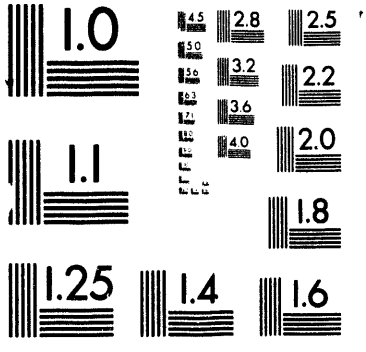
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1 of 2

PNWD-2200 HEDR
UC-000

Final Report on the Meteorological Database, December 1944-1949

Hanford Environmental Dose Reconstruction Project

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Letter report prepared for
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MASTER

Preface

The Hanford Environmental Dose Reconstruction (HEDR) Project was prompted by mounting concern about possible health effects to the public from more than 40 years of nuclear operations at the U.S. Department of Energy's (DOE) Hanford Site near Richland, Washington. The primary objective of the HEDR Project is to estimate the radiation dose (with descriptions of the uncertainties inherent in such estimates) that individuals could have received as a result of radionuclide emissions since 1944 from the Hanford Site. An independent Technical Steering Panel (TSP) directs the work on the project which is conducted by Battelle, Pacific Northwest Laboratories under contract with the Centers for Disease Control and Prevention.

The HEDR Project work includes a number of technical and administrative tasks. This report describes the sources of meteorological data used by the Atmospheric Transport Task staff to estimate air concentrations and surface contamination in the Hanford vicinity using the Regional Atmospheric Transport Code for Hanford Emissions Tracking (RATCHET). Air concentrations and surface deposition are used in estimating dose. This final report supersedes the interim report by Stage et al. (1993) and fulfills HEDR Project Milestone 0405B.

Summary

The Hanford Environmental Dose Reconstruction (HEDR) Project is estimating radiation doses that individuals may have received from operations at Hanford from 1944 to the present. An independent Technical Steering Panel (TSP) directs the project, which is being conducted by the Battelle, Pacific Northwest Laboratories in Richland, Washington. The goals of HEDR, as approved by the TSP, include both estimation of the doses and determination of the confidence ranges for these doses.

A number of computer programs are being developed by the HEDR Project to estimate doses and confidence ranges associated with radionuclides transported through the atmosphere and the Columbia River. One of the computer programs is the Source Term Release Model (STRM), which uses the laws of science and the data on Hanford operations to estimate the amounts of radionuclides vented to the atmosphere through the operating plant stacks. Another computer program is the Regional Atmospheric Transport Code for Hanford Emissions Tracking (RATCHET). RATCHET combines release data with information on atmospheric conditions including wind direction and speed. The RATCHET program uses these data to produce estimates of time-integrated air concentrations and surface contamination. These estimates are used in calculating dose by the Dynamic EStimates of Concentrations And Radionuclides in Terrestrial EnvironmentS (DESCARTES) and the Calculations of Individual Doses from Environmental Radionuclides (CIDER) computer programs.

This letter report describes the final status of the meteorological database used by RATCHET and supersedes the interim report by Stage et al. (1993). The report describes the data collection procedures and the preparation and control of the meteorological database. This report also provides an assessment of the data quality. This assessment shows the available meteorological data are adequate for atmospheric calculations. Checks of the data indicate the data entry accuracy meets the data quality objectives.

The report includes three major sections. The introduction (Section 1.0) provides background information and an overview of the meteorological database development effort. Section 2.0 includes a description of the data set and quality controls used in building the meteorological database. Section 3.0 details the information available for each location from which meteorological data have been obtained.

Glossary

Acronym/Term/ Abbreviation	Definition
AFB	Air Force Base
ALW	Walla Walla, Washington, Meteorological Station
BKE	Baker, Oregon, Meteorological Station
BNO	Burns, Oregon, Meteorological Station
BON	Bonners Ferry, Idaho, Meteorological Station
CIDER	Calculation of Individual Doses from Environmental Radionuclides (computer code)
COL	Colville, Washington, Meteorological Station
CON	Condon, Oregon, Meteorological Station
DESCARTES	Dynamic EStimates of Concentrations and Accumulated Radionuclides in Terrestrial EnvironmentS (computer code)
DLS	Dallesport, Washington, Meteorological Station
EAT	Wenatchee, Washington, Meteorological Station
ELN	Ellensburg, Washington, Meteorological Station
ENE	East-Northeast
EPH	Ephrata, Washington, Meteorological Station
ESE	East-Southeast
FY	Fiscal year
GEG	Spokane (Geiger Field), Washington, Meteorological Station
HAR	Harrington, Washington, Meteorological Station
HEDR	Hanford Environmental Dose Reconstruction
HEDRIC	HEDR Integrated Codes
histogram	A graphical representation of a distribution function using rectangles where the heights represent the number of observations occurring in each interval
HMS	Hanford, Washington, Meteorological Station
isohyet	A line drawn through geographic points recording equal amounts of precipitation for a specified period of time
LAC	LaCrosse, Washington, Meteorological Station
LWS	Lewiston, Idaho, Meteorological Station
MWH	Larson AFB, Washington, Meteorological Station
NE	Northeast
NNE	North-Northeast
NNW	North-Northwest
NW	Northwest
NWDI	National Wind Data Index
OMK	Omak, Washington, Meteorological Station
ONO	Ontario, Oregon, Meteorological Station
orographic	Pertaining to mountains, especially with regard to their location and distribution

Acronym/Term/ Abbreviation	Definition
PDT	Pendleton, Oregon, Meteorological Station
POP	Probability of precipitation
precipitation rose	A graphical representation of the distribution of wind directions when precipitation is recorded at a particular station during a specified period of time
PSC	Pasco, Washington, Meteorological Station
RATCHET	Regional Atmospheric Transport Code for Hanford Emission Tracking (computer code)
RDM	Redmond, Oregon, Meteorological Station
SE	Southeast
SFF	Spokane (Felts Field), Washington, Meteorological Station
SKA	Fairchild AFB, Washington, Meteorological Station
SMP	Stampede Pass, Washington, Meteorological Station
SSE	South-Southeast
SSW	South-Southwest
SW	Southwest
STRM	Source Term Release Model (computer code)
USGS	United States Geological Survey
wind rose	A graphical representation of the distribution of wind directions at a particular station during a specified period of time
WNW	West-Northwest
WSW	West-Southwest
YKM	Yakima, Washington, Meteorological Station

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3.19 Burns Wind Direction and Wind Speed and Stability Distributions 3.57

3.20 Condon Wind Direction and Wind Speed and Stability Distributions 3.60

3.21 Ontario Wind Direction and Wind Speed and Stability Distributions 3.63

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1.0 Introduction

This letter report describes the status of the Hanford Environmental Dose Reconstruction (HEDR) Project final meteorological database in satisfaction of HEDR Milestone 0405B (Shipler 1993). This introduction gives an overview of the computer model used for HEDR dose estimates, discusses the importance of meteorological conditions in dose reconstruction, and describes the domain and period of interest for the HEDR atmospheric model.

1.1 Overview of HEDR Integrated Code

Figure 1.1 shows the interaction of the major components of the HEDR Integrated Code (HEDRIC). HEDRIC consists of four computer code modules and their associated interfaces. The first module is based on knowledge of operations at the nuclear reactors and chemical processing plants. The records that were kept at the plants describe the materials that went into the process. Data from those records are entered into a mathematical model that simulates operation of the process. That model, the Source Term Release Model (STRM), uses knowledge of the chemistry and physics of Hanford plant operations and plant records to produce an estimate of the amounts of radionuclides vented through operating plant stacks to the atmosphere. The second module, Regional Atmospheric Transport Code for Hanford Emission Tracking (RATCHET), combines the release data with information on meteorological conditions, including wind direction and speed, and produces estimates of time-integrated air concentrations and surface contamination. As Figure 1.1 indicates, the third module, Dynamic EStimates of Concentrations And Radionuclides in Terrestrial EnvironmentS (DESCARTES), uses data on air concentrations and surface contamination to calculate radionuclide progress through the food chain. Ultimately, DESCARTES describes the radionuclide concentration in food available to the population in the HEDR Project area. The final module, Calculation of Individual Doses from Environmental Radionuclides (CIDER), uses time, location, and diet information for an individual and the results from DESCARTES to calculate dose estimates. This report focuses on the meteorological data used as input to the RATCHET code.

1.2 Need for Meteorological Data

Whenever any substance is released into the atmosphere, the fate of that substance is largely determined by meteorological conditions. Wind speed and direction, atmospheric stability, mixing layer depth, and precipitation (when present) determine the transport, dilution, and deposition rate. These factors determine the distribution of the substance in the environment. Realistic dose reconstruction requires a meteorological database that describes the temporal and spatial changes in the atmosphere during periods of significant radionuclide releases to the air.

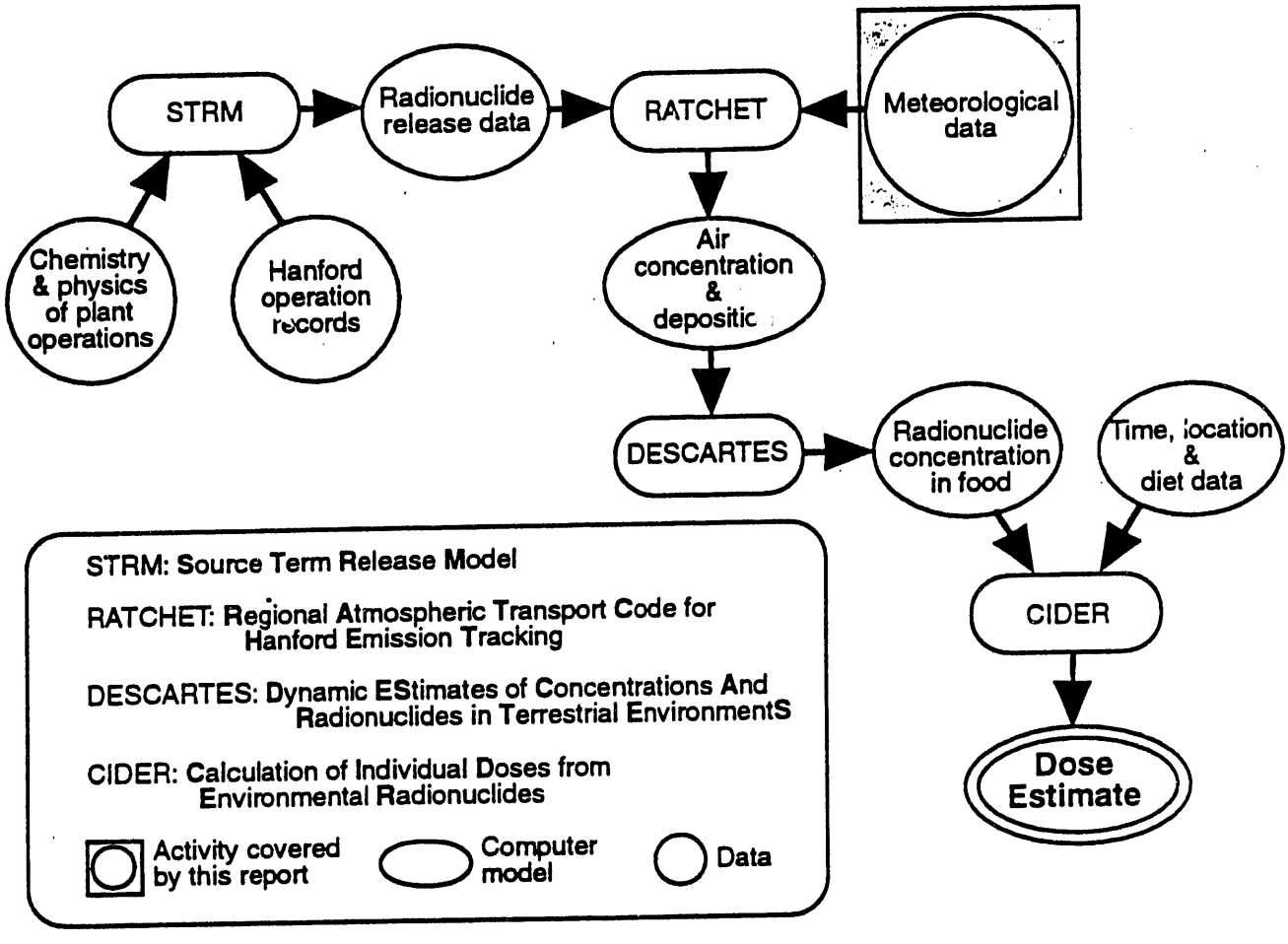


Figure 1.1. Hanford Environmental Dose Reconstruction Integrated Codes for the Atmospheric Pathway

1.3 Model Domain

Time-integrated air concentrations and surface contamination from radionuclides released to the air are to be calculated for the rectangular domain (indicated by the box with tick marks) shown in Figure 1.2. The RATCHET domain is centered at 46° 40' N, 118° 45' W. It extends 395.9 kilometers (246 miles) east to west and 492.5 kilometers (306 miles) south to north. The area covered is approximately 195,000 square kilometers (75,000 square miles). The tick marks are 12 miles apart.

The Hanford Site (shown in cross hatch) is near the center of the figure. The figure details specific locations for which data have been included in the meteorological database. (Section 3.0 contains a description of each location.)

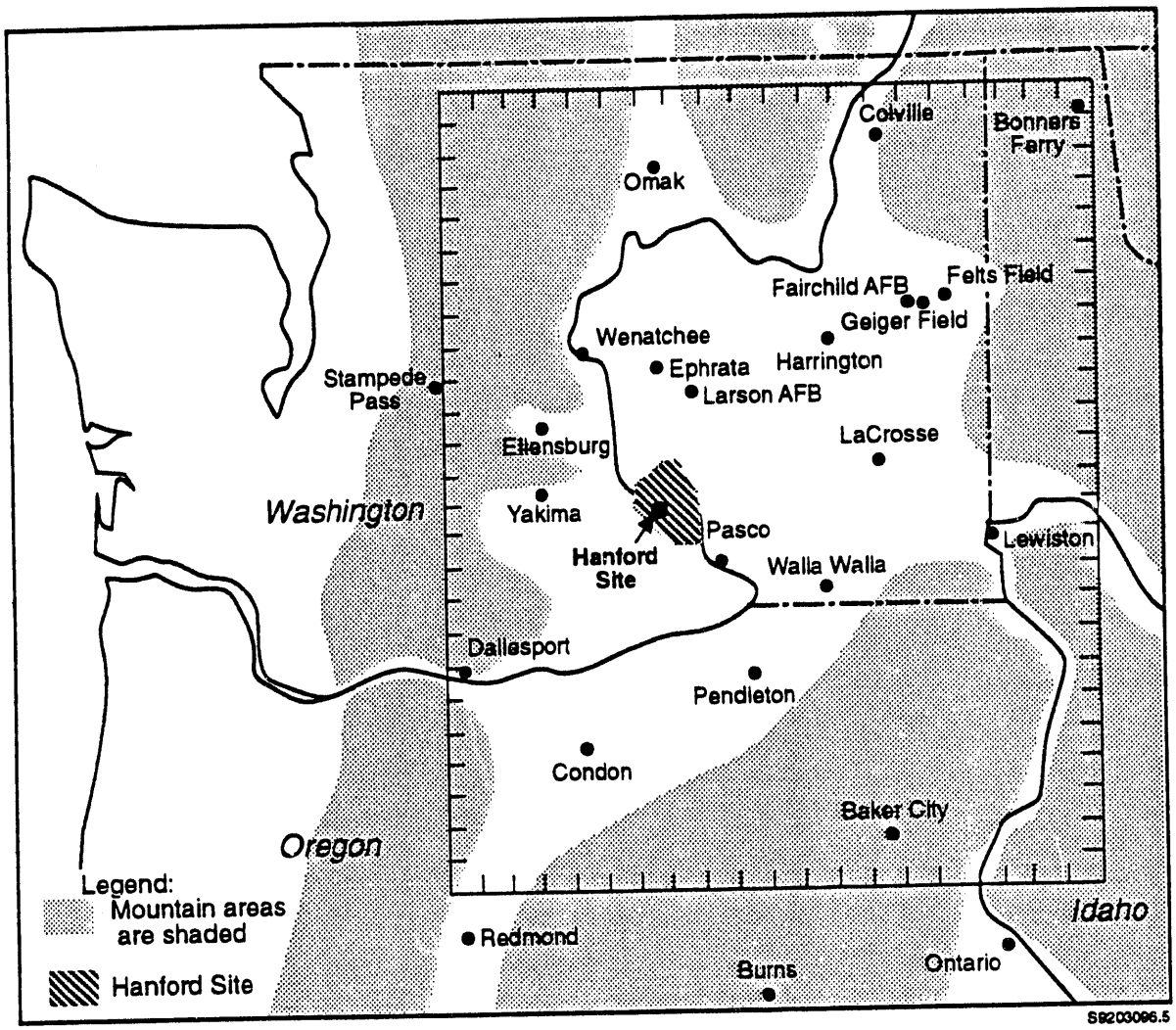


Figure 1.2. Map of RATCHET Domain and Meteorological Stations

1.4 Period of Interest

The HEDR Project has divided the operations at the Hanford Site into several time periods based on magnitude of releases (Shipler and Napier 1992). The first period of interest, between December 1944 and December 1949, corresponds to the interval of the largest radionuclide releases to the atmosphere (Heeb 1993).

1.5 Content of this Report

This report provides meteorological information for December 1944 through December 1949. Section 2.0 gives a description of the data set, procedures used to enter the data into the database, and

data quality checks used to ensure the database is an accurate reproduction of the historical records. The report contains a discussion on the accuracy of the data, the adequacy of the data for representing the meteorological conditions in the HEDR region, sources of errors and uncertainties in the data, and their probable sizes.

Section 3.2 contains detailed descriptions of the stations used in the HEDR meteorological database. These descriptions include station locations, available data and the data source, and local topography. Statistics have also been compiled for wind direction, wind speed, and wind direction during precipitation (see Section 2.7 for details). Some discussion is given of the effects of local topography on these statistics. The RATCHET module that uses the data to estimate the air concentrations and surface contamination is described in separate reports (Ramsdell and Burk 1992; Ramsdell 1992).

2.0 Description of the Data Set

Data suitable for use in the RATCHET Model are available for 25 locations for the HEDR period of interest. A list of these stations, followed by their abbreviations, is contained in Table 2.1. The locations of these stations are shown in Figure 1.2, and a more detailed description of each station is given in Section 3.0 of this report.

Table 2.1. HEDR Meteorological Data Stations

Station Name	Abbreviation	Station Name	Abbreviation
State of Washington		**State of Oregon**	
Colville	COL	Baker City	BKE
Dallesport	DLS	Burns	BNO
Ellensburg	ELN	Condon	CON
Ephrata	EPH	Ontario	ONO
Fairchild AFB	SKA	Pendleton	PDT
Hanford Meteorological Station	HMS	Redmond	RDM
Harrington	HAR		
LaCrosse	LAC		
Larson AFB	MWH	**State of Idaho**	
Omak	OMK	Bonners Ferry	BON
Pasco	PSC	Lewiston	LWS
Spokane (Felts Field)	SFF		
Spokane (Geiger Field)	GEG		
Stampede Pass	SMP		
Walla Walla	ALW		
Wenatchee	EAT		
Yakima	YKM		

2.1 Weather Service Operating Procedures

All of the stations, except the Hanford Meteorological Station (HMS) (see Section 2.2), followed standard U.S. Weather Bureau procedures (Changery 1978). During the period of interest, wind speeds were measured using rotating three-cup anemometers mounted on the roofs of buildings, on towers, or on beacons. To obtain a wind speed, the observer watched a display showing instrument output for a single 1-minute period at the observation time (30 minutes past the hour), made a visual estimate of the average, and recorded the result (to the nearest whole mile per hour) as the hourly wind speed.

During most of the 1940s, wind direction was measured by wind vanes that used output lights. The dials of these instruments had eight lights to indicate sixteen wind directions. For winds from each direction (north, northeast, east, southeast, south, southwest, west, or northwest), one light became illuminated. For intermediate wind directions, two adjacent lights were illuminated (for example, a south-southeasterly wind was indicated by illumination of the south and southeast lights).

To calculate the wind direction, the observer used a method similar to that for wind speed. Specifically, the observer watched the dial for 1 minute at the observation time and visually estimated the average. The result was recorded to the nearest compass point on a 16-point compass (northerly, north-northeasterly, northeasterly, east-northeasterly, and so forth), each comprised of a 22.5-degree direction band.

Between 1947 and the early 1950s, wind vanes at the observing stations were gradually replaced by vanes that indicated direction on dials showing 0 to 360 degrees[a]. Observers recorded wind directions based on the 16 compass points until 1965, when observers started recording directions in 10-degree increments.

Weather conditions (including precipitation, cloud cover, and ceiling) were visually estimated and recorded by the observer. The RATCHET model uses these weather observations to calculate estimated precipitation rates and atmospheric stability.

2.2 Hanford Meteorological Station Operating Procedures

Instrumentation and observation techniques at HMS in the early 1950s are described by Jenne (1954). In the absence of any other information about station procedures, it is reasonable to assume these techniques were followed from the beginning of observations in 1944. Wind speed and direction were continuously recorded on strip charts. Hourly observations were obtained by averaging the values on the strip charts.

Jenne (1954, Section 5.02, "Entries on Form R-143, Daily Hourly Wind Log") gives a detailed set of rules for determining the reported hourly wind direction. The rules are designed to make the choice of a wind direction as objective as possible. They are based on six possible wind-direction categories ranging from an easy category (with nearly steady direction for an entire hour) to much more difficult categories (with winds varying among several sectors). The wind direction is defined as the direction most representative for the hour. In actuality, the rules are designed so the chosen direction is the direction from which the wind comes for the most number of minutes.

(a) Communication Log (HEDR Project Document No. 10930166), "Wind Direction Sensors Used at HEDR Meteorological Stations," telephone conversation between S. A. Stage, BNW, and M. J. Changery, National Climate Data Center, September 16, 1993.

Each wind speed and direction recorded for HMS is based on a full-hour record, rather than the 1-minute observation periods used at the U.S. Weather Bureau stations. Therefore, the Hanford data are more representative of hourly atmospheric transport at that station than the U.S. Weather Bureau data are at their respective stations.

2.3 Use of One Spokane Station

Three stations are clustered near Spokane (Felts Field, Geiger Field, and Fairchild Air Force Base, AFB). Use of all three stations produces an unduly strong weighting of the Spokane vicinity in the RATCHET wind field. For this reason, data from only one of these stations will be used for dose computations. The Fairchild AFB Station was selected because data are available for 1944 through 1949. The data information for Felts Field is provided in this report. Information is provided for Geiger Field, but the meteorological data were not evaluated.

2.4 Data Sources

Data from HMS were obtained from a digital file provided by the Hanford Meteorological Program. This file was produced from original handwritten records.

Data from the other stations were obtained from the National Climatic Data Center Archive in the form of magnetic tapes, when available, and as microfiche copies or paper photocopies of original handwritten records made by the observers for other periods. A general description of these data is given by Changery (1978). In some cases, the archived microfiche or photocopy records were difficult to read. Figure 2.1 shows an example of a photocopied record that is readily legible. Figure 2.2 shows a record with poor legibility, and Figure 2.3 shows a record with crossed out values and misplaced numbers that make it difficult to determine wind data. Data were omitted if they could not be read with high confidence. Only a few points were illegible.

Data from microfiche and paper copies were manually entered into the database. As data were being entered, range checks were made to prevent gross errors. Wind direction was required to be in the range 0 to 16 when direction was recorded using the 16 points of the compass and 0 to 36 when direction was recorded in tens of degrees. All wind speeds were required to be in the range of 0 to 50 miles per hour (mph) or knots (kn) depending upon the units used in the original records.

Ceiling height, reported in levels of 100-foot increments, was limited to heights between 0 and 30,000 feet. Sky cover was recorded in tenths. Ranges were limited to between 0 and 9 with overcast conditions reported as 9. Precipitation types were limited to no greater than 5; codes for precipitation types ranged between 1 and 39. Additional quality checks were done after data entry to check for missing values and for data out of order. Wind speeds not in the range of 0 to 50 were flagged, as were changes of more than 10 units between consecutive hours. A check was also done to ensure that if a calm code was entered for wind speed, it was also entered for direction and vice versa.

Time entries on this form are 120 th meridian time

To convert to G. C. T. (add / subtract) 8 hours

Height of Barometer 236 ft. (MSL)

WEATHER BUREAU

SURFACE WEATHER OBSERVATIONS

(LAND STATION)

WBAN—10A

Security Classification

Station Dallesport, Wash.

Lat. 45°37' Long. 121°09'

Type (1)	Time (2)	Class. of Observation (3)	Ceiling (4)	Sky (5)	Vis. Miles (6)	Weather and/or Obstructions to Vision (7)	Sea-Level Pressure (8)	Temp. (9)	Dew Pt. (10)	Wind Direction (11)	Velocity (12)	Character and Sky (13)	Altimeter (14)	Remarks and Supplemental Coded Data (15)	Pres. Tend. (16)	Net 3-hr. Change (17)	Precip. (18)	Low Amt., Type, Direction (19)	Low Height (20)	Middle Amt., Type, Direction (21)	Middle Height (22)	High Amt., Type, Direction (23)	High Height (24)	Station Pressure (25)	Dry Bulb (26)	Wet Bulb (27)	Water Temp. (28)	Total Ceiling (29)	Obs. Div. (30)
RS1	0029		W70	⊕6⦶	2	R-F-	156	39	39	↖↙	3		998											29.760	39.4	39.0		10	
✓	0038		W55	⊕6⦶	1½	R-F-				↘↘	5		996	R- INTMT										29.740					
R	0128		W55	⊕8⦶	2	R-F-	149	38	38	↖↖	3		996	R- INTMT / 810 5009	8	.060		10T DSC	E8 W55	X		X		29.735	38.5	38.2		10	
✓	0137		W50	⊕7⦶	1½	R-F-				↖	5		995	R- INTMT ⦶V⦶										29.730					
RS2	0229		W16	⊕	3/4	F-	146	38	38	↑↗	3		995											29.730	38.3	38.0		10	
✓	0235		W16	⊕⦶	3/4	F-				↑↗	3		995	W80⊕										29.730					
R	0328		W16	⊕⦶	3/4	F-	142	39	39	↑	2		994	W90⊕										29.710	39.4	39.1		10	
✓	0337		W5	⊕	5/8	F-					0		994											29.715					
RS3	0429		W7	⊕	1	R-F-	142	37	38	↑	3		994	60406 5009 37	6	.025		10T	W7	X		X		29.720	38.8	38.4		10	
✓	0458		W6	⊕	1	R-F-				↑↗	4		994											29.720					
R	0528		W6	⊕⦶	1	R-F-	142	39	39	↖↙	3		994	W90⊕ R+ INTMT										29.715	39.3	39.1		10	
✓	0557		W7	⊕⦶	1	R-F-				↙	3		994	W75⊕										29.720					
R	0628		W7	⦶⦶	1	R-F-	142	39	38	↑↖	4		994	W75⊕ ⦶V⦶ R- INTMT										29.720	38.8	38.5		10	
✓	0707		W7	⦶⦶	1	R-F-				↓↘	3		996	W75⊕ ⦶V⦶ R- INTMT										29.735					
RS4	0729		W25	⊕40⦶	1	F-	149	39	38	←	2		996	6⦶/ 403 5209	4	.015		15T V35→	E6 E40	10RS	W75	X		29.735	38.8	38.4		10	
✓	0758		W25	⊕40⦶	1½	F-				↓	2		997	ST ALG ALL HILLS VSBY VRBL ½ TO 1½ HIR CLDS VSBY										29.750					
RS5	0828		E43	⦶⦶	10	Rw-	156	39	38	↑↖	1		998	E75⊕ BRKS VSBY 1½ SE-SW F- RW- CAPPS ST										29.760	38.7	38.5		9+	
✓	0858		E40	⊕25⦶	10					↑↖	1		998	BRKS HIR CLDS VSB VSBY VRBL IN										29.760					
RS6	0928		E37	⊕37⦶	20		166	41	40	↗	2		000	BRKS HIR CLDS VSB DRETG ST PATCHES										29.775	40.7	40.2		9+	
✓	0958		E30	⦶⦶	20					↓	2		001	W65⦶ 26⦶ DRETG ST CIG RGD										29.770					
R	1028		E45	⦶⦶	20		166	44	42	↑↖	1		001	W65⦶27⦶/41104 5709 37	4	.065		E3C→ 23T→	E75 E23	9+BL	W65	X		29.771	43.2	43.0		9+	
✓	1058		E45	⦶⦶	20					←↙	1		002	E65⦶ BRKS 27⦶ RW STMA W										29.800					
RS7	1128		W47	⦶27⦶	20	RW-	173	47	45	↑↗	1		003	27⦶ RW- MOVG E										29.810	42.8	45.8		10	
✓	1158		W45	⦶⦶	20					↑↗	1		003	E60⦶ BRKS HIR CLDS VSB										29.810					
RS8	1228		W20	⦶/⦶	20		173	53	47	↑↗	2		003	45⦶ BRKS										29.810	51.8	49.3		9+	
✓	1255			⦶/85⦶	30					↘↘	1		003	45⦶ THN SPOTS BINOVC										29.810					
R	1328			⦶/90⦶	70		176	54	44	⇒	10		004	28⦶ BRKS / 403 5705 22	4	.030		E3C→ 23T→	E40 E32	9+BL 18C N	E30 E30	X		29.815	54.0	49.0		9+	
✓	1353			⦶/75⦶	70					⇒	12		005	60⦶ 25⦶ BRKS										29.820					
R	1428		E35	⦶/⦶	70		180	53	45	→↘	19		005	60⦶ RW W CIG RGD										29.820	53.2	46.0		10	
S9	1443		W32	⦶/⦶	70	RW-				→↘	19			60⦶ CIG RGD															

SUMMARY OF DAY (midnight to midnight)

Time of sunrise ____ Time of sunset ____

24-hr. Max. Temp. 56 °F. 24-hr. Min. Temp. 37 °F.

24-hr. Precip. (water equivalent) 0.10 in. 24-hr. Snowfall (melted) 0.0 in.

Total hours of fog: Light 6 Moderate 0 Heavy 1

Max. wind (5 min.) ____ (m.p.h., knots) Direction ____ Time ____

Extreme wind (fastest single mile) ____ (m.p.h., knots) Direction ____ Time ____

Peak gust ____ (m.p.h., knots) Direction ____ Time ____

Thickness of ice on water ____ in.

Ground frozen from ____ in. to ____ in.

HOURLY OBSERVATIONS

Time of Obs.	0410	1018	1620	2220	Midnight
Precip. (in.)	0.06	0.04	T	T	0.00
Snowfall (in.)	0.0	0.0	0.0	0.0	0.0
Snow Depth (in.)	T	T	T	T	T
Max. Temp.	39.8	43.7	56.0	52.7	43.3
Min. Temp.	37.3	37.4	41.2	40.2	37.8
Amt. R. Frozen					
Rel. Hum. %	96	94	79	97	
Soil Temp.					
State of Ground	4	4	4	4	

Time of Obs.	0410	1018	1620	2220
State of Sea and Dir.				
Swell Ht. and Dir.				
Swell Period				
Surf (L.L.E.F.D)				
Barometer Reading	29.700	29.780	29.925	29.940
Attached Thermometer	74.0	62.5	73.5	76.5
Observed Reading	29.811	29.886	29.926	30.051
Total Correction	-.091	-.075	-.091	-.099
	+.020	+.010	+.010	+.010

Remarks, Notes, and Miscellaneous Phenomena

Types of air masses and frontal passages determined from synoptic maps, severe storms, miscellaneous hydrometeors, Scods

F- Unofficial E0820P

K- Unofficial E0020

R- B0024 E0225 B0420 E0723

RW- B0220P E0925P B1128P E1328P

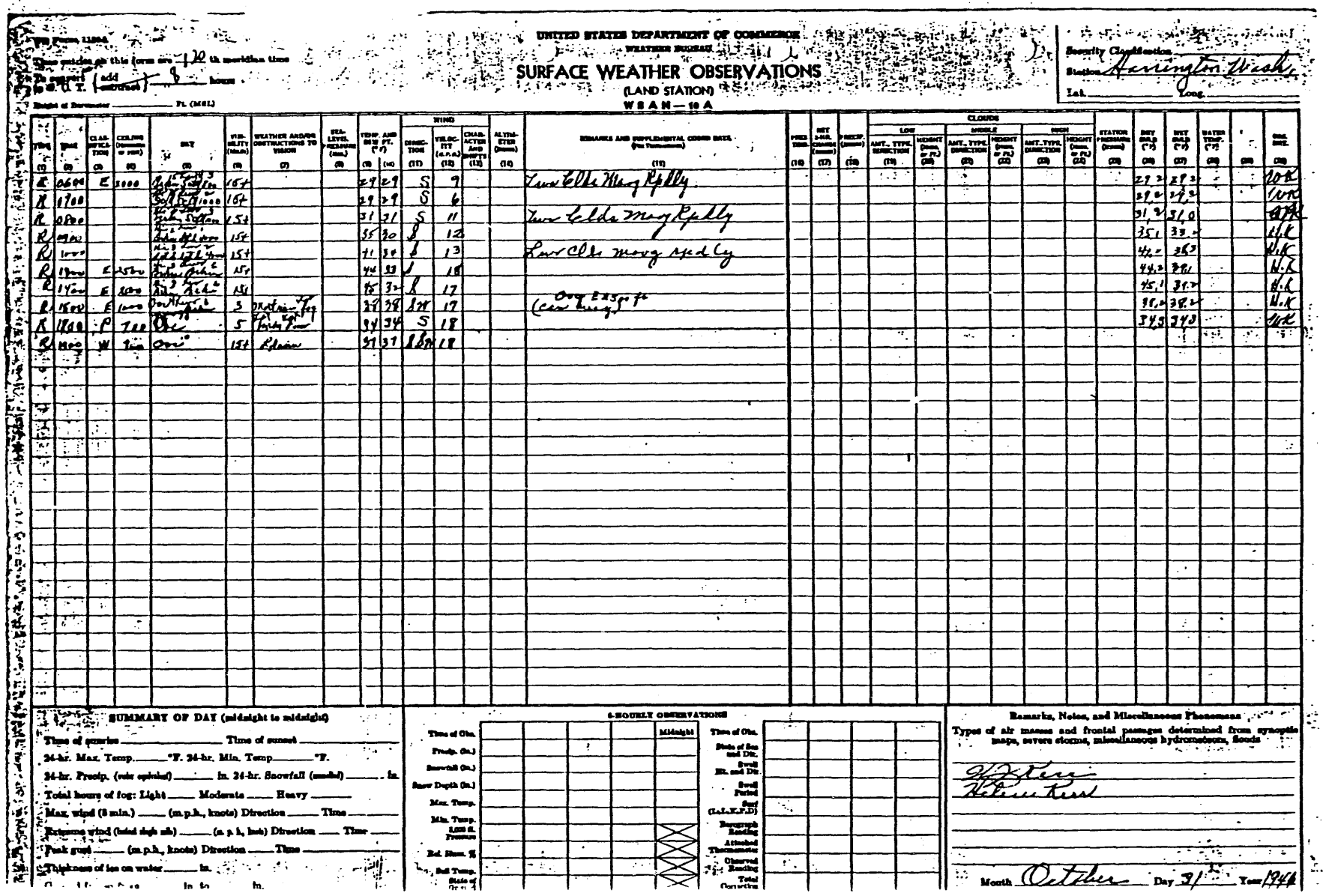
ZW- B1443P E1845

Few Pcks show DRETG GF K BIF

E+ B2333 E Unofficial

Month NOV Day 27 Year 1946

Figure 2.1. Legible Station Record (Dallesport, Washington, November 27, 1946)



UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU

SURFACE WEATHER OBSERVATIONS
(LAND STATION)
WBAN—10A

Security Classification
Station Harrington Wash.
Lat. Long.

Time watches on this form are 120th meridian time
To convert to G.C.T. (add subtract) 8 hours
Height of Barometer Ft. (MSL)

Day (1)	Time (2)	Class. (3)	Ceiling (Hundreds of feet) (4)	Sky (5)	Vis. (Miles) (6)	Weather and/or Obstructions to Vision (7)	Sea-Level Pressure (Inches) (8)	Temp. (°F) (9)	Dew Pt. (°F) (10)	Wind Direction (11)	Wind Vel. (m.p.h.) (12)	Char. Action (13)	Altimeter (Inches) (14)	Remarks and Supplemental Coded Data (Not Permanent) (15)	Pres. Tend. (16)	Net 3-hr. Change (Inches) (17)	Precip. (Inches) (18)	Low Amt., Type, Direction (19)	Low Height (Hundreds of Ft.) (20)	Middle Amt., Type, Direction (21)	Middle Height (Hundreds of Ft.) (22)	High Amt., Type, Direction (23)	High Height (Hundreds of Ft.) (24)	Station Pressure (Inches) (25)	Wet Bulb (°F) (26)	Dew Pt. (°F) (27)	Water Temp. (°F) (28)	(29)	Obs. Sig. (30)
R	0600	E	3000	[illegible]	15+			29	29	S	9			Low Clds Mag Rpdly											29.3	29.3			10R
R	1200			[illegible]	15+			29	29	S	6														29.0	29.3			10R
R	0800			[illegible]	15+			31	31	S	11			Low Clds Mag Rpdly											31.2	31.0			[illegible]
R	0900			[illegible]	15+			35	30	S	12														35.1	33.2			H.K
R	1000			[illegible]	15+			41	34	S	13			Low Clds Mag Rpdly											41.2	35.3			H.K
R	1300	E	2500	[illegible]	15+			44	33	S	18														44.2	39.1			H.K
R	1400	E	2000	[illegible]	15+			45	32	S	17														45.1	37.2			H.K
R	1500	E	1000	[illegible]	5	[illegible]		39	38	SW	17			Cloudy except for											38.2	38.2			H.K
R	1600	P	700	[illegible]	5	[illegible]		34	34	S	18														34.3	34.3			H.K
R	1900	W	700	[illegible]	15+	Haze		37	37	SW	18																		

SUMMARY OF DAY (midnight to midnight)

Time of sunrise _____ Time of sunset _____
24-hr. Max. Temp. _____ °F. 24-hr. Min. Temp. _____ °F.
24-hr. Precip. (rain equivalent) _____ in. 24-hr. Snowfall (melted) _____ in.
Total hours of fog: Light _____ Moderate _____ Heavy _____
Max. wind (5 min.) _____ (m.p.h., knots) Direction _____ Time _____
Extreme wind (total displ. mb) _____ (m.p.h., knots) Direction _____ Time _____
Peak gust _____ (m.p.h., knots) Direction _____ Time _____
Thickness of ice on water _____ in.

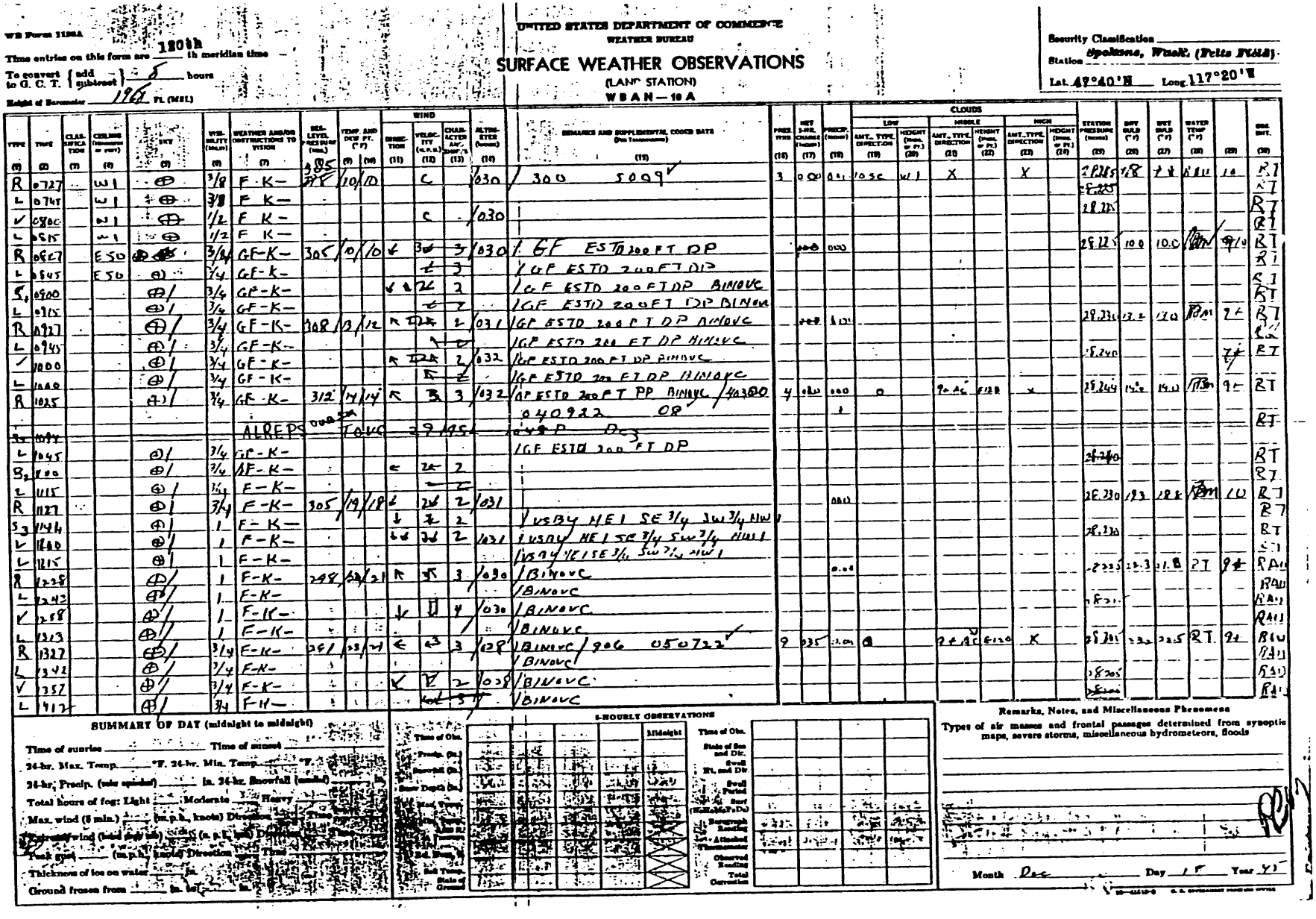
6-HOURLY OBSERVATIONS

					Midnight					
Time of Obs.						Time of Obs.				
Precip. (in.)						State of Sky and Dir.				
Snowfall (in.)						Swell Ht. and Dir.				
Snow Depth (in.)						Swell Period				
Max. Temp.						Surf (L.L.N.F.D)				
Min. Temp.						Barograph Reading				
SLPR H. Pressure						Attached Thermometer				
Rel. Hum. %						Observed Reading				
Soil Temp.						Total Correction				
State of Sky										

Remarks, Notes, and Miscellaneous Phenomena
Types of air masses and frontal passages determined from synoptic maps, severe storms, miscellaneous hydrometeors, floods

Month October Day 31 Year 1946

Figure 2.2. Station Record with Poor Legibility (Harrington, Washington, October 31, 1946)



WB Form 1130A

Time entries on this form are 120th meridian time

To convert to G. C. T. {add / subtract} 8 hours

Height of Barometer 1961 ft. (MSL)

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU

SURFACE WEATHER OBSERVATIONS
(LAND STATION)
WBAN—10A

Security Classification

Station Spokane, Wash. (Felts Field)

Lat. 47°40'N Long. 117°20'W

SUMMARY OF DAY (midnight to midnight)

Time of sunrise ____ Time of sunset ____

24-hr. Max. Temp. ____ °F. 24-hr. Min. Temp. ____ °F.

24-hr. Precip. (rain equivalent) ____ in. 24-hr. Snowfall (melted) ____ in.

Total hours of fog: Light ____ Moderate ____ Heavy ____

Max. wind (5 min.) ____ (m.p.h., knots) Direction ____ Time ____

Max. gust wind (hourly obs.) ____ (m.p.h., knots) Direction ____ Time ____

Peak gust ____ (m.p.h., knots) Direction ____ Time ____

Thickness of ice on water ____ in.

Ground frozen from ____ in. to ____ in.

3-HOURLY OBSERVATIONS

Remarks, Notes, and Miscellaneous Phenomena

Types of air masses and frontal passages determined from synoptic maps, severe storms, miscellaneous hydrometeors, floods

Month Dec Day 15 Year 45

Figure 2.3. Station Record with Crossed Out and Misplaced Numbers (Spokane, Washington, Felts Field, December 15 1945)

Until 2200 hours, September 25, 1945, data were recorded using Pacific War Time, then Pacific Standard Time was used. When War Time was used, one hour was subtracted so the database uniformly used Standard Time.

2.5 Uncertainties and Representativeness of Wind Data

Several factors lead to errors and uncertainties in the recorded wind data (both speed and direction). For example, anemometers may have systematic or random errors. Instruments can also record wind speeds distorted by nearby structures and/or the structure on which they are mounted. The second case is especially true for instruments mounted on building roofs. Spatial and temporal variations in wind fields also lead to limitations on the accuracy of wind data. Local topography tends to channel or block air flow or to generate local effects such as upslope and downslope winds. The station wind speed and direction may not be representative of the region surrounding the station. Additionally, 1-minute averages of wind speed and direction differ from the true average of the observation hour.

The fact that wind speeds are reported to the nearest mile per hour and that wind directions are reported to the nearest point of the compass (22.5 degrees) is, in part, a statement of the uncertainties in the data.

Because wind observations are within a few meters of the ground, they may differ from the winds at the height of the plume center. Ideally, transport modeling is done with the aid of winds measured at a number of heights up to the plume top. Unfortunately, no upper-level wind data are available in the RATCHET domain region for the period of interest.

2.6 Station Topography

The local topography of the HEDR stations has been assessed through an examination of U.S. Geographical Survey (USGS) 1:250,000 topographic maps and is included in the station descriptions in Section 3.0. The stations can be divided into three topographic categories:

- those in the large, flat region of the Columbia Basin, with no local topography sufficient to affect the wind flow
- those in mountainous regions, generally in the bottoms of basins or river valleys, that are expected to produce strong local effects
- stations in various intermediate situations.

Several of the HEDR stations are within the large, flat region of the Columbia Basin. This region slopes gradually upward from 150 to 210 meters (500 to 700 feet) on the Hanford reservation to 650 meters (2100 feet) near Spokane, approximately 190 km (120 miles) to the northeast. With the exception of the Saddle Mountains, which slice into the western part of the basin just north of Hanford, local variations in height are less than 100 meters or so (only a few hundred feet) and have

little effect on winds measured at the stations. Results from HEDR Phase I studies (Ramsdell and Burk 1991) indicate that maximum radionuclide deposition occurred within this basin. Therefore, the most significant doses calculated for HEDR will be based on wind fields over comparatively flat terrain and subject to relatively little small-scale spatial variability.

Most of the other stations are in the Cascade Mountains, Blue Mountains, or the mountains of Idaho. Most of these stations are located at airports that are in locally flat regions in river valleys or basins. In several cases, surrounding mountains rise a thousand meters or more (thousands of feet) above the station. Winds associated with large-scale weather systems (synoptic winds) are channeled or blocked by these local topographic features. Under conditions with weak synoptic winds, local temperature differences between the peaks and valleys generate upslope or downslope winds that are also channeled by local terrain. The winds observed at a station depend on the exact location of the station relative to local topography. Furthermore, winds may vary substantially between neighboring valleys and basins, depending on their geometry and orientation.

The Stampede Pass Station, located between two peaks at the summit of a mountain pass, is a unique case in which winds are strongly influenced by surrounding terrain. Winds at stations within mountainous regions are not very representative of the surrounding area, and winds in these regions are less resolved than in flatter terrain. For these reasons, transport within mountainous regions of the RATCHET domain is subject to much more uncertainty than transport within the Columbia Basin. Fortunately, these regions are less frequently involved in HEDR radionuclide transport calculation than the Columbia Basin.

Most other stations had topography between these two extremes. For example, Walla Walla is surrounded by rolling hills with high mountains to the southeast. Winds at stations in this category experience moderate amounts of local topographic influence and represent winds in some parts of their surroundings.

2.7 Statistical Representations of the Meteorological Data

Tables of statistical distributions of wind direction, wind speed, and wind direction during precipitation have been prepared for the HEDR stations. These distributions are also represented graphically using wind roses, wind speed histograms, and precipitation roses, respectively. The details of how these statistics are computed are discussed in this section. Data from HMS are also used here as an example.

Section 3.0 includes tables and graphs for all of the available data at each station in the HEDR database during the period December 26, 1944 through December 31, 1949. (As explained in Section 2.3, Spokane, Geiger Field is not used for RATCHET computations and, therefore, has had no statistics computed for it.) It must be emphasized that these statistics are based on the data in the database for each station. The observation periods are shorter than needed to estimate climatic statistics and some of the stations have periods of record that cause some seasons to be weighted more heavily than others. Thus, these statistics do not realistically represent the climates of the stations. They do, however, accurately represent the weather conditions that occurred in the RATCHET domain during the HEDR time period and, therefore, are useful for evaluating the conditions that

affected transport and deposition of radionuclides in HEDR. They are also helpful in evaluating conditions in the vicinity of each of the stations, including the effects of local topography. Section 3.0 includes text discussing local effects as seen in the roses and histograms.

Stage et al. (1993) presented preliminary wind roses for some of the HEDR meteorological stations based on data recorded at three-hour intervals and taken from the portion of the HEDR meteorological database available at the time of that report. For most stations, those preliminary wind roses are similar to the final HEDR wind roses shown in Section 3.0. However, due to the inclusion of additional data, the wind roses for some stations have changed significantly. The roses shown in this report are based on the final HEDR meteorological database. The roses shown in this final report should be used, rather than those from Stage et al. (1993) when considering the effects of meteorological conditions on concentration and deposition rates produced by RATCHET.

Maps of wind roses, wind speed histograms, and precipitation roses for the RATCHET domain are illustrated and discussed in Sections 2.7.1, 2.7.2 and 2.7.3.

2.7.1 Wind Direction Distributions and Wind Roses

The wind direction distribution tables show the percentage of the total number of hours of data that wind blew from each sector. The data are further divided into low wind (speed less than 6 mph) and high wind (speed greater than or equal to 6 mph) cases. For example, Table 2.2 indicates the wind at HMS had speeds less than 6 mph from the south-southwest (SSW) during 2.02 percent of the hours of data and winds from the south-southwest with speeds greater than or equal to 6 mph during 6.59 percent of the hours of data, so that a total of 8.61 percent of the hours had winds from the south-southwest. When all directions are considered, the table also shows the wind was greater than 6 mph for 61.36 percent of the total hours.

Data in the wind direction distribution are graphically represented by a wind rose. The direction of each of the petals of the wind rose indicates the wind direction and the length of the petal indicates the fraction of time the wind was from that direction. The thin parts of the petals shown near the center of the rose indicate the percentages for low wind speeds and the thicker parts near the outside indicate the percentages for high wind speeds. The combined lengths (thin plus thick parts) of the whole petals indicate the total percentage of the time the wind blew from each direction. For example, the wind rose in the upper left corner of Figure 2.4 shows the most common direction for winds at HMS was from the west-northwest.

A petal for calm conditions is shown at the lower left of the main wind rose. Of course, the calm wind petal of the wind rose cannot have a high wind speed part and is not a function of direction. As seen in the wind rose, calm conditions are rare at HMS.

Several of the stations (see, for instance, the Pasco wind rose in Section 3.0) show a telltale pattern. These stations have an alternation between low values on the eight main compass points (north, northwest, west, southwest, and so forth) and high values on the minor eight compass points (north-northwest, west-northwest, west-southwest, south-southwest, etc.). There is no physical process likely to produce this pattern, therefore, this condition probably represents an observer bias when visually averaging the wind direction. The data show that observers, when reporting the

Table 2.2. Hanford Meteorological Station Wind Direction and Wind Speed and Stability Distributions

HMS Wind Direction Distribution

Direction	< 6 mph	>= 6 mph	All Speeds
N	2.04	1.26	3.30
NNE	2.60	.79	3.39
NE	1.27	.24	1.51
ENE	2.51	.44	2.95
E	1.94	.25	2.19
ESE	2.62	1.01	3.63
SE	1.18	1.00	2.17
SSE	1.93	1.98	3.91
S	1.09	2.61	3.70
SSW	2.02	6.59	8.61
SW	1.40	5.75	7.15
WSW	3.10	8.64	11.74
W	2.48	13.94	16.43
WNW	4.60	12.56	17.16
NW	2.66	1.88	4.54
NNW	4.47	2.42	6.88
Calm	.73	.00	.73
All	38.64	61.36	

HMS Wind Speed Distribution

Speed (mph)	Stable	Neutral	Unstable	Missing	All Stabilities
0 <= S <= 2	3.92	.26	4.30	.00	8.49
2 < S <= 6	15.82	2.28	12.06	.00	30.16
6 < S <= 10	8.32	8.90	7.79	.00	25.01
10 < S <= 20	2.56	24.93	.00	.00	27.50
20 < S	.10	8.75	.00	.00	8.85
All Speeds	30.73	45.12	24.15	.00	

HMS Wind Direction Distribution During Precipitation

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	1.80	.11	.00	.74	.11	.00	2.75
NNE	1.38	.00	.00	.32	.00	.00	1.70
NE	2.01	.21	.00	.11	.00	.00	2.33
ENE	2.22	.21	.00	.00	.00	.00	2.44
E	3.18	.00	.00	.32	.00	.00	3.50
ESE	2.97	.11	.00	.85	.00	.00	3.92
SE	1.48	.21	.00	.32	.00	.00	2.01
SSE	2.65	.32	.00	.32	.00	.00	3.28
S	3.28	.11	.00	.21	.00	.00	3.60
SSW	6.46	.32	.00	.42	.00	.00	7.20
SW	5.93	.32	.00	.42	.00	.00	6.67
WSW	6.67	.21	.00	.64	.11	.00	7.63
W	7.95	.21	.00	8.69	.53	.00	17.37
WNW	14.62	.53	.00	7.10	.32	.00	22.56
NW	2.75	.53	.00	2.44	.00	.00	5.72
NNW	3.39	.32	.00	2.01	.00	.00	5.72
Calm	1.48	.00	.00	.11	.00	.00	1.59
All	70.23	3.71	.00	25.00	1.06	.00	

3.07% of hours had recorded precipitation.

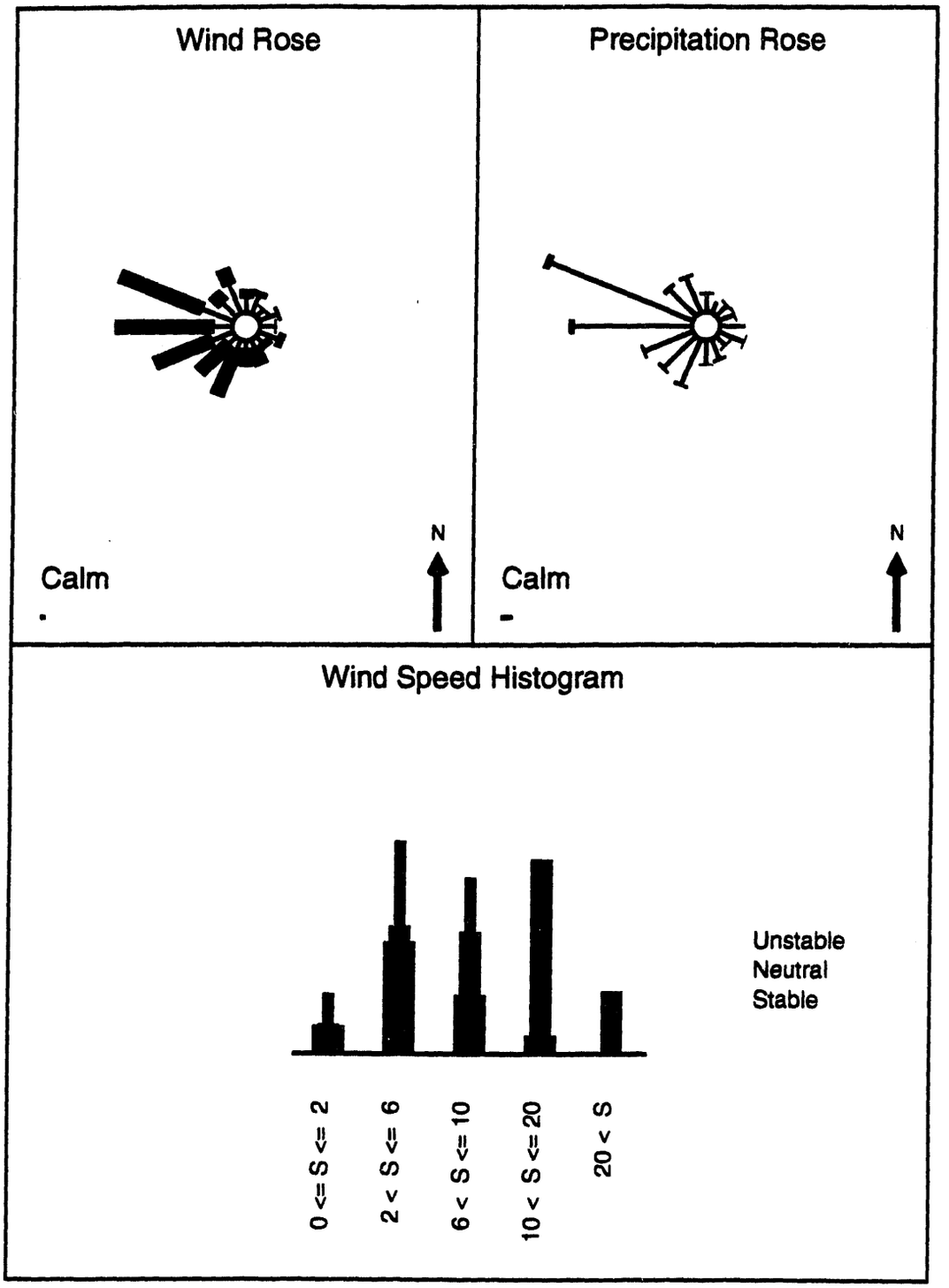


Figure 2.4. Hanford Meteorological Station Wind Rose, Precipitation Rose, and Wind Speed Histogram

average at several stations, favored wind directions with two lights on. If the observer saw the northwest light on during the entire averaging period and the west light on during some of the period, it seems plausible the observer was likely to report west-northwesterly winds, even if the west wind light was on somewhat less than half of the time. If true, such behavior would explain the pattern seen in these roses.

Because the HMS is near the radionuclide release point, meteorological data from this station are especially important in RATCHET calculations. As explained in Section 2.2, HMS used a strip chart to record wind direction during the entire hour and a careful averaging scheme rather than the light indicator panel and 1-minute visual averaging scheme used by the U.S. Weather Bureau. Nonetheless, a pattern of alternating high and low percentages is seen for most directions in both the low and high wind portions of the rose for HMS. The wind rose suggests that, despite the recording and averaging scheme at Hanford, some observer bias existed.

Stone et al. (1983, Table 17, p. V-4) tabulated the wind direction distribution for the 15.7-meter (50-foot) level at the HMS for hourly data from 1955 through 1980. This tabulation did not divide the distribution into high and low wind speeds. Figure 2.5 is a comparison of the HMS wind rose based on the HEDR data from December 1944 through December 1949 and the wind rose based on Stone et al. (1983). The Stone et al. (1983) rose is based on many more years of data than the HEDR rose and, therefore, is expected to be closer to the true climatological mean. The two roses are very similar. However, the pattern for 1944 through 1947 is shifted about one compass point

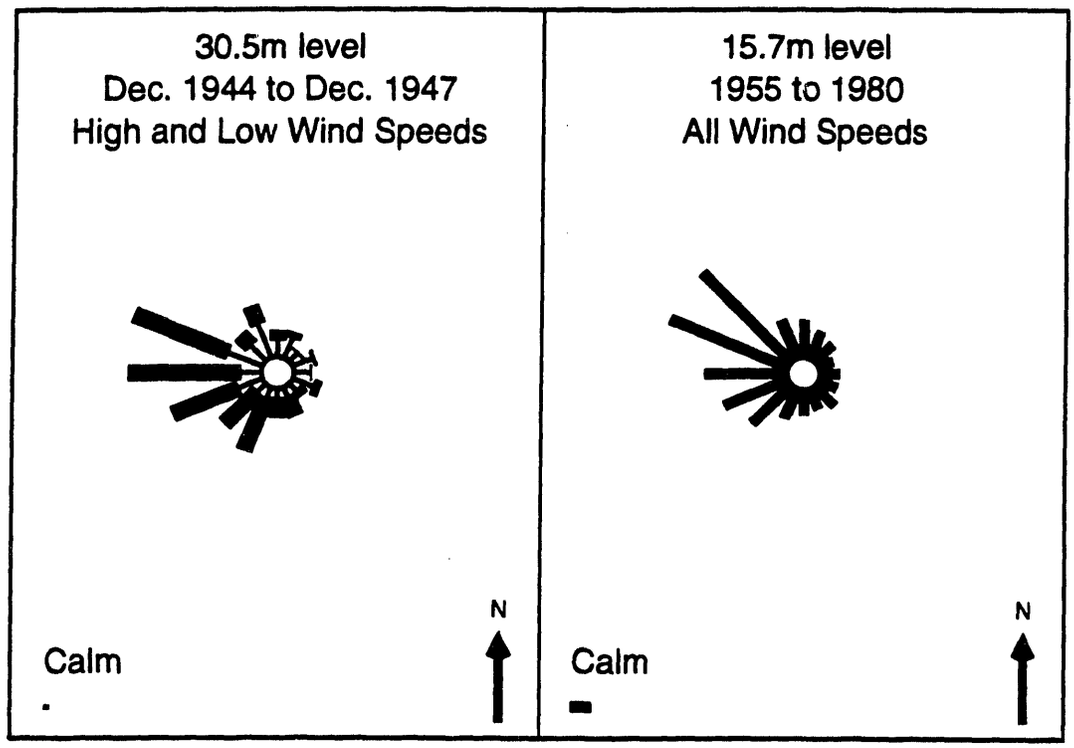


Figure 2.5. Wind Rose Comparison for HMS Between HEDR (left) and Stone et al. (1983) (right)

counterclockwise. Thus, the greatest wind frequencies were west-northwesterly and westerly, rather than northwesterly and west-northwesterly, as seen in the period 1955 through 1980. Some of this shift may be due to the differing measurement heights. The similarity of the two roses indicates that during the period of maximum release, near-normal wind directions were present at the Hanford Site

Looking at the low and high wind speed portions of wind roses can provide information on locally induced circulation patterns. For example, the comparison of the low wind part of the rose for HMS with the high winds part shows that easterly winds are more likely to occur during low wind speeds than during high wind speeds. The wind roses for Pasco and Ellensburg show even more dramatic differences between low and high speeds. (See Section 3.0 for illustrations of these wind roses.)

2.7.2 Wind Speed Distributions and Wind Speed Histograms

Wind speed distributions show the percentage of the time the wind speed at each station is within various categories. The categories used are less than or equal to 2 mph, greater than 2 mph and less than or equal to 6 mph, greater than 6 mph and less than or equal to 10 mph, greater than 10 mph and less than or equal to 20 mph, and greater than 20 mph. The categories are further divided to indicate the percentage of time the atmospheric stability, as computed by RATCHET (Ramsdell and Burk 1992), is stable, neutral, or unstable (Table 2.2). The technique for computing stability is similar to that reported by Ramsdell and Burk (1992); however, additional assumptions have been made to allow stability to be computed when one or more variables are missing. These details will be reported in the final report on RATCHET.

For example, Table 2.2 shows stable conditions with wind speeds greater than 10 mph and less than or equal to 20 mph comprised 2.56 percent of the total hours of data at HMS. Neutral conditions with wind speeds greater than 10 mph and less than or equal to 20 mph comprised 24.93 percent of the total hours. Unstable conditions with wind speeds greater than 10 mph and less than or equal to 20 mph comprised none of the hours. All stabilities with wind speeds greater than 10 mph and less than or equal to 20 mph comprised 27.50 percent of the total hours.

The information in the wind speed distributions can also be displayed graphically using a histogram, as shown at the bottom of Figure 2.4. The lengths of the thick parts of the bars near the bottom of the histogram indicate stable conditions, the lengths of medium width sections indicate neutral conditions, and the lengths of the thin sections near the top indicate unstable conditions. Data for those times when stability information was missing are not included in the histograms.

As can be seen in Section 3.0, the shapes of the histograms vary widely from station to station. Neutral conditions comprise a larger fraction of the high wind cases than of the low wind cases. This is a fundamental result of surface layer stability theory that has been designed into the Turner stability computation scheme used to compute the stabilities in this database (Ramsdell and Burk 1992).

2.7.3 Wind Direction Distributions During Precipitation and Precipitation Roses

The tables of wind direction distributions during precipitation are similar to the tables of wind directions, except that only times having recorded precipitation are considered. The tables are divided

into columns for precipitation type (liquid and frozen) and for intensity (light, moderate, and heavy). Precipitation roses are graphical representations of these same data, thus they are displays of which way the wind blows when it rains. The roses in this report have been simplified compared with the tables, by combining liquid and frozen precipitation into one graphical representation. Light precipitation is indicated by the thin parts of the petals near the center of the roses, moderate precipitation by the medium thickness portions of the petals, and heavy precipitation by the thick parts of the pedals near the outside of the rose.

Precipitation was recorded at HMS during 3.07 percent of the total hours. The part of Table 2.2 showing wind direction distributions during precipitation and the precipitation rose in Figure 2.4 (upper right corner of the page) indicate that precipitation was most likely to occur at HMS when the wind was from the west-northwest (22.56 percent of the total hours with precipitation).

Other statistics can be calculated from the values in the tables. Taking the percentage of the total hours having precipitation, multiplying by the percentage of the time that wind was from a particular direction during precipitation, and dividing by 100 gives the percentage of the total time that had precipitation and winds from that direction. For instance, 0.69 percent of the total hours of data at HMS had winds from the west-northwest and precipitation (3.07 percent times 22.56 percent divided by 100). Taking the percentage of the total time that had precipitation, dividing by the percentage of the time that wind blew from a particular direction and multiplying by 100 gives the percentage probability that precipitation occurred when the wind was from that direction. For example, a 4.02 percent probability of precipitation was the case at HMS when winds were from the west-northwest (0.69 percent divided by 17.16 percent times 100).

For most of the stations, the shapes of the precipitation rose and the wind rose are similar, indicating the shape of the wind roses is dominated by the distribution of wind directions, rather than by the dependence of the probability of precipitation on wind direction. The shape of the precipitation rose at a station is modified relative to the wind rose by the effects of local topography. Wind directions that tend to produce orographic lifting have relatively more precipitation, while those that produce sinking have relatively less. For some stations, the wind directions that prevail in the wind rose are less prevalent in the precipitation rose. For other stations, the prevailing wind directions are accentuated in the precipitation rose.

2.7.4 Discussion of Patterns Over the RACHET Domain

Tables 2.3, 2.4, and 2.5 summarize the wind speed, stability, and precipitation statistics for the meteorological stations. The column marked POP in Table 2.5 indicates the probability of precipitation (the percentage of the hours reporting precipitation).

Table 2.3. Wind Speed Summaries by Station

(Percentage of Total Number of Hours)

Stn	0<=S<=2	2<S<=6	6<S<=10	10<S<=20	20<S
HMS	8.49	25.90	25.67	28.61	11.33
ALW	15.52	40.47	22.37	18.86	2.79
BKE	12.79	40.60	23.44	20.47	2.70
BNO	17.74	45.13	24.51	12.03	.59
BON	51.10	31.56	11.38	5.88	.09
COL	48.17	39.12	9.76	2.87	.07
CON	2.61	26.39	32.35	34.31	4.34
DLS	14.85	30.38	17.79	27.57	9.41
EAT	13.98	27.81	30.11	21.43	6.67
ELN	17.22	30.96	11.03	17.97	22.81
EPH	7.61	31.89	32.57	25.57	2.37
HAR	9.31	20.81	32.17	33.85	3.86
LAC	22.74	36.87	21.10	17.81	1.49
LWS	16.08	51.11	19.44	10.85	2.53
MWH	10.92	33.50	28.20	24.26	3.12
OMK	38.42	35.68	17.88	7.74	.28
ONO	16.64	38.51	22.15	17.07	5.64
PDT	8.11	39.98	24.23	20.86	6.81
PSC	30.25	24.30	20.44	17.23	7.78
SFF	11.11	45.99	22.59	17.58	2.72
SKA	7.61	26.93	31.16	27.92	6.39
SMP	3.90	14.99	24.53	47.02	9.56
RDM	8.81	36.54	25.36	24.99	4.30
YKM	14.29	45.20	27.63	10.64	2.23

Table 2.4. Wind Stability (All Speeds) by Station

(Percentage of Total Number of Hours)

Stn	Stable	Neutral	Unstable
HMS	30.73	45.12	24.15
ALW	27.78	38.06	34.16
BKE	24.13	38.67	37.20
BNO	31.84	27.25	40.91
BON	29.15	33.38	37.46
COL	38.58	21.95	39.47
CON	17.60	56.24	26.16
DLS	20.24	48.10	31.66
EAT	28.21	53.16	18.63
ELN	22.36	51.90	25.74
EPH	23.09	44.00	32.91
HAR	28.67	58.59	12.74
LAC	26.47	37.30	36.23
LWS	31.54	29.22	39.24
MWH	27.31	39.75	32.93
OMK	27.06	37.81	35.13
ONO	28.09	41.03	30.88
PDT	26.62	37.58	35.79
PSC	38.71	31.92	29.38
SFF	27.02	35.72	37.26
SKA	17.28	57.85	24.87
SMP	12.16	73.48	14.36
RDM	21.81	41.98	36.22
YKM	30.85	28.33	40.82

Table 2.5. Probability of Precipitation by Station

(Percentage of Total Number of Precipitation Hours)

Stn	POP	Light	Moderate	Heavy
HMS	3.07	95.23	4.77	.00
ALW	10.87	97.82	1.91	.27
BKE	10.79	96.73	2.91	.36
BNO	11.87	96.21	2.80	1.00
BON	28.43	80.04	15.58	4.38
COL	21.03	70.83	25.67	3.50
CON	12.35	99.88	.13	.00
DLS	10.10	98.90	.93	.16
EAT	7.74	93.78	6.14	.08
ELN	10.63	97.39	2.31	.30
EPH	6.84	97.54	2.13	.33
HAR	7.85	91.77	8.23	.00
LAC	11.17	98.33	1.51	.16
LWS	11.54	98.89	1.08	.03
MWH	5.12	96.75	2.85	.41
OMK	16.74	82.55	12.74	4.71
ONO	8.53	97.76	2.10	.14
PDT	9.91	98.16	1.52	.32
PSC	5.30	97.97	2.03	.00
SFF	13.66	98.92	.94	.14
SKA	13.85	95.41	4.07	.52
SMP	36.13	94.86	4.15	.99
RDM	7.21	98.57	1.02	.41
YKM	6.86	98.81	1.03	.17

Figures 2.6, 2.7, and 2.8, respectively, show maps of wind roses, wind speed histograms, and precipitation roses for the RACHET domain. The centers of the roses and histograms are placed as near the station locations as possible, without allowing the symbols to collide. The large variability between stations will be discussed in Section 3.0. However, this discussion is limited to some general patterns in the wind flow.

At Hanford and to the west and northwest (that is, at HMS, the Yakima, and the Wenatchee Stations), the prevailing flow is generally from the west. North of Hanford at Ephrata, the wind rose shows a broad maximum flow from the west to north, and Larson AFB shows a broad maximum for flows from the north-northwest through southwest to south-southeast.

In the upper part of the Columbia Basin (northeast of Hanford) the Harrington, LaCrosse, and Spokane (Felts Field) Stations show remarkably bimodal wind direction distributions with maxima from the west-southwest and from the north-northeast. At all three of these stations, the west-southwesterly lobe is dominated by high wind speeds. For Spokane (Felts Field) and LaCrosse, the north-northeasterly lobe is dominated by low wind speeds. At Pasco just south of Hanford, the wind rose has a maximum from the west-southwest similar to that seen in the upper basin, but no corresponding lobe from the east-northeast.

These components indicate the prevailing wind flow into the Columbia Basin is from the west or northwest continuing out into the basin and then swinging toward the northeast. This general flow pattern is expected to be the dominant factor in determining the shape of the concentration and deposition plumes computed by RATCHET.

The other stations show considerable variation in wind roses. These stations are located in regions with strong local topographic effects. Fortunately, they are farther from the region of the expected plume center and are expected to have less influence on RATCHET computations than the stations already discussed.

Little or no pattern is discernible in the wind speed histograms. However, it is noted that HMS is one of the windiest stations in the HEDR domain. HMS had winds above 20 mph for 11.33 percent of the data, a value exceeded only by Ellensburg (22.81 percent). HMS winds were above 10 mph for 39.94 percent of the total hours (adding the 10 to 20 mph percentage to the over 20 mph percentage), thus ranking third behind Stampede Pass (56.58 percent) and Ellensburg (40.78 percent).

Figure 2.9 shows a map of average annual precipitation amounts in Washington State (van der Leeden and Troise 1974). The chief features of interest to HEDR have been described by van der Leeden and Troise (1974, p. 935) as follows:

> **Warming and drying of air as it descends along the lee (eastern) slopes of the Cascade Range results in near desert conditions in the lowest section of the Columbia Basin. Another orographic lifting of the air occurs as it flows eastward from the lowest elevations of the Inland Basin towards the Rocky Mountains. This lifting of air results in a gradual increase in precipitation from the lowest section of the basin to the higher elevations along the eastern border of the State.**

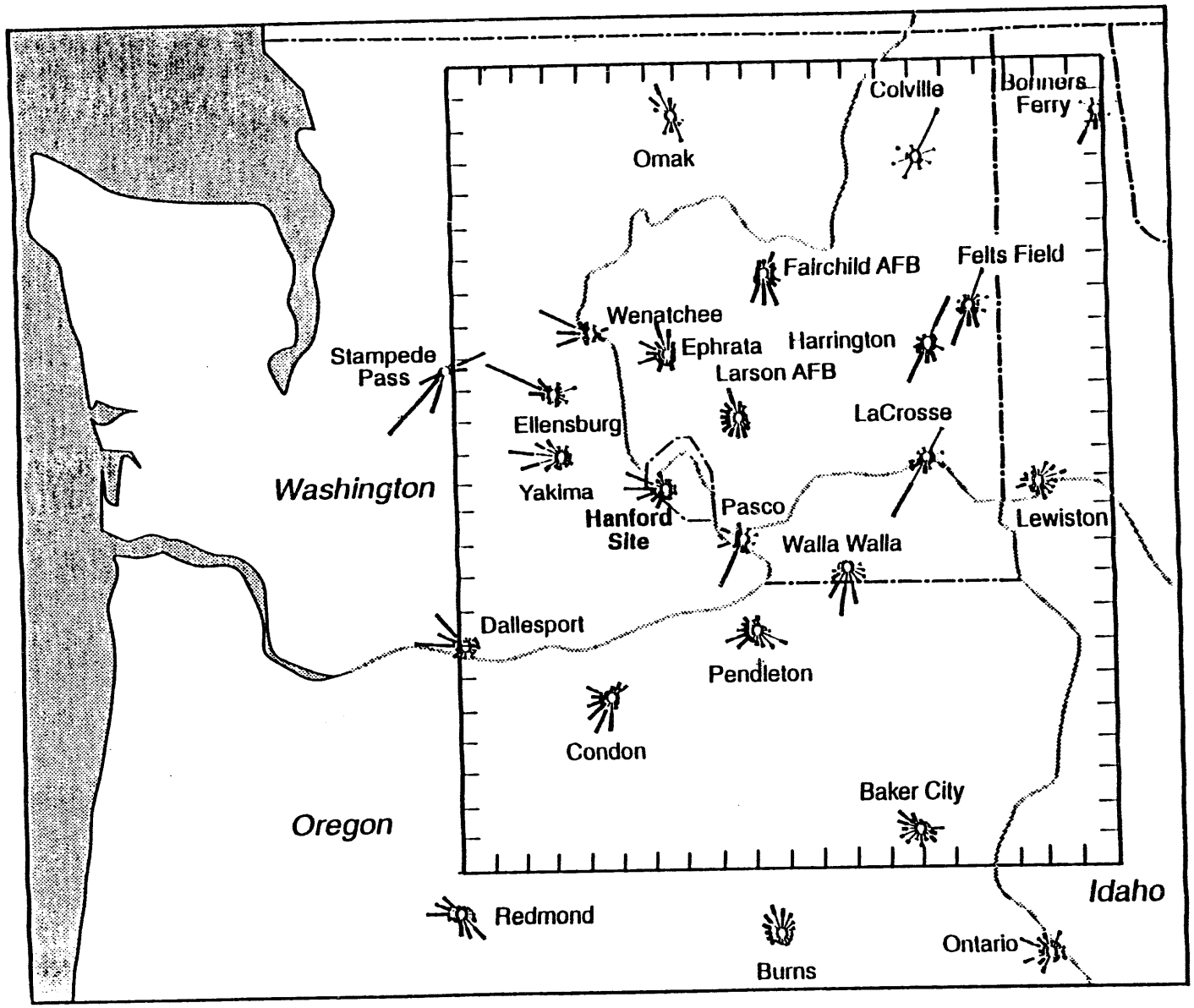


Figure 2.6. HEDR Domain Map of Wind Roses

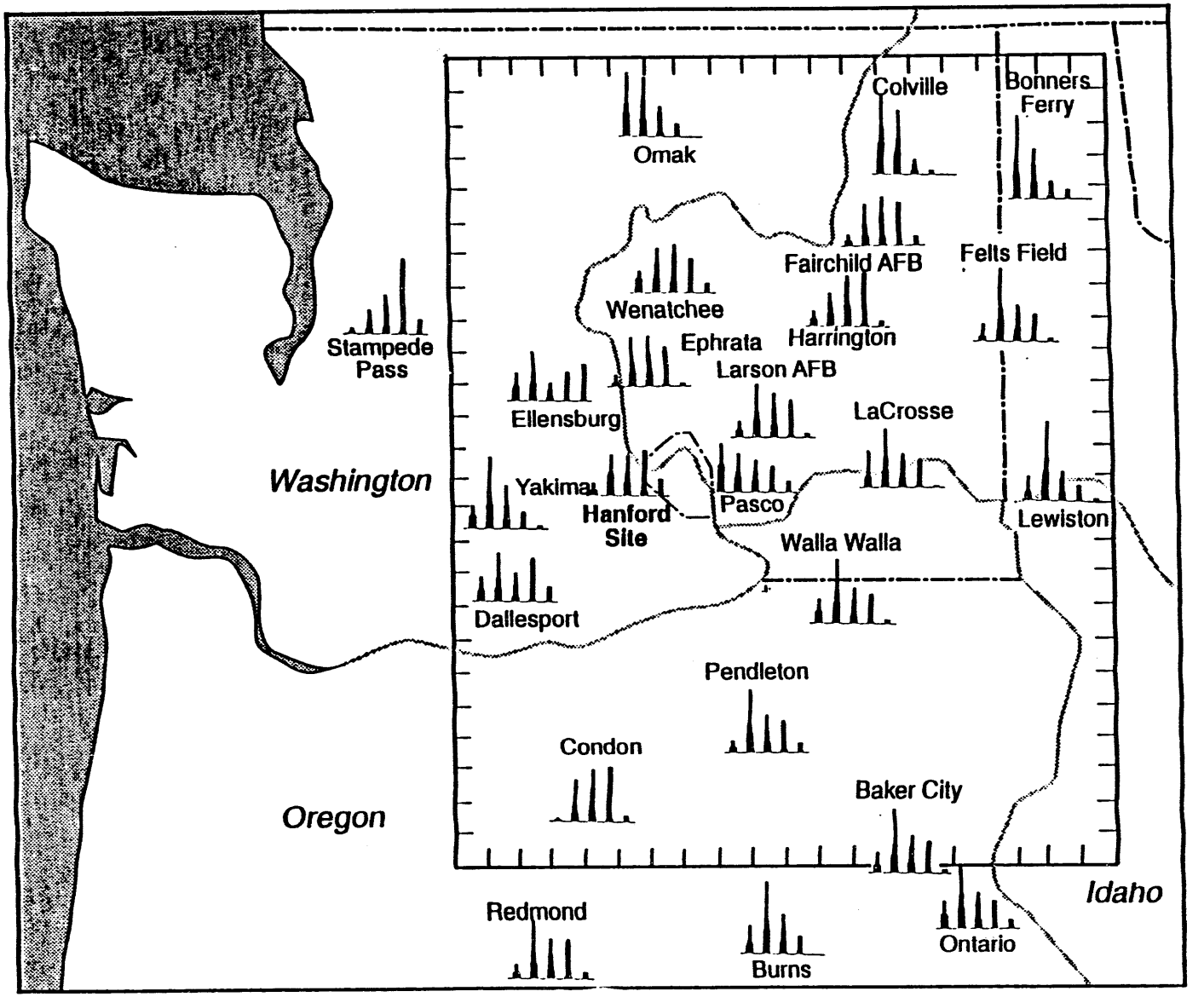


Figure 2.7. HEDR Domain Wind Speed Histograms

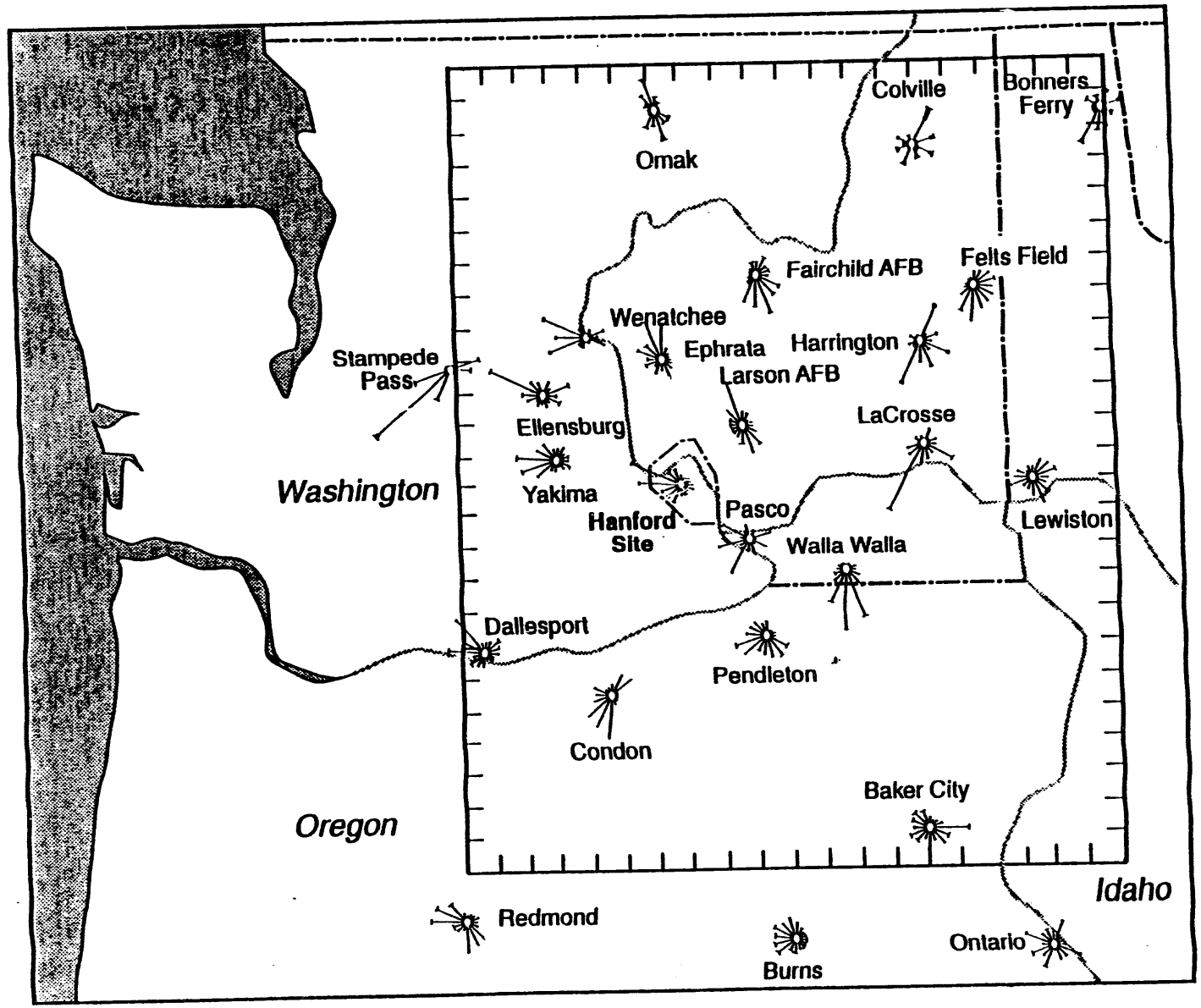


Figure 2.8. HEDR Domain Precipitation Roses

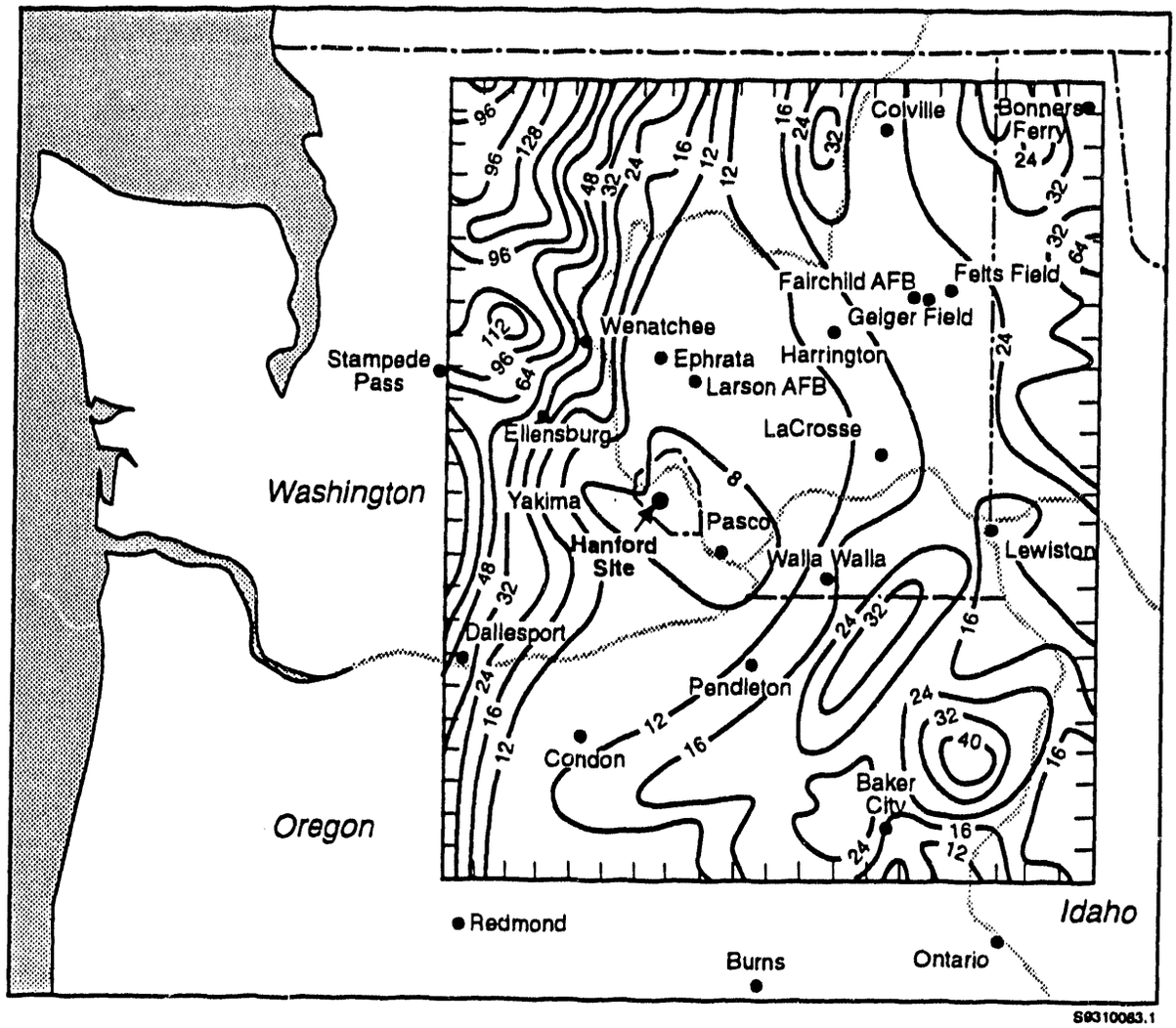


Figure 2.9. Average Precipitation (Inches), RATCHET Domain (U.S. Department of Commerce 1968)

The result is that isohyets (contours of equal mean rainfall) in eastern Washington approximately parallel the elevation contours.

Table 2.5 and Figure 2.9 show the driest portion of the region is near HMS with less than 8 inches of rain per year and only 3.07 percent of the hours showing precipitation. Pasco is nearly as dry with rain during only 5.30 percent of the total hours. Moving northeastward across the Columbia Basin toward Spokane and higher elevations shows an increase in the percentage of total hours of precipitation corresponding to the orographically induced increase in rainfall as seen in Figure 2.9. The book by van der Leeden and Troise (1974) gives the annual mean precipitation at Geiger Field in Spokane as 17.19 inches, and Table 2.5 shows precipitation for 13.85 percent of the total hours at

Fairchild AFB in Spokane. The maximum probability of precipitation for the meteorological stations in the HEDR domain is at Stampede Pass with 36.13 percent of the total hours having precipitation.

Table 2.5 also shows the vast majority of the precipitation occurring in the RATCHET domain is light and that moderate and heavy precipitation are rare in the Columbia Basin. No episodes of heavy precipitation were recorded at HMS during the period of interest and only 46 hours of moderate precipitation were reported out of a total of more than 30,000 hours of data.

2.8 HEDR Data Quality Objectives

This section evaluates the quality of the database as defined for the atmospheric model database. Specific data quality objectives required for this task are shown in bold print.

> **Accuracy — The objective is that the database contain the same information as recorded by the stations. Data entry accuracy criteria will be established by evaluating model sensitivity to data entry errors. A representative subset of the data will be examined to determine data entry accuracy. Data entry errors identified during the examination will be corrected; more extensive data checks will be made if data entry accuracy falls below an acceptable level. (Shipler 1993, p. 5.19).**

All data for December 1944 through 1949 were entered and checked for quality. The only exceptions are the two previously mentioned Spokane stations. Also, 1948 and 1949 data for Bonners Ferry, Colville, and Omak have not been entered into the database. These stations had four or fewer observations per day and are near the northern boundary of the RATCHET domain in a region not expected to have significant doses associated with the low releases during 1948 and 1949. As a further quality check to ensure against any large errors, the spatial and temporal meteorological patterns of the data were plotted and examined. Based on these checks, the HEDR meteorology database meets the QA objective which states the database needs to be an accurate reproduction of the historical record (Shipler 1993).

An initial data entry check compared more than 6720 wind speed and direction entries in the database against original records. Data entry errors in wind speed, direction, or both were detected for 17 hours; the error rate was 0.25 percent. When data entry errors in either speed or direction were considered separately, the error rates were smaller. Many of the detected data entry errors were as small as one of the units in which the data were recorded. The data entry errors in wind speed were most frequently 1 mph/kn and never more than 2 mph/kn. For 5 out of 12 detected errors, the wind direction was off by 1 compass point, and 4 were off by 2 points.. Because these errors have a relatively small effect on plume transport, only 3 errors (0.04 percent) were considered significant. In addition, during a 3-month period, wind data for one station were offset by 1 hour. This offset was caused by an error in applying the conversion from War Time to Standard Time. This error was specific to this 3-month time period and did not affect other periods.

A second check was made to further determine the frequency of data entry errors in wind speed and wind direction and to check for errors in precipitation, cloud cover, and ceiling. Data were examined for one randomly chosen day of each month during 1945 at each of 10 selected stations.

The stations used were Walla Walla, Colville, Dallesport, Ephrata, Harrington, LaCrosse, Larson AFB, Omak, Fairchild AFB, and Yakima. Values in the database for a total of 2026 hours of data were compared with the original records, or approximately 3 percent of the data for these stations during 1945.

The greatest error rate detected was 0.7 percent (less than 1.3 percent with 99 percent confidence) for wind direction. The majority of these errors were plus or minus one or two sectors and represent mistakes in interpreting wind arrows on the written records and converting them into direction codes. The rate of direction errors greater than two sectors was 0.2 percent (less than 0.6 percent with 99 percent confidence). One of these errors was a reversal of the wind direction.

The error rate for wind speed was 0.2 percent (less than 0.6 percent with 99 percent confidence). Most of these errors were plus or minus 1 or 2 knots. One error (0.5 percent) was found where the previous hour's wind was entered rather than reporting the value as missing. No wind speed errors greater than 2 knots were found.

Errors were found in 0.4 percent (less than 0.9 percent with 99 percent confidence) of the precipitation data. Some of these errors were errors in entering the precipitation type (for instance, reporting light snow instead of light snow showers) that have no effect on the precipitation amount or on concentrations computed by RATCHET. The remainder of the errors were situations in which light precipitation was omitted from the database. No cases were found in which moderate or heavy precipitation was omitted or incorrectly entered.

Cloud cover and ceiling had an error rate of 0.4 percent (less than 0.9 percent with 99 percent confidence). Nearly all of these errors have no impact on the stability class computed by RATCHET and, therefore, have no impact on computed concentrations. Only one error (0.4 percent, less than 0.9 percent with 99 percent confidence) changed the stability class, and then by only one stability class.

The number of points tested in this check for data entry errors is sufficient to state with 99 percent confidence the error rate of any of the variables larger than those detected by this check is less than 0.2 percent.

Based on these two data quality checks, the number of data entry errors is considered small and the errors themselves are generally small in amplitude. The uncertainty introduced into the database by data entry errors is much less than the uncertainties used in RATCHET to simulate uncertainties in the wind field and other meteorological parameters. Therefore, data entry errors will have an undetectable effect on concentrations and uncertainties computed by RATCHET. Thus, the meteorological database meets the HEDR data quality objective for accuracy.

All errors detected in these checks have been corrected in the database. The only exceptions are that data for 1948 and 1949 for Bonners Ferry, Colville, and Omak have not been entered into the database. These stations had four or fewer observations per day and are near the northern boundary of the RATCHET domain in a region not expected to have significant doses associated with the low releases during 1948 and 1949. As a further quality check to ensure against any large errors, the spatial and temporal meteorological patterns of the data were plotted and examined. Based on these

checks, the HEDR meteorology database meets the QA objective (Shipler 1993) which states the database needs to be an accurate reproduction of the historical record.

Precision — The objective is that uncertainties in the data be estimated from historical records and analysis of instrumentation and recording practices insofar as possible (Shipler 1993, p. 5.19).

The meteorological observation techniques used by the U.S. Weather Bureau stations and by HMS have been addressed in previous sections which present qualitative statements of the uncertainties in the data. An uncertainty also is associated with the fact that wind data from stations in mountainous regions do not fully represent the wind in the vicinity.

Completeness — The objective is to identify and obtain sufficient meteorological data from national meteorological data archives to reconstruct dispersion of radionuclides released from Hanford. Completeness will be measured by professional judgment (Shipler 1993, p. 5.19).

Hanford meteorological data records and data indices of the National Climatic Data Center have been searched to identify meteorological data available for use in HEDR atmospheric dispersion calculations. The available data have been identified and obtained. A subset of these data were used for dispersion calculations in Phase I of the HEDR Project. Additional data have been entered for use in future calculations. It is our judgment that these data are sufficient to reconstruct dispersion of radionuclides from Hanford.

Representativeness — The objective is that the database represent the known available Hanford and regional meteorological information (Shipler 1993, 5.19).

The meteorological database being prepared for use in the HEDR Project contains sufficient data to reproduce the general wind patterns for the region of interest. It contains all of the Hanford data for the period of interest and most of the data available from the National Climatic Data Center. In addition, meteorological data may be available from other sources. However, prior to using data from another source, it is necessary to establish the data quality. HEDR Project personnel believe it is unlikely that additional meteorological data would cause any large changes in the results of the atmospheric dispersion calculations.

3.0 Descriptions of Meteorological Stations

This section contains information sheets for each of the stations in the HEDR meteorological database. Except as noted, this information was obtained from Changery (1978). Figures for the wind roses, precipitation roses, and wind speed histograms, and the tables for the wind direction distribution, wind speed and stability distribution, and wind direction during precipitation are also given. (See Section 2.7 for an explanation of these figures and tables.)

3.1 Explanation of Data Sheets

The information contained on each of the data sheets is as follows:

Station: identifies the station name and abbreviation.

Type: describes the type of station (for example, Supplemental Aviation Weather Reporting Station or Air Force Base).

Location: details the latitude, longitude, and elevation above mean sea level of this station.

Measurement height: indicates the height of the wind instruments above the ground in meters and feet.

Instrument mounted: describes the type of structure on which the instruments were mounted, such as on the roof of a building.

HEDR environmental grid coordinates: gives the X and Y coordinates of this point on the RATCHET model environmental grid, as it is being used for the HEDR Project.

Data source: describes whether data obtained from the National Climatic Data Center Archive were microfiche, photocopies, or magnetic tape. NWDI refers to the National Wind Data Index (Changery 1978).

Data availability: explains how frequently and on which dates the data were taken at this station. In a few cases, magnetic tapes were obtained from the National Climatic Data Center for periods not listed in the NWDI.

Missing data: identifies historical periods for which data are not available. In most cases, this indicates that observations were not taken or, for other reasons, did not enter the archive. In a few cases, the missing data notation indicates that records in the archives were not legible. In addition to those noted, stations that recorded hourly data have an occasional hour of missing data. This total is no more than 5 hours per year per station. Stations with 6-hourly synoptic observations have more missing hours, such as Colville, with a total of 34 missing hours in 1946. This information was obtained from the data.

Local topography: provides a brief description of the topography near the station. The emphasis is on features that may affect air flow at the station. These descriptions are based on subjective evaluations of the station location using USGS 1:250,000 topographical maps.

Station moved: provides dates that stations were moved to new locations, followed by the new location or measurement height. (Most stations were moved to a new location or instrument mounting heights were changed at least once during the period of interest.) Information on station and instrument moves that occurred after 1949 is provided for completeness.

Wind roses: a brief description is given of the chief features of the wind direction distribution and the wind rose. Comments on the wind speed histograms and the precipitation roses are also given for a few stations. (See Section 2.7.)

3.2 Descriptions of Stations in the HEDR Meteorological Database

Each of the stations in the HEDR meteorology database is described in the subsections that follow. Stations within each state are listed alphabetically.

3.2.1 Station: Colville, Washington (COL)

Type: Not determined.

Location: 48:32:00N 117:53:00W 573 meters (1879 feet) elevation.

Measurement height: 11 meters (36 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 14.30, Y = 24.25.

Data source: Paper copy for 1944 through 1949.

Data availability: 4 observations per day 1944 through 1947.

Missing data: A total of 34 hours of data was missing in 1946. These were mostly scattered single hours. No data 4/7-8/47 and 5/29/47.

Local topography: This station is located in a narrow basin formed by the Colville River and several small creeks and rivers. It is surrounded by peaks that rise about 600 meters (2000 feet) above the basin floor.

Station was moved: 1/61 Measurement height: 9.1 meters (30 feet).

Station was moved: 8/66 Measurement height: 9.5 meters (31 feet).

Station was moved: 7/74 Measurement height: 10.1 meters (33 feet).

Wind roses: Of all the HEDR stations, Colville and Bonners Ferry (Idaho) were the most strongly influenced by the hesitancy to report winds having one of the eight major compass points (see Section 2.7.1). This station is the least windy HEDR station with winds calm 21.27 percent of the total hours and less than 6 mph during 87.29 percent of the hours. The maximum of the wind rose is for north-northwesterly winds. Figure 3.1 illustrates the wind rose, precipitation rose, and the wind speed histogram for this station. Table 3.1 summarizes the wind direction and wind speed and stability distributions.

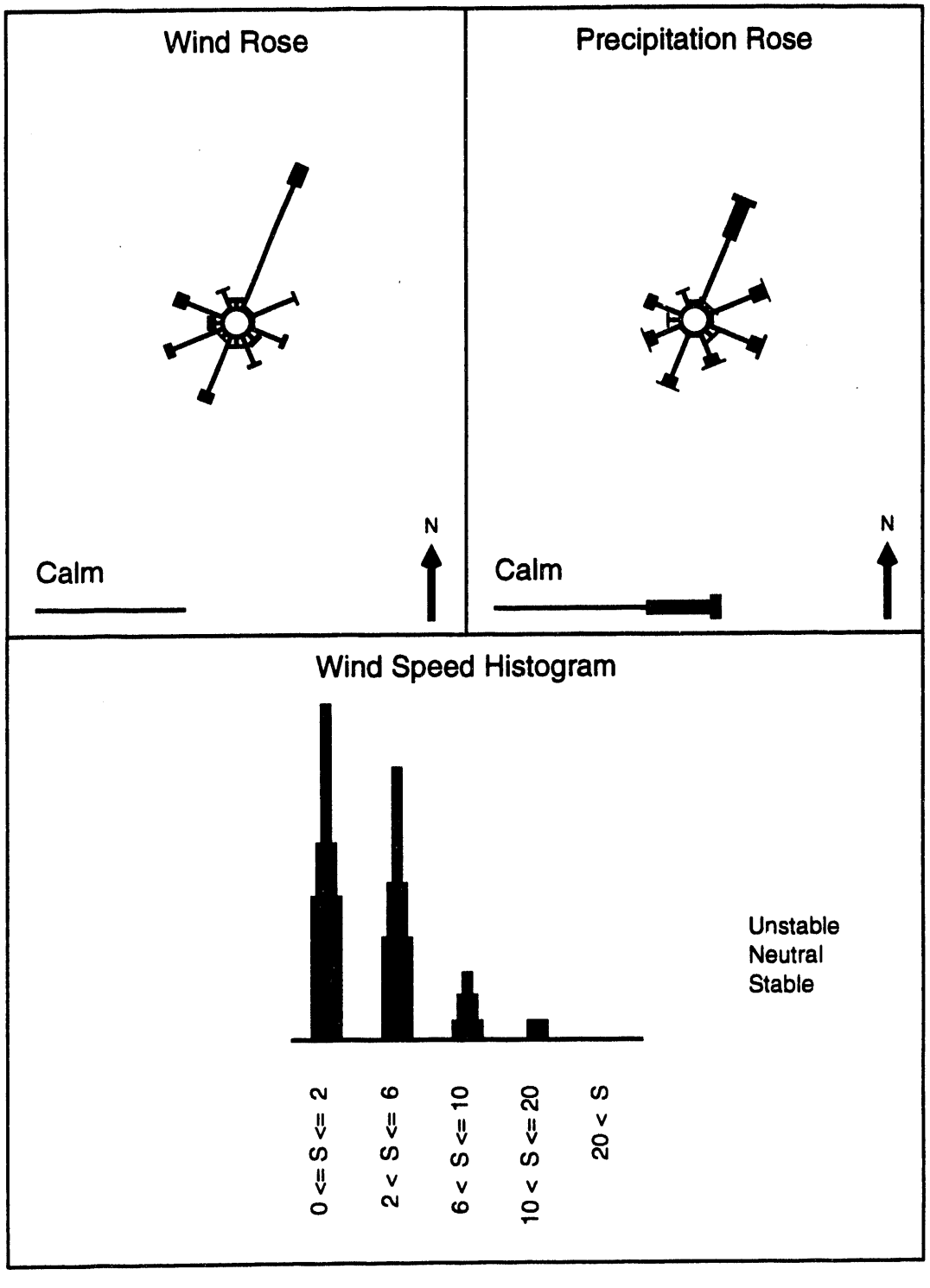


Figure 3.1. Colville Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.1. Colville Wind Direction and Wind Speed and Stability Distributions

COL Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	.91	.64	1.55
NNE	19.13	3.19	22.32
NE	.54	.05	.59
ENE	6.72	.32	7.04
E	.44	.12	.56
ESE	4.86	.61	5.47
SE	1.25	.71	1.96
SSE	4.29	.47	4.76
S	1.18	.44	1.62
SSW	8.63	1.47	10.11
SW	.83	.17	1.01
WSW	7.63	1.13	8.76
W	1.01	1.10	2.11
WNW	5.49	1.84	7.33
NW	.22	.15	.37
NNW	2.89	.29	3.19
Calm	21.27	.00	21.27
All	87.29	12.70	

COL Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	20.73	7.65	19.79	48.17
2 < S <= 6	14.77	7.90	16.46	39.12
6 < S <= 10	2.87	3.68	3.21	9.76
10 < S <= 20	.22	2.65	.00	2.87
20 < S	.00	.07	.00	.07
All Speeds	38.58	21.95	39.47	100.00

COL Wind Direction Distribution During Precipitation

21.03% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	.58	.12	.00	.00	.12	.00	.82
NNE	8.28	3.85	.58	2.22	1.52	.23	16.69
NE	.70	.00	.00	.00	.00	.12	.82
ENE	5.83	1.75	.00	.82	.47	.12	8.98
E	.35	.23	.00	.00	.00	.00	.58
ESE	5.72	1.52	.12	.58	.23	.23	8.40
SE	1.17	.23	.12	.12	.00	.00	1.63
SSE	2.68	1.05	.23	.82	.23	.00	5.02
S	.12	.00	.00	.12	.23	.00	.47
SSW	5.25	.93	.12	1.40	.58	.00	8.28
SW	.12	.00	.00	.00	.23	.00	.35
WSW	2.57	.93	.00	1.52	.47	.12	5.60
W	1.05	.23	.00	.70	.00	.00	1.98
WNW	2.68	.58	.00	1.40	.82	.00	5.48
NW	.12	.00	.00	.00	.00	.00	.12
NNW	1.75	.23	.00	.58	.00	.00	2.57
Calm	12.25	4.90	.23	9.34	4.20	1.28	32.21
All	51.22	16.57	1.40	19.60	9.10	2.10	

3.2.2 Station: Dallesport, Washington (DLS)

Type: Flight Service Station

Location: 45:37:00N 121:09:00W 72 meters (236 feet) elevation.

Measurement height: 12.5 meters (41 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 1.34, Y = 7.46.

Data source: Paper copy for 1944 through 6/48.
Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour 12/44 through 12/47.

Missing data: No data 5/28/45, 5/29/45, 7/9/45. Bad copies 5/20-21/46. No data May and June 1946.

Local topography: This station is located near the center of the Columbia River Gorge where the river has carved a narrow east-west passage through the Cascade Mountains. This station is on a small flat region located at the Dalles Airport, Dallesport, Washington, across the river from the town of The Dalles, Oregon. Between 600 and 900 meters (2000 and 3000 feet) below the surrounding terrain and no more than 8 to 16 kilometers (5 to 10 miles) wide, the gorge strongly channels winds. Strong winds are frequently produced in the gorge by synoptic pressure gradients and by thermal pressure gradients between the east and west sides of the Cascades.

Station was moved: 3/61 Measurement height: 6.1 meters (20 feet).

Wind roses: High-speed westerly or northwesterly winds up the Columbia Gorge are most common here. Low speed winds are remarkably uniform in their distribution. Figure 3.2 illustrates the wind rose, precipitation rose, and the wind speed histogram for this station. Table 3.2 summarizes the wind direction and wind speed and stability distributions.

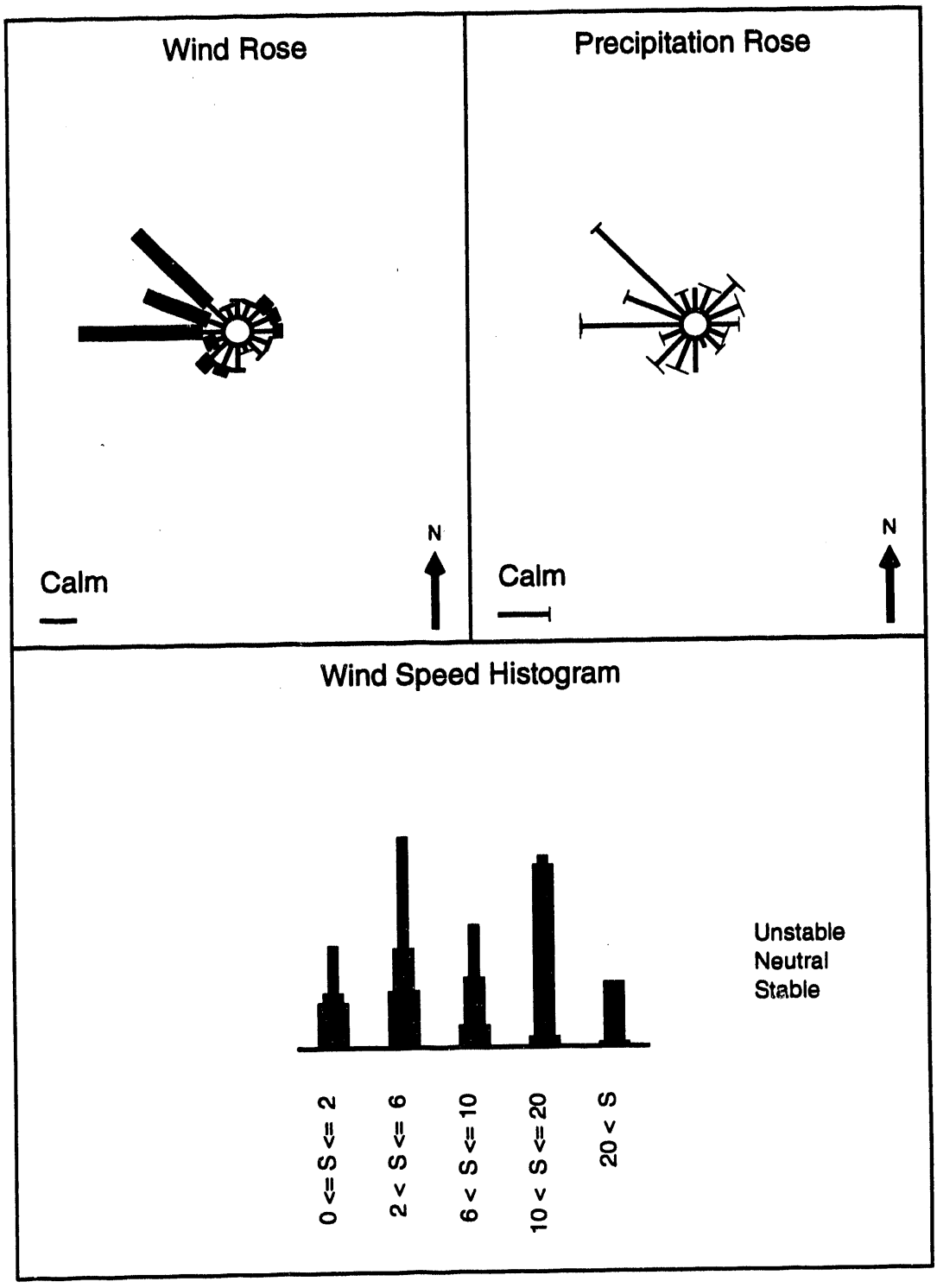


Figure 3.2. Dallesport Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.2. Dallesport Wind Direction and Wind Speed and Stability Distributions

DLS Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	2.31	.27	2.58
NNE	2.08	.53	2.61
NE	2.23	2.12	4.35
ENE	2.75	1.58	4.34
E	3.07	1.29	4.37
ESE	2.50	.49	2.99
SE	2.57	.31	2.88
SSE	1.14	.09	1.23
S	3.34	.51	3.84
SSW	3.21	1.47	4.68
SW	3.14	2.34	5.48
WSW	1.10	1.76	2.86
W	2.96	17.57	20.52
WNW	2.35	9.68	12.02
NW	3.71	14.40	18.11
NNW	1.59	.38	1.96
Calm	5.18	.00	5.18
All	45.23	54.77	

DLS Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	6.57	1.42	6.86	14.85
2 < S <= 6	8.23	6.23	15.92	30.38
6 < S <= 10	3.27	6.91	7.61	17.79
10 < S <= 20	1.50	24.81	1.26	27.57
20 < S	.69	8.72	.00	9.41
All Speeds	20.24	48.10	31.66	100.00

DLS Wind Direction Distribution During Precipitation

10.10% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	2.82	.00	.00	.37	.00	.00	3.20
NNE	2.73	.00	.00	.82	.02	.02	3.60
NE	4.04	.05	.00	2.15	.07	.02	6.33
ENE	3.45	.00	.00	1.42	.00	.02	4.90
E	3.17	.00	.00	1.07	.02	.00	4.27
ESE	2.05	.02	.00	.47	.05	.02	2.61
SE	2.78	.02	.00	.26	.00	.00	3.06
SSE	1.47	.00	.00	.05	.00	.00	1.52
S	4.46	.00	.00	.28	.00	.00	4.74
SSW	4.69	.00	.02	.19	.00	.00	4.90
SW	5.58	.02	.02	.51	.02	.00	6.16
WSW	2.89	.02	.00	.30	.02	.00	3.24
W	13.35	.09	.02	.86	.07	.00	14.40
WNW	8.08	.05	.00	.47	.02	.00	8.61
NW	17.02	.16	.00	.77	.00	.00	17.95
NNW	2.85	.02	.00	.16	.02	.00	3.06
Calm	5.70	.02	.00	1.61	.12	.00	7.45
All	87.14	.49	.07	11.77	.44	.09	

3.2.3 Station: Ellensburg, Washington (ELN)

Type: Supplemental Aviation Weather Reporting Station

Location: 47:02:00N 120:31:00W 527 meters (1729 feet) elevation.

Measurement height: 18 meters (59 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 4.07, Y = 15.61.

Data source: Paper copy for 1944 through 1947. Paper copy 1/48 through 5/48. Tape for 6/48 through 12/49.

Data availability: Observations taken every hour during 1944 to 1947.

Missing data: None.

Local topography: This station is located in the Kittitas Valley formed by the Yakima River and surrounded by Manastash and Umtanum Ridges to the southwest and by the Wenatchee Mountains to the northeast. The Kittitas Valley is a relatively flat ellipse about 32 kilometers long and 16 kilometers wide (20 miles long and 10 miles wide) with its major axis oriented from northwest to southeast. Surrounding peaks extend approximately 750 meters (2500 feet) above the valley floor.

Station was moved: 4/48. Measurement height: 18.3 meters (60 feet).

Station was moved: 7/52. Measurement height: 9.8 meters (32 feet).

Station was moved: 11/59. Measurement height: 5.2 meters (17 feet).

Instrument mounted: On a beacon tower.

Wind roses: During nearly half (49 percent) of all hours, strong winds blow down the Yakima River from the west, west-northwest, or northwest. When winds are low, they are more often east-northeasterly. Figure 3.3 illustrates the wind rose, precipitation rose, and the wind speed histogram for this station. Table 3.3 summarizes the wind direction and wind speed and stability distributions.

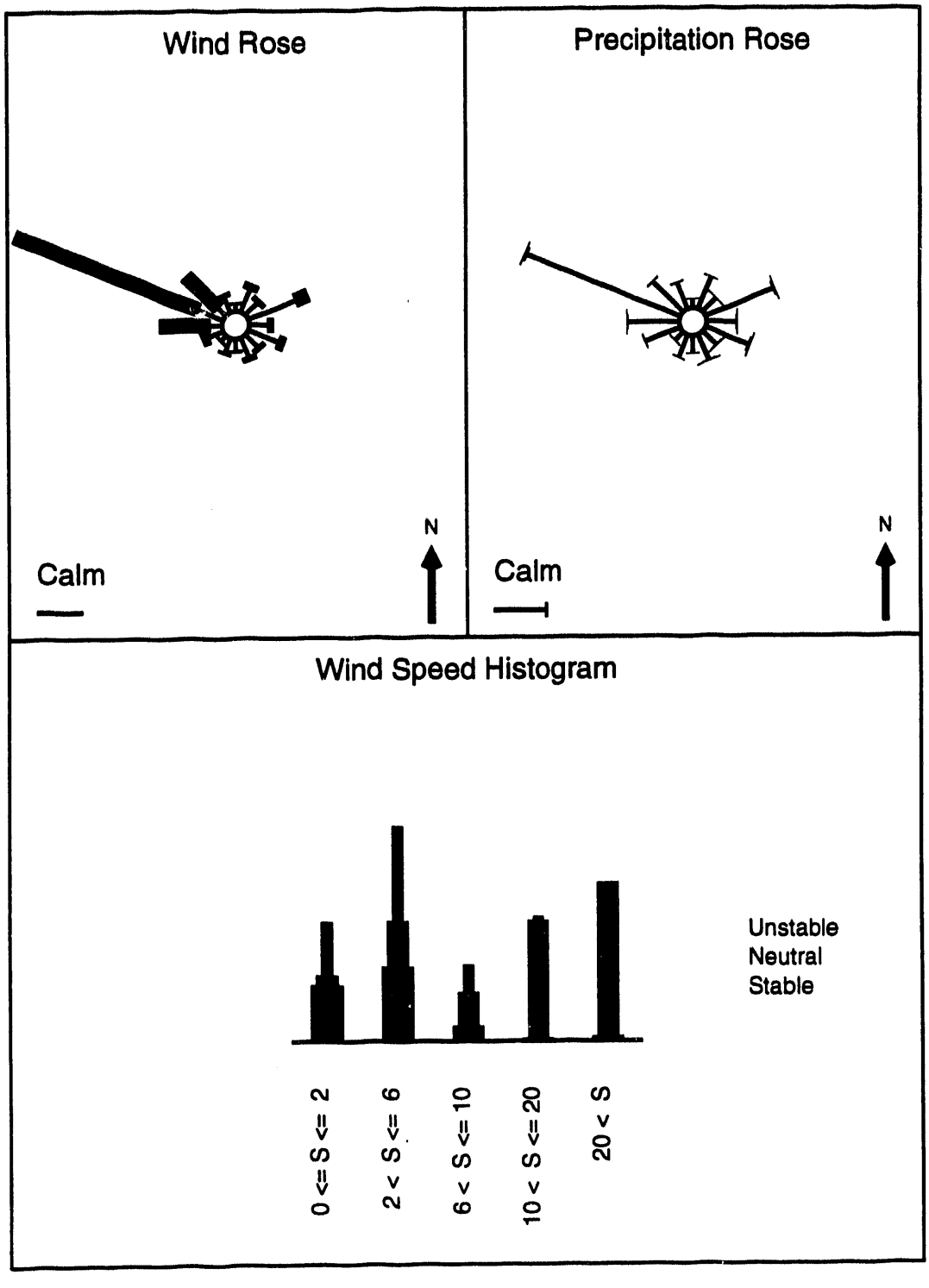


Figure 3.3. Ellensburg Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.3. Ellensburg Wind Direction and Wind Speed and Stability Distributions

ELN Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	.89	.32	1.21
NNE	3.38	.95	4.32
NE	2.28	.66	2.94
ENE	7.09	2.06	9.14
E	2.39	.90	3.29
ESE	4.30	1.05	5.35
SE	2.31	.64	2.96
SSE	2.86	.73	3.59
S	1.62	.38	2.00
SSW	2.14	.31	2.45
SW	.93	.28	1.20
WSW	2.20	1.09	3.29
W	1.71	7.20	8.90
WNW	3.73	28.29	32.02
NW	1.64	6.30	7.93
NNW	2.26	.67	2.92
Calm	6.47	.00	6.47
All	48.19	51.81	

ELN Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	8.19	1.39	7.65	17.22
2 < S <= 6	10.77	6.56	13.63	30.96
6 < S <= 10	2.23	4.89	3.90	11.03
10 < S <= 20	.47	16.96	.55	17.97
20 < S	.70	22.11	.00	22.81
All Speeds	22.36	51.90	25.74	100.00

ELN Wind Direction Distribution During Precipitation

10.63% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	.83	.02	.00	.47	.00	.00	1.33
NNE	3.23	.02	.00	1.63	.02	.00	4.90
NE	1.58	.00	.00	1.07	.02	.02	2.70
ENE	7.00	.04	.00	3.34	.26	.02	10.66
E	2.20	.00	.00	1.90	.17	.04	4.32
ESE	3.74	.02	.00	2.70	.26	.09	6.80
SE	1.82	.04	.00	.86	.04	.02	2.78
SSE	2.57	.04	.00	1.35	.06	.02	4.05
S	1.65	.02	.00	.83	.00	.00	2.50
SSW	2.10	.00	.00	1.37	.02	.00	3.49
SW	1.11	.00	.00	.62	.02	.00	1.75
WSW	3.53	.02	.00	1.73	.09	.00	5.37
W	5.41	.15	.00	1.78	.06	.02	7.43
WNW	18.70	.09	.02	4.97	.21	.04	24.03
NW	4.51	.04	.00	1.54	.09	.00	6.18
NNW	2.46	.00	.00	1.61	.09	.00	4.15
Calm	3.62	.04	.00	3.55	.34	.00	7.55
All	66.08	.56	.02	31.31	1.75	.28	

3.2.4 Station: Ephrata, Washington (EPH)

Type: Civil Aeronautics Administration

Location: 47:18:00N 119:32:00W 388 meters (1273 feet) elevation.

Measurement height: 8.2 meters (27 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 7.94, Y = 17.15.

Data source: Paper copy for 1944 through 1947. Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour during 1944 to 1947.

Missing data: None.

Local topography: This station is located in the Columbia Basin. The terrain to the south and east of the station is extremely flat; in these directions no terrain within 40 kilometers (25 miles) is more than 100 meters (300 feet) different from the station elevation. Immediately to the west and north of the station, hills rise 300 meters (1000 feet) and more above the station elevation. Just north of Ephrata is the Grand Coulee, the channel followed by the Columbia River during an ice age and now holding Soap Lake, Blue Lake, Lenore Lake, Banks Lake, and other smaller lakes.

Station was moved: 3/47 Measurement height: 11.6 meters (30 feet).

Station was moved: 5/56 Measurement height: 10.1 meters (33 feet).

Station was moved: 5/59 Measurement height: 6.1 meters (20 feet).

Wind roses: The wind rarely has components from the east. Less than 11 percent of the total hours record winds between northeasterly and southeasterly. In the remaining hours, the wind is almost evenly distributed between all angles with westerly components. When winds are weak, a predominance of north-northwesterly and northerly winds indicates drainage from the hills to the north or down the Grand Coulee. Figure 3.4 illustrates the wind rose, precipitation rose, and the wind speed histogram for this station. Table 3.4 summarizes the wind direction and wind speed and stability distributions.

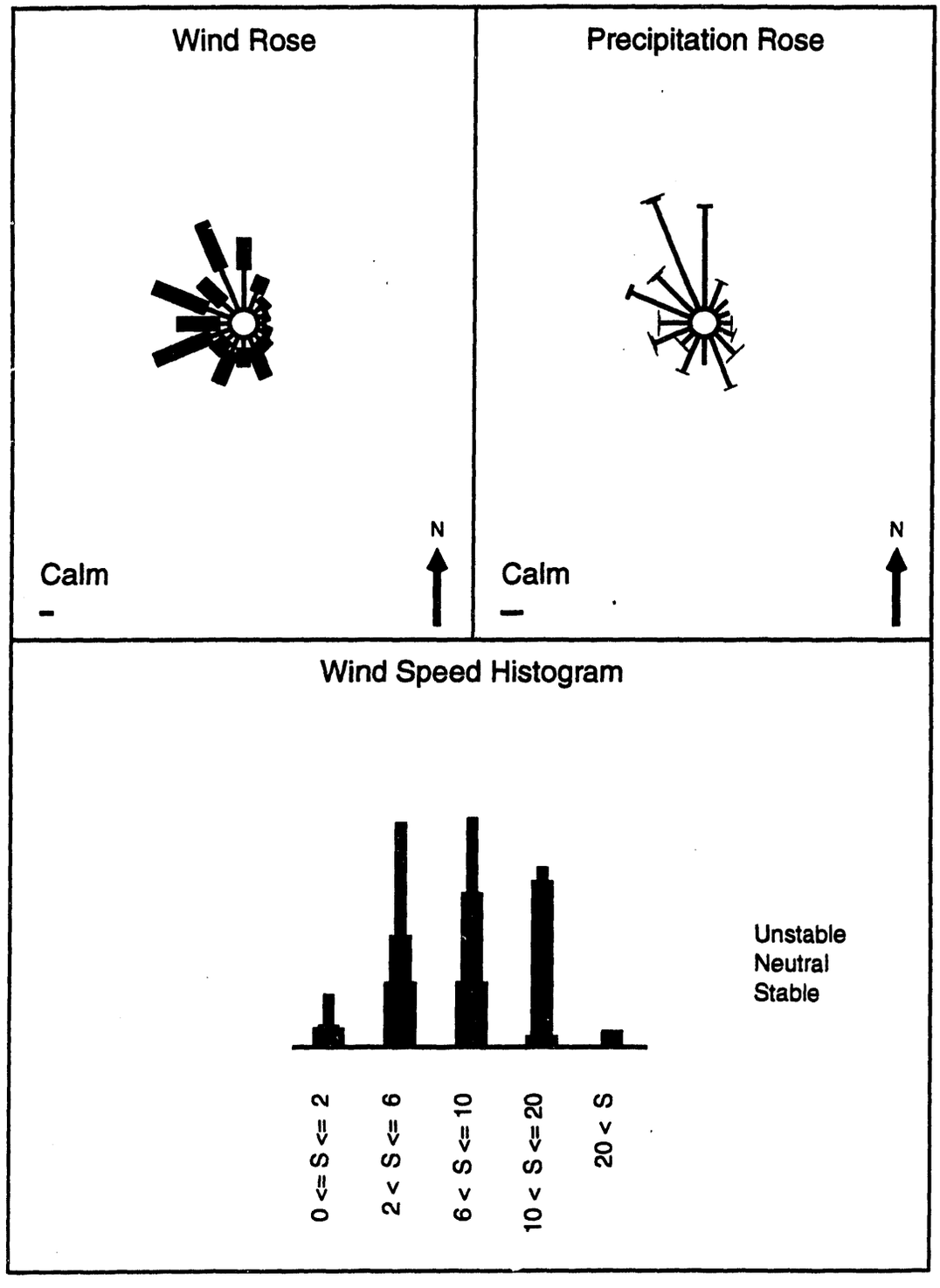


Figure 3.4. Ephrata Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.4. Ephrata Wind Direction and Wind Speed and Stability Distributions

EPH Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	5.71	4.52	10.22
NNE	2.78	2.35	5.13
NE	1.46	1.10	2.56
ENE	1.10	.66	1.76
E	.69	.51	1.20
ESE	1.09	.99	2.08
SE	1.16	1.81	2.97
SSE	2.12	4.19	6.31
S	1.53	2.66	4.18
SSW	2.40	4.79	7.19
SW	1.23	2.53	3.76
WSW	2.91	8.61	11.52
W	1.32	6.17	7.50
WNW	3.60	8.13	11.73
NW	2.09	4.29	6.38
NNW	6.40	7.20	13.60
Calm	1.90	.00	1.90
All	39.49	60.51	

EPH Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	2.78	.39	4.43	7.61
2 < S <= 6	9.27	6.65	15.96	31.89
6 < S <= 10	9.36	12.60	10.60	32.57
10 < S <= 20	1.64	22.02	1.91	25.57
20 < S	.03	2.33	.00	2.37
All Speeds	23.09	44.00	32.91	100.00

EPH Wind Direction Distribution During Precipitation

6.84% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	9.22	.30	.00	5.26	.07	.00	14.84
NNE	3.26	.03	.00	1.00	.00	.00	4.29
NE	2.06	.00	.00	.37	.00	.00	2.43
ENE	1.63	.00	.00	.17	.00	.00	1.80
E	1.56	.00	.00	.27	.10	.00	1.93
ESE	2.30	.03	.00	.23	.00	.00	2.56
SE	3.66	.00	.03	.50	.00	.00	4.19
SSE	7.49	.03	.00	.47	.00	.00	7.99
S	3.76	.00	.00	.13	.00	.00	3.89
SSW	5.42	.03	.00	.17	.00	.00	5.62
SW	2.10	.03	.00	.20	.00	.03	2.36
WSW	4.72	.00	.03	.83	.27	.00	5.86
W	3.33	.03	.03	.93	.10	.03	4.46
WNW	6.56	.10	.00	2.63	.37	.00	9.65
NW	4.76	.10	.07	2.63	.10	.03	7.69
NNW	9.82	.10	.00	6.95	.33	.07	17.27
Calm	2.20	.00	.00	.96	.00	.00	3.16
All	73.84	.80	.17	23.69	1.33	.17	

3.2.5 Station: Fairchild AFB, Washington (SKA)

Type: Air Force Base

Location: 47:38:00N 117:39:00W 743 meters (2437 feet) elevation.

Measurement height: 10 meters (33 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 15.27, Y = 19.06.

Data source: Paper copy for 1944 through 1947. Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour in the period 1944 to 1947.

Missing data: None.

Local topography: This station is located about 16 kilometers (10 miles) west of the center of Spokane. To the west and southwest, no significant terrain features are present for 120 kilometers (75 miles). To the northeast, the land gently slopes down about 8 kilometers (5 miles) to the Spokane River and then gradually climbs to hills that rise to approximately 300 meters (1000 feet) above the station.

Station was moved: 3/53 Measurement height: 25.9 meters (85 feet).

Station was moved: 4/55 Measurement height: 29.3 meters (96 feet).

Station was moved: 8/57 Measurement height: 33.5 meters (110 feet).

Station was moved: 4/58 Measurement height: 4.0 meters (13 feet).

Instrument mounted: 4/58 on a tower on the ground.

Station was moved: 3/59 Measurement height: 4.6 meters (15 feet).

Station was moved: 4/63 Measurement height: 3.4 meters (11 feet).

Station was moved: 11/66 Measurement height: 5.5 meters (18 feet).

Wind roses: Southerly winds dominate, with nearly 40 percent of the winds coming from the south-southeast, south, or south-southwest. A small secondary maximum is also present for winds from the north-northeast. Figure 3.5 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. Table 3.5 summarizes the wind direction and stability and speed distributions.

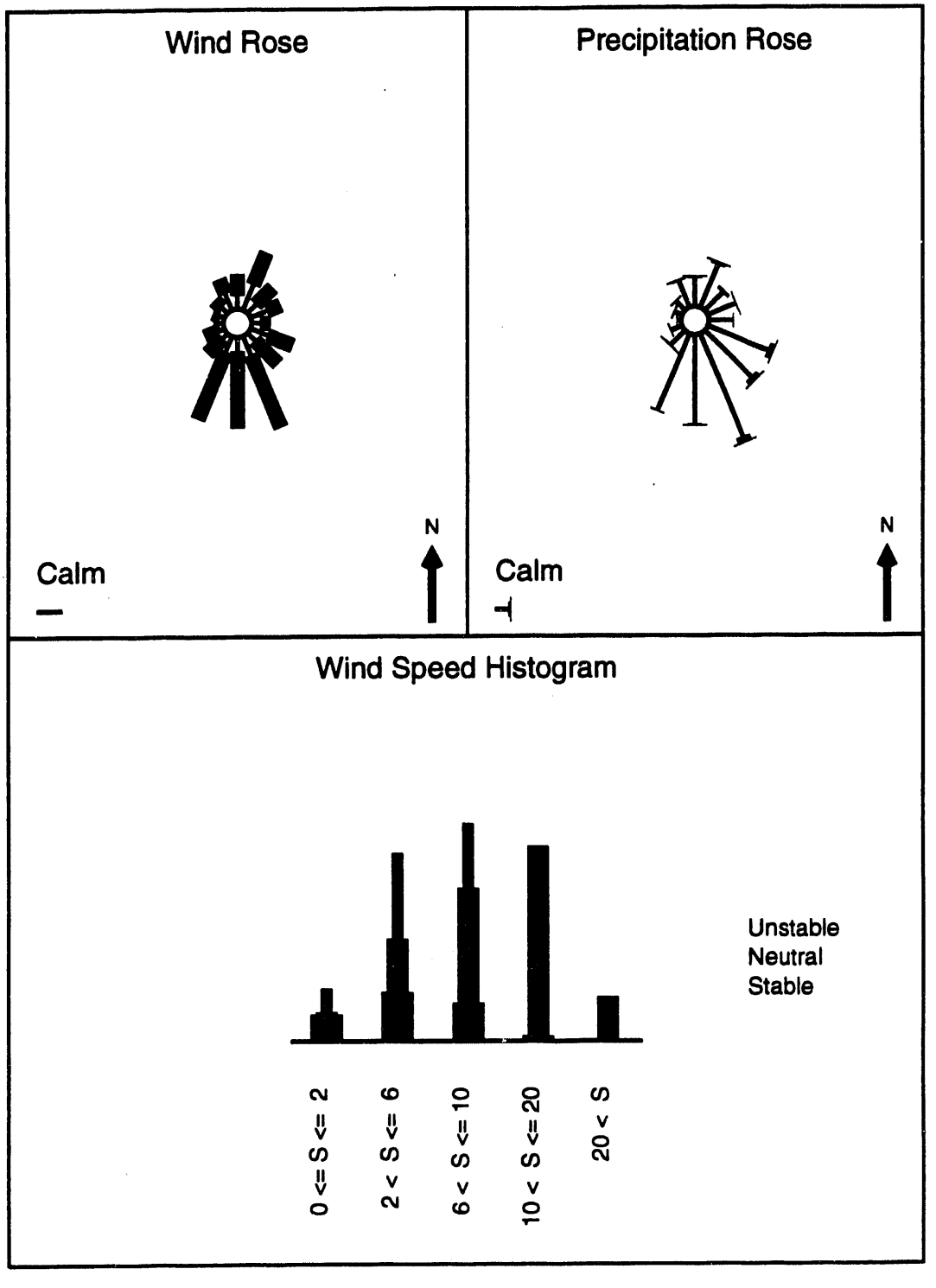


Figure 3.5. Fairchild AFB Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.5. Fairchild AFB Wind Direction and Wind Speed and Stability Distributions

SKA Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	1.97	3.02	4.99
NNE	3.95	4.91	8.86
NE	1.77	3.34	5.11
ENE	2.61	2.04	4.64
E	1.28	1.43	2.71
ESE	2.67	3.79	6.47
SE	1.54	4.63	6.17
SSE	2.95	11.18	14.13
S	2.04	11.02	13.05
SSW	2.42	10.39	12.81
SW	1.00	2.97	3.97
WSW	1.24	1.75	2.98
W	.67	.75	1.42
WNW	.95	.75	1.71
NW	1.25	1.34	2.59
NNW	2.62	2.17	4.79
Calm	3.60	.00	3.60
All	34.53	65.47	

SKA Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	3.81	.37	3.42	7.61
2 < S <= 6	7.03	7.62	12.28	26.93
6 < S <= 10	5.53	16.47	9.16	31.16
10 < S <= 20	.79	27.13	.00	27.92
20 < S	.13	6.26	.00	6.39
All Speeds	17.28	57.85	24.87	100.00

SKA Wind Direction Distribution During Precipitation

13.85% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	1.78	.14	.03	2.35	.03	.03	4.34
NNE	3.53	.08	.00	3.09	.25	.05	6.99
NE	2.30	.03	.00	1.26	.30	.00	3.88
ENE	2.87	.05	.00	1.34	.03	.03	4.32
E	2.57	.03	.00	.82	.08	.00	3.50
ESE	6.67	.22	.00	2.62	.46	.03	10.00
SE	6.83	.41	.05	2.62	.22	.05	10.19
SSE	13.17	.60	.05	2.84	.14	.03	16.83
S	10.71	.14	.03	2.02	.03	.03	12.95
SSW	8.96	.08	.00	2.92	.00	.00	11.97
SW	2.38	.03	.00	.55	.05	.03	3.03
WSW	1.01	.05	.00	.68	.00	.00	1.75
W	.44	.03	.00	.16	.00	.00	.63
WNW	.76	.08	.00	.38	.03	.00	1.26
NW	.98	.03	.00	.85	.03	.00	1.88
NNW	1.86	.08	.03	2.21	.05	.03	4.26
Calm	1.20	.27	.00	.68	.03	.03	2.21
All	68.00	2.35	.19	27.40	1.72	.33	

3.2.6 Station: Hanford Meteorological Station (HMS)

Type: Atomic Energy Commission/Department of Energy

Location: 46:33:47N 119:35:54W 223 meters (731 feet) elevation.

Measurement height: 30.5 meters (100 feet).

Instrument mounted: On a tower on the ground.

HEDR environmental grid coordinates: X = 7.64, Y = 12.90.

Data source: Digital file from Hanford Meteorology Program.

Data availability: Observations taken every hour from 12/7/44.

Missing data: 12/24-25/44, 24 hours missing (Christmas).
7/4/45, 7 hours missing (July 4th).
8/15-16/45, 38 hours missing (V-J celebration).
9/2-3/45, 24 hours missing (Labor Day).
11/21-22/45, 24 hours missing (Thanksgiving).
12/24-25/45, 24 hours missing (Christmas).
1/1/46, 23 hours missing (New Year's Day).
5/29-30/46, 24 hours missing (Memorial Day).
7/3-4/46, 24 hours missing (July 4th).
9/1-2/46, 24 hours missing (Labor Day).
No further holiday breaks.
No data missing in 1947.

Local topography: This station is located on the Hanford Reservation near the release site. It is near the western edge of a basin formed by the Columbia River and surrounded by Yakima Ridge and Rattlesnake Hills to the southwest, the Saddle Mountains to the north, Juniper Hills to the east, and Horse Heaven Hills to the south.

Skyllingstad and Schwartz (1989) indicate the topography of this basin is shown to channel winds on the Hanford Reservation. The effects of topography are most strongly seen as channeling of wind flow along the Columbia River by local mountains and as flow induced by thermal gradients between eastern and western Washington.

Wind roses: Westerly and nearly westerly winds dominate the wind roses. Low winds most frequently come from directions between the west-southwest and north-northwest, but rarely come from directions between southeast and southwest. Figure 3.6 illustrates the wind rose, precipitation rose, and the wind speed histogram for this station. Table 3.6 summarizes the wind direction and stability and speed distributions.

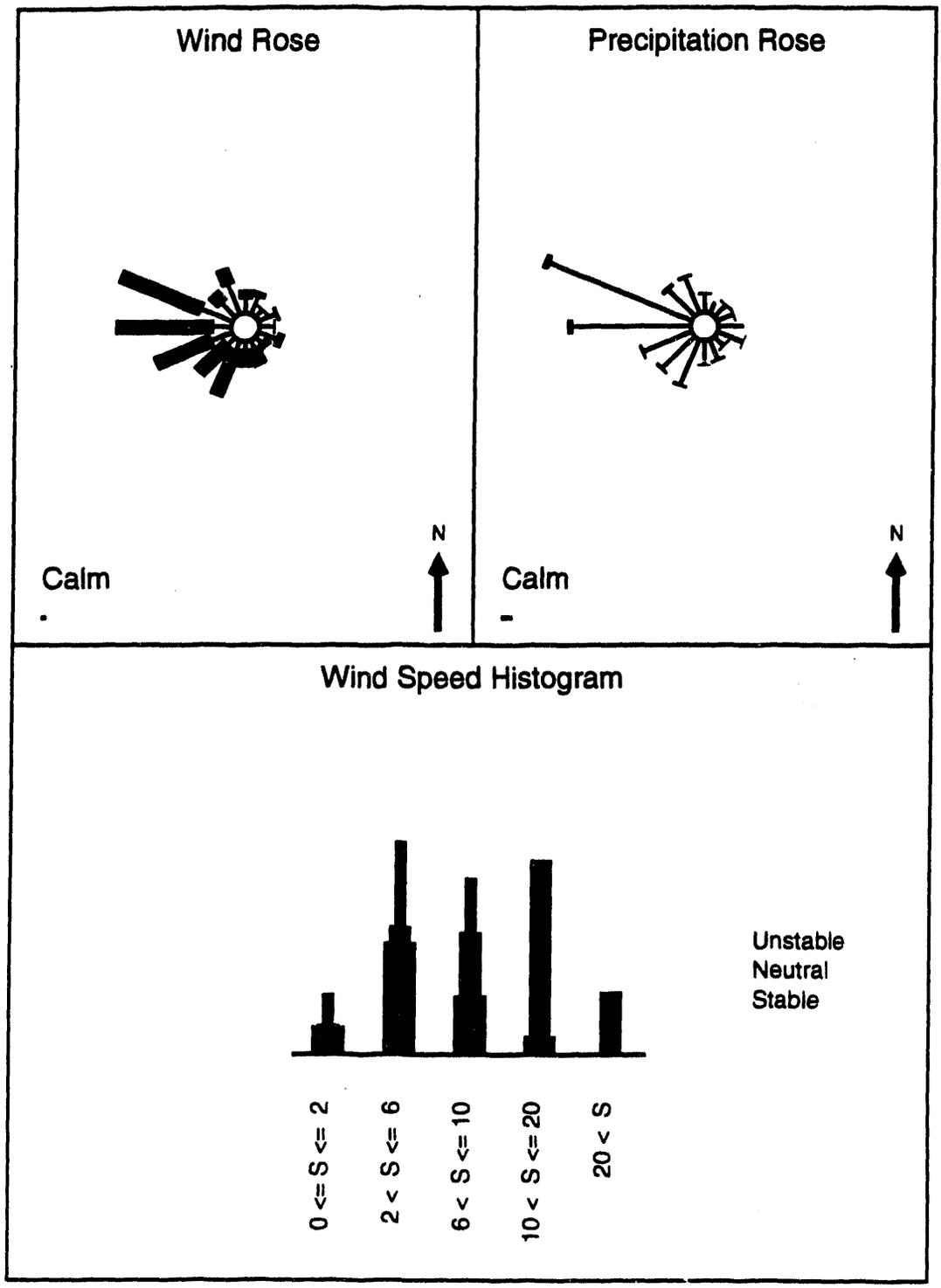


Figure 3.6. Hanford Meteorological Station Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.6. Hanford Meteorological Station Wind Direction and Wind Speed and Stability Distributions

HMS Wind Direction Distribution

Direction	< 6 mph	>= 6 mph	All Speeds
N	2.04	1.26	3.30
NNE	2.60	.79	3.39
NE	1.27	.24	1.51
ENE	2.51	.44	2.95
E	1.94	.25	2.19
ESE	2.62	1.01	3.63
SE	1.18	1.00	2.17
SSE	1.93	1.98	3.91
S	1.09	2.61	3.70
SSW	2.02	6.59	8.61
SW	1.40	5.75	7.15
WSW	3.10	8.64	11.74
W	2.48	13.94	16.43
WNW	4.60	12.56	17.16
NW	2.66	1.88	4.54
NNW	4.47	2.42	6.88
Calm	.73	.00	.73
All	38.64	61.36	

HMS Wind Speed Distribution

Speed (mph)	Stable	Neutral	Unstable	Missing	All Stabilities
0 <= S <= 2	3.92	.26	4.30	.00	8.49
2 < S <= 6	15.82	2.28	12.06	.00	30.16
6 < S <= 10	8.32	8.90	7.79	.00	25.01
10 < S <= 20	2.56	24.93	.00	.00	27.50
20 < S	.10	8.75	.00	.00	8.85
All Speeds	30.73	45.12	24.15	.00	

HMS Wind Direction Distribution During Precipitation

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	1.80	.11	.00	.74	.11	.00	2.75
NNE	1.38	.00	.00	.32	.00	.00	1.70
NE	2.01	.21	.00	.11	.00	.00	2.33
ENE	2.22	.21	.00	.00	.00	.00	2.44
E	3.18	.00	.00	.32	.00	.00	3.50
ESE	2.97	.11	.00	.85	.00	.00	3.92
SE	1.48	.21	.00	.32	.00	.00	2.01
SSE	2.65	.32	.00	.32	.00	.00	3.28
S	3.28	.11	.00	.21	.00	.00	3.60
SSW	6.46	.32	.00	.42	.00	.00	7.20
SW	5.93	.32	.00	.42	.00	.00	6.67
WSW	6.67	.21	.00	.64	.11	.00	7.63
W	7.95	.21	.00	8.69	.53	.00	17.37
WNW	14.62	.53	.00	7.10	.32	.00	22.56
NW	2.75	.53	.00	2.44	.00	.00	5.72
NNW	3.39	.32	.00	2.01	.00	.00	5.72
Calm	1.48	.00	.00	.11	.00	.00	1.59
All	70.23	3.71	.00	25.00	1.06	.00	

3.07% of hours had recorded precipitation.

3.2.7 Station: Harrington, Washington (HAR)

Type: Aviation Reports

Location: 47:29:00N 118:15:00W 664 meters (2178 feet) elevation.

Measurement height: 9.8 meters (32 feet).

Instrument mounted: On a tower on the ground.

HEDR environmental grid coordinates: X = 12.95, Y = 18.20.

Data source: Paper copy for 1944 through 6/30/48.
Microfiche for 7/48 through 1949.

Data availability: 4 to 10 observations per day during 1944 to 1947.
5 to 11 observations per day 1948 to 1949.

Missing data: No data 7/16/45.
No wind data 7/1/48 to 12/31/49.

Local topography: This station is located in a very flat region of the Columbia Basin. For 24 kilometers (15 miles) in all directions, no terrain feature is more than 100 meters (300 feet) above or below the station.

Wind roses: The wind distribution is strongly bimodal with maxima from the north-northeast and south-southwest. More than 40 percent of the total hours show winds from one of these two sectors. Figure 3.7 illustrates the wind rose, precipitation rose, and the wind speed histogram for this station. Table 3.7 summarizes the wind direction and wind speed and stability distributions.

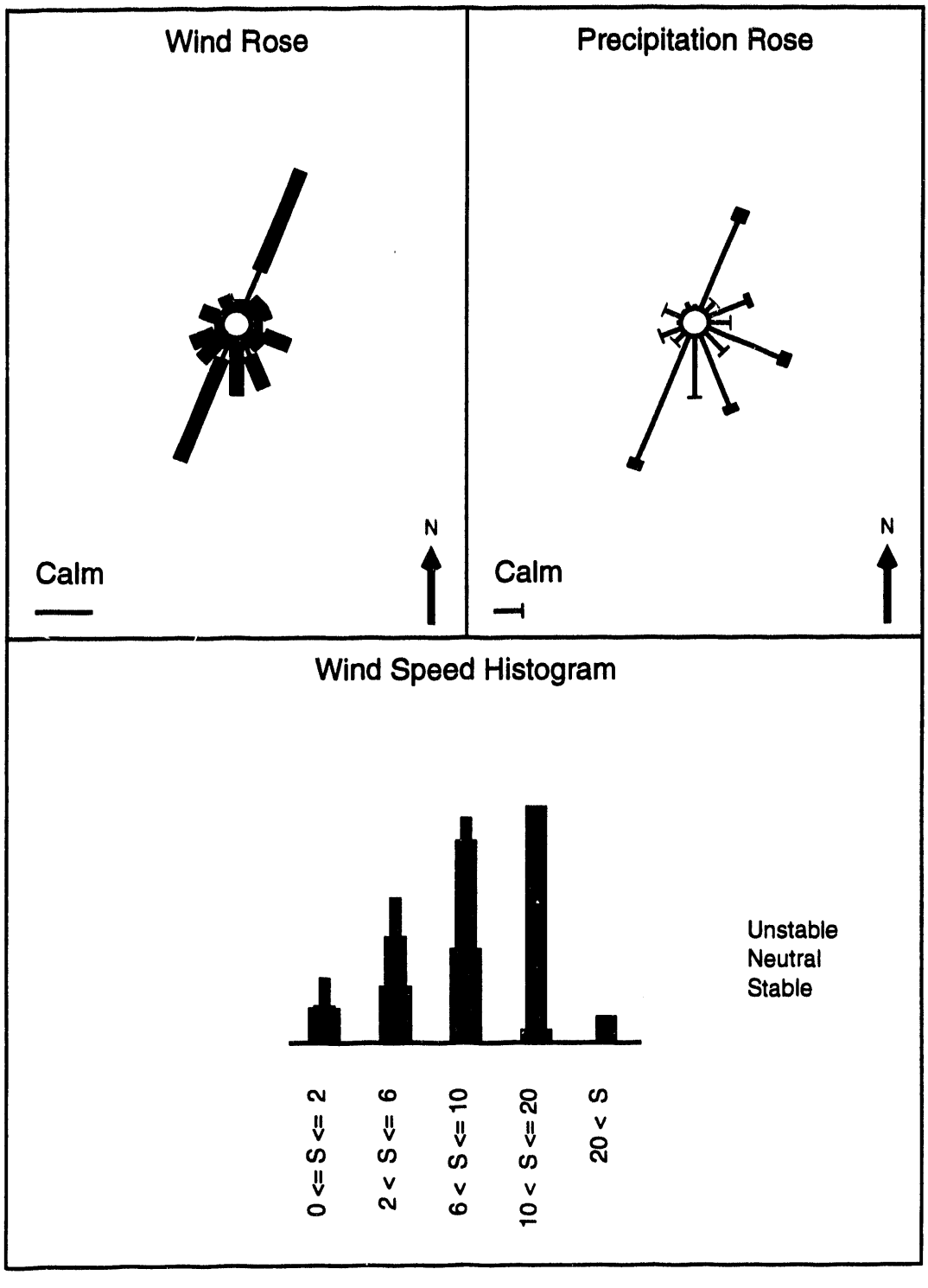


Figure 3.7. Harrington Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.7. Harrington Wind Direction and Wind Speed and Stability Distributions

HAR Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	.17	1.30	1.48
NNE	6.36	15.37	21.73
NE	.49	2.46	2.95
ENE	1.74	1.25	2.98
E	.54	1.08	1.62
ESE	2.09	3.97	6.06
SE	.28	2.37	2.65
SSE	2.87	4.99	7.86
S	.51	7.72	8.23
SSW	3.32	15.79	19.11
SW	.24	4.79	5.03
WSW	1.37	3.47	4.83
W	.09	.97	1.05
WNW	.98	2.34	3.32
NW	.12	.70	.83
NNW	1.01	1.30	2.31
Calm	7.95	.00	7.95
All	30.13	69.87	

HAR Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	5.05	.29	3.97	9.31
2 < S <= 6	8.12	7.11	5.58	20.81
6 < S <= 10	13.52	15.46	3.18	32.17
10 < S <= 20	1.92	31.93	.00	33.85
20 < S	.05	3.80	.00	3.86
All Speeds	28.67	58.59	12.74	100.00

HAR Wind Direction Distribution During Precipitation

7.85% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	.22	.00	.00	.30	.00	.00	.52
NNE	5.26	.67	.00	8.45	1.19	.00	15.57
NE	.96	.15	.00	.89	.00	.00	2.00
ENE	3.63	.81	.00	2.15	.00	.00	6.60
E	1.93	.15	.00	1.04	.00	.00	3.11
ESE	7.19	1.48	.00	3.86	.15	.00	12.68
SE	2.82	.30	.00	.89	.00	.00	4.00
SSE	8.82	1.11	.00	2.00	.00	.00	11.94
S	7.56	.22	.00	1.04	.00	.00	8.82
SSW	15.12	1.33	.00	4.15	.07	.00	20.68
SW	1.63	.07	.00	.30	.00	.00	2.00
WSW	2.15	.22	.00	.96	.00	.00	3.34
W	.52	.00	.00	.00	.00	.00	.52
WNW	2.00	.07	.00	.67	.00	.00	2.74
NW	.37	.00	.00	.00	.00	.00	.37
NNW	.74	.00	.00	.30	.00	.00	1.04
Calm	2.52	.22	.00	1.33	.00	.00	4.08
All	63.45	6.82	.00	28.32	1.41	.00	

3.2.8 Station: LaCrosse, Washington (LAC)

Type: Weather Bureau Office

Location: 46:49:00N 117:53:00W 452 meters (1483 feet) elevation.

Measurement height: 13.1 meters (43 feet).

Instrument mounted: On a tower on the ground.

HEDR environmental grid coordinates: X = 14.41, Y = 14.36.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1/1 through 9/30/48.
Not listed by NWDI after 1948.

Data availability: Observations taken every hour during 1944 to 1947.

Missing data: No data 5/1/46.

Local topography: This station is surrounded by the rolling hills of the Palouse, which have elevation variations of less than about 100 meters (a few hundred feet). The Snake River passes about 16 kilometers (10 miles) southeast of LaCrosse.

Wind roses: The wind distribution is strongly bimodal with maxima from the north-northeast and south-southwest. More than 44 percent of the total hours contain winds from one of these two sectors. The maximum for winds from the north-northeast is dominated by speeds less than 6 mph, while the maximum from the south-southwest has more winds above 6 mph than below. Figure 3.8 illustrates the wind rose, precipitation rose, and the wind speed histogram for this station. Table 3.8 summarizes the wind direction and wind speed and stability distributions.

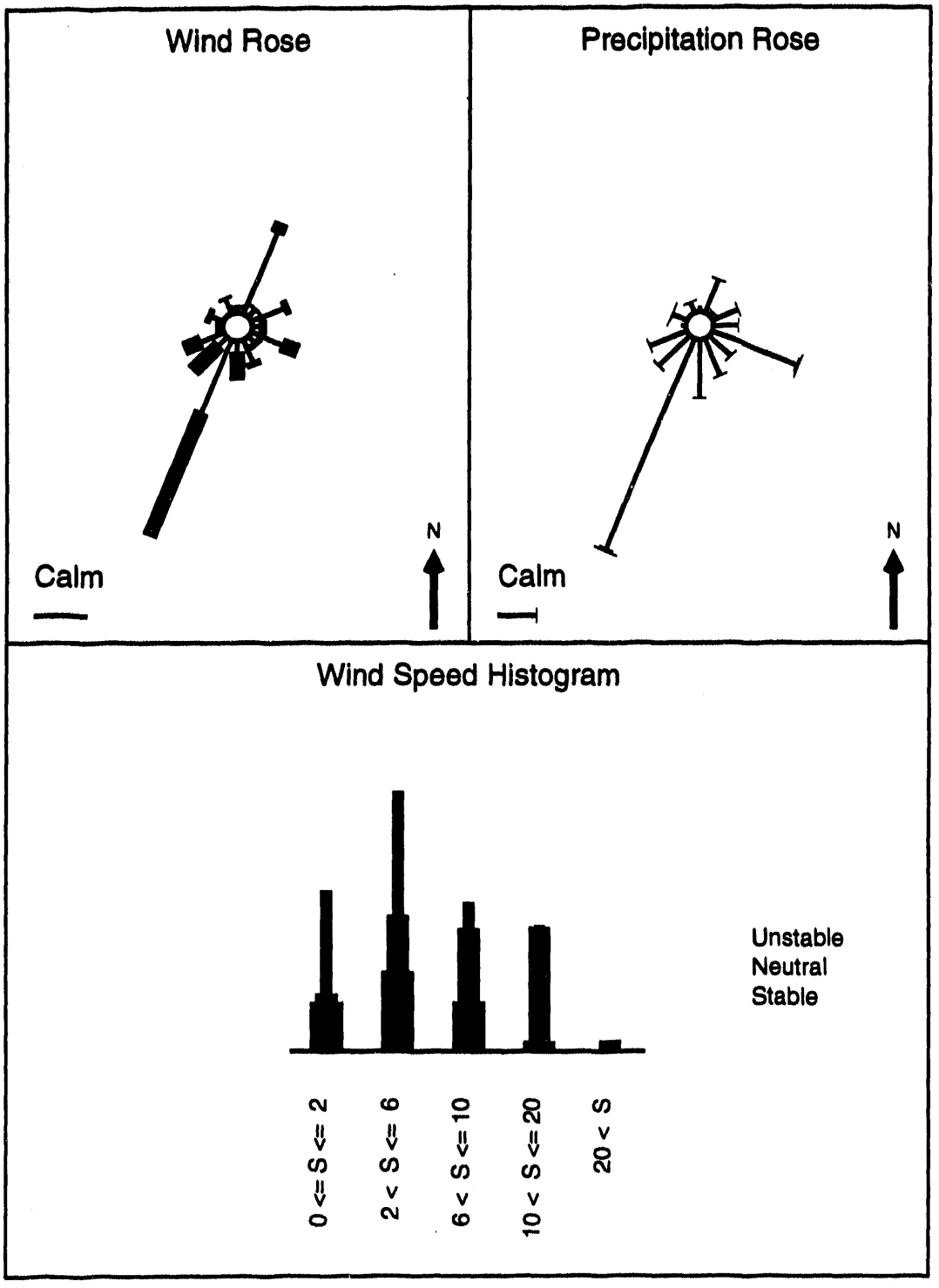


Figure 3.8. LaCrosse Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.8. LaCrosse Wind Direction and Wind Speed and Stability Distributions

LAC Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	.62	.44	1.06
NNE	12.50	1.43	13.93
NE	1.21	.36	1.57
ENE	4.87	.86	5.73
E	.96	1.03	1.99
ESE	4.67	2.45	7.12
SE	1.06	.69	1.75
SSE	3.44	.69	4.14
S	1.63	3.94	5.57
SSW	11.25	18.99	30.24
SW	1.66	5.16	6.83
WSW	3.53	2.51	6.04
W	.37	.68	1.05
WNW	1.87	.74	2.60
NW	.25	.15	.40
NNW	2.27	.26	2.53
Calm	7.47	.00	7.47
All	59.60	40.40	

LAC Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	6.89	1.24	14.61	22.74
2 < S <= 6	11.28	7.99	17.60	36.87
6 < S <= 10	6.94	10.40	3.76	21.10
10 < S <= 20	1.34	16.21	.27	17.81
20 < S	.02	1.47	.00	1.49
All Speeds	26.47	37.30	36.23	100.00

LAC Wind Direction Distribution During Precipitation

11.17% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	.60	.00	.00	.14	.00	.00	.74
NNE	4.08	.11	.00	.99	.00	.00	5.18
NE	.66	.03	.00	.03	.00	.00	.71
ENE	3.07	.03	.00	.69	.03	.00	3.81
E	3.18	.00	.00	.19	.03	.00	3.39
ESE	11.12	.14	.00	1.67	.14	.05	13.12
SE	3.97	.03	.00	.16	.05	.00	4.22
SSE	4.76	.03	.00	.90	.05	.00	5.75
S	7.61	.05	.00	.71	.00	.00	8.38
SSW	29.79	.22	.00	2.52	.19	.08	32.80
SW	5.53	.08	.00	.49	.08	.00	6.19
WSW	3.81	.03	.00	1.84	.03	.00	5.70
W	.52	.00	.00	.05	.00	.00	.57
WNW	1.89	.03	.03	.27	.03	.00	2.24
NW	.08	.00	.00	.00	.00	.00	.08
NNW	1.12	.00	.00	.47	.05	.00	1.64
Calm	4.35	.03	.00	1.07	.03	.00	5.48
All	86.14	.79	.03	12.19	.71	.14	

3.2.9 Station: Larson AFB, Washington (MWH)

Type: Army Air Field/Air Force Base

Location: 47:11:00N 119:20:00W 361 meters (1184 feet) elevation.

Measurement height: 8.5 meters (28 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 8.72, Y = 16.47.

Data source: Paper copy for 12/44 through 4/18/45.
Not listed by NWDI after 4/18/45.
Magnetic tape 3/49 through 12/49.

Data availability: Observations taken every hour until 4/18/45.
No further data after that.

Missing data: None.

Local topography: This station is located near Moses Lake in the center of the Columbia Basin. This region is very flat. Everything within a 25-kilometer (15-mile) radius has less than a 120-meter (400-foot) elevation difference from the station.

Station was moved: 4/53 Measurement height: 32 meters (105 feet).

Station was moved: 4/57 Measurement height: 3.7 meters (12 feet).

Instrument mounted: 6/69 on a tower on the ground.

Station was moved: 6/68 Location: 47:12:00N 119:19:00W. Measurement height: 6/68
6.1 meters (20.0 feet).

Wind roses: At this station, north-northwesterly is the dominant wind direction. Winds are rarely from the sector between 0 and 90 degrees and the distribution is approximately uniform for winds from south-southwest clockwise through northwest. Figure 3.9 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. The precipitation rose is much more strongly bimodal than the wind rose with nearly a third of the precipitation occurring with north-northwest or south-southwest winds. Table 3.9 summarizes the wind direction and wind speed and stability distributions.

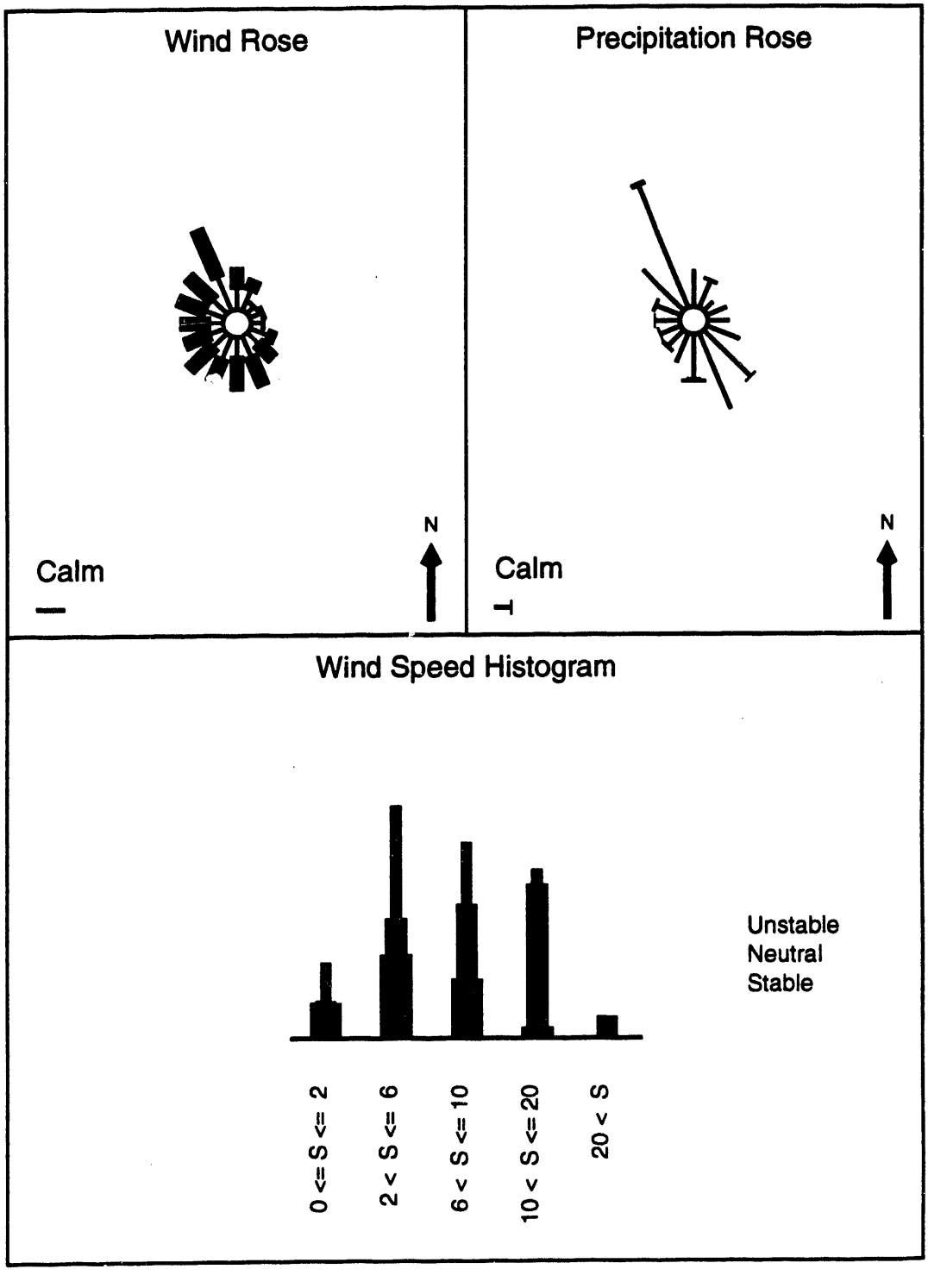


Figure 3.9. Larson AFB Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.9. Larson AFB Wind Direction and Wind Speed and Stability Distributions

MWH Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	2.98	3.11	6.09
NNE	2.96	1.80	4.76
NE	1.13	.51	1.64
ENE	1.69	.49	2.18
E	1.42	.58	2.00
ESE	2.54	1.36	3.90
SE	2.05	3.26	5.31
SSE	3.04	4.81	7.85
S	2.70	5.08	7.78
SSW	3.37	4.30	7.67
SW	2.52	4.91	7.43
WSW	2.01	3.90	5.91
W	1.69	4.37	6.06
WNW	2.54	4.51	7.05
NW	2.60	5.03	7.63
NNW	5.06	7.54	12.60
Calm	4.12	.00	4.12
All	44.42	55.58	

MWH Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	5.12	.23	5.57	10.92
2 < S <= 6	12.06	5.20	16.24	33.50
6 < S <= 10	8.52	10.71	8.97	28.20
10 < S <= 20	1.60	20.50	2.15	24.26
20 < S	.01	3.11	.00	3.12
All Speeds	27.31	39.75	32.93	100.00

MWH Wind Direction Distribution During Precipitation

5.12% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	4.07	.00	.00	1.22	.00	.00	5.28
NNE	4.07	.41	.00	.00	.00	.00	4.47
NE	1.83	.00	.00	.00	.00	.00	1.83
ENE	1.83	.00	.00	1.22	.00	.00	3.05
E	2.85	.00	.00	.20	.00	.00	3.05
ESE	4.27	.00	.00	.81	.00	.00	5.08
SE	8.94	.20	.00	.41	.00	.00	9.55
SSE	11.38	.00	.00	.41	.00	.00	11.79
S	5.89	.20	.41	.41	.00	.00	6.91
SSW	4.27	.00	.00	.20	.00	.00	4.47
SW	2.64	.41	.00	.41	.00	.00	3.45
WSW	2.44	.20	.00	.61	.00	.00	3.25
W	3.05	.20	.00	.41	.00	.00	3.66
WNW	2.85	.41	.00	.81	.00	.00	4.07
NW	6.91	.00	.00	1.42	.00	.00	8.33
NNW	8.33	.61	.00	10.37	.00	.00	19.31
Calm	1.42	.20	.00	.81	.00	.00	2.44
All	77.03	2.85	.41	19.72	.00	.00	

3.2.10 Station: Omak, Washington (OMK)

Type: Supplemental Aviation Weather Reporting Station

Location: 48:26:00N 119:32:00W 376 meters (1233 feet) elevation.

Measurement height: 7.3 meters (24 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 8.01, Y = 23.67.

Data source: Paper copy for 1944 through 1949.

Data availability: 4 observations per day during 1944 to 1947.

Missing data: None.

Local topography: This station is located along the Okanogan River in an approximately 8-kilometer (5-mile) diameter basin. The basin floor is at 250 to 400 meters (800 to 1300 feet). To the west, Buck Mountain rises to 1870 meters (6135 feet). To the east, Omak mountain rises to 1752 meters (5749 feet). The Okanogan River runs into Omak from the north through a narrow canyon and out of Omak through a narrow canyon to the southwest.

Wind roses: The wind rose is strongly bimodal with one diffuse mode for winds flowing down the Okanogan Valley from between west-northwest and north and the other mode flowing up the valley from between east-southeast and south-southwest. The up-valley mode is largely formed by winds less than 6 mph. Figure 3.10 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. Table 3.10 summarizes the wind direction and wind speed and stability distributions.

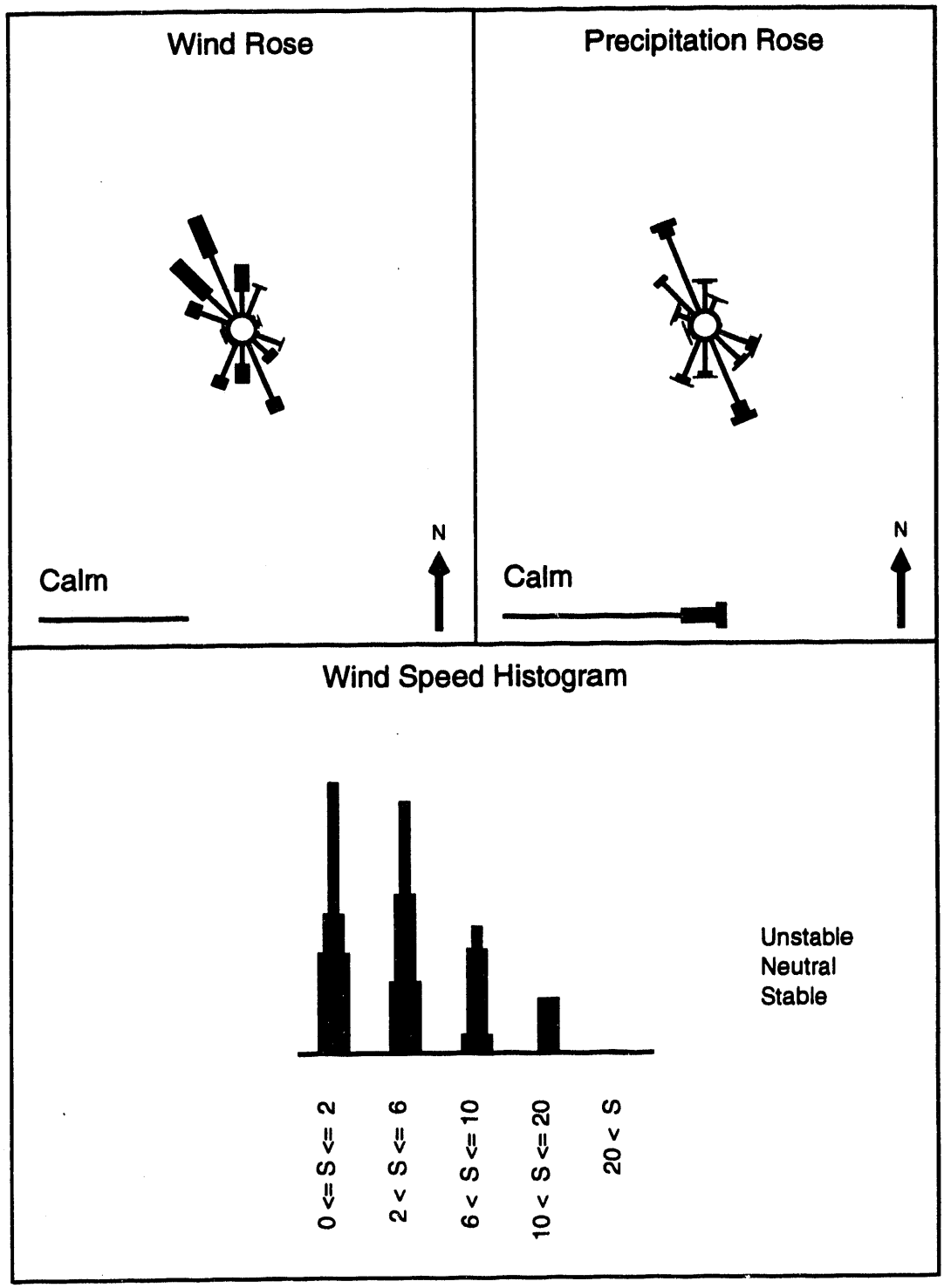


Figure 3.10. Omak Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.10. Omak Wind Direction and Wind Speed and Stability Distributions

OMK Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	3.36	3.69	7.05
NNE	4.29	.28	4.57
NE	.44	.00	.44
ENE	.72	.02	.74
E	.42	.02	.44
ESE	3.83	.14	3.96
SE	2.92	1.09	4.01
SSE	8.88	1.92	10.80
S	2.94	2.71	5.66
SSW	5.40	1.60	7.00
SW	.44	.12	.56
WSW	.74	.14	.88
W	.60	.21	.81
WNW	4.29	1.88	6.17
NW	4.73	6.31	11.04
NNW	9.27	5.77	15.05
Calm	20.82	.00	20.82
All	74.10	25.90	

OMK Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	14.17	5.54	18.71	38.42
2 < S <= 6	10.11	12.36	13.22	35.68
6 < S <= 10	2.67	12.01	3.20	17.88
10 < S <= 20	.12	7.63	.00	7.74
20 < S	.00	.28	.00	.28
All Speeds	27.06	37.81	35.13	100.00

OMK Wind Direction Distribution During Precipitation

16.74% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	3.46	.28	.14	.42	.00	.14	4.43
NNE	1.66	.14	.14	.28	.00	.00	2.22
NE	.14	.00	.00	.00	.00	.00	.14
ENE	.00	.00	.00	.28	.00	.00	.28
E	.42	.00	.00	.00	.00	.00	.42
ESE	3.74	.83	.14	.69	.42	.00	5.82
SE	4.57	.42	.28	.14	.00	.00	5.40
SSE	8.17	1.25	.69	1.80	.55	.28	12.74
S	3.60	.42	.00	.97	.28	.14	5.40
SSW	4.02	.69	.14	1.80	.14	.00	6.79
SW	.28	.00	.00	.14	.00	.00	.42
WSW	.69	.00	.14	.00	.00	.00	.83
W	.28	.00	.14	.00	.00	.00	.42
WNW	1.52	.42	.00	.55	.00	.14	2.63
NW	4.99	.42	.00	1.38	.28	.00	7.06
NNW	9.00	.69	.55	2.49	.55	.28	13.57
Calm	13.71	1.66	.69	11.36	3.32	.69	31.44
All	60.25	7.20	3.05	22.30	5.54	1.66	

3.2.11 Station: Pasco, Washington (PSC)

Type: Naval Air Station/Supplemental Aviation Weather Reporting Station

Location: 46:14:00N 119:07:00W 131 meters (430 feet) elevation.

Measurement height: 10 meters (33 feet).

Instrument mounted: On a beacon tower.

HEDR environmental grid coordinates: X = 9.54, Y = 11.01.

Data source: Magnetic tape and microfiche.

Data availability: Observations taken every hour for 1944 through 1946.
Not listed by NWDI for 1947 and 1948.
Five to six observations per day on microfiche for 3/5/49 through 12/31/49.
Wind data were entered every 3 hours during this period.

Missing data: Unknown.

Local topography: This station is located immediately south and east of the Hanford Reservation. It is at the southern apex of a basin formed by the Columbia River and surrounded by Yakima Ridge and Rattlesnake Hills to the northwest, Saddle Mountains to the north, Juniper Hills to the east, and Horse Heaven Hills to the south. The Columbia River flows into Pasco from the north and west and exits to the southeast. The Yakima River flows in from the west and the Snake River flows in from the northeast.

Wind roses: A sharp maximum is found for winds from the south-southwest. Figure 3.11 illustrates the wind rose, precipitation rose, and the wind speed histogram for this station. Table 3.11 summarizes the wind direction and wind speed and stability distributions.

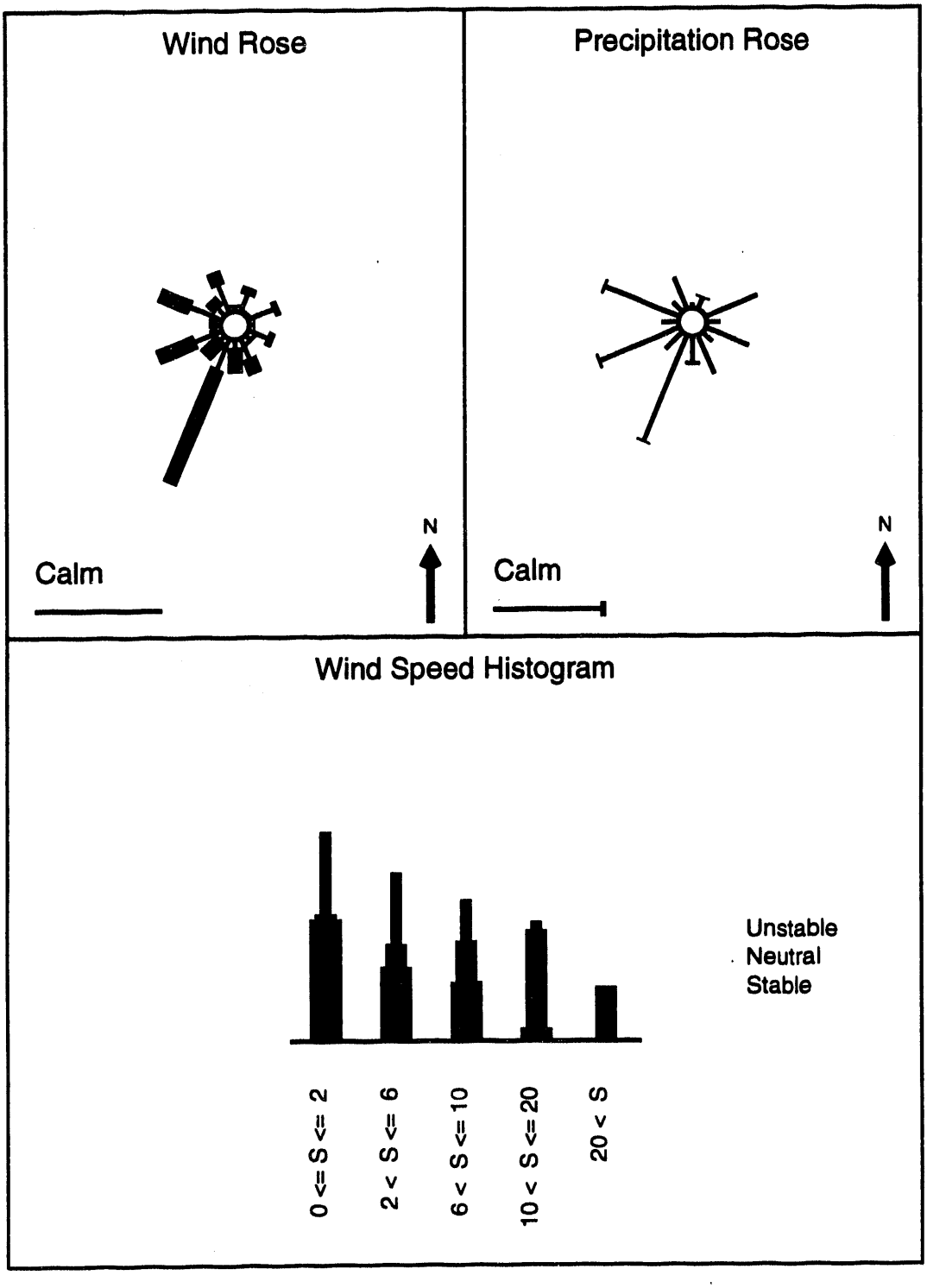


Figure 3.11. Pasco Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.11. Pasco Wind Direction and Wind Speed and Stability Distributions

PSC Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	.57	.34	.91
NNE	2.65	1.00	3.65
NE	.36	.11	.47
ENE	3.84	.78	4.62
E	.60	.22	.82
ESE	2.88	.87	3.75
SE	.85	.38	1.22
SSE	3.16	2.27	5.43
S	1.20	3.53	4.73
SSW	4.74	17.64	22.38
SW	.77	3.30	4.07
WSW	4.11	5.68	9.80
W	.54	1.16	1.70
WNW	4.80	4.67	9.47
NW	1.32	1.59	2.91
NNW	4.17	1.91	6.08
Calm	17.99	.00	17.99
All	54.56	45.44	

PSC Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	17.61	.76	11.88	30.25
2 < S <= 6	10.65	3.33	10.32	24.30
6 < S <= 10	8.46	5.99	5.98	20.44
10 < S <= 20	1.76	14.28	1.19	17.23
20 < S	.23	7.55	.00	7.78
All Speeds	38.71	31.92	29.38	100.00

PSC Wind Direction Distribution During Precipitation

5.30% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	.73	.00	.00	.00	.00	.00	.73
NNE	1.74	.14	.00	.00	.00	.00	1.89
NE	.00	.00	.00	.00	.00	.00	.00
ENE	7.98	.00	.00	.00	.00	.00	7.98
E	1.89	.00	.00	.00	.00	.00	1.89
ESE	6.53	.00	.00	.14	.00	.00	6.68
SE	1.89	.00	.00	.00	.00	.00	1.89
SSE	5.95	.00	.00	.00	.00	.00	5.95
S	3.63	.44	.00	.00	.00	.00	4.06
SSW	15.97	.14	.00	.29	.00	.00	16.40
SW	3.34	.00	.00	.00	.00	.00	3.34
WSW	10.60	.29	.00	1.60	.00	.00	12.48
W	2.32	.00	.00	.00	.00	.00	2.32
WNW	9.29	.29	.00	2.03	.00	.00	11.61
NW	1.16	.00	.00	.73	.00	.00	1.89
NNW	4.50	.00	.00	.29	.00	.00	4.79
Calm	13.93	.58	.00	1.45	.14	.00	16.11
All	91.44	1.89	.00	6.53	.14	.00	

3.2.12 Station: Spokane, Washington (Felts Field) (SFF)

Type: Weather Bureau Airport Station

Location: 47:40:00N 117:20:00W 600 meters (1968 feet) elevation.

Measurement height: 16.1 meters (53 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 16.49, Y = 19.26.

Data source: Paper copy for 1944 through 1947.
Not listed by NWDI from 1948 to 1957.

Data availability: Observations taken every hour during 1944 through 1947.
For 1946 and 1947, only wind data have been entered. Other meteorological data are found in the records, but use a nonstandard coding.

Missing data: None.

Local topography: This station is located about 10 kilometers (6 miles) southwest of the center of the city of Spokane. To the west and southwest, no significant terrain features are in the area for 120 kilometers (75 miles). To the northeast, the land gradually climbs to hills that rise to around 300 meters (1000 feet) above the station.

Station was moved: 11/58 Measurement height: 12.2 meters (40 feet).

Station was moved: 7/64 Measurement height: 6.1 meters (20 feet).

Instrument mounted: 7/64 on a tower on the ground.

Wind roses: The wind distribution is strongly bimodal with maxima from the north-northeast and south-southwest. Winds from one of these two sectors are recorded for more than 34 percent of the total hours. The maximum for winds from the north-northeast is dominated by speeds less than 6 mph, while the maximum from the south-southwest has more winds above 6 mph than below. The precipitation rose shows that precipitation seldom occurs with winds between west-southwest and north-northwest and is fairly uniformly distributed through the other directions. The two maxima in the wind rose are conspicuously absent from the precipitation rose. Figure 3.12 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. Table 3.12 summarizes the wind direction and wind speed and stability distributions.

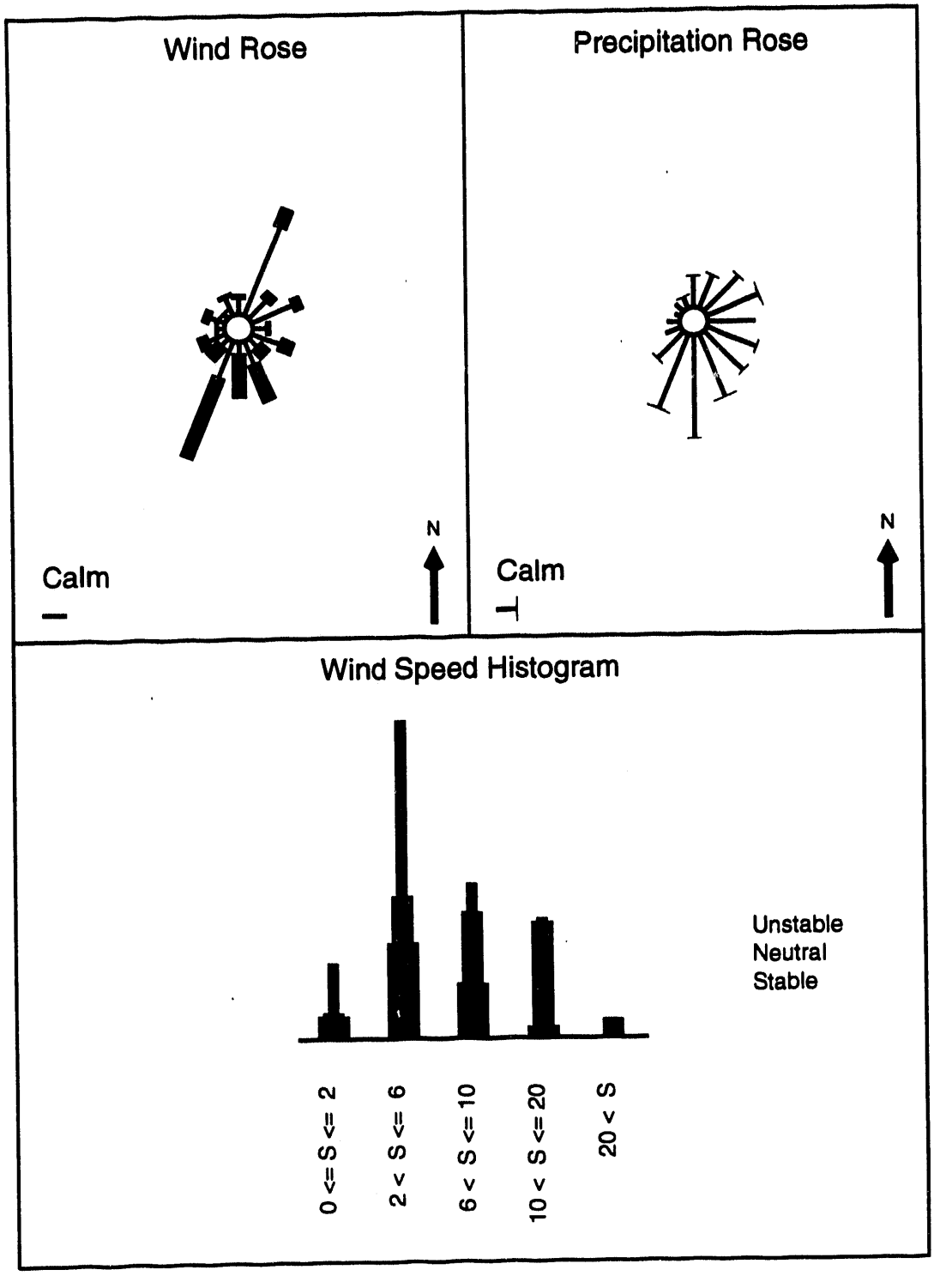


Figure 3.12. Spokane (Felts Field) Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.12. Spokane (Felts Field) Wind Direction and Wind Speed and Stability Distributions

SFF Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	2.19	.71	2.90
NNE	13.61	2.91	16.52
NE	3.46	1.36	4.81
ENE	6.16	1.58	7.73
E	1.81	.80	2.61
ESE	4.11	2.19	6.29
SE	1.54	1.88	3.42
SSE	3.45	5.84	9.29
S	1.62	6.42	8.04
SSW	5.44	12.55	17.99
SW	1.25	2.49	3.74
WSW	2.43	1.63	4.06
W	.83	.49	1.33
WNW	2.17	1.14	3.31
NW	.78	.31	1.09
NNW	2.63	.60	3.23
Calm	3.64	.00	3.64
All	57.11	42.89	

SFF Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	3.31	.48	7.33	11.11
2 < S <= 6	14.02	6.77	25.20	45.99
6 < S <= 10	8.01	10.45	4.12	22.59
10 < S <= 20	1.62	15.35	.61	17.58
20 < S	.06	2.66	.00	2.72
All Speeds	27.02	35.72	37.26	100.00

SFF Wind Direction Distribution During Precipitation

13.66% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	3.13	.00	.00	1.39	.03	.00	4.55
NNE	3.24	.03	.00	1.86	.08	.00	5.21
NE	3.52	.00	.00	3.58	.11	.00	7.21
ENE	4.93	.08	.00	2.99	.08	.03	8.12
E	5.13	.00	.00	1.66	.00	.00	6.79
ESE	5.35	.03	.00	2.22	.11	.00	7.71
SE	5.41	.03	.00	2.49	.08	.00	8.01
SSE	6.99	.00	.00	2.61	.00	.03	9.62
S	10.42	.03	.00	4.27	.00	.00	14.72
SSW	8.54	.11	.00	2.74	.03	.03	11.45
SW	3.71	.05	.00	1.66	.00	.00	5.43
WSW	1.41	.00	.00	.92	.00	.00	2.33
W	1.36	.00	.00	.44	.00	.00	1.80
WNW	.53	.00	.00	.33	.00	.00	.86
NW	1.00	.00	.00	.55	.00	.00	1.55
NNW	.92	.03	.00	.89	.00	.00	1.83
Calm	1.61	.03	.00	1.11	.00	.05	2.80
All	67.20	.42	.00	31.72	.53	.14	

3.2.13 Station: Spokane, Washington (Geiger Field) (GEG)

Type: Not determined.

Location: 47:37:00N 117:31:00W 721 meters (2365 feet) elevation.

Measurement height: 10 meters (33 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 15.79, Y = 18.97.

Data source: Magnetic tape for 1941 through 1945.

Data availability: Observations taken every hour 1941 through 1947.

Missing data: Unknown.

Local topography: This station is located northwest of the center of Spokane. To the west of the station, one encounters first the city, then the Spokane River. Further to the west and southwest, no significant terrain features are found for 120 kilometers (75 miles). To the northeast, the land gradually climbs to hills that rise to approximately 300 meters (1000 feet) above the station.

Station was moved: 12/47 Measurement height: 8.8 meters (30 feet).

Station was moved: 7/57 Measurement height: 10.4 meters (34 feet).

Station was moved: 11/57 Measurement height: 6.1 meters (20 feet).

Instrument mounted: 11/57 on a tower on the ground.

Station was moved: 5/65 Location: 47:38:00N 117:32:00W. Measurement height: 6.1 meters (20.0 feet).

HEDR environmental grid coordinates: 5/65 X = 15.72, Y = 19.06.

Wind roses: Not computed for this station.

3.2.14 Station: Stampede Pass, Washington (SMP)

Type: Weather Bureau Office

Location: 47:17:00N 121:20:00W 1209 meters (3966 feet) elevation.

Measurement height: 8.8 meters (29 feet).

Instrument mounted: On a tower on the ground.

HEDR environmental grid coordinates: X = 0.91, Y = 17.05.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour during the period from 1944 to 1947.

Missing data: No data for 2/21/46 hours 1 to 12.
No data for 4/21/46 hours 1 to 12.
No data for 5/22/46 hours 1 to 12.

Local topography: This station is located at the summit of a pass in the Cascade Mountains. Peaks rise 100 or 200 meters (300 to 600 feet) above the station within 1 mile to the northwest and to the southeast. The more general environs of the station consist of numerous jumbled peaks and valleys in all directions, including a valley formed by the Yakima River that passes about 5 kilometers (3 or so miles) to the northeast of the station.

Wind roses: This station is exposed to south-southwesterly, southwesterly, and west-southwesterly winds nearly 65 percent of the time, most often with speeds of 6 mph or more (56 percent of the total hours). An additional 22 percent of the total hours has winds from the northeast, east-northeast, or east, also most often with speeds of 6 mph or more. Figure 3.14 illustrates the wind rose, precipitation rose, and the wind speed histogram for this station. Table 3.14 summarizes the wind direction and wind speed and stability distributions.

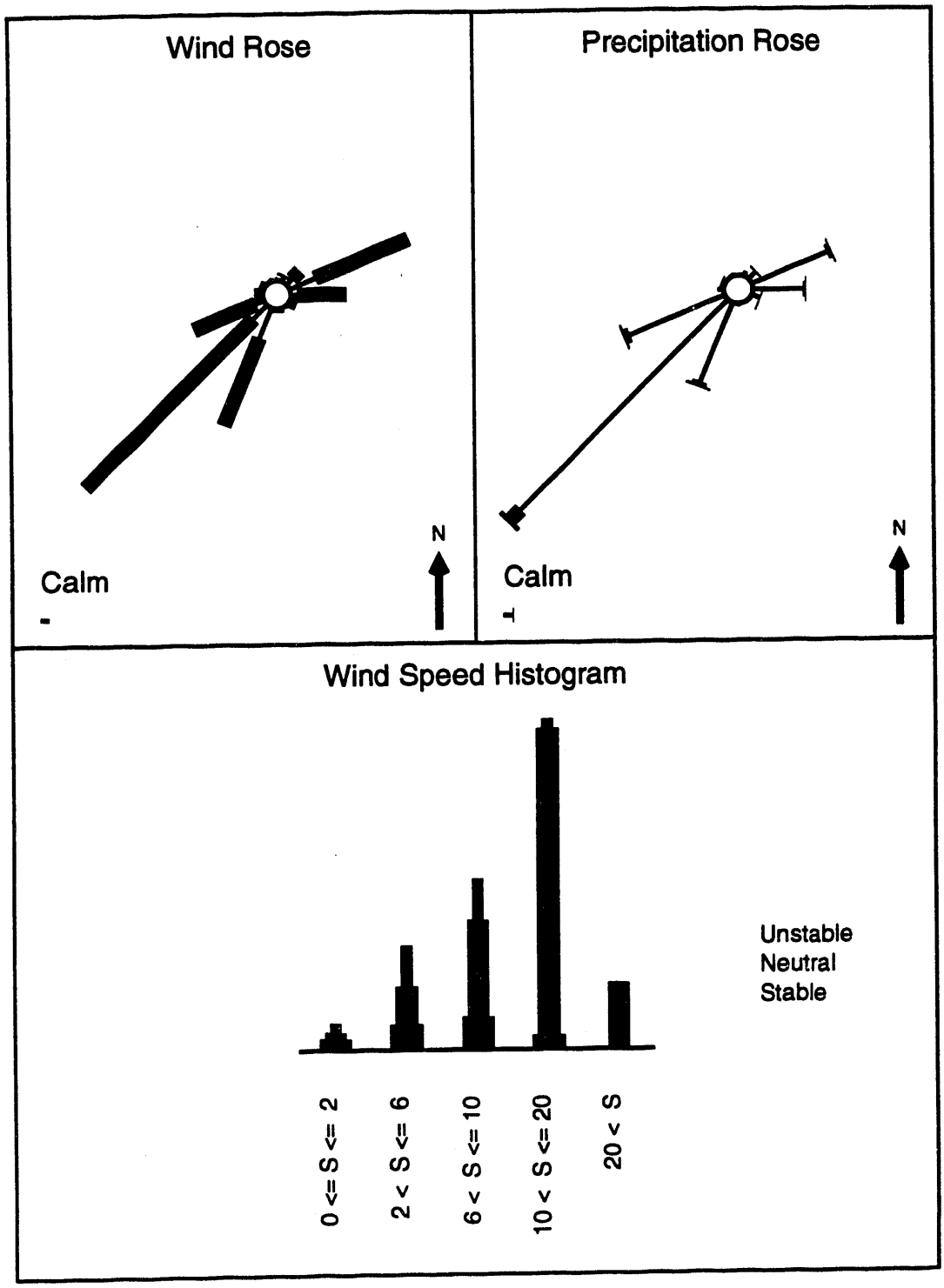


Figure 3.14. Stampede Pass Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.14. Stampede Pass Wind Direction and Wind Speed and Stability Distributions

SMP Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	.22	.03	.24
NNE	.66	.24	.90
NE	1.20	1.48	2.69
ENE	3.93	14.01	17.94
E	1.03	6.78	7.81
ESE	.41	.67	1.08
SE	.10	.04	.14
SSE	.20	.03	.23
S	.26	.23	.49
SSW	4.66	13.32	17.98
SW	2.74	33.59	36.33
WSW	1.30	9.32	10.62
W	.28	.86	1.14
WNW	.31	.39	.70
NW	.19	.07	.26
NNW	.22	.03	.25
Calm	1.20	.00	1.20
All	18.90	81.10	

SMP Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	1.61	.92	1.37	3.90
2 < S <= 6	3.69	5.49	5.82	14.99
6 < S <= 10	4.78	13.88	5.87	24.53
10 < S <= 20	2.05	43.67	1.30	47.02
20 < S	.03	9.53	.00	9.56
All Speeds	12.16	73.48	14.36	100.00

SMP Wind Direction Distribution During Precipitation

36.13% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	.15	.00	.00	.06	.00	.00	.21
NNE	.34	.00	.00	.28	.01	.01	.63
NE	.74	.03	.00	.66	.04	.01	1.47
ENE	2.97	.12	.01	8.68	.35	.04	12.17
E	2.00	.07	.01	5.13	.26	.01	7.48
ESE	.33	.01	.00	.92	.01	.04	1.30
SE	.10	.00	.00	.10	.00	.00	.19
SSE	.09	.00	.00	.17	.00	.00	.26
S	.17	.00	.00	.22	.00	.00	.38
SSW	4.49	.11	.01	7.78	.37	.15	12.90
SW	19.69	.84	.15	22.14	1.14	.38	44.35
WSW	6.28	.31	.01	8.33	.40	.15	15.48
W	.49	.01	.00	.31	.00	.00	.81
WNW	.26	.00	.00	.19	.01	.00	.47
NW	.15	.02	.00	.05	.01	.01	.23
NNW	.19	.01	.00	.10	.00	.00	.29
Calm	.35	.00	.00	.95	.05	.01	1.36
All	38.80	1.52	.19	56.07	2.63	.79	

3.2.15 Station: Walla Walla, Washington (ALW)

Type: Flight Service Station

Location: 46:06:00N 118:17:00W 362 meters (1187 feet) elevation.

Measurement height: 7.6 meters (25 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 12.86, Y = 10.24.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour during the period from 1945 to 1947.

Missing data: No data for 8/19/47.

Local topography: This station is located in a relatively flat circular region about 16 kilometers (10 miles) in diameter and surrounded by rolling hills with less than 100 meters (300 feet) of elevation variation. The Walla Walla River drains through a gap to the west. Immediately to the southeast of Walla Walla are the Blue Mountains, which run from northeast to southwest and rise 1000 meters (3000 feet) above Walla Walla.

Station was moved: 3/46 Measurement height: 10.7 meters (35 feet).

Station was moved: 4/48 Measurement height: 11.3 meters (37 feet).

Station was moved: 7/49 Measurement height: 10.1 meters (33 feet).

Station was moved: 5/62 Measurement height: 6.1 meters (20 feet)

Instrument mounted: 5/62 on a tower on the ground.

Wind roses: Winds here are most frequently from directions close to southerly. Winds with a northerly component occur in less than 17 percent of the total hours. Figure 3.15 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. Table 3.15 summarizes the wind direction and wind speed and stability distributions.

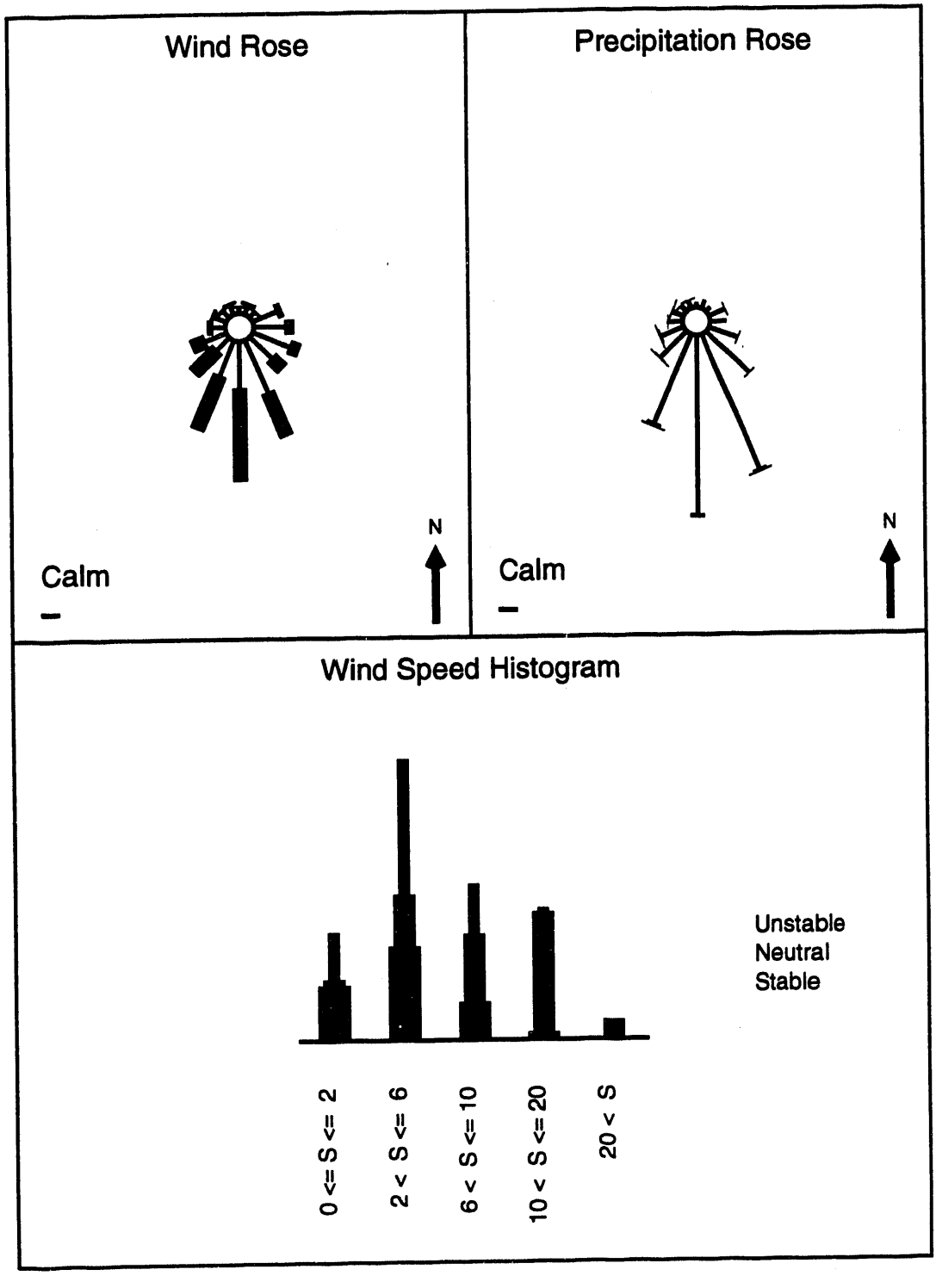


Figure 3.15. Walla Walla Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.15. Walla Walla Wind Direction and Wind Speed and Stability Distributions

ALW Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	.75	.30	1.05
NNE	1.28	.37	1.65
NE	.93	.25	1.19
ENE	3.64	.83	4.47
E	4.37	1.37	5.74
ESE	5.60	1.51	7.11
SE	4.31	2.17	6.48
SSE	8.23	6.87	15.11
S	6.81	13.45	20.26
SSW	5.46	8.43	13.89
SW	2.52	4.56	7.08
WSW	3.15	2.07	5.22
W	1.78	.73	2.51
WNW	1.87	.37	2.24
NW	1.22	.37	1.59
NNW	1.36	.35	1.71
Calm	2.70	.00	2.70
All	55.99	44.01	

ALW Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	7.85	.88	6.79	15.52
2 < S <= 6	13.43	7.44	19.60	40.47
6 < S <= 10	5.39	9.80	7.18	22.37
10 < S <= 20	1.05	17.22	.59	18.86
20 < S	.06	2.72	.00	2.79
All Speeds	27.78	38.06	34.16	100.00

ALW Wind Direction Distribution During Precipitation

10.87% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	.59	.00	.00	.06	.00	.00	.65
NNE	1.05	.00	.00	.15	.00	.00	1.20
NE	.71	.00	.00	.13	.00	.00	.84
ENE	2.29	.02	.00	.15	.00	.00	2.45
E	2.16	.00	.00	.08	.00	.00	2.24
ESE	3.75	.00	.00	.50	.04	.00	4.30
SE	7.78	.04	.00	.67	.04	.00	8.54
SSE	18.98	.25	.02	2.03	.08	.08	21.46
S	22.50	.29	.00	3.31	.17	.00	26.28
SSW	11.81	.17	.04	1.95	.31	.02	14.30
SW	4.72	.00	.00	.50	.13	.02	5.37
WSW	2.81	.13	.02	.52	.06	.02	3.57
W	1.68	.02	.00	.34	.00	.00	2.03
WNW	1.28	.04	.00	.36	.02	.04	1.74
NW	.84	.02	.00	.23	.02	.00	1.11
NNW	.96	.00	.00	.15	.04	.00	1.15
Calm	1.76	.00	.00	1.01	.00	.00	2.77
All	85.68	.99	.08	12.14	.92	.19	

3.2.16 Station: Wenatchee, Washington (EAT)

Type: Supplemental Aviation Weather Reporting Station/Flight Service Station

Location: 47:24:00N 120:12:00W 376 meters (1233 feet) elevation.

Measurement height: 8.5 meters (28 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 5.35, Y = 17.72.

Data source: Paper copy for 1944 through 1947.
Microfiche for 1948 and 1949.

Data availability: Observations began 9/16/45 with 4 to 13 observations per day.
Observation frequency changed to 4 to 24 observations per day after 5/15/46.
Observation frequency changed to 4 to 19 observations per day after 3/10/46.
In 1948 and 1949, 12 to 18 observations were made per day.

Missing data: No data 11/25/46.

Local topography: This station is located near the confluence of the Columbia and the Wenatchee Rivers. The river surface is 600 to 1100 meters (2000 to 3600 feet) below the tops of surrounding peaks and ridges. The Columbia River flows past the town of Wenatchee from the north toward the south, makes a bend to run toward the east past the station and then turns sharply toward the south about 8 kilometers (5 miles) beyond the station.

Station was moved: 11/59 Measurement height: 11.9 meters (39 feet).

Instrument mounted: On the roof of a building.

Data availability: Observations taken every hour after 11/59.

Station was moved: 3/66 Measurement height: 6.1 meters (20 feet).

Instrument mounted: On a tower on the ground.

Wind roses: Winds of all speeds at this station are dominated by flow down the local Columbia riverbed, with half (50.08 percent) of the total hours having winds from west-northwest, west, or west-southwest. Figure 3.16 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. Table 3.16 summarizes the wind direction and wind speed and stability distributions.

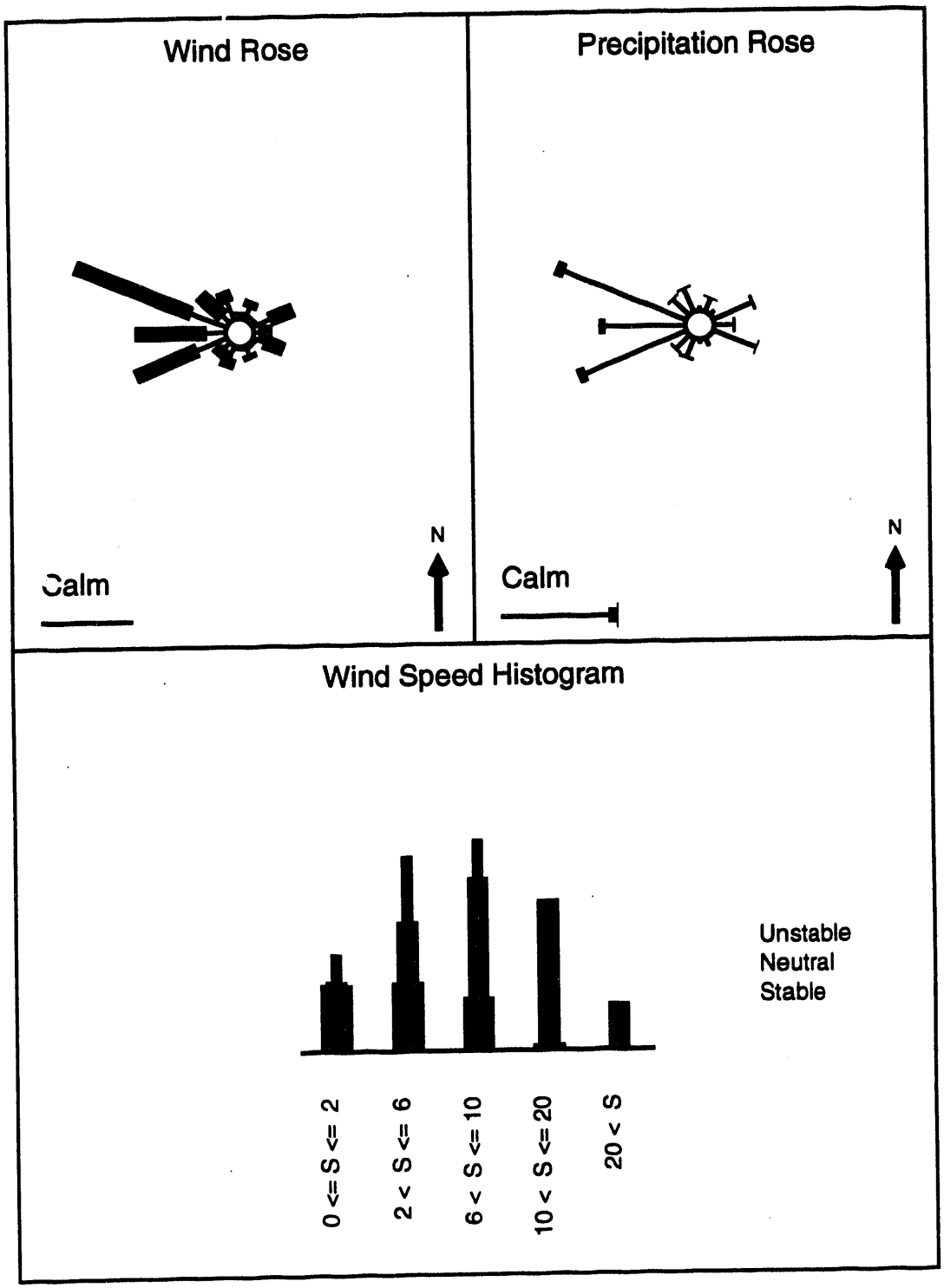


Figure 3.16. Wenatchee Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.16. Wenatchee Wind Direction and Wind Speed and Stability Distributions

EAT Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	.58	.30	.88
NNE	1.78	1.04	2.82
NE	.42	.40	.82
ENE	2.58	3.63	6.21
E	.71	1.86	2.57
ESE	1.77	2.87	4.64
SE	.31	.34	.65
SSE	1.35	.75	2.10
S	.34	.20	.55
SSW	1.88	1.50	3.38
SW	1.03	1.55	2.58
WSW	4.37	9.70	14.06
W	2.63	10.33	12.96
WNW	5.25	17.81	23.06
NW	1.33	4.28	5.61
NNW	2.61	1.65	4.26
Calm	12.86	.00	12.86
All	41.78	58.22	

EAT Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	9.56	.46	3.95	13.98
2 < S <= 6	9.87	8.66	9.28	27.81
6 < S <= 10	7.67	17.05	5.40	30.11
10 < S <= 20	.83	20.60	.00	21.43
20 < S	.28	6.39	.00	6.67
All Speeds	28.21	53.16	18.63	100.00

EAT Wind Direction Distribution During Precipitation

7.74% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	.41	.00	.00	.25	.00	.00	.65
NNE	1.39	.00	.00	.65	.08	.00	2.13
NE	.49	.00	.00	.33	.00	.00	.82
ENE	4.01	.08	.00	1.96	.25	.00	6.30
E	2.13	.08	.00	.57	.25	.00	3.03
ESE	4.66	.08	.00	1.96	.00	.00	6.71
SE	.16	.00	.00	.00	.00	.00	.16
SSE	.98	.00	.00	.25	.00	.00	1.23
S	.49	.00	.00	.16	.00	.00	.65
SSW	1.80	.16	.00	.98	.16	.00	3.11
SW	2.05	.08	.00	.57	.16	.00	2.86
WSW	8.27	.41	.00	7.28	.65	.00	16.61
W	7.36	.41	.00	4.01	.49	.00	12.27
WNW	12.77	.65	.00	5.89	.57	.00	19.89
NW	2.62	.16	.00	.57	.00	.00	3.36
NNW	2.45	.08	.00	1.06	.08	.00	3.68
Calm	7.45	.16	.00	7.77	1.06	.08	16.53
All	59.49	2.37	.00	34.29	3.76	.08	

3.2.17 Station: Yakima, Washington (YKM)

Type: Weather Bureau Airport Station

Location: 46:34:00N 120:32:00W 326 meters (1069 feet) elevation.

Measurement height: 17.7 meters (56 feet).

Instrument mounted: On a beacon tower.

HEDR environmental grid coordinates: X = 3.94, Y = 12.92.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour during the period from 1944 to 1947.

Missing data: No data 5/2/45.

Local topography: This station is located in a small basin formed by the Yakima River, Naches River, and Ahtanum Creek. This basin is surrounded by Umtanum Ridge to the north and east, Rattlesnake Hills to the southeast, Ahtanum Ridge to the south, and Cowiche Mountain to the west. The station is at the southern edge of the basin, just north of Ahtanum Ridge. Ahtanum Creek flows into this basin from the west through the broad, flat Ahtanum Valley. The Naches River flows in from the northwest through a broad valley. The Yakima River enters from the north through a narrow valley and exits to the south through Union Gap, a narrow passage between Ahtanum Ridge and Rattlesnake Hills. The Moxee Valley runs towards the station from the east-southeast.

Station was moved: 7/50 Measurement height: 14.9 meters (49 feet).

Instrument mounted: 7/50 on the roof of a building.

Station was moved: 1/62 Measurement height: 6.1 meters (20 feet).

Instrument mounted: 1/62 on a tower on the ground.

Wind roses: The wind roses for this station show that westerly winds predominate across the Ahtanum Valley with directions ranging from southwesterly to northwesterly. For low winds, secondary maxima correspond to north-northwesterly winds down the Yakima River and east-southeasterly winds out of the Moxee Valley. Figure 3.17 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. Table 3.17 summarizes the wind direction and wind speed and stability distributions.

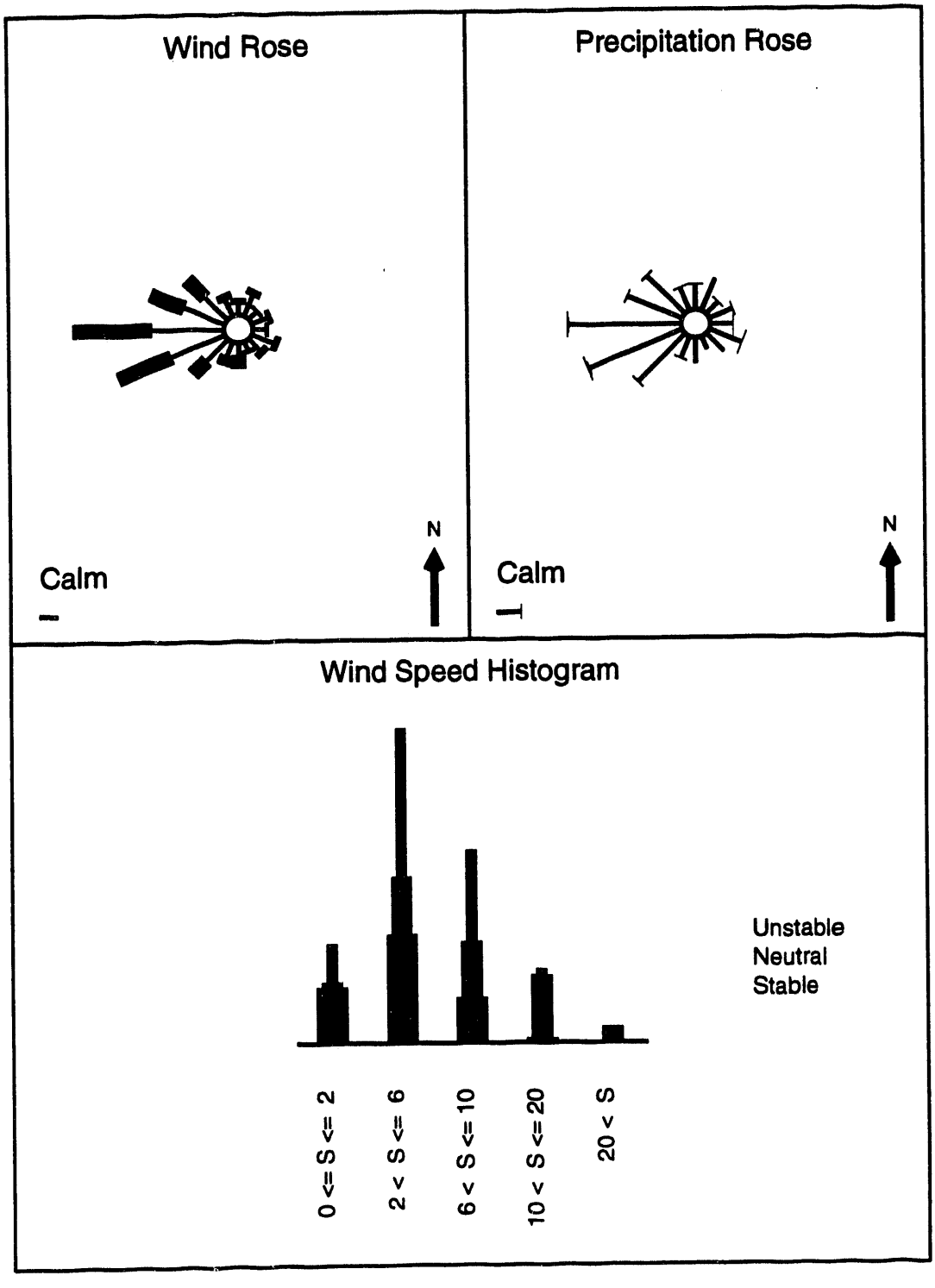


Figure 3.17. Yakima Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.17. Yakima Wind Direction and Wind Speed and Stability Distributions

YKM Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	1.58	.78	2.36
NNE	3.18	.91	4.09
NE	1.44	.44	1.88
ENE	2.34	.61	2.95
E	1.72	.55	2.27
ESE	3.23	.87	4.10
SE	2.14	.91	3.05
SSE	1.21	.53	1.74
S	1.82	1.87	3.69
SSW	2.11	1.39	3.51
SW	4.38	2.70	7.08
WSW	8.16	8.19	16.35
W	10.22	11.16	21.37
WNW	6.27	5.05	11.32
NW	4.60	3.55	8.15
NNW	2.54	.98	3.51
Calm	2.55	.00	2.55
All	59.49	40.51	

YKM Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	8.02	.76	5.51	14.29
2 < S <= 6	15.65	8.23	21.32	45.20
6 < S <= 10	6.48	8.13	13.02	27.63
10 < S <= 20	.64	9.03	.97	10.64
20 < S	.06	2.18	.00	2.23
All Speeds	30.85	28.33	40.82	100.00

YKM Wind Direction Distribution During Precipitation

6.86% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	2.62	.00	.00	1.03	.07	.00	3.72
NNE	3.48	.00	.00	1.46	.00	.00	4.94
NE	1.56	.00	.00	.80	.10	.00	2.45
ENE	2.62	.00	.00	1.03	.03	.00	3.68
E	2.49	.00	.03	.83	.00	.00	3.35
ESE	4.28	.00	.03	.83	.00	.00	5.14
SE	3.02	.00	.00	.53	.00	.00	3.55
SSE	1.69	.00	.00	.26	.00	.00	1.96
S	3.29	.00	.00	.43	.00	.00	3.72
SSW	2.82	.03	.00	.50	.03	.00	3.38
SW	7.53	.03	.00	2.12	.07	.00	9.75
WSW	10.02	.00	.00	4.31	.23	.03	14.60
W	11.15	.03	.07	4.91	.10	.00	16.26
WNW	7.03	.03	.00	1.46	.00	.00	8.53
NW	5.67	.07	.00	2.06	.10	.00	7.90
NNW	2.95	.00	.00	.63	.03	.00	3.62
Calm	2.52	.00	.00	.86	.07	.00	3.45
All	74.75	.20	.13	24.05	.83	.03	

3.2.18 Station: Baker City, Oregon (BKE)

Type: Civil Aeronautics Administration/Flight Service Station

Location: 44:50:00N 117:50:00W 1028 meters (3372 feet) elevation.

Measurement height: 8.5 meters (28 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 14.74, Y = 2.95.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: Hourly data for December 1944 through 1947.

Missing data: Bad copy for half of 11/18/45.

Local topography: To the west of Baker City, Elkhorn Ridge rises as high as 1500 meters (5000 feet) above the station.

Station was moved: 2/49 Location: 44:50:00N 117:49:00W.

Measurement height: 2/49 9.5 meters (31 feet).

HEDR environmental grid coordinates: 2/49 X = 14.81, Y = 2.95.

Station was moved: 1/54 Measurement height: 10.4 meters (34 feet).

Wind roses: Winds in-between the north and east are scarce in this area. Weak maxima are found for winds from near northwest and near east-southeast. Figure 3.18 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. Table 3.18 summarizes the wind direction and wind speed and stability distributions.

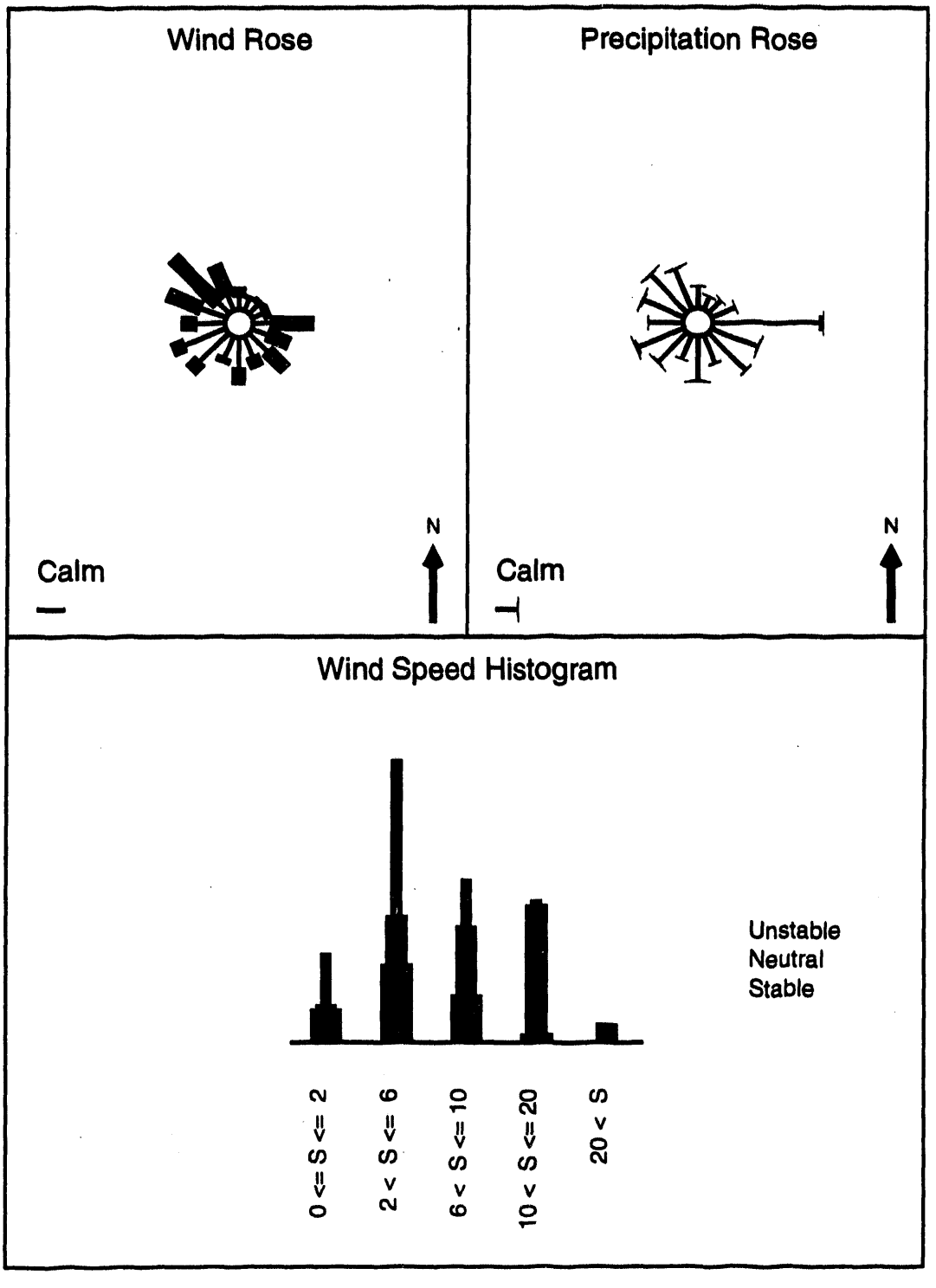


Figure 3.18. Baker City Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.18. Baker City Wind Direction and Wind Speed and Stability Distributions

BKE Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	1.78	1.36	3.14
NNE	1.67	.54	2.21
NE	1.63	.84	2.46
ENE	1.54	1.14	2.68
E	2.47	6.03	8.50
ESE	2.31	3.31	5.61
SE	3.72	3.55	7.27
SSE	3.03	1.76	4.79
S	4.39	2.38	6.77
SSW	3.26	.86	4.12
SW	5.52	1.94	7.46
WSW	6.15	1.88	8.03
W	3.81	2.33	6.14
WNW	3.62	5.18	8.80
NW	2.06	9.00	11.06
NNW	2.29	4.52	6.81
Calm	4.15	.00	4.15
All	53.39	46.61	

BKE Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

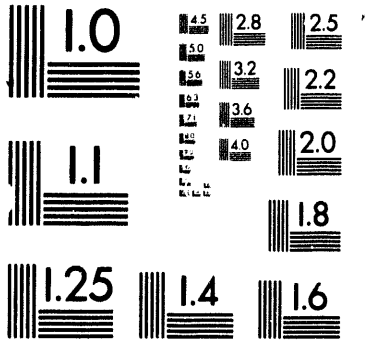
Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	4.77	.67	7.35	12.79
2 < S <= 6	11.23	6.97	22.40	40.60
6 < S <= 10	6.82	9.91	6.72	23.44
10 < S <= 20	1.24	18.50	.73	20.47
20 < S	.08	2.62	.00	2.70
All Speeds	24.13	38.67	37.20	100.00

BKE Wind Direction Distribution During Precipitation

10.79% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	1.88	.08	.00	1.18	.04	.00	3.19
NNE	1.14	.06	.00	.76	.04	.00	2.01
NE	1.63	.00	.00	.93	.02	.00	2.58
ENE	2.09	.00	.00	1.67	.08	.00	3.85
E	7.86	.02	.00	7.44	.55	.04	15.91
ESE	3.80	.08	.02	3.34	.06	.02	7.33
SE	5.53	.06	.00	2.15	.06	.00	7.82
SSE	2.54	.02	.00	1.63	.17	.00	4.35
S	4.50	.06	.00	1.88	.06	.04	6.55
SSW	1.94	.00	.00	1.67	.04	.00	3.65
SW	3.55	.04	.02	2.41	.13	.00	6.15
WSW	4.22	.06	.00	2.89	.30	.04	7.52
W	3.38	.08	.00	1.65	.08	.00	5.20
WNW	3.99	.02	.02	2.35	.19	.04	6.61
NW	5.43	.00	.00	2.13	.15	.04	7.75
NNW	4.08	.02	.00	2.05	.15	.04	6.34
Calm	1.46	.00	.00	1.58	.15	.02	3.21
All	59.02	.63	.06	37.71	2.28	.30	


1.0
4.5
2.8
2.5
5.0
5.6
3.2
2.2
6.3
3.6
7.1
4.0
2.0
1.1
1.8
1.25
1.4
1.6

2 of 2

3.2.19 Station: Burns, Oregon (BNO)

Type: Weather Bureau Office

Location: 43:35:00N 119:03:00W 1272 meters (4172 feet) elevation.

Measurement height: 14.3 meters (47 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 9.75, Y = -4.25.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour from 12/44 to 9/22/45.
Eight observations per day from 12/15/45 through the end of 1949.

Missing data: No data from 9/23/45 through 12/15/45.
Bad copy for 7/18/45.
No data 10/47 through 11/47.

Local topography: North and west of the station, mountains rise 1000 to 1300 meters (3000 to 4000 feet) above the station. To the south, the land slopes gradually downward to Malhuer and Harney Lakes.

Station was moved: 6/50 Measurement height: 18.9 meters (62 feet).

Station was moved: 5/52 Measurement height: 20.7 meters (68 feet).

Wind roses: This distribution has a weak maximum of 11.83 percent from north-northwesterly winds and decreases smoothly in both directions to a minimum for east-southeasterly winds. Figure 3.19 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. Table 3.19 summarizes the wind direction and wind speed and stability distributions.

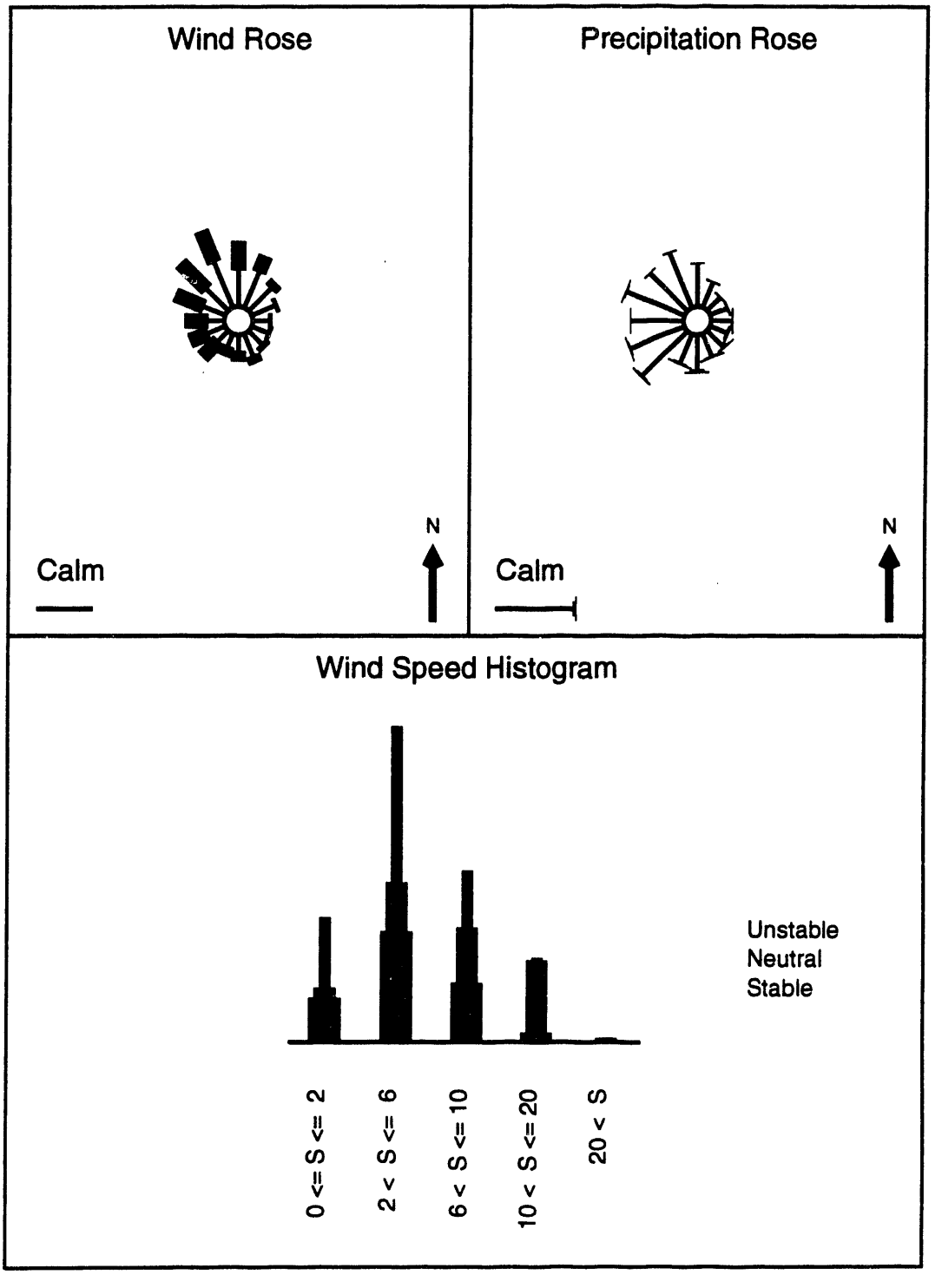


Figure 3.19. Burns Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.19. Burns Wind Direction and Wind Speed and Stability Distributions

BNO Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	5.26	4.04	9.30
NNE	5.52	2.39	7.91
NE	4.45	1.06	5.51
ENE	3.41	.51	3.92
E	2.23	.50	2.73
ESE	2.36	.54	2.89
SE	2.58	.75	3.34
SSE	3.30	1.08	4.37
S	2.29	1.44	3.73
SSW	1.85	1.42	3.28
SW	2.03	3.10	5.13
WSW	2.61	2.77	5.37
W	2.29	3.30	5.59
WNW	3.30	4.30	7.60
NW	4.41	5.14	9.55
NNW	7.04	4.79	11.83
Calm	7.95	.00	7.95
All	62.87	37.13	

BNO Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	6.32	1.40	10.02	17.74
2 < S <= 6	15.80	7.07	22.26	45.13
6 < S <= 10	8.41	7.87	8.23	24.51
10 < S <= 20	1.29	10.33	.41	12.03
20 < S	.02	.57	.00	.59
All Speeds	31.84	27.25	40.91	100.00

BNO Wind Direction Distribution During Precipitation

11.87% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	4.45	.00	.00	1.66	.05	.00	6.16
NNE	2.42	.05	.00	1.37	.14	.00	3.98
NE	1.52	.00	.00	1.00	.19	.00	2.70
ENE	1.42	.09	.00	1.04	.14	.00	2.70
E	1.47	.00	.00	1.37	.05	.14	3.03
ESE	1.04	.00	.00	1.33	.19	.19	2.75
SE	1.80	.00	.00	1.37	.19	.05	3.41
SSE	1.61	.00	.00	1.80	.09	.14	3.65
S	2.51	.00	.00	2.42	.33	.09	5.36
SSW	2.42	.00	.05	1.90	.19	.05	4.60
SW	4.88	.00	.00	3.98	.19	.09	9.15
WSW	5.21	.09	.00	2.99	.09	.05	8.44
W	4.36	.00	.00	3.08	.05	.05	7.54
WNW	5.26	.05	.00	3.60	.09	.05	9.05
NW	4.64	.00	.00	2.84	.05	.00	7.54
NNW	5.59	.05	.00	2.84	.05	.00	8.53
Calm	5.83	.05	.00	5.17	.33	.05	11.42
All	56.44	.38	.05	39.76	2.42	.95	

3.2.20 Station: Condon, Oregon (CON)

Type: Weather Bureau Office

Location: 45:15:00N 120:11:00W 887 meters (2909 feet) elevation.

Measurement height: 8.8 meters (29 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 5.19, Y = 5.34.

Data source: Paper copy for 1944 through 9/22/45.
Not listed by NWDI after 1945.

Data availability: Observations taken every hour during December 1944 until 9/22/45. No data after that time.

Missing data: None.

Local topography: This station is located near the northern apex of a triangular shelf with rolling hills surrounding the shelf.

Wind roses: Winds in between southerly and west-northwesterly present a broad maximum in this area, with a weak secondary maximum for north-northwesterly and northwesterly winds. This station has the fewest (2.61 percent) hours of winds less than or equal to 2 mph of any HEDR station; however, winds greater than 20 mph occur only 4.34 percent of the time, placing it near the median of HEDR stations for frequency of high winds. Figure 3.20 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. Table 3.20 summarizes the wind direction and wind speed and stability distributions.

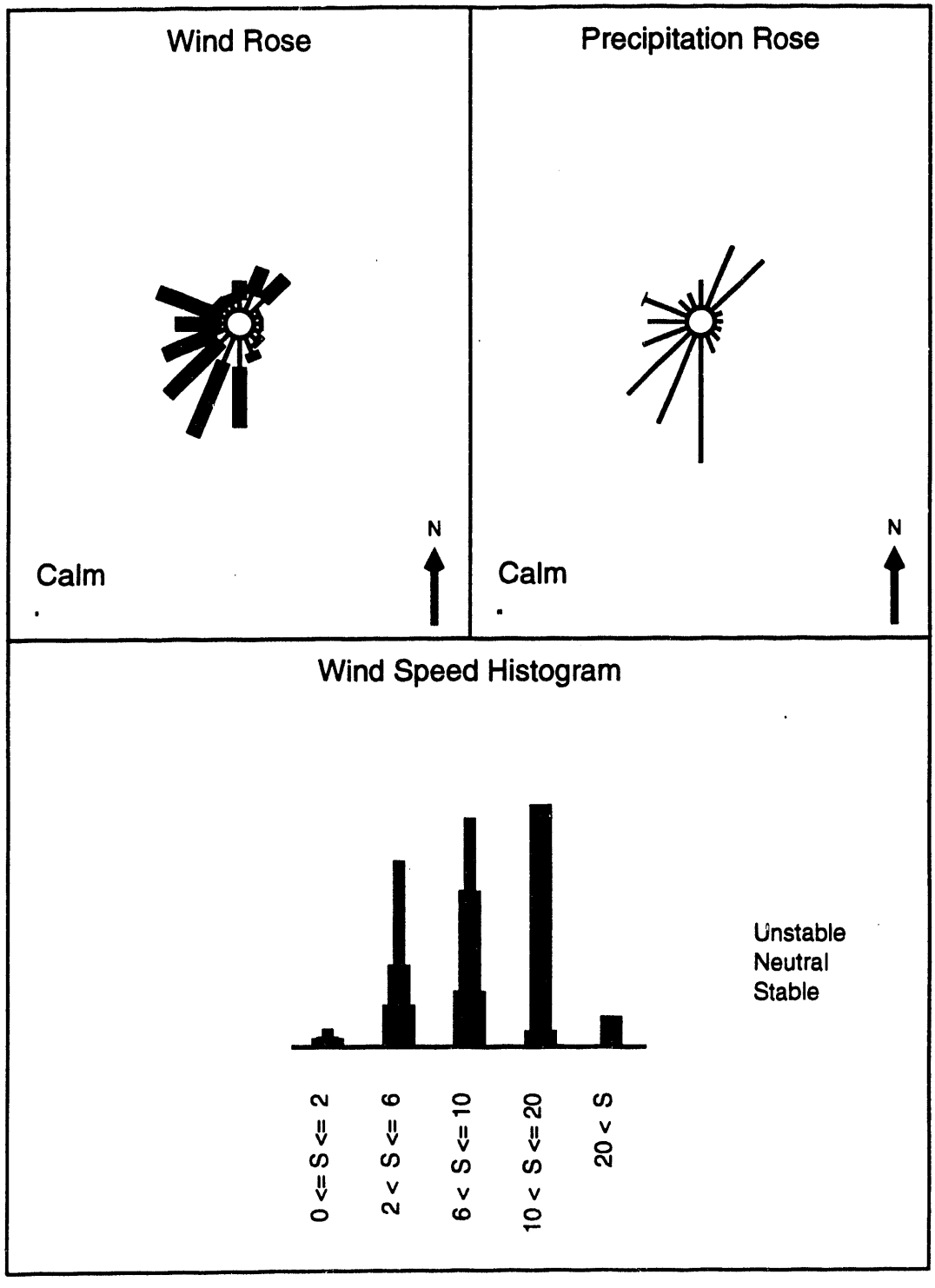


Figure 3.20. Condon Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.20. Condon Wind Direction and Wind Speed and Stability Distributions

CON Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	1.61	2.63	4.23
NNE	2.63	4.06	6.69
NE	2.81	4.51	7.32
ENE	.80	.49	1.30
E	.80	.52	1.33
ESE	.97	.26	1.24
SE	1.31	.76	2.07
SSE	2.44	1.16	3.60
S	4.25	8.51	12.75
SSW	3.94	11.18	15.12
SW	1.75	10.48	12.23
WSW	1.71	7.74	9.45
W	.62	6.41	7.03
WNW	1.25	9.08	10.33
NW	.85	1.75	2.59
NNW	.97	1.47	2.44
Calm	.29	.00	.29
All	29.00	71.00	

CON Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	1.27	.15	1.19	2.61
2 < S <= 6	6.01	5.65	14.73	26.39
6 < S <= 10	7.95	14.16	10.24	32.35
10 < S <= 20	2.32	32.00	.00	34.31
20 < S	.06	4.28	.00	4.34
All Speeds	17.60	56.24	26.16	100.00

CON Wind Direction Distribution During Precipitation

12.35% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	1.50	.00	.00	2.50	.00	.00	4.00
NNE	3.63	.00	.00	6.13	.00	.00	9.75
NE	2.13	.00	.00	8.25	.00	.00	10.38
ENE	.50	.00	.00	.75	.00	.00	1.25
E	.75	.00	.00	.38	.00	.00	1.13
ESE	.75	.00	.00	.38	.00	.00	1.13
SE	1.63	.00	.00	.00	.00	.00	1.63
SSE	2.50	.00	.00	.25	.00	.00	2.75
S	14.88	.00	.00	3.13	.00	.00	18.00
SSW	11.25	.00	.00	2.38	.00	.00	13.63
SW	8.75	.00	.00	3.75	.00	.00	12.50
WSW	4.63	.00	.00	2.13	.00	.00	6.75
W	3.75	.00	.00	1.63	.00	.00	5.38
WNW	4.75	.00	.00	1.75	.13	.00	6.63
NW	1.50	.00	.00	.75	.00	.00	2.25
NNW	1.63	.00	.00	.75	.00	.00	2.38
Calm	.25	.00	.00	.25	.00	.00	.50
All	64.75	.00	.00	35.13	.13	.00	

3.2.21 Station: Ontario, Oregon (ONO)

Type: Supplemental Aviation Weather Reporting Station

Location: 44:01:00N 117:01:00W 668 meters (2191 feet) elevation.

Measurement height: 17.4 meters (57 feet).

Instrument mounted: On a beacon tower.

HEDR environmental grid coordinates: X = 18.18, Y = -1.76.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: According to NWDI, wind direction was an estimate.
Observations taken every hour from 1944 through 1946.
8 to 16 observations per day 1/1/47 through 4/8/47.
Hourly observations from 4/9/47 through 12/31/47.

Missing data: No data for 2100 to 0800 hours during 12/6-31/46.

Local topography: This station is immediately west of the Snake River.

Station was moved: 8/51 Measurement height: 10.1 meters (32 feet).

Instrument mounted: On a tower on the ground.

Data availability: Observations taken every 3 hours.

Station was moved: 1/56 Measurement height: 10 meters (33 feet).

Station was moved: 9/68 Measurement height: 7.6 meters (25 feet).

Wind roses: This distribution is very diffuse with a broad, weak maximum from west-southwest clockwise to east-northeast and a broad, weak minimum for the remainder of the directions. Figure 3.21 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. Table 3.21 summarizes the wind direction and wind speed and stability distributions.

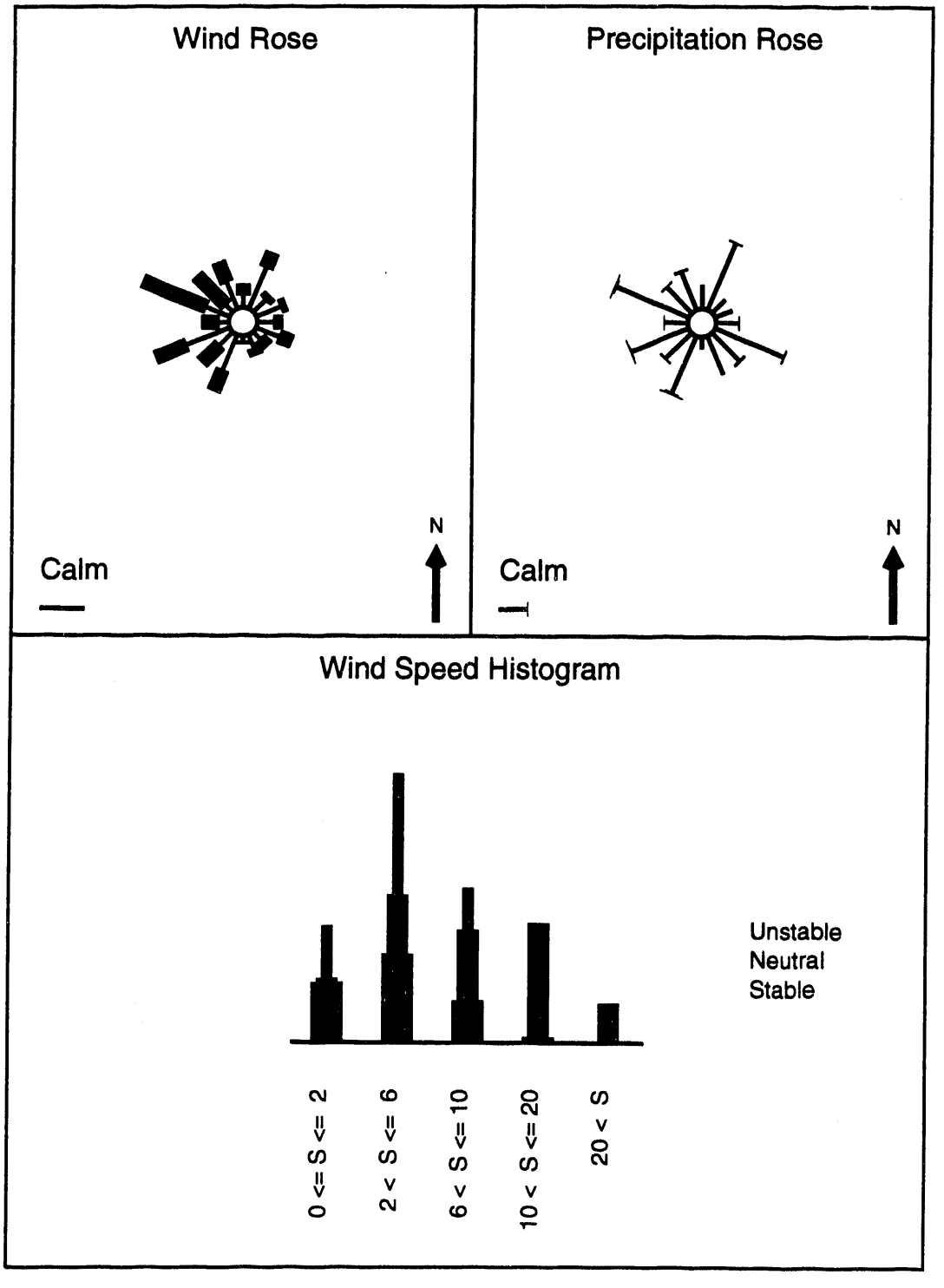


Figure 3.21. Ontario Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.21. Ontario Wind Direction and Wind Speed and Stability Distributions

ONO Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	1.77	1.57	3.34
NNE	6.37	2.29	8.66
NE	2.36	.99	3.34
ENE	3.62	.89	4.51
E	2.27	1.30	3.57
ESE	3.42	2.05	5.47
SE	1.37	1.47	2.84
SSE	2.05	1.04	3.09
S	.77	.39	1.17
SSW	5.36	3.29	8.65
SW	2.57	3.60	6.16
WSW	6.51	4.77	11.27
W	1.36	2.48	3.85
WNW	3.56	9.72	13.28
NW	1.33	5.88	7.22
NNW	4.10	3.12	7.22
Calm	6.36	.00	6.36
All	55.14	44.86	

ONO Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	8.54	.65	7.45	16.64
2 < S <= 6	12.64	8.50	17.36	38.51
6 < S <= 10	6.02	10.05	6.07	22.15
10 < S <= 20	.81	16.26	.00	17.07
20 < S	.08	5.56	.00	5.64
All Speeds	28.09	41.03	30.88	100.00

ONO Wind Direction Distribution During Precipitation

8.53% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	2.43	.00	.00	.93	.00	.00	3.36
NNE	7.70	.09	.00	2.43	.09	.00	10.32
NE	2.38	.00	.00	.19	.00	.00	2.57
ENE	2.24	.00	.00	.37	.00	.00	2.61
E	2.85	.14	.00	.33	.00	.00	3.32
ESE	9.06	.09	.00	1.49	.09	.00	10.74
SE	4.53	.05	.00	.98	.23	.00	5.79
SSE	4.95	.00	.00	1.03	.00	.00	5.98
S	1.63	.00	.00	.09	.00	.00	1.73
SSW	7.19	.09	.05	1.68	.14	.00	9.15
SW	4.67	.09	.00	.51	.09	.00	5.37
WSW	7.05	.05	.00	1.77	.05	.05	8.96
W	3.17	.00	.00	.19	.05	.00	3.41
WNW	9.90	.23	.00	1.26	.00	.05	11.44
NW	4.39	.14	.00	.65	.05	.00	5.23
NNW	4.48	.23	.00	1.21	.05	.00	5.98
Calm	2.99	.00	.00	1.03	.05	.00	4.06
All	81.61	1.21	.05	16.15	.89	.09	

3.2.22 Station: Pendleton, Oregon (PDT)

Type: Weather Bureau Airport Station

Location: 45:41:00N 118:51:00W 459 meters (1506 feet) elevation.

Measurement height: 10.7 meters (35 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 10.60, Y = 7.84.

Data source: Magnetic tape 1944 through 1949.

Data availability: Observations taken every hour.

Missing data: Unknown.

Local topography: This station is located along the Umatilla River. The river channel is not deep enough to have much effect on winds at the station. The terrain around the station has elevation variations of less than about 100 meters (a few hundred feet). About 16 kilometers (10 miles) to the southeast of Pendleton is the edge of the Blue Mountains. These mountains, which rise about 750 meters (2500 feet) above Pendleton and run from northeast to southwest, have a rather abrupt edge that makes an impressive escarpment when viewed from Pendleton.

Station was moved:	4/47	Measurement height: 12.5 meters (41 feet).
Station was moved:	10/49	Measurement height: 11.3 meters (37 feet).
Station was moved:	5/54	Measurement height: 16.2 meters (53 feet).
Station was moved:	4/58	Measurement height: 6.1 meters (20 feet).
Instrument mounted:	4/58	On a tower on the ground.
Station was moved:	2/59	Measurement height: 16.2 meters (53 feet).
Instrument mounted:	2/59	On the roof of a building.
Station was moved:	9/60	Measurement height: 6.1 meters (20 feet).
Instrument mounted:	9/60	On a tower on the ground.

Wind roses: High winds tend to blow from the west-southwest. Weaker winds tend to flow from the southeast, down off the Blue Mountains, occasionally becoming strong winds. Figure 3.22 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. Table 3.22 summarizes the wind direction and wind speed and stability distributions.

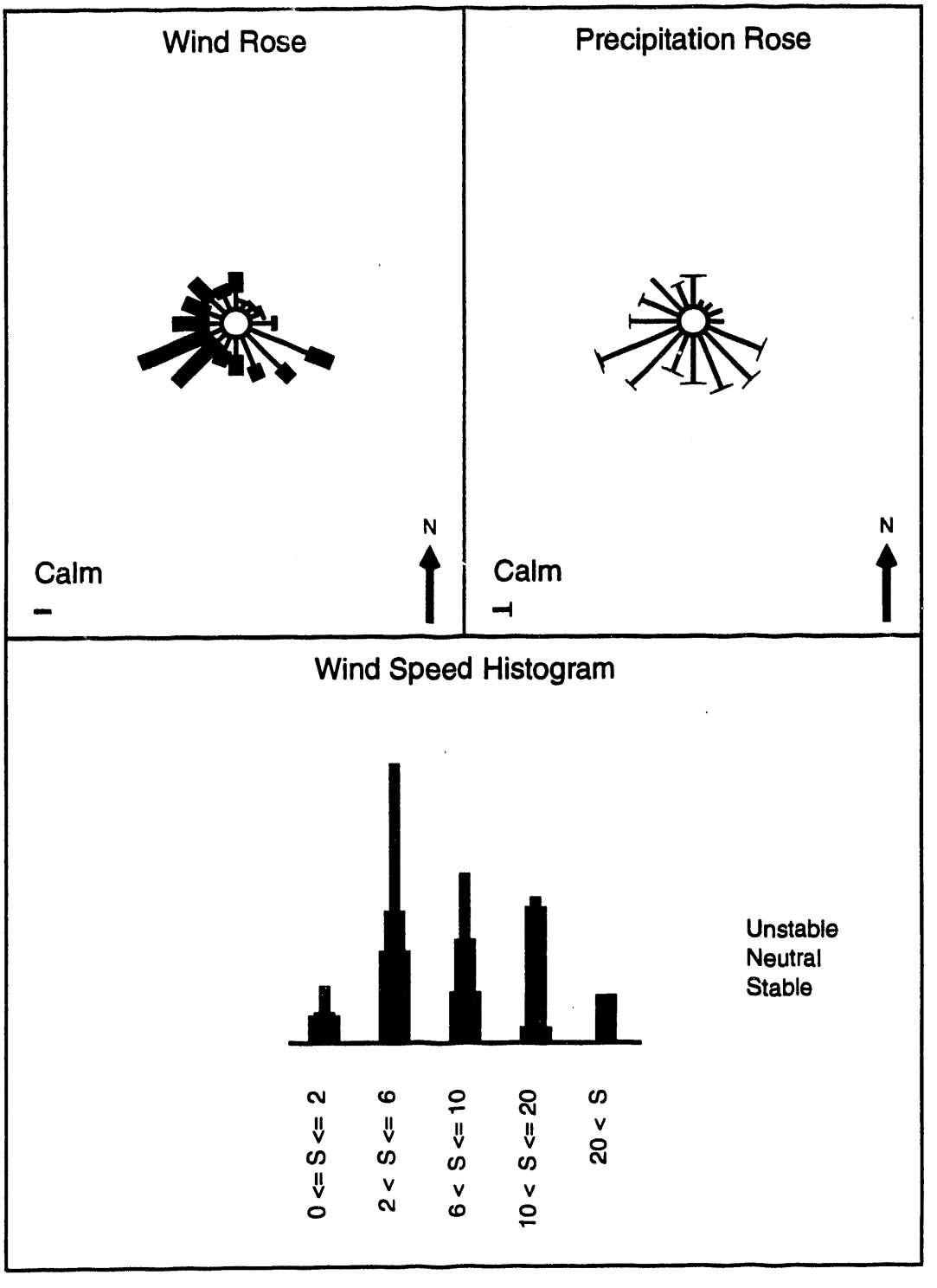


Figure 3.22. Pendleton Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.22. Pendleton Wind Direction and Wind Speed and Stability Distributions

PDT Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	2.45	2.80	5.26
NNE	.98	.43	1.41
NE	1.02	.63	1.65
ENE	1.69	.51	2.20
E	3.05	.83	3.88
ESE	9.03	3.74	12.77
SE	6.86	2.31	9.18
SSE	4.40	2.08	6.48
S	2.49	2.81	5.30
SSW	2.04	2.24	4.28
SW	1.48	8.36	9.84
WSW	1.74	10.79	12.53
W	1.64	5.26	6.90
WNW	2.05	3.76	5.80
NW	2.75	3.69	6.44
NNW	2.06	1.66	3.72
Calm	2.35	.00	2.35
All	48.09	51.91	

PDT Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	3.88	.47	3.76	8.11
2 < S <= 6	13.08	5.75	21.15	39.98
6 < S <= 10	7.31	7.44	9.47	24.23
10 < S <= 20	2.24	17.22	1.41	20.86
20 < S	.11	6.70	.00	6.81
All Speeds	26.62	37.58	35.79	100.00

PDT Wind Direction Distribution During Precipitation

9.91% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	2.44	.00	.04	1.84	.16	.00	4.49
NNE	.84	.00	.00	.24	.00	.00	1.08
NE	1.04	.00	.00	.40	.00	.00	1.44
ENE	1.84	.00	.00	.40	.00	.00	2.24
E	2.00	.00	.00	.20	.00	.00	2.20
ESE	7.34	.00	.00	1.08	.08	.04	8.54
SE	8.10	.04	.00	1.52	.04	.04	9.74
SSE	6.81	.12	.00	1.32	.00	.08	8.34
S	5.81	.00	.04	.88	.08	.00	6.81
SSW	4.65	.04	.00	.88	.08	.04	5.69
SW	9.26	.08	.00	1.36	.00	.00	10.70
WSW	10.14	.16	.04	2.08	.16	.00	12.59
W	5.61	.04	.00	1.44	.04	.00	7.13
WNW	4.41	.04	.00	1.64	.08	.00	6.17
NW	3.85	.00	.00	2.64	.00	.00	6.49
NNW	2.20	.00	.00	1.44	.08	.00	3.73
Calm	1.64	.04	.00	.76	.16	.00	2.61
All	78.00	.56	.12	20.16	.96	.20	

3.2.23 Station: Redmond, Oregon (RDM)

Type: Federal Aviation Administration

Location: 44:16:00N 121:10:00W 934 meters (3064 feet) elevation.

Measurement height: 10 meters (33 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 1.04, Y = -0.32.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour during 1944 to 1947.

Missing data: No data for 8 hours of 8/18 and 19/45.
No data for 9/25/45 to 10/9/45.

Local topography: This station is located in central Oregon slightly east of the Deschutes River.

Station was moved: 10/45 Location: 44:16:00N 121:09:00W. Measurement height: 11.3 meters (37 feet).

HEDR environmental grid coordinates: 10/45 X = 1.11, Y = -0.32.

Station was moved: 3/48 Measurement height: 11.9 meters (39 feet).

Station was moved: 10/50 Measurement height: 9.5 meters (31 feet).

Station was moved: 7/64 Measurement height: 6.1 meters (20 feet).

Wind roses: The maximum is for westerly, west-northwesterly, and northwesterly winds for 34.49 percent of the total hours and a secondary maximum for southeasterly, south-southeasterly, and southerly winds 30.22 percent of the total hours. Figure 3.23 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. Table 3.23 summarizes the wind direction and wind speed and stability distributions.

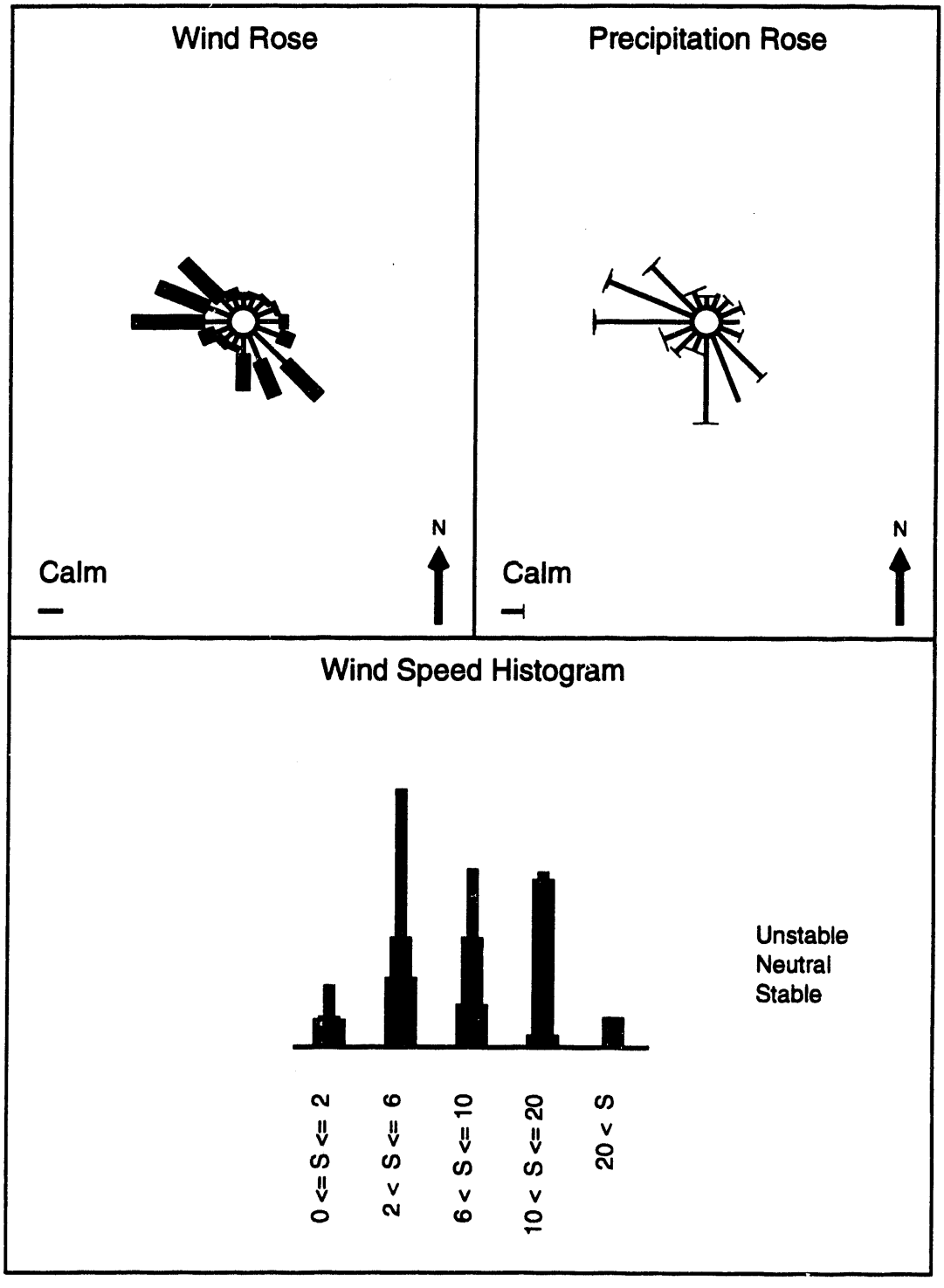


Figure 3.23. Redmond Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.23. Redmond Wind Direction and Wind Speed and Stability Distributions

RDM Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed > = 6 mph	All Speeds
N	1.16	.95	2.11
NNE	1.70	.52	2.22
NE	1.87	.72	2.59
ENE	2.44	.69	3.13
E	2.91	1.31	4.22
ESE	3.26	2.11	5.37
SE	6.25	6.79	13.04
SSE	4.01	5.44	9.45
S	2.54	5.20	7.73
SSW	1.48	.83	2.30
SW	1.47	1.16	2.63
WSW	2.22	2.18	4.40
W	3.38	10.27	13.66
WNW	3.36	7.60	10.95
NW	2.38	7.50	9.88
NNW	1.43	1.40	2.83
Calm	3.49	.00	3.49
All	45.35	54.65	

RDM Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 < = S < = 2	3.97	.38	4.46	8.81
2 < S < = 6	9.88	5.77	20.90	36.54
6 < S < = 10	6.11	9.51	9.75	25.36
10 < S < = 20	1.77	22.11	1.11	24.99
20 < S	.09	4.21	.00	4.30
All Speeds	21.81	41.98	36.22	100.00

RDM Wind Direction Distribution During Precipitation

7.21% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	1.34	.03	.00	.22	.03	.03	1.65
NNE	1.62	.00	.00	.61	.00	.00	2.23
NE	1.65	.03	.00	.64	.00	.00	2.32
ENE	2.48	.00	.00	.83	.03	.00	3.34
E	1.94	.00	.00	.64	.00	.00	2.58
ESE	2.48	.00	.00	.70	.06	.00	3.24
SE	7.51	.00	.00	1.59	.03	.00	9.13
SSE	8.08	.00	.00	2.00	.00	.00	10.09
S	10.60	.03	.03	1.72	.00	.00	12.38
SSW	1.75	.00	.03	.70	.00	.00	2.48
SW	2.80	.00	.00	1.27	.03	.00	4.10
WSW	2.51	.06	.00	1.91	.03	.03	4.55
W	8.46	.00	.00	5.15	.19	.09	13.90
WNW	6.59	.03	.00	6.27	.22	.06	13.17
NW	6.05	.03	.03	2.89	.13	.00	9.13
NNW	1.65	.00	.00	.92	.00	.09	2.67
Calm	1.69	.00	.00	1.30	.03	.00	3.02
All	69.20	.22	.09	29.37	.80	.32	

3.2.24 Station: Bonners Ferry, Idaho (BON)

Type: Not determined.

Location: 48:42:00N 116:18:00W 583 meters (1912 feet) elevation.

Measurement height: 9.8 meters (31 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 20.31, Y = 25.21.

Data source: Paper copy for 1944 through 1947.
NWDI lists paper copy for 1948 and 1949.

Data availability: 4 observations per day 12/44 through 6/16/45.
2 observations per day 6/17/45 through 2/6/46.
4 observations per day 2/7/46 through 6/1/46.
2 observations per day 6/2/46 through 7/8/46.
4 observations per day 9/27/46 through 12/31/47.

Missing data: No data 3/12 through 3/14/45.
No data 4/22 through 4/29/45.
No data 7/29 through 7/30/45.
No data 7/8/46 through 9/26/46.

Local topography: This station is located near the Kootenai River. The river flows towards the station through a narrow canyon from the east. A triangular plain about 11 kilometers (7 miles) wide is located south of the station. The river flows to the north through a 5-mile wide valley with a very flat bottom containing a series of river meanders. On all sides of the valley, mountains rise steeply 600 to 1500 meters (2000 to 5000 feet) above the valley floor.

Station was moved: 4/45 Measurement height: 7.6 meters (25 feet).
Station was moved: 2/46 Measurement height: 11.9 meters (39 feet).
Station was moved: 9/46 Measurement height: 10.1 meters (33 feet).

Wind roses: Of all the HEDR stations, Bonners Ferry and Colville were the most strongly influenced by the hesitancy to report winds having one of the eight major compass points (see Section 2.7.1). Calm conditions were reported for 30.20 percent of the total time. Winds less than or equal to 6 mph were scattered around the compass and winds stronger than 6 mph fell predominately between west-southwesterly and east-southeasterly. Figure 3.24 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. Table 3.24 summarizes the wind direction and wind speed and stability distributions.

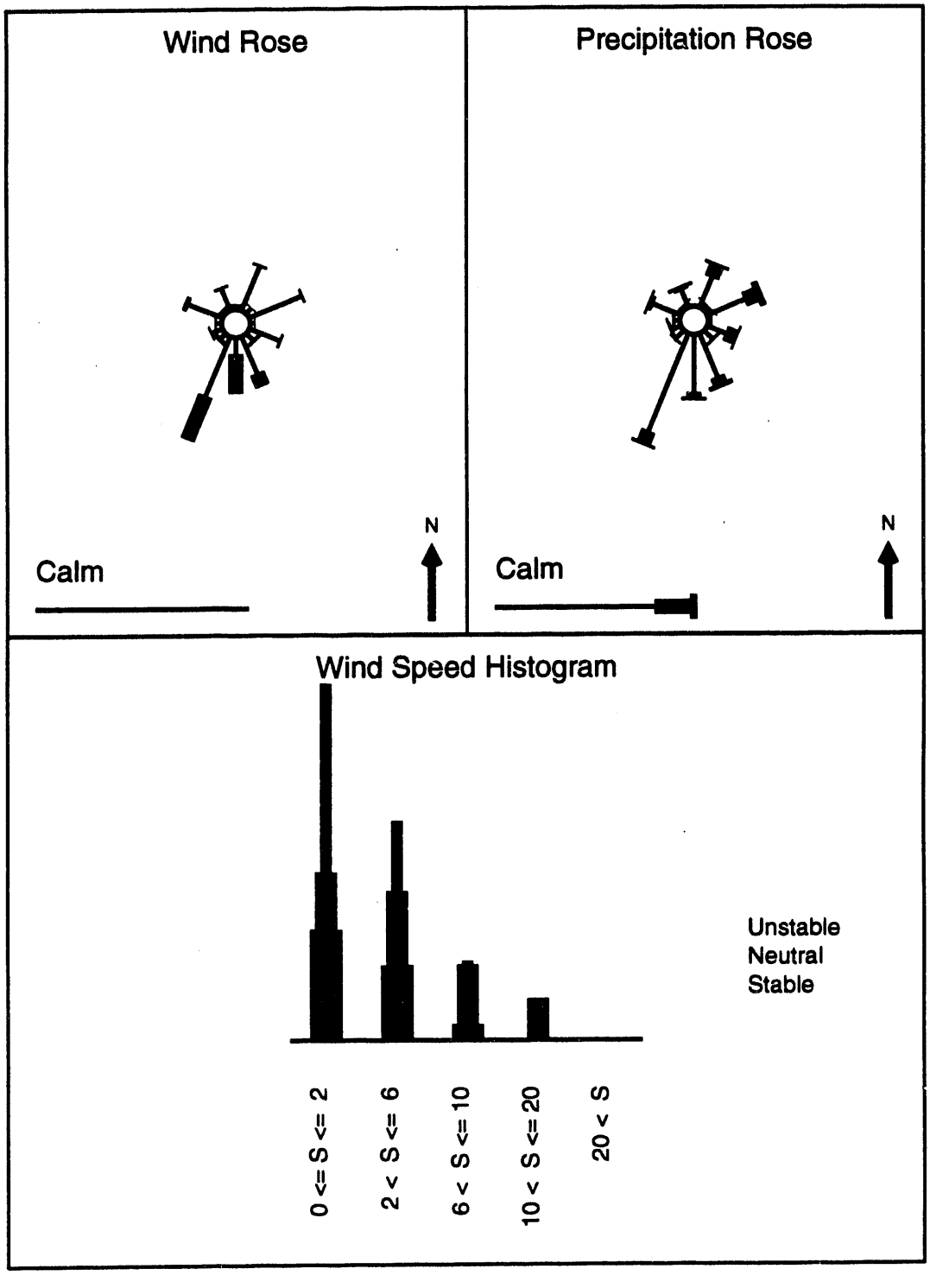


Figure 3.24. Bonners Ferry Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.24. Bonners Ferry Wind Direction and Wind Speed and Stability Distributions

BON Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed >= 6 mph	All Speeds
N	.49	.23	.72
NNE	6.72	.23	6.95
NE	1.04	.03	1.07
ENE	7.93	.23	8.16
E	.58	.12	.69
ESE	4.55	.29	4.84
SE	1.33	.41	1.74
SSE	5.79	1.88	7.67
S	2.40	5.56	7.96
SSW	9.21	6.66	15.87
SW	.98	.46	1.45
WSW	1.68	.12	1.80
W	.78	.14	.93
WNW	5.18	.58	5.76
NW	.52	.17	.70
NNW	3.27	.23	3.50
Calm	30.20	.00	30.20
All	82.66	17.34	

BON Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 <= S <= 2	15.98	8.28	26.84	51.10
2 < S <= 6	10.77	10.71	10.07	31.56
6 < S <= 10	2.26	8.57	.55	11.38
10 < S <= 20	.14	5.73	.00	5.88
20 < S	.00	.09	.00	.09
All Speeds	29.15	33.38	37.46	100.00

BON Wind Direction Distribution During Precipitation

28.43% of hours had recorded precipitation.

(Percentage of total number of hours having precipitation)

	Liquid Precipitation			Frozen Precipitation			
Direction	Light	Moderate	Heavy	Light	Moderate	Heavy	Total
N	.00	.20	.00	.10	.00	.00	.31
NNE	3.06	.81	.31	1.63	.92	.00	6.72
NE	.31	.10	.00	.31	.00	.10	.81
ENE	3.56	1.02	.61	2.24	.71	.20	8.35
E	.20	.10	.00	.20	.00	.00	.51
ESE	2.24	1.22	.00	.61	.31	.20	4.58
SE	1.53	.20	.00	.10	.00	.10	1.93
SSE	5.50	.71	.31	1.22	.31	.20	8.25
S	7.13	.41	.31	1.12	.31	.00	9.27
SSW	12.42	1.12	.20	2.65	.61	.10	17.11
SW	1.53	.20	.00	.10	.00	.00	1.83
WSW	.71	.00	.20	.61	.10	.00	1.63
W	.61	.31	.00	.10	.00	.00	1.02
WNW	3.36	.51	.10	.92	.00	.10	4.99
NW	.20	.00	.00	.31	.00	.10	.61
NNW	2.04	.10	.20	.61	.20	.10	3.26
Calm	13.65	2.34	.31	9.16	2.75	.61	28.82
All	58.04	9.37	2.55	22.00	6.21	1.83	

3.2.25 Station: Lewiston, Idaho (LWS)

Type: Weather Bureau Airport Station

Location: 46:23:00N 117:01:00W 432 meters (1416 feet) elevation.

Measurement height: 7 meters (23 feet).

Instrument mounted: On the roof of a building.

HEDR environmental grid coordinates: X = 17.88, Y = 11.87.

Data source: Paper copy for 10/28/46 through 12/31/47.
Magnetic tape for 1948 and 1949.

Data availability: No data prior to 10/28/46, then observations taken every hour.

Missing data: Data missing for a 15-hour period from 11/30/47 to 12/1/47.

Local topography: This station is located near the banks of the Snake River at the western edge of the approximately 16-kilometer (10-mile) diameter basin formed by the confluence of the Clearwater and Snake Rivers. The Clearwater River flows in from the east, and the Snake River flows in from the south, then out toward the west. Hills immediately around the basin rise to about 600 meters (1000 feet) above the basin floor.

Station was moved: 9/51 Measurement height: 12.2 meters (40 feet).

Station was moved: 3/66 Measurement height: 6.1 meters (20 feet).

Instrument mounted: On a tower on the ground.

Wind roses: This rose is very widely distributed. Figure 3.25 illustrates the wind rose, precipitation rose, and wind speed histogram for this station. Table 3.25 summarizes the wind direction and wind speed and stability distributions.

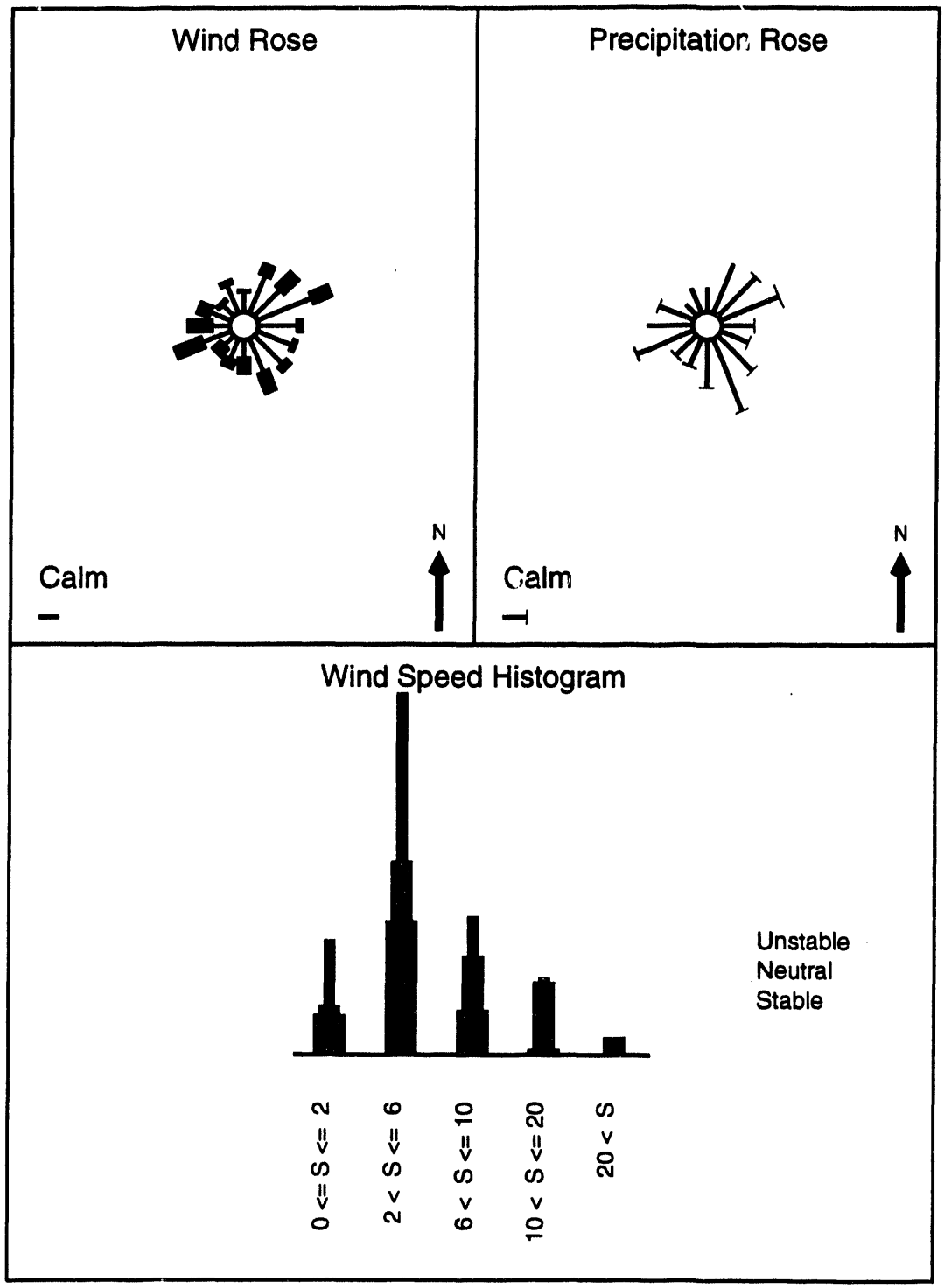


Figure 3.25. Lewiston Wind Rose, Precipitation Rose, and Wind Speed Histogram

Table 3.25. Lewiston Wind Direction and Wind Speed and Stability Distributions

LWS Wind Direction Distribution

(Percentage of total number of hours of data)

Direction	Speed < 6 mph	Speed > = 6 mph	All Speeds
N	2.71	.53	3.24
NNE	5.57	1.90	7.46
NE	5.04	3.15	8.19
ENE	8.08	3.12	11.21
E	5.29	1.13	6.42
ESE	5.04	.86	5.90
SE	5.45	1.22	6.67
SSE	4.97	3.27	8.24
S	2.45	2.43	4.89
SSW	2.87	1.55	4.42
SW	1.70	1.86	3.56
WSW	4.02	4.34	8.36
W	2.25	3.75	6.00
WNW	2.87	2.10	4.96
NW	2.02	.76	2.77
NNW	4.10	.86	4.95
Calm	2.75	.00	2.75
All	67.18	32.81	

LWS Wind Speed and Stability Distribution

(Percentage of total number of hours of data)

Speed (mph)	Stable	Neutral	Unstable	All Stabilities
0 < = S < = 2	5.65	1.27	9.15	16.08
2 < S < = 6	18.85	8.32	23.94	51.11
6 < S < = 10	6.28	7.60	5.57	19.44
10 < S < = 20	.75	9.51	.58	10.85
20 < S	.01	2.52	.00	2.53
All Speeds	31.54	29.22	39.24	100.00

LWS Wind Direction Distribution During Precipitation

11.54% of hours had recorded precipitation

(Percentage of total number of hours having precipitation)

Direction	Liquid Precipitation Light	Liquid Precipitation Moderate	Liquid Precipitation Heavy	Frozen Precipitation Light	Frozen Precipitation Moderate	Frozen Precipitation Heavy	Total
N	2.67	.00	.00	.76	.00	.00	3.44
NNE	5.54	.00	.00	1.94	.00	.00	7.48
NE	5.70	.03	.00	2.07	.03	.00	7.83
ENE	6.75	.06	.03	2.04	.03	.00	8.91
E	3.98	.03	.00	.70	.06	.00	4.77
ESE	3.79	.03	.00	.51	.00	.00	4.33
SE	5.73	.03	.00	1.30	.00	.00	7.07
SSE	9.48	.03	.00	1.56	.00	.00	11.08
S	6.05	.06	.00	.70	.00	.00	6.81
SSW	3.53	.13	.00	.67	.03	.00	4.36
SW	3.47	.03	.00	.54	.13	.00	4.17
WSW	7.10	.03	.00	1.59	.16	.00	8.88
W	5.16	.00	.00	1.30	.00	.00	6.46
WNW	4.26	.00	.00	1.02	.09	.00	5.38
NW	1.69	.00	.00	.35	.00	.00	2.04
NNW	2.80	.00	.00	.83	.00	.00	3.63
Calm	2.36	.03	.00	.95	.03	.00	3.37
All	80.04	.51	.03	18.84	.57	.00	

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