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ANALYSIS OF CHANGES IN DELTA OUTFLOW DUE TO EXISTING AND FUTURE WATER DEVELOPMENT SCENARIOS

by

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I. Introduction

In recent years, there has been growing concern over the possible adverse impacts that fresh water diversions from the Delta may have on the ecosystems of San Francisco Bay. Before considering management approaches to protect San Francisco Bay, it is necessary to quantify the extent of the changes in fresh water inflow that has occurred and is projected to occur under present water development scenarios.

This report analyzes the changes in annual, seasonal and monthly Delta outflow characteristics between unimpaired conditions, which are taken as representative of natural conditions; existing water development conditions; and future conditions, assuming full development of the State Water Project as projected by the California Department of Water Resources (DWR). The Delta outflows analyzed in this report are those computed by DWR in its operational studies and reflect all water management in the basin, including the Central Valley Project and the State Water Project.

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II. Conclusions

1. If water diversions are kept to their present level, there will continue to be a major reduction in average annual Delta outflow from unimpaired conditions amounting to 48%. In the one-in-ten wet year, the reduction is 35%, and in the one-in-ten dry year, the reduction is 68%.

2. If the level of water development projected by DWR for future conditions is implemented, the reduction in average annual Delta outflow will be 59%, further decreasing outflow 22% below present levels. In the one-in-ten wet year, the reduction will be 45%, and in the one-in-ten dry year, the reduction will be 79%.

3. The seasonal reductions in spring and summer are greater than the annual reductions. For existing conditions the average spring reduction is 60%, and in the one-in-ten dry year, it is approximately an 86% reduction. The average summer reduction is 58%.

4. Analysis of the frequency of Delta outflows shows that the median unimpaired or natural Delta outflow that once occurred every other year now only occurs on an average every 6 years. Large Delta outflows that formerly occurred once in 10 years now occur less frequently than 100 years.

5. The effect on the frequency of spring flows has been even more significant. Low spring Delta outflows that formerly occurred once in 10 years now occur in 75% of all years.

6. Future water development will further increase the frequency of low flows and decrease the frequency of occurrence of high flows.

III. Background and Methodology

The amount and timing of freshwater discharge into the San Francisco Bay Estuary from the Sacramento-San Joaquin Delta have a significant effect on the ecosystems and physical character of the Bay. Freshwater flows have been substantially modified in the last century by reservoir storage, releases, diversions, groundwater pumping, inter-basin transfers, reclamation levees, and changes in land use.

Unfortunately it is extremely difficult to measure Delta outflow directly at the western end of the Delta, because tidal flows are usually significantly larger than freshwater outflow. Therefore Delta outflows have to be calculated by adding the river flows into the Delta and subtracting the diversions and evapotranspiration within the Delta.

For its operational studies of the California Aqueduct the Department of Water Resources has analyzed the monthly "unimpaired" flows for the 1922 to 83 water years, computing what the monthly Delta outflow would have been in those years if no dams or diversions had taken place (DWR 1987). This is done by adjusting the measured river flows to compensate for upstream modifications. The term "unimpaired" is used rather than "natural" because the computation assumes that the existing river and levee system is in place. This was because it was difficult to estimate flows in the natural system primarily due to four effects:

1. Groundwater discharges to the Sacramento and San Joaquin Rivers. In the natural state this flow could be large. It would have been relatively constant from year to year and would most likely add to Delta ouflow in the summer.

2. Evapotranspiration loss from Central Valley wetlands. This would also be fairly constant from year to year and would subtract from Delta outflow in the summer.

3. Flood storage in Central Valley wetlands. This would tend to delay runoff from winter to later spring and early summer in all except dry years (Division of Water Resources Bulletin 27).

4. Overflow from Tulare Lake Basin. This would have tended to have increased Delta ouflow during the spring of wet years.

The net result of using "unimpaired" instead of "natural" Delta outflows would appear to underestimate the spring outflow. Consequently, this analysis is somewhat conservative in analyzing flow reductions. The effect on summer outflow is less clear. Because no flow reconstructions have yet been carried out of the natural hydrology of the Central Valley, DWR's "unimpaired" flows were used for the purpose of this analysis as representing undisturbed conditions. These flows are shown in Table 1.

As part of its operational analysis for estimated State Water Project water deliveries, DWR has evaluated various future

scenarios of water development (DWR Feb. 1985) and has computed monthly Delta outflows for these scenarios assuming a repetition of its hydrologic base period, 1922 to 1978. In its computations DWR assumes the Delta outflow requirements of D1485 are in place.

This report analyzes Delta outflows computed by DWR for two of its scenarios referred to as:

- Existing Conditions. This is DWR's "1985 scenario" and represents the water projects and water management conditions that are in place today. It assumes that the Suisun Marsh facilities have been completed. The "1985 scenario" assumes a 2.4 million acre target delivery for the State Water Project. For 1987, State Water contractors' requests for deliveries were 2.7 million acre-ft (DWR 1986). However, while it appears that this scenario underestimates SWP exports, it is the scenario that most closely represents present water management conditions. The Delta outflows are shown in Table 2.

- Future Conditions. This is based on DWR's "2020B scenario" and represents the effects on Delta outflow of completing all facilities DWR assumes necessary to fully develop the State Water Project. The scenario assumes: expansion of the Delta pumping plant, completion of the North Bay Aqueduct, water deliveries to the North Delta Water Agency, increasing the size of the East and West Branch of the Aqueduct, a cross-Delta water transfer facility, addition of the Coastal Branch

of the Aqueduct, construction of Los Banos Grandes Reservoir, enlargement of the San Luis Canal, and seven million acre feet of new reservoir storage in the Central Valley. The resulting Delta outflows are shown in Table 3.

IV. Results

Comparison of the annual spring and summer Delta outflow for the existing conditions water management scenario and the future conditions scenario for the 1922-78 base period is shown in Figures 1, 2, and 3. It can be seen that there is a significant depletion of Delta outflow which is most marked in the spring and summer. This is illustrated in Figures 4 through 9, showing the percent reduction in Delta outflow for the two scenarios plotted against the percent of the average annual unimpaired Delta outflow for that particular year. These show that the flows are reduced 30-90%, with most extreme reductions occurring in the spring of average and below-normal years. Figure 10 shows the percent reduction of annual flows of future conditions from existing conditions.

Computed Unimpaired Delta outflow is used as the index of wetness rather than the 4 River index, as there is some scatter introduced by significant inflows from the San Joaquin and Delta rivers. In addition, the 4 River index terminology "wet," "dry," and "critical" is misleading, as it tends to categorize a large number of years as "wet". The relationship between unimpaired Delta outflow and 4 River index is shown in Figure 11. It can be seen that the "step" method of designating year type based on the Four River index is only a crude indicator of Delta outflow conditions.

The statistical distribution of annual, spring, and summer Delta outflow for each of the scenarios is shown in Figures 12, 13, and 14. It can be seen that flows of the magnitude of the median unimpaired annual flow (the median flow is one that is exceeded 50% of the time, or has a return frequency of 2 years) under existing conditions only occur 17% of the time, or every 6 years, and under future conditions will only occur 12% of the time, or every 8 years.

The changes in the spring flow are more marked, with flows of the magnitude of the median now only occurring every 10 years. While high Delta outflow years become less frequent, low Delta outflow years become more frequent. This is illustrated in the change in annual flow frequency. High annual flows that formerly occurred once in 10 years now occur less than once in 100 years. Low annual flows that formerly occurred once in 10 years now occur 55% of the time.

A summary of the Delta outflow statistics and their changes is shown in Table 4.

Another useful plot is to compare the changes due to water development in each month. This is shown in Figures 15, 16, and 17 for an artificially constructed hydrograph for the average median, average 10th percentile dry, and average 90th percentile wet years. It can be seen that there are substantial changes in median and dry years, and in the spring of wet years. Essentially, almost all flows in excess of D1485 and carriage

water requirements are diverted in drier-than-average years, and substantial amounts are diverted in the spring of wet years.

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TABLE 1 -- "UNIMPAIRED" DELTA OUTFLOW (TAF)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1922	330.0	464.0	1636.0	1487.0	4484.0	3457.0	4565.0	7665.0	5494.0	1376.0	483.0	324.0	31765.0
1923	390.0	783.0	3240.0	2491.0	1604.0	1784.0	4161.0	4128.0	2206.0	1065.0	393.0	357.0	22602.0
1924	404.0	375.0	468.0	566.0	1318.0	656.0	1092.0	1086.0	352.0	249.0	179.0	179.0	6924.0
1925	320.0	869.0	1148.0	1132.0	6858.0	2650.0	4691.0	4307.0	2204.0	823.0	397.0	304.0	25703.0
1926	350.0	494.0	708.0	910.0	4246.0	1979.0	4603.0	2326.0	871.0	382.0	234.0	220.0	17323.0
1927	289.0	2455.0	2414.0	2928.0	8827.0	4508.0	6003.0	4810.0	3395.0	1074.0	416.0	320.0	37439.0
1928	351.0	1643.0	1295.0	1704.0	2591.0	7511.0	4519.0	3306.0	1181.0	507.0	287.0	257.0	25152.0
1929	273.0	514.0	700.0	655.0	1343.0	1440.0	1780.0	2642.0	1462.0	456.0	195.0	210.0	11670.0
1930	211.0	247.0	2870.0	1842.0	2315.0	3547.0	2989.0	2470.0	1621.0	497.0	250.0	247.0	19106.0
1931	277.0	430.0	353.0	886.0	837.0	1307.0	1277.0	1180.0	455.0	192.0	152.0	156.0	7502.0
1932	263.0	359.0	2401.0	1825.0	2804.0	2943.0	3066.0	4582.0	3179.0	985.0	339.0	228.0	22974.0
1933	228.0	264.0	401.0	808.0	645.0	2196.0	2154.0	2590.0	2605.0	564.0	234.0	204.0	12893.0
1934	247.0	302.0	1286.0	1760.0	1974.0	2129.0	1709.0	1084.0	598.0	242.0	169.0	165.0	11865.0
1935	245.0	924.0	879.0	2610.0	2013.0	2934.0	7808.0	5338.0	3145.0	811.0	343.0	242.0	27293.0
1936	334.0	357.0	521.0	4247.0	7897.0	3466.0	4576.0	4148.0	2546.0	843.0	327.0	248.0	29510.0
1937	260.0	273.0	454.0	619.0	3819.0	4675.0	4653.0	5622.0	2635.0	753.0	288.0	225.0	24276.0
1938	344.0	2000.0	6158.0	2454.0	8447.0	11189.0	7528.0	8681.0	5820.0	2016.0	712.0	461.0	55810.0
1939	573.0	645.0	841.0	849.0	941.0	2226.0	2470.0	1523.0	659.0	314.0	216.0	251.0	11508.0
1940	378.0	307.0	698.0	5182.0	8147.0	8179.0	5572.0	4285.0	2016.0	624.0	328.0	309.0	36025.0
1941	390.0	624.0	4603.0	6122.0	7616.0	6710.0	6302.0	6770.0	3819.0	1618.0	624.0	449.0	45647.0
1942	464.0	691.0	4698.0	6062.0	7351.0	2948.0	5806.0	5622.0	4742.0	1699.0	609.0	429.0	41121.0
1943	441.0	1232.0	2315.0	6752.0	3866.0	7506.0	5056.0	4087.0	2482.0	1063.0	498.0	369.0	35667.0
1944	417.0	474.0	556.0	890.0	1910.0	2591.0	2135.0	3680.0	1884.0	807.0	331.0	261.0	15938.0
1945	350.0	1386.0	1784.0	1243.0	5789.0	2856.0	3300.0	4264.0	2846.0	1017.0	418.0	293.0	25546.0
1946	667.0	1546.0	6361.0	3387.0	1631.0	2804.0	3977.0	4036.0	1793.0	693.0	379.0	305.0	27599.0
1947	400.0	1021.0	1236.0	641.0	1925.0	3035.0	2495.0	2155.0	1170.0	389.0	260.0	244.0	14971.0
1948	692.0	586.0	489.0	2145.0	769.0	2029.0	5372.0	5141.0	3645.0	926.0	393.0	333.0	22520.0
1949	358.0	474.0	719.0	567.0	1116.0	4692.0	3752.0	3724.0	1571.0	441.0	286.0	246.0	17946.0
1950	277.0	381.0	414.0	2402.0	3597.0	2980.0	4366.0	4120.0	2240.0	665.0	314.0	288.0	22044.0
1951	1016.0	6079.0	8097.0	5028.0	4544.0	3421.0	3190.0	3574.0	1654.0	637.0	370.0	303.0	37913.0
1952	463.0	1068.0	4636.0	6123.0	5619.0	5538.0	7470.0	8613.0	5117.0	2205.0	754.0	501.0	48107.0
1953	438.0	509.0	2614.0	7216.0	1839.0	2617.0	3785.0	3826.0	3703.0	1430.0	526.0	437.0	28940.0
1954	439.0	887.0	847.0	2875.0	3703.0	4583.0	5482.0	3606.0	1505.0	636.0	402.0	367.0	25332.0
1955	378.0	836.0	1658.0	1646.0	1130.0	1442.0	2250.0	3562.0	1948.0	566.0	312.0	290.0	16018.0
1956	303.0	615.0	12818.0	10926.0	5388.0	3797.0	4064.0	5957.0	3844.0	1585.0	624.0	471.0	50392.0
1957	628.0	594.0	600.0	879.0	3339.0	4167.0	2688.0	4424.0	2625.0	743.0	398.0	429.0	21514.0
1958	946.0	901.0	1925.0	3271.0	11029.0	6961.0	8980.0	7777.0	4696.0	1729.0	769.0	536.0	49520.0
1959	484.0	520.0	576.0	2666.0	3518.0	2256.0	2482.0	1910.0	1044.0	443.0	297.0	509.0	16705.0
1960	349.0	334.0	437.0	1003.0	4236.0	3833.0	2783.0	2586.0	1324.0	429.0	284.0	277.0	17875.0
1961	316.0	781.0	1559.0	1017.0	2568.0	2275.0	2251.0	2339.0	1233.0	401.0	323.0	286.0	15349.0
1962	322.0	574.0	1360.0	981.0	5659.0	3134.0	4387.0	3414.0	2653.0	866.0	371.0	287.0	24008.0
1963	3214.0	774.0	2319.0	2217.0	6101.0	2754.0	7389.0	5775.0	2882.0	1192.0	534.0	433.0	35584.0
1964	575.0	1981.0	935.0	2046.0	1154.0	1290.0	2112.0	2659.0	1621.0	509.0	292.0	250.0	15424.0
1965	345.0	1089.0	11763.0	8065.0	2795.0	2332.0	6015.0	4285.0	2996.0	1359.0	811.0	417.0	42272.0
1966	419.0	1722.0	1323.0	2604.0	2072.0	2947.0	3762.0	2731.0	888.0	427.0	306.0	295.0	19496.0
1967	293.0	1582.0	3900.0	5153.0	3220.0	5277.0	5539.0	7594.0	6202.0	2797.0	775.0	453.0	42785.0
1968	488.0	541.0	960.0	2116.0	4796.0	3125.0	2425.0	2323.0	1081.0	475.0	449.0	331.0	19110.0
1969	473.0	974.0	2375.0	11364.0	7697.0	5097.0	6927.0	8555.0	4932.0	1902.0	698.0	467.0	51461.0
1970	638.0	675.0	4231.0	14492.0	4022.0	4115.0	2087.0	3043.0	2049.0	771.0	441.0	362.0	36926.0
1971	497.0	2426.0	4666.0	3986.0	2240.0	4674.0	3900.0	4645.0	3627.0	1247.0	549.0	461.0	32918.0
1972	505.0	693.0	1487.0	1621.0	2096.0	3838.0	2772.0	2575.0	1532.0	493.0	313.0	418.0	18343.0
1973	602.0	1549.0	2266.0	6175.0	5739.0	4621.0	3723.0	5310.0	2370.0	716.0	434.0	391.0	33896.0
1974	634.0	5662.0	4925.0	9148.0	2716.0	8417.0	6486.0	5299.0	3482.0	1415.0	646.0	455.0	49285.0
1975	481.0	615.0	966.0	1163.0	4312.0	6538.0	3708.0	6139.0	4426.0	1250.0	589.0	497.0	30684.0
1976	945.0	915.0	812.0	649.0	1054.0	1447.0	1420.0	1460.0	498.0	302.0	420.0	354.0	10276.0
1977	346.0	356.0	317.0	478.0	447.0	534.0	656.0	905.0	682.0	250.0	225.0	308.0	5504.0
1978	281.0	466.0	2262.0	8396.0	4999.0	7174.0	5880.0	5434.0	4083.0	1714.0	566.0	726.0	41981.0
AVG	479.7	1014.7	2256.2	3366.5	3766.9	3774.2	4077.0	4134.9	2514.6	904.9	412.8	341.0	27083.4

TABLE 2 -- EXISTING CONDITIONS DELTA OUTFLOW (TAF) 1985 SCENARIO

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1922	274.4	269.8	802.3	697.6	2677.5	1712.4	893.8	2047.3	1122.2	502.4	363.9	269.7	11573.3
1923	515.8	502.0	2695.2	1655.6	849.7	566.4	1227.2	674.4	565.0	400.0	315.9	269.9	10236.1
1924	272.5	279.4	305.7	309.0	569.3	283.0	240.0	226.0	184.0	184.0	175.0	191.0	3217.9
1925	276.2	266.3	402.1	304.6	2767.8	586.2	1222.1	900.7	637.0	473.0	331.6	239.1	8406.7
1926	241.1	280.5	305.7	499.6	2725.5	327.0	1366.3	386.0	301.1	298.0	286.9	236.9	7254.5
1927	260.2	940.6	700.5	1408.9	7628.6	2197.5	2642.9	1453.2	833.0	615.0	339.4	250.4	19270.1
1928	558.4	996.8	646.2	899.3	1494.3	6241.4	1163.6	504.2	369.0	339.0	307.3	240.7	13760.2
1929	259.7	326.5	353.9	320.6	639.1	367.7	252.0	226.0	207.0	275.1	307.3	212.3	3749.1
1930	211.2	238.4	455.6	1079.6	648.4	1670.1	452.2	410.9	355.3	400.7	320.2	243.2	6485.8
1931	239.6	249.2	313.0	322.7	293.1	296.2	240.0	226.0	184.0	184.0	175.0	193.1	2915.9
1932	206.4	210.8	621.1	951.2	739.8	327.0	412.9	775.6	339.0	289.0	281.1	247.5	5402.4
1933	240.7	218.5	319.0	403.6	456.2	283.0	229.0	224.0	184.0	254.6	231.4	204.4	3277.4
1934	212.0	251.1	324.1	666.2	297.4	283.0	240.0	226.0	235.4	256.4	242.5	211.2	3447.3
1935	214.3	280.4	318.6	1496.2	328.0	1240.7	2899.5	1127.1	637.0	519.9	369.4	220.7	9840.3
1936	297.0	283.3	305.7	1962.0	5000.6	1531.5	959.8	821.7	637.0	473.0	346.2	236.9	12894.7
1937	398.6	265.5	305.7	473.6	2422.3	3167.4	1015.0	996.1	565.0	400.0	309.9	226.6	10545.6
1938	450.0	1086.5	4086.5	1596.3	8156.2	10256.0	3997.1	4320.0	2759.5	615.0	335.9	488.6	38147.6
1939	1188.8	450.1	434.3	649.2	637.1	492.3	384.0	251.3	225.6	291.4	297.5	232.0	5533.6
1940	240.2	242.5	274.8	1380.5	3717.1	6660.6	3549.3	814.0	637.0	509.7	319.0	229.1	18573.8
1941	390.0	321.5	2673.8	6446.2	7049.8	5991.7	4873.3	2674.3	925.4	615.0	324.1	267.9	32553.0
1942	970.8	585.8	3768.4	5043.7	8046.0	1344.5	2861.6	2289.5	1618.4	615.0	324.1	260.6	27728.4
1943	1019.6	771.1	1428.0	5061.3	3234.0	5117.5	1488.4	1047.4	833.0	615.0	341.8	248.5	21205.6
1944	378.7	288.4	305.7	507.2	1610.6	1016.7	399.0	465.1	294.3	366.9	307.4	234.1	6174.1
1945	266.8	509.2	659.2	396.4	3229.5	1581.8	499.3	746.8	565.0	400.0	311.1	255.5	9420.6
1946	502.6	514.0	4553.5	2738.9	869.6	1132.7	447.6	816.6	637.0	477.6	354.3	240.2	13284.6
1947	324.9	326.4	502.1	307.4	833.0	1401.9	411.1	386.0	306.6	298.0	289.4	235.8	5622.6
1948	292.1	306.9	305.7	334.8	332.0	571.2	1628.0	1515.6	958.1	534.6	345.9	279.4	7404.3
1949	345.5	317.7	325.9	310.0	395.5	2994.5	422.9	588.4	302.0	363.2	318.5	263.4	6947.5
1950	263.9	287.0	305.7	921.3	1832.2	1155.3	673.5	1028.9	565.0	402.0	325.3	302.0	8062.1
1951	642.6	3554.7	6139.2	3843.9	3685.6	1742.7	503.7	1074.3	375.0	481.8	356.2	296.4	22696.1
1952	319.5	585.8	3194.1	5544.8	4823.2	4208.0	3966.5	4470.1	2558.5	629.0	477.8	575.6	31352.9
1953	1137.8	464.1	2613.6	6151.4	1146.1	997.7	782.7	1523.2	1329.9	615.0	337.6	331.7	17430.8
1954	756.2	782.8	351.5	1519.9	3206.0	2748.4	2190.2	848.5	637.0	478.7	357.9	272.4	14149.5
1955	297.5	554.4	1154.1	1019.6	481.3	441.5	399.9	425.8	294.0	376.3	319.1	271.6	6035.1
1956	260.8	309.1	6717.7	10061.0	4923.3	1891.6	947.8	2743.0	1440.2	615.0	334.6	371.1	30615.2
1957	1405.5	353.7	310.2	609.1	1768.6	2739.6	399.0	1122.6	565.0	400.0	328.4	294.5	10296.2
1958	938.7	598.0	1265.6	2284.5	9118.4	8083.8	6391.3	2992.4	2309.5	615.0	347.9	618.2	35563.3
1959	1192.3	357.0	306.2	1899.5	2995.1	792.6	399.0	386.0	306.6	320.2	289.3	311.9	9555.7
1960	239.5	254.4	319.0	322.4	1700.7	1341.7	512.5	401.0	353.0	339.0	309.0	260.4	6352.6
1961	233.6	325.8	409.1	325.2	1228.5	1020.8	399.0	386.0	305.3	310.6	295.6	256.8	5496.3
1962	230.0	272.0	456.3	319.8	3686.8	1181.9	399.0	654.0	565.0	403.6	329.9	289.0	8787.3
1963	2463.4	389.4	1358.5	875.1	4301.8	1511.5	5278.2	1831.1	833.0	615.0	361.3	275.2	20093.5
1964	577.3	1268.3	325.7	1124.0	547.9	487.1	399.0	386.0	296.4	320.5	297.4	246.9	6276.5
1965	260.6	399.7	5955.8	7006.5	1589.6	912.1	2508.7	1156.6	833.0	615.0	332.1	265.4	21835.1
1966	606.3	1391.5	712.7	1592.5	1482.0	1382.7	495.1	471.6	366.4	379.2	325.0	258.5	9463.5
1967	220.4	383.4	2475.8	3824.5	3089.9	3566.8	3242.6	3405.7	2992.9	928.4	493.8	389.6	25013.8
1968	1147.9	520.7	775.8	1644.0	3530.3	1969.5	399.0	401.0	353.0	336.6	312.1	256.9	11646.8
1969	282.3	338.7	1024.5	8083.0	7529.0	3437.7	3054.4	4212.3	2119.9	615.0	485.3	567.7	31749.8
1970	1026.0	718.8	3322.6	12777.0	4732.6	2144.5	399.0	401.0	375.0	507.9	362.6	254.8	27021.8
1971	326.4	1181.1	4638.0	2801.7	1229.7	2829.1	960.7	1659.0	1085.9	615.0	344.2	521.0	18191.8
1972	644.4	453.8	929.9	758.6	1076.8	1469.8	399.0	401.0	353.0	381.1	321.4	293.2	7482.0
1973	355.7	1115.5	1311.4	5493.5	5570.5	3648.2	751.4	859.4	833.0	615.0	349.8	280.3	21183.7
1974	335.4	3840.9	4166.3	8031.4	2573.6	6907.1	4058.8	1542.3	1013.0	615.0	397.4	523.3	34004.5
1975	898.2	550.1	752.3	777.3	3718.9	5440.2	1256.6	1744.4	1176.8	507.9	353.7	615.3	17791.7
1976	1275.0	594.5	438.3	421.8	276.4	417.0	240.0	226.0	184.0	358.9	323.2	254.5	5009.6
1977	213.5	242.3	272.4	335.9	318.6	285.3	214.0	221.0	184.0	184.0	175.0	169.4	2815.4
1978	184.7	212.9	355.3	3752.6	2827.7	4505.1	3672.0	1568.7	833.0	615.0	336.9	316.0	19179.9
AVG	522.5	594.4	1418.4	2321.9	2677.5	2261.4	1433.3	1157.4	751.8	452.0	324.4	295.9	14205.9

TABLE 3 -- FUTURE DELTA OUTFLOW (TAF) 2020B SCENARIO

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
1922	154.0	167.0	466.3	360.5	2338.8	1334.7	399.0	1958.8	959.4	473.0	243.0	149.0	9005.5
1923	178.3	229.2	2360.9	1258.1	408.8	327.0	873.6	654.0	565.0	400.0	219.0	149.0	7622.9
1924	154.0	167.0	172.0	209.0	315.1	283.0	240.0	226.0	184.0	184.0	168.0	149.0	2451.1
1925	154.0	167.0	172.0	209.0	2106.1	327.0	550.7	843.3	637.0	473.0	243.0	149.0	6031.1
1926	154.0	167.0	172.0	209.0	1913.0	327.0	399.0	386.0	294.0	228.0	189.0	149.0	4587.0
1927	154.0	476.2	220.7	852.8	5313.1	1540.5	1887.3	1216.4	833.0	615.0	263.0	149.0	13521.0
1928	154.0	358.2	312.3	470.6	996.3	5128.3	870.7	401.0	369.0	339.0	243.0	149.0	9791.4
1929	154.0	167.0	172.0	209.0	338.0	283.0	252.0	228.0	184.0	184.0	168.0	149.0	2488.0
1930	154.0	167.0	172.0	592.5	480.5	1414.1	399.0	386.0	339.0	289.0	219.0	149.0	4761.1
1931	154.0	167.0	172.0	209.0	255.0	283.0	240.0	226.0	184.0	184.0	168.0	149.0	2391.0
1932	154.0	167.0	315.5	615.4	485.3	327.0	384.0	554.0	339.0	289.0	219.0	149.0	3998.2
1933	154.0	167.0	172.0	209.0	255.0	283.0	228.0	224.0	184.0	184.0	168.0	149.0	2377.0
1934	154.0	167.0	172.0	286.5	255.0	283.0	240.0	226.0	184.0	184.0	168.0	149.0	2468.5
1935	154.0	167.0	172.0	1206.1	255.0	976.1	1683.7	668.5	637.0	473.0	243.0	149.0	6984.4
1936	154.0	167.0	172.0	1245.1	3363.0	915.7	399.0	788.0	637.0	473.0	243.0	149.0	8705.8
1937	154.0	167.0	172.0	209.0	2053.0	2481.9	399.0	743.4	565.0	400.0	219.0	149.0	7712.3
1938	154.0	478.7	1844.6	1010.2	4918.5	7413.2	3324.6	3818.4	2456.4	615.0	263.0	149.0	26445.6
1939	462.0	174.4	172.0	209.0	432.2	382.8	384.0	250.0	184.0	184.0	168.0	149.0	3151.4
1940	154.0	167.0	172.0	937.9	1950.0	5085.7	3140.2	788.0	637.0	473.0	263.0	149.0	13916.8
1941	154.0	167.0	1999.7	5530.9	6652.6	5547.4	4463.2	2565.6	833.0	615.0	263.0	149.0	28940.4
1942	400.8	283.0	3310.6	4738.5	7607.6	1088.1	2785.6	2217.6	1383.1	615.0	263.0	149.0	24841.9
1943	461.5	376.8	1152.6	4711.7	2913.0	5071.0	1246.0	896.0	833.0	615.0	263.0	149.0	18688.6
1944	154.0	167.0	172.0	209.0	1356.1	590.8	399.0	386.0	294.0	228.0	189.0	149.0	4293.9
1945	154.0	167.0	225.3	209.0	2554.4	1137.3	399.0	654.0	565.0	400.0	219.0	149.0	6833.0
1946	154.0	279.7	2730.9	2103.5	381.3	593.9	399.0	788.0	637.0	473.0	243.0	149.0	8932.3
1947	154.0	167.0	172.0	209.0	606.4	836.4	399.0	386.0	294.0	228.0	189.0	149.0	3789.8
1948	154.0	167.0	172.0	209.0	265.0	327.0	608.5	1275.8	640.2	473.0	243.0	149.0	4683.5
1949	154.0	167.0	172.0	209.0	255.0	1950.5	399.0	427.9	294.0	228.0	189.0	149.0	4594.4
1950	154.0	167.0	172.0	518.5	1223.7	602.6	399.0	785.7	565.0	400.0	219.0	149.0	5355.5
1951	154.0	2258.4	4893.6	3223.9	2703.5	1418.6	399.0	948.8	369.0	381.0	263.0	149.0	17161.8
1952	154.0	396.4	2525.8	4923.1	4157.6	3879.8	3631.0	4148.4	2228.0	615.0	263.0	394.8	27316.9
1953	796.2	167.0	2147.9	5742.7	896.6	844.2	609.5	1383.4	1122.3	615.0	263.0	149.0	14736.8
1954	351.9	324.2	172.0	1094.5	2719.7	2554.3	1948.5	788.0	637.0	473.0	243.0	149.0	11455.1
1955	154.0	167.0	679.0	718.9	255.0	327.0	399.0	386.0	294.0	228.0	189.0	149.0	3945.9
1956	154.0	167.0	4650.3	9483.2	4602.7	1439.2	403.4	2748.0	1180.8	615.0	263.0	149.0	25855.6
1957	793.4	167.0	172.0	209.0	1434.2	2353.2	399.0	834.0	565.0	400.0	219.0	149.0	7694.8
1958	210.9	230.4	977.7	2007.7	9826.4	6785.0	6122.1	2802.6	1945.2	615.0	263.0	175.6	31961.6
1959	651.1	167.0	172.0	1410.7	2726.6	550.5	399.0	386.0	294.0	228.0	189.0	149.0	7322.9
1960	154.0	167.0	172.0	209.0	1217.8	883.9	399.0	401.0	353.0	289.0	219.0	149.0	4613.7
1961	154.0	167.0	172.0	209.0	936.5	372.7	399.0	386.0	294.0	228.0	189.0	149.0	3656.2
1962	154.0	167.0	172.0	209.0	1861.9	743.9	399.0	654.0	565.0	400.0	219.0	149.0	5693.8
1963	1245.7	167.0	524.6	551.7	3455.8	1117.8	3739.9	1632.7	833.0	615.0	263.0	149.0	14295.2
1964	154.0	653.5	172.0	695.8	265.0	327.0	399.0	386.0	294.0	228.0	189.0	149.0	3912.3
1965	154.0	167.0	4686.1	6056.6	1102.4	327.7	2310.2	1008.1	833.0	615.0	263.0	149.0	17672.1
1966	154.0	655.3	420.5	1289.3	1032.9	1037.2	399.0	401.0	353.0	289.0	219.0	149.0	6399.2
1967	154.0	187.1	1425.6	3331.7	2713.0	3148.1	3092.3	3138.3	2757.0	615.0	263.0	352.1	21177.2
1968	844.0	173.8	327.0	1446.0	3463.7	1733.1	399.0	401.0	353.0	289.0	219.0	149.0	9797.6
1969	154.0	167.0	686.6	6756.9	7105.4	2873.6	2759.6	4141.3	1580.1	615.0	263.0	394.5	27497.0
1970	652.3	317.2	2850.7	12368.0	4518.4	1890.2	399.0	401.0	369.0	381.0	263.0	149.0	24558.8
1971	154.0	756.0	3834.7	2435.4	831.6	2421.9	691.3	1510.8	875.8	615.0	263.0	149.0	14538.5
1972	234.1	180.0	588.0	390.8	975.1	1262.9	399.0	401.0	353.0	289.0	219.0	149.0	5440.9
1973	154.0	488.6	969.0	4953.3	5040.9	3405.3	490.6	788.1	833.0	615.0	263.0	149.0	18149.8
1974	154.0	2834.6	3962.5	7810.7	2160.6	6669.5	3760.7	1329.9	833.0	615.0	263.0	164.5	30558.0
1975	406.2	223.3	472.3	288.9	3762.9	5294.3	899.5	1667.9	955.3	473.0	243.0	223.7	14910.3
1976	697.3	347.3	209.4	209.0	265.0	283.0	240.0	226.0	184.0	184.0	168.0	149.0	3162.0
1977	154.0	167.0	172.0	209.0	255.0	283.0	214.0	221.0	184.0	184.0	168.0	149.0	2360.0
1978	154.0	167.0	172.0	3179.0	2459.8	3677.1	3003.1	1002.8	833.0	615.0	263.0	149.0	15674.8
AVG	260.6	322.1	989.8	1939.8	2192.9	1842.9	1166.6	1047.2	683.9	407.8	226.9	163.2	11243.5

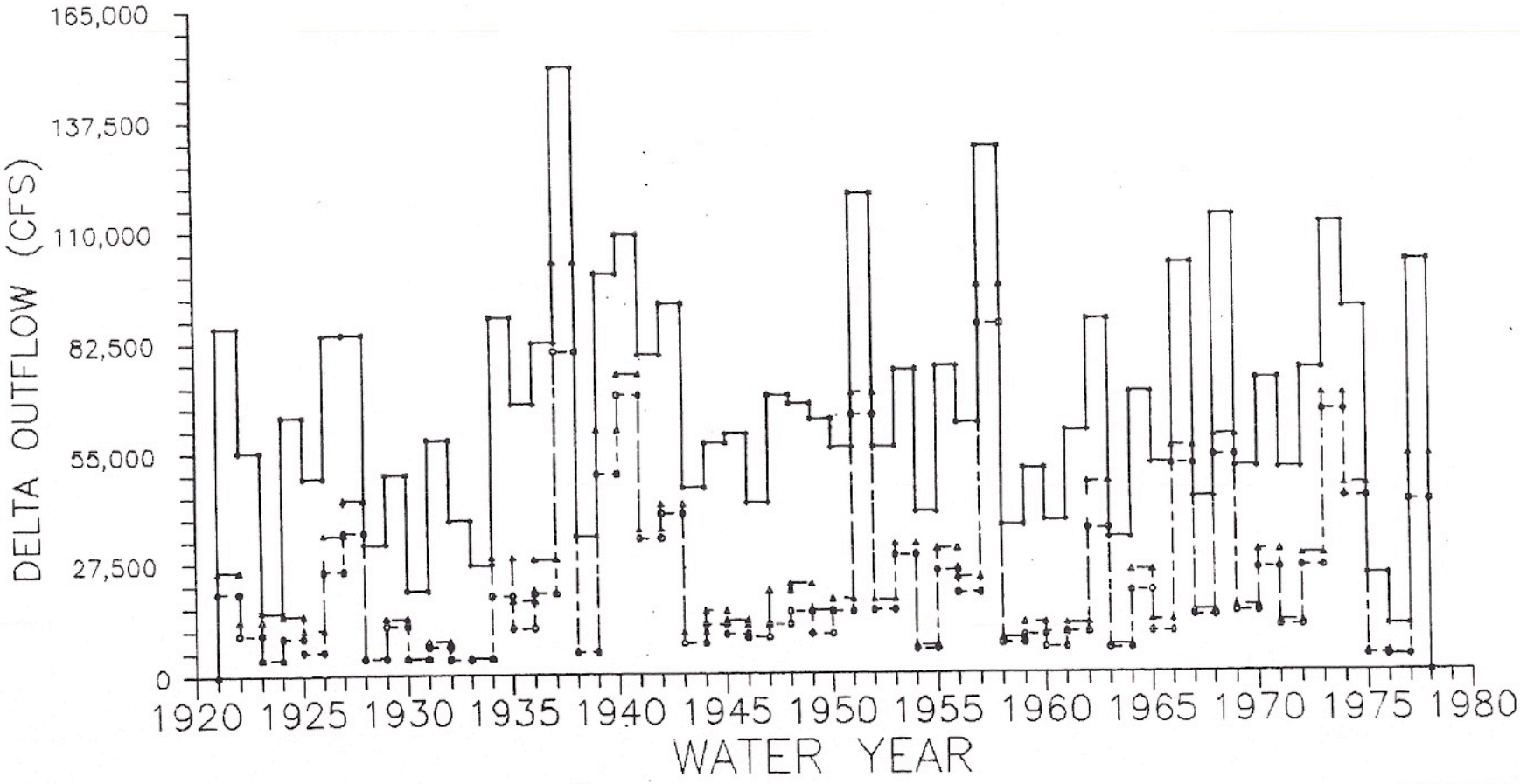
Table 4

SUMMARY OF DELTA OUTFLOW CHANGES

	Period	Delta Outflow MAF			Percent Reduction	
		Natural Unimpaired	Existing 1985	Future 2020B	Existing 1985	Future 2020B
Average	(Annual	27.08	14.21	11.24	48	59
	(Spring	11.99	4.85	4.06	60	66
	(Summer	3.83	1.53	1.32	60	66
One in Ten Dry	(Annual	11.60	3.64	2.48	68	79
	(Spring	5.68	0.83	0.75	85	87
	(Summer	1.21	0.78	0.54	36	56
One in Ten Wet	(Annual	48.30	31.40	26.60	35	45
	(Spring	19.87	11.32	10.15	43	49
	(Summer	7.23	2.69	2.30	63	68

Corrected 5/14

SPRING DELTA OUTFLOW
(March, April, May)



DATE: 5/04/87

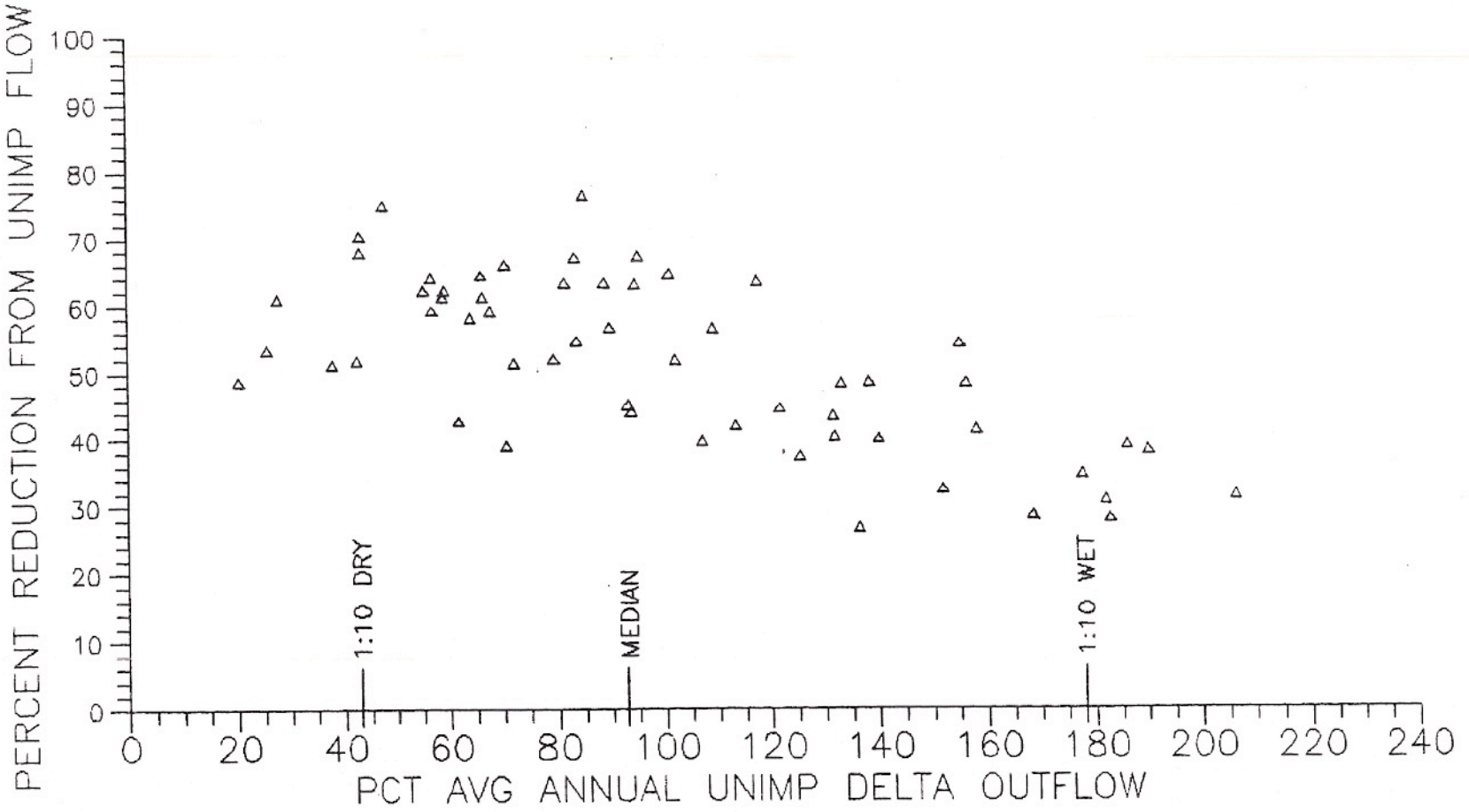
BY: L. FISHBAIN

UNIMPAIRED
EXISTING
FUTURE

Philip Williams & Associates
Pier 35, The Embarcadero
San Francisco, California 94111

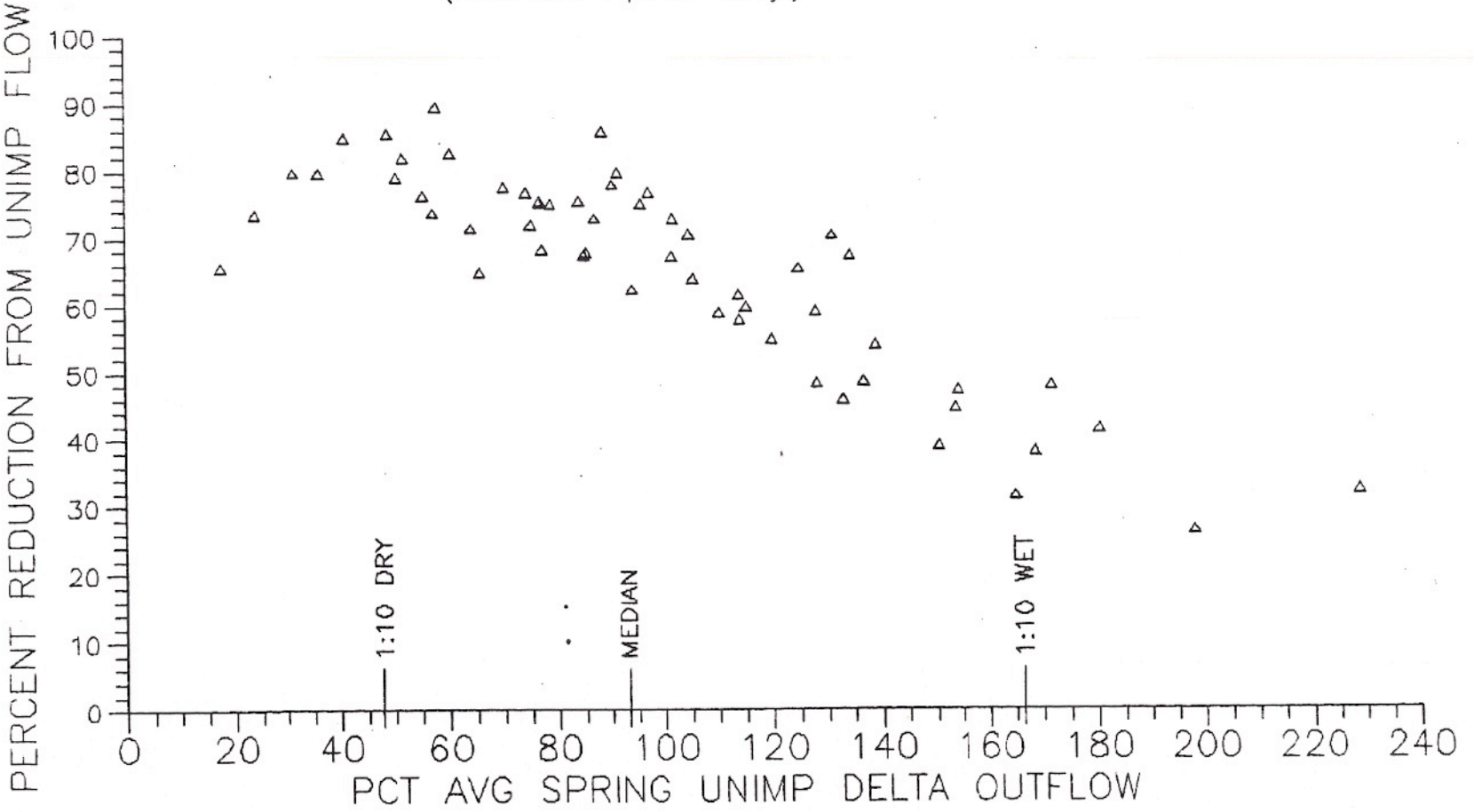
FIGURE 2

ANNUAL REDUCTION IN DELTA OUTFLOW OF EXISTING CONDITIONS FROM UNIMPAIRED FLOW



DATE: 5/04/87 BY: L. FISHBAIN		Philip Williams & Associates Pier 35, The Embarcadero San Francisco, California 94111	FIGURE 4

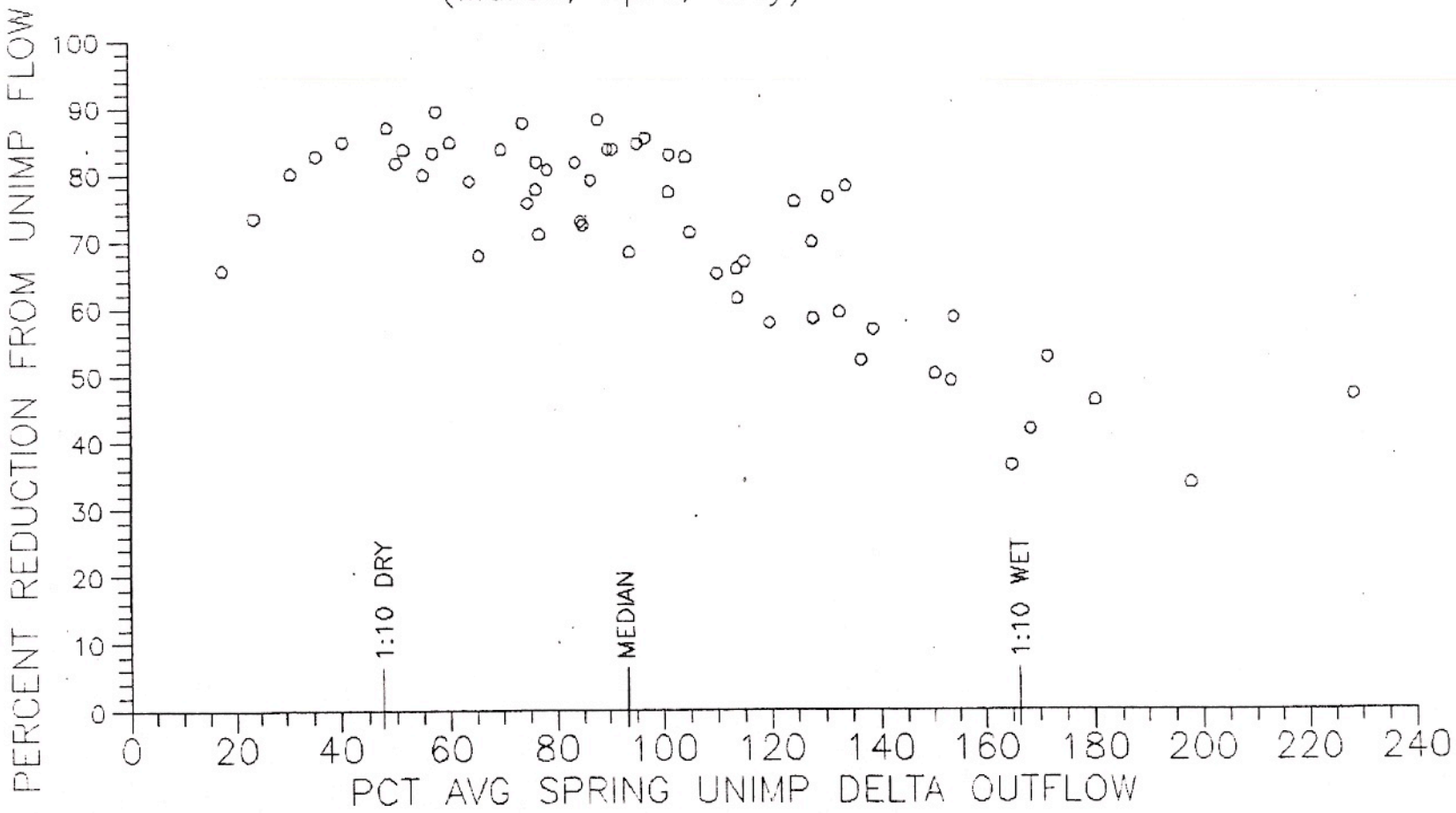
SPRING REDUCTION IN DELTA OUTFLOW OF EXISTING CONDITIONS FROM UNIMPAIRED FLOW
(March, April, May)



DATE: 5/04/87 BY: L. FISHBAIN		Philip Williams & Associates Pier 35, The Embarcadero San Francisco, California 94111	FIGURE 5

SPRING REDUCTION IN DELTA OUTFLOW OF FUTURE CONDITIONS FROM UNIMPAIRED FLOW

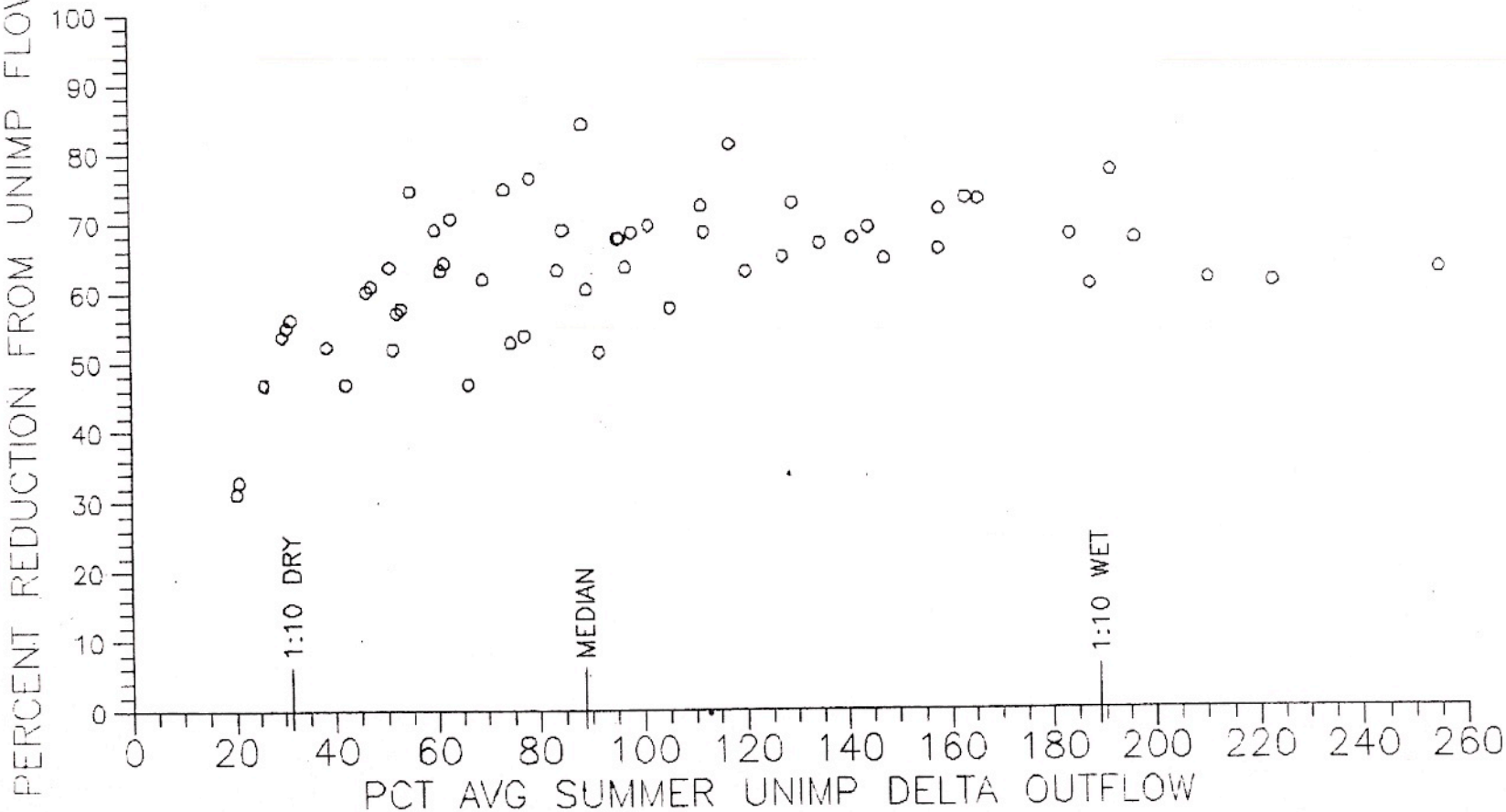
(March, April, May)



DATE: 5/05/87 BY: L. FISHBAIN		Philip Williams & Associates Pier 35, The Embarcadero San Francisco, California 94111	FIGURE 8

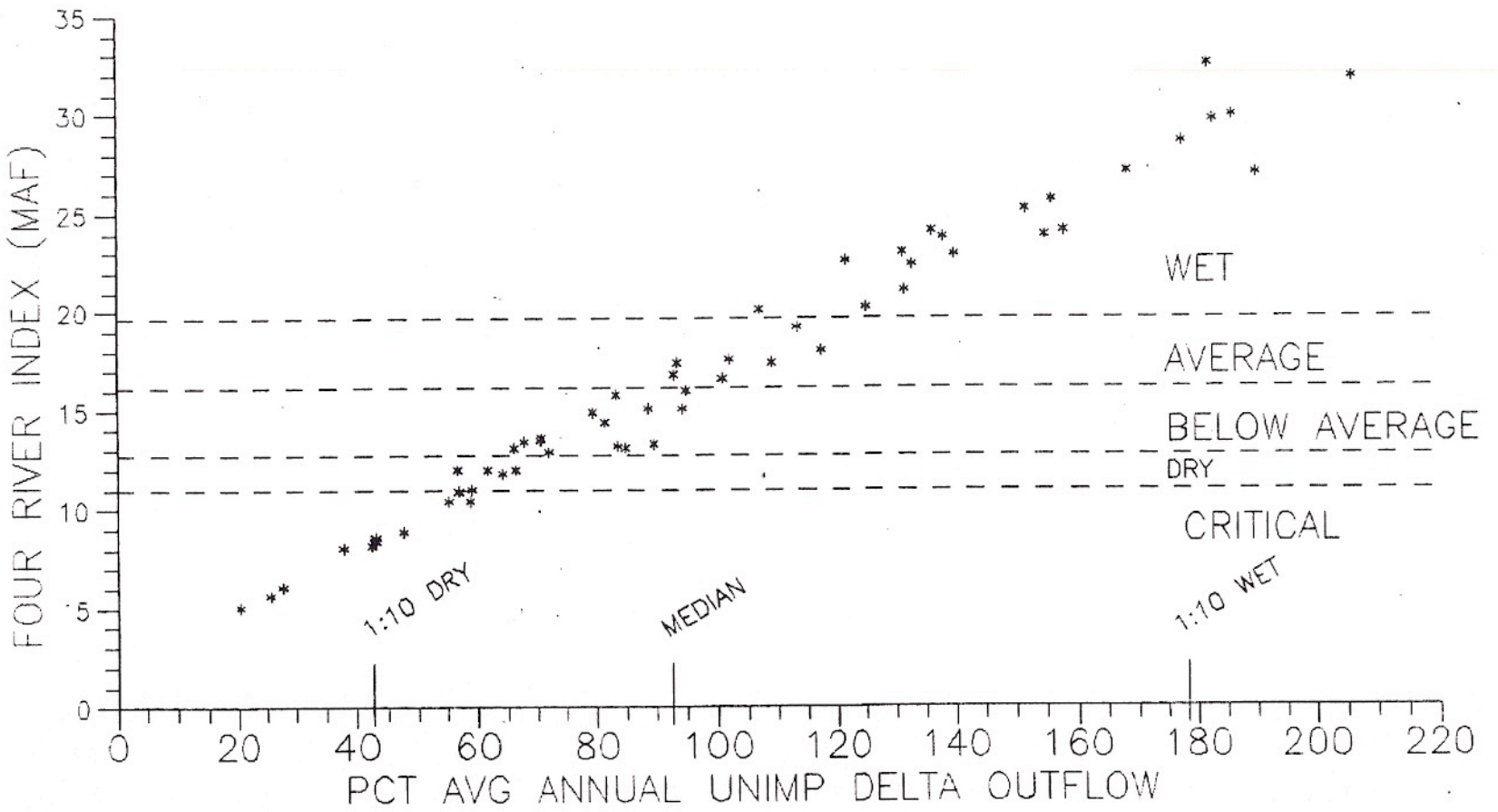
SUMMER REDUCTION IN DELTA OUTFLOW OF FUTURE CONDITIONS FROM UNIMPAIRED FLOW

(June, July, August)



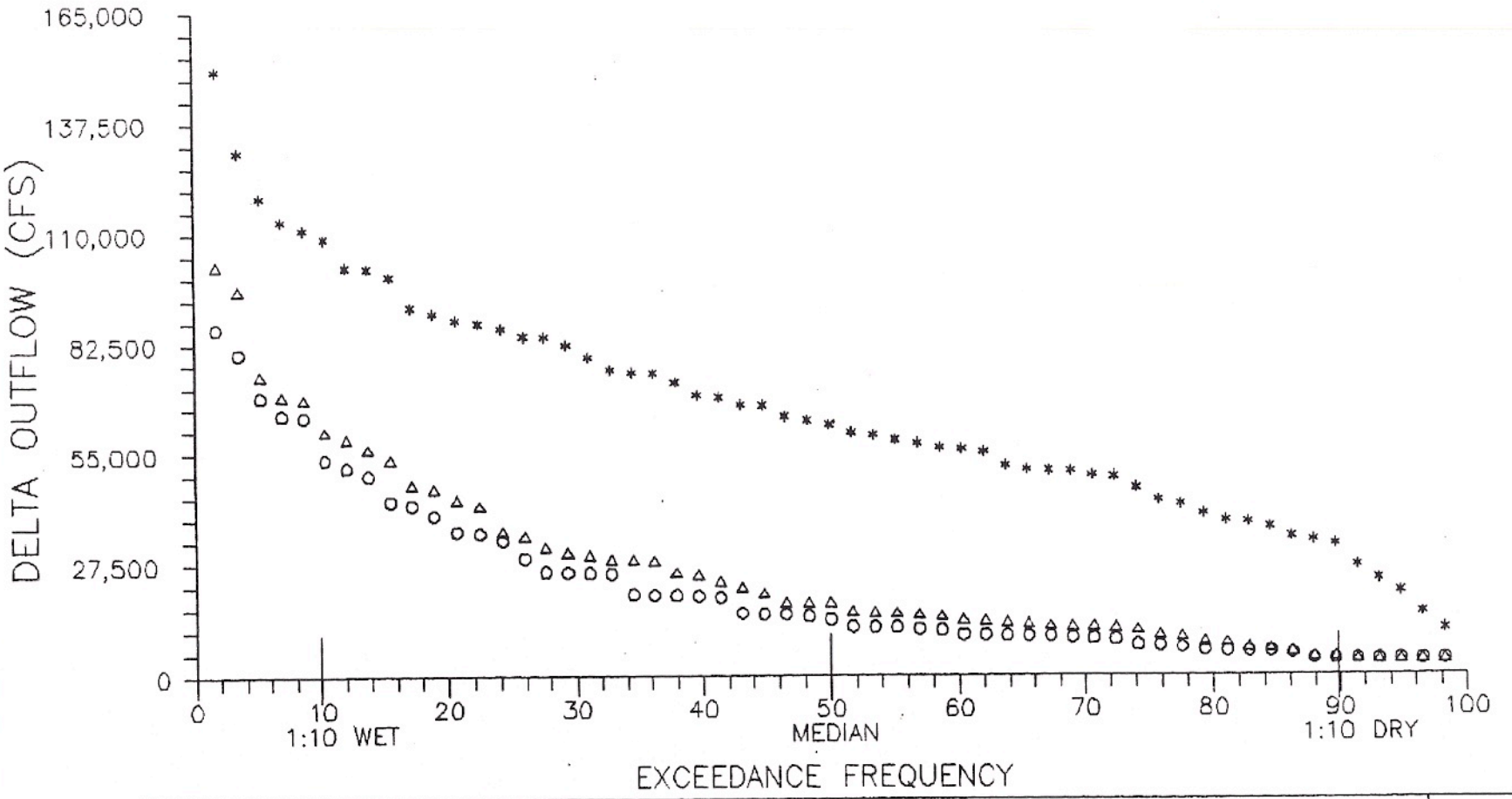
DATE: 5/05/87 BY: L. FISHBAIN		Philip Williams & Associates Pier 35, The Embarcadero San Francisco, California 94111	FIGURE 9

FOUR RIVER INDEX VS
PERCENT OF AVERAGE ANNUAL UNIMPAIRED DELTA OUTFLOW



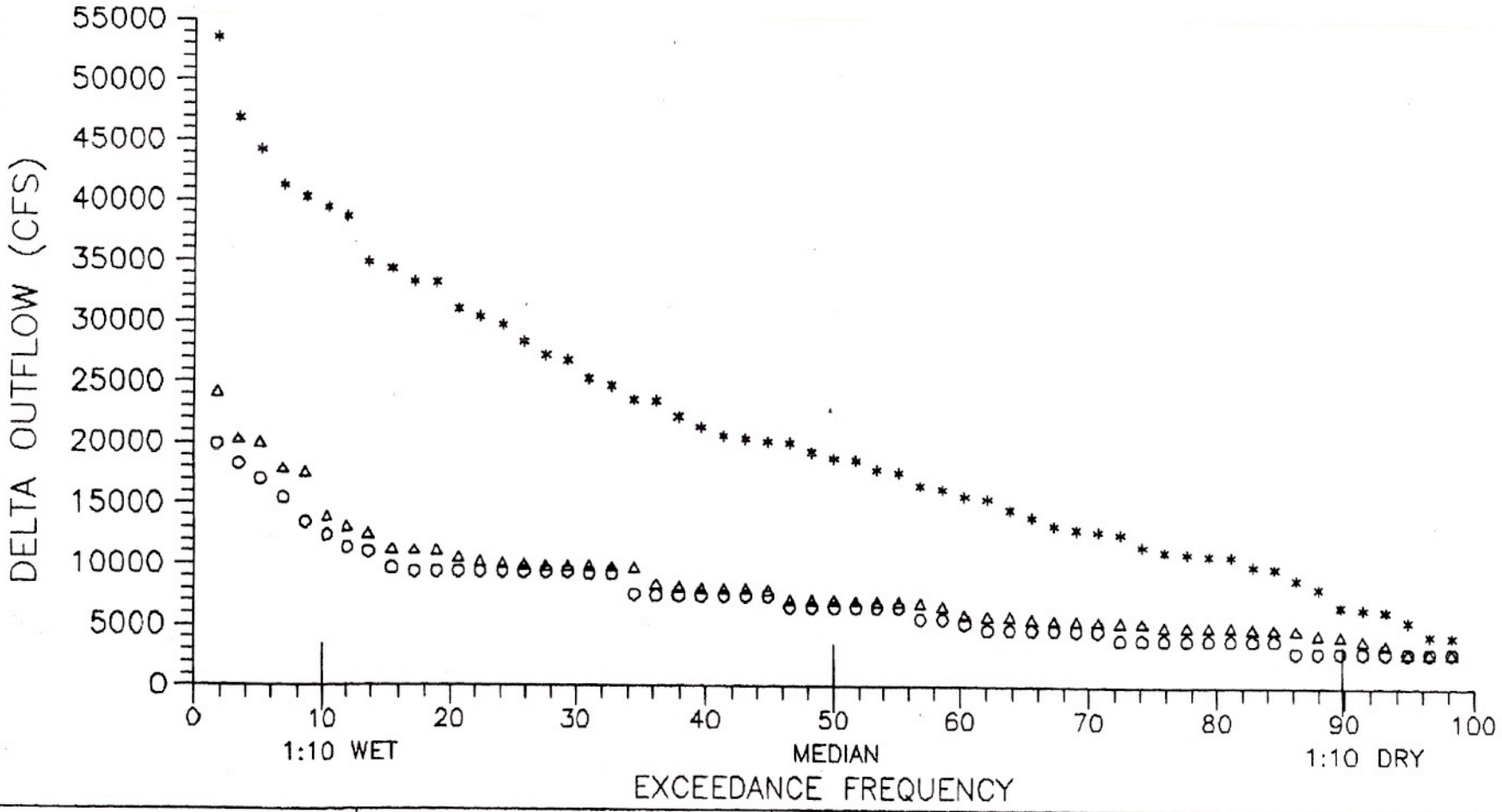
DATE: 5/04/87 BY: L. FISHBAIN		Philip Williams & Associates Pier 35, The Embarcadero San Francisco, California 94111	FIGURE 11

SPRING FLOW FREQUENCY RELATIONSHIP



DATE: 5/04/87 BY: L. FISHBAIN	* UNIMPAIRED △ EXISTING ○ FUTURE	Philip Williams & Associates Pier 35, The Embarcadero San Francisco, California 94111	FIGURE 13

SUMMER FLOW FREQUENCY RELATIONSHIP



DATE: 6/22/87 BY: L. FISHBAIN	* UNIMPAIRED △ EXISTING ○ FUTURE	Philip Williams & Associates Pier 35, The Embarcadero San Francisco, California 94111	FIGURE 14