

Barfield, Dave

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Sent: Friday, September 20, 2002 2:08 PM
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Subject: RRCL Settlement-Accounting-Flood Flows



Rep.R@Hardy(2).xls



WordPerfect 6.1

Attached for your information is a spreadsheet and narrative describing

an evaluation that was done concerning flood flows at Hardy. Gordon did did most of the evaluation.

Dennis

REPUBLICAN RIVER COMPACT
Method for Dealing with Flood Flows
Federal Team Perspective

Draft

Confidential - For Settlement Purposes Only

9/10/02

Background: The plan to use a 5 year running average to account for both the states' allocations and their consumptive use presents a problem when dealing with higher flood flow years. A large portion of the flood flows are not useable by any of the three states as this water is considerable more than can be stored or diverted for beneficial use. This surplus water simply flows from the Basin untouched. This would not be a problem if the flood flow for a given year was allocated to the states in that specific year as this would simply result in an unused allocation for that year. However, under the running average accounting method this is not the case as most, if not all, of the unused flood water is carried into the next 4 year accounting and allocated to the states in those years. As a result the allocations are artificially large in the later years exceeding the actual water supply physically available for use during those years. The consequence of this is a state either under uses its allocation or it pumps groundwater beyond the groundwater recharge capability. This results in groundwater mining further depleting the future surface water supply and increasing water shortages for surface users and the downstream states.

A similar problem does not exist for the low flow drought years as all of the water in those years is useable either through direct diversion or reservoir storage.

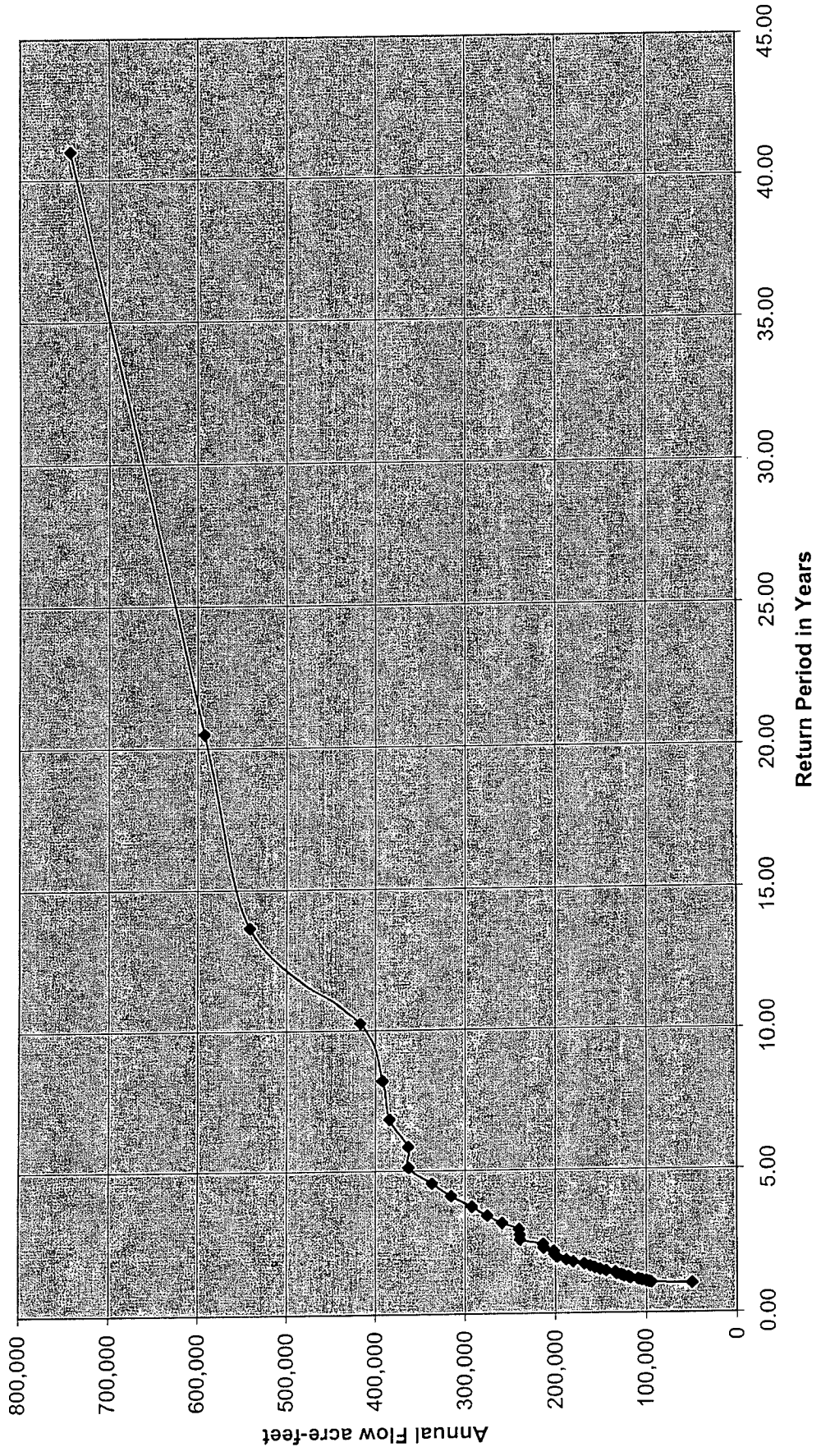
Federal Evaluation: The three states and the U. S. all agree that some adjustment is needed to remove the larger flood flows from the 5 year running average. The Federal reservoirs provide a certain degree of flood regulation that allows the states to beneficially use flood water occurring during smaller flood events, but this is not the case for larger floods as large extended spills are necessary from Harlan County and other reservoirs to pass flows during high flood runoff. Generally speaking the Republican River flow at Hardy provides a good indication of the quantity of flood water that is unused by the three states.

The annual flow volume, 5 consecutive month max flow volume and 2 consecutive month max flow volume at Hardy were analyzed for the years 1962 through 2001 to determine flood return periods. Although the Excel spread sheet can be used to calculate a return period and percentile values it does not treat the data set correctly for a flood frequency type analysis. Excel apparently treats the data set as finite computing a 100 percentile figure for the highest flow value and a 0 percentile figure for the lowest value. Since the 40 year set of data is only a sample set of the total flow events the commonly used equation $Tr = (n+1)/m$ was used to compute return periods where Tr equals the return period, n equals the number of years of record and m is the rank of the event. These return periods were then plotted against the runoff volumes to determine if a flood level could be identified where flood flows were clearly above what could reasonably be used. Both regular graph paper and probability paper was used for the annual flows. These graphs showed that there was a definite break in the curve when

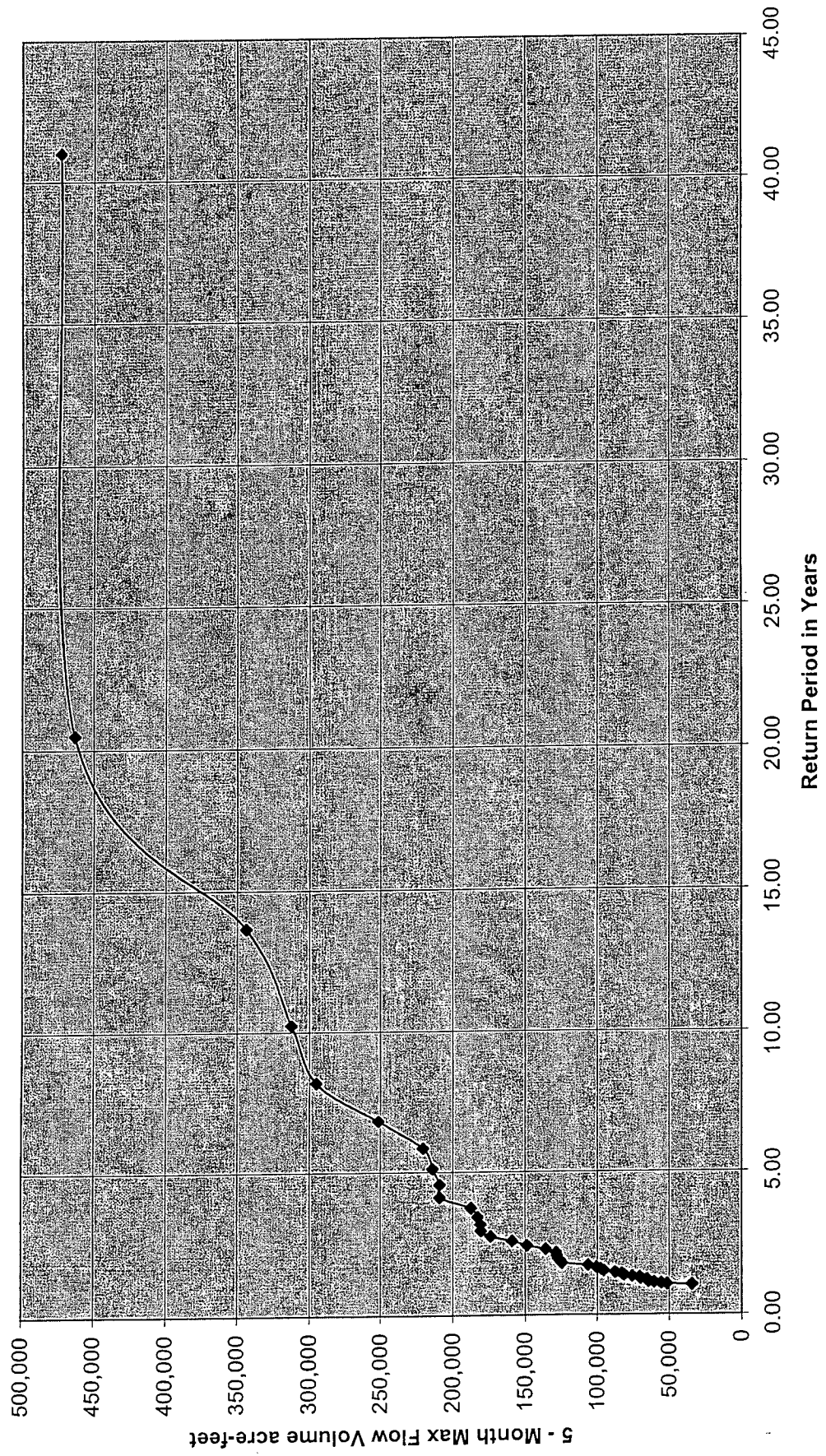
annual flows exceeded 410,000 acre-feet (10 year flood or 90 percentile year), and when the 5-month max flow volume exceeded about 325,000 acre-feet (12 year return period). The 2-month max flow volumes did not provide a smooth distribution above a 75 percentile flow. This is likely due to the fact that 2 months is not sufficient time for Harlan County Reservoir to route flows larger than a 75 percentile event. The annual flows plotted on the probability paper shows a good linear fit up to a return period of 10 years but beyond that the points formed a separate linear line. These breaks in the graphs are likely due to the fact that the runoff is not naturally occurring but is regulated up to a point by the reservoirs in the basin, primarily Harlan County Reservoir. The reservoirs are capable of providing good regulation of flows up to a 10 year runoff event but beyond that the excess flow is passed on downstream at a fairly high flow rate. Thus the flow events do not form one normal frequency distribution pattern but two separate patterns.

This evaluation indicates that annual flows above 410,000 acre-feet and 5-month max flows above about 325,000 acre-feet should be removed from the 5 year running averages as these higher flows are not available for use in the Basin by any of the three states due to the inability of the existing reservoirs to store or regulate them for later use.

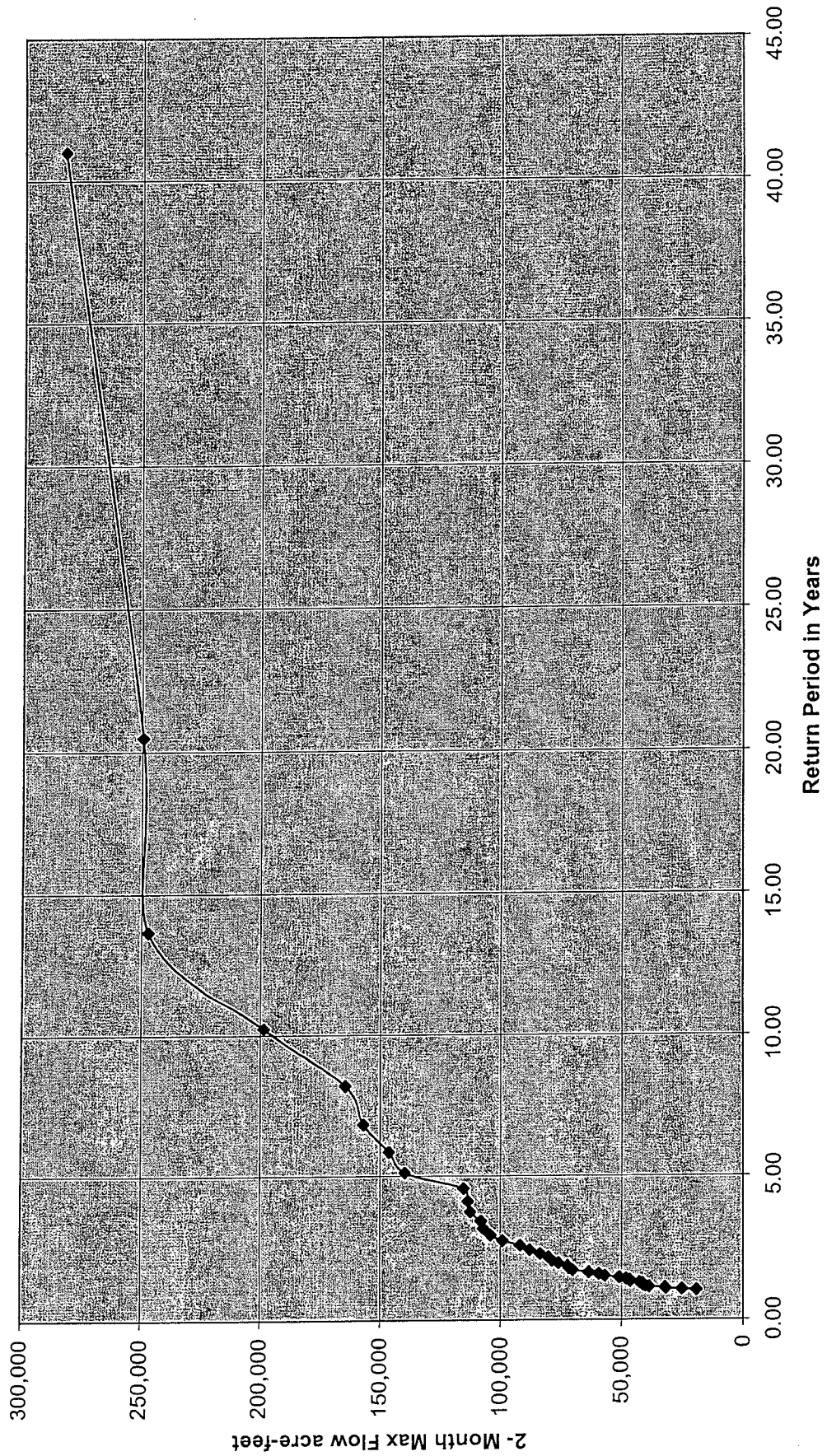
Republican River @ Hardy, NE
1962 -2001



Republican River @ Hardy, NE 1962-2001



Republican River @ Hardy, NE 1962-2001



REPUBLICAN RIVER NEAR HARDY, NE
1962-2001

Annual Flows				5-Month Max Flows				2-Month Max Flows						
YEAR	Return Period (n+1)/m	Annual Flow acre-feet descending	Rank	Percentile	Return Period (n+1)/m	5-Month Max Volume descending	Rank	Percentile	Return Period (n+1)/m	2-Month Max Volume Descending	Rank	Percentile		
1993	41.00	743,187	1	97.6	1993	41.00	473,238	1	97.6	1962	41.00	282,535	1	97.6
1962	20.50	592,220	2	95.1	1962	20.50	463,191	2	95.1	1993	20.50	249,517	2	95.1
1965	13.67	541,401	3	92.7	1965	13.67	343,550	3	92.7	1967	13.67	247,131	3	92.7
1967	10.25	416,865	4	90.2	1967	10.25	312,402	4	90.2	1965	10.25	198,664	4	90.2
1983	8.20	391,989	5	87.8	1986	8.20	295,032	5	87.8	1973	8.20	164,791	5	87.8
1996	6.83	384,151	6	85.4	1984	6.83	251,456	6	85.4	1984	6.83	157,269	6	85.4
1969	5.86	363,265	7	82.9	1973	5.86	220,237	7	82.9	1996	5.86	146,255	7	82.9
1973	5.13	362,811	8	80.5	1983	5.13	213,648	8	80.5	1995	5.13	139,618	8	80.5
1984	4.56	336,597	9	78.0	1969	4.56	208,805	9	78.0	1982	4.56	115,101	9	78.0
1966	4.10	315,351	10	75.6	1966	4.10	208,789	10	75.6	1966	4.10	113,218	10	75.6
1963	3.73	291,863	11	73.2	1982	3.73	187,411	11	73.2	1983	3.73	112,191	11	73.2
1982	3.42	275,004	12	70.7	1995	3.42	182,742	12	70.7	1987	3.42	107,855	12	70.7
1987	3.15	258,548	13	68.3	1974	3.15	180,659	13	68.3	1963	3.15	106,808	13	68.3
1994	2.93	239,907	14	65.9	1987	2.93	180,402	14	65.9	1969	2.93	104,063	14	65.9
1974	2.73	239,015	15	63.4	1984	2.73	173,697	15	63.4	1994	2.73	99,045	15	63.4
1995	2.56	238,820	16	61.0	1963	2.56	158,937	16	61.0	1975	2.56	91,868	16	61.0
1997	2.41	213,397	17	58.5	1970	2.41	148,757	17	58.5	1974	2.41	87,774	17	58.5
1985	2.28	212,781	18	56.1	2001	2.28	135,727	18	56.1	1970	2.28	83,488	18	56.1
1979	2.16	201,836	19	53.7	1997	2.16	128,542	19	53.7	1979	2.16	80,186	19	53.7
1970	2.05	201,168	20	51.2	1979	2.05	127,894	20	51.2	1997	2.05	78,767	20	51.2
1998	1.95	197,852	21	48.8	1985	1.95	127,166	21	48.8	1998	1.95	75,993	21	48.8
1975	1.86	187,922	22	46.3	1975	1.86	125,435	22	46.3	1992	1.86	72,125	22	46.3
1986	1.78	180,247	23	43.9	1998	1.78	124,489	23	43.9	2001	1.78	71,712	23	43.9
1968	1.71	168,122	24	41.5	1968	1.71	106,423	24	41.5	1977	1.71	69,973	24	41.5
1999	1.64	161,326	25	39.0	1999	1.64	100,540	25	39.0	1999	1.64	63,425	25	39.0
2001	1.58	156,507	26	36.6	1977	1.58	97,580	26	36.6	1968	1.58	59,353	26	36.6
1977	1.52	150,360	27	34.1	1992	1.52	95,347	27	34.1	1985	1.52	56,939	27	34.1
1978	1.46	143,560	28	31.7	1986	1.46	87,601	28	31.7	1980	1.46	51,019	28	31.7
1981	1.41	133,329	29	29.3	1980	1.41	83,057	29	29.3	1978	1.41	48,158	29	29.3
1964	1.37	132,616	30	26.8	1981	1.37	81,487	30	26.8	1986	1.37	45,383	30	26.8
1980	1.32	127,156	31	24.4	1990	1.32	75,747	31	24.4	1988	1.32	46,362	31	24.4
1988	1.28	123,966	32	22.0	1971	1.28	70,484	32	22.0	1964	1.28	42,484	32	22.0
1992	1.24	119,074	33	19.5	1978	1.24	70,126	33	19.5	1981	1.24	41,443	33	19.5
1971	1.21	116,373	34	17.1	1988	1.21	65,429	34	17.1	1990	1.21	41,320	34	17.1
1972	1.17	108,253	35	14.6	1964	1.17	64,708	35	14.6	1989	1.17	40,459	35	14.6
1990	1.14	104,878	36	12.2	2000	1.14	64,566	36	12.2	2000	1.14	38,908	36	12.2
1976	1.11	100,123	37	9.8	1976	1.11	60,673	37	9.8	1971	1.11	32,356	37	9.8
1989	1.08	96,798	38	7.3	1989	1.08	55,727	38	7.3	1976	1.08	32,051	38	7.3
2000	1.05	94,283	39	4.9	1972	1.05	51,650	39	4.9	1972	1.05	25,456	39	4.9
1991	1.03	49,927	40	2.4	1991	1.03	34,172	40	2.4	1991	1.03	19,486	40	2.4