	8.61
313	1.39	470	1.86
314	1.39	464	1.64
315	7.94	470	11.03
316	7.94	490	11.50
317	1.26	483	1.56
318	0.00	810	8.47
November 10, 1985 (Cases 8, 9, 10, 18, 19 and 20)			
Allied Chem:			
101	0.13	350	11.94
Texaco:			
201	179.30	545	77.10
Shell:			
301	0.00	NA	NA
302	7.69	481	9.77
303	14.74	621	17.78
304	2.02	523	2.50
305	6.43	458	8.16
306	91.22	503	79.56
307	68.54	523	62.65
308	4.03	622	6.77
309	0.88	611	1.79
310	33.52	478	20.99
311	33.64	489	21.50
312	4.03	621	7.09
313	2.90	510	4.55
314	1.51	483	2.43
315	11.34	498	15.84
316	11.34	494	15.72
317	2.02	519	3.61
318	1.89	793	6.41

2.4 Meteorology

The air quality models require meteorological information in the form of wind speed, wind direction, atmospheric stability, mixing height and ambient temperature. One of the major limitations of a Gaussian Plume Model, such as the SHORTZ Model and the ISCST Model (and virtually every other model in the Guideline on Air Quality Models) is that it assumes that the atmosphere is in steady-state over all space and time for the individual period being modeled (the base meteorological data input rate). For the current study the base data rate is hourly, and the models assume a single value for wind speed, wind direction, stability, mixing height and temperature applies for the entire area for one hour.

There were a number of sources of meteorological data for use in the air quality modeling, and the first step in the modeling procedure was the selection of the single value to use for each of the cases selected by the Department of Ecology. The sources of meteorological information included the three industry monitors (Texaco, Shell and Allied) and various airport weather stations, including Bellingham, Whidbey Island Naval Air Station, Friday Harbor, and Paine Field (Everett). A composite table including all the meteorological data was prepared, and in a meeting between the EPA and TRC, values selected for use. Ultimately, the Texaco Monitor was selected for the wind speed and wind direction, while the Bellingham airport data was used for selection of the atmospheric stability, mixing height and temperature information.

The basis for the selection involved the consistency of the Texaco and Bellingham data with the other stations, and the proximity of location of these monitors to the sources and receptors. The Texaco Monitor agreed well with the Allied monitor, while the Shell monitor differed substantially. Also the Shell data were not available for some of the period of interest. The Texaco monitor was also closest to the receptor locations, since the Texaco refinery is south of the Shell refinery, and the receptors (state-operated monitors) were to the south of the Texaco refinery. The Texaco monitor did not collect cloud-cover data (used for atmospheric stability and mixing height) or temperature data. The Whidbey Island Naval Air Station data was consistently in disagreement with the other three airports. The Bellingham station was the closest of the three remaining airports, and appeared to be the most representative of the March Point area.

The meteorological data selected for use in the air quality modeling are summarized in Table 2-2. It will be noted that the stability information are presented by a letter class designation. The letter classes were developed by Mr. Bruce Turner to simulate different atmospheric mixing conditions and are taken from the cloud cover and wind speed information in a procedure recommended by the EPA (EPA, 1970). The procedure involves the computation of the solar angle and the determination of an insolation class number. The National Climatic Center uses precisely the same methodology as used here to generate stability class for development of statistical wind roses.

2.5 Receptors

The air quality models require the specification of locations at which to compute concentrations, called receptor locations. The three primary locations used here are the sites of the three temporary air quality monitors. They are referred to by the names "Beebe", "Island Warehouse" and "Bullfinch". The figures to be presented in Section 3.0 illustrate the

Table 2-2

Meteorological Data Used In the Air Quality Modeling

Date	Hours	Wind Speed (m/sec)	Wind Direction degrees	Atm. Stab. Class	Mixing Height (m)	Amb. Temp. (°K)
Case 1: 5/22/85	1300	1.79	360	B	1500	295
Case 2: 6/20/85	1300	2.68	360	A	1500	292
Case 3: 6/24/85	1400	1.79	360	B	1000	289
Case 4: 8/15/85	1100	8.94	340	D	750	300
Case 5: 9/27/85	1200	5.36	360	C	750	293
Case 6: 9/27/86	0900	4.47	360	D	750	290
Case 7: 10/5/86	1100	0.89	270	B	1500	286
Case 8: 11/10/85	0900	7.15	30	D	750	274
Case 9: 11/10/85	1000	7.15	20	D	750	275
Case 10: 11/10/85	1100	7.15	20	D	750	275
Case 11: 5/22/85	1200	2.68	360	C	1000	295
	1300	1.79	360	B	1500	295
	1400	2.68	340	B	1500	296
Case 12: 5/22/85	1300	1.79	360	B	1500	295
	1400	2.68	340	B	1500	296
	1500	2.68	320	B	1500	298
Case 13: 6/24/85	1200	2.68	360	C	1000	287
	1300	2.68	360	A	1500	288
	1400	1.79	360	B	1500	289

Table 2-2
(continued)

Date	Hours	Wind Speed (m/sec)	Wind Direction degrees	Atm. Stab. Class	Mixing Height (m)	Amb. Temp. (°K)
Case 14:						
8/15/85	1100	8.94	340	D	750	300
	1200	4.47	360	C	750	301
	1300	8.94	350	D	750	302
Case 15:						
9/27/85	1000	5.36	360	D	750	291
	1100	4.47	350	C	750	292
	1200	5.36	360	C	750	293
Case 16:						
9/27/85	0900	4.47	360	C	750	290
	1000	5.36	360	D	750	291
	1100	4.47	350	C	750	292
Case 17:						
9/27/85	1100	4.47	350	C	750	292
	1200	5.36	360	C	750	293
	1300	5.36	360	C	750	293
Case 18:						
11/10/85	0800	7.15	30	D	750	274
	0900	7.15	30	D	750	274
	1000	7.15	20	D	750	275
Case 19:						
11/10/85	0900	7.15	30	D	750	274
	1000	7.15	20	D	750	275
	1100	7.15	20	D	750	275
Case 20:						
11/10/85	1100	7.15	20	D	750	275
	1200	7.15	10	D	750	275
	1300	7.15	20	D	750	275

locations of these monitors. The information provided to the models concerning these monitors include the location in Universal Transverse Mercator (UTM) coordinates, and the elevation of the ground at the receptor location. For the current project, UTM coordinates had been provided to TRC in the data for the air quality monitoring stations. However, these coordinates did not match the map-identified locations for the sources. Consequently, to be consistent with the display maps, the UTM coordinates were modified slightly to so they would plot correctly in the figures of Chapter 3.0. Receptor heights were also provided to TRC with the data for the monitor sites.

In addition to the three air quality monitoring sites, a grid of receptors was determined for the air quality modeling. A total of 143 receptors, spaced at 250 meters apart on an 11 by 13 grid were established. For each receptor, the UTM coordinate and terrain elevation were determined.

2.6 Other Model Information

The final block of information provided to the models included the values to use for a number of switches and miscellaneous parameters. In general, default values were used for most of the other parameters, such as potential temperature gradients, entrainment coefficients, accelerations due to gravity, rectilinear plume expansion distance, power law exponents for the wind speed, and the turbulence intensities for each stability class.

One particular area deserves comment. The User's Instructions for the SHORTZ Model provide guidance concerning stack-tip downwash, a process whereby the plume is caused to decrease in height due to the aerodynamic influence of the stack in the wind. It has been determined from experimental evidence that the tendency of stack-tip downwash to influence a plume is a function of the Froude Number for the stack, a mathematical construct which ratios the momentum force of a plume to its buoyant force. For plumes with Froude numbers greater than 3.0, the momentum dominates, and the stack tip downwash is applicable. For plumes with Froude Numbers less than 1.0, the buoyant forces dominate and the stack-tip downwash does not apply. For stacks with Froude Numbers in the range between 1.0 and 3.0, the applicability of the stack-tip downwash is not certain. For the current study, the value of 3.0 was used to determine if stack-tip downwash should be used. However, the sensitivity analysis discussed in Section 4.0 addresses the use of the alternate (1.0) Froude Number criterion.

3.0 ANALYSIS RESULTS

The SHORTZ Model was run for the 20 cases selected by the Department of Ecology. For each case, concentrations were computed at a total of 146 receptors -- the three monitor locations and the 143 grided receptors. Results at the monitor locations are summarized in Table 3-1, while Figures 1-20 illustrate the full picture for both the grided receptors and the three monitor locations.

The ISCST Model was run for the same 20 cases selected by the Department of Ecology. For each case, concentrations were computed at a total of 146 receptors -- the three monitor locations and the 143 grided receptors. Results at the monitor locations are summarized in Table 3-1, while Figures 21-40 illustrate the full picture for both the grided receptors and the three monitor locations.

In addition to the summaries shown in the table and figures, Appendix A contains sample SHORTZ and ISCST computer printouts.

Table 3-1 also includes the measured values at the three monitors for the period of interest. By comparison of the measured versus the predicted values in Table 3-1, the overall performance of the models can be assessed. Both the SHORTZ and the ISCST Model had concentrations in the same order of magnitude as the measured values. Neither of the models predict concentrations which correlate well with the measured values. A linear regression was performed for each of the three sites with the result indicating that the correlation coefficient (r-squared) was 0.04 and 0.02 for the one-hour and three-hour concentrations respectively when evaluated with the SHORTZ Model. For the ISCST Model the correlation

Table 3-1

Comparison of Model Results with Measured Concentrations

SO_2 Concentration (ppm)

	Island Warehouse			Bullfinch			Beebe		
Case	Meas.	Shortz	ISCST	Meas.	Shortz	ISCST	Meas.	Shortz	ISCST
One-hour Cases:									
1	0.03	0.03	0.03	0.08	0.07	0.07	NA	0.05	0.05
2	0.02	0.08	0.07	0.02	0.04	0.02	0.08	0.06	0.08
3	0.03	0.02	0.03	0.03	0.06	0.05	0.10	0.03	0.04
4	0.03	0.00	0.01	0.01	0.00	0.00	0.09	0.00	0.00
5	0.05	0.01	0.01	NA	0.03	0.04	0.16	0.03	0.03
6	0.01	0.01	0.01	0.04	0.05	0.07	0.11	0.01	0.02
7	0.03	0.00	0.00	0.04	0.00	0.00	0.08	0.00	0.00
8	0.02	0.00	0.00	0.01	0.00	0.00	0.09	0.00	0.00
9	0.01	0.00	0.00	0.01	0.00	0.00	0.10	0.00	0.00
10	0.09	0.00	0.00	0.01	0.00	0.00	0.06	0.00	0.00
Three-hour Cases:									
11	0.02	0.02	0.03	0.06	0.04	0.05	NA	0.03	0.05
12	0.02	0.02	0.02	0.06	0.02	0.02	NA	0.02	0.02
13	0.02	0.04	0.04	0.03	0.04	0.04	0.06	0.04	0.05
14	0.03	0.05	0.03	NA	0.01	0.02	0.06	0.02	0.03
15	0.03	0.03	0.03	NA	0.03	0.04	0.10	0.03	0.04
16	0.02	0.03	0.03	0.02	0.03	0.04	0.09	0.03	0.04
17	0.03	0.03	0.03	NA	0.02	0.03	0.09	0.04	0.05
18	0.02	0.00	0.00	0.01	0.00	0.00	0.08	0.00	0.00
19	0.04	0.00	0.00	0.01	0.00	0.00	0.08	0.00	0.00
20	0.08	0.00	0.00	0.01	0.03	0.01	0.04	0.00	0.00

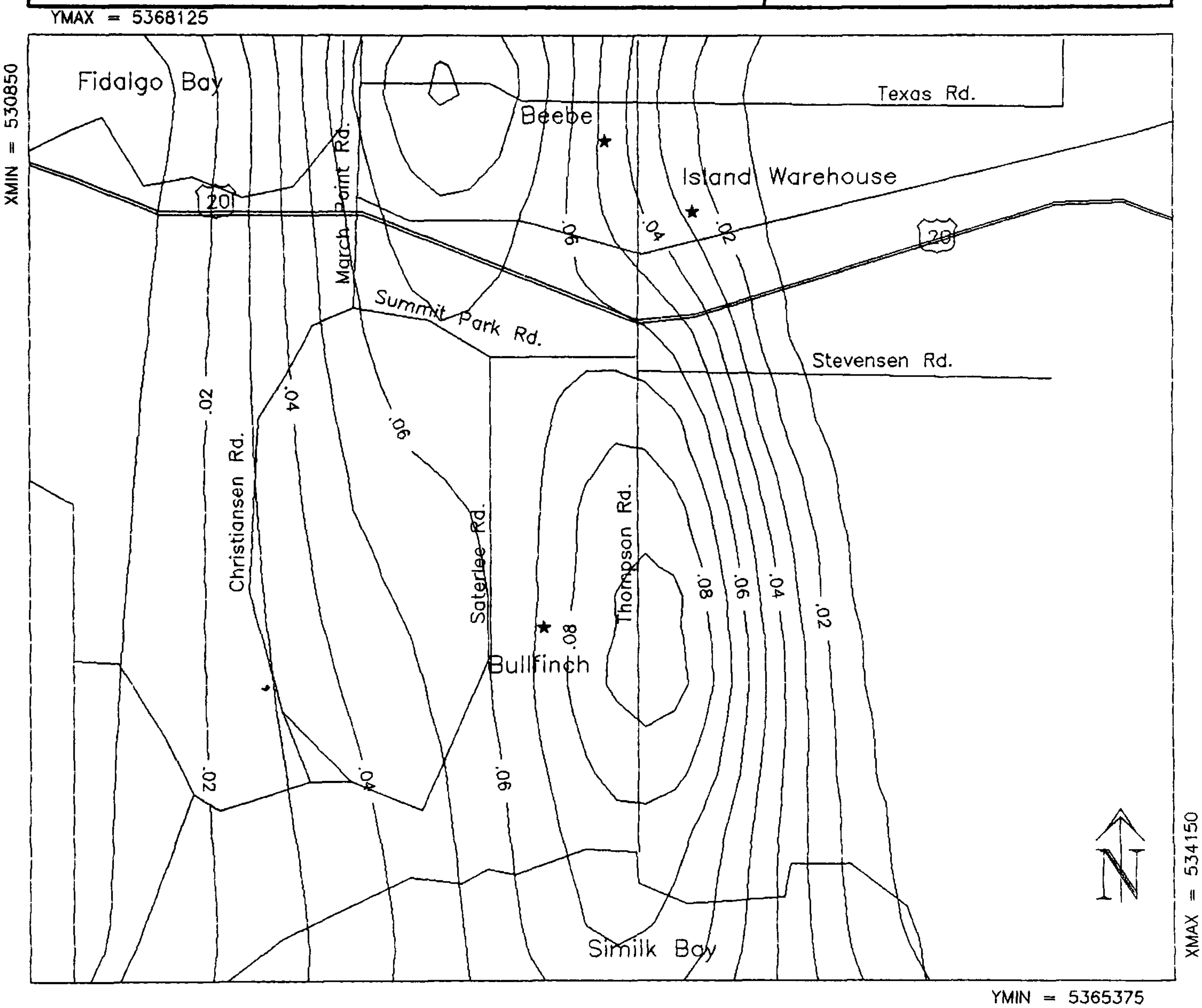
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



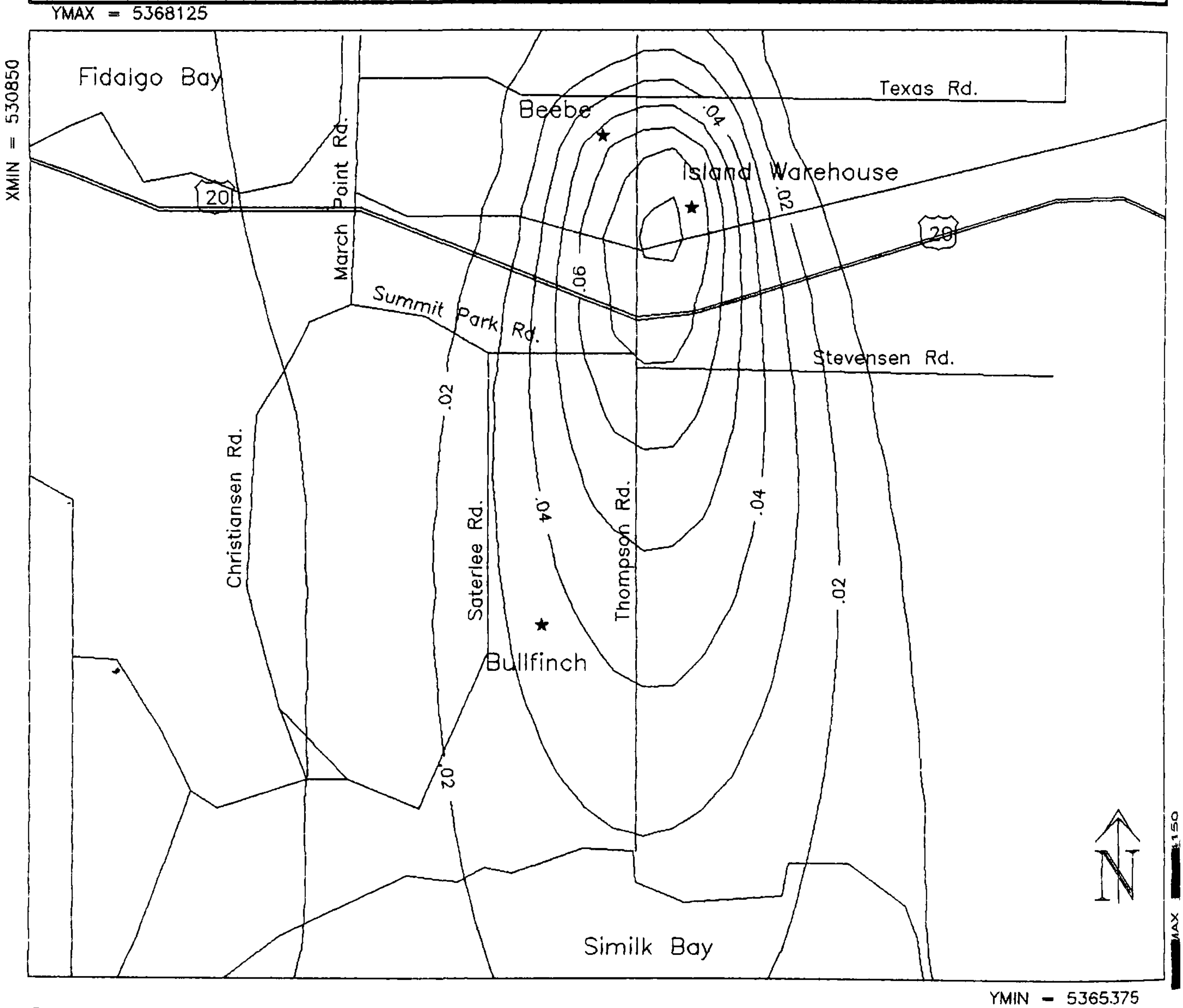
★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 1

CASE 1 - SHORTZ
1-Hour Concentrations
for May 22, 1985, 1300 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT SO_2 CONCENTRATIONS (ppm)	Date Prepared: Dec. 7, 1986 TRC Environmental Consultants, Inc.



★ Monitor Location 0 0.5 1.0 1.5 Scale in Kilometers	Figure 2 CASE 2 - SHORTZ 1-Hour Concentrations for June 20, 1985, 1300 PST (contour interval = 0.01 ppm)

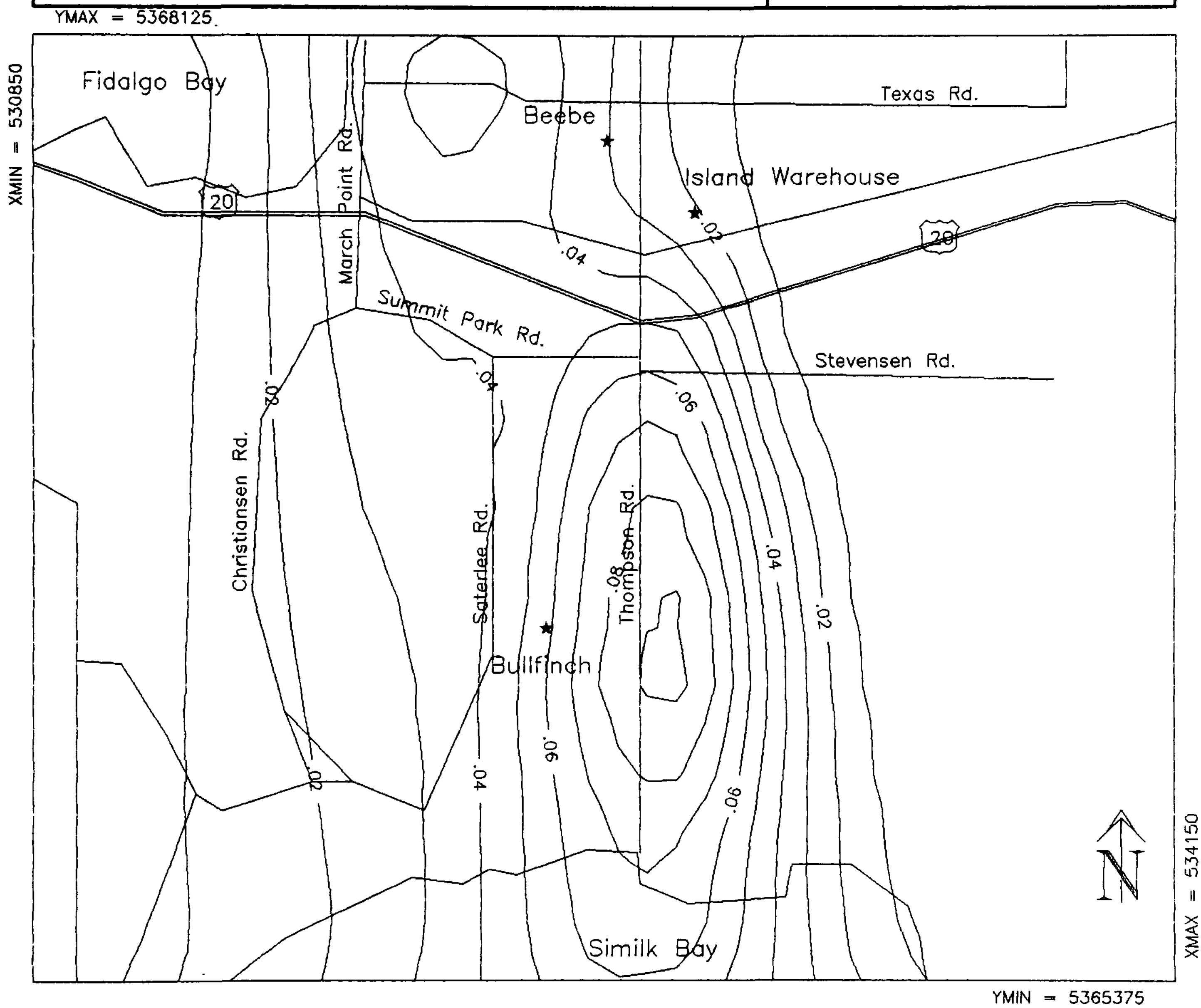
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 3

CASE 3 - SHORTZ
1-Hour Concentrations
for June 24, 1985, 1400 PST
(contour interval = 0.01 ppm)

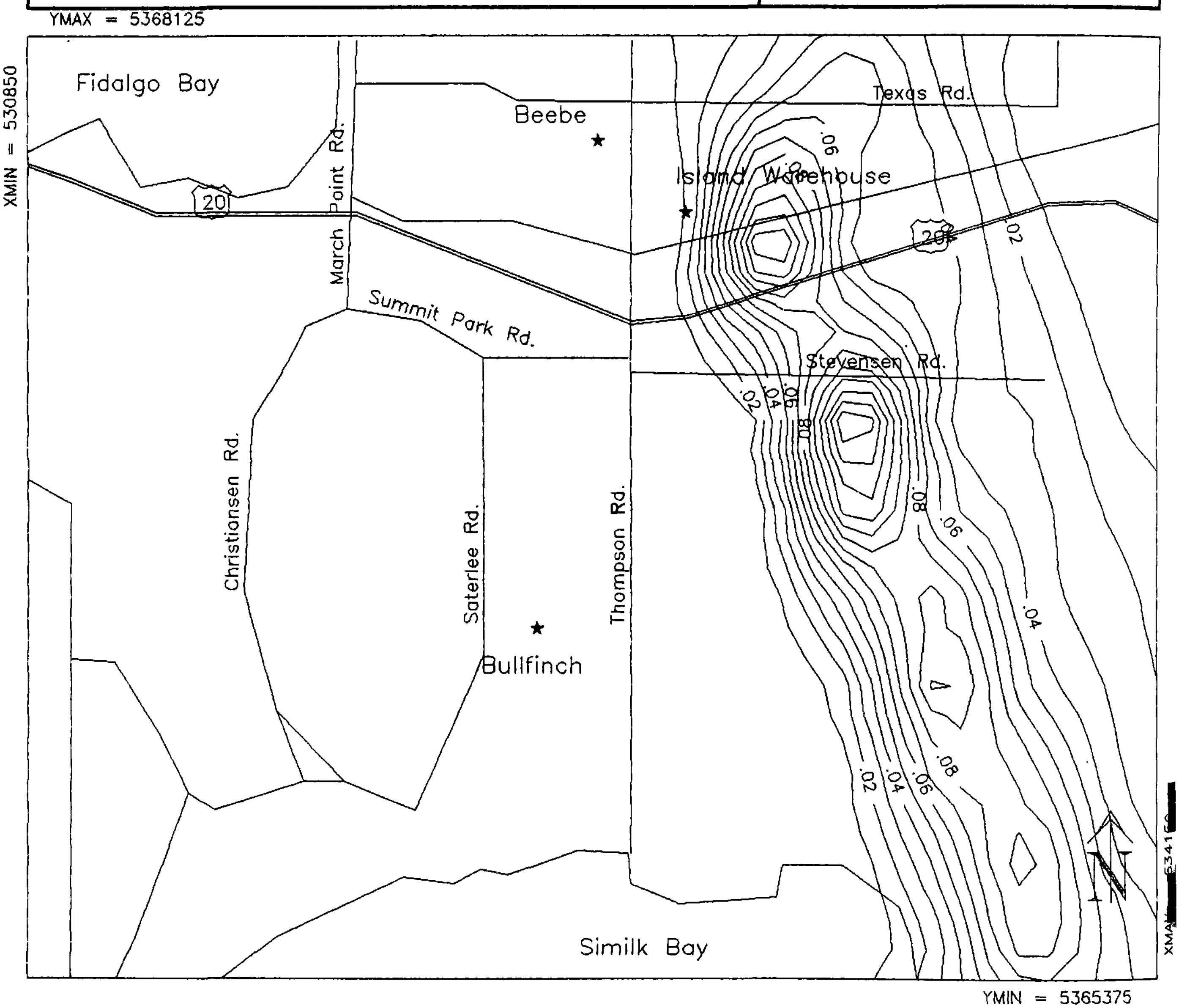
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 4

CASE 4 - SHORTZ
1-Hour Concentrations
for Aug. 14, 1985, 1100 PST
(contour interval = 0.01 ppm)

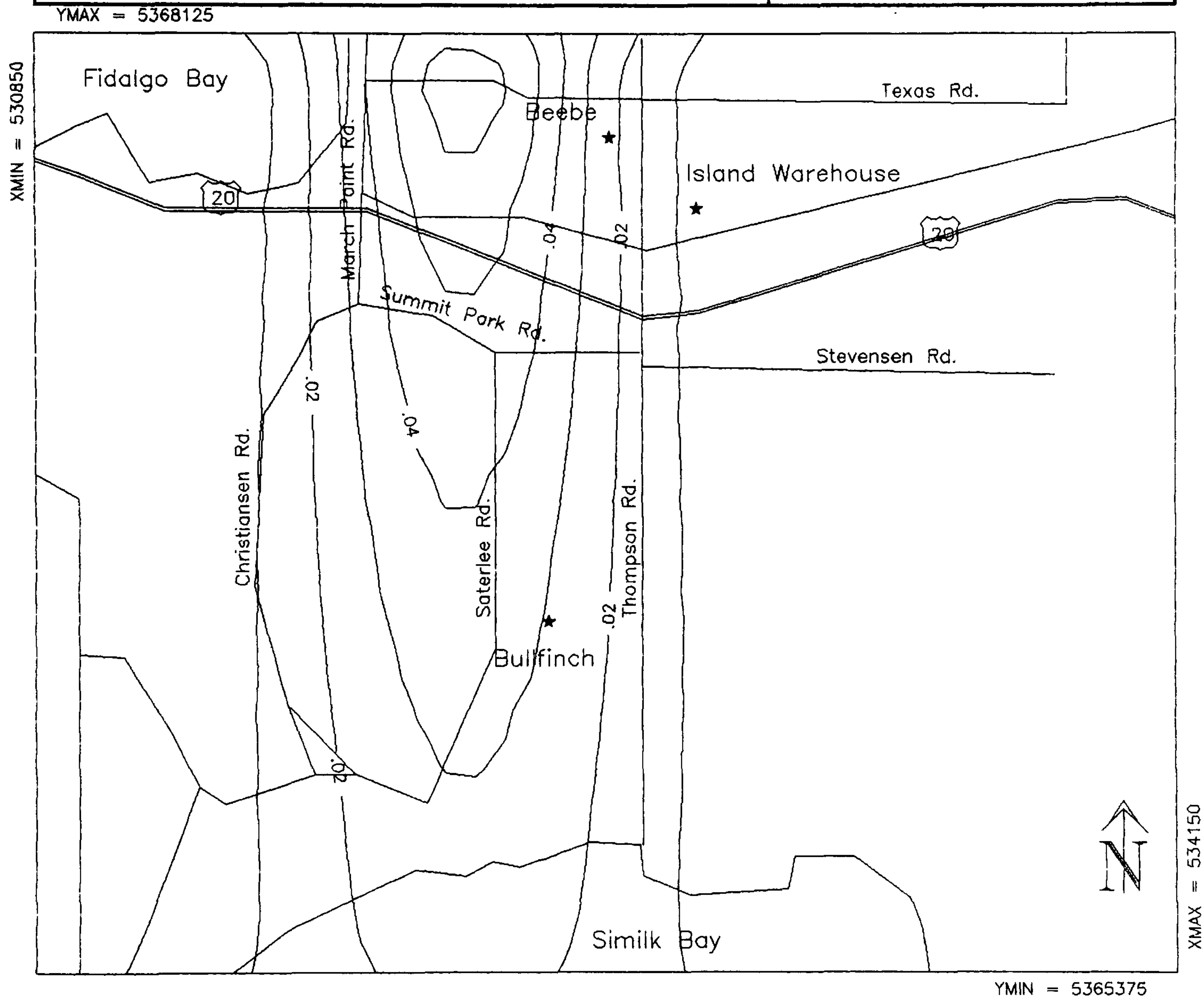
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 5

CASE 5 - SHORTZ
1-Hour Concentrations
for Sept. 27, 1985, 1200 PST
(contour interval = 0.01 ppm)

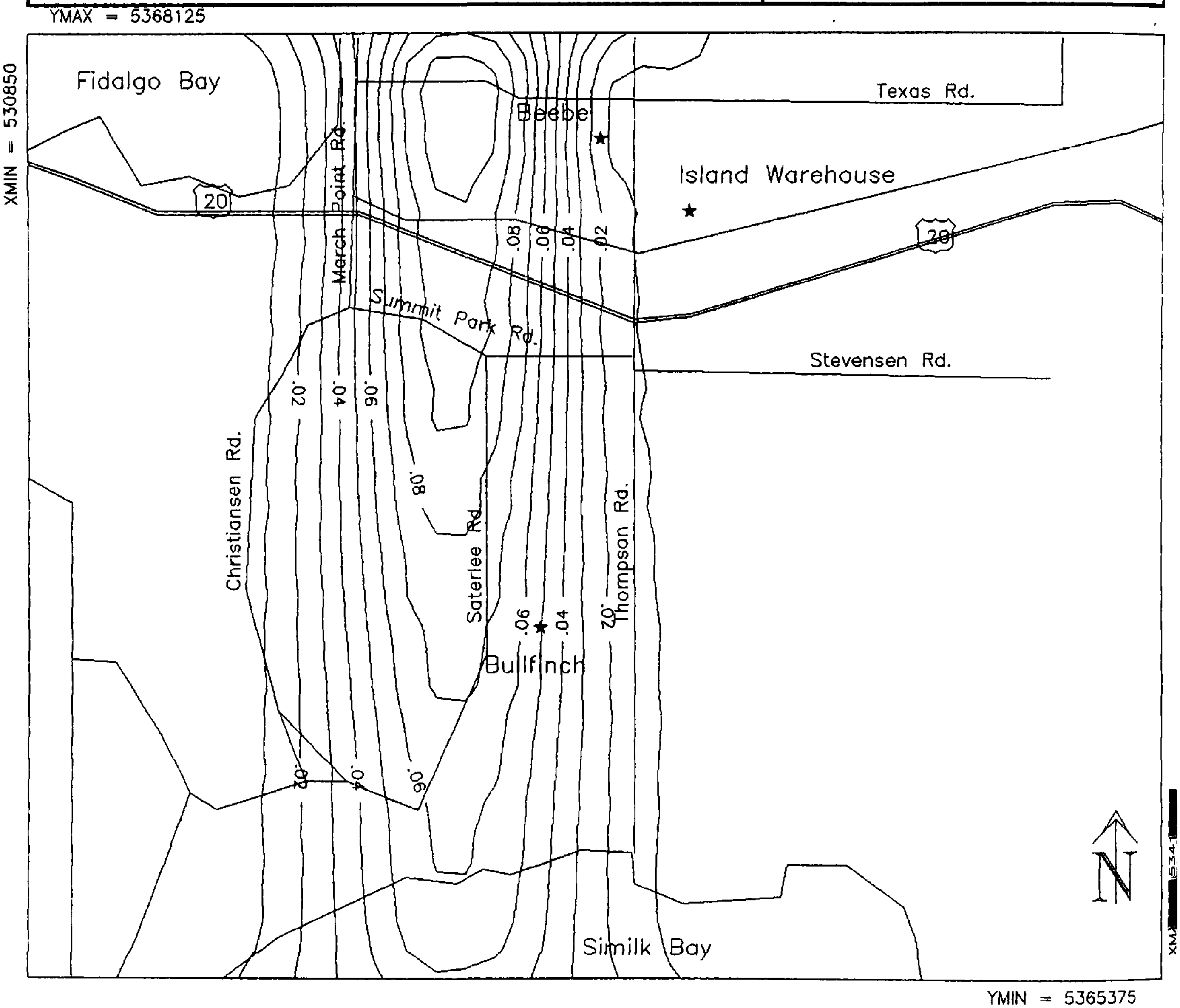
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 6

CASE 6 - SHORTZ
1-Hour Concentrations
for Sept. 27, 1985, 0900 PST
(contour interval = 0.01 ppm)

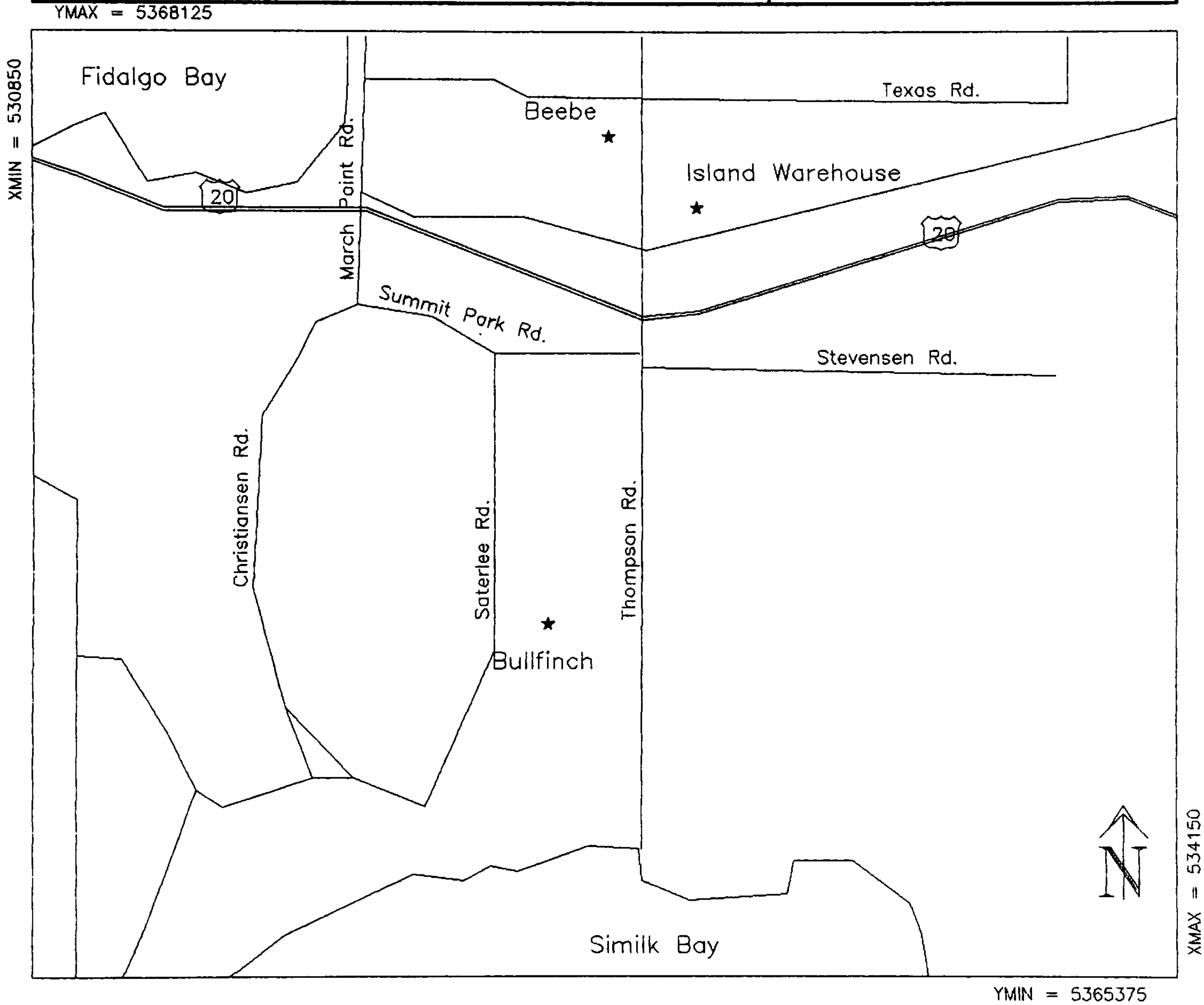
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 7

CASE 7 - SHORTZ
1-Hour Concentrations
for Oct. 5, 1985, 1100 PST
(contour interval = 0.01 ppm)

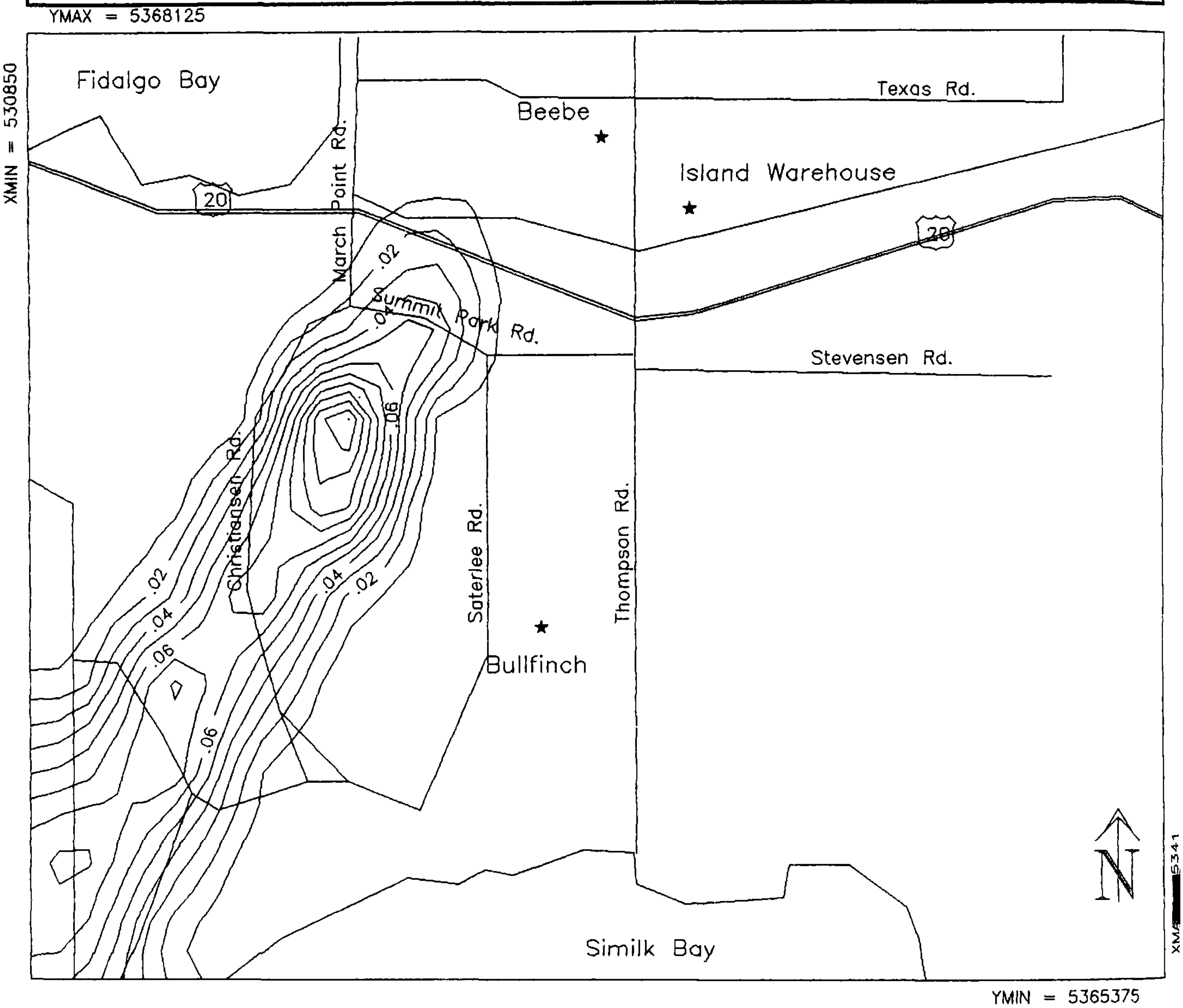
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 8

CASE 8 - SHORTZ
1-Hour Concentrations
for Nov. 10, 1985, 0900 PST
(contour interval = 0.01 ppm)

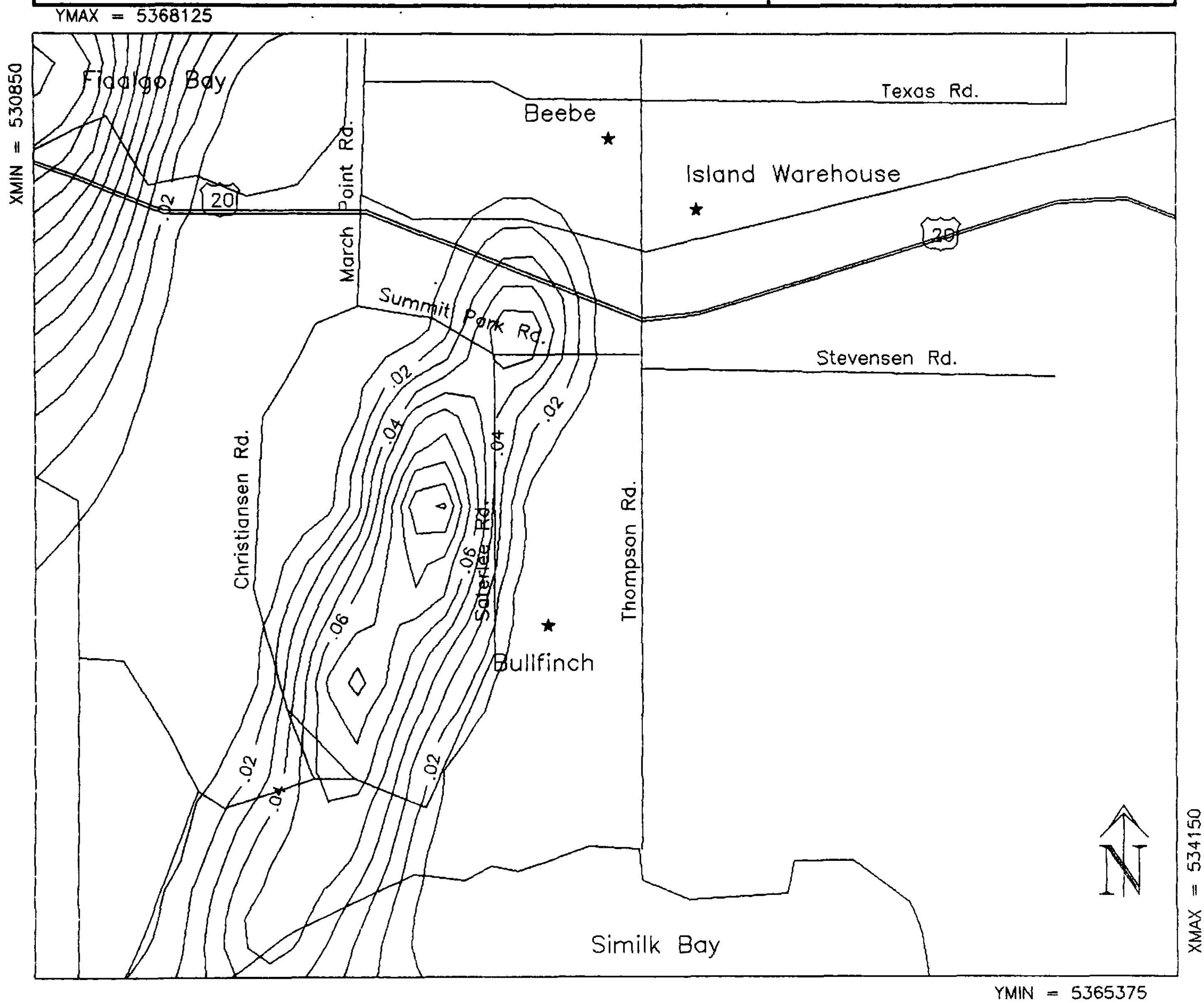
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 9

CASE 9 - SHORTZ
1-Hour Concentrations
for Nov. 10, 1985, 1000 PST
(contour interval = 0.01 ppm)

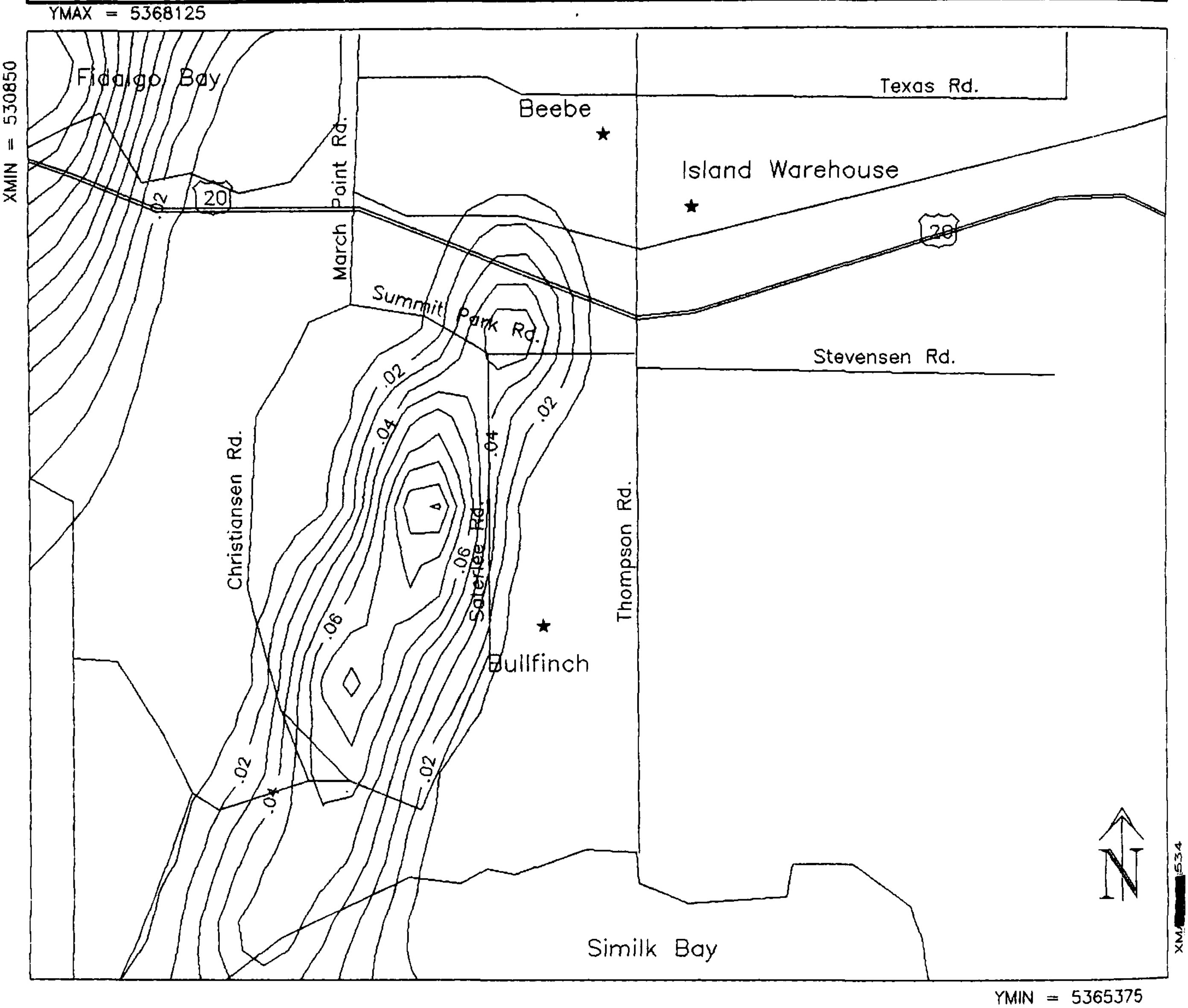
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 10

CASE 10 – SHORTZ
1-Hour Concentrations
for Nov. 10, 1985, 1100 PST
(contour interval = 0.01 ppm)

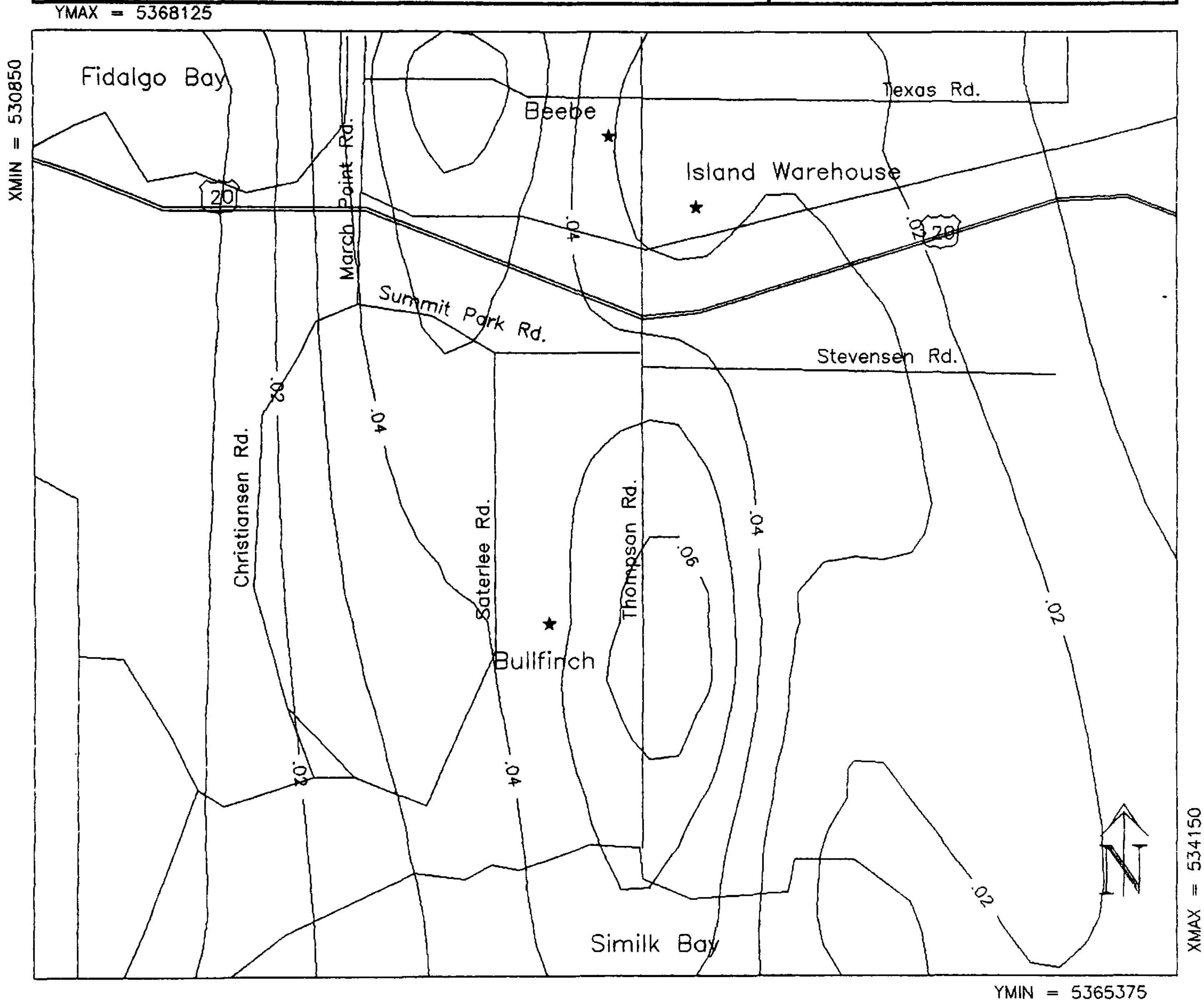
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 11

CASE 11 - SHORTZ
3-Hour Concentrations
for May 22, 1985, 1200-1400 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT

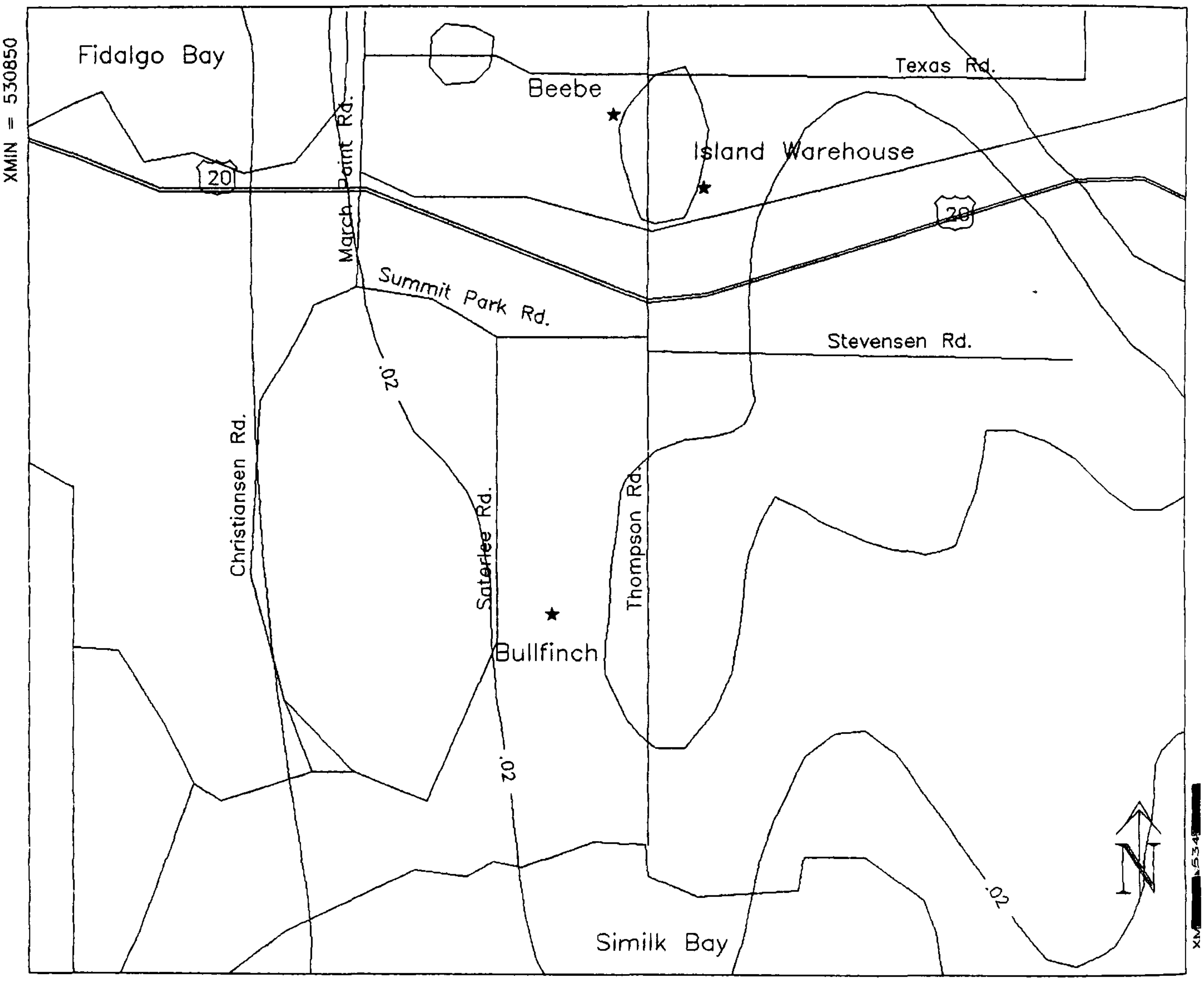
SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.

YMAX = 5368125



YMIN = 5365375

★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 12

CASE 12 - SHORTZ
3-Hour Concentrations
for May 22, 1985, 1300-1500 PST
(contour interval = 0.01 ppm)

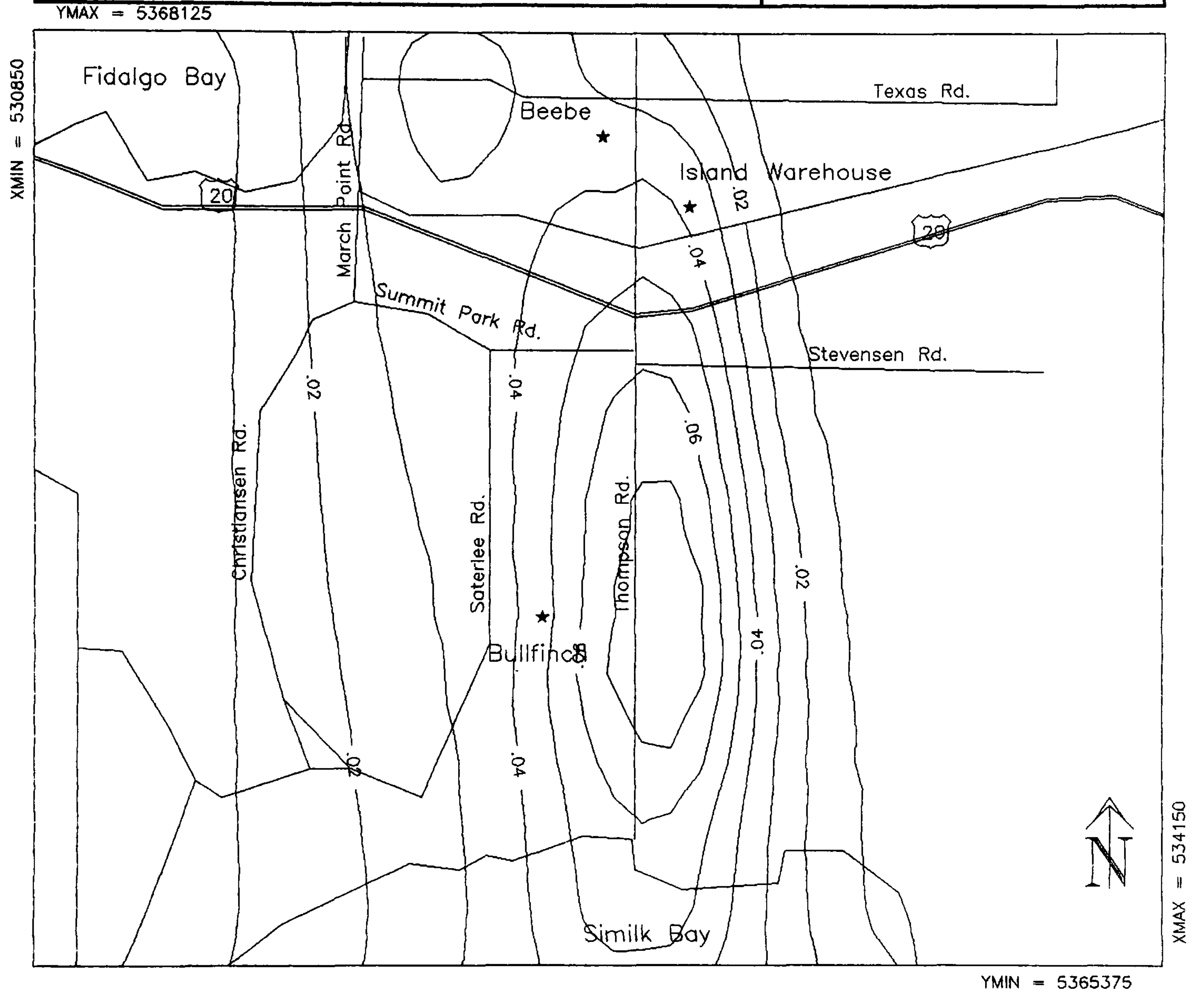
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5

Scale in Kilometers

Figure 13

CASE 13 - SHORTZ
3-Hour Concentrations
for June 24, 1985, 1200-1400 PST
(contour interval = 0.01 ppm)

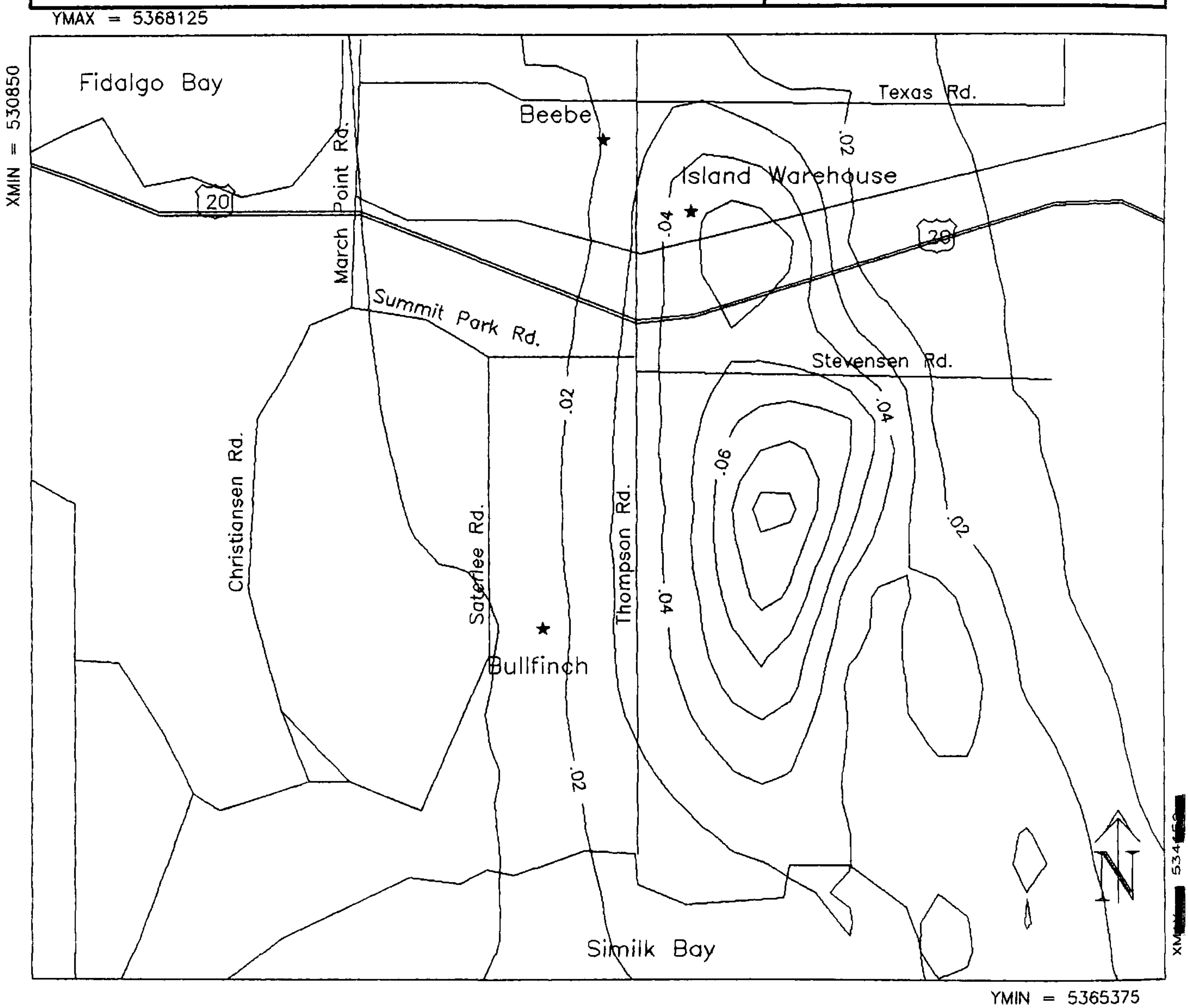
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 14

CASE 14 - SHORTZ
3-Hour Concentrations
for Aug. 15, 1985, 1100-1300 PST
(contour interval = 0.01 ppm)

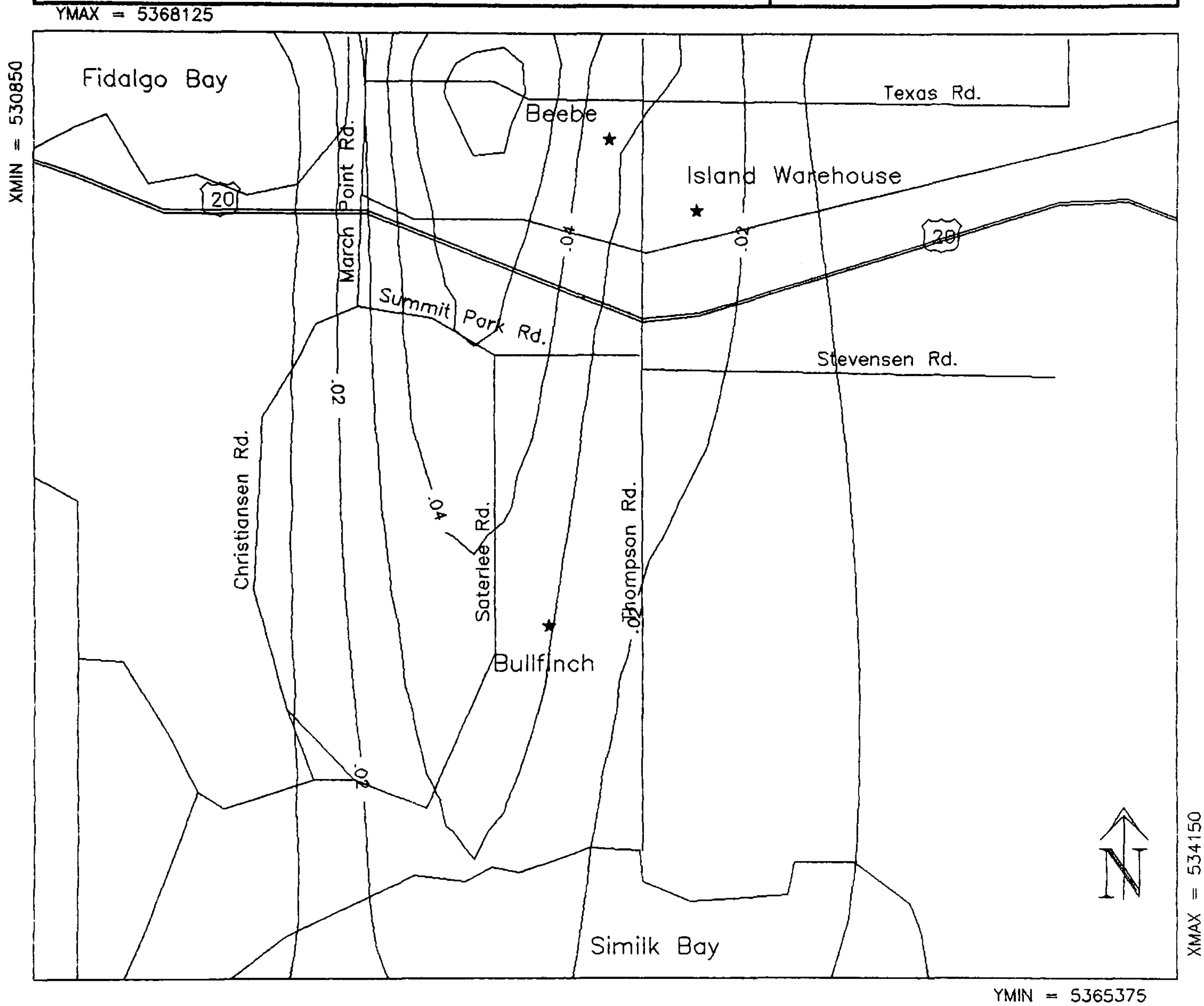
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 15

CASE 15 - SHORTZ
3-Hour Concentrations
for Sept. 27, 1985, 1000-1200 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT

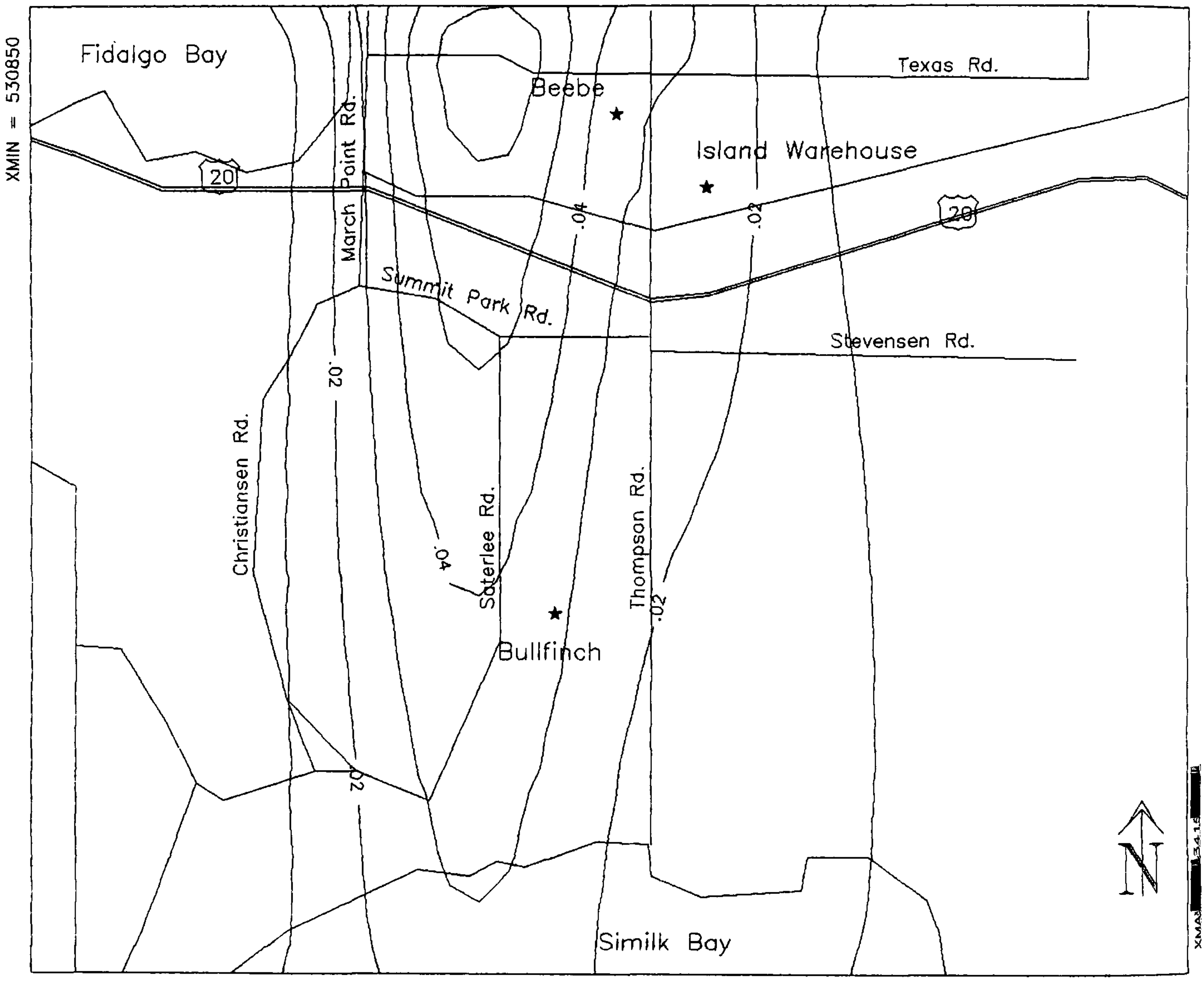
SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.

YMAX = 5368125



YMIN = 5365375

★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 16

CASE 16 - SHORTZ
3-Hour Concentrations
for Sept. 27, 1985, 0900-1100 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT

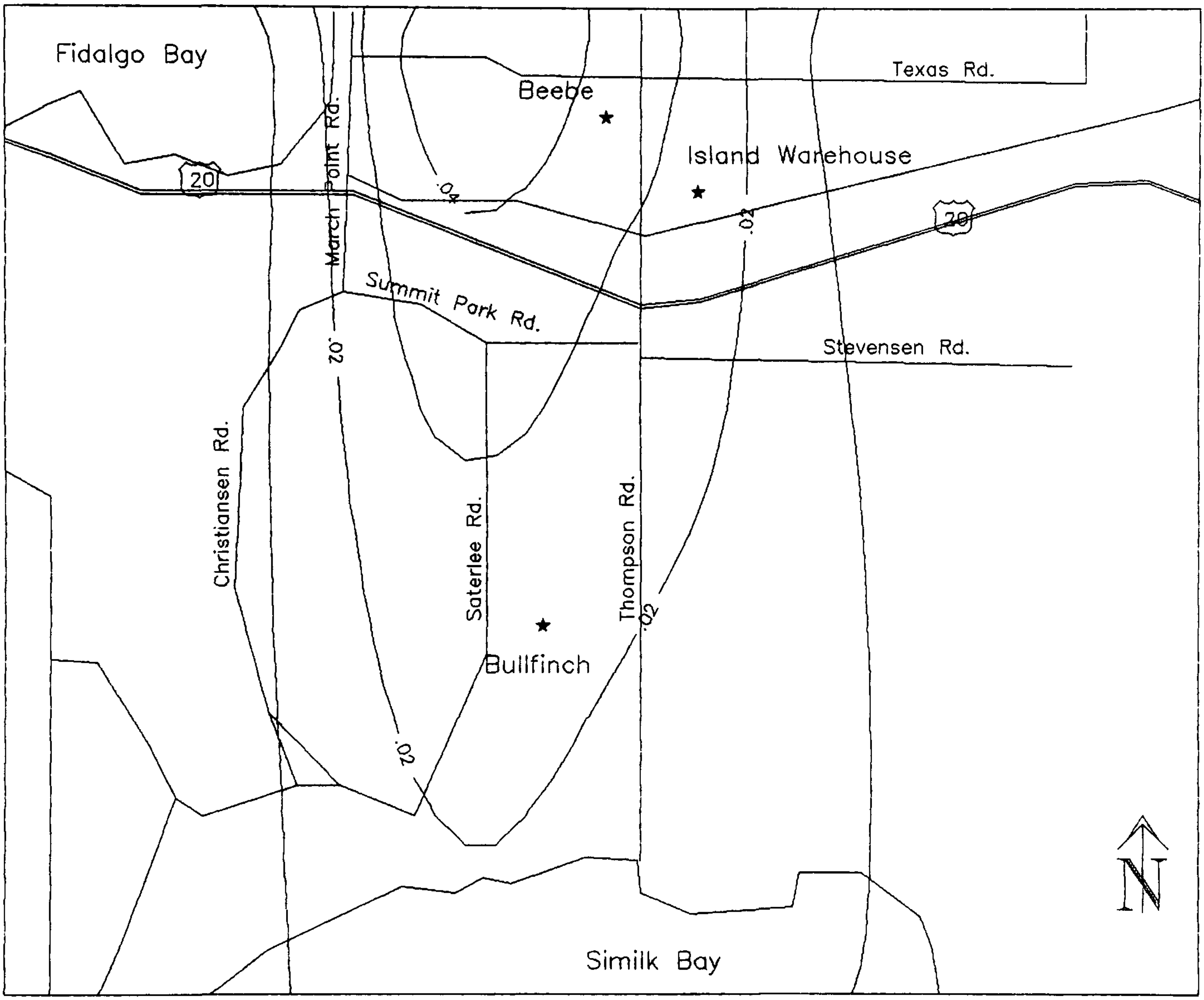
SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.

YMAX = 5368125



YMIN = 5365375

★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 17

CASE 17 - SHORTZ
3-Hour Concentrations
for Sept. 27, 1985, 1100-1300 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.

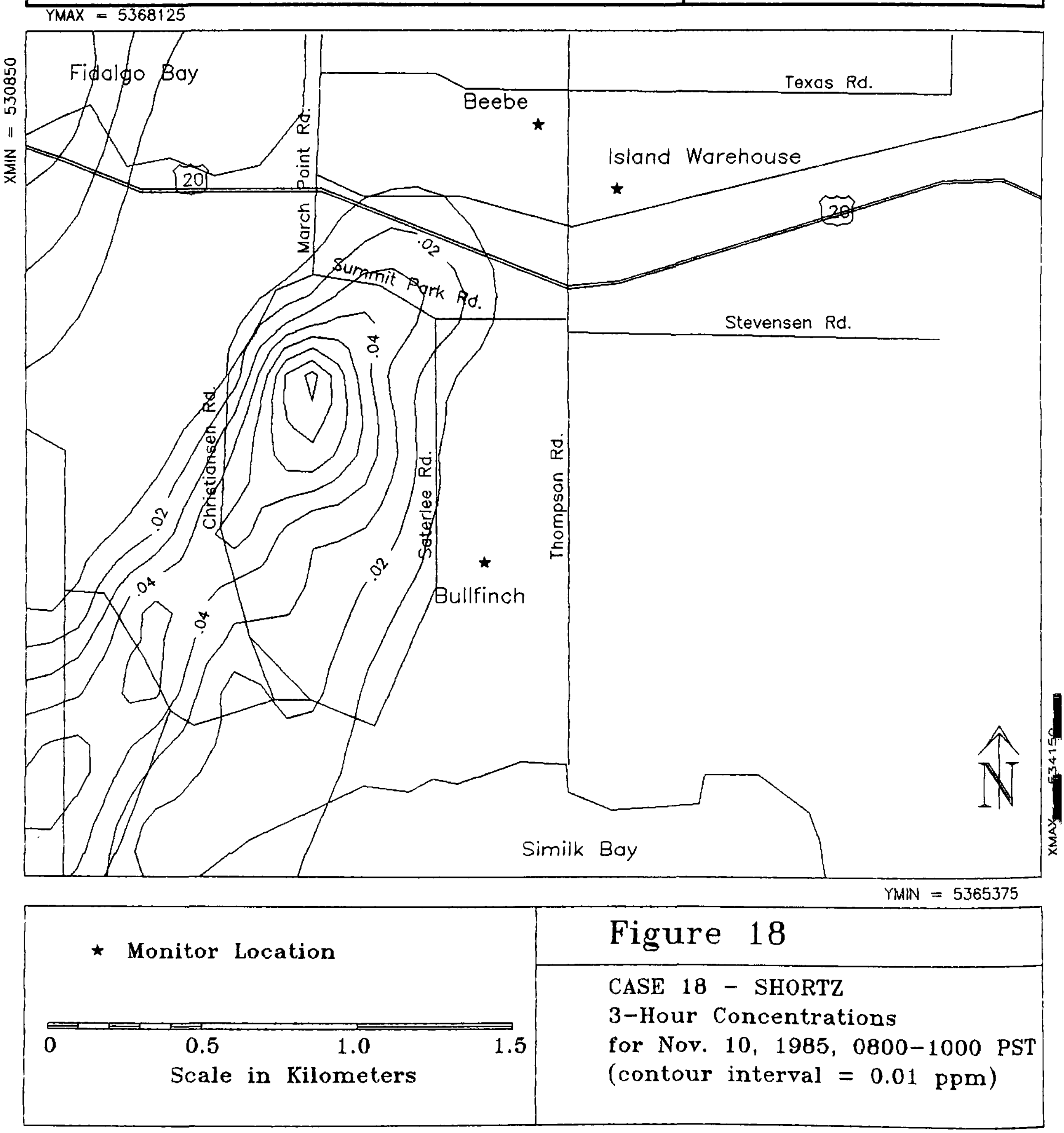


Figure 18

CASE 18 - SHORTZ
3-Hour Concentrations
for Nov. 10, 1985, 0800-1000 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT

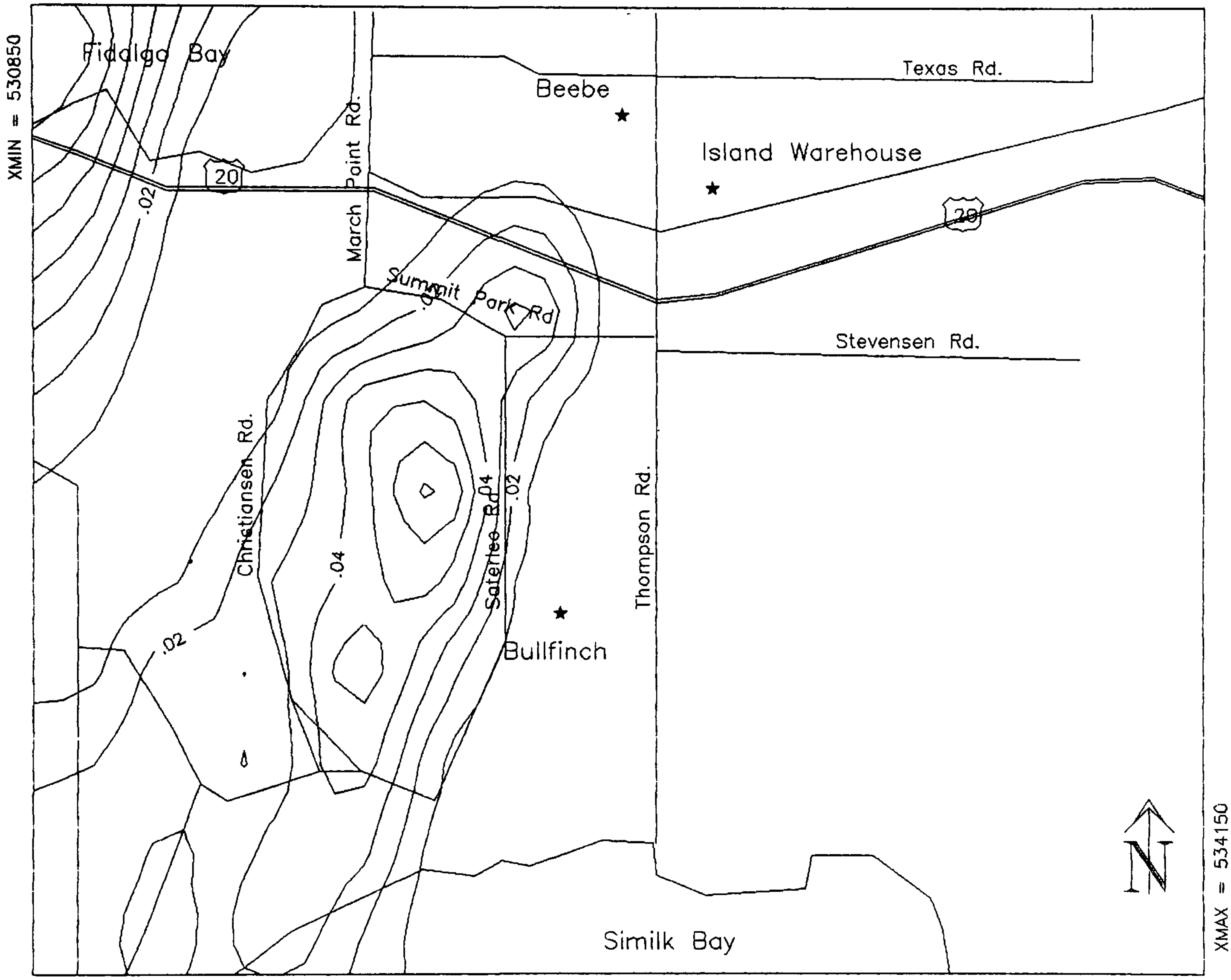
SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.

YMAX = 5368125



YMIN = 5365375

★ Monitor Location

0 0.5 1.0 1.5

Scale in Kilometers

Figure 19

CASE 19 - SHORTZ
3-Hour Concentrations
for Nov. 10, 1985, 0900-1100 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.

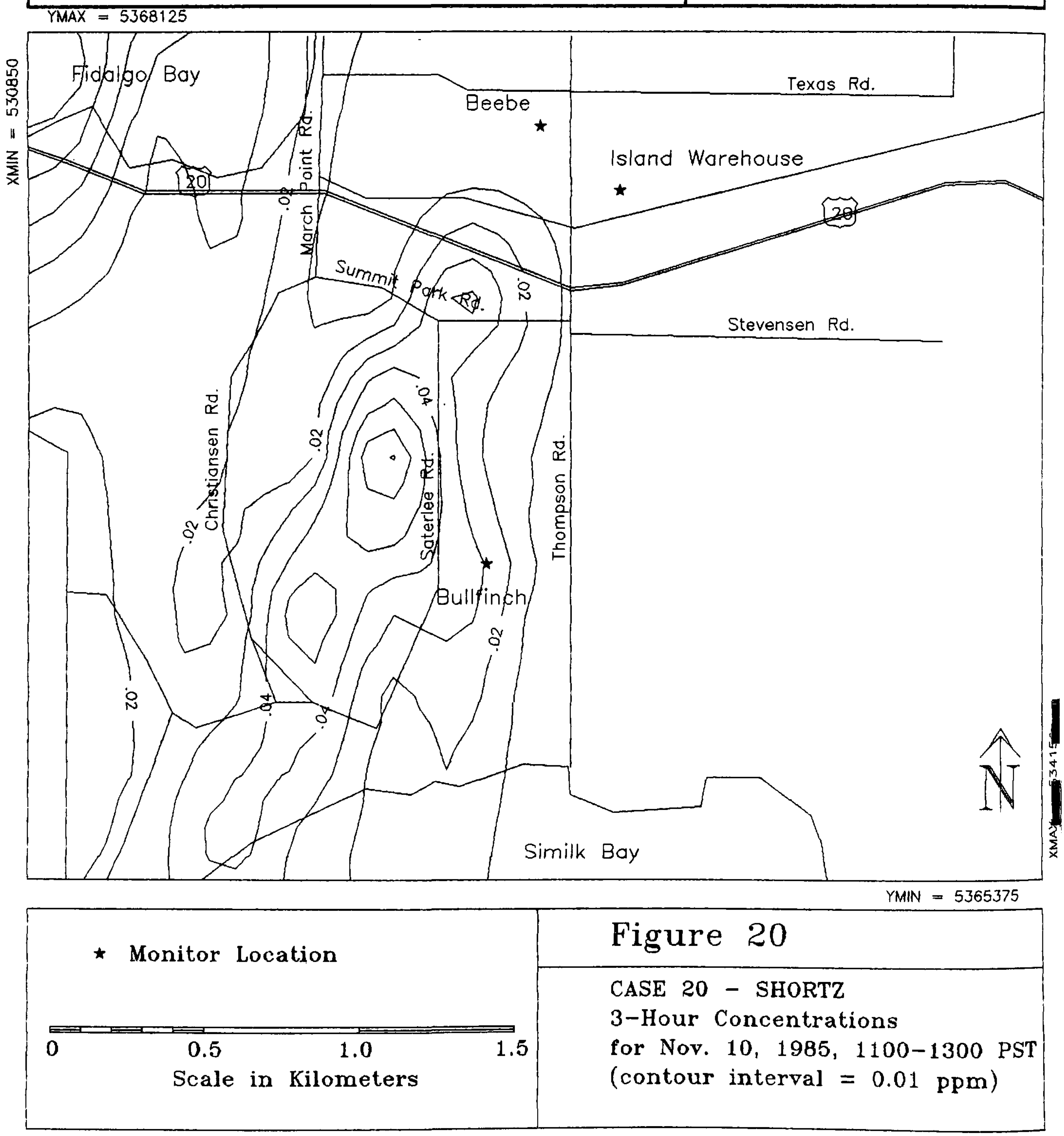


Figure 20

CASE 20 - SHORTZ
3-Hour Concentrations
for Nov. 10, 1985, 1100-1300 PST
(contour interval = 0.01 ppm)

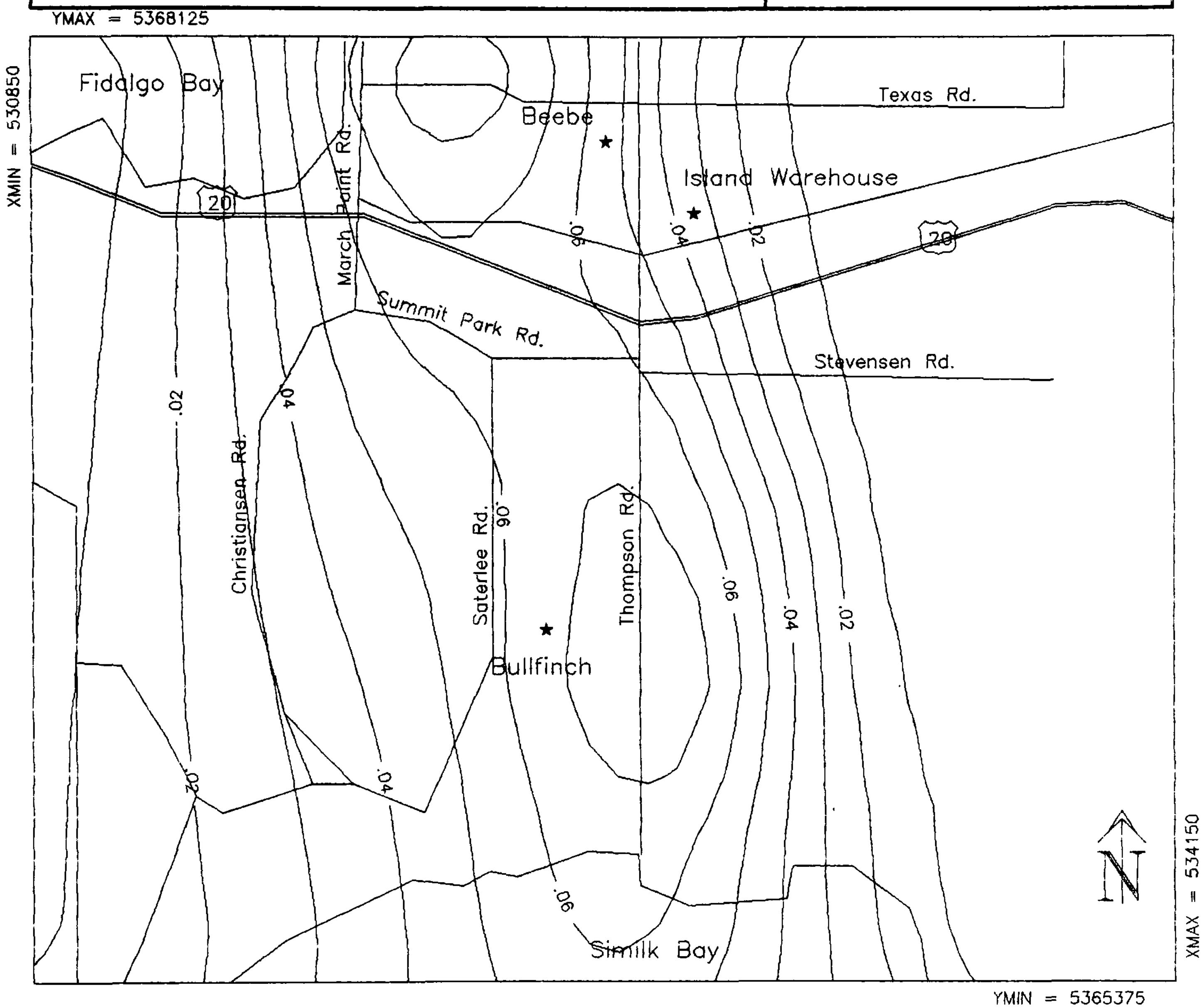
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 21

CASE 1 - ISCST
1-Hour Concentrations
for May 22, 1985, 1300 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

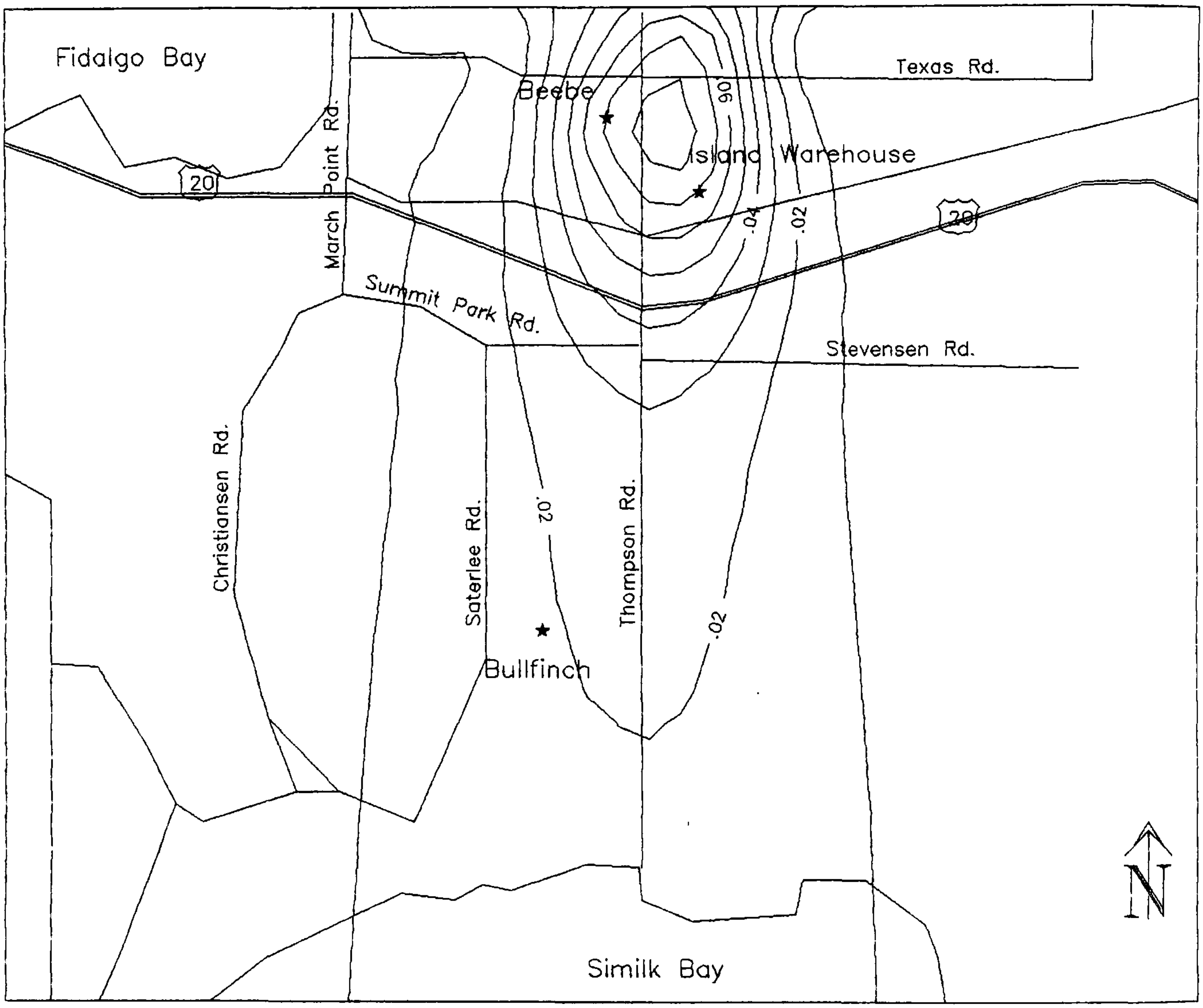
Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.

YMAX = 5368125

XMIN = 530850



XMAX

YMIN = 5365375

★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 22

CASE 2 – ISCST
1-Hour Concentrations
for June 20, 1985, 1300 PST
(contour interval = 0.01 ppm)

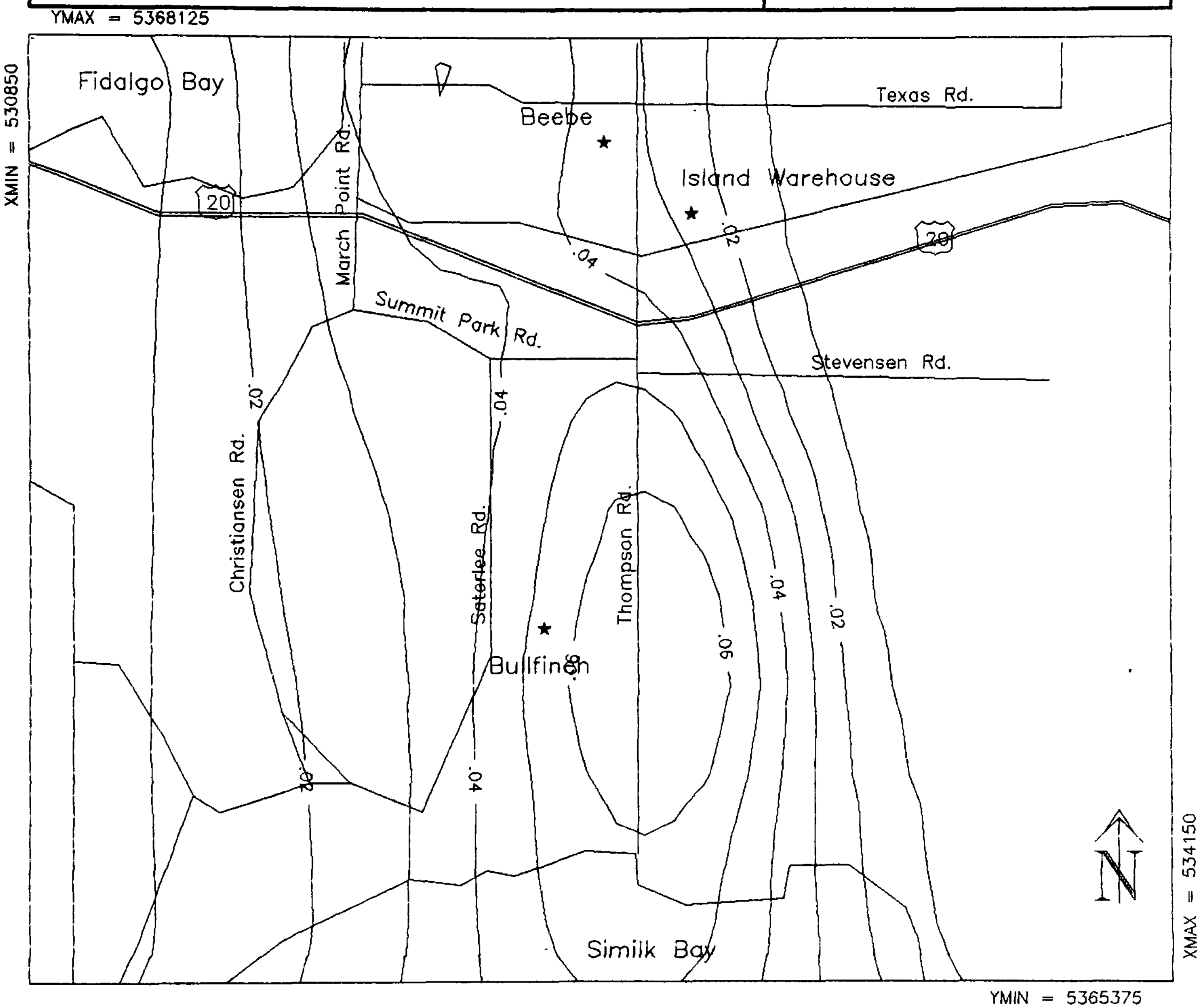
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



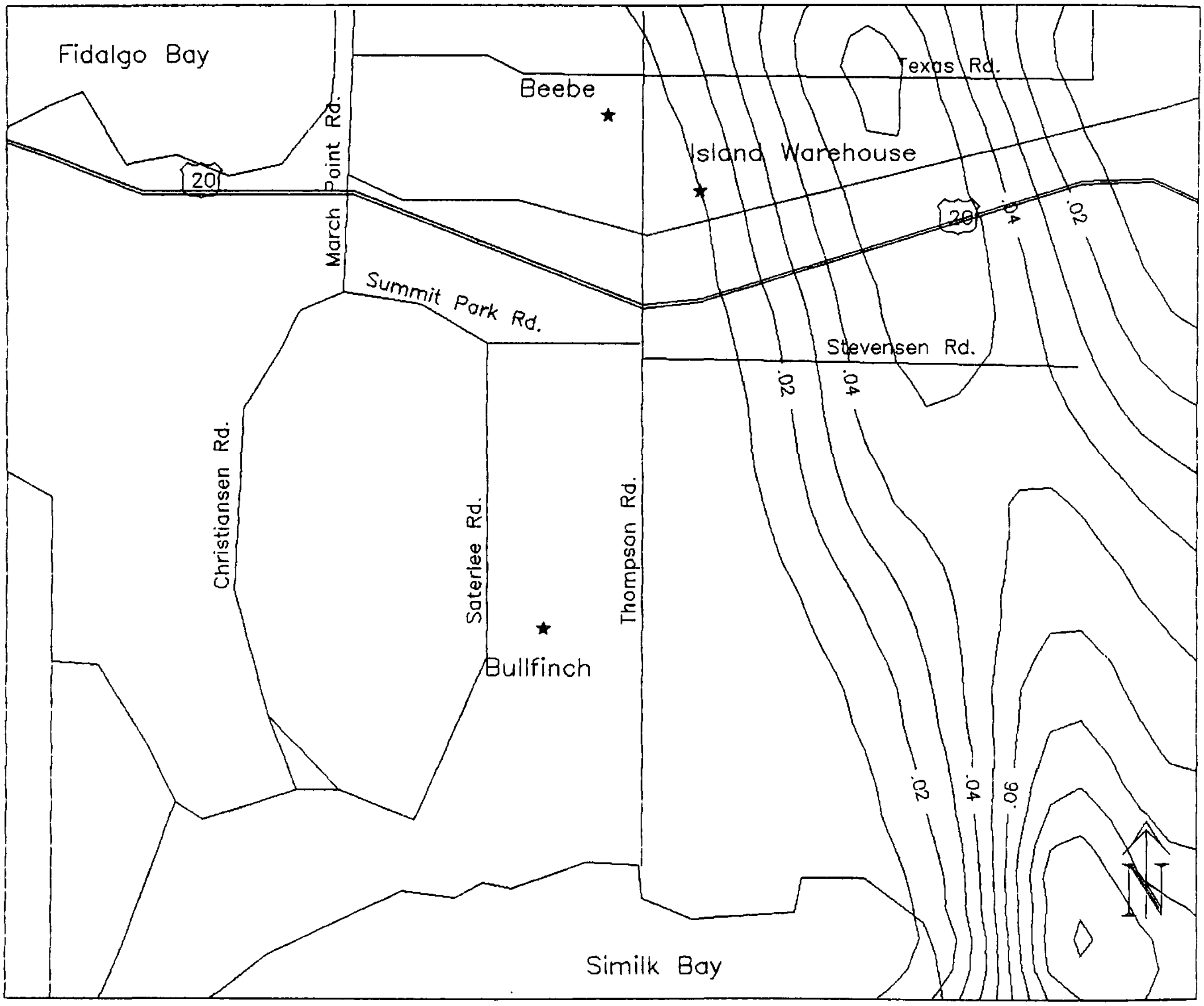
★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 23

CASE 3 - ISCST
1-Hour Concentrations
for June 24, 1985, 1400 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT SO_2 CONCENTRATIONS (ppm)	Date Prepared: Dec. 7, 1986 TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 24

CASE 4 - ISCST
1-Hour Concentrations
for Aug. 14, 1985, 1100 PST
(contour interval = 0.01 ppm)

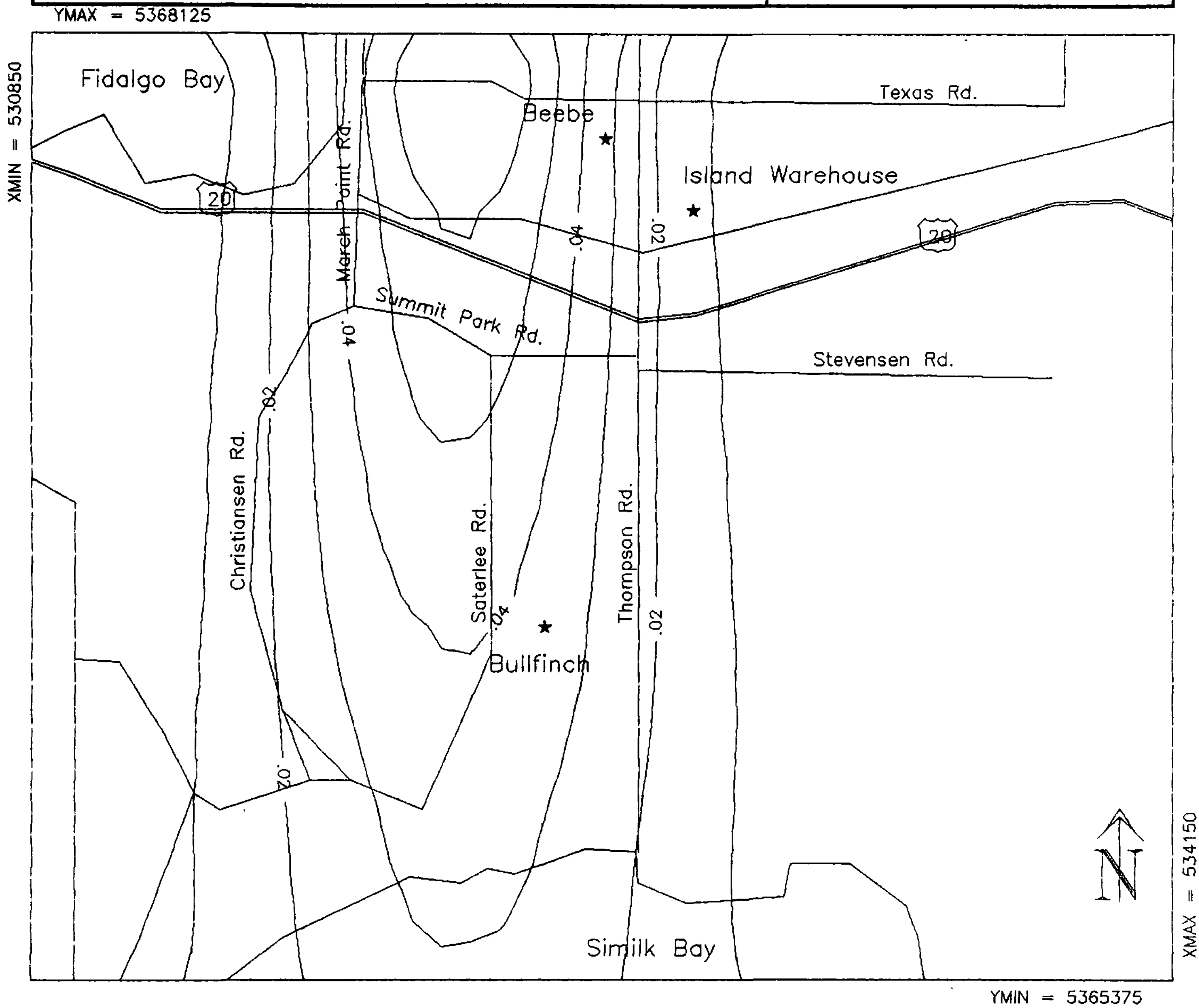
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5

Scale in Kilometers

Figure 25

CASE 5 - ISCST
1-Hour Concentrations
for Sept. 27, 1985, 1200 PST
(contour interval = 0.01 ppm)

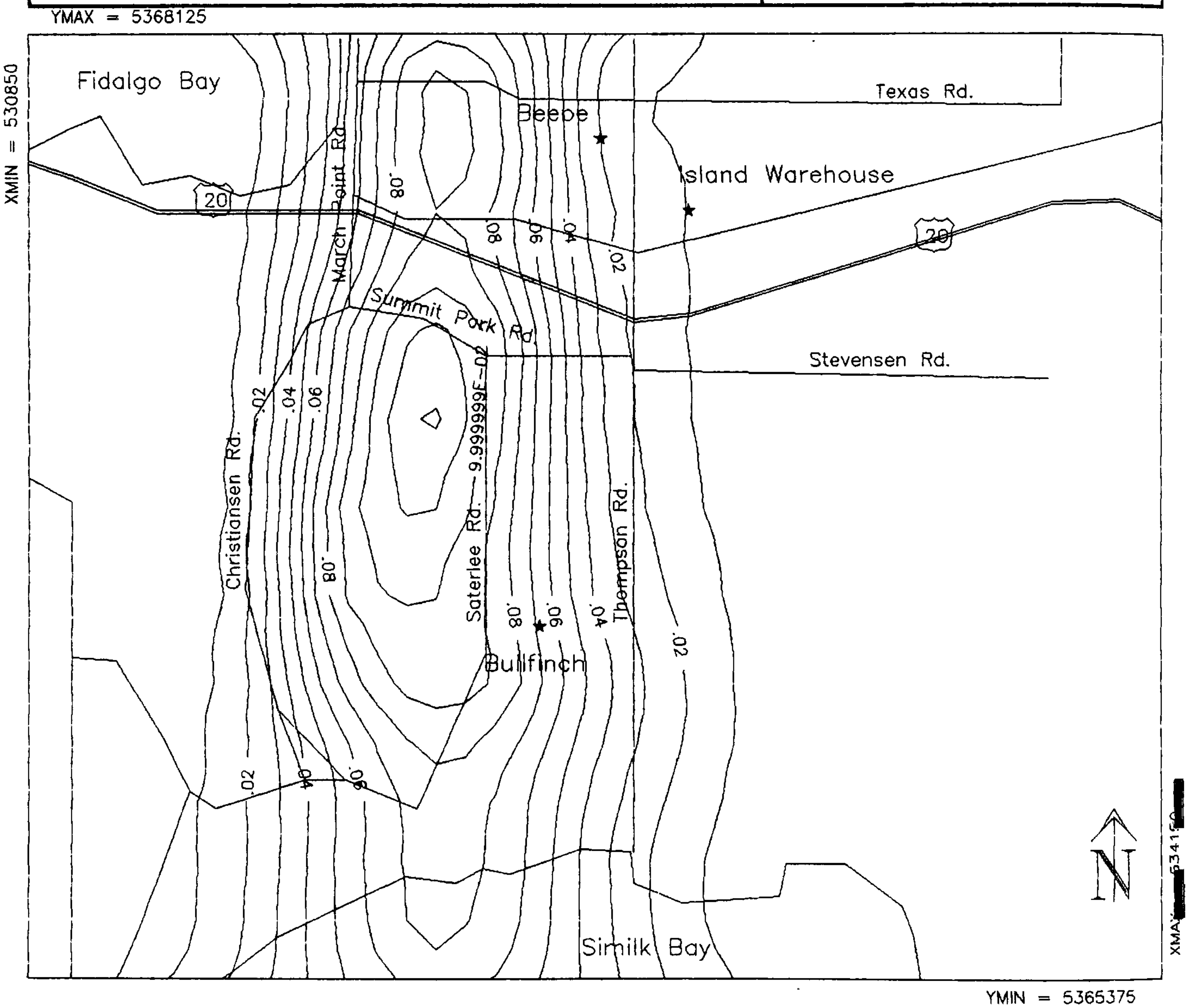
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 26

CASE 6 – ISCST
1-Hour Concentrations
for Sept. 27, 1985, 0900 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT

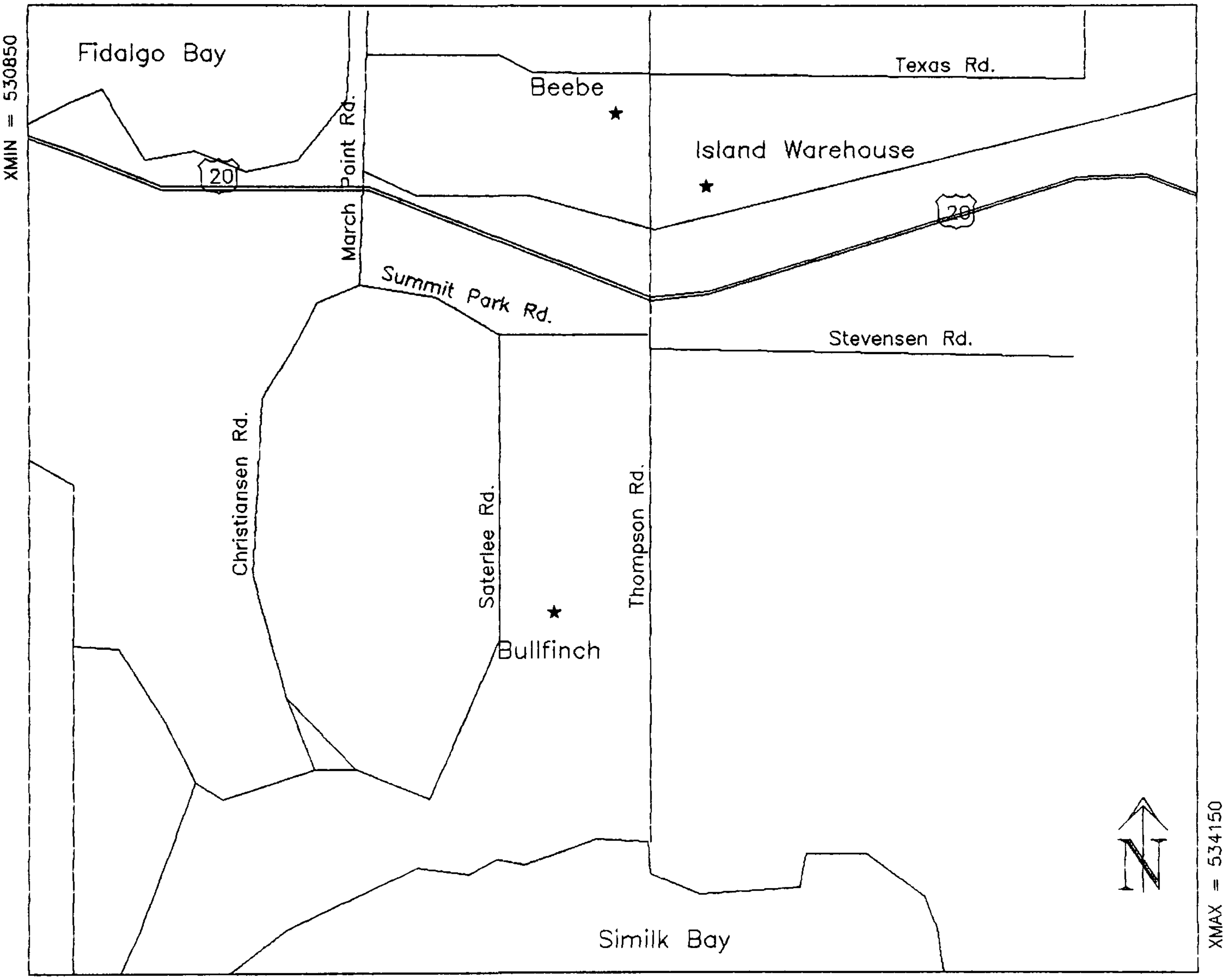
SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.

YMAX = 5368125



YMIN = 5365375

★ **Monitor Location**

0 0.5 1.0 1.5
Scale in Kilometers

Figure 27

CASE 7 - ISCST
1-Hour Concentrations
for Oct. 5, 1985, 1100 PST
(no concentrations)

MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

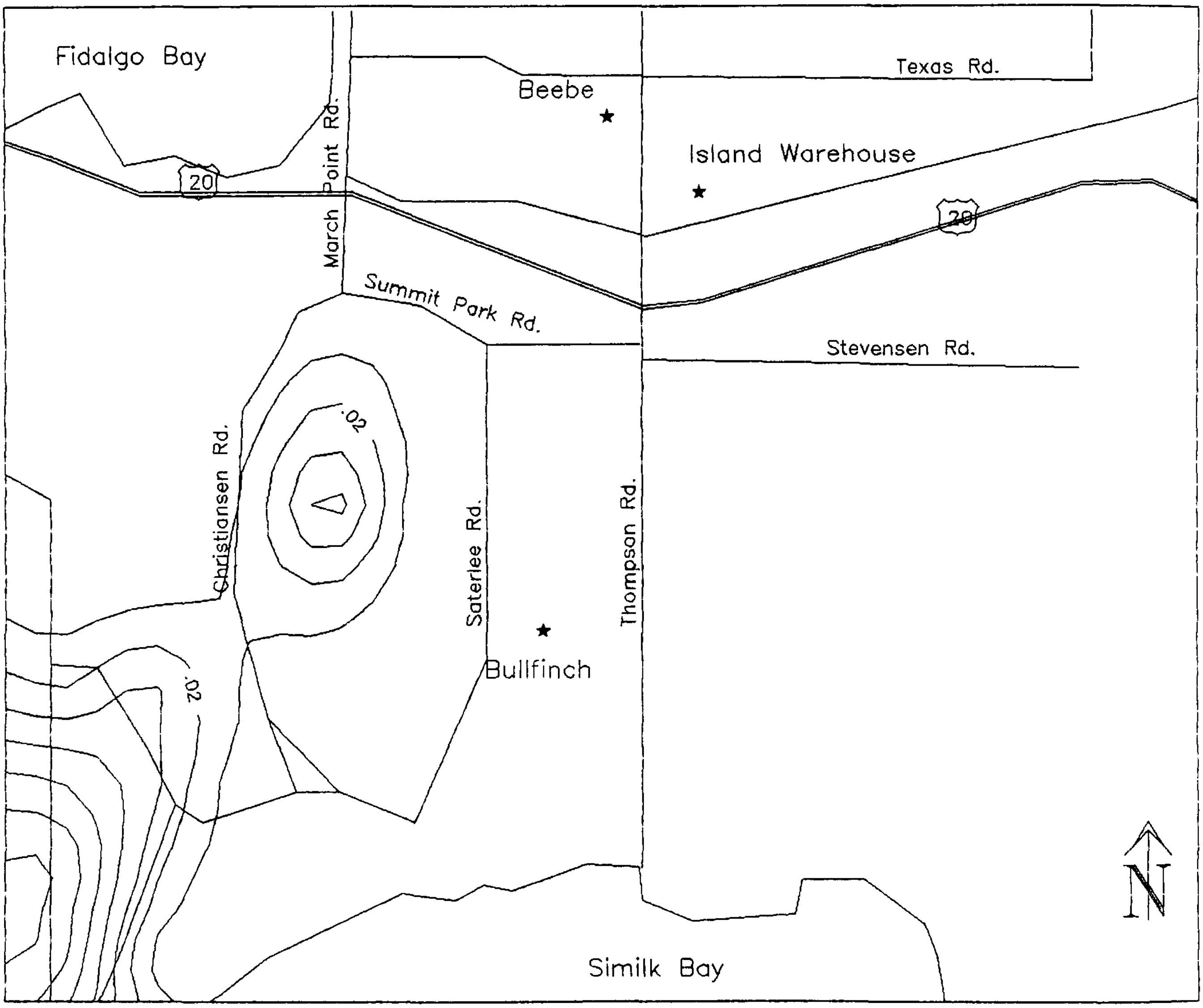
Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.

YMAX = 5368125

XMIN = 530850



YMIN = 5365375

★ Monitor Location

0 0.5 1.0 1.5

Scale in Kilometers

Figure 28

CASE 8 – ISCST
1-Hour Concentrations
for Nov. 10, 1985, 0900 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.

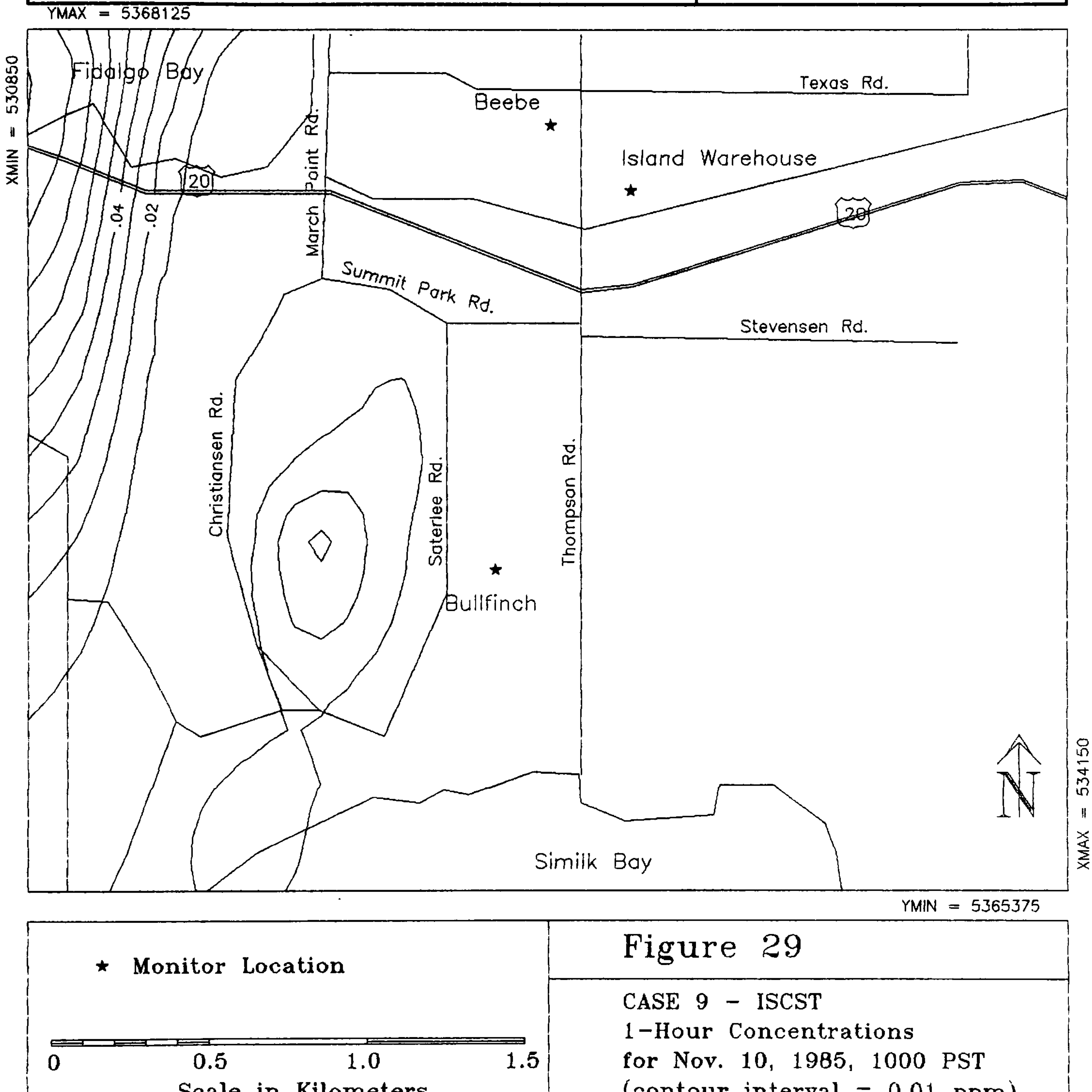


Figure 29

CASE 9 - ISCST
1-Hour Concentrations
for Nov. 10, 1985, 1000 PST
(contour interval = 0.01 ppm)

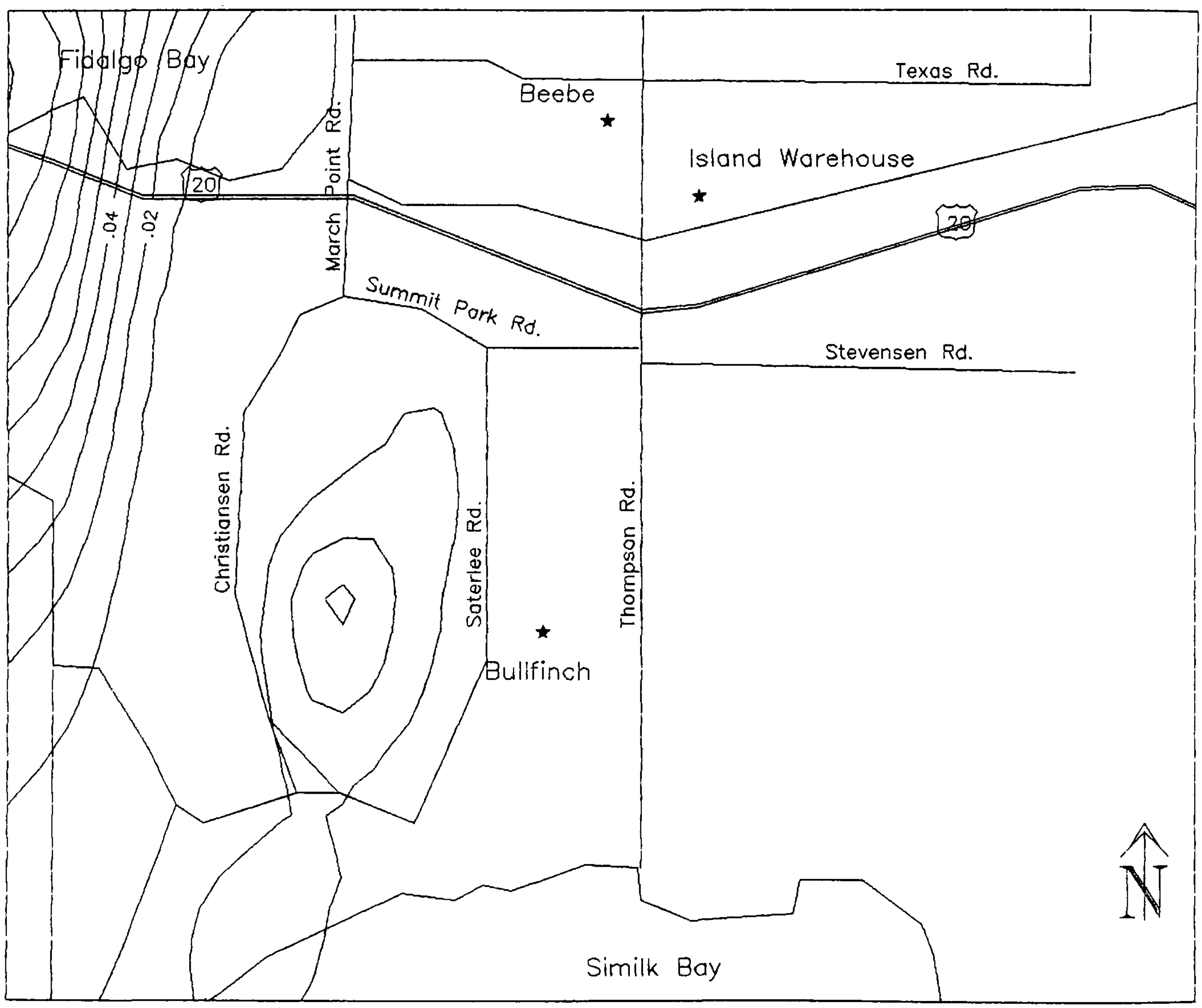
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

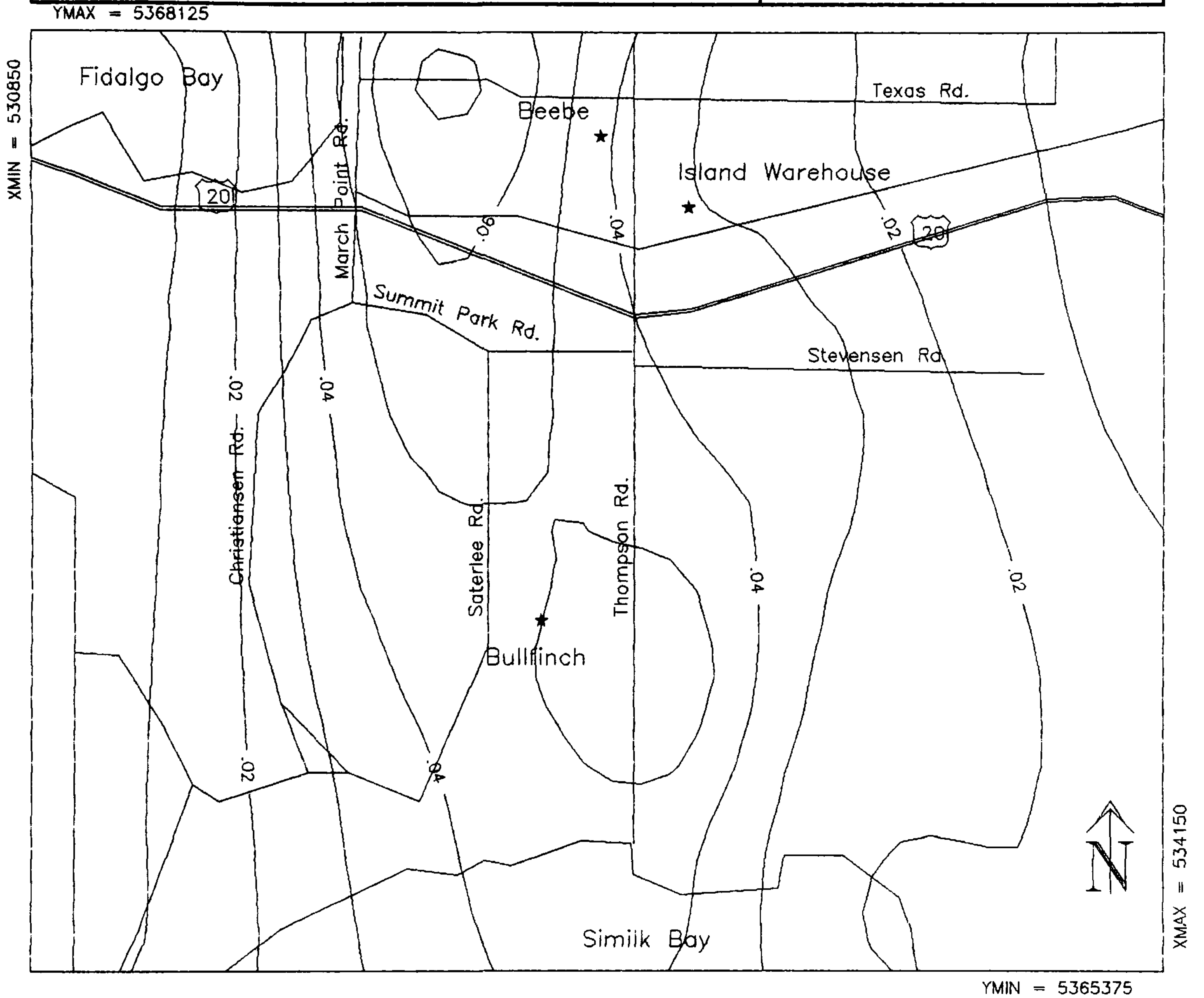
0 0.5 1.0 1.5

Scale in Kilometers

Figure 30

CASE 10 – ISCST
1-Hour Concentrations
for Nov. 10, 1985, 1100 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT SO_2 CONCENTRATIONS (ppm)	Date Prepared: Dec. 7, 1986 TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 31

CASE 11 - ISCST
3-Hour Concentrations
for May 22, 1985, 1200-1400 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.

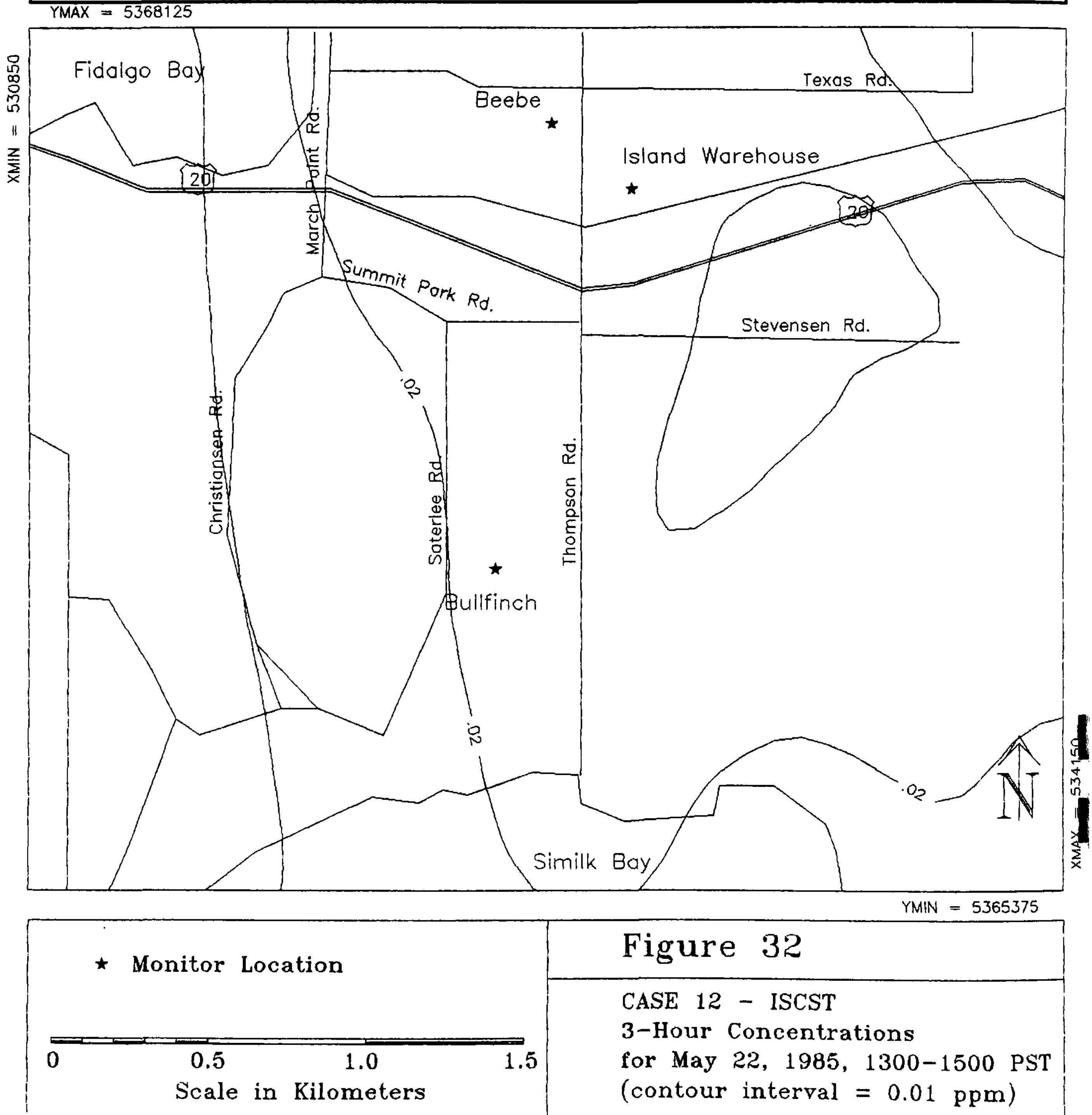
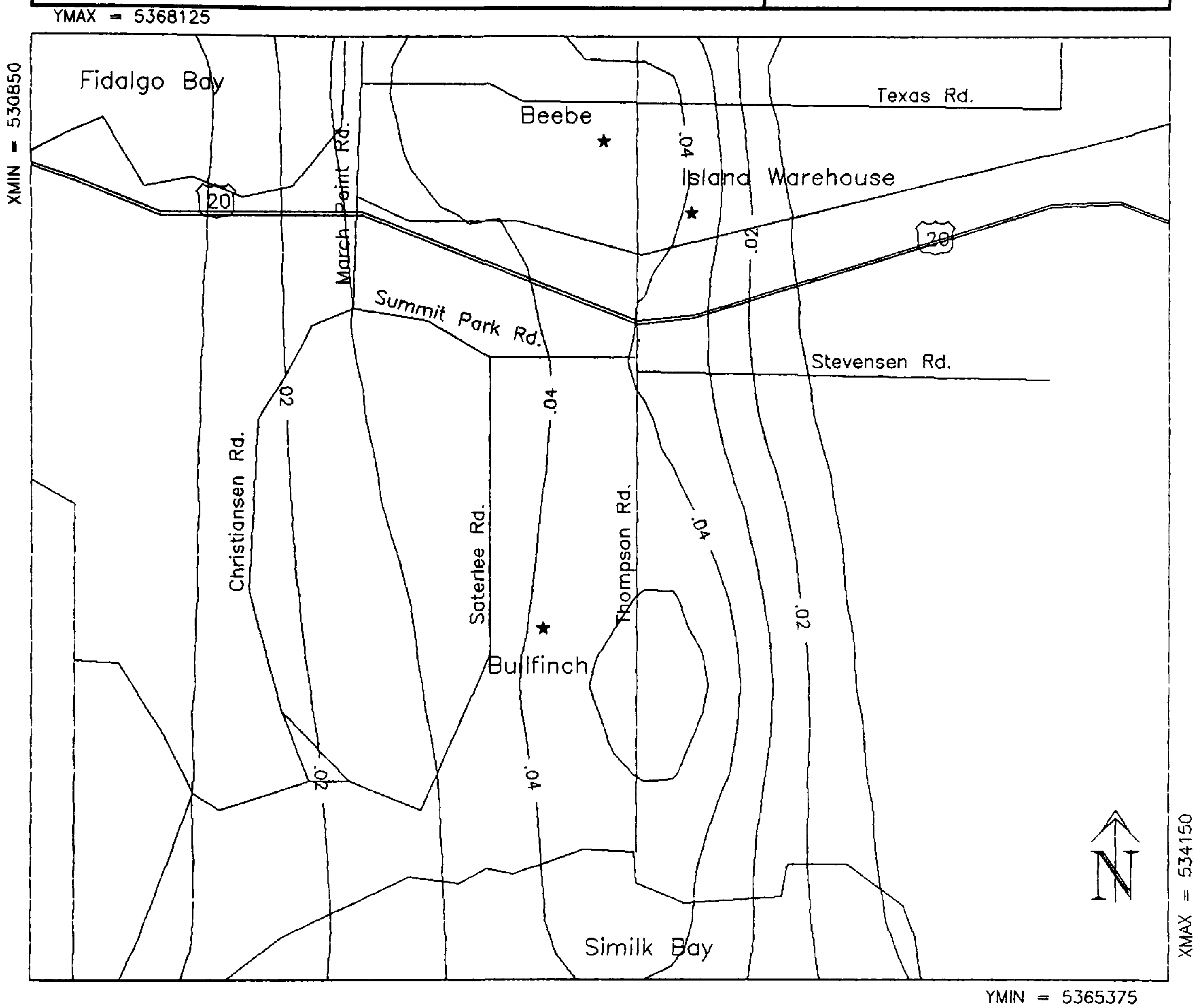


Figure 32

CASE 12 - ISCST
3-Hour Concentrations
for May 22, 1985, 1300-1500 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT SO_2 CONCENTRATIONS (ppm)	Date Prepared: Dec. 7, 1986 TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 33

CASE 13 - ISCST
3-Hour Concentrations
for June 24, 1985, 1200-1400 PST
(contour interval = 0.01 ppm)

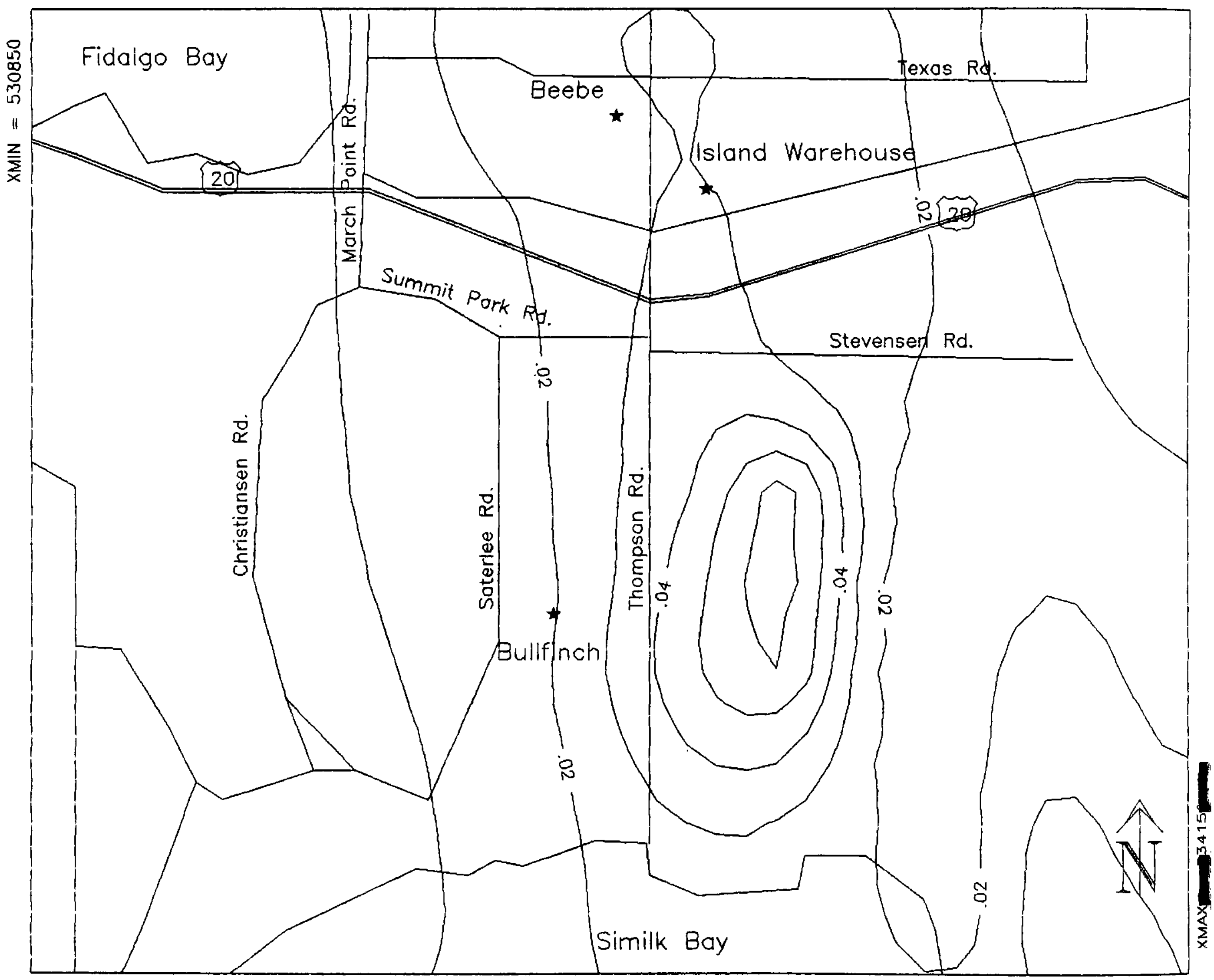
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5

Scale in Kilometers

Figure 34

CASE 14 - ISCST
3-Hour Concentrations
for Aug. 15, 1985, 1100-1300 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT

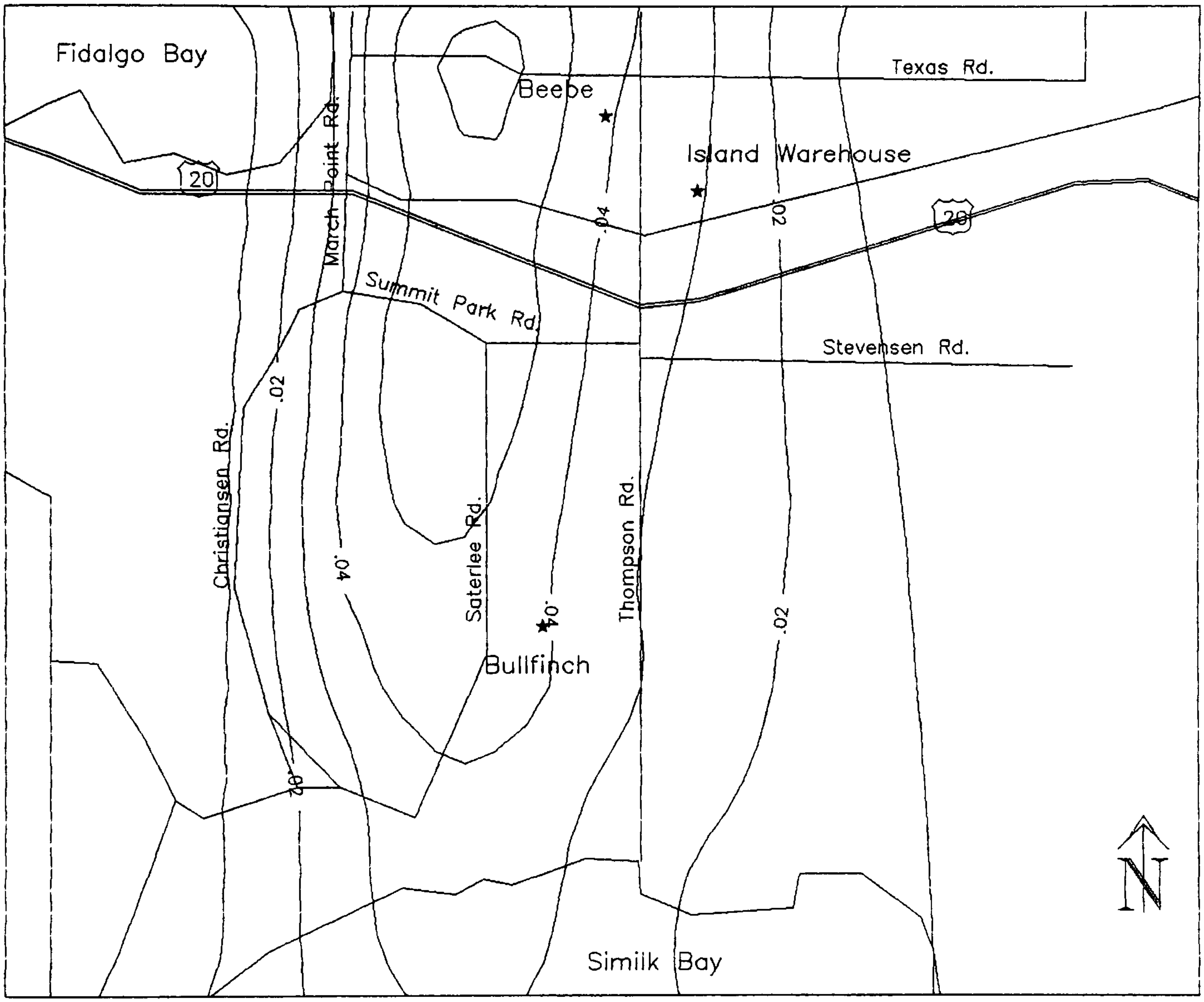
SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.

YMAX = 5368125



YMIN = 5365375

★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 35

CASE 15 - ISCST
3-Hour Concentrations
for Sept. 27, 1985, 1000-1200 PST
(contour interval = 0.01 ppm)

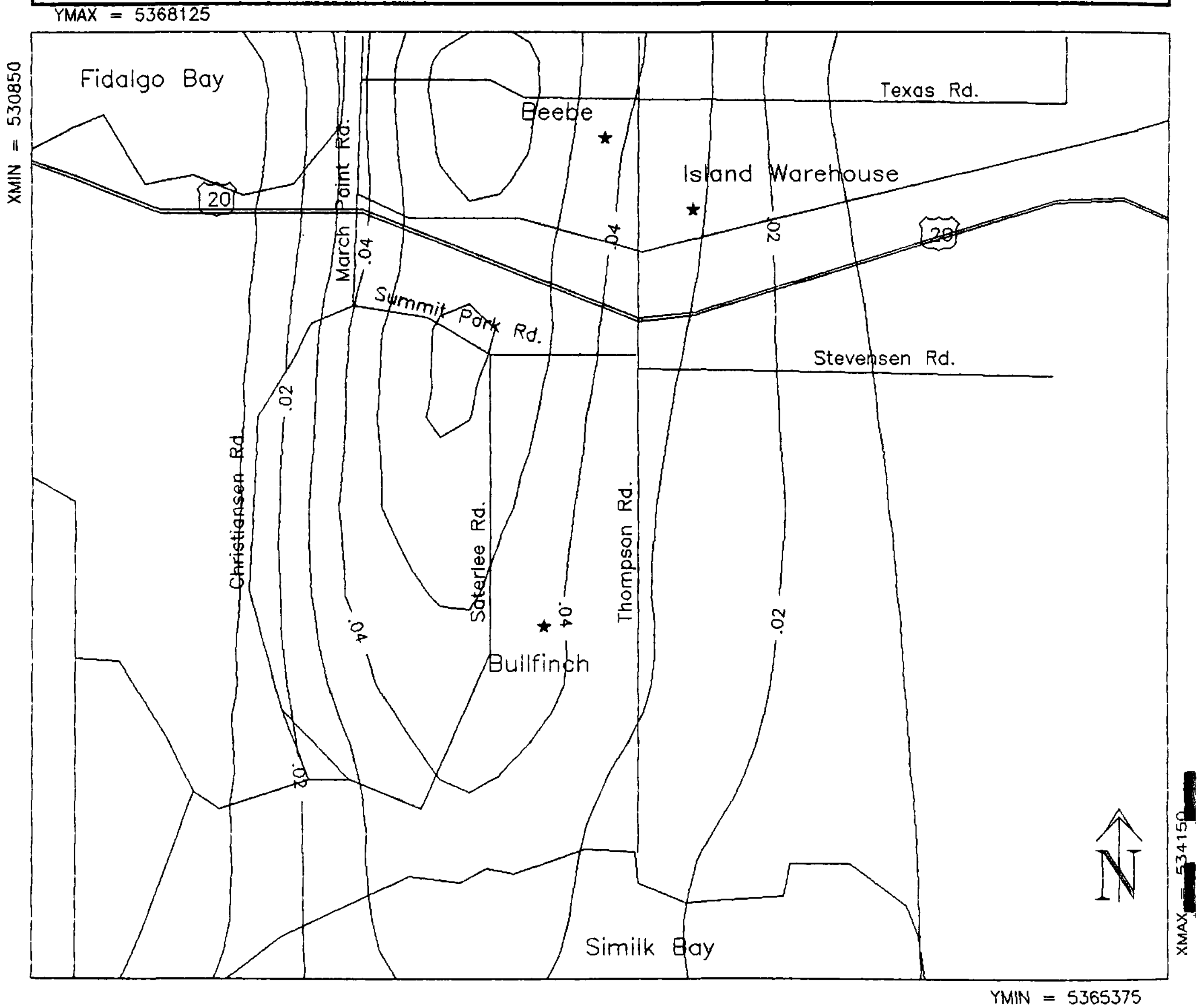
MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.



★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

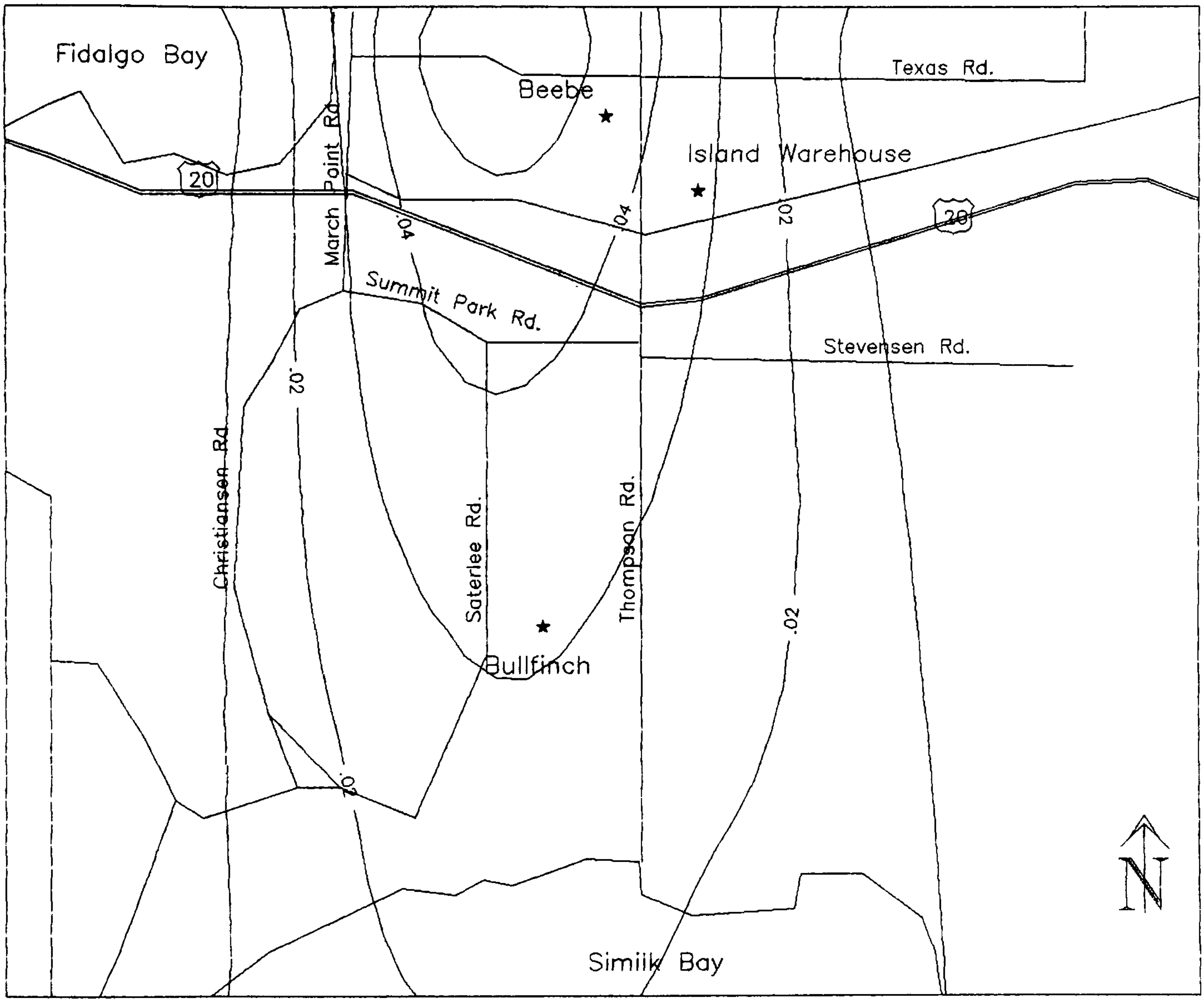
Figure 36

CASE 16 - ISCST
3-Hour Concentrations
for Sept. 27, 1985, 0900-1100 PST
(contour interval = 0.01 ppm)

# MARCH POINT MODEL EVALUATION PROJECT ## SO_2 CONCENTRATIONS (ppm)	Date Prepared: Dec. 7, 1986 TRC Environmental Consultants, Inc.

YMAX = 5368125

XMIN = 530850



XMAX = 534150

YMIN = 5365375

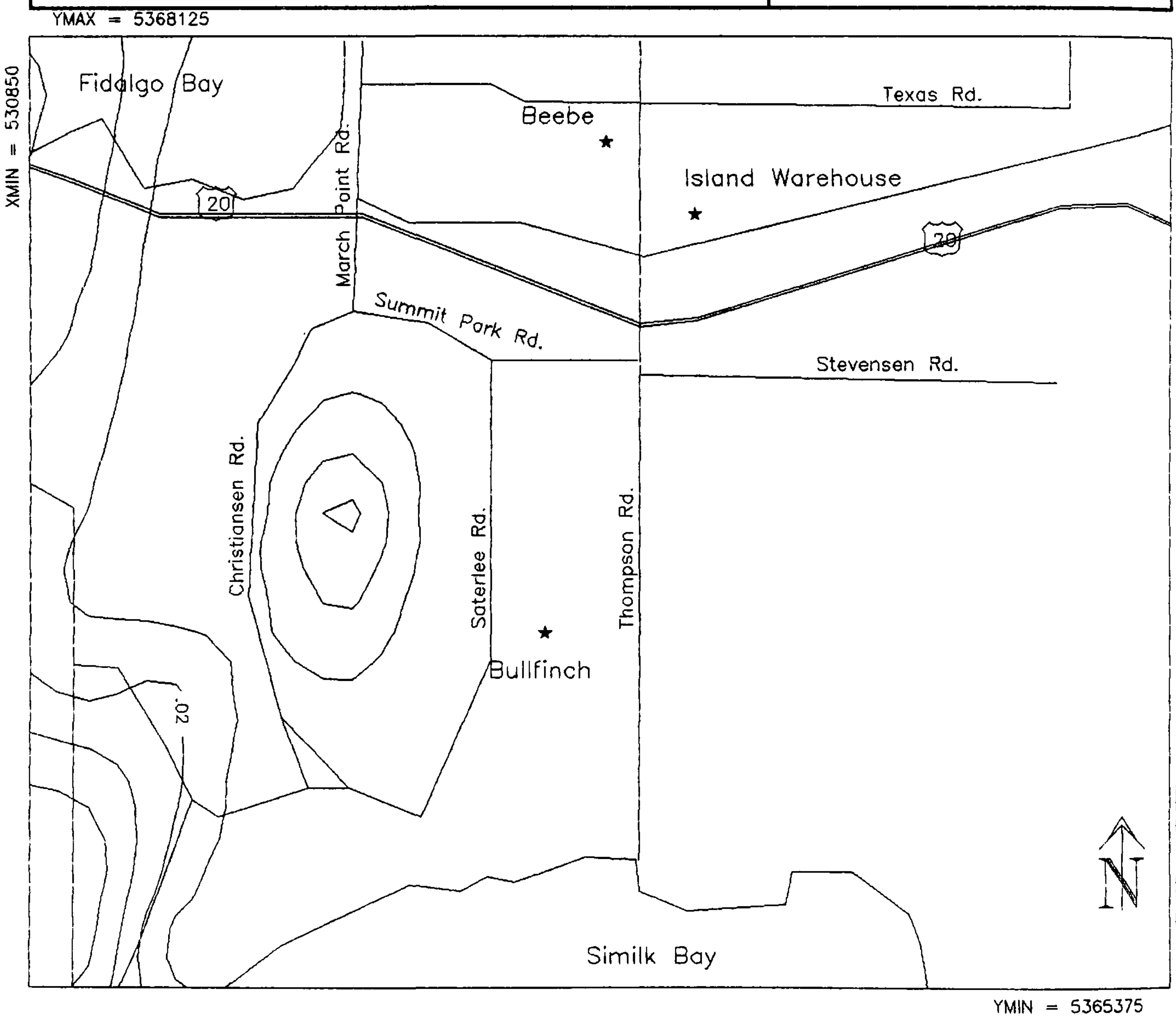
★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 37

CASE 17 - ISCST
3-Hour Concentrations
for Sept. 27, 1985, 1100-1300 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT SO_2 CONCENTRATIONS (ppm)	Date Prepared: Dec. 7, 1986 TRC Environmental Consultants, Inc.



★ Monitor Location 0 0.5 1.0 1.5 Scale in Kilometers	**Figure 38** CASE 18 – ISCST 3-Hour Concentrations for Nov. 10, 1985, 0800–1000 PST (contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT

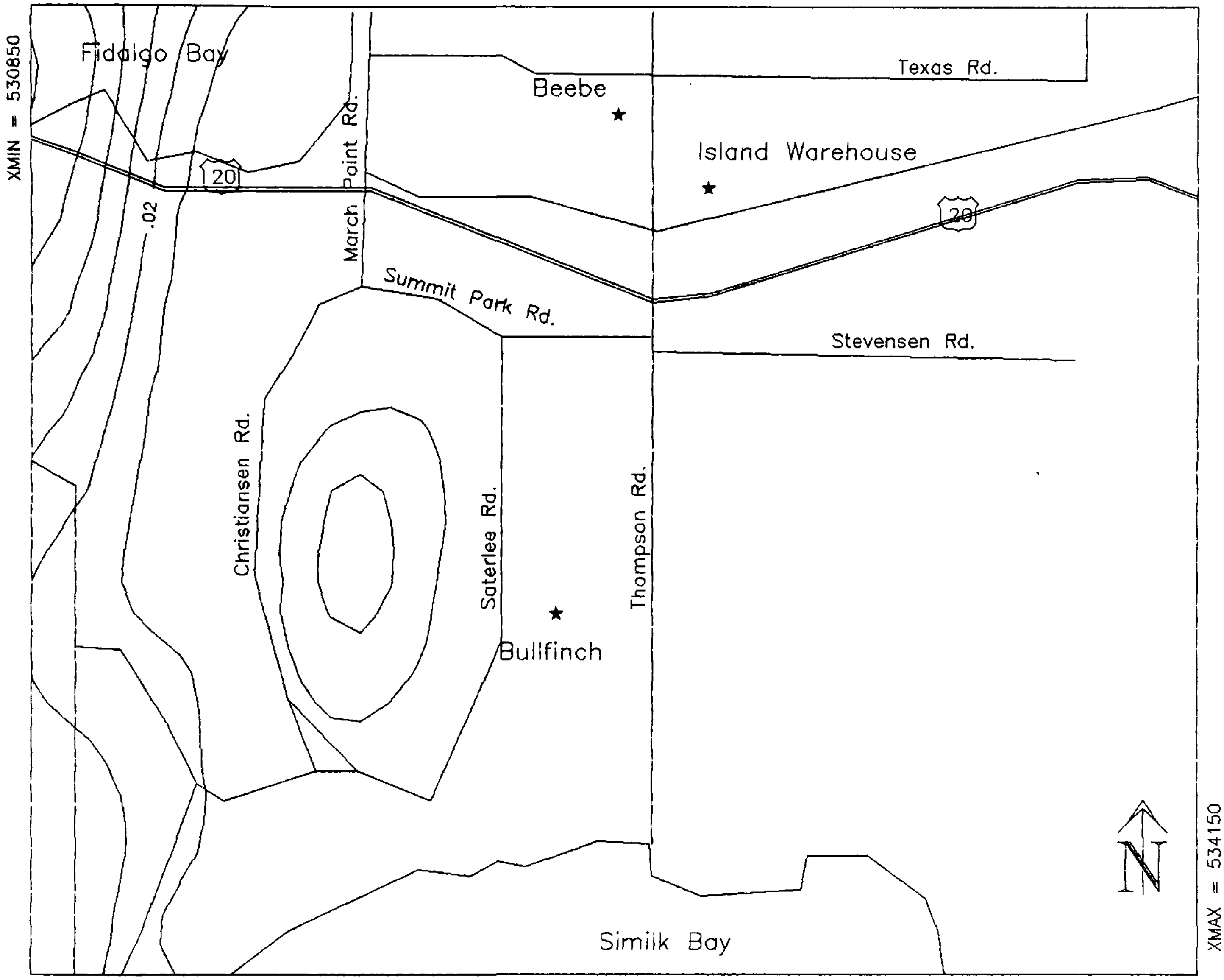
SO_2 CONCENTRATIONS (ppm)

Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.

YMAX = 5368125



YMIN = 5365375

★ Monitor Location

0 0.5 1.0 1.5
Scale in Kilometers

Figure 39

CASE 19 – ISCST
3-Hour Concentrations
for Nov. 10, 1985, 0900–1100 PST
(contour interval = 0.01 ppm)

MARCH POINT MODEL EVALUATION PROJECT

SO_2 CONCENTRATIONS (ppm)

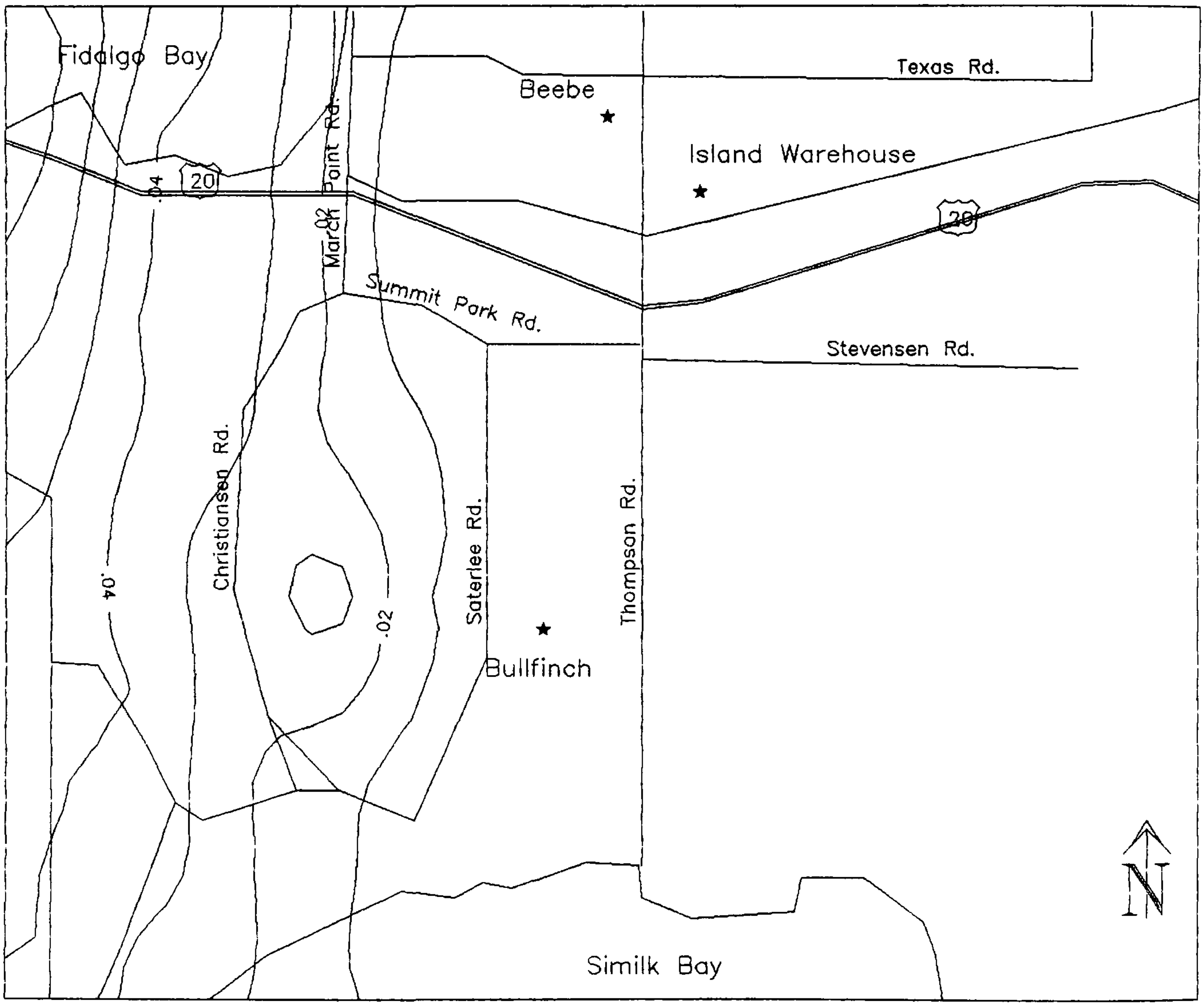
Date Prepared:

Dec. 7, 1986

TRC Environmental Consultants, Inc.

YMAX = 5368125

XMIN = 530850



XMAX

YMIN = 5365375

★ Monitor Location

0 0.5 1.0 1.5

Scale in Kilometers

Figure 40

CASE 20 - ISCST
3-Hour Concentrations
for Nov. 10, 1985, 1100-1300 PST
(contour interval = 0.01 ppm)

coefficients were even lower (0.0001 and 0.005 for the one-hour and three hour cases respectively.

The data from Table 3-1 have been plotted in Figures 41 and 42 in the format of a scatter plot. The lack of correlation is evident by the wide spread from the perfect agreement line which would run on a diagonal from the lower left of the box to the upper right in each of the plots.

Linear regressions are certainly not the only means of evaluation of a model's performance. In fact the linear regression is not often not used in air quality model evaluation, because linear regression illustrates how well two data sets are correlated, but not how accurate the model is at predicting concentrations. The model might over-predict by a factor of five and still give perfect correlation.

More importantly, many regulatory applications concern only the ability of the air quality model to predict the peak or worst-case concentration, not the entire distribution of concentrations. Thus, often the model is evaluated simply in terms of its ability to predict the highest concentrations measured over the entire field of receptors. Cumulative frequency plots are made of the model's performance, where highest predicted is compared to highest measured value without regard to whether the two values coincide in space and time.

A new technique has recently been prepared to assess air quality model performance. The technique, presented by Cox, et. al. (1985) involves the computation of two parameters: a fractional bias of the average values (FB) and a fractional bias of the standard deviation (FO). The FB and FO are then plotted on a special graph and the closer the values come to the center of the graph, the better the agreement of the model

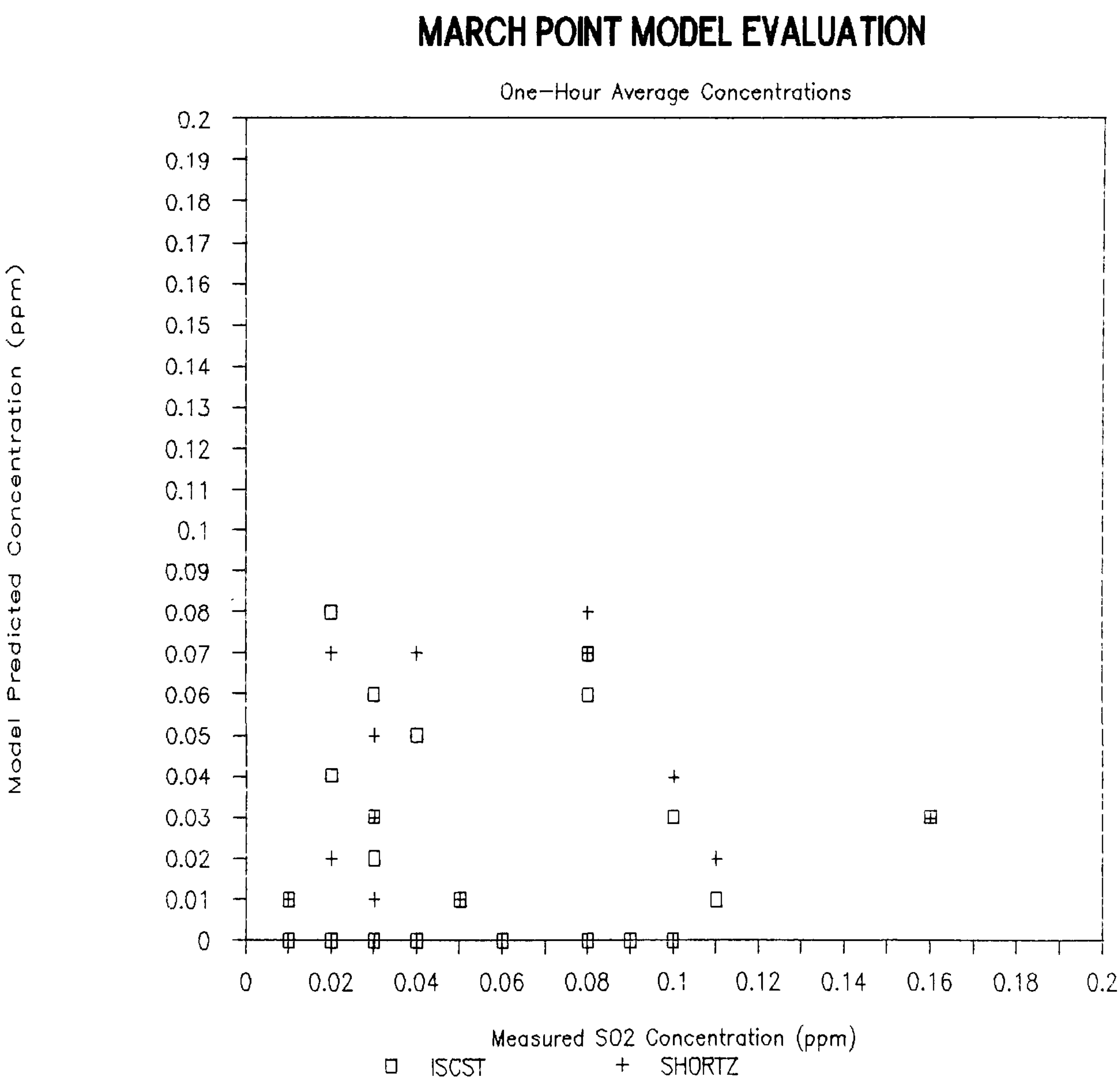


Figure 41 Scatter Plot for 1-hour Concentrations

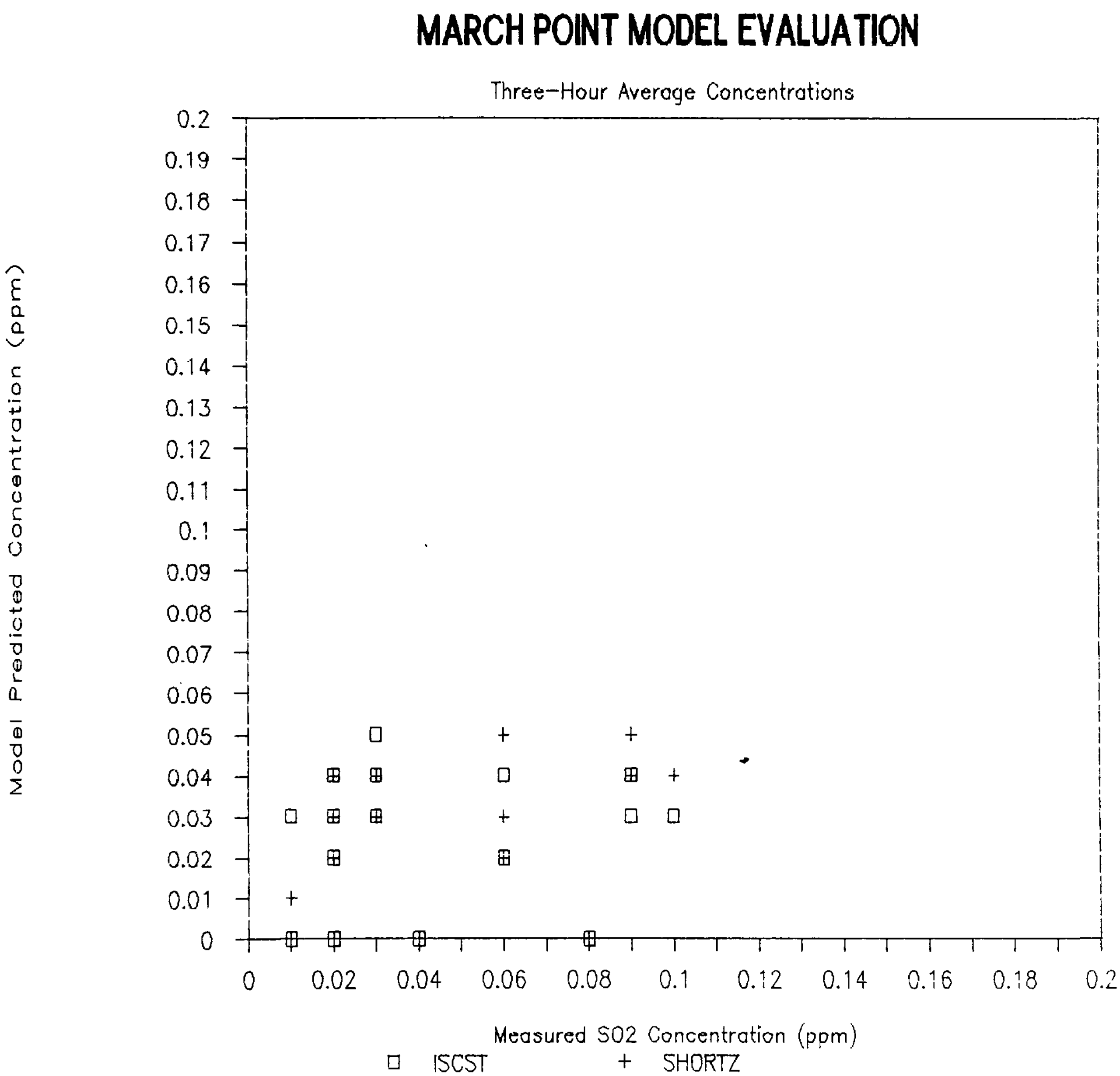


Figure 42 Scatter Plot for 3-hour Concentrations

predictions with observed concentrations.

Figure 43 illustrates such a graph for the current project for the one-hour concentrations. Figure 44 illustrates the same information for the three-hour concentrations. The performance of the ISCST and SHORT air quality models is seen in these figures. The box at the center of each figure is said to represent the "factor of two" agreement that is often referenced for air quality models. As the two figures show, only one of the four points plotted is inside the factor of two box, and even that value (ISCST, 3-hour concentrations) is almost out of the box. In general, then the SHORTZ and ISCST air quality models are not performing within the factor of two performance level when predictions and observations are paired in space and time.

The models both agree on the source apportionment. In general, for the receptors close to the Texaco refinery, the Texaco source does not contribute to the calculated concentrations. The Allied source is a minor contributor during all conditions, due to the low emission rate. The large number and emissions of the Shell sources make them the major contributors for the close receptors, although under some conditions, the Texaco source was seen to contribute 20% of the concentration. For the Bullfinch receptor, the contribution of the Texaco source increases to 40% or more. The reason is that the receptor is higher and the Texaco plume no longer passes overhead as it does with the closer receptors. Additionally, since the source/receptor distance is large, there is more time for the plume to mix to the ground in transit, and since the Texaco source is a major source and closer to the Bullfinch receptor than the Shell or Allied sources, it's percentage contribution increases.

One additional analysis was performed by comparing the maximum

March Point Model Evaluation

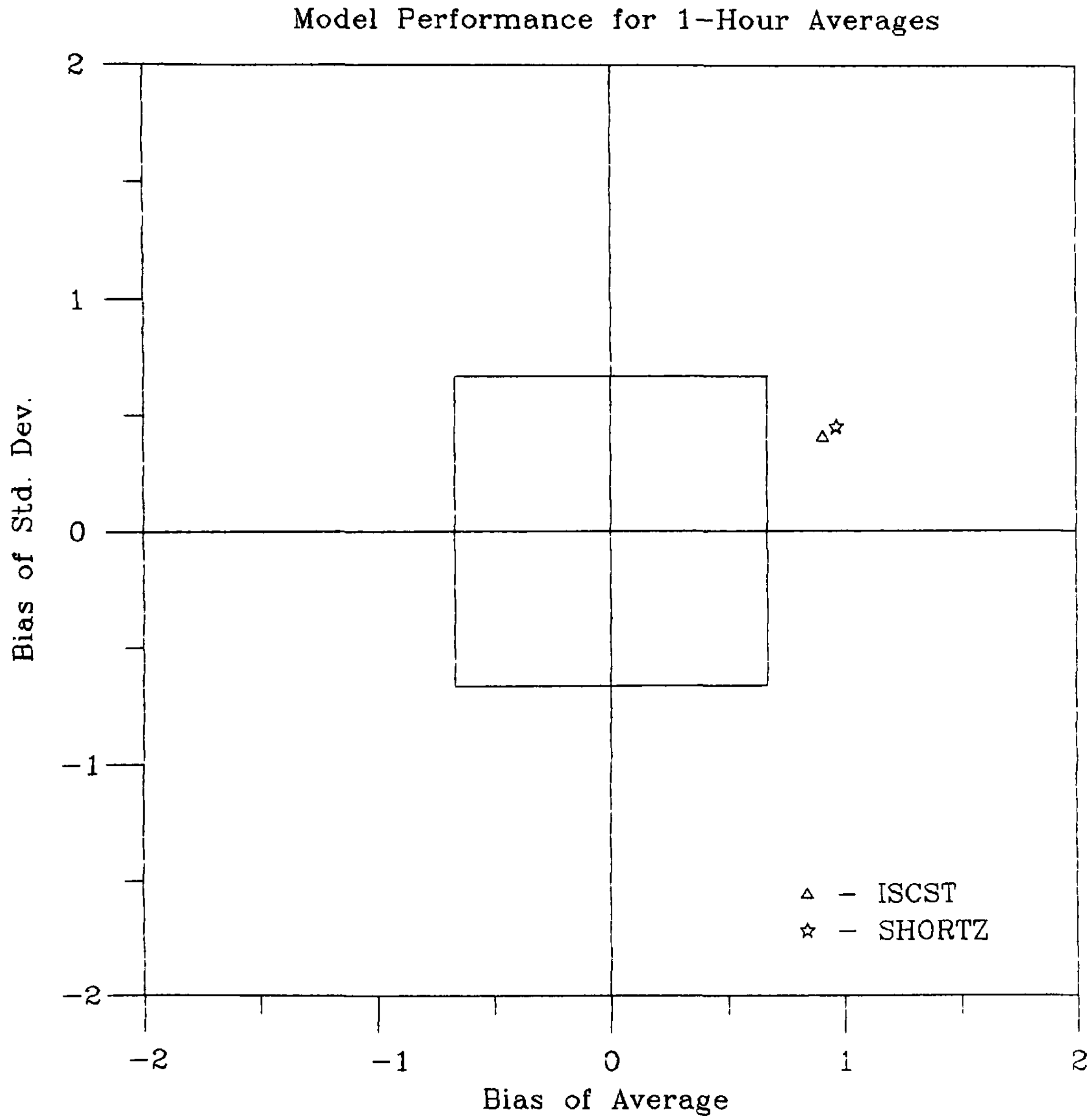


Figure 43

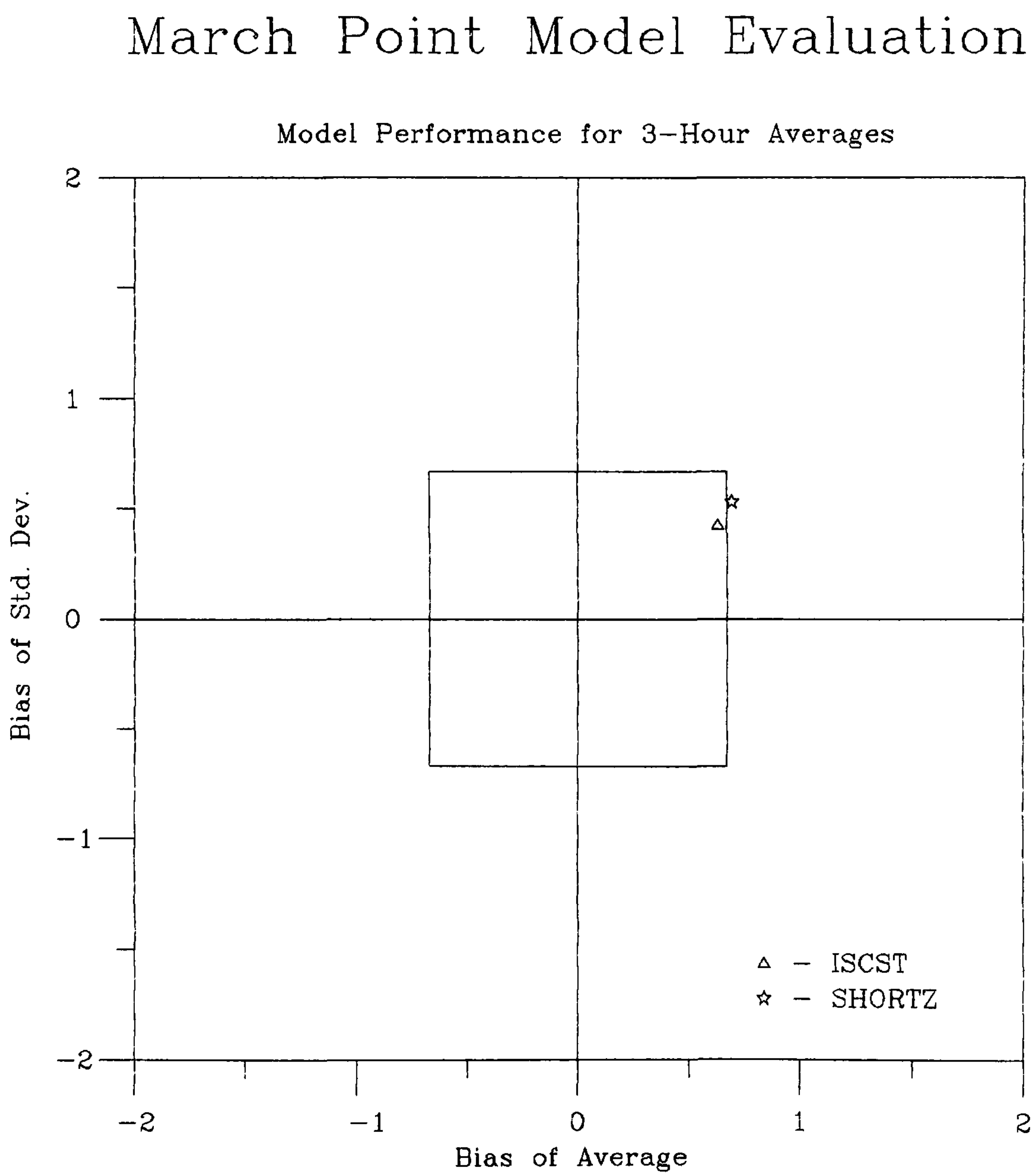

March Point Model Evaluation
Model Performance for 3-Hour Averages
2
1
0
-1
-2
Bias of Std. Dev.
-2
-1
0
1
2
Bias of Average
△ - ISCST
☆ - SHORTZ

Figure 44

prediction and observed concentrations from each time period, regardless of location (paired in time, but unpaired in space). The results, depicted in Figures 45 and 46 indicate agreement between measured and predicted is much better. The implication of this final analysis is that the models are capable of predicting the maximum concentrations, and even capable of predicting when they may occur, but not capable of predicting the location. Therefore the models may not provide accurate siting information for the location of monitors in the vicinity of sources.

The general conclusion is that both the SHORTZ and ISCST air quality models perform poorly with the March Point data. Figures 43 and 44 clearly show a tendency of both models toward underprediction.

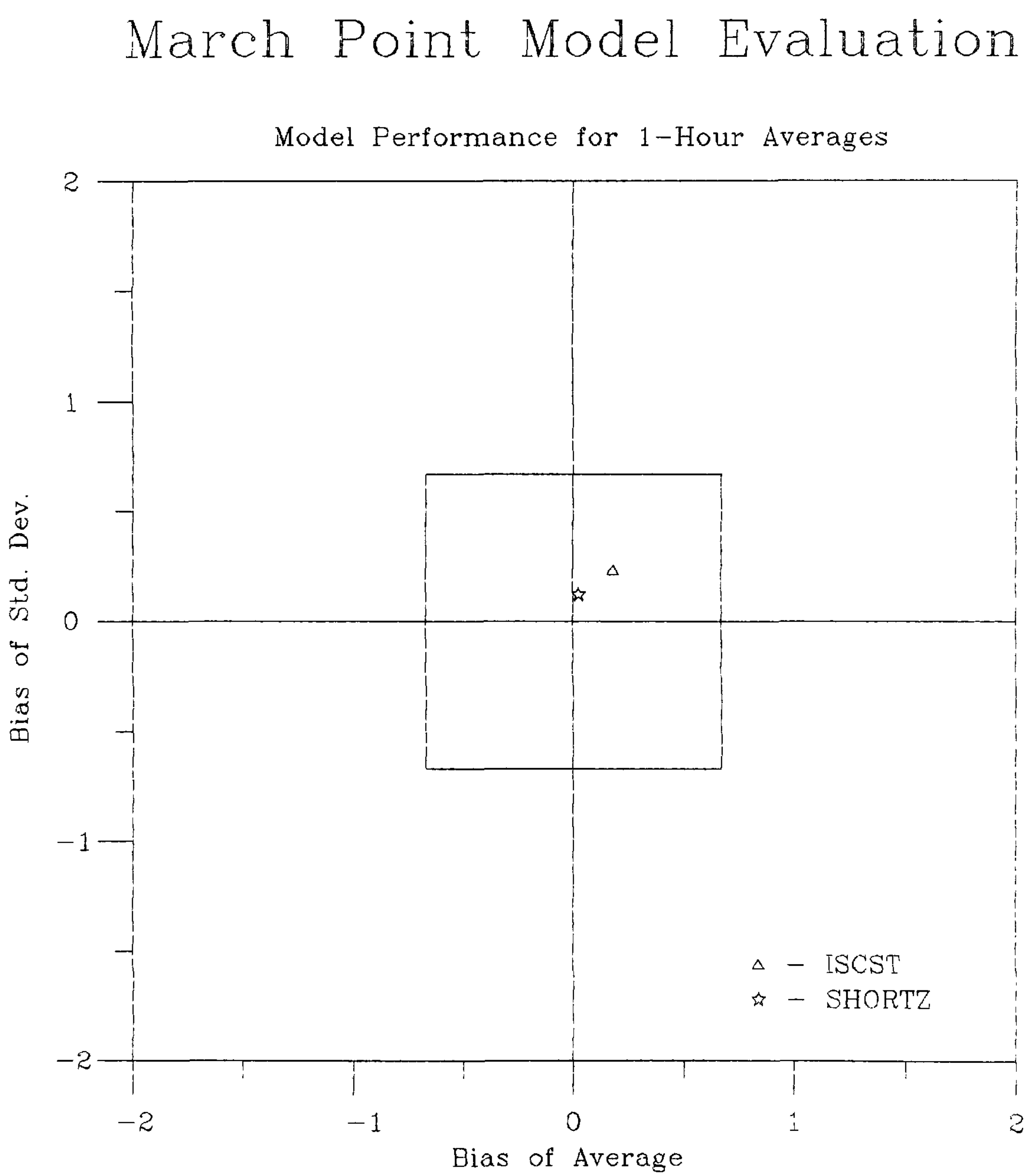


Figure 45 Comparison of Measured Versus Predicted for Data Paired in Time, but not in Space.

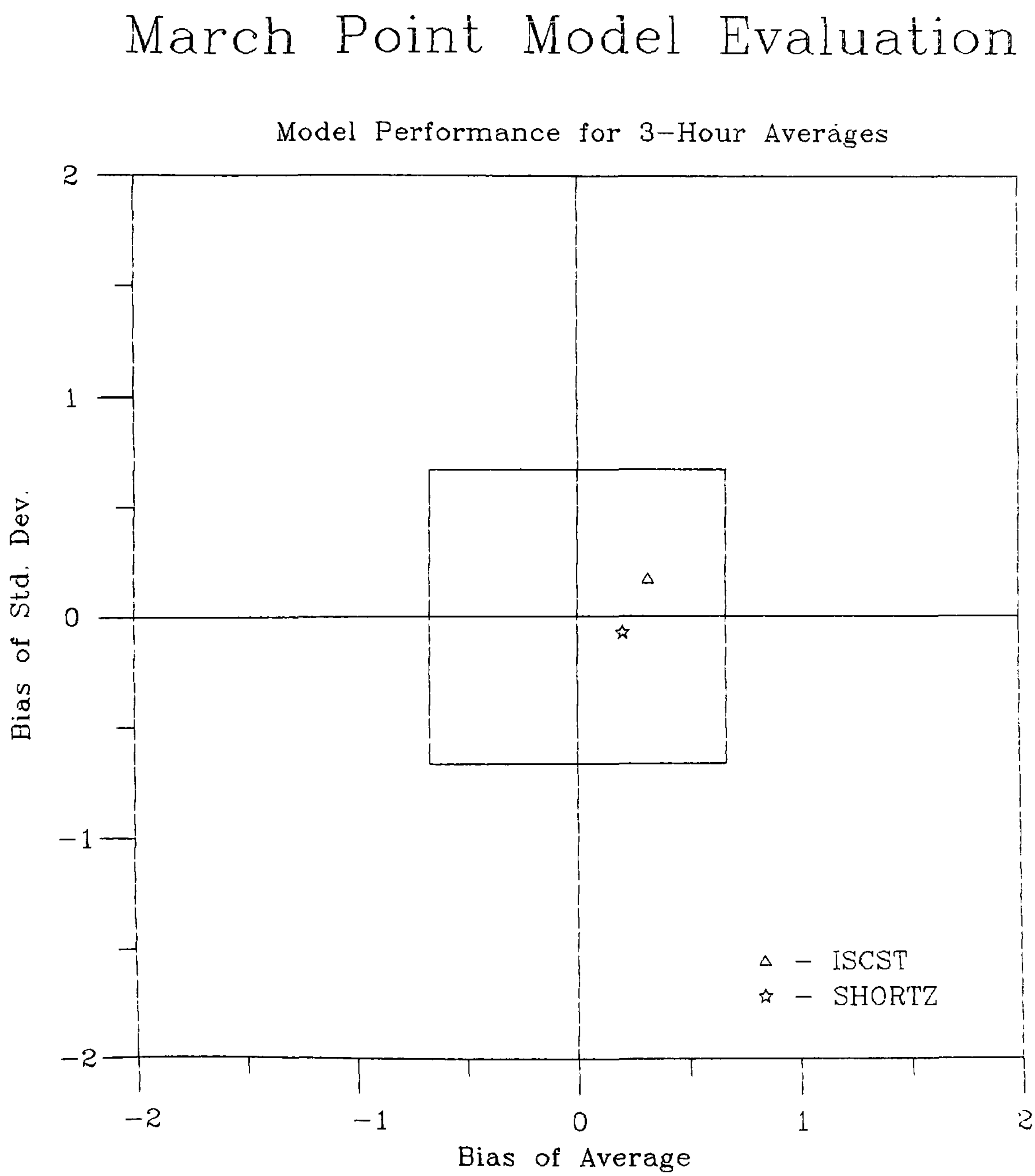


Figure 46 Comparison of Measured Versus Predicted for Data Paired in Time, but not in Space.

4.0 SENSITIVITY ANALYSIS

The following sections discuss the sensitivity of the predicted model results to the values assumed for the inputs.

4.1 Stack Tip Downwash

As discussed in Section 2.0, the Froude Number is computed for the SHORTZ Model to determine if stack tip downwash is to be used for a particular source. The value to use as a criterion for applying the downwash correction based on the Froude Number is a point of some uncertainty. In the current analysis, a value of 3.0 was used as a criterion. Stacks with Froude Numbers greater than 3.0 were assumed to experience stack tip downwash, while those with Froude Numbers less than 3.0 were not. A sensitivity analysis was conducted to determine the effect on the results if the Froude Number criterion had been 1.0 instead of 3.0. For two cases (Cases 1 and 9), the model predictions were repeated with the Froude Number criterion changed, and the computed concentrations were identical to those with the Froude Number criterion of 3.0. Thus, the Froude Number criteria is determined to have no influence on the modeled concentrations.

The Froude number computation is not a part of the ISCST Model analysis.

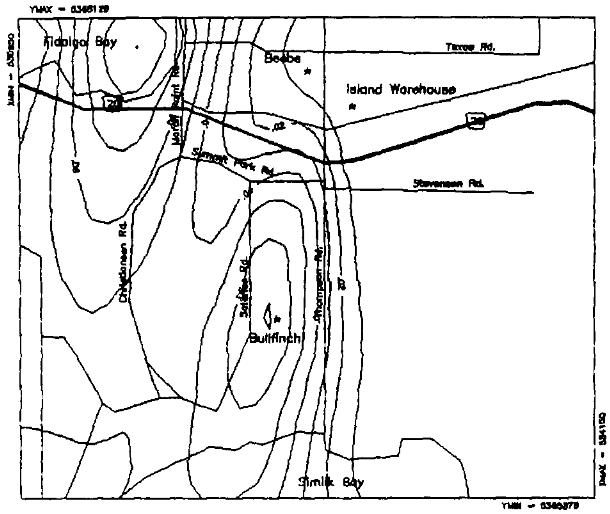
4.2 Wind Direction

The model predictions at a given location are highly dependant on wind direction. The effect results because the wind directions are imprecisely known, and because any short-term Gaussian Plume model will have a strong concentration gradient in the cross wind direction. Examination of Figure 1 for the SHORTZ Model near the Beebe monitor shows this gradient particularly well. To illustrate the effect of a change in wind direction on the results, Figure 47 has been prepared which shows Case 1, repeated with the wind direction modified by 10 degrees either to the east or to the west using the SHORTZ Model. A similar plot is show in Figure 48 for the ISCST Model. Although the plots are reduced, and somewhat difficult to read, the effect on concentration of changing the wind direction is dramatic, and can easily be seen by examining the position of the Beebe and Island Warehouse monitors. For the Case 1 plot (center of Figure 47), the Beebe monitor is located near the 0.05 isopleth. When the wind shifts 10 degrees to the east (lower plot), the Beebe monitor is moved to the center of the plume and concentrations are increased to over 0.08 ppm.

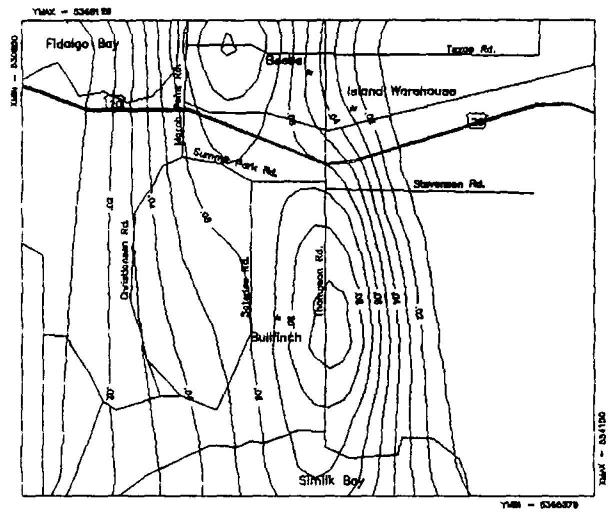
The opposite occurs when the wind is shifted the other direction. The shift of only 10 degrees results in a decrease in concentration at the Beebe monitor to only 0.01 ppm. The net effect of a 20 degree change in wind direction is a change in the concentration by a factor of 8. The same effect is seen at the Island Warehouse receptor. The effect is present, although less pronounced at the Bullfinch monitor. In general, the sensitivity to wind direction changes decreases with increasing distance from the source. Table 4-1 summarizes the sensitivity analysis for Case 1. As Table 4-1 shows, virtually the identical sensitivity to wind direction is observed for the ISCST Model.

Since the wind direction is imprecisely known and could easily vary by 10 degrees or more within an hour, the magnitude of change in the concentrations greatly reduces the confidence in the model predictions.

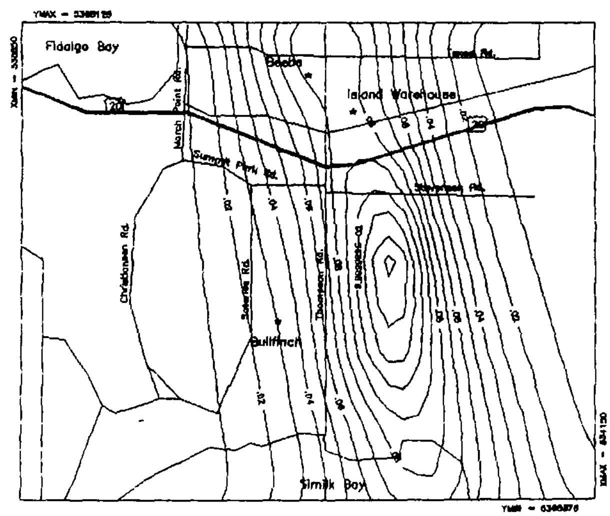
Figure 47 Wind Direction Sensitivity for SHORTZ



Wind Direction Shifted 10 Degrees West

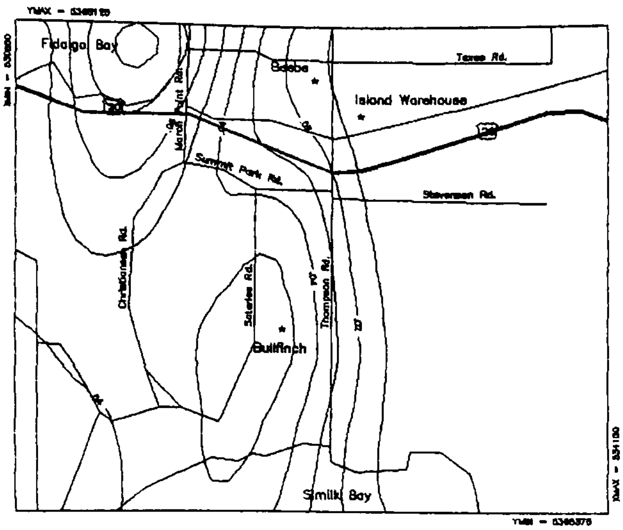


Wind Direction as in Case 1

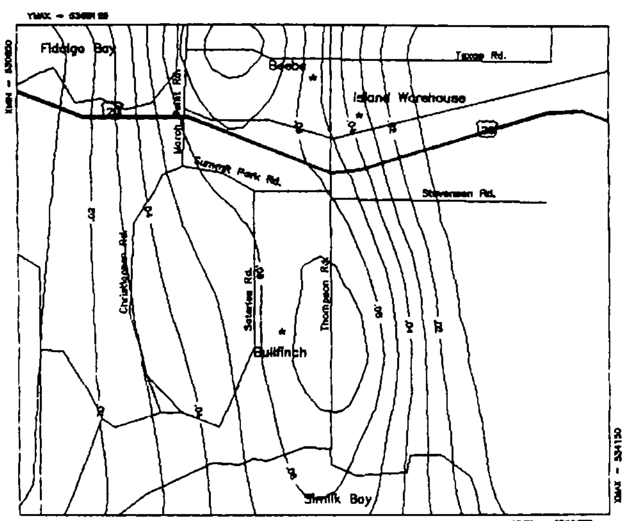


Wind Direction Shifted 10 Degrees East

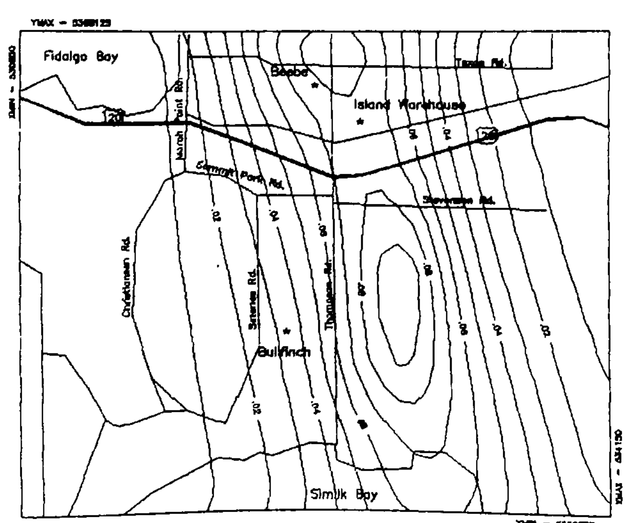
Figure 48 Wind Direction Sensitivity for ISCST



Wind Direction Shifted 10 Degrees West



Wind Direction as in Case 1



Wind Direction Shifted 10 Degrees East

Table 4-1

Sensitivity Analysis for Wind Direction, Wind Speed, and Stability

Case	Island Warehouse	Bullfinch	Beebe
	Model Predicited Concentration of Sulfur Dioxide in ppm		
SHORTZ			
Case 1 Unchanged	0.03	0.07	0.05
Wind Direction:			
10° East	0.00	0.07	0.01
10° West	0.08	0.03	0.08
Wind Speed:			
1 m/sec increase	0.05	0.06	0.04
1 m/sec decrease	0.03	0.08	0.05
Stability:			
1 Class less stable	0.06	0.05	0.05
1 Class more stable	0.01	0.07	0.04
ISCST			
Case 1 Unchanged	0.03	0.07	0.05
Wind Direction:			
10° East	0.00	0.05	0.01
10° West	0.08	0.03	0.08
Wind Speed:			
1 m/sec increase	0.04	0.06	0.04
1 m/sec decrease	0.04	0.08	0.08
Stability:			
1 Class less stable	0.08	0.03	0.07
1 Class more stable	0.02	0.09	0.06

4.3 Wind Speed

The effect of wind speed on the model prediction of concentrations is also significant. To illustrate the influence of wind speed, Case 1 was modeled with the wind speed increased by 1 m/sec and decreased by 1 m/sec. The results are summarized for the three monitor locations in Table 4-1. As the table indicates, the concentrations are generally increased for a reduction in wind speed, while an increase in wind speed usually results in a decrease in concentrations. The results are not as sensitive to wind speed as they are to wind direction. The sensitivity decreases as wind speed increases, so for some of the other cases, where wind speeds were higher, (e.g. Cases 4, 5, 6, 8, 9, 10, 14, 15, 18, 19 and 20) the sensitivity should not be as great. A 1 m/sec variation in the wind speed is not an unexpected level of uncertainty for such measurements.

4.4 Atmospheric Stability

The atmospheric stability influences the mixing in the atmosphere and hence the dilution of the plume as it moves downwind. As a result, the stability assumed in the modeling has a significant influence on the model concentrations. To illustrate the effect of stability, Case 1, which was originally modeled as a class "B" stability has also been modeled as a class "A" and a class "C" stability. The effect is shown in Table 4-1.

As the table shows, the model results are very significantly influenced by the assumed stability. Since stability was determined for the current analysis from cloud cover observations at Bellingham and on site wind speed observations on the Texaco refinery, there are large uncertainties in the stability class assignments for each of the cases.

5.0 CONCLUSIONS

The current analysis has been performed to evaluate the ability of the SHORTZ and ISCST air quality models to predict sulfur dioxide concentrations in the vicinity of March Point, Washington. Both models were used to predict concentrations for a total of 20 test cases for an experimental period running from May, 1985 through November, 1985. Both one-hour and three-hour cases were considered, and the results compared to measured concentrations at three monitoring sites located just to the south of the industrialized area of March Point. While measured concentrations were relatively low, the ten highest one-hour and three-hour average concentrations were selected for evaluation.

Neither model was judged to give good agreement between measured and predicted concentrations paired in space and time. A major reason for the poor performance is the inaccuracy of the input information. A sensitivity analysis illustrated both models' extreme sensitivity to values of input parameters, particularly wind direction. The inability to accurately specify the wind direction for an hourly average could result in concentrations being off by close to an order of magnitude. Another element of uncertainty is the knowledge of the emission information. For many of the sources the stack parameters were only imprecisely known, and better information on the exact emission rates and emission conditions would probably greatly improve model reliability.

When the predictions and observations were paired in space and time, the models were biased toward underprediction. When the predictions and observations were unpaired in space but paired in time, the models performed more favorably. In fact the overall magnitude of the measured values was quite similar to the model predictions, so that on a cumulative frequency basis, both models may have done acceptably. However, the models did not predict within the customary "factor-of-two" performance usually given to air quality models when the data are paired in space and time.

The inaccuracy of the input information, while a major source of error, may not be the only problem. Complex terrain settings, such as March Point are very difficult to model accurately. In particular, the assumption of steady state in space (the assumption that a single value of the wind direction and speed applies for all space), is simply not valid for rough terrain settings. It is true there are not other options in the absence of additional data, and for regulatory purposes, the Gaussian-plume (steady state) models will continue to be used because they have wide agency acceptance. Situations like the March Point analysis are the inevitable consequence of the reliance on Gaussian dispersion.

To improve the March Point model performance, better on-site data should be collected and reduced. In particular, detailed knowledge of the wind direction both at the source and the receptor would enable a more accurate air quality analysis.

The results of the current analysis do not favor one model over the other; therefore, no recommendation can be given concerning the most appropriate air quality model to use for the March Point location, except for the areas where receptor heights are greater than stack height, and the SHORTZ Model must be used since the ISCST Model does not permit receptor heights greater than stack height.

An important question which must be asked is the need for continued monitoring at March Point. The concentrations of sulfur dioxide were not approaching any applicable air quality standard at any of the monitors and it might be concluded that the public is not at risk from exposure to sulfur dioxide. However, oil refineries can change emission rates drastically depending on the quality of the feed stock and the fuels combusted at the site. Future monitoring may see higher concentrations if conditions change at the refinery and it may be important to continue to monitor in the March Point area. The Beebe residence is the location where maximum concentrations have been measured previously, and it should continue to be the point of measurement. Future ambient monitoring, if performed with accurate meteorological and emissions sampling programs could yield a valuable air quality data set for model validation and calibration in the March Point area.

It should be noted here that the conclusions stated here concern solely sulfur dioxide concentrations. No consideration has been given to other chemical species which might be emitted by any of the facilities in the March Point area.

REFERENCES

U.S. EPA, 1970. "Workbook for Atmospheric Diffusion Estimates", EPA Document No. AP-26, Research Triangle Park, NC.

U.S. EPA, 1982. "User's Instructions for the SHORTZ and LONGZ Computer Programs, Volumes I and II", EPA Report Number EPA-903/9-82-004.

U.S. EPA, 1986. "User's Guide for the Industrial Source Complex Model", EPA Document Number EPA-450/4-86-005.

Appendix A
Sample Computer Output for the Test Cases

SHORTZ (VERSION 82326)
AN AIR QUALITY DISPERSION MODEL IN
SECTION 2. NON-GUIDELINE MODELS,
IN UNAMAP (VERSION 5) DEC 82.
SOURCE: FILE 23 ON UNAMAP MAGNETIC TAPE FROM NTIS.

TABLE 1

GENERAL INPUT DATA -

```
NUMBER OF INPUT SOURCES                                     (NSOURC) =   20
NUMBER OF X GRID COORDINATES                                (NXPNTS)     13
NUMBER OF Y GRID COORDINATES                                (NYPNTS) =   11
TOTAL NUMBER OF HOURS IN EACH DAY                           (NHOURS) -    1
NUMBER OF DAYS OR CASES                                     ( NDAYS) =    1
NUMBER OF CONCENTRATION REPORTS (SOURCE COMBINATIONS)       (NGROUP) -    0
NUMBER OF DISCRETE CALCULATION POINTS                       (NXWYPT)      3
MET DATA INPUT CARD RATE (1=HOURLY,2=2 HOURLY,ETC)          (ISW(1)) -    1
IS CONCENTRATION CALCULATED AT BASE RATE PRINTED            (ISW(2)) -    1
NO. OF HOURS IN FIRST AVERAGE CONCENTRATION PRINTED         (ISW(3)) -    0
NO. OF HOURS IN SECOND AVERAGE CONCENTRATION PRINTED        (ISW(4)) =    0
NO. OF HOURS IN THIRD AVERAGE CONCENTRATION PRINTED         (ISW(5)) -    0
ARE TERRAIN ELEVATION HEIGHTS USED                          (ISW(7))      1
IS WIND SPEED TERRAIN FOLLOWING                             (ISW(9)) -    0
ARE CONCENTRATIONS AVERAGED OVER DAYS OR CASES              (ISW(11))=    0
IS THE FORMAT FOR SOURCE DATA READ                          (ISW(12))=    0
IS COORDINATE SYSTEM CARTESIAN (=0) OR POLAR (=1)           (ISW(13))=    0
ARE DISCRETE RECEPTORS CARTESIAN (=0) OR POLAR (=1)         (ISW(14))=    0
ARE SOURCE COORDINATES CARTESIAN (=0) OR POLAR (=1)         (ISW(15))=    0
SIGEPU SIGAPU FOR ALL SOURCES OPTION                        (ISW(16))=    0
RURAL/URBAN MODE OPTION (RURAL=0),(URBAN=1)                 (ISW(17))=    0
MODEL UNITS CONVERSION FACTOR                               (  TK  )   .38180000E+03
ACCELERATION OF GRAVITY                                     (  G   )     9.8000       (METERS/SEC**2)
HEIGHT OF MEASUREMENT OF WIND SPEED, ETC                    (  ZR  ) -  10.0000       (METERS)
ENTRAINMENT COEFFICIENT FOR UNSTABLE ATMOSPHERE             (GAMMA1) =  .600
ENTRAINMENT COEFFICIENT FOR STABLE ATMOSPHERE               (GAMMA2)    .660
DISTANCE OVER WHICH RECTILINEAR PLUME EXPANSION OCCURS ( XRY  ) - 50.0000             (METERS)
DECAY COEFFICIENT FOR PHYSICAL OR CHEMICAL DEPLETION   (DECAY ) =, .00000000E+00
ANGULAR DISPL OF GRID SYSTEM FROM TRUE NORTH                (ROTATE)      .000
ELEVATION OF BASE OF WEATHER STATION                           (HA) -   30.48         (METERS)
X ORIGIN OF POLAR COORDINATES                                (UTMX) -       .00       (METERS)
Y ORIGIN OF POLAR COORDINATES                                (UTMY) -       .00       (METERS)
0                 *-* COORDINATE SYSTEM X AXIS (METERS) *-*

 .53100000E+06,  .53125000E+06,  .53150000E+06,  .53175000E+06,  .53200000E+06,  .53225000E+06,  .53250000E+06,  .53275000E+06
 .53300000E+06,  .53325000E+06,  .53350000E+06,  .53375000E+06,  .53400000E+06,
0                 *-* COORDINATE SYSTEM Y AXIS (METERS )*-*

 .53655000E+07,  .53657500E+07,  .53660000E+07,  .53662500E+07,  .53665000E+07,  .53667500E+07,  .53670000E+07,  .53672500E+07
 .53675000E+07,  .53677500E+07,  .53680000E+07,
0                                          *-* COORDINATES OF DISCRETE POINTS (METERS,METERS )*-*

 (X,Y) = ( 532762.0, 5367619.0), ( 532332.0, 5366404.0), ( 532509.0, 5367825.0), (
```

TABLE 2

- GENERAL INPUT DATA

- GRID SYSTEM TERRAIN HEIGHTS (METERS) *-*

- GRID SYSTEM X AXIS (METERS) -

Y AXIS (METERS)	531000.000	531250.000	531500.000	531750.000	532000.000	532250.000	532500.000	532750.000	533000.00
	HEIGHT -								
5368000.000	.0000000	.0000000	.0000000	.0000000	6.1000000	18.3000000	18.3000000	18.3000000	18.30000
5367750.000	6.1000000	.0000000	.0000000	.0000000	6.1000000	18.3000000	18.3000000	19.3000000	19.30000
5367500.000	15.2000000	6.1000000	6.1000000	6.1000000	6.1000000	12.2000000	18.3000000	18.3000000	18.30000
5367250.000	27.4000000	6.1000000	6.1000000	30.5000000	21.3000000	24.4000000	18.3000000	18.3000000	19.30000
5367000.000	36.6000000	15.2000000	12.2000000	36.6000000	30.5000000	21.3000000	18.3000000	18.3000000	30.50000
5366750.000	51.8000000	6.1000000	12.2000000	51.0000000	24.4000000	18.3000000	18.3000000	24.4000000	61.00000
5366500.000	54.9000000	15.2000000	6.1000000	57.9000000	18.3000000	18.3000000	18.3000000	42.7000000	61.00000
5366250.000	61.0000000	36.6000000	6.1000000	30.5000000	18.3000000	24.4000000	33.5000000	61.0000000	61.00000
5366000.000	64.0000000	33.5000000	3.0000000	.0000000	3.0000000	6.1000000	15.2000000	42.7000000	33.50000
5365750.000	67.1000000	33.5000000	.0000000	.0000000	.0000000	3.0000000	.0000000	3.0000000	3.00000
5365500.000	67.1000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.00000

GRID SYSTEM X AXIS (METERS)

Y AXIS (METERS)	533250.000	533500.000	533750.000	534000.000
	HEIGHT -			
5368000.000	15.2000000	12.2000000	12.2000000	6.1000000
5367750.000	15.2000000	12.2000000	12.2000000	6.1000000
5367500.000	18.3000000	12.2000000	12.2000000	12.2000000
5367250.000	18.3000000	12.2000000	6.1000000	18.3000000
5367000.000	15.2000000	6.1000000	6.1000000	33.5000000
5366750.000	12.2000000	6.1000000	18.3000000	48.8000000
5366500.000	6.1000000	.0000000	27.4000000	48.8000000
5366250.000	.0000000	.0000000	36.6000000	48.8000000
5366000.000	.0000000	.0000000	36.6000000	51.8000000
5365750.000	.0000000	.0000000	48.8000000	54.9000000
5365500.000	.0000000	.0000000	54.9000000	61.0000000

- DISCRETE POINT TERRAIN HEIGHTS (METERS) *-*

X (METERS)	Y (METERS)	HEIGHT	X (METERS)	Y (METERS)	HEIGHT	X (METERS)	Y (METERS)	HEIGHT
532762.0	5367619.0	17.7000000	532332.0	5366404.0	19.8000000	532509.0	5367825.0	17.8000000

TABLE 3

SOURCE INPUT DATA

SOURCE INVENTORY

CARD	TAPE	SOURCE NUMBER	TYPE	SOURCE STRENGTH (GRAMS/SEC)	X COORDINATE (METERS)	Y COORDINATE (METERS)	HEIGHT ABOVE GROUND (METERS)	IF TYPE=0 TEMP (DEG K) IF TYPE=1OR2 LENGTH SHORT SIDE (MTRS)	IF TYPE=0 VOL. EMISS. RT M**3/SEC IF TYPE=1OR2 LENGTH LONG SIDE (MTRS)	ANGLE TO LONG SIDE (DEG)	STACK INNER RADIUS (METERS)	ELEVATION AT STACK BASE (METERS)	PARTICULATE SETTLING VELOCITY (METERS/SEC)	DISTRIB FREQU OCCURR (FRACT
X		101	0	2.680	532722.00	5369522.00	30.50	350.000	11.940	.0	.610	30.00		
X		201	0	175.400	532661.00	5369539.00	52.00	545.000	77.100	.0	1.410	30.00		
X		301	0	8.950	531961.00	5371117.00	37.00	601.000	11.760	.0	.000	14.00		
X		302	0	11.720	531945.00	5371117.00	40.00	486.000	10.190	.0	.000	14.00		
X		303	0	10.460	531923.00	5371117.00	46.00	584.000	13.540	.0	.000	14.00		
X		304	0	3.780	531897.00	5371117.00	46.00	523.000	3.790	.0	.000	14.00		
X		305	0	9.070	532029.00	5371120.00	40.00	515.000	8.540	.0	.000	14.00		
X		306	0	78.370	532178.00	5371115.00	54.00	497.000	51.010	.0	.000	14.00		
X		307	0	64.640	532170.00	5371132.00	53.00	526.000	44.700	.0	1.140	14.00		
X		308	0	5.290	531833.00	5371030.00	40.00	610.000	5.750	.0	.000	14.00		
X		309	0	1.260	531845.00	5371030.00	40.00	615.000	1.380	.0	.000	14.00		
X		310	0	17.010	532125.00	5371190.00	38.00	466.000	13.310	.0	.000	14.00		
X		311	0	19.910	532125.00	5371202.00	38.00	472.000	15.450	.0	.870	14.00		
X		312	0	5.900	531932.00	5370843.00	52.00	626.000	7.120	.0	.000	20.00		
X		313	0	5.420	531924.00	5370843.00	52.00	481.000	4.040	.0	.000	20.00		
X		314	0	1.890	531915.00	5370843.00	52.00	441.000	1.510	.0	.000	20.00		
X		315	0	19.530	531875.00	5370845.00	52.00	508.000	17.980	.0	.000	20.00		
X		316	0	19.530	531887.00	5370845.00	52.00	513.000	18.160	.0	.000	20.00		
X		317	0	2.140	531906.00	5370843.00	52.00	475.000	1.570	.0	.000	20.00		
X		318	0	.630	531898.00	5370843.00	34.00	715.000	.920	.0	.000	20.00		

TABLE 4

- METEOROLOGICAL INPUT DATA -

HOUR	WIND DIRECTION (DEGREES) THETA	WIND SPEED (MTR/SEC) UBAR	LAYER DEPTH (METERS) HM	AMBIENT TEMP (DEG K) TA	VERT GRAD OF POT TMP (DEG K/M) DPDZ	STAB ILITY CAT. ISTBLE	WND SPD POWER LAW EXPONENT P	STD DEV EL ANGLE, SOR TYPE 0 SIGEPU(RAD)	STD DEV AZ ANGLE, SOR TYPE 0 SIGAPU(RAD)	STD DEV EL ANGLE, SOR TYPE 1OR2 SIGEPL(RAD)	STD DEV AZ ANGLE, SOR TYPE 1OR2 SIGAPL(RAD)	LATERAL DIFFUSION COEFFICIENT ALPHA
1300	360.0000	1.7900	1500.000	295.000	.0000	B	.1000	.1080000	1544000	.1080000	.1544000	.9000

TABLE 5

1 HOUR GROUND LEVEL CONCENTRATION PARTS PER MILLION   FROM ALL SOURCES

0   - HOUR(S)   0 TO   0

GRID SYSTEM X AXIS (METERS) -

(THE MAXIMUM CONCENTRATION IS .0940959 AT X= 532750.0, Y=5366250.0)

Y AXIS (METERS)	531000.000	531250.000	531500.000	531750.000	532000.000	532250.000	532500.000	532750.000	533000
	CONCENTRATION -								
5368000.000	.0013136	.0080816	.0297979	.0666656	.0935208	.0841547	.0490503	.0207170	.00
5367750.000	.0020039	.0097181	.0305209	.0621160	.0839890	.0767540	.0482821	.0229482	.00
5367500.000	.0027969	.0112334	.0309430	.0582270	.0756527	.0695236	.0534218	.0350871	.0
5367250.000	.0036466	.0124089	.0306463	.0555364	.0696585	.0658268	.0662544	.0548641	.0
5367000.000	.0044844	.0134629	.0302431	.0516195	.0637415	.0634560	.0786094	.0709092	.020
5366750.000	.0053074	.0140345	.0294127	.0486459	.0579663	.0631376	.0859948	.0824679	.0
5366500.000	.0060200	.0146337	.0283043	.0449189	.0535175	.0638013	.0880958	.0917987	.0
5366250.000	.0066649	.0151571	.0272852	.0410121	.0505050	.0648311	.0910704	.0940959	.044
5366000.000	.0072127	.0152617	.0261784	.0375913	.0475557	.0621194	.0826770	.0822945	.04
5365750.000	.0076743	.0152749	.0251009	.0355164	.0457247	.0606381	.0756734	.0703349	.0
5365500.000	.0080425	.0149171	.0241302	.0338020	.0442922	.0586345	.0714955	.0659093	.04

GRID SYSTEM X AXIS (METERS)

(THE MAXIMUM CONCENTRATION IS .0940959 AT X= 532750.0, Y=5366250.0)

Y AXIS (METERS)	533250.000	533500.000	533750.000	534000.000
	- CONCENTRATION			
5368000.000	.0005822	.0000445	.0000023	.0000001
5367750.000	.0010093	.0001046	.0000077	.0000004
5367500.000	.0015404	.0002081	.0000204	.0000014
5367250.000	.0021575	.0003625	.0000450	.0000042
5367000.000	.0030484	.0005650	.0000872	.0000106
5366750.000	.0045553	.0008344	.0001534	.0000227
5366500.000	.0066769	.0012066	.0002466	.0000428
5366250.000	.0091656	.0017706	.0003762	.0000735
5366000.000	.0118777	.0025621	.0005565	.0001189
5365750.000	.0143759	.0035602	.0008231	.0001806
5365500.000	.0164874	.0046955	.0011842	.0002693

TABLE 5 (CONT)

1 HOUR GROUND LEVEL CONCENTRATION PARTS PER MILLION FROM ALL SOURCES

0 HOUR(S) 0 TO 0

- DISCRETE POINT RECEPTORS -

(THE MAXIMUM CONCENTRATION IS, .0715010 AT X= 532332.0, Y=5366404.0)

0 X (METERS)	Y (METERS)	CONCENTRATION	X (METERS)	Y (METERS)	CONCENTRATION	X (METERS)	Y (METERS)	CONCENTRATION
532762.0	5367619.0	.0261222	532332.0	5366404.0	.0715010	532509.0	5367825.0	.0471671

```
ISCSTU (VERSION 86170)
AN AIR QUALITY DISPERSION MODEL IN
SECTION 2.  NON-GUIDELINE MODELS.
IN UNAMAP (VERSION 5)  JUNE  86.
SOURCE: UNAMAP FILE ON EPA'S UNIVAC 1110, RTP, NC.                    CONVERTED TO IBM PC BY TRC ENVIRON
1 3 1 1 0 2 1 0 0 0 0 0 0 0 0 1 0 0 2 0 1 1 0 2 2 1 1 2 1 1 1 0 0 0 0 0 0 0 0 0
  20    13    11     3     0     0     1     1
  .53100E+06   .25000E+03
  .53655E+07   .25000E+03
  .22000E+03   .00000E+00   .00000E+00   .00000E+00   .00000E+00   .00000E+00   .00000E+00   .00000E+00
  .00000E+00   .00000E+00   .00000E+00   .18000E+03   .20000E+03
  .22000E+03   .11000E+03   .00000E+00   .00000E+00   .00000E+00   .10000E+02   .00000E+00   .10000E+02
  .10000E+02   .00000E+00   .00000E+00   .16000E+03   .18000E+03
  .21000E+03   .11000E+03   .10000E+02   .00000E+00   .10000E+02   .20000E+02   .50000E+02   .14000E+03
  .11000E+03   .00000E+00   .00000E+00   .12000E+03   .17000E+03
  .20000E+03   .12000E+03   .20000E+02   .10000E+03   .60000E+02   .80000E+02   .11000E+03   .20000E+03
  .20000E+03   .00000E+00   .00000E+00   .12000E+03   .16000E+03
  .18000E+03   .50000E+02   .20000E+02   .19000E+03   .60000E+02   .60000E+02   .60000E+02   .14000E+03
  .20000E+03   .20000E+02   .00000E+00   .90000E+02   .16000E+03
  .17000E+03   .20000E+02   .40000E+02   .20000E+03   .80000E+02   .60000E+02   .60000E+02   .80000E+02
  .20000E+03   .40000E+02   .20000E+02   .60000E+02   .16000E+03
  .12000E+03   .50000E+02   .40000E+02   .12000E+03   .10000E+03   .70000E+02   .60000E+02   .60000E+02
  .10000E+03   .50000E+02   .20000E+02   .20000E+02   .11000E+03
  .90000E+02   .20000E+02   .20000E+02   .10000E+03   .70000E+02   .80000E+02   .60000E+02   .60000E+02
  .60000E+02   .60000E+02   .40000E+02   .20000E+02   .60000E+02
  .50000E+02   .20000E+02   .20000E+02   .20000E+02   .20000E+02   .40000E+02   .60000E+02   .60000E+02
  .60000E+02   .60000E+02   .40000E+02   .40000E+02   .40000E+02
  .20000E+02   .00000E+00   .00000E+00   .00000E+00   .20000E+02   .60000E+02   .60000E+02   .60000E+02
  .60000E+02   .50000E+02   .40000E+02   .40000E+02   .20000E+02
  .00000E+00   .00000E+00   .00000E+00   .00000E+00   .20000E+02   .60000E+02   .60000E+02   .60000E+02
  .60000E+02   .50000E+02   .40000E+02   .40000E+02   .20000E+02
  .53276E+06   .53676E+07   .58000E+02
  .53233E+06   .53664E+07   .65000E+02
  .53251E+06   .53678E+07   .58000E+02
  .00000E+00   .00000E+00   .00000E+00   .00000E+00   .00000E+00   .00000E+00
  .38180E+03   .00000E+00         parts per million          0 0
```

```
CALCULATE (CONCENTRATION=1,DEPOSITION=2)                              ISW(1) -   1
RECEPTOR GRID SYSTEM (RECTANGULAR=1 OR 3, POLAR=2 OR 4)               ISW(2) -   3
DISCRETE RECEPTOR SYSTEM (RECTANGULAR=1,POLAR=2)                      ISW(3)     1
TERRAIN ELEVATIONS ARE READ (YES=1,NO=0)                              ISW(4) -   1
CALCULATIONS ARE WRITTEN TO TAPE (YES=1,NO=0)                         ISW(5)     0
LIST ALL INPUT DATA (NO=0,YES=1,MET DATA ALSO=2)                      ISW(6) =   2

COMPUTE AVERAGE CONCENTRATION (OR TOTAL DEPOSITION)
WITH THE FOLLOWING TIME PERIODS:
  HOURLY (YES=1,NO=0)                                                 ISW(7) =   1
  2-HOUR (YES=1,NO=0)                                                 ISW(8)     0
  3-HOUR (YES=1,NO=0)                                                 ISW(9)     0
  4-HOUR (YES=1,NO=0)                                                ISW(10)     0
  6-HOUR (YES=1,NO=0)                                                ISW(11) =   0
  8-HOUR (YES=1,NO=0)                                                ISW(12) =   0
  12-HOUR (YES=1,NO=0)                                               ISW(13) -   0
  24-HOUR (YES=1,NO=0)                                               ISW(14) =   0
PRINT 'N'-DAY TABLE(S) (YES=1,NO=0)                                  ISW(15) -   0

PRINT THE FOLLOWING TYPES OF TABLES WHOSE TIME PERIODS ARE
SPECIFIED BY ISW(7) THROUGH ISW(14):
  DAILY TABLES (YES=1,NO=0)                                          ISW(16) =   1
  HIGHEST & SECOND HIGHEST TABLES (YES=1,NO=0)                       ISW(17) =   0
  MAXIMUM 50 TABLES (YES=1,NO=0)                                     ISW(18) =   0
METEOROLOGICAL DATA INPUT METHOD (PRE-PROCESSED=1,CARD=2)            ISW(19) =   2
RURAL-URBAN OPTION (RU.=0,UR. MODE 1=1,UR. MODE 2=2,UR. MODE 3=3)    ISW(20)     0
WIND PROFILE EXPONENT VALUES (DEFAULTS=1,USER ENTERS=2,3)            ISW(21) -   1
VERTICAL POT. TEMP. GRADIENT VALUES (DEFAULTS=1,USER ENTERS=2,3)     ISW(22) -   1
SCALE EMISSION RATES FOR ALL SOURCES (NO=0,YES>0)                    ISW(23)     0
PROGRAM CALCULATES FINAL PLUME RISE ONLY (YES=1,NO=2)                ISW(24)     2
PROGRAM ADJUSTS ALL STACK HEIGHTS FOR DOWNWASH (YES=2,NO=1)          ISW(25)     2
PROGRAM USES BUOYANCY INDUCED DISPERSION (YES=1,NO=2)                ISW(26)     1
CONCENTRATIONS DURING CALM PERIODS SET - 0 (YES=1,NO=2)              ISW(27)     2
REG. DEFAULT OPTION CHOSEN (YES=1,NO=2)                              ISW(28)     2
TYPE OF POLLUTANT TO BE MODELLED (1=SO2,2=OTHER)                     ISW(29)     1
DEBUG OPTION CHOSEN (1=YES,2=NO)                                     ISW(30)     1

NUMBER OF INPUT SOURCES                                               NSOURC =  20
NUMBER OF SOURCE GROUPS (=0,ALL SOURCES)                              NGROUP     0
TIME PERIOD INTERVAL TO BE PRINTED (=0,ALL INTERVALS)                  IPERD =   0
NUMBER OF X (RANGE) GRID VALUES                                       NXPNTS    13
NUMBER OF Y (THETA) GRID VALUES                                       NYPNTS =  11
NUMBER OF DISCRETE RECEPTORS                                          NXWYPT     3
NUMBER OF HOURS PER DAY IN METEOROLOGICAL DATA                        NHOURS     1
NUMBER OF DAYS OF METEOROLOGICAL DATA                                  NDAYS     1
SOURCE EMISSION RATE UNITS CONVERSION FACTOR                              TK=.38180E+03
HEIGHT ABOVE GROUND AT WHICH WIND SPEED WAS MEASURED                     ZR -  10.00  METERS
LOGICAL UNIT NUMBER OF METEOROLOGICAL DATA                              IMET =   5
ALLOCATED DATA STORAGE                                                 LIMIT - 43500 WORDS
REQUIRED DATA STORAGE FOR THIS PROBLEM RUN                             MIMIT -  4914 WORDS
```

*** UPPER BOUND OF FIRST THROUGH FIFTH WIND SPEED CATEGORIES ***
(METERS/SEC)

1.54, 3.09, 5.14, 8.23, 10.80,

*** X-COORDINATES OF RECTANGULAR GRID SYSTEM ***
(METERS)

531000.0, 531250.0, 531500.0, 531750.0, 532000.0, 532250.0, 532500.0, 532750.0, 533000.0, 533250.0,
533500.0, 533750.0, 534000.0,

*** Y-COORDINATES OF RECTANGULAR GRID SYSTEM ***
(METERS)

5365500.0, 5365750.0, 5366000.0, 5366250.0, 5366500.0, 5366750.0, 5367000.0, 5367250.0, 5367500.0, 5367750.0,
5368000.0,

*** X,Y COORDINATES OF DISCRETE RECEPTORS ***
(METERS)

(532762.0,5367619.0), (532332.0,5366404.0), (532509.0,5367825.0), (

* ELEVATION HEIGHTS IN METERS *
* FOR THE RECEPTOR GRID *

Y-AXIS / (METERS) /	X-AXIS (METERS) 531000.0	531250.0	531500.0	531750.0	532000.0	532250.0	532500.0	532750.0	533000.0
5368000.0 /	.00000	.00000	.00000	.00000	6.09601	18.28804	18.28804	18.28804	18.28804
5367750.0 /	6.09601	.00000	.00000	.00000	6.09601	18.28804	18.28804	18.28804	18.28804
5367500.0 /	15.24003	6.09601	6.09601	6.09601	6.09601	12.19202	18.28804	18.28804	18.28804
5367250.0 /	27.43205	6.09601	6.09601	30.48006	21.33604	24.38405	18.28804	18.28804	18.28804
5367000.0 /	36.57607	15.24003	12.19202	36.57607	30.48006	21.33604	18.28804	18.28804	30.48006
5366750.0 /	51.81610	6.09601	12.19202	60.96012	24.38405	18.28804	18.28804	24.38405	60.96012
5366500.0 /	54.86411	15.24003	6.09601	57.91211	18.28804	18.28804	18.28804	42.67208	60.96012
5366250.0 /	60.96012	36.57607	6.09601	30.48006	18.28804	24.38405	33.52806	60.96012	60.96012
5366000.0 /	64.00813	33.52806	3.04801	.00000	3.04801	6.09601	15.24003	42.67208	33.52806
5365750.0 /	67.05613	33.52806	.00000	.00000	.00000	3.04801	.00000	3.04801	3.04801
5365500.0 /	67.05613	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

* ELEVATION HEIGHTS IN METERS *
* FOR THE RECEPTOR GRID *

Y-AXIS / (METERS) /	X-AXIS (METERS) 533250.0	533500.0	533750.0	534000.0
5368000.0 /	15.24003	12.19202	12.19202	6.09601
5367750.0 /	15.24003	12.19202	12.19202	6.09601
5367500.0 /	18.28804	12.19202	12.19202	12.19202
5367250.0 /	18.28804	12.19202	6.09601	18.28804
5367000.0 /	15.24003	6.09601	6.09601	33.52806
5366750.0 /	12.19202	6.09601	18.28804	48.76810
5366500.0 /	6.09601	.00000	27.43205	48.76810
5366250.0 /	.00000	.00000	36.57607	48.76810
5366000.0 /	.00000	.00000	36.57607	51.81610
5365750.0 /	.00000	.00000	48.76810	54.86411
5365500.0 /	.00000	.00000	54.86411	60.96012

* ELEVATION HEIGHTS IN METERS *
* FOR THE DISCRETE RECEPTOR POINTS *

X -	- Y -	HGT.	- X -	Y -	HGT.	- X	- Y -	HGT.
532762.0	5367619.0	17.67843	532332.0	5366404.0	19.81204	532509.0	5367825.0	17.67843

*** ONE HOUR CASE 1 - NO DOWNWASH FOR FR < 3 May 22, 1985 ***

*** SOURCE DATA ***

SOURCE NUMBER	TYPE	WAKE	NUMBER PART. CATS.	EMISSION RATE TYPE=0,1 (GRAMS/SEC) TYPE=2 (GRAMS/SEC) *PER METER**2	X (METERS)	Y (METERS)	BASE ELEV. (METERS)	HEIGHT (METERS)	TEMP. TYPE=0 (DEG.K); VERT.DIM TYPE=1 (METERS)	EXIT VEL. TYPE=0 (M/SEC); HORZ.DIM TYPE=1,2 (METERS)	DIAMETER TYPE=0 (METERS)	BLDG. HEIGHT TYPE=0 (METERS)	BLDG. LENGTH TYPE=0 (METERS)	BLDG. WIDTH TYPE=0 (METERS)
101	0	0	0	.26800E+01	532722.0	5369522.0	30.0	30.50	350.00	10.21	1.22	.00	.00	.00
201	0	0	0	.17540E+03	532661.0	5368539.0	30.0	52.00	545.00	12.43	2.81	.00	.00	.00
301	0	0	0	.89500E+01	531961.0	5371117.0	14.0	37.00	601.00	4.89	1.75	.00	.00	.00
302	0	0	0	.11720E+02	531945.0	5371117.0	14.0	40.00	486.00	4.23	1.75	.00	.00	.00
303	0	0	0	.10460E+02	531923.0	5371117.0	14.0	46.00	584.00	4.40	1.98	.00	.00	.00
304	0	0	0	.37800E+01	531897.0	5371117.0	14.0	46.00	523.00	2.33	1.44	.00	.00	.00
305	0	0	0	.90700E+01	532029.0	5371120.0	14.0	40.00	515.00	3.85	1.68	.00	.00	.00
306	0	0	0	.78370E+02	532178.0	5371115.0	14.0	54.00	497.00	7.78	2.89	.00	.00	.00
307	0	0	0	.64640E+02	532170.0	5371132.0	14.0	53.00	526.00	11.05	2.27	.00	.00	.00
308	0	0	0	.52900E+01	531833.0	5371030.0	14.0	40.00	610.00	3.90	1.37	.00	.00	.00
309	0	0	0	.12600E+01	531845.0	5371030.0	14.0	40.00	615.00	2.17	.90	.00	.00	.00
310	0	0	0	.17010E+02	532125.0	5371190.0	14.0	38.00	466.00	5.66	1.73	.00	.00	.00
311	0	0	0	.19910E+02	532125.0	5371202.0	14.0	38.00	472.00	6.57	1.73	.00	.00	.00
312	0	0	0	.58000E+01	531932.0	5370843.0	20.0	52.00	626.00	3.92	1.52	.00	.00	.00
313	0	0	0	.54200E+01	531924.0	5370843.0	20.0	52.00	481.00	1.82	1.68	.00	.00	.00
314	0	0	0	.18900E+01	531915.0	5370843.0	20.0	52.00	441.00	.68	1.68	.00	.00	.00
315	0	0	0	.19530E+02	531875.0	5370845.0	20.0	52.00	508.00	3.05	2.74	.00	.00	.00
316	0	0	0	.19530E+02	531887.0	5370845.0	20.0	52.00	513.00	3.08	2.74	.00	.00	.00
317	0	0	0	.21400E+01	531906.0	5370843.0	20.0	52.00	475.00	.87	1.52	.00	.00	.00
318	0	0	0	.63000E+00	531898.0	5370843.0	20.0	34.00	715.00	.62	1.37	.00	.00	.00

*** ONE HOUR CASE 1 - NO DOWNWASH FOR FR < 3 May 22, 1985 ***

* METEOROLOGICAL DATA FOR DAY 1 *

HOUR	FLOW VECTOR (DEGREES)	WIND SPEED (MPS)	MIXING HEIGHT (METERS)	TEMP. (DEG. K)	POT. TEMP. GRADIENT (DEG. K PER METER)	STABILITY CATEGORY	WIND PROFILE EXPONENT	DECAY COEFFICIENT (PER SEC)
1	180.0	1.79	1500.0	295.0	.0000	2	.0700	.000000E+00

*** ONE HOUR CASE 1 - NO DOWNWASH FOR FR < 3 May 22, 1985 ***

* DAILY 1-HOUR AVERAGE CONCENTRATION parts per million *
* ENDING WITH HOUR 1 FOR DAY 1 *
* FROM ALL SOURCES *
* FOR THE RECEPTOR GRID *

* MAXIMUM VALUE EQUALS .08727 AND OCCURRED AT (532000.0, 5368000.0) *

Y-AXIS / (METERS) /	X-AXIS (METERS) 531000.0	531250.0	531500.0	531750.0	532000.0	532250.0	532500.0	532750.0	53300
5368000.0 /	.00455	.01597	.03946	.06906	.08727	.08087	.05650	.03145	.01
5367750.0 /	.00579	.01728	.03825	.06272	.07734	.07279	.05482	.03325	.0
5367500.0 /	.00696	.01825	.03694	.05739	.06891	.06588	.05688	.03960	.0
5367250.0 /	.00800	.01874	.03518	.05331	.06270	.06318	.06218	.04877	.02
5367000.0 /	.00885	.01904	.03351	.04876	.05743	.06165	.06808	.05759	.02
5366750.0 /	.00957	.01887	.03166	.04525	.05303	.06137	.07221	.06558	.0
5366500.0 /	.01006	.01874	.02978	.04174	.04994	.06158	.07376	.07318	.0
5366250.0 /	.01042	.01856	.02815	.03844	.04802	.06193	.07618	.07630	.04
5366000.0 /	.01065	.01808	.02665	.03565	.04576	.05874	.07018	.06948	.0
5365750.0 /	.01078	.01759	.02536	.03404	.04429	.05678	.06493	.06038	.0
5365500.0 /	.01083	.01689	.02431	.03275	.04297	.05441	.06161	.05717	.04

*** ONE HOUR CASE 1 - NO DOWNWASH FOR FR < 3 May 22, 1985 ***

* DAILY 1-HOUR AVERAGE CONCENTRATION parts per million *
* ENDING WITH HOUR 1 FOR DAY 1 *
* FROM ALL SOURCES *
* FOR THE RECEPTOR GRID *

* MAXIMUM VALUE EQUALS .08727 AND OCCURRED AT (532000.0, 5368000.0) *

Y-AXIS / (METERS) /	X-AXIS (METERS) 533250.0	533500.0	533750.0	534000.0
5368000.0 /	.00262	.00045	.00006	.00001
5367750.0 /	.00358	.00077	.00013	.00002
5367500.0 /	.00461	.00116	.00024	.00004
5367250.0 /	.00591	.00162	.00039	.00008
5367000.0 /	.00788	.00217	.00058	.00014
5366750.0 /	.01060	.00291	.00083	.00022
5366500.0 /	.01356	.00391	.00116	.00033
5366250.0 /	.01640	.00524	.00161	.00047
5366000.0 /	.01910	.00677	.00219	.00065
5365750.0 /	.02123	.00834	.00295	.00090
5365500.0 /	.02275	.00984	.00380	.00122

*** ONE HOUR CASE 1 - NO DOWNWASH FOR FR < 3 May 22, 1985 ***

* DAILY 1-HOUR AVERAGE CONCENTRATION parts per million *
* ENDING WITH HOUR 1 FOR DAY 1 *
* FROM ALL SOURCES *
* FOR THE DISCRETE RECEPTOR POINTS *

- X -	- Y	CON.	- X -	- Y -	CON.	- X -	Y -	CON.
532762.0	5367619.0	.03478	532332.0	5366404.0	.06653	532509.0	5367825.0	.05446

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. EPA-910/9-86-147	2.	3. Recipient's Accession No.

4. Title and Subtitle COMPARISON OF AIR QUALITY MODEL ESTIMATES WITH MEASURED SO2 CONCENTRATIONS NEAR MARCH POINT, WASHINGTON	5. Report Date December 1986 6.
7. Author(s) Kirk D. Winges	8. Performing Organization Rept. No. 3710-Q81
9. Performing Organization Name and Address TRC Environmental Consultants, Inc. 15924 22nd Avenue SE Mill Creek, Washington 98012	10. Project/Task/Work Unit No. 11. Contract(C) or Grant(G) No. (C) 68-02-3886 (G)
12. Sponsoring Organization Name and Address U. S. Environmental Protection Agency Region 10 1200 Sixth Avenue Seattle, Washington 98101	13. Type of Report & Period Covered Final 14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

This report documents an air quality modeling study of sulfur dioxide concentrations near March Point, Washington. Previous Modeling conducted by the EPA was used to site air quality monitors in the vicinity of March Point. The current study evaluated the measured data from these air quality monitors with predictions using the SHORTZ and ISCST air quality models. A series of 20 different test periods were used in the model evaluations. Neither model preformed well in a comparison of measured and predicted values when the data are paired in space and time. However, model prediction improved for both models when comparison was performed with the data paired in time, but not in space. The main conclusions were that air monitoring is not necessary, given the low level of impacts, and that neither model offers significant advantages unless terrain heights are higher than the stack heights, in which case the SHORTZ Model is preferred.

17. Document Analysis a. Descriptors

Air Pollution, Meteorology, Turbulent Diffusion

b. Identifiers/Open-Ended Terms

Dispersion Modeling, ISC, SHORTZ.

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Release unlimited	Unclassified	97
	20. Security Class (This Page) Unclassified	22. Price

(See ANSI–Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4–77) (Formerly NTIS–35) Department of Commerce