APPENDIX E

1994 WASTEWATER FLOW ANALYSIS

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The following Wastewater Treatment Plant (WWTP) flow analysis was included in the November 1994 Draft Wastewater Treatment Facilities Plan, Redwood SSSD.

1. HISTORICAL RECORDS

Since 1978, the Redwood Wastewater Treatment Plant has recorded effluent flow measurements. These are collected from a Fischer and Porter flow meter and recorder calibrated to the 60° V-notch weir located in the effluent outlet structure. The last six years (January 1988 - August 1993) of recorded data are shown in Figure 1. Also, the entire flow data files are included in Appendix B.

The effluent flow meter has periodically experienced operational problems. During the spring of 1990, it malfunctioned and was repaired. In August 1991, it had problems again and was repaired. Finally, in September 1991 it broke down completely; a decision was made not to repair it, and a new flow meter was ordered. From September 1991 to late September 1992, effluent flows were not recorded. On September 24, 1992, however, the new flow meter and recorder was installed and began operation. This flow meter has recorded flows through August 19, 1993. After this date, the new meter also malfunctioned and has not yet been repaired.

2. DATA VALIDATION

Two separate data validation analyses were conducted on the plant flow data. These consisted of comparisons of flow data to both the hours of operation of the influent pumps and the monthly power consumption at the plant. Both of these recorded indicators may be related to plant flow and may be used to validate flow data. These two comparisons are shown in Figure 2.

Figure 2 compares the daily hours of operation of influent pumps and the total daily wastewater flow treated at the plant. A linear relationship is generally observed, which would tend to confirm plant flow records. The line shown in the figure has been plotted based on the flow capacity of the influent pumps. It represents the calculated total plant flow versus hours of operation of the pumps. Since virtually all of the data points are above the line, this causes the flow records to be suspect. In fact, the data should fit the line shown if the pump capacity information is correct. Field pump capacity verification is suggested to confirm this information.

Figure 3 compares the monthly power consumption at the plant and the total wastewater flow treated during the same time period at the plant. No relationship between the data is observed. Power consumption generally is not affected by total flow treated by the plant.

This is not unexpected. Since most of the major electrical equipment at the plant operates irrespective of volume treated, this would include such electrical devices as blowers, disinfection equipment, lights, etc. There is no correlation between power consumption and volume treated at the plant.

Based on data validation analyses conducted on the plant flow data, data generally appear accurate. The most accurate flow data are, however, records collected from September 24, 1992, to August 19, 1993, since these data were received from the recently installed and calibrated flow meter.

3. 1993 CONDITIONS

To determine existing maximum monthly dry weather flow (MMDWF), maximum monthly wet weather flow (MMWWF), peak instantaneous flow (PIF), and seasonal average flows, a thorough analysis of six years of recorded flow data was conducted. Flow and rainfall data were analyzed in conformance to the ODEQ guidance document, "Flow Projections for Sewage Treatment: MMDWF, MMWWF, and PIF" dated January 7, 1991. Existing flows were determined with a 20 percent probability of recurrence (i.e., the existing maximum monthly dry weather flow which has only a 20 percent probability of being experienced during May through October in any given year if no future connections to the sewer occurred). Figures 4 and 5 show the summer (dry weather - May through October) and winter (wet weather - November through April) flow records at the plant for a 30-day running average during the last six years.

3.1 Rainfall

Monthly rainfall data from Grants Pass for the period 1961 through 1993 were analyzed to determine the 5-year recurrence maximum rainfall for each month of the year. The following table summarizes the results of these analyses which are shown in tabular form in the back of this Appendix.

Monthly 5-Year Recurrence Rainfall Events, Inches					
January	7.54	May	2.18	September	1.65
February	5.82	June	1.06	October	3.97
March	5.26	July	0.78	November	8.09
April	3.04	August	1.09	December	8.77

October is the wettest summer (dry weather) month and December is the wettest winter (wet weather) month.

3.2 Rainfall/Plant Flow Analysis

Monthly rainfall versus monthly plant flow data for years 1988 to 1993 were graphed in an attempt to correlate rainfall to plant flow in accordance with ODEQ guidance. These graphs are included at the end of this Appendix.

No correlation was evident, however, due to several conditions in the Redwood Sanitary Sewer Service District that were different than those suggested by ODEQ.

- High groundwater occurs during April 15 to October 1 of each year in the district due to irrigation, rather than in January as expected by ODEQ.
- October and December are the wettest summer and winter months in the district, respectively, rather than May and January as expected by ODEQ.

For these reasons, a different approach to predict the 20 percent recurrence MMWWF and MMDWF at the plant was used. Individually, each year of plant flow and rainfall data were used to conduct the following analysis:

Step 1: Develop an equation to predict plant flow from rainfall using the "line of best fit" for each year of data.

Step 2: Compare actual monthly rainfall to recorded plant flow, and

Step 3: Compare the 5-year recurrence maximum monthly rainfall to its predicted plant flow using the equation from Step 1 for several wet summer and winter months, and then

Step 4: Estimate the 20 percent recurrence MMWWF and MMDWF based on these comparisons and engineering judgment.

Using this technique, the equations to predict monthly plant flow from monthly rainfall for each of the six years, 1988 to 1993, of plant flow data were as follows:

1988 **Plant Flow = 22.63 x Rainfall - 5.57**
Data Correlation Factor 87 Percent

1989 **Plant Flow = 20.07 x Rainfall - 5.84**
Data Correlation Factor 91 Percent

1991 **Plant Flow = 21.23 x Rainfall - 8.82**
Data Correlation Factor 99 Percent

1993 **Plant Flow = 6.73 x Rainfall - 0.15**
Data Correlation Factor 85 Percent

3.3 Maximum Monthly Dry Weather Flow (MMDWF)

The 1993 maximum monthly dry weather flow (MMDWF) was estimated at 0.48 mgd. This was based on the following data analysis:

MMDWF Analysis					
Month	Actual Flow (mgd)	Predicted Flow (based on actual rain) (mgd)	Actual Rainfall (inches)	5-Year Rain (inches)	5-Year Predicted Flow (based on 5-year rain) (mgd)
May '93	.36	.40	2.91	2.17	.30
June '93	.41	.14	1.12	1.06	.13
July '93	.48	0.02	0	.78	.09
August '93	.45	.15	1.17	1.08	.14

- May, June, and August 1993 each experienced greater than 5-year recurrence monthly rainfalls yet actual plant flows average only 0.41 mgd.

- The 0.48 mgd plant flow experienced in July 1993 was therefore very likely a typically high flow event. In fact, it was probably around a 5-year recurrence maximum plant flow since the total rainfall occurring during May through August 1993 totalled 5.20 inches. The 5-year recurrence maximum total rainfall for May through August is 5.09 inches.

3.4 Maximum Monthly Wet Weather Flow (MMWWF)

The 1993 maximum monthly wet weather flow (MMWWF) was estimated at 1.09 mgd. This was based on the following data and analysis:

MMWWF Analysis					
Month	Actual Flow (mgd)	Predicted Flow (based on actual rain) (mgd)	Actual Rainfall (inches)	5-Year Rain (inches)	5-Year Predicted Flow (based on 5-year rain) (mgd)
January '89	.49	.46	3.31	7.54	.66
February '89	.37	.37	1.51	5.81	.58
March '89	.59	.61	6.41	5.26	.55
November '89	.32	.35	1.12	8.09	.69
December '89	.32	.34	.99	8.77	.73
November '92	.39	.42	3.00	8.09	1.18
December '92	.67	1.48	10.10	8.77	1.28
January '93	.69	.72	5.00	7.54	1.09
February '93	.57	.58	4.06	5.81	.84
April '93	.58	.61	4.31	3.05	.43

- In March 1989, rainfall was 22 percent greater than the 5-year rainfall and yet plant flow was only 0.59 mgd, and
- In December 1992, rainfall was 15 percent greater than the 5-year rainfall and yet plant flow was only 0.67 mgd.
- In April 1993, rainfall was 41 percent greater than the 5-year rainfall and yet plant flow was only 0.58 mgd.
- During January 1993, the highest plant flows of record were measured. Actual flows were 0.69 mgd even though rainfall was only 66 percent of a 5-year rainfall event.
- The predicted flow for January 1993 based on actual rainfall was, however, 0.72 mgd which is very similar to the actual flow.
- Therefore, the predictions for 1993 appear to be most accurate of all the predictions made during the wet weather months.
- Based on the January 1993 prediction, the 20 percent recurrence maximum plant flow would have been 1.09 mgd which is considered the MMWWF.

3.5 Peak Instantaneous Flow (PIF)

To determine peak instantaneous flows, peaking factors were developed from flow measurements taken during the detailed flow monitoring conducted in September, October, and December 1992 and January 1993 in the collection system. Specifically, from continuous flow measurements taken at Manhole RI-5, the ratio of peak instantaneous flow to average daily flow was developed and is shown in the following table:

Date	Q Average	Q Peak Inst.	Ratio
October 25	.29	.42	1.45
October 26	.29	.43	1.48
October 27	.30	.41	1.37
October 28	.30	.41	1.37
October 29	.33	.45	1.37
October 30	.32	.48	1.5
October 31	.48	.60	1.26
			Average = 1.40
December 31	1.37	1.77	1.29
January 1	0.90	1.25	1.39
January 2	0.83	1.03	1.24
			Average = 1.30

Based on these data, a conservative peaking factor of 1.4 was estimated.

3.6 Summary

Based on the above analysis, the following existing wastewater flow conditions exist at the plant:

1993 Plant Flow Conditions				
	Max. Month	**Max. Week**	**Peak Day**	**Average**
Summer - Dry Weather	.48[1]	.51	0.67	.43
Winter - Wet Weather	1.09[2]	1.12	1.39[3]	.59
Annual	—	—	—	.50

(1) Monthly dry weather flow - MMDWF.
(2) Monthly wet weather flow - MMWWF.
(3) Peak instantaneous is 1.95 mgd based on a peaking factor of 1.4.

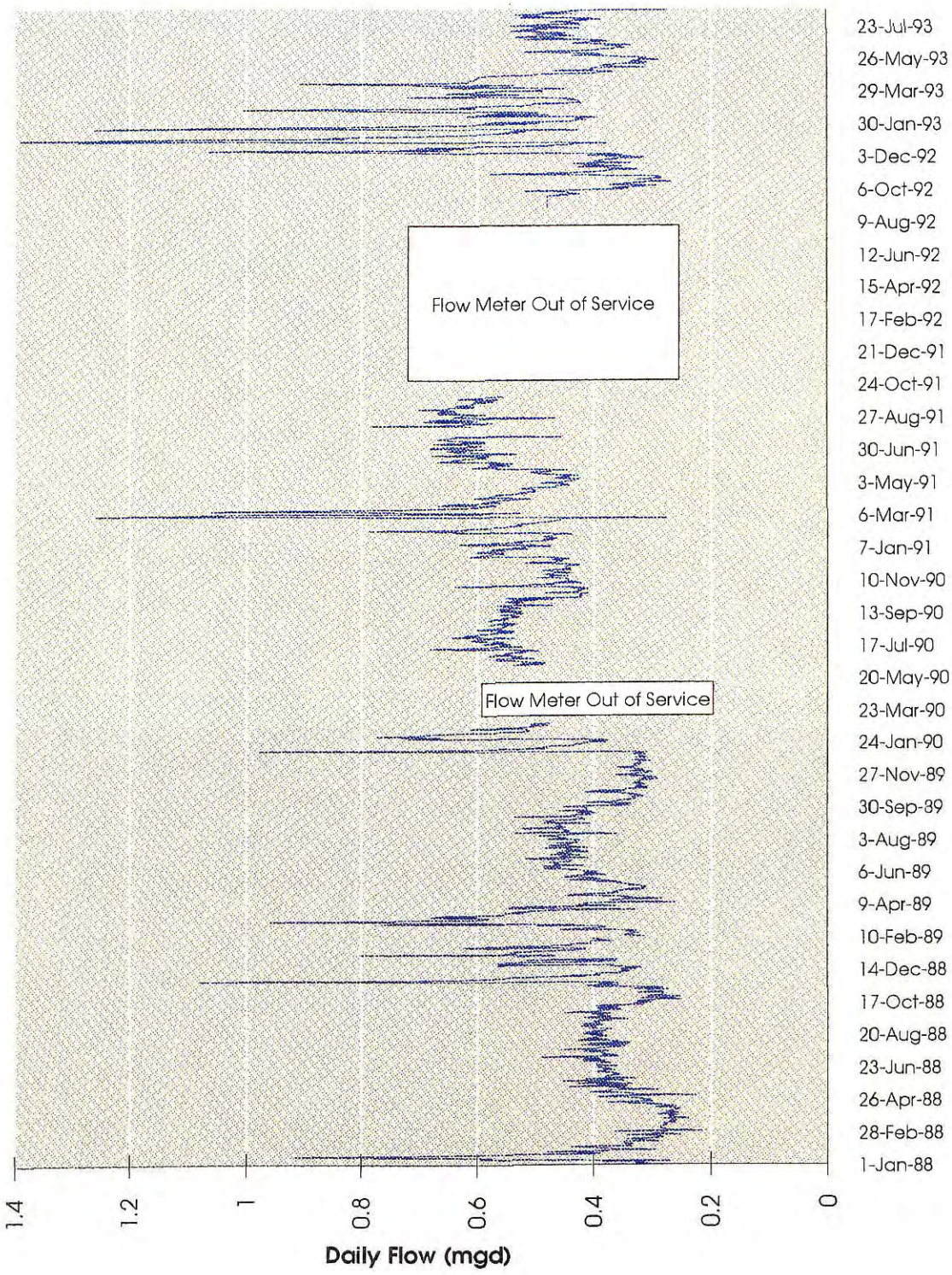

Figure 1
Influent BOD Load vs. BOD Removed
30-Day Running Average

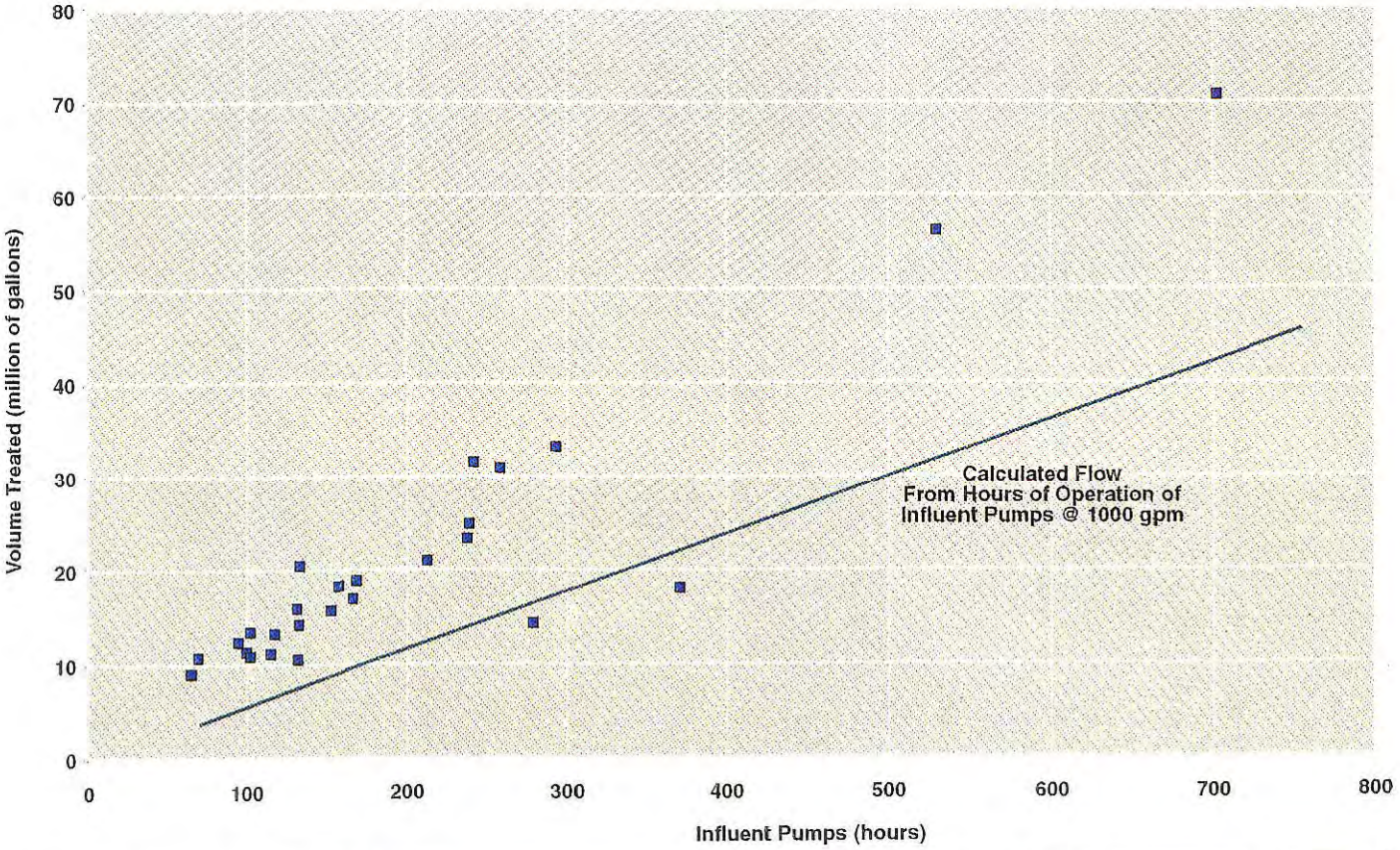

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Figure 2
Flow Data Validation Analysis
Influent Pump Operation vs.
Volume Treated

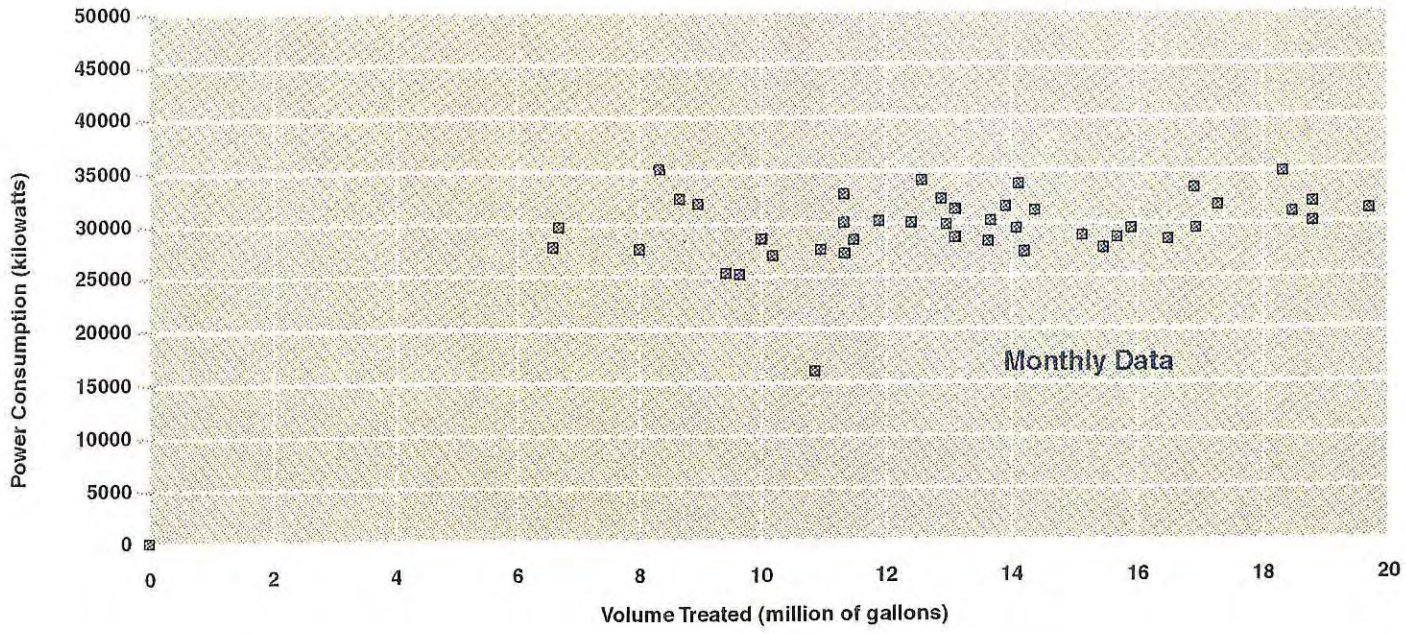

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Figure 3
Flow Data Validation Analysis
Power Consumption vs.
Volume Treated

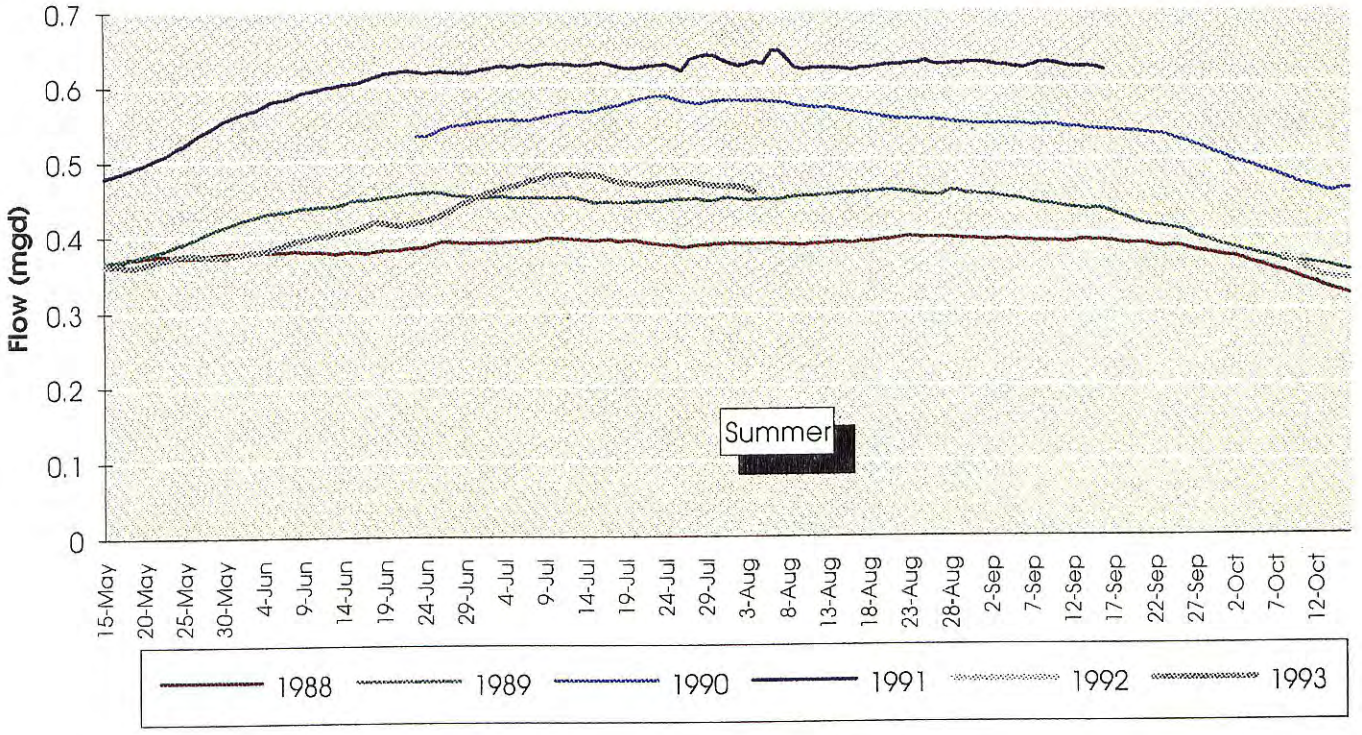

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Figure 4
Summer 30-Day Running Average Flow

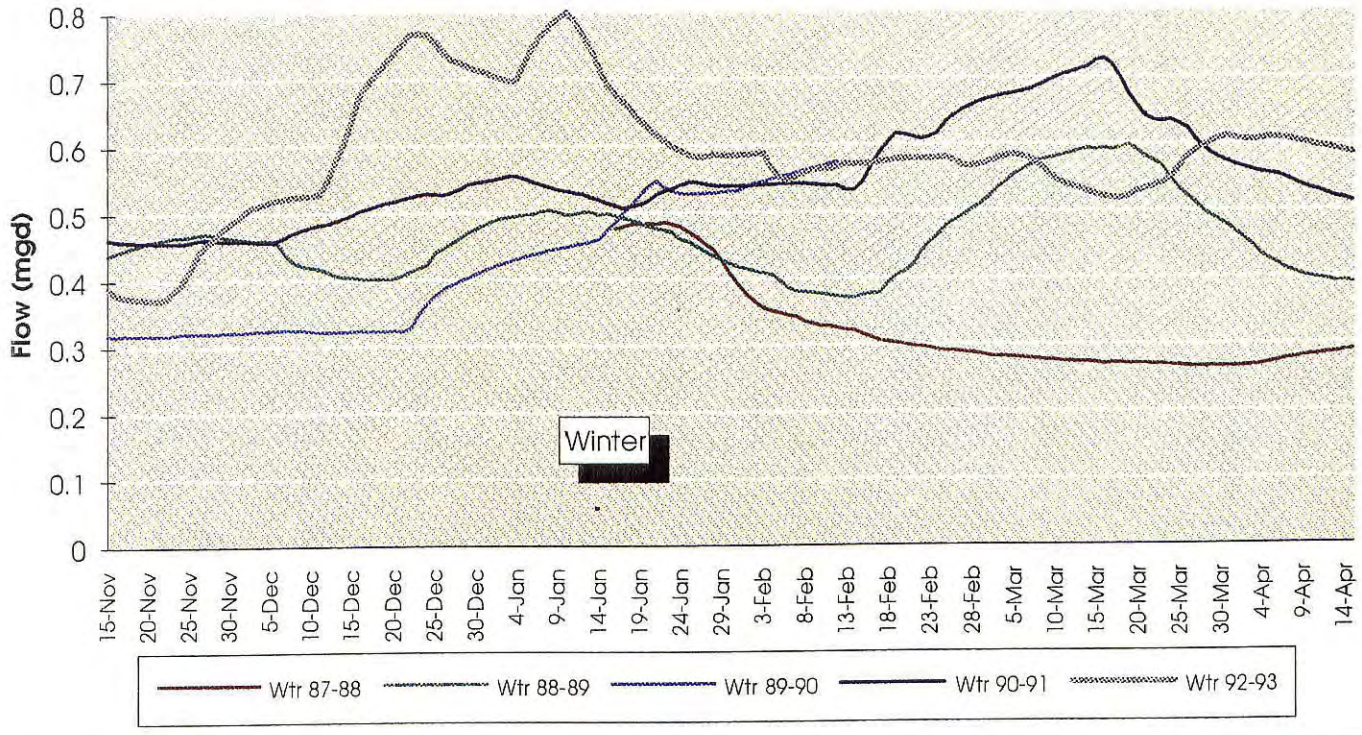

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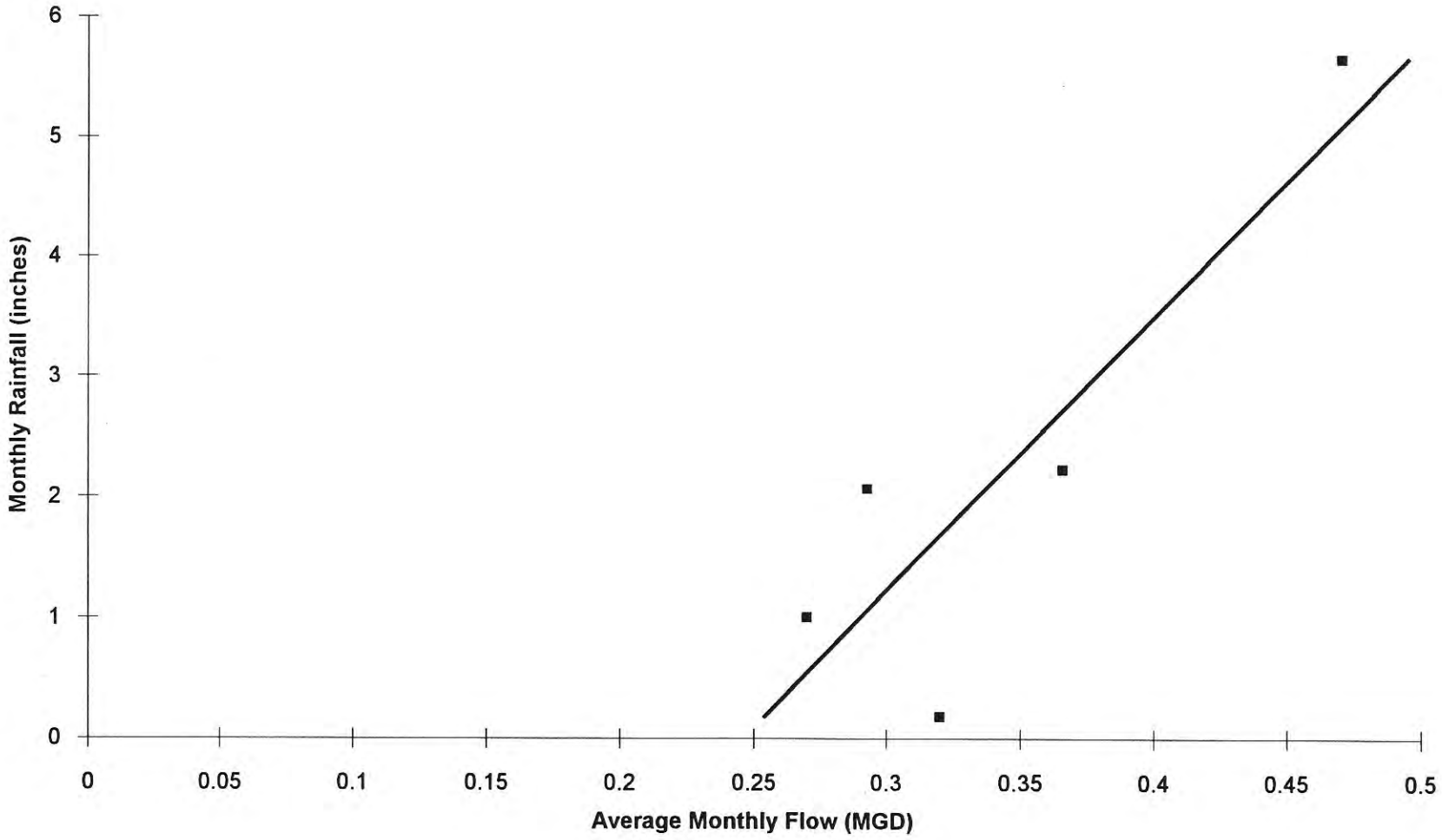
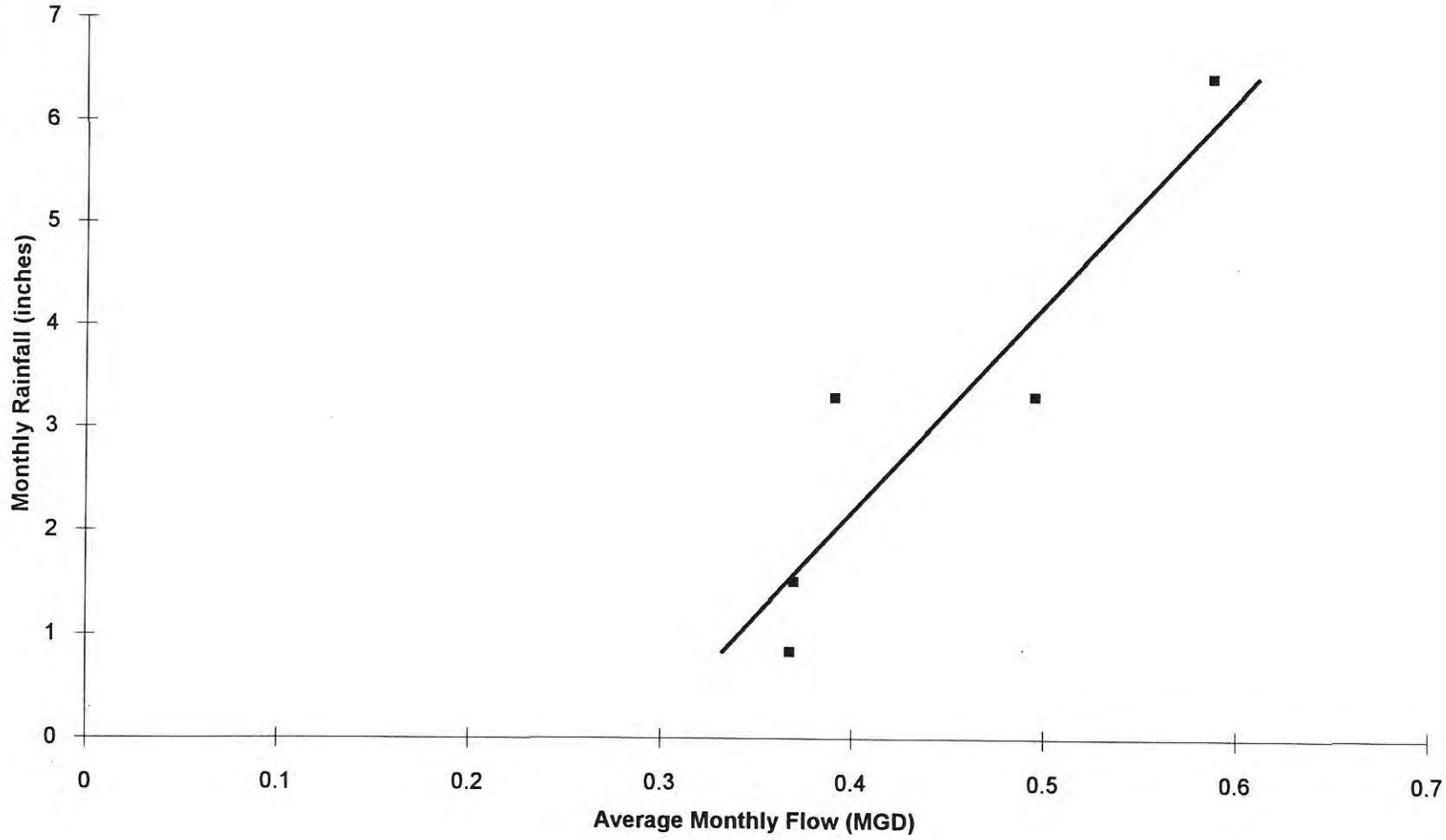
Figure 5
Winter 30-Day Running Average Flow

YEAR	November	December	January	February	March	April	May	June	July	August	September	October
1961	4.92	3.21	3.66	7.53	6.18	1.33	2.37	0.5	0.06	0.24	0.72	3.59
1962	5.3	4.37	2.33	4.05	2.79	1.41	1.23	0.18	0	1.52	1.34	8.86
1963	7.57	2.08	2.92	4.44	4.23	5.32	3.95	1.13	0.1	0	0.13	2.29
1964	5.35	16.06	9.26	0.66	4.2	0.4	0.73	0.53	0.21	0.04	0.08	0.59
1965	4.61	9.27	7.54	0.91	0.1	4.01	0.27	1.52	0.01	1	0	0.96
1966	9.41	5.7	9.55	1.28	4.65	1.15	0.16	0.25	0.43	0.19	1.65	0.8
1967	2.14	4.96	8.41	1.12	3.85	2.11	0.49	0.31	0	0	0.51	2.79
1968	4.95	6.92	6.97	3.98	2.68	0.46	1.9	0.08	0.03	1.71	0.48	2.17
1969	1.31	9.56	9.69	2.24	0.62	0.94	1.89	0.67	0.88	0	1.19	3.82
1970	9.9	8.23	12.03	2.52	1.61	1.59	0.4	0.52	0	0.01	0.14	2.56
1971	6.13	3.74	6.74	1.9	5.42	2.41	0.56	0.98	0.02	0.24	1.58	1.14
1972	2.91	6.35	3.41	6.27	3.18	2.65	1.28	0.17	0	0.77	0.81	1.96
1973	15.15	6.58	4.5	1.53	3.02	0.39	0.3	0.13	0.08	0.02	1.23	3.36
1974	2.25	5.62	10.6	4.7	6.22	1.7	0.15	0.01	0.31	0	0	1.17
1975	2.58	4.57	3.42	6.14	7.66	2.04	0.18	0.11	0.29	0.39	0.07	4.27
1976	0.67	0.65	1.68	3.14	1.97	0.82	0.41	0.04	0.77	3.33	1.03	0.57
1977	6.22	6.6	1.38	2.5	2.02	0.75	2.31	0.06	0.68	0.27	4.19	1.33
1978	2.03	1.3	5.21	6.73	3.04	2.06	0.75	0.62	0.5	1.05	2.91	0.04
1979	4.75	6.41	2.87	5.33	1.63	3.59	3.07	0.35	0.14	0.32	0.21	6.1
1980	3.76	6.83	4.68	3.66	3.03	2.47	0.91	0.55	0	0	0.07	2.74
1981	9.28	12.36	1.65	2.68	2.64	0.71	0.98	0.58	0.15	0	1.07	4.25
1982	4.91	10.01	4.26	4.12	4.29	4.6	0	2.72	0.01	0.05	1.16	3.98
1983	9.19	9.72	5.06	10.68	8.82	1.79	0.41	0.31	0.49	1.46	0.24	1.61
1984	13.43	2.64	0.4	4.63	3.92	2.02	0.68	0.45	0	0.45	0.72	2.37
1985	3.1	1.85	0.13	2.36	2.86	0.53			0.03	0.05		1.79
1986	3.18	2.09	6.1	9.47	2.53	0.51	1.59	0.44	0	0	2.91	2.22
1987	1.67	8.07	6.1	5.24	3.23	0.31	0.22	0.06	1.08	0	0	
1988	9.42	2.73	5.63	0.18	1	2.06	2.22	1.21	0	0.06	0.04	0.03
1989	1.12	0.99	3.31	1.15	6.41	3.3	0.84	0.17	0.01	0.2	1.33	2.27
1990	2.23	1.2	5.63	2.85	1.65	0.63	4.08	0.34	0.32	0.99	0.07	2.95
1991	3.73	3.42	1.9	2.32	6.57	1.94	1.77	0.7	1.13	0.2	0	0.65
1992	3	10.1	3.16	3.26	2.39	3.02	0.49	1.51	2.77	0	0.08	3.44
1993	1.18	5.14	5	4.06	2.79	4.31	2.91	1.12	0	1.17	0	0.88
average	5.071212	**5.73727**	5.005455	3.746364	3.551515	1.919091	1.234375	0.5725	0.318182	0.476667	0.81125	**2.42344**
stdev	3.589208	3.606713	3.008665	2.459767	2.030373	1.337435	1.120104	0.574832	0.549753	0.723994	1.000754	1.833556
80% rain	8.092558	**8.77335**	7.538106	5.816961	5.260654	3.044925	2.177262	1.056386	0.780956	1.086114	1.65367	**3.9669**

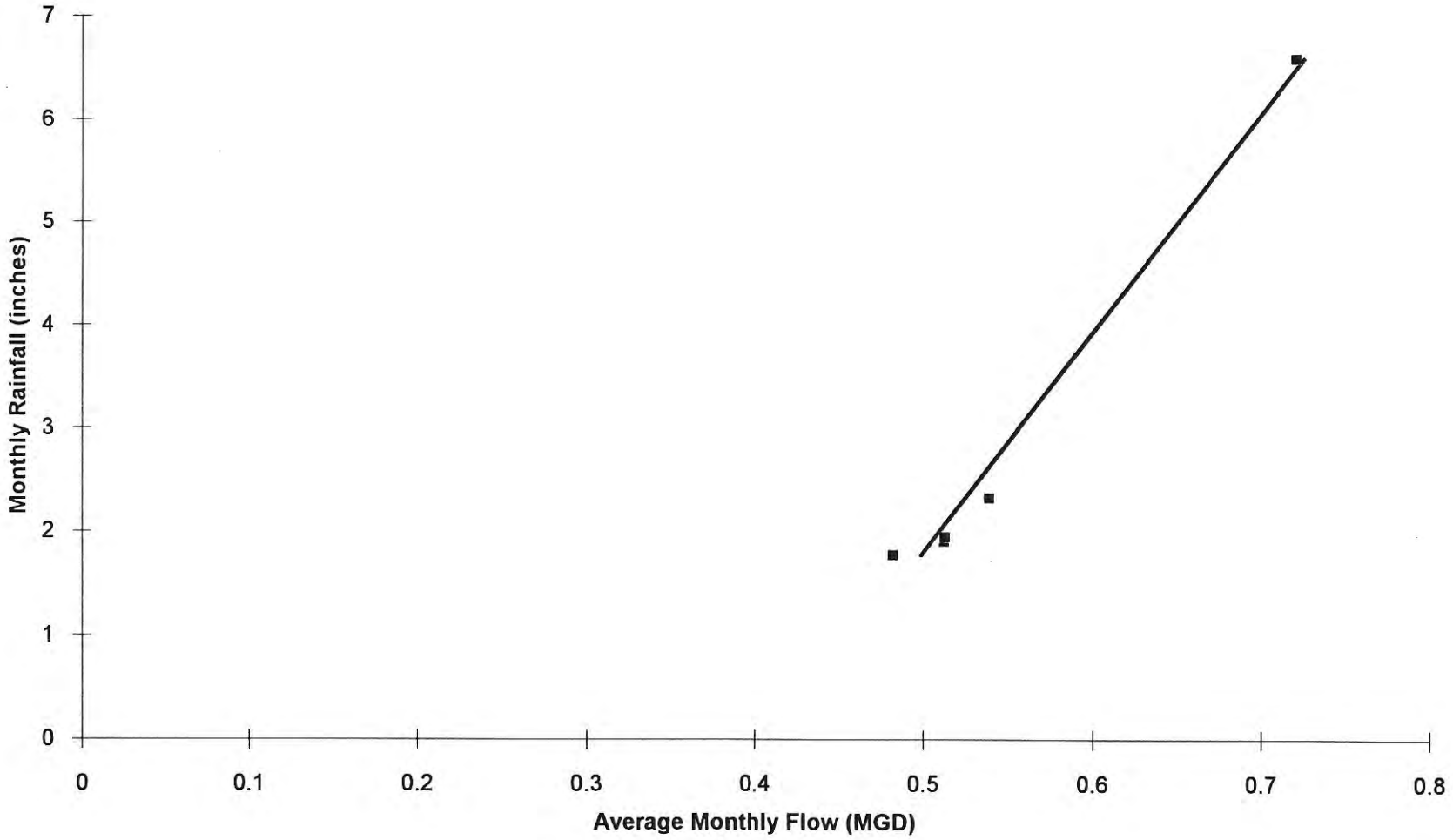
Rainfall vs. Plant Flow
Jan - May, 1988



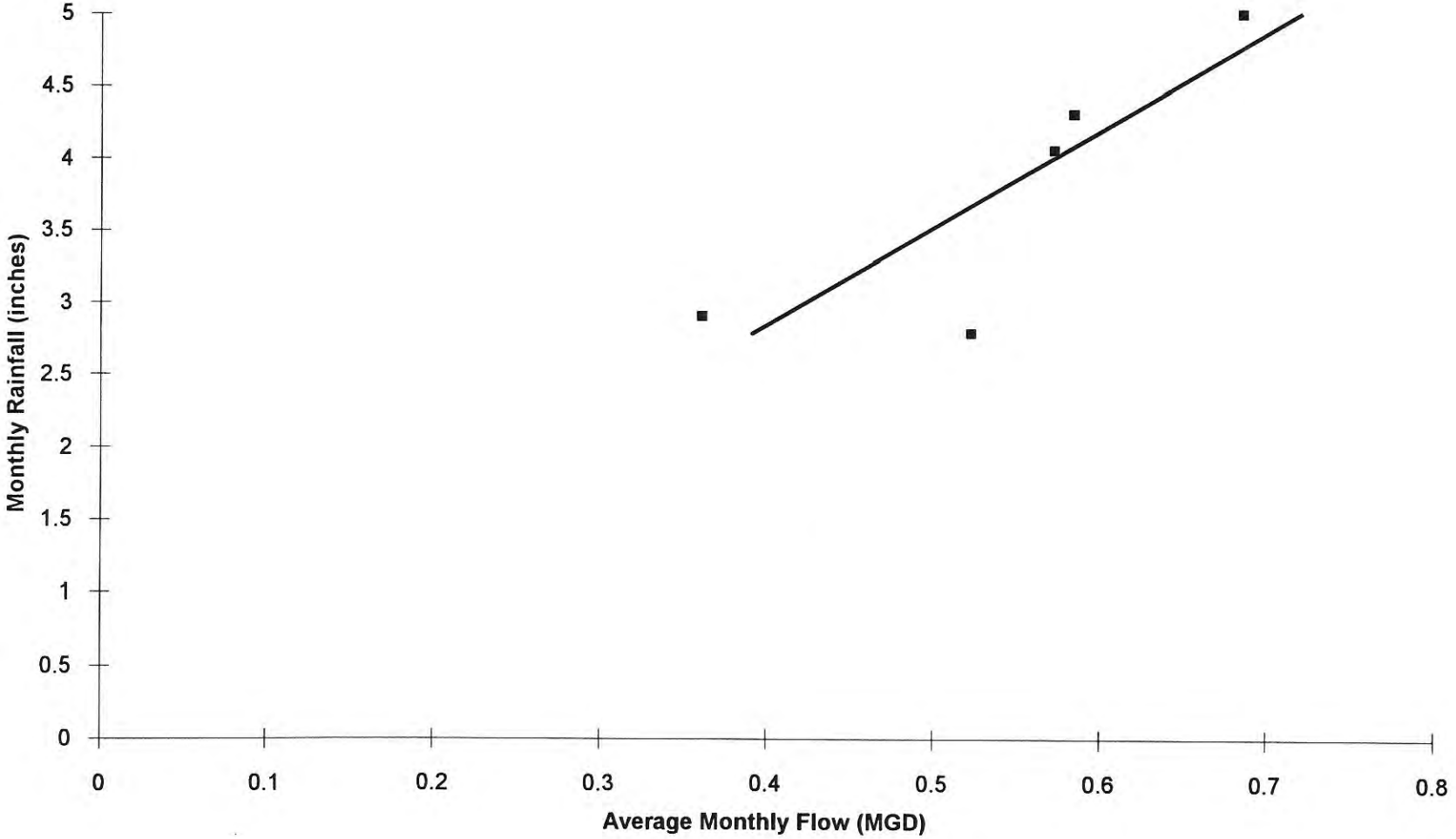
Rainfall vs. Plant Flow
Jan - May, 1989



Rainfall vs. Plant Flow
Jan - May, 1991



Rainfall vs. Plant Flow
Jan - May, 1993



Rainfall vs. Plant Flow (Jan - May)
1988, '89, '91, '93