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No. 7

Western Region Technical Memorandum

FINAL REPORT ON PRECIPITATION PROBABILITY TEST PROGRAMS
October 1965 to March 1966

by

Edward D. Diemer

May 1966

ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
U. S. WEATHER BUREAU

Western Region Technical Memoranda:

No. 1 "Some Notes on Probability Forecasting" by Edward D. Diemer

No. 2 "Climatological Precipitation Probabilities" compiled by Lucianne Miller

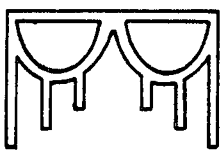
No. 3 "Western Region Pre- and Post-FP-3 Program" by Edward D. Diemer

No. 4 "Use of Meteorological Satellite Data"

No. 5 "Station Descriptions of Local Effects on Synoptic Weather Patterns" by Philip Williams, Jr.

No. 6 "Improvement of Forecast Wording and Format" by C. L. Glenn

No. 7 "Final Report on Precipitation Probability Test Programs" Edward D. Diemer



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

Western Region Technical Memorandum No. 7, May 1966

FINAL REPORT ON PRECIPITATION PROBABILITY TEST PROGRAMS
October 1965 to March 1966

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I - Description of Test Programs

Three programs were conducted during the probability test period. A report on the Pre-and-Post FP-3 program was given in Western Region Technical Memorandum Number 3.

A six-month program in which 6 FP centers and 26 local stations made daily precipitation probability forecasts was conducted from October through March. Verification during this program was done by SSD using a modified Brier Score. Results were returned monthly to participating stations. These data are on file at SSD.

The third program involved 16 stations during the three-month period January through March. Each station compiled data and plotted reliability curves. The reliability curves for most stations based on three-months' data are included in Attachment No. 2.

II - Objectives of the Test Programs

1. To orient forecasters who were not familiar with probability forecasting.

2. To evaluate the usefulness and accuracy of probability forecasts used by different forecast offices.

3. To evaluate the local office improvement on the FP-3 guidance probabilities.

III - General Summary of Results

1. Data from the six-month and from the three-month programs indicate that nearly all stations attained proficiency in precipitation probability forecasting. Insufficient data were received from Eugene and Havre to make an evaluation.

2. Forecast skill varied considerably from station to station. Most local stations can improve over FP-3 guidance out to 24 hours, and a few stations can improve over FP-3 guidance beyond 24 or 36 hours. The amount of improvement varied from station to station for similar forecast periods.

Therefore, if maximum local forecast skill is to be utilized, a uniform forecast period should not be assigned to all local stations beyond which they will copy guidance probabilities.

A summary of the forecasts made by stations in the six-month program is given in Attachment No. 1.

The following table gives an average of the percent improvements for all local stations for six months. This is not the average percent improvement as would be computed directly from total Brier Scores.

Table I

0 to 36 hours combined	FP over Climate	+14%
	Local over Climate	+21%
36 to 72 hours combined	FP over Climate	+ 3%
	Local over Climate	+ 6%

3. The FP-3 guidance probabilities proved to be a useful method of communicating guidance to the local station. The local stations benefited from this guidance. Local stations were able to improve upon their nearly independent forecasts after receipt of the FP-3 guidance. Refer to Western Region Technical Memo No. 3 for details of the Pre-and-Post FP-3 results.

ATTACHMENT 1

UNITED STATES DEPARTMENT OF COMMERCE
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
WEATHER BUREAU

Salt Lake City, Utah
September 1, 1965

RO4/M

REGIONAL MEMORANDUM
(To Selected First-Order Stations in Region IV)

Subject: Precipitation-Probability Forecast Program

The purpose of this memo is to state the policy and procedures which will be used by Fourth Region offices taking part in the pending precipitation-probability forecast test program.

The Central Office plans on or about October 1, 1965 to order the FP-1 replaced by an FP-3 guidance forecast. Precipitation probabilities will be included in the FP-3 on a test basis, not for public release, for a six-month period. You are one of the selected local stations which will take part in this test by making probability forecasts based on the FP-3 guidance. Upon completion of the probability forecast test program, the accumulated data will be evaluated to see if precipitation-probability forecasting should be continued and issued to the public.

I enlist your enthusiastic support of the probability forecasting test. There are many questions to be answered and problem areas to be studied. I have asked my Scientific Services Division, who will monitor the test program at the RO, to prepare a technical note on probability forecasting. We hope to have this publication distributed before the test program begins.

Attached is a copy of the CO memo which discusses the improved usefulness of probability forecasting and an attachment which gives the details of our Regional program.

Hazen H. Bedke
Regional Director

Attachments

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

June 10, 1965

IN REPLY PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO
MS-6.1

MEMORANDUM

TO : All Regional Directors

FROM : Director, National Meteorological Services

SUBJECT: Improving the Accuracy and Usefulness of Weather Forecasts

The most difficult problem confronting the Weather Bureau in its day to day forecasting operations is that of reducing the errors in weather forecasts to levels which fairly represent the current state of the science of meteorology and, hopefully, to levels which are acceptable to the using public. At the present time no one knows precisely where either of these levels should lie, and concrete measures which will determine acceptable error are not likely to be developed in the near future. In the meantime, we should make every effort to achieve the highest possible level of forecast accuracy and, at the same time, try to improve the usefulness of our forecasts by informing the public of the expected error or the uncertainty that is characteristic of the weather information provided.

Carefully designed programs aimed at improving weather forecasting technology are now underway in both the National Meteorological Center and the Systems Development Office. I am confident that improvements in forecast performance will result from both of these efforts, particularly in the forecasts of basic weather elements.

The problem of deriving and communicating the uncertainty that is bound to be present in all forecasting must also be addressed. There are a variety of ways in which this could be handled. Comprehensive, well-designed verification programs will provide many reliable performance measures; however, these often prove difficult for the average layman to understand or to use. I am inclined to think that the most practical way of communicating uncertainty to the user, therefore, is through the language of probability.

Many recent experiments involving the development and use of probability statements in weather forecasting have concluded that useful probability measures can be derived for weather forecasts, and that these can be communicated effectively to the public. I would like to see the Weather Bureau move into the use of probability concepts wherever appropriate in our weather forecasts, particularly in the wording of forecasts for phenomena that have important effects on public activity.

Prior to the introduction of such a program on a large scale, the public will need to be educated and indoctrinated on the meaning and use of probability statements. Some of our forecasters will also require brief training in methods for developing probability measures. The attached plan for a phased program involving the widespread use of probability statements in precipitation forecasting is designed to assist Regional Offices in the development of a practical program for their respective regions.

When the probability of precipitation at a point is used, as in the attached proposal, the assignment of areal coverage to a particular precipitation event will be unnecessary in the Zone and Local Forecasts. Unless there are valid objections, we plan to discontinue also the use of areal coverage factors in the State Forecasts.

We anticipate that the Public Information Office at the C. O. will be able to supply appropriate releases to be made to the public prior to the introduction of probability forecasts. This will greatly assist in assuring public acceptance of the forecasts.

Please provide any comments and criticisms of this proposal that you feel are appropriate. Each comment will assist us in drafting the final plan which will be established this summer.

George P. Cressman

George P. Cressman

Attachment

ATTACHMENT

Objectives of the Test Period

The objectives of the six-month test period (forecasts not for public release) are as follows:

1. To orient forecasters who are not familiar with probability forecasting.

2. To evaluate the usefulness and accuracy of probability forecasts prepared by different forecast offices.

3. To evaluate the improvement that local offices make on the FP-3 guidance probabilities when issuing their local and zone forecasts.

Method

In order to accomplish these objectives, FP centers will make precipitation-probability forecasts four times a day for certain stations in their FP-3 area. The local stations receiving these guidance probabilities will also make a probability forecast. These forecasts will be for five time periods covering a 72-hour period. The RO will verify these forecasts using the Sanders Score.

Description of the Probability Forecasts

1. FP-3 Probability Forecast: This is a determination, mainly subjective but using any objective aids available, by the FP forecaster of the probability of a precipitation event during the five time periods described below. A precipitation event has been defined as .01 of an inch or more of precipitation observed at the official rain gage during a particular forecast time-period. This forecast will be transmitted on Service C with the FP-3. The precipitation probability guidance will be in the form of a numerical message making up the last lines of the FP-3. Format in Region IV will be as follows:

$$S_iS_iS_i \quad I_iI_iI_i \quad P_1P_1P_2P_2P_3P_3 \quad /// \; P_4P_4P_5P_5$$

where $S_iS_iS_i$ is the letter designation of the station, $I_iI_iI_i$ is the international index number, P_1P_1 is the probability of precipitation in the first time period, P_2P_2 is the probability in the second time period, etc. These time periods are defined below.

The following is a list of FP centers and the stations for which they will make probability forecasts:

Great Falls	- Great Falls, Billings, Glasgow, Helena, Missoula, Kalispell
Los Angeles	- Los Angeles, Bishop, Las Vegas, San Diego
San Francisco	- San Francisco, Eureka, Red Bluff, Sacramento, Fresno, Bakersfield, Reno
Salt Lake City	- Salt Lake City, Cedar City, Roosevelt, Ely, Boise, Pocatello
Seattle	- Seattle, Yakima, Spokane, Astoria, Medford, Pendleton

2. Local (Loc.) Probability Forecast: This forecast is made by the local offices listed above, except Cedar City and Roosevelt, which receive probability guidance in the FP-3. Again, this is a determination (mainly subjective but using any objective aids available and the FP-3 guidance probabilities) by the local forecaster of the probability of a precipitation event during each of the five time periods described below. The local forecaster will make a probability forecast four times a day (Bishop, California will make two forecasts per day). These forecasts will be made after receipt of the FP-3 and concurrent with the corresponding local or zone forecast.

3. Climatology (Climat.) Forecast: The climatology forecast is the climatological expectancy of a precipitation event. The RO is computing the climatological expectancy for the above-listed stations and will make this information available as soon as possible.

Verification

Verification by the Sanders Score will be done at the RO. The Sanders Score consists of two parts, Reliability and Resolution:

Reliability of probability forecasts is shown by a comparison of forecast probabilities with observed occurrences of precipitation. Thus, high reliability would be obtained by having only rain cases observed on 100% precipitation probability forecasts, 50% rain occurrences on 50% probability, no-rain occurrences on zero-rain probability forecasts, etc.

Resolution measures the ability to move the forecasts away from the climatological frequency. For example, if climat. expectancy of precipitation for Salt Lake City in February is 0.20, this would be the climat. forecast for each day of February. In order for the forecasters to beat climatology, they will have to issue a probability higher than 0.20 on days when precipitation is observed, and a probability lower than 0.20 on days when no precipitation occurs. The closer the forecasters can get to 1.00 on rain days and to 0.00 on no-rain days, the higher their resolution score.

Sanders Score: $S = 100(1 - \frac{Bf}{Bc})$ where B is Brier's score, defined as follows:

$B = Nnr\,(P_f - 0)^2 + Nr\,(1 - Pf)^2$

Nnr is number of no-rain cases
Nr is number of rain cases
P_f is forecast probability
Bf is forecaster's Brier score
Bc is climat Brier score

This is the sum of the mean square errors for rain and no-rain cases.

A few words of caution: The best forecast is the one with the best reliability and resolution. The longer the forecast period, the closer the forecast probabilities should approach climatology.

Instructions on Using the Local Precipitation Probability Data Sheet

Please write legibly and complete the entire form. Forward the completed forms to the RO weekly. (These forms are being printed and will be distributed in the near future.)

Each sheet provides space for the forecast and verification data for one station for one day--four forecasts. FCST #1 is the 03 MST or 02 PST forecast, FCST #2 is the 09 MST or 08 PST forecast, etc.

"FP-3 Fcst" is the FP-3 probability forecast which is transmitted as guidance. This forecast is entered in Column "F", using one of the following probability values: 0, .02, .05, .10, .20, .30, .40, .50, .60, .70, .80, .90, 1.00. Some FP centers may wish to make some slight modification in the values less than .10. However, once a set of values has been determined, no further change should be made. The local forecast is entered in Column "F" under "Loc. Fcst". The precipitation probability will be one of the values listed above. The climatological forecast is entered in Column "F" under "Climat Fcst" using the climatological values that we will send you.

The "Obs Prec" is the amount of precipitation observed for each time period.

The forecast time periods are given below (adjust for Pacific time):

	Time Period				
	(1)	(2)	(3)	(4)	(5)
Fcst. #1 (03M)	05-17M	17-05M	05-17M	17-05M	05-05M
Fcst. #2 (09M)	11-17M	17-05M	05-17M	17-05M	05-05M
Fcst. #3 (15M)	17-05M	05-17M	17-05M	05-17M	17-17M
Fcst. #4 (21M)	23-05M	05-17M	17-05M	05-17M	17-17M

"E" (error) columns are to be completed by the local forecast office. Observed precipitation verifies as 1.00 and no precipitation verifies as zero. The E value for a specific period is obtained by squaring the difference between the forecast probability and 1.0 or 0.0, depending on whether or not a precipitation event has been observed during that period.

Examples:

F = .20, Obs. Prec. = 0.00, Then E = $(0.0 - .20)^2 = .0400$
F = .20, Obs. Prec. = 1.21, Then E = $(1.0 - .20)^2 = .6400$
F = .02, Obs. Prec. = 0.00, Then E = $(0.0 - .02)^2 = .0004$
F = .02, Obs. Prec. = 1.21, Then E = $(1.0 - .02)^2 = .9604$

"E Total Periods 1, 2, 3" is the sum of the E values for Periods (1), (2), and (3). "E Total Periods 1 . . . 5" is the sum of the E values for Periods (1), (2), (3), (4), and (5).

If you have any questions or difficulties concerning the probability program, do not hesitate to call Scientific Services.

SELECTED STATIONS IN REGION IV

WBAS - Ely
Boise
Pocatello
Bishop
Las Vegas
San Diego
Yakima
Spokane
Astoria
Medford
Pendleton
Billings
Glasgow
Helena
Missoula
Kalispell
Red Bluff
Fresno
Bakersfield
Reno
Salt Lake City
Los Angeles
Great Falls
San Francisco
WBFC - Seattle
WBO - Eureka
Sacramento

ATTACHMENT 2

FORM CD-121 (11-63) (PRES. BY A O 206 10)

UNITED STATES GOVERNMENT

Memorandum

U.S. DEPARTMENT OF COMMERCE
WEATHER BUREAU

ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION

TO : Listed Below

DATE: December 30, 1965

In reply refer to: WFW/S-2

FROM : Chief, Scientific Services
Western Region, Salt Lake City, Utah

SUBJECT: Probability Forecasting Orientation

It is necessary that all stations become familiar with probability forecasts since it is anticipated that most zone and all local forecasts will be issued in terms of precipitation probabilities upon the completion of an orientation period. All personnel who issue forecasts should study the memoranda (see attachment) pertaining to this subject.

During the past three months about thirty stations have been participating in the probability forecasting orientation program. Since climatology has now been completed for the remaining stations in the region for which data are available, the program is being expanded.

Enclosed are instructions and data sheets to be used for the orientation period during the next three months.

Note: These forecasts are <u>not</u> for public release.

L. W. Snellman

L. W. Snellman

Enclosures

WBO, Mount Shasta
WBO, Pomona
WBO, Walla Walla
WBO, Wenatchee
WBO, Burns
WBO, Elko
WBAS, Tucson
WBAS, Yuma
WBAS, Santa Maria
WBAS, Winnemucca
WBAS, Eugene
WBAS, Havre
WBAS, Lewiston
WBAS, Milford
WBAS, Olympia
WBAS, Portland
WBAS, Salem
WBAS, Klamath Falls
WBAS, Santa Catalina Is.
WBAS, Stockton

cc: Charles Roberts
Operations, Western Region
MIC, WBAS, Albuquerque
Dr. Cressman

To be returned to Scientific Services by January 10, 1966.

We have received and understand the instructions for the precipitation probability program.

Practice forecasts will be made routinely at the following times:

________ ________ ________ ________

Signed ______________________________

Comments:

INSTRUCTIONS FOR PROBABILITY FORECASTING ORIENTATION

No specific forecast guidance for each station will be made by FP Centers during the orientation period--about three months' duration--except for Arizona stations which receive guidance from Albuquerque. Guidance probabilities can be inferred from the FP-3 wording and interpolated from nearby stations for which guidance probabilities are issued.

General instructions on how to make probability forecasts can be obtained from Western Region Technical Memorandum No. 1 and from Notes to Forecasters No. 1 by Charles Roberts, WXAP, Washington. Guidance climatological probabilities have been published in Western Region Technical Memorandum No. 2. Klamath Falls, Pomona, Santa Catalina, and Stockton should be guided by climatology from the nearest station.

Results from the verification of probability forecasts during the past few months indicate that several points need further emphasis. The longer the time range of the forecast, the closer the probability forecasts should approach climatology. Stations with low climatological probabilities should use high probabilities with caution. For instance, if climatology is 04 percent, a probability forecast of 20 percent is five times climatology which indicates a relatively high chance of precipitation compared to normal. Such a forecast is analogous to a 100 percent forecast on a climatology of 20 percent. Also, stations with low climatology should make considerable use of the 02 percent and 05 percent forecast values. Experience has shown that forecasters have more skill in forecasting these low values than they do in forecasting the higher values, 60, 70, 80 percent. In fact, there is usually considerable over-forecasting in the higher probability values.

Data Sheets: Due to the variability of station operation, it is not possible to set definite times at which to make probability forecasts, thus the following should be used as a guide.

There is space provided for 12 forecast days on each data sheet. The Nos. 1, 2, 3, and 4 refer to the four quasi-standard forecast times corresponding to the FP release times. The line above the Nos. 2 and 3 is for the date. The Nos. 1, 2, and 3 in the extreme left column refer to the forecast time periods. These correspond to the time periods of the local forecast. For example, a forecast made at 0400 MST: period 1 is from 0500 to 1700 MST (today); period 2 is from 1700 to 0500 MST (tonight); and period 3 is from 0500 to 1700 MST (tomorrow). Note period 1 is a 12-hour period in this case. For a forecast made at 0900 MST, period 1 is from 1100 to 1700 MST (afternoon), period 2 from 1700 to 0500 MST, and period 3 from 0500 to 1700 MST. Note period 1 is a 6-hour period in this case. Period 1 for a forecast made at 1500 MST is from 1700 to 0500 MST. Period 1 for a forecast made at 2200 MST is from 2300 to 0500. Periods 2 and 3 are always consecutive 12-hour periods. Period 1 may be either a 6- or a 12-hour period.

All stations should make probability forecasts for their station whenever they issue a local forecast--plus or minus an hour for convenience--but at a definite time each day. These forecasts should be entered in the "F" column for each time period. In the "P" column enter the observed precipitation. To make verification easier, we recommend that the "P" column be kept current.

The forecast probability values to be used are: 00%, 02%, 05%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%.

Computation Sheets: At the end of January, February, and March compute a reliability curve for the month. (See technical memoranda referred to above for a discussion of reliability curves.) The computation sheet is completed in the following manner.

The numbers at the extreme left represent the time periods of the forecast. NF(0) stands for "number of forecasts of 00%", NF(02) stands for "number of forecasts of 02%", etc. NP(0) stands for "number of precipitation occurrences when 00% was forecasted", NP(02) stands for the "number of precipitation occurrences when 02% was forecasted", etc. From the data sheets count the number of times 00% was used in period 1, regardless of the time the forecast was made, and the number of times precipitation occurred. Repeat for each period for each forecast probability value and enter the totals in "TOT" line.

With these totals enter the ratios below each column. The NP( ), number of observed precipitation cases, divided by the NF( ) , number of forecasts, yields the observed frequency of precipitation for a given probability value. Ideally, this should equal the forecast probability. For example, if 30% were forecasted 100 times and precipitation occurred on 30 of the forecasts then,

$$\frac{NP(30)}{NF(30)} = \frac{30}{100} = .30 = 30\%$$

which is perfect reliability. That is, a 30% forecast means that precipitation should occur on 30 forecasts out of 100, and it did. Another example, if 80% were forecasted 40 times and precipitation occurred on 24 of the forecasts then,

$$\frac{NP(80)}{NF(80)} = \frac{24}{40} = .60 = 60\%.$$

Perfect reliability was not achieved, 60% being the observed frequency on an 80% forecast. This is over-forecasting.

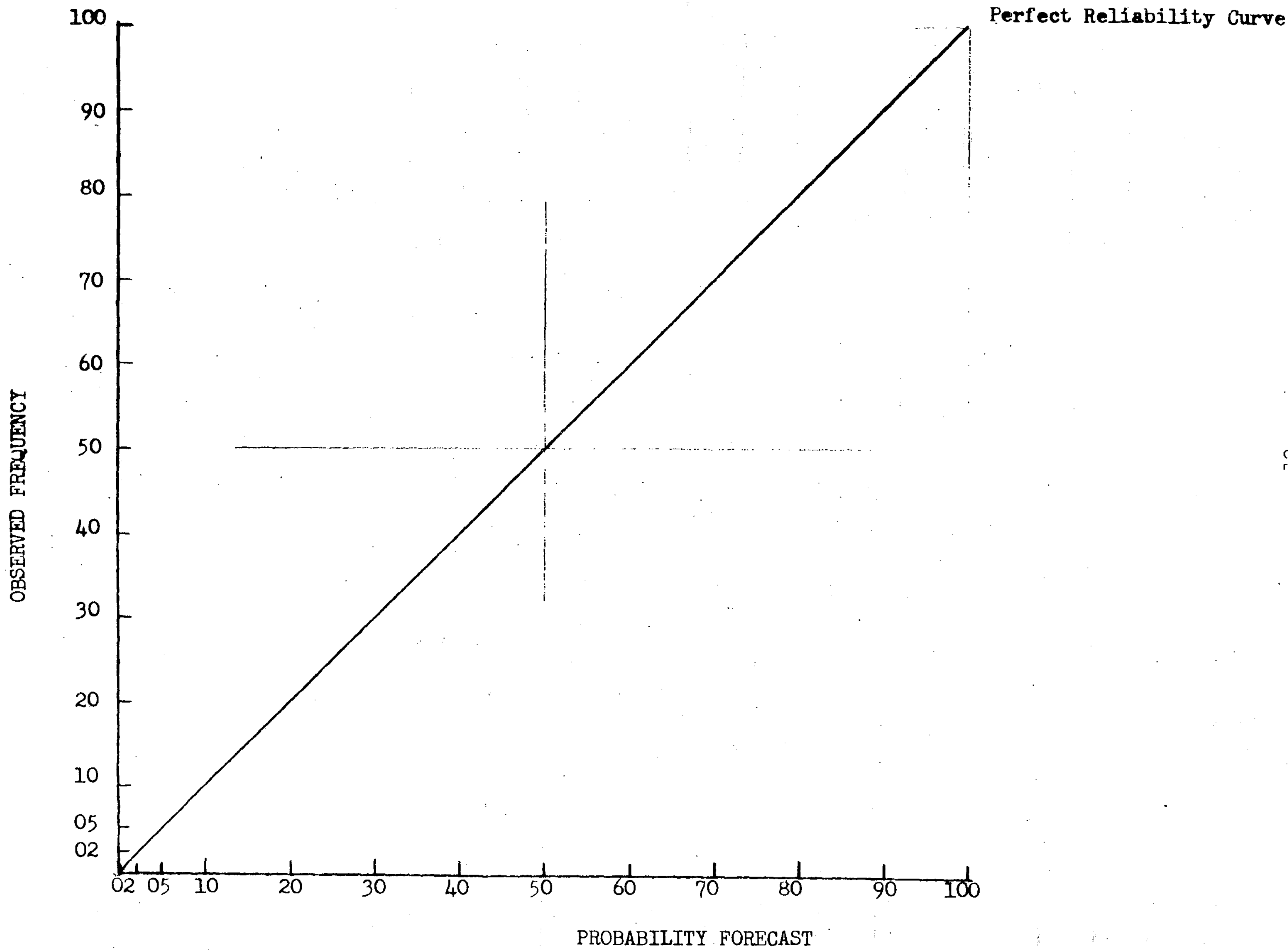
Graph Sheets: Plot the observed occurrences of precipitation as the ordinate (vertical coordinate) and the forecast probabilities as the abscissa (horizontal coordinate) on the graph sheets. Plot period 1 as a solid pencil line, period 2 in a dashed red line, and period 3 in a dotted green line on the same graph.

The straight line printed on the graph represents perfect reliability. The closer your plots are to this line, the better your forecasts. If your plotted lines fall below the perfect reliability line, you are over-forecasting; if they fall above the perfect reliability line, you are under-forecasting.

Obtaining good reliability is the first step in making probability forecasts. The second step is to achieve resolution, that is, to use as many high values and as many low values as possible in the forecast but yet maintain reliability. This comes with experience in probability forecasting.

Send the data sheets, computation sheets, and graphs to Scientific Services within 10 days after the end of each month. We will make comments and return them for your information. Should any questions arise, please call Scientific Services.

Enclosed is a completely worked out example based on the actual consensus forecasts made at the Regional Headquarters from July through December. These forecasts are made daily at 0910 MST by 5 to 10 meteorologists based on a 10-minute briefing by a member of Scientific Services who has spent 30 to 45 minutes analyzing the fax charts.



STATION ______________ MONTH ______________

	#1		#2		#3		#4		#1		#2		#3		#4		#1		#2		#3		#4	
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P
1																								
2																								
3																								

	#1		#2		#3		#4		#1		#2		#3		#4		#1		#2		#3		#4	
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P
1																								
2																								
3																								

	#1		#2		#3		#4		#1		#2		#3		#4		#1		#2		#3		#4	
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P
1																								
2																								
3																								

	#1		#2		#3		#4		#1		#2		#3		#4		#1		#2		#3		#4	
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P
1																								
2																								
3																								

DATA SHEET

STATION ______________ MONTH ______________

	0%		02%		05%		10%		20%		30%	
	NF(0)	NP(0)	NF(02)	NP(02)	NF(05)	NP(05)	NF(10)	NP(10)	NF(20)	NP(20)	NF(30)	NP(30)
1												
	TOT.											
2												
	TOT.											
3												
	TOT.											

(1) $\frac{NP(0)}{NF(0)} =$ $\frac{NP(02)}{NF(02)} =$ $\frac{NP(05)}{NF(05)} =$ $\frac{NP(10)}{NF(10)} =$ $\frac{NP(20)}{NF(20)} =$ $\frac{NP(30)}{NF(30)} =$

(2) $\frac{NP(0)}{NF(0)} =$ $\frac{NP(02)}{NF(02)} =$ $\frac{NP(05)}{NF(05)} =$ $\frac{NP(10)}{NF(10)} =$ $\frac{NP(20)}{NF(20)} =$ $\frac{NP(30)}{NF(30)} =$

(3) $\frac{NP(0)}{NF(0)} =$ $\frac{NP(02)}{NF(02)} =$ $\frac{NP(05)}{NF(05)} =$ $\frac{NP(10)}{NF(10)} =$ $\frac{NP(20)}{NF(20)} =$ $\frac{NP(30)}{NF(30)} =$

STATION ______________ MONTH ______________ COMPUTATION SHEET

	40%		50%		60%		70%		80%		90%		100%	
	NF(40)	NP(40)	NF(50)	NP(50)	NF(60)	NP(60)	NF(70)	NP(70)	NF(80)	NP(80)	NF(90)	NP(90)	NF(100)	NP(100)
1														
	TOT.													
2														
	TOT.													
3														
	TOT.													

(1) $\frac{NP(40)}{NF(40)} =$ $\frac{NP(50)}{NF(50)} =$ $\frac{NP(60)}{NF(60)} =$ $\frac{NP(70)}{NF(70)} =$ $\frac{NP(80)}{NF(80)} =$ $\frac{NP(90)}{NF(90)} =$ $\frac{NP(100)}{NF(100)} =$

(2) $\frac{NP(40)}{NF(40} =$ $\frac{NP(50)}{NF(50)} =$ $\frac{NP(60)}{NF(60)} =$ $\frac{NP(70)}{NF(70)} =$ $\frac{NP(80)}{NF(80)} =$ $\frac{NP(90)}{NF(90)} =$ $\frac{NP(100)}{NF(100)} =$

(3) $\frac{NP(40)}{NF(40)}$ $\frac{NP(50)}{NF(50)}$ $\frac{NP(60)}{NF(60)}$ $\frac{NP(70)}{NF(70)}$ $\frac{NP(80)}{NF(80)}$ $\frac{NP(90)}{NF(90)}$ $\frac{NP(100)}{NF(100)}$

STATION________________ MONTH ________________ COMPUTATION SHEET

ATTACHMENT 3

SUMMARY OF RESULTS FOR EACH STATION IN THE SIX-MONTH PROGRAM

SALT LAKE CITY FP CENTER

Salt Lake FP-3 for Salt Lake:

There was a definite improvement over climatology out to 36 hours. It was estimated that there was some improvement over climatology in the 36- to 48-hour period, but none beyond 48 hours. The 0900 local consensus forecast improved over the concurrent FP-3 forecast by about 10 percent for the first 36 hours combined.

Salt Lake FP-3 for Cedar City*:

The FP-3 guidance forecast made good improvement over climatology out to 36 hours, beyond which there was little or no improvement. The percent improvement was negative for the first 36 hours combined during March. The 0900 local consensus forecast improved over the FP-3 forecast by about 8 percent for the first 36 hours combined.

Salt Lake FP-3 for Roosevelt*:

The Salt Lake FP-3 forecasts made a very good improvement over climatology for the first 36 hours and little improvement beyond 36 hours. The 0900 consensus forecasts did not improve over the FP-3 forecast for the first 36 hours of the forecast period.

Salt Lake FP-3 and Ely Forecast:

The Salt Lake FP-3 guidance improved over climatology for 36 hours, with the October through December forecasts being better than the January through March forecasts. February had a negative improvement for 36 hours. Little or no improvement over climatology was achieved beyond 36 hours. The 0900 consensus (3 months' data) improved over the FP-3 by about 10 percent for the first 36 hours combined.

The skill at Ely showed an increase during the test period. On the average Ely made good improvement over the FP-3 guidance out to 36 hours, although October and December improvements were negative. Beyond 36 hours there was no improvement over the FP-3.

*Cedar City and Roosevelt do not issue local forecasts.

Salt Lake FP-3 and Pocatello Forecasts:

The Salt Lake FP-3 guidance consistently made very good improvement over climatology out to 36 hours, but little if any improvement beyond 36 hours. The 0900 consensus (3 months' data) indicated about 10 percent improvement over the concurrent FP-3 forecast for the first 36 hours combined.

The skill at Pocatello increased somewhat during the test program with slight improvement over the FP-3 during November, January, February, and March. It is estimated that much of this improvement was made during the first 24 hours of the forecast. There was definitely no improvement over the FP-3 after 36 hours.

Salt Lake FP-3 and Boise Forecast:

The Salt Lake FP-3 guidance forecast made good improvement over climatology out to 36 hours with little or no improvement beyond 36 hours. December and January improvement was negative. The 0900 consensus forecast (3 months' data) was markedly better than the FP-3 forecast, about 20 percent, out to 36 hours.

The Boise local forecast made a good improvement over the Salt Lake guidance during all months for the 36-hour forecast period. Beyond 36 hours, little if any improvement was made.

GREAT FALLS FP CENTER

Great Falls FP-3 for Great Falls:

The FP-3 forecasts for Great Falls showed a consistent and significant improvement over climatology out to 36 hours. Little or no improvement was made over climatology beyond 36 hours. Consensus forecasts were made four times per day at Great Falls; however, these forecasts did not make any improvement over the FP-3 forecasts.

Great Falls FP-3 and Helena Forecasts:

The Great Falls FP-3 guidance was variable; but, in general, a slight improvement over climatology, on the average, was achieved out to 36 hours. The four-a-day consensus forecast was also variable. Possibly a slight improvement over the FP-3 was made for the first 36 hours combined.

Great Falls FP-3 and Helena Forecasts: (Continued)

Helena made a significant improvement over FP-3 guidance in all months out to 36 hours. After 36 hours Helena made some improvement over guidance, mainly during October, November, and December. Thus, Helena also made a slight improvement over climatology beyond 36 hours. It was estimated that this improvement most likely extends to 42 or 48 hours.

Great Falls FP-3 and Kalispell Forecast:

In general Great Falls guidance FP-3 forecast improved over climatology out to 36 hours, although November and February improvement was slightly negative. Definitely there was no improvement over climatology beyond 36 hours. For the most part the four-a-day consensus forecasts at Great Falls did not improve over the FP-3 forecast for the first 36 hours combined.

Kalispell made good improvement over guidance out to 36 hours. December improvement was slightly negative. After 36 hours, Kalispell occasionally made improvement over the FP-3 but on the average, improvement over climatology still remained negative.

Great Falls FP-3 and Glasgow Forecasts:

FP-3 guidance for Glasgow indicated only slight improvement over climatology out to 36 hours and no improvement beyond 36 hours. January guidance was slightly negative for the first 36 hours combined. Consensus forecast did not improve over the FP-3.

The Glasgow forecast made great improvement over the FP-3 guidance during the first 36 hours. Beyond 36 hours, little if any improvement was achieved over either the FP-3 or climatology.

Great Falls FP-3 and Billings Forecasts:

Great Falls FP-3 guidance made very good improvement over climatology out to 36 hours. It was estimated that guidance improved over climatology out to 42 or 48 hours. The four-a-day consensus forecast improved on the FP-3 by about 5 percent for the first 36 hours combined.

Billings made only a slight improvement over FP-3 guidance for the first 36 hours and little if any improvement thereafter. October, November, and February had negative improvement over the FP-3.

Great Falls FP-3 and Missoula Forecasts:

FP-3 guidance for Missoula improved significantly over climatology for 36 hours, although November showed a negative improvement. It was estimated that a slight improvement was achieved out to 42-48 hours. The four-a-day consensus forecasts did not improve over the FP-3.

Missoula made very good improvement over the FP-3 guidance and over climatology during the 36- to 48-hour period.

ALBUQUERQUE FP CENTER
(data for December through March)

Albuquerque FP-3 and Flagstaff Forecasts:

In general Albuquerque FP-3 guidance made very good improvement over climatology out to 36 hours. Although the available data is very limited, it appeared that some improvement over climatology was achieved beyond 36 hours.

Flagstaff forecast improved markedly over guidance for the first 36 hours. Some improvement over FP-3 and over climatology was also evidenced beyond 36 hours.

Albuquerque FP-3 and Phoenix Forecasts:

FP-3 guidance made good improvement over climatology out to 36 hours with little if any improvement beyond 36 hours.

Phoenix forecasts improved over guidance in all months out to 36 hours. Slight improvement over the FP-3 was made beyond 36 hours. Again due to very limited data, it was difficult to estimate if there was any improvement over climatology beyond 36 hours.

Albuquerque FP-3 and Winslow Forecasts:

Albuquerque guidance made good improvement over climatology for 36 hours. Little, if any, improvement was made beyond 36 hours.

Winslow forecasts improved over guidance during two of the five months. However, Winslow was introduced to facsimile charts during the test program, which might have influenced their forecasting.

LOS ANGELES FP CENTER

Los Angeles Forecasts:

The FP-3 forecasts for Los Angeles made improvement over climatology out to 36 hours with some improvement indicated beyond 36 hours, possibly out to 42-48 hours. Consensus forecasts were made for five months. These forecasts improved over the FP-3 by an estimated 5 to 10 percent.

Los Angeles FP-3 and San Diego Forecasts:

Except for October, which had a negative improvement, the Los Angeles FP-3 guidance made a marked improvement over climatology out to 36 hours. Some improvement was also evidenced beyond 36 hours.

San Diego made a 7 percent improvement over guidance in November and a 1 percent improvement in February; other months showed a negative improvement for the first 36 hours combined. Little if any improvement over FP-3 guidance was made beyond 36 hours.

Los Angeles FP-3 and Las Vegas Forecasts:

Los Angeles guidance for Las Vegas was poor. The only improvement over climatology for the first 36 hours was 3 percent during December. Actually the FP-3 improvement appeared somewhat better during periods 4 and 5 than during the first 3 periods, which indicates considerable overforecasting the first 36 hours.

The Las Vegas forecasts made good improvement over guidance during all months for the first 36 hours and little if any improvement beyond 36 hours. As a result the Las Vegas forecasts improved over climatology during 3 of the 6 months.

Los Angeles FP-3 and Bishop Forecasts:

Los Angeles guidance for Bishop showed considerable variation between large positive and large negative improvement over climatology during all periods.

Bishop (only service A teletype data is available on Bishop) made very good improvement over the FP-3 out to 72 hours. Furthermore, Bishop made improvement over climatology out to 42-48 hours and possibly beyond.

SEATTLE FP CENTER

Seattle FP-3 Forecast for Seattle:

Seattle consistently made a good improvement over climatology during the test program for the first 36 hours of the forecast period. It was doubtful that much improvement was achieved beyond 36 hours. The consensus forecast did not appear to improve over the FP-3 forecast.

Seattle FP-3 and Astoria Forecasts:

Guidance FP-3 made improvement over climatology out to 36 hours for all six months. Little, if any,improvement was made beyond 36 hours.

In general Astoria made improvement over FP-3 guidance for 36 hours, although January showed a negative improvement. The skill at Astoria increased during the test program.

Seattle FP-3 and Medford Forecasts:

In general Seattle FP-3 guidance improved over climatology, although November and February had a rather large negative improvement. Little, if any, improvement was evident beyond 36 hours.

Medford made significant improvement over FP-3 guidance during all months resulting in local improvement over climatology in each month, except November, for the first 36 hours of the forecast period. It was estimated that some improvement over FP-3 and climatology was achieved out to 42-48 hours.

Seattle FP-3 and Pendleton Forecasts:

Guidance FP-3 forecasts for Pendleton showed a negative improvement over climatology for the first 36 hours combined during October, November, and December. A breakdown of the October data showed a positive improvement for the first 6-12 hours. Guidance improved during January, February, and March, +6 percent, +10 percent, and +19 percent respectively. Little, if any, improvement was evidenced beyond 36 hours.

Pendleton made significant improvement over guidance FP-3 forecasts in all months resulting in local forecasts improving over climatology out to 36 hours in all months except October. Little, if any, improvement over FP-3 or climatology was evident beyond 36 hours.

Seattle FP-3 and Spokane Forecasts:

Guidance forecasts for Spokane were variable. October, November, and February were negative for the first 36 hours combined. A breakdown of the October results should show positive improvement for the first 6-12 hours. However, some improvement over climatology was estimated for periods beyond 36 hours.

Astoria made improvement over guidance in all months except January and March. However, guidance was very good in March and improvement would have been difficult; March local over FP-3 was 1.0%. Astoria did not improve over guidance beyond 36 hours.

Seattle FP-3 and Yakima Forecasts:

The guidance FP-3 forecasts showed an improvement over climatology for the first 36 hours excepting October and February. There was little improvement evident beyond 36 hours.

Yakima improved over guidance except in November and March out to 36 hours. Little, if any, improvement was evident beyond 36 hours.

SAN FRANCISCO FP CENTER

San Francisco FP-3 Forecasts for San Francisco:

The San Francisco forecasts made very significant improvements over climatology out to 72 hours. Consensus seemed to contribute more to the last 36 hours of the forecast than to the first 36 hours.

San Francisco FP-3 and Fresno Forecasts:

The FP-3 guidance forecasts made large improvements over climatology out to 72 hours. From the limited data, it was difficult to evaluate the influence of the consensus forecasts.

Fresno made an improvement over guidance in three of the six months for the first 36 hours, and in four of the six months for the last 36 hours of the forecasts.

San Francisco FP-3 and Sacramento Forecasts:

San Francisco FP-3 guidance made a marked improvement over climatology for 36 hours and some improvement from 36 to 72 hours.

San Francisco FP-3 and Sacramento Forecasts: (Continued)

Sacramento only made good improvement over guidance during November and December for the first 36 hours combined. Little or no improvement was evident beyond 36 hours.

San Francisco FP-3 and Red Bluff Forecasts:

The FP-3 guidance made good improvement over climatology out to 36 hours with little or no improvement beyond 36 hours.

Red Bluff improved over 36-hour guidance only during October and February.

San Francisco FP-3 and Reno Forecasts:

San Francisco guidance for Reno was somewhat variable, January and February having a negative improvement over climatology for the first 36 hours combined. Perhaps there was some improvement over climatology beyond 36 hours. From the limited data, it appeared that the consensus forecast contributed to more improvement during the last 36 hours than during the first 36 hours of the forecast.

In general, Reno made good improvement over guidance out to 72 hours, and also some improvement over climatology.

San Francisco FP-3 and Bakersfield Forecasts:

The FP-3 guidance made good improvement over climatology for 36 hours except during October and November, which had negative improvements. There was some improvement beyond 36 hours, possibly out to 42-48 hours.

Bakersfield made improvement over guidance except during December and January for the first 36 hours of the forecast and possibly some improvement beyond 36 hours.

San Francisco FP-3 and Eureka Forecasts:

Guidance improved over climatology for 36 hours in all months. Some improvement was also indicated beyond 36 hours. Again the consensus forecast appeared to contribute to the last 36 hours, but not to the first 36 hours of the forecast.

San Francisco FP-3 and Eureka Forecasts: (Continued)

Eureka improved over 36-hour guidance only during October and March. No improvement beyond 36 hours was indicated. (Eureka did not receive facsimile data.)

San Francisco FP-3 and Winnemucca Forecasts: (4 months' data)

San Francisco made some improvement over climatology for two months out to 36 hours with little or no improvement indicated beyond 36 hours.

Winnemucca did not improve on the 36-hour guidance during any month.

ATTACHMENT 4

RELIABILITY CURVES FOR STATIONS IN THE THREE-MONTH PROGRAM

Sixteen stations participated in a probability orientation program in which individual stations compiled data for reliability curves. This program was conducted during January, February, and March 1966.

For the most part, station skill increased as forecasters became acquainted with probability forecasting.

Elko, Lewiston, Salem, Klamath Falls, Olympia, Milford, Portland, Stockton, and Tucson achieved good reliability.

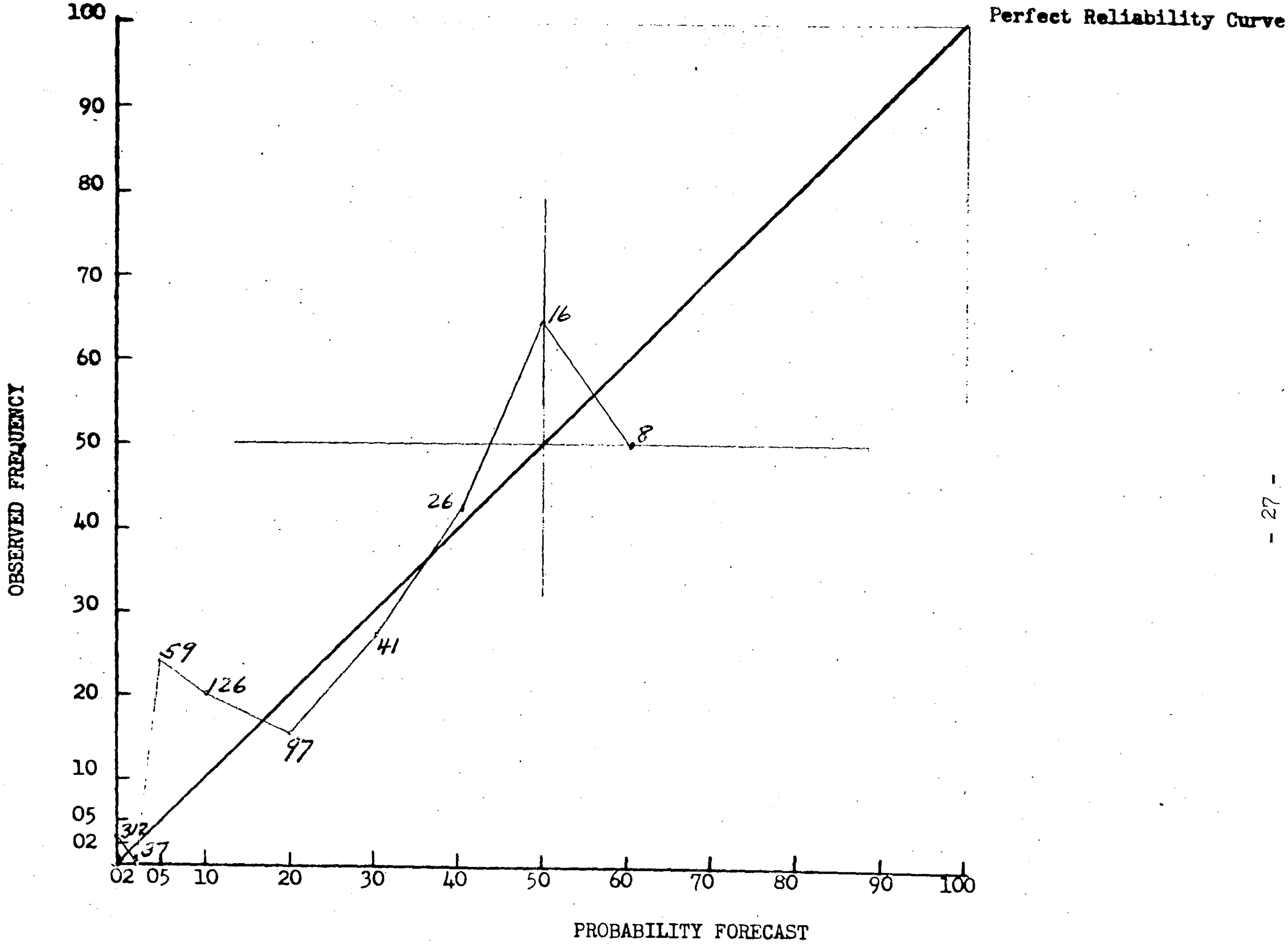
Stockton and Salem made a commendable extra effort and computed the percent improvement over climatology for each 15-hour forecast period and for the entire forecast. Both stations made very significant improvements over climatology.

The reliability curves for Wenatchee, Pomona, Winnemucca, Walla Walla, and Santa Maria indicate that these stations need further training in the use of precipitation probabilities.

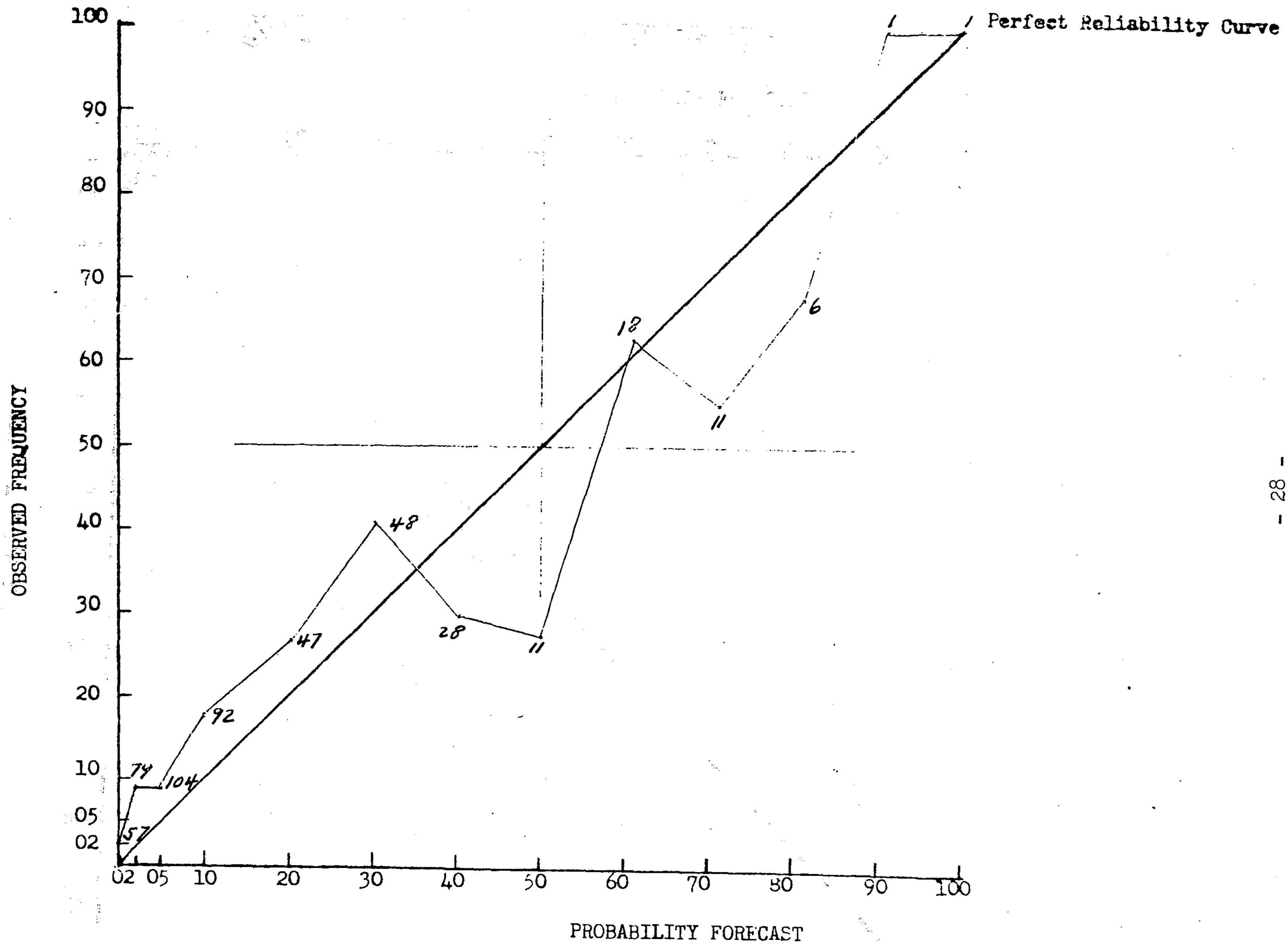
Insufficient data was received from Eugene and Havre to make an evaluation.

Station reliability curves for all forecasts made during the program are enclosed.

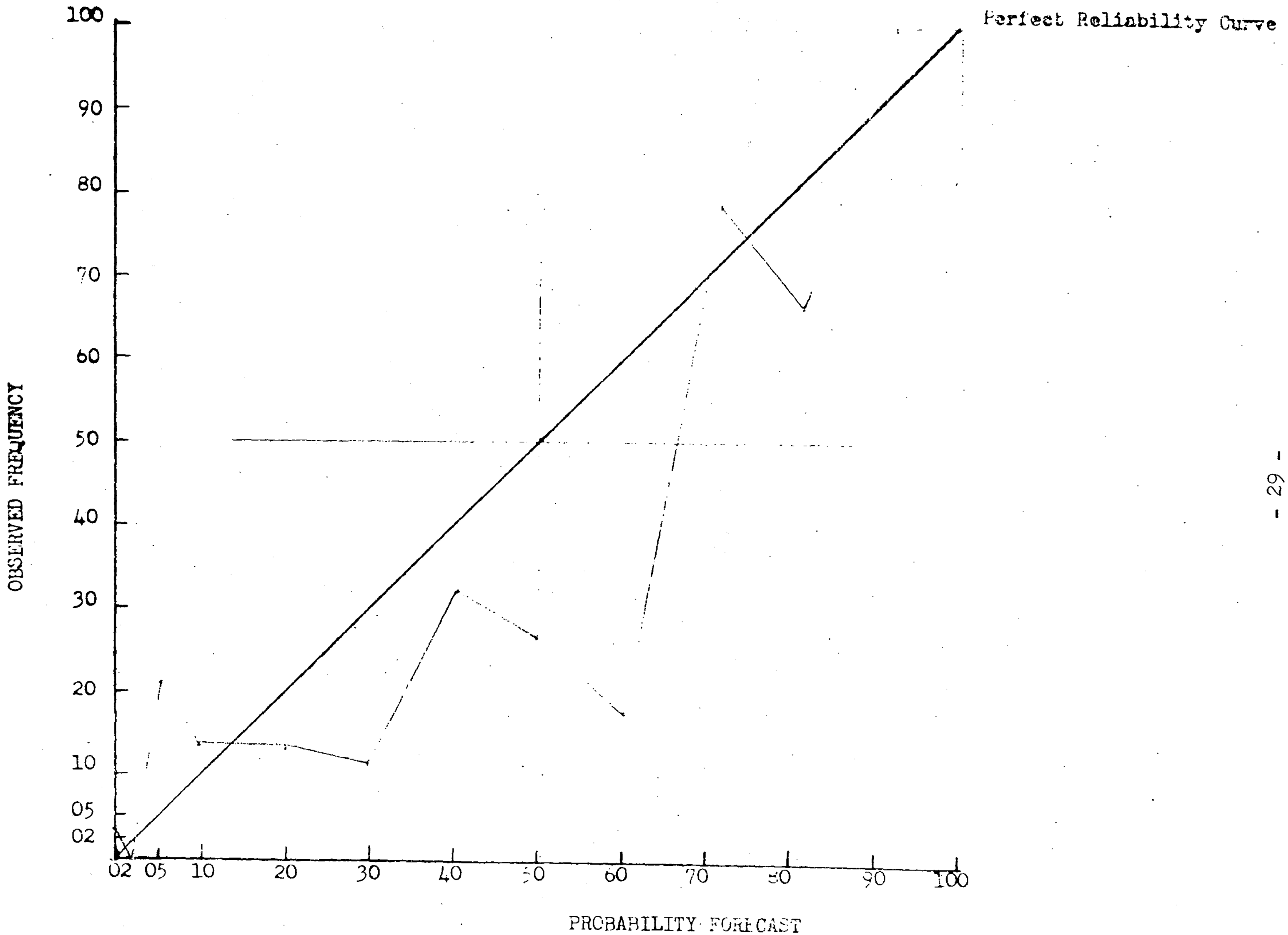
Number plotted adjacent to the curve indicates the number of forecasts. A dashed line indicates insufficient data.



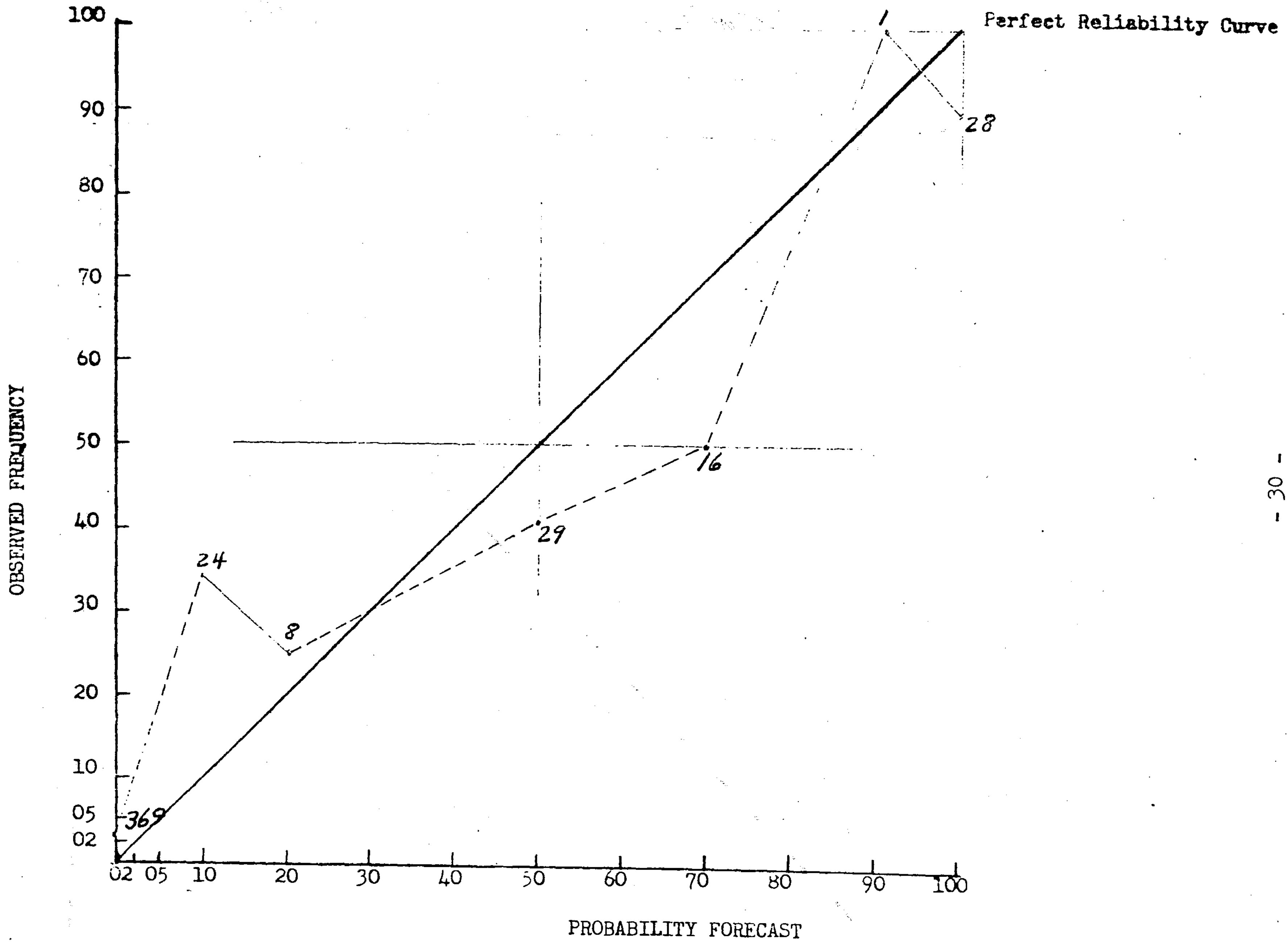
STATION Elko MONTH Jan., Feb., Mar.



STATION *Klamath Falls* MONTH *Jan., Feb., Mar.*

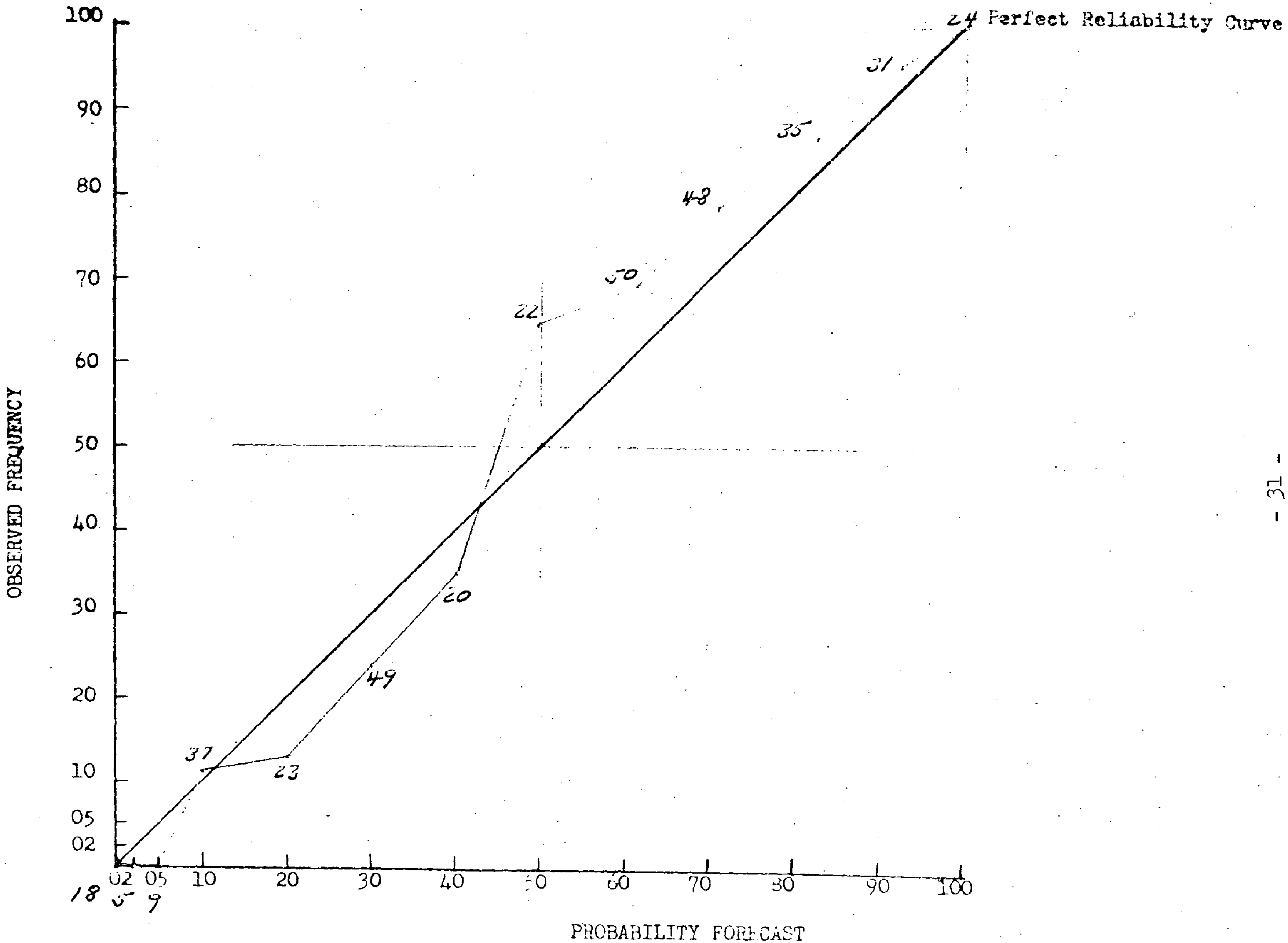


STATION *Lewiston* MONTH *Jan, Feb, Mar.*

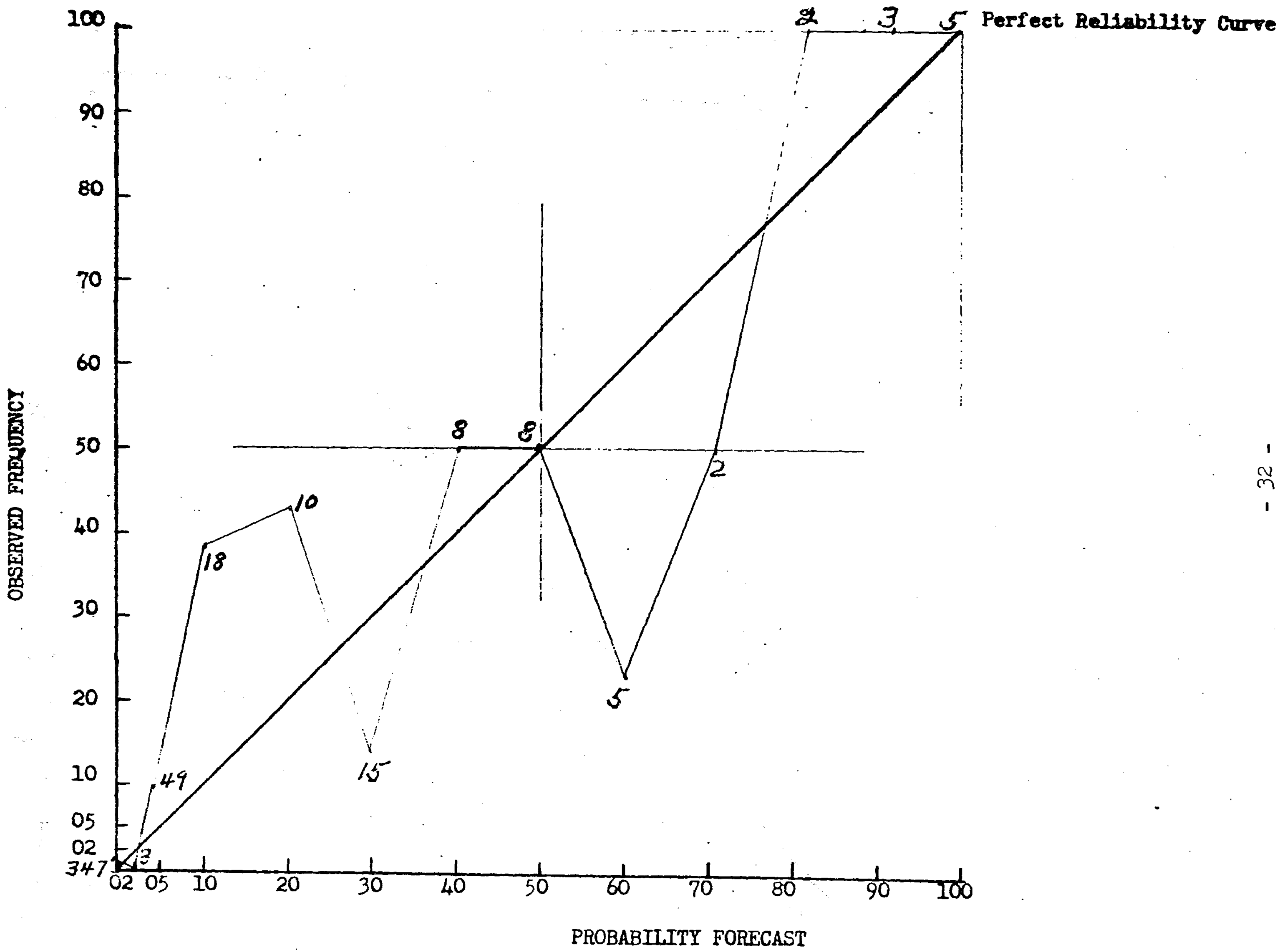


STATION: *Milford*

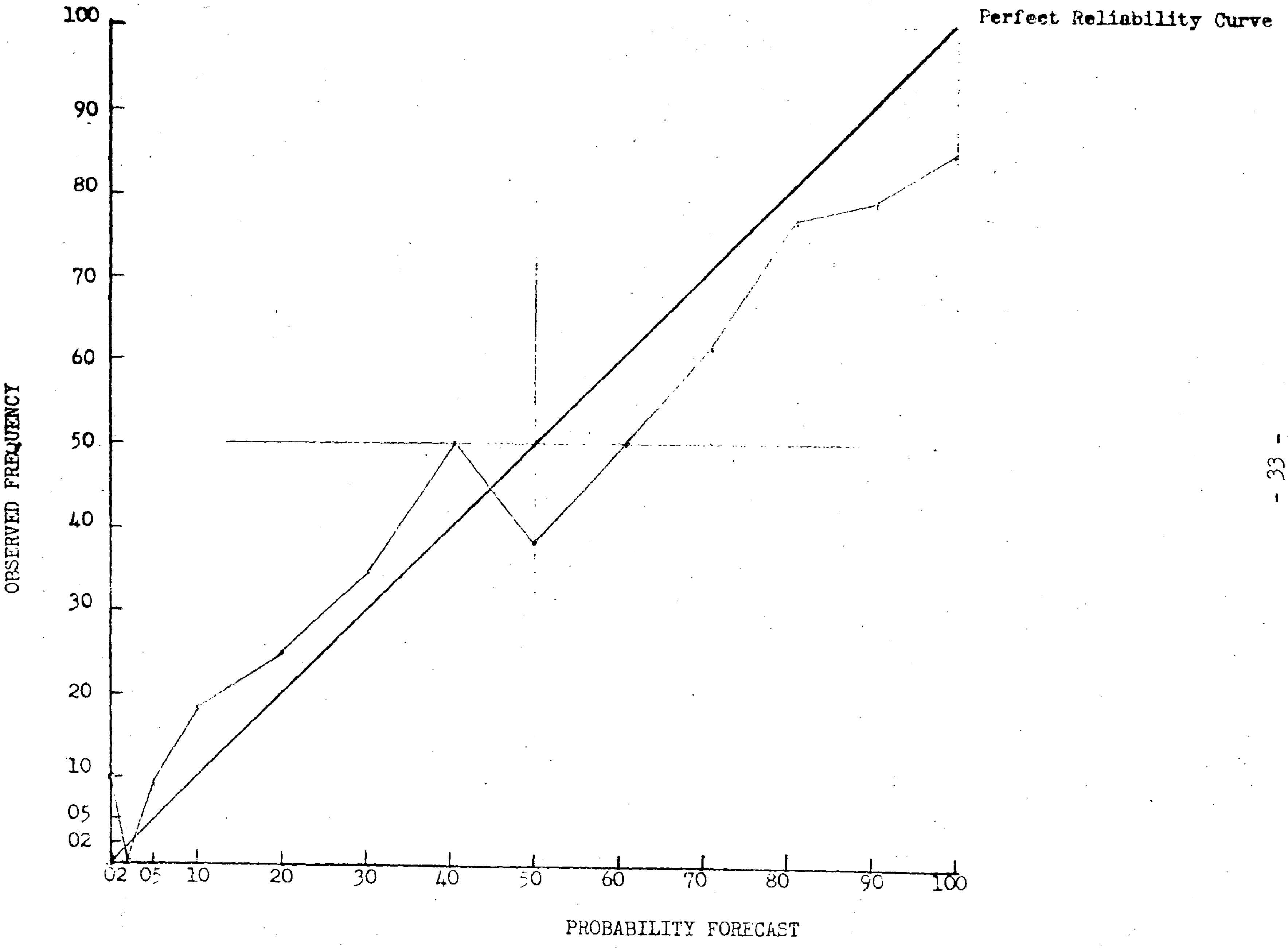
MONTH *Jan, Feb, Mar.*



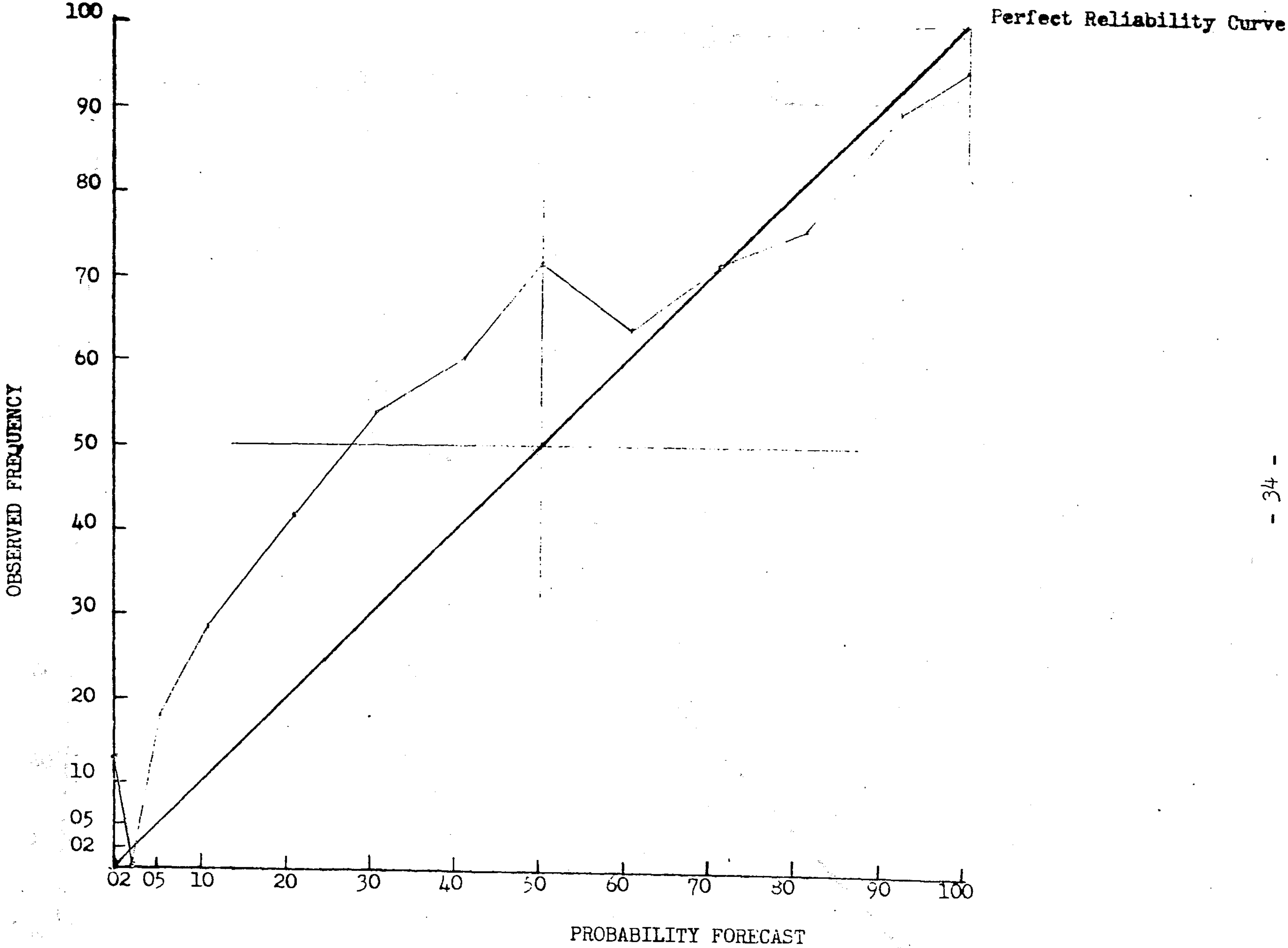
STATION Olympia MONTH Jan, Feb, Mar.



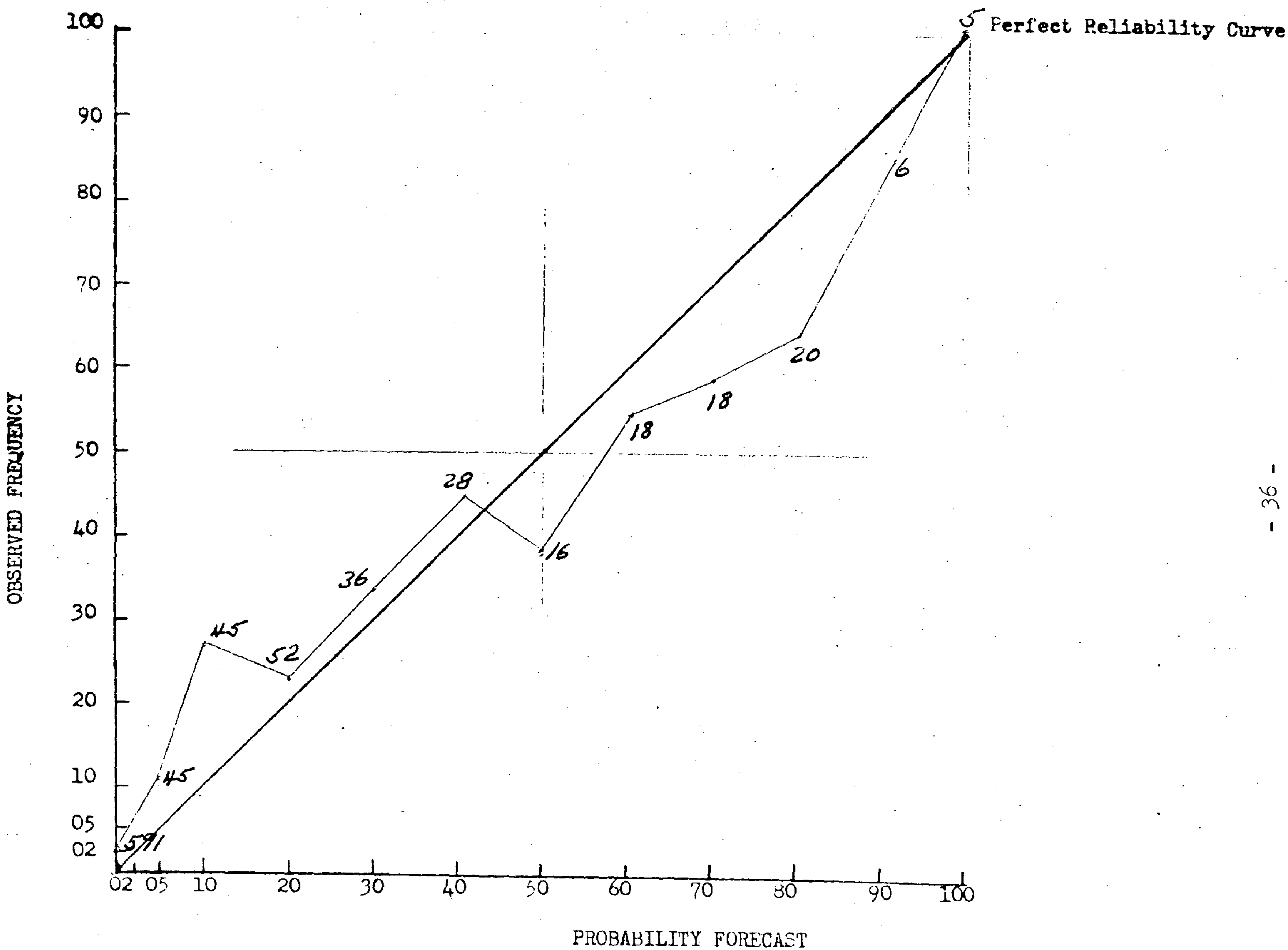
STATION *Pomona* MONTH *Jan., Feb., Mar.*



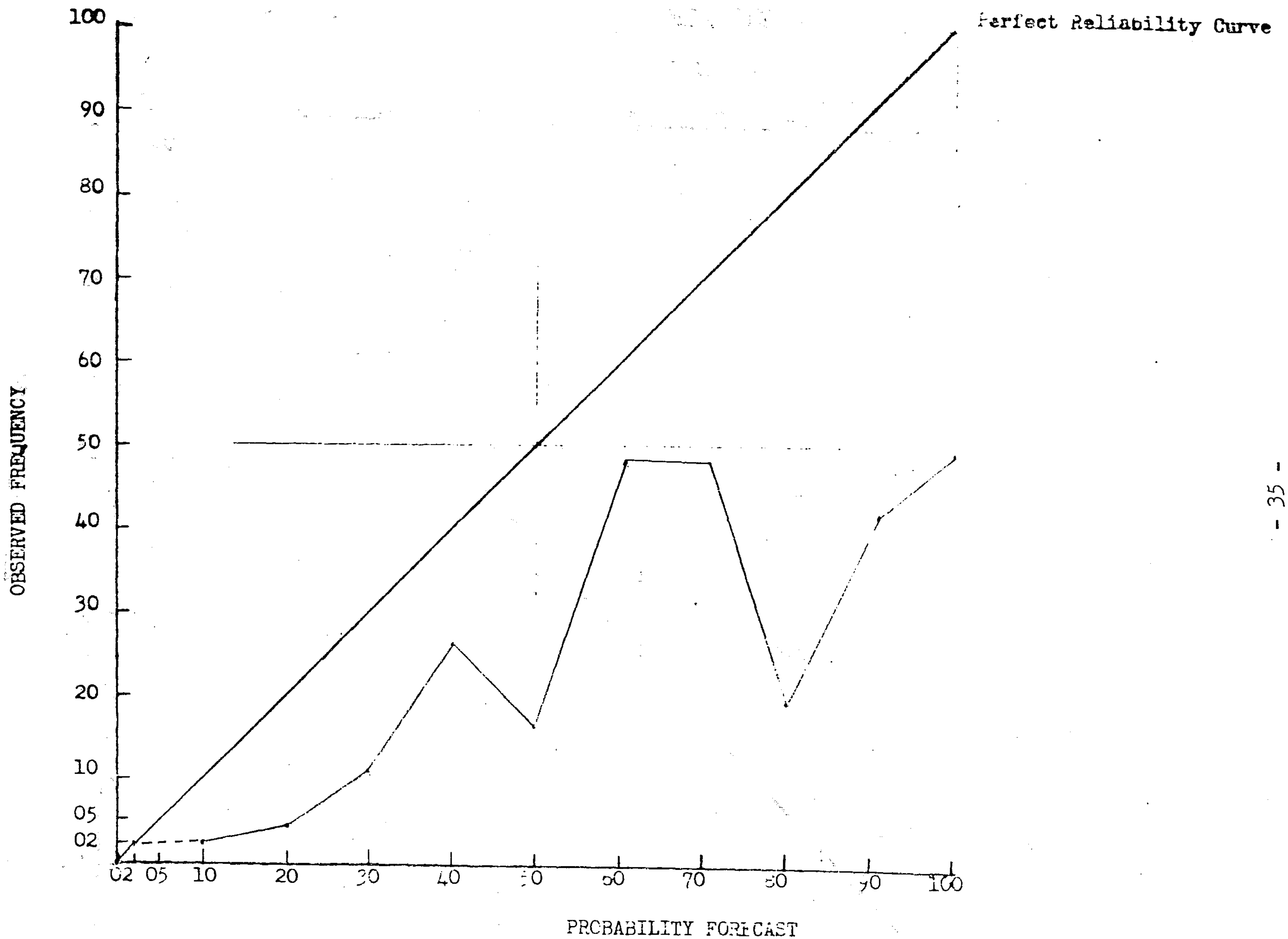
STATION *Portland* MONTH *Jan., Feb., Mar.*



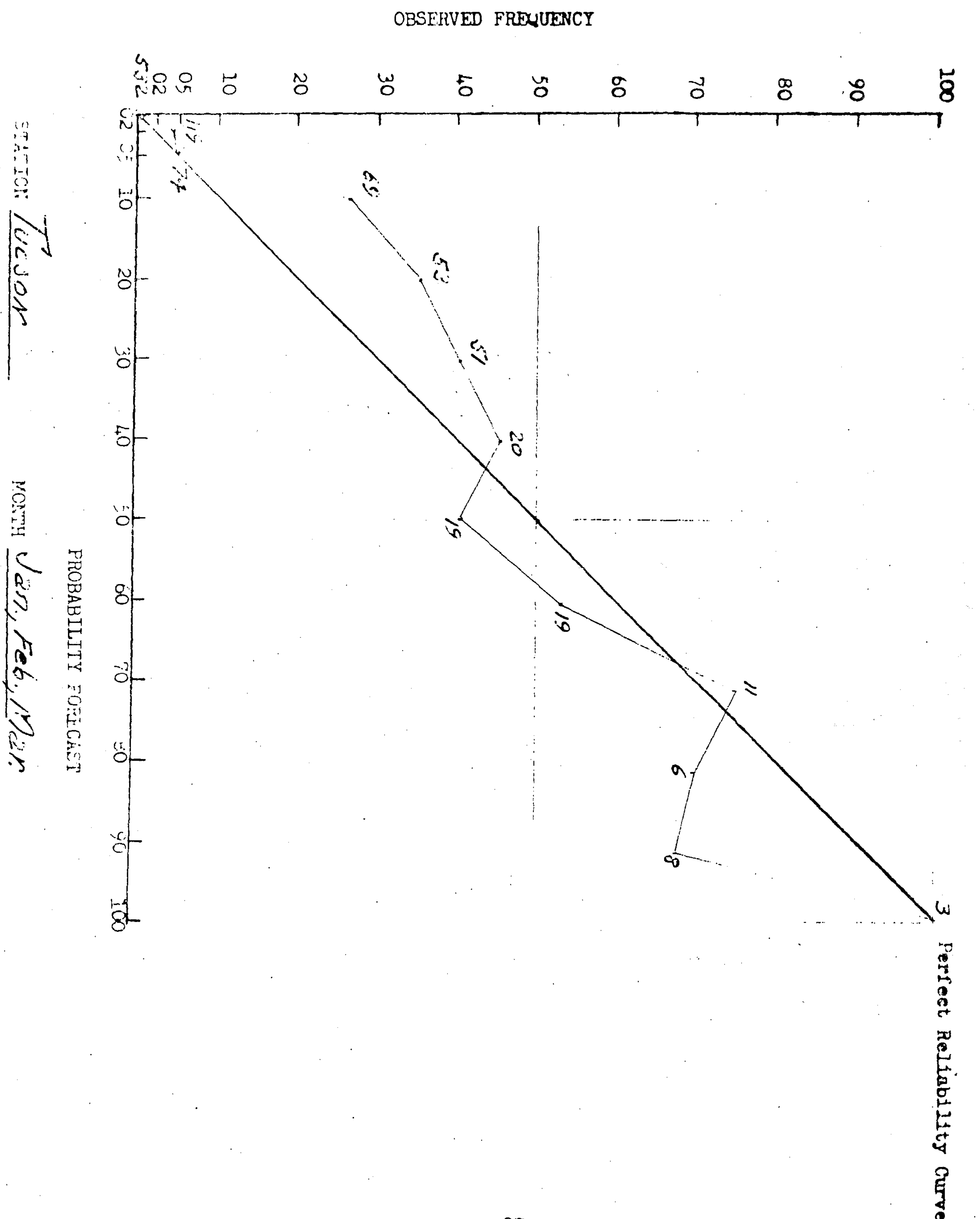
STATION *WBAS Salem* MONTH *Jan., Feb., Mar.*

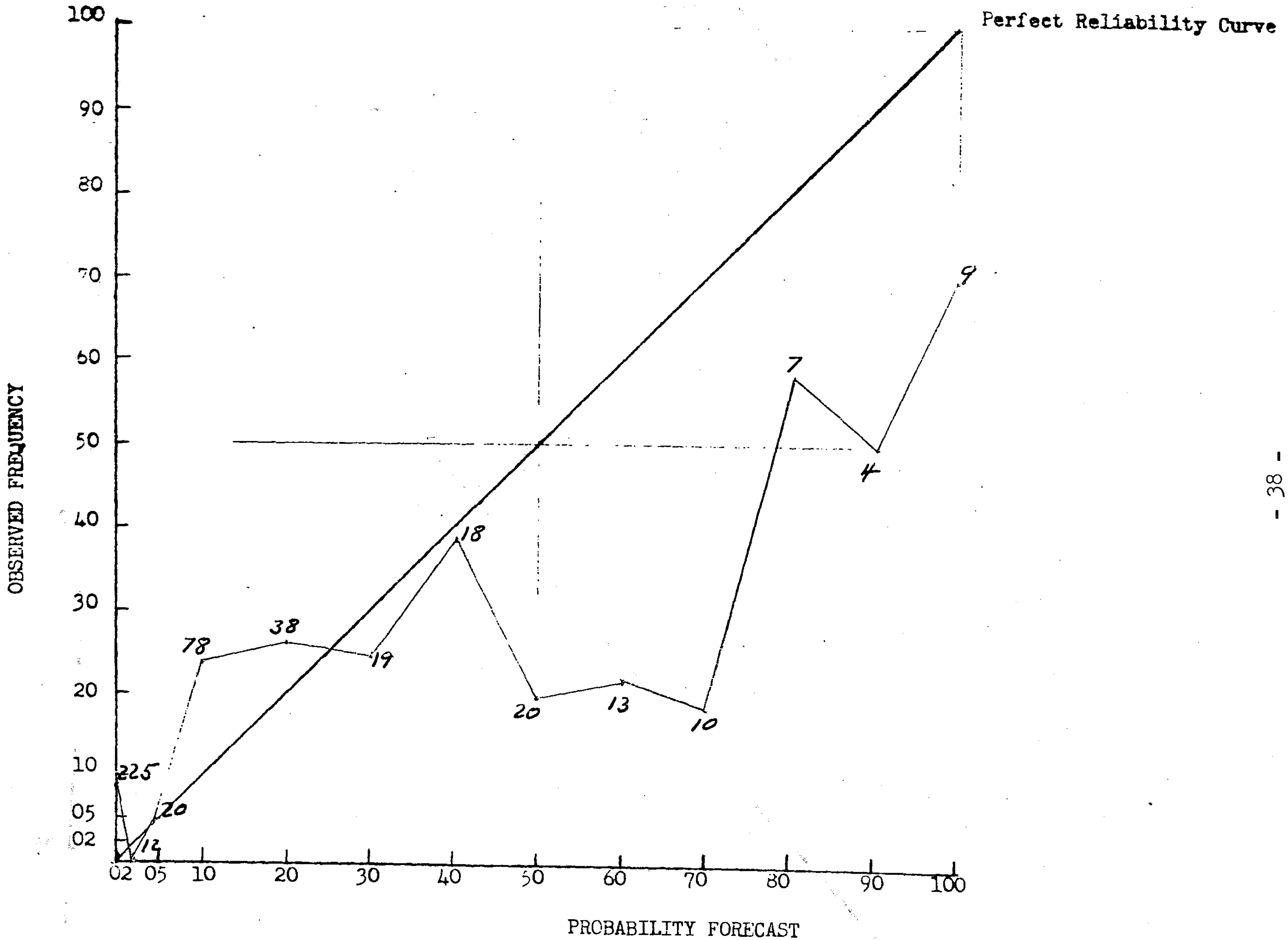


STATION Stockton MONTH Jan., Feb., Mar.

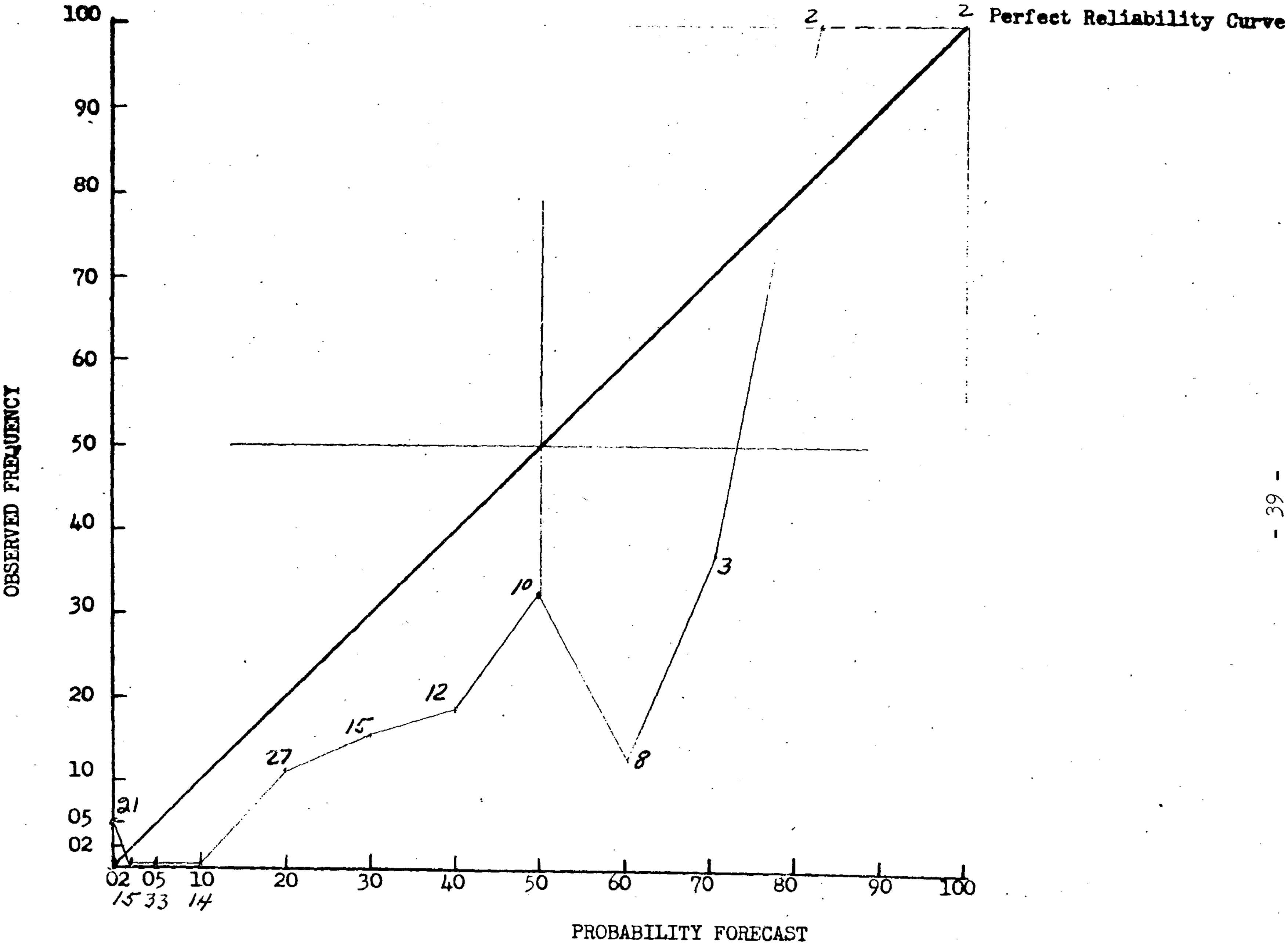


STATION Santa Maria MONTH Jan, Feb, Mar.

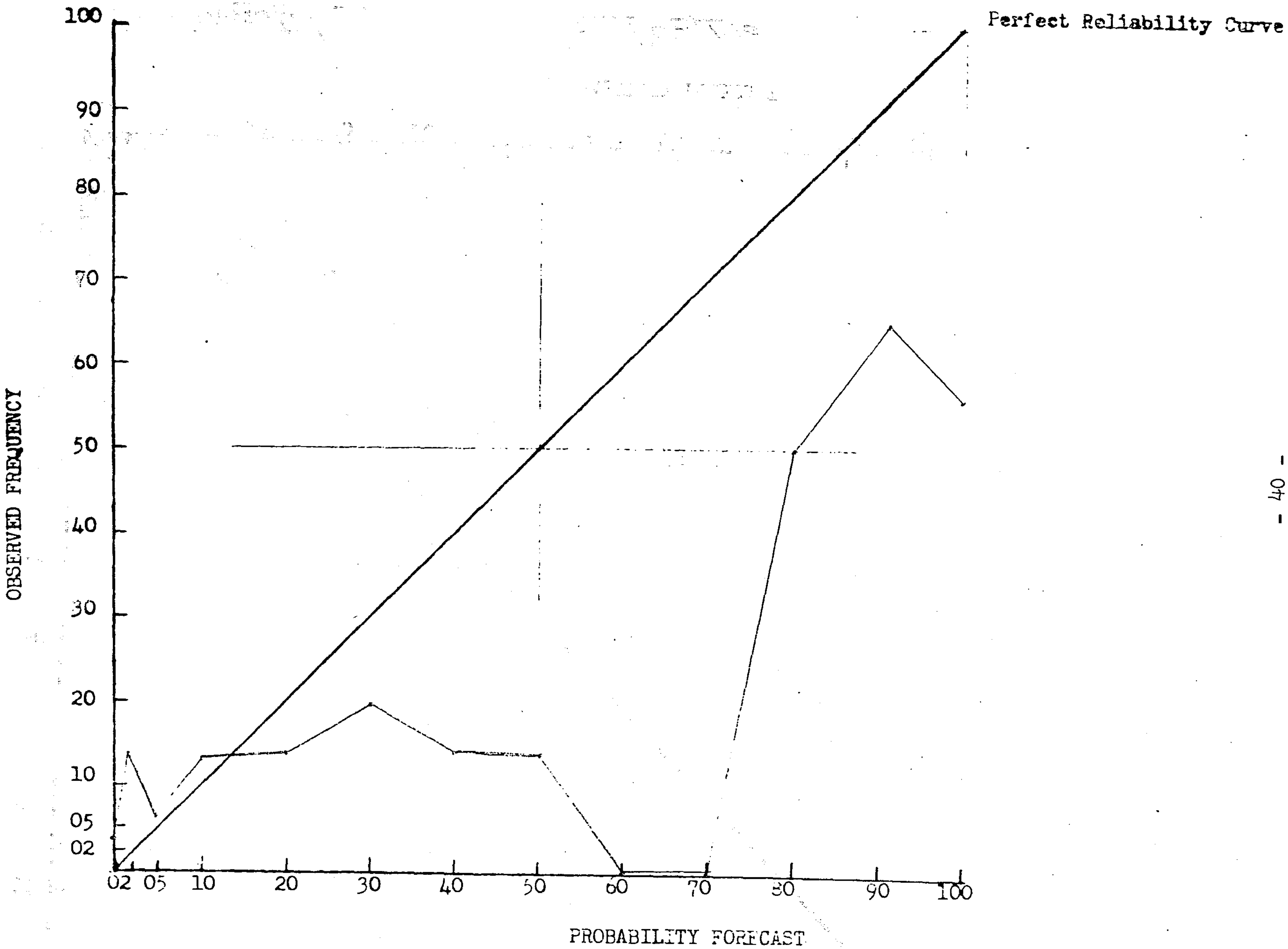

OBSERVED FREQUENCY
PROBABILITY FORECAST
Perfect Reliability Curve
STATION Tucson
MONTH Jan, Feb, Mar.
100
90
80
70
60
50
40
30
20
10
05
02
532
117
74
69
52
57
20
15
19
11
6
8
3



STATION *Walla Walla* MONTH *Jan, Feb., Mar.*



STATION *Wenatchee* MONTH *Jan, Feb, Mar.*



STATION Winnemucca MONTH Jan., Feb., Mar.