WEATHER AND CROP SUMMARY, 1999

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Weather records for Klamath Falls date back to 1884, when the U.S. Water Bureau monitored precipitation and stream flows. Kingsley Field was selected as the site for an official National Oceanic and Atmospheric Administration (NOAA) weather station established in 1949. Kingsley Field is located at 42°09'N latitude, 121°44'W longitude, and 4,092 feet elevation. This station was closed in 1996. The Klamath Experiment Station (KES), located 1/4 mile west of Kingsley Field, was designated as the official NOAA station for Klamath Falls in 1997. The KES weather station has been in operation since 1984.

Long-term comparisons of data from KES and Kingsley Field generally show good agreement, although daily minimum air temperatures frequently have been 2 to 3°F lower at KES. This is probably due to the Kingsley Field station being in close proximity to large buildings and paved areas. Both locations experience warmer temperatures than several important agricultural production areas in other portions of the Klamath Basin. During spring and summer frost events, areas in Lower Klamath Lake and south of Tulelake are often 5 to 7°F cooler than temperatures observed at Klamath Falls.

The 1999 weather conditions at the KES were monitored with standard (NOAA) equipment as in past years. In April, equipment was installed to include the KES in the regional Agricultural Meteorology (AgriMet) network. The AgriMet installation is intended primarily to provide daily crop-specific water use estimates to assist in irrigation scheduling. The system includes sensors to monitor soil temperature at 4- and 8-inch depths, solar radiation, air temperature, relative humidity, wind speed and direction, and precipitation. Readings on 15-minute intervals are stored and transmitted every 4 hours through a geostationary satellite to an U.S. Bureau of Reclamation office in Boise, Idaho. Crop water use data are displayed on Internet Web Pages at the Klamath County Cooperative Extension Service or the KES Homepage; or they can be obtained from the Bureau of Reclamation's regional Hydromet System at:

http://www.pn.usbr.gov/agrimet.

Minor changes in monitoring the KES NOAA station have been implemented in 1998 and 1999. In previous years, the minimum temperature thermometer was reset at midday to avoid the situation where a low at time of observation was below the minimum during the following night. Since November 1998, this no longer is done. Maximum and minimum air temperatures are based on the 24-hour period before time of observation, which is 7:30 am. Soil temperature sensors installed with the AgriMet station have replaced the sensors used before April 1999. Soil temperature data is now

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based on the 24-hour period ending at midnight of the day before temperatures are reported.

Although the NOAA and Agrimet stations are located less than 20 feet apart, there were minor differences in data from them. The greatest differences were in soil temperatures. The AgriMet sensors were clearly more accurate and responsive and have been used for all reporting since April. Minor differences in air temperatures, wind miles, and precipitation are discussed later in this report.

A 5-year period of above-normal precipitation appears to have come to an end. The 1998-1999 water year ending September 30, 1999 remained above average at 16.70 inches. However, most of 1999 was below normal in precipitation (Table 1). Total rainfall for 1999 of 11.54 inches was 88 percent of the 15-year average for 1984-98 and 64 percent of the average for 1995-98, the wettest 4-year period in Klamath Falls since records began in 1884 (Tables 2 and 3). The record August precipitation of 3.02 inches saved the region from an extremely dry year.

Mean annual maximum, minimum, and mean air temperatures in 1999 were 1°F below means for 1984-98. While this suggests a normal year for temperatures, there were extremes of high and low temperatures throughout the year. Below-normal temperatures were experienced from February through August. Frequent frosts occurred in May and June. Temperatures were above normal from early September through December. Daily maximum temperatures reached 90°F on only 5 days in 1999. For the third time in 7 years, at least one frost was recorded in each month in 1999. The official frost-free season extended from July 5 to August 30.

Growing-season air and soil temperatures and precipitation for 1970 through 1999 are shown in Table 2. Data for 1970 to 1983 were obtained from the NOAA station at Kingsley Field. The KES station was the source for 1984-99 data. The mean air temperature in 1999 was among the lowest in 30 years. The only year with a lower mean temperature was 1993. Soil temperature range between maximum and minimum was greater in 1999 than in previous years for KES records. This was probably an indication of reduced sensitivity in the sensors used from 1984-98. Mean soil temperature was similar to values for previous years of KES records. Growing season precipitation in 1999 was dominated by the 3.02 inches received in August. Without this contribution, the 1999 growing season would have received less rainfall than all other years since 1970. A 1-day event on August 12 contributed 1.64 inches of this total. Areas near Merrill and Tulelake received less than 0.50 inches from the August 12 storm. The average growing-season precipitation for the agricultural production area within the Klamath Basin was less than the amount recorded at KES.

A more detailed summary of growing-season conditions is presented in Tables 4 and 5. The 30-week period from April 1 through October 27 encompasses most local field activities from land preparation through harvest. Data for 1999 are compared with data for a 19-year period from 1979-98. Temperatures were well below normal in early May,

early June, early July, and early August (Table 4). Frosts were recorded on 15 days in May, 6 days in June, and on July 4 at KES. An additional 12 days from May through July had minimum temperatures between 33 and 36°F, with frosts in surrounding areas. There were no extended periods with above-normal temperature during the season. Total growing-season precipitation in 1999 was 83 percent of the mean for the previous 19 years (Table 5). However, 75 percent of the rainfall occurred in August, and no measurable precipitation was recorded in June, July, or September.

The installation of an AgriMet station at KES has enhanced weather monitoring and increased capabilities by adding several parameters to routine observations. In the first partial year of operation, minor differences were observed in the parameters measured by both systems. Comparisons are made between the NOAA and AgriMet observations for air temperatures, precipitation, and wind miles in Table 6. Using monthly means, the NOAA station consistently has a slightly wider spread in air temperatures. The daily highs are about 1°F higher and lows about 2°F lower for the NOAA station. Precipitation varied slightly between the stations. Over the 9-month period, the AgriMet station recorded 6 percent less than the NOAA station. The differences were not always in the same direction. Wind miles were 4 percent less for the AgriMet station. This station also provides wind direction and maximum gust data daily. As expected, evapotranspiration (ET) was about 10 percent less than pan evaporation. The ET value reported is for actively growing alfalfa cover. Considerably lower values would be found for row crops and cereals. Additional parameters monitored by the AgriMet station include solar radiation, relative humidity, dew point temperature, and growing degree-days. These parameters will be useful for the future.

To maintain continuity in weather records, while both systems will continue in use, long-term records for air temperatures, precipitation, wind miles, and pan evaporation will be reported for the NOAA station.

For the second consecutive year, weather-related crop damage qualified Klamath County for a Federal Disaster Declaration. Losses were related to frost damage. Sugarbeets suffered the greatest yield losses. Most of the crop was planted before mid-May. Emerged crops were severely damaged by several widespread hard frosts in the first and second week of May. About 65 percent of sugarbeet acres were replanted after May 15. Frosts on June 7-10 damaged more crops, resulting in replanting for a second time on several hundred acres in the Lower Klamath Lake area and other parts of Klamath County. Several fields were not replanted due to the expected low yields associated with late planting. Crops that survived frost injury experienced delayed emergence and slow growth during the early part of the season. Average yields for the nearly 8,000 acres of commercial crops were about 19.5 ton / acre, down from an average of 23 ton / acre in 1998. Several fields planted in June produced less than 15 ton / acre.

Cereal crops in Klamath County suffered injury from June and July frosts.

The worst damage was experienced in the Lower Klamath Lake area. Cereal yields in the Tulelake area were generally good.

Cold weather reduced yields on the first cutting of hay crops. Alfalfa quality was excellent in the first cutting, but rain damage occurred on part of the second cutting. The absence of rain during June, July, and September provided excellent conditions for harvesting most of the hay crop and all cereals. Dry weather also contributed to a relatively disease-free season for cereal and row crops. Barley stripe rust was of no consequence in 1999. The isolated cases that did occur infected crops too late to affect yields or quality. After potato late blight infections in 1997 and 1998, this disease was not detected in 1999 crops. In addition to dry and cool weather during most of the season, the absence of potato volunteer plants may have helped reduce the threat of late blight infection.

While low rainfall during the growing season was an advantage for disease-free crop production, continuing dry conditions pose a potential water deficit situation for irrigation supplies for 2000. Bountiful water supplies following four successive years of high rainfall in the watershed have allowed full irrigation concurrently with increased flows to Klamath River and maintenance of higher elevations in Klamath Lake. A return to normal water supplies clearly will reduce deliveries for irrigation if Klamath Irrigation Project management priorities established in recent years are implemented.

Table 1. Mean monthly air temperatures and total monthly precipitation recorded at the Klamath Experiment Station, Klamath Falls, OR for 1999 and for 1984-98.

Month	Mean monthly temperature max	min	mean	Total precipitation
		°F		inches
		1999		
January	42	18	30	2.75
February	39	18	29	2.50
March	47	26	36	0.26
April	55	28	42	0.60
May	64	33	49	0.36
June	72	39	55	0.00
July	81	43	62	0.00
August	80	46	63	3.02
September	77	40	59	0.00
October	69	29	49	0.47
November	53	30	41	1.06
December	43	19	31	0.52
Mean/Total	60	31	45	11.54
		1984-98		
January	39	20	30	1.78
February	45	23	34	1.11
March	52	27	39	1.34
April	59	31	45	0.89
May	66	37	51	1.31
June	74	43	58	0.90
July	83	48	66	0.42
August	83	46	65	0.39
September	76	40	58	0.75
October	65	31	48	0.75
November	47	24	36	1.76
December	38	18	28	1.68
Mean/Total	61	32	46	13.08

Table 2. Mean air temperatures for April through September, mean 4-inch soil temperatures for May through October, and total precipitation for April through September and annually from 1970-99 at Klamath Falls, OR.

	Air temperature Apr.-Sept.			4" Soil temperature May-Oct.			Total precipitation	
Year	max	min	mean	max	min	mean	Apr.-Sept.	annual
			°F				inches	
1999	72	39	55	68	55	61	3.98	11.54
1998	73	41	57	59	57	58	6.95	19.51
1997	73	41	57	60	57	58	4.52	14.29
1996	72	39	56	61	59	60	5.50	19.54
1995	72	40	56	61	57	59	7.10	19.06
1994	76	40	58	63	59	61	3.42	7.72
1993	70	38	54	60	55	58	5.82	14.96
1992	77	42	60	66	58	62	3.41	11.34
1991	73	40	57	61	55	59	3.41	9.29
1990	74	41	58	61	55	58	5.66	12.46
1989	72	40	56	62	55	59	5.16	12.08
1988	75	41	58	64	56	60	3.13	10.15
1987	76	41	59	65	56	61	3.24	10.13
1986	73	42	58	70	59	64	3.87	13.06
1985	74	40	57	64	53	59	5.50	10.13
1984	71	41	56	70	57	64	4.36	13.32
1983	69	40	55	73	59	66	3.88	18.56
1982	70	40	55	71	57	64	4.18	13.90
1981	74	42	58	73	58	66	2.43	15.57
1980	71	41	56	74	59	67	2.75	11.03
1979	74	42	58				3.77	14.10
1978	70	40	55	71	58	65	4.57	9.30
1977	73	43	58	71	58	65	4.97	12.37
1976	69	41	55	72	57	65	4.94	8.70
1975	71	41	56				4.10	13.21
1974	74	42	58	70	56	63	1.82	8.64
1973	75	42	59	69	55	62	1.29	11.03
1972	73	41	57				1.87	11.72
1971	70	40	55				4.68	12.68
1970	74	39	57	70	57	64	1.25	12.61
Mean	73	41	57	68	57	62	4.05	12.73

Table 3. Annual precipitation for Klamath Falls, OR, recorded by the U.S. Water Bureau (U.S.WB) (1884-1948), National Weather Service (NOAA) (1949-99), and Klamath Experiment Station (KES) (1984-99)

Year	Precipitation inches	Year	Precipitation inches	Year	Precipitation inches	Year	Precipitation inches	
	U.S. Water Bureau			NOAA				KES
1884	17.94	1921	11.94	1949	6.86	1979	14.10	
1885	18.71	1922	15.19	1950	13.56	1980	11.03	
1886	18.06	1923	9.85	1951	10.76	1981	15.57	
1887	10.71	1924	11.28	1952	10.97	1982	13.90	
1888	13.75	1925	14.26	1953	10.76	1983	18.56	
1889	10.40	1926	13.23	1954	8.57	1984	12.98	13.32
1890	IN †	1927	15.47	1955	11.31	1985	9.17	10.15
1891-99	NA ‡	1928	11.65	1956	12.52	1986	13.49	13.06
1900	NA	1929	8.56	1957	18.38	1987	10.11	10.13
		1930	9.44	1958	13.25	1988	10.32	10.15
				1959	6.72	1989	12.11	12.08
				1960	15.86	1990	13.33	12.46
1901	NA	1931	9.50	1961	13.21	1991	10.50	9.29
1902	11.26	1932	9.84	1962	16.92	1992	11.68	11.34
1903	IN	1933	11.01	1963	10.41	1993	16.78	14.96
1904	15.04	1934	10.47	1964	15.45	1994	9.84	7.72
1905	8.32	1935	11.25	1965	10.12	1995	22.66	19.06
1906	14.87	1936	13.44	1966	11.50	1996	23.91	19.54
1907	16.67	1937	19.41	1967	9.21	1997	14.29	14.29
1908	10.02	1938	13.05	1968	10.18	1998	19.51	19.51
1909	17.67	1939	11.99	1969	15.38	1999	11.54	11.54
1910	14.70	1940	17.12	1970	12.61			
1911	9.73	1941	19.71	1971	12.68			
1912	19.56	1942	14.09	1972	11.72			
1913	16.11	1943	13.82	1973	11.03			
1914	11.42	1944	12.42	1974	8.64			
1915	11.72	1945	16.52	1975	13.21			
1916	10.98	1946	11.46	1976	8.70			
1917	10.22	1947	11.32	1977	12.37			
1918	9.51	1948	20.91	1978	9.30			
1919	9.40							
1920	12.22							

Means	1884-1948	13.22
	1949-1983	12.51
NOAA	1984-1997	13.65
KES	1984-1999	13.04

† IN: datum incomplete

‡ NA: datum unavailable

Table 4. Weekly average maximum, minimum, and mean air temperatures for the 1999 growing season and 1979-98 at Klamath Falls, OR.

Weekly period		1999 Weekly average max	1999 Weekly average min	1999 Weekly average mean	1979-98 Weekly average max	1979-98 Weekly average min	1979-98 Weekly average mean
		°F			°F		
April	1 - 7	44	25	34	54	29	42
	8 - 14	50	29	40	57	29	43
	15 - 21	63	36	50	60	32	46
	22 - 28	56	32	44	59	32	46
	29 - 5	55	32	44	63	34	49
May	6 - 12	57	27	42	63	35	49
	13 - 19	58	28	43	66	36	51
	20 - 26	76	41	59	69	39	54
	27 - 2	74	39	57	69	41	55
June	3 - 9	60	31	46	70	42	56
	10 - 16	78	41	59	73	43	58
	17 - 23	78	43	61	76	44	60
	24 - 30	77	43	60	78	46	62
July	1 - 7	75	39	57	79	46	62
	8 - 14	89	51	70	82	48	65
	15 - 21	80	40	60	83	50	66
	22 - 28	82	44	63	85	50	68
	29 - 4	85	46	66	85	49	67
August	5 - 11	78	46	62	86	49	68
	12 - 18	77	45	61	84	47	65
	19 - 25	84	48	66	81	46	63
	26 - 1	78	44	61	80	43	62
September	2 - 8	74	39	57	81	43	62
	9 - 15	81	47	64	76	40	58
	16 - 22	83	43	63	73	38	56
	23 - 29	74	36	55	73	38	56
	30 - 6	77	34	55	73	36	54
October	7 - 13	72	32	52	68	34	51
	14 - 20	68	26	47	63	29	46
	21 - 27	71	28	49	61	31	46
Mean		72	38	55	72	39	56

Table 5. Weekly minimum air temperatures, frost days, and precipitation for the 1999 growing season and 1979-98 at Klamath Falls, OR.

Weekly period		Weekly min.		Frost days/week		Weekly precip.		Accum. precip.	
		1999	1979-98	1999	1979-98	1999	1979-98	1999	1979-98
		°F		%		inches			
April	1 -7	15	11	100	75	0.20	0.15	0.20	0.15
	8 - 14	22	15	71	67	0.34	0.16	0.54	0.31
	15 - 21	29	17	28	53	0.00	0.22	0.54	0.53
	22 - 28	25	20	43	52	0.04	0.26	0.58	0.79
	29 - 5	22	19	43	35	0.15	0.29	0.73	1.08
May	6 - 12	18	23	71	42	0.00	0.22	0.73	1.30
	13 - 19	20	19	100	30	0.06	0.28	0.79	1.58
	20 - 26	31	24	14	19	0.00	0.25	0.79	1.83
	27 - 2	30	27	14	17	0.15	0.34	0.94	2.17
June	3 - 9	26	27	57	8	0.00	0.28	0.94	2.45
	10 - 16	31	27	14	7	0.00	0.18	0.94	2.63
	17 - 23	41	30	0	4	0.00	0.08	0.94	2.71
	24 - 30	34	31	0	0	0.00	0.14	0.94	2.85
July	1 - 7	31	33	14	0	0.00	0.06	0.94	2.91
	8 - 14	47	34	0	0	0.00	0.05	0.94	2.96
	15 - 21	36	32	0	1	0.00	0.13	0.94	3.09
	22 - 28	40	35	0	0	0.00	0.04	0.94	3.13
	29 - 4	43	36	0	0	0.00	0.09	0.94	3.22
August	5 - 11	41	34	0	0	2.13	0.03	3.07	3.25
	12 - 18	36	29	0	2	0.04	0.11	3.11	3.36
	19 - 25	42	30	0	3	0.32	0.15	3.43	3.51
	26 - 1	29	32	28	1	0.53	0.17	3.96	3.68
September	2 - 8	34	29	0	4	0.00	0.08	3.96	3.76
	9 - 15	43	24	0	10	0.00	0.15	3.96	3.91
	16 - 22	40	24	0	14	0.00	0.21	3.96	4.12
	23 - 29	29	24	43	19	0.00	0.15	3.96	4.27
	30 - 6	30	20	28	23	0.09	0.07	4.05	4.34
October	7 - 13	27	18	57	40	0.02	0.16	4.07	4.50
	14 - 20	22	18	100	68	0.00	0.12	4.07	4.62
	21 - 27	26	15	86	64	0.02	0.33	4.09	4.95

Table 6. A comparison of monthly mean air temperatures and wind miles, total precipitation, and pan evaporation (EVAP), versus evapotranspiration (ET) for NOAA and AgriMet (AGM) weather stations at Klamath Experiment Station, 1999.

	Air Temperature											
	Maximum		Minimum		Mean		Precipitation		Wind		EVAP	ET
	NOAA	AGM	NOAA	AGM	NOAA	AGM	NOAA	AGM	NOAA	AGM	NOAA	AGM
	°F						inches		miles/day		inches	
April	55	54	28	31	42	43	0.60	0.58	153	145		
May	64	62	33	36	49	49	0.36	0.26	135	127	6.31	5.47
June	72	71	39	41	56	56	0.00	0.02	112	107	8.36	7.58
July	81	81	43	46	62	64	0.00	0.00	87	81	10.21	9.11
August	80	79	46	48	63	64	3.02	2.84	78	76	7.44	6.52
September	77	77	40	43	59	60	0.00	0.00	90	89	6.61	5.72
October	69	67	29	33	49	50	0.47	0.39	66	69		
November	53	52	30	33	42	43	1.06	1.03	115	109		
December	43	43	19	22	31	33	0.52	0.55	62	60		
Mean/Total	66	65	34	37	50	51	6.03	5.67	100	96	38.93	34.40