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AND RESEARCH DEPARTMENT
FOLSOM BLVD., SACRAMENTO 95819

May 1972
CA-HWY-MR657107-1-72-24

Mr. Dale F. Downing
Assistant State Highway Engineer
Operations

Dear Sir:

Submitted herewith is a report titled:

STOCKTON FOG DISPERSAL

STUDY

Study made by . . . . . Environmental Improvement Section

Under general direction of . . . . . John Skog

Work supervised by . . . . . Earl Shirley
Kenneth Pinkerman

Field investigation by . . . . . Eric Torguson

Report by . . . . . Eric Torguson

Field Assistance . . . . . Ron Thompson

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

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REFERENCE: Torguson, E. D.; Shirley, E. C.; and Skog, J. B., Stockton Fog Dispersal Study, State of California, Department of Public Works, Division of Highways, Materials and Research Department, Report CA-HWY-MR657107-1-72-24, May 1972.

ABSTRACT: The Materials and Research Department monitored a fog dispersal operation conducted by World Weather, Inc. in the Stockton area during February and March of 1972. The primary purpose of the study was to evaluate the effectiveness of the contractor's truck-mounted ionized, water-surfactant fog dispersal technique. A Fog Visiometer from Meteorolgy Research, Inc. was used to detect changes in visibility. A secondary objective was to determine the potential of the Fog Visiometer for use in future visibility studies.

The visibility improved significantly on 6 of the 13 passes monitored. However, on only one pass did the visibility improve from a restricted sight distance (<500 feet) to 500 feet or better. Based on these data, it was concluded that the fog dispersal technique used by World Weather did not clearly demonstrate effectiveness in dispersing fog for high speed highway purposes.

The Fog Visiometer was found to be a valuable tool for detecting changes in visibility.

The Materials and Research Department recommends that future fog dispersal techniques be tried in a fog chamber prior to atmospheric testing. Secondly, the Fog Visiometer has potential as a fog monitoring device. However, additional testing is needed to correlate driver sight distances with visiometer output.

KEY WORDS: fog dispersal, Fog Visiometer, fog, visibility, instrumentation.

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CONTENTS

	Page
ABSTRACT	i
ACKNOWLEDGMENT	iii
INTRODUCTION	1
CONCLUSIONS AND RECOMMENDATIONS	1
METHOD OF INVESTIGATION	2
RESULTS	11
INTERPRETATION OF RESULTS	11
APPENDIX	17
1. Location Map	18
2. Test Locations	19

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ILLUSTRATIONS

		Page
Plates 1 and 2	- Truck-mounted Fog Dispersal Apparatus	2-3
Plate 3	- Electrometer	3
Plate 4	- Fog Dispersion	4
Plates 5-10	- Visibility Monitoring	5-8
Plates 11 and 12	- Fog Visiometer	9-10
Table A	- Stockton Fog Dispersal Study Results	14
Figure 1	- Site Distance Curves	15
Figure 2	- Visiometer Output	16

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INTRODUCTION

Fog has been a persistent problem for automobile and airplane traffic for many years. It is particularly serious in northern California where long periods of reduced visibility are often the cause of large chain collision accidents. As a result, considerable thought and effort has been given to ideas and devices designed to improve traffic safety.

Over the past years the Division of Highways has met with various companies interested in providing solutions to the fog accident problem. In January the Maintenance Department negotiated a contract with World Weather, Inc. to disperse fog in the Stockon area. A short time later, the Materials and Research Department was asked to evaluate the effectiveness of World Weather's technique.

The testing took place along State Route 99, U.S. Highway 50, and Interstate 5 near Stockton. A Fog Visiometer from Meteorology Research, Inc. was used to detect changes in visibility.

The primary purpose of this study was to determine whether or not World Weather's dispersal program was effective at increasing the visibility within the highway corridor. A secondary objective was to determine the potential of the Fog Visiometer for use in future visibility studies.

CONCLUSIONS AND RECOMMENDATIONS

The effectiveness of the highway fog dispersal technique used by World Weather in the Stockton trials was not proven in this study. However, the limited amount of data collected, the large number of variables, and the present shortcomings of the Fog Visiometer do leave an element of doubt concerning the results. It is strongly recommended that any additonal testing be conducted in a fog chamber. A demonstrated ability to dissipate fog under controlled conditions should be a prerequisite to further atmospheric testing.

Based on the Stockton program, it would seem that the Fog Visiometer is a valuable tool for detecting changes in visibility. The instrument is sturdy, portable, easy to operate, and could be made more effective with a few minor modifications. It is recommended that further testing be conducted to correlate driver sight distances to visiometer output. It is also recommended that the integration time be lengthened to remove unnecessary fluctuations.

Additional fog chamber tests for the visiometer will be required to provide the necessary data to develop a more accurate taillight sight distance curve or to confirm the accuracy of relationships provided by Meteorology Research, Inc.

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METHOD OF INVESTIGATION

World Weather, Inc., under the terms of the contract, was required to demonstrate techniques for fog dispersal. Their equipment, pictured in Plate 1, consisted of a truck-mounted dispersion device rigged to spray an ionized water-surfactant mixture. The dispersal mix theoretically imparted a charge to the fog droplets which would cause them to be attracted to each other. As they coalesced, the droplets would become larger and fewer, thus improving visibility. World Weather estimated that it used approximately one pint of chemicals for each mile of highway treated. Plate 2 is a close-up view of the dispersion apparatus.

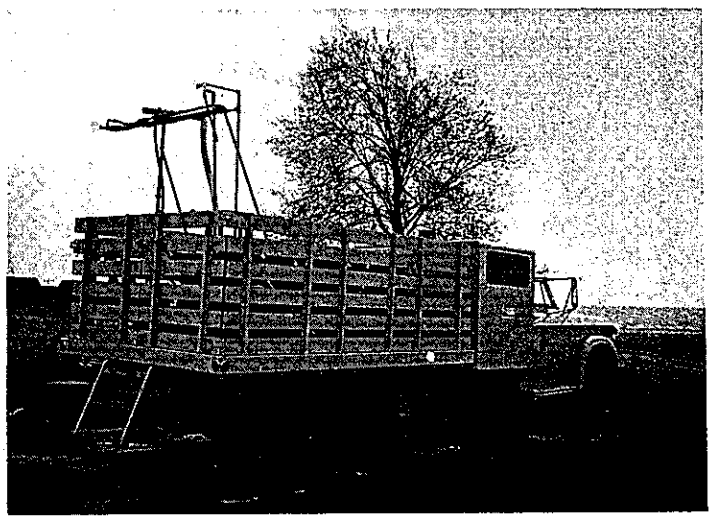

Plate 1

Truck-mounted fog dispersion device used by the contractor. (2/72)

An electrometer (see Plate 3) was used by World Weather to detect electric-potential differences in the atmosphere. In this manner the contractor attempted to apply a charge opposite that of the atmosphere to the dispersal mix.

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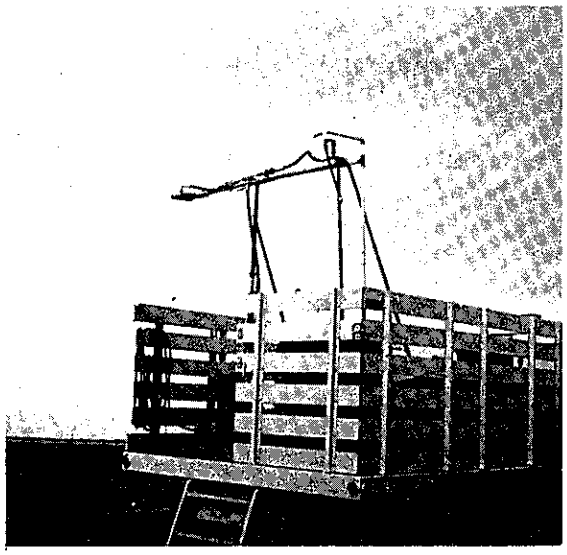

Plate 2

Close-up view of contractor's dispersion apparatus.
(2/72)

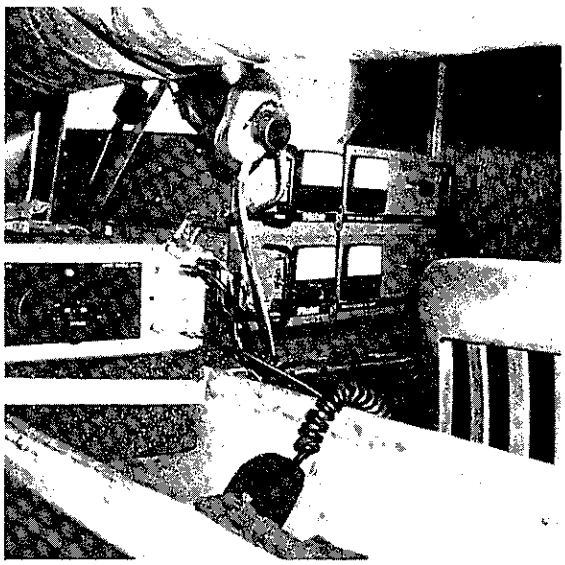

Plate 3

Electrometer used by the contractor to detect electric potential differences in the atmosphere.
(2/72)

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During periods of heavy fog, the dispersal truck was escorted by the California Highway Patrol at traffic speeds through the critical areas as a part of "Operation Fogbound", which is a program conducted by the CHP to aid highway travelers during heavy fog periods. Plate 4 is a photograph of the contractor in operation near Ripon. Whenever the average visibility dropped below 200 feet, driving conditions were considered critical and the CHP would begin convoy operations. Essentially the program consisted of ferrying groups of motorists through the critical areas at safe traveling speeds. In addition, the CHP has determined that when the average visibility falls between 200 and 500 feet, driving conditions are still considered restricted.

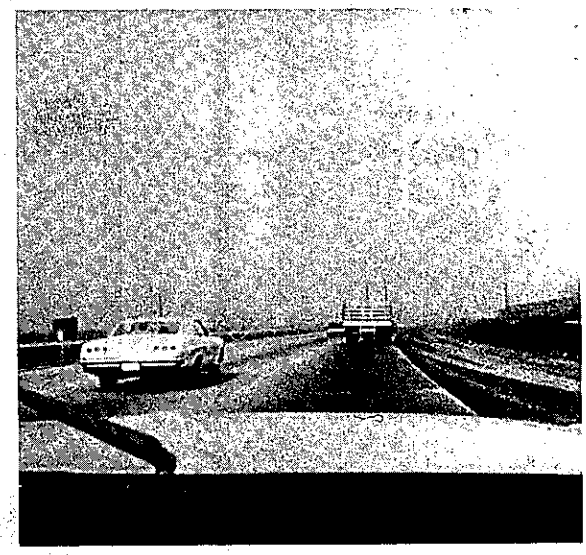

Plate 4

Contractor in Operation
State Route 99 near Ripon
(2/72)

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In most cases, the contractor made numerous passes through the fogbound zones trying to effect an improvement in visibility. Plates 5 through 10 are photographs of a large billboard approximately 800 feet north of the monitoring location. The sequenced pictures show no dramatic improvement in the visibility after any of the dispersal runs. Only a gradual change with time can be detected, which could be attributed to a natural lifting of the fog. It was felt an effective dispersal method should improve conditions to the point where they can no longer be considered restrictive. Based on the Patrol's criteria, 500 feet is used in this report as that minimum value.

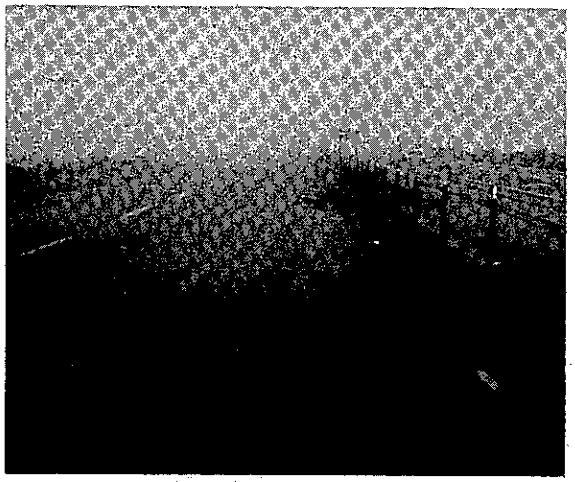

Plate 5

Visibility conditions at 10:30 AM on February 7, 1972 prior to the contractor's first pass. State Route 99 near Stockton Airport.

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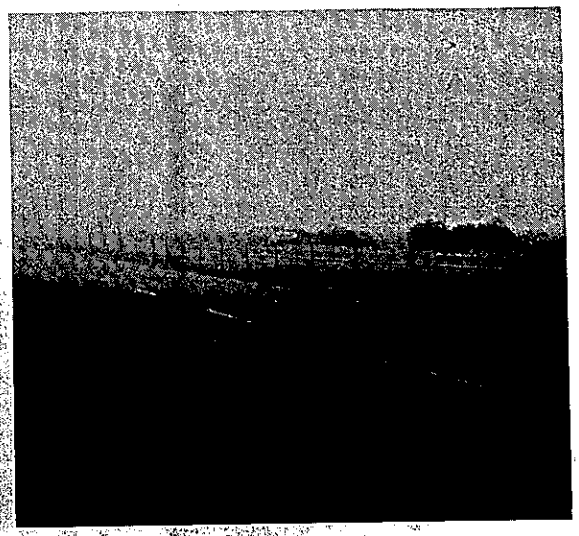

Plate 6

Conditions at 10:40 AM on February 7, 1972, 4 minutes after fog dispersant application.

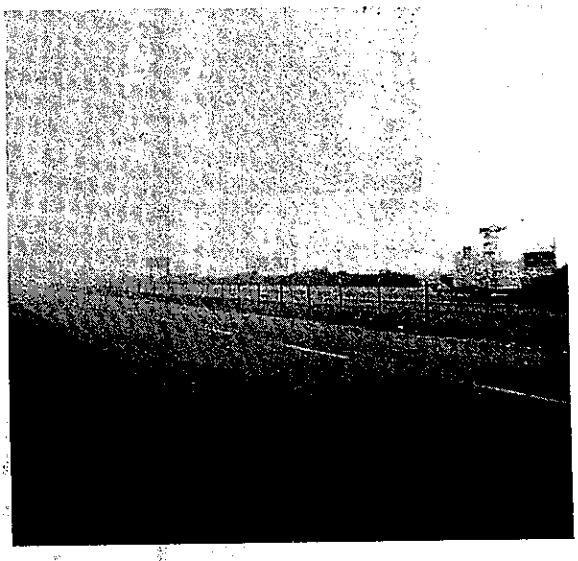

Plate 7

Conditions at 10:45 AM on February 7, 1972, 2 minutes after the second fog dispersal application. Note appearance of large sign.

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Plate 8

Conditions at 11:00 AM on February 7, 1972, 7 minutes after the second fog dispersal application.

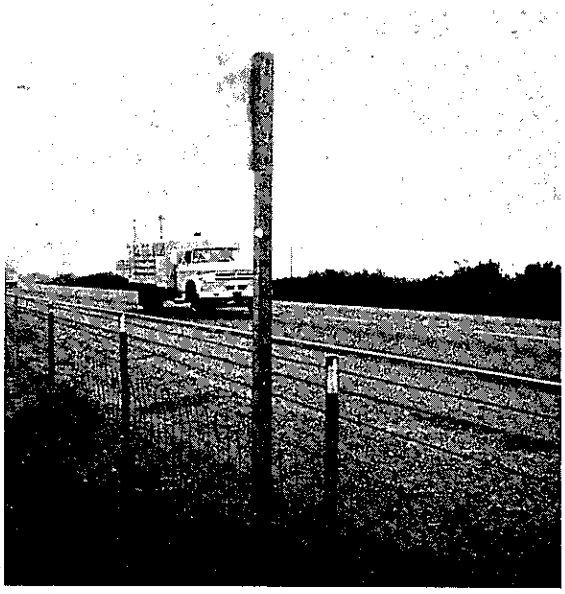

Plate 9

Conditions at 11:15 AM on February 7, 1972 as contractor makes fourth pass 7 minutes after third pass. Note large sign to left rear of truck.

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Plate 10

Conditions at 11:25 AM on February 7, 1972, 10 minutes after fourth pass by the contractor.

The test procedure consisted of selecting a suitable location within the limits of the critical fog area, monitoring the prevailing visibility before dispersion, and then monitoring the changes in visibility for a period of 15 to 30 minutes after application of the dispersant. The Fog Visiometer was mounted on a state car and remained stationary during the monitoring periods. This procedure was adopted because Meteorology Research Inc., manufacturers of the instrument, felt that the accuracy of the Fog Visiometer would be adversely affected if the recording team were to become a part of the fog dispersal convoy when its speed exceeded 25 miles per hour. Since the average convoy speed approached 50 miles per hour, it was felt a slow moving vehicle would present an additional traffic hazard under conditions that were already critical.

The lack of radio communication between the recording team and the Highway Patrol hampered the experiment. Since it was necessary to calibrate the visiometer and monitor the prevailing visibility before World Weather made its first pass, a certain amount of lead time was required. Often this was not the case and a number of recording opportunities were lost.

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A total of 13 fog dispersal passes by World Weather were monitored during February and March 1972. At each test location the wind speed and direction were recorded before and after the monitoring period. In addition, the bearing of the highway was also recorded. A correlation between wind speed and fog density was not found in the data collected. As a result, the ambient temperature was recorded at five minute intervals on run 13 in an attempt to determine if natural lifting took place or if the increase in visibility could be attributed to the fog dispersal attempts.

The data presented in this report were obtained using a Fog Visiometer from Meteorology Research, Inc. The visiometer is a continuous monitoring instrument which measures the scattering coefficient resulting from the scattering of light from suspended droplets and particles in the air.

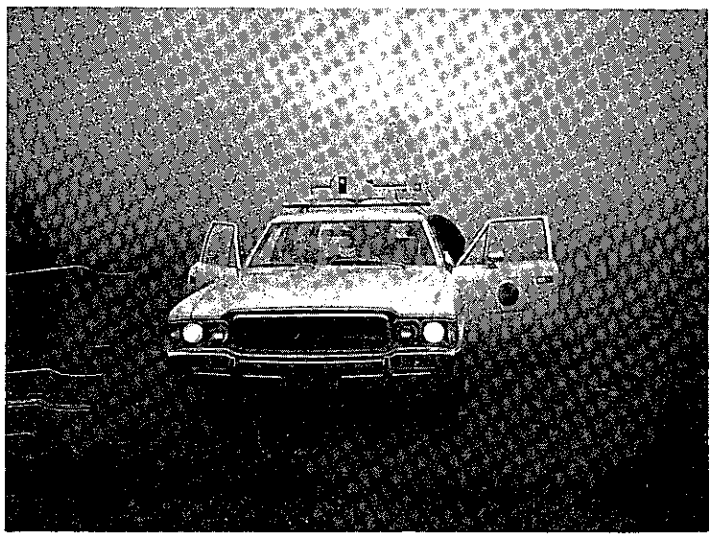

Plate 11

Visibility monitoring with Fog Visiometer at Austin Road, State Route 99 near Stockton.
(2/11/72)

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Plate 11 shows the visiometer mounted and in operation. This measurement can be related to visibility by using Figure 1. A Heath strip chart recorder was used to obtain a continuous record of the visiometer output.

The Fog Visiometer consists of two sets of diaphragms which are permanently aligned facing each other. A photomultiplier tube at one end of the assembly looks through the open center into a light trap at the other end. A xenon flashtube illuminates the atmosphere and the scattering from a portion of this region is measured by the photomultiplier. The instrument had a 15 second integration time. The calibration controls and the monitoring voltage meter are shown in Plate 12.

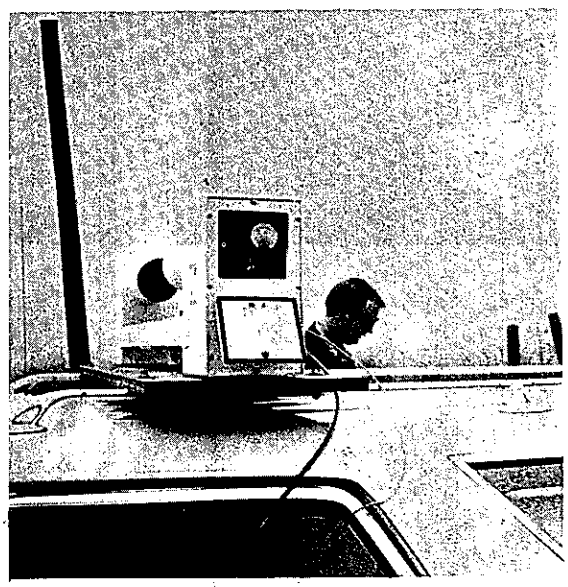

Plate 12

Visibility monitoring with Fog Visometer at Stockton Airport on State Route 99, showing visiometer controls.
(2/11/72)

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A direct correlation between visiometer response and highway visibility was difficult. Values of local visibility obtained from MRI's curves (see Figure 1) did not correspond with visual sightings. Therefore, the Materials and Research Department conducted a series of taillight visibility extinction tests to provide a better correlation with actual driver sight distances.

The extinction values plotted in Figure 1 were found by marking the point at which an observer could no longer see the lighted taillights (parking lights only) of a 1971 Rambler. The visiometer output was recorded and the distance from the observer to the car was measured.

RESULTS

The results of the Stockton Fog Study are shown in Table A. Overall, the prevailing visibility increased significantly after 6 of the 13 passes monitored during the dispersal operations. The average improvement was 34% in four positive tests (excluding trials 1 and 2 for reasons shown below). The maximum time span during which the visibility exceeded 500 feet after a pass by the contractor was 16 minutes. This occurred on run 12.

In addition, the results of the Fog Visiometer visual extinction tests are shown in Figure 1 along with three extinction curves plotted by Meteorology Research, Inc.

INTERPRETATION OF RESULTS

The most important measure of a fog dispersal technique is an improvement in visibility. Although the prevailing visibility increased significantly on 6 of the 13 passes, the ionized water-surfactant technique failed to dissipate fog in the tests. Passes 1 and 2 took place under light fog conditions (>800 feet visibility) and the results cannot be extrapolated for heavy fogs. Furthermore, according to company officials, the ionization equipment was not operative on runs 4 through 10 as noted in Table 1. This could account for the random nature of that series and hence, the improvements were probably chance occurrences. The two remaining positive trials (runs 11 and 12) were conducted using a non-ionized water-chemical mixture. Both registered a significant improvement in visibility using this technique.

Another important criterion is the length of time an improvement in visibility persists. Figure 2 illustrates a test where a significant improvement occurred. Prior to the first pass, the visibility was near 400 feet. Six minutes later it reached a maximum of 1100 feet than fell to an average of 500 feet for the remainder of the test. The total length of time the mean visibility exceeded 500 feet was 16 minutes.

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It is important to note that on only this occasion after the first two passes did the average visibility improve to 500 feet or better for any significant length of time.

Four major problems were encountered during the Stockton tests. During periods of reduced visibility the contractor had to be available for "Operation Fogbound", therefore, his equipment was not available for testing under more statistically valid conditions. Secondly, the weather did not yield dense fog patterns, thus restricting the visiometer and dispersion tests to lighter fogs. This point was critical because small changes in voltage output from the visiometer correspond to large changes in visibility under light fog conditions. Third, the Fog Visiometer had a 15 second intergration time and this interval was not sufficient to eliminate fluctuations in the instrument output. The curves shown in Figure 1 are logarithmic plots where small changes in voltage at values under one volt result in fairly large changes in sight distances. Finally, it was not possible to differentiate between an improvement in visibility due to fog dispersal efforts or an improvement due to natural causes. Wind speed and direction were recorded before and after each test series. However, these measurements failed to predict changes in fog densities. As a result, the atmospheric temperature was recorded on February 27 at 5 minute intervals, but the data collected were not sufficient to reach a conclusion on temperature effects.

The data presented in Table A were calculated using the standard "t" test. The "t" statistic is a function of the sample mean, the sample standard deviation, and the sample size. The test was used to determine whether or not there was a significant difference between the means (averages) of two samples at some level of confidence. In each case, the mean visiometer output before was compared with the mean output after each fog dispersal pass and the comparison was reported in Table A at a 95% confidence level.

The curves presented in Figure 1 represent some of the various definitions of visibility. The RVV curves refer to runway visibility and are defined as the maximum distance that an observer could see a dark object against the horizon in daylight, or at night the maximum distance an observer could see an unfocused light of moderate intensity.

The third curve (Lvd) is commonly referred to as the "Meteorological Range." It is the greatest distance at which a sufficiently large black object can be seen against the daytime horizon, assuming the eye is able to distinguish differences in contrast of 2%. The "Lvd" curve is somewhat of an idealization and is usually considered as the upper limit of daytime visibility.

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It was obvious from the first recordings that the "Lvd" curve did not correlate with highway sight distances under fog conditions. Therefore, the Materials and Research Department conducted a series of taillight extinction tests to relate visiometer output to highway visibility. The data points are shown in Figure 1 and the "Taillight Sight Distance" (TSD) curve was fitted by applying a least squares regression analysis to the data. As a result, the visibility obtained from the TSD curve is about 1/4 of the distance given by the Lvd curve for any given voltage output. The values of visibility presented in Table A are based on the TSD curve.

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TABLE A

STOCKTON FOG DISPERSAL STUDY RESULTS

Test No.	Date	Location	Test Length Min.	"t" Test 95% Confidence Level: Significant Increase Visibility	No Significant Change	Significant Decrease Visibility	Change in Average Visibility	Percent Increase Visibility	Time in Min. Visibility ≥ 500 ft.
1	2/7/72	SSR 99 Stock. Airport	25	X			800'-2800'	250	25
2		"	7	X			2800'-5600'	100	7
3		"	11			X	5600'-5200'		11
4	2/11/72	"	26			X(1)	380'-330'		0
5		"	4	X(1)			330'-400'	21	0
6		SSR 99 Austin Rd.	14			X(1)	400'-280'		0
7		"	14			X(1)	280'-235'		0
8		"	21		X(1)		235'-235'		0
9		"	26	X(1)			235'-300'	28	0
10		"	14		X(1)		300'-310'		0
11		US 50 Louise Rd.	19	X(2)			280'-360'	29	3
12		US 50 Lathrop Rd.	21	X(2)			400'-620'	55	16
13	2/27/72	I5 French Camp Rd.	6			X	380'-215'		0

(1) World Weather's ionization device was inoperative, water and surfactant mixture only.

(2) Mixture of water and chemicals, no ionization.

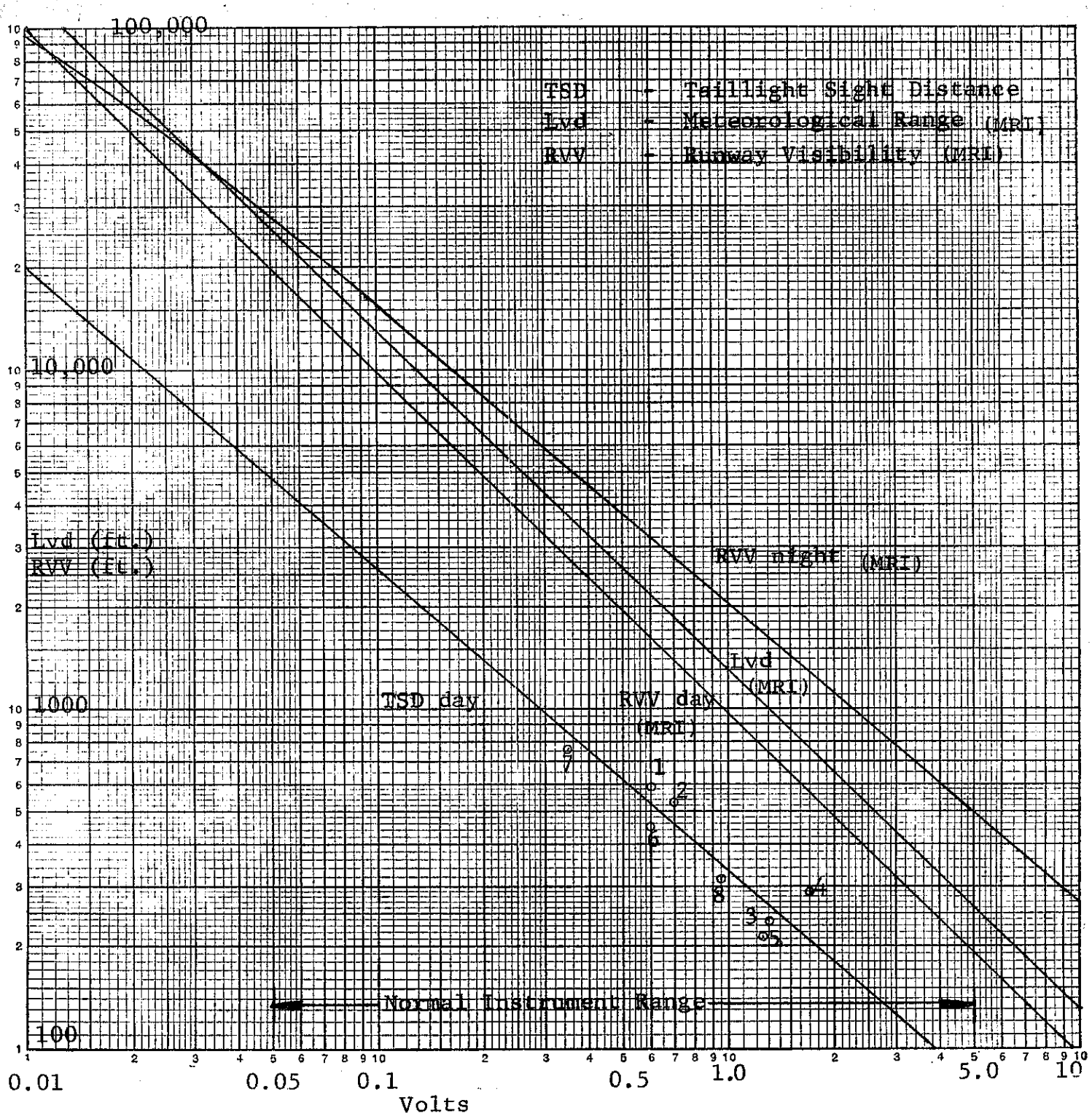

FIGURE 1

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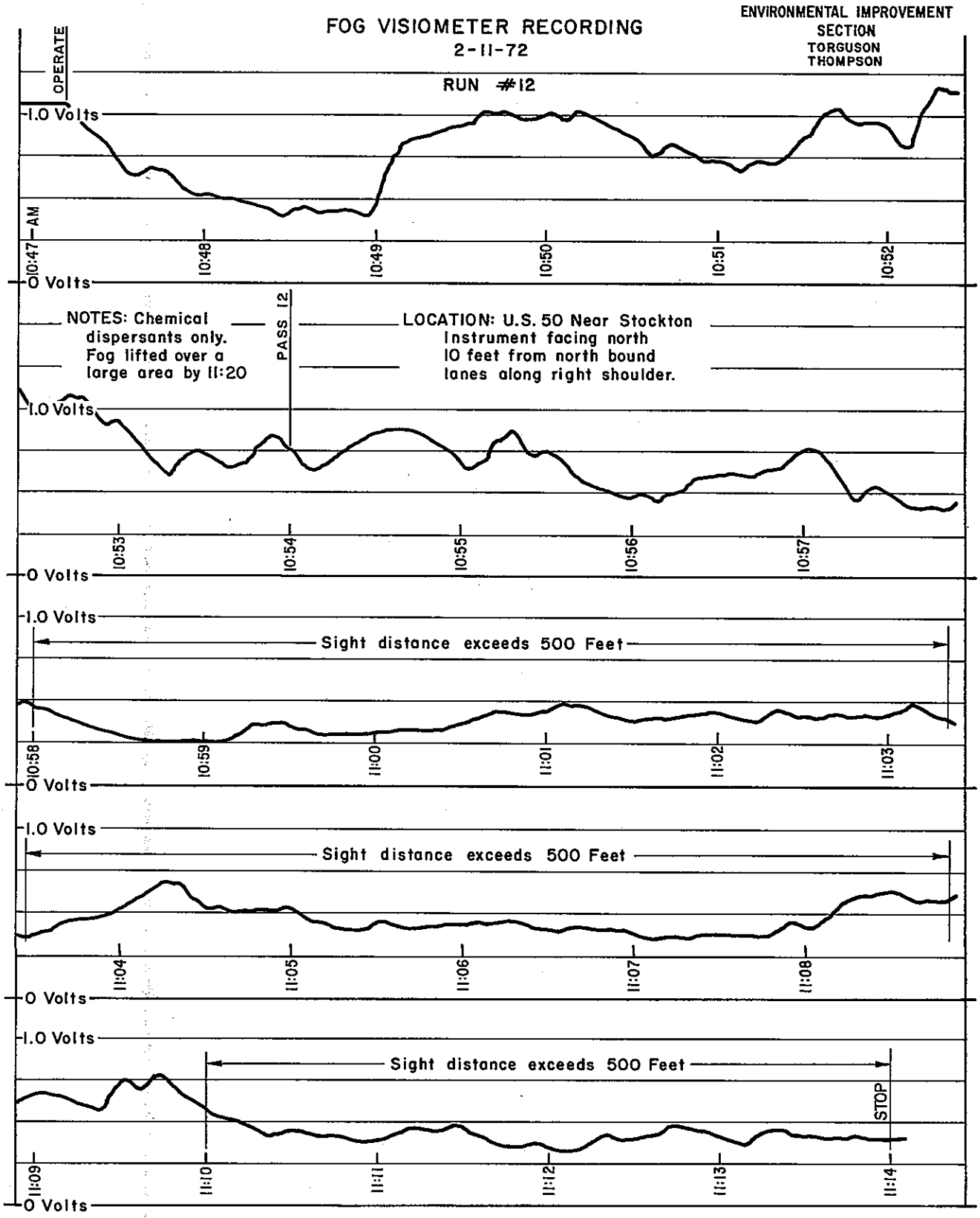
Figure 2



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APPENDIX

Location Map

Test Locations

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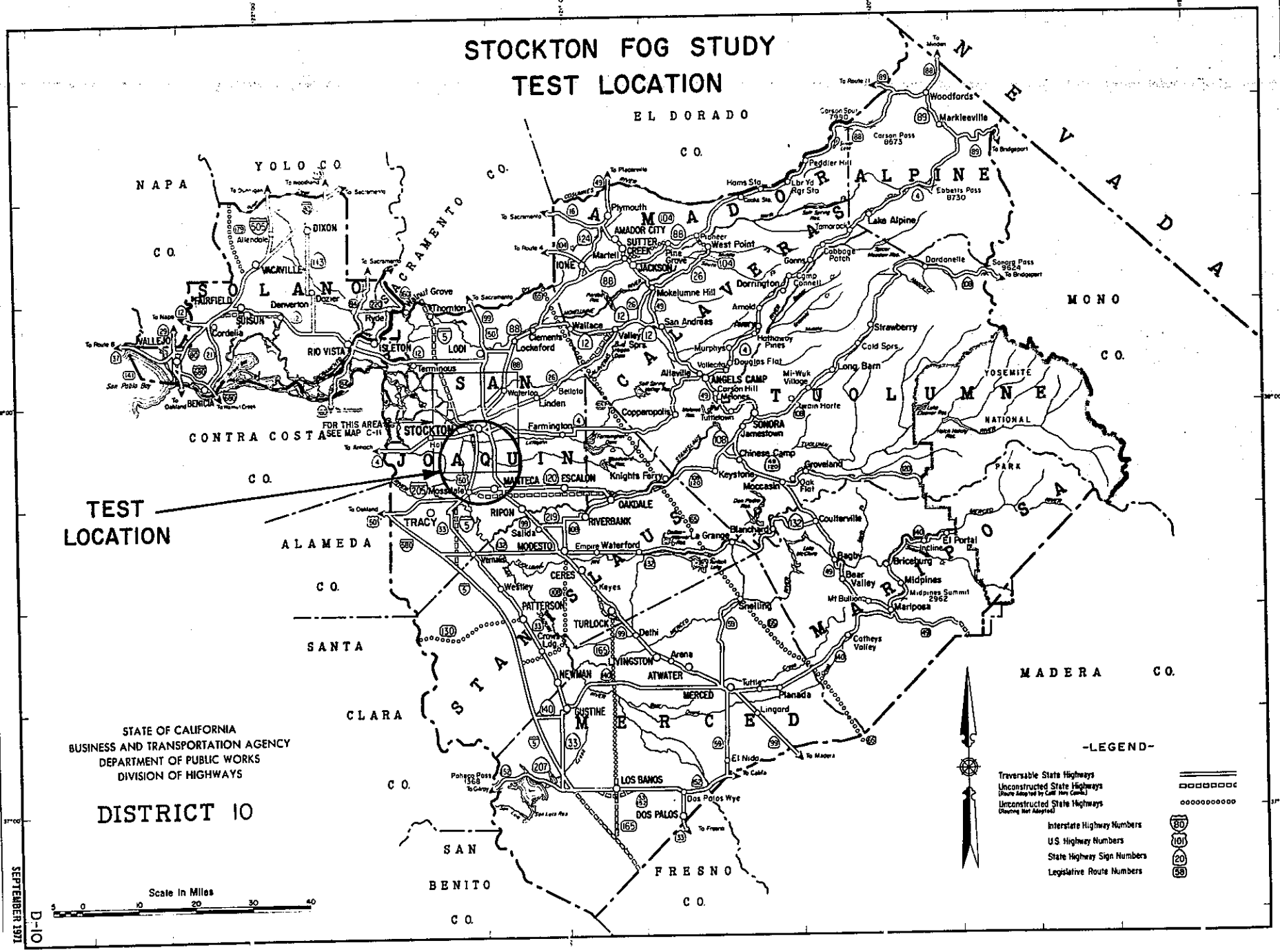

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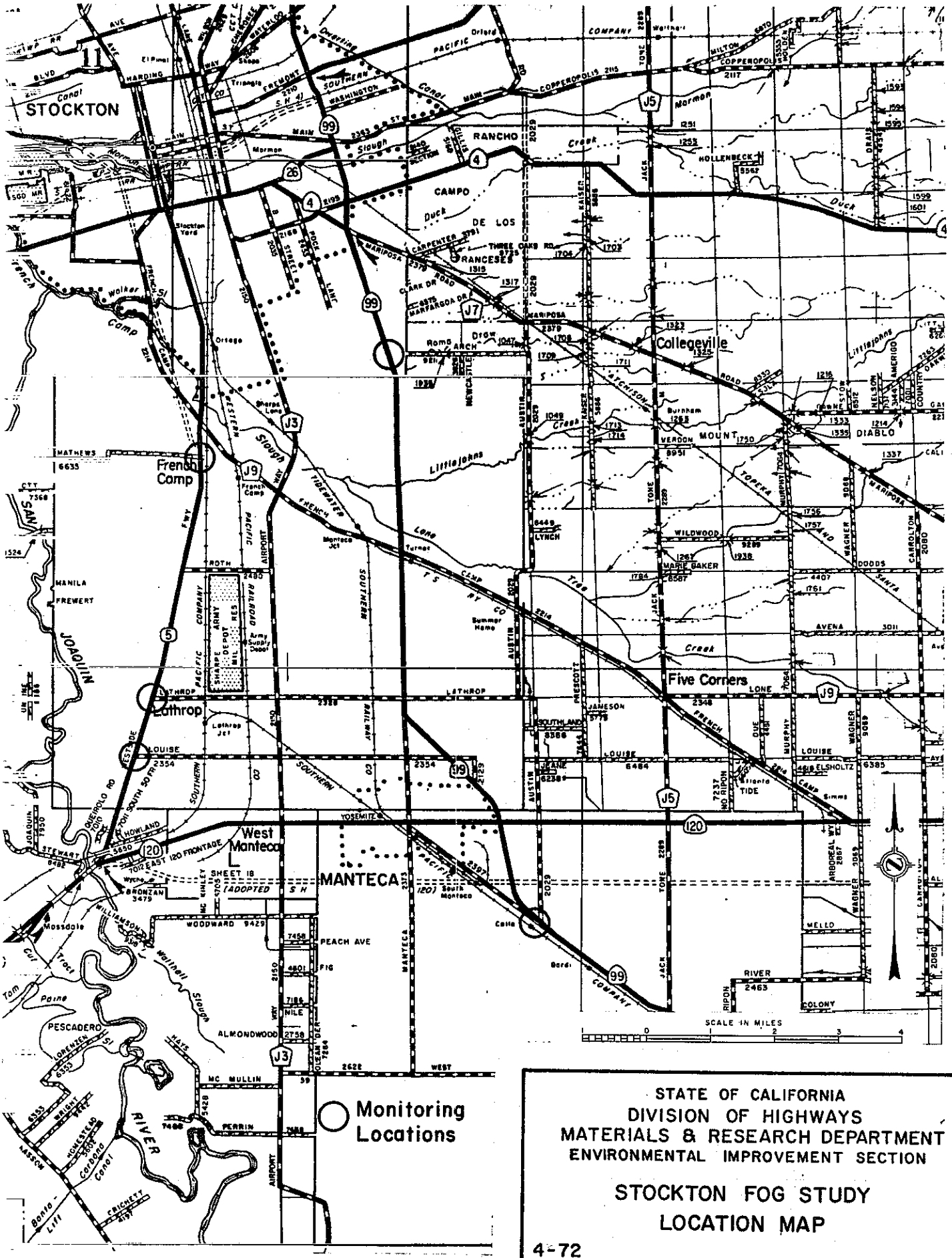

STATE OF CALIFORNIA
DIVISION OF HIGHWAYS
MATERIALS & RESEARCH DEPARTMENT
ENVIRONMENTAL IMPROVEMENT SECTION

STOCKTON FOG STUDY
LOCATION MAP

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