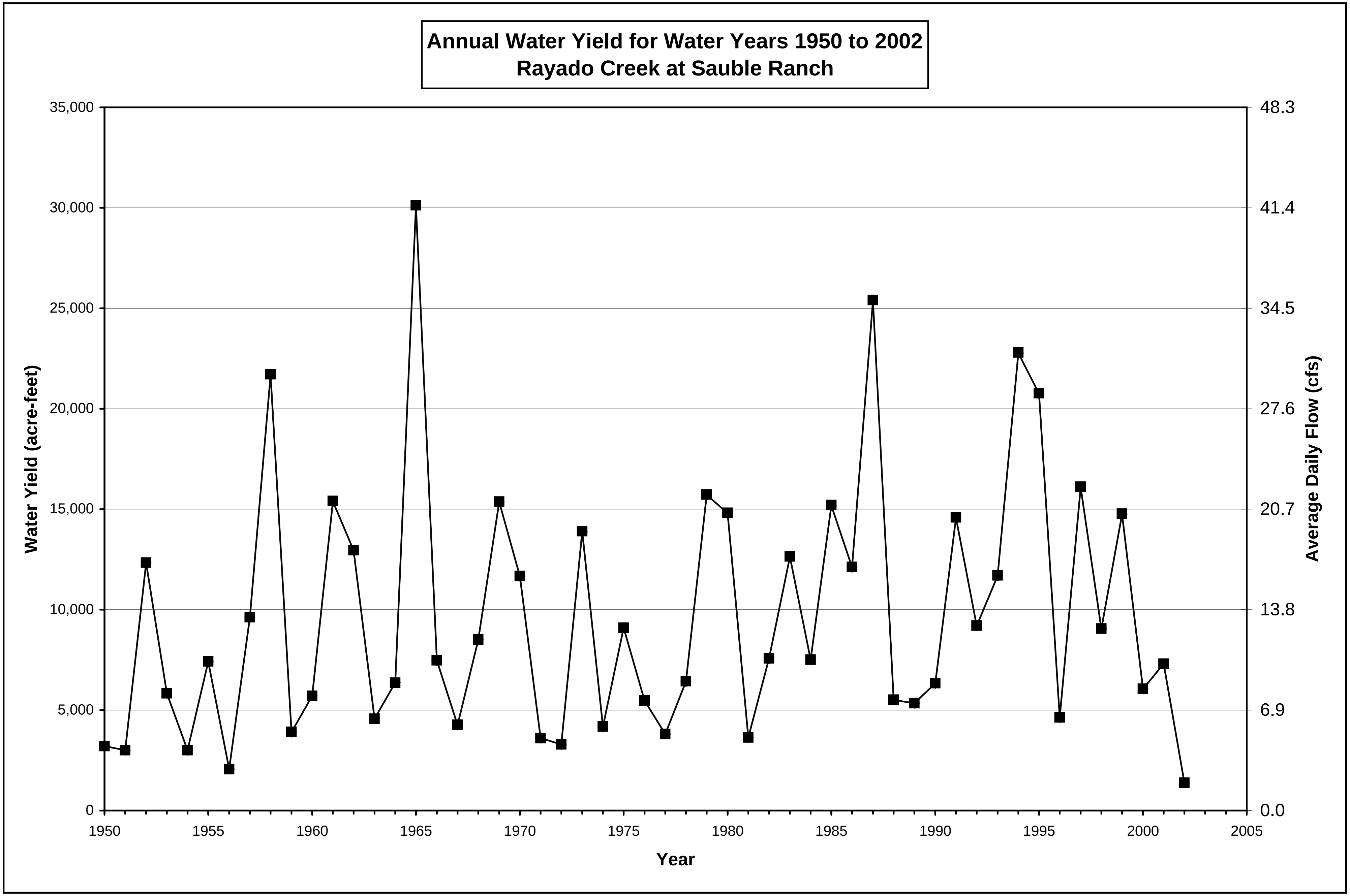
Appendix F

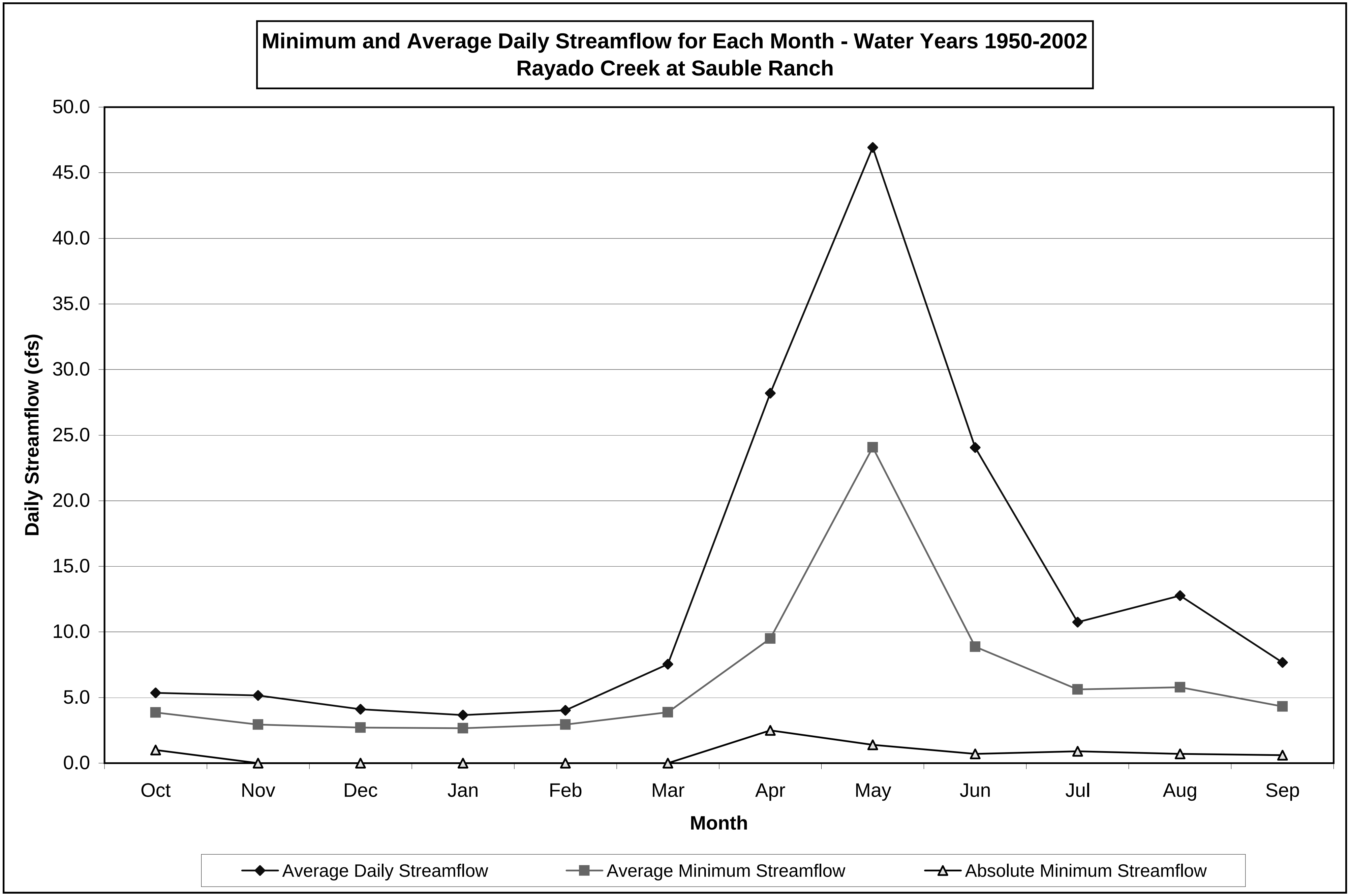
Streamflow Information

Appendix F1

Hydrographs



S:\Projects\9362\Sheets\Updates_WY2001-02\RayadoCrkatSaubleRanchNM.xls [Annual Chart]



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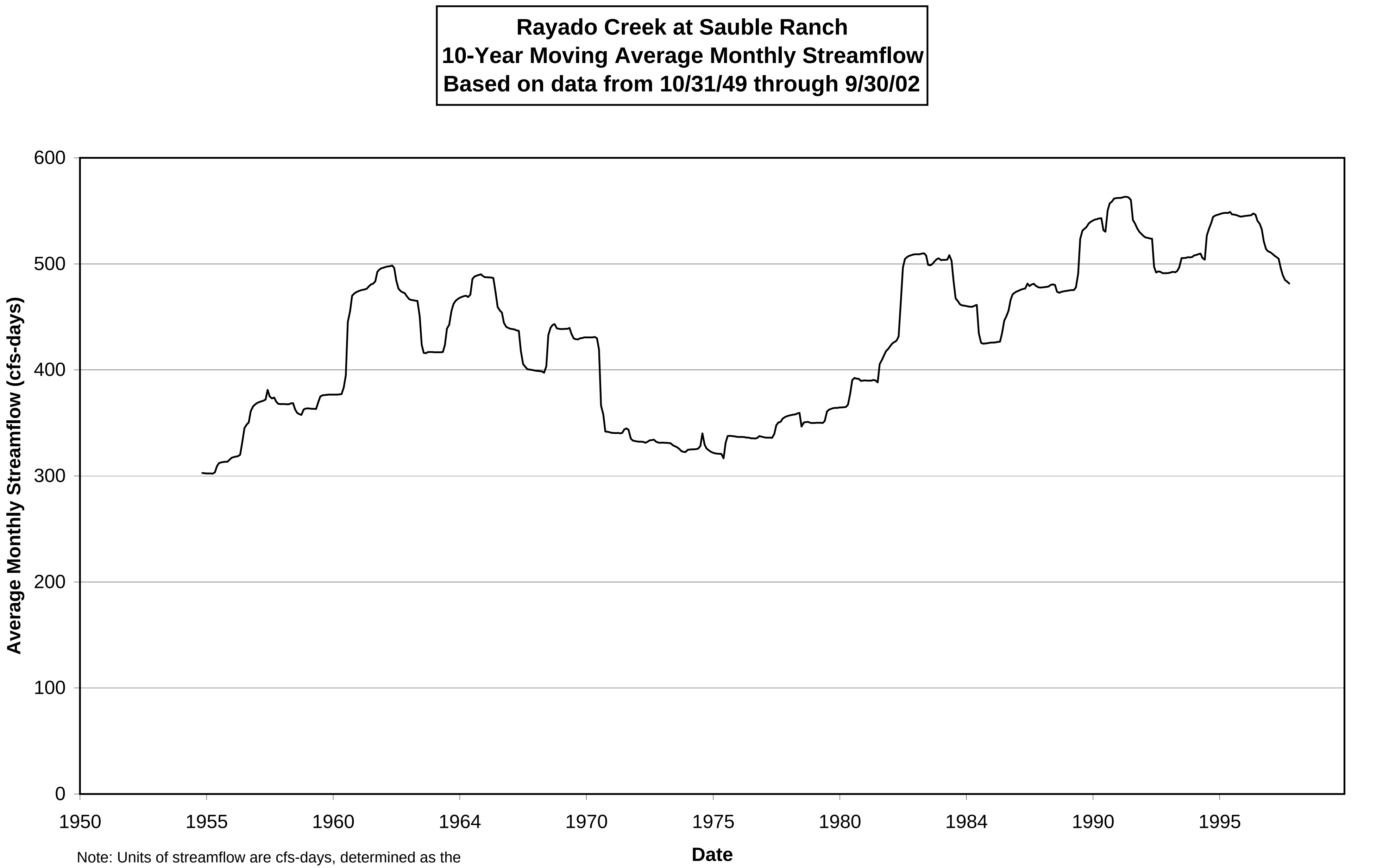

Note: Units of streamflow are cfs-days, determined as the monthly sum of mean daily discharges in cubic feet per second.

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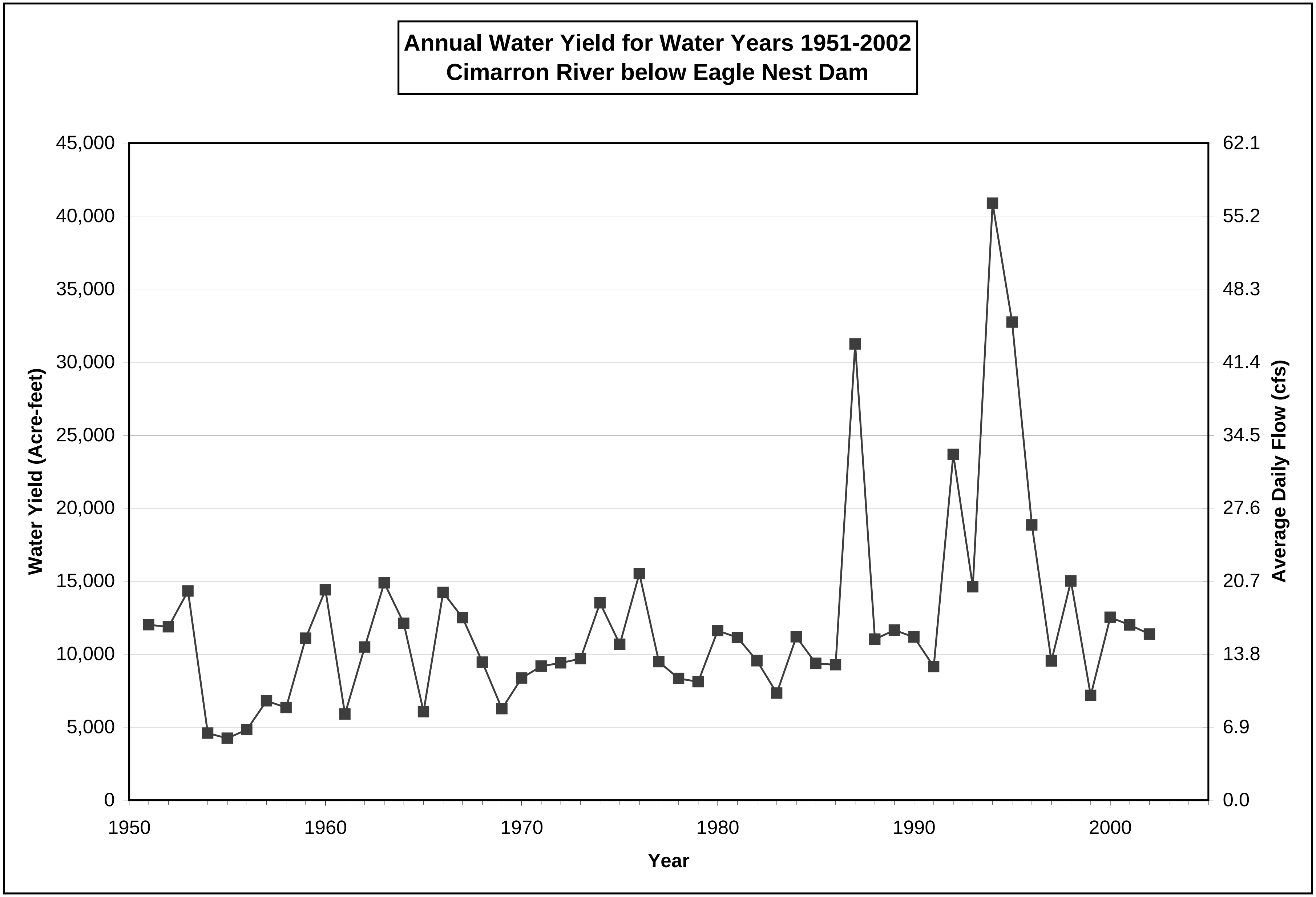

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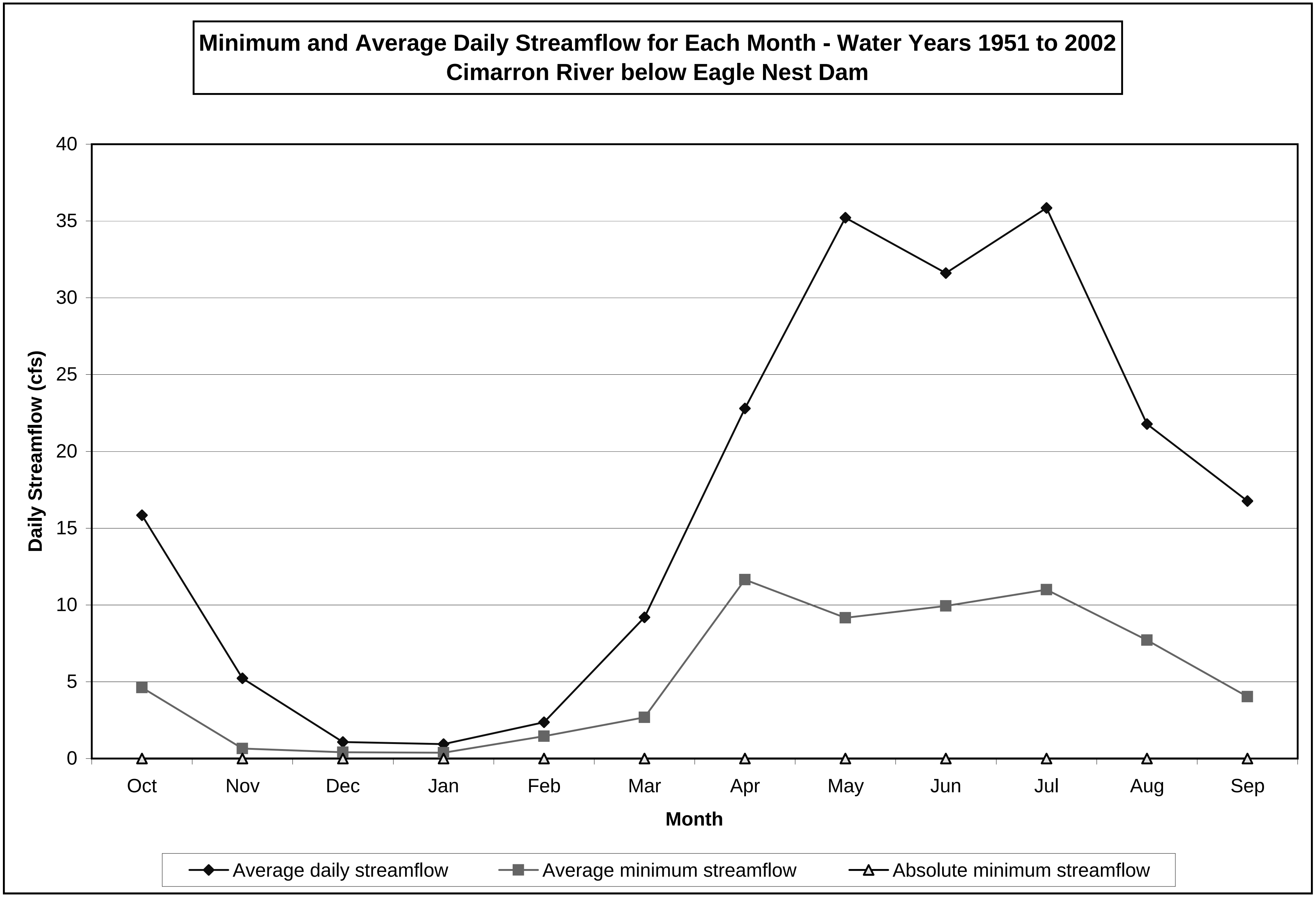

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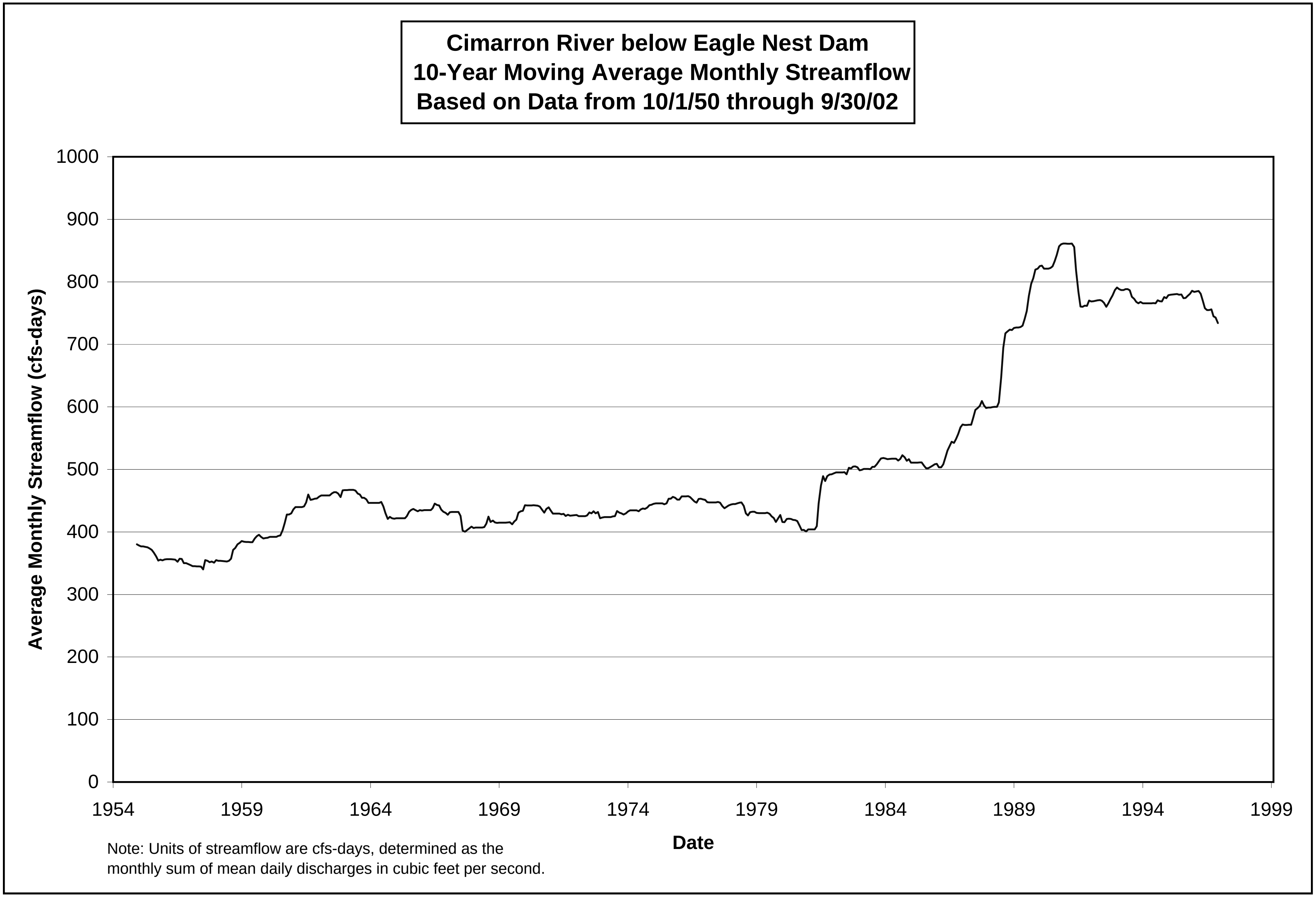

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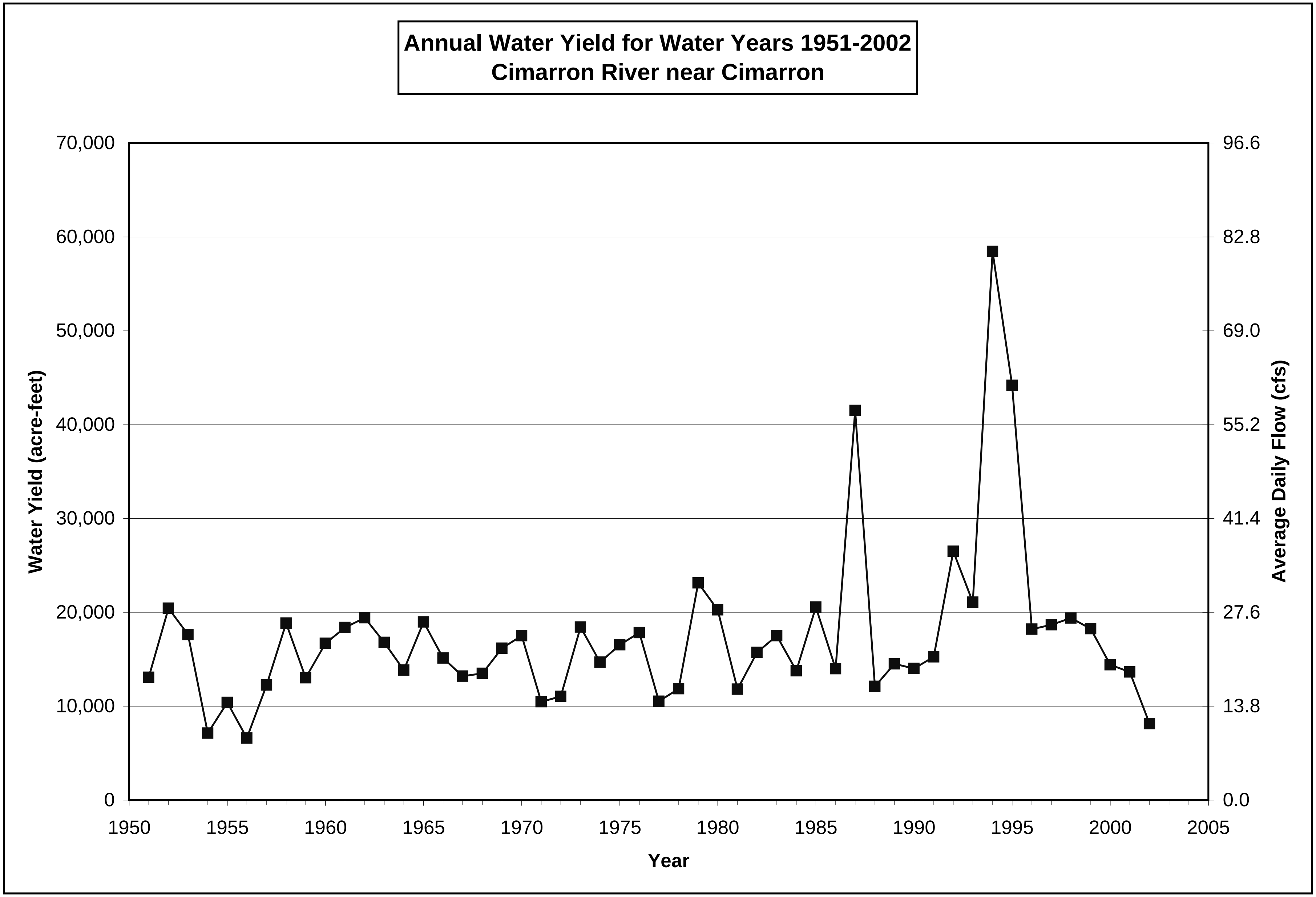

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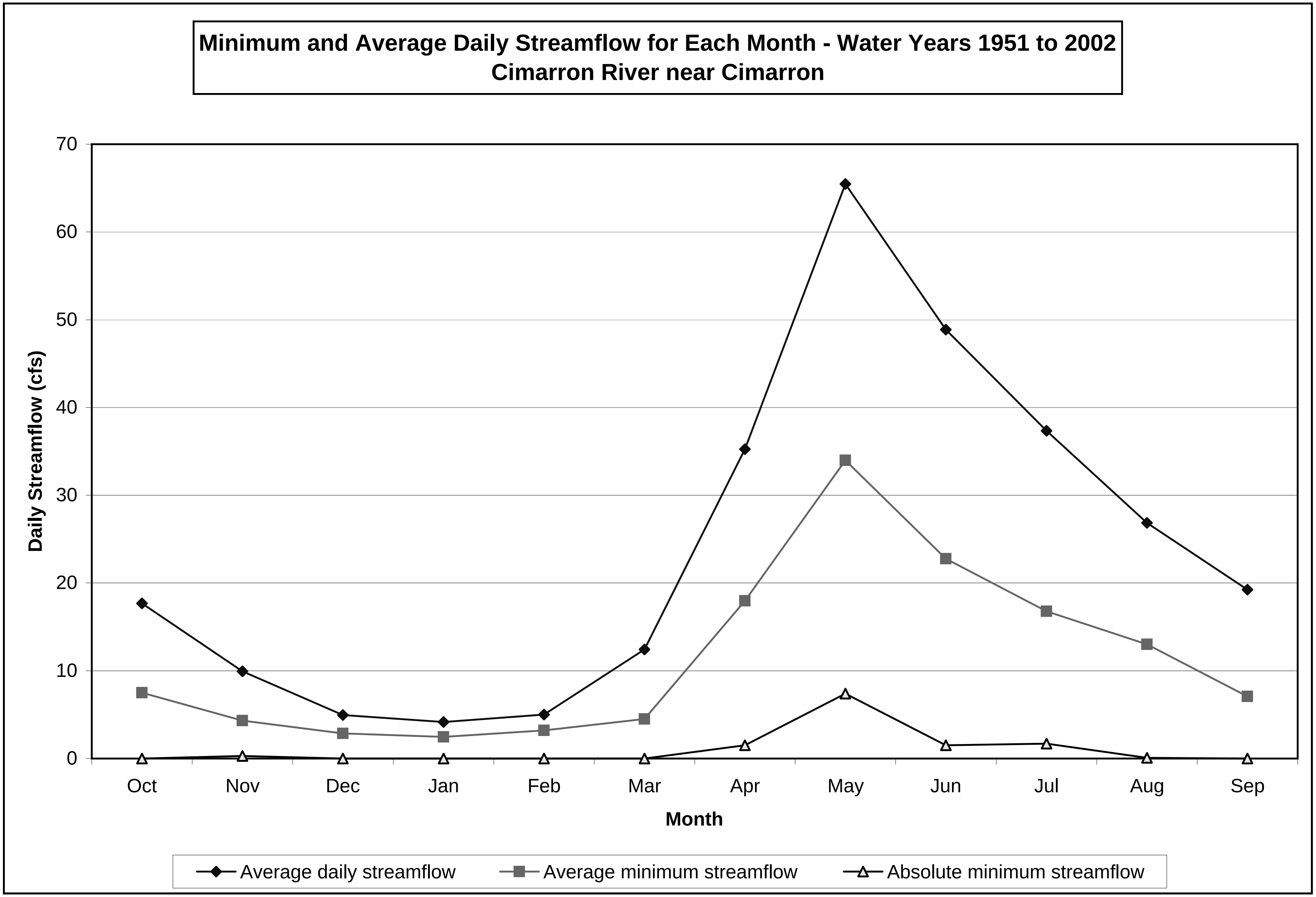

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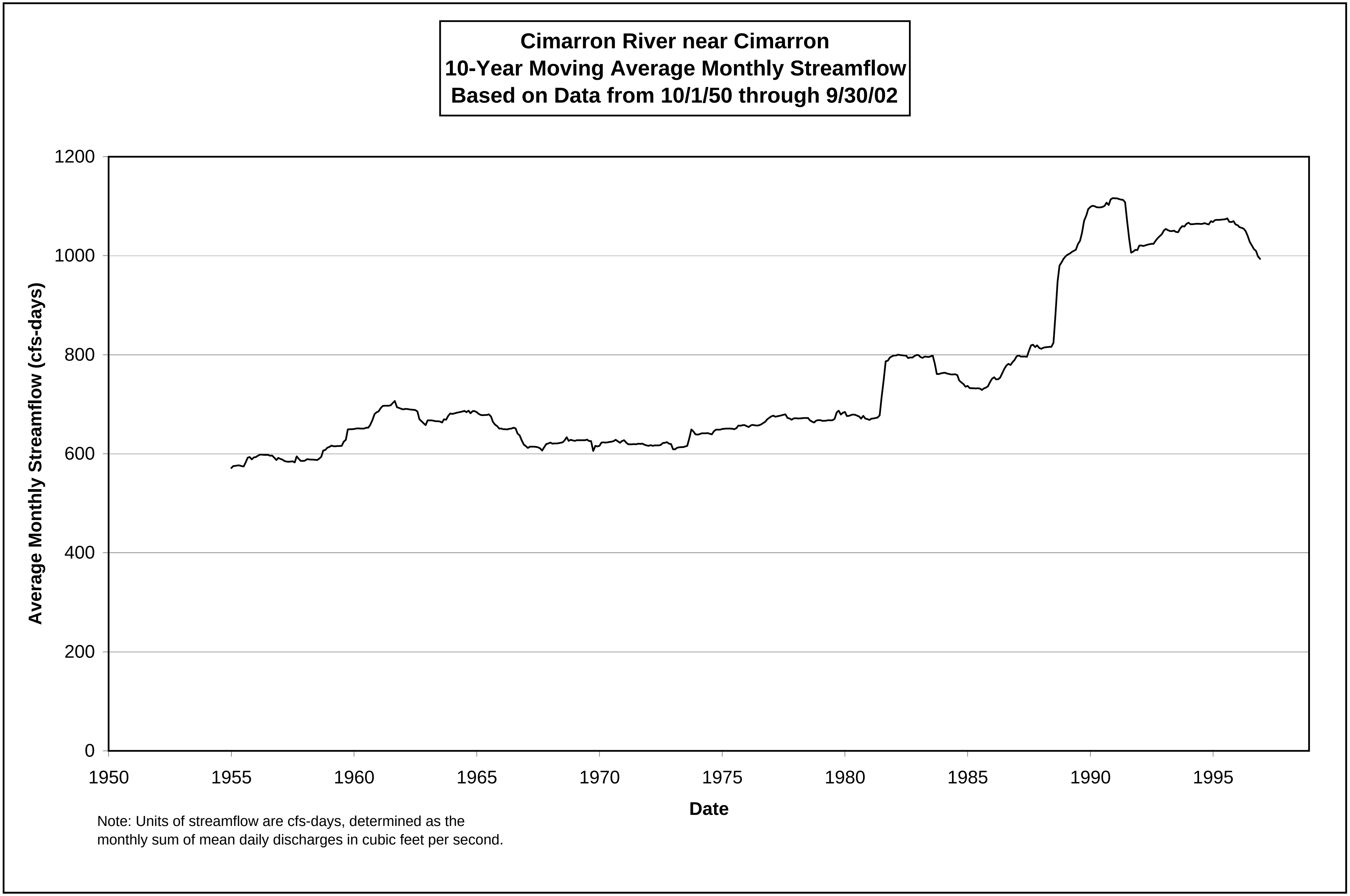

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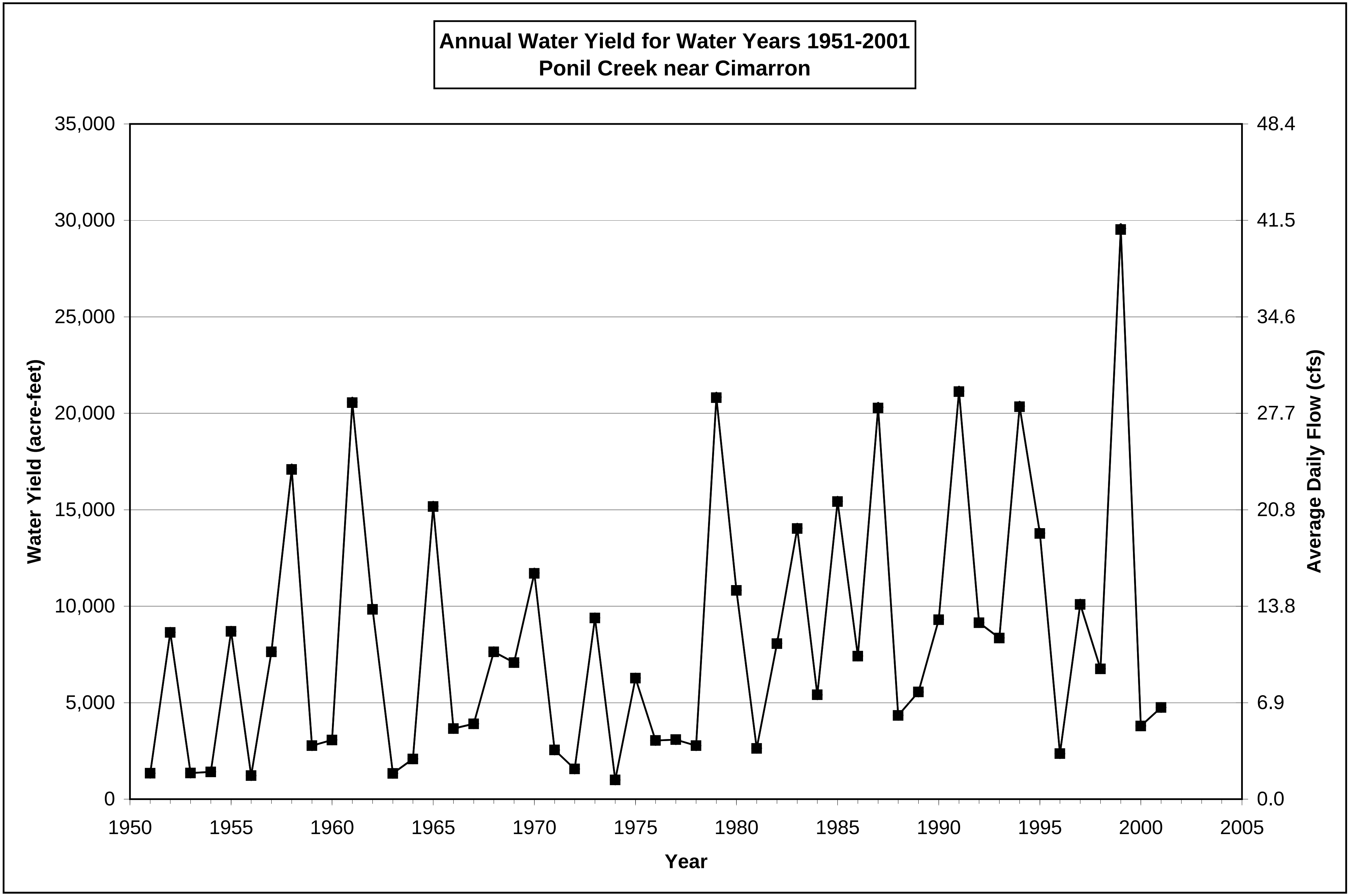

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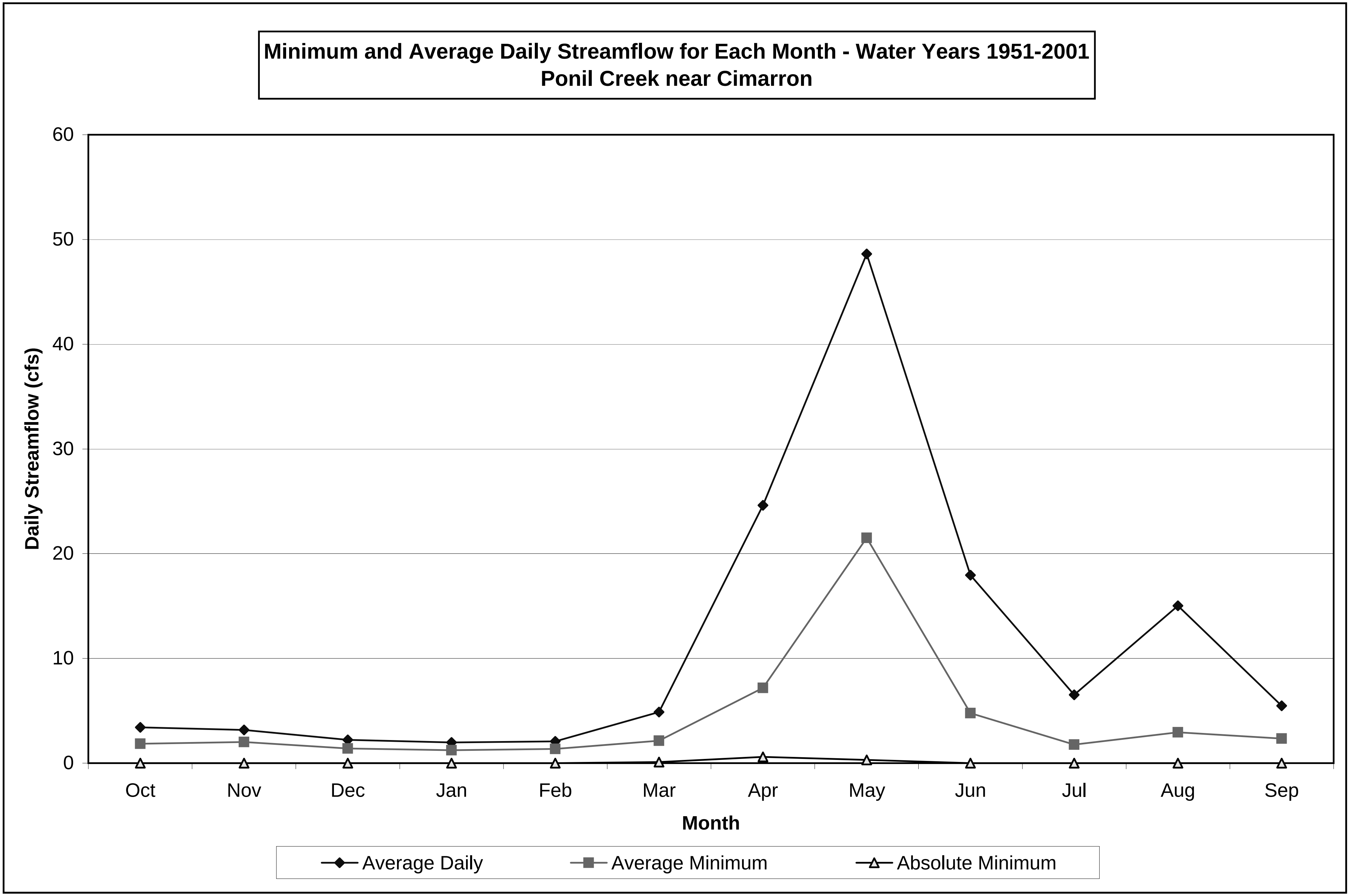

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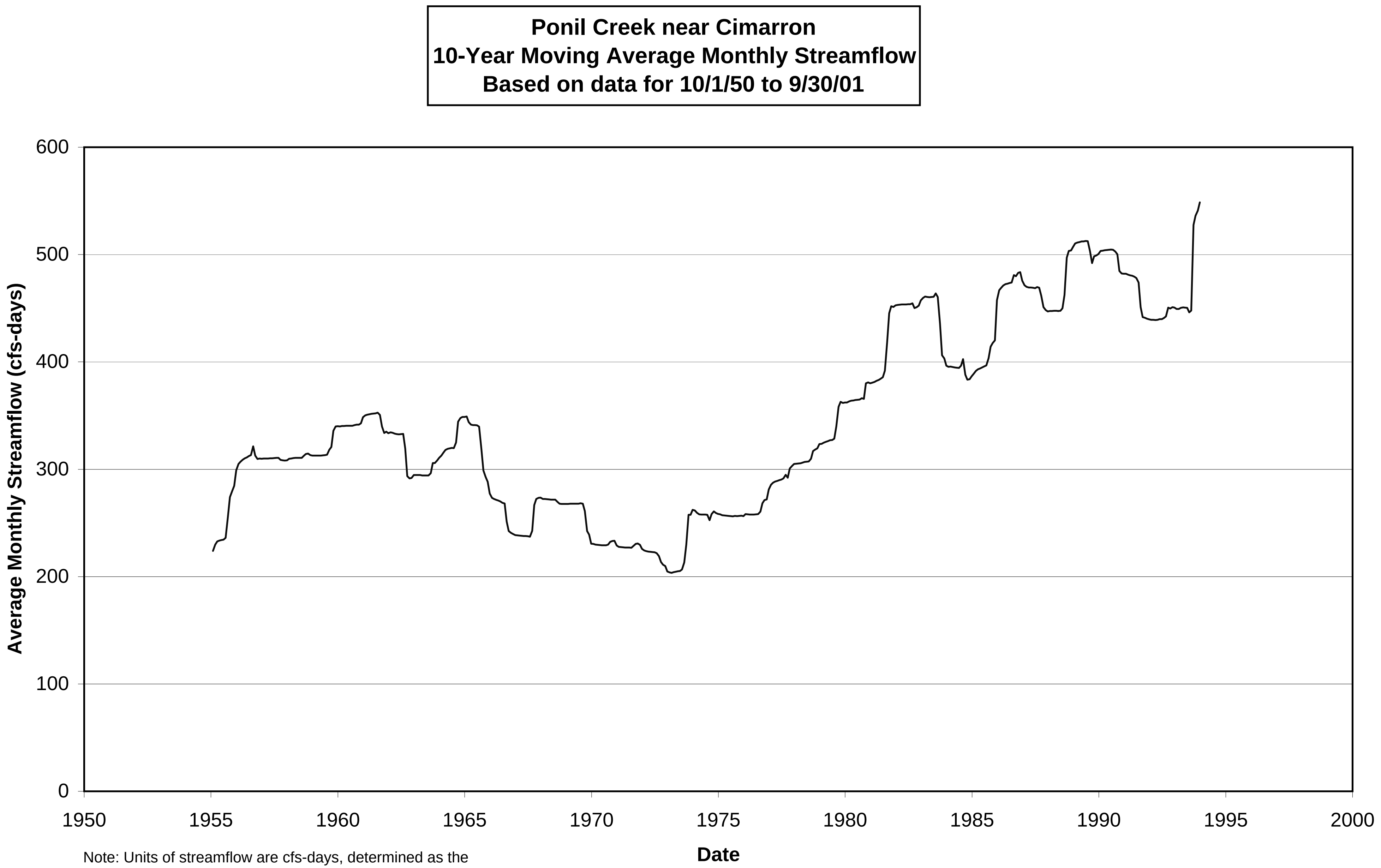

Note: Units of streamflow are cfs-days, determined as the monthly sum of mean daily discharges in cubic feet per second.

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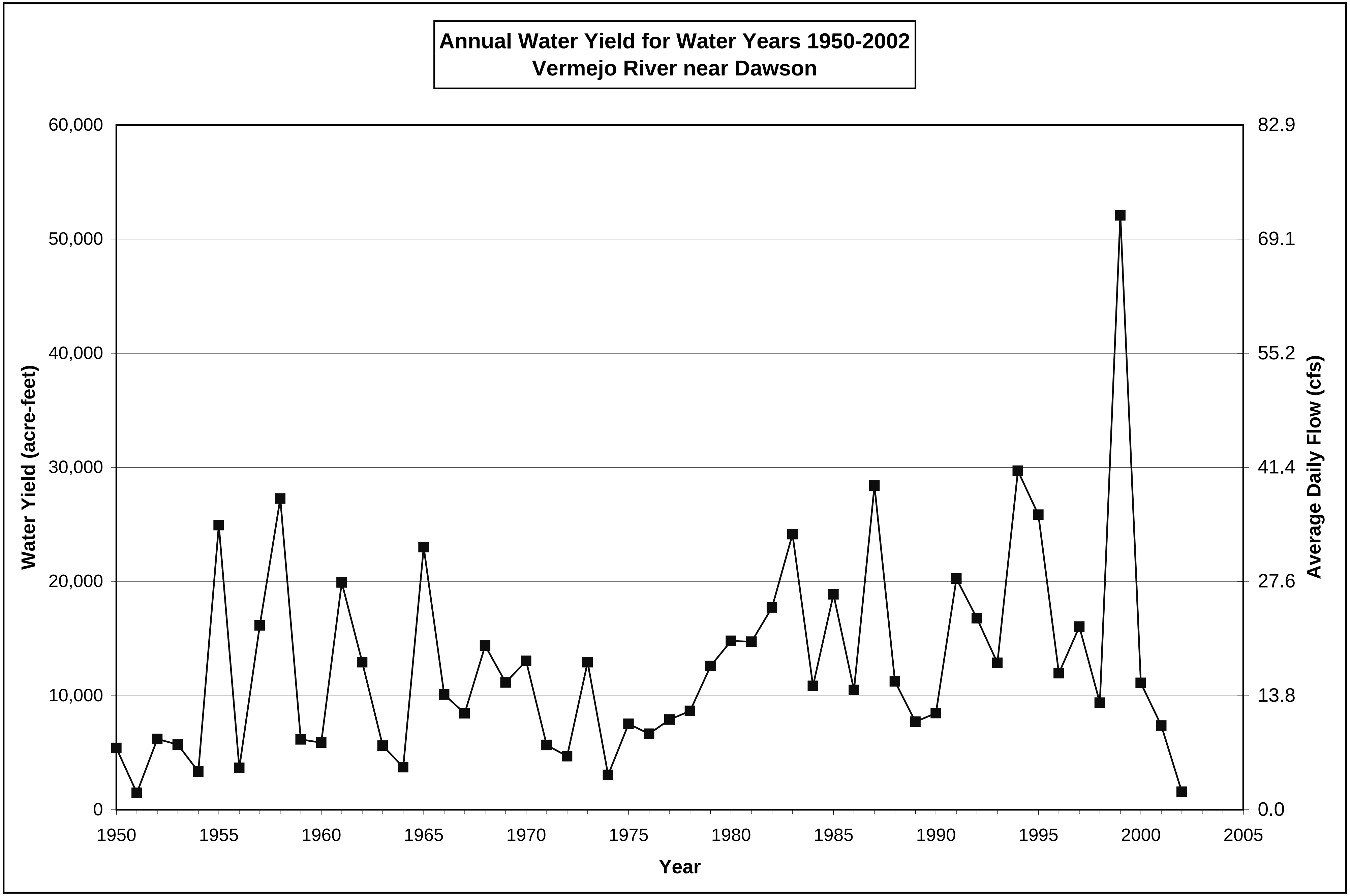

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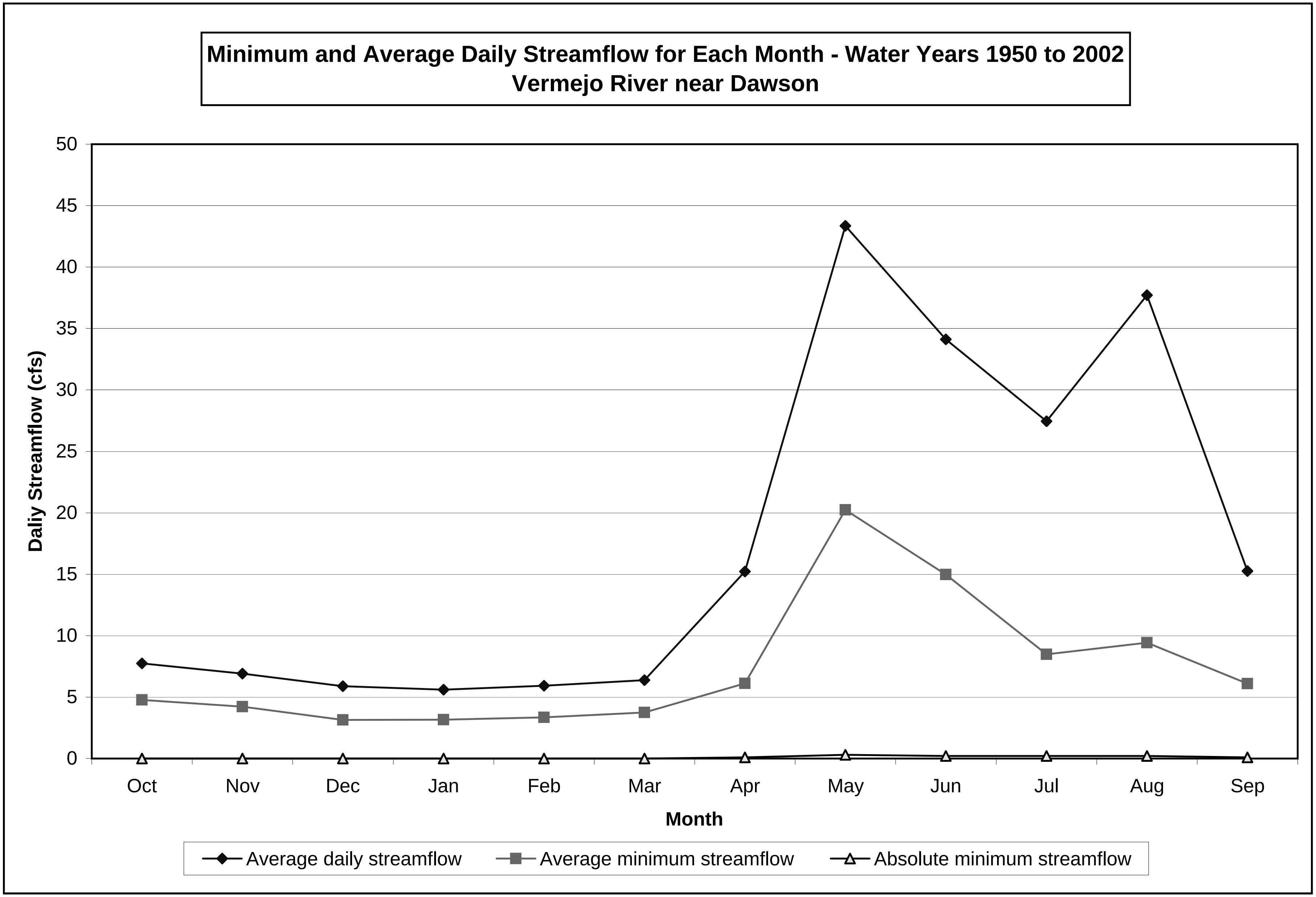

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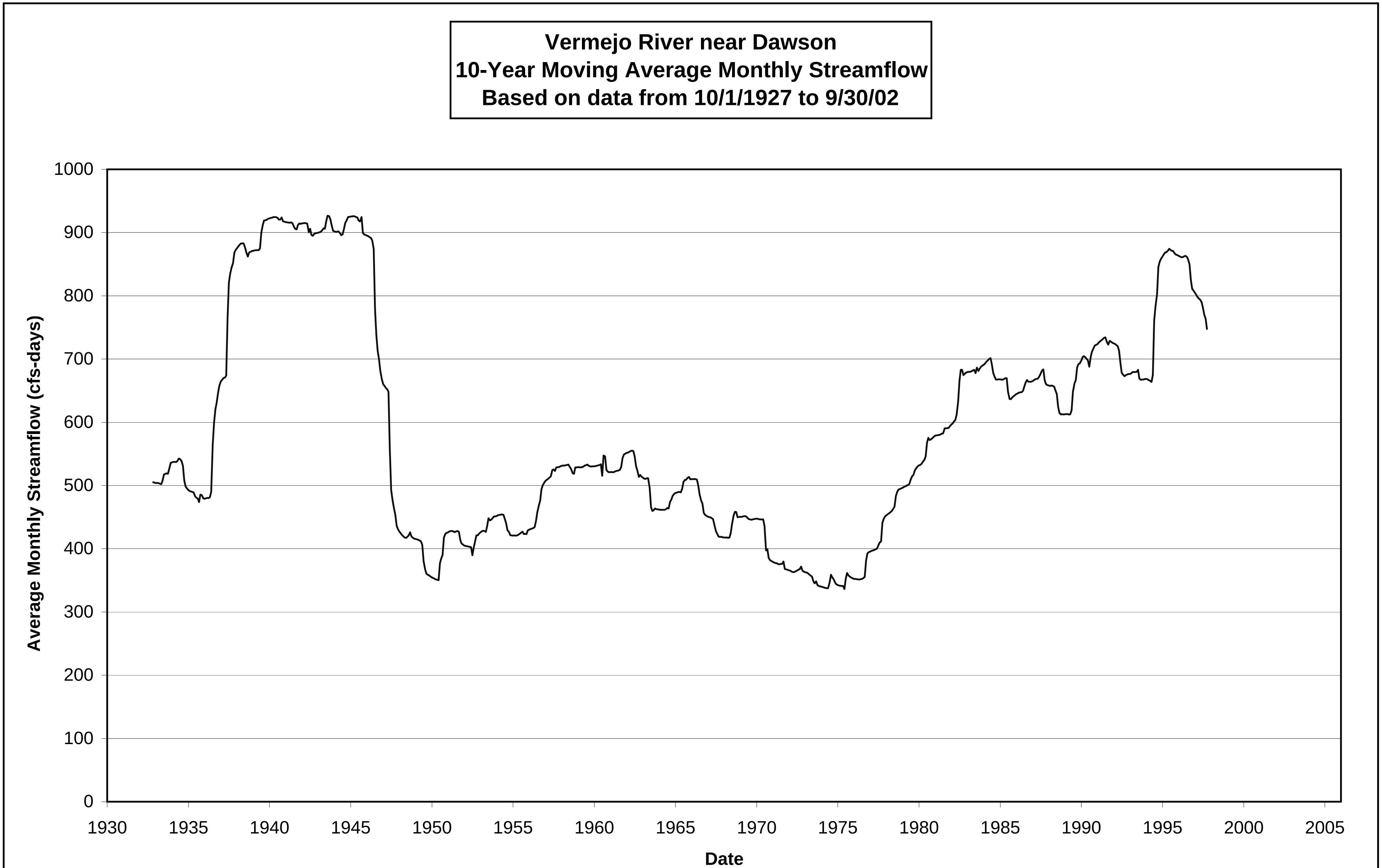
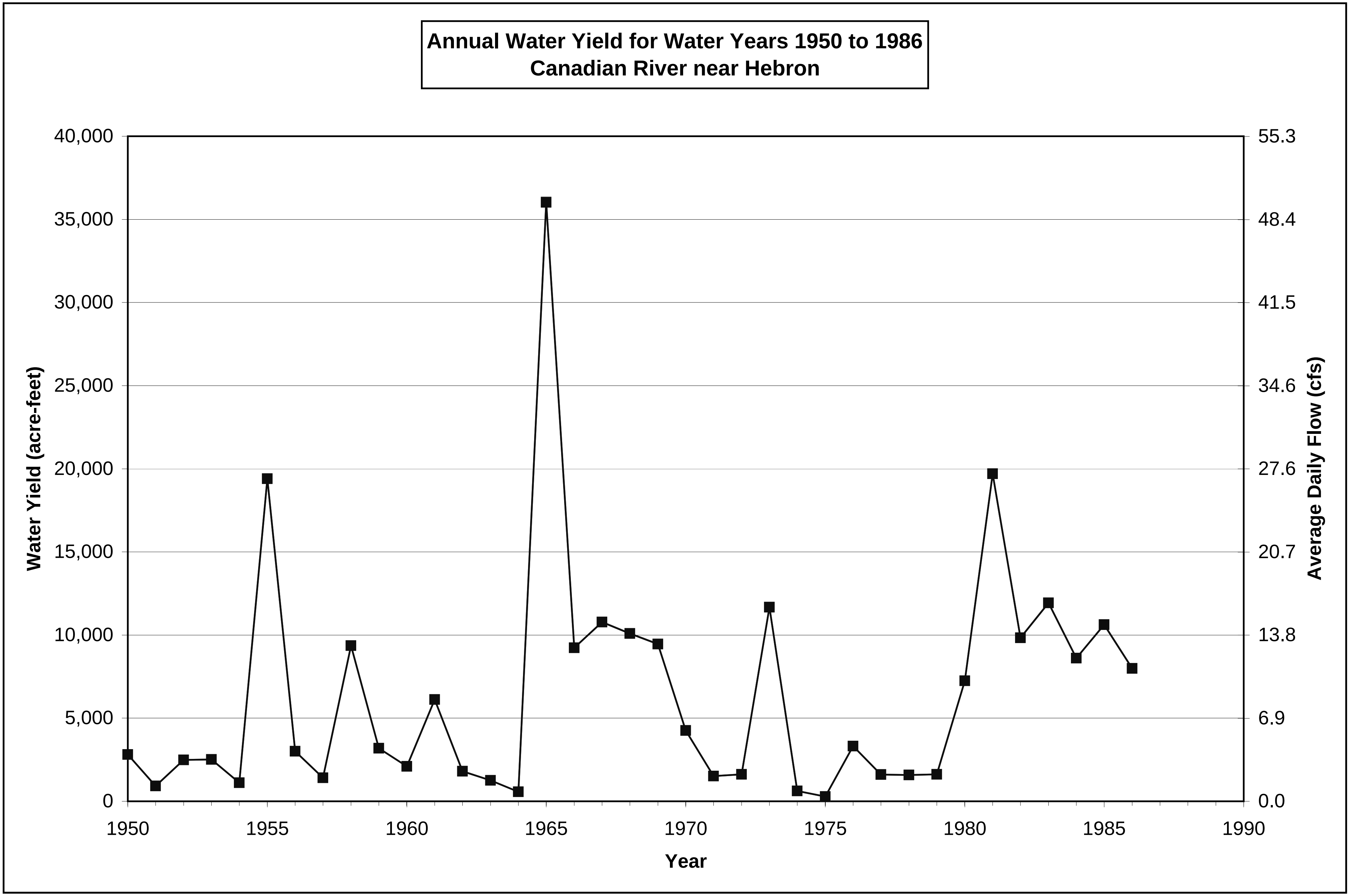
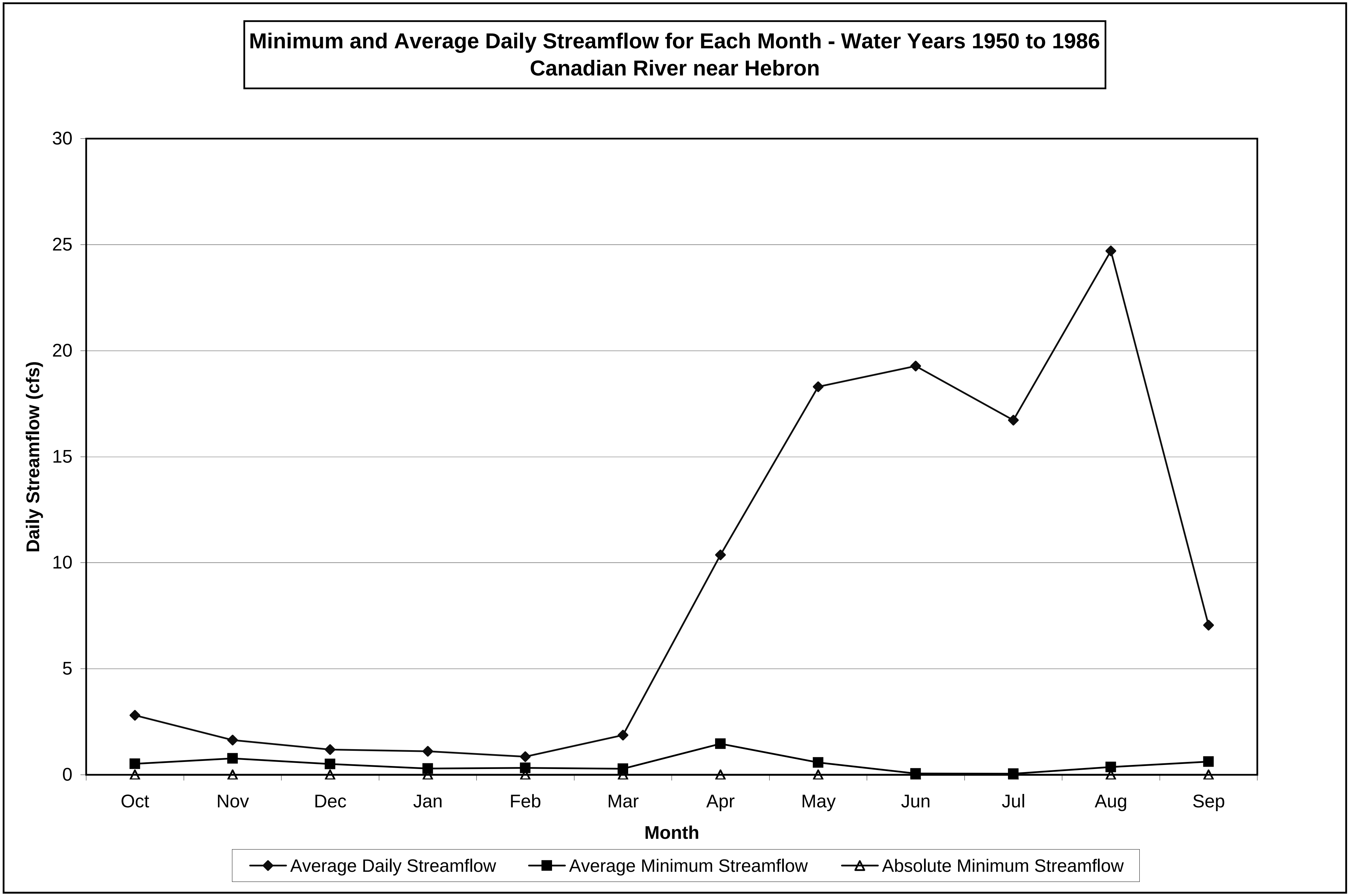


Note: Units of streamflow are cfs-days, determined as the monthly sum of mean daily discharges in cubic feet per second.

S:\Projects\9362\Sheets\Updates_WY2001-02\VermejoRivernrDawsonNM_bb.xls [120 month moving average]



S:\Projects\9362\Sheets\Updates_WY2001-02\CanadianRivernrHebronNM.xls [Annual Chart]



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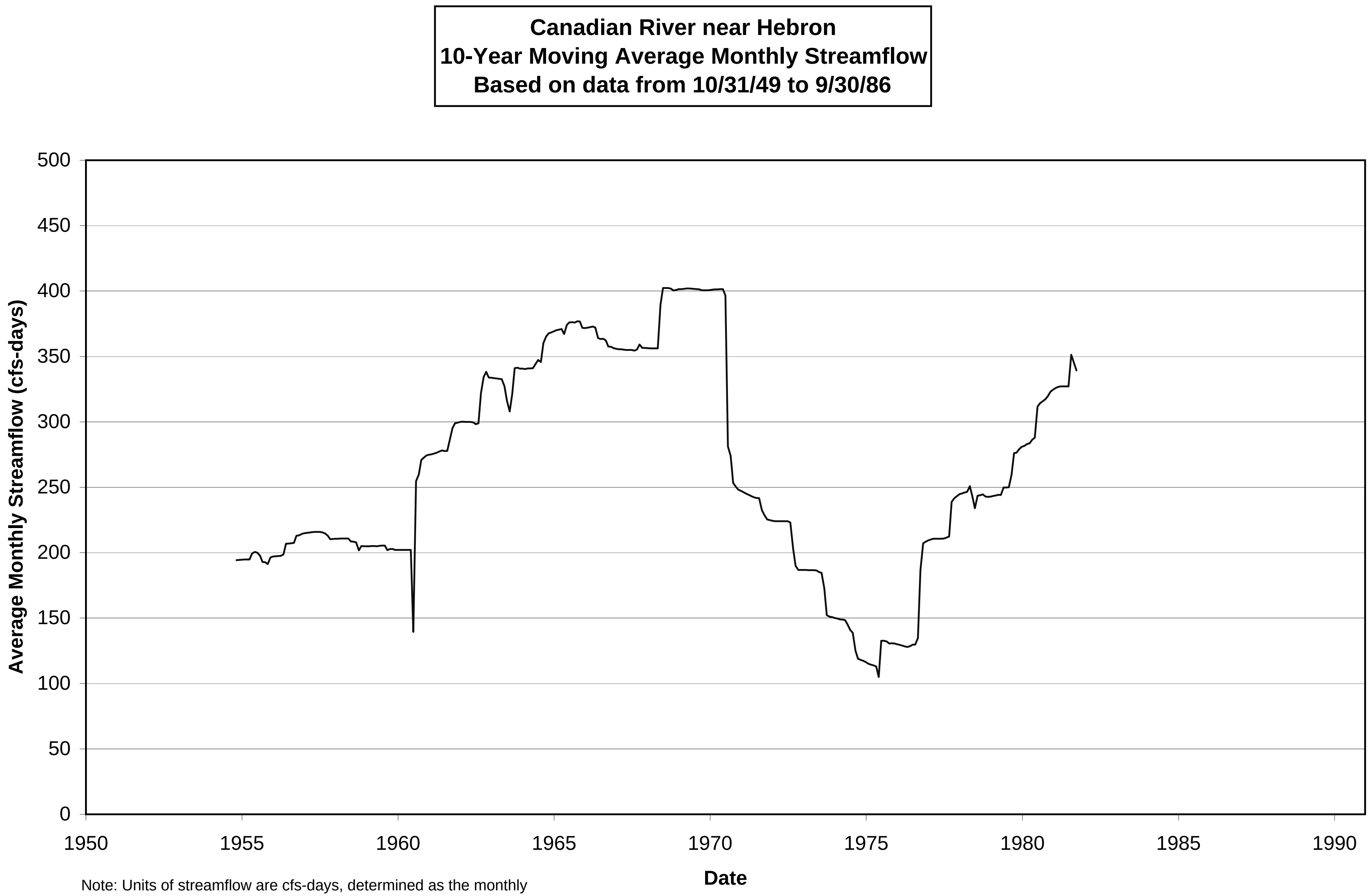

Note: Units of streamflow are cfs-days, determined as the monthly sum of mean daily discharges in cubic feet per second.

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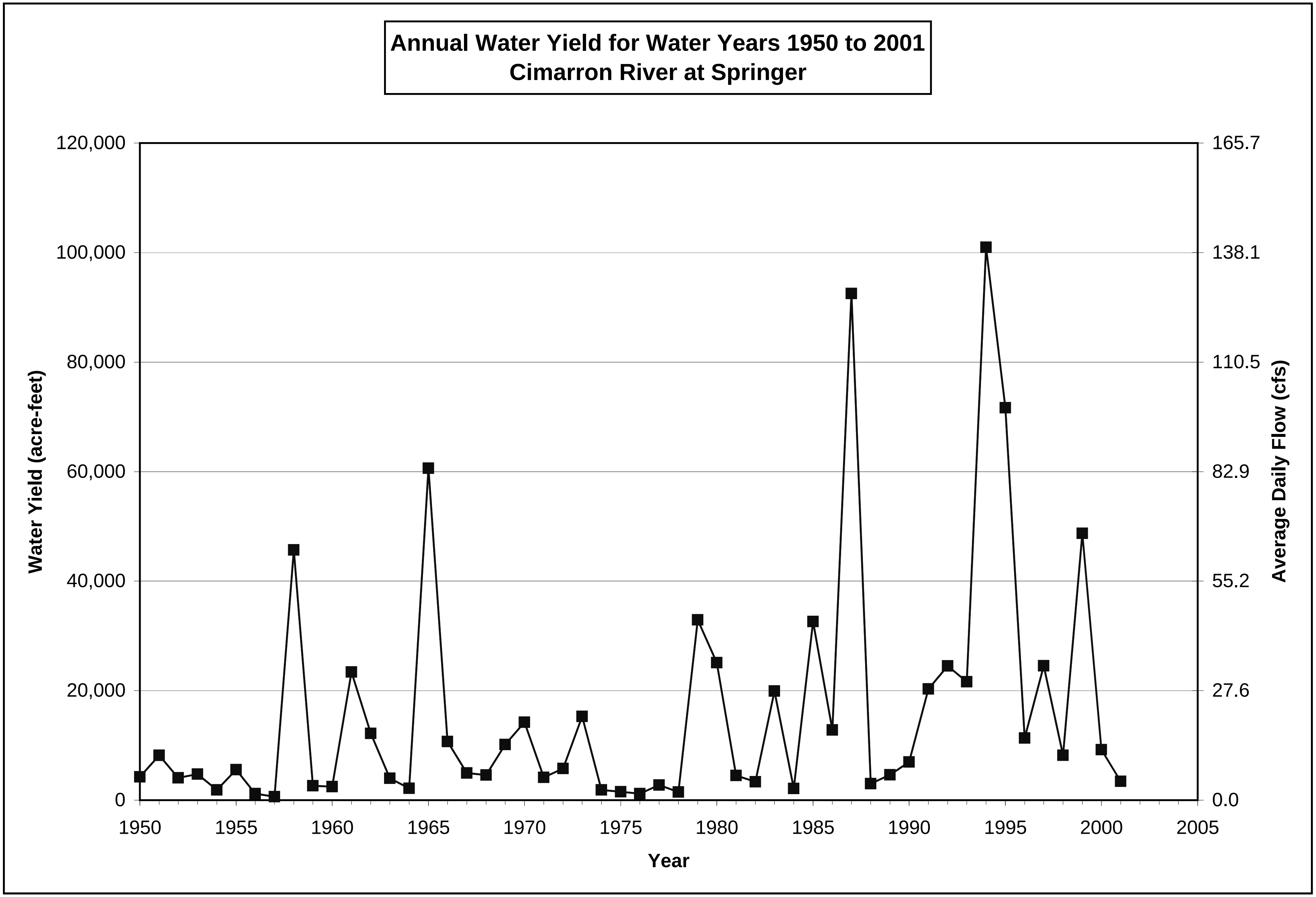

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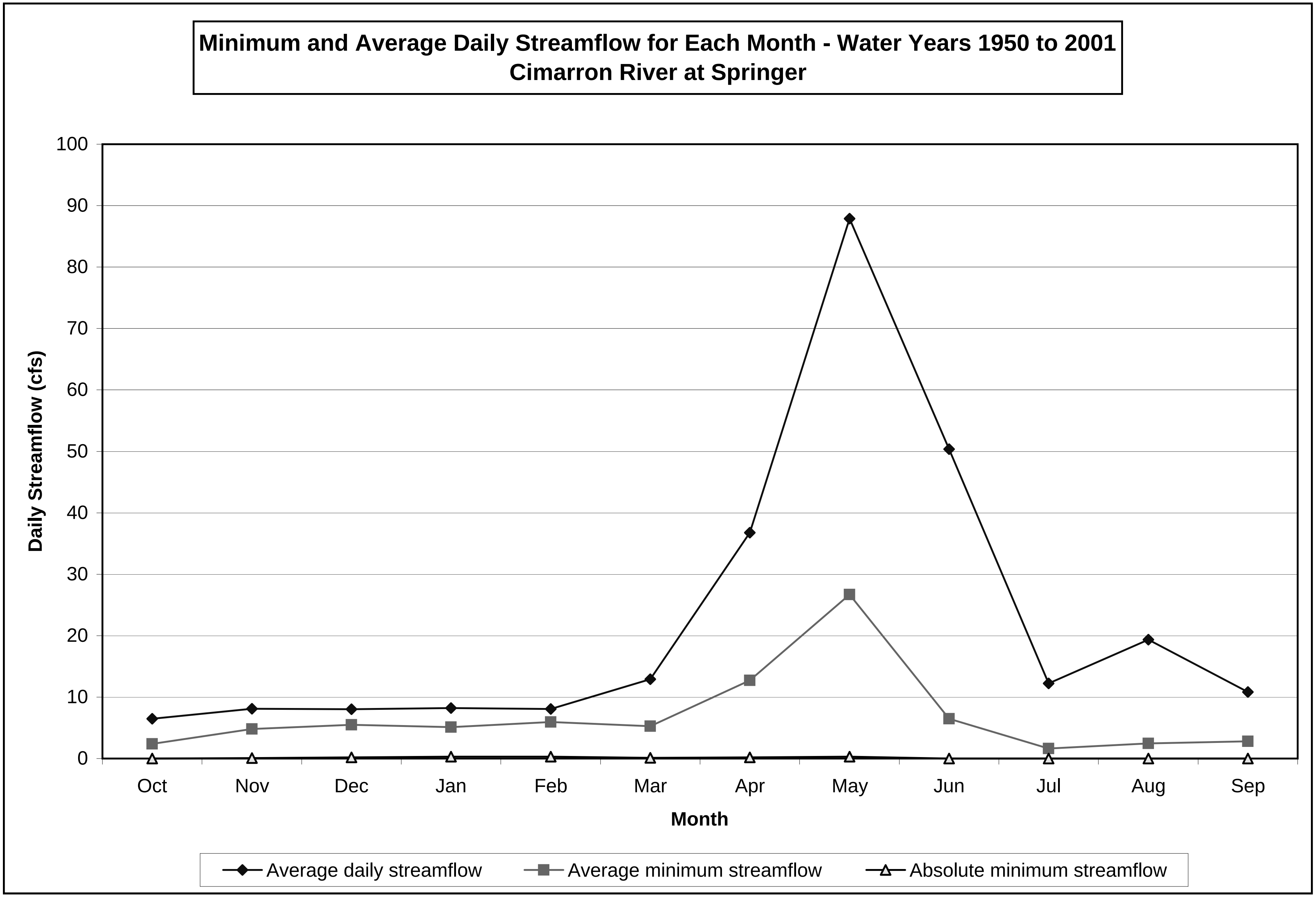
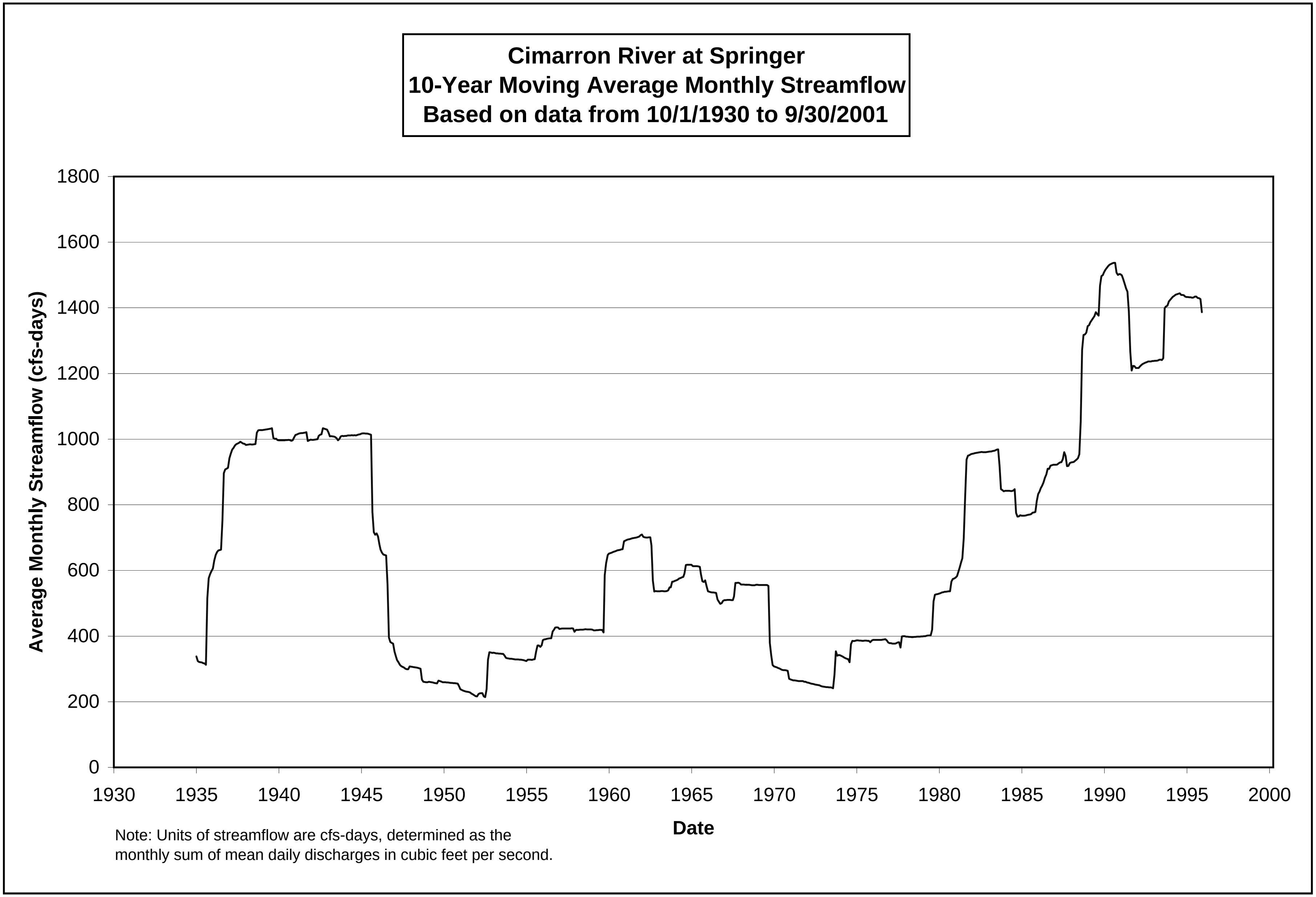
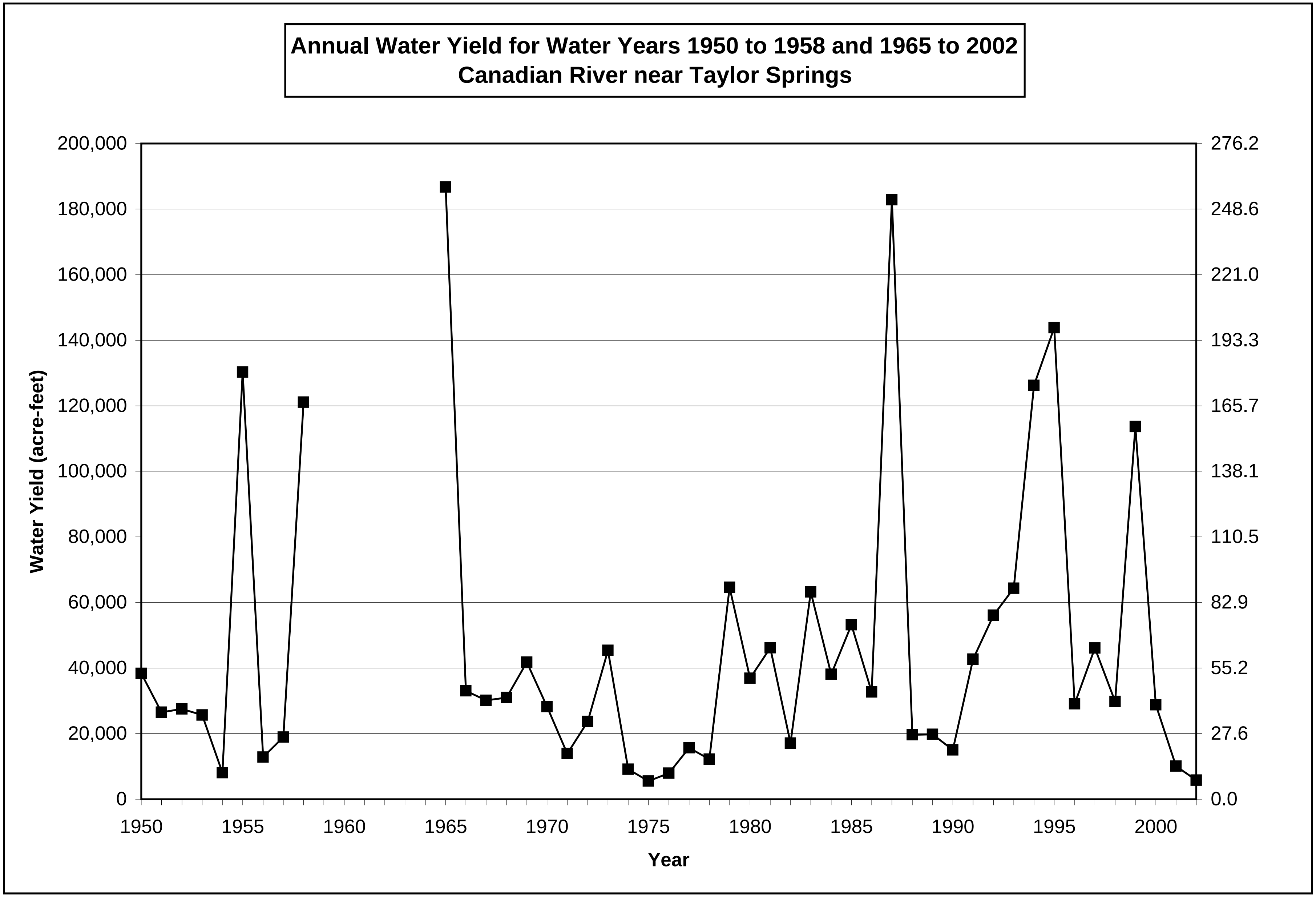


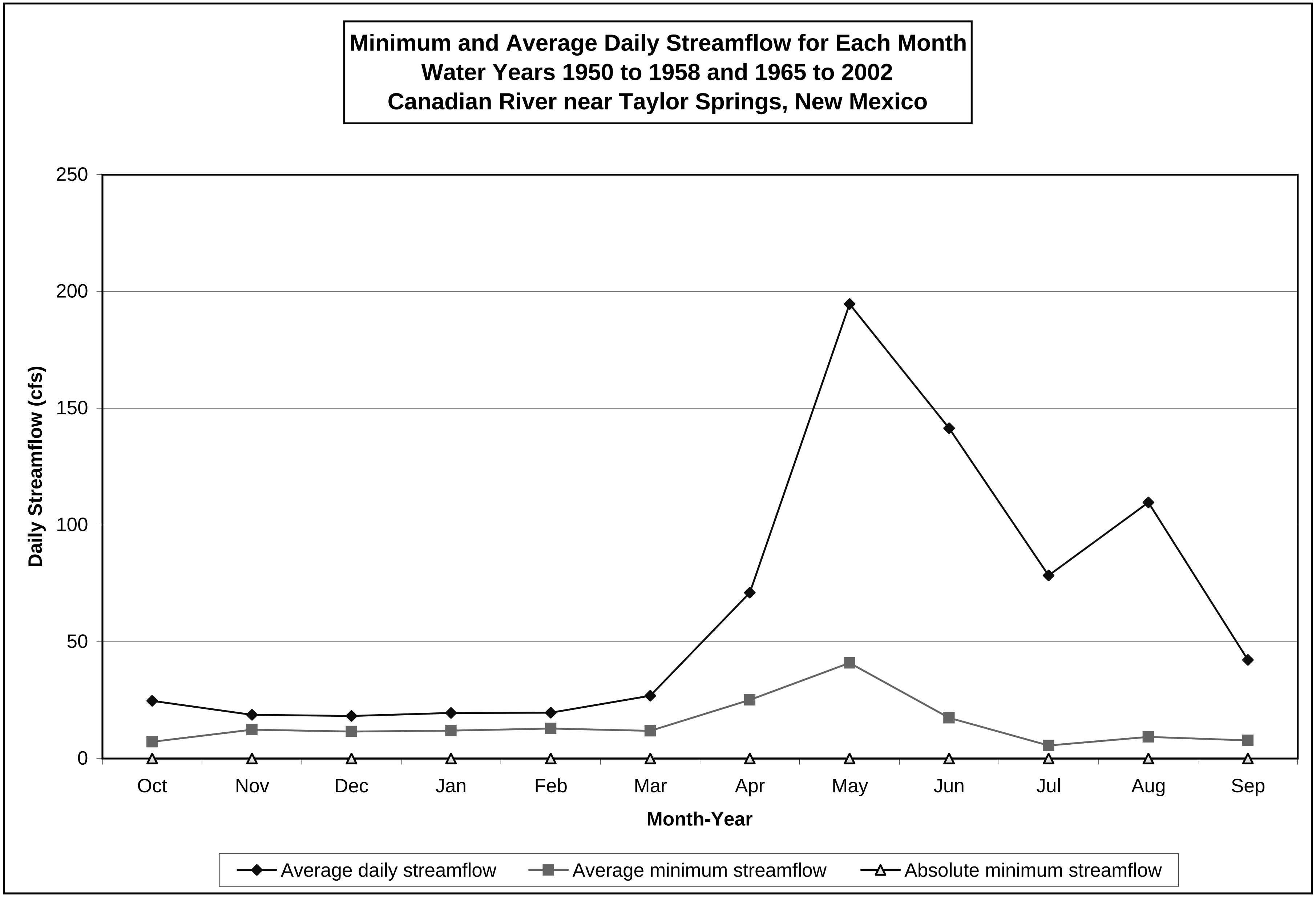
S:\Projects\9362\Sheets\Updates_WY2001-02\CimarronRiveratSpringerNM.xls [Chart-Monthly Avg and Min]



S:\Projects\9362\Sheets\Updates_WY2001-02\CimarronRiveratSpringerNM.xls [120 month average chart]



S:\Projects\9362\Sheets\Updates_WY2001-02\CanadianRivernrTaylorSpringsNM.xls [Annual chart]



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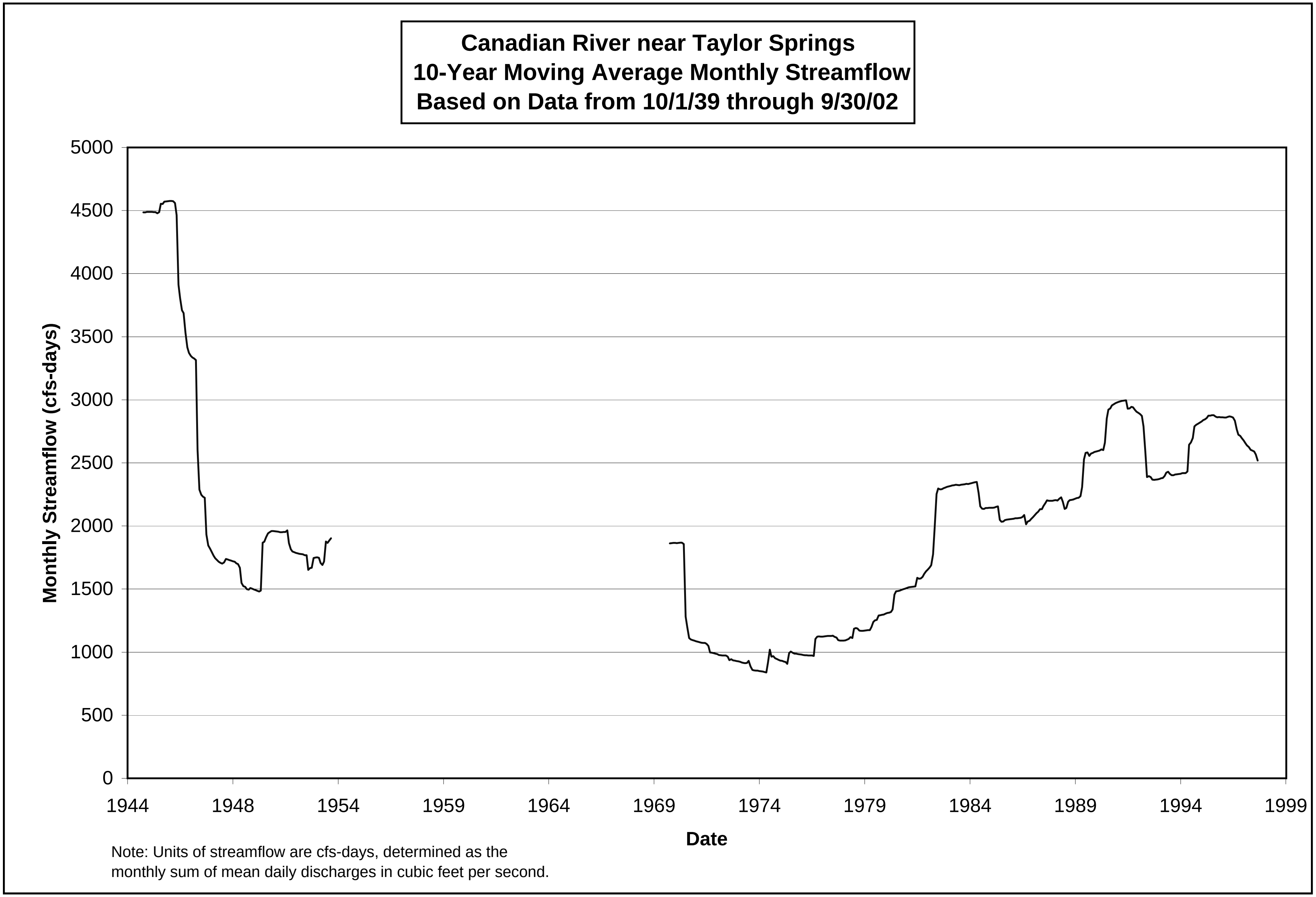


S:\Projects\9362\Sheets\Updates_WY2001-02\CanadianRivernrTaylorSpringsNM.xls [120 month average chart]

Appendix F2

Streamflow Statistics

Monthly statistics for Rayado Creek at Sauble Ranch (nr Cimarron)

Month	Average Yield (cfs-days)	Standard Deviation	Median Yield (cfs-days)	Maximum Yield (cfs-days)	Minimum Yield (cfs-days)
Oct	167	90	146	490	38
Nov	155	83	134	434	42
Dec	129	56	118	384	39
Jan	115	37	104	199	49
Feb	115	40	107	243	55
Mar	234	134	198	720	93
Apr	857	773	640	4330	156
May	1512	1343	1311	5371	113
Jun	756	1098	453	6933	54
Jul	345	314	279	1695	44
Aug	413	413	261	2216	65
Sep	239	189	158	991	26

Daily statistics for Rayado Creek at Sauble Ranch (nr Cimarron)

Month	Absolute Daily Max (cfs)	Average Daily Max (cfs)	Absolute Daily Min (cfs)	Average Daily Min(cfs)	Average DailyYield (cfs)	Median DailyYield (cfs)
Oct	45.00	9.52	1.00	3.90	5.37	4.69
Nov	74.00	8.85	0.40	2.96	5.17	4.48
Dec	21.00	6.06	0.80	2.75	4.15	3.80
Jan	12.00	5.03	0.60	2.70	3.70	3.35
Feb	17.00	5.97	0.80	2.97	4.08	3.79
Mar	63.00	15.21	1.60	3.92	7.55	6.38
Apr	332.00	65.88	2.50	9.34	28.56	21.35
May	474.00	99.07	2.20	25.09	48.78	42.27
Jun	2000.00	89.55	0.70	9.19	25.20	15.09
Jul	268.00	27.55	0.90	5.79	11.13	8.99
Aug	214.00	30.99	0.80	5.97	13.32	8.41
Sep	236.00	22.67	0.60	4.47	7.96	5.26

Based on available data, 1950-1999 period of record

Monthly statistics for Cimarron River blw Eagle Nest

Month	Average Yield (cfs-days)	Standard Deviation	Median Yield (cfs-days)	Maximum Yield (cfs-days)	Minimum Yield (cfs-days)
Oct	494	265	521	1559	5
Nov	158	162	128	776	0
Dec	31	94	5	633	0
Jan	28	88	3	593	0
Feb	69	216	3	1363	0
Mar	299	710	106	4535	0
Apr	695	937	509	5120	0
May	1102	1139	869	6569	23
Jun	944	659	860	3356	80
Jul	1120	509	1021	2140	222
Aug	646	470	545	2653	23
Sep	493	373	397	1540	2

Daily statistics for Cimarron River blw Eagle Nest

Month	Absolute Daily Max (cfs)	Average Daily Max (cfs)	Absolute Daily Min (cfs)	Average Daily Min (cfs)	Average Daily Yield (cfs)	Median Daily Yield (cfs)
Oct	112.00	30.72	0.00	4.76	15.95	16.80
Nov	57.00	16.23	0.00	0.63	5.26	4.28
Dec	62.00	2.95	0.00	0.34	0.99	0.18
Jan	42.00	2.49	0.00	0.35	0.91	0.11
Feb	64.00	4.47	0.00	1.49	2.43	0.11
Mar	158.00	20.13	0.00	2.78	9.64	3.40
Apr	197.00	39.62	0.00	12.19	23.15	16.96
May	303.00	71.71	0.00	9.31	35.55	28.03
Jun	254.00	66.33	0.00	9.22	31.45	28.65
Jul	168.00	65.98	0.00	10.53	36.13	32.93
Aug	114.00	41.53	0.00	6.91	20.85	17.59
Sep	172.00	36.14	0.00	3.87	16.45	13.25

Based on available data, 1950-1999 period of record

Monthly statistics for Ponil Creek nr Cimarron

Month	Average Yield (cfs-days)	Standard Deviation	Median Yield (cfs-days)	Maximum Yield (cfs-days)	Minimum Yield (cfs-days)
Oct	106	132	56	719	0
Nov	96	87	73	355	0
Dec	69	46	65	206	4
Jan	61	39	49	154	1
Feb	58	40	52	206	4
Mar	149	144	96	789	10
Apr	740	743	462	3489	70
May	1543	1793	1140	10033	30
Jun	556	715	340	3652	5
Jul	208	176	165	800	0
Aug	483	760	272	4937	10
Sep	171	252	108	1550	0

Daily statistics for Ponil Creek nr Cimarron

Month	Absolute Daily Max (cfs)	Average Daily Max (cfs)	Absolute Daily Min (cfs)	Average Daily Min(cfs)	Average Daily Yield (cfs)	Median Daily Yield (cfs)
Oct	85.00	7.03	0.00	1.85	3.42	1.81
Nov	25.00	5.03	0.00	2.01	3.19	2.42
Dec	8.50	3.41	0.00	1.39	2.23	2.09
Jan	13.00	3.16	0.00	1.22	1.97	1.57
Feb	32.00	3.72	0.00	1.35	2.05	1.82
Mar	48.00	9.80	0.10	2.13	4.82	3.09
Apr	690.00	68.50	0.60	7.01	24.66	15.40
May	805.00	105.53	0.30	22.07	49.78	36.77
Jun	819.00	64.76	0.00	4.92	18.52	11.32
Jul	132.00	28.03	0.00	1.77	6.70	5.32
Aug	572.00	68.56	0.00	3.03	15.59	8.77
Sep	155.00	16.79	0.00	2.43	5.69	3.61

Based on available data, 1950-1999 period of record

Monthly statistics for Vermejo River nr Dawson

Month	Average Yield (cfs-days)	Standard Deviation	Median Yield (cfs-days)	Maximum Yield (cfs-days)	Minimum Yield (cfs-days)
Oct	233	174	207	724	5
Nov	205	143	191	814	1
Dec	181	140	144	790	18
Jan	172	104	146	419	20
Feb	167	93	150	407	35
Mar	193	166	152	1079	25
Apr	457	570	227	2716	36
May	1393	1868	782	10760	30
Jun	1069	1100	720	5365	46
Jul	884	523	880	2499	57
Aug	1227	1221	738	5510	139
Sep	476	431	367	1847	11

Daily statistics for Vermejo River nr Dawson

Month	Absolute Daily Max (cfs)	Average Daily Max (cfs)	Absolute Daily Min (cfs)	Average Daily Min (cfs)	Average DailyYield (cfs)	Median DailyYield (cfs)
Oct	158.00	16.36	0.00	4.61	7.51	6.67
Nov	42.00	9.99	0.00	4.13	6.83	6.36
Dec	60.00	10.52	0.00	3.07	5.84	4.66
Jan	36.00	10.02	0.10	3.13	5.54	4.70
Feb	54.00	10.99	0.31	3.28	5.90	5.31
Mar	63.00	9.94	0.20	3.63	6.24	4.91
Apr	822.00	45.63	0.10	5.82	15.22	7.58
May	951.00	124.31	0.60	20.85	44.93	25.24
Jun	2260.00	130.35	0.20	15.58	35.63	24.00
Jul	500.00	120.06	0.20	8.78	28.52	28.40
Aug	1040.00	181.36	0.30	9.82	39.59	23.79
Sep	473.00	71.94	0.10	6.39	15.86	12.22

Based on available data, 1950-1999 period of record

Monthly statistics for Canadian River nr Hebron

Month	Average Yield (cfs-days)	Standard Deviation	Median Yield (cfs-days)	Maximum Yield (cfs-days)	Minimum Yield (cfs-days)
Oct	87	150	11	601	0
Nov	49	63	15	249	0
Dec	37	44	16	140	0
Jan	34	44	22	191	0
Feb	24	29	10	122	1
Mar	58	136	6	560	1
Apr	311	832	6	4005	1
May	567	1495	48	8105	2
Jun	578	2303	23	13844	2
Jul	518	679	208	2919	5
Aug	766	1294	181	6477	0
Sep	212	422	51	2498	0

Daily statistics for Canadian River nr Hebron

Month	Absolute Daily Max (cfs)	Average Daily Max (cfs)	Absolute Daily Min (cfs)	Average Daily Min (cfs)	Average DailyYield (cfs)	Median DailyYield (cfs)
Oct	324.00	22.51	0.00	0.51	2.81	0.35
Nov	30.00	3.23	0.00	0.77	1.64	0.51
Dec	16.00	2.28	0.00	0.51	1.18	0.51
Jan	14.00	2.12	0.00	0.29	1.10	0.72
Feb	11.00	1.97	0.00	0.32	0.86	0.37
Mar	66.00	5.20	0.00	0.29	1.87	0.19
Apr	580.00	40.16	0.00	1.46	10.37	0.19
May	4490.00	212.62	0.00	0.58	18.30	1.54
Jun	7800.00	272.97	0.00	0.06	19.28	0.76
Jul	722.00	201.46	0.00	0.05	16.72	6.72
Aug	2780.00	243.55	0.00	0.37	24.70	5.84
Sep	704.00	75.91	0.00	0.62	7.05	1.69

Based on available data, 1950-1999 period of record

Monthly statistics for Cimarron river near Cimarron

Month	Average Yield (cfs-days)	Standard Deviation	Median Yield (cfs-days)	Maximum Yield (cfs-days)	Minimum Yield (cfs-days)
Oct	557	243	577	1392	4
Nov	304	153	280	802	54
Dec	157	98	130	573	41
Jan	131	92	104	574	35
Feb	146	188	106	1268	31
Mar	399	709	207	4628	51
Apr	1076	1148	831	7117	81
May	2085	1552	1770	10191	728
Jun	1510	877	1252	4748	257
Jul	1199	527	1144	2466	190
Aug	855	456	743	2512	61
Sep	582	348	517	1511	4

Daily statistics for Cimarron river near Cimarron

Month	Absolute Daily Max (cfs)	Average Daily Max (cfs)	Absolute Daily Min (cfs)	Average Daily min (cfs)	Average Daily Yield (cfs)	Median Daily Yield (cfs)
Oct	104	7.74	0.00	32.09	17.96	18.60
Nov	65	4.41	0.30	22.11	10.14	9.33
Dec	49	2.90	0.30	9.24	5.06	4.21
Jan	40	2.50	0.20	7.22	4.23	3.34
Feb	52	3.32	0.20	7.81	5.17	3.79
Mar	171	4.68	0.19	24.25	12.87	6.67
Apr	387	18.67	1.50	68.95	35.85	27.70
May	450	34.94	7.40	112.06	67.26	57.10
Jun	1240	23.13	1.50	113.58	50.32	41.73
Jul	141	17.21	1.70	67.00	38.69	36.89
Aug	106	13.05	0.08	52.79	27.58	23.96
Sep	141	7.29	0.00	42.01	19.40	17.25

Based on available data, 1950-1999 period of record

Monthly statistics for Cimarron river near Springer

Month	Average Yield (cfs-days)	Standard Deviation	Median Yield (cfs-days)	Maximum Yield (cfs-days)	Minimum Yield (cfs-days)
Oct	196	252	110	1080	1.2
Nov	238	329	138	1594	7.0
Dec	248	324	135	1829	8.8
Jan	254	349	140	1932	10.2
Feb	227	327	124	1851	9.3
Mar	406	1104	121	7497	10.9
Apr	1142	2777	136	15172	15.1
May	2874	5481	225	26510	22.6
Jun	1595	3774	186	20970	37.2
Jul	396	844	148	4527	12.0
Aug	632	969	220	4782	5.4
Sep	339	599	119	2951	0.2

Daily statistics for Cimarron river near Springer

Month	Absolute Daily Max (cfs)	Average Daily Max (cfs)	Absolute Daily Min (cfs)	Average Daily min (cfs)	Average Daily Yield (cfs)	Median Daily Yield (cfs)
Oct	357	28.89	0.00	2.23	6.31	3.54
Nov	75	12.68	0.08	4.65	7.92	4.59
Dec	82	11.80	0.20	5.40	7.99	4.35
Jan	84	12.16	0.30	5.03	8.19	4.52
Feb	72	11.03	0.30	5.89	8.02	4.31
Mar	369	25.61	0.10	5.24	13.09	3.91
Apr	941	109.09	0.20	12.95	38.07	4.53
May	2930	281.50	0.30	28.10	92.72	7.26
Jun	10500	361.39	0.00	6.77	53.16	6.19
Jul	790	86.56	0.00	1.64	12.77	4.79
Aug	1140	165.40	0.00	2.57	20.38	7.08
Sep	478	61.34	0.00	2.92	11.31	3.98

Based on available data, 1950-1999 period of record

Monthly statistics for Canadian River nr Taylor Springs

Month	Average Yield (cfs-days)	Standard Deviation	Median Yield (cfs-days)	Maximum Yield (cfs-days)	Minimum Yield (cfs-days)
Oct	776	1503	398	9587	0
Nov	562	504	488	2339	28
Dec	563	478	458	2295	33
Jan	602	497	499	2357	38
Feb	554	467	465	2380	29
Mar	817	1615	340	10437	61
Apr	2189	4556	359	25914	42
May	6403	10779	1044	46034	111
Jun	4459	11134	1081	69395	83
Jul	2586	2631	1602	10314	48
Aug	3610	3553	2296	17441	146
Sep	1350	1358	903	5702	0

Daily statistics for Canadian River nr Taylor Springs

Month	Absolute Daily Max (cfs)	Average Daily Max (cfs)	Absolute Daily Min (cfs)	Average Daily Min (cfs)	Average DailyYield (cfs)	Median DailyYield (cfs)
Oct	4100.00	214.17	0.00	7.13	25.04	12.85
Nov	308.00	39.15	0.00	12.20	18.73	16.28
Dec	98.00	27.01	0.00	11.44	18.15	14.76
Jan	174.00	30.28	0.00	11.76	19.43	16.11
Feb	182.00	32.85	1.00	12.68	19.59	16.46
Mar	505.00	52.65	0.00	11.50	26.35	10.96
Apr	1710.00	214.88	0.00	25.29	72.98	11.98
May	18200.00	1147.40	0.00	43.18	206.55	33.68
Jun	43000.00	1457.43	0.00	18.61	148.62	36.02
Jul	3540.00	643.03	0.00	5.93	83.41	51.68
Aug	3500.00	846.61	0.00	9.90	116.45	74.06
Sep	4150.00	396.14	0.00	8.33	44.99	30.09

Based on available data, 1950-1999 period of record

Appendix F3

Miscellaneous Climatic
Surface Water Analyses

Average Monthly Precipitation for Selected Climate Stations [a]

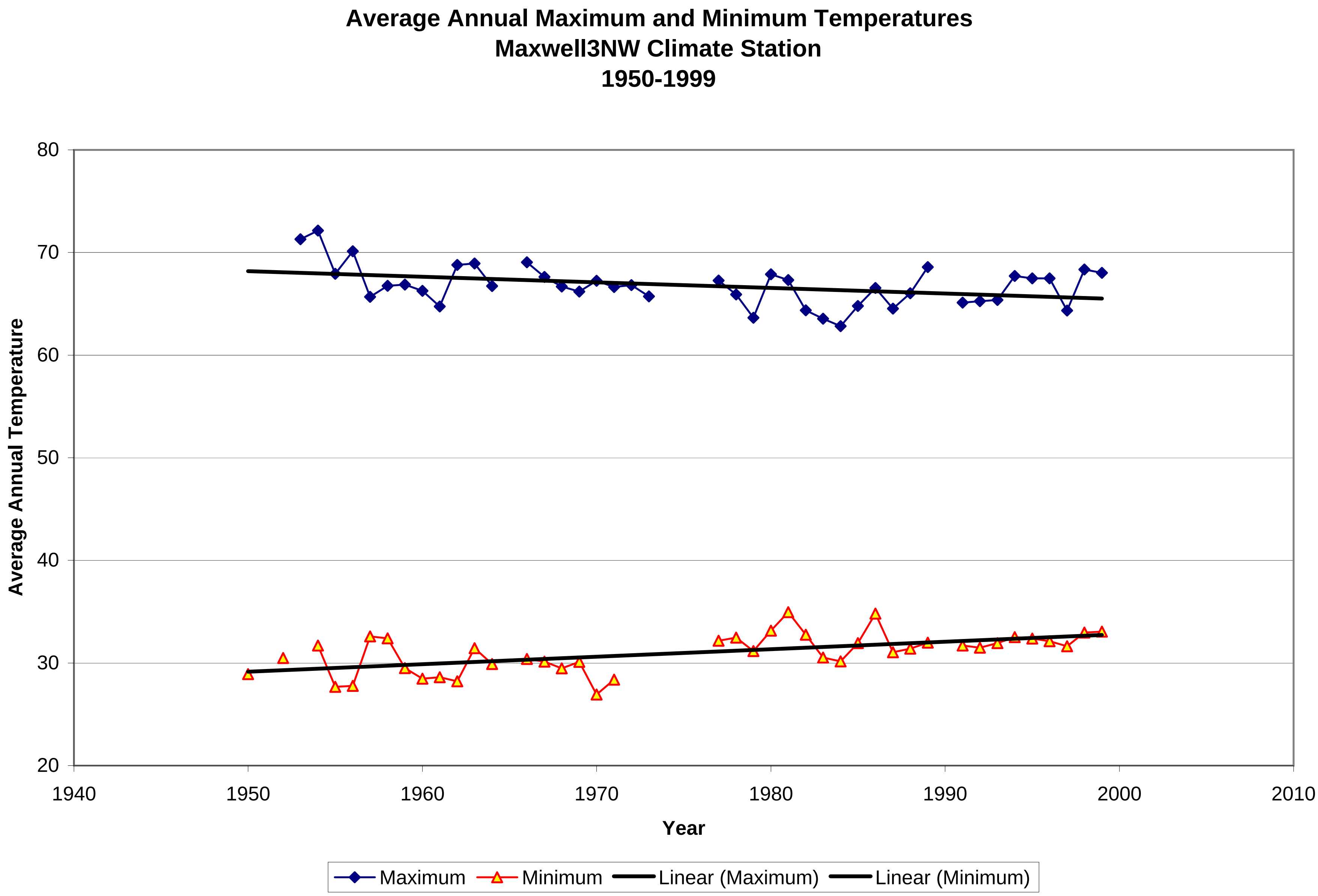
Month	Climate Station Average Monthly Precipitation (inches)											
	Black Lake	Eagle Nest	Vermejo Park	Cimarron 4 SW	Springer	Maxwell 3 NW	Raton WB Airport	Raton KRTN Radio	Raton Filter Plant	Lake Maloya	Abbott 1 SE	Cunico Ranch
January	0.90	0.72	0.19	0.44	0.40	0.30	0.36	0.37	0.46	0.93	0.25	0.22
February	1.02	0.60	0.21	0.53	0.33	0.26	0.28	0.38	0.50	1.17	0.32	0.24
March	1.42	1.02	0.96	0.80	0.61	0.48	0.39	0.87	1.01	1.73	0.55	0.30
April	1.51	1.01	1.10	1.02	0.92	0.66	0.76	1.01	1.04	1.83	0.61	0.51
May	1.94	1.43	1.56	1.96	1.85	1.84	1.80	2.44	2.52	2.84	1.98	1.79
June	1.91	1.25	1.52	1.93	1.81	1.78	2.40	2.15	2.01	2.25	1.83	1.86
July	3.79	2.66	4.26	2.85	2.73	2.52	2.90	2.98	2.83	3.48	3.11	3.91
August	3.69	2.89	3.70	3.25	3.40	3.25	2.91	3.24	3.38	3.31	3.35	2.75
September	1.68	1.15	1.28	1.69	1.66	1.57	1.25	1.71	1.42	1.73	1.35	1.21
October	1.48	0.97	0.92	1.11	1.20	1.08	0.95	1.15	1.20	1.37	0.89	0.73
November	1.09	0.74	0.78	0.64	0.64	0.48	0.41	0.48	0.64	1.40	0.38	0.24
December	0.86	0.65	0.60	0.44	0.38	0.24	0.33	0.41	0.53	0.91	0.26	0.25

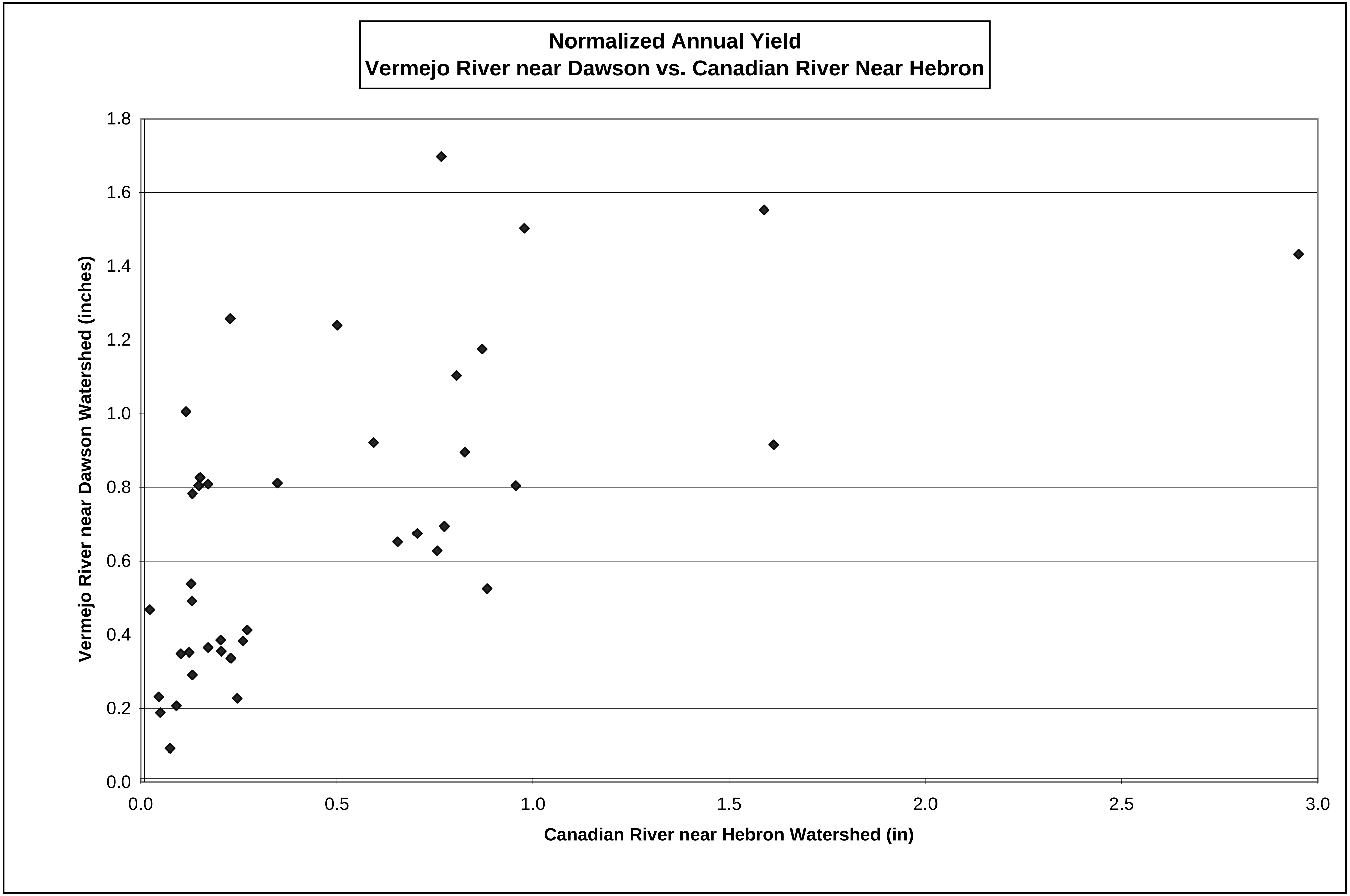
[a] Station order is from West to East.

Average Monthly Temperature for Selected Climate Stations

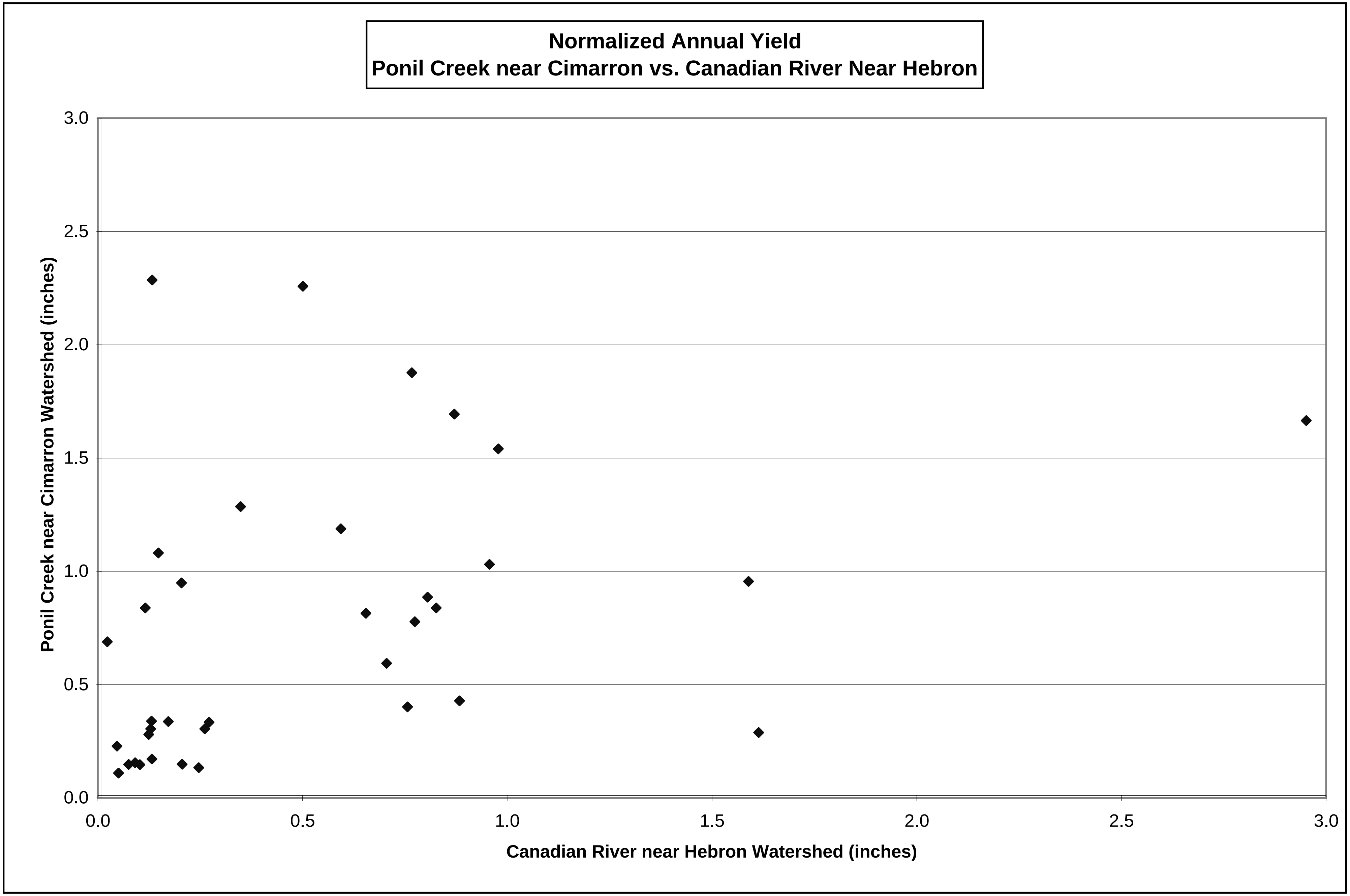
LONGITUDE	STANAME	Maximum Recorded Temp	Minimum Recorded Temp	Average Temperature	Average Maximum Temperature	Average Minimum Temperature
W105:15:46	EAGLE NEST	91	-47	40	57.6	22.2
W104:57:00	VERMEJO PARK	94	-28	48	63.0	32.0
W104:56:44	CIMARRON 4 SW	99	-35	50	65.2	34.4
W104:35:37	SPRINGER	104	-37	51	68.8	32.9
W104:34:00	MAXWELL 3 NW	100	-35	49	66.8	30.9
W104:30:00	RATON WB AIRPORT	98	-31	49	65.0	32.3
W104:27:00	RATON KRTN RADIO	98	-24	48	64.3	31.5
W104:25:57	RATON FILTER PLANT	97	-26	49	62.7	36.0
W104:22:00	LAKE MALOYA	93	-33	44	59.7	28.4

Average Maximum Temperature is the average of the average maximum temperature for each month.
Average Minimum Temperature is the average of the average minimum temperature for each month.
Average Temperature is the Average of the Average Maximum Temperature and the Average Minimum Temperat

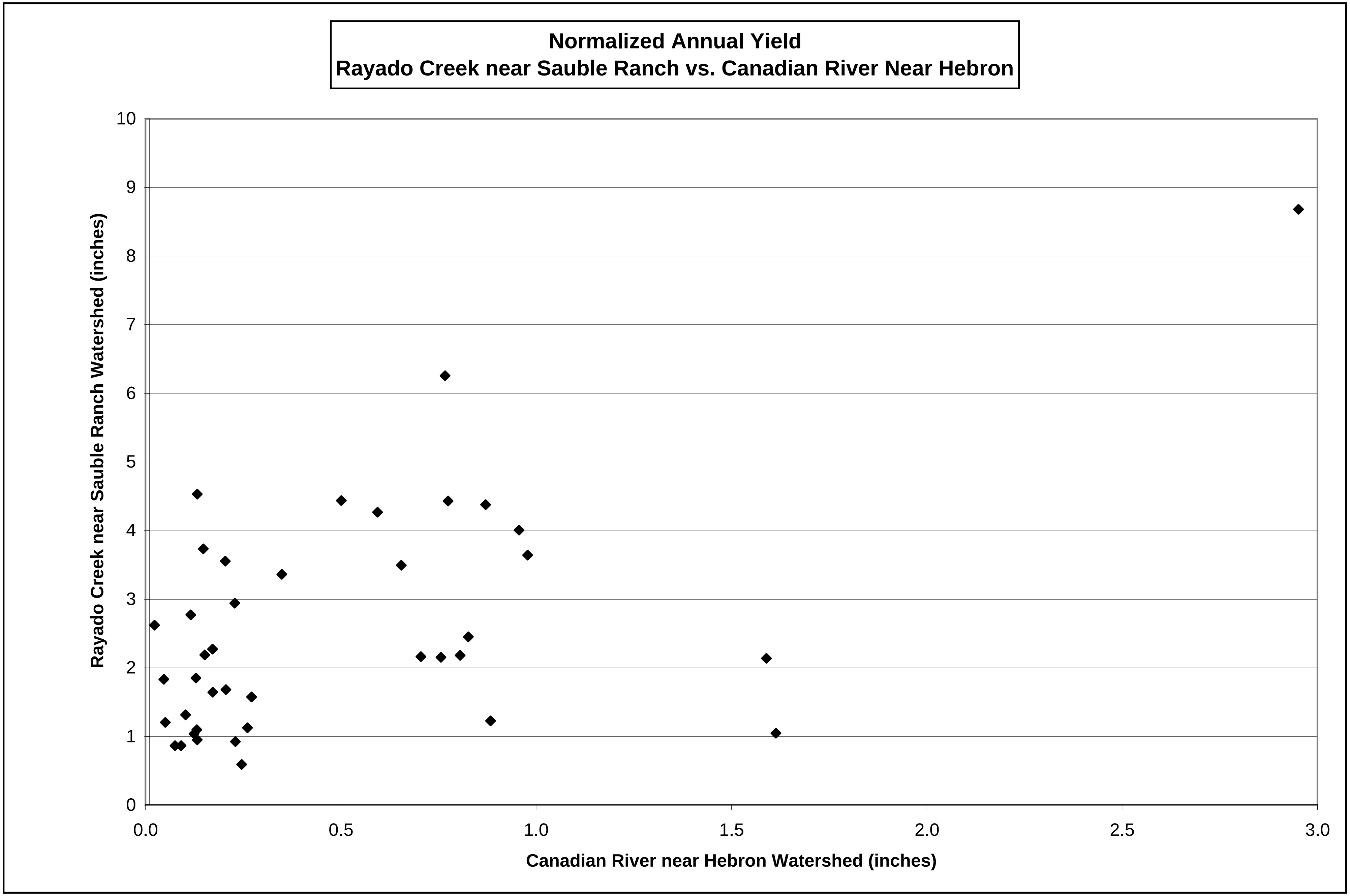

Average Annual Maximum and Minimum Temperatures
Maxwell3NW Climate Station
1950-1999
Average Annual Temperature
80
70
60
50
40
30
20
1940
1950
1960
1970
1980
1990
2000
2010
Year
Maximum
Minimum
Linear (Maximum)
Linear (Minimum)



T:\projects\9208\sheets\Scatter plots for the main stations.xls (Canadian v Dawson)



T:\projects\9208\sheets\Scatter plots for the main stations.xls (Canadian v Ponil)



T:\projects\9208\sheets\Scatter plots for the main stations.xls (Canadian v Rayado)

Transitions Sum of Upstream includes chages in Eagle Nest
Values in AF

WY	Sum with Eagle Nest	Type of Year	Dry to	Average to	Wet to
1950	44344	Average			
1951	11443	Dry	FALSE	1	FALSE
1952	49858	Average	2	FALSE	FALSE
1953	21850	Dry	FALSE	1	FALSE
1954	12354	Dry	1	FALSE	FALSE
1955	66887	Average	2	FALSE	FALSE
1956	12363	Dry	FALSE	1	FALSE
1957	46720	Average	2	FALSE	FALSE
1958	101317	Wet	FALSE	3	FALSE
1959	18681	Dry	FALSE	FALSE	1
1960	24224	Average	2	FALSE	FALSE
1961	79218	Wet	FALSE	3	FALSE
1962	55585	Average	FALSE	FALSE	2
1963	17881	Dry	FALSE	1	FALSE
1964	18294	Dry	1	FALSE	FALSE
1965	123814	Wet	3	FALSE	FALSE
1966	41159	Average	FALSE	FALSE	2
1967	32772	Average	FALSE	2	FALSE
1968	49865	Average	FALSE	2	FALSE
1969	59570	Average	FALSE	2	FALSE
1970	55574	Average	FALSE	2	FALSE
1971	15606	Dry	FALSE	1	FALSE
1972	13756	Dry	1	FALSE	FALSE
1973	67522	Average	2	FALSE	FALSE
1974	13703	Dry	FALSE	1	FALSE
1975	36056	Average	2	FALSE	FALSE
1976	26285	Average	FALSE	2	FALSE
1977	21122	Dry	FALSE	1	FALSE
1978	26161	Average	2	FALSE	FALSE
1979	85900	Wet	FALSE	3	FALSE
1980	64993	Average	FALSE	FALSE	2
1981	42228	Average	FALSE	2	FALSE
1982	53720	Average	FALSE	2	FALSE
1983	86188	Wet	FALSE	3	FALSE
1984	48023	Average	FALSE	FALSE	2
1985	88665	Wet	FALSE	3	FALSE
1986	50431	Average	FALSE	FALSE	2
1987	102647	Wet	FALSE	3	FALSE
1988	26556	Average	FALSE	FALSE	2
1989	27268	Average	FALSE	2	FALSE
1990	33829	Average	FALSE	2	FALSE
1991	77365	Wet	FALSE	3	FALSE
1992	49045	Average	FALSE	FALSE	2
1993	53694	Average	FALSE	2	FALSE
1994	113901	Wet	FALSE	3	FALSE
1995	92523	Wet	FALSE	FALSE	3
1996	22681	Dry	FALSE	FALSE	1
1997	60824	Average	2	FALSE	FALSE
1998	32584	Average	FALSE	2	FALSE
1999	111055	Wet	FALSE	3	FALSE
Maximum	123814				
Mean	49762				
Median	47371				
Minimum	11443				

Transition Matrix

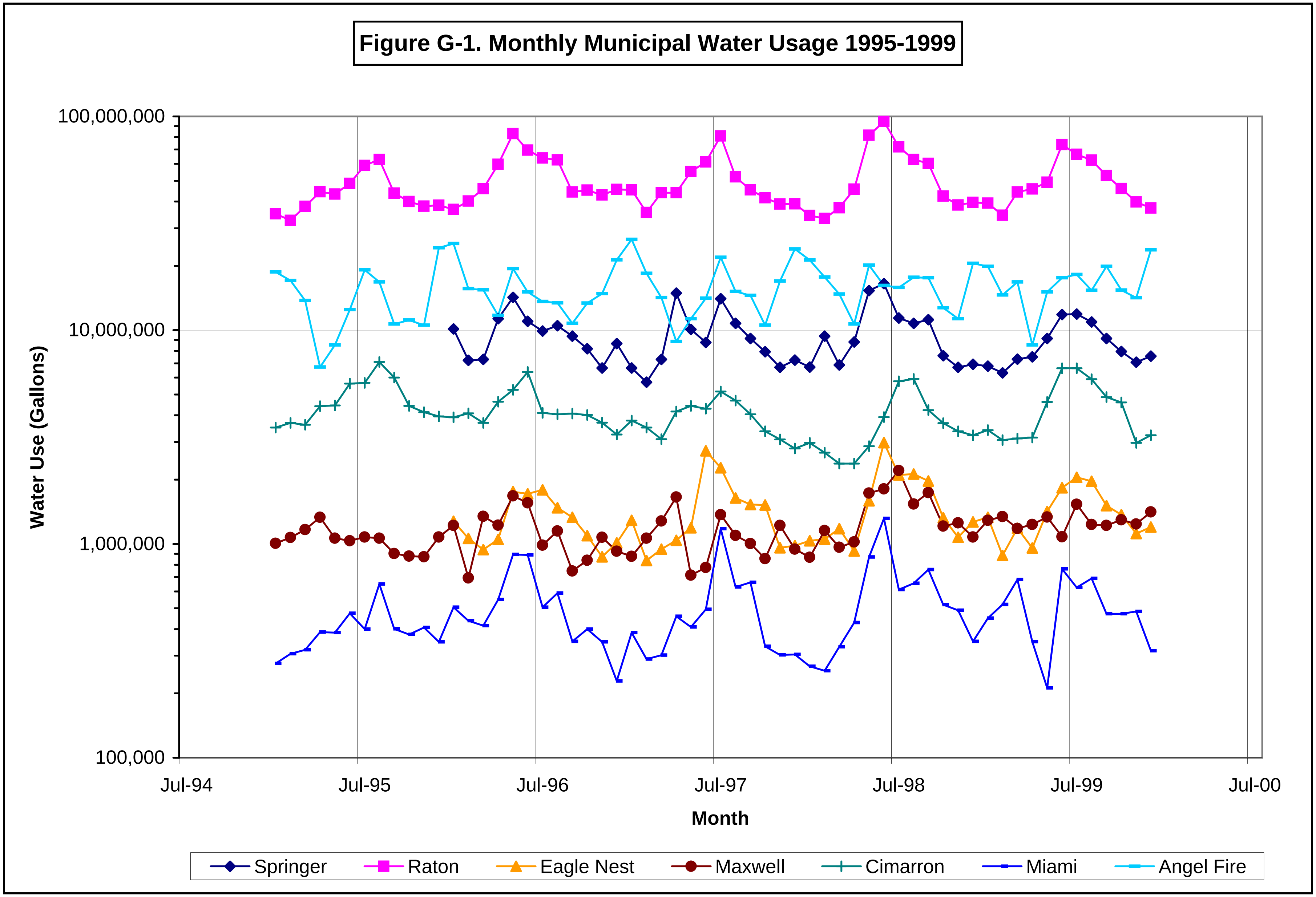
	To		
From	Dry	Average	Wet
Dry	0.250	0.667	0.083
Average	0.259	0.445	0.296
Wet	0.200	0.700	0.100

In 50 Year Record:

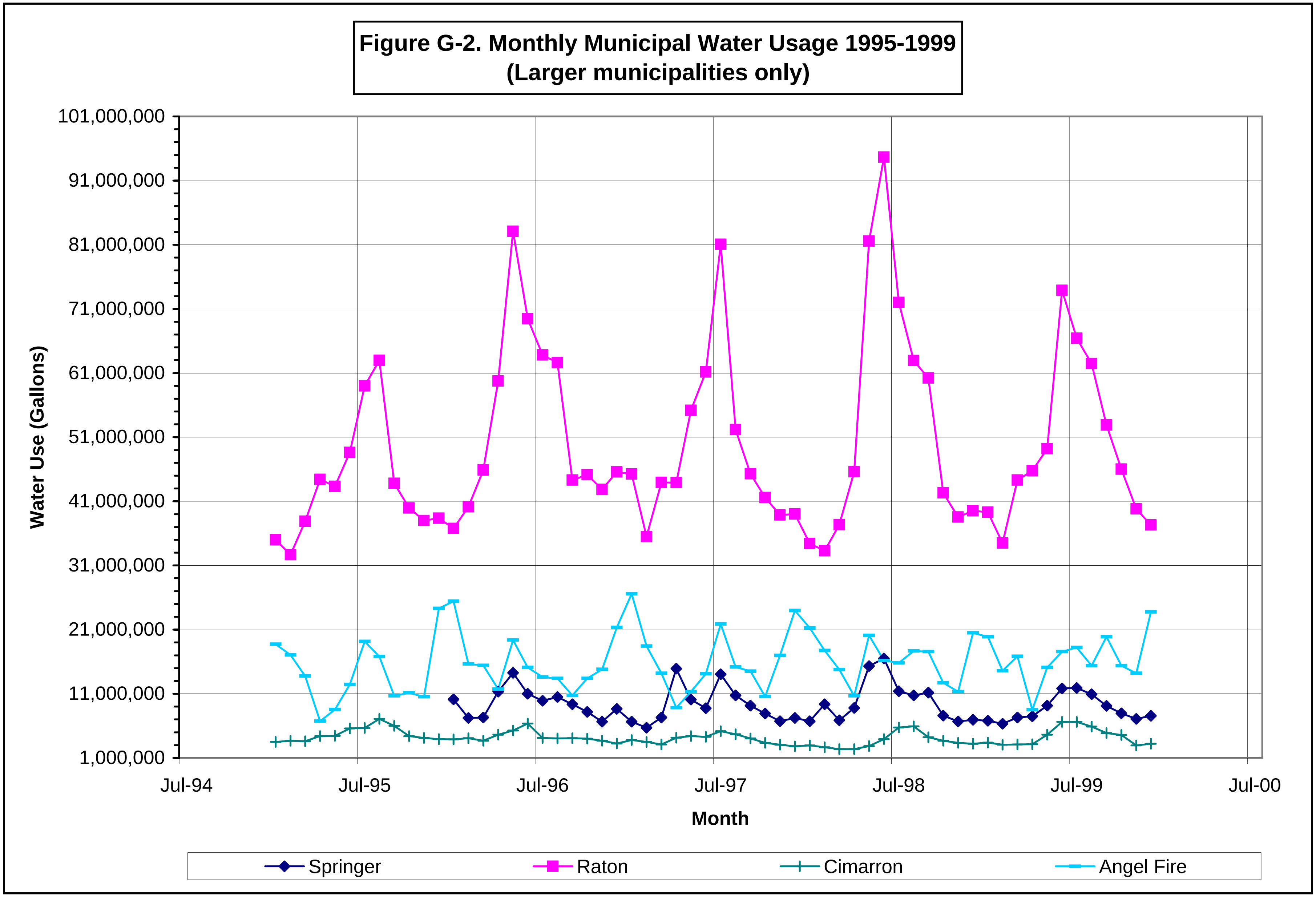
Dry = 12	less than 23686 AF/year
Average = 27	in between
Wet = 11	more than 71056 AF/year

Appendix G

Water Use Information



P:\9362-9417\RegWtrPlan.4-03\Appx_G\Township Water data.xls All townships



P:\9362-9417\RegWtrPlan.4-03\Appx_G\Township Water data.xls Selected Townships

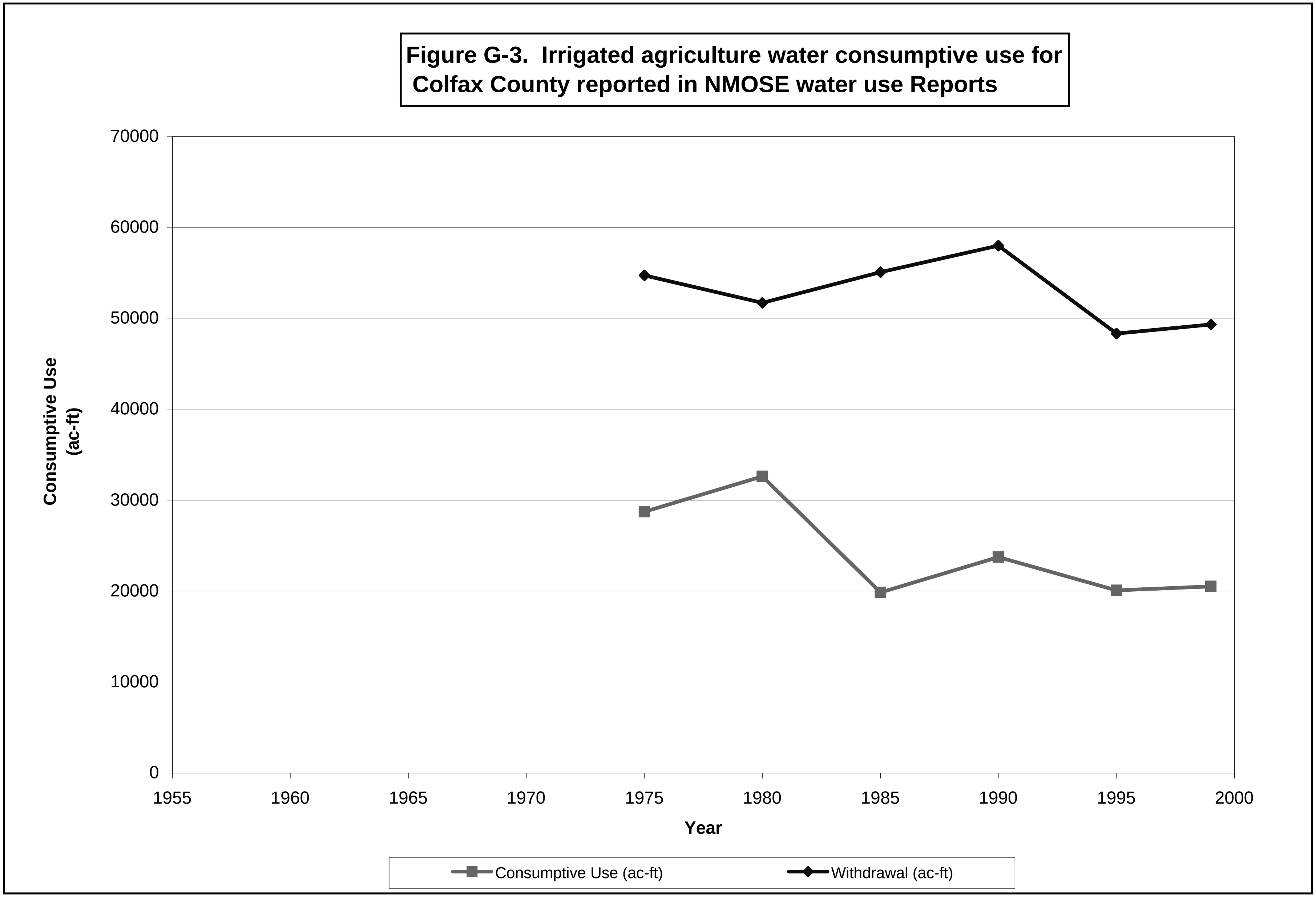


Figure G-3. Irrigated agriculture water consumptive use for Colfax County reported in NMOSE water use Reports
70000
60000
50000
40000
30000
20000
10000
0
Consumptive Use (ac-ft)
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year
Consumptive Use (ac-ft)
Withdrawal (ac-ft)

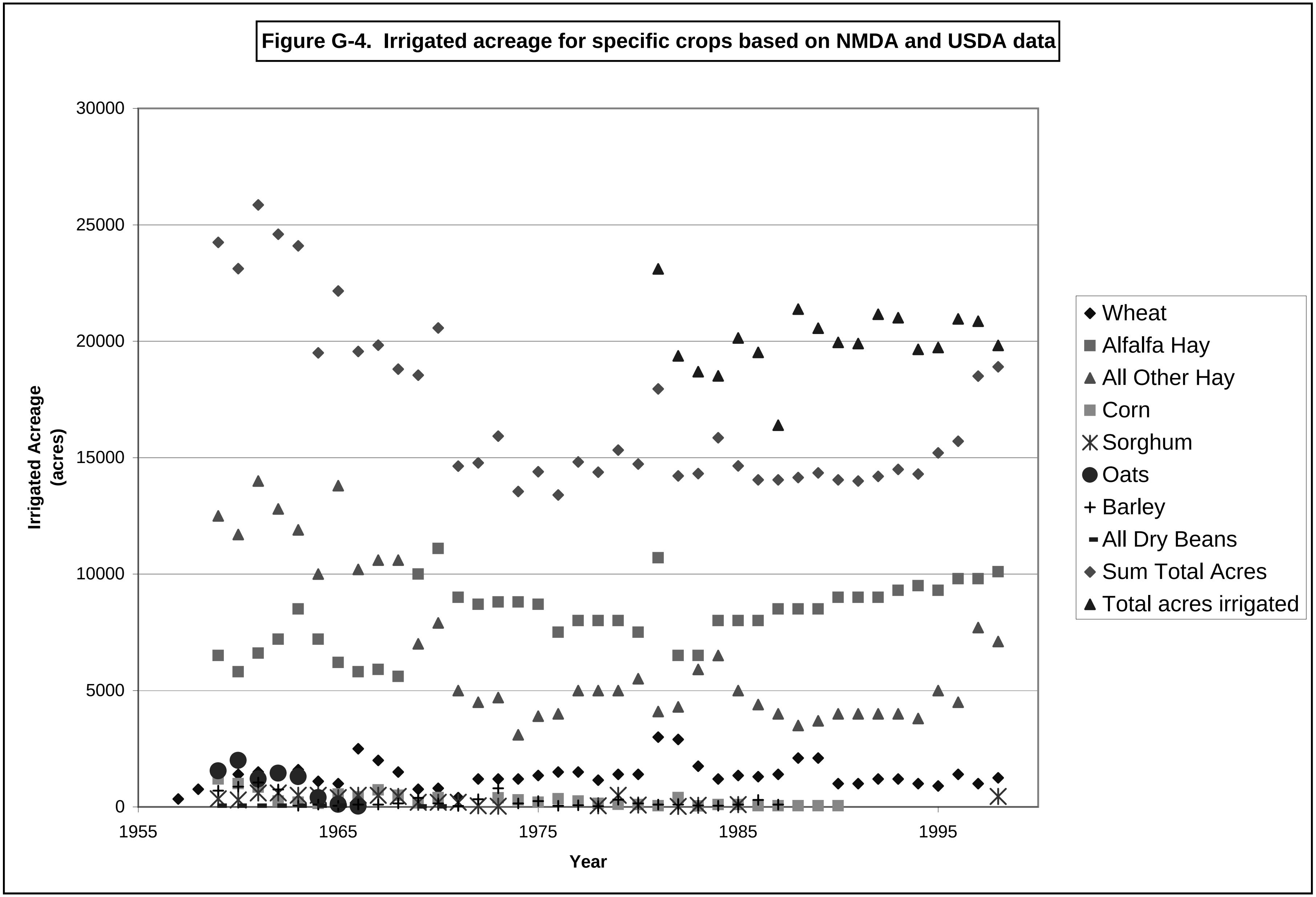
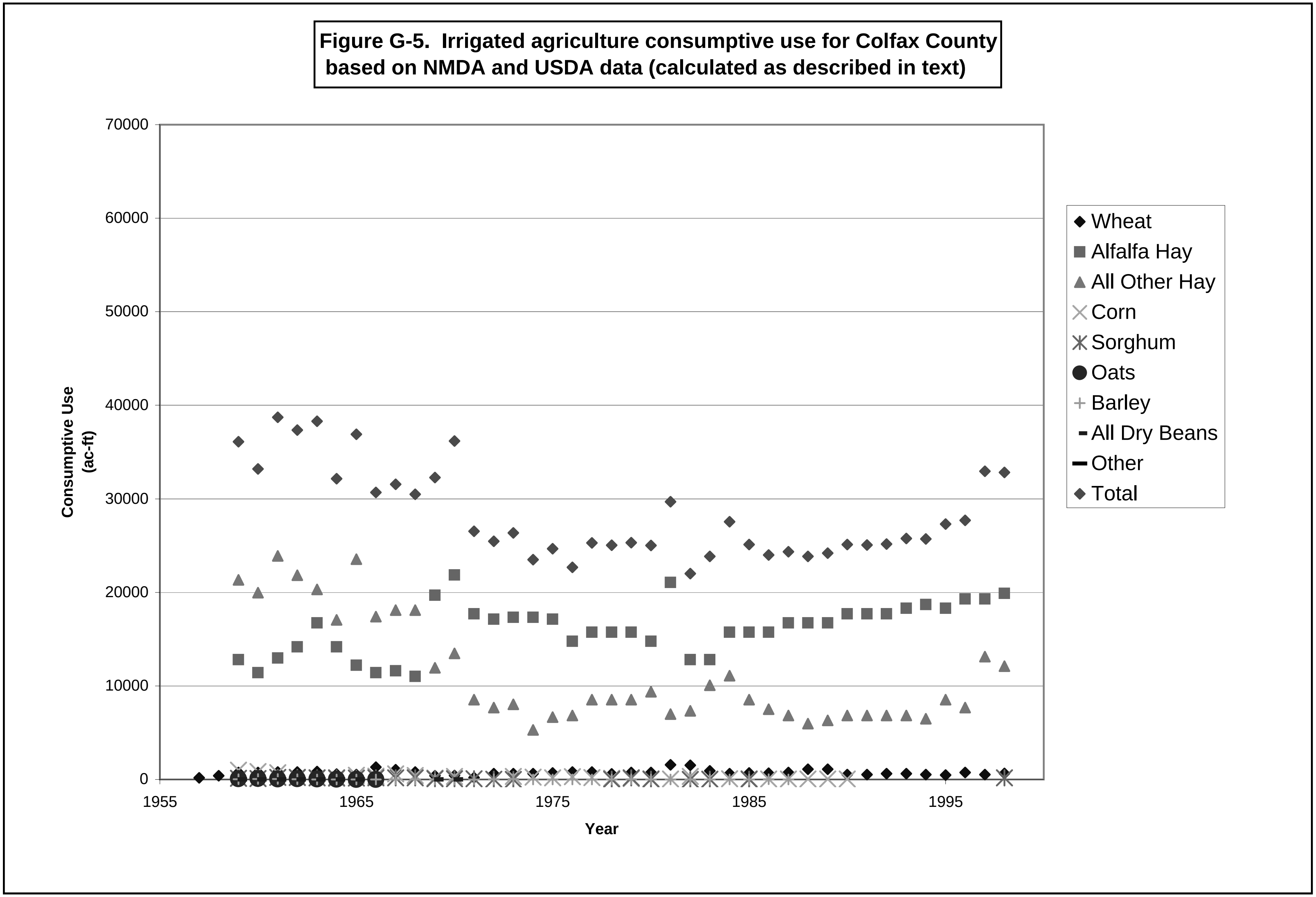
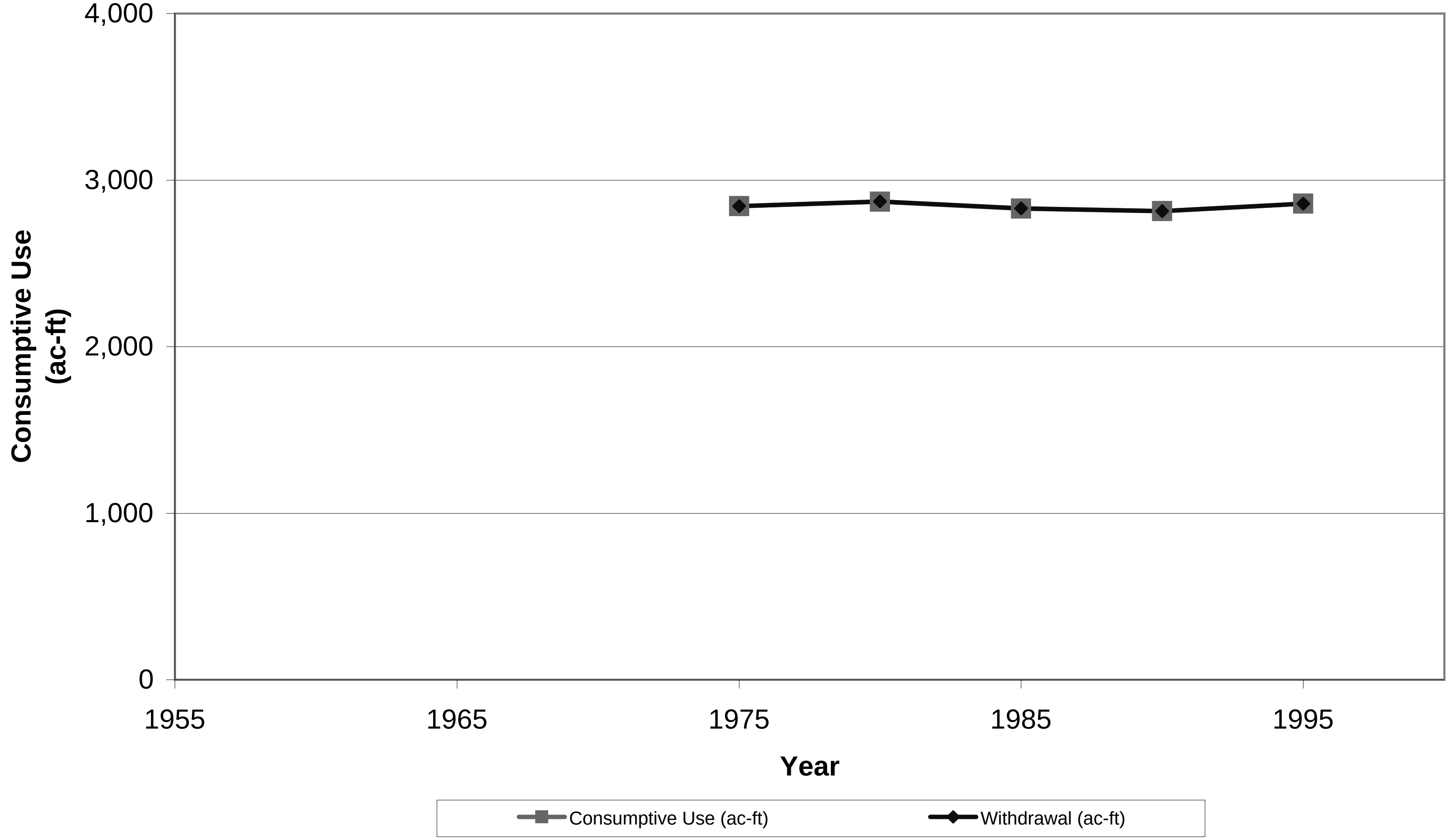


Figure G-4. Irrigated acreage for specific crops based on NMDA and USDA data
Irrigated Acreage (acres)
30000
25000
20000
15000
10000
5000
0
1955
1965
1975
1985
1995
Year
Wheat
Alfalfa Hay
All Other Hay
Corn
Sorghum
Oats
Barley
All Dry Beans
Sum Total Acres
Total acres irrigated



P:\9362-9417\RegWtrPlan.O-2002\Appx_G\IrrAgHRC_Colfax revised.xls Figure G-5 Chart 1

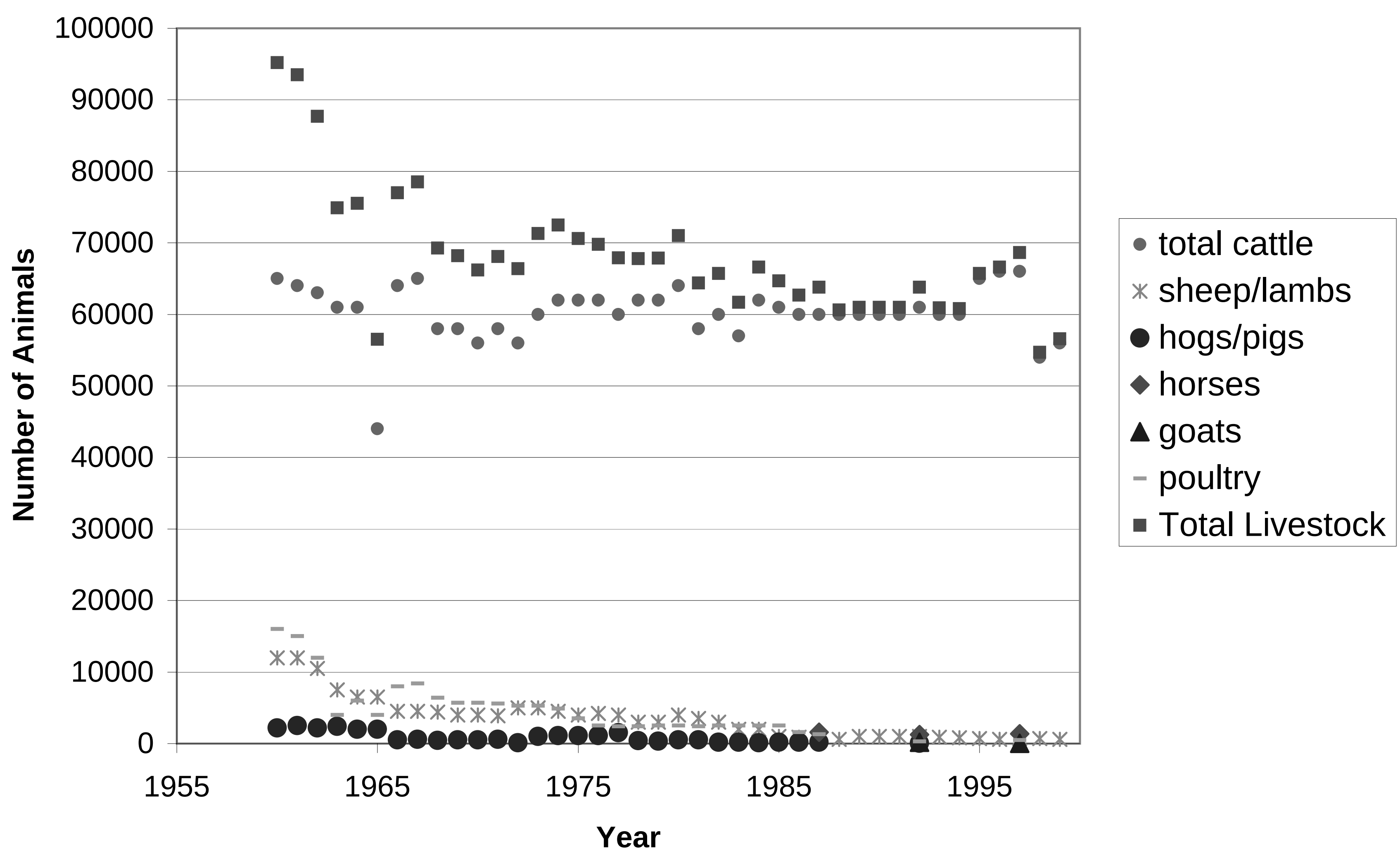
Figure G-6. Livestock consumptive use and withdrawal values for Colfax County based on the NMOSE water use reports and estimated stockpond evaporation



Sorensen, 1976; Sorensen, 1981; Wilson, 1986;
Wilson, 1992; Wilson and Lucero, 1997

P:\9362-9417\RegWtrPlan.4-03\Appx_G\LSHRC_Colfax2 revised.xls

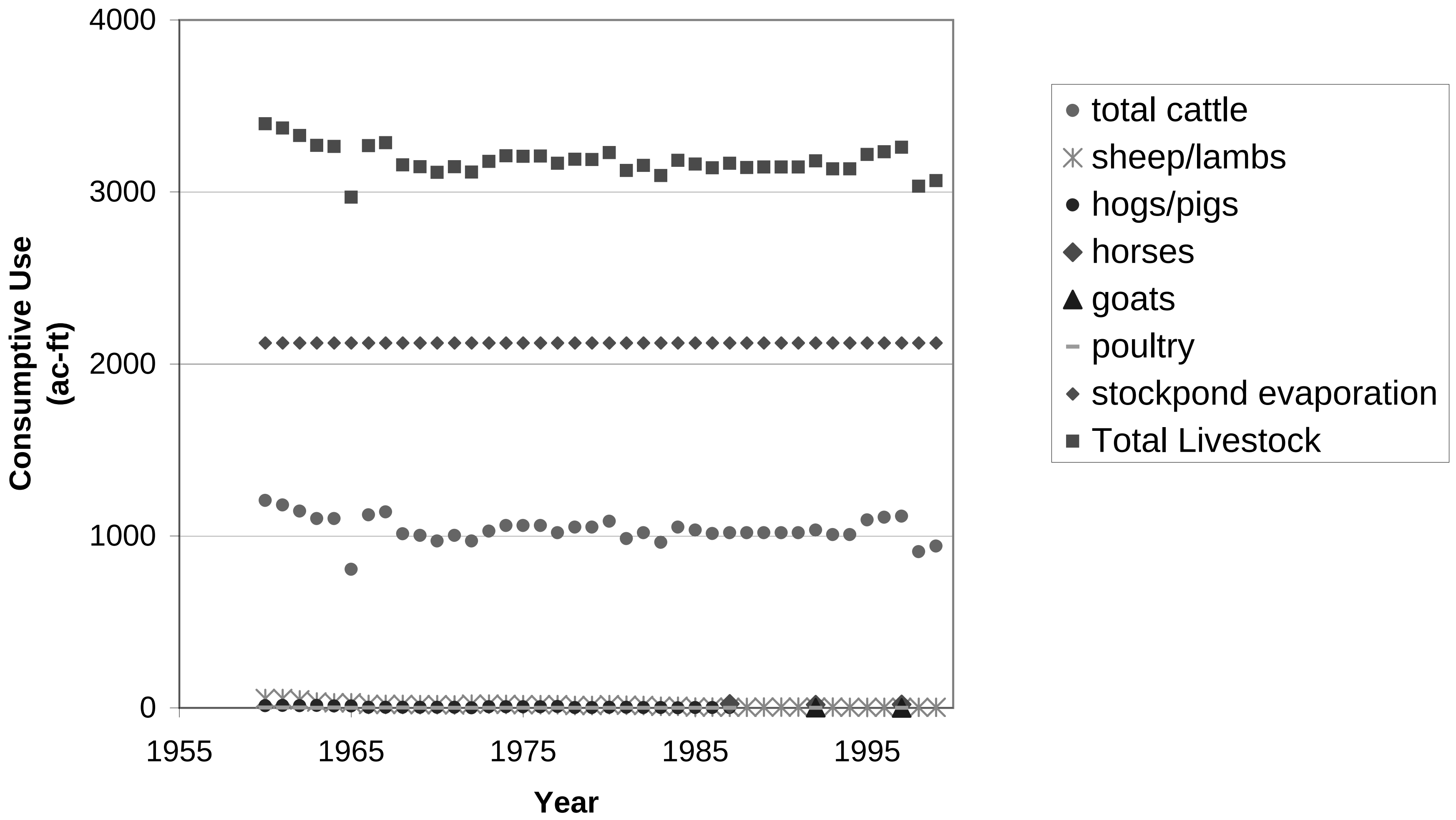
Figure G-7. Livestock inventory values based on NMDA and USDA data



NMDA, 1962-1998; USDA, 1999

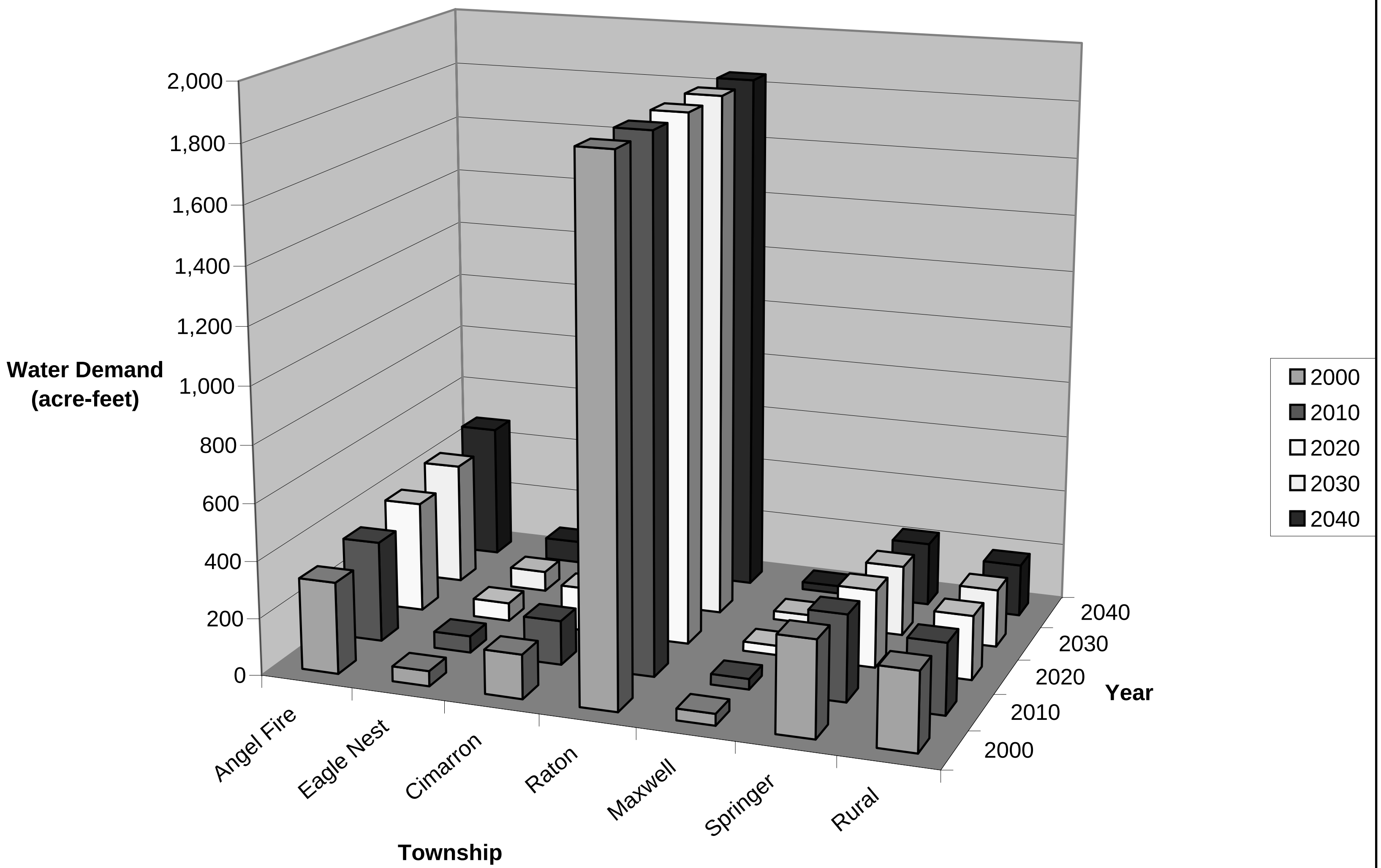
P:\9362-9417\RegWtrPlan.4-03\Appx_G\LSHRC_Colfax2 revised.xls HRC Chart 2

Figure G-8. Livestock consumptive use for Colfax County based on NMDA and USDA (data calculated as described in text)



P:\9362-9417\RegWtrPlan.4-03\Appx_G\LSHRC_Colfax2 revised.xls HRC Chart 1

Figure G-9. 40-Year Water Usage Projection Based on Low Population Growth
Colfax County, New Mexico



P:\9362-9417\RegWtrPlan.4-03\Appx_G\waterdemand.xls Chart2-low growth

Figure G-10. 40-Year Water Usage Projection Based on High Population Growth Colfax County, New Mexico

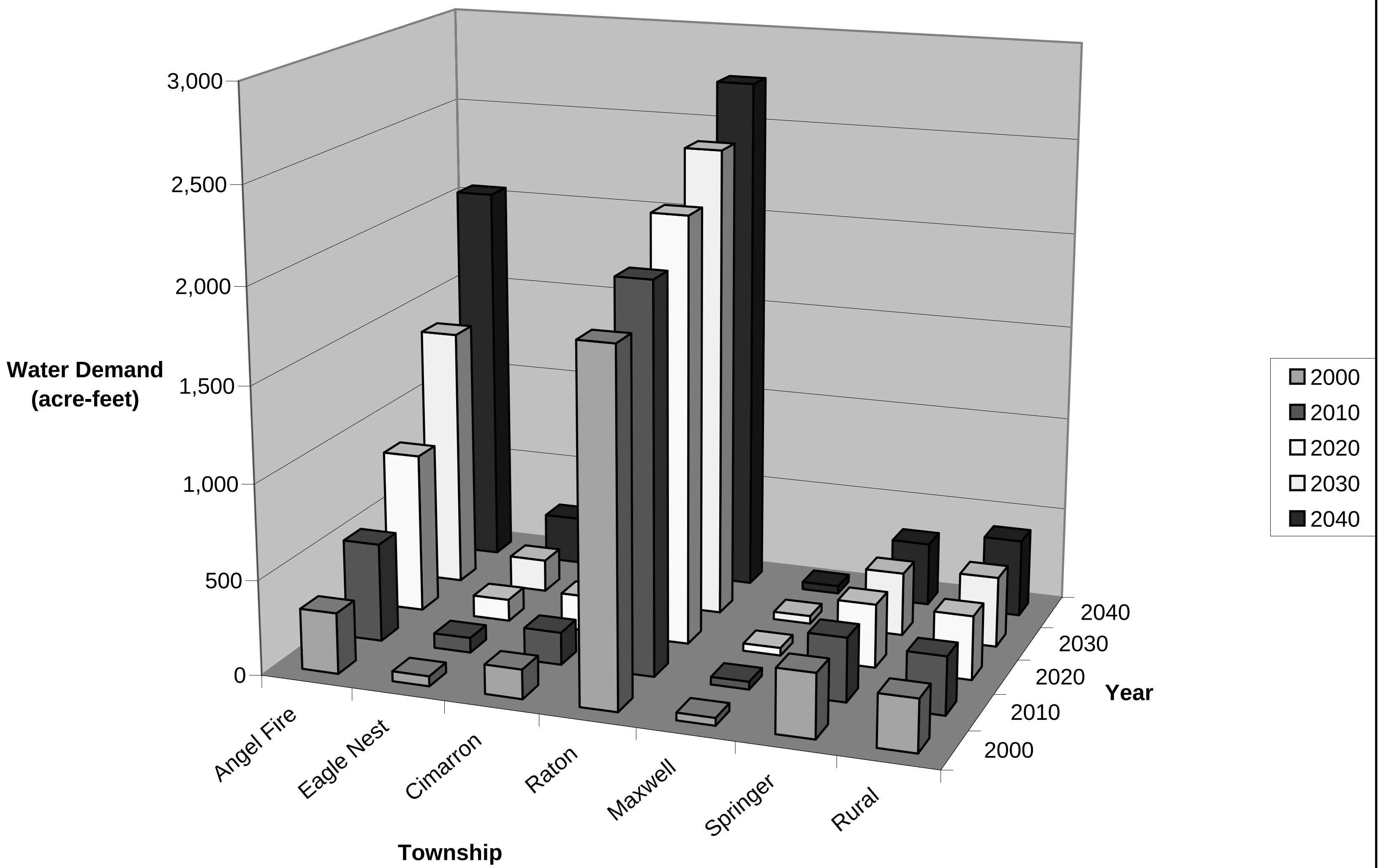


Table G-1. Colfax County Public Water System Summary (Page 1 of 3)

Water System Name	Water System Location	System Mailing Address	Type of System	Minimum Population Served	Maximum Population Served	Number of Connections	Number of Meters	Average System Production (GPD)	Minimum System Production (GPD)	Maximum System Production (GPD)	Water Source Classification	System Source Information	Number of Wells	Total Well Pumping Capacity (GPM)	Number of Reservoirs	Total Capacity of Reservoirs (Gallons)	Number of Tanks	Total Capacity of Tanks (Gallons)	Number of Pressure Tanks	Total Volume of Pressure Tanks (Gallons)
Angel Fire Mobile Home Estates	Hwy 434 at the base of Palo Flechado Pass	PO Drawer B Angel Fire, NM 87710	Community	15	45	19	19	15,000	15,000	15,000	Groundwater	Well	1	14	0	0	1	16,500	1	100
Angel Fire Services - Village of Angel Fire	DNP	P.O. Drawer 469 Angel Fire, NM 87710	Community	1,500	6,000	1,090	1,090	38,409	38,409	38,409	Groundwater	Wells	8	2,455	0	0	15	3,585,000	1	215 (GPM)
Angel Nest Apartments	Between Eagle nest and Angel fire on Hwy 56 adjacent to Wheeler Peek Subdivision	P.O. Box 696 Angel Fire, NM 87710	Community	50	50	24	2	unknown	unknown	unknown	Groundwater	Well	1	10	0	0	1	3,000	6	100
Camp Elliot Barker	1.5 miles west of Angel Fire. Turn west at Inn at Angel Square	450 St. Michael's Drive Santa Fe, NM 87501	Non Community	50	125	9	DNP	2,400	2,400	2,400	Groundwater	Well	1	25	0	0	1	4,000	1	30
Casa Del Gavilan	2 miles south of Philmont Scout Ranch Headquarters	PO Box 42 Cimarron, NM 87714	Non Community	Varied	Varied	2	DNP	3,000	3,000	3,000	Groundwater	Well	1	10	0	0	1	6,000	2	50
Cedar Rail Campground	7 miles North on I-25 to top of Raton Pass on east side	PO Box 26 Raton, NM 87740	Non Community	70	70	8	DNP	5,760	5,760	5,760	Groundwater	Infiltration Gallery	0	0	0	0	2	40,000	2	430
Cimarron Canyon Tolby Camp	Cimarron Canyon State Park. Hwy 64 West end of park	PO Box 147 Ute Park, NM 87749	Non Community	4,500	4,500	6	DNP	400	400	400	Groundwater	Well	1	8	0	0	1	500	2	180
Cimarron Canyon-Maverick Campground	Hwy 64 at center of park02 campgrounds	PO Box 147 Ute Park, NM 87749	Non Community	9,400	9,400	9	DNP	2,000	2,000	2,000	Groundwater	Well	1	12	0	0	1	500	3	150
City of Raton	City Hall 224 Savage Ave. Raton, NM	PO Box 99 Raton, NM 87740	Community	12,800	12,800	3,573	3,355	1,310,000	910,000	1,710,000	Surface	Surface Intake (Lakes)	0	0	4	4570 acre feet	4	7,850,000	0	0
DAV- Vietnam Veterans Memorial	One mile south of Angel Fire on Hwy 34	PO Drawer 608 Angel Fire, NM 87710	Non Community	DNP	DNP	2	DNP	DNP	DNP	DNP	Groundwater	Well	1	DNP	0	0	1	DNP	1	DNP
Eagle Gem RV Park #A	1.25 miles south of Eagle Nest on Marina Road	Rural Route 3 Eagle Nest, NM 87714	Non Community	25	75	23	DNP	1,200	1,200	1,200	Groundwater	Well	1	4	0	0	1	2,000	4	100
Eagle Gem RV Park #B	1.25 miles south of Eagle Nest on Marina Road	Rural Route 3 Eagle Nest, NM 87714	Non Community	25	50	25	DNP	1,500	1,500	1,500	Groundwater	Well	1	4	0	0	1	20,000	4	50
Eagle Nest Reintegration Center	About 3 miles east of Eagle Nest off Hwy 64	PO Box 317 Eagle Nest, NM 87718	Non Community	33	33	3	1	2,190	2,190	2,190	Groundwater	Well	1	1	0	0	0	0	1	80
French Domestic User Assoc.	NW of I-25 and Hwy 58	Route 1, Box 36 Springer, NM 87747	Non Community	150	150	100	100	20,500	16,000	25,000	Purchased Surface	Surface Intake	0	0	0	0	2	24,000	0	0
Inn at Angel Fire	Hwy 434 W. of Angel Fire 1/2 mile	Currently owned by International State Bank Raton	Non Community	60	60	1	DNP	10,080	8,640	11,520	Groundwater	Well	1	8	0	0	0	0	4	100
Kamp Komfort RV Park	Hwy 434 Towards Angel Fire. 1.5 miles south of caution light	PO Box 944 Angel Fire, NM 87710	Non Community	25	50	15	DNP	Unknown	Unknown	Unknown	Groundwater	Well	1	Unknown	0	0	0	0	1	150
Leisure Estates	0.5 mile west of Eagle Nest	PO Box 21 Eagle Nest, NM 87718 C/O June Thompson	Non Community	Varies	Varies	23	DNP	5,760	5,760	5,760	Groundwater	Well	1	10	0	0	1	2,000	1	240
Maxwell Cooperative Water Users Association	3 miles NW of Hwy 64 at Dawson Road	PO Box 207 Maxwell, NM 87728	Community	330	330	70	101	172,800	172,800	172,800	Groundwater	Wells	2	120	0	0	2	120,000	0	0
Miami - MDWCA	West of Springer, East and South of Rayado	PO Box 24 Miami, NM 877729	Community	160	160	52	52	12,167	9,333	15,000	Surface	Surface Intake (Lake)	0	0	1	145,000	1	45,000	0	0
MV - RV Park	Hwy 434 one mile south of the intersection of 434 and 64	PO Box 173 Angel Fire, NM 87740	Non Community	25	80	20	DNP	800	800	800	Groundwater	Well	1	4	0	0	0	0	1	50
NM Boys School	2 miles NW of Springer on HWY 468	PO Box 38 Springer, NM 87747	Community	375	375	20	1	200,000	200,000	200,000	Surface	Surface Intake (Lakes)	0	0	0	0	1	440,000	1	1,000
Philmont Boy Scout Ranch - Main Camp	3 miles south of Cimarron on Hwy 21	Cimarron, NM 87714	Community	2,500	2,500	90	1	83,000	83,000	83,000	Surface	Surface Intake (Lakes)	0	0	2	726,000	3	670,000	0	0
Philmont Out Camp - Abreau	DNP	Cimarron, NM 87714	Non Community	30	75	3	DNP	6,000	6,000	6,000	Groundwater	Well	1	25	0	0	1	5,000	0	0
Philmont Out Camp - Apache Springs	DNP	Cimarron, NM 87714	Non Community	25	50	3	DNP	1,440	1,440	1,440	Groundwater	Well	1	8	0	0	1	3,500	0	0
Philmont Out Camp - Baldy	DNP	Cimarron, NM 87714	Non Community	25	80	4	DNP	2,500	2,500	2,500	Groundwater	Well	1	5	0	0	2	2,400	0	0
Philmont Out Camp - Beubien	DNP	Cimarron, NM 87714	Non Community	200	300	9	DNP	5,200	5,200	5,200	Groundwater	Well	1	10	0	0	1	10,000	0	0
Philmont Out Camp - Clarks Fork	DNP	Cimarron, NM 87714	Non Community	100	200	6	DNP	4,000	4,000	4,000	Groundwater	Well	1	2	0	0	1	2,000	0	0
Philmont Out Camp - Clear Creek	DNP	Cimarron, NM 87714	Non Community	25	50	3	DNP	500	500	500	Groundwater	Well	1	4	0	0	1	2,000	0	0
Philmont Out Camp - Crater Lake	DNP	Cimarron, NM 87714	Non Community	30	50	4	DNP	1,500	1,500	1,500	Groundwater	Spring	0	0	0	0	1	1,200	0	0
Philmont Out Camp - Cyphers Mine	Cimarroncito Creek above Cito Reservoir	Cimarron, NM 87714	Non Community	60	80	4	DNP	3,000	3,000	3,000	Surface	Stream	0	0	0	0	1	1,200	0	0
Philmont Out Camp - Dean Cow	DNP	Cimarron, NM 87714	Non Community	60	100	3	DNP	2,400	2,400	2,400	Groundwater	Well	1	5	0	0	1	2,000	0	0
Philmont Out Camp - Fish Camp	DNP	Cimarron, NM 87714	Non Community	30	60	3	DNP	1,200	1,200	1,200	Groundwater	Well	1	2	0	0	1	2,000	0	0
Philmont Out Camp - Harlan	DNP	Cimarron, NM 87714	Non Community	70	100	5	DNP	2,000	2,000	2,000	Groundwater	Spring	0	0	0	0	2	2,400	0	0
Philmont Out Camp - Head of Dean	DNP	Cimarron, NM 87714	Non Community	25	80	2	DNP	2,000	2,000	2,000	Groundwater	Well	1	2	0	0	1	2,000	0	0

Table G-1. Colfax County Public Water System Summary (Page 2 of 3)

Water System Name	Water System Location	System Mailing Address	Type of System	Minimum Population Served	Maximum Population Served	Number of Connections	Number of Meters	Average System Production (GPD)	Minimum System Production (GPD)	Maximum System Production (GPD)	Water Source Classification	System Source Information	Number of Wells	Total Well Pumping Capacity (GPM)	Number of Reservoirs	Total Capacity of Reservoirs (Gallons)	Number of Tanks	Total Capacity of Tanks (Gallons)	Number of Pressure Tanks	Total Volume of Pressure Tanks (Gallons)
Philmont Out Camp - Indian Writings	DNP	Cimarron, NM 87714	Non Community	25	50	5	DNP	1,200	1,200	1,200	Groundwater	Well	1	2	0	0	1	1,200	0	0
Philmont Out Camp - Miners Park	DNP	Cimarron, NM 87714	Non Community	80	130	3	DNP	2,400	2,400	2,400	Groundwater	Well	1	4	0	0	1	2,000	0	0
Philmont Out Camp - Miranda	DNP	Cimarron, NM 87714	Non Community	80	120	5	DNP	1,200	1,200	1,200	Groundwater	Well	1	2	0	0	1	2,000	0	0
Philmont Out Camp - Phillips Junction	DNP	Cimarron, NM 87714	Non Community	25	40	2	DNP	1,800	1,800	1,800	Groundwater	Well	1	2	0	0	1	2,000	0	0
Philmont Out Camp - Ponil	DNP	Cimarron, NM 87714	Non Community	70	150	15	DNP	4,000	4,000	4,000	Groundwater	Well	1	25	0	0	1	35,000	0	0
Philmont Out Camp - Pueblano	DNP	Cimarron, NM 87714	Non Community	40	75	3	DNP	1,200	1,200	1,200	Groundwater	Well	1	2	0	0	1	1,200	0	0
Philmont Out Camp - Rayado	DNP	Cimarron, NM 87714	Non Community	25	100	8	DNP	4,000	4,000	4,000	Groundwater	Well	1	22	0	0	1	5,000	0	0
Philmont Out Camp - Rocky Mountain	DNP	Cimarron, NM 87714	Non Community	40	80	4	DNP	2,000	2,000	2,000	Surface	DNP	0	0	1	DNP	1	2,500	0	0
Philmont Out Camp - Santa Claus	DNP	Cimarron, NM 87714	Non Community	40	60	4	DNP	1,440	1,440	1,440	Groundwater	Well	1	60	0	0	1	2,000	0	0
Philmont Out Camp - Sawmill	DNP	Cimarron, NM 87714	Non Community	50	100	6	DNP	1,500	1,500	1,500	Groundwater	Spring	0	0	0	0	2	5,200	0	0
Philmont Out Camp - Uracca	DNP	Cimarron, NM 87714	Non Community	30	60	3	DNP	1,000	1,000	1,000	Groundwater	Spring	0	0	0	0	1	1,200	0	0
Philmont Out Camp - Ute Gulch	DNP	Cimarron, NM 87714	Non Community	25	40	3	DNP	1,200	1,200	1,200	Groundwater	Well	1	2	0	0	1	1,200	0	0
Philmont Out Camp - Zastro	DNP	Cimarron, NM 87714	Non Community	25	25-200	6	DNP	2,500	2,500	2,500	Groundwater	Well	1	15	0	0	1	2,000	0	0
Philmont Out Camp - Bent	DNP	Cimarron, NM 87714	Non Community	25	250	DNP	DNP	12,000	12,000	12,000	Groundwater	Well	1	25	0	0	1	2,000	0	0
Philmont Out Camp - Cimarroncito	DNP	Cimarron, NM 87714	Non Community	150	250	15	DNP	20,000	20,000	20,000	Groundwater	Well	1	25	0	0	2	36,200	0	0
Philmont Out Camp - Dan Beard	DNP	Cimarron, NM 87714	Non Community	70	100	4	DNP	1,200	1,200	1,200	Groundwater	Well	1	2	0	0	1	3,700	0	0
Pinewood Plaza	Hwy 434, 1/2 mile north of Angel Fire	PO Box 595 Angel Fire, NM	Non Community	20	140	1	DNP	17,280	17,280	17,280	Groundwater	Well	1	12	0	0	0	0	1	100
Raton Pass Portal-West	7.5 miles N of Raton on I-25. Exit 460	PO Box 1400 Raton, NM 87740	Non Community	200	300	6	DNP	500	500	500	Groundwater	Spring	0	0	0	0	1	100	1	12
Sierra Grande Rest Area	Two miles east of Des Moins on Hwy 64/87	PO Box 7 Des Moines, NM 88418	Non Community	30	100	14	DNP	17,280	17,280	17,280	Groundwater	Well	1	12	0	0	1	1,000	2	150
Springer Water System	1.3 miles NW of Springer on Hwy 468	PO Box 488 Springer, NM 87747	Community	1,400	1,400	578	578	500,000	500,000	500,000	Surface	Surface Intake (Lakes)	0	0	2	60,000,000	4	835,000	0	0
Sugarite Canyon State Park - Lake Alice campground	8 miles NE of Raton on Hwy 72 and 526	HCR 63, Box 386 Raton, NM 87740	Non Community	25	25	13	DNP	5,040	4,320	5,760	Groundwater	Springs	0	0	0	0	1	300	0	0
Sugarite Canyon State Park - Soda Pocket	10 miles NE of Raton on Hwy 72 and 526	HCR 63, Box 386 Raton, NM 87740	Non Community	40	40	4	DNP	1,440	1,440	1,440	Groundwater	Springs	0	0	0	0	1	500	0	0
Thaxton Rest Area	15 miles south of Raton on I-25	PO Box 1333 Raton, NM 87740	Non Community	100	300	9	DNP	1,150	300	2,000	Groundwater	Well	1	8	0	0	1	5,000	1	30
Val Verde II Water Users	West of the Dav Memorial off Hwy 64 near Angel Fire	PO Box 453 Angel Fire, NM 87710	Non Community	50	100	24	DNP	4,500	4,500	4,500	Groundwater	Well	1	15	0	0	1	4,000	3	325
Vermejo Park - Headquarters	45 miles W. of Raton on Hwy 555	PO Drawer E Raton, NM 87740	Community	185	185	41	2	55,000	55,000	55,000	Groundwater	Wells	5	60	0	0	2	54,000	0	0
Vermejo Park Ranch	5 miles North of Costilla Dam	PO Box Drawer E Raton, NM 87740	Non Community	150	150	1	DNP	3,000	3,000	3,000	Groundwater	Well	1	DNP	0	0	1	3,000	1	30

Table G-1. Colfax County Public Water System Summary (Page 3 of 3)

Water System Name	Water System Location	System Mailing Address	Type of System	Minimum Population Served	Maximum Population Served	Number of Connections	Number of Meters	Average System Production (GPD)	Minimum System Production (GPD)	Maximum System Production (GPD)	Water Source Classification	System Source Information	Number of Wells	Total Well Pumping Capacity (GPM)	Number of Reservoirs	Total Capacity of Reservoirs (Gallons)	Number of Tanks	Total Capacity of Tanks (Gallons)	Number of Pressure Tanks	Total Volume of Pressure Tanks (Gallons)
Village of Cimarron	Cimarron, NM	PO Box 654 Cimarron, NM, 87714	Community	1,250	1,250	484	454 Active 30 Inactive	190,000	190,000	190,000	Surface	Surface Intake (Lake)	0	0	1	2 Surface Acres	2	375,000	1	110
Village of Eagle Nest	Turn off Hwy 64 onto Iron Queen Dr. 2 blocks North on left side	PO Box 168 Eagle Nest, NM 87718	Community	200	450	170	170	44,770	44,770	44,770	Groundwater	Wells	2	195	0	0	2	220,000	0	0
Village of Maxwell	DNP	PO Box 282 Maxwell, NM 87740	Community	330	330	175	166	33,000	33,000	33,000	Groundwater	Wells	7	201	0	0	4	860,000	0	0
Weather Store and RV Park	East of Eagle Nest, north side of Eagle Nest Lake	PO Box 347 Eagle Nest, NM 87718	Non Community	25	60	7	DNP	Unknown	Unknown	Unknown	Groundwater	Well	1	unknown	0	0	0	0	1	150
Zebediahs Restaurant and Bar	0.5 mile north of Angel fire on Hwy 434	PO Box 812 Angel Fire, NM 87710	Non Community	75	125	1	DNP	1,300	1,300	1,300	Groundwater	Well	1	DNP	0	0	0	0	1	50

DNP = Data Not Provided
GPD = Gallons per Day
GPM = Gallons per Minute

Table G-2. Water Use in Colfax County Townships

	Gallons Used							
	Springer	Raton	Eagle Nest	Maxwell	Cimarron	Miami	Angel Fire	Totals
1995	0	524,056,000	0	12,544,200	56,551,000	4,728,800	169,858,670	767,738,670
1996	114,466,247	639,415,000	15,377,800	13,438,400	51,126,000	6,110,700	190,007,820	1,029,941,967
1997	109,252,200	583,014,000	16,936,000	12,857,166	46,372,000	5,744,700	196,607,990	970,784,056
1998	118,204,300	642,569,000	18,630,000	16,569,700	43,354,000	6,850,400	196,335,830	1,042,513,230
1999	103,470,000	591,891,000	16,818,900	15,398,300	52,162,000	6,033,700	199,289,000	985,062,900
2000	102,349,799	628,208,143	18,540,922	9,097,760	52,918,202	6,745,116	219,734,363	1,037,594,305
	Acre-Feet Used							
	Springer	Raton	Eagle Nest	Maxwell	Cimarron	Miami	Angel Fire	
1995	0.0	1608.3	0.0	38.5	173.5	14.5	521.3	2,356
1996	351.3	1962.3	47.2	41.2	156.9	18.8	583.1	3,161
1997	335.3	1789.2	52.0	39.5	142.3	17.6	603.4	2,979
1998	362.8	1972.0	57.2	50.9	133.0	21.0	602.5	3,199
1999	317.5	1816.4	51.6	47.3	160.1	18.5	611.6	3,023
2000	314.1	1927.9	56.9	27.92	162.4	20.7	674.34	3,184
	Gallons Per Capita Per Day							
	Springer	Raton	Eagle Nest	Maxwell	Cimarron	Miami	Angel Fire [b]	
Pop. [a]	*1,285*	*7,282*	*306*	*274*	*917*	*160*	*1,048*	*11,272*
1995	0.0	197.2	0.0	125.4	169.0	81.0	444.1	187
1996	243.4	239.9	137.3	134.0	152.3	104.3	495.4	250
1997	232.9	219.3	151.6	128.6	138.5	98.4	514.0	236
1998	252.0	241.8	166.8	165.7	129.5	117.3	513.3	253
1999	220.6	222.7	150.6	154.0	155.8	103.3	521.0	239
2000	218.2	236.4	166.0	91.0	158.1	115.5	574.4	252
Avg	233.4	226.2	154.5	133.1	150.6	103.3	510.4	236.3

[a] Population data are from 2000 Census.

[b] The Angel Fire per capita usage based on 2000 Census data varies from the usage figure reported by the Office of the State Engineer (Table G-5), most likely because the OSE included some rural population in its calculation.

Table G-3. Irrigated Agriculture Consumptive Use and Withdrawal Estimates as Reported in OSE Water Use Reports

Year	Withdrawal (ac-ft)	Consumptive Use (ac-ft)
1975	54700	28710
1980	51680	32610
1985	55069	19848
1990	57989	23736
1995	48324	20089
1999	49315	20507

Soures: Sorenson, 1976; Sorenson, 1981; Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997

Table G-4. Livestock Consumptive Use and Withdrawal Values as Reported in OSE Water Use Reports and Estimated Stockpond Evaporation

Year	Withdrawal (ac-ft)	Consumptive Use (ac-ft)
1975	2,844	2,844
1980	2,871	2,870
1985	2,830	2,829
1990	2,814	2,813
1995	2,859	2,859

Sources: Sorenson, 1976; Sorenson, 1981; Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997

Table G-5. 40-Year Water Usage Projection Based on Population Growth
Colfax County, New Mexico

Township	Average Daily Per Capita Water Usage [a] (gpcd)	2000 Water Usage [b]		2010 Water Usage [c]		2020 Water Usage [c]		2030 Water Usage [c]		2040 Water Usage [c]	
		Population	(ac-ft/yr)	Population	(ac-ft/yr)	Population	(ac-ft/yr)	Population	(ac-ft/yr)	Population	(ac-ft/yr)
High Population Growth											
Angel Fire	273	1,048	320	1,707	522	2,781	850	4,529	1,385	6,705	2,051
Eagle Nest	155	306	53	453	78	670	116	992	172	1,469	254
Cimarron	151	917	155	1,013	171	1,119	189	1,236	209	1,365	230
Raton	226	7,282	1,845	8,044	2,038	8,885	2,251	9,815	2,487	10,842	2,747
Maxwell	133	274	41	274	41	274	41	274	41	274	41
Springer	233	1,285	336	1,285	336	1,285	336	1,285	336	1,285	336
Rural	80	3,077	276	3,399	305	3,755	337	4,147	372	4,581	411
County total	210	14,189	3,338	16,175	3,805	18,769	4,415	22,279	5,241	26,521	6,239
Low Population Growth											
Angel Fire	273	1,048	320	1,158	354	1,279	391	1,413	432	1,560	477
Eagle Nest	155	306	53	338	58	373	65	412	71	456	79
Cimarron	151	917	155	917	155	917	155	917	155	917	155
Raton	226	7,282	1,845	7,282	1,845	7,282	1,845	7,282	1,845	7,282	1,845
Maxwell	133	274	41	248	37	224	33	203	30	183	27
Springer	233	1,285	336	1,162	304	1,051	275	951	249	860	225
Rural	80	3,077	276	2,783	249	2,517	226	2,276	204	2,058	184
County total	210	14,189	3,338	13,887	3,267	13,643	3,209	13,453	3,165	13,316	3,133

gpcpd = Gallons per capita per day
ac-ft/yr = Acre-feet per year

[a] Average daily per capita data for Eagle Nest, Cimarron, Raton, Maxwell, and Springer are the averages of the daily per capita data in Table G-2. Angel Fire and Rural daily per capita data are from the OSE water use report for 2000 (Wilson, 2002). County daily per capita data were calculated by dividing the total county water use for Year 2000 (gallons per day) by the population.

[b] The amounts of surface water and groundwater usage in 2000 are given in Table 6-1.

[b] The future amounts of surface water and groundwater usage will depend on implementation of the alternatives.

Appendix H

Agriculture Conservation Plan

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Attachment

Appendix H. Agricultural Water Conservation

This appendix presents a general evaluation of agricultural water conservation and system efficiency measures that can result in increased delivery to water-short acreage in Colfax County. For most if not all irrigation systems in the county, improving individual system efficiency is a first step in this process, as significant amounts of water are lost in off-farm delivery structures, particularly in canals. Before on-farm conservation measures are contemplated, these types of system delivery improvements need to be addressed. Another major factor influencing the reduced efficiency of the larger irrigation systems in the county is impoundment siltation. The capacity of many of the reservoirs that serve these systems has been reduced by approximately 25 to 50 percent due to sediment accumulation.

If water lost to delivery inefficiencies can be reduced and reservoirs can be dredged to restore their original capacity, much more irrigation water can be made available for all existing farmed acreage. These improvements will, however, be costly and time consuming. After these steps are taken, the establishment of on-farm water-conservation techniques would further reduce crop water requirements and allow for additional acreage to be irrigated or for additional water to be applied to existing acreage.

Adjustments in water system management, including distribution and pricing of irrigation water, should also be factored into future improvement projects and programs. Consideration of these measures may be necessary to attract the major investment that is required for physical improvements.

This remainder of this appendix provides background information related to agricultural water use in Colfax County, discusses approaches to conserving agricultural water and improving irrigation efficiency, as well as related financial considerations, and provides recommendations for further actions to address agricultural water conservation.

H.1 Background Information

More than 80 percent of the water used in Colfax County goes into agricultural activities. Wilson and Lucero (1997) define irrigated agriculture as all "diversions of water for the irrigation of crops grown on farms, ranches, and wildlife refuges." Surface water is the primary source of water for irrigated agriculture in the county, although a small percentage of land is watered through the use of irrigation wells. According to Wilson and Lucero (1997), more than 94 percent of all irrigation water in Colfax County is applied by flood irrigation, with the balance applied using sprinkler type systems. The majority of irrigated agricultural land is in the central portion of Colfax County (Figure H-1).

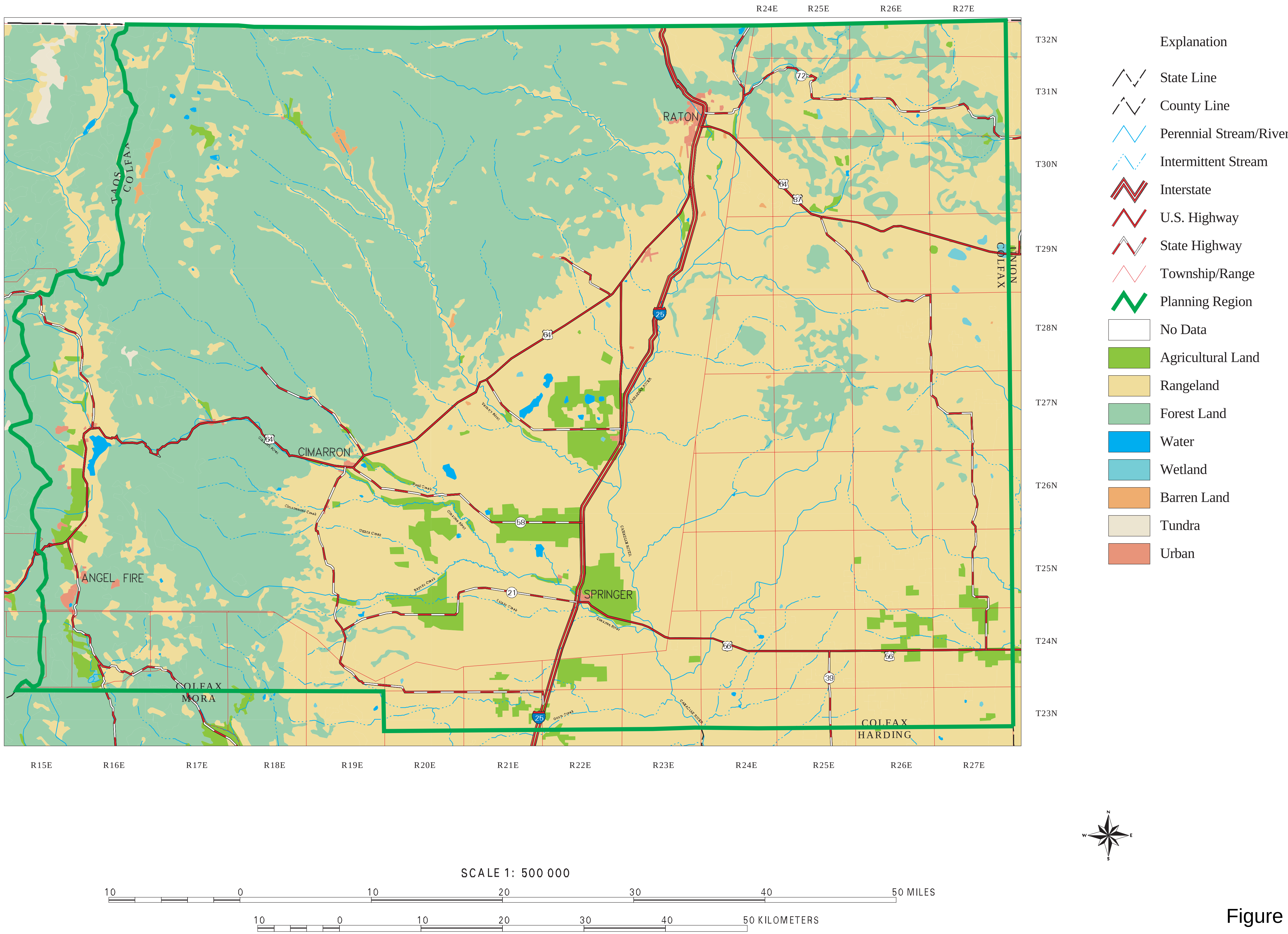
H.1.1 Overview of Irrigated Agriculture in Colfax County

The distribution of irrigated agricultural land in the planning region is shown in Figure H-1. A 1978 State Engineer Office (NM SEO) report lists 24 irrigation systems that operate within the county (Table H-1). According to recent surveys and the 1978 SEO report, these systems irrigate more than 43,500 acres. As shown in Table H-1, the Cimarron River serves as the source for more than half of all irrigation water in the county, with the balance coming predominantly from Rayado Creek, the Vermejo River, and Ponil Creek.

Published crop bulletins from 1960 to 1985 report alfalfa, hay, wheat, corn, oats, sorghum, barley, and dry beans grown in the county, with alfalfa by far the leading crop (Figure H-2, Attachment H1). Starting in the late 1980s, the variety of crops grown began to decline. With the exception of a small amount of sorghum in 1998, the New Mexico Department of Agriculture (NMDA) and U.S. Department of Agriculture (USDA) have reported essentially only wheat, alfalfa, and other hay crops grown in Colfax County for the past ten years (Figure H-2, Attachment H1).

Water withdrawn for agricultural irrigation is also used to water livestock. Wilson and Lucero (1997) report that in 1995, 737 acre-feet were withdrawn for this purpose, with about half of that amount obtained from wells. Additional detail on livestock water use is included in Section 6 of the main body of this Regional Water Plan.

Colfax County Water Plan
Landuse in the Region



Produced by New Mexico Water Resources Research Institute, April 2002

Base map prepared by the U.S. Geological Survey

Compiled from digital data provided by the New Mexico Resource Geographic Information System Program (RGIS). Original base maps digitized from 1:500,000 mylar sheets and 100,000 paper maps for New Mexico. These data meets National Mapping Accuracy Standards for 1:500,000 and 1:100,000 scale maps. Landuse coverage developed by USGS/EPA at 1:250,000 scale. Boundary of the Colfax County Water Planning Region is based on New Mexico county boundaries, and surface drainage divides. The cadastral accuracy of the county boundaries where verified by the use of 1:100,000 Public Land Survey System (PLSS) from RGIS.

Horizontal accuracy: At the scale of 1:500,000 at least 90 percent of the points tested are within 1/30th inch (0.033 inch), or within 423 ground meters, of their true location.

Projection: Universal Transverse Mercator, Zone 13, Units meters, NAD83.

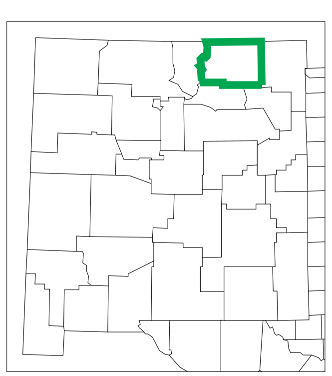


Figure H-1

Table H-1. Summary of Irrigation Systems in Colfax Water Planning Region
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Source	Diverter [a]	Type of Organization [b]	Approximate Irrigated Area [c] (acres)	Source of Information		Percentage of Total County Irrigated Acreage
				Date	Type	
Ponil Creek	Chase Ranch Ditch	CA	308	1929	Court adjudication	
	Antelope Valley Irrigation District	ID	5,000	1977	SEO records	
		Subtotal	5,308			12.15
Rayado Creek	North and South Abreu Ditches	CA	478	1969	CNIC Report	
	Farmers Development Company	IC	6,500	1929	Court adjudication	
	Antonio Jose Valdez Ditch	CA	95	1929	Court adjudication	
	Valdez-Porter Ditch	CA	440	1929	Court adjudication	
	Miami Water Users Association	CA	150	1968	ASCS records	
		Subtotal	7,663			17.54
Wheaton Creek	Upper Wheaton Ditch	CA	6	1969	CNIC Report	
	Upper Lucero Ditch	CA	25	1969	CNIC Report	
	Lower Lucero Ditch	CA	36	1969	CNIC Report	
	Middle Lucero Ditch	CA	4	1969	CNIC Report	
	Neurauter Ditch	CA	6	1969	CNIC Report	
		Subtotal	77			0.18
Chico Rico Creek	Red River Irrigation Company	IC	180 [d]	1977	SCS records	
		Subtotal	180			0.41

Source: NM SEO, 1978.

[a] Additional private diverters (i.e., C S Ranch diversions through Clouthier Reservoir on Rayado Creek and Clayton Lake on Salado Creek) are not included on this list. An updated agricultural survey is needed to reflect all current agricultural uses. This table provides only an initial estimate of irrigated acreage.

[b] Type of organization: CA = Community acequia
ID = Irrigation district
IC = Incorporated irrigation ditch

[c] Based on SEO (1978) acreage calculation

SEO = New Mexico State Engineer Office (currently known as the Office of the State Engineer [OSE])
CNIC = Conservation Needs Inventory Committee
ASCS = Agricultural Stabilization and Conservation Service
SCS = Soil Conservation Service

Table H-1. Summary of Irrigation Systems in Colfax Water Planning Region Page 2 of 2

Source	Diverter [a]	Type of Organization [b]	Approximate Irrigated Area [c] (acres)	Source of Information: Date	Source of Information: Type	Percentage of Total County Irrigated Acreage
Canadian River	Stockton Ditch	CA	369	1968	ASCS records	
		Subtotal	369			0.84
Vermejo River	Vermejo Conservancy District	CD	7,400	1977	SEO records	
		Subtotal	7,400			16.94
Ute Creek	Ute Creek Irrigation Company	IC	349	1969	CNIC Report	
		Subtotal	349			0.80
Cimarron River	Charles Springer Cattle Company	IC	8,000	1977	SEO records	
	Old Mill Ditch	CA	68	1929	Court adjudication	
	Clutton-Maxwell Ditch	CA	112	1929	Court adjudication	
	Porter-Morley Ditch	CA	424	1929	Court adjudication	
	Springer Ditch Company	IC	7,500	1977	SEO records	
	C S Main Canal	IC	5,661	1969	CNIC Report	
	North C S Canal	IC	566	1969	CNIC Report	
		Subtotal	22,331			51.11
Bonita Creek	Bonita Ditch	CA	16	1969	CNIC Report	
		Subtotal	16			0.04
		Total	43,693			

Source: NM SEO, 1978.

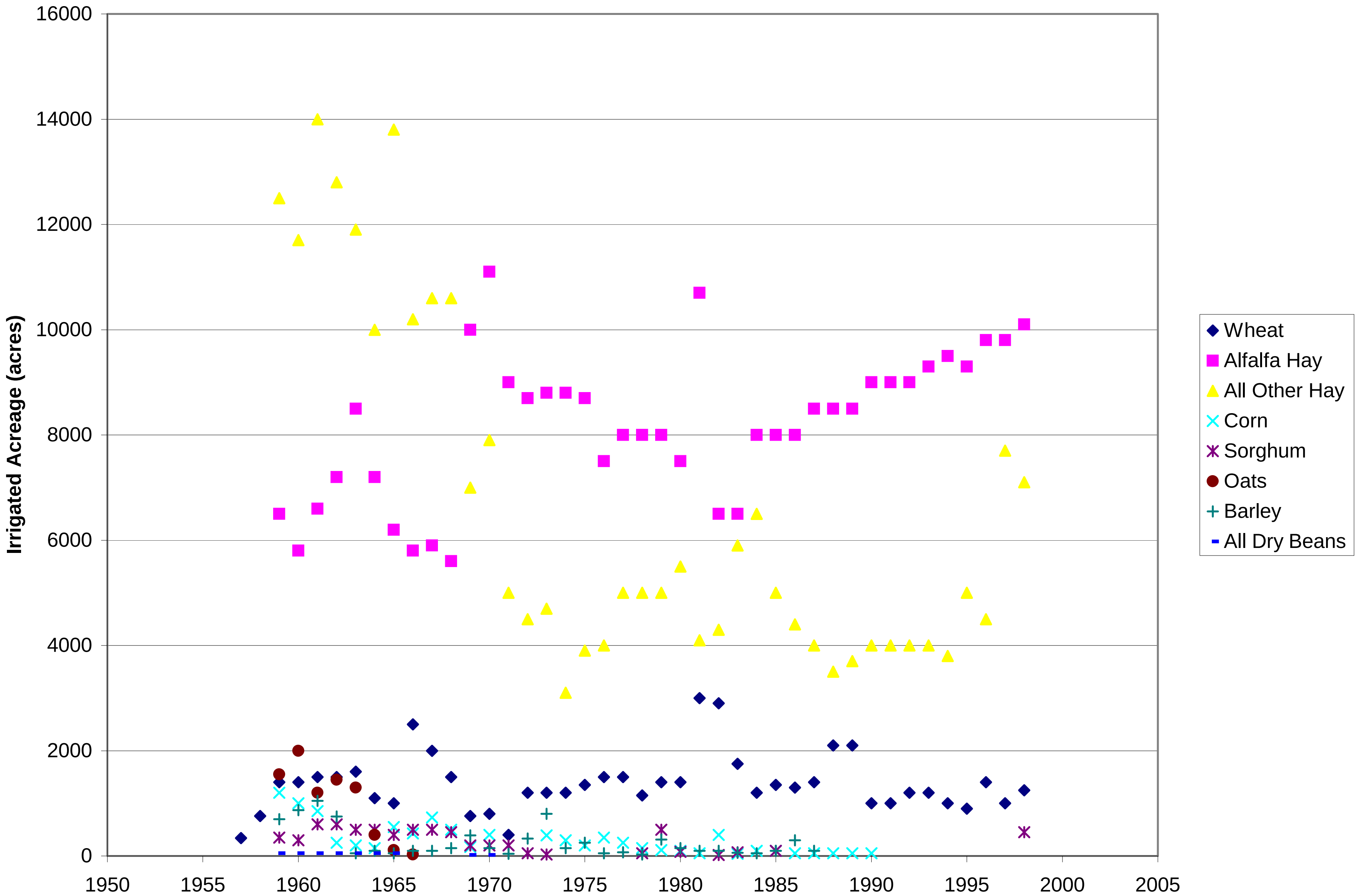
[a] Additional private diverters (i.e., C S Ranch diversions through Clouthier Reservoir on Rayado Creek and Clayton Lake on Salado Creek) are not included on this list. An updated agricultural survey is needed to reflect all current agricultural uses. This table provides only an initial estimate of irrigated acreage.

[b] Type of organization: CA = Community acequia
ID = Irrigation district
IC = Incorporated irrigation ditch

[c] Based on SEO (1978) acreage calculation

[d] USDA records indicate 996.7 acres for the Red River Irrigation Company

SEO = New Mexico State Engineer Office (currently known as the Office of the State Engineer [OSE])
CNIC = Conservation Needs Inventory Committee
ASCS = Agricultural Stabilization and Conservation Service
SCS = Soil Conservation Service



Sources: NMDA, 1962-1998
USDA, 1999

Daniel B. Stephens & Associates, Inc.

COLFAX REGIONAL WATER PLAN

Historical Irrigated Acreage by Crop in Colfax County

Figure H-2

H.1.2 Water Rights

As discussed in Section 4.4 of the main body of this Regional Water Plan, water rights for the majority of entities and individuals in Colfax County were adjudicated in the early part of this century. Regardless of the type of entity that manages water deliveries for irrigation, water rights remain with the owner to whom they were legally adjudicated or transferred under New Mexico water law.

Water users either own the water rights or have a contract (lease) that allows them to use water for which they pay a fee. Generally, irrigation and conservancy districts are organized around water rights holders, and the individual districts do not own water unless they own land and have the water rights that go with that land. A water company usually owns the water rights, and individual users on the system own shares in the company that allow them to use specific amounts of water.

Most of the water rights holders in the county have an irrigation duty of 1.5 acre-feet per acre. This amount was used in the calculations regarding potential water savings.

H.1.3 Irrigation Organizations in Colfax County

The majority of irrigated agricultural land is in the central portion of Colfax County (Figure H-1). A closeup of this portion of the county is shown in Figure H-3. The background is an October 1999 LANDSAT 7 satellite image, with irrigated lands shown in bright red-orange. In addition, this figure shows the diversion points and irrigation canals in the area.

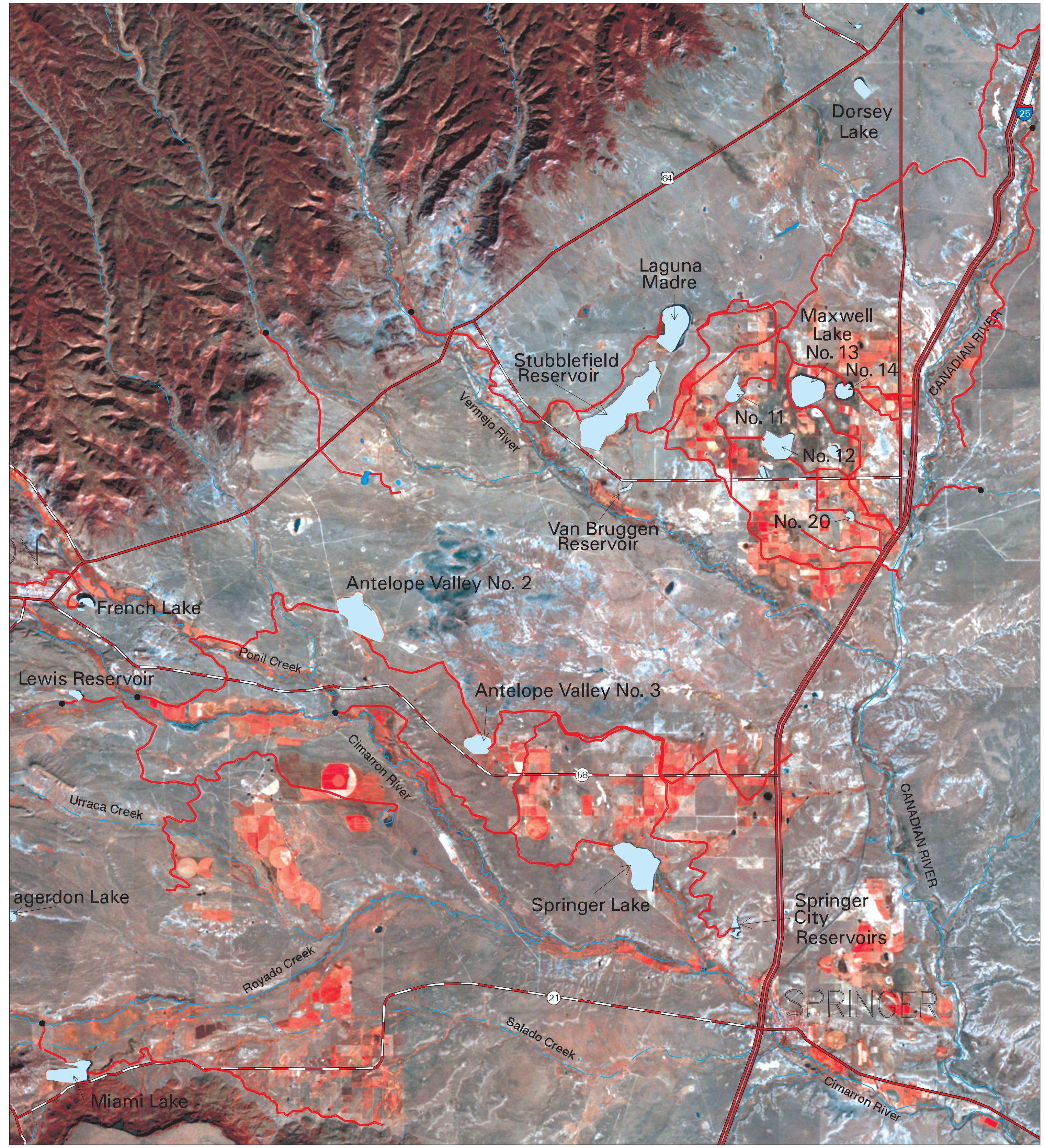
As part of the development of this agricultural conservation plan, DBS&A conducted a survey of the major irrigation systems in Colfax County (Table H-2). In general, the irrigable acres reported by the irrigation systems are consistent with the amounts shown in Table H-1, which came from a 1978 New Mexico State Engineer Office report. In some cases there is a difference in the reported size of the irrigation district as shown on Table H-1 and the area under irrigation as shown in Figure H-3. Discrepancies could be due to several reasons, such as overall irrigation water availability or, most likely, the time of year that the image was obtained.

Colfax County Water Plan
Irrigation Districts

Explanation

- Diversion Point
- Ditches and Canals
- State Line
- County Line
- Perennial Stream/River
- Intermittent Stream
- Interstate
- U.S. Highway
- State Highway
- Township/Range
- Planning Region

Irrigation District	Acreage
Vermejo	6800
Antelope Valley	3600
Miami	2300
Springer Ditch	2700



Produced by New Mexico Water Resources Research Institute, April 2002

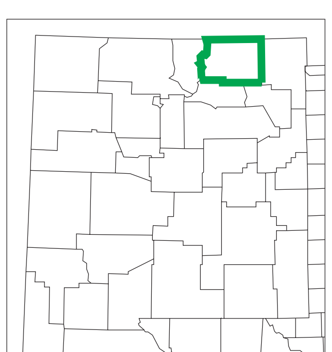
Base map prepared by the U.S. Geological Survey

Compiled from digital data provided by the New Mexico Resource GeographicInformation System Program (RGIS). Original base maps digitized from 1:500,000 mylar sheets and 100,000 paper maps for New Mexico. These data meets National Mapping Accuracy Standards for 1:500,000 and 1:100,000 scale maps. Areal extent of lakes and reservoirs derived from USGS DLG hydrography layer. Annotation derived from USGS maps and a table compiled by B.C. Wilson, New Mexico Office of the State Engineer. Points of diversion derived from the point were water is diverted from natural streams to man made structures. Background image is a October 1999, LANDSAT 7 ETM satelite image using bands 4, 3, 2 for RGB. Irrigation acreage estimates derived from vegetation index classification of the LANDSAT 7 image using ArcView Image Analysest software. Boundary of the Colfax County Water Planning Region is based on New Mexico county boundaries, and surface drainage divides. The cadastral accuracy of the county boundaries where verified by the use of 1:100,000 Public Land Survey System (PLSS) from RGIS.

Horizontal accuracy: At the scale of 1:200,000 at least 90 percent of the points tested are within 1/30th inch (0.033 inch), or within 169 ground meters, of their true location.

Projection: Universal Transverse Mercator, Zone 13, Units meters, NAD83.

Natural Resource Conservation Service (NRCS), 1982, Soil Survey of Colfax County, New Mexico: USDA, 191p, 103 plates.



SCALE 1: 200 000

5 0 5 10 15 MILES

5 0 5 10 15 20 KILOMETERS

Figure H-3

Table H-2. Summary of Interviews Regarding Colfax County Irrigation Systems

Interview Information	Irrigation System			
	Antelope Valley Irrigation District	Miami Water Users Association	Vermejo Conservancy District	Springer Ditch Company
Interviewee	Frank Burton	Tony Searer	Joe Hronich	Tommy Crawford
Interview date	January 29, 2002	January 29, 2002	January 30, 2002	January 30, 2002
Estimated number of acres in district	5000	6500	7289	7500
Approximate number of acres irrigated each season	2500	4000	5831 (80% of total acreage)	Not known
Number of unirrigated acres that are farmed	0	0	0	0
Any canal lining	Two 36" PVC siphons, each one mile long	One small PVC underground pipe is old and in disrepair.	Some ditches were lined in the 1960s, but are now in much disrepair.	Some ditches are lined in straightaways, none lined on curves. There is a 4' concrete siphon. Four pipelines were put in about 10 to 15 years ago.
Irrigation return flows	No return flow; every bit of water used.	No return flow; every bit of water used.	No return flow. When there is enough water it flows back to the Canadian River.	No return flow
What crops are grown	Alfalfa	Brome hay, brome and alfalfa, and other types of grass hay	Alfalfa hay; some (~20%) wheat and oats	Alfalfa, grass, brome, hay, very little cereal grains
Cuttings per year	3	1 or 2	3	3

ac-ft = Acre-foot   ac-in = Acre-inch

Table H-2. Summary of Interviews Regarding Colfax County Irrigation Systems

Interview Information	Irrigation System			
	Antelope Valley Irrigation District	Miami Water Users Association	Vermejo Conservancy District	Springer Ditch Company
Amount of water diverted	1600 to 1700 ac-ft	2500 ac-ft	11,000 ac-ft	Water Master lets 6,000 ac-ft out of the Lake.
Method of measuring water	A weir below Lake #3 is used by the Water Master to measure the amount of water released.	The Water Master measures how much water is let out of the lake. Flow into each farmer's field is also measured to see how much water is being received.	Lake level is measured monthly. Each farmer has a measuring device at his/her field that is monitored twice a day when water is being received.	Ditch rider measures water at each shareholder's property using a measuring device installed at the property.
Frequency of shortfalls in fulfillment of the water rights	Full 1.5 ac-ft water right never filled.	Full water right never filled.	About once in 10 years, but times when no one received their proration have historically occurred.	Full water right never filled.
Amount of water they receive in a wet year	The maximum they have ever received is 9.5 ac-in	12 to 14 ac-in	Full proration (1.5 ac-ft) plus some to keep the system running.	9 ac-in
Water available in a dry year	1 ac-in	6 to 8 ac-in (0 in some years)	9 ac-in (0 at times in the past)	5 ac-in
Water available in an average year	4 to 5 ac-in	9 to 12 ac-in	12 to 18 ac-in	7 ac-in
Water allocation method during shortfalls	Available water distributed equally	Available water distributed equally	Divided equally among all shareholders (equal water for equal shares)	Equal amount for an equal share.
Written drought policy	None	None	None	None

ac-ft = Acre-foot ac-in = Acre-inch

Table H-2. Summary of Interviews Regarding Colfax County Irrigation Systems
Page 3 of 3

Interview Information	Irrigation System			
	Antelope Valley Irrigation District	Miami Water Users Association	Vermejo Conservancy District	Springer Ditch Company
Surface water diversion location	Cimarron River Ponil Creek Cerrasosa Creek	Rayado Creek	Vermejo River Tributary to Canadian River	Cimarron River (at Ponil Creek confluence)
Total reservoir storage	Lake #2: 2200 ac-ft current maximum Lake #3: 300 ac-ft	Miami Lake: 2500 ac-ft	Lake #12: ~1500 ac-ft Lake #13: ~5000 ac-ft in the best shape Lake #14: ~780 ac-ft Lake #2: ~2000 ac-ft; Stubblefield: ~13,490 ac-ft	Springer Lake: 4000 ac-ft
Approximate reduction in reservoir storage due to silt	50%	40%	35%	25%
Recommendations for water conservation	Pipeline, silt removal, dam stabilization to use entire capacity	Pipeline	Lining ditches or pipeline	More pipeline

ac-ft = Acre-foot ac-in = Acre-inch

Individual irrigators may divert directly from a stream system or, in some cases, a well. In most cases, however, agricultural water use takes place within irrigation or conservancy districts, or an entity such as a water company supplies the water used for irrigation. Each type of organization (i.e., water companies, irrigation and conservancy districts) has a different statutory mandate, and the purpose, authority, power, and duties of each entity define the activities it may undertake. The irrigation and conservancy districts are organized under NMSA 73-9-1 to 62 and NMSA 73-14-1 to 88. The original purpose for creating these entities was to facilitate delivery of water and to be able to secure loans to construct the irrigation works necessary for the delivery of the water. Whatever the organizational structure of the entity in charge of delivering agricultural water, agricultural water conservation can be most easily facilitated by working directly with these water providers since they often manage the delivery systems where losses occur.

Sections H1.3.1 through H.1.3.5 briefly describe the county's major irrigation systems, and Table H-2 summarizes pertinent information regarding these systems. Water supplies provided through Eagle Nest Permit 71 are discussed in Section 4.

H.1.3.1 Antelope Valley Irrigation District

Agricultural land in the Antelope Valley Irrigation District is located near the intersection of State Highway 58 and Interstate 25 (Figure H-3). Water is diverted from both Ponil and Cerrasosa Creeks into Antelope Valley Lake No. 2 and then on to Lake No. 3 for delivery to individual landowners (Burton, 2002). The total irrigable acreage in the district is 5,000 acres (Burton, 2002; NM SEO, 1978).

This district has never received their full 1.5 acre-foot allotment. The most they have ever received is 9.5 inches per acre, and in a typical year they receive about 4 inches per acre (Burton, 2002). Alfalfa is the primary crop grown in the district, with growers usually harvesting three crops per year (Burton, 2002).

H.1.3.2 Springer Ditch Company

Shareholder land in the Springer Ditch Company is located near the Town of Springer and is mostly east of Interstate 25 (Figure H-3). Water is diverted from the Cimarron River (where the

Cimarron and Ponil come together) into Springer Lake. Water for the Town of Springer, which is also a shareholder in the Ditch Company, is delivered to the two Springer city reservoirs (Crawford, 2002). The total irrigable acreage in the district is 7,500 acres (Crawford, 2002).

The Ditch Company has also never received its full 1.5 acre-foot allotment. The most water ever received in one year (during the irrigation season) is 9 inches per acre, which is only 50 percent of its adjudicated water right. In a typical year the company receives about 7 inches per acre (Crawford, 2002). The primary crops grown in the area are alfalfa, grass, and brome hay, all of which produce three cuttings per year (Crawford, 2002).

H.1.3.3 Miami Water Users Association

Miami Water Users Association agricultural land is located on both sides of State Highway 21 near the Town of Miami (Figure H-3). Water is diverted from Rayado Creek into Miami Lake; this diversion also supplies the town of Miami (Searer, 2002; NM SEO, 1978). The total irrigable acreage in the district is 6,500 acres (Searer, 2002).

This association has never received its full 1.5 acre-foot allotment. The most ever received is 12 to 14 inches per acre. In an average year the association receives about 9 to 12 inches per acre (Searer, 2002). The primary crops grown are brome and alfalfa hay, which yield 1 to 2 cuttings per year (Searer, 2002).

H.1.3.4 Vermejo Conservancy District

The Vermejo Conservancy District is located west of Interstate 25 near the Town of Maxwell (Figure H-3). In addition to farm lands, the district also includes the Maxwell National Wildlife Refuge.

Congress authorized the Vermejo Project in 1955, which allowed the U.S. Bureau of Reclamation (USBR) to construct improvements and rehabilitate the existing facilities (USBR, 1983). In the current system water is diverted from the Vermejo River into Stubblefield Reservoir and Laguna Madre (Hronich, 2002). The District also diverts water from Chico Rico Creek, a tributary to the Canadian River (USBR, 1983). The total irrigable acreage in the district is 7,300 acres (Hronich, 2002).

The conservancy district normally receives the full 1.5-acre-foot allotment. The primary crops grown are alfalfa hay (approximately 80 percent) and wheat and oats (approximately 20 percent) with usually three harvests per year (Hronich, 2002).

H.1.3.5 Acequias and Other Irrigation Systems

Table H-1 lists 20 other acequias and irrigation systems that reportedly serve a combined area that is less than the total area served by the four major systems noted above. For the purposes of this report, DBS&A's analysis focused on the four larger systems described in Sections H.1.3.1 through H.1.3.4, as these larger systems are the most likely entities to begin implementation of conservation measures. However, much of the information provided is applicable to other agricultural systems as well.

H.2 Improvements to Conserve Water and Increase Efficiency

Agricultural water conservation is well studied and documented. A large amount of irrigation water management and planning conservation information is downloadable from the Internet along with the names and contact numbers of government and private sector experts who are available to assist. In New Mexico, USDA, Natural Resources Conservation Service (NRCS), and State of New Mexico government staff are also readily available to give advice and to help any irrigation manager and/or user develop and implement a large or small water management and/or conservation plan. Several irrigation and/or conservancy districts in southern Colorado, just north of New Mexico, have active and successful water management and conservation programs that are supported by the NRCS and USBR.

Non-government agencies are also active in assisting farmers and irrigators with conservation. In particular, the Irrigation Association (www.irrigation.org), founded in 1949, is a non-profit trade organization whose members represent all segments of the irrigation industry. One of the principal goals of the organization is to provide the membership with a full array of programs and services that will help them keep pace with the industry's rapidly changing technology.

The association is also dedicated to promoting water and soil conservation through proper water management. In 1990, the association formally adopted a water conservation policy that stresses the importance of improving irrigation efficiency. The Irrigation Association advocates that any long-range conservation planning should incorporate the following ten goals:

1. Measure all water use.

2. Price water so as to recognize its finite nature. Pricing mechanisms should provide incentives to water users who conserve water as well as penalties for those who waste it.

3. Hold all water users responsible for protecting the quantity and quality of water resources at their disposal.

4. Create financial incentives to reward users for efficient irrigation. Key elements to observe are farm layout and farm operations and maintenance, combined with effective water use, scheduling, and management practices.

5. Create educational programs on a regional level that emphasize to all water users the absolute necessity of supporting regulatory policies that reward conservative and efficient water use.

6. Support water reclamation initiatives including, where practical, the use of reclaimed water from municipal, industrial, agricultural, and other available sources.

7. Increase support for developing new water resources, along with conveyance and storage facilities that enhance dependable water supplies, with proper consideration given to legitimate environmental concerns.

8. Promote participation by all users in water conservation planning as an ongoing program. These plans must be in place prior to a critical need and must encourage each water user to accept a fair share of any water conservation effort.

9. Institute studies to identify water use and misuse by all users in order to collect data on which to base decisions regarding equitable water distribution during periods of shortage.

10. Promote policies that allow for the lease, sale, or transfer of established water rights and/or water without jeopardizing established water rights.

This section discusses several initiatives recommended for Colfax regional water planners. These initiatives can be grouped under some of these ten recommendations; however, any system wishing to embrace conservation as a serious part of their operational plan must first develop its own system water management plan. The Vermejo Conservancy recently took a first step in that direction by completing a long-term water conservation plan.

One of the most important components of agricultural conservation, and therefore the focus of many of the initiatives presented, is the efficiency of the irrigation system. Irrigation efficiency is a measurement of the ratio of the quantity of water withdrawn from some source to the quantity actually applied to agricultural fields. The higher the irrigation efficiency, the more withdrawn water farmers have available for irrigating additional acreage or increasing the amount of water applied to existing farmed acreage. In a perfect system, irrigation efficiency would be 100 percent, with all water withdrawn being available for crop irrigation. From a practical standpoint, however, an irrigation efficiency greater than 80 percent is considered a reasonable goal for a system that is conservation conscious. In Colfax County, efficiencies currently are much lower, with as much as 50 percent of delivery water lost to seepage (Section H.3.2).

H.2.1 Industrial Agriculture vs. Supplemental Income Agriculture

Two types of agriculture are present in Colfax County: (1) larger farms where farmers derive their primary income from agriculture (referred to as industrial agriculture for the purpose of this report) and (2) agricultural land where the income earned from it is secondary to an income from another source (referred to as supplemental income agriculture). The distinction between these two types of farming is typically the amount of time, effort, and money applied to farming. In industrial agriculture, farmers typically pay more for their water and invest more in on-farm irrigation and farming infrastructure, whereas supplemental income farmers may be less likely to spend time and money to operate and/or improve their farms. Irrigation systems may serve either one type exclusively or both types of agriculture.

The type of agriculture (industrial or supplemental income) becomes an issue when an irrigation system seeks to implement management and conservation planning, physical and structural changes, or programmatic shifts in the way it does its business. Such planning and changes are normally more acceptable to farmers who carry on agriculture as their primary means of earning and income; however, in Colfax County, where irrigators have never or haven't in many years received their water allotment, such system improvements are necessary to increase the amount of water reaching every farmer's fields.

H.2.2 Water System Management

The streamlining of water conservancy requires four fundamental components:

- Water measurement and accounting system
- Water pricing based on efficiency procedures
- Informed and educated water users
- A water conservation director or coordinator

To help optimize these components, each individual water system should adopt a water management plan that includes the following:

- Procedures should be developed for quantifying irrigation withdrawals and depletions, tabulating the irrigated acreage for individual cropping patterns by the type of irrigation system, measuring water, budgeting water, and scheduling water deliveries. The plan should take into consideration average, low, and high water availability projections.

- Consumptive irrigation requirements (CIR), indices of the cropping patterns, irrigation methods, sources of water, and overall depletion and withdrawals of water in each system, should be determined to help direct the management of the system (Section H.2.2.1, Attachment H2).

- A conservation plan for both off- and on-farm water delivery should be developed and implemented. Development of such a plan will require a detailed understanding of each system's sources of water, its users, the crops they grow, and each of their farms. The plan should identify needed improvements and should include financing provisions.

- Drought contingency plans are an essential part of the planning process as well. Examination of water rights and stream flow records and a detailed investigation of the strengths and weaknesses of each system are required to develop the data upon which this plan will be founded and from which an approximate water measurement and accounting system can be developed.

A water management plan developed in one year can be used and modified in each successive year.

Developing and implementing either a long- or short-term irrigation water conservation plan in any one of the county's irrigation systems will be a challenging undertaking for its management staff and the users of the system, whether it be an acequia, a water company, or an irrigation district. It will require commitment, energy, and public participation as well as agreement to change. Developing effective plans will also require some amount of additional outside expertise, time, and money.

H.2.2.1 Measurement

Effective source withdrawal and farm delivery water measurement is essential for developing and implementing a sound water management plan. Without effective water measurement it will not be possible to know if the plan's goals are being achieved.

A management area's measurement method should be adequate to track water deliveries to each water user. Thorough water measurement is an effective tool for both the water user and the district about the quantity, scheduling, budgeting, and location of the water use. At the farm, ranch, and wildlife refuge level, water measurement aids in meeting water requirements for proper crop moisture, thereby reducing erosion, fertilizer leaching, and drainage problems. Many of the techniques for water measurement are discussed briefly here; further detail regarding these techniques is provided by the USBR (1997b) and Wilson (1992).

A commonly used water measurement technique is to determine the theoretical consumptive use (U) or evapotranspiration (ET) of water by the individual crops in each type of irrigation system. Agricultural consumptive use of water is generally not directly measured, but is instead estimated based on a model of crop water needs. For the Colfax regional water planning study, consumptive use was estimated for crops grown in the region using the Blaney-Criddle method (Blaney and Criddle, 1950, 1962). This method was created during studies conducted in New Mexico in 1939 and 1940 for the Pecos River Joint Investigation initiated by the National Resources Planning Board. It factors in air temperature, daylight hours, and a crop-specific coefficient to determine the amount of water required to achieve viable crop yields.

The results of the Blaney Criddle calculation of consumptive use can be used in conjunction with rainfall estimates to estimate the amount of irrigation water required, known as the consumptive irrigation requirement (CIR), for every farm and each crop in the water system. This is done by subtracting the total annual effective rainfall (Attachment H2) from the consumptive use:

$$CIR = U - Re \text{ (acre-feet/acre)} \tag{4}$$

where CIR = Consumptive irrigation requirement
U = Consumptive use
Re = Effective rainfall

The results of this calculation for the crops grown in Colfax County are provided in Table H-3. The method and results of the calculations for the planning region are discussed in more detail in Attachment H2.

A variation of this is the CIR_a method, used in cases in which the cropping pattern includes multiple-cropped acreage, that is, acreage in which two or more crops are produced in the same year. In this case, the CIR is multiplied by a ratio of the gross irrigated acreage to the net irrigated acreage to yield the CIR for the cropping pattern:

$$CIR_a = CIR\left(\frac{A_g}{A_g - A_m}\right) \tag{5}$$

where A_g = Gross acreage

A_m = Multi-cropped acreage

The results of these calculations provide a baseline consumptive water use per acre of irrigated land, which may then be used to assemble a detailed watering schedule, identify areas where additional efficiency can be achieved, and implement a billing system based on consumptive requirements.

Table H-3. Consumptive Irrigation Requirement for Crops Grown in Colfax Water Planning Region

Crop	Consumptive Use (inches)	Consumptive Irrigation Requirement [a] (inches)
Alfalfa	37.18	23.62
All other hay	34.04	20.48
Corn	23.57	10.01
Wheat	19.86	6.30
Oats	14.13	0.57
Barley	14.13	0.57
Sorghums	17.95	4.39
Dry beans	15.39	1.83

[a] Consumptive use less total annual effective rainfall

While the estimated consumptive use per acre is helpful in planning, the actual water consumption of individual users will need to be measured for billing and other purposes, such as helping growers carefully assess their irrigation supplies. Water use can be measured in the field using physical measurement devices such as flow meters and flumes placed throughout the management area. The most efficient water measurement system would evaluate flows at all points in the delivery system where a flow diversion takes place, including the diversions, canals, laterals, farm turnouts, and tailwaters. These measurements will provide a ledger sheet of deliveries and possibly returns from users down the conveyance system to the water management, thereby enabling a billing system by tracking water deliveries to individual users. Depending on the complexity of the management area, commercially available computer software or custom software may be required to track deliveries throughout the system.

H.2.2.2 Water Pricing

Billing procedures and rates must be directly correlated with water deliveries in order to provide an economic incentive for efficient water use. Designing a water pricing structure based on information on irrigated acreage, water application methods, growing season, and water use measurement will ensure that water costs are fair to all consumers. When developing the pricing structure, planners must ensure that revenues will be sufficient to cover operating costs and fund improvements or future development. The specific structure will be dependent on the objectives of the water management district.

Quantity-based charges based on blocked increments, or base price per unit of water sold up to a certain amount, encourage efficient water use when combined with increases in the unit price of water per delivery increase. Several tiers of unit prices per range of water quantity may exist within a pricing structure. Various pricing structures based on incentive pricing are discussed in more detail in the USBR *Incentive Pricing Handbook for Agricultural Water Districts* (1997a).

New Mexico water systems are currently charging between $10 and $50 per acre-foot of water delivered for agricultural purposes. These amounts need to be compared with those charged in other states for water used in similar systems. Some systems in Colfax County also charge a user, member, or shareholder fee. Once appropriate levels of fees are determined, collection must then be addressed. Some systems adopt a policy stating that those who do not pay their fees will be penalized for non- or late payment, and continued non-collection of fees for a given period could result in water cutoff.

H.2.2.3 Scheduling

Properly scheduling water deliveries provides for the allocation of water in accordance with actual and projected crop use, rainfall, cultural practices, delivery system carrying capacity, and field irrigation characteristics. Demands for water within an irrigation district are based on crop production, planning, and scheduling decisions made at the farm level and are variable even within a farm due to crop selection, irrigation techniques, and soil characteristics. System-wide irrigation scheduling bases the timing of water deliveries on the aggregated needs of individual on-farm requirements. System-wide scheduling requires information on crop water requirements, soil moisture, acreage for each type of crop grown, and ET rates in order to forecast water requirements for the entire system.

On-farm irrigation scheduling must coincide with system-wide scheduling to maintain crop and soil appearance and water availability and to determine ET rates and allowable soil moisture depletions. Seasonal variations in ET rates and precipitation will affect the irrigation schedule, and adjustments will have to be made to accommodate both water requirements and conservation objectives.

Several computer programs based on climate information and soil conditions may aid the district in forecasting irrigation needs. One such program is the California Irrigation Management Information System (CIMIS), developed by the California Department of Natural Resources, which uses automated weather stations to provide up-to-the-minute ET information. Yet another system, developed especially for personal computers, uses soil moisture probes to forecast irrigation needs. Examination of available information management systems, water budgeting, and climate patterns will help determine the best management practices with regard to irrigation scheduling.

H.2.3 Infrastructure Improvements

Water lost between a point of withdrawal and the point of application can be significant. These inefficiencies cause unnecessary water supply shortages that in turn result in idle or fallow acreage, limiting the crops grown on farms, ranches, and wildlife refuges, and reducing agricultural income. Identifying and adopting water management measures and improving off- and on-farm infrastructure will increase efficiency, conserve water, and result in higher agricultural incomes.

Canals, laterals, and reservoirs experience significant water losses due to seepage, leakage, evaporation, and transpiration by plants growing near the unlined channels and laterals. Wilson and Lucero (1997) estimate off-farm canal losses at 37 percent on average throughout the state of New Mexico. Many factors affect seepage and evaporative losses, including soil characteristics, silt deposition, water depth and surface area, water velocity, depth of groundwater, and ground slope. Characteristics that indicate significant seepage losses include visible seepage, water logging on adjacent properties, presence of riparian phreatophytes, and return flow problems.

Lining canals, laterals, and reservoirs, installing piping systems (rather than channel delivery systems), or increasing storage capacity will increase the efficiency of energy use and water use, production, and distribution, and may reduce water losses to less than 10 percent in some instances. A reevaluation of conveyance systems on a county-wide basis may be of some benefit in identifying opportunities for implementing these improvements to gain efficiencies in distributory canals that may serve more than one water user. The various options for reducing conveyance water losses are discussed in Sections H.2.3.1 through H.2.3.3.

H.2.3.1 Canal Lining

Lining canals improves system efficiencies while increasing delivery and possibly improving water quality. Additional benefits are reduced maintenance, increased safety, and reduced erosion. Canal lining systems can also be built in a manner that does not degrade the aesthetics in and around suburban areas. Perforated or semipermeable linings can be installed in some reaches of canals to promote and maintain desirable vegetation; however, the steering committee indicated that this may not be necessary in Colfax County

The degree of seepage loss reduction due to canal lining depends on the site characteristics and type of lining used. Common methods and materials used for canal linings are concrete, plastic linings, and clay or soil sealant (Table H-4). Because many factors influence the type of lining chosen, no single lining can be recommended to correct all seepage loss situations. In addition to initial installation costs, other factors to consider in decisions regarding lining materials are their effectiveness, durability, and maintenance costs (Table H-5).

Table H-4. Conceptual Cost Estimate for Distributory Canal Lining
Colfax Water Planning Region

Description	Lining Material ($/sq ft)				Subgrade Preparation ($/sq ft)	Installation ($/sq ft)	Overhead and profit (%)	Total ($/sq ft)
	Geomembrane	Geotextile	Shotcrete	Other costs				
4-mil PE geocomposite with polyfiber-reinforced shotcrete cover	0.30	---	0.87	0.06	0.26	0.65	17	2.50
30-mil VLDPE textured geomembrane with 16-ounce geotextile cushion and unreinforced shotcrete cover	0.25	0.12	0.87	None	0.26	0.65	17	2.52
40-mil PVC with 3-inch grout-filled mattress	0.35	---	0.65	0.45	0.12	0.60	17	2.54
Exposed 80-mil HDPE textured geomembrane	0.70	0.12	---	---	0.26	0.10	17	1.38
3-inch Unreinforced grout-filled mattress	---	---	0.65	0.45	0.04	0.50	17	1.92
Spray-applied polyurethane foam with Urethane 500/550 protective coating	---	---	---	2.41	0.04	1.25	17	4.33
Shotcrete, steel fiber-reinforced, 25 lb/yd^3	---	---	1.08	0.11	0.04	0.65	17	2.20
Shotcrete, polyfiber-reinforced, 1 lb/yd^3	---	---	1.08	0.06	0.04	0.65	17	2.14
Unreinforced shotcrete	---	---	1.08	---	0.04	0.65	17	2.07
Exposed GCL, Bentomat DN	0.29	---	---	---	0.26	0.10	17	0.76

Source: USBR, 2001.
$/sq ft = Cost per square foot
PE = Polyethylene
--- = Not used
VLDPE = Very low density polyethylene
PVC = Polyvinyl chloride
HDPE = High density polyethylene
lb/yd^3 = Pounds per cubic yard
GCL = Geosynthetic clay layer

Table H-5. Performance and Maintenance Characteristics of Selected Lining Materials

Type of Lining	Effectiveness in Reducing Seepage (%)	Durability (years)	Maintenance ($\$/ft^2/yr$)
Concrete	70	40-60	0.005
Exposed geomembrane	90	20-40	0.01
Fluid-applied geomembrane	90	10-20	0.01
Concrete with geomembrane underliner	95	40-60	0.005

Source: USBR, 1999
$\$/ft^2/yr$ = Cost per square foot per year

Lining main and off-farm distributory canals (D-canal) on each system in Colfax County is the best solution to conserve water and increase system efficiencies. Table H-6 summarizes the D-canals in Colfax County, provides a rough estimate of costs to line 67 percent of all D-canals in each system in the county, and illustrates potential water savings throughout the county. The costs in Table H-6 are based on the following assumptions:

- Although it is recommended that 100 percent of the canals eventually be lined to maximize conservation savings, for the purpose of developing a preliminary estimate of potential savings, it was assumed that 67 percent (two-thirds) of the canals would be lined. Operational or financing issues may prevent lining of all canals, but a significant amount of savings can still be realized through lining 67 percent of the canals.

- Lining of D-canals would reduce the percentage of water lost to approximately 20 percent (irrigators interviewed estimated that current water losses in Colfax County canals are greater than the 37 percent average for the entire state).

- The estimated per-foot construction cost for a soil-stabilized base, shotcrete-type lining is $22.77 ($2.20 [Table H-4] times 9 square feet of canal area per linear foot plus a 15 percent contingency). (This unit cost would decrease as the amount of lining footage increases.)

Table H-6. Estimated Distributory Canal Details
Colfax Water Planning Region
Page 1 of 2

Source	Diverter	Approximate Irrigated Area (acres)	Estimated Amount of Water Diverted [a] (ac-ft)	Estimated Total Length of D-Canals (feet)	Estimated Total D-Canal Water Losses (ac-ft)	Estimated Cost for Lining 67% of D-Canals ($)	Estimated Total Water Saved (ac-ft)
Ponil Creek	Chase Ranch Ditch	308	462	12,320	171	187,953	92
	Antelope Valley Irrigation Ditch	5,000	7,500	200,000	2,775	3,051,180	1,487
	Subtotal	5308	7,962				
Rayado Creek	North and South Abreu Ditches	478	717	19,120	265	291,693	142
	Farmers Development Company	6,500	9,750	260,000	3,608	3,966,534	1,934
	Antonio Jose Valdez Ditch	95	143	3,800	53	57,972	28
	Valdez-Porter Ditch	440	660	17,600	244	268,504	131
	Miami Water Users Association	150	225	6,000	83	91,535	45
	Subtotal	7663	11,495				
Wheaton Creek	Upper Wheaton Ditch	6	9	240	3	3,661	2
	Upper Lucero Ditch	25	38	1,000	14	15,256	7
	Lower Lucero Ditch	36	54	1,440	20	21,968	11
	Middle Lucero Ditch	4	6	160	2	2,441	1
	Neuraute Ditch	6	9	240	3	3,661	2
	Subtotal	77	116				
Chico Rico Creek	Red River Irrigation Company	180	270	7,200	100	109,842	54
	Subtotal	180	270				
Canadian River	Stockton Ditch	369	554	14,760	205	225,177	110
	Subtotal	369	554				
Vermejo River	Vermejo Conservancy District	7,400	11,100	296,000	4,107	4,515,746	2,201
	Subtotal	7,400	11,100				

[a] Assumes an irrigation duty of 1.5 acre-feet (ac-ft) per acre (although this amount is not always available; however, estimates based on this assumption provide the maximum amount that could be withdrawn).

Table H-6. Estimated Distributory Canal Details
Colfax Water Planning Region
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Source	Diverter	Approximate Irrigated Area (acres)	Estimated Amount of Water Diverted [a] (ac-ft)	Estimated Total Length of D-Canals (feet)	Estimated Total D-Canal Water Losses (ac-ft)	Estimated Cost for Lining 67% of D-Canals ($)	Estimated Total Water Saved (ac-ft)
Ute Creek	Ute Creek Irrigation Company	349	524	13,960	194	212,972	104
	Subtotal	349	524				
Cimarron River	Charles Springer Cattle Company	8,000	12,000	320,000	4,440	4,881,888	2,380
	Old Mill Ditch	68	102	2,720	38	41,496	20
	Clutton-Maxwell Ditch	112	168	4,480	62	68,346	33
	Porter-Morley Ditch	424	636	16,960	235	258,740	126
	Springer Ditch Company	7,500	11,250	300,000	4,163	4,576,770	2,231
	C S Main Canal	5,661	8,492	226,440	3,142	3,454,546	1,684
	North C S Canal	566	849	22,640	314	345,394	168
	Subtotal	22,331	33,497				
Bonita Creek	Bonita Ditch	16	24	640	9	9,764	5
	Subtotal	16	24				
Total		43,693	65,540	1,747,720	24,250	26,663,042	12,998

[a] Assumes an irrigation duty of 1.5 acre-feet (ac-ft) per acre (although this amount is not always available; however, estimates based on this assumption provide the maximum amount that could be withdrawn).

- For every irrigated acre in each system, there are 40 feet of D-canals. This figure is based on known D-canal lengths in the Vermejo Irrigation District (47 feet of D-canal per acre over the entire system) and nine other acequias included in a recent study of the Santa Cruz Irrigation District (SCID) (37 feet of D-canal per acre irrigated) (DBS&A, 2002).

The information in Table H-6 is intended to provide an overview of costs and potential water savings in Colfax County. However, each system needs to address this issue individually.

H.2.3.2 Piping

Similar seepage reduction benefits may be accomplished through the replacement of unlined conveyances with piping, which also has the benefits of system pressurization and reduction of evaporative losses. Piping may be constructed of an assortment of materials such as polyethylene, polyvinyl chloride (PVC), corrugated metal, cast-in-place concrete, and reinforced concrete. Again, the selection of material depends largely on the site-specific conditions, hydraulic considerations, and material availability and cost.

In theory, closed conduits or piping systems as an alternative irrigation water conveyance offer even more water savings than canal lining systems. Although lined canals eliminate or greatly reduce seepage, they still allow water evaporation losses, while in a piped irrigation system, evaporation can be largely diminished. Other factors that must be addressed, however, when considering the use of pipes as irrigation water conveyances are more intensive irrigation system design, increased construction quality control, more thorough operations and maintenance, and overall cost issues.

Piped off-farm systems also demand the construction and recurring operation and maintenance of desiltation basins (sand traps) at the system intake structure in order to prevent to the extent possible all debris and sand from entering the pipes. If this issue is not addressed, piping systems can become seriously clogged and extremely difficult to troubleshoot. In this instance, off-farm irrigation piping systems require the planning, design, and construction of pipe cleanout structures that can allow access to short reaches of the pipe to carry out maintenance.

Considering these issues, it is difficult to compare the use of pipe systems as an alternative to canal lining systems as a measure to improve water conveyance efficiency. A straight comparison in terms of cost per linear foot for the piped alternative must include the distributed costs over the entire length of the irrigation system for greater design time, more intensive construction inspection, design and construction of desilting and debris chambers and their follow-on operation and maintenance, and the cost for pipe cleanouts.

Typically, piping in irrigation systems is used in canal reaches where maintenance due to adjacent cut/fill slope erosion is an issue, on difficult access sections, or for certain special structures such as intake-sections, siphons, and cross drainage works. Because of the increased operations and maintenance time required, piping may be a more feasible option for smaller on-farm canal systems where individual farmers are more easily able to devote intensive operation and maintenance to their water conveyance systems.

H.2.3.3 Increased Storage Capacity

In Colfax County, the larger irrigation districts rely on storage reservoirs for flow augmentation and equalization. These reservoirs, which are often isolated and self-contained, are the focal point for demands by the conveyance system. Additional infrastructure improvements such as installing reservoir lining, dredging reservoirs, or constructing additional reservoirs can achieve increased water efficiency and conservation:

- As with canal lining, lining reservoirs will provide erosion control, reduced percolation, increased safety, and potential regulation and increased storage.

- Dredging reservoirs on a periodic basis to remove debris from the storage system will increase reservoir capacity and eliminate many operating problems, including controlling aquatic growth that consumes water and reducing sedimentation along the conveyance system.

- The construction of additional reservoirs will also increase storage capacity, amassing a more reliable source of water supply in addition to increasing the water delivery capacity.

Many of the reservoirs in Colfax County are 25 to 50 percent full of sediment. Dredging these during dry years would be extremely beneficial in increasing the irrigation water for all users, while failing to do so will result in continued sedimentation and the continued incremental reduction of water available each year. As discussed in Section 8.3, however, costs of dredging need to be compared to the costs of new storage to determine the most viable option for each system.

Reservoir dredging is expensive and time-consuming. Successful operations will require the construction of bypass canals around these reservoirs while they are out of service. In addition, nearby spoil areas must be located within 2,000 feet of each reservoir to stockpile excavated material. Removal of all the accumulated sediment from a reservoir whose capacity is 3,000 acre-feet but is 40 percent filled by sediment is estimated to cost close to $4 million; a small portion of this cost could be recouped by using the dredged sediment as fill dirt for other construction activities within the county. Such a dredging project would take about six months to complete, excluding the planning and design phase. Nevertheless, a program of repairing these reservoirs over, for instance, a 10-year period may make sense. Additional information on reservoir dredging is included in Section 8.3 of the main body of this Regional Water Plan.

H.2.4 On-Farm Improvements

Several more recently developed on-farm technologies are available to increase the efficiency of production agriculture irrigation systems (many of these techniques are used by farms in southern Colorado). While they appear attractive and do save significant quantities of water, their introduction in Colfax County's irrigation systems should be looked upon as a third step in system improvement, behind the development of viable and meaningful water management plans and off-farm infrastructure needs (Sections H.2.2 and H.2.3). Some farms in Colfax County may benefit from these technologies; however, the widespread application of such on-farm techniques may be years away. Nevertheless, individual farmers who find that improvements such as gated piping and more efficient sprinkler systems provide significant water savings in their operations may choose to implement on-farm measures at any time. For future planning purposes, these technologies are summarized below and discussed in more detail in Attachment H3.

- *Surge valves:* For some fields currently using furrow irrigation, surge valves can be added to increase application efficiencies and reduce deep percolation losses of irrigation water. The principle behind surge irrigation is to apply water in spurts or surges interspersed with “soaking” periods that allow the water to percolate into the soil before the next application. This method of irrigation advances the water more quickly and efficiently through the field than continuous irrigation. Surge valves typically improve furrow irrigation efficiency by an average of 10 to 40 percent, depending on soil type, land slope, and the length of the runs, and some growers have cut irrigation amounts by as much as 50 percent. Given these and other benefits (Attachment H3), surge irrigation is relatively inexpensive. However, the use of surge valves requires more farmer time and daily adjustment, and irregularities in farm topography, which can be covered by flood irrigation, are not compatible with surge techniques (Attachment H3). In Colfax County, many of the fields would not be suitable for surge irrigation without leveling.

- *Gated piping:* Pipeline conveyance systems, either underground or aboveground, are often installed to reduce labor and maintenance costs, as well as water losses to seepage, evaporation, spills, and non-crop vegetative consumption. One form of aboveground pipeline, gated pipe, distributes water to gravity-flow systems from individual gates (valves) along the pipe. In this method of irrigation, a moveable plug passes slowly through a long section of gated pipe, causing water to gradually cease flowing into the first rows irrigated as the plug progresses down the pipe. Improved water management is achieved by varying the speed of the plug, which controls the timing of water flows into each furrow.

- *Sprinkler systems:* Sprinkler systems are well suited for germinating seed and establishing ground cover for crops like lettuce, alfalfa, and sod because they can provide the light, frequent applications that are desirable for this purpose. Many types of sprinkler devices/systems are available today, including rotating head sprinklers (apply water in circular pattern), low-pressure spray nozzles (often used on center pivot and linear move systems or in orchards), under-tree rotating heads that keep the spray below tree foliage, and perforated pipe that sprays water from small-diameter holes in pipes. Land leveling is not normally required, thus making sprinkler irrigation easier to apply in Colfax County than other methods such as surge valves.

- *Drip/micro-irrigation systems:* Drip/micro-irrigation methods can conserve water because they deliver water directly to the root zone through emitters placed along a water delivery line (typically a polyethylene hose). Drip/micro-irrigation systems are of three main types: (1) aboveground drip systems, (2) buried drip systems, and (3) aboveground microspray and microsprinkler systems.

- *Soil treatments:* Water available to plants depends not only on the amount of rainfall and/or irrigation, but also on the physical, chemical, and biological properties of the soil. Soil characteristics such as structure, density, and amount and type of organic content can severely restrict the downward percolation of water into the soil. In situ moisture conservation, in which all rainfall is conserved where it falls and no runoff is permitted, can be achieved through covers or mulches, soil tilling, contour cultivation, and terracing. Such moisture conservation measures should be encouraged on lands with marginal rainfall.

- *Crop management:* Crop management can be used to reduce water losses and optimize water use in any farming system. Planting density and crop mix have an effect on the hydrologic characteristics of the system. Increased plant density can increase the soil cover by crops and thus decrease evaporation losses (although it can also increase water uptake from the soil). Mixing plants that use moisture mainly from the top layer with plants such as fruit and other trees that tap water beyond the reach of the annuals may yield more abundant crop production while protecting critical top soils.

Further information on the irrigation methods described above is available in the manual *Selection of Irrigation Methods for Agriculture*, prepared by the On-Farm Irrigation Committee of the Irrigation and Drainage Division of the American Society of Civil Engineers (Burt et al., 2000). This manual also discusses other types of irrigation systems not covered in this report.

H.3 Financing of Agricultural Conservation Programs

The cost of water conservation improvements such as canal lining, reservoir dredging, and gated piping often deters irrigation associations from maximizing their water efficiency. In determining whether the cost of improvements warrants financing, it is useful to compare the cost of the improvements versus the value of the water, that is, how much the water is worth. The value of a crop at market and the quantity of water needed to produce that crop can be analyzed to assign a dollar value to each acre-foot of water. Once this dollar value has been determined, a cost/benefit analysis can be done for each water conservation improvement alternative to help an irrigation association decide what improvements are most worthwhile to undertake. An example of a cost/benefit analysis for selected infrastructure improvements is provided in Sections H.3.1 through H.3.5.

H.3.1 Cost of Improvements

The costs of the most promising infrastructure improvements (Sections H.3.3) are:

- *Canal lining:* According to a June 2001 report by the USBR (2001), canal lining can cost between $0.76 and $4.33 per square foot depending on the lining material, which ranges from bentonite clay lining to impervious plastics, and method of application. Table H-4 shows a sample of some of the lining costs from the USBR report (2001).

- *Reservoir dredging:* The greatest variable in the cost of reservoir dredging is the transportation of the spoils off-site. The conceptual cost for the dredging ranges from $3,000 to $14,000 per acre-foot of sediment removed. The cost range depends on the type of dredging used and the location of sediment disposal (on- or off-site).

H.3.2 Water Savings from Improvements

Canal lining can virtually stop canal loses due to water seepage. Concrete lining has been shown to reduce seepage by 85 percent, while concrete combined with a plastic geomembrane reduces seepage by 95 percent (USBR, 1999). Most of the Colfax County irrigation associations interviewed for this analysis estimated their water loses from the ditch to be around 50 percent. An irrigation district in Colfax County could, therefore, theoretically increase their available water supply significantly by installing concrete liners. Section H.2.3.1 projected a 20 percent savings of withdrawn water lost to seepage by lining just 67 percent of all D-canals. This calculation assumed that current seepage losses are 37 percent; an even greater water savings would be realized if current seepage losses are actually closer to 50 percent.

Even more water can be saved if linings are installed on main canals and on large on-farm canals. Every amount of water saved allows more acreage to be irrigated and/or allows more water to be applied to existing acreage. Since Colfax County irrigators routinely receive substantially less water than their water right allotments, saving water will not result in a loss of the water right but rather will allow the fulfillment of the right.

Water supplies are increased directly by adding new storage capacity or by dredging reservoirs. A larger reservoir can deliver more water to downstream users. The irrigation associations interviewed estimated that siltation of the reservoirs had decreased their capacity by approximately 25 to 50 percent. By dredging the reservoirs to original volumes, irrigation associations could deliver almost double the amount of water they are delivering now.

On-farm irrigation improvements such as gated piping and surge valves have been shown to decrease water use by 50 percent. Using modern farming techniques could allow farmers to double the acreage they are irrigating or plant higher-value crops that require more water.

H.3.3 System Improvement Cost/Benefit Analysis

A cost/benefit calculation consists simply of dividing the benefits (water savings expressed in dollars) of the project by the costs of the project. If the cost/benefit ratio is less than one, the cost of the project outweighs the benefits; if the resulting ratio is greater than one, the benefits of the project are greater than the costs. The larger the cost/benefit ratio, the more beneficial the project.

The first step in the cost/benefit evaluation is to determine the value of water in dollars. Each irrigation association can decide what value they want to assign to the water. This may be based on the market value of water rights, the amount each user pays in water fees, or the value of the crop produced with the water. Once the value of water has been determined, the next step is to determine how much water a given improvement will save each year. Water savings from canal lining and reservoir dredging are discussed in Section H.3.2. Other resources such as the USDA and vendors of irrigation products can provide estimates of water savings from various improvements.

When the water savings from a given technology is determined, the value of the water can be multiplied by the quantity of water saved. This value is the “benefit” of implementing the technology for a year.

Next, the “cost” of the improvement will be calculated. By knowing the initial costs, design life, and maintenance costs of any given improvement, the life-cycle cost ($/yr) can be calculated. The benefit cost in water savings can then be divided by the life-cycle cost of the improvement to determine the cost/benefit ratio.

External investors, including federal and state funding sources, will use such techniques when making decisions about funding and levels of funding any project. Another factor that will come into play is the future prospects for the long-term viability of the irrigation system itself. Adopting water management and conservation plans, charging correct prices for water use, and using innovative techniques such as water banking are signals to investors that their funds will be going to systems where there is forward thinking and a greater likelihood of future successes.

H.3.4 Benefits of Increased Water Supply

With a greater supply of irrigation water, farmers could increase their irrigated acreage and/or increase the water applied to existing farmed land. By planting more crops, farmers have the opportunity to increase annual incomes. In their interviews with DBS&A, irrigation associations in Colfax County indicated that the type of crops grown was dependent on the amount of water available. If additional water supplies were available, farmers would have the option to plant higher value crops that require more water or are not as drought tolerant.

Typical crops grown throughout the state of New Mexico in the year 2000, along with their value, are outlined in Table H-7.

The most efficient use of the available resources can be determined through an evaluation of the types of crops that can be grown in Colfax County's climate, the amount of water required to grow these crops, and the value these crops would bring at market.

Table H-7. Value of Typical Crops Grown in New Mexico in 2000

Crop	Average Yield per Acre	Market Price per Unit ($)	Value per Acre ($)
Wheat	24 bushels	2.65	63.60
Hay	4.39 tons	120.00	526.80
Alfalfa	5.2 tons	122.00	634.40
Sorghum	25 bushels	2.05	51.25
Corn	160 bushels	2.50	400.00
Potatoes	385 Cwt.	4.25	1,636.25
Chile	5.2 tons	494.00	2,568.80
Onions	460 Cwt.	9.25	4,255.00
Pecans	1,180 pounds	1.37	1,616.60

Source: NMDA, 2000 Cwt. = 100 weight (100 lb)

H.3.5 Sources of Funding

Water conservation projects can be expensive, but social, economic, and environmental benefits are realized when great and steady supplies of water are available. Because of these benefits, state and federal agencies provide funding to assist irrigation associations with water conservation improvements, including infrastructure improvements and technical assistance. Prior to developing a capital project plan, it is recommended that an irrigation system study its existing and future operations, including its potential to remain viable through the engagement of new farmers and the planting of crops that bring a reasonable rate of economic return. The more prepared an applicant system is in terms of its management and planning, the better it will do when seeking external funding for any improvement.

Some of the major sources of funding are listed below:

- The U.S. Army Corps of Engineers offers a funding program for irrigation system infrastructure improvements. This program consists of a 75 percent grant for projects such as canal lining, reservoir dredging, and flow control and measuring appurtenances. The program works in conjunction with a similar program offered by the New Mexico Interstate Stream Commission (ISC) that assists systems taking advantage of the Corps program. The ISC program provides grant funding for an additional 15 percent of a given project's improvements, leaving just 10 percent of the total cost to be funded by the irrigation organization.

- Low-interest loans are available to systems through the New Mexico Finance Authority (NMFA) and the USDA. These loans could provide funds for the 10 percent not covered by the above funding.

- The USBR offers various project funds in grants and loans for all types of infrastructure projects.

- The State of New Mexico Water Trust Board funds selected water projects in New Mexico.

- The State of New Mexico Capital Outlay Program offers grant funds for approved projects that are championed by local State representatives and senators.

- The NRCS Environmental Quality Incentives Program provides financial and technical assistance to farmers and ranchers to implement structural and management conservation practices on eligible agricultural land.

H.4 Summary and Recommendations

Based on the information in this section, DBS&A offers the following recommendations:

- For some time, irrigation systems in the county have not received their normal allotment of water in order to provide their share of diverted water rights to their users. In many cases this shortage is a result of system inefficiencies, due in part to irrigation infrastructure that is in need of repair, and significant amounts of water are lost in off-farm delivery structures, particularly in canals. The successful repair of and improvements to this infrastructure would address much of this problem.

- These off-farm system repairs and improvements should be the initial focus of conservation efforts.

- Irrigation system management in all county systems is hampered by lack of user participation and funds. This situation requires further study with the recognition of the types of farming now ongoing in the county and with a view to a desired vision of future farming in each system. Each system needs to develop a picture of its future through such studies and then develop appropriate water management and water conservation plans.

- Each system should name a Water Conservation Officer who is or becomes educated in water conservation techniques that can work for each of the individual systems today as well as those that might be applicable tomorrow.

- Each system should develop a workable management plan for today and the future and a capital improvement plan to correct off-farm canal losses and repair existing reservoir impoundments through dredging of accumulated sediment. The capital improvement plan can serve as the basis for obtaining external funding for its projects.

- Each system should seek legal advice on water banking within its own system boundaries or perhaps within county boundaries. An acceptable system or county-wide water banking program could help conserve farm water now without any physical/structural or programmatic improvements.

- A user education program on water conservation and irrigation system management needs to be undertaken to help farmers in Colfax County understand the issues that face the future of farming in the county so they can make sound decisions on issues that can improve and sustain the county's farming future. Such an education program might also attract younger and new farmers into Colfax County agriculture in the future.

- Reservoir dredging should be undertaken if funds are available. Increasing storage in the area will provide for improved water management.

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Attachment H1

Historical Irrigated Acreage in Colfax County

Attachment H1. Historical Irrigated Acreage in Colfax County

Year	Crop (acres)									Total Crop Acreage [a]	Irrigable Acreage [b]	Acreage Actually Irrigated [c]
	Wheat	Alfalfa Hay	All Other Hay	Corn	Sorghum	Oats	Barley	All Dry Beans	Other			
1957	340											
1958	760											
1959	1,400	6,500	12,500	1,200	350	1,550	700	50		24,250		
1960	1,400	5,800	11,700	1,000	300	2,000	870	50		23,120	36,740	
1961	1,500	6,600	14,000	850	600	1,200	1,050	50		25,850		
1962	1,500	7,200	12,800	250	600	1,450	750	50		24,600		
1963	1,600	8,500	11,900	200	500	1,300	50	50		24,100		
1964	1,100	7,200	10,000	150	500	400	100	50		19,500		
1965	1,000	6,200	13,800	550	400	110	50	50		22,160		
1966	2,500	5,800	10,200	430	500	30	100			19,560		
1967	2,000	5,900	10,600	730	500		100			19,830		
1968	1,500	5,600	10,600	500	450		150			18,800		
1969	760	10,000	7,000	170	200		390	20		18,540		
1970	800	11,100	7,900	400	200		150	20		20,570	34,780	
1971	400	9,000	5,000		200		40			14,640		
1972	1,200	8,700	4,500		50		330			14,780	33,200	
1973	1,200	8,800	4,700	390	30		800			15,920	33,200	
1974	1,200	8,800	3,100	300			150			13,550	33,200	
1975	1,350	8,700	3,900	200			250			14,400	33,200	
1976	1,500	7,500	4,000	350			50			13,400	33,200	
1977	1,500	8,000	5,000	250			70			14,820	33,200	
1978	1,150	8,000	5,000	150	50		30			14,380	33,200	

Source: NMDA, 1962-1998; USDA, 1999

[a] Total acres of all crops for which data exist

[b] Includes crops irrigated, crops planted on irrigated land but not irrigated, and idle and fallow land in crop rotation.

[c] Includes total acres actually irrigated (for which data are available).

Attachment H1. Historical Irrigated Acreage in Colfax County

Year	Crop (acres)									Total Crop Acreage [a]	Irrigable Acreage [b]	Acreage Actually Irrigated [c]
	Wheat	Alfalfa Hay	All Other Hay	Corn	Sorghum	Oats	Barley	All Dry Beans	Other			
1979	1,400	8,000	5,000	110	500		310			15,320	33,200	
1980	1,400	7,500	5,500	100	80		150			14,730	33,200	
1981	3,000	10,700	4,100	50			100		5,160	17,950	33,200	23,110
1982	2,900	6,500	4,300	400	20		100		5,150	14,220	33,200	19,370
1983	1,750	6,500	5,900	40	70		60		4,370	14,320	33,200	18,690
1984	1,200	8,000	6,500	100			50		2,660	15,850	33,200	18,510
1985	1,350	8,000	5,000	100	100		100		5,490	14,650	30,800	20,140
1986	1,300	8,000	4,400	50			300		5,470	14,050	30,800	19,520
1987	1,400	8,500	4,000	50			100		2,345	14,050	30,800	16,395
1988	2,100	8,500	3,500	50					7,225	14,150	30,800	21,375
1989	2,100	8,500	3,700	50					6,205	14,350	30,800	20,555
1990	1,000	9,000	4,000	50					5,905	14,050	30,800	19,955
1991	1,000	9,000	4,000						5,905	14,000	30,800	19,905
1992	1,200	9,000	4,000						6,955	14,200	30,800	21,155
1993	1,200	9,300	4,000						6,505	14,500	30,800	21,005
1994	1,000	9,500	3,800						5,350	14,300	30,800	19,650
1995	900	9,300	5,000						4,530	15,200	30,800	19,730
1996	1,400	9,800	4,500						5,255	15,700	30,800	20,955
1997	1,000	9,800	7,700						2,355	18,500	30,800	20,855
1998	1,250	10,100	7,100		450				925	18,900	30,800	19,825

Source: NMDA, 1962-1998; USDA, 1999
[a] Total acres of all crops for which data exist
[b] Includes crops irrigated, crops planted on irrigated land but not irrigated, and idle and fallow land in crop rotation.
[c] Includes total acres actually irrigated (for which data are available).

Attachment H2

Calculation of Consumptive Irrigation Requirement

Attachment H2. Calculation of Consumptive Irrigation Requirement for Crops Typically Grown in Colfax Water Planning Region

Agricultural consumptive use of water is not directly measured, but is instead estimated based on a model of crop water needs. For the Colfax regional water planning study, consumptive irrigation uses were estimated using the Blaney-Criddle method (Blaney and Criddle, 1950, 1962). Consumptive use (U) is calculated using the formula:

$$U = K\left(\frac{t * p}{100}\right) \quad (1)$$

where: K = Seasonal consumptive use coefficient

t = Mean monthly air temperature in degrees Fahrenheit

p = Monthly percentage of annual daylight hours

Values for mean monthly air temperature (averaged for 70 to 80 years) were obtained from Kunkel (1984), and monthly percentages of annual daylight hours were obtained from Blaney and Hanson (1965). Both are listed in Table H2-1 along with the calculated monthly consumptive use factor ((t * p)/100).

Table H2-1. Monthly Consumptive Use Factor in Colfax Water Planning Region

Month	Air Temperature (°F)	Percentage of Annual Daylight Hours	Monthly Consumptive Use Factor
January	29.2	6.96	2.03
February	33.7	6.84	2.31
March	40.4	8.35	3.37
April	49.4	8.86	4.38
May	58.7	9.84	5.78
June	67.5	9.86	6.66
July	71.0	10.02	7.11
August	70.4	9.42	6.63
September	62.7	8.37	5.24
October	51.9	7.84	4.07
November	39.4	6.90	2.72
December	30.7	6.76	2.07

The seasonal consumptive use coefficient (K) varies for each crop and with each season. Table H2-2 lists the growing season for each crop, the frost-free period for Colfax County, the K values for each crop during the frost and frost-free period, and the resulting consumptive use for each crop.

Table H2-2. Consumptive Use for Crops Grown in Colfax Water Planning Region

Crop	Growing Season	Frost-Free Period	Consumptive Use Coefficient (K)		Consumptive Use
			Frost-Free	Frost	
Alfalfa	5/10-10/3	5/10-10/3	0.85	0.50	37.18
All Other Hay	5/10-10/3	5/10-10/3	0.75	0.50	34.04
Corn	5/15-9/15	5/10-10/3	0.75	---	23.57
Wheat	9/15-7/1	5/10-10/3	0.70 [a]	0.35 [b]	19.86
Oats	3/15-7/10	5/10-10/3	0.70 [c]	---	14.13
Barley	3/15-7/10	5/10-10/3	0.70 [c]	---	14.13
Sorghums	6/1-9/29	5/10-10/3	0.70	---	17.95
Dry Beans	6/1-9/15	5/10-10/3	0.60	---	15.39

Source: Blaney and Hanson, 1965
[a] Period March 1 to harvest date.
[b] For months of September, October, November, January, and February.
[c] Between planting and harvesting dates.

K = Seasonal consumptive use
U = Annual consumptive use
Re = Effective rainfall
--- = Not provided

To obtain the annual consumptive use value (U) for each crop, the monthly consumptive use factor for each growing month (Table H2-1) is multiplied by the appropriate K value. The products for each growing month are then summed. An example of the calculation for wheat (winter small grains) is given below.

- According to Blaney and Hanson (1965) the frost-free K value should be used for the months of March, April, May, and June. The K for the frost period should be used for the months of September, October, November, January, and February. Therefore, the calculation of consumptive use for wheat is:

$$U = (3.37 + 4.38 + 5.78 + 6.66) * 0.70 + (5.24 + 4.07 + 2.72 + 2.03 + 2.31) * 0.35 = 20 \quad (2)$$

To obtain the total water demand required by each crop, the effective rainfall (Re) must be subtracted from the consumptive use. Re can be determined based on the mean monthly precipitation (R) using a method developed by the U.S. Bureau of Reclamation (USBR). The USBR formulas are provided in Table H2-3.

Table H2-3. U.S. Bureau of Reclamation Formulas for Calculating Effective Rainfall

Monthly Rainfall (inches)	Effective Rainfall (inches)
R≤1	Re = 0.95 R
1<R≤2	Re = 0.95 + 0.90 (R–1)
2<R≤3	Re = 1.85 + 0.82 (R–2)
3<R≤4	Re = 2.67 + 0.65 (R–3)
4<R≤5	Re = 3.32 + 0.45 (R–4)
5<R≤6	Re = 3.77 + 0.25 (R–5)
R>6	Re = 4.02 + 0.05 (R–6)

R = Monthly rainfall Re = Effective rainfall

This evaluation used mean monthly precipitation values obtained from Kunkel (1984) and shown in Table H2-4. Re values were then calculated using the formulas in Table H2-3, and the results are shown in Table H2-4.

Table H2-4. Monthly Effective Rainfall in Colfax Water Planning Region

Month	Monthly Rainfall (inches)	Effective Rainfall (inches)
January	0.31	0.29
February	0.35	0.33
March	0.58	0.55
April	0.98	0.93
May	1.79	1.66
June	1.58	1.47
July	2.79	2.50
August	2.81	2.51
September	1.49	1.39
October	1.10	1.04
November	0.50	0.48
December	0.42	0.40
Total Annual Effective Rainfall		13.56

To determine the consumptive irrigation requirement (i.e., that part of the consumptive use not fulfilled by rainfall) for each crop (Table H2-5), the total annual effective rainfall of 13.56 inches was subtracted from the previously calculated consumptive use (Table H2-2).

Table H2-5. Consumptive Irrigation Requirement for Crops Grown in Colfax Water Planning Region

Crop	Consumptive Use (inches)	Consumptive Irrigation Requirement [a] (inches)
Alfalfa	37.18	23.62
All other hay	34.04	20.48
Corn	23.57	10.01
Wheat	19.86	6.30
Oats	14.13	0.57
Barley	14.13	0.57
Sorghums	17.95	4.39
Dry beans	15.39	1.83

[a] Consumptive use less total annual effective rainfall

These results indicate that it takes approximately 40 times more water to irrigate alfalfa than it does to irrigate small spring grains such as oats and barley.

References

Blaney, H.F., and W.D. Criddle. 1950. *Determining water requirements in irrigated areas from climatological and irrigation data.* SCS-TP-96, USDA, Soil Conservation Service, Washington, DC.

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Attachment H3

On-Farm Improvements

Attachment H3. On-Farm Improvements to Increase Irrigation Efficiency / Conserve Water

Several more recently developed on-farm technologies are available to increase the efficiency of production agriculture irrigation systems (many of these techniques are used by farms in southern Colorado). These technologies are discussed in Sections H3.1 through H3.6.

H3.1 Surge Valves

For some fields currently using furrow irrigation, surge valves can be added to increase application efficiencies and reduce deep percolation losses of irrigation water. The principle behind surge irrigation is to switch the water back and forth between irrigation sets using an automated valve. The valve may be set for different lengths of out-times, or times when water is applied to advance it through the length of run. At the end of this part of the irrigation cycle, the valve changes to shorter time lengths to switch back and forth between the sets, called "cutback" and "soaking" cycles. Correct out-times and cutback times minimize runoff (tailwater) and deep percolation.

This method of irrigation advances the water more quickly and efficiently through the field than continuous irrigation. Surge valves typically improve furrow irrigation efficiency by an average of 10 to 40 percent, depending on soil type, land slope, and the length of the runs, and some growers have cut irrigation amounts by as much as 50 percent.

Surge irrigation is an inexpensive method to adopt given its benefits of more uniform water distribution, reduced deep percolation, reduced tailwater, and reduced total irrigation. Although surge valves cost approximately $1,000 to 1,500 per valve, a surge valve may be used on one or more fields. Many Colorado irrigation districts have programs for farmers to assume loans to purchase surge valves.

The use of surge valves requires more farmer time and daily adjustment. Laser leveled fields are also usually required, as the principle behind surge irrigation is that water applied uniformly on a given area has time to percolate before the following application. Irregularities in farm topography, which can be covered by flood irrigation, are not compatible with surge techniques. In Colfax County, many of the fields would not be suitable for surge irrigation without leveling.

H3.2 Gated Piping

Pipeline conveyance systems are often installed to reduce labor and maintenance costs, as well as water losses to seepage, evaporation, spills, and non-crop vegetative consumption. Underground pipeline constructed of steel, plastic, or concrete is permanently installed, while aboveground pipeline generally consists of lightweight, portable aluminum, plastic, or flexible rubber-based hose that can be moved. One form of aboveground pipeline, gated pipe, distributes water to gravity-flow systems from individual gates (valves) along the pipe. One method of irrigation (commonly called “cablegation”) using gated piping involves the use of a moveable plug that passes slowly through a long section of gated pipe, with the rate of movement controlled by a cable and brake. Due to the oversizing and required slope of the pipe, water will gradually cease flowing into the first rows irrigated as the plug progresses down the pipe. Improved water management is achieved by varying the speed of the plug, which controls the timing of water flows into each furrow.

H3.3 Sprinkler Systems

Most crops can be irrigated with some type of sprinkler system, although crop characteristics such as height must be considered in system selection. Sprinkler systems are well suited for germinating seed and establishing ground cover for crops like lettuce, alfalfa, and sod because they can provide the light, frequent applications that are desirable for this purpose. Most soils can be irrigated with the sprinkler method, although soils with an intake rate below 0.2 inch per hour may require special measures. Sprinkler systems are useful for irrigating soils that are too shallow to permit surface shaping or too variable for efficient surface irrigation. In general, sprinklers can be used on any topography that can be farmed. Land leveling is not normally required, thus making sprinkler irrigation easier to apply in Colfax County than other methods such as surge valves.

There are some disadvantages to using sprinkler systems for irrigation. Sprinklers may require more pumping energy than other irrigation methods. They also require better quality (or filtered) source water than other surface irrigation methods, except for drip/micro-irrigation (Section H3.4). Sprinkler systems can be labor-intensive, especially systems that must be moved manually. If source water is salty, sprinkler methods that apply water to leaves may be unsuitable.

Many types of sprinkler devices and sprinkler systems are available today. Sprinkler devices include rotating head sprinklers (apply water in circular pattern), low-pressure spray nozzles (often used on center pivot and linear move systems or in orchards), under-tree rotating heads that keep the spray below tree foliage, and perforated pipe that sprays water from small-diameter holes in pipes. The more common types of systems include:

- *Hand-move or portable sprinkler systems* consist of a lateral pipeline, typically made of aluminum, with sprinklers installed at regular intervals. The lateral is operated in one location until sufficient water has been applied and is then disassembled and moved to the next position. Initial costs for this type of system are low, but the labor costs associated with moving the lateral lines are fairly high. These systems can be used on varying terrain and for most crops, except tall crops such as corn that make moving the lateral difficult.

- *Side roll systems* have lateral lines mounted on wheels, with the pipe forming an axle that is high enough to clear the crop as it is moved. A drive unit is used to move the system from one irrigation position to another by rolling the wheels. These systems are vulnerable to high winds and may be damaged or pushed long distances if not staked down.

- *Traveling gun systems* use a high-volume, high-pressure sprinkler "gun" mounted on a trailer and are commonly operated as continuous move systems, with the gun sprinkling as the trailer moves. Although appropriate for most crops, these systems are best used on coarse, permeable soils because of the large droplets and high application rates produced.

- *Center pivot systems* consist of a single sprinkler lateral supported by a series of self-propelled towers that allow the lateral to rotate around a pivot point (one end of the lateral) in the center of the irrigated area. A single revolution can range from a half day to many days. The length of the lateral affects the speed at which the end of the lateral travels as well as the size of the area irrigated by the end section. Because of this, the water application rate must increase with distance from the pivot to deliver an even application amount, and the high application rate at the outer end of the system may cause runoff on some soils. Also, because of the circular application area, the corners of the field are not irrigated unless special equipment is added to the system. Center pivots, which have moderate initial costs and low labor costs, can be used for most field crops.

- *Linear move systems* are similar to center pivot systems in construction except that neither end of the lateral pipeline is fixed. The whole line moves down the field in a direction perpendicular to the lateral and is designed to irrigate rectangular fields free of tall obstructions. As with the center pivot system, the linear move system is capable of very-high-efficiency water application. It requires high capital investments but low labor costs.

- *LEPA systems:* Low energy precision application (LEPA) systems are similar to linear move irrigation systems except the lateral line is equipped with drop tubes and very-low-pressure orifice emission devices that discharge water just above the ground surface into furrows. This distribution system is often combined with micro-basin land preparation for improved runoff control (and for retention of rainfall). High-efficiency irrigation is possible, but requires either very high soil intake rates or adequate surface storage in the furrow micro-basins to prevent runoff or non-uniformity along a furrow.

- *Solid set and permanent systems:* Solid set systems are similar to the hand-move lateral sprinkler system, except that they include enough laterals placed in the field to avoid the necessity of moving pipe during the season. The solid set system requires significant labor at the beginning and end of the irrigation season, but minimal labor during the irrigation season. A permanent system is a solid set system where the main supply lines and the sprinkler laterals are buried and left in place permanently (this is usually done with PVC pipe).

Attainable irrigation efficiencies for different sprinkler systems are listed in Table H3-1. More detailed descriptions of these systems are provided by Burt et al. (2000).

Table H3-1. Attainable Sprinkler Irrigation Efficiencies

System Type	Efficiency (%)
Hand-move or portable	65-85
Side roll	65-85
Traveling gun	60-75
Center pivot	75-90
Linear move	75-90
Solid set or permanent	70-80
Low energy precision application	80-93

Source: Burt et al., 2000.

As indicated in the above descriptions, labor requirements vary depending on the degree of automation and mechanization of the equipment used. Hand-move systems require the least degree of operational skill, but the greatest amount of labor. At the other extreme, center pivot, linear move, and LEPA systems require considerable skill in operation and maintenance, but the overall amount of labor needed is low.

Energy consumption relates to operating pressure requirements, which vary considerably among sprinkler systems. At the extremes, the LEPA systems may require only 15 pounds per square inch (psi), while the traveling gun system may require 100 psi or more. Other systems may use 30 to 60 psi, depending on the design of the sprinklers and the nozzles chosen.

Table H3-2 summarizes cost factors for sprinkler irrigation systems. Capital costs depend on the type of system and size of the irrigated area and include costs for the mainline and the pumping plant. All costs assume that water is available at ground level at the side of the field. Energy, labor, and maintenance costs are variable and the following items should be considered:

- Energy requirements in Table H3-2 may be used to estimate costs by applying the locally appropriate unit energy cost. A pump efficiency of 75 percent has been assumed.

- Operating labor costs vary by system type and local costs for labor. Table H3-2 gives typical values for labor hours required per acre-inch (gross) of irrigation water applied.

- Maintenance costs are difficult to predict, but the data in Table H3-2 may be used as an approximate guide. The annual maintenance cost is estimated by multiplying the initial capital cost of the system by the tabulated percentage factor.

Table H3-2. Sprinkler Irrigation System Costs

System Type	Field Size (acres)	Capital Cost [a] ($/acre)	Energy Use (kWh/ac-in)	Labor Required (hrs/ac-in)	Maintenance Cost Factor [b] (%)
Hand-move or portable	160	175-275	9-22	0.175	2
Side roll	160	325-450	9-22	0.123	2
Traveling gun	80	400-500	36-50	0.072	6
Center pivot:					
Without corner system	125-200	275-450	9-24	0.010	5
With corner system	150	400-500	10-25	0.010	6
Linear move (ditch fed)	320	450-525	9-24	0.021	6
Linear move (hose fed)	320	650-825	12-27	0.021	6
Solid set	160	1,100-1,300	9-22	0.103	2
Permanent	160	925-1,400	9-22	0.010	1

Source: Burt et al., 2000
[a] Capital costs given in terms of 1995 U.S. dollars.
[b] Annual maintenance costs are expressed as a percentage of the system capital cost.

$/acre = Cost per acre
kWh/ac-in = Kilowatt hours per acre-inch
hrs/ac-in = Hours per acre-inch

H3.4 Drip/Micro-Irrigation Systems

Drip/micro-irrigation methods can conserve water because they deliver water directly to the root zone through emitters placed along a water delivery line (typically a polyethylene hose). Also, in contrast to most other types of irrigation systems, a properly designed and well operated drip/micro-irrigation system:

- Can be used on steep slopes
- Requires minimal land grading
- Can be installed on parcels of land of any size or shape
- Has few, if any, runoff problems or chances of excessive over-irrigation
- Has greater distribution uniformity (especially the newer system designs)
- Provides optimal soil moisture through more frequent irrigation
- Allows direct application of fertilizer to the root zone

Systems can be installed permanently (typical for orchards and vineyards) or seasonally (typical for row crops), or they may have permanent main lines with removable or disposable lateral lines. Because drip/micro-irrigation system components typically remain in place for the growing season, the systems can be automated (however, it should be monitored and shut off temporarily as appropriate during rainy periods).

Drip/micro-irrigation systems should be tailored to meet crop needs. For example, water is generally applied to plants through drip/micro-irrigation systems on a frequent basis such as daily or several times per week. However, some crops (such as lettuce) do not yield as well with irrigation that is too frequent, and the watering frequency should be adjusted accordingly. Because emitter devices typically have low flow rates (0.4 to 2.1 gallons per hour [gph]), larger plants such as trees may require multiple emitters (Burt et al., 2000).

Regional and micro-climate conditions should also be considered in the design of drip/micro-irrigation systems. For example, in arid regions emitters are often spaced so that at least 60 percent of the potential root zone volume is wet, thereby providing an adequate moisture reservoir for periods of high ET and insurance against several days of breakdowns. A lower percentage of wetted area is common in areas that receive supplemental rainfall.

H3.4.1 Types of Drip/Micro-Irrigation Systems

Drip/micro-irrigation systems are of three main types: (1) aboveground drip systems, (2) buried drip systems, and (3) aboveground microspray and microsprinkler systems.

Aboveground drip systems have been used in orchards and vineyards since the 1980s, and a variety of designs can be used depending on the crop, orchard configuration, and available water pressure. Where rows do not exceed 12 or 13 feet in width, one hose is typically used per row, with varying numbers of emitters per tree or vine. Aboveground row crop drip irrigation typically uses a thin-walled hose with built in emitters (drip tape). The drip tape can be installed under plastic, rolled up to allow cultivation and harvest, or buried just below the ground surface (maximum ½ to 2 inches deep) to protect it from the wind (Burt et al., 2000).

Buried drip systems in orchards and vineyards are a relatively new concept that is not yet widely used. However, interest in this technology is high, as it potentially reduces soil evaporation and weeds and allows workers to drive through or cultivate a field at any time, regardless of the irrigation schedule. Drawbacks include potentially extensive soil surface wetting due to low soil hydraulic conductivity or excessive emitter flow rates, pinching of the hose by roots, root intrusion into the emitters, and a high cost of installation. In addition, the proper depth and location of buried emitters with respect to plant trunks is not yet fully understood (Burt et al., 2000).

Buried drip systems are used for “one-crop” row crops such as strawberries and sugar cane, where the drip can be installed before planting and removed before the plants are disked into the soil. Permanently buried systems are also used commonly in the southwest, where more than 150,000 acres of high-value crops such as tomatoes, peppers, broccoli, lettuce, and cauliflower are estimated to be irrigated with permanent drip systems (Burt et al., 2000). These systems are designed to be in place for 6 to 10 years; however, special equipment is needed during tilling to ensure that the drip tape is not damaged during removal of the old crops. Also, considerable time must be spent checking the system during the first year or two of operation to ensure proper functioning (Burt et al., 2000).

Microspray systems typically have larger hose diameters than drip because the flow rates of the emissions devices are much higher than for drip. They also tend to have smaller hose lengths than drip for the same reason. Because of the high application rates, a microspray field is often divided into six or more blocks with only one block irrigated at a time, whereas many drip fields are divided into only two blocks. The net result is that microsystems are usually more expensive than drip systems. The exception would be on widely spaced plants such as walnuts, in which case several drip hoses would be required per tree row compared to only one hose for microspray.

Microspray systems have the advantages of requiring less stringent filtration than drip because of the large and short paths of micro nozzles. In addition, they result in a larger soil wetted volume than a single hose drip system. In situations where frost protection is important, micro-sprinkler/sprayer designs offer better climate control than do emitters.

Disadvantages of microspray as compared to drip include the higher cost in some designs, the higher evaporation losses (especially if the water is extended past the canopy), higher humidity, and inability to easily restrict the wetted area during certain times of the year. Also, some microspray systems have high sprayer flow rates (10.5 to 15.8 gph) and could be classified as low-flow permanent sprinklers rather than micro-irrigation systems (Burt et al., 2000).

H3.4.2 System Requirements and Costs

Clean water should be used in drip/micro-irrigation systems to avoid plugging the small orifices of emitters, and consequently, filtration components represent a major portion of the cost and maintenance of these systems. It may also be necessary to use chemicals to reduce the likelihood of plugging due to bacterial growth and/or chemical precipitation in the laterals and emitters (Burt et al., 2000).

Pumping energy requirements depend upon the application efficiency and the total dynamic head (TDH) required at the pump, which in turn depends on the type of filters required and selected. Application efficiencies of drip/micro-irrigation systems tend to be high because of inherent limitations related to low to medium system flow rate capacities. The TDH of drip/micro systems for flat terrain tends to be about 40 to 45 psi for vineyard and orchard systems and 30 to 40 psi for row crop systems (Burt et al., 2000).

The Irrigation Training and Research Center (ITRC) at California Polytechnic State University has conducted total energy audits for the California Energy Commission on drip/micro systems.

The ITRC found that a well designed drip/micro system often has a higher energy efficiency than do other systems because of (1) reduced fertilizer applications and (2) higher yields.

Energy costs should consider overall energy efficiency, which is defined as the total output (i.e., water yield) versus the total energy inputs (pump, fertilizer, material manufacturing, etc.). Well designed and operated drip/micro systems have high overall energy efficiencies, even in relation to irrigation systems that do not require irrigation pumps.

Design costs for a drip or micro-irrigation system will vary from about $40 to $1,500 per acre (Burt et al., 2000), depending on the size and complexity of the project and fields. Costs also depend on the spacing of the plants or plant rows. For example, a microspray system for a widely spaced walnut orchard will be much less expensive than one for a vineyard, which has many more rows (i.e., hoses) and plants (i.e., microsprayers). Approximate initial costs range from about $600 to $2,000 per acre, with permanent subsurface drip on vegetables being the most expensive (Burt et al., 2000).

Labor costs vary with the design, the type of crop, and the quality of installation and management. Some farms with more than 2,500 acres of trees have only one operator, with a repair crew occasionally required. On the other extreme, a poorly designed system with serious rodent problems, insufficient filtration, and inattention to chemigation may have one person working full time on a 250-acre field, yet maintaining only a minimal system performance (distribution uniformity of about 60 percent). Permanent subsurface row crop drip systems require the highest level of sophisticated manual labor during the first installation on a farm. For these systems, it is not unusual during the first season for a manager of a farm with 20 fields to spend 30 to 40 percent of his/her time on one drip irrigated field trial.

As with labor, operation and maintenance costs are highly variable. Even in systems with good design, equipment, and installation, some unanticipated factors can arise in new drip/micro installations that puzzle even veteran designers and farmers. Examples of such problems include wasps that lay eggs in microsprayers of a certain configuration but not in other configurations, birds that remove emitters of a certain color, unusual densities of sand from wells that cannot be easily removed by sand separators or media filters, wireworms that bore through drip tape, and microscopic snails that live in wells and cause filters to plug. Such circumstances should be expected for initial installations, but can be solved over time, albeit sometimes at considerable expense.

Further information on these irrigation methods is available in the manual *Selection of Irrigation Methods for Agriculture*, prepared by the On-Farm Irrigation Committee of the Irrigation and Drainage Division of the American Society of Civil Engineers (Burt et al., 2000). This manual also discusses other types of irrigation systems not covered in this report.

H3.5 Soil Treatments

Water available to plants depends not only on the amount of rainfall and/or irrigation, but also on the physical, chemical, and biological properties of the soil. The soil acts as an absorbent for water from precipitation and irrigation and serves as a reservoir of water for plants in the interval between water applications.

Soil structure is an important physical parameter to consider, as soil sealing and soil crusting decrease the infiltration rate of water into the soil. A common constraint to both water filtration and root penetration in the soil is the degree of soil compactness or density. Structureless soil can severely restrict the downward percolation of water. Other soil characteristics that affect water availability to plants include the extent of organic matter in the soil and the types and density of soil organisms present.

In situ moisture conservation is a form of water conservation in which all rainfall is conserved where it falls and no runoff is permitted. Measures that can be adopted by farmers to optimize the physical, chemical, and biological soil parameters with a view to increasing the water efficiency include:

- Covers or mulches laid down on the surface of the soil and along rows. This practice is very important for water and soil conservation as well as for organic matter preservation. These mulches protect soil structure by reducing the mechanical action of raindrops on soil aggregates, thus preventing runoff and erosion. Mulching dramatically decreases evaporation and improves soil moisture retention capacity and, therefore, soil water content. Soil temperature, soil strength, and soil aeration are also improved, thus increasing soil productivity and crop yield.

- Tilling or physically (manually or mechanically) breaking up the plough layer is a common agronomic practice, that can improve the infiltration rate of rainwater, thus conserving soil moisture. Tilling also helps to control soil pests and weeds. The pests are brought up to the surface where they are then killed by radiation and/or predators. This approach therefore reduces the need for pesticides and their attendant use of fairly large quantities of water.

- Planting in small depressions, known as planting pits, is a practice common in arid areas. These pits conserve and concentrate both water and nutrients.

- Contour cultivation slows down the movement of water across the soil surface and also helps to conserve water. This can be achieved by constructing physical barriers such as ridges, with or without ties, across the contours to prevent runoff and soil erosion. In contour cultivation, the runoff from the higher elevations is trapped in furrows in the contours, thereby increasing infiltration into the soil.

- Terracing fields is another measure of collecting and conserving water. Different types of terraces can be constructed (e.g., stone terraces, earth banks, bench terraces, and contour stone) to conserve soil moisture as well as to collect water.

Such in situ moisture conservation measures should be encouraged on lands with marginal rainfall.

H3.6 Crops

Crop management is an extra means of reducing water losses and optimizing water use in any farming system. Crop management considerations include crop water requirements, timing of irrigation, crop selection, crop configuration (plant density, crop mix), and cropping calendar (planting dates, rotation).

Planting density and crop mix have an effect on the hydrologic characteristics of the system. Increasing planting density increases the soil cover by crops and can lead to a decrease in evaporation losses; however, these measures can also increase water uptake from the soil. Annual crops and some perennials (i.e., sugar cane) use moisture mainly from the top layer, whereas deep-rooted plants such as fruit and other trees tap water that is beyond the reach of the annuals. Additionally, some trees shed their leaves in winter, thereby covering the soil and creating mulch. A synergistic planting of this nature may yield more abundant crop production while protecting critical top soils. In addition, mixed cropping systems in particular combinations can help to significantly reduce pest damage. For instance, cabbages grown in alternate rows with either tomatoes or garlic or carrots have been shown to suffer fewer insect attacks.

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Appendix I

Population and Economic Growth Projections

Projection of Colfax County Growth 2000 – 2040

Submitted to:

Colfax Regional Water Plan

Submitted by:

Southwest Planning & Marketing
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June 2002

COLFAX COUNTY POPULATION PROJECTIONS, REVISIONS

In January 2001, Southwest Planning & Marketing submitted a report on population projections for Colfax County through 2040 for the purpose of regional water planning. That report was prepared prior to the release of the 2000 census and was based on Census estimates of population for 1999. With the release of the 2000 census data, it has been possible to revise the projections, based on actual 2000 population and more accurate recent growth rates.

We have revised the low and high forecasts to reflect the census data. It should be noted, however, that the census figure for Angel Fire may be low, due to homeowners who maintain two residences and report their primary residence as elsewhere (possibly to avoid paying New Mexico state income taxes). In any case, there are a number of second homes in Angel Fire, which inflate water use beyond that of the year-round population.

Comparing the actual 2000 census results with our estimates, we find that population was lower than estimated in Angel Fire, Cimarron, Raton, and Springer. We also find that population was higher than estimated in Eagle Nest, Maxwell, and the rural area. Overall, there were 426 fewer people living in Colfax County than our estimates.

We have revised both scenarios to reflect the correct base for 2000. We have also revised growth estimates in a downward direction. This reflects both the lower actual rates of growth that occurred in the 1990s and the impact of recent adverse economic events within the County. These adverse events include the closing of the coalmine, the failure to reopen the racetrack, routing of the primary Ports to Plains Highway through Texas and Oklahoma, and the effect of the prolonged drought on the economy. In addition, there have been no major new positive initiatives, e.g. construction of a proposed power plant.

In the low scenario, we have reduced growth rates to 1% in Angel Fire and Eagle Nest and to 0% in Raton and Cimarron. We have, however, increased the rural growth rate from –2% to –1%. This results in a population figure of 13,316 in 2040, compared with the earlier projection of 17,071.

In the high scenario, we have reduced growth rates in Angel Fire (to 5% through 2030), in Raton (to 1%) and in Maxwell and Springer (to 0%). We have increased the rural rate to 1%. The effect of this change is to reduce population in 2040 to 26,521, a substantial decrease from the earlier projection of 43,793. The bulk of this decrease is related to lower projected growth rates in Angel Fire and Raton.

PROJECTION OF COLFAX COUNTY GROWTH, 2000-2040

To project future water demand, it is necessary to project the future growth of the population and economy of Colfax County. Growth must be forecast in each of eight sectors (two other sectors, fish and wildlife and reservoir evaporation, are not driven by demand):

1. Public water supply
2. Domestic (self-supplied)
3. Commercial (self-supplied)
4. Industrial (self-supplied)
5. Power (self-supplied)
6. Mining (self-supplied)
7. Irrigated Agriculture
8. Livestock (self-supplied)

Growth is forecast in ten-year increments from 2000 to 2040. In the balance of this report, we project growth in each of these sectors. For convenience of organization, we have grouped the eight sectors into three categories:

1. Public water supply, domestic, and commercial
2. Industrial, power, and mining
3. Irrigated agriculture and livestock

PUBLIC WATER SUPPLY, DOMESTIC, AND COMMERCIAL

Future requirements for public water supply, domestic, and commercial use will depend in large part on the degree of future population growth. (Of course, demand will also be affected by other factors, such as the cost of water and electricity and the availability of new water-conserving technologies.) In this section, we project the future growth of population for Colfax County and three sub-regions under two different growth scenarios. The sub-regions are 1) the Moreno Valley (Angel Fire, Eagle Nest, and vicinity), 2) Cimarron, and 3) the Balance of the County.

The two growth scenarios are referred to as Low and High, respectively. The Low Scenario, lower than the University of New Mexico Bureau of Business & Economic Research (BBER) forecast for the County, represents a surprise-free future with little new economic activity within the County. Rural areas would experience a decline in population, while there would be no change in Raton and Cimarron and slow growth in the Moreno Valley. The High Scenario represents a more optimistic future in which new economic activity would lead to considerable net in-migration into the County. Raton and rural areas would stabilize or experience slight population growth, while the Moreno Valley would expand at a healthy rate of growth. Because each of these scenarios is plausible, consideration should be given to each being realized. However, to ensure an adequate supply of water, it would be prudent to use the High Scenario as the basis for future water planning.

To develop the scenarios, we collected voluminous data on the historic growth of the County and its communities, taking into account population, registered voters, water meters, and other factors. We also examined other forecasts of growth for the County and its communities, from which we developed our own forecasts for the County and the sub-regions, as described below. This report is a revision of an early report, which was issued prior to the release of the 2000 Census.

Historic Growth Trends

Exhibit 1 shows historic population for the state and Colfax County and historic growth rates, as well as the County's share of the state population. It can be seen that Colfax County population declined during both the decade of the 1960's and the decade of the 1980's; growth did occur during the 1970's and 1990's. The County's growth, in large part, has been a function of the cyclical opening and closing of the York Canyon coal mine. There was net out-migration during each year from 1984 to 1991, net in-migration during each year from 1992 to 1995, net out-migration during the years 1996 to 1998, and net in-migration during 1999.

During each of the past four decades, the New Mexico economy outperformed that of Colfax County, leading to a significant reduction in the County's share of the total state population, from 1.45% in 1960 to 0.78% in 2000. (This long-term reduction in share is even greater if consideration is given to the County's population of approximately 16,000 in 1910.)

The Colfax County economy has been dominated by employment in services (33.0%), government (25.3%), and retail trade (21.0%). In 1995, there were 449 businesses in Colfax County, of which 410 had fewer than 20 employees. In 1998, gross receipts from retail trade were $105 million, up from $80 million in 1992. Average wages in 1997 were $19,452, equivalent to 78.1% of the average for the State of New Mexico. Per capita personal income averaged $16,944, equivalent to 87.8% of the average for the state.

Exhibit 2 shows historic population growth for the communities within Colfax County and the three sub-regions, as reported by Bureau of the Census. It can be seen that most of the communities in the County have lost population since 1960. Growth has occurred in the Moreno Valley and certain rural areas.

Factors That Could Affect Growth

We conducted extensive interviews within Colfax County to identify factors that could affect growth in the County as a whole and within each of the sub-regions. (See list of Contacts) We also received assistance from the Colfax Regional Water Planning Steering Committee in identifying the factors that could influence growth. What follows is a list of those factors that could impact growth in the short or long run.

Short Term

Coal methane gas production. Coal methane gas production is generating new jobs and some in-migration to Colfax County, although many of the new residents are living across the state line in Colorado. This issue is discussed further below under Mining.

Reopening of the Raton Race Track. The new owner of the Raton Race Track previously projected that he would rehabilitate and reopen the track by 2002. The track would then offer year-round simulcasting of races and eventually contain 300 to 500 slot machines, creating 200 permanent jobs. This project is currently on hold.

Growth of Angel Fire Resort. Substantial investments have been made in the Angel Fire Resort since the new owner took possession of the property. This has created a healthy new business climate in Angel Fire that has reenergized the community and bodes well for future growth.

New subdivisions. There is the potential for a number of new subdivisions to be constructed within the Moreno Valley.

Logging and biomass power plant. There is the potential for job creation through logging small diameter timber and using part of the timber and scraps in a 13 megawatt biomass power plant. This project, which is discussed below under Power, could lead to the creation of approximately 50 new permanent jobs.

Long Term

Water availability and community capacity. The long-term growth of the region is dependent upon the continuing availability of water and the ability of community water systems to deliver that water. The lack of capacity currently affects proposed new hookups in Springer and Maxwell. The lack of sewage capacity was previously a deterrent to growth in Angel Fire. The current drought could adversely affect growth if it continues for an extended period of time.

Rural migration. There has been a national trend for businesses and self-employed individuals to relocate to rural communities with a high quality of life. This trend has spurred in-migration into the Rocky Mountain States to communities such as Santa Fe, Flagstaff, and Durango. This trend is partly a result of the Information Revolution and attendant telecommuting and partly a result of new wealth allowing the purchase of second homes. Rural migration is also bolstered by retirement to the Sunbelt. To the degree that this trend continues and Colfax County positions itself to take advantage of it, there will be additional growth in population.

Constructing a coal methane power plant. There has been a proposal to construct a power plant which utilizes coal methane gas. This would create a number of construction jobs, as well as permanent operation jobs.

Closing the coal mine. The York Canyon coal mine is currently in the process of closing. This will eliminate the 126 jobs at the mine. It is possible that the mine could reopen at some future date.

Tourism growth. Colfax County has a number of tourist attractions, such as the Philmont Scout Ranch, Vermejo Park, Eagle Nest Lake, Angel Fire ski area, Vietnam Veterans Memorial, NRA Whittington Center, several state parks, and the Capulin Volcano National Monument (just east of Colfax County, but serviced by Raton). An aggressive tourism development and marketing program could accelerate the growth of the economy.

Selling off ranch land for subdivisions. One of the current factors limiting growth is the lack of developable land around Cimarron and Raton. However, in the long run, it is likely that some of the ranches will sell off land for subdivisions.

Expansion or closing of Boys School. The Springer economy is highly dependent upon the New Mexico Boys School. It is possible that the school will one day be expanded or, in the alternative, closed.

Routing of U.S. Highway 87 Corridor. The federal government plans to build a four-lane "Ports to Plains" U.S. Highway 87, connecting Laredo, Texas and Denver. The primary route will bypass northeast New Mexico; however, there will now be a spur to the route that will include U.S. Highway 87 from Clayton to Raton, where it will connect with I-25. This spur is important to the New Mexico economy and should help accelerate travel-related growth in Colfax County.

Low Scenario

To develop the low scenario, we began with the BBER forecast of population growth for Colfax County through 2060, prepared for the Interstate Stream Commission for the purpose of regional water planning. BBER used historic trends dating from 1960 to project population at the state and county levels, as shown in Exhibit 1. It should be noted that this forecast was developed prior to the release of the 2000 Census.

The BBER forecast is predicated upon a continuing decline of the County's share of the state's total population. As shown in Exhibit 3, BBER projects that the County's share of the state population will decline from 0.82% in 1995 to 0.57% in 2040. This reflects a projected significantly lower growth rate for Colfax County than for the state. While BBER forecasts that the state's annual compound growth rate will decline from about 1.5% to 1.1%, it projects that the County's rate of growth will drop from 1.0% to 0.2% over the next 40 years. This would result in a County population of 17,081 in 2040, up from the estimated population of 14,615 in 2000.

We have modified the BBER forecast to slow the rate of growth, reflective of rural declines that have continued through the 1990's. Exhibit 4 shows the growth rates and projections under the Low Scenario for each of the major communities in the County. In aggregrate, the population would decline from the current 14,189 to 13,316 in 2040.

Exhibit 5 aggregates these projections for the three sub-regions. We discuss the projections below.

Moreno Valley. DBS&A and SPM recently completed the development of a 40-year water plan for the Village of Angel Fire. As part of that work, SPM interviewed a number of individuals in the Angel Fire area regarding the prospects for growth. SPM also collected data to enable it to estimate the current population of Angel Fire, which is considerably higher than the official estimate of the U.S. Census Bureau. SPM then developed three sets of growth projections for Angel Fire, which are shown in Exhibit 6. The forecasts ranged from a Limited Growth Scenario to a Trend Scenario to a Rapid Growth Scenario.

SPM obtained a copy of the 40-year water plan for the Village of Eagle Nest, developed in 1994. That plan projects a future annual growth rate in domestic and commercial water use of 3.4%. SPM also conducted interviews with individuals in Eagle Nest regarding the potential growth of the community.

We project some growth in the Moreno Valley, even under the Low Scenario. Angel Fire is expected to grow at an average annual rate of 1.0%. (This represents a significant reduction in the growth rates under the Trend Scenario from the Angel Fire plan.) Eagle Nest is also projected to grow at an annual rate of 1.0%. In aggregate, the sub-region's population is projected to increase from 1,354 in 2000 to 2,016 in 2040 under this scenario.

Cimarron. In 1997, DBS&A and Consensus Planning, Inc. prepared a 40-year water plan for the Village of Cimarron. The plan provided three growth series: low, middle, and high, ranging from 0.43% per year to 0.90% to 2.39%, as shown in Exhibit 7. (The plan incorrectly states these growth rates as being somewhat higher.) The low series represents a continuation of historic trends, while the other series assume that additional areas are developed within or adjacent to the Village.

Under the Low Scenario, we project that Cimarron's growth will be even more modest than that of the Consensus Planning low series. Our low projection is for no additional growth from 2000 to 2040.

Balance of the County. The Balance of the County includes the larger communities of Raton, Springer, and Maxwell, as well as smaller communities and rural areas. The most recent BBER forecasts for these communities were made in 1994 and projected continuing population declines in each community. Projected growth rates for the period 2000 to 2010 were –0.99% for Raton, -0.70% for Springer, and –1.73% for Maxwell.

We have been more optimistic than BBER in projecting growth in Raton under the Low Scenario. Our projection is for no growth or loss beyond 2000. (This is equivalent to the low forecast for Cimarron.) We project that, under the Low Scenario, Springer, Maxwell, and the rural areas will lose population at an annual rate of 1.0%.

High Scenario

The high scenario is predicated on a revival of the County's economy and an influx of in-migrants (and/or a reduction in out-migration), including employees in new industries, workers in the construction and tourism industries, and retirees. Population growth rates and projections for each of the major communities under the High Scenario are tabulated in Exhibit 8. Exhibit 9 aggregates these projections for the three sub-regions. Under the High Scenario, the County's population would increase from the current 14,189 to 16,175 in 2010, 18,769 in 2020, 22,279 in 2030, and 26,521 in 2040. More than half of this increase would occur in Angel Fire and Eagle Nest, with the balance be experienced in Raton and rural areas. We discuss these projections below.

Moreno Valley. The High Growth scenario for Angel Fire is a bit lower than the Rapid Growth Scenario in the 2000 Angel Fire water plan, which, in turn, is more conservative than the most optimistic estimates that we encountered in Angel Fire. It projects annual average growth of 5% until 2030 and 4% during the 2030's. Under this scenario, the Angel Fire population would increase substantially to 6,705 in 2040, making it the second largest community in Colfax County.

Under the High Scenario, we project annual growth in Eagle Nest of 4.0%. This is somewhat higher than the forecast of 3.4% contained in the Village water plan of 1994. Under this forecast, Eagle Nest would increase in population from 306 in 2000 to 1,469 in 2040.

Cimarron. Our High Scenario for Cimarron projects annual growth at a rate of 1.0% per year. This is slightly higher than the middle series in the 1997 water plan. Under this scenario, population in Cimarron would increase from 917 in 2000 to 1,365 in 2040, an increase of about 50%.

Balance of the County. Under this scenario, we project that Raton would grow at an annual rate of 1%, and that Springer and Maxwell will show no change in population. We also project that the rural area outside of these three communities will grow at a 1% rate. Under this High Scenario, Raton's population increase by 50% over the next 40 years, from 7,282 to 10,842.

INDUSTRIAL, POWER, AND MINING

There is currently no self-supplied industrial or power generation water use in Colfax County. The only mining use is that of the York Canyon Coal Mine.

Industrial. There is no industrial self-supplied water use in Colfax County. It is unlikely that this will change substantially in the future. There has been mention of a possible cement plant, which would need a supply of water.

Power Generation. There is no self-supplied water use for power generation in Colfax County. This situation could change if a proposed 13-megawatt biomass power plant is constructed. The plant would require 460 acre-feet per year. This water might be supplied as a byproduct of extracting coal gas methane (see below).

There is also discussion of the possible construction of a power plant that would burn coal-bed methane gas. This project, however, seems extremely speculative at this time.

Mining. In 1995, the Pittsburgh & Midway York Canyon coalmine withdrew 626 acre-feet, of which it depleted 421 acre-feet. Most of the water was used in the coal preparation plant. With the closure of the mine, this water use will end.

IRRIGATED AGRICULTURE AND LIVESTOCK

Agriculture had traditionally been the mainstay of the Colfax County economy. Much of the population decline during the twentieth century is attributable to the decline in agriculture. In 1997 there were 322 farms in Colfax County, up from 303 in both 1987 and 1992. In this section, we examine the trends in both irrigated agriculture and livestock in the County.

Irrigated Agriculture. Irrigated agriculture is the predominant water user in Colfax County. In 1995, irrigated agriculture withdrew 48,234 acre-feet and depleted 20,089 acre-feet. While this was a decline from 1990, these figures have not been adjusted for weather conditions.

In 1998, 19,825 acres were irrigated in Colfax County. This was a slight increase from the 19,520 acres irrigated in 1986, as shown in Exhibit 10. The total acreage of irrigated cropland (not all of which was actually irrigated) declined from 34,780 acres in 1970 to 30,800 in 1985 to 1998. The total hay acreage harvested increased from 12,400 acres in 1986 to 17,200 acres in 1998; of this harvest, alfalfa accounted for 8,000 acres in 1986 and 10,100 acres in 1998. Irrigated wheat accounted for 1,250 acres in 1998, down from 1,300 acres in 1986. And irrigated sorghum acreage planted stood at 450 acres in 1998.

We spoke with several knowledgeable individuals about trends in irrigated agriculture in Colfax County. We are projecting that the rural economy and population of the County will either stabilize or decline during the twenty-first century. Under the Low Scenario presented above, it is quite possible that irrigated acreage will decline at an annual rate of 1%, proportional to the projected decline in population. Under the High Scenario, it is possible that there will be no change in acreage planted.

Another factor also comes into play: conservation. According to a preliminary analysis by Dr. Robert Flynn of New Mexico State University, there is likely to be a potential for conserving water through improved irrigation efficiency. If farmers were able to go from an assumed efficiency of 70% to an efficiency of 80% during the growing season, water requirements would drop by 12%. That, by no means, represents the limit on possible efficiency; with drip irrigation, efficiencies as high as 90 to 98% can be achieved.

Livestock. In 1995, livestock use of water resulted in both a withdrawal and depletion of 737 acre-feet. Livestock production has been fairly constant in Colfax County during the past two decades, as shown in Exhibit 11 (cattle production actually peaked at 66,000 head in 1997). We believe that, absent the introduction of a new major feedlot, livestock water use will follow the same trend as irrigated agriculture water use, i.e. between no growth and a 1% annual decline.

CONTACTS

In addition to the persons listed below, we also relied on the input received from members of the Steering Committee, other stakeholders, and the general public.

Ahlers, Joanie, Cimarron School District board member, Angel Fire

Barraza, Sandra, County Agent/Program Director, Colfax County Extension Office

Boone, Glenn, Angel Fire Resort, Angel Fire

Borgeson, Don, Bush Realtors, Angel Fire

Bush, Ruth, Bush Realtors, Angel Fire

Campbell, Dan, Raton Water Works

Chuck Campbell, Developer, Angel Fire

Davidson, Kelly, Angel Fire Resort, Angel Fire

Fleishner, Betty, Eagle Nest Realty, Eagle Nest

Gilmore, Terry, Angel Fire

Holman, George, AMS Western States, North Las Vegas, Nevada

Honeyfield, Eric, City Manager, Raton

Johnson, Richard, Mayor Pro Tem, Eagle Nest

Jojola, Mary Ann, U.S. West, Albuquerque

Libbey, Linda, Village of Angel Fire, Angel Fire

Liddle, Mike, Angel Fire Resort, Angel Fire

Loscerbo, Dominic, Sun Valley Realty, Angel Fire

Luksich, Ruth, El Paso Natural Gas, Raton

Martinez, Tania, Colfax County Clerk's Office, Raton

Michels, Jeremy, Pittsburgh & Midway, Raton

Montoya, Sam, Pittsburgh & Midway, Raton

Morrow, Bob, Developer, Angel Fire

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Ortiz, Judy, Colfax County Clerk's Office, Raton

Ribble, Melanie, Angel Fire Services, Angel Fire

Roper, Mark, Raton Chamber & Economic Development Council

Rumley, Donald, Village of Angel Fire, Angel Fire

Schmeits, Ron, President, International Bank, Raton

Schrandt, John, Gannet Fleming West, Albuquerque

Siskind, William, Raton Race Track, New Jersey

Wilson, Deborah, International Bank, Angel Fire

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Village of Eagle Nest, *The Village of Eagle Nest 40 Year Water Plan*, 1994

EXHIBIT 1

HISTORIC POPULATION NEW MEXICO AND COLFAX COUNTY 1960 - 2000

	New Mexico	*Colfax County*	*County Share of State*
1960	951,023	13,806	1.45%
1970	1,017,055	12,170	1.20%
1980	1,303,302	13,667	1.05%
1990	1,515,069	12,925	0.85%
2000	1,819,046	14,189	0.78%

SOURCE: US Census Bureau, 2001

EXHIBIT 2

HISTORIC POPULATION
COLFAX COUNTY SUB-REGIONS
1960 - 1999

	1960	*1970*	*1980*	*1990*	*1999*
Cimarron	*997*	*927*	*888*	*763*	*893*
Angel Fire	0	0	68	452	484
Eagle Nest	0	94	202	187	219
Subtotal	*0*	*94*	*270*	*639*	*703*
Maxwell	392	393	316	196	231
Springer	1,564	1,574	1,657	1,288	1,485
Raton	8,146	6,962	8,225	7,566	7,660
Rural Areas	2,707	2,220	2,311	2,473	2,625
Subtotal	*12,809*	*11,149*	*12,509*	*11,523*	*12,001*
Colfax County	***13,806***	***12,170***	***13,667***	***12,925***	***13,597***

SOURCE: US Census Bureau & SPM, 2001

EXHIBIT 3

PROJECTED POPULATION OF NEW MEXICO AND COLFAX COUNTY
July 1, 1995 to July 1, 2060

Projection Year	*New Mexico*	*Colfax County*	
		Population	*Share of State*
1995	1,686,299	13,912	0.83%
2000	1,821,078	14,615	0.80%
2005	1,956,725	15,063	0.77%
2010	2,090,678	15,391	0.74%
2015	2,232,424	15,794	0.71%
2020	2,380,802	16,157	0.68%
2025	2,534,964	16,439	0.65%
2030	2,691,578	16,691	0.62%
2035	2,851,648	16,907	0.59%
2040	3,014,355	17,081	0.57%
2045	3,179,541	17,188	0.54%
2050	3,352,960	17,255	0.51%
2055	3,535,157	17,288	0.49%
2060	3,726,486	17,303	0.46%

SOURCE: BBER, 1996

EXHIBIT 4

COLFAX COUNTY POPULATION FORECAST FOR COMMUNITIES
LOW SCENARIO
2000 - 2040

	Population 2000	*Growth Rate 2000 - 2010*	*Population 2010*	*Growth Rate 2010 - 2020*	*Population 2020*	*Growth Rate 2020 - 2030*	*Population 2030*	*Growth Rate 2030 - 2040*	*Population 2040*
Angel Fire	1,565	*5.0%*	2,549	*4.0%*	3,773	*2.2%*	4,691	*1.4%*	5,391
Eagle Nest	225	*2.0%*	274	*1.5%*	318	*1.5%*	369	*1.0%*	408
Cimarron	985	*0.4%*	1,025	*0.0%*	1,025	*0.0%*	1,025	*0.0%*	1,025
Raton	7,700	*0.4%*	8,014	*0.0%*	8,014	*0.0%*	8,014	*0.0%*	8,014
Maxwell	240	*-1.0%*	217	*-1.0%*	196	*-1.0%*	178	*-1.0%*	161
Springer	1,500	*-1.0%*	1,357	*-1.0%*	1,227	*-1.0%*	1,110	*-1.0%*	1,003
Rural	2,400	*-2.0%*	1,961	*-2.0%*	1,602	*-2.0%*	1,309	*-2.0%*	1,070
Total	14,615		15,397		16,156		16,695		17,071

Note: Growth rates are annual rates which are compounded over 10 years.

SOURCE: BBER, 1996, and SPM, 2001

EXHIBIT 5

COLFAX COUNTY POPULATION FORECAST FOR SUB-REGIONS
LOW SCENARIO
2000 - 2040

	2000	*2010*	*2020*	*2030*	*2040*
Moreno Valley	1,790	2,853	4,091	5,060	5,799
Cimarron	985	1,025	1,025	1,025	1,025
Balance of County	11,840	11,519	11,040	10,610	10,247
Total	14,615	15,397	16,156	16,695	17,071

SOURCE: BBER, 1996, and SPM, 2001

EXHIBIT 6

PROJECTIONS OF POPULATION
VILLAGE OF ANGEL FIRE
2000 - 2040

	2000	*2010*	*2020*	*2030*	*2040*
Low Scenario	1,565	1,721	1,893	2,082	2,290
Mid Scenario	1,565	2,540	3,744	5,002	6,072
High Scenario	1,565	4,055	7,951	12,906	19,023

SOURCE: SPM, 03/00

EXHIBIT 7

PROJECTED LOW, MIDDLE AND HIGH POPULATION SERIES FOR CIMARRON 2000 - 2040

	Low	***Medium***	***High***
2000	985	985	985
2010	1,028	1,078	1,247
2020	1,072	1,171	1,509
2030	1,115	1,265	1,771
2040	1,158	1,358	2,033
Average Annual Growth Rate	***0.43%***	***0.90%***	***2.39%***

SOURCE: Consensus Planning, Inc., 08/97

EXHIBIT 8

COLFAX COUNTY POPULATION FORECAST FOR COMMUNITIES
HIGH SCENARIO
2000 - 2040

	Population 2000	*Growth Rate 2000 - 2010*	*Population 2010*	*Growth Rate 2010 - 2020*	*Population 2020*	*Growth Rate 2020 - 2030*	*Population 2030*	*Growth Rate 2030 - 2040*	*Population 2040*
Angel Fire	1,565	*10.0%*	4,059	*7.0%*	7,985	*5.0%*	13,007	*4.0%*	19,253
Eagle Nest	225	*4.0%*	333	*4.0%*	493	*4.0%*	730	*4.0%*	1,080
Cimarron	985	*1.0%*	1,088	*1.0%*	1,202	*1.0%*	1,328	*1.0%*	1,467
Raton	7,700	*2.0%*	9,386	*2.0%*	11,442	*2.0%*	13,947	*2.0%*	17,002
Maxwell	240	*1.0%*	265	*1.0%*	293	*1.0%*	323	*1.0%*	357
Springer	1,500	*1.0%*	1,657	*1.0%*	1,830	*1.0%*	2,022	*1.0%*	2,233
Rural	2,400	*0.0%*	2,400	*0.0%*	2,400	*0.0%*	2,400	*0.0%*	2,400
Total	14,615		19,189		25,645		33,757		43,793

Note: Growth rates are annual rates which are compounded over 10 years.

SOURCE: SPM, 2001

EXHIBIT 9

COLFAX COUNTY POPULATION FORECAST FOR SUB-REGIONS
HIGH SCENARIO
2000 - 2040

	2000	***2010***	***2020***	***2030***	***2040***
Moreno Valley	1,790	4,392	8,478	13,737	20,333
Cimarron	985	1,088	1,202	1,328	1,467
Balance of County	11,840	13,709	15,965	18,692	21,993
Total	14,615	19,189	25,645	33,757	43,793

SOURCE: BBER, 1996, and SPM, 2001

EXHIBIT 10

COLFAX COUNTY IRRIGATED AGRICULTURE
1970, 1986 and 1998

	1970	*1986*	*1998*
Acres in Irrigated Cropland	34,780	30,800	30,800
Acres Actually Irrigated	NA	19,520	19,825
Hay Acreage Harvested *	NA	12,400	17,200
Alfalfa Acreage Harvested *	NA	8,000	10,100
Irrigated Wheat Acreage Planted	NA	1,300	1,250
Irrigated Sorghum Acreage Planted	NA	0	450

* Hay acreage includes alfalfa acreage

SOURCE: New Mexico Agriculture Statistics, 1986 & 1998

EXHIBIT 11

COLFAX COUNTY LIVESTOCK
1986 and 1998

	1986	***1998***
Cattle	60,000	54,000
Sheep	900	700

SOURCE: NM Agricultural Statistics 1986 & 1998

Appendix J

Sample Water Conservation Ordinances and Rate Structure Information

Appendix J1

Water Ordinance Prototype

PROTOTYPE FOR WATER WASTE ORDINANCE

Prohibitions on Water Waste and Restrictions on Water Use During Drought or Emergencies

BE IT ORDAINED by the Board of directors of the American Water Utility as follows:

Section 1: Prohibition on Waste

No customer shall waste any water supplied through the distribution system of the water utility. The following uses of water constitute "waste" as used in this Ordinance.

(A) The watering of grass, lawns, groundcover, shrubbery, trees, and open ground, in a manner or to an extent which allows substantial amounts of water to run off the area being watered.
(B) The washing of sidewalks, walkways, driveways, parking lots and all other hard-surfaced areas by direct hosing, except such as may be necessary to dispose of flammable or otherwise dangerous liquids or substances or otherwise necessary to prevent or eliminate matters dangerous to the public health and safety.
(C) The escape of water through breaks or leaks within the customer's plumbing or distribution system for any substantial period of time within which the break or leak should reasonably have been discovered and corrected. It shall be presumed that a period of eight hours after the customer discovers the break or leak is a reasonable time within which to correct the break or leak.
(D) The watering of grass, lawns, groundcover, shrubbery, trees, and open ground within any portion of the water utility's service area between the hours of 10 a.m. and 6 p.m. daily, except where a water conserving irrigation practice such as drip irrigation is used to minimize evaporation losses and no amount of water is permitted to run off the area of application. Irrigation by commercial nurseries, on their own sites, are exempt from the hours restrictions.

Section 2: Restrictions on Use During Droughts or Emergencies

(A) Every customer shall restrict their use of water supplied through the water utility's distribution system to the amount of the allotment established from time to time by resolution of the Board of Directors and specified in Section 3 below.
(B) Priority, by customer class, for continued water service during times of shortage is established as follows:
  (1) Residential indoor (domestic use only) and fire protection have the highest priority.
  (2) Commercial/Institutional/Industrial uses have the second highest priority.
  (3) Public and private landscape irrigation sites including golf courses, athletic fields, parks, cemeteries, and greenbelts have the third highest priority.
  (4) Other uses-including firefighting training, main flushing, storm drain flushing, sewer cleaning, street cleaning, decorative water facilities, and swimming pools-have the lowest priority.
(C) From time to time the water utility's Board of Directors may, based upon the existing and projected water supply and demand, establish allotments for each customer account within each of the above classifications, based upon the following criteria:
  (1) For the residential class, a quantity of water for indoor domestic use shall be allotted for each inhabitant served by each service account based on reasonable conservative water use. Such per capita water use allocation shall be determined by the Board of Directors in their sole discretion. In so doing, the Board of Directors is not required to review and analyze each and

every particular customer account, but may, where it deems appropriate, use samples, averages and projections, and any other factors it deems material. It shall be presumed that any customer exceeding the water allotment for indoor domestic use is using water for some other purpose, and shall have the burden of proof to show actual indoor domestic use in any proceeding or controversy involving that issue.

(2) For commercial, institutional, industrial, public and private landscape irrigation sites, and other, for each water service account within these customer classes, the Board of Directors shall from time to time, after first allotting water to the residential class, apportion and allot the projected remaining available water among each of the remaining customer classes, and amongst each customer account within such customer class as it determines in its sole discretion to be reasonable and in the best interests of the water utility, based upon all facts and circumstances it deems material to the issue. In so doing, the Board of Directors may make a greater apportionment of the available water supply to one customer class than another, and may from time to time alter such priority of apportionment.

Section 3: Allotment Schedule

(A) The allotments referred to shall be as specified in Exhibit A to this Ordinance, which shall be adopted separately by the Board of Directors and shall be attached hereto and incorporated herein by reference.

(B) From time to time said allotments may be modified by the Board of Directors by amending Exhibit A to this Ordinance.

(C) During any period in which no current Exhibit A allotment schedule is in effect, all customer classes and customer accounts shall be deemed to have an allotment of 100% of actual water use during such period.

Section 4: Manner or Use of Allotment Water

It shall be the sole responsibility of each customer to use and manage their allotted water in such manner as not to exceed such allotment.

Section 5: Place of Use of Allotment Water

Water allotments for each customer account shall be used only on and for the premises for which such customer account is designated or intended, and no other premises.

Section 6: Notice of Customer Class and Allotment

On the next water billing statement following the determination of water allotments, each affected account customer will be notified in writing of the applicable customer class and water allotment for such account for the next following monthly billing period, or such other period specified therein.

Section 7: Violations and Surcharges

(A) Use of the amount of water by a water customer during a given monthly billing period in excess of the water allotment for that period, or during a period of months in excess of the cumulative total of the monthly water allotments for said months, shall constitute a violation of this

Ordinance, and the water utility shall, by writing, notify the account customer by name and at the address shown on water utility records of such violation. Such notification may be stated upon the normal water billing statement.

(B) For the first and second violation of a water allotment under this Ordinance within any calendar year, an excess water use rate shall be charged for the amount of such excessive use for each such violation at four times the highest water rate for the customer class.

(C) For the third and all subsequent violations of a water allotment under this Ordinance within any calendar year, an excess water use rate shall be charged for the amount of such excessive use for each such violation at ten times the highest water rate for the customer class.

(D) All excess water use charges shall appear on the account statement for the monthly billing period immediately following the monthly period for which the excess use occurred, and shall be due and payable at the time the basic bill is due and payable. Failure to make payment of the entire amount due (basic amount plus the surcharge) shall subject the customer to the same penalties as imposed in the water utility's rules and regulations, or by law, for failure to pay the basic water rate bill.

Section 8: Cure of Violations and Refunds for Water Conservation

Any violation of a water allotment may be cured and any surcharge paid pursuant to Section 7 of this Ordinance shall be refunded to the customer, upon application in writing, provided that water use through the customer account for which the violation occurred has, during two monthly allotment periods following the period of violation, been reduced to an extent below the allotments equal to the amount of the prior excess use. In such event, the violation shall be deemed cured for all purposes, including purposes of calculating the number of violations under Section 7, B and C.

Section 9: Additional Penalties

(A) **Civil Remedies.** In the event any person, firm, partnership, association, corporation or political entity is found by the Board of Directors to be in violation of any restriction or prohibition of this Ordinance, the Board of Directors may impose a special water waste surcharge against such person's account and may temporarily or permanently discontinue or restrict with a flow regulating device, water service to the affected property. Before taking such action, the Board of Directors shall give any such person reasonable notice and an opportunity to be heard to protest against the finding of such violation and the imposition of such measures. The Board may determine the terms and conditions of the discontinuance or restriction of service and may establish by Resolution, a schedule or the amounts or such surcharges as in its sole discretion will fully compensate the water utility and it customers for all loss or water and other damages incurred and as will foster water conservation within the water utility's service area.

(B) **Emergency Staff Action.** In unusual emergency circumstances where members of the water utility staff observe substantial amounts or water being wasted in violation of this Ordinance and where after reasonable efforts have been made to persuade the water service account registrant to terminate such waste, but have failed, the General Manager may authorize the immediate temporary discontinuance or restriction with a flow regulating device of service to the expected property. A written notice of such action and the reasons therefore shall be delivered to any adult person present at the premises, or if none can be found, left in a conspicuous place on the property within twenty-four hours of the discontinuance or restriction of service. Any such person may have water service promptly reinstated by applying therefore at the water utility, upon payment of the utility's standard connection fee. Notwithstanding such reinstatement, such person may still be cited for and subject to all other penalties for water wastage provided elsewhere in this Ordinance.

Section 10: Appeals and Exceptions

(A) **Appeals.** Any customer may appeal any decision or application of the provisions of this Ordinance by the water utility's General Manager, to the Board of Directors by filing a written appeal with the utility's secretary within ten days from the date of the decision or application appealed from, and the Board of Directors shall set the matter for a hearing de novo at a regular or special meeting within thirty days from the date the appeal is filed, and may in its discretion thereafter affirm, reverse, or modify the General Manager's decision, and impose any conditions it deems just and proper.

(B) **Exception.** The Board of Directors may, in its discretion, grant exceptions to the terms of this Ordinance, including exceptions to any water allotment, if it finds and determines that (1) restrictions herein would cause an undue hardship or emergency conditions, or (2) that the granting of the exception will not adversely affect the water supply or service to other existing customers, or (3) that due to peculiar facts and circumstances, the Board of Directors at its discretion finds that the Applicant is entitled to substantially similar treatment as set forth in some provision of this Ordinance not otherwise specifically applicable to the circumstances. Such exceptions may be granted only upon application in writing therefore and review of the matter at a regular or special meeting of the Board of Directors, except that the Board may in its discretion, dispense with the writing and meeting requirements if it finds that an emergency condition requiring immediate action exists. Upon granting any such exception, the Board of Directors may impose any conditions it determines to be just and proper. The terms of any exception shall be set forth in writing, the original to be kept on file with the water utility, and a copy to be furnished to the Applicant.

Section 11: Definitions

The terms customer, customer account, service account, and applicant used herein shall apply to every person, firm, partnership, association, corporation, city, county, state, or local agency, political subdivision, district, or entity of every kind receiving water service from the water utility. All water customers whose names are shown on utility account records shall be equally responsible and liable for water use by tenants, lessees, co-owners, and all other persons utilizing water on the premises through the account.

Section 12: Severability

If any section, subsection, sentence, clause or phrase of this Ordinance is for any reason held to be unconstitutional or invalid, such decision shall not affect the validity or the remaining portions of this Ordinance. The utility hereby declares that it would have passed this Ordinance and each section, subsection, sentence, clause, or phrase thereof irrespective of the fact that any one or more sections, subsections, sentences, clauses, or phrases be unconstitutional or invalid.

Section 13: Effective Date

This Ordinance shall become effective on the date of its adoption.

Section 14: Board Findings

The Board of Directors of the American Water Utility finds and determines that the provisions hereof will conserve the water supply for the greatest public benefit, that all uses of water prohibited hereby are nonessential, and that the restrictions on use are reasonable and necessary.

Adopted by the following role call vote:

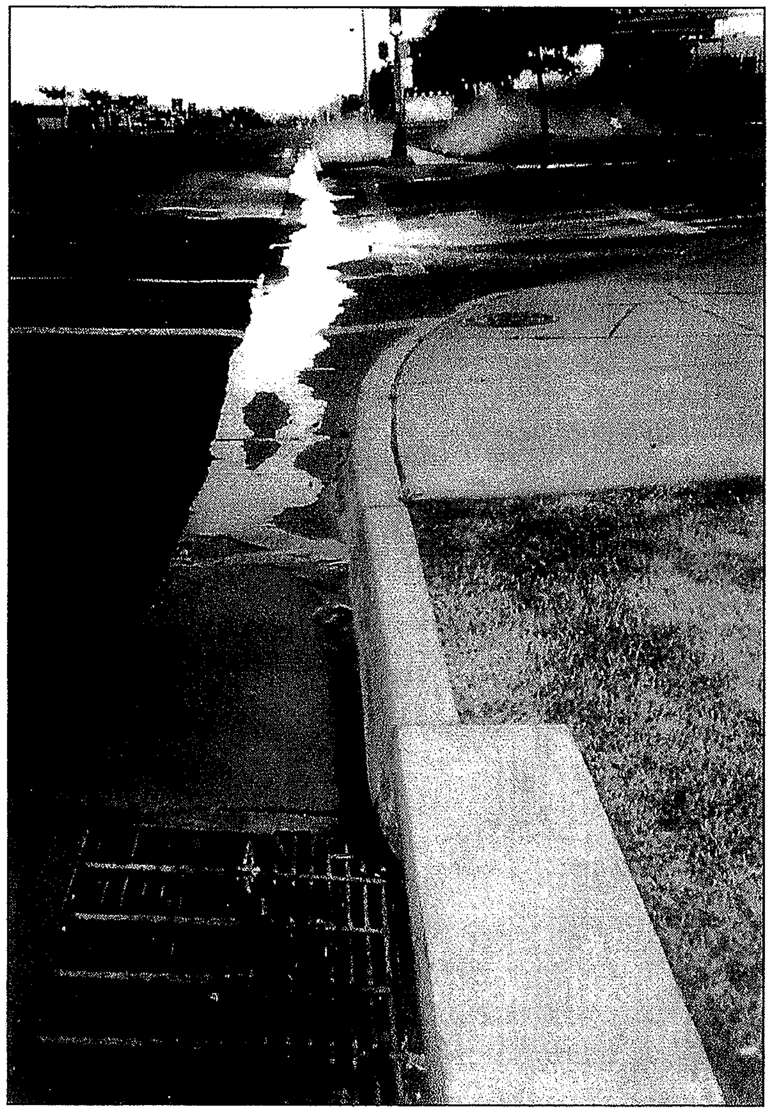
AYE: ______________________

NAY: ______________________

ABSTAIN: ______________________

ABSENT: ______________________

DATED: ______________________



Appendix J2

City of Albuquerque

Public Works - Water Conservation Office

Long-Range Water Conservation Strategy Resolution

CITY of ALBUQUERQUE
ELEVENTH COUNCIL

COUNCIL BILL NO. R-173
ENACTMENT NO. 40-1995
SPONSORED BY: Angela M. Robbins

RESOLUTION:

ADOPTING A LONG-RANGE WATER CONSERVATION STRATEGY FOR THE CITY OF ALBUQUERQUE AND THE PROPERTIES SERVED BY THE CITY'S WATER UTILITY.

WHEREAS, the adopted "Albuquerque/Bernalillo County Comprehensive Plan" requires that "The water resources of the metropolitan area shall be managed to ensure permanent adequate supply;" and

WHEREAS, recent findings of the U.S. Geological Survey and the New Mexico Bureau of Mines and Mineral Resources indicate that the City is pumping local ground water at a rate that cannot be sustained; and

WHEREAS, conservation can extend the City's supply at a fraction of the cost of other alternatives; and

WHEREAS, active water conservation is a condition of State Engineer consideration of requests to obtain additional water supply; and

WHEREAS, conservation will be a prerequisite for state or federal permits necessary to begin using City surface water resources in more effective ways; and

WHEREAS, protection of the limited ground water resources is a regional issue since all ground water used in the Middle Rio Grande Basin is from the same aquifer; and

WHEREAS, an aggressive strategy which achieves a 30% reduction in water usage in six to ten years will reduce the current average 250 gallons per capita per day to 175 gallons per capita per day and is estimated to reduce water demand in the year 2004 by 37 million gallons a day and water demand in the year 2060 by 57 million gallons a day; and

WHEREAS, Albuquerque's usage averages 250 gallons per capita per day while other southwestern cities of comparable size and climate have successfully reduced their usage to less than 180 gallons per capita per day; and

WHEREAS, City Council Resolution Bill No. R-58, Enactment No. 49-1992, calls for the development of a long-term water conservation strategy for the City of Albuquerque; and

WHEREAS, the aggressive strategy was validated and strengthened by the Mayor's and City Council's Town Hall meetings on Water Conservation on September 9th and 10th of 1994; and

WHEREAS, raising the price of water is probably the most effective method for reducing its usage; and

WHEREAS, low and fixed income residents of Albuquerque and customers using reasonable amounts of water should be protected from excessive increases in water rates; and

WHEREAS, voluntary compliance with most recommended water conservation measures for single family residences is preferable and may be modified to mandatory compliance in the future if desired reductions in usage are not achieved.

BE IT RESOLVED BY THE COUNCIL, THE GOVERNING BODY OF THE CITY OF ALBUQUERQUE:

Section 1. That the City's Long-Term Water Conservation Strategy, as described in the following sections of this Resolution, is hereby adopted and implementation will be initiated in January or February of 1995.

Section 2. PLANNING AND OVERALL APPROACH. The City shall initiate the following measures.

(A) Promote the regional awareness and planning that is essential to ground water resource management in the Middle Rio Grande Basin and includes the following:

1. A long-range water resource planning process which incorporates the goal of sustainable growth;
2. Inclusion of other city, county, and tribal governments and water users in the planning process;
3. Addressing water quality and quantity issues as well as conservation.

(B) In general, encourage voluntary water conservation for existing single family residences while requiring conservation for other properties.

(C) Apply more stringent requirements to City-owned facilities to set an example within the City.

(D) Set the example for water conservation in the Middle Rio Grande Basin and strive to involve other communities and water users in the conservation effort.

(E) Determine the best use of San Juan-Chama water and reuse of effluent to reduce aquifer depletion.

(F) Embrace the natural and cultural environment of Albuquerque in the water conservation effort.

(G) Evaluate existing land use planning and zoning laws affecting water use and revise them to be consistent with the conservation strategy.

(H) Create a water resources intern program in cooperation with the University of New Mexico's Master of Water Resource Administration program.

Section 3. REDUCTION GOALS. The City shall adopt the following water use reduction goals.

(A) Reduce current overall per capita usage of 250 gallons per capita per day by 30% to achieve 175 gallons per capita per day by the year 2004.

(B) Reduce current summer outdoor usage by 25%

(C) Reduce current year-round indoor usage by 33%.

(D) Reduce peak day usage by 20% within six to ten years.

(E) Set parcel-specific goals for all customers by the year 1998.

(F) Measure and evaluate the effectiveness of the elements of the Water Conservation Strategy on an ongoing basis: revise the Strategy annually, as necessary, to reflect and enhance the effectiveness of its various elements.

Section 4. RATES. The City shall implement the following measures related to rates.

(A) Allow sufficient lead time for extensive public education prior to implementation of higher excess use surcharges.

(B) Retain average residential winter median by meter size for meter sizes up to and including two inch meters.

(C) Utilize excess use surcharge revenues to offset declining revenues resulting from decreased demand. The Mayor shall not increase the excess water use surcharge prior to April 1996. Before any increase in the excess water use surcharge, the Mayor shall authorize a thorough analysis of alternative surcharge rates, their impact on different categories of water customers in terms of current use, family size, income, etc., and their reasonableness and fairness with regard to financial penalties for individual households failing to meet their water conservation goals. As conservation is achieved and surcharge revenues decrease significantly, alternative funding sources will be necessary.

Section 5. EDUCATION/PUBLIC AWARENESS. The City will initiate or continue the following to educate and get feedback from the community about conservation issues.

(A) Establish a citizens Water Conservation Advisory Committee.

(B) Continue the water conservation marketing and awareness program and provide adequate funding to effectively inform the public of the need for water conservation and of the ways that they can conserve.

(C) Include a bar chart of the previous month's usage and the current month's usage on the monthly bill, in addition to conservation tips and information.

(D) Cooperatively, with the Albuquerque Public Schools, fund a K-12 environmental education specialist in 1995 to develop and implement an ongoing ecological program for water conservation and related environmental issues in our schools.

(E) Continue the annual education programs offered in all public schools.

(F) Collaborate with existing community organizations to promote water conservation.

Section 6. RESIDENTIAL USE/PLUMBING. The City shall implement the following measures to reduce interior/plumbing uses.

(A) Adopt a Plumbing Code amendment requiring low-volume plumbing fixtures for all customers (now mandatory for only residential customers).

(B) Initiate a voluntary residential fixture retrofit program to install, without charge to customers, water-saving retrofit devices in existing residential development.

(C) Implement a 1.6 gallon-per-flush, low-volume toilet rebate program with rebates of up to $100 per toilet for replacement of three gallons or more per flush toilets for all residential and commercial customers.

(D) Actively encourage owners to replace high volume toilets with low- flow toilets whenever a building permit is obtained.

(E) Promote voluntary, City provided water use surveys and retrofit kits for residential customers to reduce both indoor and outdoor usage; target the highest 25% of users but make available to all customers.

(F) Encourage plumbing fixture wholesalers and retailers to sell only low-flow plumbing fixtures.

Section 7. LANDSCAPING/WATER WASTE. The City shall implement the following measures to reduce landscaping water use and water waste.

(A) Adopt the proposed "Water Conservation Landscaping and Water Waste Ordinance" which makes compliance with water conservation measures a condition of water service from the Albuquerque water utility system and requires the following:

1. No watering of City properties in April through September between 10:00 a.m. and 5:00 p.m.; voluntary for private sector;
2. Water even/water odd watering on City properties; voluntary for private sector;
3. No water waste or fugitive water in the public right-of-way, onto adjacent property, or into storm or sanitary sewers;
4. Water waste fees applied to water bill; increasingly higher fees for repeat violations; installation of flow-restriction device at water meter with the eighth violation to provide only enough water for basic drinking and sanitation needs;
5. No more than 20% of landscaped area in high water use plants for new private development or as allowed through water budget formula to achieve comparable low use; voluntary for existing single family residential;
6. No high water use plants for new City development, excepting parks and golf courses, or as allowed through water budget formula to achieve comparable low use;
7. Surcharge on parks or golf course usage above annual allowance; allowance goes down over time;
8. No high water use turf in medians, on slopes steeper than 6:1, or in areas less than ten feet in any dimension; voluntary for existing single family residential;
9. Efficient new irrigation systems;
10. Installation of new sprinkler heads at least eight inches from the curb.

(B) Initiate irrigation system water use surveys on new properties with one acre or more turf area, beginning in the year 1996; voluntary for single family residential.

(C) Combine all City of Albuquerque requirements regarding landscaping into one manual; eliminate conflicts with the conservation strategy.

(D) Initiate Xeriscape landscape retrofit and rebate program offering five cents per square foot rebate or credit, with a customer limit of $150, for replacement of high water use turf and landscape plants with low or medium water use turf and plants.

(E) Initiate efficient irrigation system retrofit and rebate program offering rebates or credits of up to $150 for replacement of old, inefficient irrigation systems with approved water-efficient systems.

(F) Initiate a Xeriscape education program including:

1. Creation of additional Xeriscape demonstration gardens;
2. Expansion of Parks and General Services irrigation efficiency weather network;
3. Sponsoring an irrigation auditor training and certification program;
4. Promotion and participation in Xeriscape research projects;
5. Initiation or cooperation with other agencies on public workshops, tours, videos, newsletters, events, etc.

(G) Improve the effectiveness of water waste enforcement:

1. Escalate fees for repeat offenders; install flow restriction device with eighth violation;
2. Assess fee on first violation observed by enforcement officers;
3. Apply fees to water bill;
4. Hire an irrigation specialist to supervise unit.

Section 8. EVALUATION. After this Resolution has been in effect for approximately nine months from the date of publication, a comprehensive evaluation and analysis shall be conducted by the Public Works Department in which input is received from residents, businesses, and others. This report shall be forwarded to the City Council.

Section 9. INSTITUTIONAL, COMMERCIAL, AND INDUSTRIAL USE (ICI). The City shall implement the following measures to reduce water use in the Institutional, Commercial, and Industrial billing classifications.

(A) Prepare, through a public process, and adopt a Large Water Users Policy specific to institutional, commercial, and industrial water uses and including, but not limited to, these provisions:

1. Require new customers using over 50,000 gallons per day to prepare and implement a Water Conservation Plan;
2. Prohibit use of City water for the purpose of diluting customer's effluent.
3. Initiate periodic surveys of new customers using more than 300,000 gallons per day; require implementation of auditor's recommendations defined through negotiations with the City;
4. Retrofit existing large water users to reduce use by 2000, in proportion to their growth or downsizing, unless longer period agreed to by the City.

(B) Adopt ordinance prohibiting once-through cooling systems.

(C) Promote City-provided water use surveys and retrofit for the highest 25% of the ICI customers to address both indoor and outdoor usage.

(D) Initiate a City and school building plumbing fixture retrofit program; costs to be shared by the customer and the City.

(E) Implement a strategy for reducing excess water use for City facilities or services.

(F) Initiate a Water Utility unaccounted-for-water loss reduction program including:

1. Water loss reduction program to audit and repair system water losses on a continuous basis;
2. Meter maintenance and replacement program to identify, repair, and/or replace inaccurate or malfunctioning meters;
3. Installation of meters in all unmetered City parks;
4. Development and implementation of strategy to reduce and use well wash water and water system discharge water.

Section 10. Conservation requirements, as they apply to new construction, shall take effect six months after the effective date of this legislation.

FAQs | General Information | How to Information | Rebate Programs | Resolutions / Ordinances | Links | Contact Information

Comments to:
Kay Lang
City of Albuquerque
Public Works Department
P.O. Box 1293
Albuquerque, NM 87103
(505) 768-3688

CHAPTER 6: WATER, SEWERS AND STREETS

Article

ARTICLE 1: WATER

Section

Part 1: Water Conservation Landscaping and Water Waste

Cross-reference:

Ground Water Protection Advisory Board, see §§ 2-6-8-1 et seq.

PART 1: WATER CONSERVATION LANDSCAPING AND WATER WASTE

§ 6-1-1-1 SHORT TITLE.

This article shall be known as the “Water Conservation Landscaping and Water Waste Ordinance.”

(Ord. 18-1995)

§ 6-1-1-2 INTENT.

(A) To implement the outdoor water use recommendations of the Water Conservation Task Force, as called for in Resolution Bill No. R-58, Enactment No. 49-1992, adopted by the Council in May of 1992.

(B) To assist in reducing overall per capita water use in the city by 30%.

(C) To reduce yard irrigation and irrigation-related water waste, which comprise over 40% of the city's total annual water usage. To reduce peak summer usage, which is two to three times winter usage and determines the need for capital facilities to adequately meet system demand. To reduce irrigation water usage without sacrificing landscape quality by using lower water use plants, improved design and planting practices, different watering practices, and better irrigation system design and maintenance.

(D) To reduce water waste; i.e., overwatering, inefficient watering, or release of excess water which generates fugitive water in the public right-of-way. To reduce damage to publicly owned streets and the public expenditures necessary to repair the damage caused by this wasted water. To increase street safety by reducing the potential of frozen water on public right-of-way.

(E) To initially encourage voluntary water conservation for existing single-family residences while requiring conservation on all other properties. To apply more stringent requirements to city-owned facilities to set an example.

(Ord. 18-1995)

§ 6-1-1-3 DEFINITIONS.

For the purpose of this article, the following definitions shall apply unless the context clearly indicates or requires a different meaning.

ATHLETIC FIELD. A turf area used primarily for organized sports.

AUTOMATIC CONTROLLER. A solid state timer capable of operating valve stations to set the days and length of time water is applied.

BUBBLERS. Irrigation heads which deliver water to the soil adjacent to the heads.

CITY OWNED. Property owned by the City of Albuquerque.

DEVELOPMENT. The construction, erection, or emplacement of one or more buildings, structures, or surface improvements on land which is a premises in order to establish or expand a principal residential or nonresidential use.

DISTURBED SLOPES. Slopes that have been altered from their natural configuration or vegetative cover by human activity.

DRIP IRRIGATION. Low pressure, low volume irrigation applied slowly, near or at ground level to minimize runoff and loss to evaporation.

EVAPOTRANSPIRATION. The quantity of water evaporated from adjacent soil surfaces and transpired by plants during a specific time.

EVEN-NUMBERED PROPERTIES. Properties whose official address ends in an even number, excluding city parks and golf courses. Landscaped areas associated with a building will use the number of that building as their address. Only one address shall be used for a large landscaped area associated with one building or activity, even if the landscaped area is broken into many separate subareas.

FLOW RESTRICTION DEVICE. Device applied by the water utility to the customer's meter that restricts the volume of flow to the customer.

FUGITIVE WATER. The pumping, flow, release, escape, or leakage of any water from any pipe, valve, faucet, connection, diversion, well, or any facility for the purposes of water supply, transport, storage, disposal, or delivery onto adjacent property or the public right-of-way.

HAND WATERING. The application of water for irrigation purposes through a hand-held hose, including hoses moved into position by hand and left to flow freely or through a shut-off nozzle.

HARVESTED WATER. Precipitation or irrigation runoff collected, stored and available for reuse for irrigation purposes.

HIGH WATER USE TURF. A surface layer of earth containing regularly mowed grass, with its roots, which requires large volumes and/or frequent application of water throughout its life. High water use grasses include but are not limited to varieties of Bluegrass, varieties of Ryegrass, varieties of Fescue, and Bentgrass.

INFILTRATION RATE. The amount of water absorbed by the soil per unit of time, usually expressed in inches per hour.

INSPECTION. An entry into and examination of premises for the purpose of ascertaining the existence or nonexistence of violations of this article.

LANDSCAPE AREA. The entire parcel less the building footprint, driveways, non-irrigated portions of parking lots and required off-street parking. Includes the public right-of-way.

LOW WATER USE PLANTS. Plants which are able to survive without supplemental water once established as specified in the “Albuquerque Plant List”, published by the city.

MAYOR. The Mayor of Albuquerque or his/her designated representative.

MEDIUM AND LOW WATER USE TURF. A surface layer of earth containing regularly mowed grass, with its roots, which requires moderate or low volumes and/or frequency of application of water once established as specified in the "Albuquerque Plant List" published by the city. Low and medium water use grasses include but are not limited to Bermuda and Bermuda hybrids, Zoysia, blue grama, and Buffalo grass.

MEDIUM WATER USE PLANTS. Plants which require some supplemental watering throughout the life of the plant as specified in the “Albuquerque Plant List” published by the city.

MISTER. A device that produces a cooling effect by emitting fine particles of water into the air in the form of a mist.

MULCH. Any material such as leaves, bark, straw, or other materials applied to the soil surface to reduce evaporation.

NEW DEVELOPMENT. Any development approved by the Albuquerque Planning Department on or after October 1, 1995. For development for which landscaping is required, which is all development except single family residential, only that portion approved by the Albuquerque Planning Department on or after October 1, 1995 shall be considered new development. Development approved by the Albuquerque Planning Department prior to October 1, 1995, but not completed by October 1, 1998 shall also be considered new development.

NON-CITY OWNED. All property which is not owned by the City of Albuquerque.

ODD-NUMBERED PROPERTIES. Properties whose official address ends in an odd number, excluding city parks and golf courses. Large landscaped areas associated with a building will use the number of that building as their address. Only one address shall be used for a large landscaped area associated with one building or activity, even if the landscaped area is broken into many separate subareas.

PRECIPITATION RATE. The amount of water applied per unit of time, usually expressed in inches per hour.

PUBLIC RIGHT-OF-WAY. The area of land acquired or obtained by the city, county, or state primarily for the use of the public for the movement of people, goods, vehicles, or storm water. For the purposes of this article the public right-of-way shall include curbs, streets, and storm water drainage inlets.

RESPONSIBLE PARTY. The owner, manager, supervisor, or person who receives the water bill, or person in charge of the property, facility, or operation during the period of time the violation(s) is observed.

RESTRICTED PLANTS. Plants which, as specified in the "Albuquerque Plant List" published by the city, are classified as restricted due to their high water use requirements and their potential for extensive use in landscaping. Restricted plants include high water use turf, clover, and Dichondra.

RUNOFF. Water which is not absorbed by the soil or landscape to which it is applied. Runoff occurs when water is applied too quickly (application rate exceeds infiltration rate), particularly if there is a severe slope. This article does not apply to stormwater runoff which is created by natural precipitation rather than human-caused or applied water use.

SHUT-OFF NOZZLE. Device attached to end of hose that completely shuts off the flow, even if left unattended.

SINGLE-FAMILY RESIDENTIAL. A lot or premises upon which is established one dwelling only. Of the allowable principal uses, such use shall be the only use on that lot or premises.

SPRAY IRRIGATION. The application of water to landscaping by means of a device that projects water through the air in the form of small particles or droplets.

SPRINKLER HEAD. A device that projects water through the air in the form of small particles or droplets.

STATIC WATER PRESSURE. The pipeline or municipal water supply pressure when water is not flowing.

TEMPORARY IRRIGATION SYSTEMS. Irrigation systems which are installed and permanently disabled within a period of 36 contiguous months.

VALVE. A device used to control the flow of water in the irrigation system.

WATER WASTE. The nonbeneficial use of water. Nonbeneficial uses include but are not restricted to:

(1) Landscape water applied in such a manner, rate and/or quantity that it overflows the landscaped area being watered and runs onto adjacent property or public right-of-way;

(2) Landscape water which leaves a sprinkler, sprinkler system, or other application device in such a manner or direction as to spray onto adjacent property or public right-of-way;

(3) Washing of vehicles, equipment, or hard surfaces such as parking lots, aprons, pads, driveways, or other surfaced areas when water is applied in sufficient quantity to flow from that surface onto adjacent property or the public right-of-way;

(4) Water applied in sufficient quantity to cause ponding on impervious surfaces on non-city owned property.

(Ord. 18-1995; Am. Ord. 24-1998; Am. Ord. 42-2001)

§ 6-1-1-4 APPLICABILITY.

(A) Section 6-1-1-8, Water Budgets and Planting Restrictions, applies to all new development and to existing golf courses, city owned parks, and city owned athletic fields.

(B) Section 6-1-1-9, Design Regulations, applies to all new development and to major renovations of existing golf courses, city owned parks, and city owned athletic fields *originally constructed after 1971*.

(C) Section 6-1-1-10, Irrigation System Standards, applies to all new development and to expansions or major renovations of existing golf courses, city owned parks, and city owned athletic fields *originally constructed after 1971*. Single family residential shall be exempt from this section.

(D) Section 6-1-1-11, Inspection Requirements, applies to all new development.

(E) This article does not apply to water provided through the Middle Rio Grande Conservancy District for irrigation purposes. Water obtained through non-city water system sources, however, will be included in the calculation of inches per year for the water budgets for golf courses and parks, as described in Section 6-1-1-8.

(F) Certificates of occupancy for all new development except single family residential shall depend upon compliance with all requirements of this article.

(Ord. 18-1995; Am. Ord. 24-1998)

§ 6-1-1-5 WATERING RESTRICTIONS.

These restrictions apply to all properties within the city limits and/or served by the municipal water utility.

(A) All spray irrigation during the period beginning on April 1 and ending on October 1 of each year must occur between 6:00 p.m. and 10:00 a.m. beginning April 1, 2000. This restriction serves as a guideline for landscape watering on non-city owned property during 1999. This restriction shall not apply to drip irrigation and low precipitation bubblers, hand watering, or watering of containerized plants and plant stock.

(B) All spray irrigation on city owned property during the months of December through March must occur between 10:00 a.m. and 2:00 p.m. This restriction serves as a guideline for landscape watering on non-city owned property. This restriction shall not apply to drip irrigation and low precipitation bubblers, hand watering, or watering containerized plants and plant stock. This restriction shall not apply to golf courses or parks that are in regular use or in use for a special event during these hours.

(C) Shutoff nozzles are required on any hoses used for hand watering, car washing or other outdoor uses, excepting hoses on single-family residential.

(D) All city owned properties other than parks and golf courses shall water no more than every other day. All even-numbered properties shall water only on even-numbered dates. All odd-numbered properties shall water only on odd-numbered dates. This restriction serves as a guideline for landscape watering on non-city owned property.

(E) Restrictions in divisions (A), (B) and (D) above do not apply to the following:

(1) Outdoor irrigation necessary for the establishment of newly sodded lawns and landscaping within the first 30 days of planting or watering of newly seeded turf within the first year of planting;

(2) Irrigation necessary for one day only where treatment with an application of chemicals requires immediate watering to preserve an existing landscape or to establish a new landscape;

(3) Water used to control dust or compact soil;

(4) Visually supervised operation of watering systems for short periods of time to check system condition and effectiveness.

(F) The city shall undertake an aggressive public information campaign to address the requirements of the spray irrigation restrictions for the remainder of 1999 and each year thereafter.

(G) 6-1-1-1 through 6-1-1-99 Water Conservation Landscaping and Water Waste shall be reviewed in its entirety in FY/04 as to its effectiveness and for necessary revisions. This evaluation will be incorporated into the FY/04 budget process.

(Ord. 18-1995; Am. Ord. 24-1998; Am. Ord. 54-1999) Penalty, see § 6-1-1-99

§ 6-1-1-6 WATER WASTE.

These restrictions apply to all properties within the city limits and/or served by the municipal water utility.

(A) No person, firm, corporation, or municipal or other government facility or operation shall waste, cause or permit to be wasted any water.

(B) No person, firm, corporation, or municipal or other government facility or operation shall cause or permit the flow of fugitive water onto adjacent property or public right-of-way.

(C) The restrictions in divisions (A) and (B) of this section do not apply to the following:

(1) Storm runoff allowed under provisions of the city's Drainage Ordinance as currently adopted or subsequently amended;

(2) Flow resulting from temporary water supply system failures or malfunctions. These failures or malfunctions shall be repaired as quickly as possible;

(3) Flow resulting from firefighting or routine inspection of fire hydrants or from fire training activities;

(4) Water applied as a dust control measure as may be required under Chapter 9, Article 5 of this code;

(5) Water applied to abate spills of flammable or otherwise hazardous materials, where water is the appropriate methodology;

(6) Water applied to prevent or abate health, safety, or accident hazards when alternate methods are not available;

(7) Flow resulting from routine inspection, operation, or maintenance of the municipal water supply system;

(8) Flow resulting from routine inspection or maintenance of irrigation systems;

(9) Water used by the Traffic Engineering Division, City of Albuquerque, in the course of installation or maintenance of traffic flow control devices;

(10) Water used for construction or maintenance activities where the application of water is the appropriate methodology and where no other practical alternative exists.

(Ord. 18-1995; Am. Ord. 24-1998) Penalty, see § 6-1-1-99

§ 6-1-1-7 SPECIAL PERMITS

These requirements apply to all properties within the city limits and/or served by the municipal water utility.

(A) Use of Misters

(1) The use of misters shall require a special permit, issued by the city. The Mayor shall develop regulations and administrative procedures for the issuance and conditions of such permits. The Mayor shall have the authority to limit the number of permits or revoke permits as deemed necessary to protect the public interest.

(2) Effective April 1, 1999, the use of misters without a permit, or in violation of permit conditions, shall constitute a violation of this article and shall be subject to the fee assessment processes described in §§ 6-1-1-13 and 6-1-1-99.

(3) Any person, firm, corporation, or municipal or other government facility selling, leasing, renting, installing or otherwise making misters available to any other

person, firm, corporation, or municipal or other government facility shall provide notification to their customers of the special permit requirement for mister use. Notice may be delivered by prominently posting a sign at the point of purchase or by providing a document to each individual customer. The city shall provide approved language for such notification.

(Ord. 24-1998)

§ 6-1-1-8 WATER BUDGETS AND PLANTING RESTRICTIONS

Subsection (A) of this section applies to all city and non-city owned golf courses, and to all city owned parks and athletic fields. Subsection (B) of this section applies to all new development.

(A) Water Budgets for Parks and Golf Courses.

(1) Parks and golf courses shall use medium and low water use plants as much as possible. High water use turf or other restricted plants shall be allowed only in those areas with heavy usage or foot traffic, such as athletic fields, playgrounds, and golf course tees, greens, and fairways.

(2) All golf courses existing prior to October 1, 1995 will be allowed up to 40 inches of water per acre of landscape area per year. Golf courses using wells must report well usage to the city on a monthly basis. Any usage over the allowable amount will be subject to the excess use surcharge(s) described in division (A)(6) of this section. Usage will be calculated on a per individual golf course basis and shall include municipal and non-municipal water supplies.

(3) All new golf courses or existing golf course expansions permitted by the city after October 1, 1995 will be allowed up to 37 inches per acre of landscape area per year. Any usage over the allowable amount will be subject to the excess use surcharge(s)

described in division (A)(6) of this section. Usage will be calculated on a per individual golf course basis and shall include municipal and non-municipal water supplies. The landscaped area for new golf courses shall not exceed 90 acres per 18 holes or 45 acres per 9 holes.

(4) All parks will be allowed up to 35 inches of water per acre of landscape area per year. Any usage over the allowable amount will be subject to the excess use surcharge(s) described in division (A)(6) of this section. Usage will be calculated on a per individual park basis and shall include municipal and non-municipal water supplies.

(5) Athletic fields will be allowed up to 45 inches per acre of landscape area per year. Any usage over the allowable amount will be subject to the excess use surcharge(s) described in division (A)(6) of this section. Usage will be calculated on a per individual athletic field basis and shall include municipal and non-municipal water supplies.

(6) Any usage over the approved water budget will be subject to the excess use surcharge(s) defined in the Water and Sewer Rate Ordinance as currently adopted or subsequently amended (6-4-1 et seq.), and established by the Mayor's rules and regulations. This surcharge(s) will be calculated on an annual basis and applied to the February water bill for the property. If two different surcharges are defined in the Water and Sewer Rate Ordinance or the Mayor's rules and regulations, the surcharge for excess usage up to 10% of the water budget shall be the lower of the surcharges. The surcharge for excess usage over 10% of the water budget shall be the higher of the surcharges.

(7) For all parks, golf courses and other facilities with greater than ten acres of restricted plants, and developed after the effective date of this section, the owner or developer shall, when available and economically feasible, use reclaimed wastewater, shallow groundwater or other alternative water supplies, as specified by the policies of the Albuquerque Water Resources Management Strategy.

(C) *Planting Restrictions* .

(1) All city owned new development other than parks, golf courses, and housing shall use medium and low water use plants on 100% of the landscape area.

(2) All city owned housing and all non-city owned properties other than golf courses shall not use high water use turf or other restricted plants on more than 20% of the landscape area, except that for single family residential properties;

(a) In the event that 20% of the landscape area is greater than 3,000 square feet, high water use turf and other restricted plants shall not be used on more than 3,000 square feet of the landscape area;

(b) In the event that 20% of the landscape area is less than 300 square feet, high water use turf and other restricted plants may be used on up to 300 square feet of the landscape area.

(Ord. 18-1995; Am. Ord. 1-1998; Am. Ord. 24-1998) Penalty, see § 6-1-1-99

§ 6-1-1-9 DESIGN REGULATIONS

The following regulations apply to all new development, and to expansions or major renovations as existing city owned parks, city and non-city owned golf courses, and city-owned athletic fields *originally constructed after 1971.*

(A) With the exception of temporary irrigation systems needed to establish low water use plants, spray irrigation shall not be used on slopes greater than four feet of horizontal distance per one foot vertical change (4:1).

(B) All existing disturbed slopes and all man-made slopes shall receive erosion control from plantings and/or terracing. Concrete, asphalt, or any other water and air impervious paving/cover will be allowed only where it is the most appropriate methodology and where no other practical alternative exists.

(C) Plants that require spray irrigation or a mowing frequency of more than three times per year shall not be used in street medians, except that spray irrigation may be used in street medians for up to 36 months where the primary objective is to reclaim disturbed areas with low water use plants.

(D) Spray irrigation shall not be used to apply water to any area within eight feet of a street curb or storm sewer inlet. These areas may be irrigated by drip, bubbler, soaker, or sub-surface irrigation systems.

(E) Sprinkler heads shall be installed at least eight inches away from impermeable surfaces.

(F) No spray irrigation shall be used in areas less than ten feet in any dimension excepting within back or side yards of residential properties, or where such an area is contiguous with adjacent property so that the dimension totals ten feet minimum. Within parking lots no spray irrigation shall be used on any area less than 15 feet in any dimension. These areas may be irrigated by drip, bubbler, soaker, or sub-surface irrigation systems.

(G) Any existing features should be evaluated for incorporation in design to include natural drainage, rock outcroppings, stands of native vegetation which can be protected, or detention areas where vegetation has grown and is being supported by nuisance flows or harvested water.

(H) The potential for using harvested water should be evaluated and, when practical, incorporated into landscape design. Such design shall be consistent with the requirements of the city's Flood Hazard Control Ordinance and the Drainage Ordinance as currently adopted or subsequently amended.

(I) Ponds, fountains, wetlands, marshes, water features for wildlife habitat, functional holding ponds or other reservoirs that are supplied in whole or in part by the municipal water supply shall not exceed 500 square feet or surface area unless approved by the Mayor. Multiple water features on the same property will be considered together to determine surface area. Flowing water used in fountains, waterfalls and similar features shall be recirculated.

(Ord. 18-1995; Am. Ord. 24-1998) Penalty, see § 6-1-1-99

§ 6-1-1-10 IRRIGATION SYSTEM STANDARDS

The following standards apply to all expansions or major renovations at existing parks, golf courses and athletic fields *originally constructed after 1971,* and to all new development except single family residential. The standards serve as voluntary guidelines for single-family residential development. In general, irrigation systems shall be designed to be site-specific, reflecting plant type, soil type, infiltration rates, slopes, and prevailing wind direction.

(A) Irrigation systems shall be designed to be in conformance with all provisions of this article. Temporary irrigation systems shall not be required to meet these standards.

(B) Application equipment for which the manufacturer specifies flow rates in gallons per minute (gpm) shall not share a control valve with equipment for which the manufacturer specifies flow rates in gallons per hour (gph). Irrigation systems shall be controlled by an automatic controller equipped with the following features:

(1) Two or more independent programming schedules;

(2) Capable of programming run times in one-minute increments and displaying the programmed run time as a numeric display;

(3) Total program memory retention;

(4) Ability to be fitted with an external rain switch interrupter and soil moisture sensor.

(C) No intentional overspray is allowed where it may obstruct pedestrian traffic on a city-required pedestrian walkway, as defined by the city's Sidewalk, Drive Pad, Curb and Gutter Ordinance as currently adopted or subsequently amended.

(D) Irrigation systems shall be designed such that water pressure at the sprinkler or emitter is not more than 20% in excess of the manufacturer's maximum recommended pressure range for that device. Pressure may be regulated by design or by the installation of a pressure regulating device or devices.

(E) Irrigation systems shall be designed to minimize low head line drainage.

(F) All new development with new spray irrigated landscaped areas totaling one-half acre or more shall have a Landscape Irrigation Audit performed by a Certified Landscape Irrigation Auditor, certified by the Irrigation Association. The auditor shall be independent of the property owner and of all contractors associated with the property. The audits will be conducted in accordance with the current edition of the Landscape Irrigation Auditor's Handbook. The minimum efficiency requirements to meet in the audit are a 60% distribution uniformity for all fixed spray systems and a 70% distribution uniformity for all rotary systems. The results of the audit shall be provided to the city in a letter or other form acceptable to the city and shall be signed by the Auditor. Compliance with this provision is required before the city will issue a Certificate of Occupancy or, in the case of park development, a Letter of Final Acceptance.

(G) All new development with spray irrigated landscapes greater than ten acres shall have the sprinkler heads tested for uniformity of performance using the Center for Irrigation Technology's (CIT) Sprinkler Profile and Coverage Evaluation (SPACE) program, or a comparable assessment acceptable to the city. The sprinkler heads shall have a scheduling coefficient of 1.3 or less for full circle heads and 1.5 or less for partial circle heads, with a rating of 1.0 being perfect. The sprinkler heads shall be installed in the spacing and pressure range tested. The results of this test shall be provided to the city in a form acceptable to the city. Compliance with this provision is required before the city will issue a Certificate of Occupancy or, in the case of park development, a Letter of Final Acceptance.

(Ord. 18-1995; Am. Ord. 24-1998) Penalty, see § 6-1-1-99

§ 6-1-1-11 INSPECTION PROCEDURES

The following procedures apply to all new development:

(A) Inspection by Consent.

(1) Within the scope of his authority, the Mayor may conduct an inspection, with the voluntary consent of an occupant or custodian of the premises to be inspected who reasonably appears to be in control of the places to be inspected or otherwise authorized to give such consent.

(2) Before requesting consent for an inspection, the Mayor shall inform the person to whom the request is directed of the authority under and purposes for which the inspection is to be made and shall exhibit an identification card or document evidencing his authority to make such inspections.

(3) Inspections undertaken pursuant to this section shall be carried out with due regard for the convenience and privacy of the occupants, and during the daytime, unless, because of the nature of the premises, the convenience of the occupants, the nature of the possible violation or other circumstances, there is a reasonable basis for conducting the inspection at night.

(4) Notice of the purpose and approximate time of an inspection of an area not open to the general public shall be sent to the occupants or custodians of premises to be

inspected not less than seven days before the inspection is undertaken.

(B) Inspection without Consent.

(1) Upon sufficient showing that consent to an inspection has been refused or is otherwise unobtainable with a reasonable period of time, the Mayor may make application for an inspection order/search warrant. Such application shall be made to a court having jurisdiction over the premises to be inspected. Such application shall set forth:

(a) The particular premises, or portion thereof sought to be inspected;

(b) That the owner or occupant of the premises has refused entry;

(c) That inspection of the premises is necessary to determine whether they comply with the requirements of this article;

(d) Any other reason necessitating the inspection, including knowledge or belief that a particular condition exists on the premises which constitutes a violation of this article; and

(e) That the Mayor is authorized by the city to make the inspection.

(2) The application shall be granted and the inspection order/search warrant issued upon a sufficient showing that inspection in the area in which the premises in question are located, or inspection of the particular premises, is in accordance with reasonable legislative or administrative standards, and that the circumstances of the particular inspection for which application is made are otherwise reasonable. The court shall make and keep a record of the proceedings on the application, and enter thereon its finding in accordance with the requirements of this section.

(3) While executing the inspection order/search warrant the Mayor shall, if the premises in question are unoccupied at the time of execution, be authorized to use such

force as is reasonably necessary to effect entry and make the inspection.

(4) While conducting the inspection the Mayor shall, if authorized by the court on proper showing, be accompanied by one or more law enforcement officers authorized to serve search warrants who shall assist the Mayor in executing the order at his direction.

(5) After execution of the order or after unsuccessful efforts to execute the order, as the case may be, the Mayor shall return the order to the court with a sworn report of the circumstances of execution or failure thereof.

(Ord. 18-1995; Am. Ord. 24-1998) Penalty, see § 6-1-1-99

§ 6-1-1-12 VARIANCES AND APPEALS

The Mayor shall be responsible for the enforcement of this article. The Mayor may prescribe policies, rules, or regulations to carry out the intent and purposes of this article.

(A) Variances to § 6-1-1-5 (Watering Restrictions) and § 6-1-1-6 (Water Waste), and § 6-1-1-7 (Special Permits).

(1) Administrative variances to the restrictions in §§ 6-1-1-5, 6-1-1-6, and 6-1-1-7 may be issued by the Mayor or his/her designee, provided that the general intent of this article has been met, compliance with this article is proven to cause practical difficulties and unnecessary hardship, and all options for abatement through modified water management have been exhausted. The criteria to determine hardship shall include level of capital outlay and time required to be in compliance with this article.

(2) Variances may be issued for a period not to exceed one year and shall stipulate both short-term corrective measures and a schedule for completion of long-term corrective measures. Variances must be renewed on an annual basis if long-term corrective measures cannot be completed within one year.

(B) Appeal of § 6-1-1-5 (Watering Restrictions), § 6-1-1-6 (Water Waste), and § 6-1-1-7 (Special Permits). Any responsible party may appeal fees for violations of §§ 6-1-1-5, 6-1-1-6, and 6-1-1-7 to the City Hearing Officer by filing an appeal within seven calendar days of receiving a notice of violation. Such request shall be made in writing and filed in the Office of the City Clerk. The appeal shall identify the property and state the grounds of appeal together with all material facts in support thereof. A filing fee of $20 shall be added to the water bill in the event the violation is upheld by the Hearing Officer. When a hearing is requested, the Hearing Officer shall send written notice by certified mail, return receipt requested, to the appellant of the time and place of the hearing. At the hearing the appellant shall have the right to present evidence as to the alleged fact upon which the Mayor based the determination of the need for assessment of fee or restriction of service and any other facts which may aid the Hearing Officer in determining whether this article has been violated. The Hearing Officer shall, within seven working days following the hearing, issue a written decision specifying the fee, if appropriate, and the action that must be taken to avoid additional penalty. Fees will be void and service will not be restricted if the written decision is not issued within seven working days.

(C) Judicial Review. The exclusive remedy for parties dissatisfied with the action of the City Hearing Officer on §§ 6-1-1-5, 6-1-1-6, and 6-1-1-7 shall be the filing of a petition for a writ of certiorari with the State District Court. The petition for review shall be limited to the record made at the administrative hearing held pursuant to this article.

(D) Variances to §§ 6-1-1-8 through 6-1-1-10 requirements. A variance to the regulations in §§ 6-1-1-8 through 6-1-1-10 may be issued by the Mayor, through the Zoning Hearing Examiner, provided that the general intent of this article has been met and compliance with this article is proven to cause practical difficulties and unnecessary hardship. The variance procedure for this article will comply with the variance procedure in the Zoning Code as currently adopted or subsequently amended. (This procedure is described in § 14-16-4-2.) Appeals of decisions of the Zoning Hearing Examiner are to the Environmental Planning Commission. Appeals of decisions of the Environmental Planning Commission are to the City Council. Appeal is made by filing written notice with the

Planning Department within 15 days after the request for variance has been denied. Appeal procedures will comply with those in the Zoning Code, § 14-16-4-4.

(Ord. 18-1995; Am. Ord. 24-1998)

§ 6-1-1-13 FEES; ASSESSMENT

(A) Fees and Restriction of Service. Any responsible party who violates any of the provisions of §§ 6-1-1-5, 6-1-1-6, and 6-1-1-7 shall be subject to progressively higher fees and flow restriction until the violation ceases or a variance is granted. The assessment of fees and application of flow restriction shall be consecutive for violations separated by less than three calendar years. Fees and flow restriction shall be suspended pending the outcome of an appeal or variance request.

(B) Assessment of Fees. Assessment of fees for violations of the regulations in §§ 6-1-1-5, 6-1-1-6, and 6-1-1-7 will be through the city utility bills for the responsible party's billing account. Fees shall be assessed to the account within 15 days following expiration of the appeal period or issuance of appeal findings and shall be listed as separate line item on the utility bill. Responsible parties shall be notified of the fee through certified mail within 15 days of the violation. Fees must be paid within the normal payment period allowed by the city utility billing system.

(C) In lieu of fees for violations of §§ 6-1-1-5 and 6-1-1-6, the responsible party may have a landscape water audit performed by an authorized landscape irrigation auditor, certified by the Irrigation Association. The audit will be conducted in accordance with the current edition of the Landscape Auditor's Handbook. The audit must be performed within 30 days of notification of violation and the audit recommendation must be implemented within 60 days of the audit. If these deadlines are not met, the fees for violation will apply.

(Ord. 18-1995; Am. Ord. 24-1998) Penalty, see § 6-1-1-99

§ 6-1-1-99 PENALTY.

(A) The schedule for assessment of fees and application of flow restriction for a violation of §§ 6-1-1-5, 6-1-1-6, and 6-1-1-7 shall be as follows:

(1) First observed violation – $20;

(2) Second observed violation – $50;

(3) Third observed violation - $100;

(4) Fourth observed violation - $150;

(5) Fifth observed violation - $200;

(6) Sixth observed violation - $300;

(7) Seventh observed violation - $400;

(8) Eighth observed violation - $500;

(9) Ninth or more observed violation: Either a $500 fee per violation plus application of a flow restriction device at meter or a $1,000 fee per each violation. The flow restriction device cannot be removed by the responsible party and will not be removed by the utility until the responsible partyadequately demonstrates to the city that the violation has ceased or until a variance is granted.

(B) For the purpose of assessing fees or flow restriction for violations of §§ 6-1-1-5, 6-1-1-6, and 6-1-1-7, any previous violation shall not be considered if:

(1) A period of five years has elapsed since the violation was incurred; or

(2) The property is acquired by a new owner; or

(3) The violation occurred prior to July 1, 1998.

(C) Any responsible party who violates any provision of §§ 6-1-1-8 through 6-1-1-10 shall be deemed guilty of a misdemeanor, and upon conviction thereof, shall be punished by a fine not to exceed $500 and/or imprisonment for a period not to exceed 90 days. Application of fines for violations of the regulations in §§ 6-1-1-8 through 6-1-1-10 will comply with the Zoning Code as currently adopted or subsequently amended. (See §§ 14-16-4-1 through 14-16-4-12, and 14-16-4-99).

(D) Any person who violates the provisions of this article for which no other penalty is set forth, shall be subject to the general penalty provision of this code set forth in § 1-1-99.

(Ord. 18-1995; Am. Ord. 24-1998; Am. Ord. 42-2001)

PART 2: FLUORIDATION OF WATER

§ 6-1-2-1 DECLARATION OF PURPOSE OF INTENT.

The City Council, based on information supplied to it by various sources, finds and declares that:

(A) The addition of fluorides to public water supplies is a process which has been adopted and used in many parts of the United States as a measure for improving the permanent condition of the teeth, in particular the teeth of children, and is a means of benefitting the population generally at a minimal cost and difficulty.

Appendix J3

City of Las Cruces

MUNICIPAL CODE
City of
LAS CRUCES, NEW MEXICO

Codified through
Ord. No. 1894, enacted Sept. 17, 2001.
(Includes Ord. No. 1884, Aug. 6, 2001)
(Supplement No. 6, Add.)

ARTICLE VII. WATER CONSERVATION

Sec. 28-301. Title; purpose.

This article shall be known as the Water Conservation Ordinance. This article shall both require and encourage all users of water within the city limits to reduce water consumption and waste.

(Code 1988, § 29-361)

Sec. 28-302. Applicability.

(a) The restrictions contained in this article shall apply to all users of city-provided water and to all users of water provided by water utility companies franchised by the city; however, the water use restrictions contained in subsection 28-304(b)(1) shall apply to all water users within the city limits.

(b) The outdoor vegetation watering restrictions in section 28-303 shall not apply to users of irrigation water provided by Elephant Butte Irrigation District, or to users of water provided by mutual domestic water companies or from domestic wells.

(Code 1988, § 29-362)

Sec. 28-303. Outdoor vegetation watering restrictions.

(a) All outdoor vegetation on residential and commercial properties located (i) on the even numbered side of the street shall be watered only on Tuesdays, Thursdays and Saturdays, and (ii) on the odd numbered side of the street shall be watered only on Wednesdays, Fridays and Sundays. For corner buildings or properties having both odd and even numbers, the number shown on the city's or the franchised water companies' utility records shall control.

(b) From April 1 to September 30, all outdoor watering of vegetation is prohibited between the hours of 10:00 a.m. and 6:00 p.m.

(c) A water utility company franchised by the city may apply yearly to the city's utilities division for a waiver from the outdoor vegetation watering restrictions in this section in accordance with the following:

> (1) The waiver will be granted by the utilities division if it determines that compliance with these restrictions will negatively impact the company's water system operations. The granting and the renewal of any waiver will be based on the company's consumption patterns being comparable to the city's residential water use.
>
> (2) Each waiver request must be accompanied by monthly water use records for the past year. The utilities division may require that the company provide additional information to justify the waiver request.
>
> (3) If the utilities division denies the waiver, the water company may file a written appeal with the city manager within ten days of the denial. The city manager will issue a final written decision within 20 days of receipt.
>
> (4) The waiver may be revoked by the city in a declared water emergency.

(Code 1988, § 29-363)

Sec. 28-304. Miscellaneous water use restrictions.

(a) The washing of vehicles and other types of mobile equipment shall be done only with a handheld bucket or a handheld hose equipped with a functioning shutoff nozzle for quick rinses. This restriction does not apply to the washing of vehicles or mobile equipment at a commercial carwash or commercial service station. When used in this subsection, the term "bucket" means a container holding five gallons of water or less.

(b) The following uses of water are defined as wasting water and are prohibited:

> (1) Allowing water to flow onto adjacent property or onto any street, alley or other public right-of-way.
>
> (2) Watering outdoor vegetation excessively so that water ponds on site.
>
> (3) Failing to repair a water leak within five working days of the discovery of the leak.
>
> (4) Washing sidewalks, driveways, parking areas, tennis courts, patios and other impervious surfaces with a hose, except in emergencies to remove spills of hazardous materials or to eliminate dangerous conditions which threaten the public health, safety or welfare. When used in this subsection, the term "impervious surface" means any surface covered with nonporous material.

(Code 1988, § 29-364)

Sec. 28-305. Penalty, injunctive relief authorized.

(a) Any person who is convicted of a violation of any section of this article shall be guilty of a petty misdemeanor and shall be punished in accordance with section 1-10.

(b) With respect to violations that are continuous in time, each day the violation continues is a separate offense.

(c) Violations that are continuous in time may be abated by injunctive or other equitable relief. The imposition of a criminal penalty does not prevent equitable relief.

(Code 1988, § 29-365)

Sec. 28-306. Exceptions to enforcement.

The following shall constitute exceptions from compliance with this article concerning outdoor vegetation watering restrictions and miscellaneous water use restrictions:

(1) The water flow is a result of natural events such as rain or snow, unless the user is watering at the same time.

(2) The water flow is a result of temporary malfunctions of or vandalism to the municipal water supply system.

(3) The water flow is a result of water used for firefighting purposes, including the inspection and pressure testing of fire hydrants, or the use of water for firefighting training activities.

(4) The use of water is required for the control of dust or the compaction of soil as may be required by municipal codes.

(5) The water is used to wash down areas where flammable or otherwise hazardous material has spilled, creating a dangerous condition.

(6) The water is used to prevent or abate public health, safety or accident hazards when alternate methods are not available.

(7) The water is used for routine inspection or maintenance of the municipal water supply system.

(8) The water is used to facilitate construction within public a right-of-way in accordance with city requirements and good construction practices.

(9) The use of the water is permitted under a variance granted by the city.

(10) The water is used for street sweeping, sewer maintenance or other established utility practices.

(11) Watering contrary to the odd/even or time of day requirements is permitted for one day only where application of chemicals requires immediate watering to preserve an existing lawn.

(12) Watering contrary to the odd/even or time of day requirements is permitted for up to two weeks for newly planted landscaping vegetation.

(Code 1988, § 29-366)

Sec. 28-307. Water emergency; restriction of water use.

(a) The city council may declare a water emergency during a severe drought or during any condition which significantly reduces the city's ability to supply water in order to protect the public health, safety or welfare or to preserve the water supply.

(b) During such a water emergency, the city manager may implement water use restrictions approved by the city council.

(Code 1988, § 29-367)

Secs. 28-308--28-350. Reserved.

Appendix J4

City of Santa Fe

SANGRE DE CRISTO WATER

NEW WATER USE REQUIREMENTS

On November 14, 2001, the Santa Fe City Council adopted a host of new water conservation requirements to further promote wise water use in our city. In part, the intent is to minimize our vulnerability to future water shortage emergencies through aggressive water conservation. These provisions apply to all customers on the city water system and all water users within the City limits (e.g. private well users).

Restaurants and Banquet Operations Shall Only Serve Water and Other Beverages Upon Request

This provision includes unstaffed banquet operations (i.e. pre-setting of water and ice tea is not permitted). Beverages in single serving containers (e.g. cans or bottles) shall not be served with an accompanying glass unless requested by the customer. These provisions must be posted in a manner visible to the customer (on the menu, as a table tent, or as a sign posted in a prominent location).

Plant Nurseries

1. **Shall make City-provided conservation literature readily available to their customers**
2. **Are strongly encouraged to tag or sign their low water use plants that require little to no supplemental watering**

In addition to the general conservation literature requirement, customers purchasing turf seed or sod shall be provided city literature indicating the restrictions to planting cool season water consumptive turf under the City's new landscape ordinance. Among other provisions, the landscape ordinance does not allow the planting of turf seed or sod in excess of 25% Kentucky bluegrass content. However, the ordinance does not prohibit the sale or purchase of Kentucky bluegrass - just the planting of Kentucky bluegrass within the city limits.

Fugitive Water and Water Waste Prohibited

"Fugitive water", usually involved with watering landscaping, is when water flows onto hard surfaces or leaves the landscaped area intended to be watered. The water does not need to flow off property to be a fugitive water violation. The irrigation system shall not be operated again until the problem (e.g. broken sprinkler head) has been repaired. Washing hard surfaces is only allowed for public health and safety reasons. Vehicle washing is allowed if a shut-off hose nozzle is in use! Hose washing of outdoor eating areas is not permitted. "Water waste" is any indoor or outdoor leak in excess of 0.25 gallons per minute (gpm). Indoor leaks (e.g. faucets and toilets) must be repaired within 15 calendar days. Your facility manager and your landscape maintenance company (if you have one) need to be well aware of these provisions.

Landscape Watering Prohibited 10 am to 6 pm, May through October

The previous 3 day per week "odd-even address" outdoor watering restriction has been removed. However, we emphasize that most established landscaping can do well on just once per week watering.

Compliance

For violation of any of the provisions noted above, "Water Use Citations" will be issued. Citation fees will be assessed on the water bill and range from $20 for the 1st violation to $200 for the 4th and each subsequent violation. As a last resort, discontinuance of water service will be considered for habitual violators.

Buildings Must Be Retrofitted With 1.6 Gallon Per Flush (gpf) Toilets by January 1, 2003

An "Ultra Low Flush Toilet Fact Sheet" is available from the Water Division to acquaint you with the different types on the market.

Contrary to a common rumor, the newer generation ULFT's work quite well. Toilets that use a "quick closing flapper" to limit the flush to 1.6 gpf may not be used to satisfy this requirement. In addition, buildings must have low flow showerheads (2.5 gal/min) and faucet aerators (2.5 gpm or less) by January 1, 2003. These provisions do not apply to homes or multi-family apartment complexes.

Conservation Sign in All Public Restrooms

This requirement has existed since 1997. Signs are available from the Water Division or entities may make their own signs using the City-established text.

Lodging Facilities

1. **May not provide daily linen and towel changing for multiple night guests unless the guest specifically requests it**
2. **Shall provide a conservation informational card or brochure in each guest room**

Lodging facilities commonly instruct their guests to place a request card on the bed and to throw the towels in the bathtub if linen and towel changing are desired. A request card "table tent" and conservation information towel rack hanger are being jointly produced by the City and the Santa Fe Lodgers Association and will soon be available from the Water Division. Lodging facilities may develop their own request card and conservation literature.

These provisions are legally enforceable requirements. However, the City's goal is to assist water users in any way possible to prevent violations from occurring in the first place. Our emphasis is on ensuring wise water use <u>not</u> on issuing as many citations as possible.

Thank you for making Santa Fe a "Water Friendly" community!

City of Santa Fe

For assistance or more information call 954-7199.

December 2001

The City of Santa Fe Water Conservation Brochure is available in hard copies of the *Colfax Regional Water Plan*

Stage 3 Drought Emergency Water Restrictions Information

Current & Past Reservoir Levels

WATER SHORTAGE EMERGENCY

Mandatory Water Use Restrictions *Declared April 10, 2002*

Vehicle washing at residences is prohibited

- All vehicle washing is limited to once per month at commercial car wash facilities
- Car lots and other commercial and governmental entities with on-site vehicle washing facilities are limited to washing their vehicles one time per month during the first full week of the month

One day per week outdoor watering restriction

- Odd-addresses: TuesdaysEven-addresses: Fridays
- All new plantings must comply with the once per week watering restriction
- Plants in above ground containers movable by hand (e.g. hanging baskets, potted plants) are exempt from one day per week watering
- Water harvested from precipitation, effluent water and gray water are exempt from one day per week watering

No new grass seed or sod may be planted

All swimming pools must be covered when not in use

- Swimming pools and spas may not be filled or refilled

The use of ornamental fountains is prohibited

Lodging facilities shall not change the sheets and towels more than once every four days for guests staying more than one night

Drought emergency surcharges

- Residential: $15 per 1000 gallons for usage above 10,000 gallons per month - $25 per 1000 gallons for usage above 20,000 gallons per month
- Commercial: $2 per 1000 gallons on all usage

Water use violation fees

- Violating the restrictions described above and other restrictions results in fees being placed on the customer's water bill.
- 1st Violation: $20 2nd Violation: $50 3rd Violation: $100 4th and additional Violations: $200
- Water service may be suspended for repeat violators

Year Round Water Restrictions

- Restaurants and banquets may serve water only upon request
- Washing hard surfaces is not permitted (e.g. driveways, sidewalks, parking lots, outdoor eating areas)
- Fugitive water is not permitted (i.e. water that flows onto any surface or leaves the intended landscaped area)
- Water waste is not permitted (e.g. indoor and outdoor leaks including faucets, toilets, evaporative coolers, hoses, etc.)
- No landscape watering permitted between 10 am and 6 pm (in effect May 1, through October 31)

These provisions apply to all Sangre de Cristo Water customers and all water users within the City limits, including domestic well users. Stage 3 restrictions are in addition to Stage 2 and the year round restrictions.

To report water use violations call 954-4220

E-mail

Email the Water Division for questions or comments

| Stage 3 Drought Emergency Water Restrictions Information |
| Daily & Weekly Water Reports | Current & Past Reservoir Levels |
| Water Conservation Brochure (PDF) |
| Water Conservation Ordinance (PDF) |
| 2001 Water Quality Report (PDF) |
| Water Wise Home |

Water Conservation

Water Wise Home

Stage 3 Water Restrictions

Stage 3 Drought Emergency Water Restrictions Information

Daily & Weekly Water Reports

Current & Past
Reservoir Levels

Water Conservation Brochure (PDF)

Water Conservation Ordinance (PDF)

2001 Water Quality Report (PDF)

----------- City Services -------------	----------- City Departments ------------

Appendix J5

Rate Structures

conjunction with a water auditing program.

- Coordination with local communities to develop ordinances that limit outdoor water use by customers, and to require all new construction projects to utilize water efficient fixtures. Encourage local building inspectors to rigorously enforce existing plumbing and building codes.

System Metering And Improvements

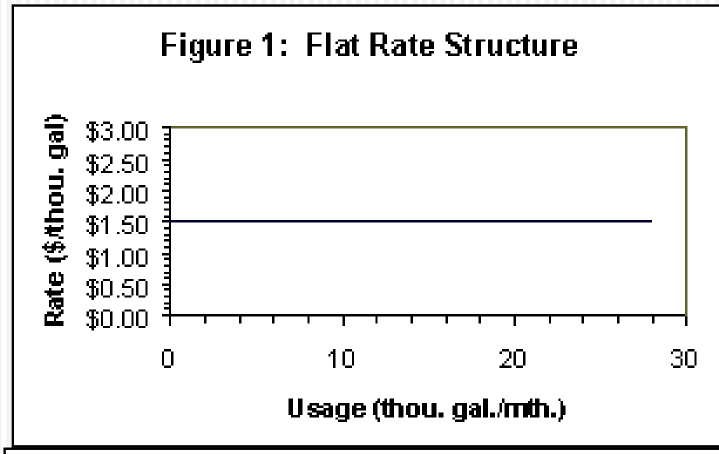
Complete system metering lets customers know how much water they are using, provides the supplier with valuable knowledge of customer use patterns, assists in demand management programs, and enables the supplier to bill the customer accurately. Sub metering is also recommended in non-residential applications like industrial and some commercial facilities. With accurate knowledge about current demand, the supplier can more effectively identify potential water savings, assist specific users to implement water saving measures, provide the opportunity to reduce overall system demand, and plan efficiently for system growth.

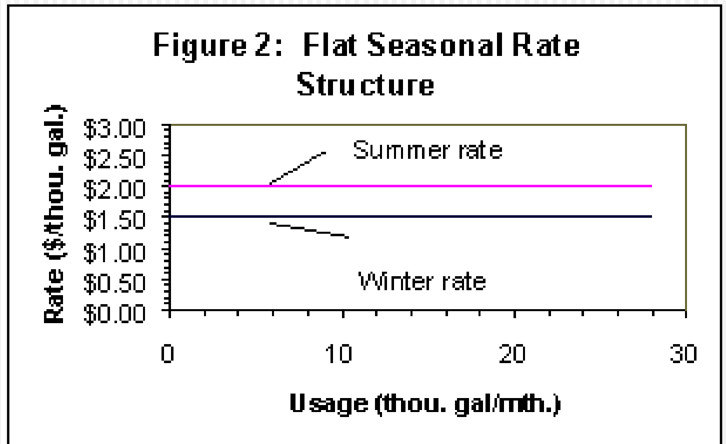
A metered water system tracks the volume of water used and the volume of water that is "lost" in the system. When a utility has a significant unaccounted for water problem, it can become its own biggest customer. Therefore, an effective metering and leak detection program should be able to account for 90 percent of total production. Utilities should set the right example in leak detection if they want their customers to follow.

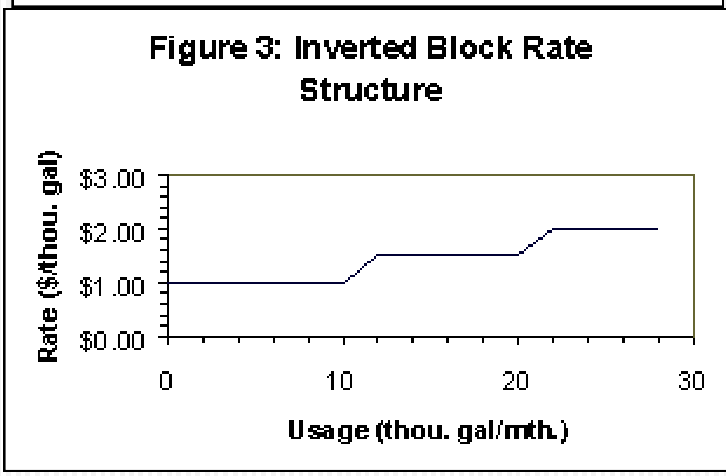
Water Conservation Incentives Through Rate Structuring

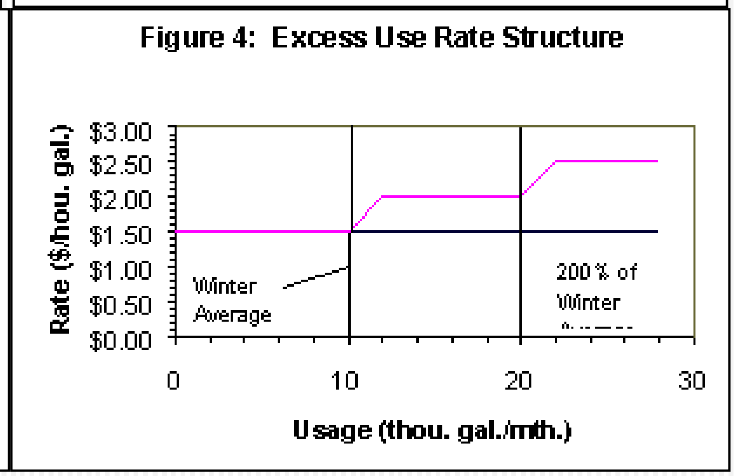
More and more utilities are using price as a demand management tool. According to a 1992 AWWA survey, approximately 60% of the utilities in the United States use a conservation rate structure. There are four different types of rate structures that can generally be classified as conservation oriented. These rate structures are classified as:

- **Uniform commodity rates** - This is a rate structure whereby all usage is charged at the same unit rate (see Figure 1). Although not often viewed as being a water efficiency oriented rate, uniformrates are an improvement over declining-block rate structures in which the price of water decreases as the volume of water used increases.
- **Flat seasonal rates** - This rate structure incorporates two or more different uniform volume charges for different seasons during the year (see Figure 2). Generally, a higher rate is charged to usage during the peak water usage season than is charged during the off-peak season.
- **Inverted block rates** - An inverted-block rate structure involves the use of increasing rates for units of water consumption at higher levels of usage (see Figure 3).
- **Excess use rates** - An excess use rate structure involves the establishing an average base water usage volume during the non-peak period, which is calculated separately for each customer. This base water usage is then charged at a base rate. During the peak period or season, water usage above this base level is charged at the base rate plus an excess use rate (see Figure 4). Several variations of the excess use rate structure exist. Some utilities provide an allowance above the base usage during the peak season to recognize an increase in non-discretionary use during peak periods.









Which Rate Structure Is Right For A Utility?

Each utility will be presented with a unique set of circumstances that it must assess prior to implementing a conservation rate structure. In general, the criteria that may be helpful in evaluating the effectiveness of a specific type of water efficiency oriented rate structure include:

- Which rate structure produces a measurable reduction in water usage?
- Which rate structure increases the awareness of resource availability by its customers?
- Which rate structure allows the utility to stabilize and predict revenue?
- What is the general public acceptance of the rate structure?
- What is the perceived equitability of the rate structure?
- What is the administrative efficiency of the proposed rate structure?

The appropriateness of a given conservation rate structure is dependent in part upon the circumstances of the particular utility. Each rate structure has advantages and disadvantages. The type of rate structure currently in place can also have an influence on the response to a conservation oriented rate structure. For example, an immediate change from a declining block rate structure to an inclining block rate structure would likely result in large increases in cost to large quantity water users, but could result in lower rates to small quantity water users (which collectively are the largest user group of water) inducing the group of small quantity water users to use more water.

Similarly, the type of customer base served by a utility is important to consider when implementing a conservation rate structure. For example, an inverted-block rate structure may provide a considerable incentive for large water users to reduce their usage requirements without charging high water rates to water users with low monthly usage levels. However, in some instances, those large water users may be industrial facilities with limited options to implement substantial water conservation measures, and yet they would be paying higher water rates under the inverted rate structure. A utility should research and work with its customer base to determine the best method for achieving its water conservation goals.

Importance of Billing Frequencies.

The billing frequency of the water utility is an important factor in the implementation of water efficiency oriented rates. Lengthy billing periods can be a limiting factor. The more frequent the billing, the more likely conservation rates will be successful.

How Does a Utility Project Future Revenue?

Although uncertainty in revenue is not unique to any utility rate structure, it is greater when implementing conservation rate structures, as these pricing policies usually do not exhibit the high minimum charge that standard rate structures incorporate. A utility must assess the interrelationships between rates, consumption, and costs, and how these issues affect the revenue requirements of the utility. A utility should study its billing records and survey its primary customers to better understand the potential revenue impacts from a proposed pricing structure.

Include the Protection of Future Water Resources in the Application of Any Water Rate Structure.

A reduction in overall water use may cause a water system to defer purchasing the rights to, or securing land to protect new water resource areas. With the passage of time these nearby, relatively low cost water resource sites could be developed for other purposes and lost forever. Any new rate structure should be designed to provide the revenue to enable the utility to purchase and protect future sources of water for the system.

Coordination With Local Elected Officials To Develop Ordinances Relating To Outdoor Landscape Construction And Water Use Restrictions.

To combat excessive outdoors water use, local municipalities have begun instituting ordinances banning new installation of in-ground irrigation systems. Others place severe restrictions on their use. The water utility can encourage local officials to adopt such ordinances, siting the sizeable water and cost savings that can be achieved by this type of legislation.

For Additional Information

Should you have any questions about implementing a water conservation program, contact the Water Supply Engineering Bureau at (603) 271-0660. Reference documents are available from the Department to assist with the implementation of water conservation programs.

WaterWiser, a program of the American Water Works Association
www.waterwiser.org/

North Carolina Division of Pollution Prevention and Environmental Assistance.
www.p2pays.org/

Massachusetts Water Resources Authority - Conservation Issues
www.mwra.com/water/html/wat.htm

EPA's Water Efficiency Program
www.epa.gov/owmitnet/genwave.htm

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Appendix K

Public Education Materials

This appendix is available in hard copies of the

Colfax Regional Water Plan