# Technical Report No. 75 HYDROLOGIC DATA, 1970, PAWNEE GRASSLANDS

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GRASSLAND BIOME

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## **ABSTRACT**

This report presents the data collected during the 1970 calendar year as part of the hydrologic process studies of the Grassland Biome Intensive Site Studies, IBP. Data presented are from the field recording instrumentation and daily observations and include precipitation, runoff from the microwatersheds, and observations from an evaporation station.

In general, the 1970 year was drier than normal with an annual total of 245 mm as compared to the 30-year mean annual rainfall of 310 mm. The greatest deficit occurred during the summer months from May through August. Precipitation during March and April was above normal, which helped to recharge soil water storage and offset the lack of rainfall later in the growing season.

Three runoff events occurred during the year. However, only one was of sufficient magnitude to produce runoff from all the microwatersheds and permit a comparison between treatments.

## INTRODUCTION

This report presents the hydrologic data collected during the 1970 calendar year as part of the Hydrologic Process Studies of the Grassland Biome Intensive Site Studies, IBP. Data reported are primarily those which are collected on a routine basis in support of the hydrologic process studies and other studies and do not include results of individual field investigations. These are reported in other separate reports.

# **METHODS**

Data collected during 1970 include precipitation, runoff, soil water content, and basic meteorological measurements. Since the automatic data collection system was still not completely operational, the bulk of the data reported was obtained using the back-up instrumentation and field measurements. The data obtained are suitable for general hydrologic and water balance analysis, but are not sufficiently detailed for rainfall/runoff modelling of the microwatersheds or central basin studies.

# Precipitation

Precipitation was measured using a variety of gages. Beginning

January 25, 1970, a recording rain gage was installed at microwatershed

2. February and March precipitation was measured by hand, using the modified standard rain gages at each microwatershed. An additional four recording rain gages were added on May 28 at microwatersheds 5, 6, 7, and

8. Thus, the recording gage of microwatershed 2 gives a good indication of precipitation at microwatershed 2 and 3 and a slightly less reliable indication at microwatershed 1. The gage at microwatershed 5 also was

representative of rainfall at microwatershed 4, and the other microwatersheds each had a separate recording gage. In addition to the five recording gages, a small plastic gage was installed at each microwatershed and measurement of selected storms begun about June 1.

in the process of installing the recording gage in January, it was observed that shielding the gages had an important effect on gage catch, especially snow storms accompanied by wind. Although this was anticipated, the magnitude of the effect was not. During March, for example, the shielded gages averaged about 1.25 inches while the unshielded gage recorded only .69 inches. The recording gages, have, therefore, all been shielded with modified alter shields. The plastic gages, which are not suitable for snow measurement, have not been shielded, and are read only during the warmer months.

During the growing season, the recording gages were operated with a six hour chart rotation. For rainfall/runoff modelling of small watersheds or runoff plots with rapid response systems, it is necessary to have at least 5 minute storm intensities with a good degree of accuracy. This is obtainable only with a rapid chart rotation. The primary difficulty with 6 hour rotation is that charts should be changed directly following a storm so that real time referencing can be obtained and the trace is not obscured by gage evaporation. This objective was not always obtained during the summer of 1970. Chart rotation was changed to 8-day rotation in October and will be continued until about March 15. Recording gage data are presented in Appendix A.

## Runoff

Runoff from the microwatersheds was gaged during the year using Fischer/Porter A/D punched tape recorders. During the early summer, gages were operated continuously using a 5-minute punch interval. However, since rainfall/runoff modelling of rapid response system requires a more detailed hydrograph, the A/D recorder clocks were replaced with solid state electronic timers with 30, 60, or 120 second read-outs. The recorders were triggered with a microswitch so that a .01 ft increase in stage would turn the timer on and stage would be recorded at 30-second intervals thereafter. Electronic timers were installed in two phases as procurement permitted. The first timers were installed in July, the second four in September. Performance of the timers and trigger circuits has been satisfactory.

# Water Samplers

Pumping type samplers were installed at microwatersheds 1, 2, 3, 5, and 7. These samplers pump a sample from the flow through the flume at preselected intervals. Individual samples are collected in separate bottles which may be returned to the laboratory for analysis. Sampling ports were installed in the flumes opposite the stilling well ports. Samples were triggered to the stage recorder triggers so that a rise in stage, in addition to starting the recorder timer, also started the sampler. Sampler timers were set at the shortest time interval possible and still get a sufficient volume of water for analysis. This consisted of a two-minute pumping period followed by a one-minute "off" period, or a separate sample every three minutes. Samples were returned to the lab and frozen until analysis could be obtained.

Soil Water Tensions and Soil Temperature

Although the automatic data system was not completely operational, a number of intervals when the system was operational did provide an intermittant record of soil water tensions and soil temperature. Soil water tension data were obtained from Coleman fiberglass resistance units and are reported in megohms. These data can be converted to bars of soil water tension using the calibration curves developed and making the necessary temperature corrections. Soil temperature data are printed out in °C. Both tension and temperature data are available at the 2, 10, 20, 40, and 80 cm depths.

## Climatic Station

Beginning June 24, 1970, a class A Evaporation Station has been operated continuously with daily observations of maximum and minimum temperatures, pan evaporation, state of the weather, and continuous observations of temperature, humidity, and barometric pressure. Maximum and minimum temperatures were obtained with a standard USWB Max-Min Thermometers. Pan evaporation was measured by using a USWB 4 ft pan. A continuous record of temperature and humidity was obtained by using a hygrothermograph, and barometric pressure was measured by using a microbarograph. Data from the climatic stations are presented in Appendix B. Additional barometric pressure data were obtained from the Engineering Research Station (old missile site) and is given in Appendix C.

#### PRECIPITATION

Precipitation on the Pawnee Site during 1970 was below normal for the year, with the deficit occurring during May, June, July, and August (Fig. 1).

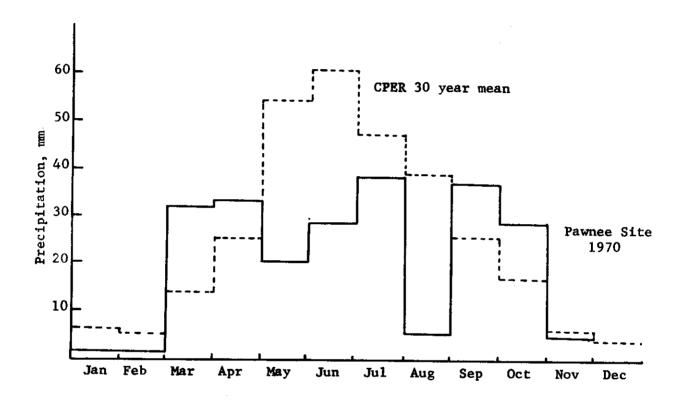


Fig. 1. Monthly precipitation, Pawnee Site, 1970.

Based on the CPER 30 year mean of 310 mm annually, 1970 precipitation was 65 mm below normal, or 245 mm (Fig. 2). Slight deficits occurred during January and February, with greater deficits during May, June, July, and August when evaporation demands were greatest. March and April were above normal and helped to recharge soil water to near maximum levels so that available water during the early part of the growing season was sufficient even though rainfall was below normal.

Precipitation on the microwatersheds showed considerable variation both for individual storms and monthly totals (Table 1). Greatest variation occurred during the summer months when rainfall events were largely convective storms with relatively small areal coverage. Maximum monthly differences occurred during July when 43 mm were recorded at watershed 2 and 27 mm recorded at watershed 5. Maximum difference for an individual storm occurred on July 12 when 30.5 mm were recorded on watershed 8, and 16.5 mm were recorded on watershed 5. There were numerous instances of up to 5 or 6 mm being recorded on a watershed with other watersheds receiving nothing.

For the period of actual recording on the microwatersheds (February to December, 1970), a total of 59 rainfall events were recorded. The size distributions of these events is given in Table 2.

The data given in Table 2 probably underestimate the less than 1 mm events, since the Belfort weighing gage lacked sufficient resolution to accurately detect very small rainfall events. This was especially true for events accompanied by wind or for gages with a 6 hour chart rotation. The tipping bracket gage, on the other hand, gave excellent resolution for small events, but is only operated during the growing season.

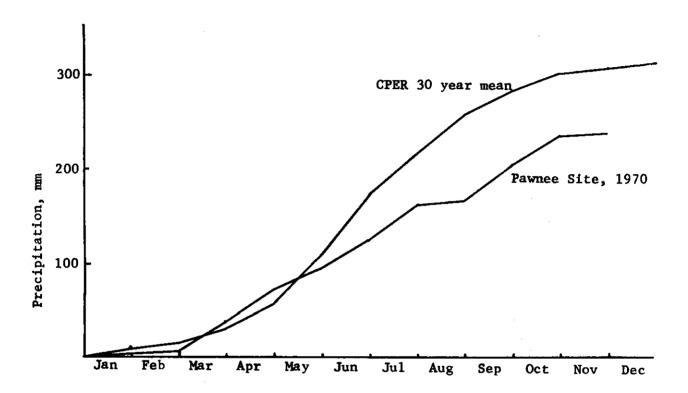


Fig. 2. Cumulative precipitation, Pawnee Site, 1970.

Table 1. Monthly precipitation in mm, Pawnee Site, 1970.

				Microwa	tershed				CDEO
Month	1	2	3	4	5	6	7	8	CPER
January	1.3*	1.3*	1.3*	1.3*	1.3*	1.3*	1.3*	1.3*	1.3
February	0.8	2.0	1.3	1.3	1.0	0.8	<b>T</b> -	Т	1.3
March	33.0	33.3	33.3*	31.0	30.7	33.0	33.0	32.5	33.3
April	33.5*	33.5*	33.5*	33.5*	33.5*	33.5*	33.5*	33.5*	34.0
May	22.3*	22.3	22.3	22.3*	22.3*	22.5*	22.3*	22.3	21.3
June	10.2*	10.2	10.2	10.2	10.2	14.5	18.8	21.3	29.0
July	43.2*	43.2	43.2	26.7	26.7	27.2	27.9	44.7	39.6
Au <b>gus</b> t	5.8	11.4	11.4	2.5	2.5	3.0	4.1	4.6	6.1
September	35.1	35.8	35.8	32.5	32.5	32.0	31.5	33.0	37.6
October	19.6*	19.6	19.6	21.6	21.6	21.6	20.1	18.5	29.2
November	4.6*	4.6	4.6	5.1	5.1	5.8	5.6	5.6	
December	4.3*	4.3	4.3	4.8	4.8	4.1	3.8	4.1	
Total	213.7	221.5	221.1	192.8	192.2	199.3	201.9	221.4	

Gage data not complete. Monthly total estimated from adjacent gages or CPER gages.

Table 2. Size distribution of recorded precipitation events.

Month	< 1 mm	1 - 5 mm	5 - 10 mm	> 10 mm
February	3	-	<u>-</u>	_
March	2	6	1	-
April	2	-	3	1
May	1	2	3	-
June	3	1	-	1
July	6	5	-	1
August	3	1	-	-
September	1	3	1	1
October	-	2	-	-
November	1	2	-	-
December	-	2	-	-
(Total =58)	22 = 3890	24 417	8 1470	4
			417 ***	(S)
	k	(317.) 8.6mm	(4120)	(3

Table 3. Storm runoff events, 1970.

Microwatershed	Grazing Treatment	Total Storm Precipitation	Total Storm Runoff	Peak Runoff
		(mm)	(mm)	(1/sec)
Storm of July 12,	1970			
1	Heavy	25.9	2.64	7.42
3	Heavy	24.1	0.83	3.65
6	Moderate	18.3	0.24	0.97
7	Moderate	19.1	0.16	0.58
2	None	24.1	0.12	0.47
8	None	30.5	0.05	0.37
Storm of August 2	2, 1970			
3	Heavy	10.2	0.04	0.58
Storm of Septembe	er 2, 1970			
1	Heavy	6.35	0.02	0.04
3	Heavy	6.35	0.01	0.39
2	None	6.25	0.01	0.09

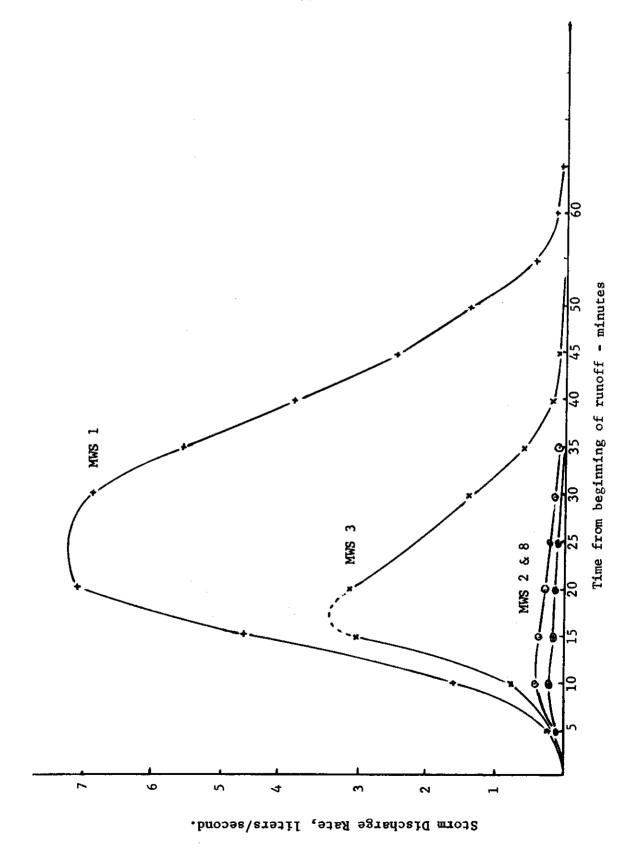


Fig. 3. Stormflow hydrographs, July 12, 1970.

# RUNOFF

Three runoff events occurred during the year. Runoff will be produced by storms with intensities greater than the infiltration rate and of sufficient duration to permit the overland flow component to reach the channel or collector. Thus, in most runoff-producing storms, runoff is produced by only the more intense rainfall periods when infiltration capacities are exceeded.

The runoff events measured during 1970 are summarized in Table 3. The first and largest event occurred July 12 and caused runoff to occur on all microwatersheds. Unfortunately, two of the eight had the recorders removed for modification, but good hydrographs were recorded on the remaining six microwatersheds. The storm flow hydrographs are presented in Fig. 3.

As might be expected, surface runoff, both total and peak, is greatest on the heavy grazed pastures. Total runoff and peak runoff rates were substantially less on the moderately grazed pasture and lowest on the exclosed microwatersheds.

Runoff from the other two events (August 2 and September 2) was insignificant. The storm of August 2 amounted to 10.2 mm and produced .04 mm of runoff on microwatershed 3, a heavily grazed microwatershed. The adjacent ungrazed watershed produced no runoff. Recorded rainfall at the other microwatersheds during the same period was less than half that at #2 and #3 and produced no runoff.

Runoff from the storm of September 2 was caused by a 6.3 mm rain at microwatershed 1, 2, and 3. The maximum 10-minute intensity of this storm was about 33 mm/hour. The total runoff produced was very small.

Appendix A. Daily precipitation (mm), Pawnee Site, 1970.

Manak	D		Re	ecording Gag	e	
Month	Day	MWS 2	MWS 5	MWS 6	MWS 7	MWS 8
February	1	0.5	_		<b>-</b> .	_
	2	0.8	-	-	-	-
	4	0.8	-	-	-	-
March	5	1.3	-	-	-	<b>-</b>
	9	0.5	-	-	•	-
	10	1.8	-	-	-	-
	15	6.9	-	-	-	-
	17	3.3	-	-	-	_
	18	4.3	-	-	-	-
	29	1.8	-	-	-	-
	30	3.0	-	-	-	-
	31	0.5	-	-		-
April	17	11.7	-	-	-	-
	18	9.9	-	-	-	-
	19	0.5	-	-	-	-
	20	0.8	-	-	-	_
	21	5.1	-	-	•	-
	22	5.6	-	-	-	-
May	13	0.8	-	-	-	_
	21	5.1	-	-	-	-
	22	5.6	-	-	-	4.3
	23	-	-	-	-	0.5
	24	1.3	-	-	_	0.8
	26	3.3	-	-		-
	29	6.4	6.4	6.4	4.1	4.3
	30	-	-	-	-	0.5

Appendix A. (Continued)

			Re	cording Gag	е	
Month	Day	MWS 2	MWS 5	MWS 6	MWS 7	MWS 8
June	9	-	•		-	0.5
	10	2.5	3.8	5.6	8.9	-
	11	7.6	6.4	8.9	8.9	17.5
	12	-	-	-	-	2.5
	23	. •	-	-	0.5	0.3
	28	-	-	-	0.5	0.5
July	2	2.5	-	-	-	0.3
ou.,	6	-	-	-	-	0.3
	9	1.5	1.3	1.3	1.5	1.3
	12	24.1	16.5	18.3	19.1	30.5
	13	-	-	-	0.8	0.3
	17	1.3	3.8	2.5	2.5	2.8
	18	-	-	-	-	0.5
	19	-	-	-	-	1.3
	20	6.4	-	-	-	-
	22	-	-	•	-	0.5
	23	1.3	-	1.3	-	0.5
	25	-	-	-	-	2.3
	26	3.8	5.1	3.8	4.1	4.3
August	2	10.2	2.5	3.0	4.1	3.3
•	14	-	-	-	**	0.5
	29	-	•	-	-	0.3
	30	1.3	-	-		0.5

Appendix A. (Continued)

M4-b	D		Re	cording Gag	e	
Month	Day	MWS 2	MWS 5	MWS 6	MWS 7	MWS 8
September	2	6.4	5.8	5.1	3.8	2.8
	13	5.1	3.8	-	-	2.0
	14	-	-	3.6	5.1	2.3
	15	-	-	-	-	0.5
	16	1.5	-	-	-	-
	21	15.2	17.8	17.8	17.5	19.8
	24	7.6	5.1	5.6	5.1	5.6
October	8	2.5	5.3	5.6	5.1	3.8
	10	-	0.8	_		-
	12	3.0	3.3	2.5	2.5	2.5
	25	5.1	12.2	12.4	12.4	12.2
	26	8.9	-	-	-	_
	27	-	-	1.0	-	-
November	7	1.3	1.5	1.8	1.5	1.8
	12	1.8	2.5	3.0	2.8	3.0
	23	1.5	1.0	1.0	1.3	0.8
December	10	2.8	2.5	2.5	2.5	2.3
	18	0.8	1.5	1.5	1.3	1.8
	20	0.8	0.8	-	40	_

# APPENDIX B

Climatic Station Observations June 24 - December 6, 1970

STAMMADD WEATHED OFFEDVATIONS PAWNEE SITE US-IBP GRASSLAND BIOME STAMMAD NUNN. COLORADM FLE. 1652 W (HSL) FXCLOSURE F 1/2 SFC 23 TION R66W. 6TH P. M. CENTRAL PLAINS EXPERIMENTAL RANGE NUNN. COLORADM

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15   33   14   27   -11.43   CLEAR   HOT   GUSTY   COOLER     10   34   11   29   -13.72   SCATTRRED   HOT   CLY WIND     11   29   -13.72   SCATTRRED   HOT   CLY WIND     12   -10.16   SCATTRRED   HOT   CLY WIND     12   -10.16   SCATTRRED   HOT   CLY WIND     13   13   29   -10.16   SCATTRRED   HOT   CLY WIND     14   29   -2.62   OVERCAST   WARH   CLY WIND     15   29   14   20   -3.48   SCATTRRED   HOT   CLY WIND     16   29   14   20   -3.48   SCATTRRED   HOT   CLY WIND     17   29   14   20   -3.48   SCATTRRED   HOT   CLY WIND     18   29   20   20   20   20   20   20     19   27   -3.04   SCATTRRED   HOT   CLY WIND     19   27   -3.04   SCATTRRED   HOT   CLY WIND     10   27   -3.04   SCATTRRED   HOT   CLY WIND     10   27   -3.04   SCATTRRED   HOT   CLY WIND     11   20   -3.04   SCATTRRED   HOT   CLY WIND     12   20   -3.04   SCATTRRED   HOT   CLY WIND     15   29   20   -3.04   SCATTRRED   HOT   CLY WIND     10   37   29   20   -3.04   SCATTRRED   HOT   CLY WIND     11   20   -3.04   SCATTRRED   HOT   CLY WIND     12   20   -3.04   SCATTRRED   HOT   CLY WIND     13   29   20   20   20   20   20     20   20	-	130	~		<u>ج</u>			- ( • 1 -		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Ç			
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13   13   29   -7.37   SCATIFRED   HOT   10.001     10   29   14   24   -10.16   SCATTERED   HOT   GUSTY     10   29   14   29   -10.16   SCATTERED   HOT   GUSTY     10   29   14   29   -7.62   OVERCAST   HOT   GUSTY     11   29   14   29   -11.43   SCATTERED   HOT   GUSTY     12   24   -2.4   -10.16   SCATTERED   HOT   C.* WIND     13   29   27   -10.16   SCATTERED   HOT   C.* WIND     14   29   -2.2   OVERCAST   CHILLY   STRONG     15   29   12   27   -10.41   SCATTERED   HOT   C.* WIND     15   29   12   24   -3.81   SCATTERED   HOT   C.* WIND     16   29   24   -3.81   SCATTERED   HOT   C.* WIND     17   29   22   -10.41   SCATTERED   HOT   C.* WIND     15   29   20   -11.43   SCATTERED   HOT   C.* WIND     16   29   -10.41   SCATTERED   HOT   C.* WIND     17   20   20   -10.41   SCATTERED   HOT   C.* WIND     18   29   -10.41   SCATTERED   HOT   C.* WIND     19   29   -10.41   SCATTERED   HOT   C.* WIND     10   20   -10.41   SCATTERED   HOT   C.* WIND     10   20   -10.41   SCATTERED   HOT   C.* WIND     11   20   -10.41   SCATTERED   HOT   C.* WIND     12   24   -2.4   -10.41   SCATTERED   HOT   C.* WIND     13   25   -10.41   SCATTERED   HOT   C.* WIND     14   24   -2.4   -2.4   SCATTERED   HOT   C.* WIND     15   27   -10.41   SCATTERED   HOT   C.* WIND     16   24   -2.4   -2.4   SCATTERED   HOT   C.* WIND     17   27   -2.4   -2.4   SCATTERED   HOT   C.* WIND     18   29   -2.4   -2.4   SCATTERED   WARM   C.* WIND     19   20   -2.4   -2.4   SCATTERED   WARM   C.* WIND     10   20   20   20   20   20   20   20	-	000	34	1	\$			-13.72		ないというない	2 5	S. ISTV		
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STANDARD WEATHER DRSERVATIONS PAWNEE SITE US-IBP GRASSLAND BIOME FLE. 1652 V (MSL) EXCLOSURE 5 172 SFC 23 TION R66W. 6TH P. M. CENTRAL PLAINS EXPERIMENTAL RANGE NUNN. COLORADO

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TEMPERATURES (C). EVAPORATION (MM). WIND TRAVEL (KM/DAY)

EVAP.STOR.WINT. SHOW THAT NITE LT. SNOW. RAIN TIME WAX MIN OBS MAX MIN AMOUNT TRAVEL SKY TEMP. WIND PRECIPITATION COMMENTS LIGHT RAIN ON PAN ON PAN ON PAN LIGHT SNOW STANDARD WEATHED DRSFRVATIONS PAWNEE SITE US-IAP GRASSLAND BIOME EXCLOSURE E 1/2 SFC 23 TION R66W, 6TH P. M. CENTRAL PLAINS EXPERIMENTAL RANGE NUNN, COLORADO SNOWING ICE ON P ICE ON P GENERAL DRIFTED SNOW GENTLE RAIN GENTLE RAIN LT. SNOW LT. SNOW LT. SNOW LT. WIND LT. WIND LT. WIND LT. WIND LT. WIND LT. WIND STRONG LT. WIND STRONG LTT. WIND LTT. WIND LTT. WIND LTT. WIND LTT. WIND LT. WIND LT. WIND LT. WIND LT. WIND CHIM . LT SIS T. EIND STRONG STRONG GUSTY ---CHILLY CHILLY WARN CHILLY CHILLY CHILLY CHILLY CHILLY WARN CHILLY CHILLY CHILLY CHILLY CHILLY 0700 SCATTERED SCATTERED OVERCAST SCATTERED OVERCAST OVERCAST SCATTERED OVERCAST SCATTERED SCATTERED CLEAR CLEAR CLEAR CLEAR SCATTERED OVERCAST CLEAR OVERCAST CLEAR OVERCAST OVERCAST CLEAR OVERCAST OVERCAST OVERCAST SCATTFRED SCATTERFD OVERCAST OVERCAST OVERCAST OVERCAST CLEAR CLFAR CLEAR HAZY CLEAR CLEAR CLEAR CLEAR CLEAP HAZY HAZY HA2Y HAZY YZAH WIND MT. ST. AIR-TEMPEDATURE PAN-TEMPERATURE EVAP. TIME WAX MIN OBS MAX MIN AMOUNT -7.62 -5.84 -3.81 3.81 0.00 -7-111 -7-62 -7-62 -7-62 -10-62 -13-46 -3-81 -3.81 0.00 0.00 0.00 0000 4.1 ELE. 1652 M (MSL) 9457 00401415000114 8 2 2 5 8 4 5 V -255 \$ \$ \$ \$ \$ \$ 1700 1715 1715 2000 1700 1715 710 700 1700 1700 1700 1710 1710 1710 1710 1700 630 800 7115 7115 7118 7125 7120 7130 7130 7130 7130 1800 640 840 630 600 11/03/70 11/05/70 10/05/70 10/06/70 10/09/70 10/09/70 10/11/70 10/11/70 10/13/70 10/15/70 10/16/70 10/17/70 10/19/70 10/19/70 10/22/70 10/23/70 10/23/70 10/25/70 10/25/70 07.29/70 10/30/70 01/10/11 1/08/70 1/09/70 1/07/70 1/10/70 10/01/70 0/21/70 0/04/10 09/27/70 09/28/70 07/30/70 0/63/70 07/62/60 DATE

TEMPERATURES (C) . EVAPORATION (MM) . WIND TRAVEL (KM/DAY)

STANDARD WEATHER OBSERVATIONS PAWNEE SITE US-IRP GRASSLAND BIOME NUNN. COLORADO

4. COLORADO	RESERVED WINDFEWD TEMP. WIND PRECIPITATION COMMENTS	MERKENDERFERENTERFE										MONS NI 6				FOG-CEILING U											
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# APPENDIX C

Barometric Pressure as Reported by the Engineering Research Station

January 20 - October 30, 1970

Appendix C. Barometric pressure as reported by the Engineering Research Station (old missile site) approximately six miles south of the Pawnee Site. Data are from a mercury barometer, corrected for scale error and temperature, but not reduced to sea level pressures.

	Date	Hour	Pressure (mb)	
-	1 - 20	0930	829.432	
	1 - 20	1320	832.052	
	3031	1300	831.432	
	4 - 15	1500	822.882	
	5 - 11	1000	827.364	
	6 - 4	1000	839.568	
	6 - 4	1400	837.361	
	6 - 10	1000	824.035	
	7 - 14		835.982	
	7 - 15		841.981	
	7 - 20	1545	836.948	
	7 - 21	1305	832.535	
	7 - 22	1030	831.156	
	7 - 23	1345	831.156	
	7 - 24	1300	833.569	
	7 - 31	1015	834.259	
	8 - 3	1020	833.914	
	9 - 4	0920	832.121	
	8 - 5	1255	832.535	
	8 - 5	1615	831.501	
	8 - 26	1500	835.638	
	8 - 27		836.948	
	8 - 28	1000	834.190	
	9 - 7	1400	831.501	
	9 - 10		836.672	
	9 - 17	1300	837.223	
	9 - 18	1045	835.500	

Appendix C. (Continued)

Date	Hour	Pressure (mb)	
10 - 1	1400	834.948	
10 - 5	1300	821.159	
10 - 6	1630	821.710	
10 - 8	1600	831.501	
10 - 15	1500	841.153	
10 - 21	1500	825.985	
10 - 22	1400	822.538	
10 - 23	1300	824.606	
10 - 29	1500	830.122	
10 - 30	1300	828.743	