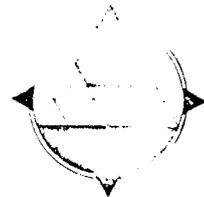


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ROBERT DE CHANCENOTTE

THE CLIMATIC FEASIBILITY OF A
FOG NET AT JALAMA RANCH
WESTERN SANTA BARBARA COUNTY,
CALIFORNIA
FOR THE BIXBY RANCH COMPANY



SUMMARY

Our on-site weather observational program conducted recently indicates that during the summer months fog is present along the northern portion of the Jalama Ranch on the average of 200 hours per month.

At the rate of 15 miles per hour and typical quantities of water in the fog, approximately 2 gallons of water would pass through each square meter of a hypothetical "fog net" each hour.

For a net having an area of 10 meters square, an average of 400 gallons of water per day of fog would be available if only 30 percent of the moisture in the fog could be collected.

On this basis, we recommend a study to provide for a design of a fog net and its installation at Jalama prior to the onset of the summer fog season.

THE CLIMATIC FEASIBILITY OF A FOG NET AT
JALAMA RANCH, CALIFORNIA

INTRODUCTION

Reference 1 (in our preliminary study of the area) documented climatic conditions for the general vicinity of the Bixby Ranch properties located at the Jalama and Cojo Ranch areas. This documentation was based primarily on peripheral off-site long-term weather station records. Most of these records were obtained from the National Weather Records Center at Asheville, North Carolina. The locations of sites for which climatic information was obtained (in Reference 1) are shown on Plate 1.

The preliminary studies (Reference 1) indicated that Point Arguello, which is west of the ranch, experienced a predominantly north-westerly wind flow on an annual basis. Also, these studies showed certain climatic statistics which are reproduced below for comparison's sake.

TABLE 1 - SEPTEMBER DATA (REF. 1)

Mean Monthly Temperature (Pt. Arguello)	59.5°F
Average Daily Temperature Range (Pt. Arguello)	15°F
Mean Relative Humidity (%) & Deviations (Pt. Arguello)	89 ± 14
(Vandenburg AFB)	82 ± 15
Percentage Frequency of Ceilings Less Than 1,000 feet (fog) (Pt. Arguello)*	50%
(Santa Maria)	30.6%

* Under normal conditions, the months of July and August experience 67.8% and 61.6%, respectively.

These statistics and a visit to the ranch to examine the terrain convinced us that it might be possible to use fog nets to collect supplemental moisture out of the low stratus clouds in the summertime. The summer season normally produces no precipitation over the ranch areas. Before going to the expense of constructing a fog net and installing it on the ranch, we felt it desirable to examine an area of interest. This area was to measure, on the ranch, certain climatic data to estimate what a fog net water-producing potential would be.

PURPOSE

Essentially then, this report had one principal end in sight. It was related to the possible use and feasibility of a fog net at the ranch property areas. The purpose was to determine what amount of moisture supply would be in the air and how often.

ORIENTATION AND LOCATION OF WEATHER STATIONS

Since the time available to document the frequency of fog was short, it was judged to be prudent to select the optimum fog path orientation possible based on data taken from off-site stations and that found in reference 2.

As it turned out, the principal orientation of fog trajectories was from the northwest to southeast. This was not too surprising, since the summertime most frequent wind direction at Point Arguello and Vandenburg AFB is northwest and a large percent of the summer experiences fog at both locations.

It was decided then, to locate three stations on an approximate NW-SE line, the first and most important of which would be located near a saddleback in the coastal hills located in the extreme northwestern corner of the Jalama Ranch. Plate 2 shows the location and approximate terrain near Station 1. Note the NW-SE orientation and the saddleback just northwest of this location. Station elevation was 1,550 feet.

Stations 2 and 3 were located on an extension of the NW-SE line. Their locations are shown on Plate 3. Distances between the stations and the Jalama Ranch headquarters are shown on Plate 3. Station elevations were 1,300 feet for No. 2 and 1,280 feet for No. 3.

WEATHER EQUIPMENT AT EACH STATION

It was decided to use an absolute minimal instrumentation array on the site. The purpose of this array was to document the frequency of fog at various locations on the site. The instrumental observations were aided by the physical presence of one of our staff meteorologists who lived on the site and corroborated weather data with personal observations.

The weather instrument located at position 1 (the most NW location) was a MRI, Model 1072 Weather Station. This station operates on battery power and records wind direction, wind speed, air temperature and precipitation amounts. Supplementing these data at position 1 was a hygrothermograph, placed in a standard weather instrument shelter. This instrument recorded air temperature and humidity continuous with time.

Stations 2 and 3 were equipped with a single hygrothermograph placed in an instrument shelter. The instruments were exactly like the one at Station 1.

No further stations were proposed on this ranch or the Cojo Ranch since the bulk of the summer had passed and the probability of success in procuring valuable instrumental data on this other property was regarded as too small to warrant the additional cost.

DURATION OF FIELD OBSERVATIONS

The weather equipment was shipped to the West Coast and installed on the site by August 31, 1968. The equipment was dismantled and returned to the East in early October, 1968. This period was adjudged to be sufficient to indicate fog net feasibility after a field inspection of the results on September 30, 1968.

FOG FREQUENCY AT THE VARIOUS STATIONS

Station No. 1 experienced fog 27.7% of the 718 hours of observation. Station 2 experienced 17.1% for the same time period. Station 3 showed 22.6% fog. It seems that the fog does drive in from the Pacific Ocean from the northwest. It also moves into the area north of the Lompoc Hills and moves on into the Jalama Ranch from the northeast. The wind speeds associated with the fog were as follows. (All wind speeds were measured at Station 1.)

<u>Fog at Station No.</u>	<u>Average Wind Speed at No.1 (1550 ft. station elevation)</u>
1	15.1 mph
2	14.0 mph
3	14.2 mph

These speeds were surprisingly strong, but upon re-examination, they make sense in that prior to colliding with the Pacific coast hills, the northwest winds have no significant frictional losses, thus permitting them to retain reasonable speeds over land. Also, the elevation of Station 1 (at 1,550 feet) is roughly 1,400 feet above Vandenburg AFB so that wind speeds would be expected to be higher at Station 1 than at Vandenburg AFB.

At Station 1, 74% of fog hours were found with a NW wind. A slight secondary maximum was found in the opposite sector (SSE) but only about 7% came from this direction. (The high frequency of fog with a NW wind was not surprising since the main flow and the terrain are both normally oriented to channel winds in this manner.)

Data taken at Station 1 was compared with the simultaneous observational logs at Point Arguello and Vandenburg AFB. The following statistics were determined:

SEPTEMBER 1968

Probability of Fog Simultaneously at <u>Pt. Arguello and Station 1</u>	Probability of Fog Simultaneously at <u>Vandenburg and Station 1</u>
44%	56%

(Apparently, from this limited sample, the anticipation of fog at Station 1 would be difficult to estimate from standard off-site stations.)

The overall frequency of fog was noted for each station and is compared below with Station 1 fog frequency (September, 1968 only).

<u>Point Arguello</u>	<u>Vandenburg</u>	<u>Station 1</u>	<u>2</u>	<u>3</u>
33%	47%	28%	17%	23%

One might well ask why the frequency of fog or stratus at Vandenburg AFB was greater than that noted at Station 1, even though the wind at Vandenburg during fog hours was blowing in the direction of Station 1. The answer lies in the thickness of the fog. As already cited, Vandenburg AFB weather station is at least 1,400 feet lower in elevation than Station 1. Therefore, if the fog top over Vandenburg was not at least up to 1,550 feet msl, the fog would not be observed at Station 1.

A check on the frequency of whether fog was that high could be made since Vandenburg AFB carries an hourly fog top report when fog is over the observation station. It appears that the fog reaches up to the 1,550-foot level only about 50-60% of those times when fog occurs.

Examining the frequencies of fog at Station 1 (28%) versus those observed at Vandenburg AFB (47%) we find that the expected frequency of occurrence at Station 1 would be about 50-60% of 47% or (23.5-28.2%). This compares well with the 28% actually recorded.

From a limited study of Vandenburg AFB data for September, 1968, it would now appear that anticipation of fog at Station 1 could well be accomplished using Vandenburg hourly weather.

A comparison between normal September wind frequencies at Vandenburg AFB and those observed at Vandenburg AFB during September, 1968, was made to see if during the time we were there conditions were typical of fog producing wind directions.

Table 2 shows the comparison: note the winds at Vandenburg were more favorable (about 5.0% above the normal 37.9% anticipated for NW and NNW wind directions). If anything, then the period of on-site observational conditions represents fog frequency of occurrence of

TABLE 2

COMPARISON OF WIND DIRECTIONAL FREQUENCIES
AT VANDENBURG AFB

<u>Wind Direction</u>	<u>September (11 Years of Record) (%)</u>	<u>Sept. 1968 (%)</u>
N	5.2	5.0
NNE	1.2	0.4
NE	0.8	0.4
ENE	0.5	0.4
E	2.1	5.4
ESE	3.2	5.4
SE	2.3	3.4
SSE	0.8	0.9
S	0.7	0.4
SSW	0.5	0.4
SW	1.1	4.3
WSW	1.9	6.2
W	7.5	5.8
WNW	6.9	5.8
NW	26.8	33.7
NNW	11.1	10.4
		(Fog producing flow toward Station 1)
CALM	27.4	11.7

Note in this table that the companion wind speeds in 1968 must have been somewhat stronger than normal since the frequency of "calm" is considerably diminished.

wind directions which were typical of September months in other years - possibly a bit more fog in 1968 than in most Septembers.

SUMMARY OF WEATHER DATA

We have shown that fog does penetrate the Jalama Ranch from the northwest at and near the Station 1 location. Fog also enters the Jalama Ranch from the northeast after moving along the Lompoc Hills to the north of the site or tends to form in the vicinity of Stations 2 and 3 on less frequent occasions.

The frequency of fog penetration at Station 1 on the Jalama Ranch can be tied directly to the fog conditions (bases and tops) and simultaneous wind directions observed at Vandenburg Air Force Base. Fog was observed more frequently at Vandenburg AFB than at Station 1 but at least 60% of the fog at Vandenburg AFB appears to penetrate the Jalama Ranch Station 1 location.

Fog was observed at Station 1 on Jalama Ranch 28% of the time during the month of September, 1968.

Cross-checks with long-term data at Vandenburg AFB indicate that the field observations made on the Jalama Ranch are typical of what might be expected during other summer months and in other years of exposure.

THE AMOUNT OF MOISTURE AVAILABLE IN FOG WITH SEA TO LAND TRAJECTORIES NEAR THE COAST

Although no direct measurements were made of the liquid water content of the fog at Jalama Ranch, reference 3 permits us to estimate what moisture might be available from the fog.

It turns out that about 0.30 gms per cubic meter is typical for the area. This value comes from aircraft sampling of actual stratus and stratocumulus clouds on and near the California coast. It is confirmed in reference 4.

FOG NET UTILITY AT JALAMA RANCH

As it turns out, using a wind speed of 15.1 mph (6.8 m/sec) in one hour, 24,600 meters of air would pass a given point. This is equivalent to a moisture supply of 7,500 gms of water per hour per square meter of a net. This can be shown to be equal to approximately two gallons of water per hour per square meter of net.

Assuming fog is present 200 hours per month and moisture (if one could collect it all) would be available at two gallons per hour per square meter of net, a 10-meter square net would collect 40,000 gallons per month or 1,300 gallons per day (54 gallons per hour or one gallon per minute).

If the net were 100% efficient (collected all moisture) a net of 10 m² could provide 1,300 gallons per day, or enough water to supply 130 head of cattle @ 10 gallons per head per day.

Assuming that the net is only 30% efficient in collecting the moisture, the maximum amount collected would be about 400 gallons per day or enough for 40 head. Fog nets which have been used in the past have not been carefully examined for collection efficiency under outdoor exposure.

WATER ANALYSIS OF FOG AT BIXBY

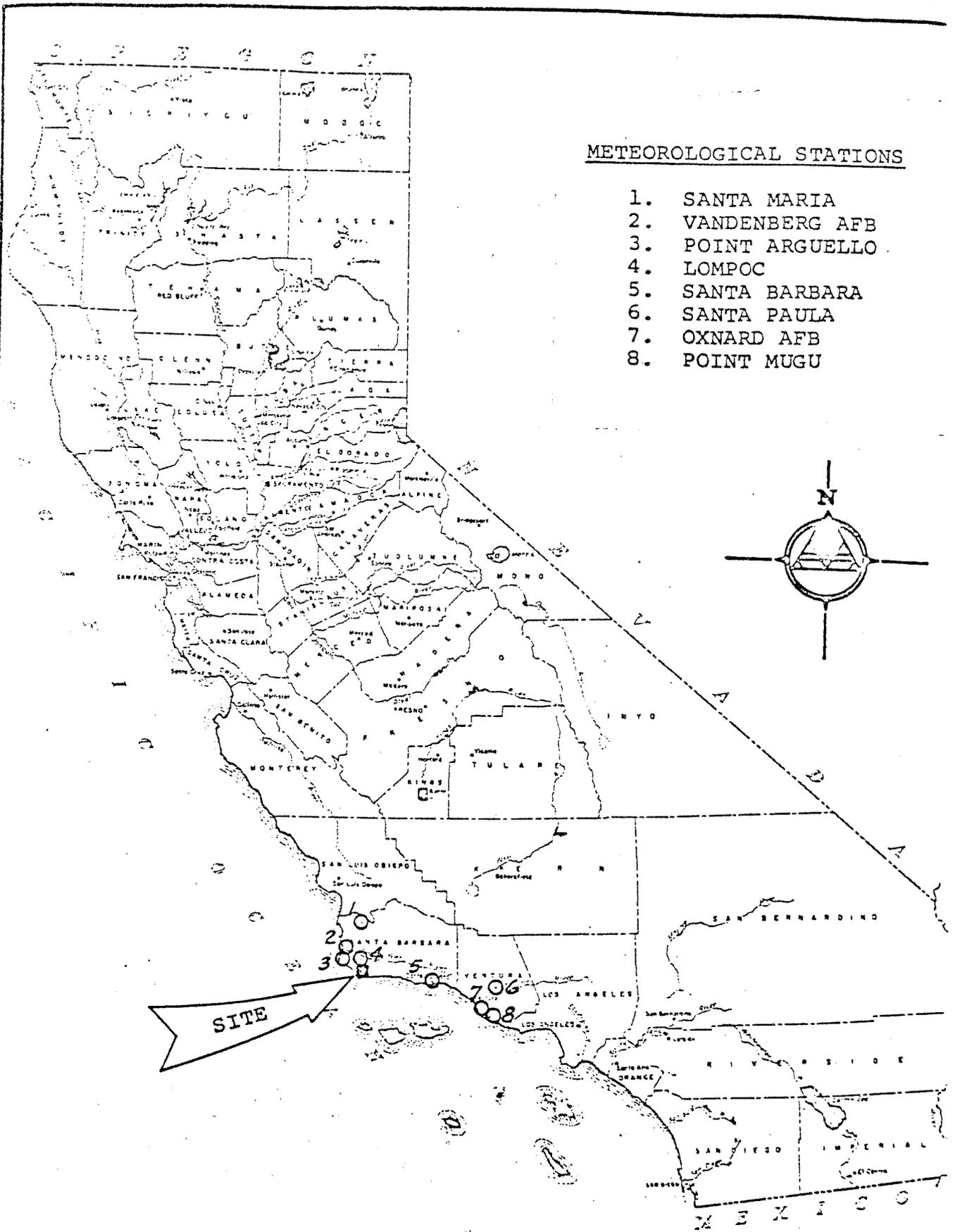
We had the opportunity to have a single sample of the water analyzed that was collected at Bixby from the fog. The detailed analysis is shown as Appendix 1. The chloride content of the water at 500 ppm was too great to be of value for human consumption (threshold limit is 250 ppm for drinking water - U. S. Public Health Service) but that cattle can tolerate water with chloride content up to 3,000-4,000 ppm without experiencing difficulty. (Reference 5).

The chloride content also appears a bit high for irrigation purposes according to reference 5 also. (It is cautioned that this was not part of our work scope and only one small sample was taken.)

CONCLUSIONS

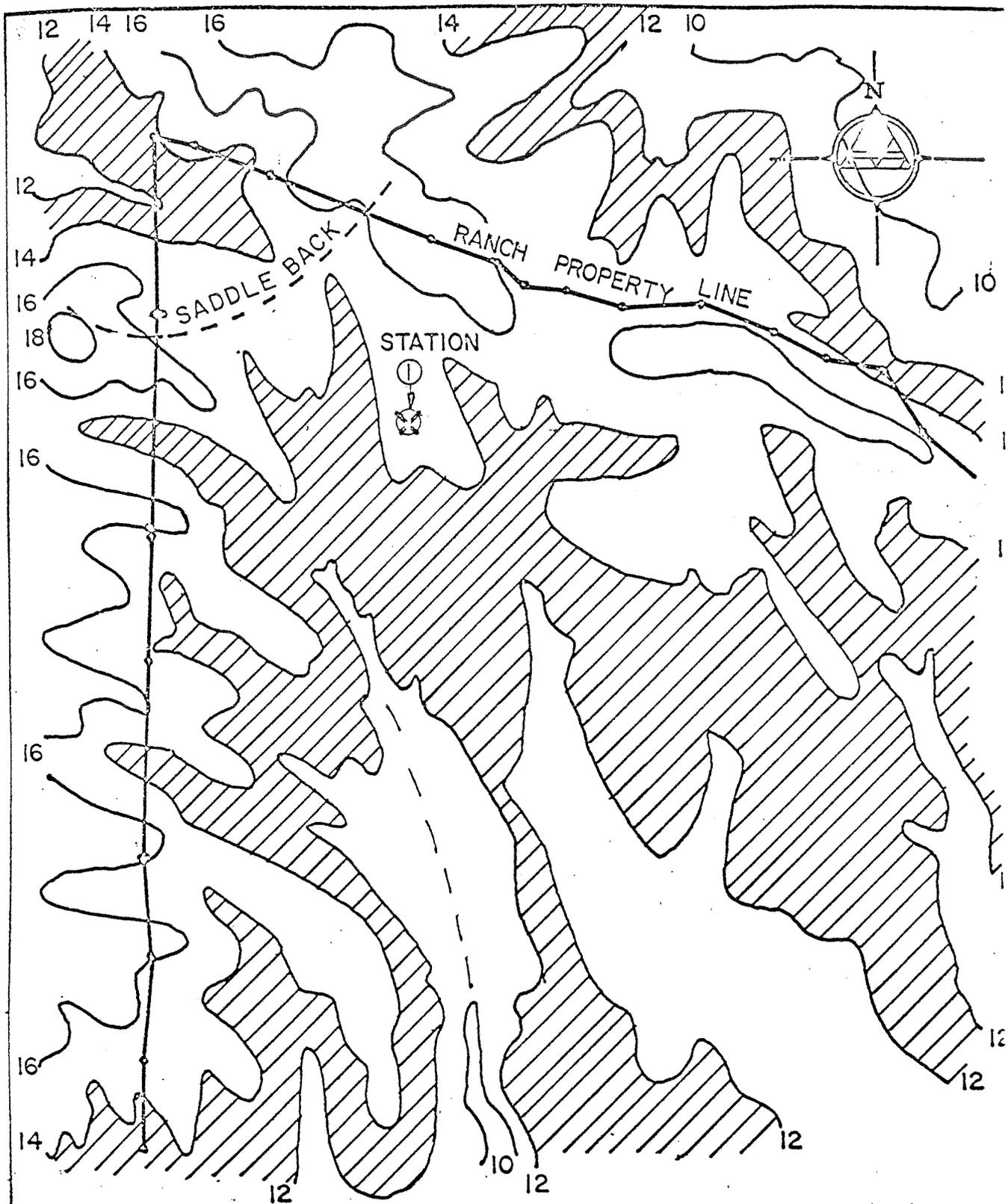
It would appear that there is sufficient moisture in the fog which could be collected by a fog net to produce water which is tolerable for cattle consumption; possibly some other activities. The exact amount which could be collected could best be determined by a construction of a prototype fog net if quantities of water postulated herein are of sufficient interest to the ranch owners and operators.

We recommend that a prototype net be constructed and would be happy to participate in a further study of fog net design and placement at Bixby Ranch. The net would also collect some moisture of value over the year (not only summer) and thus could provide some additional water supply in other seasons of the year.

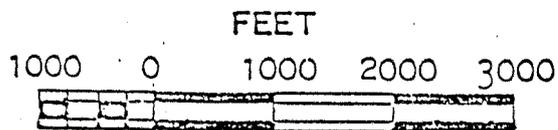


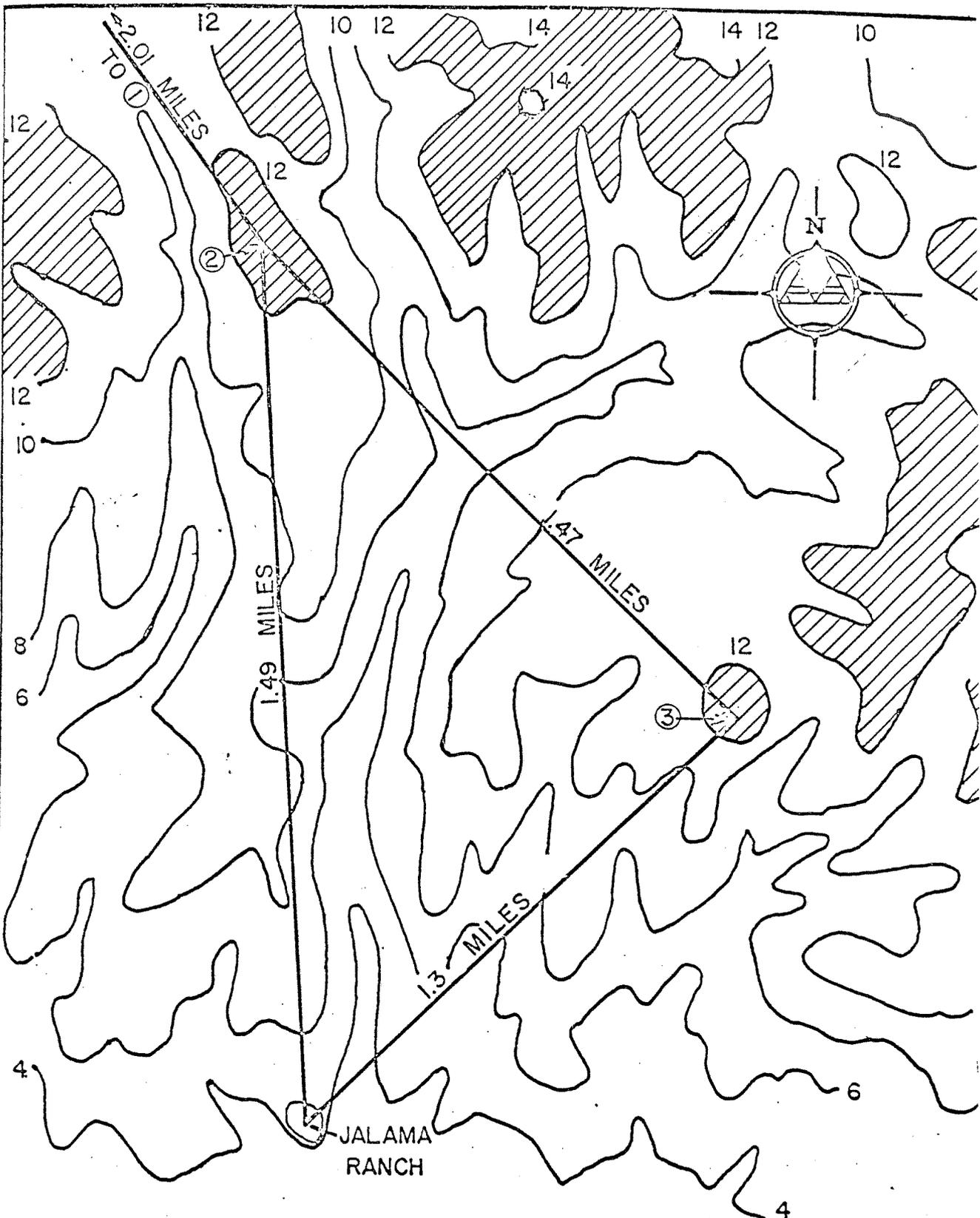
VICINITY MAP

FROM STATE OF CALIFORNIA,
 DEPARTMENT OF WATER RESOURCES,
 BULLETIN NO. 116

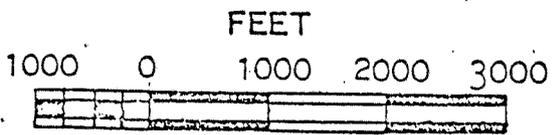


STATION I LOCATION
JALAMA RANCH
 (ELEVATIONS IN HUNDREDS OF FEET)





STATIONS 2 & 3 LOCATIONS
JALAMA RANCH
 (ELEVATIONS IN HUNDREDS OF FEET)



REFERENCES

1. "Preliminary Environmental Site Studies, Jalama Ranch and Cojo Ranch Properties," May 28, 1968, Dames & Moore.
2. "Plant Climates of California - Santa Barbara County," University of California, Agricultural Extension Service, January, 1965.
3. "Meteorological Aspects of Aircraft Icing," by William Lewis, U. S. Weather Bureau, Washington, D. C., pp 1200, COMPENDIUM OF METEOROLOGY, American Meteorological Society, Boston, Massachusetts, 1951.
4. THE PHYSICS OF CLOUDS, by B. J. Mason, Oxford at Clarendon Press, 1957. pp. 106-107.
5. GROUND WATER AND WELLS, First Edition, 1966, Edward E. Johnson, Inc., St. Paul, Minnesota.

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873-6159
CODE 404

Oct. 22, 1968

Dames & Moore
1314 W. Peachtree St., N.W.
Atlanta, Ga. 30309

Attention: Mr. R. de Chancenotte

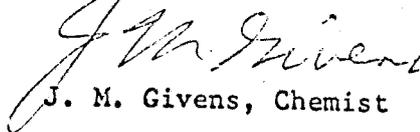
Sample: Water sample from Fog, Bixby Ranch Co., Jalama, Calif. Sample B
Job # 01-006 Oct. 1968

Lab. No.: 9360

CERTIFICATE OF ANALYSIS

Calcium (Ca), ppm	120
Magnesium (Mg), ppm	73
Sodium (Na), ppm	297
Potassium (K), ppm	25
Chloride (Cl), ppm	500
Specific Conductance, mohs	550

Respectfully submitted,
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J. M. Givens, Chemist