

1.67  
WR  
TM-53

A UNITED STATES  
DEPARTMENT OF  
COMMERCE  
PUBLICATION



# ESSA Technical Memorandum WBTM WR 53

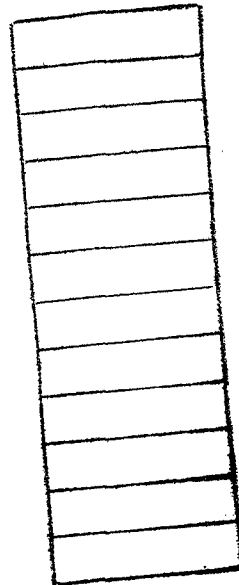
U.S. DEPARTMENT OF COMMERCE  
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION  
Weather Bureau

LIBRARY, BOULDER LABORATORIES,  
ENVIRONMENTAL SCIENCE SERVICES  
ADMINISTRATION BLDG. 700 COLORADO

SEP 23 1970

## Experimental Air Quality Forecasts in the Sacramento Valley

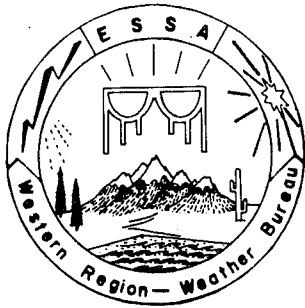
NORMAN S. BENES



Western Region

SALT LAKE CITY,  
UTAH

August 1970



## WESTERN REGION TECHNICAL MEMORANDA

The Technical Memorandum series provide an informal medium for the documentation and quick dissemination of results not appropriate, or not yet ready, for formal publication in the standard Journals. The series are used to report on work in progress, to describe technical procedures and practices, or to report to a limited audience. These Technical Memoranda will report on investigation devoted primarily to Regional and local problems of interest mainly to Western Region personnel, and hence will not be widely distributed.

These Memoranda are available from the Western Region Headquarters at the following address: Weather Bureau Western Region Headquarters, Attention SSD, P. O. Box 11188, Federal Building, Salt Lake City, Utah 84111.

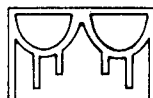
The Western Region subseries of ESSA Technical Memoranda, No. 5 (revised edition), No. 10 and all others beginning with No. 24, are available also from the Clearinghouse for Federal Scientific and Technical Information, U. S. Department of Commerce, Sills Building, Port Royal Road, Springfield, Va. 22151. Price: \$3.00 paper copy; \$0.65 microfiche. Order by accession number shown in parentheses at end of each entry.

### Western Region Technical Memoranda:

- No. 1\* Some Notes on Probability Forecasting. Edward D. Diemer. September 1965.
- No. 2 Climatological Precipitation Probabilities. Compiled by Lucianne Miller. Dec. 1965.
- No. 3 Western Region Pre- and Post-FP-3 Program. Edward D. Diemer. March 1966.
- No. 4 Use of Meteorological Satellite Data. March 1966.
- No. 5\*\* Station Descriptions of Local Effects on Synoptic Weather Patterns. Philip Williams, Jr. October 1969 (Revised). (PB-178 000)
- No. 6\* Improvement of Forecast Wording and Format. C. L. Glenn. May 1966.
- No. 7 Final Report on Precipitation Probability Test Programs. Edward D. Diemer. May 1966.
- No. 8\* Interpreting the RAREP. Herbert P. Benner. May 1966. (Revised January 1967.)
- No. 9 A Collection of Papers Related to the 1966 NMC Primitive-Equation Model. June 1966.
- No. 10\* Sonic Boom. Loren Crow (6th Weather Wing, USAF, Pamphlet). June 1966. (AD-479 366)
- No. 11 Some Electrical Processes in the Atmosphere. J. Latham. June 1966.
- No. 12\* A Comparison of Fog Incidence at Missoula, Montana, with Surrounding Locations. Richard A. Dightman. August 1966.
- No. 13\* A Collection of Technical Attachments on the 1966 NMC Primitive-Equation Model. Leonard W. Snellman. August 1966.
- No. 14 Application of Net Radiometer Measurements to Short-Range Fog and Stratus Forecasting at Los Angeles. Frederick Thomas. September 1966.
- No. 15 The Use of the Mean as an Estimate of "Normal" Precipitation in an Arid Region. Paul C. Kangieser. November 1966.
- No. 16 Some Notes on Acclimatization in Man. Edited by Leonard W. Snellman. November 1966.
- No. 17 A Digitalized Summary of Radar Echoes Within 100 Miles of Sacramento, California.
- No. 18 Limitations of Selected Meteorological Data. December 1966.
- No. 19\* A Grid Method for Estimating Precipitation Amounts by Using the WSR-57 Radar. R. Granger. December 1966.
- No. 20\* Transmitting Radar Echo Locations to Local Fire Control Agencies for Lightning Fire Detection. Robert R. Peterson. March 1967.
- No. 21 An Objective Aid for Forecasting the End of East Winds in the Columbia Gorge. D. John Coparanis. April 1967.
- No. 22 Derivation of Radar Horizons in Mountainous Terrain. Roger C. Pappas. April 1967.
- No. 23 "K" Chart Application to Thunderstorm Forecasts Over the Western United States. Richard E. Hambidge. May 1967.
- No. 24 Historical and Climatological Study of Grinnell Glacier, Montana. Richard A. Dightman. July 1967. (PB-178 071)
- No. 25 Verification of Operational Probability of Precipitation Forecasts, April 1966-March 1967. W. W. Dickey. October 1967. (PB-176 240)
- No. 26 A Study of Winds in the Lake Mead Recreation Area. R. P. Augulis. Jan. 1968. (PB-177 830)
- No. 27 Objective Minimum Temperature Forecasting for Helena, Montana. D. E. Olsen. Feb. 1968. (PB-177 827)

\*Out of Print

\*\*Revised



A western Indian symbol for rain. It also symbolizes man's dependence on weather and environment in the West.

U. S. DEPARTMENT OF COMMERCE  
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION  
WEATHER BUREAU

Weather Bureau Technical Memorandum WR-53

EXPERIMENTAL AIR QUALITY FORECASTS IN THE SACRAMENTO VALLEY

Norman S. Benes  
Principal Assistant  
WBO, Sacramento, California



WESTERN REGION  
TECHNICAL MEMORANDUM NO. 53

SALT LAKE CITY, UTAH  
AUGUST 1970

U. S. DEPARTMENT OF COMMERCE  
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION  
WEATHER BUREAU

Weather Bureau Technical Memorandum WR-53

EXPERIMENTAL AIR QUALITY FORECASTS IN THE SACRAMENTO VALLEY

Norman S. Benes  
Principal Assistant  
WBO, Sacramento, California



WESTERN REGION  
TECHNICAL MEMORANDUM NO. 53

SALT LAKE CITY, UTAH  
AUGUST 1970

## TABLE OF CONTENTS

	<u>Page</u>
List of Figures	iii
Introduction	1
Procedures	2
Table 1	4
Table 2	5
Table 3	5
Table 4	7
Conclusions	6
Acknowledgment	8
References	8

	<u>Page</u>
FIGURE 1	9
Map of the Sacramento Valley of Northern California, showing 2000-foot contours and visibility-reporting stations.	
FIGURE 2a	10
WBAN-10A for Sacramento WBAS - showing very good visibility on October 30, 1967.	
FIGURE 2b	11
WBAN-10A for Sacramento WBAS - showing reduction on visibility as the mixing height lowered on October 31, 1967.	
FIGURE 3a	12
Oakland, 4:00 a.m., October 31, 1967, upper-air sounding - mixing height depicted using Sacramento WBAS actual maximum temperature	
FIGURE 3b	13
Oakland, 4:00 p.m. Upper-air sounding twelve hours after Figure 3a, using Sacramento WBAS actual maximum temperature; note how mixing height lowered.	
FIGURE 4	14
California Air Basins, as adopted by California Air Resources Board. Note that the Sacramento Valley Air Basin includes Northern Sierra Nevada.	
FIGURE 5	15
Comparison of Oakland and Chico upper-air soundings, four hours apart; Chico warmer lower layers, colder upper layers.	
FIGURE 6	16
Forecast Form - the worksheet used in preparing Ventilation Index forecast.	
FIGURE 7	17
Objective Maximum Temperature Scheme (Zimmerman, 1959) - Used for maximum temperature prediction.	

## EXPERIMENTAL AIR QUALITY FORECASTS IN THE SACRAMENTO VALLEY

### INTRODUCTION

About 400,000 acres of rice are harvested annually in the Sacramento Valley (see Figure 1). The disposal of straw and rubble residue after harvest presents a problem of large proportions to the rice grower. Historically, burning of this straw has been the most efficient means of disposal. With steady urban encroachment into the agriculturally productive areas of California, a tolerance limit is fast approaching regarding acceptable air quality standards. Dr. Douglas H. K. Lee (1963) listed 13 atmospheric factors affecting man; among them were smoke and dust.

Rice-straw burning generally produces a highly visible smoke. With sufficient acreage afire under certain atmospheric conditions, this smoke may interfere with many human urban and suburban pursuits. Principally affected is horizontal visibility, an aesthetical variable especially important in this location. The California State Forester, Francis Raymond, commented (1967), "Sacramento city is currently being 'scourged' daily with smoke from burning rice stubble. Outcries demanding control of this air pollution are in each daily paper." This remark was triggered by the rapid deterioration in visibility from one day to the next as shown in Figures 2a and 2b. Figures 3a and 3b show that a decrease in mixing height on the 31st was associated with the decrease in visibility. In the middle of 1968, representatives of the agricultural community in the Sacramento Valley contacted the Sacramento Weather Bureau Office regarding the possibility of providing a weather forecast that would enable them to dispose of their agricultural wastes by burning and still maintain a socially acceptable level of air quality.

During the "twilight" period before the Air Resources Board set air quality standards for California, concern was felt by the rice growers regarding the impact that their farming practices might have on a well-publicized, and at times somewhat emotional, issue. At the time of their request for aid from our Sacramento Weather Bureau Office, it was pointed out that Weather Bureau forecast information would be advisory only. The State Air Resources Board (ARB), under provisions of the Mulford-Carrell Act (1967), was empowered to establish air basins throughout the state (see Figure 4). One of these basins is, essentially, the Sacramento Valley. However, in that same act, individual counties within the air basins retained the right to establish their own air pollution control district (APCD). In addition to the San Francisco APCD and the Los Angeles APCD, almost one-half of the state's counties have formed their own APCDs.

Sacramento County was reported by NACORF (1967) to have a 1965 expenditure of 5.6¢ per capita for air pollution control, compared to 60.8¢ per capita for Los Angeles County and 31.8¢ per capita for the San

Francisco Bay Area. This means that more than three and one-half million dollars for Los Angeles County, a little over one million dollars for the San Francisco Bay Area, but only twenty-eight thousand dollars for Sacramento County were spent in 1965 for air pollution control. The NACORF report does not list any areas in the United States spending less than five thousand dollars annually.

Air pollution potential (APP) forecasts are available via national teletype. The nearest locality to Sacramento for which a forecast is made is Oakland in the San Francisco Bay Area. However, the San Francisco APCD (1968) does not rely on APP forecasts for their regulatory activities concerning agricultural waste disposal by burning, as they are not detailed enough. Consequently, they have established procedures based on a local temperature-inversion climatology. A minimum requirement of 2500-foot vertical mixing (to the base of the inversion) is considered adequate, provided that there is a 7.5 degree centigrade temperature decrease in that layer from the ground to 2500 feet. In the fall of 1968 and 1969, the National Meteorological Center (NMC) mixing-height forecasts for Oakland showed a bias toward higher values with time. Forecasts for "tomorrow afternoon" were higher about 80 percent of the time than forecasts for "this afternoon". Data compiled for the Sacramento Valley by the Sacramento Weather Bureau Office, using Oakland radiosonde data and valley maximum temperatures, indicated that in the autumn of 1968, mixing heights were the same or higher the next afternoon 45 percent of the time and lower 55 percent of the time. In autumn 1969, mixing heights for the next afternoon were the same or higher 56 percent of the time and lower 44 percent of the time.

In response to pollution problems in the Willamette Valley of Oregon, Bates and Chilcote (1969) derived a regression equation that provides the approximate number of acres of agricultural waste that can be burned before visibility at a control point (Eugene) is reduced to a prescribed value, six miles. Variables used were 850-millibar wind speed and direction at Salem and 7:00 a.m. visibility at Eugene. Smoke management advisories were recently inaugurated in Oregon as aids in critical silviculture operations.

#### PROCEDURES

The Sacramento Weather Bureau Office approach was to generate a rather easily understood forecast that would enable the decision maker (the agriculturist) to choose from his options, whether to burn and how much to burn, in a manner that will produce the least particulate matter concentration in lower levels of the atmosphere. The forecast ability of the atmosphere to diffuse pollutants was called the "Ventilation Index". Panofsky (1969) states that the concentration of pollutants is inversely proportional to  $V \times D$ , the "Ventilation Factor", where  $V$  is the average wind speed in the mixed layer  $D$ . The Sacramento Valley is similar to a large box canyon, easily trapping pollutants. However, with sufficient vertical lifting and sufficient horizontal wind movement, pollutants can be dispersed.



A measure of atmospheric stability is obtained from the early morning Oakland radiosonde. Lower-level mean winds are transmitted on the preliminary raob report and provide the mean speed from the surface to five thousand feet, and from five thousand feet to ten thousand feet. Sacramento WBO used the former. Wind speeds in the valley south of Sacramento were obtained from a television broadcasting tower at Walnut Grove via a telephone call to the duty engineer at about 5:00 a.m. Wind speed there is measured near the 600-foot level and near the top, 1500 feet.

Knowledge of low-level, lower Sacramento Valley wind speeds provides the forecaster with more confidence as to existing conditions when extrapolating the Oakland surface to 5000-foot winds into the entire Sacramento Valley during the preparation of air pollution forecasts. Pibal observations taken at 1800 GMT at the Sacramento Executive Airport were used as input for possible forecast revision in the noon release via direct radio broadcasts. This noon forecast includes an "outlook" for ventilation conditions expected the next afternoon. The U. S. Air Force has a weather detachment at Chico, California, which takes some radiosonde observations in support of the Air Force's high-altitude, balloon-borne soundings released there. Prior to Sacramento WBO's first ventilation forecast season (autumn 1968), all Chico flights that were launched in the early morning during October 1967 were obtained and compared with Oakland 1200 GMT flights for the same day. The comparison indicated that the observations were similar enough to use the Oakland sounding in an experimental forecast program (see Figure 5).

Since visibility was used as the measure of air quality, the aid of several cooperators was obtained in reporting the 4 p.m. visibility at Biggs, Willows, Woodland, Arbuckle, and Davis (see Figure 1). In addition, hourly visibility reports were available from the following aviation weather-reporting stations in the Sacramento Valley: Redding (RDD), Chico (CIC), Red Bluff (RBL), Beale Air Force Base (BAB), Marysville (MYV), Sacramento Metropolitan Field (SMF), Sacramento Executive Airport (SAC), McClellan Air Force Base (MCC), Mather Air Force Base (MHR), and Travis Air Force Base (SUU). Cooperators were supplied with charts indicating prominent landmarks at known distances, and arrangements were made to have their observations telephoned to Sacramento WBO each afternoon. This would, ordinarily, be the time of day that maximum ventilation through mixing should occur. These observations would also indicate the accuracy of forecasts distributed via radio broadcast at 6:30 a.m. that morning. Holzworth (1961) concluded that visibility data can be an important source of information in the evaluation of air pollution problems.

Two work sheets were used by the Sacramento WBO forecaster: one was the forecast form (Figure 6), the other was a portion of a large pseudoadiabatic diagram (Figure 5). On the pseudoadiabatic chart, 850- and 700-mb mandatory level data, mean-layer winds and significant

level data to 700 mbs were plotted. After forecasts of representative maximum temperatures for the southern and northern halves of the valley had been made, the mixing height was determined by following the dry adiabat from its point at the surface corresponding to the forecast maximum temperature up to its intersection with the observed free-air temperature curve. An objective maximum-temperature forecasting aid based on the 850-mb temperature at 1200 GMT and the Travis AFB surface wind speed and direction at 1500 GMT was used, but modified to fit operational time requirements (see Figure 7).

The formula used for the Ventilation Index (VI) is:

$$VI \text{ equals } MH \text{ times } \overline{WS}$$

where MH is the mixing height (hundreds of feet) based on the forecast maximum temperature and  $\overline{WS}$  is the forecast average wind speed in knots through the mixed layer. In the first season, late September - early December of 1968, the numerical ventilation categories were labeled as shown in Table 1:

TABLE I - VENTILATION CATEGORIES

<u>Ventilation Index (VI)</u>	<u>Category</u>
> 600	Excellent
401 - 600	Good
181 - 400	Fair
< 180	Poor

Miller (1968) reported that the average mixing depth for the Sacramento Valley in October was a relatively low value of 3000 feet. This was the next to the lowest value of the four seasons sampled; therefore, it was considered more appropriate to label the best ventilating conditions something other than "Excellent", particularly when used in one of the poorer seasons. In 1969, the label for the best ventilation category was changed from "Excellent" to "Very Good".

During the 1968 and 1969 seasons, forecasts were made daily except Sunday in fall and early winter, but verification data were not available on all days. Distribution of forecasts according to category is given in Table II:

TABLE II - VENTILATION FORECASTS

<u>Category</u>	<u>1968</u>	<u>1969</u>
Excellent (Very Good)	0	7
Good	8	10
Fair	25	15
Poor	<u>13</u>	<u>28</u>
Total	48	60

These forecasts were based on forecast mean wind speed through the mixing height stratum and forecast mixing height. The latter is a function of the observed temperature lapse rate and the forecast surface maximum temperature. In the two seasons, maximum-temperature forecasts were just a little more than two degrees in error on the average. However, the average mixing height forecast was in error by almost 1000 feet.

In the list of criteria proposed by the California Air Resources Board, the following conditions are considered to exceed (be worse than) the air quality standard: Relative humidity less than 70 percent, and two successive observations one hour apart indicating visibility 7.5 miles or less occurring on seven or more days in a 90-day period or on three or more consecutive days. Data from Sacramento Executive Airport show that this standard was not met in the 1969 season. From the 22nd of September through the 6th of December, 32 of the 75 days were below proposed standards. Every day that showed two successive observations one hour apart with visibility 7 miles or less and relative humidity less than 70 percent was counted; from the 21st of November through the 6th of December, this was a daily occurrence. During most of this latter period, the Sacramento Valley was included in the area forecast by the Washington National Meteorological Center to have high air pollution potential. A comparison of two categories of visibility (six miles less, and less than three miles) for November 1969 proved interesting when arrayed against a ten-year November record, 1951-1960, for the Sacramento Executive Airport, as shown in Table 3.

TABLE III - OBSERVED VISIBILITY CATEGORIES

	<u>November 1951-1960 Average</u>	<u>November 1969</u>
Less than 3 miles	101	84
6 miles and less	302	343

Thus, November 1969 conditions were not grossly different from normal conditions. Data from hourly observations were used in the comparison.

Verification by category of forecast, i.e., "Poor", "Fair", "Good", or "Excellent" (Very Good) for the 1968 and 1969 fall seasons is given in Table 4. The 0000GMT Oakland radiosonde data was used in the verification, assuming that it represented afternoon low atmospheric structure in the Sacramento Valley. The Oakland observed lapse rate and Sacramento observed maximum temperature were used to determine the mixing depth. Oakland winds aloft were then used to compute the mean-layer wind speed through the mixing depth. This speed was then assumed to be representative of the Sacramento Valley.

It may be seen that verification was good, with 59/96 or 62% of the forecasts in the correct category for combined data and 80/96 or 83% within one category of being correct.

Informal verification was obtained also through aircraft flights during the 1968 season. Several flights were made by University of California Agricultural Extension Service personnel to assess the degree of cooperation on the part of the user (rice grower) and as a check on Weather Bureau forecasts, the 6:35 a.m. forecast broadcast through commercial radio being closely monitored. Through personal communication, the Sacramento WBO learned that its forecasts were judged to be highly satisfactory.

#### CONCLUSIONS

In response to a request from private citizens, the Sacramento Weather Bureau Office initiated an advisory air quality forecast program based on a "ventilating index" concept. Forecast terminology was kept simple, as was the method of forecast preparation. Decisions regarding management of agricultural waste disposal were incumbent upon the forecast user. Wind observations from a TV tower in the valley were used and a temporary meso-scale network of visibility observing stations was set up. This satisfied, in part, recommendation of the Meteorology Panel, United States Technical Conference on Air Pollution (1950), and Recommendation A1 of an American Chemical Society Subcommittee on Environmental Improvement (1969) regarding low-level winds, more dense observation sites, and general measurement of the atmosphere's turbidity. Information to date indicates that the Sacramento WBO program was successful.

The simple methods used in arriving at an estimation of atmospheric ventilating qualities presented here may not suffice for the more complex future requirements. When legal constraints are added to strict California Air Resource Board ambient air quality standards, more pertinent data may be required than that used in this experiment.

Smaller scale wind observing networks and low-level temperature soundings in the Sacramento Valley will undoubtedly be required.

TABLE IV

VENTILATION INDEX FORECAST VERIFICATION BY CATEGORY

P-Poor; F-Fair; G-Good; E-Excellent. E(1968) equals VG(1969)

1968 OBSERVED						1969 OBSERVED							
		P	F	G	E	Total			P	F	G	VG	Total
F O R E C A S T	P	8	2	0	2	12	F O R E C A S T	P	19	4	0	0	23
	F	4	14	3	4	25		F	2	8	2	2	14
	G	2	3	1	0	6		G	1	3	2	1	7
	E	0	0	1	1	2		VG	0	1	1	6	8
Total		14	19	5	7	45	Total		22	16	5	9	52

1968-1969 COMBINED						1968-1969 COMBINED OBSERVED PERCENT						
		P	F	G	E, VG	Total			P	F	G	E, VG
F O R E C A S T	P	27	6	0	2	35	F O R E C A S T	P	77	17	0	6
	F	6	22	5	6	39		F	15	56	14	15
	G	3	6	3	1	13		G	23	46	23	8
	E, VG	0	1	2	7	10		E, VG	0	11	11	78
Total		36	35	10	16	97						

ACKNOWLEDGMENT: Mr. James R. Miller, Meteorologist in Charge; and Mr. David I. Wise, Agricultural Forecaster, deserve most of the credit for initiating and designing the working features of this program.

#### REFERENCES

- Bates, Earl M. and D. O. Chilcote, 1969: Preliminary report on agricultural field burning vs. atmospheric visibility in the Willamette Valley of Oregon. Preprint. Presented at Agricultural Meteorology Conference, Seattle, Washington, September 8 - 10 (to be published as WR Tech Memo).
- Cooke, Lloyd M., Chairman, 1969: Cleaning our environment - the chemical basis for action. Report by the Subcommittee on Environmental Improvement. American Chemical Society, P. 7-8.
- Hewson, E. Wendell, Chairman, 1950: Recommendation of the Meteorology Panel, United States Technical Conference on air pollution. BAMS 31, 264-265.
- Holzworth, George G., 1961: Some effects of air pollution on visibility in and near cities. Air Over Cities, p. 86.
- Lee, Douglas H. K., 1963: Biometeorology in occupational health. Bulletin American Institute of Biological Sciences. June, p 29.
- Miller, James R., 1968: The problem of controlling air pollution in the Sacramento Valley - the role of the U. S. Weather Bureau (Unpublished Manuscript), WBO, Sacramento.
- NACORF, (National Association of Countries Research Foundation), 1967: No. 1, The Areawide Approach. Air Pollution Control.
- Panofsky, Hans A., 1969: Air pollution meteorology. American Scientist, 57, 278.
- Raymond, Francis, 1967: Controlled burning on California wildlands. Proceedings Tall Timber Fire Ecology Conference 7, 29.
- Technical Services Division, 1968: An agricultural burning control program derived from inversion climatology in the San Francisco Bay Area. Bay Area Air Pollution Control District, p. 13-14.

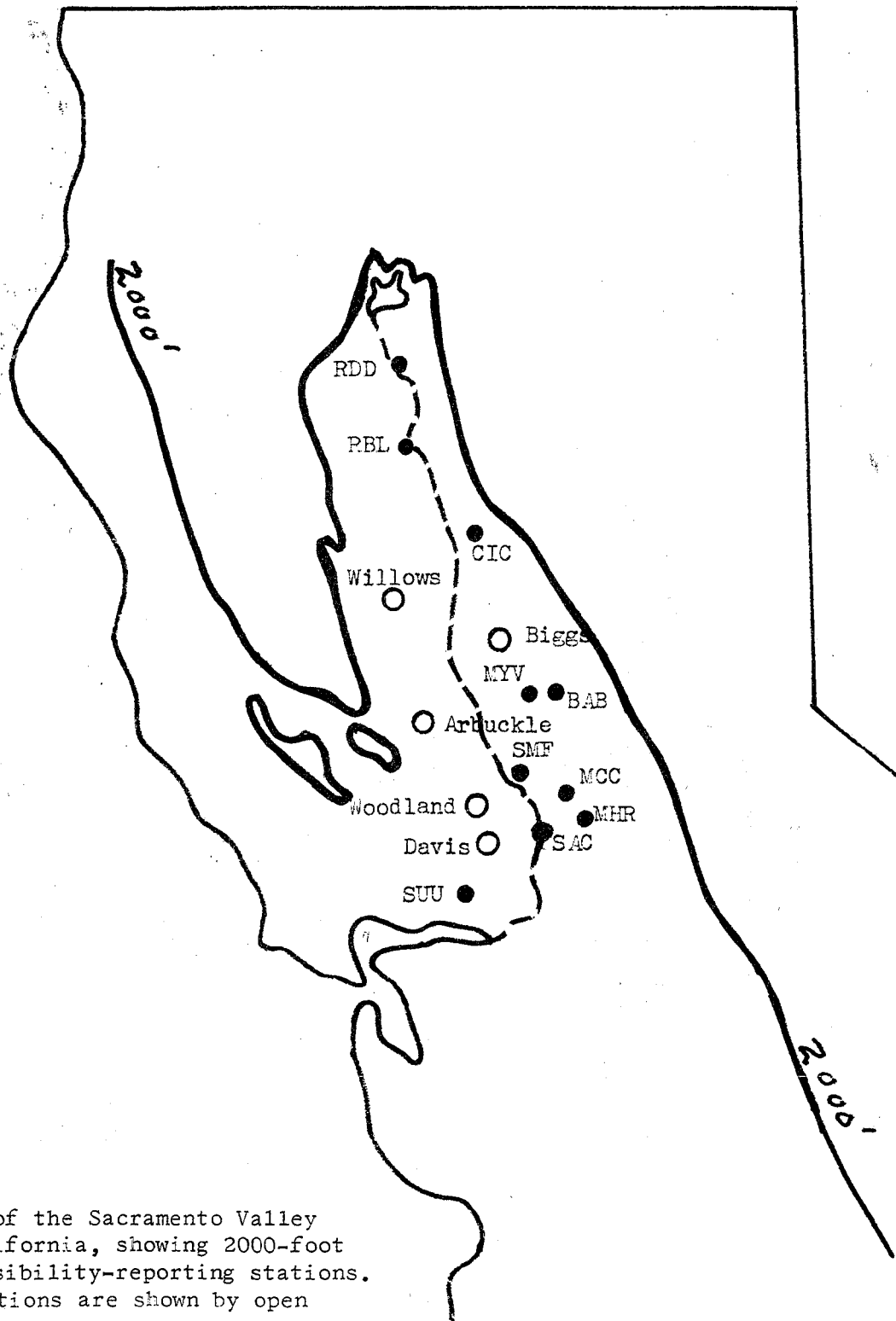


Figure 1. Map of the Sacramento Valley of northern California, showing 2000-foot contours and visibility-reporting stations. Cooperative stations are shown by open circles.

SURFACE WEATHER OBSERVATIONS

DATE  
OCT 30 1967

Type (1)	Time (LST) (2)	Sky and ceiling (Hundreds of Feet) (3)	Visibility (Statute Miles) (4)		Weather and obstructions to vision (5)	Sea level press. (mb.) (6)	Temp. (F) (7)	Dew pt. (F) (8)	Wind (9)			Altim- eter setting (Inches) (12)	Remarks and supplemental coded data (13)	Ob- serv- er's initials (15)
			Surface (4a)	Tower (4b)					Dir- ec- tion Miles (9a)	Speed (Kts) (10)	Charac- ter (11)			
R	0055	0	15			207	50	32	35	03	015	317		BB
R	0157	0	15			212	51	33	35	04	014			ST
R	0258	0	15			214	49	35	00	00	015			ST
R	0358	0	15			218	48	35	00	00	016			ST
72483	00000	00000	74020		21809	00900	022	0	47	847	CITY 765152	640000		RL
R	0458	0	15			216	45	33	00	00	017			RL
R	0558	0	15			222	44	33	00	00	018			RL
R	0658	0	25			229	45	35	00	00	020	312		RL
R	0758	0	20			236	54	37	00	00	022	MOCTY		RL
R	0858	0	15			239	62	40	00	00	023	USBY NS MOCTY		RL
R	0958	0	15			239	66	40	16	02	023	MOCTY		RL
72483	01602	01602	74020		23919	00900	041	10	46	744	46744			RL
R	1058	0	10			239	71	46	18	04	023			RL
R	1158	-X	6		K	233	72	47	24	06	021	K1		RL
R	1259	0	10			223	74	48	19	06	018	817 1001		JC
R	1355	0	10			216	77	47	24	06	016			JC
R	1456	1-0	15			216	78	46	18	03	016			JC
R	1555	1-0	15			212	78	45	15	04	015	KLVR W-N		JC
72483	11504	11504	74020		21226	00901	077	10	47	944	CITY 804979			JC
R	1657	200/0	10			212	74	46	15	03	015	K20		JC
R	1756	0	15			218	68	46	18	04	016	KLVR W-N		JC
R	1857	0	15			219	65	43	00	00	017	307		JC
R	1956	0	15			219	61	44	00	00	017			JC
R	2055	0	15			222	59	44	10	05	018			(S)
R	2155	0	15			226	57	43	17	05	019	307 79		(S)
R	2258	0	15			229	56	42	00	00	020			(S)
R	2358	0	15			229	56	41	00	00	020			(S)

555 2.6

Figure 2a

the following related aviation observation.



SURFACE WEATHER OBSERVATIONS

DATE  
OCT 31 1967

Type	Time (LST)	Sky and ceiling (Hundreds of Feet)	Visibility (Statute Miles)		Weather and obstructions to vision	Sea level press. (Mbs.)	Temp. (°F)	Dew pt. (°F)	Wind			Altimeter setting (In.)	Remarks and supplemental coded data	Observer's initials	
			Surface (4)	Tower (4a)					Direction (true) (9)	Speed (Kts) (10)	Character (11)				
(1)	(2)	(3)	(4)	(4a)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14a) (14b)	(15)
R	0055	0	15			229	54	40	11	03	020	103			BB
R	0155	0	15			236	52	40	33	03	021	WNW DIR VRL			BB
R	0255	0	15			229	50	41	30	02	020				BB
R	0358	0	10			229	49	40	00	00	020				RL
T	0458	00000	66	020		229	09	24	400	00	020	4	944 CITY 805253 CD		RL
R	0458	0	10			233	49	40	00	00	021				RL
R	0558	0	10			236	49	40	00	00	022				RL
R	0618	0	8			237	48	42	00	00	022	208			RL
R	0758	0	4		K	241	54	44	36	03	023				RL
R	0858	0	4		K	241	62	45	36	04	023				RL
R	0958	0	5		K	241	66	47	30	03	023				RL
T	1245	03003	58	040		209	00		08	103	022	46747 CD			RL
R	1058	0	4		K	236	70	47	32	04	022				RL
R	1158	0	5		K	226	76	48	32	07	019				RL
R	1258	0	6		K	212	79	47	34	06	015	829			JL
R	1357	0	5		K	202	80	45	33	05	012				JL
S	1430	-X	2	2	K				36	07	011	VSBY SSW 3	K6		JL
R	1458	-X	1 1/2	1 1/2	K	195	80	45	35	04	010	R02VV 1 1/2+	K6		JL
R	1558	-X	1 1/2	1 1/2	K	191	79	46	02	04	008	R02VV 1 1/2+	K6		JL
T	1658	00204	24	040		191	26	00	09	00	086	22-48147 CITY 794878 CD			JL
R	1658	-X	1	1	K	185	72	48	00	00	007	R02VV 1 3/8	K8		JL
R	1758	-X	1 1/2	1 1/2	K	183	68	47	00	00	006	R02VV 1 1/2+	K8		JL
R	1858	-X	1 1/2	1 1/2	K	182	64	46	26	03	006	R02VV 1 1/2+	K7 608		JL
R	1957	-X	1 1/2	1 1/2	K	182	59	45	00	00	006	R02VV 1 1/2+	K7		JL
S	2031	-X	3	3	K	-	-	-	00	00	006	K7			RL
R	2057	-X	3	3	K	185	57	47	00	00	007	K7			WT
R	2157	-X	2	2	K	185	58	46	10	04	007	K7 / 103 81			RL
R	2256	-X	2	2	K	181	57	43	10	04	005	K76 VSBY E 2 1/2			KK
S	2329	-X	3	3	K	-	-	-	11	04	005	K7 VSBY NW 2 1/2			RL
R	2355	-X	4	4	K	180	55	42	11	03	005	K6			RL

related aviation observation.

Figure 2b

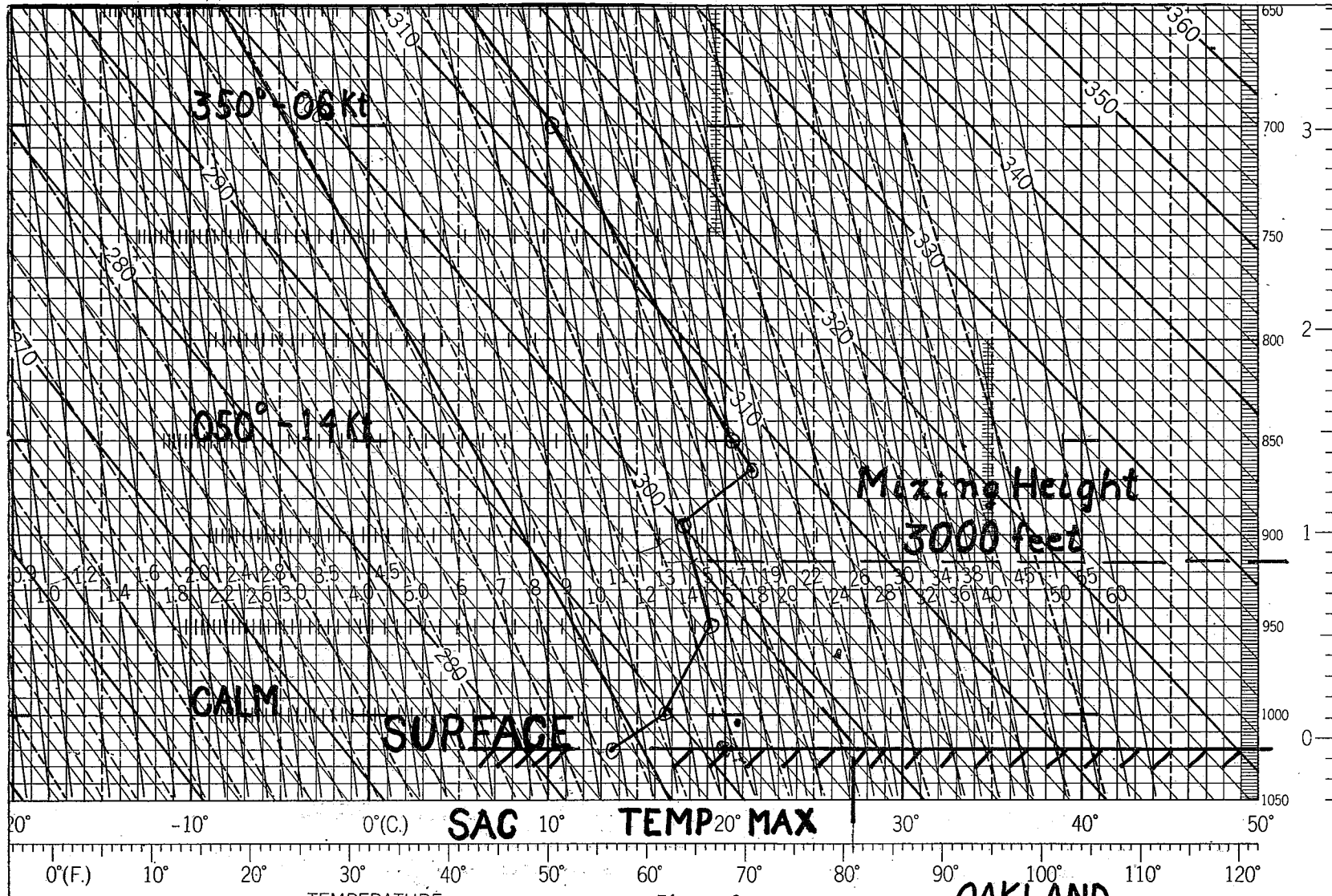


Figure 3a

Station **OAKLAND**

Date (G.C.T.) **OCT. 31, 1967**

Hour (G.C.T.) **1200** Drawn by **AB**

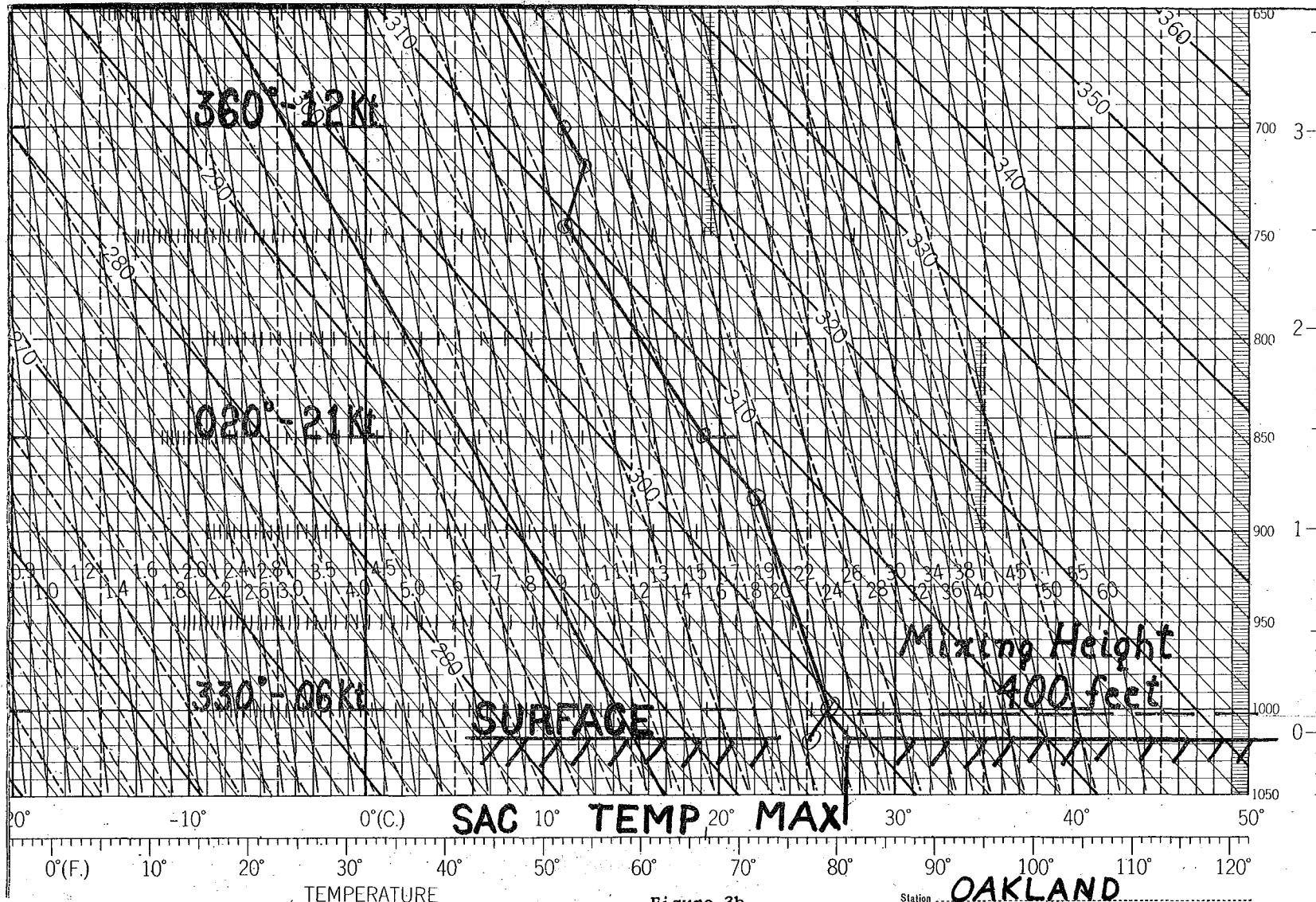


Figure 3b

Station **OAKLAND**  
 Date (G.C.T.) **NOV 1, 1967**  
 Hour (G.C.T.) **0000** Drawn by **NB**

STATE OF CALIFORNIA  
AIR BASINS



CALIFORNIA AIR RESOURCES BOARD  
Adopted November 1968

Figure 4

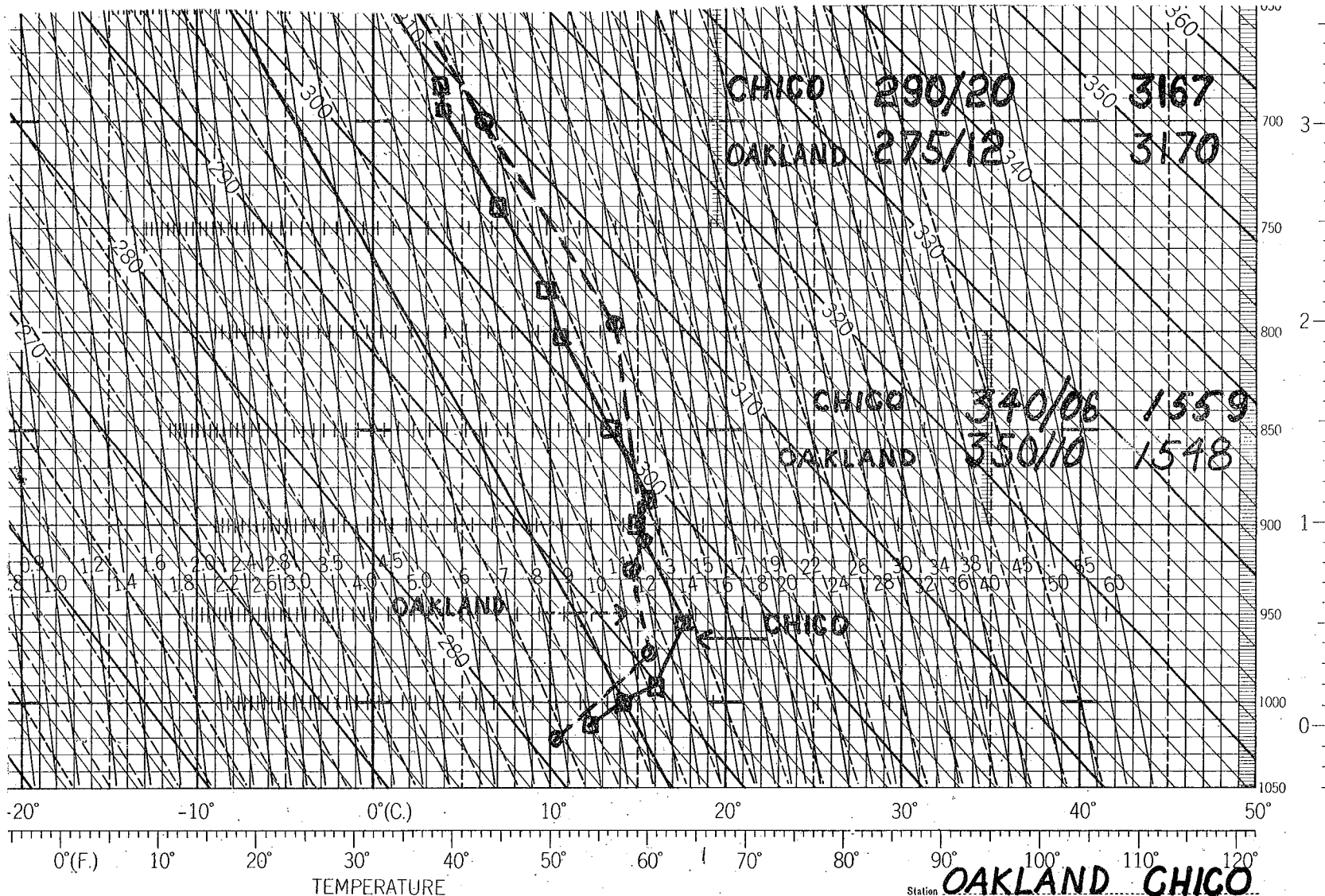


Figure 5

VENTILATION FORECAST

WBO, Sacramento, California

Date: \_\_\_\_\_

The atmospheric ventilation forecast for agricultural operations in the Sacramento Valley indicates that this afternoon conditions will be:

(6:30 AM)

(Noon)

The outlook for tomorrow afternoon indicates the atmospheric ventilation conditions will be (the same) (better) (worse).

OAKLAND 12Z RAOB DATA

Lower Inversion

Base \_\_\_\_\_ Ft. MSL

Top \_\_\_\_\_ Ft. MSL

Upper Inv/Isothermal

Base \_\_\_\_\_ Ft. MSL

Top \_\_\_\_\_ Ft. MSL

OAK 850 Mb. Temp. \_\_\_\_\_

SAC 850 Mb. Temp. \_\_\_\_\_ (Est.)

	Fcst Sfc Wnd Speed & Dir	Max Temp Fcst Obs	Mixg Hgt Based on Fcst T   Obsr T	Mean Wnd in Mixg Layer	Ventilation Index*	Rating
N. Sutter B						
S. Sutter B						

\*Ventilation Index = Mixing Height in 100' x Mean Wind in Knots

Ventilation Index: Under 180 - Poor                      401-600 - Good  
 181-400 - Fair    Over 600 - Very Good

OAKLAND AIR POLLUTION POTENTIAL DATA (Sent 1720Z)

This AM                      This PM                      Tomorrow PM                      Verification  
 MH - Wnd                      MH - Wnd                      MH - Wnd                      Prev. Col.

(Decameter x 30 = Ft.; Mps x 2.2 = Mph)

WIND DATA

	TV 590'	1440'	SAC	SMF	MYV	RBL	BIGGS	WILLOWS	WILLIAMS	WOODLAND	ARBUCKLE
6 AM							X	X	X	X	X
11 AM							X	X	X	X	X
4 PM											

VISIBILITY REPORTS

	SAC	SMF	MYV	RBL	BIGGS	WILLOWS	WILLIAMS	WOODLAND	ARBUCKLE
Sunrise					X	X	X	X	X
10 AM					X	X	X	X	X
Moon					X	X	X	X	X
4 PM									
Sunset					X	X	X	X	X

Figure 6

OBJECTIVE AID FOR TODAY'S MAXIMUM TEMPERATURE, SACRAMENTO

-- S E P T E M B E R --

SUU 1500 Z WINDS ARE NEARLY ALWAYS FROM DIRECTION S THRU W. WHEN EASTERLY OR NORTHERLY COMPONENTS OCCUR, REGARDLESS OF VELOCITY, USE CURVE "5 OR LESS." WHEN GUSTS ARE REPORTED, USE GUST VELOCITY.

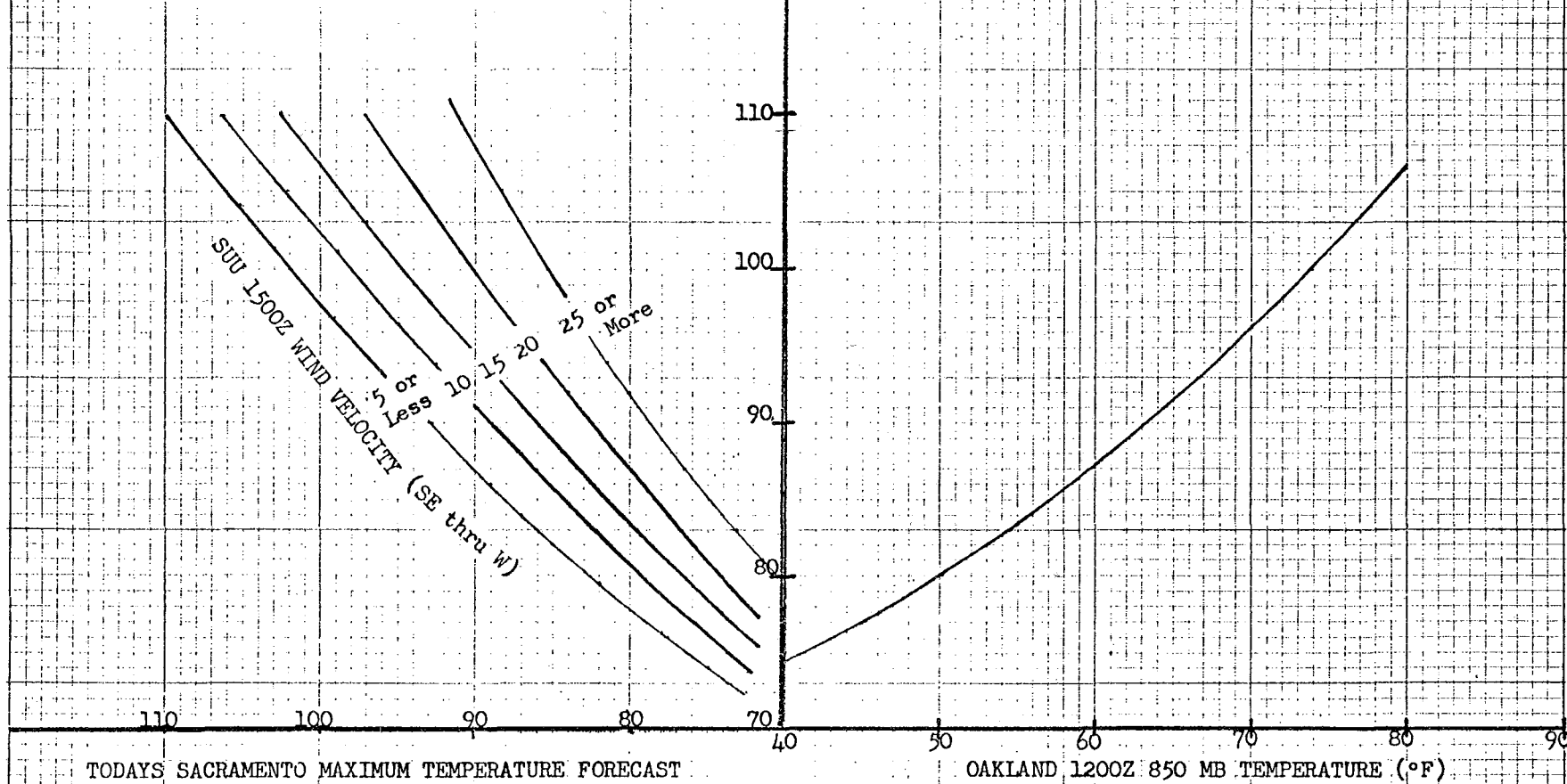


Figure 7

Western Region Technical Memoranda (Continued):

- No. 28\*\* Weather Extremes. R. J. Schmidli. April 1968. (PB-178 928)
- No. 29 Small-Scale Analysis and Prediction. Philip Williams, Jr. May 1968. (PB-178 425)
- No. 30 Numerical Weather Prediction and Synoptic Meteorology. Capt. Thomas D. Murphy, U.S.A.F. May 1968 (AD-673 365)
- No. 31\* Precipitation Detection Probabilities by Salt Lake ARTC Radars. Robert K. Belesky. July 1968. (PB-179 084)
- No. 32 Probability Forecasting in the Portland Fire-Weather District. Harold S. Ayer. July 1968. (PB-179 289)
- No. 33 Objective Forecasting. Philip Williams, Jr. August 1968. (AD-680 425)
- No. 34 The WSR-57 Radar Program at Missoula, Montana. R. Granger. October 1968. (PB-180 292)
- No. 35\*\* Joint ESSA/FAA ARTC Radar Weather Surveillance Program. Herbert P. Benner and DeVon B. Smith. December 1968. (AD-681 857)
- No. 36\* Temperature Trends in Sacramento--Another Heat Island. Anthony D. Lentini. February 1969. (PB-183 055)
- No. 37 Disposal of Logging Residues Without Damage to Air Quality. Owen P. Cramer. March 1969. (PB-183 057)
- No. 38 Climate of Phoenix, Arizona. R. J. Schmidli, P. C. Kangieser, and R. S. Ingram. April 1969. (PB-184 295)
- No. 39 Upper-Air Lows Over Northwestern United States. A. L. Jacobson. April 1969. (PB-184 296)
- No. 40 The Man-Machine Mix in Applied Weather Forecasting in the 1970s. L. W. Snellman, August 1969. (PB-185 068)
- No. 41 High Resolution Radiosonde Observations. W. W. Johnson. August 1969. (PB-185 673)
- No. 42 Analysis of the Southern California Santa Ana of January 15-17, 1966. Barry E. Aronovitch. August 1969. (PB-185 670)
- No. 43 Forecasting Maximum Temperatures at Helena, Montana. David E. Olsen. October 1969. (PB-187 762)
- No. 44 Estimated Return Periods for Short-Duration Precipitation in Arizona. Paul C. Kangieser. October 1969. (PB-187 763)
- No. 45/1 Precipitation Probabilities in the Western Region Associated with Winter 500-mb Map Types. Richard P. Augulis. Dec. 1969. (PB-188 248)
- No. 45/2 Precipitation Probabilities in the Western Region Associated with Spring 500-mb Map Types. Richard P. Augulis. Jan. 1970. (PB-184 434)
- No. 45/3 Precipitation Probabilities in the Western Region Associated with Summer 500-mb Map Types. Richard P. Augulis. Jan. 1970. (PB-189 414)
- No. 45/4 Precipitation Probabilities in the Western Region Associated with Fall 500-mb Map Types. Richard P. Augulis. Jan. 1970. (PB-189 435)
- No. 46 Applications of the Net Radiometer to Short-Range Fog and Stratus Forecasting at Eugene, Oregon. L. Yee and E. Bates. Dec. 1969. (PB-190 476)
- No. 47 Statistical Analysis as a Flood Routing Tool. Robert J. C. Burnash. December 1969. (PB-188 744)
- No. 48 Tsunami. Richard P. Augulis. February 1970. (PB-190 157)
- No. 49 Predicting Precipitation Type. Robert J. C. Burnash and Floyd E. Hug. March 1970. (PB-190 962)
- No. 50 Statistical Report of Aeroallergens (Pollens and Molds) Fort Huachuca, Arizona 1969. Wayne S. Johnson. April 1970. (PB-191 743)
- No. 51 Western Region Sea State and Surf Forecaster's Manual. Gordon C. Shields and Gerald B. Burdwell. July 1970. (PB-193 102)
- No. 52 Sacramento Weather Radar Climatology. R. G. Pappas and C. M. Veliquette. July 1970.

\* Out of Print

\*\* Revised