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Techniques for Forecasting Low Water Occurrences at Baltimore and Norfolk

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Environmental Science Services Administration
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TECHNIQUES FOR FORECASTING LOW WATER OCCURRENCES
AT BALTIMORE AND NORFOLK

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TECHNIQUES FOR FORECASTING LOW WATER OCCURRENCES AT BALTIMORE AND NORFOLK

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ABSTRACT

This report describes the development of manual techniques for forecasting low water occurrences at Baltimore and Norfolk. Each technique is based on a regression equation, derived by the multiple correlation-screening process, which requires certain surface wind and pressure data from three Chesapeake Bay stations. The minimum and maximum time lags for each equation are 6 and 24 hours, respectively. Tests on independent data from Baltimore and Norfolk show root-mean-square errors of 0.6 feet and 0.4 feet, respectively. These techniques can be useful forecast aids when used under synoptic conditions favorable for low water occurrences.

INTRODUCTION

In December 1968, the Coast and Geodetic Survey inquired about the possibility of obtaining forecasts of low water conditions at Baltimore and Norfolk. They stated that occasionally meteorological conditions cause below-normal water levels which hinder the operations of C&GS vessels in these harbors. Mr. Stuart Brown later informed us that the Baltimore Weather Bureau Office receives numerous calls from shipping interests concerning the water level there, since deep draft ships have their movements affected by below-normal levels. Such low water occurrences can result in expensive delays and/or damage to ships and cargos.

Low water occurrences as specified in this report are actually periods of negative storm surge. Storm surge, the meteorological effect on sea level, is defined as the difference between the observed tide and the predicted astronomical tide. The principal cause of storm surge is the action of wind stress on the water surface. Other factors affecting Chesapeake Bay include:

1. The effects of atmospheric pressure
2. The height of the tide in the Atlantic Ocean near the mouth of the bay
3. Transport of water by waves and swell in shallow areas
4. Modifying effects of bathymetry and coastline configuration.

The purpose of this study was to develop a technique which uses readily available meteorological data to forecast low water occurrences at Baltimore and Norfolk (Hampton Roads). Storm surges at Baltimore and Hampton Roads were related to winds and pressures at Baltimore, Norfolk, and Patuxent River Naval Air Station by a procedure used by N. A. Pore [2] to develop a technique to forecast extratropical storm surges on Chesapeake Bay. The use of data

from all three stations allowed us to take into account the effects of wind and pressure patterns over the entire bay. The two harbors were considered separately so that the local effects of coastline configuration and bathymetry might be more fully appreciated.

DATA

Wind and pressure data for the three stations (shown in Figure 1) were obtained from Surface Weather Observations (WBAN 10A), which are archived in the National Weather Records Center. The storm surge data were obtained from hourly tide records of the Coast and Geodetic Survey for the period 1955-1969. The datum planes for mean sea level for Baltimore and Hampton Roads were determined from the average sea level at those locations for the period 1941-1959.

Wind observations were converted to u (easterly) and v (northerly) components.

Throughout this report the notation BAL represents Baltimore, ORF denotes Norfolk, and NHK signifies the Patuxent River Naval Air Station.

PROCEDURE

Storm surge records for Baltimore and Norfolk for the months November through April from 1955 to 1969 were examined. For Baltimore, we selected for study only those cases in which the water level reached a minimum at least two feet below normal during the low water occurrence. There were twenty of these. We had planned to use the same criterion for Norfolk, but there were few cases that met it. There were, however, thirty-one cases in which the level reached at least 1.5 feet below normal. This, then, became the selection criterion for Norfolk.

Data for each case were then tabulated for Baltimore, Patuxent, and Norfolk. These data described the general wind and pressure patterns that existed over the bay prior to and during the low water occurrences. The screening process was then used to determine practical prediction equations of the following form:

1. $SS = A_1 + B_1 X_1$
2. $SS = A_2 + B_2 X_1 + C_1 X_2$
3. $SS = A_3 + B_3 X_1 + C_2 X_2 + D_1 X_3$
- .
- .
- .
- n. $SS = A_n + B_n X_1 + C_{n-1} X_2 + \dots + N X_n$

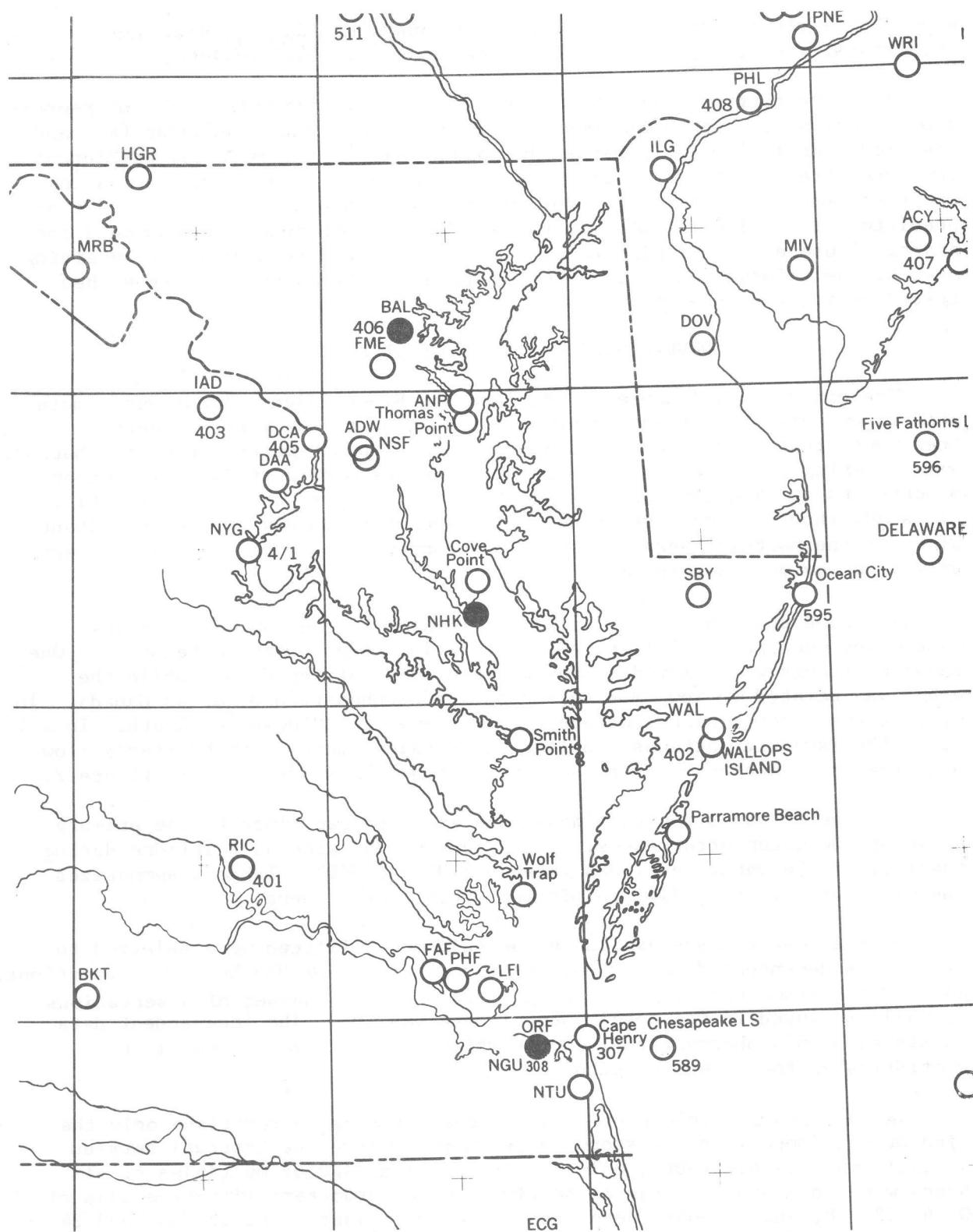


Figure 1. Map of Chesapeake Bay area.

where SS is storm surge, A_1 , A_2 , etc. are constants, X_1 , X_2 , etc. are predictors, and B_1 , B_2 , C_1 , C_2 , etc. are regression coefficients.

The screening process selects the best single predictor (X_1) for regression equation 1. The second equation includes the first predictor (X_1) and the predictor (X_2) which gives maximum reduction of the residual predictand variance after the first predictor is considered. Additional screening steps are made until the amount of improvement gained by including additional predictors is insignificant. In this project we attempted to recommend for practical use equations with no more predictors than necessary for retaining most of the information in the predictand set. These equations were then tested on independent data.

DEVELOPMENT OF BALTIMORE TECHNIQUE

The harbor at Baltimore is the Patapsco River inlet. The river's main axis is oriented approximately northwest-southeast. We might suspect, therefore, that a northwest wind would tend to "push" water out of the harbor, thus lowering the water level. Stuart Brown has made a study of low water occurrences at Baltimore and relates them primarily to the local wind [1]. His study shows a strong relationship between the monthly average resultant wind and the monthly average number of occurrences of water levels two feet or more below mean sea level.

We found that the weather patterns leading to the low water occurrences included in the Baltimore data fell into two general categories. One involved storms which moved up the Eastern coast of the U. S., while the other was related to lows moving across the Northeastern U. S. or Canada. In many of the cases a high pressure area was over the Midwest or South. In all cases the isobaric patterns resulted in an approximately northwesterly flow over the bay. Weather maps of several typical cases are shown in Figure 2.

All twenty cases for Baltimore were examined for clues to the primary cause of low water occurrences. In all cases, the wind at Baltimore during the fall of the water level was between 270° and 360° . Table 1 summarizes the wind conditions leading to minimum water levels there.

Of the twenty cases available for Baltimore, fifteen were selected to be used as dependent data. These cases had a total of 958 hourly observations. We used a maximum time lag of 24 hours, so the total number of observations actually included in the developmental data was 598. The independent data consisted of 329 observations, 209 of which were utilized in obtaining statistics on the forecast technique.

We made two multiple correlation-screening runs to correlate only the wind at Baltimore with the storm surge there. Since the interval between synoptic maps is six hours, only predictors with lags of multiples of six hours were included. In run 1, Baltimore wind parameters with time lags of 0, 6, 12, 18, and 24 hours were used. In run 2, lags of 6, 12, 18, and 24 hours were used. The results appear in Table 2.

Table 1. Summary of wind conditions at Baltimore leading to minimum water levels.

	Wind at time of lowest water level (a) (b)		Duration of wind W to N (c)	Average wind speed over duration in (c)	Highest wind speed recorded	Lowest water level
1	315°	17 kt	17 hrs	14.5 kts	18 kts	-3.1 ft
2	337	22	41	18.2	28	-2.9
3	337	17	17	17.8	23	-3.3
4	292	25	27	21.9	30	-3.3
5	270	20	26	17.0	27	-2.5
6	292	15	52	16.0	25	-4.2
7	315	14	32	15.8	22	-2.7
8	340	14	17	13.3	18	-3.0
9	300	7	19	14.6	22	-2.7
10	310	18	48	18.6	26	-4.1
11	290	13	18	18.0	23	-2.8
12	310	18	27	13.1	22	-2.1
13	250*	5	23	13.1	18	-2.7
14	290	16	22	14.1	17	-2.1
15	310	18	22	18.2	25	-2.8
16	330	20	30	15.8	24	-2.3
17	320	20	30	17.5	26	-2.1
18	310	20	29	16.3	24	-2.2
19	310	20	30	18.4	33	-2.3
20	300	21	30	17.6	23	-3.9

* 290° at 9 kts. one hour before.

Table 2. Selection of Baltimore predictors when only Baltimore wind was considered. The letter "r" represents the correlation coefficient, and RMSE is the root-mean-square error. 508 sets of data were included in this sample.

Min. lag 0 hrs						Min. lag 6 hrs.					
Eq.	Var	Lag	Station	r	RMSE	Var	Lag	Station	r	RMSE	
1	u	6	BAL	.39	.80 ft	u	6	BAL	.39	.80 ft	
2	u	12	BAL	.42	.78	u	12	BAL	.42	.78	
3	v	0	BAL	.49	.76	v	6	BAL	.47	.76	
4	u	18	BAL	.50	.75	u	18	BAL	.49	.75	
5	v	6	BAL	.52	.74	v	12	BAL	.50	.75	
6	v	12	BAL	.53	.73	v	24	BAL	.52	.74	
7	v	24	BAL	.54	.73	u	24	BAL	.52	.74	
8	u	24	BAL	.55	.72	v	18	BAL	.52	.74	

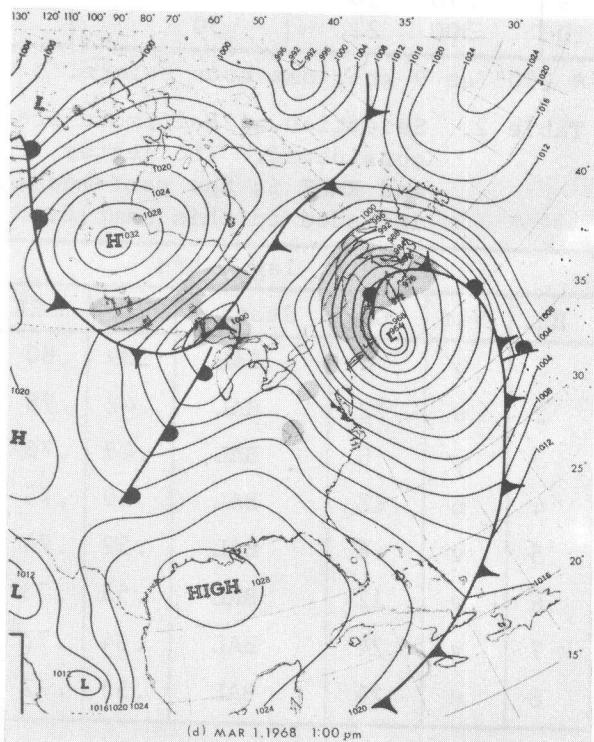
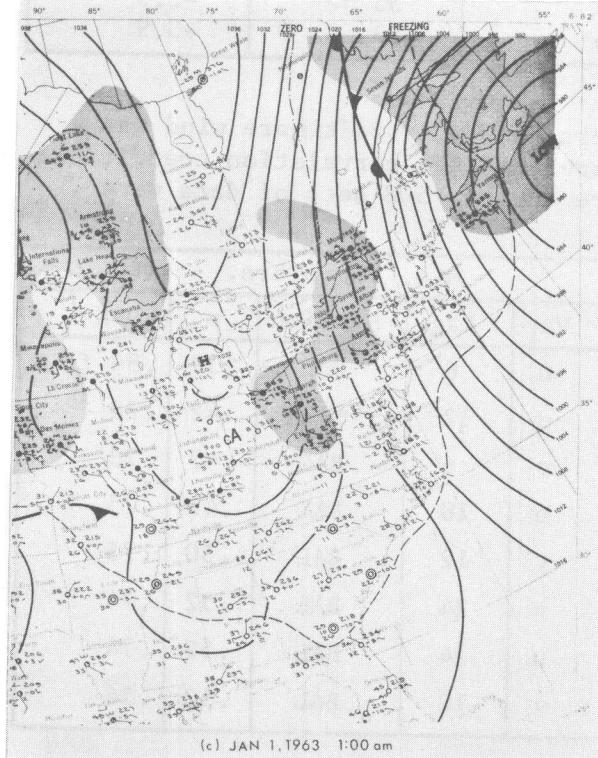
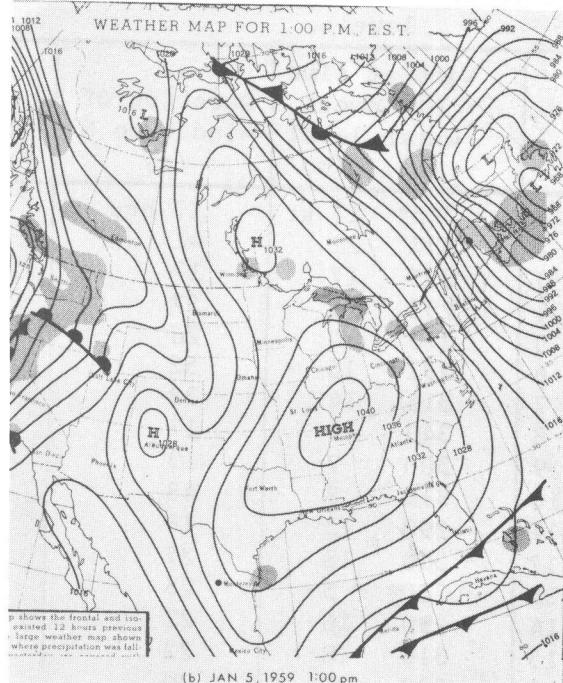
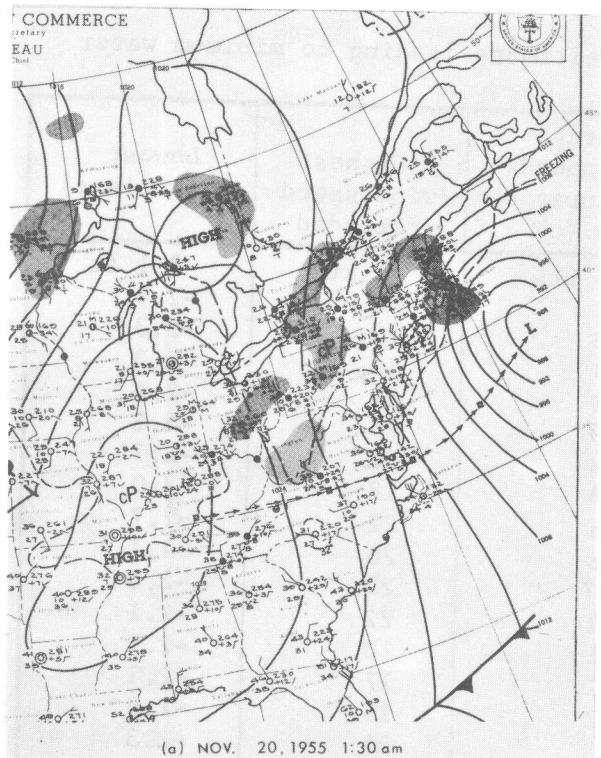


Figure 2. Weather maps of typical Baltimore low water cases.

We made three regression runs which related the Baltimore storm surge to wind and pressure data from Baltimore, Norfolk, and Patuxent. These runs had minimum lags of 0, 6, and 12 hours. The results are given in Table 3.

Table 3. Selection of predictors for Baltimore when wind and pressure data from three stations were available. The sample size was 598 sets of data.

Min. lag 0 hrs.						Min. lag 6 hrs.						Min. lag 12 hrs.					
Eq	Var	Lag	Sta	r	RMSE	Var	Lag	Sta	r	RMSE	Var	Lag	Sta	r	RMSE		
1	v	6	ORF	.37	.77ft	v	6	ORF	.37	.78ft	u	12	NHK	.35	.78ft		
2	u	12	NHK	.52	.71	u	12	NHK	.52	.71	v	12	NHK	.43	.75		
3	v	0	NHK	.58	.68	v	6	NHK	.57	.69	P	24	ORF	.52	.71		
4	P	24	ORF	.63	.65	P	24	ORF	.62	.66	v	24	BAL	.55	.70		
5	u	12	BAL	.67	.62	u	6	BAL	.66	.62	u	18	ORF	.56	.69		
6	u	6	ORF	.71	.59	u	6	ORF	.68	.61	P	12	ORF	.57	.69		
14				.77	.54				.74	.56					.63	.65	

The best single predictor selected for an equation with lags of 6, 12, 18, and 24 hours was the v component at Norfolk with a 6 hour lag. The correlation of this predictor to the Baltimore storm surge is .37. Adding four additional predictors raises the correlation coefficient to .66 and lowers the root-mean-square error from .78 to .62 feet.

A comparison of equations with minimum lags of 0, 6, and 12 hours reveals, as suspected, that skill is lost as the minimum lag is increased. The most useable forecast technique, however, would depend only on conditions that occurred several hours previous. We, therefore, eliminated from consideration equations with minimum lags of 0 hours. We examined the remaining equations closely and decided that an excessive amount of skill was lost when the minimum lag was raised from 6 to 12 hours.

After deciding to use an equation with a six-hour minimum lag, we calculated estimated water levels for all dependent cases, using equations with different numbers of variables. These values were plotted against the observed levels. After careful scrutiny, we decided to recommend as a forecast aid the five-predictor equation which follows:

$$\begin{aligned} SS_{BAL} = & 341.50 - .20(v_{-6})_{ORF} + .43(u_{-12})_{NHK} - .44(v_{-6})_{NHK} - .34(P_{-24})_{ORF} \\ & + .44(u_{-6})_{BAL} \end{aligned}$$

where SS_{BAL} is the Baltimore storm surge in tenths of feet, u and v are in knots, and P is the sea level atmospheric pressure in millibars. The numerical subscripts represent the time lags (in hours) relative to the time for which the forecast is valid.

This equation was tested on an independent data sample consisting of five low water cases with a total of 329 hourly observations. Since the maximum lag is 24 hours, only 209 of these could be used in the independent data sample. Table 4 contains a summary of statistics obtained with this sample together with similar statistics for the developmental data.

Table 4. Summary of statistics on Baltimore data obtained by using five-predictor equation

	Dependent	Independent
Observed mean	-1.97 ft.	-1.89 ft.
Standard deviation of observed heights	.84 ft.	.68 ft.
Specified mean	-1.97 ft.	-2.15 ft.
Standard deviation of specified heights	.56 ft.	.65 ft.
Mean residual	.00 ft.	.26 ft.
RMSE	.62 ft.	.61 ft.
Correlation coefficient	.66	.65
Sample size	598	209

Following the testing of this independent sample, additional sets of data were added to most of the cases in order to better determine how well the specified values would follow the trend of the water level. We added 284 independent sets to the dependent data, yielding a total of 882 sets. This sample had a mean observed height of -1.32 feet. To the original independent sample we added 91 additional sets of data, and the resulting sample had a mean observed height of -1.45 feet. Statistics obtained by using these increased samples are tabulated in table 5.

Table 5. Summary of statistics for Baltimore obtained by using increased sample size with five-predictor equation.

Sample characteristics	Mean observed height	r	RMSE
1. 598 Dependent and 284 independent sets	-1.32 ft.	.82	.75 ft.
2. 300 Independent sets	-1.45 ft.	.82	.72 ft.

Comparing tables 4 and 5, we see that the samples with higher mean observed values had higher correlation coefficients, but larger root-mean-square errors. The negligible differences in statistics for dependent and independent data indicate that the equation is stable.

Figures 3 and 4 show graphs of all the Baltimore data, with a vertical dashed line separating the original data, which is on the right side of the line, from that which was added later (on the left side of the line). The correlation coefficient and RMSE are shown on the right side for the original data (summarized in table 4), and on the left side for all of the data

BALTIMORE

DEPENDENT

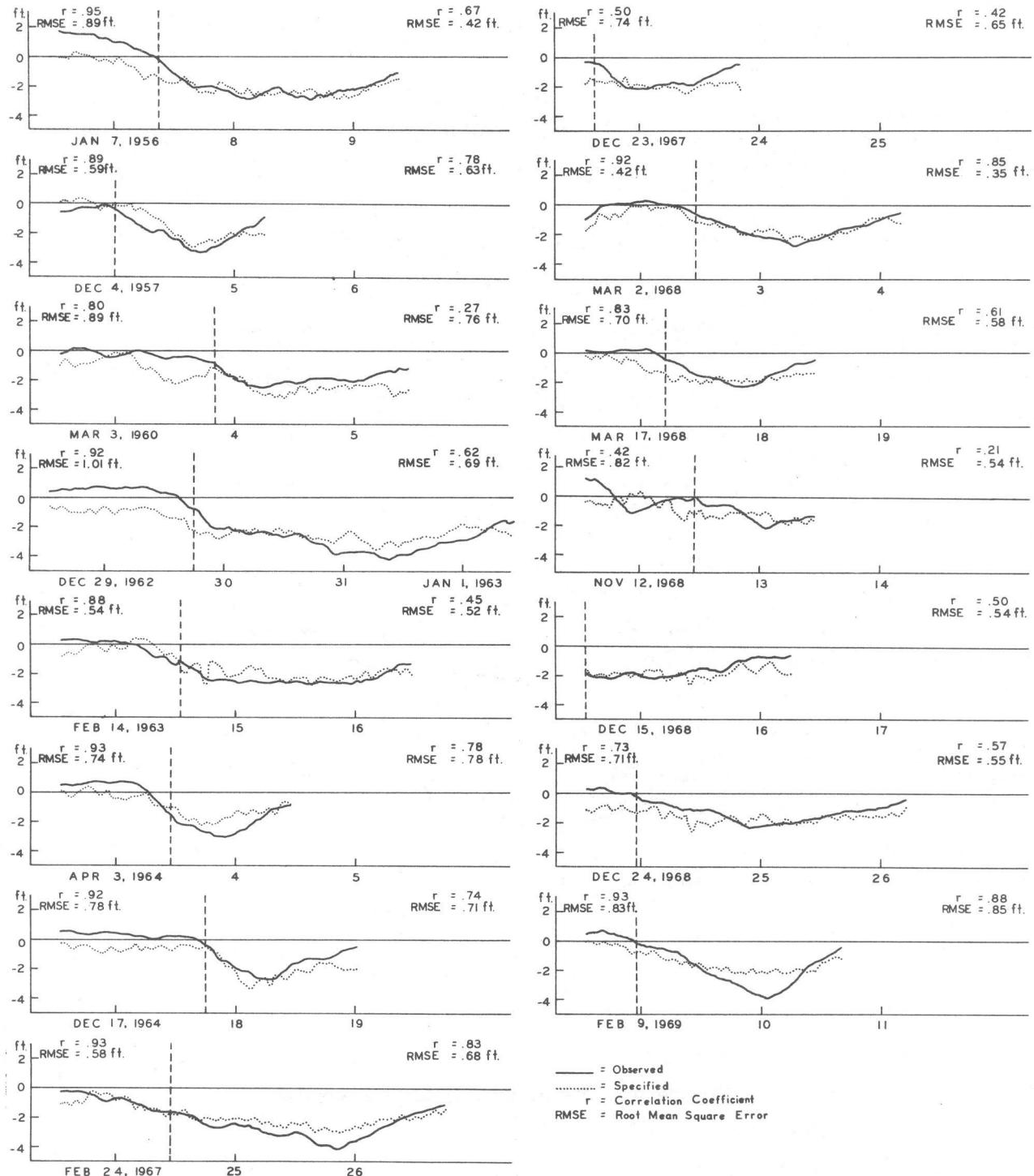


Figure 3. Baltimore dependent data. Each date is marked at the 12 noon (local time) position.

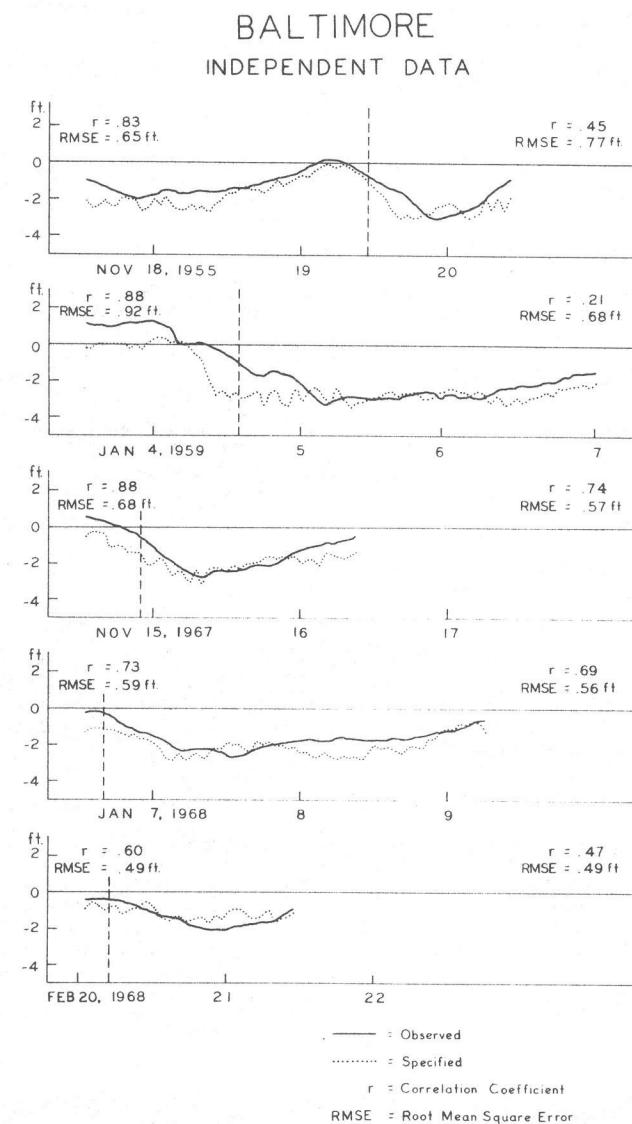


Figure 4. Baltimore independent data.

(summarized in Table 5) used in each individual case. Bear in mind that the additional data included with the dependent cases are actually independent data, and the statistics for these cases (on the left side of the graphs in Figure 3) pertain to a combination of dependent and independent data.

DEVELOPMENT OF NORFOLK TECHNIQUE

A forecast technique was developed for Norfolk (Hampton Roads) by a procedure similar to that followed for Baltimore. When the thirty-one available cases were examined, we discovered that a wide range of synoptic patterns existed during low water occurrences. Several of these are illustrated in Figure 5. The most predominate pattern involved a high pressure area south of Norfolk, with resulting southerly to westerly winds at Hampton Roads. Another pattern that appeared several times involved a low pressure center moving approximately northeastward and passing west of Norfolk. In nearly all of the cases the resulting wind at Norfolk was southerly to westerly.

Twenty cases, with a total of 1916 hourly observations, were selected as dependent data. The use of a 24-hour maximum lag resulted in a developmental data sample of 1676 cases. We made three screening runs, using minimum lags of 0, 6, and 12 hours. Table 6 contains the results.

Table 6. Selection of predictors for Hampton Roads when wind and pressure data from three stations were available. The sample included 1676 sets of data.

Min. lag 0 hrs.						Min. lag 6 hrs.						Min. lag 12 hrs.					
Eq	Var	Lag	Sta	r	RMSE	Var	Lag	Sta	r	RMSE	Var	Lag	Sta	r	RMSE		
1	v	6	NHK	.36	.49ft	v	6	NHK	.36	.49ft	u	24	BAL	.33	.49ft		
2	u	18	BAL	.57	.43	u	18	BAL	.57	.43	v	12	NHK	.48	.46		
3	u	6	ORF	.61	.41	u	6	ORF	.61	.41	u	12	ORF	.54	.44		
4	u	24	BAL	.65	.40	u	24	BAL	.65	.40	P	18	NHK	.57	.43		
5	P	24	ORF	.67	.39	P	24	ORF	.67	.39	u	18	BAL	.58	.43		
6	u	12	ORF	.69	.38	u	12	ORF	.69	.38	P	12	BAL	.59	.42		
14				.75	.34				.76	.34					.65	.40	

There is very little difference between the results of the runs using 0 and 6 hour minimum lags. In fact, the first six predictors are the same. A significant amount of skill is lost, however, when increasing the minimum lag from 6 to 12 hours. We therefore decided, as with Baltimore, to use an equation with a 6-hour minimum lag. After examining statistics and graphs pertaining to equations with different numbers of variables, we selected a

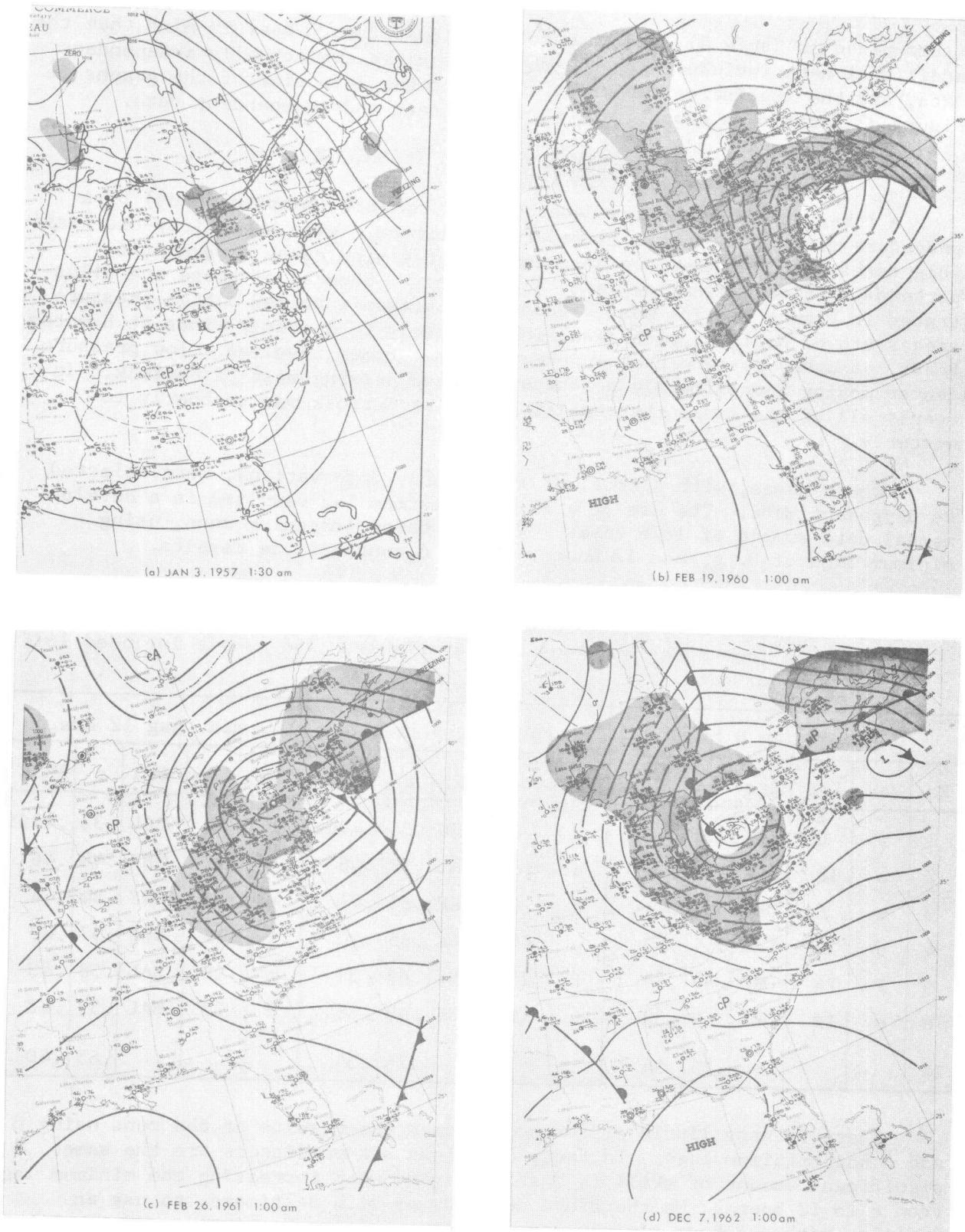


Figure 5. Weather maps of typical Hampton Roads low water cases.

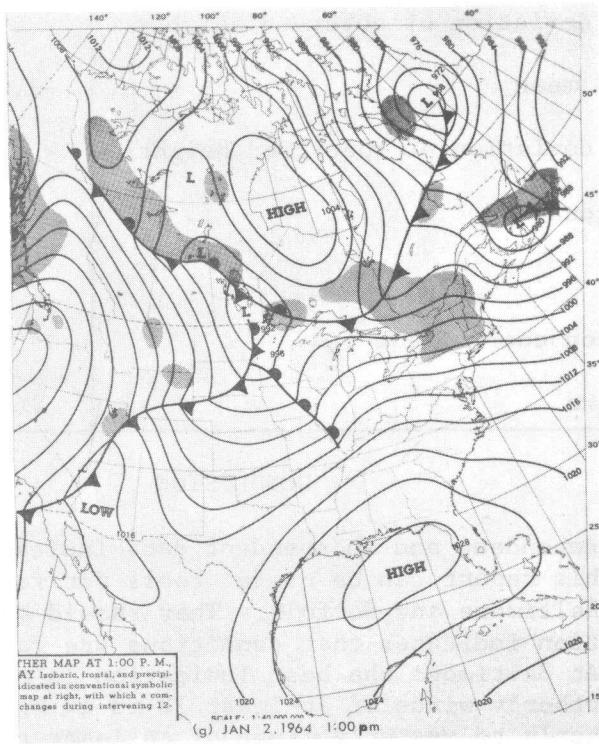
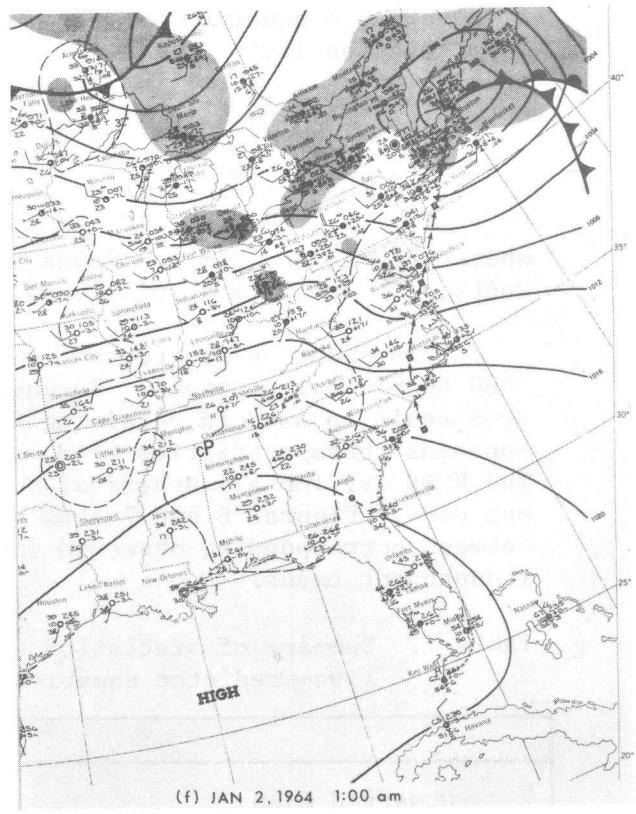
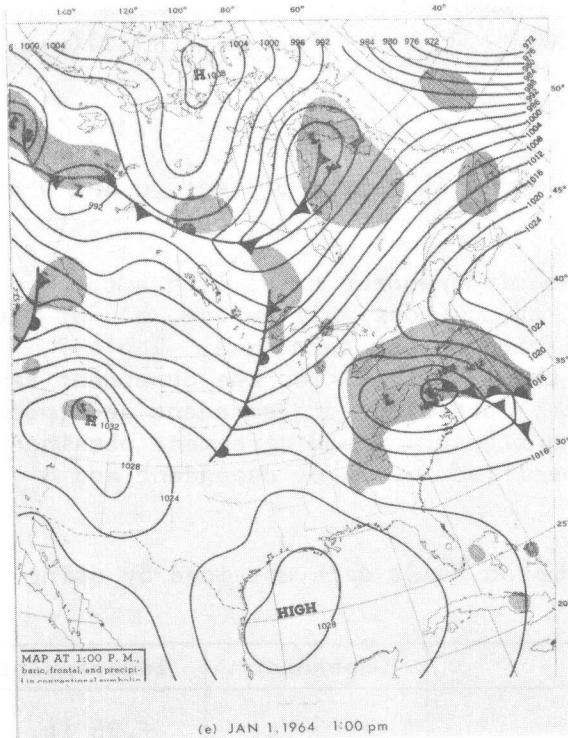


Figure 5-Continued Weather maps of typical Hampton Roads low water cases. These three maps show synoptic patterns at 12-hour intervals during one low water occurrence.

five-variable equation as the most promising for use as a forecast tool. This equation is:

$$\begin{aligned} SS_{HR} = & 111.64 + .30(v_{-6})_{NHK} + .20(u_{-18})_{BAL} + .24(u_{-6})_{ORF} + .17(u_{-24})_{BAL} \\ & - .11(P_{-24})_{ORF} \end{aligned}$$

where SS_{HR} is the Hampton Roads storm surge in tenths of feet, u and v are in knots, and P is in millibars.

This equation was tested on eleven independent cases with a total of 1080 hourly observations. Because of the 24-hour maximum lag, 816 of these sets could be used in obtaining statistics on the technique. Table 7 contains these statistics along with the statistics for the dependent sample. The RMSE is, for all practical purposes, the same for dependent and independent data. Figures 6 and 7 show the consistently good agreement obtained between corresponding observed and specified levels of dependent and independent cases.

Table 7. Summary of statistics on Hampton Roads data obtained by using five-predictor equation.

	Dependent	Independent
Observed mean	-1.03 ft.	-.96 ft.
Standard deviation of observed heights	.52 ft.	.44 ft.
Specified mean	-1.03 ft.	-.96 ft.
Standard deviation of specified heights	.35 ft.	.35 ft.
Mean residual	.00 ft.	.00 ft.
RMSE	.39 ft.	.40 ft.
Correlation coefficient	.67	.51
Sample size	1676	816

CONCLUSION

Tests on dependent and independent data indicate that the techniques presented in this report can be useful tools for forecasting low water conditions at Baltimore and Norfolk. They should be used whenever the synoptic situation indicates that conditions are favorable for low water occurrences. At Baltimore the best indication is a prolonged period of westerly to northerly winds of at least 12 to 14 knots. At Norfolk, prolonged southerly to westerly winds of at least this strength would provide a proper opportunity for using the technique. These techniques are not applicable to higher than normal water conditions. Tables for simplifying the use of these techniques and instructions for their use appear in the appendices.

HAMPTON ROADS DEPENDENT

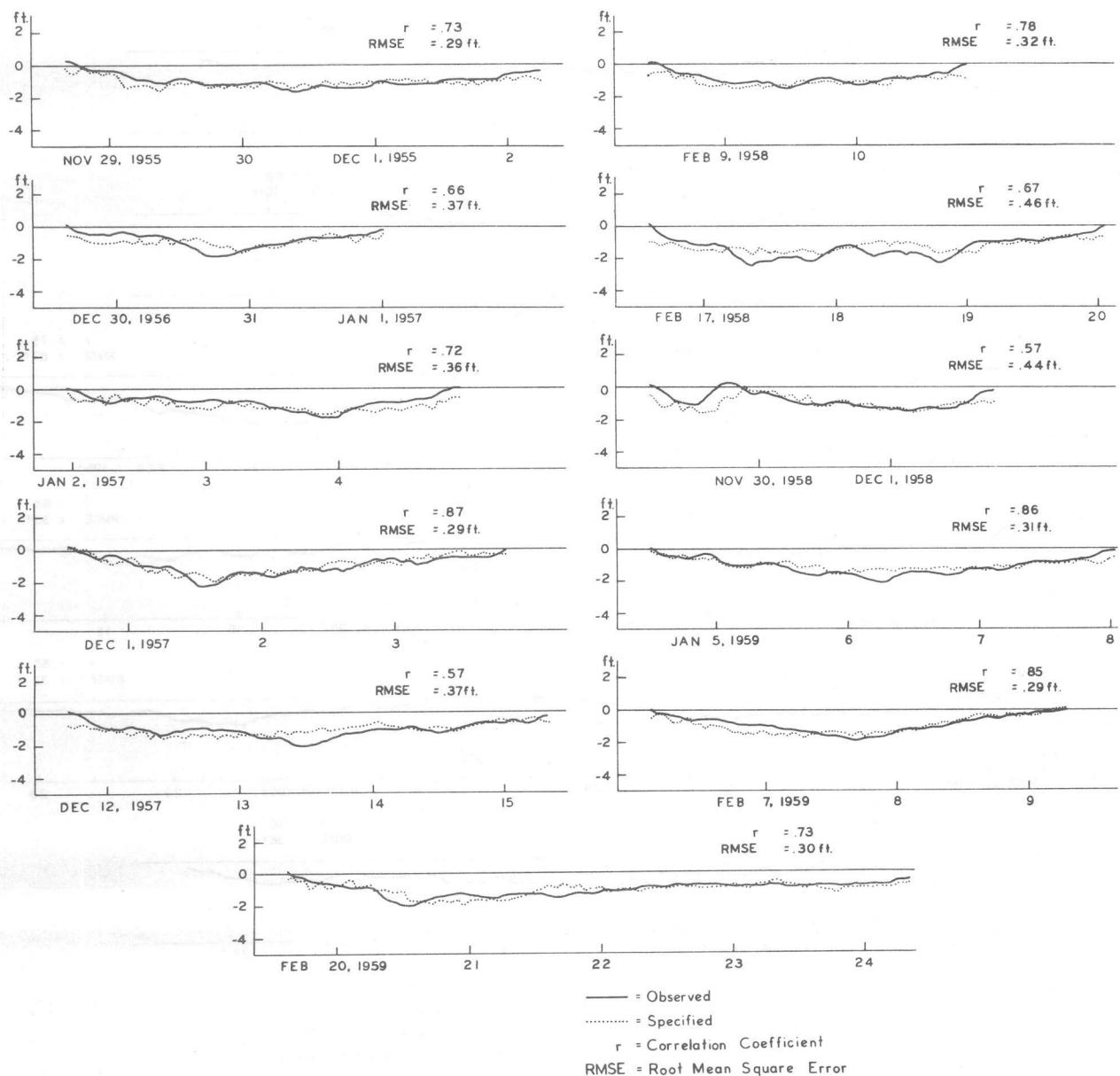


Figure 6. Hampton Roads dependent data.

HAMPTON ROADS DEPENDENT

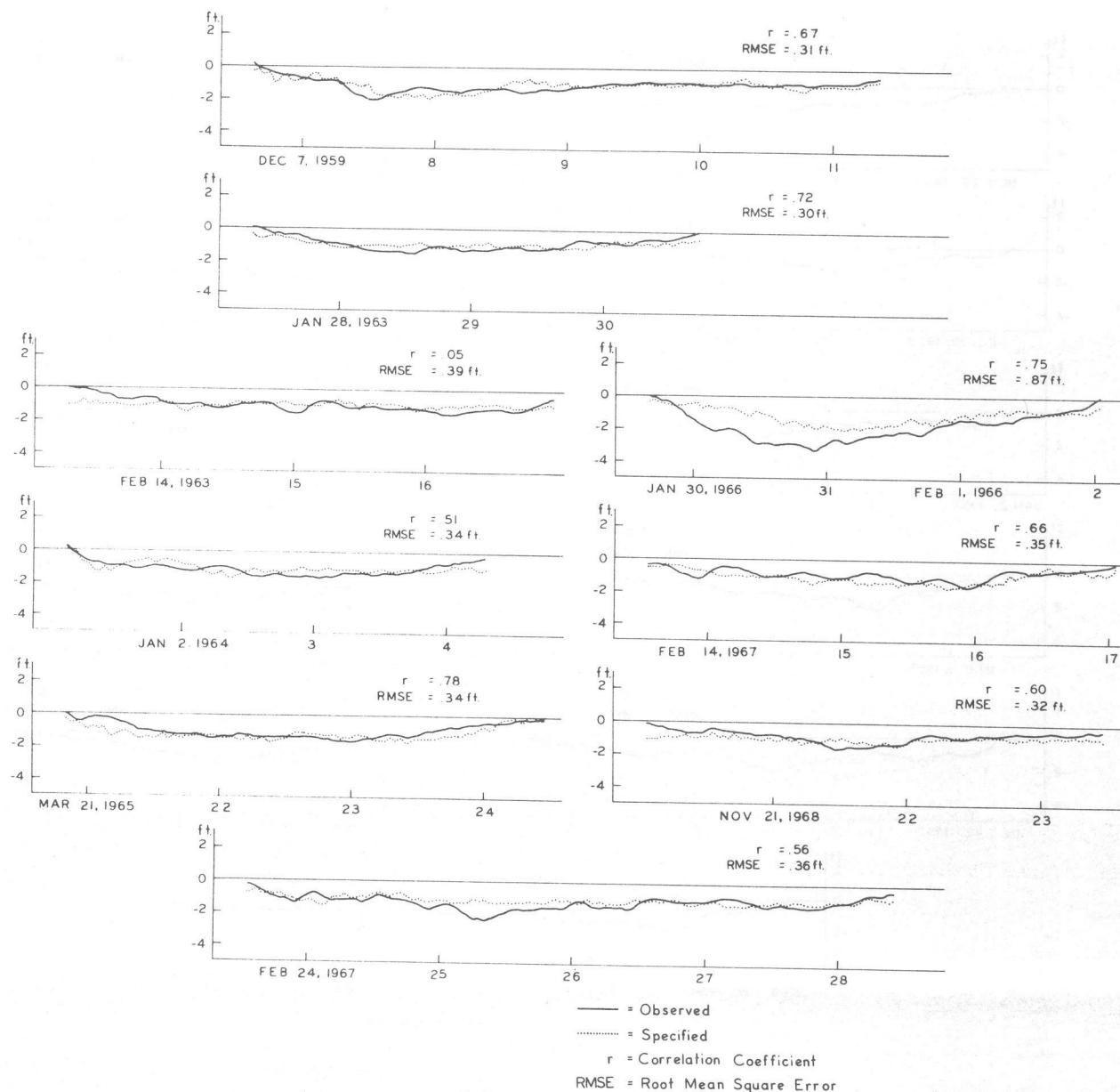


Figure 6 - Continued Hampton Roads dependent data.

HAMPTON ROADS INDEPENDENT DATA

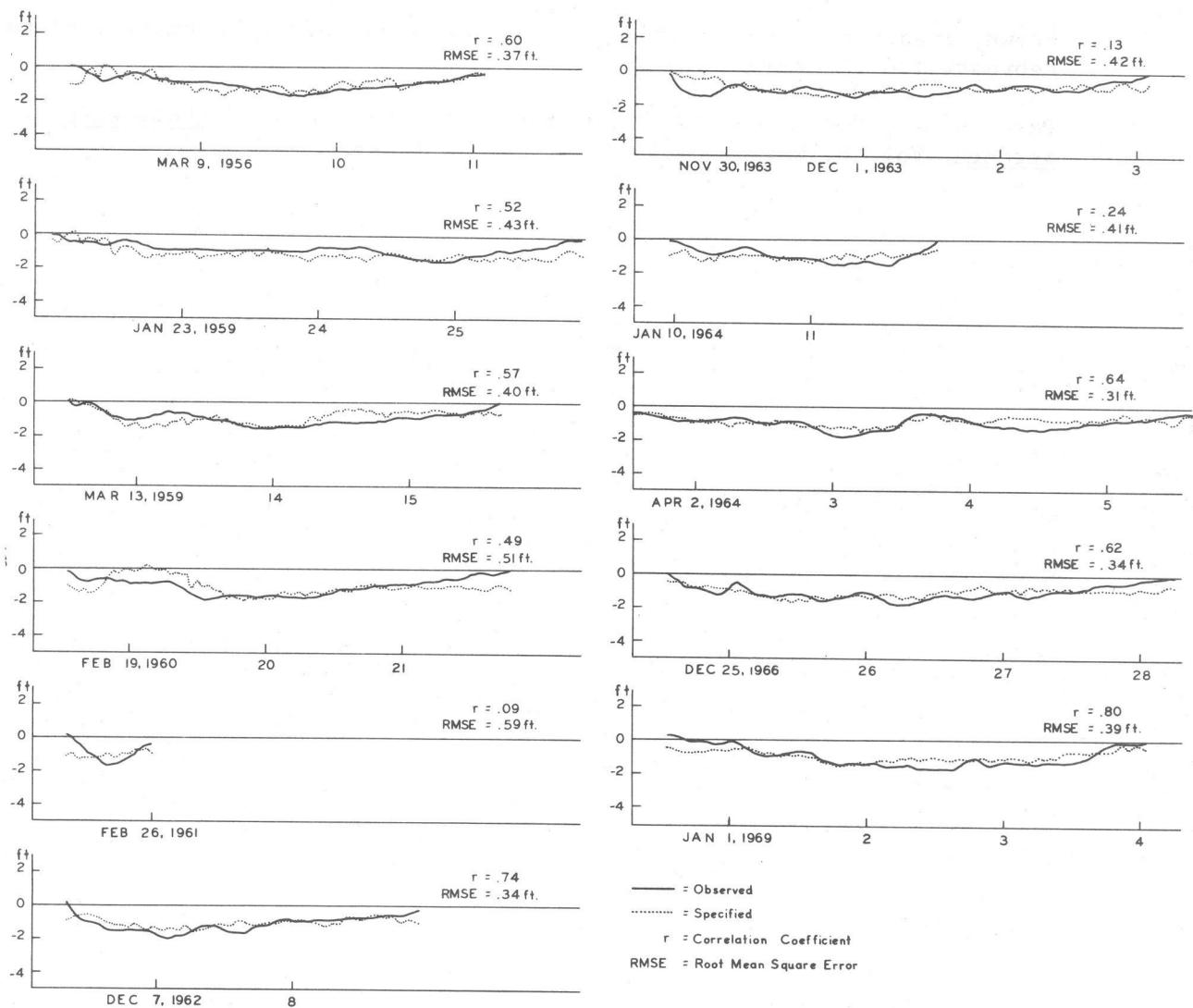


Figure 7. Hampton Roads independent data.

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1. Brown, Stuart F., "Low Water Levels in Baltimore Harbor, January 1961 to February 1969." Manuscript.
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APPENDIX A

INSTRUCTIONS FOR CALCULATING BALTIMORE LOW WATER LEVELS

When conditions indicate that a low water occurrence is likely, the regression equation described for Baltimore in the body of this report can be used. Use of the calculation sheet in Figure A-1 and Tables A-1 through A-5 provides a straightforward, simplified method of determining a low water forecast. This method is as follows:

1. Determine the time for which the forecast will be valid. This is time "T".
2. In Step 1 on the calculation sheet, subtract six hours from "T" and enter the result in the Date/Time column. Then enter the wind direction and speed at Norfolk for this time. If the forecast is to be more than six hours in advance, this wind will be a forecast value; otherwise, it will be observed. Next, go to Table A-1 and, using arguments of wind speed and direction, extract the proper water level component. Enter this component in the appropriate + or - column. It will be necessary to interpolate if the wind speed is not an even number.
3. Follow the above procedure in Steps 2 through 5, in each case subtracting the appropriate number of hours from "T", entering the proper wind or pressure data, and extracting the water level component from the appropriate table. In Table 4, the argument is millibars and tenths. All of the tables contain components in feet.
4. Add the + components and place in the "+ Semitotal" space. Add the - components and place in the "- Semitotal" space. Transfer the "+ Semitotal" to the space beneath the "- Semitotal" and add the two numbers algebraically. The sum is the water level forecast in feet for time "T".

Figure A-2 depicts an example of the above procedure.

BALTIMORE LOW WATER FORECAST CALCULATIONS

Verification Time of Forecast (T) _____
 mo. day year hour

<u>Step</u>	<u>Date/Time</u>	Water Level Components From Tables (Feet)			<u>Table</u>
		+	-	Constant	
1.	T- 6 = _____ ORF Wind Dir. ____° Speed ____ kt.	34.15	_____	_____	A-1
2.	T-12 = _____ NHK Wind Dir. ____° Speed ____ kt.	_____	_____	_____	A-2
3.	T- 6 = _____ NHK Wind Dir. ____° Speed ____ kt.	_____	_____	_____	A-3
4.	T-24 = _____ ORF Pressure ____ mb	_____	_____	_____	A-4
5.	T- 6 = _____ BAL Wind Dir. ____° Speed ____ kt.	_____	_____	_____	A-5
Semitotals		+ _____	- _____	_____	
		+ _____	+ _____	_____	
Water Level Forecast at Time "T" _____ ft.					

Figure A-1 Baltimore low water forecast calculation sheet.

BALTIMORE LOW WATER FORECAST CALCULATIONS

Verification Time of Forecast (T) 12 - 18 - 64 1700
 mo. day year hour

<u>Step</u>	<u>Date/Time</u>	Water Level Components From Tables (Feet)			<u>Table</u>
		+	-	Constant	
1.	T- 6 = <u>12-18/1100</u> ORF Wind Dir. <u>340</u> ° Speed <u>21</u> kt.	34.15	_____	_____	A-1
2.	T-12 = <u>12-18/0500</u> NHK Wind Dir. <u>330</u> ° Speed <u>9</u> kt.	_____	_____	_____	A-2
3.	T- 6 = <u>12-18/1100</u> NHK Wind Dir. <u>330</u> ° Speed <u>30</u> kt.	_____	_____	_____	A-3
4.	T-24 = <u>12-17/1700</u> ORF Pressure <u>1019.0</u> mb	_____	_____	34.70	A-4
5.	T- 6 = <u>12-18/1100</u> BAL Wind Dir. <u>320</u> ° Speed <u>15</u> kt.	_____	_____	_____	A-5
Semitotals		+ <u>34.15</u>	- <u>36.86</u>	_____	
		+ <u>34.15</u>	+ <u>34.15</u>	_____	
Water Level Forecast at Time "T" <u>- 2.71</u> ft.					

Figure A-2 Example of Baltimore low water calculations.

Table A-1

WIND DIR.	WATER LEVEL COMPONENTS (IN FEET) X 10 ⁻¹												
	COMPONENT		WIND SPEED (KNOTS)										
WIND DIR.	WIND DIR.	18	20	22	24	26	28	30	32	34	36	38	40
0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
6	2	1	0	0	0	0	0	0	0	0	0	0	0
8	6	4	2	0	0	0	0	0	0	0	0	0	0
10	10	9	7	5	3	1	0	0	0	0	0	0	0
12	12	11	9	7	5	3	1	0	0	0	0	0	0
14	14	13	11	9	7	5	3	1	0	0	0	0	0
16	16	15	13	11	9	7	5	3	1	0	0	0	0
18	18	17	15	13	11	9	7	5	3	1	0	0	0
20	20	19	17	15	13	11	9	7	5	3	1	0	0
22	22	21	19	17	15	13	11	9	7	5	3	1	0
24	24	23	21	19	17	15	13	11	9	7	5	3	1
26	26	25	23	21	19	17	15	13	11	9	7	5	3
28	28	27	25	23	21	19	17	15	13	11	9	7	5
30	30	29	27	25	23	21	19	17	15	13	11	9	7
32	32	31	29	27	25	23	21	19	17	15	13	11	9
34	34	33	31	29	27	25	23	21	19	17	15	13	11
36	36	35	33	31	29	27	25	23	21	19	17	15	13
38	38	37	35	33	31	29	27	25	23	21	19	17	15
40	40	39	37	35	33	31	29	27	25	23	21	19	17
42	42	41	39	37	35	33	31	29	27	25	23	21	19
44	44	43	41	39	37	35	33	31	29	27	25	23	21
46	46	45	43	41	39	37	35	33	31	29	27	25	23
48	48	47	45	43	41	39	37	35	33	31	29	27	25
50	50	49	47	45	43	41	39	37	35	33	31	29	27
52	52	51	49	47	45	43	41	39	37	35	33	31	29
54	54	53	51	49	47	45	43	41	39	37	35	33	29
56	56	55	53	51	49	47	45	43	41	39	37	35	33
58	58	57	55	53	51	49	47	45	43	41	39	37	35
60	60	59	57	55	53	51	49	47	45	43	41	39	37
62	62	61	59	57	55	53	51	49	47	45	43	41	39
64	64	63	61	59	57	55	53	51	49	47	45	43	41
66	66	65	63	61	59	57	55	53	51	49	47	45	43
68	68	67	65	63	61	59	57	55	53	51	49	47	45
70	70	69	67	65	63	61	59	57	55	53	51	49	47
72	72	71	69	67	65	63	61	59	57	55	53	51	49
74	74	73	71	69	67	65	63	61	59	57	55	53	49
76	76	75	73	71	69	67	65	63	61	59	57	55	49
78	78	77	75	73	71	69	67	65	63	61	59	57	49
80	80	79	77	75	73	71	69	67	65	63	61	59	49

Table A-2

Detailed description: This is a scatter plot with 'WIND COMPONENT (U WIND)' on the horizontal axis and 'WATER LEVEL COMPONENT (V WIND)' on the vertical axis. Both axes range from 0 to 10, with major tick marks every 2 units. The data points, represented by small dots, form a dense, roughly triangular cloud that slopes downwards from left to right, indicating a negative correlation between the two variables.

Table A-3

WIND DIR.	WATER LEVEL COMPONENTS (IN FEET)										
	COMPONENT = (IV WIND COMPONENT) X (0.441760) X .1										
	WIND SPEED (KNOTS)	20	24	26	28	30	32	34	36	38	40
10	0.887432	0.887432	0.887432	0.887432	0.887432	0.887432	0.887432	0.887432	0.887432	0.887432	0.887432
8	1.184720	1.184720	1.184720	1.184720	1.184720	1.184720	1.184720	1.184720	1.184720	1.184720	1.184720
6	1.482008	1.482008	1.482008	1.482008	1.482008	1.482008	1.482008	1.482008	1.482008	1.482008	1.482008
4	1.779296	1.779296	1.779296	1.779296	1.779296	1.779296	1.779296	1.779296	1.779296	1.779296	1.779296
2	2.076584	2.076584	2.076584	2.076584	2.076584	2.076584	2.076584	2.076584	2.076584	2.076584	2.076584
0	2.373872	2.373872	2.373872	2.373872	2.373872	2.373872	2.373872	2.373872	2.373872	2.373872	2.373872
54	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6
52	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0
50	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4
48	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8
46	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2
44	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6
42	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
40	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4
38	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8
36	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2
34	-0.4	-0.2	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6
32	-0.8	-0.6	-0.4	-0.2	0.0	0.2	0.4	0.6	0.8	1.0	1.2
30	-1.2	-1.0	-0.8	-0.6	-0.4	-0.2	0.0	0.2	0.4	0.6	0.8
28	-1.6	-1.4	-1.2	-1.0	-0.8	-0.6	-0.4	-0.2	0.0	0.2	0.4
26	-2.0	-1.8	-1.6	-1.4	-1.2	-1.0	-0.8	-0.6	-0.4	-0.2	0.0
24	-2.4	-2.2	-2.0	-1.8	-1.6	-1.4	-1.2	-1.0	-0.8	-0.6	-0.4
22	-2.8	-2.6	-2.4	-2.2	-2.0	-1.8	-1.6	-1.4	-1.2	-1.0	-0.8
20	-3.2	-3.0	-2.8	-2.6	-2.4	-2.2	-2.0	-1.8	-1.6	-1.4	-1.2
18	-3.6	-3.4	-3.2	-3.0	-2.8	-2.6	-2.4	-2.2	-2.0	-1.8	-1.6
16	-4.0	-3.8	-3.6	-3.4	-3.2	-3.0	-2.8	-2.6	-2.4	-2.2	-2.0
14	-4.4	-4.2	-4.0	-3.8	-3.6	-3.4	-3.2	-3.0	-2.8	-2.6	-2.4
12	-4.8	-4.6	-4.4	-4.2	-4.0	-3.8	-3.6	-3.4	-3.2	-3.0	-2.8
10	-5.2	-5.0	-4.8	-4.6	-4.4	-4.2	-4.0	-3.8	-3.6	-3.4	-3.2
8	-5.6	-5.4	-5.2	-5.0	-4.8	-4.6	-4.4	-4.2	-4.0	-3.8	-3.6
6	-6.0	-5.8	-5.6	-5.4	-5.2	-5.0	-4.8	-4.6	-4.4	-4.2	-4.0
4	-6.4	-6.2	-6.0	-5.8	-5.6	-5.4	-5.2	-5.0	-4.8	-4.6	-4.4
2	-6.8	-6.6	-6.4	-6.2	-6.0	-5.8	-5.6	-5.4	-5.2	-5.0	-4.8
0	-7.2	-7.0	-6.8	-6.6	-6.4	-6.2	-6.0	-5.8	-5.6	-5.4	-5.2
58	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0
56	5.4	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4
54	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.6	6.8
52	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2
50	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6
48	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0
46	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4
44	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8
42	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2
40	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6
38	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
36	-0.4	-0.2	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6
34	-0.8	-0.6	-0.4	-0.2	0.0	0.2	0.4	0.6	0.8	1.0	1.2
32	-1.2	-1.0	-0.8	-0.6	-0.4	-0.2	0.0	0.2	0.4	0.6	0.8
30	-1.6	-1.4	-1.2	-1.0	-0.8	-0.6	-0.4	-0.2	0.0	0.2	0.4
28	-2.0	-1.8	-1.6	-1.4	-1.2	-1.0	-0.8	-0.6	-0.4	-0.2	0.0
26	-2.4	-2.2	-2.0	-1.8	-1.6	-1.4	-1.2	-1.0	-0.8	-0.6	-0.4
24	-2.8	-2.6	-2.4	-2.2	-2.0	-1.8	-1.6	-1.4	-1.2	-1.0	-0.8
22	-3.2	-3.0	-2.8	-2.6	-2.4	-2.2	-2.0	-1.8	-1.6	-1.4	-1.2
20	-3.6	-3.4	-3.2	-3.0	-2.8	-2.6	-2.4	-2.2	-2.0	-1.8	-1.6
18	-4.0	-3.8	-3.6	-3.4	-3.2	-3.0	-2.8	-2.6	-2.4	-2.2	-2.0
16	-4.4	-4.2	-4.0	-3.8	-3.6	-3.4	-3.2	-3.0	-2.8	-2.6	-2.4
14	-4.8	-4.6	-4.4	-4.2	-4.0	-3.8	-3.6	-3.4	-3.2	-3.0	-2.8
12	-5.2	-5.0	-4.8	-4.6	-4.4	-4.2	-4.0	-3.8	-3.6	-3.4	-3.2
10	-5.6	-5.4	-5.2	-5.0	-4.8	-4.6	-4.4	-4.2	-4.0	-3.8	-3.6
8	-6.0	-5.8	-5.6	-5.4	-5.2	-5.0	-4.8	-4.6	-4.4	-4.2	-4.0
6	-6.4	-6.2	-6.0	-5.8	-5.6	-5.4	-5.2	-5.0	-4.8	-4.6	-4.4
4	-6.8	-6.6	-6.4	-6.2	-6.0	-5.8	-5.6	-5.4	-5.2	-5.0	-4.8
2	-7.2	-7.0	-6.8	-6.6	-6.4	-6.2	-6.0	-5.8	-5.6	-5.4	-5.2
0	-7.6	-7.4	-7.2	-7.0	-6.8	-6.6	-6.4	-6.2	-6.0	-5.8	-5.6

Table A-4

PRESSURE (MILLIBARS)	WATER LEVEL COMPONENTS (IN FEET) COMPONENT = (sea level pressure) X (.340560) X .1									PRESSURE
	.0	.1	.2	.3	.4	.5	.6	.7	.8	
950	-32.35	-32.36	-32.36	-32.37	-32.37	-32.37	-32.37	-32.38	-32.38	950
951	-32.39	-32.39	-32.39	-32.40	-32.40	-32.40	-32.40	-32.41	-32.42	951
952	-32.42	-32.42	-32.43	-32.43	-32.43	-32.43	-32.43	-32.44	-32.45	952
953	-32.46	-32.46	-32.46	-32.47	-32.47	-32.47	-32.47	-32.48	-32.49	953
954	-32.49	-32.49	-32.50	-32.50	-32.50	-32.50	-32.50	-32.51	-32.52	954
955	-32.52	-32.52	-32.53	-32.53	-32.53	-32.53	-32.53	-32.54	-32.55	955
956	-32.56	-32.56	-32.56	-32.56	-32.56	-32.56	-32.56	-32.57	-32.58	956
957	-32.59	-32.59	-32.60	-32.60	-32.60	-32.60	-32.60	-32.61	-32.62	957
958	-32.63	-32.63	-32.63	-32.64	-32.64	-32.64	-32.64	-32.65	-32.66	958
959	-32.66	-32.66	-32.67	-32.67	-32.67	-32.67	-32.67	-32.68	-32.69	959
960	-32.69	-32.70	-32.70	-32.70	-32.70	-32.70	-32.70	-32.71	-32.72	960
961	-32.73	-32.73	-32.73	-32.74	-32.74	-32.74	-32.74	-32.75	-32.76	961
962	-32.76	-32.76	-32.77	-32.77	-32.77	-32.77	-32.77	-32.78	-32.79	962
963	-32.80	-32.80	-32.80	-32.81	-32.81	-32.81	-32.81	-32.82	-32.83	963
964	-32.83	-32.83	-32.84	-32.84	-32.84	-32.84	-32.84	-32.85	-32.86	964
965	-32.86	-32.87	-32.87	-32.87	-32.87	-32.87	-32.87	-32.88	-32.89	965
966	-32.90	-32.90	-32.90	-32.91	-32.91	-32.91	-32.91	-32.92	-32.93	966
967	-32.93	-32.94	-32.94	-32.94	-32.94	-32.94	-32.94	-32.95	-32.96	967
968	-32.97	-32.97	-32.97	-32.98	-32.98	-32.98	-32.98	-32.99	-32.99	968
969	-33.00	-33.00	-33.01	-33.01	-33.01	-33.01	-33.01	-33.02	-33.02	969
970	-33.03	-33.04	-33.04	-33.04	-33.04	-33.04	-33.04	-33.05	-33.06	970
971	-33.07	-33.07	-33.08	-33.08	-33.08	-33.08	-33.08	-33.09	-33.10	971
972	-33.10	-33.11	-33.11	-33.11	-33.11	-33.11	-33.11	-33.12	-33.13	972
973	-33.14	-33.14	-33.14	-33.14	-33.14	-33.14	-33.14	-33.15	-33.16	973
974	-33.17	-33.17	-33.17	-33.18	-33.18	-33.18	-33.18	-33.19	-33.20	974
975	-33.20	-33.21	-33.21	-33.21	-33.21	-33.21	-33.21	-33.22	-33.23	975
976	-33.24	-33.24	-33.25	-33.25	-33.25	-33.25	-33.25	-33.26	-33.26	976
977	-33.27	-33.28	-33.28	-33.28	-33.28	-33.28	-33.28	-33.29	-33.29	977
978	-33.31	-33.31	-33.31	-33.32	-33.32	-33.32	-33.32	-33.33	-33.33	978
979	-33.34	-33.34	-33.35	-33.35	-33.35	-33.35	-33.35	-33.36	-33.36	979
980	-33.37	-33.38	-33.38	-33.39	-33.39	-33.39	-33.39	-33.40	-33.40	980
981	-33.41	-33.41	-33.42	-33.42	-33.42	-33.42	-33.42	-33.43	-33.44	981
982	-33.44	-33.45	-33.45	-33.45	-33.45	-33.45	-33.45	-33.46	-33.47	982
983	-33.48	-33.48	-33.48	-33.49	-33.49	-33.49	-33.49	-33.50	-33.51	983
984	-33.51	-33.51	-33.52	-33.52	-33.52	-33.52	-33.52	-33.53	-33.54	984
985	-33.55	-33.55	-33.55	-33.56	-33.56	-33.56	-33.56	-33.57	-33.58	985
986	-33.58	-33.58	-33.59	-33.59	-33.59	-33.59	-33.59	-33.60	-33.61	986
987	-33.61	-33.62	-33.62	-33.62	-33.62	-33.62	-33.62	-33.63	-33.64	987
988	-33.65	-33.65	-33.66	-33.66	-33.66	-33.66	-33.66	-33.67	-33.67	988
989	-33.68	-33.68	-33.69	-33.70	-33.70	-33.70	-33.70	-33.71	-33.71	989
990	-33.72	-33.72	-33.73	-33.73	-33.73	-33.73	-33.73	-33.74	-33.75	990
991	-33.75	-33.75	-33.76	-33.76	-33.76	-33.76	-33.76	-33.77	-33.78	991
992	-33.78	-33.79	-33.79	-33.80	-33.80	-33.80	-33.80	-33.81	-33.81	992
993	-33.82	-33.82	-33.83	-33.83	-33.83	-33.83	-33.83	-33.84	-33.85	993
994	-33.85	-33.86	-33.86	-33.87	-33.87	-33.87	-33.87	-33.88	-33.88	994
995	-33.89	-33.89	-33.90	-33.90	-33.90	-33.90	-33.90	-33.91	-33.91	995
996	-33.92	-33.92	-33.93	-33.93	-33.93	-33.93	-33.93	-33.94	-33.95	996
997	-33.95	-33.96	-33.96	-33.97	-33.97	-33.97	-33.97	-33.98	-33.98	997
998	-33.99	-33.99	-33.99	-34.00	-34.00	-34.00	-34.00	-34.01	-34.02	998
999	-34.03	-34.03	-34.03	-34.04	-34.04	-34.04	-34.04	-34.05	-34.05	999

Table A-4 - Continued

WATER LEVEL COMPONENTS (IN FEET)
COMPONENT = (sea level pressure) X (-.340560) X .1

PRESSURE (MILLIBARS)										PRESSURE			
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9			
1.000	-34.06	-34.06	-34.06	-34.07	-34.07	-34.07	-34.08	-34.08	-34.08	-34.09	1000		
1.001	-34.09	-34.09	-34.10	-34.10	-34.10	-34.11	-34.11	-34.11	-34.12	-34.12	1001		
1.002	-34.12	-34.12	-34.13	-34.13	-34.14	-34.14	-34.14	-34.14	-34.15	-34.15	1002		
1.003	-34.16	-34.16	-34.16	-34.17	-34.17	-34.17	-34.18	-34.18	-34.18	-34.19	1003		
1.004	-34.19	-34.20	-34.20	-34.20	-34.21	-34.21	-34.21	-34.21	-34.22	-34.22	1004		
1.005	-34.23	-34.23	-34.23	-34.24	-34.24	-34.24	-34.25	-34.25	-34.25	-34.26	1005		
1.006	-34.26	-34.26	-34.27	-34.27	-34.27	-34.28	-34.28	-34.28	-34.29	-34.29	1006		
1.007	-34.29	-34.30	-34.30	-34.30	-34.31	-34.31	-34.31	-34.31	-34.32	-34.33	1007		
1.008	-34.33	-34.33	-34.34	-34.34	-34.34	-34.35	-34.35	-34.35	-34.36	-34.36	1008		
1.009	-34.36	-34.37	-34.37	-34.37	-34.37	-34.38	-34.38	-34.38	-34.39	-34.39	1009		
1.010	-34.40	-34.40	-34.40	-34.41	-34.41	-34.41	-34.42	-34.42	-34.42	-34.43	1010		
1.011	-34.43	-34.43	-34.43	-34.44	-34.44	-34.44	-34.45	-34.45	-34.46	-34.46	1011		
1.012	-34.46	-34.47	-34.47	-34.47	-34.48	-34.48	-34.48	-34.49	-34.49	-34.50	1012		
1.013	-34.50	-34.50	-34.51	-34.51	-34.51	-34.52	-34.52	-34.52	-34.53	-34.53	1013		
1.014	-34.53	-34.54	-34.54	-34.54	-34.54	-34.55	-34.55	-34.55	-34.56	-34.56	1014		
1.015	-34.57	-34.57	-34.57	-34.58	-34.58	-34.58	-34.59	-34.59	-34.59	-34.60	1015		
1.016	-34.60	-34.60	-34.61	-34.61	-34.61	-34.62	-34.62	-34.62	-34.63	-34.63	1016		
1.017	-34.63	-34.64	-34.64	-34.65	-34.65	-34.65	-34.66	-34.66	-34.66	-34.66	1017		
1.018	-34.67	-34.67	-34.68	-34.68	-34.68	-34.69	-34.69	-34.69	-34.70	-34.70	1018		
1.019	-34.70	-34.70	-34.71	-34.71	-34.72	-34.72	-34.72	-34.73	-34.73	-34.73	1019		
1.020	-34.74	-34.74	-34.74	-34.75	-34.75	-34.75	-34.76	-34.76	-34.77	-34.77	1020		
1.021	-34.77	-34.77	-34.78	-34.78	-34.78	-34.79	-34.79	-34.80	-34.80	-34.80	1021		
1.022	-34.81	-34.81	-34.81	-34.82	-34.82	-34.82	-34.83	-34.83	-34.83	-34.84	1022		
1.023	-34.84	-34.84	-34.85	-34.85	-34.85	-34.86	-34.86	-34.86	-34.87	-34.87	1023		
1.024	-34.87	-34.88	-34.88	-34.88	-34.89	-34.89	-34.89	-34.90	-34.90	-34.90	1024		
1.025	-34.91	-34.91	-34.91	-34.92	-34.92	-34.92	-34.93	-34.93	-34.93	-34.94	1025		
1.026	-34.94	-34.94	-34.95	-34.95	-34.95	-34.96	-34.96	-34.97	-34.97	-34.97	1026		
1.027	-34.98	-34.98	-34.98	-34.99	-34.99	-34.99	-35.00	-35.00	-35.00	-35.01	1027		
1.028	-35.01	-35.01	-35.02	-35.02	-35.02	-35.03	-35.03	-35.03	-35.04	-35.04	1028		
1.029	-35.04	-35.05	-35.05	-35.05	-35.06	-35.06	-35.06	-35.07	-35.07	-35.07	1029		
1.030	-35.08	-35.10	-35.08	-35.09	-35.09	-35.10	-35.10	-35.10	-35.11	-35.11	1030		
1.031	-35.11	-35.12	-35.12	-35.13	-35.13	-35.13	-35.13	-35.14	-35.14	-35.14	1031		
1.032	-35.15	-35.15	-35.16	-35.16	-35.16	-35.16	-35.17	-35.17	-35.17	-35.18	1032		
1.033	-35.18	-35.18	-35.19	-35.19	-35.19	-35.20	-35.20	-35.20	-35.21	-35.21	1033		
1.034	-35.21	-35.22	-35.22	-35.23	-35.23	-35.23	-35.23	-35.23	-35.24	-35.24	1034		
1.035	-35.25	-35.25	-35.25	-35.26	-35.26	-35.26	-35.27	-35.27	-35.28	-35.28	1035		
1.036	-35.28	-35.29	-35.29	-35.30	-35.30	-35.30	-35.31	-35.31	-35.31	-35.31	1036		
1.037	-35.32	-35.32	-35.33	-35.33	-35.33	-35.34	-35.34	-35.34	-35.35	-35.35	1037		
1.038	-35.35	-35.36	-35.36	-35.36	-35.36	-35.37	-35.37	-35.37	-35.38	-35.38	1038		
1.039	-35.39	-35.39	-35.39	-35.40	-35.40	-35.40	-35.40	-35.41	-35.41	-35.41	1039		
1.040	-35.42	-35.42	-35.43	-35.43	-35.43	-35.44	-35.44	-35.44	-35.45	-35.45	1040		
1.041	-35.45	-35.46	-35.46	-35.47	-35.47	-35.47	-35.47	-35.47	-35.48	-35.48	1041		
1.042	-35.49	-35.49	-35.49	-35.50	-35.50	-35.50	-35.51	-35.51	-35.52	-35.52	1042		
1.043	-35.52	-35.52	-35.53	-35.53	-35.53	-35.54	-35.54	-35.54	-35.55	-35.55	1043		
1.044	-35.55	-35.56	-35.56	-35.56	-35.57	-35.57	-35.57	-35.58	-35.58	-35.59	1044		
1.045	-35.59	-35.60	-35.60	-35.61	-35.61	-35.61	-35.61	-35.61	-35.62	-35.62	1045		
1.046	-35.62	-35.63	-35.63	-35.64	-35.64	-35.64	-35.65	-35.65	-35.65	-35.65	1046		
1.047	-35.66	-35.66	-35.66	-35.67	-35.67	-35.67	-35.68	-35.68	-35.68	-35.69	1047		
1.048	-35.69	-35.70	-35.70	-35.71	-35.71	-35.71	-35.71	-35.72	-35.72	-35.73	1048		
1.049	-35.72	-35.73	-35.73	-35.74	-35.74	-35.74	-35.75	-35.75	-35.75	-35.76	1049		

Table A-5

Detailed description: This figure is a scatter plot titled 'WIND DIR'. The vertical axis is labeled 'WIND SPEED (KNOTS)' and ranges from 2 to 40. The horizontal axis is labeled 'COMPONENT = (U + V * COS(45))' and ranges from -0.5 to 1.5. A dashed horizontal line is drawn at 0.0. The data points, represented by small dots, are mostly located below the 0.0 line, indicating negative wind speeds. There is a slight upward trend as wind speed increases.

Wind Speed (KNOTS)	Component = (U + V * COS(45))
2.0	-0.45
4.0	-0.40
6.0	-0.35
8.0	-0.30
10.0	-0.25
12.0	-0.20
14.0	-0.15
16.0	-0.10
18.0	-0.05
20.0	-0.00
22.0	-0.05
24.0	-0.10
26.0	-0.15
28.0	-0.20
30.0	-0.25
32.0	-0.30
34.0	-0.35
36.0	-0.40
38.0	-0.45
40.0	-0.50

APPENDIX B

INSTRUCTIONS FOR CALCULATING HAMPTON ROADS LOW WATER LEVELS

When conditions indicate that a low water occurrence is likely, the regression equation described for Hampton Roads in the body of this report can be used. Use of the calculation sheet in Figure B-1 and Tables B-1 through B-5 provides a straightforward, simplified method of determining a low water forecast. This method is as follows:

1. Determine the time for which the forecast will be valid. This is time "T".
2. In Step 1 on the calculation sheet, subtract six hours from "T" and enter the result in the Date/Time column. Then enter the wind direction and speed from Patuxent River Naval Air Station for this time. If the forecast is to be more than six hours in advance, this wind will be a forecast value; otherwise, it will be observed. Next, go to Table B-1 and, using arguments of wind speed and direction, extract the proper water level component. Enter this component in the appropriate + or - column. It will be necessary to interpolate if the wind speed is not an even number.
3. Follow the above procedure in Steps 2 through 5, in each case subtracting the appropriate number of hours from "T", entering the proper wind or pressure data, and extracting the water level component from the appropriate table. In Table 5, the argument is millibars and tenths. All of the tables contain components in feet.
4. Add the + components and place in the "+ Semitotal" space. Add the - components and place in the "- Semitotal" space. Transfer the "+ Semitotal" to the space beneath the "- Semitotal" and add the two numbers algebraically. The sum is the water level forecast in feet for time "T".

Figure B-2 depicts an example of the above procedure.

HAMPTON ROADS LOW WATER FORECAST CALCULATIONS

Verification Time of Forecast (T) _____
 mo. day year hour

<u>Step</u>	<u>Date/Time</u>	Water Level Components From Tables (Feet)			<u>Table</u>
		Constant	+	-	
1.	T- 6 = _____	NHK Wind Dir. ____ ° Speed ____ kt.	11.16	_____	B-1
2.	T-18 = _____	BAL Wind Dir. ____ ° Speed ____ kt.	_____	_____	B-2
3.	T- 6 = _____	ORF Wind Dir. ____ ° Speed ____ kt.	_____	_____	B-3
4.	T-24 = _____	BAL Wind Dir. ____ ° Speed ____ kt.	_____	_____	B-4
5.	T-24 = _____	ORF Pressure _____ mb	_____	_____	B-5
		Semitotals	+ _____	- _____	
			↓ +	_____	
Water Level Forecast at Time "T" _____ ft.					

Figure B-1 Hampton Roads low water forecast calculation sheet.

HAMPTON ROADS LOW WATER FORECAST CALCULATIONS

Verification Time of Forecast (T) 12 - 26 - 66 0500
 mo. day year hour

<u>Step</u>	<u>Date/Time</u>	Water Level Components From Tables (Feet)			<u>Table</u>
		Constant	+	-	
1.	T- 6 = <u>12-25/2300</u> NHK Wind Dir. <u>210</u> ° Speed <u>4</u> kt.	11.16	_____	.10	B-1
2.	T-18 = <u>12-25/1100</u> BAL Wind Dir. <u>260</u> ° Speed <u>15</u> kt.	_____	_____	.29	B-2
3.	T- 6 = <u>12-25/2300</u> ORF Wind Dir. <u>250</u> ° Speed <u>15</u> kt.	_____	_____	.34	B-3
4.	T-24 = <u>12-25/0500</u> BAL Wind Dir. <u>270</u> ° Speed <u>17</u> kt.	_____	_____	.29	B-4
5.	T-24 = <u>12-25/0500</u> ORF Pressure <u>1014.2</u> mb	_____	_____	11.63	B-5
		Semitotals	+ <u>11.16</u>	- <u>12.65</u>	
			↓ +	<u>11.16</u>	
Water Level Forecast at Time "T" - <u>1.49</u> ft.					

Figure B-2 Example of Hampton Roads low water calculations.

Table B-1
WATER LEVEL COMPONENTS (IN FEET)
 $\text{COMPONENT} = (v \text{ wind component}) \times (.298080) \times .1$

WIND D.R.	10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	330	350	370	390	410	430	450	470	490	510	530	550	570	590	610	630	650	670	690	710	730	750	770	790	810	830	850	870	890	910	930	950	970	990	1010	1030	1050	1070	1090	1110	1130	1150	1170	1190	1210	1230	1250	1270	1290	1310	1330	1350	1370	1390	1410	1430	1450	1470	1490	1510	1530	1550	1570	1590	1610	1630	1650	1670	1690	1710	1730	1750	1770	1790	1810	1830	1850	1870	1890	1910	1930	1950	1970	1990	2010	2030	2050	2070	2090	2110	2130	2150	2170	2190	2210	2230	2250	2270	2290	2310	2330	2350	2370	2390	2410	2430	2450	2470	2490	2510	2530	2550	2570	2590	2610	2630	2650	2670	2690	2710	2730	2750	2770	2790	2810	2830	2850	2870	2890	2910	2930	2950	2970	2990	3010	3030	3050	3070	3090	3110	3130	3150	3170	3190	3210	3230	3250	3270	3290	3310	3330	3350	3370	3390	3410	3430	3450	3470	3490	3510	3530	3550	3570	3590	3610	3630	3650	3670	3690	3710	3730	3750	3770	3790	3810	3830	3850	3870	3890	3910	3930	3950	3970	3990	4010	4030	4050	4070	4090	4110	4130	4150	4170	4190	4210	4230	4250	4270	4290	4310	4330	4350	4370	4390	4410	4430	4450	4470	4490	4510	4530	4550	4570	4590	4610	4630	4650	4670	4690	4710	4730	4750	4770	4790	4810	4830	4850	4870	4890	4910	4930	4950	4970	4990	5010	5030	5050	5070	5090	5110	5130	5150	5170	5190	5210	5230	5250	5270	5290	5310	5330	5350	5370	5390	5410	5430	5450	5470	5490	5510	5530	5550	5570	5590	5610	5630	5650	5670	5690	5710	5730	5750	5770	5790	5810	5830	5850	5870	5890	5910	5930	5950	5970	5990	6010	6030	6050	6070	6090	6110	6130	6150	6170	6190	6210	6230	6250	6270	6290	6310	6330	6350	6370	6390	6410	6430	6450	6470	6490	6510	6530	6550	6570	6590	6610	6630	6650	6670	6690	6710	6730	6750	6770	6790	6810	6830	6850	6870	6890	6910	6930	6950	6970	6990	7010	7030	7050	7070	7090	7110	7130	7150	7170	7190	7210	7230	7250	7270	7290	7310	7330	7350	7370	7390	7410	7430	7450	7470	7490	7510	7530	7550	7570	7590	7610	7630	7650	7670	7690	7710	7730	7750	7770	7790	7810	7830	7850	7870	7890	7910	7930	7950	7970	7990	8010	8030	8050	8070	8090	8110	8130	8150	8170	8190	8210	8230	8250	8270	8290	8310	8330	8350	8370	8390	8410	8430	8450	8470	8490	8510	8530	8550	8570	8590	8610	8630	8650	8670	8690	8710	8730	8750	8770	8790	8810	8830	8850	8870	8890	8910	8930	8950	8970	8990	9010	9030	9050	9070	9090	9110	9130	9150	9170	9190	9210	9230	9250	9270	9290	9310	9330	9350	9370	9390	9410	9430	9450	9470	9490	9510	9530	9550	9570	9590	9610	9630	9650	9670	9690	9710	9730	9750	9770	9790	9810	9830	9850	9870	9890	9910	9930	9950	9970	9990	10010	10030	10050	10070	10090	10110	10130	10150	10170	10190	10210	10230	10250	10270	10290	10310	10330	10350	10370	10390	10410	10430	10450	10470	10490	10510	10530	10550	10570	10590	10610	10630	10650	10670	10690	10710	10730	10750	10770	10790	10810	10830	10850	10870	10890	10910	10930	10950	10970	10990	11010	11030	11050	11070	11090	11110	11130	11150	11170	11190	11210	11230	11250	11270	11290	11310	11330	11350	11370	11390	11410	11430	11450	11470	11490	11510	11530	11550	11570	11590	11610	11630	11650	11670	11690	11710	11730	11750	11770	11790	11810	11830	11850	11870	11890	11910	11930	11950	11970	11990	12010	12030	12050	12070	12090	12110	12130	12150	12170	12190	12210	12230	12250	12270	12290	12310	12330	12350	12370	12390	12410	12430	12450	12470	12490	12510	12530	12550	12570	12590	12610	12630	12650	12670	12690	12710	12730	12750	12770	12790	12810	12830	12850	12870	12890	12910	12930	12950	12970	12990	13010	13030	13050	13070	13090	13110	13130	13150	13170	13190	13210	13230	13250	13270	13290	13310	13330	13350	13370	13390	13410	13430	13450	13470	13490	13510	13530	13550	13570	13590	13610	13630	13650	13670	13690	13710	13730	13750	13770	13790	13810	13830	13850	13870	13890	13910	13930	13950	13970	13990	14010	14030	14050	14070	14090	14110	14130	14150	14170	14190	14210	14230	14250	14270	14290	14310	14330	14350	14370	14390	14410	14430	14450	14470	14490	14510	14530	14550	14570	14590	14610	14630	14650	14670	14690	14710	14730	14750	14770	14790	14810	14830	14850	14870	14890	14910	14930	14950	14970	14990	15010	15030	15050	15070	15090	15110	15130	15150	15170	15190	15210	15230	15250	15270	15290	15310	15330	15350	15370	15390	15410	15430	15450	15470	15490	15510	15530	15550	15570	15590	15610	15630	15650	15670	15690	15710	15730	15750	15770	15790	15810	15830	15850	15870	15890	15910	15930	15950	15970	15990	16010	16030	16050	16070	16090	16110	16130	16150	16170	16190	16210	16230	16250	16270	16290	16310	16330	16350	16370	16390	16410	16430	16450	16470	16490	16510	16530	16550	16570	16590	16610	16630	16650	16670	16690	16710	16730	16750	16770	16790	16810	16830	16850	16870	16890	16910	16930	16950	16970	16990	17010	17030	17050	17070	17090	17110	17130	17150	17170	17190	17210	17230	17250	17270	17290	17310	17330	17350	17370	17390	17410	17430	17450	17470	17490	17510	17530	17550	17570	17590	17610	17630	17650	17670	17690	17710	17730	17750	17770	17790	17810	17830	17850	17870	17890	17910	17930	17950	17970	17990	18010	18030	18050	18070	18090	18110	18130	18150	18170	18190	18210	18230	18250	18270	18290	18310	18330	18350	18370	18390	18410	18430	18450	18470	18490	18510	18530	18550	18570	18590	18610	18630	18650	18670	18690	18710	18730	18750	18770	18790	18810	18830	18850	18870	18890	18910	18930	18950	18970	18990	19010	19030	19050	19070	19090	19110	19130	19150	19170	19190	19210	19230	19250	19270	19290	19310	19330	19350	19370	19390	19410	19430	19450	19470	19490	19510	19530	19550	19570	19590	19610	19630	19650	19670	19690	19710	19730	19750	19770	19790	19810	19830	19850	19870	19890	19910	19930	19950	19970	19990	20010	20030	20050	20070	20090	20110	20130	20150	20170	20190	20210	20230	20250	20270	20290	20310	20330	20350	20370	20390	20410	20430	20450	20470	20490	20510	20530	20550	20570	20590	20610	20630	20650	20670	20690	20710	20730	20750	20770	20790	20810	20830	20850	20870	20890	20910	20930	20950	20970	20990	21010	21030	21050	21070	21090	21110	21130	21150	21170	21190	21210	21230	21250	21270	21290	21310	21330	21350	21370	21390	21410	21430	21450	21470	21490	21510	21530	21550	21570	21590	21610	21630	21650	21670	21690	21710	21730	21750	21770	21790	21810	21830	21850	21870	21890	21910	21930	21950	21970	21990	22010	22030	22050	22070	22090	22110	22130	22150	22170	22190	22210	22230	22250	22270	22290	22310	22330	22350	22370	22390	22410	22430	22450	22470	22490	22510	22530	22550	22570	22590	22610	22630	22650	22670	22690	22710	22730	22750	22770	22790	22810	22830	22850	22870	22890	22910	22930	22950	22970	22990	23010	23030	23050	23070	23090	23110	23130	23150	23170	23190	23210	23230	23250	23270	23290	23310	23330	23350	23370	23390	23410	23430	23450	23470	23490	23510	23530	23550	23570	23590	23610	23630	23650	23670	23690	23710	23730	23750	23770	23790	23810	23830	23850	23870	23890	23910	23930	23950	23970	23990	24010	24030	24050	24070	24090	24110	24130

Table B-2

WATER LEVEL COMPONENTS (IN FEET)

COMPONENT = (u wind component) $\times (1.195300) \times .1$

WIND DIR.	WIND SPEED (KNOTS)	WATER LEVEL COMPONENT (IN FEET)
4.0	1.4	1.0
4.0	1.7	1.195300
4.0	2.0	1.390600
4.0	2.4	1.781200
4.0	2.7	2.171800
4.0	3.0	2.562400
4.0	3.4	3.053000
4.0	3.6	3.443600
4.0	3.8	3.834200
4.0	4.0	4.224800
4.0	4.2	4.615400
4.0	4.4	5.006000
4.0	4.6	5.396600
4.0	4.8	5.787200
4.0	5.0	6.177800
4.0	5.2	6.568400
4.0	5.4	6.959000
4.0	5.6	7.349600
4.0	5.8	7.740200
4.0	6.0	8.130800
4.0	6.2	8.521400
4.0	6.4	8.912000
4.0	6.6	9.292600
4.0	6.8	9.673200
4.0	7.0	10.053800
4.0	7.2	10.434400
4.0	7.4	10.815000
4.0	7.6	11.195600
4.0	7.8	11.576200
4.0	8.0	11.956800
4.0	8.2	12.337400
4.0	8.4	12.718000
4.0	8.6	13.098600
4.0	8.8	13.479200
4.0	9.0	13.859800
4.0	9.2	14.240400
4.0	9.4	14.621000
4.0	9.6	15.001600
4.0	9.8	15.382200
4.0	10.0	15.762800
4.0	10.2	16.143400
4.0	10.4	16.524000
4.0	10.6	16.904600
4.0	10.8	17.285200
4.0	11.0	17.665800
4.0	11.2	18.046400
4.0	11.4	18.427000
4.0	11.6	18.807600
4.0	11.8	19.188200
4.0	12.0	19.568800
4.0	12.2	19.949400
4.0	12.4	20.320000
4.0	12.6	20.690600
4.0	12.8	21.071200
4.0	13.0	21.451800
4.0	13.2	21.832400
4.0	13.4	22.213000
4.0	13.6	22.593600
4.0	13.8	22.974200
4.0	14.0	23.354800
4.0	14.2	23.735400
4.0	14.4	24.116000
4.0	14.6	24.496600
4.0	14.8	24.877200
4.0	15.0	25.257800
4.0	15.2	25.638400
4.0	15.4	26.019000
4.0	15.6	26.399600
4.0	15.8	26.780200
4.0	16.0	27.160800
4.0	16.2	27.541400
4.0	16.4	27.922000
4.0	16.6	28.302600
4.0	16.8	28.683200
4.0	17.0	29.063800
4.0	17.2	29.444400
4.0	17.4	29.825000
4.0	17.6	30.205600
4.0	17.8	30.586200
4.0	18.0	30.966800
4.0	18.2	31.347400
4.0	18.4	31.728000
4.0	18.6	32.108600
4.0	18.8	32.489200
4.0	19.0	32.869800
4.0	19.2	33.250400
4.0	19.4	33.631000
4.0	19.6	34.011600
4.0	19.8	34.392200
4.0	20.0	34.772800
4.0	20.2	35.153400
4.0	20.4	35.534000
4.0	20.6	35.914600
4.0	20.8	36.295200
4.0	21.0	36.675800
4.0	21.2	37.056400
4.0	21.4	37.437000
4.0	21.6	37.817600
4.0	21.8	38.198200
4.0	22.0	38.578800
4.0	22.2	38.959400
4.0	22.4	39.330000
4.0	22.6	39.710600
4.0	22.8	40.091200
4.0	23.0	40.471800
4.0	23.2	40.852400
4.0	23.4	41.233000
4.0	23.6	41.613600
4.0	23.8	41.994200
4.0	24.0	42.374800
4.0	24.2	42.755400
4.0	24.4	43.136000
4.0	24.6	43.516600
4.0	24.8	43.897200
4.0	25.0	44.277800
4.0	25.2	44.658400
4.0	25.4	45.039000
4.0	25.6	45.419600
4.0	25.8	45.790200
4.0	26.0	46.170800
4.0	26.2	46.551400
4.0	26.4	46.932000
4.0	26.6	47.312600
4.0	26.8	47.693200
4.0	27.0	48.073800
4.0	27.2	48.454400
4.0	27.4	48.835000
4.0	27.6	49.215600
4.0	27.8	49.596200
4.0	28.0	49.976800
4.0	28.2	50.357400
4.0	28.4	50.738000
4.0	28.6	51.118600
4.0	28.8	51.499200
4.0	29.0	51.879800
4.0	29.2	52.260400
4.0	29.4	52.641000
4.0	29.6	53.021600
4.0	29.8	53.392200
4.0	30.0	53.772800
4.0	30.2	54.153400
4.0	30.4	54.534000
4.0	30.6	54.914600
4.0	30.8	55.295200
4.0	31.0	55.675800
4.0	31.2	56.056400
4.0	31.4	56.437000
4.0	31.6	56.817600
4.0	31.8	57.198200
4.0	32.0	57.578800
4.0	32.2	57.959400
4.0	32.4	58.330000
4.0	32.6	58.710600
4.0	32.8	59.091200
4.0	33.0	59.471800
4.0	33.2	59.852400
4.0	33.4	60.233000
4.0	33.6	60.613600
4.0	33.8	60.994200
4.0	34.0	61.374800
4.0	34.2	61.755400
4.0	34.4	62.136000
4.0	34.6	62.516600
4.0	34.8	62.897200
4.0	35.0	63.277800
4.0	35.2	63.658400
4.0	35.4	64.039000
4.0	35.6	64.419600
4.0	35.8	64.790200
4.0	36.0	65.170800
4.0	36.2	65.551400
4.0	36.4	65.932000
4.0	36.6	66.312600
4.0	36.8	66.693200
4.0	37.0	67.073800
4.0	37.2	67.454400
4.0	37.4	67.835000
4.0	37.6	68.215600
4.0	37.8	68.596200
4.0	38.0	68.976800
4.0	38.2	69.357400
4.0	38.4	69.738000
4.0	38.6	70.118600
4.0	38.8	70.499200
4.0	39.0	70.879800
4.0	39.2	71.260400
4.0	39.4	71.641000
4.0	39.6	72.021600
4.0	39.8	72.392200
4.0	40.0	72.772800
4.0	40.2	73.153400
4.0	40.4	73.534000
4.0	40.6	73.914600
4.0	40.8	74.295200
4.0	41.0	74.675800
4.0	41.2	75.056400
4.0	41.4	75.437000
4.0	41.6	75.817600
4.0	41.8	76.198200
4.0	42.0	76.578800
4.0	42.2	76.959400
4.0	42.4	77.330000
4.0	42.6	77.710600
4.0	42.8	78.091200
4.0	43.0	78.471800
4.0	43.2	78.852400
4.0	43.4	79.233000
4.0	43.6	79.613600
4.0	43.8	80.094200
4.0	44.0	80.474800
4.0	44.2	80.855400
4.0	44.4	81.236000
4.0	44.6	81.616600
4.0	44.8	81.997200
4.0	45.0	82.377800
4.0	45.2	82.758400
4.0	45.4	83.139000
4.0	45.6	83.519600
4.0	45.8	83.890200
4.0	46.0	84.270800
4.0	46.2	84.651400
4.0	46.4	85.032000
4.0	46.6	85.412600
4.0	46.8	85.793200
4.0	47.0	86.173800
4.0	47.2	86.554400
4.0	47.4	86.935000
4.0	47.6	87.315600
4.0	47.8	87.696200
4.0	48.0	88.076800
4.0	48.2	88.457400
4.0	48.4	88.838000
4.0	48.6	89.218600
4.0	48.8	89.599200
4.0	49.0	89.979800
4.0	49.2	90.350400
4.0	49.4	90.731000
4.0	49.6	91.111600
4.0	49.8	91.492200
4.0	50.0	91.872800
4.0	50.2	92.253400
4.0	50.4	92.634000
4.0	50.6	93.014600
4.0	50.8	93.395200
4.0	51.0	93.775800
4.0	51.2	94.156400
4.0	51.4	94.537000
4.0	51.6	94.917600
4.0	51.8	95.298200
4.0	52.0	95.678800
4.0	52.2	96.059400
4.0	52.4	96.430000
4.0	52.6	96.810600
4.0	52.8	97.191200
4.0	53.0	97.571800
4.0	53.2	97.952400
4.0	53.4	98.333000
4.0	53.6	98.713600
4.0	53.8	99.094200
4.0	54.0	99.474800
4.0	54.2	99.855400
4.0	54.4	100.236000
4.0	54.6	100.616600
4.0	54.8	100.997200
4.0	55.0	101.377800
4.0	55.2	101.758400
4.0	55.4	102.139000
4.0	55.6	102.519600
4.0	55.8	102.890200
4.0	56.0	103.270800
4.0	56.2	103.651400
4.0	56.4	104.032000
4.0	56.6	104.412600
4.0	56.8	104.793200
4.0	57.0	105.173800
4.0	57.2	105.554400
4.0	57.4	105.935000
4.0	57.6	106.315600
4.0	57.8	106.696200
4.0	58.0	107.076800
4.0	58.2	107.457400
4.0	58.4	107.838000
4.0	58.6	108.218600
4.0	58.8	108.599200
4.0	59.0	108.979800
4.0	59.2	109.350400
4.0	59.4	109.731000
4.0	59.6	110.111600
4.0	59.8	110.492200
4.0	60.0	110.872800
4.0	60.2	111.253400
4.0	60.4	111.634000
4.0	60.6	112.014600
4.0	60.8	112.395200
4.0	61.0	112.775800
4.0	61.2	113.156400
4.0	61.4	113.537000
4.0	61.6	113.917600
4.0	61.8	114.298200
4.0	62.0	114.678800
4.0	62.2	115.059400
4.0	62.4	115.430000
4.0	62.6	115.810600
4.0	62.8	116.191200
4.0	63.0	116.571800
4.0	63.2	116.952400
4.0	63.4	117.333000
4.0	63.6	117.713600
4.0	63.8	118.094200
4.0	64.0	118.474800
4.0	64.2	118.855400
4.0	64.4	119.236000
4.0	64.6	119.616600
4.0	64.8	120.017200
4.0	65.0	120.397800
4.0	65.2	120.778400
4.0	65.4	121.159000
4.0	65.6	121.539600
4.0	65.8	121.920200
4.0		

Table B-3

WATER LEVEL COMPONENTS (IN FEET)
 COMPONENT = (u wind component) $\times (2.38170) \times .1$

WIND DIR.	WIND SPEED (KNOTS)	WIND DIR.	WIND SPEED (KNOTS)
40	16	36	16
38	15	34	14
36	13	32	13
30	12	28	12
28	11	26	11
26	10.9	24	10.9
24	10.6	22	10.6
22	10.3	20	10.3
18	7	18	7
16	0.7	14	0.6
12	0.5	10	0.4
8	0.3	6	0.2
4	0.1	2	1.0
0	0.0	100	0.0

Table B-4

WATER LEVEL COMPONENTS (IN FEET)

$$\text{COMPONENT} = (u \text{ wind component}) \times (.174430) \times .1$$

Table B-5

WATER LEVEL COMPONENTS (IN FEET)

Table B-5 - Continued

WATER LEVEL COMPONENTS (IN FEET)										
COMPONENT = (sea level pressure) X (-1.114690) X 1										
PRESSURE (MILLIBARS)	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1000	-11.47	-11.47	-11.47	-11.47	-11.47	-11.47	-11.47	-11.47	-11.47	-11.48
1001	-11.48	-11.48	-11.48	-11.48	-11.48	-11.49	-11.49	-11.49	-11.49	-11.49
1002	-11.49	-11.49	-11.49	-11.49	-11.49	-11.50	-11.50	-11.50	-11.50	-11.50
1003	-11.50	-11.50	-11.50	-11.50	-11.50	-11.51	-11.51	-11.51	-11.51	-11.51
1004	-11.51	-11.51	-11.52	-11.52	-11.52	-11.52	-11.52	-11.52	-11.52	-11.53
1005	-11.53	-11.53	-11.53	-11.53	-11.53	-11.53	-11.53	-11.53	-11.53	-11.54
1006	-11.54	-11.54	-11.54	-11.54	-11.54	-11.54	-11.54	-11.54	-11.54	-11.55
1007	-11.55	-11.55	-11.55	-11.55	-11.55	-11.56	-11.56	-11.56	-11.56	-11.56
1008	-11.56	-11.56	-11.56	-11.56	-11.56	-11.57	-11.57	-11.57	-11.57	-11.57
1009	-11.57	-11.57	-11.57	-11.57	-11.57	-11.58	-11.58	-11.58	-11.58	-11.58
1010	-11.58	-11.58	-11.59	-11.59	-11.59	-11.59	-11.59	-11.59	-11.59	-11.59
1011	-11.60	-11.60	-11.60	-11.60	-11.60	-11.60	-11.60	-11.60	-11.60	-11.61
1012	-11.61	-11.61	-11.61	-11.61	-11.61	-11.61	-11.61	-11.61	-11.61	-11.62
1013	-11.62	-11.62	-11.62	-11.62	-11.62	-11.62	-11.62	-11.62	-11.62	-11.63
1014	-11.63	-11.63	-11.63	-11.63	-11.63	-11.63	-11.63	-11.63	-11.63	-11.64
1015	-11.64	-11.64	-11.64	-11.64	-11.64	-11.65	-11.65	-11.65	-11.65	-11.65
1016	-11.65	-11.65	-11.65	-11.65	-11.65	-11.66	-11.66	-11.66	-11.66	-11.66
1017	-11.66	-11.67	-11.67	-11.67	-11.67	-11.67	-11.67	-11.67	-11.67	-11.67
1018	-11.68	-11.68	-11.68	-11.68	-11.68	-11.68	-11.68	-11.68	-11.68	-11.69
1019	-11.69	-11.69	-11.69	-11.69	-11.69	-11.69	-11.69	-11.69	-11.69	-11.70
1020	-11.70	-11.70	-11.70	-11.70	-11.70	-11.70	-11.70	-11.70	-11.70	-11.70
1021	-11.71	-11.71	-11.71	-11.71	-11.71	-11.71	-11.71	-11.71	-11.71	-11.71
1022	-11.72	-11.72	-11.72	-11.72	-11.72	-11.72	-11.72	-11.72	-11.72	-11.72
1023	-11.73	-11.73	-11.74	-11.74	-11.74	-11.74	-11.74	-11.74	-11.74	-11.74
1024	-11.74	-11.75	-11.75	-11.75	-11.75	-11.75	-11.75	-11.75	-11.75	-11.75
1025	-11.76	-11.76	-11.76	-11.76	-11.76	-11.76	-11.76	-11.76	-11.76	-11.77
1026	-11.77	-11.77	-11.77	-11.77	-11.77	-11.77	-11.77	-11.77	-11.77	-11.78
1027	-11.78	-11.78	-11.78	-11.78	-11.78	-11.78	-11.78	-11.78	-11.78	-11.79
1028	-11.79	-11.79	-11.79	-11.79	-11.79	-11.80	-11.80	-11.80	-11.80	-11.80
1029	-11.80	-11.80	-11.81	-11.81	-11.81	-11.81	-11.81	-11.81	-11.81	-11.81
1030	-11.81	-11.81	-11.82	-11.82	-11.82	-11.82	-11.82	-11.82	-11.82	-11.82
1031	-11.82	-11.83	-11.83	-11.83	-11.83	-11.83	-11.83	-11.83	-11.83	-11.83
1032	-11.84	-11.84	-11.84	-11.84	-11.84	-11.84	-11.84	-11.84	-11.84	-11.85
1033	-11.85	-11.85	-11.85	-11.85	-11.85	-11.85	-11.85	-11.85	-11.85	-11.86
1034	-11.86	-11.86	-11.86	-11.86	-11.86	-11.86	-11.86	-11.86	-11.86	-11.86
1035	-11.87	-11.87	-11.87	-11.87	-11.87	-11.87	-11.87	-11.87	-11.87	-11.87
1036	-11.88	-11.88	-11.88	-11.88	-11.88	-11.89	-11.89	-11.89	-11.89	-11.89
1037	-11.89	-11.89	-11.90	-11.90	-11.90	-11.90	-11.90	-11.90	-11.90	-11.90
1038	-11.90	-11.91	-11.91	-11.91	-11.91	-11.91	-11.91	-11.91	-11.91	-11.92
1039	-11.92	-11.92	-11.92	-11.92	-11.92	-11.92	-11.92	-11.92	-11.92	-11.93
1040	-11.93	-11.93	-11.93	-11.93	-11.93	-11.93	-11.93	-11.93	-11.93	-11.94
1041	-11.94	-11.94	-11.94	-11.94	-11.94	-11.94	-11.94	-11.94	-11.94	-11.94
1042	-11.95	-11.95	-11.95	-11.95	-11.95	-11.96	-11.96	-11.96	-11.96	-11.96
1043	-11.96	-11.96	-11.96	-11.96	-11.96	-11.97	-11.97	-11.97	-11.97	-11.97
1044	-11.97	-11.97	-11.98	-11.98	-11.98	-11.98	-11.98	-11.98	-11.98	-11.98
1045	-11.99	-11.99	-11.99	-11.99	-11.99	-11.99	-11.99	-11.99	-11.99	-11.99
1046	-12.00	-12.00	-12.00	-12.00	-12.00	-12.00	-12.00	-12.00	-12.00	-12.00
1047	-12.01	-12.01	-12.01	-12.01	-12.01	-12.01	-12.01	-12.01	-12.01	-12.01
1048	-12.02	-12.02	-12.02	-12.02	-12.02	-12.02	-12.02	-12.02	-12.02	-12.03
1049	-12.03	-12.03	-12.03	-12.03	-12.03	-12.04	-12.04	-12.04	-12.04	-12.04

(Continued from inside front cover)

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