

APPENDIX D-4

CLIMATOLOGY

Introduction

Climatological data presented for the amendment area are data collected from the Ten Sleep 4 NE Station #488852 of the Western Region Climate Center. The Record Monthly Climate Summary for the period of June 1, 1964 through December 31, 2005 is included at the end of this section of the amendment application as Appendix D4-Addendum 1. Also included, as Appendix D4-Addendum 2, is the National Climatic Data Center's Climatology Summary for the period of 1971-2000.

Setting

The amendment area is located approximately 6 miles west of the town of Ten Sleep, Wyoming, in northeastern Washakie County. The average elevation of the area is approximately 4,600 feet above sea level with a cool, semiarid, inland continental climate. Weather in the area is rapidly changing and can produce a variety of extreme conditions in a relatively short period of time.

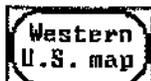
The average wind velocity for the entire area is less than five miles per hour. This portion of the Big Horn Basin is generally protected from the prevailing southwesterly winds; however, the strongest winds are northerly.

Temperature and Precipitation

Climatological records for Ten Sleep, Wyoming reveal that temperatures in this area tend to be cool with substantial seasonal and diurnal variations. The large temperature fluctuations are due to the advent of warm and cold air masses and the relatively high elevation of the area. This permits rapid incoming and outgoing radiation. The mean daily temperature is 48.2 degrees. The hottest month is July. January is typically the coldest month. Temperatures may reach as high as 102 degrees in July and as low as -34 degrees in December.

The average annual precipitation for the area is 13.00 inches. May typically has the highest mean precipitation (2.20 inches) while January had the lowest (0.51 inches). Approximately 70 percent of the moisture falls in thunderstorms during the growing season of late spring and early summer. Snowfall amounts are fairly uniform from November through February. Snowfall amounts are somewhat heavier during February and March.

Back to:

**NOTE:**

To print data frame (right side), click on right frame before printing.

1971 - 2000

- Daily Temp. & Precip.
- Daily Tabular data (~23 KB)
- Monthly Tabular data (~1 KB)
- NCDC 1971-2000 Normals (~3 KB)

1961 - 1990

- Daily Temp. & Precip.
- Daily Tabular data (~23 KB)
- Monthly Tabular data (~1 KB)
- NCDC 1961-1990 Normals (~3 KB)

Period of Record

- Station Metadata
- Station Metadata Graphics

General Climate Summary Tables

- Temperature
- Precipitation
- Heating Degree Days
- Cooling Degree Days
- Growing Degree Days

Temperature

- Daily Extremes and Averages

TEN SLEEP 4 NE, WYOMING (488852)**Period of Record Monthly Climate Summary****Period of Record : 6/ 1/1964 to 12/31/2005**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	36.9	41.2	49.9	59.5	69.4	79.0	87.9	86.1	75.4	62.7	46.2	38.0	61.0
Average Min. Temperature (F)	13.6	18.2	26.1	34.1	42.3	50.4	57.1	55.6	45.4	35.3	23.9	15.6	34.8
Average Total Precipitation (in.)	0.51	0.41	0.81	1.45	2.20	2.05	0.96	0.71	1.35	1.14	0.79	0.63	13.00
Average Total SnowFall (in.)	9.1	7.2	7.9	5.4	1.8	0.0	0.0	0.0	0.8	3.0	7.7	9.8	52.7
Average Snow Depth (in.)	3	2	1	0	0	0	0	0	0	0	1	2	1

Percent of possible observations for period of record.

Max. Temp.: 99.5% Min. Temp.: 99.4% Precipitation: 98.6% Snowfall: 99.1% Snow Depth: 98%

Check Station Metadata or Metadata graphics for more detail about data completeness.

Western Regional Climate Center, wrcc@dri.edu

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatology of the United States No. 20

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TEN SLEEP 4 NE, WY

1971-2000

COOP ID: 488852

Climate Division: WY 4

NWS Call Sign:

Elevation: 4,820 Feet Lat: 44°04N

Lon: 107°23W

Temperature (°F)																					
Mean (1)				Extremes										Degree Days (1) Base Temp 65		Mean Number of Days (3)					
Month	Daily Max	Daily Min	Mean	Highest Daily(2)	Year	Day	Highest Month(1) Mean	Year	Lowest Daily(2)	Year	Day	Lowest Month(1) Mean	Year	Heating	Cooling	Max >= 100	Max >= 90	Max >= 50	Max <= 32	Min <= 32	Min <= 0
Jan	35.6	13.7	24.7	64	1981	23	35.7	1981	-25+	1997	11	7.9	1979	1251	0	.0	.0	3.9	10.3	29.8	5.8
Feb	40.4	18.4	29.4	66+	1982	22	38.3	1992	-31	1989	3	15.8	1989	996	0	.0	.0	6.8	5.6	26.4	2.9
Mar	49.7	26.5	38.1	79	1986	27	45.7	1986	-12	1989	4	31.0	1996	835	0	.0	.0	17.4	2.1	24.4	.4
Apr	59.2	34.2	46.7	87+	2000	29	55.0	1987	10+	1997	11	38.5	1975	551	2	.0	.0	24.5	.4	13.4	.0
May	69.2	43.0	56.1	91	1987	15	61.6	2000	20	1967	1	51.4	1975	291	15	.0	@	30.1	.0	3.3	.0
Jun	79.0	51.9	65.5	100	1970	27	75.0	1988	31	1970	13	58.6	1998	90	105	.0	3.1	29.9	.0	.0	.0
Jul	86.7	58.4	72.6	102	1976	13	77.1	1988	38	1983	16	66.0	1993	12	244	.1	12.2	31.0	.0	.0	.0
Aug	85.6	57.8	71.7	100+	2001	7	77.7	1971	36	1965	31	67.7	1977	20	227	.0	9.5	31.0	.0	.0	.0
Sep	75.1	48.0	61.6	95+	1983	2	68.1	1979	15	1984	25	55.5	1984	163	60	.0	1.3	29.1	@	2.2	.0
Oct	62.3	37.6	50.0	87+	1992	3	54.5	1988	4+	1991	31	45.2	1984	468	1	.0	.0	27.1	.4	11.7	.0
Nov	45.2	25.5	35.4	74+	2001	6	46.6	1999	-16	1985	23	21.9	1985	889	0	.0	.0	11.8	4.1	25.0	1.2
Dec	37.4	16.4	26.9	66	1980	27	36.4	1980	-34	1990	22	14.4	1983	1182	0	.0	.0	4.8	8.4	29.2	3.8
Ann	60.5	36.0	48.2	102	Jul 1976	13	77.7	Aug 1971	-34	Dec 1990	22	7.9	Jan 1979	6748	654	.1	26.1	247.4	31.3	165.4	14.1

+ Also occurred on an earlier date(s)

@ Denotes mean number of days greater than 0 but less than .05

Complete documentation available from: www.ncdc.noaa.gov/oa/climate/normal/usnormals.html

Issue Date: February 2004

(1) From the 1971-2000 Monthly Normals

(2) Derived from station's available digital record: 1964-2001

(3) Derived from 1971-2000 serially complete daily data

Climatography of the United States

No. 20 1971-2000

National Climatic Data Center
 Federal Building
 151 Patton Avenue
 Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TEN SLEEP 4 NE, WY

COOP ID: 488852

Climate Division: WY 4

NWS Call Sign:

Elevation: 4,820 Feet Lat: 44°04N

Lon: 107°23W

Precipitation (inches)																								
Precipitation Totals										Mean Number of Days (3)				Precipitation Probabilities (1) Probability that the monthly/annual precipitation will be equal to or less than the indicated amount										
Month	Means/ Medians(1)		Extremes							Daily Precipitation				Monthly/Annual Precipitation vs Probability Levels These values were determined from the incomplete gamma distribution										
	Mean	Median	Highest Daily(2)	Year	Day	Highest Monthly(1)	Year	Lowest Monthly(1)	Year	≥ 0.01	≥ 0.10	≥ 0.50	≥ 1.00	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
Jan	.57	.50	.95	1967	14	1.62+	1978	.00	1983	5.8	2.0	.1	.0	.03	.08	.17	.25	.34	.44	.56	.70	.90	1.23	1.55
Feb	.39	.30	.46	1991	17	1.24	1971	.00	1985	4.5	1.6	.0	.0	.02	.06	.12	.17	.24	.30	.38	.48	.62	.84	1.06
Mar	.94	.84	1.10	1981	17	2.43	1996	.25	1979	6.7	3.2	.2	.1	.26	.35	.48	.60	.72	.84	.97	1.13	1.34	1.67	1.97
Apr	1.39	1.31	1.49	1978	28	3.52	1978	.08	1985	8.0	4.6	.5	.1	.35	.48	.68	.86	1.04	1.23	1.43	1.68	2.01	2.52	3.00
May	2.32	1.97	2.26	1988	7	4.32	1975	.16	1994	8.6	5.6	1.3	.2	.67	.89	1.23	1.51	1.79	2.09	2.41	2.79	3.28	4.05	4.77
Jun	1.83	1.88	2.62	1969	25	4.56	1993	.06	1971	7.8	4.7	1.2	.2	.32	.49	.75	1.00	1.26	1.54	1.85	2.23	2.74	3.56	4.35
Jul	.96	.68	2.02	1977	4	3.03	1997	.02	1999	5.3	2.5	.5	.2	.07	.13	.25	.39	.53	.70	.91	1.17	1.53	2.14	2.74
Aug	.67	.58	1.50	1976	2	2.21	1976	.00	1981	4.4	2.0	.2	.1	.02	.06	.15	.24	.35	.48	.63	.82	1.09	1.55	2.00
Sep	1.44	1.40	1.76	1990	19	3.56	1986	.00+	1981	6.3	3.8	.8	.1	.00	.23	.51	.74	.97	1.21	1.49	1.80	2.24	2.93	3.60
Oct	1.25	1.01	1.95	1971	1	5.61	1971	.00	1984	6.0	3.7	.6	.1	.06	.17	.35	.54	.73	.96	1.22	1.54	1.99	2.73	3.45
Nov	.79	.76	1.30	1984	9	1.90	1984	.08	1985	5.4	2.6	.2	.1	.18	.26	.37	.48	.58	.69	.81	.96	1.16	1.46	1.75
Dec	.60	.45	.81	1984	24	1.85	1982	.00+	1985	5.5	1.9	.2	.0	.00	.09	.21	.31	.40	.50	.61	.75	.92	1.21	1.49
Ann	13.15	13.02	2.62	Jun 1969	25	5.61	Oct 1971	.00+	Dec 1985	74.3	38.2	5.8	1.2	9.07	9.85	10.86	11.63	12.32	12.98	13.67	14.43	15.36	16.71	17.88

+ Also occurred on an earlier date(s)

Denotes amounts of a trace

@ Denotes mean number of days greater than 0 but less than .05

** Statistics not computed because less than six years out of thirty had measurable precipitation

(1) From the 1971-2000 Monthly Normals

(2) Derived from station's available digital record: 1964-2001

(3) Derived from 1971-2000 serially complete daily data

Complete documentation available from:

www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

Climatology of the United States

No. 20 1971-2000

Station: TEN SLEEP 4 NE, WY

COOP ID: 488852

Climate Division: WY 4

NWS Call Sign:

Elevation: 4,820 Feet

Lat: 44°04N

Lon: 107°23W

Snow (inches)																								
Snow Totals															Mean Number of Days (1)									
Means/Medians (1)					Extremes (2)										Snow Fall ≥ Thresholds					Snow Depth ≥ Thresholds				
Month	Snow Fall Mean	Snow Fall Median	Snow Depth Mean	Snow Depth Median	Highest Daily Snow Fall	Year	Day	Highest Monthly Snow Fall	Year	Highest Daily Snow Depth	Year	Day	Highest Monthly Mean Snow Depth	Year	0.1	1.0	3.0	5.0	10.0	1	3	5	10	
Jan	10.5	9.9	4	4	20.0	1978	25	40.5	1978	36	1978	27	14	1979	4.6	3.0	1.1	.3	.1	23.5	16.1	7.8	1.5	
Feb	6.3	5.0	3	2	6.0	1976	4	17.0	1978	22	1978	1	11	1979	3.5	2.5	.6	.2	.0	16.0	9.5	4.5	1.1	
Mar	8.5	7.0	1	1	9.0	1982	24	24.0	1977	11	1998	8	4	1998	4.5	3.5	1.0	.2	.0	6.3	3.0	1.4	.2	
Apr	5.7	5.5	#	#	7.0	1999	1	16.0	1975	8	1977	2	1	1991	2.7	2.1	.6	.2	.0	1.4	.6	.2	.0	
May	2.1	.0	#	0	8.0	1983	12	14.0	1975	6	1983	12	#+	1999	.6	.6	.3	.1	.0	.3	.1	@	.0	
Jun	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Jul	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Aug	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Sep	.6	.0	#	0	6.0	1985	28	6.0	1985	4+	2000	23	#+	2000	.4	.2	.1	.1	.0	.1	.1	.0	.0	
Oct	3.3	1.5	#	#	6.0	1971	2	21.0	1971	10	1971	29	1	1993	1.5	1.1	.4	.2	.0	1.2	.6	.4	@	
Nov	7.8	7.2	1	1	8.0	1978	10	16.5	1986	10	1973	3	3	1986	3.6	3.0	1.0	.3	.0	9.1	4.1	1.5	@	
Dec	8.8	5.7	2	2	10.0	1998	18	32.0	1989	15	1989	22	10	1978	4.6	3.3	1.2	.5	@	15.4	7.3	3.6	.5	
Ann	53.6	41.8	N/A	N/A	20.0	Jan 1978	25	40.5	Jan 1978	36	Jan 1978	27	14	Jan 1979	26.0	19.3	6.3	2.1	.1	73.3	41.4	19.4	3.3	

+ Also occurred on an earlier date(s) #Denotes trace amounts

@ Denotes mean number of days greater than 0 but less than .05

-9/-9.9 represents missing values

Annual statistics for Mean/Median snow depths are not appropriate

(1) Derived from Snow Climatology and 1971-2000 daily data

(2) Derived from 1971-2000 daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normal/usnormals.html

**Climatology
 of the United States
 No. 20
 1971-2000**

Station: TEN SLEEP 4 NE, WY

COOP ID: 488852

Climate Division: WY 4

NWS Call Sign:

Elevation: 4,820 Feet

Lat: 44°04N

Lon: 107°23W

Freeze Data									
Spring Freeze Dates (Month/Day)									
Temp (F)	Probability of later date in spring (thru Jul 31) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	6/14	6/08	6/04	5/31	5/28	5/24	5/21	5/17	5/11
32	5/28	5/22	5/18	5/15	5/12	5/08	5/05	5/01	4/26
28	5/16	5/10	5/06	5/02	4/29	4/25	4/22	4/17	4/11
24	4/28	4/22	4/17	4/14	4/10	4/07	4/03	3/30	3/24
20	4/22	4/14	4/09	4/04	3/31	3/27	3/22	3/17	3/09
16	4/11	4/03	3/28	3/24	3/19	3/14	3/10	3/04	2/24
Fall Freeze Dates (Month/Day)									
Temp (F)	Probability of earlier date in fall (beginning Aug 1) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	9/06	9/09	9/12	9/15	9/17	9/19	9/21	9/24	9/28
32	9/11	9/16	9/20	9/23	9/26	9/29	10/02	10/05	10/10
28	9/20	9/26	9/30	10/03	10/07	10/10	10/13	10/17	10/23
24	10/02	10/08	10/12	10/16	10/19	10/22	10/26	10/30	11/05
20	10/10	10/17	10/22	10/26	10/30	11/04	11/08	11/13	11/20
16	10/15	10/22	10/27	11/01	11/05	11/09	11/13	11/18	11/25
Freeze Free Period									
Temp (F)	Probability of longer than indicated freeze free period (Days)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	130	124	119	115	111	107	103	99	92
32	162	153	147	141	136	131	126	120	111
28	186	177	171	165	160	155	150	143	134
24	217	208	202	196	191	186	180	174	164
20	250	237	228	220	213	205	198	188	176
16	265	253	244	237	230	223	216	207	195

* Probability of observing a temperature as cold, or colder, later in the spring or earlier in the fall than the indicated date.

0/00 Indicates that the probability of occurrence of threshold temperature is less than the indicated probability.

Derived from 1971-2000 serially complete daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normal/usnormals.html

Climatograph of the United States

No. 20 1971-2000

Station: TEN SLEEP 4 NE, WY

COOP ID: 488852

Climate Division: WY 4

NWS Call Sign:

Elevation: 4,820 Feet Lat: 44°04N

Lon: 107°23W

Degree Days to Selected Base Temperatures (°F)													
Base	Heating Degree Days (1)												
Below	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
65	1251	996	835	551	291	90	12	20	163	468	889	1182	6748
60	1096	856	680	409	172	35	1	4	81	320	739	1027	5420
57	1003	772	587	330	116	17	0	1	47	240	652	934	4699
55	941	716	526	280	86	10	0	0	31	193	596	872	4251
50	787	582	382	175	33	1	0	0	8	98	458	723	3247
32	310	182	46	7	0	0	0	0	0	2	111	264	922

Base	Cooling Degree Days (1)												
Above	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
32	82	111	235	448	747	1005	1256	1231	887	558	212	106	6878
55	0	0	2	30	119	324	543	518	227	36	7	0	1806
57	0	0	1	20	88	271	481	457	184	22	3	0	1527
60	0	0	0	10	50	199	389	367	128	8	0	0	1151
65	0	0	0	2	15	105	244	227	60	1	0	0	654
70	0	0	0	0	2	43	125	117	21	0	0	0	308

Growing Degree Units (2)																								
Base	Growing Degree Units (Monthly)												Growing Degree Units (Accumulated Monthly)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
40	5	17	91	246	497	762	989	954	617	308	67	14	5	22	113	359	856	1618	2607	3561	4178	4486	4553	4567
45	0	2	38	141	354	612	834	799	473	189	24	2	0	2	40	181	535	1147	1981	2780	3253	3442	3466	3468
50	0	0	10	72	226	465	679	644	336	96	5	0	0	0	10	82	308	773	1452	2096	2432	2528	2533	2533
55	0	0	2	28	119	322	525	490	217	37	0	0	0	0	2	30	149	471	996	1486	1703	1740	1740	1740
60	0	0	0	9	52	192	373	336	113	11	0	0	0	0	0	9	61	253	626	962	1075	1086	1086	1086
Base	Growing Degree Units for Corn (Monthly)												Growing Degree Units for Corn (Accumulated Monthly)											
50/86	1	15	75	176	319	486	638	623	411	219	53	9	1	16	91	267	586	1072	1710	2333	2744	2963	3016	3025

(1) Derived from the 1971-2000 Monthly Normals

(2) Derived from 1971-2000 serially complete daily data

Note: For corn, temperatures below 50 are set to 50, and temperatures above 86 are set to 86

Complete documentation available from:

www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

Notes

- a. The monthly means are simple arithmetic averages computed by summing the monthly values for the period 1971-2000 and dividing by thirty. Prior to averaging, the data are adjusted if necessary to compensate for data quality issues, station moves or changes in station reporting practices. Missing months are replaced by estimates based on neighboring stations.
- b. The median is defined as the middle value in an ordered set of values. The median is being provided for the snow and precipitation elements because the mean can be a misleading value for precipitation normals.
- c. Only observed validated values were used to select the extreme daily values.
- d. Extreme monthly temperature/precipitation means were selected from the monthly normals data.
Monthly snow extremes were calculated from daily values quality controlled to be consistent with the Snow Climatology.
- e. Degree Days were derived using the same techniques as the 1971-2000 normals.
Complete documentation for the 1971-2000 Normals is available on the internet from:
www.ncdc.noaa.gov/oa/climate/normal/usnormals.html
- f. Mean "number of days statistics" for temperature and precipitation were calculated from a serially complete daily data set.
Documentation of the serially complete data set is available from the link below.
- g. Snowfall and snow depth statistics were derived from the Snow Climatology.
Documentation for the Snow Climatology project is available from the link under references.

Data Sources for Tables

Several different data sources were used to create the Clim20 climate summaries. In some cases the daily extremes appear inconsistent with the monthly extremes and or the mean number of days statistics. For example, a high daily extreme value may not be reflected in the highest monthly value or the mean number of days threshold that is less than and equal to the extreme value. Some of these difference are caused by different periods of record. Daily extremes are derived from the station's entire period of record while the serial data and normals data were for the 1971-2000 period. Therefore extremes observed before 1971 would not be included in the 1971-2000 normals or the 1971-2000 serial daily data set. Inconsistencies can also occur when monthly values are adjusted to reflect the current observing conditions or were replaced during the 1971-2000 Monthly Normals processing and are not reconciled with the Summary of the Day data.

- | | |
|---|---|
| <ol style="list-style-type: none">a. Temperature/ Precipitation Tables<ol style="list-style-type: none">1. 1971-2000 Monthly Normals2. Cooperative Summary of the Day3. National Weather Service station records4. 1971-2000 serially complete daily datab. Degree Day Table<ol style="list-style-type: none">1. Monthly and Annual Heating and Cooling Degree Days Normals to Selected Bases derived from 1971-2000 Monthly Normals2. Daily Normal Growing Degree Units to Selected Base Temperatures derived from 1971-2000 serially complete daily data | <ol style="list-style-type: none">c. Snow Tables<ol style="list-style-type: none">1. Snow Climatology2. Cooperative Summary of the Dayd. Freeze Data Table
1971-2000 serially complete daily data |
|---|---|

References

- U.S. Climate Normals 1971-2000, www.ncdc.noaa.gov/normal.html
U.S. Climate Normals 1971-2000-Products Clim20, www.ncdc.noaa.gov/oa/climate/normal/usnormalsprod.html
Snow Climatology Project Description, www.ncdc.noaa.gov/oa/climate/monitoring/snowclim/mainpage.html
Eischeid, J. K., P. Pasteris, H. F. Diaz, M. Plantico, and N. Lott, 2000: Creating a serially complete, national daily time series of temperature and precipitation for the Western United States. *J. Appl. Meteorol.*, 39, 1580-1591,
www1.ncdc.noaa.gov/pub/data/special/serialcomplete_jam_0900.pdf