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Richards Watson & Gershon

Water Resources Evaluation
Nipomo Mesa Management Area

DRAFT

SAIC
Water Resources Division
May 28, 2003

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
WATER RESOURCES DIVISION - SANTA BARBARA

MEMORANDUM

ATTORNEY WORK PRODUCT
CONFIDENTIAL AND PRIVILEGED

TO: James Markman, Esq.
Richards, Watson & Gershon

FROM: R. G. Beeby

RE: Status of Hydrologic Inventory for the Nipomo Mesa Management Area, SAIC Project No.: 01-0122-00-3994-000

DATE: August 1, 2002

Science Applications International Corporation (SAIC) was asked to prepare a detailed hydrologic inventory for the Nipomo Mesa Management Area (NMMA) and to estimate the change in the amount of groundwater in storage between 1975 and 2000. This period was selected to include the most recent year with available data. SAIC was also asked to estimate current and future water production, production safe yield and consumptive safe yield, and the effects of land use conversion on water supply to the NMMA.

This work was completed and documented in a draft memorandum to Mr. Markman dated January 23, 2002, and discussed with Mr. Markman and the Nipomo Community Services District (NCSD) Board on March 14, 2002. This work was also presented to the Technical Advisory Committee (TAC) on June 3, 2002. Based on those discussions additional evaluations were conducted to improve the correlation between the hydrologic inventory and the change in groundwater storage estimated from groundwater elevation contour maps. This memorandum is a summary of findings and results of the investigation to date and reflects the additional work done after the March 14th NCSD Board meeting and June 3rd TAC Meeting. The results presented in this memorandum are supported by a series of technical memoranda that have been provided to Mr. Markman and some members of the TAC for review and comment.

1. Long-term Hydrologic Inventory

Table 1 is a detailed summary of the NMMA Hydrologic Inventory for the period 1975-2000. The cumulative change in groundwater storage in the NMMA for the period 1975-2000 is estimated to be approximately -18,540 acre-feet. This total does not include the root zone deficit of approximately 2,720 acre-feet occurring at the end of the study period. This deficit is the water required to return the root zone to the saturated conditions assumed for the beginning of

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the study period. If this deficit is included in the cumulative change in groundwater storage, the cumulative water deficit is 21,260 acre-feet, or an average deficit of approximately 820 acre-feet per year.

2. Year 2000 Hydrologic Inventory

As shown in Table 1, the water balance for year 2000 has a deficit of 4,690 acre-feet. This total does not include the root zone deficit of approximately 2,720 acre-feet at the end of the study period as discussed above. If this additional volume is included in the Year 2000 deficit, the total deficit is 7,410 acre-feet as follows:

Year 2000 Water Supply	4,250 acre-feet
Year 2000 Water Use and Outflow	- 8,940 acre-feet
Year 2000 Surplus/(Deficit) [Table 1]	-4,690 acre-feet
Year 2000 Root Zone Deficit (End of Year)	- 2,720 acre-feet
Year 2000 Total Deficit	-7,410 acre-feet

3. Groundwater Storage Conditions

Changes in groundwater storage were estimated from analyses of groundwater contours to check the inventory. Table 2 is a summary of the results. The groundwater contour analyses show a deficit for the period 1975 to 2000 of approximately 9,900 acre-feet. The deficit in the portion of NMMA north of the Santa Maria River (SMR) fault was more pronounced than that south of the fault.

The NMMA Hydrologic Inventory shows a deficit for the same period. The groundwater storage deficit from the groundwater contour analyses is approximately 8,600 acre-feet less than the storage deficit from the hydrologic inventory over the 26-year period of study. The difference in the two approaches is due to the available data and assumptions used in the analyses. The groundwater contour analyses used available groundwater depth data from wells in the NMMA that may have been affected by the following factors: (1) Uncertainties in groundwater elevations using land surface elevation estimates; (2) Possible effects of a multiple aquifer system affecting measured heads in groundwater wells; (3) Effects of nearby pumping wells on groundwater elevations; and (4) Engineering judgment used in extrapolating contours in areas with sparse groundwater elevation data

4. Effects of Land Use Conversion on Water Supply

The effects to water supply from converting land use were evaluated. Table 3 shows a unit rate value and net water gain/loss on different land use types from varying precipitation rates.

Precipitation was incremented every 5 inches from 5 inches to 35 inches. The effects on the water supply for each land use category are shown.

Table 3 shows that when 25 inches of rain occurs, converting an agricultural area with citrus trees to urban uses will result in a net water gain of 1.5 AF/acre.

5. Future Water Use and Land Use

Water demands and land use for Agricultural, Urban, Native Vegetation and Golf Courses categories were estimated for the year 2020. Agricultural water demands and land use were assumed to be the same as in the year 2000. Urban land use and water demands were assumed to increase based on data provided by NCSD, Cal Cities Water, and Rural Water Company, the urban water purveyors in the NMMA. Golf courses were expected to increase with the development of the 27-hole golf course at the Woodlands Development. The increase in area for urban land use and golf courses is assumed to come out of the native vegetation land use category, 60 percent from grasses, 40 percent from trees. The remaining native vegetation area was assumed to be 60 percent grasses and 40 percent trees, consistent with 1996 land use data. A summary of water demands and land use for the year 2000 and at 2020 are provided below.

Land Use	**2000 Area (acres)**	**2020 Area (acres)**
Urban	6,540	8,320
Agricultural	2,000	2,000
Golf Courses	660	850
Native Vegetation	10,210	8,240
Total	**19,410**	**19,410**

6. Production Safe Yield and Consumptive Safe Yield Calculation

Production Safe Yield is the amount of groundwater that can be produced without resulting in adverse effects, such as lowered groundwater levels, under a given set of conditions. Current and projected Production Safe Yields based on 1996 and 2020 data were estimated using three different sets of assumptions to revise portions of the hydrologic inventory. The three different sets of conditions were the following:

(1) Condition (1) used 1996 land uses in the 1975-2000 hydrologic inventory to estimate the deep percolation of precipitation as shown in Table 5. Subsurface and surface flows were assumed to be equal to the study period averages. 1996 consumptive use of production and groundwater production data were then used to calculate Safe Yields.

(2) Condition (2) adjusted Condition (1) data to represent the long-term average for 1959 to 2000. 1959 to 2000 is the long-term record for the Nipomo CDF precipitation gage used in the hydrologic inventory. The average annual rainfall during the period 1959-2000 is approximately 92.8 percent of the average annual rainfall during the study period 1975-2000. Therefore, the deep percolation of precipitation and subsurface and surface flow data from Condition (1) were multiplied by 0.928. 1996 consumptive use of production and groundwater production data were then used to calculate Safe Yields.

(3) Condition (3) applied 2020 land uses to the 1975-2000 hydrologic inventory to estimate the deep percolation of precipitation due to projected cultural practices as shown in Table 6. The resultant net deep percolation and subsurface and surface flows from Condition (1) were reduced by 7.2 percent to reflect drier long-term average conditions. The 2020 consumptive use of production and groundwater production for agriculture were assumed to remain the same as year 2000. 2020 urban and golf course production and consumptive use of production were then used to calculate Safe Yields.

The Production Safe Yield for each set of conditions was then calculated based on the study period averages as Total Supply minus Total Use plus groundwater production. Consumptive Safe Yield is equal to the natural water supply less groundwater outflow. Consumptive Safe Yield was calculated for the same three sets of conditions described above. A detailed summary of Production and Consumptive Safe Yield calculations are in Table 4. In summary the results show:

Revised Hydrologic Inventory	Condition (1): 1996 Land Use	Condition (2): 1996 Land Use and Reduced Water Supply	Condition (3): 2020 Land Use and Reduced Water Supply)
Production Safe Yield	7,860 AF	7,520 AF	11,6100 AF
Consumptive Safe Yield	4,780 AF	4,440 AF	5,490 AF

Based on the adjusted long-term consumptive safe yield of 4,440 acre-feet, consumptive use of production has exceeded consumptive safe yield annually since 1986. Consumptive use of groundwater production has ranged from 4,930 to 7,330 acre-feet per year since 1986 as shown in Table 1.

TABLE 1. HYDROLOGIC INVENTO
(Rounded to

	ELEMENTS OF HYDROLOGIC INVENTORY																
3	**WATER YEAR**	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
4																	
5	**ANNUAL PRECIPITATION (INCHES)**	17.29	13.45	10.23	30.66	15.80	16.57	13.39	18.58	33.21	11.22	12.20	16.85	11.29	12.66	12.22	7.12
6	**AREA (ACRES)**	19,410	19,410	19,410	19,410	19,410	19,410	19,410	19,410	19,410	19,410	19,410	19,410	19,410	19,410	19,410	19,410
7																	
8	**ELEMENTS OF HISTORICAL SUPPLY**																
9	DEEP PERCOLATION OF PRECIPITATION [1]																
10	NATIVE TREES [3]	0	0	0	0	0	0	0	0	1,080	0	0	0	0	0	0	0
11	NATIVE GRASSES [3]	0	0	0	8,450	0	0	0	0	10,650	0	0	0	0	0	0	0
12	AGRICULTURAL LAND	1,190	640	60	3,420	1,170	1,360	850	1,790	4,360	680	800	1,610	720	880	790	10
13	URBAN LAND	870	250	0	3,690	790	1,000	320	1,590	5,350	0	50	1,420	0	210	80	0
14	GOLF COURSES	0	0	0	0	0	0	0	0	0	0	0	180	70	100	90	0
15	**TOTAL PERCOLATION OF PRECIPITATION**	2,060	890	60	15,560	1,960	2,360	1,170	3,380	21,440	680	850	3,210	790	1,190	960	10
16																	
17	SUBSURFACE INFLOW [2]																
18	FROM SANTA MARIA RIVER VALLEY	(10)	70	150	230	300	380	460	540	610	690	770	840	920	1,000	1,080	1,150
19	FROM NIPOMO VALLEY	120	150	250	110	110	80	150	140	190	100	40	190	290	260	320	340
20	**TOTAL SUBSURFACE FLOW**	110	220	400	340	410	460	610	680	800	790	810	1,030	1,210	1,260	1,400	1,490
21																	
22	**TOTAL SUPPLY**	2,170	1,110	460	15,900	2,370	2,820	1,780	4,060	22,240	1,470	1,660	4,240	2,000	2,450	2,360	1,500
23																	
24	**ELEMENTS OF USE/ OUTFLOW**																
25	CONSUMPTIVE USE OF PRODUCTION [4]																
26	AGRICULTURAL [5]	1,840	1,930	2,160	1,810	2,100	2,150	2,210	2,240	2,140	2,460	2,440	2,500	2,630	2,620	2,680	3,160
27	URBAN [6]	730	840	900	1,010	1,060	1,180	1,290	1,460	1,570	1,680	1,850	2,020	2,180	2,350	2,580	2,740
28	GOLF COURSE [5][7]	0	0	0	0	0	0	0	0	0	0	0	410	440	440	440	480
29	**TOTAL CONSUMPTIVE USE OF PRODUCTION**	2,570	2,770	3,060	2,820	3,160	3,330	3,500	3,700	3,710	4,140	4,290	4,930	5,250	5,410	5,700	6,380
30																	
31																	
32	SURFACE OUTFLOW [8]	0	0	0	120	0	0	0	0	130	0	0	0	0	0	0	0
33																	
34																	
35	SUBSURFACE OUTFLOW [2]																
36	TO PACIFIC OCEAN	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420
37	TO NORTHERN CITIES	1,290	1,240	1,250	1,190	1,210	1,280	1,190	1,210	1,150	1,350	1,300	1,300	1,300	1,270	1,290	1,290
38	**TOTAL SUBSURFACE OUTFLOW**	1,710	1,660	1,670	1,610	1,630	1,700	1,610	1,630	1,570	1,770	1,720	1,720	1,720	1,690	1,710	1,710
39																	
40	**TOTAL USE**	4,280	4,430	4,730	4,550	4,790	5,030	5,110	5,330	5,410	5,910	6,010	6,650	6,970	7,100	7,410	8,090
41																	
42	**SURPLUS/ DEFICIENCY BY WATER YEAR**	(2,110)	(3,320)	(4,270)	11,350	(2,420)	(2,210)	(3,330)	(1,270)	16,830	(4,440)	(4,350)	(2,410)	(4,970)	(4,650)	(5,050)	(6,590)
43	**CUMULATIVE SURPLUS/DEFICIENCY**	(2,110)	(5,430)	(9,700)	1,650	(770)	(2,980)	(6,310)	(7,580)	9,250	4,810	460	(1,950)	(6,920)	(11,570)	(16,620)	(23,210)
44																	
45	GROUNDWATER PRODUCTION																
46	AGRICULTURAL	2,510	2,610	2,950	2,440	2,820	2,880	2,960	3,000	2,860	3,320	3,240	3,320	3,550	3,500	3,590	4,330
47	URBAN	1,300	1,500	1,600	1,800	1,900	2,100	2,300	2,600	2,800	3,000	3,300	3,600	3,900	4,200	4,600	4,900
48	GOLF COURSE	0	0	0	0	0	0	0	0	0	0	0	480	510	510	510	570
49	TOTAL EXTRACTIONS	3,810	4,110	4,550	4,240	4,720	4,980	5,260	5,600	5,660	6,320	6,540	7,400	7,960	8,210	8,700	9,800

59 [1] Rainfall data provided by San Luis Obispo County Department of Public Works. Groundwater recharge due to deep percolation of precipitation estimated using Nipomo CDF precipitation gage for water years 1975 throug

60 [2] Data developed from 1975, 1995, and 2000 Groundwater Contour maps and available well data. Years without well data estimated with linear interpolation of contour data.

61 [3] Accounts for precipitation used to meet root zone moisture deficit from previous dry year.

62 [4] Historical land use data provided by DWR for 1977, 1985 and 1996. Land use data for all other years estimated by linear interpolation.

63 [5] Consumptive use varies by crop type. Assume 90% of ag land is irrigated.

64 [6] Assume 56% consumptive use for all urban water produced.

65 [7] Assume Black Lakes Golf Course began irrigating in 1986. Assume Cypress Ridge Golf course began irrigating in 1998.

66 [8] Surface water outflow occurs in years of 25 inches or greater precipitation.

67 [9] 2020 estimate based on data obtained from D. Jones (NCSD) and CH2M Hill (representing RWC and Cal Cities Water). AG water demands for 2020 assumed to be same as for 2000. Water supply for 2020 is average for period 1975-2000.

68 [10] Total deficit increased by 2,720 due to root zone deficit at end of year 2000.

INVENTORY - NIPOMO MESA MANAGEMENT AREA
Rounded to nearest ten acre-feet)

A	AH	AJ	AL	AN	AP	AR	AT	AV	AX	AZ	BB	BD	BF	BH	BJ
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	TOTALS	MEAN 1975-2000	FUTURE 2020[9]	MEAN 1975-1995
	7.12	13.06	15.66	20.17	12.15	25.47	16.54	20.50	33.67	12.98	14.47	437.4	16.82	16.82	16.15
	19,410	19,410	19,410	19,410	19,410	19,410	19,410	19,410	19,410	19,410	19,410				
0	0	0	0	0	0	0	0	0	970	0	0	2,050	80	4,620	51
0	0	0	0	470	0	3,530	0	1,260	8,650	0	0	33,010	1,270	6,930	1,100
0	10	940	1,370	2,070	770	2,860	1,490	2,100	4,170	900	1,150	38,150	1,470	2,420	1,350
0	0	400	1,460	3,420	70	6,120	2,150	4,170	11,030	510	1,350	46,300	1,780	11,660	1,290
0	0	110	160	220	90	320	180	230	1,040	110	150	3,050	120	1,190	64
0	**10**	**1,450**	**2,990**	**6,180**	**930**	**12,830**	**3,820**	**7,760**	**25,860**	**1,520**	**2,650**	**122,560**	**4,720**	**4,720**	**3,855**
0	1,150	1,230	1,310	1,380	1,460	1,540	1,510	1,480	1,450	1,420	1,390	23,350	900	900	767
0	340	370	250	320	280	150	210	290	380	190	210	5,490	210	210	200
0	**1,490**	**1,600**	**1,560**	**1,700**	**1,740**	**1,690**	**1,720**	**1,770**	**1,830**	**1,610**	**1,600**	**28,840**	**1,110**	**1,110**	**967**
0	**1,500**	**3,050**	**4,550**	**7,880**	**2,670**	**14,520**	**5,540**	**9,530**	**27,690**	**3,130**	**4,250**	**118,390**	**5,830**	**5,830**	**4,822**
80	3,160	2,800	2,850	2,850	2,980	2,890	3,090	3,100	3,030	3,280	3,330	67,270	2,590	3,330	2,450
80	2,740	2,690	2,630	2,520	2,410	2,300	2,460	2,630	2,860	3,020	3,250	52,210	2,010	6,060	1,809
40	480	440	410	370	440	340	410	370	580	790	750	7,110	270	1,090	200
00	**6,380**	**5,930**	**5,890**	**5,740**	**5,830**	**5,530**	**5,960**	**6,100**	**6,470**	**7,090**	**7,330**	**126,590**	**4,870**	**10,480**	**4,459**
0	0	0	0	0	0	100	0	0	130	0	0	480	20	20	17
0	420	420	420	420	420	420	420	420	420	420	420	10,920	420	420	420
0	1,290	1,290	1,270	1,230	1,250	1,170	1,170	1,110	1,050	1,110	1,190	31,950	1,230	1,230	1,253
0	**1,710**	**1,710**	**1,690**	**1,650**	**1,670**	**1,590**	**1,590**	**1,530**	**1,470**	**1,530**	**1,610**	**42,870**	**1,650**	**1,650**	**1,673**
0	**8,090**	**7,640**	**7,580**	**7,390**	**7,500**	**7,220**	**7,550**	**7,630**	**8,070**	**8,620**	**8,940**	**169,940**	**6,540**	**12,150**	**6,149**
0)	**(6,590)**	**(4,590)**	**(3,030)**	**490**	**(4,830)**	**7,300**	**(2,010)**	**1,900**	**19,620**	**(5,490)**	**(4,690)** [10]	**(18,540)** [10]	**(710)**	**(6,320)**	**(1,327)**
0)	**(23,210)**	**(27,800)**	**(30,830)**	**(30,340)**	**(35,170)**	**(27,870)**	**(29,880)**	**(27,980)**	**(8,360)**	**(13,850)**	**(18,540)** [10]				
0	4,330	3,760	3,840	3,850	4,020	3,940	4,180	4,210	4,110	4,460	4,530	90,780	3,490	4,530	3,300
0	4,900	4,800	4,700	4,500	4,300	4,100	4,400	4,700	5,100	5,400	5,800	93,200	3,580	10,820	3,229
0	570	510	480	440	510	410	480	440	670	920	880	8,320	320	1,270	235
0	9,800	9,070	9,020	8,790	8,830	8,450	9,060	9,350	9,880	10,780	11,210	192,300	7,390	16,620	6,763

s 1975 through 2000.

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Change in Groundwater Storage in the NMMA

(All values in Thousand Acre-Feet)

	1975-2000		1975-95	
Area	**Groundwater Contour, Specific Yield Method**	**NMMA Hydrologic Inventory [a]**	**Groundwater Contour, Specific Yield Method**	**NMMA Hydrologic Inventory [a]**
South of SMR Fault	-1.6	not estimated	-11.0	not estimated
North of SMR Fault	-8.3	not estimated	-12.9	not estimated
Total NMMA	**-9.9**	**-18.5**	**-23.9**	**-27.9**

[a] From Table 1

TABLE 3

Effects of Land Use Conversion on Net Water Supply by Land Use Category

All Values Acre-Feet/Acre, unless noted

Rainfall Amount (Inches)	5	10	15	20	25	30	35
			Net Water Surplus (Deficit) for Given Rainfall				
Urban	(0.50)	(0.50)	(0.25)	0.17	0.59	1.00	1.42
Native Trees	0.00	0.00	0.00	0.00	0.00	0.34	0.76
Native Grasses	0.00	0.00	0.00	0.22	0.63	1.05	1.47
Citrus and Subtropical	(2.58)	(2.17)	(1.75)	(1.33)	(0.92)	(0.50)	(0.08)
Deciduous	(1.98)	(1.57)	(1.15)	(0.73)	(0.32)	0.10	0.52
Grain and Hay	(0.88)	(0.47)	(0.05)	0.37	0.78	1.20	1.62
Truck, Nursery & Berry	(0.78)	(0.37)	0.05	0.47	0.88	1.30	1.72
Pasture	(2.38)	(1.97)	(1.55)	(1.13)	(0.72)	(0.30)	0.12
Multi-Crop Grain	(1.78)	(1.37)	(0.95)	(0.53)	(0.12)	0.30	0.72
Multi-Crop Truck	(1.98)	(1.57)	(1.15)	(0.73)	(0.32)	0.10	0.52
Golf Courses	(1.88)	(1.47)	(1.05)	(0.63)	(0.22)	0.20	0.62

To estimate the impact to the water supply of a land use conversion:

1. Select the annual rainfall
2. Water Impact = Surplus (Deficit) from above table for proposed land use - Surplus (Deficit) from above table for current land use

Examples:

1. Wet Year, Citrus to Urban

Find the impact to the water supply in a wet year (25 inches rainfall) of converting Citrus to Urban land use
From the above table under the 25 inch rainfall column:
Urban surplus is 0.59 AF/Acre and Citrus deficit is 0.92 AF/Acre
Water impact = 0.59 - (-.92) = 1.51 AF/acre of net gain to the water supply

2. Dry Year, Citrus to Urban

Find the impact in a dry year (10 inches rainfall), of converting Citrus to Urban land use:
From the above table under the 10 inch rainfall column:
Urban deficit is 0.50 AF/Acre and Citrus deficit is 2.2 AF/Acre
Water impact = -.50-(-2.2) = 1.7 AF/acre of net gain to the water supply

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TABLE 4

NMMA SAFE YIELD CALCULATIONS

All Values Rounded to Nearest Ten Acre-feet

	Condition 1. 1996 Land Use Assumed for Study Period [1]	Condition 2. 1996 Land Use Study Period Results Adjusted to Long-Term Average (1959-2000) [2]	Condition 3. 2020 Land Use Assumed for Study Period and Adjusted to Long-Term Average [3]
ELEMENTS OF SUPPLY			
DEEP PERCOLATION OF PRECIPITATION [4]	5,320	4,940	5,990
SUBSURFACE INFLOW [5]			
FROM SANTA MARIA RIVER VALLEY	900	840	840
FROM NIPOMO VALLEY	210	190	190
TOTAL SUBSURFACE FLOW	1,110	1,030	1,030
TOTAL SUPPLY	**6,430**	**5,970**	**7,020**
ELEMENTS OF USE/ OUTFLOW			
CONSUMPTIVE USE OF PRODUCTION			
AGRICULTURAL	3,090	3,090	3,330
URBAN	2,460	2,460	6,060
GOLF COURSE	410	410	1,090
TOTAL CONSUMPTIVE USE OF PRODUCTION	**5,960**	**5,960**	**10,480**
SURFACE WATER OUTFLOW	20	20	20
SUBSURFACE OUTFLOW [5]			
TO PACIFIC OCEAN	420	390	390
TO NORTHERN CITIES	1,230	1,140	1,140
TOTAL SUBSURFACE OUTFLOW	**1,650**	**1,530**	**1,530**
TOTAL USE	**7,630**	**7,510**	**12,030**
SURPLUS/ DEFICIENCY	**(1,200)**	**(1,540)**	**(5,010)**
GROUNDWATER PRODUCTION	**9,060**	**9,060**	**16,620**
PRODUCTION SAFE YIELD	**7,860**	**7,520**	**11,610**
CONSUMPTIVE SAFE YIELD [6]	**4,780**	**4,440**	**5,490**

(1) Study period is 1975-2000 for NMMA Hydrologic Inventory. Applies 1996 land use from 1975-2000 to calculate Deep Percolation of Precipitation (Table 5). Uses study period averages from Table 1 for subsurface and surface flows and 1996 consumptive use of production and groundwater production.

(2) Deep percolation of precipitation, subsurface inflow and outflow, and surface outflow from Condition 1 multiplied by 0.928 to reflect drier long-term (1959-2000) conditions. Consumptive use of production and groundwater production assumed same as 1996 from Table 1.

(3) Future urban water demands based on data provided by NCSD (D. Jones) and CH2M Hill (for RWC and Cal Cities Water). Golf course estimate for 2020 includes Cypress Ridge Golf Course and Woodlands Golf Course. 2020 agricultural consumptive use of production and groundwater production assumed equal to 2000 conditions. Urban and golf course consumptive use of production and golf course groundwater production calculated for 2020 conditions. Assumes 2020 land and water use for 1975-2000 (Table 6) to calculate average deep percolation of precipitation over study period; result reduced by 7.2% to reflect drier long-term average rainfall. Subsurface and surface flows from Condition 2.

(4) Rainfall data provided by San Luis Obispo County Department of Public Works. Groundwater recharge due to deep percolation of precipitation estimated using Nipomo CDF precipitation gage.

(5) Average subsurface flow for period 1975 - 2000, developed from 1975, 1995, and 2000 groundwater contour maps and well data. Years with missing well data estimated through linear interpolation of groundwater contour results.

(6) Consumptive Safe Yield is natural water supply (deep percolation of precipitation and subsurface inflow) minus subsurface outflow.

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WATER RESOURCES DIVISION – SANTA BARBARA

MEMORANDUM

ATTORNEY WORK PRODUCT
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TO: R. G. Beeby

FROM: Mark Bandurraga

RE: Update of Hydrologic Inventory for the Nipomo Mesa Management Area (3994)

DATE: June 11, 2002

The purpose of this memorandum is to describe the work done to update the hydrologic inventory of the Nipomo Mesa Management Area (NMMA) to make it more consistent with the groundwater change in storage estimate developed from groundwater elevation contour maps. The hydrologic inventory dated January 23, 2002, showed a cumulative change in groundwater storage from 1975 through 2000 of approximately -5,500 acre-feet (af). The change in groundwater storage based on the elevation contour maps is approximately -9,900 af. However, several of the assumptions used in the January hydrologic inventory were re-evaluated based on additional information on consumptive use by native trees and urban outdoor use of groundwater. Based on the revised assumptions to update the NMMA hydrologic inventory, the change in groundwater storage over the study period is approximately –5,760 af, primarily due to a decrease in return flow from outdoor use of groundwater.

1.0 NATIVE TREE VEGETATION CONSUMPTIVE USE

As described in the memo "Estimate of Water Demands from Urban, Golf Course, and Native Vegetation Land Use on the Hydrologic Inventory for the Nipomo Mesa Management Area" dated January 22, 2002, the ET value used for native tree vegetation was 2.2 feet per year (ft/yr) based on a comparison to citrus orchards and previous DWR estimates. Inspection of 1995 aerial photos showed that approximately 8% of the native vegetation occurs along Nipomo and Los Berros Creeks and Black Lake Canyon in the NMMA. Blaney et al. (1963, pg 46) measured riparian consumptive use of water by riparian vegetation in Santa Barbara County at approximately 4.92 feet per year. Native trees have a higher consumptive use than grasses because their deeper roots can extract more soil moisture than shallow-rooted grasses, and may have some similarities to permanent tree crops like citrus. The native tree ET was assumed to be the average of the mean native grass ET of 1.45 ft/yr provided by DWR (1996) and the ET rate of 2.4 ft/yr given for deciduous orchards in central coast coastal valleys and plains by DWR

(1975). The native tree ET rate was therefore calculated to be (1.45+2.4)/2=1.925 ft/yr. The areally-weighted average ET value for native trees including 8% riparian vegetation was 0.92*1.925+0.08*4.92=2.16 ft/yr.

2.0 URBAN APPLIED WATER RETURN TO GROUNDWATER

Cleath and Associates (1994) suggest that groundwater return flow of pumpage for urban outdoor uses does not occur, likely because this water is used during relatively dry periods when landscaping ET rates are high. The hydrologic inventory originally used a groundwater return flow of 20% of the water used for outdoor needs (6% of the total pumped) to provide for leaching of landscaping soils to remove salts. However, the hydrologic inventory also assumes that any annual precipitation over 12 inches is able to recharge to groundwater, which provides salt leaching for soils underlying landscaping. The leaching volume is actually greater than the depth of rain above 12 inches times the total area because the runoff from urban impervious areas increases the recharge in pervious areas. Therefore, the hydrologic inventory was adjusted by assuming that there is no return flow to groundwater from pumpage used in outdoor applications. This reduces the urban uses return flow from 50% to 44% of the groundwater pumped. The 44% return flow occurs from water used indoors and recharged to groundwater through septic systems and municipal wastewater treatment plants.

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Cleath and Associates. (1994). "Cypress Ridge Limited Parnership Water Resources Management Study for Cypress Ridge". September 1994.

DWR, 1996. Email from David Inouye to Mike Meissner, September 6, 1996. Range of native grass consumptive use from 1.3 to 1.67 ft/yr.

DWR, 1975. "Vegetative Water Use in California, 1974". DWR Bulletin 113-3, April, 1975. Table 15, page 33.

CHANGE IN GW STORAGE

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WATER RESOURCES DIVISION – SANTA BARBARA

MEMORANDUM

ATTORNEY WORK PRODUCT
CONFIDENTIAL AND PRIVILEGED

TO: R. G. Beeby

FROM: Mark Bandurraga

RE: Estimation of 1975 to 2000 Change in Groundwater Storage for the Hydrologic Inventory of the Nipomo Mesa Management Area, SAIC Project No.: 01-0122-00-3994-000

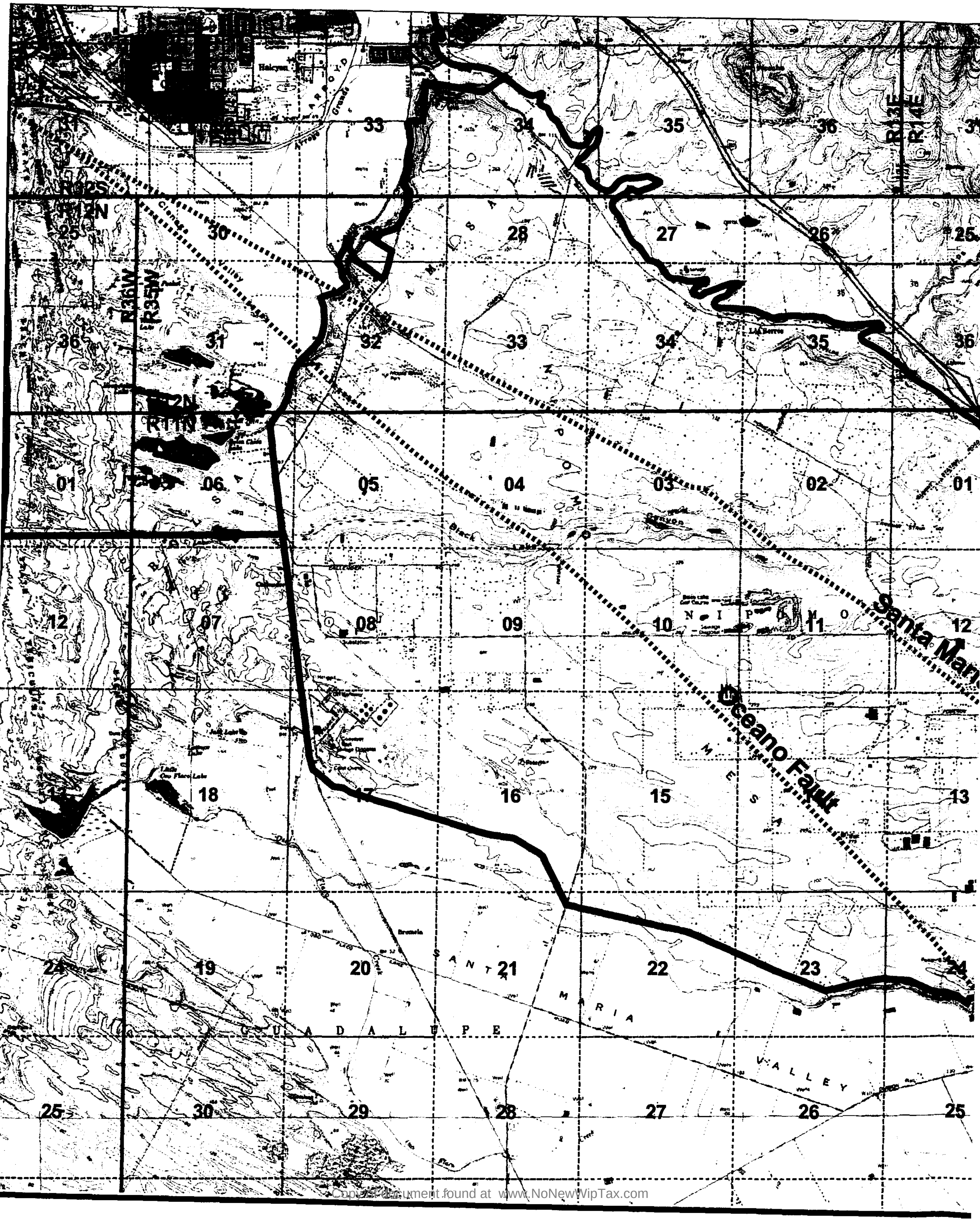
DATE: June 14, 2002

EXECUTIVE SUMMARY

This memorandum describes the estimate of the change in groundwater storage from 1975 to 2000 for the hydrologic inventory of the Nipomo Mesa Management Area (NMMA) as shown in Figure 1. Groundwater elevations based on well measurements obtained during the Spring months of 1975, 1995, and 2000 were used develop contour maps of the groundwater surfaces. The contours were digitized and the data used to estimate the change in volume using the SURFER software package. Specific yield data from DWR's evaluation of the Nipomo Mesa Area (DWR, 2000) were used to convert the volume change from SURFER to a groundwater volume change estimate. The estimated decrease in the volume of groundwater in storage in the NMMA is approximately 9,900 acre-feet from 1975 to 2000. The evaluation indicates that groundwater storage has decreased more on the north side of the Santa Maria River fault than on the south side of the fault. By the Spring of 2000, groundwater levels on the south side of the fault had largely recovered to 1975 conditions except in localized areas around municipal production wells. The recharge occurring in the late 1990s largely eliminated the pumping trough shown in the DWR (2000) report for the relatively dry 1995 conditions.

1.0 METHODOLOGY

The methodology used in the evaluation included using available groundwater level data from the County of San Luis Obispo's Department of Public Works (SLO DPW) to create contour maps of the groundwater surface elevation in the NMMA. A review was done of available reports providing discussions of the hydrogeologic system and contour maps of the groundwater surfaces at various time periods as follows:



Santa Maria
Oceano Fault
N I P O M O
M E S A
S A N T A M A R I A
V A L L E Y
G U A D A L U P E
Black Lake Canyon
T12N R35W
R36W
R35W
33
34
35
36
30
28
27
26
25
32
31
33
34
35
36
01
06
05
04
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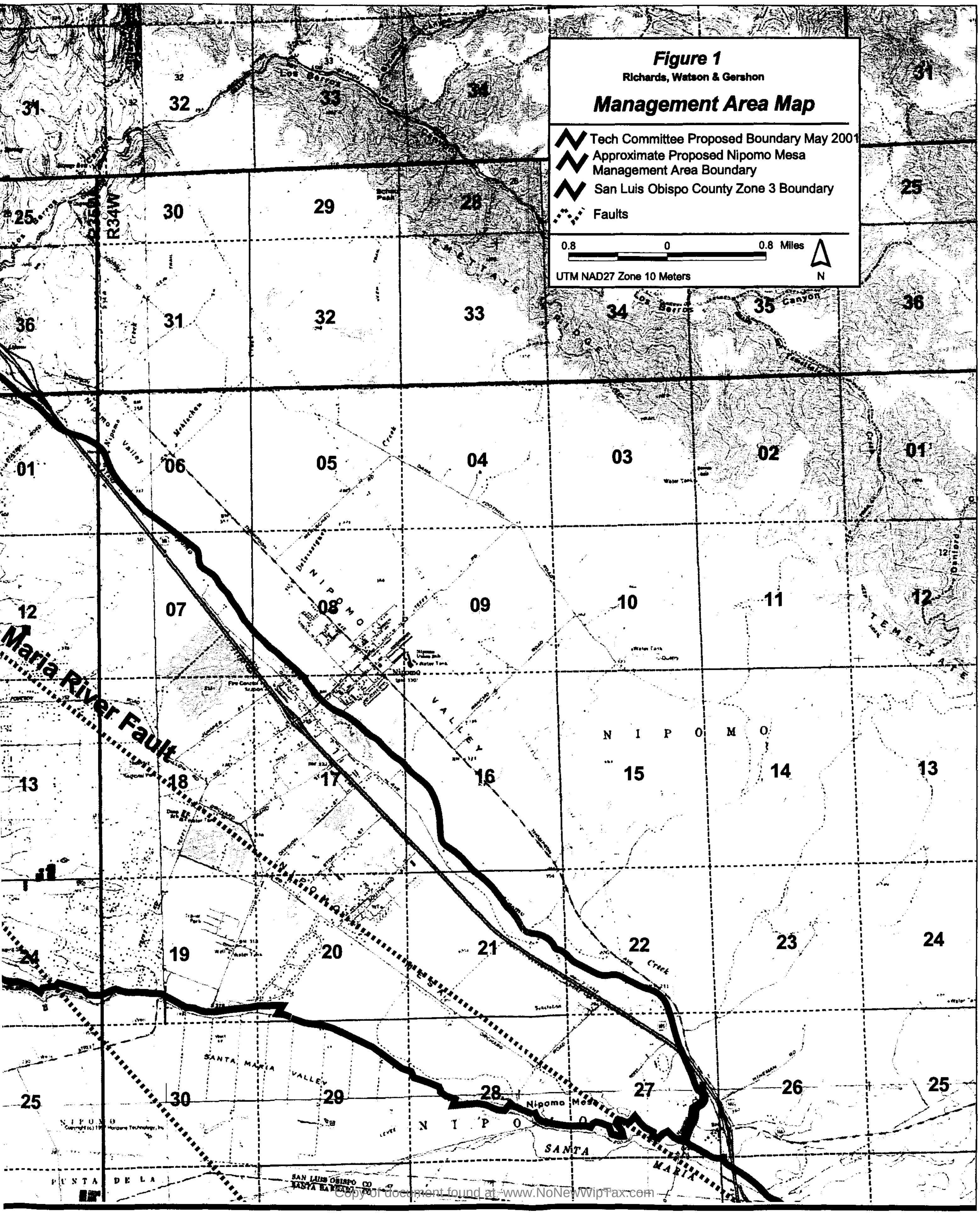

Figure 1
Richards, Watson & Gershon
Management Area Map
Tech Committee Proposed Boundary May 2001
Approximate Proposed Nipomo Mesa Management Area Boundary
San Luis Obispo County Zone 3 Boundary
Faults
0.8 0 0.8 Miles
N
UTM NAD27 Zone 10 Meters
R34W
Maria River Fault
NIPOMO
NIPOMO VALLEY
SANTA MARIA VALLEY
Nipomo Mesa
SANTA MARIA
SAN LUIS OBISPO CO
SANTA BARBARA CO

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- Luhdorff & Scalmanini, 2000. Development of a Numerical Ground-Water Flow Model and Assessment of Ground-Water Basin Yield, Santa Maria Valley Ground-Water Basin. March, 2000.
- Richard C. Slade and Associates, 2000. Groundwater Elevations, Spring 1975.
- Richard C. Slade and Associates, 2000. Groundwater Elevations, Spring 1995.
- Richard C. Slade and Associates, 2000. Base of Freshwater.
- CH2M-Hill, 2000. Cross-Sections Relating Nipomo Mesa Area Well Groundwater Levels to Screened Interval Depth.

NMMA Hydrogeology

The following discussion of the hydrogeology of the NMMA was primarily summarized from the DWR (2000) report. Groundwater in the NMMA occurs within the pore spaces in the sedimentary deposits including, from oldest to youngest, the Squire Member of the Pismo Formation; the Careaga, Paso Robles, and Orcutt Formations; the alluvium; and the dune sands. With the exception of the dune sands, the basin-fill sediments were deposited by water in either fluvial, marginal marine, or shallow marine environments, whose exact locations varied widely over geologic time. Consequently, a heterogeneous array of sands, gravels, boulders, silts, and clays, occur in layers or lenses of varying composition, texture, and thickness. The varied lithologic layers or lenses are discontinuous, leading to generally unconfined conditions with localized semi-confined to confined conditions and perched zones.

Occurrence and movement of groundwater are affected by the faults crossing the basin. Faults can act either as impediments to groundwater flow or as conduits for flow, depending on the degree of fracture, displacement, and nature of the material in the fault zone. Faulting has changed the geometry of the basin, through uplifted bedrock northeast of the Santa Maria River

(SMR) and Oceano faults, decreasing the aquifer thickness on the uplifted side. Based on water elevations measured on either side of the fault, the SMR fault appears to act as a barrier to groundwater flow while there is no evidence that the Oceano fault is a flow barrier. This is supported by discussions with drillers with experience in installing wells in the NMMA.

The existence of localized semi-confined to confined zones in the NMMA is supported by studies reporting multiple aquifer layers separated by aquitard clay lenses. Lower aquifers have been observed to have both higher and lower heads than upper aquifers depending on the portion of the NMMA being studied. In one location a well screened in both aquifer zones was found to be draining water from the upper zone into the lower zone because falling water was heard. The discontinuity in heads between the two zones may indicate that the lower aquifer had been subjected to pumping rates higher than recharge rates through the aquitard layer, causing a decrease in head.

A study of boring log and groundwater level data by CH2M-Hill (2000) concluded that well water levels in the NMMA are dependent on whether the wells are screened in the upper or lower aquifer zones. Wells screened in the upper zone tend to have groundwater elevation measurements on the order of 100 feet above sea level (FASL), while wells screened in the lower zone tend to have groundwater levels on the order of 50 FASL or less. Again, the lower head in the lower aquifer indicates that this zone has been subjected to pumping greater than recharge rates.

Groundwater Elevation Data

SLO DPW currently has a monitoring program that measures well water levels in the Spring and fall of each year, with most of the wells sampled semi-annually since 1975. Some wells were sampled prior to 1975. The groundwater depth measurements are converted to elevations based on land surface values contained in a well ownership and completion data file obtained from SLO DPW. Many of the values are appear to have been rounded to the nearest ten feet, indicating that they may have been estimated using USGS topographical maps with the approximate location of the well based on the State Well Number. Due to the errors involved in plotting the well locations on the maps and the uncertainty in the contour values, it is estimated that the accuracy of the land surface elevations obtained using this method may be +/- 20 feet, affecting the resultant groundwater elevations. However, the change in storage estimate should not be affected because the groundwater elevation bias caused by the land surface elevation estimate is the same for each contouring period.

An evaluation of the Slade Groundwater Elevation Contour Maps for 1975 and 1995 shows that the contours on the maps are controlled by relatively few measurements. Some of these critical measurements, leading to large changes in groundwater elevations over short distances, are not part of the SLO DPW database but are provided in a file from Slade called USGS_WL.xls. These critical data points are summarized in Table 1 with hydrographs shown in Figure 2.

Because the elevation data reported for these wells are inconsistent with adjacent well data some of them were omitted from the contouring as follows:

- The 1975 data point from a well located in Section 11N35W04 on Slade's 1975 map was not found in any data file.
- The hydrograph for the 12N/35W-33Q02 (33Q02) well located adjacent to the SMR fault shows little response to precipitation or pumping and is concluded to be inconsistent with other well data. The data from the 33Q02 well was also omitted from the contouring done for the Spring 1995 and 2000 groundwater elevations.
- The 1975 data from wells 11N/34W-30G01 and 11N/35W-09G01 are significantly lower than adjacent wells and appear to be affected by pumping. They were omitted from the contouring intended to show average groundwater levels across the study area.

Table 1. Critical Wells Used in Slade Contouring, 1975 Groundwater Elevations

State Well Number	GW Elevation (fasl)	Adj. Well GW Elev. (fasl)	Source	Well Details	Hydrograph Evaluation Results
12N35W33Q2	160- In Fault Zone	109	SLO DPW	None	Small decline over record, no response to precip. or pumping
11N35W04E?	100	21	None	None	Shown on Slade map but not in DWR or Slade GW data files- therefore not used in this contouring
11N35W10R01	97	61	In USGS WL file	2 hp pump, has well log	Ends in 1990 Owned by Jim & Maria Pudwell, Rt 1 Willow Rd 343-1523
11N35W24D01	134	58	USGS WL file	8″ casing, perfed @350′, no log	No data after 1998 Cecilia & Juan Truegas, 855 Mesa Rd
11N34W30G01	17	46	USGS WL file	None	2 measurements in 3/75 only; appears to be affected by pumping
11N35W09G01	-13	57	USGS WL file	None	No data after 1978; appears to be affected by pumping

Hydrograph Review

The well data provided by Slade and SLO DPW were evaluated to identify trends based on the well hydrographs. As a first step, the wells with Spring groundwater data for the study period starting in 1975 and ending in 2000 were used to calculate the change in groundwater levels. If well data were not available for either the Spring of 1975 and 2000, measurements from adjacent reporting periods were used if they did not appear to be inconsistent with the hydrographs. The wells were then grouped according to whether they were located north or south of the SMR fault. The results are presented in Figure 3. Wells showing changes in excess of 20 feet or more were probably affected by nearby pumping during an observation period.

Figure 3 shows that the groundwater levels in wells south of the fault appear to have increased slightly from 1975 to 2000. However, other wells in the vicinity of municipal pumping zones show a decrease in groundwater levels over the study period. Few of these municipal wells with a significant impact on the change in storage had data records from 1975-2000 and so most are not included on Figure 3. Groundwater levels in wells north of the fault appear to have decreased from 1975 to 2000. Figure 4 shows hydrographs from wells on either side of the fault showing the general trend. The well north of the fault (03B01) shows a decrease of about 10 feet over the study period. The well south of the fault (23B01), although affected by pumping, shows a general decrease in groundwater elevations during the dry period from the late 1980s to early 1990s. By 2000, however, groundwater elevations in the well are higher than they were in 1975 due to increased precipitation and resultant recharge.

The third hydrograph shown on Figure 4 is from a well in the vicinity of the Black Lake Golf Course. This well is near NCSD's Black Lake and Bevington wells, and shows a general decrease in groundwater levels through the mid-1990s with only a small amount of recovery of well levels during the recharge occurring in the late 1990s.

Contouring

The groundwater elevations available from SLO DPW and Slade from 1975, 1995, and 2000 were used to create contour maps of the groundwater elevation. The two high groundwater levels from 1975 in wells 10R01 and 24D01 from Figure 2 were expected to have a significant effect on the resultant contour maps. Since neither of these wells had available data for the Spring of 2000 observation period, a regression analysis was used to estimated their groundwater levels for the Spring 2000 groundwater elevation contour map. The regression analysis predicted groundwater elevations for 2000 that were more than 10 feet lower than the 1975 readings even though water levels recovered to greater than 1975 levels in many of the wells located south of the SMR fault. Therefore, the regression analysis likely underestimates the actual levels in these wells.

The contours were drawn based on the groundwater elevation data set available for each period. The groundwater elevations were assumed to vary linearly between the well locations with known elevations. The SMR fault was assumed to be a barrier to groundwater flow based on the differences in well groundwater elevations measured on either side of the fault.

Once the contours maps were developed, the contours were digitized and used to estimate the change in volume from 1975 to 1995 and 1975 to 2000 using the SURFER code. The median specific yield of 0.12 reported for the Nipomo Mesa area by DWR (2000, p. 78) was used to convert the change in volume estimate to a change in groundwater storage. The results are presented in Table 2. The change in storage on the south side of the SMR fault of –1,600 ac-ft from 1975 to 2000 is affected by the likely underestimated 2000 groundwater elevations in the two high wells using a regression analysis, and may be close to no change in storage. The decrease in storage may also be partially due to the decrease in water levels in the vicinity of the Black Lake Golf Course as shown in Figure 4 and in the vicinity of the Cal-Cities Vista wells near the Santa Maria River Valley boundary.

Table 2. NMMA Change in Groundwater Storage, 1975 to 1995 and 1975 to 2000

Scenario	Change South of Fault (Ac-ft)	Change North of Fault (Ac-ft)	Total Change (Ac-ft)
1975 to 1995	-12,900	-11,000	-23,900
1975 to 2000	-1,600	-8,300	-9,900

The estimated decrease in the volume of groundwater in storage in the NMMA is approximately 23,900 acre-feet from 1975 to 1995, and 9,900 acre-feet from 1975 to 2000. The evaluation indicates that from 1975 to 2000, the volume of groundwater in storage has decreased more on the north side of the Santa Maria River fault than on the south side of the fault. By the Spring of 2000, groundwater levels on the south side of the fault had largely recovered to 1975 conditions except in localized areas around municipal production wells. The analysis indicates that the recharge occurring in the late 1990s largely eliminated the pumping trough shown in the DWR (2000) report for the relatively dry 1995 conditions.

Figure 2.
NMMA Wells with Groundwater Elevation Discrepancies

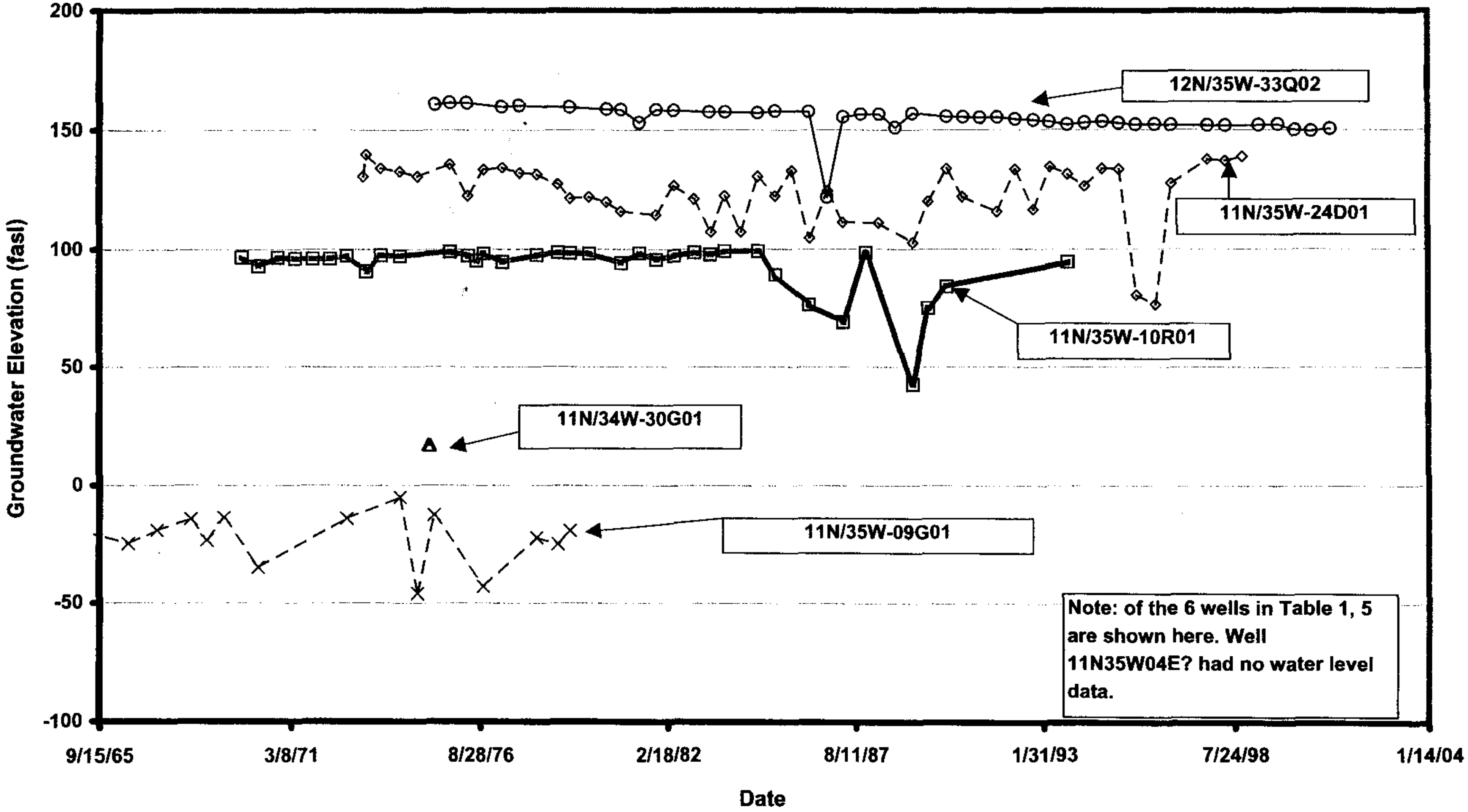
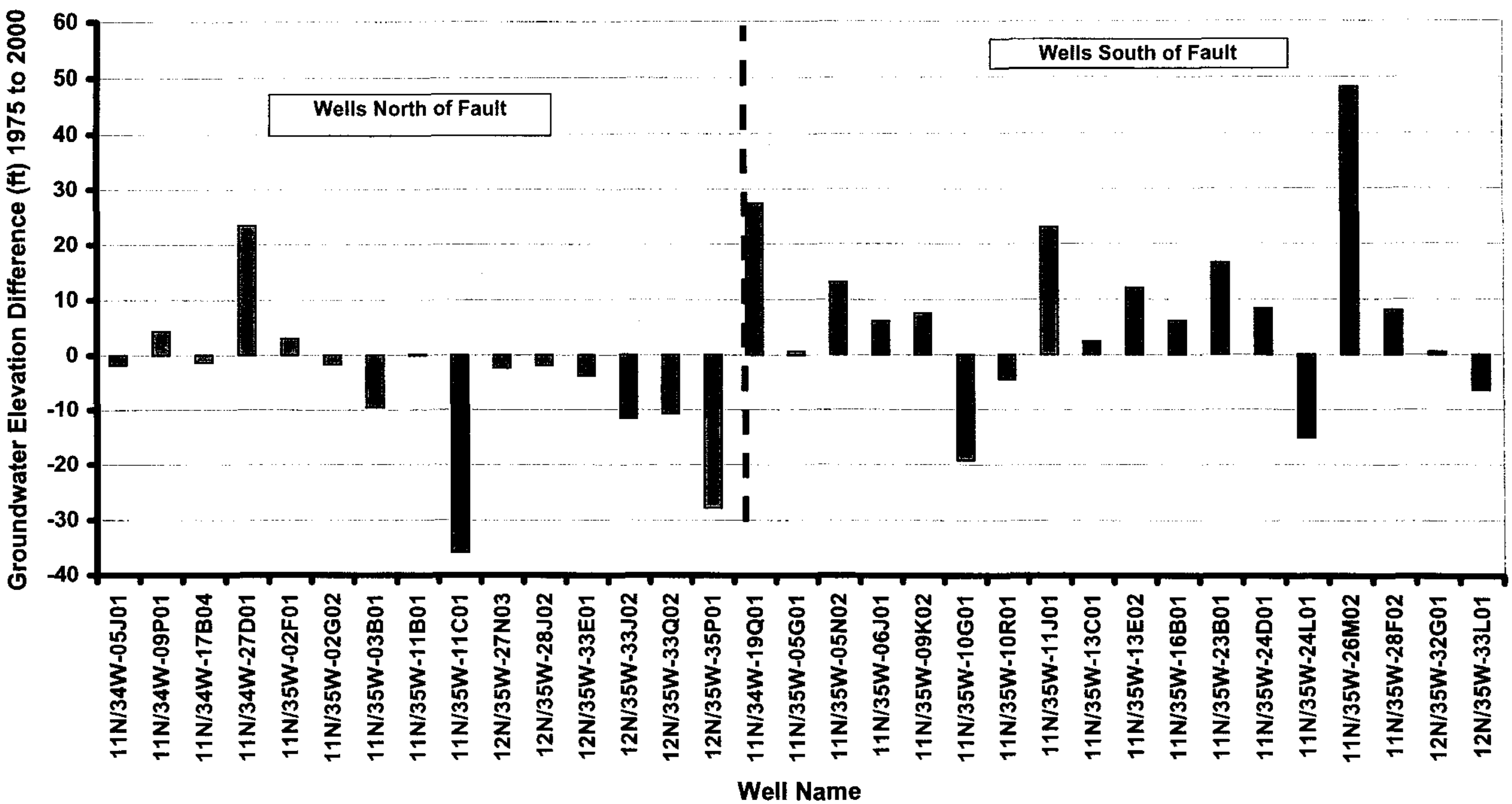


Figure 3.
Groundwater Elevation Change - NMMA Wells, 1975 to 2000
[Positive Value Indicates Groundwater Levels Increasing]



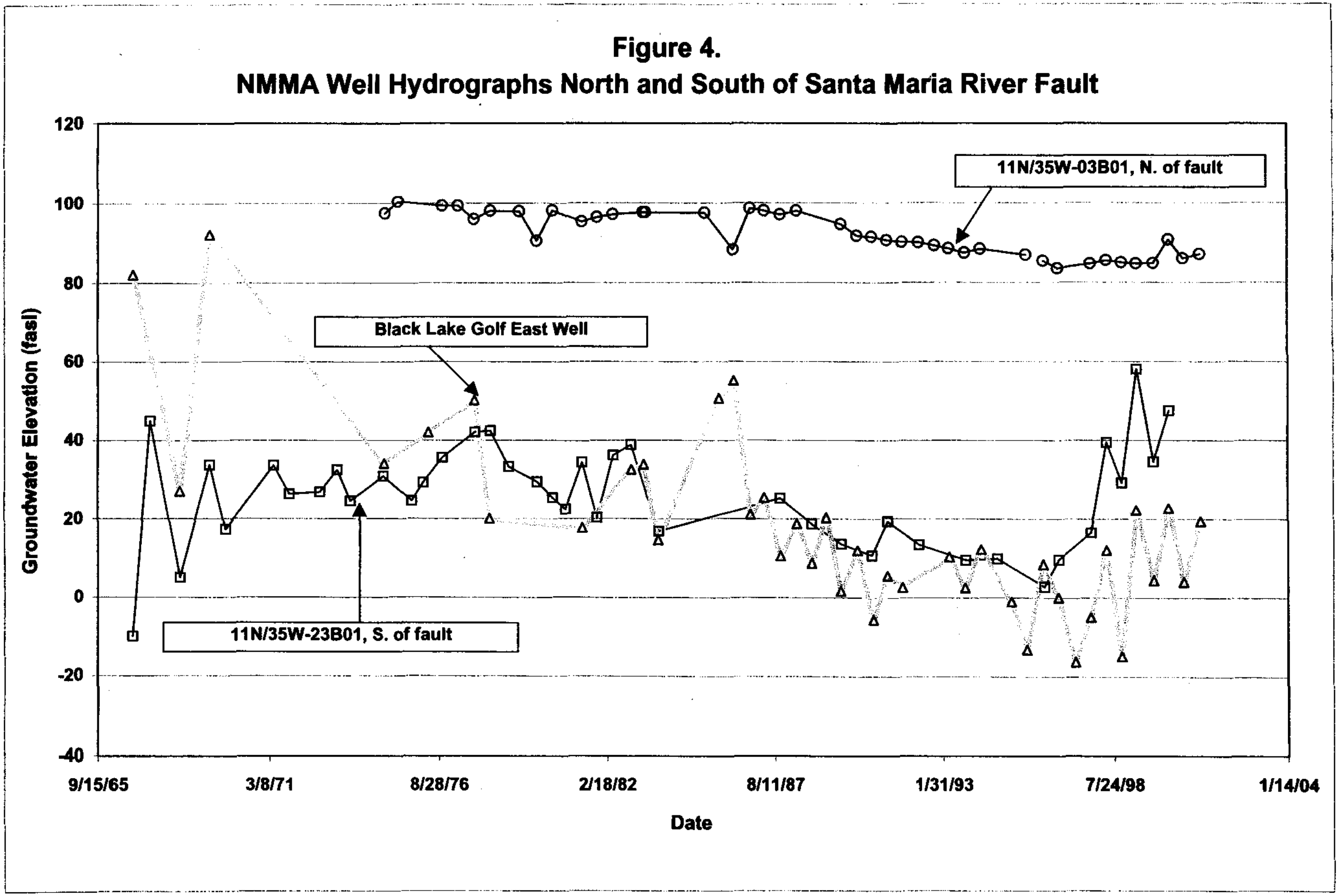


Figure 4.
NMMA Well Hydrographs North and South of Santa Maria River Fault
120
100
80
60
40
20
0
-20
-40
Groundwater Elevation (fasl)
11N/35W-03B01, N. of fault
Black Lake Golf East Well
11N/35W-23B01, S. of fault
9/15/65
3/8/71
8/28/76
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
Date

SUBSURFACE INFLOW

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WATER RESOURCES DIVISION - SANTA BARBARA

MEMORANDUM

ATTORNEY WORK PRODUCT
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TO: R. G. Beeby

FROM: Mark Bandurraga

RE: Estimation of Subsurface Inflow for the Hydrologic Inventory for the Nipomo Mesa Management Area, SAIC Project No.: 01-0122-00-3994-000

DATE: June 11, 2002

This memorandum describes the estimation of subsurface flow of groundwater for the hydrologic inventory of the Nipomo Mesa Management Area (NMMA). Subsurface inflows and outflows are calculated on an annual basis from 1975 through 2000 and the results compared to estimates done by DWR.

1.0 METHODOLOGY

The methodology used in the evaluation included the use of Darcy's equation to estimate the flow of water across the NMMA boundary. In this equation, the flow of water across through a cross-section is equal to the product of the cross-sectional area, hydraulic conductivity, and gradient.

Cross-Sectional Area

The NMMA boundary was divided into five different segments adjacent to the following areas: 1) Nipomo Valley, 2) Los Berros Creek, 3) Arroyo Grande Plain, 4) Pacific Ocean, and 5) Santa Maria River Valley (see Figure 1). The cross-sectional flow area associated with each segment was calculated using a contour map of the elevations of the aquifer base to define the bottom boundary and groundwater elevations from wells adjacent to the boundary to define the top of the aquifer. The contour map of the elevation of non-water bearing formations underlying the water bearing sediments is entitled "Base of Fresh Water" by Richard C. Slade and Associates. The groundwater elevation data were provided by the San Luis Obispo County Department of Public Works. The cross-sectional area was calculated as the distance from the groundwater surface to the top of the non-water bearing formations multiplied by the segment length. Since the aquifer bottom elevation or water surface elevation varied along the segment, each segment was discretized into subsegments, refining the cross-sectional area calculation.

816 State Street, Suite 500 ◆ Santa Barbara, California 93101 ◆ 805/966-0811

Gradient

The gradient associated with each segment was established using available groundwater elevation data showing the drop in water table across the segment. Elevations are measured in the spring and fall, but only the spring data were used to generate groundwater elevation contour maps to show maximum yearly elevations occurring after recharge and before summer pumping. The contour maps showing spring groundwater elevations across the study area were used further refine the gradient calculations by adjusting the segment lengths and helping to identify wells to use in the gradient calculations. The contour maps developed by SAIC show groundwater elevations during spring of 1975, 1995, and 2000.

As discussed in the memo entitled "Estimate of 1975 to 2000 Change in Groundwater Storage for the Hydrologic Inventory of the Nipomo Mesa Management Area", groundwater elevation measurements from two wells south of the Santa Maria River fault are higher than levels measured in adjacent wells by more than 50 feet. Including these wells in the contouring has a significant effect on the resultant maps and change in storage estimates.

After evaluating the resultant contour maps the gradients were calculated for the various segments as follows:

Nipomo Valley Segment- Data from two wells adjacent to the boundary were used to calculate the gradient on an annual basis.

Los Berros Creek Segment- The groundwater elevation contour maps developed for 1975, 1995, and 2000 show contours that are nearly perpendicular to the boundary in this region, indicating that flow primarily occurs parallel to the boundary. Therefore, the segment along Los Berros Creek was omitted from the inflow calculations.

Arroyo Grande Segment- Data from two wells, one located upgradient and one located downgradient of the boundary, were used to define the gradient on an annual basis.

Ocean Segment- Wells located near the segment with water level data from 1975 to 2000 appear to be affected by adjacent pumping wells. Based on the contour maps, a portion of the segment has flow parallel to the boundary similar to the Los Berros Creek Segment. Analysis of available 2000 well data which appear to be unaffected by nearby pumping provides a gradient of approximately 0.0004 ft/ft in this region. This gradient is consistent with the gradient required to predict groundwater elevations close to mean sea level at the land/ocean boundary. Therefore, this gradient was used for the ocean segment during the study period.

Santa Maria River Valley Segment- The groundwater elevation contour maps show variable gradients along this boundary. The inflow is not well constrained due to the sparseness of available well data along this segment. The contour map showing spring 2000 conditions shows a localized trough near the Cal Cities-Vista La Serena Well dominating the contour results. The contour map showing spring 1995 groundwater elevations shows the same behavior. Inflows for years between the calculated inflow points of 1975, 1995, and 2000, were estimated using linear interpolation.

Hydraulic Conductivity

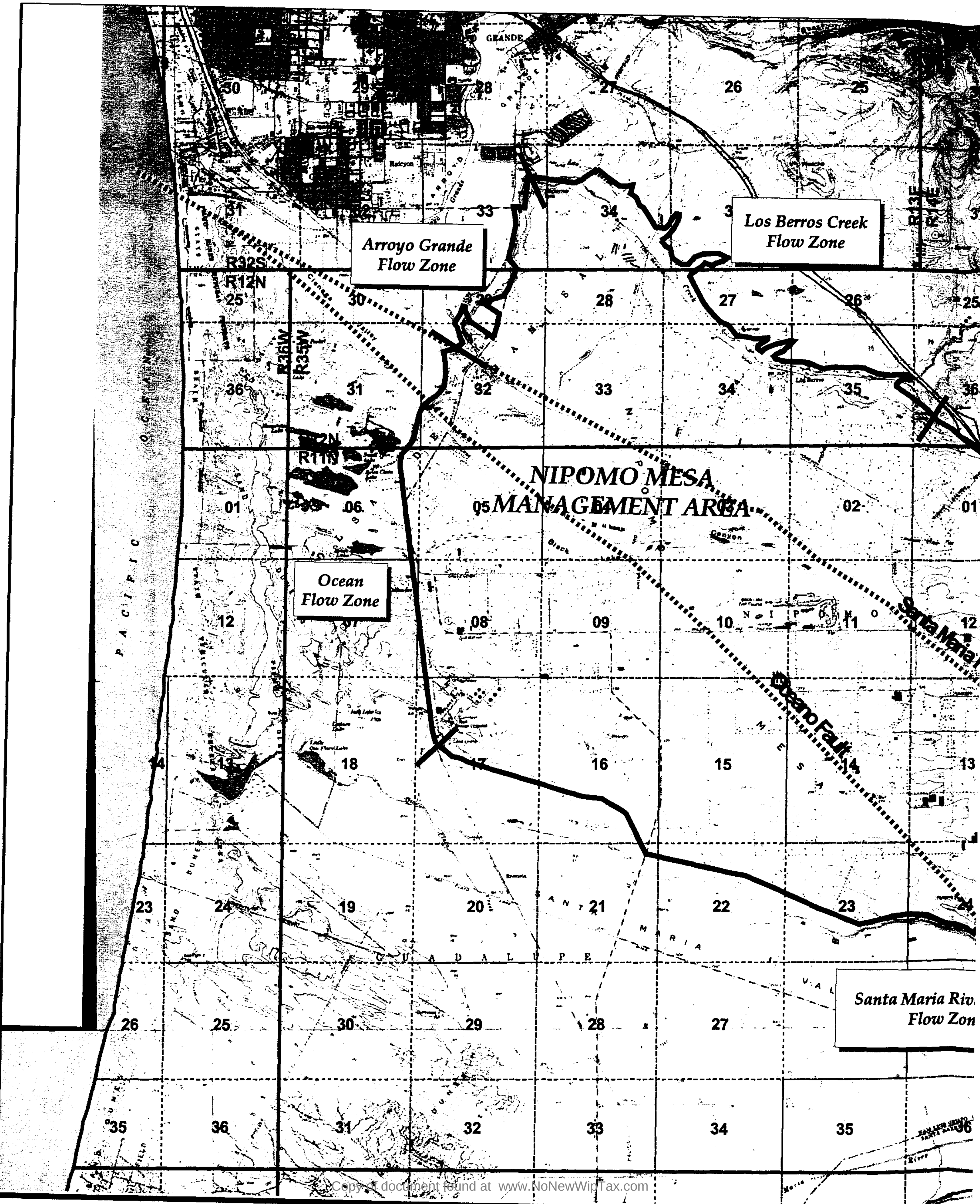
Hydraulic conductivity values for Nipomo Mesa are available from the January 2000 Revised Final Draft Report entitled "Water Resources of the Arroyo Grande-Nipomo Mesa Area," (DWR, January, 2000). Furthermore, the hydraulic conductivities used in the subsurface inflow and outflow calculations done for the report (Evelyn Tompkins, DWR, personal communication) were provided showing the ranges and geometric means of the conductivity data measured along different portions of their study boundary. For this work, the hydraulic conductivity geometric means reported by DWR were used for the subsurface flow calculation except along the Arroyo Grande Segment. Since the well used to define the relatively high upgradient water level along the Arroyo Grande Segment is located in the Nipomo Mesa Paso Robles and Careaga formations similar to the wells in the Nipomo Valley area, the geometric mean hydraulic conductivity used for the Nipomo Valley segment was applied to the Arroyo Grande segment.

2.0 SUBSURFACE FLOW RESULTS

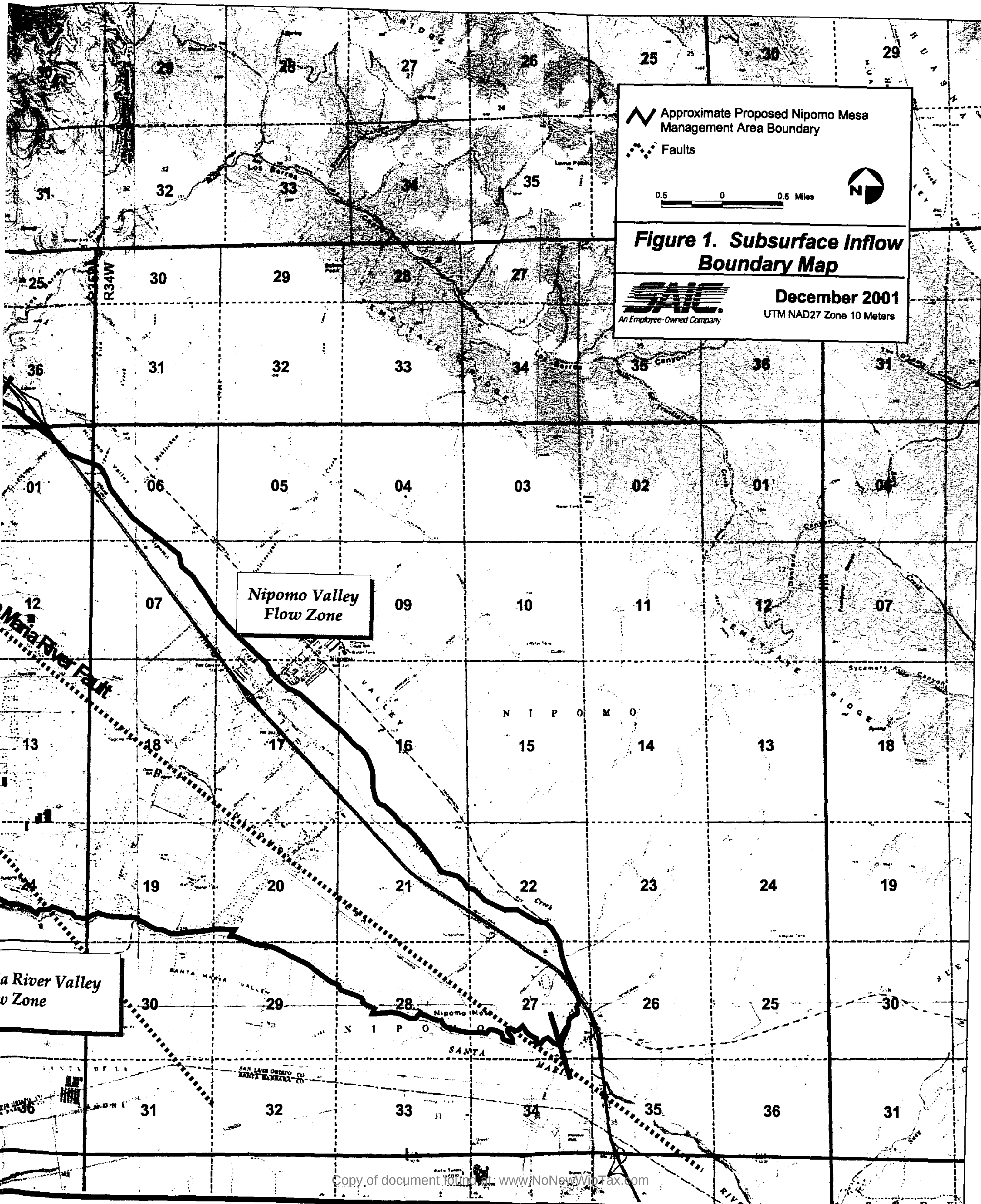
The subsurface flows were estimated using the data in Darcy's Equation. The results for spring 1975 and 1995 are presented in Table 1, along with a comparison of the results from DWR subsurface flow estimates discussed previously. DWR flow areas are based on average assumed aquifer thicknesses and segment lengths that yield smaller area estimates. DWR's estimated gradients are generally higher than those estimated by this study. These factors offset each other so that the resultant net inflows are similar to those presented in Table 1. The data used by DWR to calculate the gradients used in their calculations are not available for evaluation. Figure 2 shows the net annual inflow to the NMMA during the study period. The results show that the net annual inflow ranges from approximately 360 to -1,600 acre-feet per year, with a cumulative inflow of -14,110 acre-feet over the study period.

Table 1. Subsurface Flow Estimates and DWR Comparison

Boundary	SAIC (2001)					DWR (2000)				SAIC-DWR
1975	K (gpd /ft2)		Area (Ac.)	Grad. (Ft/Ft)	Inflow (AF)	K (gpd /ft2)	Area (Ac.)	Grad. (Ft/Ft)	Inflow (AF)	Diff. (AF)
Nipomo Valley	18.4		29	0.0046	120	18.4	29	0.0189	500	380
Arroyo Grande	18.4		84	-0.0171	-1,300	120	17	-0.0133	-1,300	0
Ocean	95		227	-0.0004	-420	95	195	-0.0003	-300	-120
Santa Maria V.	52		394	Varies	0	52	206	0.0019	1,000	-1,000
1995										
Nipomo Valley	18.4		35	0.0048	150	18.4	29	0.0189	500	-350
Arroyo Grande	18.4		87	-0.0149	-1,170	120	17	-0.0133	-1,300	130
Ocean	95		228	-0.0004	-420	95	195	-0.0003	-400	-20
Santa Maria V.	52		85	0.007	1,540	52	206	0.0019	1,000	540

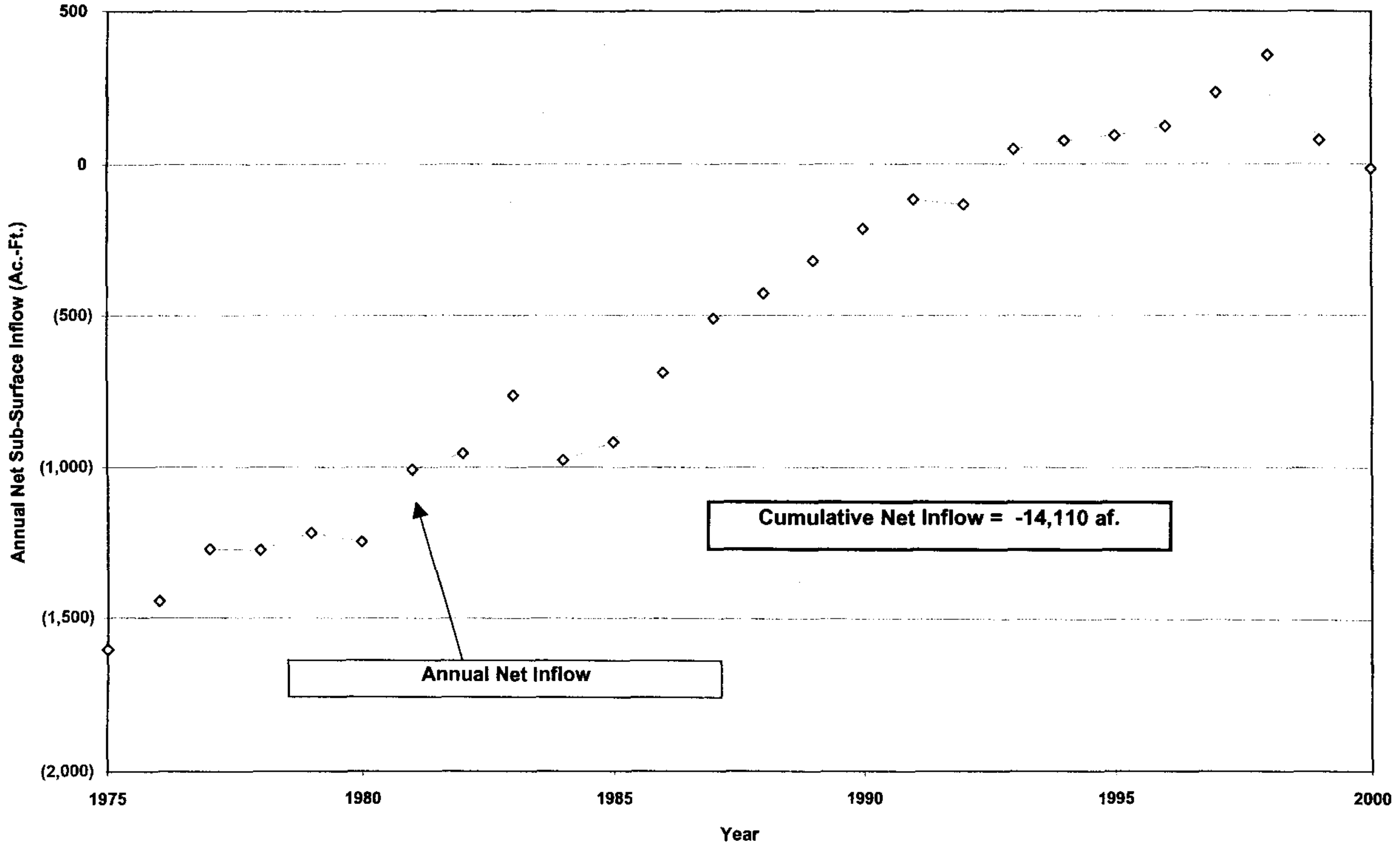


Arroyo Grande
Flow Zone
Los Berros Creek
Flow Zone
NIPOMO MESA
MANAGEMENT AREA
Ocean
Flow Zone
Santa Maria Riv
Flow Zon
Oceano Fault
Santa Maria
PACIFIC
OCEAN
R32S
R12N
R36W
R35W
R12N
R11N
GUADALUPE
SANTA MARIA
NIPOMO



Approximate Proposed Nipomo Mesa Management Area Boundary
Faults
0.5 0 0.5 Miles
N
Figure 1. Subsurface Inflow Boundary Map
SAIC
An Employee-Owned Company
December 2001
UTM NAD27 Zone 10 Meters
Nipomo Valley Flow Zone
Maria River Fault
a River Valley
v Zone
R34W
NIPOMO

Figure 2.
Annual Net Sub-Surface Inflow to NMMA, 1975-2000



Effect of Reservoirs on Subsurface Inflows

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WATER RESOURCES DIVISION – SANTA BARBARA

MEMORANDUM

ATTORNEY WORK PRODUCT
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TO: R. G. Beeby

FROM: Mark Bandurraga

RE: Evaluation of the Effect of Twitchell and Lopez Reservoirs on Subsurface Inflows to the Hydrologic Inventory for the Nipomo Mesa Management Area, SAIC Project No.: 01-0122-00-3994-000

DATE: January 14, 2002

This memorandum describes an evaluation of the effect of the increased recharge due to Lopez Lake and Twitchell Reservoir on subsurface inflow to the Nipomo Mesa Management Area (NMMA). The methodology used to estimate subsurface inflows and outflows to NMMA is described in a technical memorandum entitled "Estimation of Subsurface Inflow for the Hydrologic Inventory of the Nipomo Mesa Management Area". Portions of the NMMA boundary are adjacent to the Santa Maria River and Arroyo Grande Creek Valleys. Inflow from these valleys to the NMMA was calculated based on gradients estimated from groundwater elevation contour maps using available data from 1975, 1995, and 2000.

There has been increased recharge to these valleys after the construction of Lopez Lake and Twitchell Reservoir due to their regulating effect on stream flow. A sensitivity study was done to investigate the effect of the increased recharge on the subsurface inflow calculations. The study involved estimating the decrease in groundwater elevations adjacent to the NMMA if the reservoirs were not present.

A decrease in groundwater elevations of 5 feet along NMMA boundary adjacent to the Santa Maria River would decrease the inflow to the NMMA by approximately 130 to 770 acre-feet per year for the three years included in the study (1975, 1995, and 2000). A comparison of the inflow results using the available groundwater data and removing the effect of the increased recharge caused by Twitchell Reservoir is presented in Table 1. Also shown is the effect on estimated outflows to the Arroyo Grande Creek Valley if the same 5 feet decrease is applied to the Arroyo Grande groundwater elevation data used to calculate the gradient in the outflow calculations.

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For the Santa Maria River Valley, a decrease in groundwater levels of 5 ft occurring across an approximately 3.5 miles width along the river alignment from the confluence with Cuyama River to the coast would equal the change in groundwater storage of about 32,000 acre-feet due to the presence of Twitchell Reservoir (Ludhorff & Scalmanini, 2000). The 5 feet decrease in groundwater elevations applied to the Tri-Cities area in the vicinity of Arroyo Grande Creek represents a decrease in storage of about 3,300 acre-feet. Table 2 summarizes these calculations. Based on these results, the assumed decrease in groundwater elevations of 5 ft is reasonable.

References

DWR, January 2000, Revised Final Draft Report. Water Resources of the Arroyo Grande-Nipomo Mesa Area.

Ludhorff& Scalmanini, March 2000, Development of a Numerical Ground-Water Flow Model and Assessment of Ground-Water Basin Yield, Santa Maria Valley Ground-Water Basin

Table 1, Comparison of Boundary Inflow to NMMA			
(Volumes in Acre-Feet, negative value is outflow from NMMA)			
	Spring 1975	Spring 1995	Spring 2000
Santa Maria River Valley (SMRV)	(5)	1,539	1,392
SMRV without Twitchell (Assume GW Elevations decrease 5 ft)	(136)	769	699
Arroyo Grande Valley	(1,295)	(1,173)	(1,194)
Arroyo Grande Valley without Lopez (Assume GW Elevations decrease 5 ft)	(1,354)	(1,234)	(1,256)

Table 2. Estimate of Effect of Recharge due to Reservoirs			
Twitchell Reservoir	Variable	Values	Units
Increased Recharge to Santa Maria River Valley due to Twitchell, pg 23 L&S. (1)	Q	32,000	afy
Length of Santa Maria River, Cuyama River confluence to coast	L	114,000	ft
Specific Yield of Valley Sediments. pg 19 L&S	Sy	0.13	cf/cf
Assumed groundwater elevation decrease due to removal of Twitchell	D	5	ft
Calculated width of strip subject to decrease based on above data W=43560*Q(Sy*L*D) (rounded)	W	18,800	ft
Lopez Lake			
Estimated Tri-Cities Area influenced by water level decrease (8 sections)	A	5,120	ac
Specific Yield of Valley Sediments. pg 78 DWR 2000 (2)	Sy	0.13	cf/cf
Assumed groundwater elevation decrease due to omitting Lopez Lake	D	5	ft
Calculated decrease in groundwater storage by omitting Lopez V=A*D*Sy (rounded)	V	3,300	ac-ft

(1) Data from Ludhorff& Scalmanini, 3/2000, Development of a Numerical Ground-Water Flow Model and Assessment of Ground-Water Basin Yield, Santa Maria Valley Ground-Water Basin

(2) Data from DWR, January 2000, Revised Final Draft Report. Water Resources of the Arroyo Grande-Nipomo Mesa Area.

Mean Precipitation

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WATER RESOURCES DIVISION – SANTA BARBARA

MEMORANDUM

ATTORNEY WORK PRODUCT
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TO: R. G. Beeby

FROM: Diane Ohlmann

RE: Mean Precipitation for the Hydrologic Inventory for the for the Nipomo Mesa Management Area, SAIC Project No.: 01-0122-00-3994-000

DATE: January 22, 2002

The purpose of this memorandum is to document the long-term rainfall trends and estimates of annual precipitation for the Nipomo Mesa Management Area (NMMA) for use in calculating the long-term water supply and hydrologic inventory for the NMMA.

ANNUAL RAINFALL FOR THE NMMA

Two different methods were evaluated for estimating representative average annual rainfall over the NMMA: Thiessen Polygons and the Isohyetal method.

Thiessen Polygon Method

Using the Thiessen polygon method, polygons are constructed around rain gages, showing the gage's area of influence. Average precipitation over the NMMA is calculated by weighing each station's rainfall depth in proportion to its area of influence. According to the Thiessen polygon method, the three rain gages closest to the NMMA: Nipomo CDF, Nipomo 2NW, and CSA No. 13 influence the NMMA in the following proportions: 28 percent, 46 percent, and 28 percent respectively. Figure 1 shows the rain gages that influence the NMMA using the Thiessen polygon method. This method would produce a long term average annual precipitation over the NMMA for 1975 through 2000 of 18.16 inches/year.

Isohyetal Method

Seven rain gages located within proximity to the NMMA were selected for analysis. These are shown on Figure 2, attached. The Puritan Ice Company, and the City of Santa Maria gages, both located in the Santa Maria Valley, were the rain gages closest to the NMMA in the southern region.

The long-term average annual precipitation, in inches, was plotted for each gage. Table 1 lists the years of available data and average annual precipitation for each gage. Isohyet contours were created using Arc View GIS software. The contours are lines of average annual equal precipitation for the period of available data. It was assumed that even though the gages have different periods of record, the records are long enough for purposes of this analysis. The mid-distance between two adjacent isohyets is used to delineate the area of influence of each isohyet. The average precipitation over the NMMA is calculated by weighing each isohyetal increment in proportion to its area of influence. Figure 2 shows that using the isohyetal method; the 15 inches/year and 16-inches/year contours would have the largest influence over the NMMA.

Table 1. Rain Gages in NMMA Area

Gage	Longitude	Latitude	Years	Average Annual Rainfall (Inches)
Lopez Dam	-120.4842	35.1867	1968- 1995	20.00
Nipomo CDF	-120.4861	35.0406	1959-2000	15.60
Nipomo 2 NW	-120.5000	35.0667	1921-2000	16.70
CSA No 13	-120.6097	35.1044	1960-2000	16.10
Puritan Ice Co	-120.5667	34.9500	1921-1993	12.40
City of Santa Maria	-120.4333	34.9500	1886-1995	13.40
Huasana Valley	-120.3833	35.1000	1930-1976	19.10

Representative Annual Rainfall over the NMMA for Hydrologic Inventory

Due to the sparse network of rain gages in the NMMA area, the two methods produce very different long-term average rainfall over the NMMA. The Thiessen polygon method indicates a disproportionate amount of rainfall weighted by the Nipomo 2 NW rain gage. The contour method shows the trend of rainfall over the NMMA better than the Thiessen polygon method but would necessitate creating a contour map for each year in order to derive annual average precipitation over the NMMA. Table 1 shows that the data is not available for all gages for the period of the hydrologic inventory (1975-2000) to create contour maps for each year. Based on its proximity to the isohyet that passes through the centroid of the NMMA, the Nipomo CDF gage will be used as representative gage for annual average rainfall over the NMMA. The isohyet map (Figure 2) shows that annual rainfall is greater in the north and over the mountains to the east of the Nipomo Mesa and annual rainfall decreases to the south in the Santa Maria Valley region. Table 2 is a summary of annual rainfall data that will be used for the hydrologic inventory, showing annual rainfall at Nipomo CDF gage.

Double Mass Analysis Nipomo Rain Gages

As a check on the quality of data of the Nipomo CDF gage, a double mass analysis was made. The two rain gages in Nipomo, Nipomo 2NW and Nipomo CDF, have long-term averages that differ by about 1 inch per year. Figure 3 shows the results of a double mass analysis for Nipomo 2NW versus Nipomo CDF. The linearity of the figure shows that the data appear to be consistent and reflect actual differences in rainfall amounts.

LONG TERM RAINFALL TRENDS

Analysis of long-term rainfall trends was made for comparison to the study period used for the hydrologic inventory. Accumulated departure from the mean was plotted for the Nipomo 2NW gage for the period of record and for the Nipomo CDF gage for the period of record. The results are shown in Figure 4. For the Nipomo 2NW gage, the 1975 through 2000 annual average precipitation, in inches was 18.98 in/year, 13.4 percent (%) greater than the long-term annual average of 16.73 inches/year. For the Nipomo CDF gage, the 1975 through 2000 annual average precipitation, in inches was 16.82 in/year, 7.8 percent (%) greater than the long-term annual average of 15.61 inches/year.

Because the Nipomo CDF gage is considered to be representative of the NMMA, based on the information presented herein, it is estimated that the hydrologic inventory spans a period with approximately 8 percent greater rainfall than the long-term average.

Table 2. Annual Rainfall [1],
Nipomo Mesa Management Area
(All values in Inches/Year)

Water Year	Nipomo CDF
1975	17.29
1976	13.45
1977	10.23
1978	30.66
1979	15.8
1980	16.57
1981	13.39
1982	18.58
1983	33.21
1984	11.22
1985	12.2
1986	16.85
1987	11.29
1988	12.66
1989	12.22
1990	7.12
1991	13.06
1992	15.66
1993	20.17
1994	12.15
1995	25.47
1996	16.54
1997	20.5
1998	33.67
1999	12.98
2000	14.47
Average	16.82

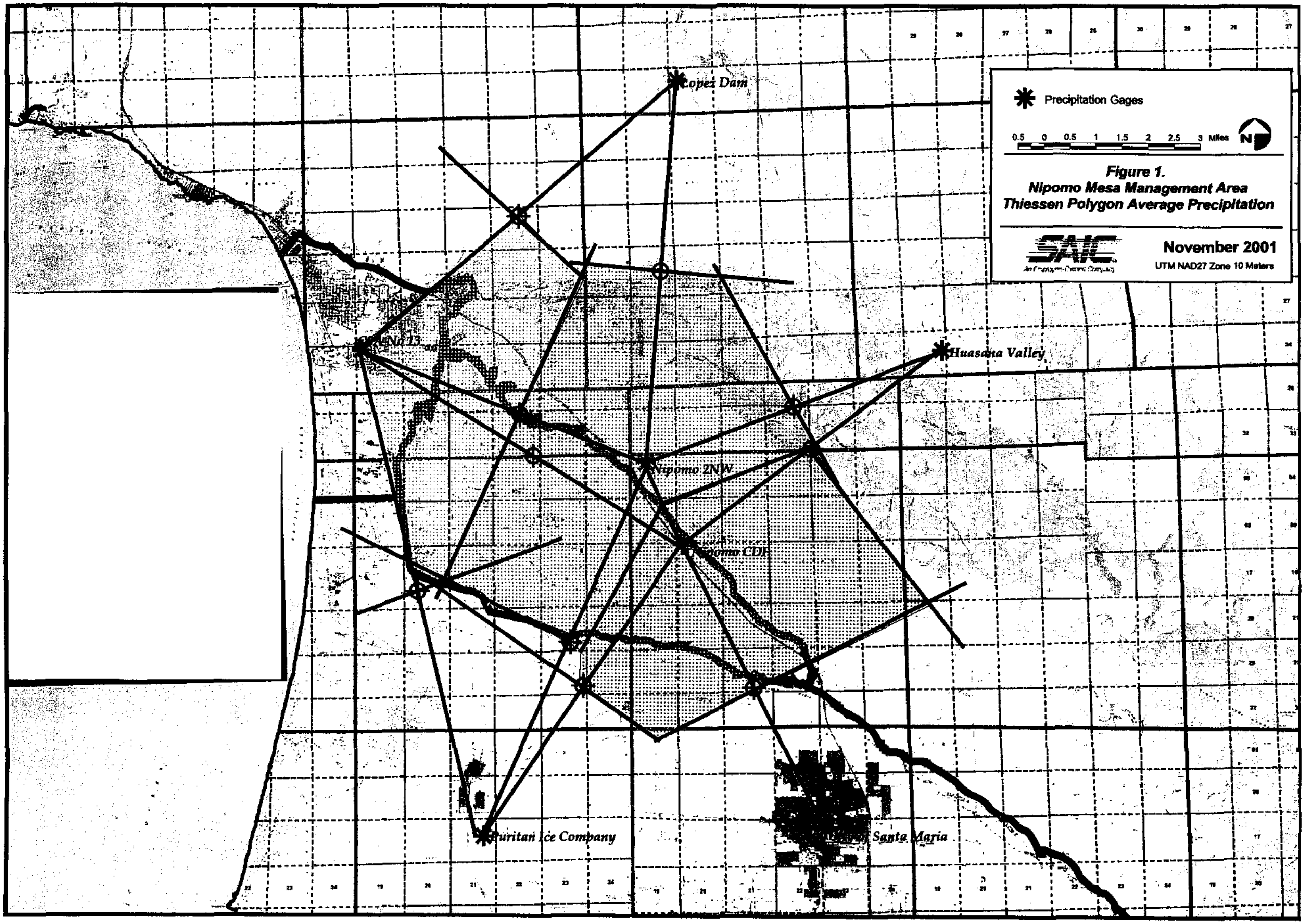
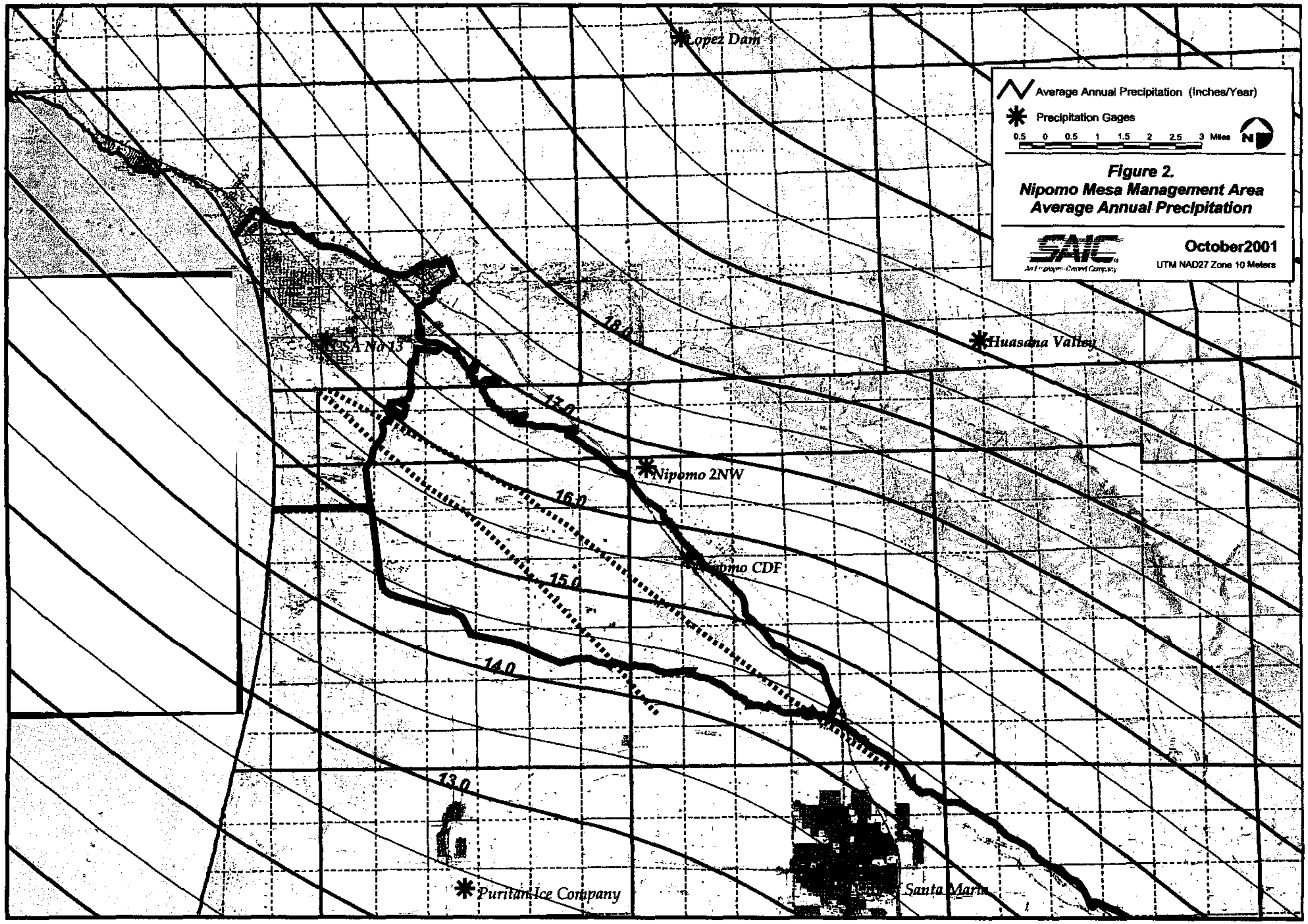


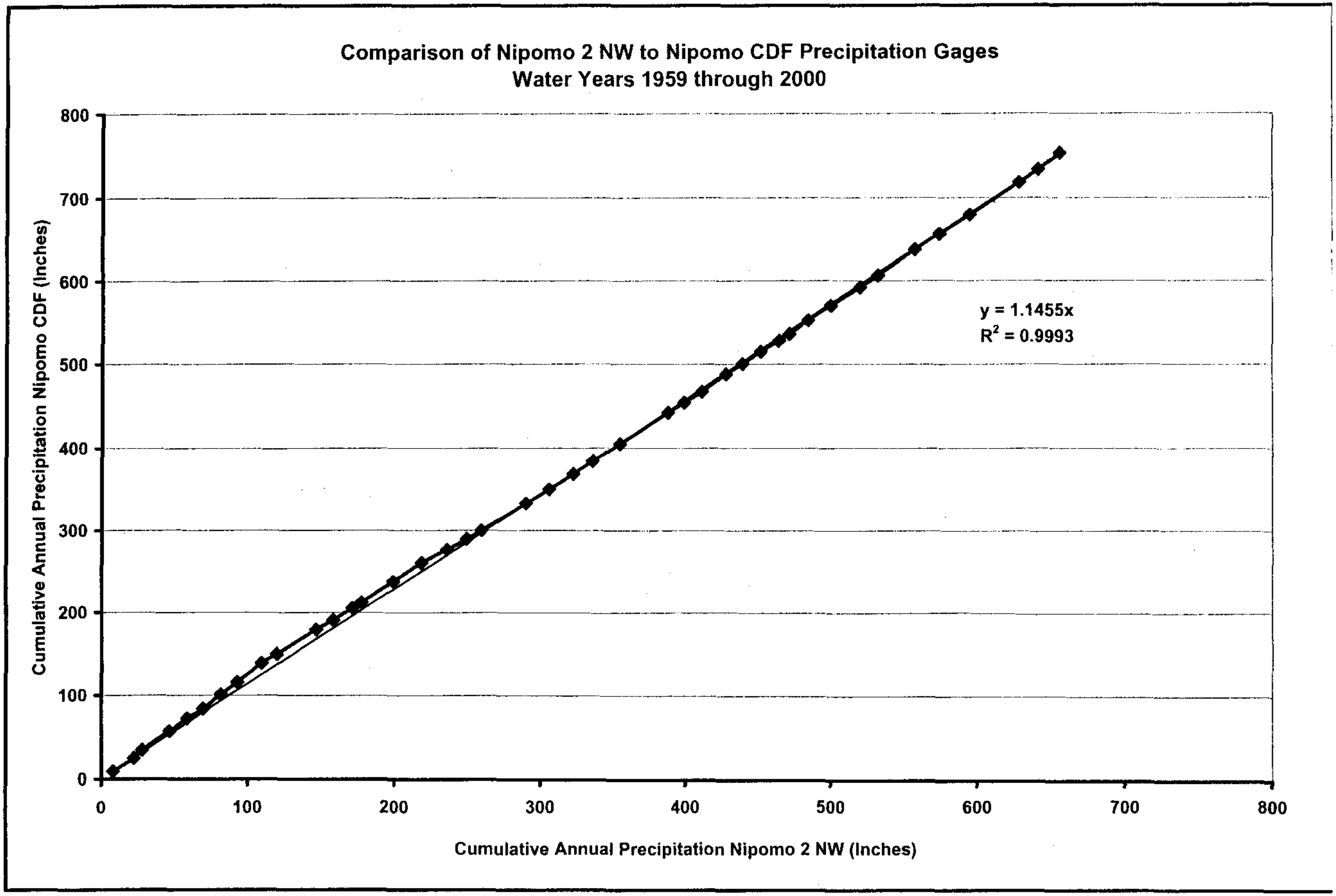
Figure 1.
Nipomo Mesa Management Area
Thiessen Polygon Average Precipitation

November 2001



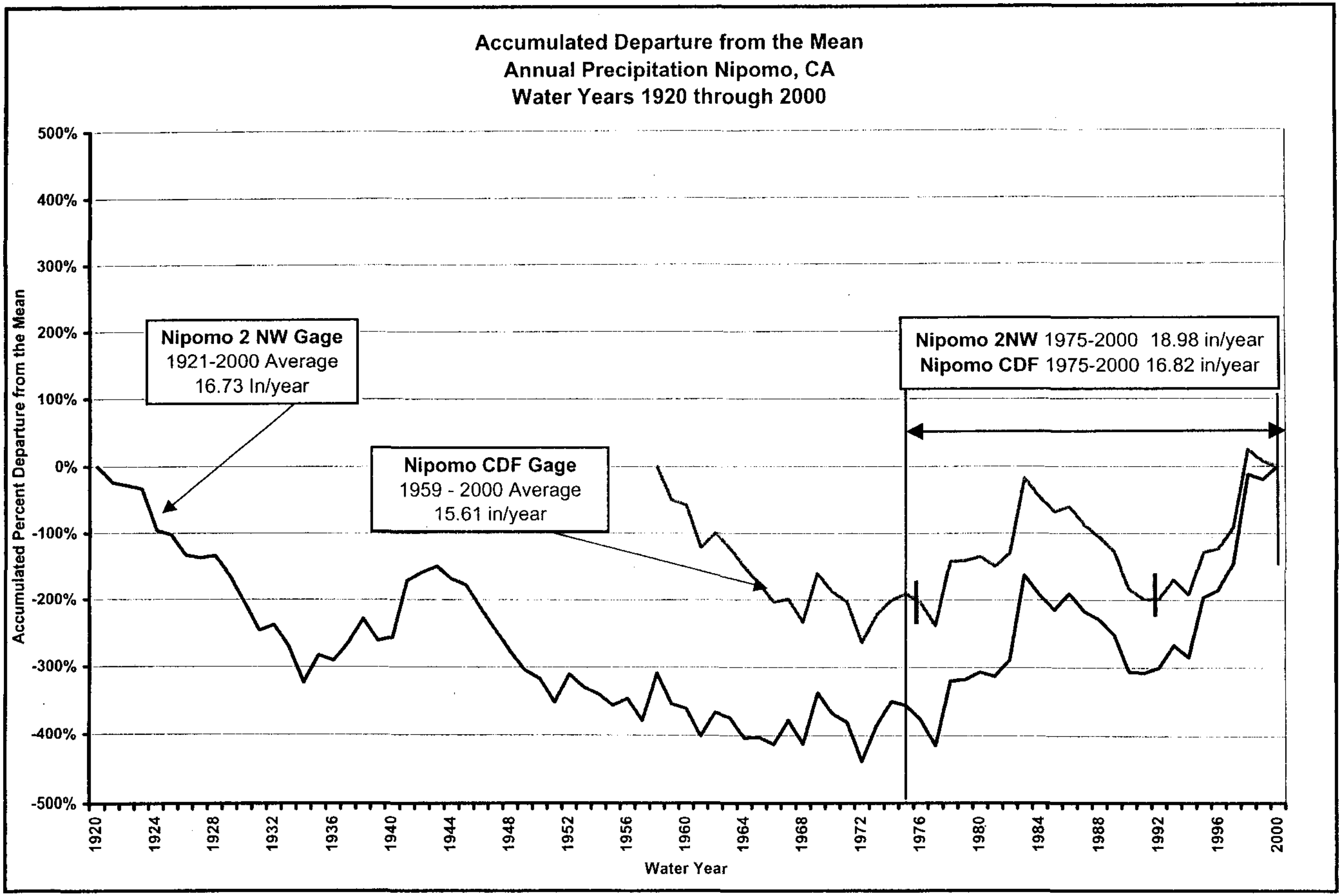
Lopez Dam
Average Annual Precipitation (Inches/Year)
Precipitation Gages
0.5 0 0.5 1 1.5 2 2.5 3 Miles
N
Figure 2.
Nipomo Mesa Management Area
Average Annual Precipitation
SAIC
October2001
UTM NAD27 Zone 10 Meters
18.0
Huasana Valley
17.0
Nipomo 2NW
16.0
15.0
14.0
13.0
Puritan Ice Company
Santa Maria

FIGURE 3



Comparison of Nipomo 2 NW to Nipomo CDF Precipitation Gages
Water Years 1959 through 2000
y = 1.1455x
R^2 = 0.9993
Cumulative Annual Precipitation Nipomo CDF (Inches)
Cumulative Annual Precipitation Nipomo 2 NW (Inches)
0
100
200
300
400
500
600
700
800

FIGURE 4



Precip_NMMA_Historical2.xls - Departure-Chart-Nipomo 2NW

5/28/03 - 2:40 PM

GW Recharge from Deep Percolation

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WATER RESOURCES DIVISION – SANTA BARBARA

MEMORANDUM

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TO: R. G. Beeby

FROM: Diane Ohlmann

RE: Estimate of Groundwater Recharge from Deep Percolation of Precipitation for the Hydrologic Inventory for the Nipomo Mesa Management Area, SAIC Project No.: 01-0122-00-3994-000

DATE: June 11, 2002

The purpose of this memorandum is to describe how deep percolation from precipitation was calculated in connection with the hydrologic inventory for the Nipomo Mesa Management Area (NMMA). Figure 1 is a base map showing the boundary of the NMMA.

It was assumed the main source of groundwater supply to the NMMA comes from deep percolation of precipitation. This is the same approach used by DWR (2000). Los Berros Creek is located along a portion of the northeastern boundary of the NMMA. Based on the SAIC groundwater contour maps drawn for 1975 and 2000, subsurface flow is parallel to creek alignment and therefore no subsurface flow enters the NMMA from Los Berros Creek. The Santa Maria River is located along a portion of the southern boundary of the NMMA. The amount of groundwater recharge to the NMMA from the Santa Maria River range is from 0 to 1,400 AFY. A detailed description of this calculation is addressed in the memorandum describing the estimate of subsurface inflows/outflows.

For purposes of the hydrologic inventory, annual precipitation at the Nipomo CDF gage was used as the representative precipitation over the NMMA. A separate memorandum (January 22, 2002) describes the basis for using the Nipomo CDF precipitation gage.

The volume of water available from precipitation for a specific area of the NMMA is equal to the amount of precipitation multiplied by the area. Evapotranspiration of applied water (ETAW) or water held in the soil profile on idle land is subtracted from this amount to give an estimate of available water to percolate to the groundwater. It was assumed that all surface runoff within the NMMA stays within the boundaries, and therefore rainfall minus evapotranspiration (or soil water) percolates to the groundwater.

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Deep Percolation of Precipitation- Native Land Use

It was estimated that approximately 40 percent of the native land on the NMMA is classified as native trees, included in this category are eucalyptus and other trees such as oak, etc. The remaining 60 percent of the native land is classified as native grasses. The evapotranspiration rate of native grasses was estimated to be approximately 1.44 acre-feet/acre. The evapotranspiration rate of native trees is estimated to be approximately 2.2 acre-feet/acre. It was assumed that precipitation in excess of evapotranspiration was available for groundwater recharge due to deep percolation. Table 1 shows groundwater recharge due to deep percolation from precipitation on native land.

Deep Percolation of Precipitation-- Urban Land Use

An evapotranspiration rate of 1 acre-feet/acre was assumed for urban land use. It was assumed that any precipitation in excess of 1 acre-feet per acre was available for groundwater recharge. Table 1 shows groundwater recharge due to deep percolation from precipitation on urban land.

Deep Percolation of Precipitation— Agricultural Land Use

It was assumed that on areas identified as agricultural land use, 90 percent of the area was irrigated. Groundwater recharge due to deep percolation of precipitation on the irrigated agricultural lands was calculated for various crop types (i.e. citrus, truck crop, etc.) based on a number of factors including effective precipitation for the crop, evapotranspiration rates by crop type etc. Effective precipitation is assumed to be the portion of precipitation that contributes to satisfying the evapotranspiration and/or leaching requirement of a crop, expressed as a depth in inches or feet. Effective precipitation includes the evapotranspiration provided by precipitation during the growing season. Crop ET rates and effective precipitation are described in more detail in a separate memorandum.

It was assumed that the precipitation available for groundwater recharge through deep percolation on the irrigated areas was rainfall minus effective precipitation minus non-growing season evapotranspiration.

It was assumed that precipitation available for groundwater recharge through deep percolation on the non-irrigated 10 percent of the area was equal to precipitation minus evapotranspiration. An evapotranspiration rate of 1.0 acre-feet/acre was assumed for land classified as semi-ag. An evapotranspiration rate of 0.5 acre-feet/acre was assumed for land classified as fallow. Table 1 shows groundwater recharge due to deep percolation from precipitation on agricultural land.

63 **Table 1. Estimated Groundwater Recharge due to Deep Percolation from Precipitation**

Water Year	Precipitation	Native Trees	Native Grasses	Agricultural	Urban	Golf Courses	Total
	Inches	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet
1975	17.29	0	0	1,190	870	0	2,060
1976	13.45	0	0	640	250	0	890
1977	10.23	0	0	60	0	0	60
1978	30.66	2,380	9,950	3,420	3,690	0	19,440
1979	15.8	0	0	1,170	790	0	1,960
1980	16.57	0	0	1,360	1,000	0	2,360
1981	13.39	0	0	850	320	0	1,170
1982	18.58	0	850	1,790	1,590	0	4,230
1983	33.21	3,450	11,230	4,360	5,350	0	24,390
1984	11.22	0	0	680	0	0	680
1985	12.2	0	0	800	50	0	850
1986	16.85	0	0	1,610	1,420	180	3,210
1987	11.29	0	0	720	0	70	790
1988	12.66	0	0	880	210	100	1,190
1989	12.22	0	0	790	80	90	960
1990	7.12	0	0	10	0	0	10
1991	13.06	0	0	940	400	110	1,450
1992	15.66	0	0	1,370	1,460	160	2,990
1993	20.17	0	1,670	2,070	3,420	220	7,380
1994	12.15	0	0	770	70	90	930
1995	25.47	0	4,700	2,860	6,120	320	14,000
1996	16.54	0	0	1,490	2,150	180	3,820
1997	20.5	0	1,740	2,100	4,170	230	8,240
1998	33.67	2,740	8,650	4,170	11,030	1,040	27,630
1999	12.98	0	0	900	510	110	1,520
2000	14.47	0	0	1,150	1,350	150	2,650
Total	437.41	8,570	38,790	38,150	46,300	3,050	134,860

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Deep Percolation of Precipitation—Golf Courses

On golf courses groundwater recharge due to deep percolation of precipitation was calculated based on a number of factors including effective precipitation for the golf courses, evapotranspiration rates, etc. Effective precipitation is assumed to be the portion of precipitation that contributes to satisfying the evapotranspiration and/or leaching requirement of a crop, (in this case the golf course turf) expressed as a depth in inches or feet. Effective precipitation includes the evapotranspiration provided by precipitation during the growing season. Crop ET rates and effective precipitation are described in more detail in a separate memorandum.

An evapotranspiration rate of 2.3 acre-feet/acre was assumed on the irrigated portions of the golf courses. An evapotranspiration rate of 1.8 acre-feet/acre was assumed on the un-irrigated portions of the golf courses. Table 1 shows groundwater recharge due to deep percolation from precipitation on golf courses.

Total Groundwater Recharge due to Deep Percolation of Precipitation

Total groundwater recharge due to deep percolation from precipitation for the NMMA is estimated to be approximately 134,860 acre-feet for the period 1975 through 2000. This is an average annual amount of approximately 5,190 acre-feet/year. DWR estimated groundwater recharge from deep percolation from precipitation for the Nipomo Area is 122,900 acre-feet for the period 1975 through 1995. SAIC's estimate of groundwater recharge due to deep percolation from precipitation is 91,000 acre-feet for the same period of record. DWR's estimate is approximately 25 percent greater than SAIC's estimate.

LAND USE/AG USE WATER DEMANDS

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WATER RESOURCES DIVISION – SANTA BARBARA

MEMORANDUM

ATTORNEY WORK PRODUCT
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TO: R.G. Beeby

FROM: Sam Schaefer

RE: Land Use and Agricultural Water Demands for the Hydrologic Inventory for the Nipomo Mesa Management Area, SAIC Project No.: 01-0122-00-3994-000

DATE: June 12, 2002

This memorandum describes the work performed to evaluate the land use surveys and the agricultural water use data for the Nipomo Mesa Hydrologic Inventory. The memo presents an evaluation of the individual components of the crop consumptive use that are used in the hydrologic inventory.

1.0 LAND USE SURVEYS AND ATTRIBUTES

Land use surveys for the Arroyo Grande – Nipomo Mesa Area were obtained from the Department of Water Resources (DWR) for the years 1977, 1985, and 1996 in an electronic format. The 1977 and 1985 surveys were in an AutoCAD file format and were sent to SAIC by Michael Maisner (818) 543-4666. These files were converted to GIS coverages and loaded into the GIS database using software at SAIC. The 1996 land use survey was downloaded from the DWR site (http://www.waterplan.water.ca.gov/landwateruse/landuse/ludataindex.htm) and then loaded into the Nipomo Mesa Area GIS database. Since SAIC had land use data in a GIS file format that represents the year 2000 for the Nipomo Mesa Management Area (NMMA), the same NMMA boundary was used to "clip out" the area from the older DWR files.

The DWR surveys have legends that provide explanation of the attributes for the various land use categories used in the surveys. Five major land use categories were used: 1) Agricultural; 2) Semi agricultural; 3) Urban; 4) Native; and 5) Unclassified. These classes provide the primary framework and more detail is obtained by adding the following information:

- Types of agricultural, urban, or native land use
- Specific crops

- Multiple land use (percentage of different land uses within a given area)
- Sources of water supply
- Type of irrigation system

Individual crops types are identified using the subclass numbering system. In addition, the DWR land use surveys were delineated in 3-acre parcels. A summary of DWR's land use surveys for the NMMA by class, category, and area for years 1977, 1985 and 1996 is shown in Table 1. For purposes of estimating net irrigated area for agriculture, an assumption that 90 percent of gross area represents the net irrigated area was made for the NMMA. This assumption is based on the observation that NMMA agricultural land is of smaller farmed parcels where the irrigated portion of the parcels are reasonably less than in a large district like WRMWSD where the irrigated land portion of agricultural land is found to be about 0.94. The remaining un-irrigated 10 percent was assumed to have a consumptive use of 0.5 acre-feet/acre, the equivalent of fallow land.

It is important to note that the level of detail captured by each survey changed as the focus of each survey differed. For example, the early land use surveys had more detail on types of urban land uses than the later surveys. For this hydrologic inventory, SAIC used a combination of the major land use classes and subclass information available for years 1977, 1985, and 1996 to estimate general land use changes, in acres, from 1975 to 2000 for Agricultural, Golf Courses, Native, and Urban land uses. Using the acres for the major classes in 1977, 1985, and 1996, acreages were assigned by linear interpolation to the years that were not surveyed. A summary of the interpolated acres for the NMMA land use for years 1975-2000 is shown in Tables 2-6.

Detailed information was contained in the land use surveys for agriculture and this analysis uses several general crop types, whereas data within the urban land use categories were combined into one general urban category. By combining the urban land use into one general category, data from the 1977 and 1985 surveys coincided with the level of detail used in the 1996 survey. The majority of the urban land use in the 1977 and 1985 surveys was categorized as residential. In addition, the native land use class was combined to one land use category called Native Vegetation.

2.0 AGRICULTURAL WATER USE

For the purpose of this hydrologic inventory, the components of agricultural water use that are considered outflow are: 1) the consumptive use of the crop; 2) surface runoff from irrigation that leaves the NMMA boundary; and 3) water consumptively used for climate control (frost protection).

62 **Table 1. Nipomo Mesa Management Area Land Use from DWR Surveys (Gross Acres)**

Class	Land Use Category	Year 1977	Year 1985	Year 1996
Agricultural		Area (Acres)	Area (Acres)	Area (Acres)
C	Citrus and Subtropical	497	530	338
D	Deciduous	21	45	62
S	Semi Agricultural	432	354	116
P	Pasture	310	259	191
G	Grain Crops	306	24	---
G*	Grain Crops	---	---	247
T	Truck, Nursery, and Berry Crops	280	981	305
T*	Truck, Nursery, and Berry Crops	---	---	754
I	Idle	10	42	---
F	Fallow	150	---	---
	Total Agricultural	*2,006*	2,235	*2,013*
Native				
NB	Barren and Wasteland	53	---	---
NR	Riparian Vegetation	<1	80	---
NV	Native Vegetation	15,049	13,811	11,451
NW	Water Surface	---	---	124
	Total Native	*15,102*	*13,891*	*11,575*
Urban				
SR	Suburban Residential	---	1,276	---
UC	Commercial	40	64	---
UI	Industrial	165	238	---
UR	Residential	1,832	1,284	---
UV	Vacant	201	423	---
U	Urban	---	---	*5,674*
UL	Urban Landscape (Black Lakes Golf Course)	---	---	143
	Total Urban	*2,238*	*3,285*	*5,817*
Unidentified	(Assigned to NV)	70	---	---
	Total	*19,416*	*19,411*	*19,405*

Notes
* Denotes Triple Cropped, i.e. three consecutive crops grown on land

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Table 2. Nipomo Mesa Management Area, Land Uses for Years 1975-2000 (Gross Acres)[a]

Year	*1975*	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Agricultural	1,951	1,977	2,006	2,035	2,065	2,092	2,122	2,150	2,181	2,207	2,236	2,099	2,088	2,082	2,072	2,065	2,054	2,047	2,037	2,031	2,020	2,013	2,012	2,007	2,007	2,003
Golf Courses[b]	-	-	-	-	-	-	-	-	-	-	-	287	287	287	287	287	287	287	287	287	287	287	287	662	662	662
Native	15,493	15,332	15,172	15,012	14,852	14,692	14,532	14,371	14,211	14,051	13,891	13,523	13,313	13,102	12,892	12,681	12,471	12,260	12,050	11,839	11,629	11,431	11,220	10,635	10,424	10,214
Urban	1,977	2,107	2,238	2,370	2,500	2,631	2,762	2,894	3,024	3,155	3,285	3,502	3,719	3,937	4,154	4,371	4,588	4,805	5,022	5,240	5,457	5,674	5,891	6,108	6,326	6,543
Total Area	*19,421*	*19,416*	*19,416*	*19,417*	*19,417*	*19,415*	*19,416*	*19,415*	*19,416*	*19,413*	*19,412*	*19,411*	*19,407*	*19,408*	*19,405*	*19,404*	*19,400*	*19,399*	*19,396*	*19,397*	*19,393*	*19,405*	*19,410*	*19,412*	*19,419*	*19,422*

Notes:

[a] Actual land use surveys were only performed for years 1977, 1985, and 1996. Acres of various land uses for all other years are interpolated from data of years 1977, 1985, and 1996.

[b] Golf courses were not developed until 1986

67 **Table 3. Nipomo Mesa Management Area, Gross Acres of Agricultural Land for Years 1975-2000[a]**

Year	*1975*	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Citrus and Subtropical	489	493	497	501	505	509	514	518	522	526	530	513	495	478	460	443	425	408	390	373	355	338	321	303	286	268
Deciduous	15	18	21	24	27	30	33	36	39	42	45	47	48	50	51	53	54	56	57	59	60	62	64	65	67	68
Grain[b]	377	341	306	271	236	200	165	130	95	59	24	44	65	84	105	125	146	166	187	206	227	247	269	292	314	337
Truck, Nursery, Berry, and Field Crops[b]	105	192	280	368	455	543	631	718	806	893	981	989	995	1,003	1,009	1,017	1,023	1,031	1,037	1,045	1,051	1,059	1,067	1,073	1,081	1,087
Pasture	323	316	310	304	298	291	285	279	273	266	260	254	247	241	235	229	222	216	210	204	197	191	185	178	172	166
Idle or Fallow	190	175	160	145	131	116	101	86	72	57	42	38	34	31	27	23	19	15	11	8	4	0	0	0	0	0
Semi Agriculture	452	442	432	422	413	403	393	383	374	364	354	214	204	195	185	175	165	155	145	136	126	116	106	96	87	77
Total Agricultural	*1,951*	*1,977*	*2,006*	*2,035*	*2,065*	*2,092*	*2,122*	*2,150*	*2,181*	*2,207*	*2,236*	*2,099*	*2,088*	*2,082*	*2,072*	*2,065*	*2,054*	*2,047*	*2,037*	*2,031*	*2,020*	*2,013*	*2,012*	*2,007*	*2,007*	*2,003*

Notes:

[a] Actual land use surveys were only performed for years 1977, 1985, and 1996. Acres of various land uses for all other years are interpolated from data of years 1977, 1985, and 1996.

[b] There are both single and triple crops in this category.

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Table 4. Nipomo Mesa Management Area, Acres of Golf Course for Years 1975-2000

Year	*1975*	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Black Lakes	-	-	-	-	-	-	-	-	-	-	-	287	287	287	287	287	287	287	287	287	287	287	287	287	287	287
Cypress Ridge	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	375	375	375
Total Golf Courses	-	-	-	-	-	-	-	-	-	-	-	***287***	***287***	***287***	***287***	***287***	***287***	***287***	***287***	***287***	***287***	***287***	***287***	***662***	***662***	***662***

[a] Black Lakes course was not developed until 1986, Cypress Ridge was not developed until 1998.

Table 5. Nipomo Mesa Management Area, Acres of Native Land for Years 1975-2000

Year	*1975*	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Native Vegetation[b, c]	15,493	15,332	15,172	15,012	14,852	14,692	14,532	14,371	14,211	14,051	13,891	13,523	13,313	13,102	12,892	12,681	12,471	12,260	12,050	11,839	11,629	11,431	11,220	10,635	10,424	10,214

Notes:

[a] Actual land use surveys were only performed for years 1977, 1985, and 1996. Acres of various land uses for all other years are interpolated from data of years 1977, 1985, and 1996.
[b] Golf courses are not included in this land use category.
[c] Native Vegetation land use was separated into two categories; 40 percent was assigned to predominately trees and 60 percent was assigned predominately grasses.

Table 6. Nipomo Mesa Management Area, Acres of Urban Land for Years 1975-2000

Year	*1975*	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Urban Residential	1,650	1,741	1,832	1,764	1,695	1,627	1,558	1,490	1,421	1,353	1,284								See Note [b]							
Urban Vacant	146	173	201	229	257	284	312	340	368	395	423															
Urban Industrial	147	156	165	174	183	192	202	211	220	229	238															
Urban Commercial	34	37	40	43	46	49	52	55	58	61	64															
Suburban Residential	0	0	0	160	319	479	638	798	957	1,117	1,276															
Urban						See Note [b]						3,502	3,719	3,937	4,154	4,371	4,588	4,805	5,022	5,240	5,457	5,674	5,891	6,108	6,326	6,543
Total Urban	*1,977*	*2,107*	*2,238*	*2,370*	*2,500*	*2,631*	*2,762*	*2,894*	*3,024*	*3,155*	*3,285*	*3,502*	*3,719*	*3,937*	*4,154*	*4,371*	*4,588*	*4,805*	*5,022*	*5,240*	*5,457*	*5,674*	*5,891*	*6,108*	*6,326*	*6,543*

Notes:

[a] Actual land use surveys were only performed for years 1977, 1985, and 1996. Acres of various land uses for all other years are interpolated from data of years 1977, 1985, and 1996.

[b] The land use categories Urban Residential, Urban Vacant, Urban Commercial, and Suburban Residential were only used in land use surveys prior to 1986. In 1986 and after there were only two land use categories used in surveys, "Urban" (which consists of all urban uses except for golf courses) and "Urban Landscape" (which consists of both the Black Lakes and Cypress Ridge golf courses). Golf Courses are accounted for as their own category in Table 4.

2.1 Irrigation Efficiency Values

The irrigation efficiency values used for this hydrologic inventory are from the San Luis Obispo County (SLO) Master Water Plan Update, Water Planning Area #6 – Nipomo Mesa (see Table 9 of the SLO report). Irrigation efficiencies were assigned to crop groups according to prevalent irrigation system type and knowledge of typical local irrigation practices. The Cachuma Resource Conservation District was stated as the source of this information used in the SLO report. Irrigation efficiency for the purposes herein is expressed as:

$$\text{Irrigation Efficiency} = \text{Consumptive Use}/\text{Applied Water}$$

Assigned irrigation efficiency averages for the following crop groups were used: Nursery (60-70%); Permanent (60-70%); Vegetable (65-75%); and Vineyard (65-75%). For this hydrologic inventory, the high-end of the range was used for all crops since the SLO report indicates a projected average increase in irrigation efficiency of 5 percent.

For the NMMA, it is assumed that all irrigation occurs within the boundary using the groundwater supply and the deep percolation water returns to the groundwater supply within the same year. Under these assumptions, the irrigation efficiency does not have an affect on the hydrologic inventory. However, if irrigation water were supplied from outside the boundary, then irrigation efficiency would have an affect on the hydrologic inventory.

2.2 Crop Consumptive Use Values

The total seasonal consumptive use for a crop (ETc) is met by the combination of evapotranspiration of applied water (ETAW) and effective precipitation. The DWR has presented unit values of ETAW for the irrigated crop classes identified within the land use area. The DWR ETAW values were based on a combination of direct field measurements and theoretical calculations. In addition, recommendations of the Farm Advisors of San Luis Obispo and Santa Barbara Counties and the National Resources Conservation Districts were taken into consideration. Description of methods used to calculate Crop Applied Water and measured data are presented in DWR Bulletin 113-4 "Crop Water Use in California", April 1986.

2.3 Irrigation Applied Water and Deep Percolation

For each year in the hydrologic inventory, a lookup table was used to select the ETAW for a crop based on the annual precipitation in order to estimate effective precipitation. Effective precipitation was estimated as the difference between assumed constant ETc and assigned ETAW for each year.

The irrigation applied water (Irr AW) was calculated by dividing the assigned ETAW value by the irrigation efficiency and then adding climate water:

Irr AW = (ETAW / Irr Eff) + Climate Water

The irrigation deep percolation (Irr Deep Perc) was calculated as the difference between the Irr AW and the ETAW and then subtracting the climate water:

Irr Deep Perc = (Irr AW - ETAW) - Climate Water

Although the unit ETAW values used in DWR's water balance and SAIC's hydrologic inventory are very close, the quantity for deep percolation from irrigation is different. The DWR applies an unrecoverable loss factor of 40% to the deep percolation from irrigation. It is understood that this factor is to represent water that becomes unusable due to water quality issues. In this hydrologic inventory, all the deep percolation from irrigation is shown returning to the groundwater in the same year as applied.

For this hydrologic inventory of the NMMA, deep percolation due to irrigation is defined as the irrigation applied water (Irr AW) minus the sum of ETAW and the climate water. For example, since the unit Irr AW for Pasture is 3.0 AF/A ((2.1 AF/A)/(0.70) + 0), then the unit Irr Deep Perc for pasture is 0.9 AF/A ((3.0 – 2.1) – 0).

The volume of Irr Deep Perc for each of the agricultural land use categories was found by multiplying the unit Irr Deep Perc value by the percent of land use acres estimated as irrigated:

Volume of Irr Deep Perc = Irr Deep Perc * Land Use Acres * Percent Irrigated.

2.4 Non-growing Season ET

Estimates of the non-growing season ET for each of the irrigated crops was obtained by combining growing season information in Table 14 of the 1974 Bulletin 113-3 and monthly ET values for idle ground, provided by the Irrigation Training and Research Center (IRTC), California Polytechnic State University (see Table 9). These estimates of non-growing season ET may be added to the seasonal crop ETc to represent the annual ET for an agricultural field.

Table 9. Non-Growing Season ET for Irrigated Agricultural Lands

Land Use Class Code	ET (non-growing season in inches)
Citrus and Subtropical[1]	0
Deciduous[2]	4
Grain[3]	1
Field Crops, Truck, Nursery and Berry[4]	1
Pasture[2]	4
Grain Multi-Crop[4]	1
Field Crops Multi Crop[4]	1

Notes:

[1]ETc uses 12-month growing season.
[2]Estimated non-growing season as four winter months at 1"/month.
[3]Estimated non-growing season in summer months with low ETc for Idle land.
[4]Estimated non-growing season as short amount of time.

URBAN USE WATER DEMANDS

MEMORANDUM

ATTORNEY WORK PRODUCT
CONFIDENTIAL AND PRIVILEGED

DRAFT

TO: R. G. Beeby

FROM: Sam Schaefer

RE: Estimate of Water Demands from Urban, Golf Course, and Native Vegetation Land Use on the Hydrologic Inventory for the Nipomo Mesa Management Area, SAIC Project No.: 01-0122-00-3994-000

DATE: June 10, 2002

The purpose of this memorandum is to describe how land use surveys and urban, golf course, and native vegetation water use data were used to estimate water demands for the hydrologic inventory of the Nipomo Mesa Management Area (NMMA).

1.0 LAND USE SURVEYS

Land use surveys for the Arroyo Grande – Nipomo Mesa Area were obtained from the California Department of Water Resources (DWR) for the years 1977, 1985, and 1996 in an electronic format. A general explanation of the land use surveys is contained in a separate memo on the Land Use and Agricultural Water Demands for the Nipomo Mesa Hydrologic Inventory.

It is important to note that the level of detail captured by each survey changed as the focus of each survey differed. For example, the early land use surveys had more detail on types of urban land uses than the later surveys. Using the acres for the major classes in 1977, 1985, and 1996, acreages were assigned by linear interpolation to the years that were not surveyed. A summary of the interpolated urban acres for the NMMA land use for years 1975 to 2000 is shown in Tables 1, 2 and 6 of the Land Use and Agricultural Water Demands memo. By combining the urban land use into one general category, data from the DWR's 1977 and 1985 surveys coincided with the level of detail used in their 1996 survey. A summary of the golf course and native vegetation acres is shown in Tables 1, 2, 4 and 5 of Land Use and Agricultural Water Demands Memo.

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2.0 NET URBAN WATER DEMAND

The net urban water demand for the NMMA was obtained by estimating the urban delivered water (the applied water demand minus system losses in delivery), the depletions (the water consumed within a service area no longer available as a source supply), and the return flows to groundwater.

2.1 Urban Applied Water Demand for NMMA

An estimate for the urban applied water demand for NMMA for years 1975 to 2000 was conducted using an Area Method. This method was based on the YR 2000 production estimate divided by the YR 2000 urban land use area. The YR 2000 production per area (urban applied water demand of 0.89 AF/A) was then varied for each year (pro-rated) by the DWR's per-capita water use values from the DWR report (see Table 1). Varying the production estimate by the DWR's per-capita water use represents changes in water use per household over the time of this study. The urban applied water demand used in the NMMA hydrologic inventory consists of the pro-rated value representing urban water production per acre times the estimated urban land use acres for each year.

In comparison, the DWR's production estimate uses the Per-Capita water use times the estimated population for NMMA. The per-capita water use values for years 1975, 1980, 1985, 1990, 1995, and 2000 were obtained from Table D2, "Per Capita Water Use" of the DWR report "Water Resources of the Arroyo Grande – Nipomo Mesa Area", January 2000. The per-capita water use values from Table D2 represent the water delivered to an urban system (assumed to be at the meter). The net urban water demands that are shown in Table D3 of the DWR report indicate 80 percent of the urban water delivered to the system does not return to the groundwater as usable water. In the DWR's representation of the urban water use, some of the water returns to the groundwater and is designated to a salt sink and is assigned as unusable, however, this water is not accounted for in their water level balance.

In comparison to the DWR's Bulletin 160 for general planning, the percent of urban applied water demand that could make it back to reusable water supply (groundwater in NMMA's case) ranged from 20 to 60 percent. An evaluation of the DWR's estimated production using the high and low points for the percent of water that could return to the groundwater as usable water indicated it bracketed the Area Method production. The assumptions used for the SAIC NMMA hydrologic inventory placed the NMMA at 44 percent of production returning to the groundwater source, which is close to the middle of the range of water returning to the source in the DWR's urban models.

Table 1. Estimated Urban Applied Water Demand for NMMA, 1975-2000.

Year	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
NMMA Urban Acres [1]	1,977	2,107	2,238	2,370	2,500	2,631	2,762	2,894	3,024	3,155	3,285	3,502	3,719	3,937	4,154	4,371	4,588	4,805	5,022	5,240	5,457	5674	5,891	6,108	6,326	6,543
Nipomo Mesa Area Population [1,2] (DWR HSA)	5820	6,044	6,268	6491	6715	6939	7,146	7,353	7561	7768	7975	8,215	8,456	8,696	8,937	9,177	9,531	9,885	10,239	10,593	10947	11,418	11,888	12,359	12,829	13,300
GPCD (gallons per capita per day) [1] (DWR HSA)	229	237	245	253	261	269	283	297	311	325	339	347	355	363	371	379	353	328	302	277	251	261	271	280	290	300
AFPCA (AF per capita annually) [1] (DWR HSA)	0.257	0.266	0.275	0.284	0.293	0.302	0.318	0.333	0.3488	0.364	0.38	0.389	0.398	0.407	0.416	0.425	0.396	0.368	0.339	0.311	0.282	0.293	0.304	0.314	0.325	0.336
Percent Difference of GPCD Or AFPCA from YR 2000 [3]	-24%	-21%	-18%	-15%	-13%	-10%	-5%	-1%	4%	8%	13%	16%	18%	21%	24%	26%	18%	9%	1%	-8%	-16%	-13%	-10%	-6%	-3%	0%
Prorated Average Production from YR 2000 (AF/A) [4]	0.68	0.70	0.73	0.75	0.78	0.80	0.84	0.88	0.92	0.97	1.01	1.03	1.05	1.08	1.10	1.13	1.05	0.97	0.90	0.82	0.75	0.78	0.80	0.83	0.86	0.89
Estimated Urban Production [5] (AF) (Area Method)	1300	1500	1600	1800	1900	2100	2300	2600	2800	3000	3300	3600	3900	4200	4600	4900	4800	4700	4500	4300	4100	4400	4700	5100	5400	5800
Estimated Urban Return as 44% to GW using Area Method	570	660	700	790	840	920	1010	1140	1230	1320	1450	1580	1720	1850	2020	2160	2110	2070	1980	1890	1800	1940	2070	2240	2350	2550

Notes:

1 Known data from DWR studies are shown as shaded, other values are linearly interpolated between the known values. This AFPCA value is a net urban water demand based on the population of the urban area. This value may be compared to the YR 2000 production value by making the following assumptions; 1.5 persons per urban acre and 56 percent of production water is consumed. Then the comparison is (0.336AFPCA)*(1.5C/A)/(0.56% CU/ AF Production)= 0.90 AF/A, as compared to 0.89 AF/A from the YR 2000 production estimate.

2 Nipomo Mesa Area population is not the same as Nipomo Mesa Management Area population.

3 Calculated percent difference from YR 2000 for GPCD or AFPCA, which represent changes to water use in time.

4 Varied the production rate of the YR 2000 estimate for each year by relating it to the water use per day values.

5 Estimated urban production represents the estimated urban applied water demand, rounded to nearest 100 AF.

Linear interpolation was used to assign per-capita water use values to each year within 1975 to 2000 that did not already have a value. The population values used for this estimate are likely greater than the actual population for the NMMA since the NMMA area is smaller than the DWR's study area. The difference in population for NMMA and the DWR study area is not known, but assumed small.

2.2 Urban Applied Water Demands, Depletions, and Returns to Groundwater

The amount of urban water returning to the groundwater was estimated as 44 percent of the applied water demand for the NMMA hydrologic inventory. This percentage was obtained by reviewing past records and estimates of NMMA urban applied water demands, depletions, and returns to groundwater. Individual components of the NMMA urban water use are shown in Table 2.

Table 2. Estimated Returns and Depletions for NMMA Urban Applied Water Demands.

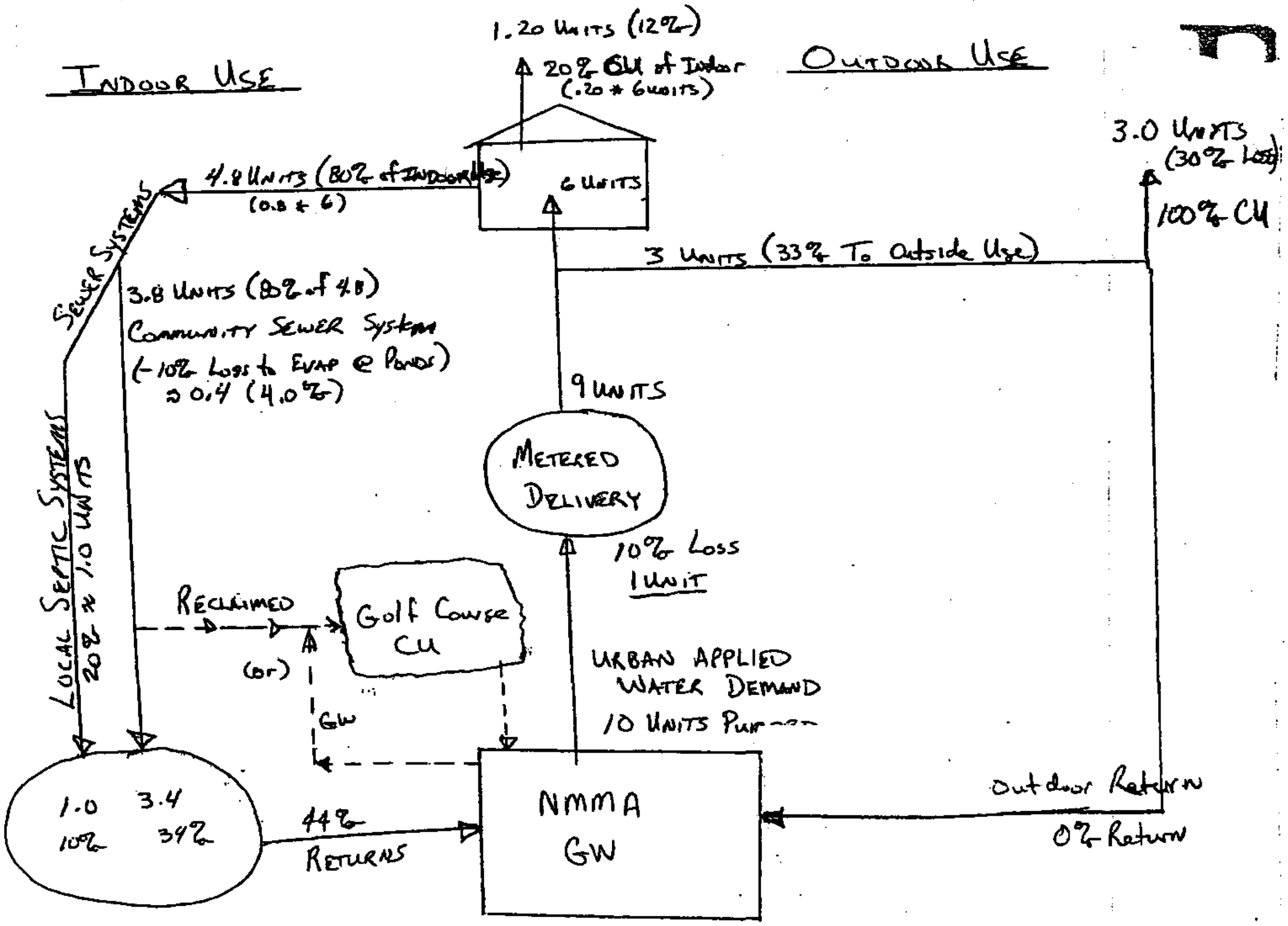
Returns to Groundwater **44% of Urban Applied Water Demand** *Sum of the following:*	**Depletions from Groundwater** **56% of Urban Applied Water Demands** *Sum of the following:*
Septic System Leaching (10%)	Delivery Loss (10%)
Outdoor Returns (0%)	Outdoor Consumptive Use (30%)
Community Sewer Leaching (34%)	Indoor Consumptive Use (12%)
	Evaporation from Sewer Ponds (4%)

Delivery Losses were estimated by reviewing Nipomo Community Services District ground water pumping and metered delivery records. Annual delivery losses ranged from 4 percent to 19 percent, with an average of 10 percent, which was used for this estimate. The wide range of losses was influenced by construction activities and growth in the area.

Urban delivered water use was estimated as 66.7 percent indoor and 33.3 percent outdoor. This was the same outdoor and indoor use factor as assigned in the DWR study. Consumptive use (CU) of indoor water was estimated as 20 percent, whereas, 100 percent of outdoor water use was estimated as CU (based on a planning report written by Cleath and Associates). Of the indoor water use, 80 percent was estimated to exit to a local septic or community sewer system. The percentage of wastewater returns going to a community sewage system was estimated to be 80 percent with the remaining 20 percent going to a local septic system. All of the community wastewater in the NMMA is delivered to leaching ponds or becomes reclaimed (supply) water to golf courses. An evaporation loss of 10 percent was estimated for the

Figure 1. Schematic Representation of NMMA Urban Water Use.

Returns to Groundwater **44% of Urban Applied Water Demand** *Sum of the following:*	**Depletions from Groundwater** **56% of Urban Applied Water Demands** *Sum of the following:*
Septic System Leaching (10%) Outdoor Returns (0%) Community Sewer Leaching (34%)	Delivery Loss (10%) Outdoor Consumptive Use (30%) Indoor Consumptive Use (12%) Evaporation from Sewer Ponds (4%)



CU = Consumptively Used

wastewater leaching ponds. See Figure 1 for a schematic representation of the urban water balance.

The consumptive use due to precipitation for Urban Land Use was estimated by averaging the DWR's assigned 0.9 acre-feet per acre per year and a representative non-irrigated crop water use for Barley of 1.1 AF/A per year. The value of 1.0 AF/A per year was used in the spreadsheet analysis for the NMMA Hydrologic Inventory.

Reclaimed water consumed by golf courses was accounted for in the hydrologic inventory by assigning a separate land use category for golf course grasses. Since all supply water to the golf course land use originates as local groundwater, the net change did not affect the urban water use schematic and the urban returns estimated for the NMMA hydrologic inventory.

3.0 GOLF COURSE WATER USE

Golf course acres were treated as a separate land use category for the NMMA hydrologic inventory. The percent of each golf course development area that was golf course grasses and native grasses was estimated using the GIS maps layers. A consumptive use was assigned to the golf course grass area and the native grass area of the developments. Golf course grasses are irrigated using recycled wastewater. The housing portion of the golf courses was assigned to the urban land use category.

The water consumed by the golf course grasses was estimated using evapotranspiration (ET) of grasses that represent fairway, green, rough and fringe areas. The ET estimates for Cypress Ridge were obtained from the 1994 planning report by Cleath and Associates. A weighted average consumptive use rate for the golf course grasses was calculated as 2.3 AF/A per year that includes some contribution from rainfall. The non-irrigated portion of the golf course grasses was estimated and assigned a consumptive use of 1.8 AF/A per year, which represents a water use similar to a mix of grasses and trees. The percent of golf courses that was irrigated and non-irrigated was estimated using the GIS layers. Cypress Ridge was 50 percent irrigated and Black Lakes Golf Course was 80 percent irrigated.

4.0 DWR'S NATIVE VEGETATION WATER USE

Based on field observation, the DWR Land Use Surveys, and the 1994 aerial photography in the GIS representation of the NMMA, an estimated 40 percent of the DWR's native vegetation land use was predominately trees and 60 percent was predominately grasses mixed with some shrubs (this 40/60 tree to grass ratio was held constant for all years of the study). Therefore, estimates for the DWR's native vegetation water use were split into two categories representing predominately trees and the other predominately grasses with some shrubs. In addition, some of the predominately tree areas were in areas, such as Black Lake Canyon, that may receive some lateral drained water that supports higher consumptive use.

Measured ET values to represent grasses and trees are not as readily available as ET values for agriculture crops. Representative ET values were assigned to the tree and grasses areas by averaging the few ET sources and comparing the ET values found to representative agricultural crops.

The following assumptions were used in for the NMMA hydrologic inventory:

	Predominately grasses with some shrubs– Average ET (AF/A per year)	
1)	Non-irrigated Bean/Barley crop estimate (only effective rainfall)	1.4 (2.3 AF/A with irrigation supplement)
2)	DWR Range for native vegetation (<2% trees)	1.49 (1.3-1.67)
3)	Blaney report (17" threshold for no deep perc)	1.42
	Average ET for predominately grasses with some shrubs (AF/A per year)	1.45

	Predominately Trees – Average ET (AF/A per year)	
1)	Deciduous orchard + 0.33 (total use)	2.7
2)	Eucalyptus in Riparian type land from Australian Report	3.0 – 5.0
3)	DWR Email for Native Vegetation (high end of range)	1.7
	Average ET for predominately trees (AF/A per year) (Data sources 1 and 3)	2.2

Average ET for Predominately Trees category was calculated using the average of items 1 and 3 above was used to assign the ET value used for the NMMA hydrologic inventory of 2.2 AF/A ((2.7 + 1.7)/2).

A review and update of this Hydrologic Inventory for the Nipomo Mesa Management Area was conducted by SAIC and documented in a memo by Mark Bandurraga to R. G. Beeby on April 3, 2002.

FUTURE WATER DEMANDS

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
WATER RESOURCES DIVISION – SANTA BARBARA

MEMORANDUM

ATTORNEY WORK PRODUCT
CONFIDENTIAL AND PRIVILEGED

TO: R. G. Beeby

FROM: Diane Ohlmann

RE: Estimate of Future Urban Water Demands and Land Use on Nipomo Mesa Management Area

DATE: June 12, 2002

Prior to SAIC's development of a hydrologic inventory for the Nipomo Mesa Management Area (NMMA) in January, 2002, work was done to estimate current and future water demands for the NMMA. This work is described in a draft memorandum dated September 28, 2001 titled *Preliminary Estimate of Production Nipomo Mesa Management Area.* Much of the work and details described in the September 28th memorandum have been superceded by the memorandums on land use and water use pertaining specifically to the hydrologic inventory (dated June 2002 by Sam Schaefer). However, not all of the work done on estimating future water demands in the September 28th memorandum was superceded and these data were used for the future estimates of land and water use in the hydrologic inventory. The purpose of this memorandum is to synthesize the data from the various memorandums that were used in the estimates of future urban water demand and land use for the NMMA in the hydrologic inventory.

Urban Land Use

The urban areas currently (year 2000) being serviced by Cal Cities Water and Rural Water Company (represented by CH2M Hill), and other urban purveyors such as small Mutual Water Companies were obtained from field investigations and (1994) aerial photography interpretation. Year 2000 urban land use was estimated to be 6,558 acres.

Future Urban land use was obtained through discussions with Doug Jones (General Manager of the Nipomo Community Services District [NCSD]) as well as other data obtained through field investigations and from the SLO County planning department. The future urban areas were the Woodlands Project, Black Lakes Village, the proposed Bluffs Project, the Woodland Project and another 300 to 500 units of future development (conversations with Doug Jones and field investigation, July 18, 2001), totaling approximately 1,066 acres. There were an additional 1, 389

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acres within the NMMA where land use was not identified into any land use category based on DWR land use survey information from 1996. Based on 1994 aerial photography, this unidentified land close in proximity to the boundaries of urban water purveyors appeared to be undeveloped, native land. Based on this proximity, it was assumed that about one half of this land (695 acres of 1,389 total) would be converted to urban land use by the year 2020.

The total future (2020) urban land use area was projected to be approximately 8,319 acres. The increase in urban land use is assumed to come out of the native land category. It was assumed that 40 percent of the developed native land is native trees and 60 percent of the developed native land is native grasses.

Urban Water Demands

Future projected NCSD water demand at build out is based on estimates by Doug Jones. The projected water demand estimate includes the current NCSD service area plus the Black Lakes Village, the proposed Bluffs Project, the Woodland Development and an additional 300-500 units of future development. The estimate of future water demands in 2020 for NCSD according to Doug Jones is approximately 6,000 AFY.

The total service area for Cal Cities Water (CCW) within the NMMA is approximately 1,300 acres. Estimates of current (2000) and future (2020) water demands are based on the Southern California Water Company 2000 Urban Water Management Plan. All estimates of current water demand are based on metered connections. The future water demand in 2020 of Cal Cities Water is 2,370AFY. Total acreage of Rural Water Company (RWC) service area is approximately 1,100 acres. The service area of RWC that is within the NMMA is approximately 855 acres. All groundwater production however by RWC is from wells within the boundary of the NMMA. Current (2000) and projected (2020) demands were provided by CH2M Hill, the consulting engineer to Hatch and Parent who represents both Rural Water Company and Cal Cities Water. Future water demands in 2020 are estimated to be 860 AFY. Included in other urban demands are areas identified as mutual water companies. These are small private water purveyors. The total acreage of the small private purveyors within the NMMA identified by SAIC is approximately 870 acres. Production data were not available for all mutual water companies. SAIC contacted the SLO County Department of Environmental Health requesting production data by the mutual water companies. If no production data were reported, groundwater production was estimated based on the number of connections for each mutual water company multiplied by the average consumption per water account per NCSD, which is 0.61 AFY. Approximate current groundwater production is 1,560 AFY.

Included in the projected future acreage for "Other Urban Demands" is the 160-acre site that was categorized "future development" after SAIC field investigations and from information received from the county. This is a future development called the Highlands Project (per Doug Jones) of 51 homes which will be serviced by a mutual water company. The assumed water demand is estimated to be 51 homes multiplied by the average consumption per water account per NCSD, which is 0.61 AFY. This is approximately 31 AFY.

Table 1 is an estimate of Future (2020) Land Use and Water Demands that were used in the Hydrologic Inventory.

Table 1. Estimate of Future Urban Land Use and Water Demand for the NMMA

URBAN WATER PURVEYOR	**Area (Acres)**	**Water Demand (AFY)**
NCSD	4,412	6,000
RWC	855	860
Cal Cities Water	1,332	2,370
Other Urban Purveyors	1,025	1,590
Additional Urban Land to be Incorporated to Service Area of Urban Water Purveyor	695	0
Total	8,319	10,820

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WATER RESOURCES DIVISION – SANTA BARBARA

MEMORANDUM

ATTORNEY WORK PRODUCT
CONFIDENTIAL AND PRIVILEGED

TO: R. G. Beeby

FROM: Mark Bandurraga

RE: Surface Water Outflow from the Nipomo Mesa Management Area (3994)

DATE: July 16, 2002

The purpose of this memorandum is to describe the work done to add a surface outflow component to the hydrologic inventory of the Nipomo Mesa Management Area (NMMA). Based on discussions with the Technical Advisory Committee (TAC) on June 3, 2002 (see memo dated June 4, 2002, entitled *memo_TAC Meeting6_03_02.doc*) it was concluded that the omission of surface water outflow from the NMMA hydrologic inventory may be causing an overestimate of the water supply component. This study evaluated the available areas likely to contribute surface water outflow from the NMMA, rainfall amounts causing the outflow, and percentage of rain occurring as outflow from the NMMA. The results show that approximately 1,600 acres may contribute surface water outflow from the NMMA in water years with greater than 25 inches of rainfall. The percent of rain occurring as surface water outflow from the NMMA is estimated to be approximately 3 percent of the total water year rainfall. If a surface water outflow component is included in the inventory, approximately 490 acre-feet exits the NMMA as surface water outflow, reducing the volume of water available for groundwater recharge in the hydrologic inventory.

1.0 AREAS CONTRIBUTING FLOW OUT OF THE NMMA

Table 1 presents a summary of areas evaluated for potentially contributing surface water outflow from the NMMA study area during rain events as delineated on 1:24,000 scale USGS topographical maps of the area. The steep bluffs adjacent to the Santa Maria River Valley are outside of the NMMA boundary as it is currently drawn, and are not concluded to contribute flow outside of NMMA boundary. The portion of the Nipomo Creek watershed in the NMMA is relatively small and flat compared to the much larger and steeper watershed contributing flow from the hills east of the NMMA, and was assumed to not contribute any surface water outflow from the NMMA.

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Our understanding is that Black Lake Canyon is blocked by a road crossing and a search of news clippings did not find any reports of washouts during rain events which would indicate that significant surface water outflow occurs. Bob Wagner reported at the TAC meeting that he had verified with hydrologist Tim Cleath (see 6/4/02 memo referenced above) that Black Lake Canyon is considered to have minimal surface water outflow. Therefore, the total area that contributes surface flow out of the NMMA boundary includes the bluffs adjacent to Arroyo Grande Valley and the portion of the Los Berros Creek watershed that is inside the NMMA boundary, a total of approximately 1,600 acres.

Table 1. Areas Potentially Contributing Surface Water Outflow from the NMMA

Area Description	Approx. Area in NMMA (Acres)
Los Berros Creek Watershed in NMMA	1,500
Steep bluffs between the top and toe of the NMMA adjacent to Arroyo Grande Valley	100
Black Lake Canyon in NMMA	2,100
Steep bluffs between the top and toe of the NMMA adjacent to Santa Maria River Valley	0
Nipomo Creek Watershed in NMMA	0

2.0 RAINFALL EVALUATION

The Nipomo CDF gage data used to evaluated precipitation water supply in the hydrologic inventory were used develop criteria for the amount of rainfall leading to significant surface water runoff out of the NMMA. Monthly data were available from 1959 through 2000, while daily data were available from 1980 through 2000. Table 2 shows a summary of rainfall data evaluation results as follows:

1. The years with the highest water year total rainfall during the hydrologic inventory study period of 1975 through 2000 were 1978, 1983, 1995, and 1998, with total water year rainfall of 30.7, 33.2, 25.5 and 33.7 inches, respectively.

2. Most of the months during the study period had rainfall totals less than 7.2 inches. Six months during the study period had rainfall totals greater than 8.6 inches. Three of these months occurred during water years with greater than 25 inches of rainfall and were preceded by two months with at least eight inches of rainfall leading to very wet antecedent moisture conditions. The other three months occurred during relatively dry years or had relatively dry antecedent moisture conditions.

Table 2. Summary of Rainfall Data for Months with Rainfall Totals Greater Than Five Inches
(All Rainfall Depths in Inches)

Year	Water Year Rainfall	Month	Monthly Total Rainfall	No. of Storm Totals > 1" During Month (1)	Max. Storm Total Rainfall	Prev. 2 Mos Rainfall
1998	33.67	FEB	10.71	4	2.65	8.86
1995	25.47	JAN	11.35	3	4.56	2.11
1995	25.47	MAR	8.64	3	4.5	12.38
1996	16.54	FEB	9.53	2	4.52	4.64
1983	33.21	JAN	6.3	3	3.03	6.30
1983	33.21	FEB	9.18	2	3.22	8.43
1983	33.21	MAR	6.8	2	7.11 (2)	15.48
1991	13.06	MAR	10.77	3	5.11	1.34
1997	20.50	JAN	6.37	3	2.81	11.67
1997	33.67	NOV	5.17	1	2.2	0.23
1993	20.17	JAN	6.46	2	3.5	2.98
1986	16.85	MAR	5.44	3	1.81	6.37
1996	16.54	DEC	7.16	1	4.48	6.71
1992	15.66	FEB	6.62	3	3.71	5.96
2000	14.47	FEB	7.13	2	3.2	3.48
1981	13.39	MAR	5.14	3	2.77	6.20
1988	12.66	DEC	6.1	3	2.23	1.38

(1) Storm totals include rain on consecutive days separated from other storms by at least one dry day.

(2) Storm total includes 3.79 inches from rainfall occurring at the end of February.

Based on these data, it was assumed that runoff occurred from the NMMA during months with rainfall totals greater than 8.6 inches and with at least eight inches of rainfall occurring in the preceding two months. These conditions are met in water years with rainfall greater than 25 inches during the study period.

3.0 RUNOFF COEFFICIENT

Soil surveys (USDA SCS Table 14) of the NMMA show the uppermost soils to be primarily Oceano, of hydrologic group A characterized by relatively high permeabilities and low runoff. The permeability range given for this soil is 6 to 20 inches per hour. Approximately 30% of the soils in the portion of the watersheds contributing surface water outflow from the NMMA to Los Berros Creek and the Arroyo Grande Valley are Still, Chamise, and mixed soils of the steep escarpments, hydrologic groups B, C, and C, respectively. Aerial photos of the Los Berros Creek watershed in the NMMA and the bluffs adjacent to Arroyo Grande Valley contributing surface water outflow from the NMMA show them to be relatively undeveloped, with significant areas of native vegetation and agriculture. Ponce (1989) provides SCS curve numbers for a unit hydrograph runoff model for low density rural development, brush, and pasture areas ranging from 39 to 79 depending on the percent impervious area assumed, hydrologic condition of the vegetation, and soil type. For this study, a weighted-area composite curve number of 49 was calculated to represent the mixed land uses contributing surface water outflow.

The SCS curve number was used with storm total rainfalls to estimate the runoff for each storm occurring in a month with at least 8.6 inches of rainfall and at least 8 inches of rainfall occurring in the previous two months (February and March 1983, March 1995, and February 1998). The storms occurring in March 1983 were included in the runoff analysis because although the total monthly rainfall was less than 8.6 inches, the largest storm in the study period started in the final days of February and continued into the beginning of March. The average percent runoff of water year precipitation was calculated from the storm runoff results. The annual results were averaged to provide a mean value of the percent of runoff of approximately 3 percent of annual rainfall. Based on this, it was assumed that an average of approximately 3 percent of the rain falling on the areas contributing outflow from the NMMA would occur as surface water outflow in a water year with greater than 25 inches of rainfall.

3.0 STUDY RESULTS

If surface water outflow is included in the inventory as described above, approximately 490 acre-feet is estimated to exit the NMMA as surface water outflow during the study period. This reduces the volume of water available for groundwater recharge. Table 3 summarizes the estimated annual surface water outflow volumes during the study period water years with more than 25 inches of rainfall.

Table 3. Surface Water Outflow During Water Years with Greater Than 25 Inches of Rainfall

Water Year	Annual Surface Water Outflow Rounded to nearest 10 (Acre-Feet)
1978	-120
1983	-130
1995	-100
1998	-140
Total	-490

References:

Ponce, VM, 1989. Engineering Hydrology- Principles and Practices, Prentice-Hall, New Jersey, USA.

USDA SCS. Soil Survey of San Luis Obispo County, California, Coastal Part.

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
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MEMORANDUM

ATTORNEY WORK PRODUCT
CONFIDENTIAL AND PRIVILEGED

TO: R. G. Beeby

FROM: Diane Ohlmann and Mark Bandurraga

RE: NMMA Estimate of Root Zone Deficit and Deep Percolation from Native Vegetation, 01-0122-00-3994-000

DATE: July 25, 2002

The purpose of this memorandum is to describe the revisions made to the estimate of groundwater recharge from deep percolation of rainfall over native vegetation for the Nipomo Mesa Management Area (NMMA) Hydrologic Inventory. At a June 3, 2002 TAC meeting and June 13, 2002 meeting at Richards, Watson & Gershon (RWG), it was discussed that when estimating deep percolation from rainfall over native vegetation, the Hydrologic Inventory should account for moisture deficits in the root zone due to previous dry years. The Hydrologic Inventory results shown at the TAC meeting and at the meeting with RWG did not account for any deficit in the root zone.

Since the meetings, soil-deficit accounting has been added to the Hydrologic Inventory spreadsheet. This memorandum provides a summary of the assumptions used and the results to the cumulative change in storage calculation resulting from adding the soil deficit accounting.

Trees and Shrubs

- For 1975 – 2000 it was assumed that 40 percent of the native vegetation land use was trees and shrubs based on GIS area calculations from the distribution shown in 1994 aerial photography. Aerial photos show that the areas defined as native trees are a mixture of trees and shrubs.

- It has been reported that Eucalyptus trees have a root zone around three to four feet whereas Oak shrubs have a root zone depth of up to 12 to 14 feet. (Refer to memorandum entitled "MEMORANDUMSoilsandVegRootDepth.doc" by Sam Schaefer, dated June 5, 2002, and contact report with Ben Farbor of UCCE dated June 7, 2002).

- Due to the predominance of eucalyptus trees based on field observations of native vegetation in the NMMA, the representative root zone depth for native tree areas was assigned as five feet. This assumes that 90 percent of the native tree areas consist of Eucalyptus trees, with the remaining 10 percent consisting of Oak shrubs or similar vegetation.

Native Grasses

- For 1975 – 2000 it was assumed that 60 percent of the native land use was predominantly grasses based on GIS area calculations from the distribution shown in 1994 aerial photography.

- It has been reported that the native grass areas have annual grasses with root zone depths around one to two feet and weeds with roots up to 10 feet. (Refer to memorandum referenced above by Sam Schaefer based on discussions with Royce Larson of UCCE, dated June 5, 2002, and contact report with Ben Farbor of UCCE dated June 7, 2002).

- Grasses were assigned a root zone of 2 feet corresponding to the upper end of the range for annual grasses provided above and assuming that relatively deep rooted weeds do not comprise a large percentage of the native grass areas.

The water holding capacity of the soils in the San Luis Obispo area are estimated to be about 0.05 to 0.08 in/in (See memorandum referenced above by Sam Schaefer, dated June 5, 2002). The water holding capacity of a soil is defined as the water available for use by plants. Water holding capacity was multiplied by root zone depth to derive a total water availability (in inches) for trees and grasses. The water holding capacity selected for use in the Hydrologic Inventory was the upper end of the range described above. Table 1 (below) provides a breakdown of the variables used for the root zone deficit calculation.

Table 1. Root Zone and Available Water for Soils in the Nipomo Mesa

Native Vegetation Category	Root Zone Depth (feet)	Water Holding Capacity (Inch/Inch)	Water Holding Capacity Inches/Foot	Water Availability of Root Zone (rounded to nearest inch)
Trees and Shrubs	5	0.08	0.96	5
Grasses	2	0.08	0.96	2

For the spreadsheet soil-deficit accounting, it was assumed that in the study period start year of 1975, there was no water deficit in the root zone. If rainfall was not sufficient to meet the plants' consumptive needs, they used water from the soil. At the end of the year, the soil could be in a deficit up to the water availability of the root zone. The following year, the native vegetation would need rainfall to make up the deficit in the root zone plus meet consumptive needs before any deep percolation of rainfall could occur.

The hydrologic inventory results presented June 14, 2002, showed a cumulative change in groundwater storage of approximately -5,760 acre-feet (AF) over the study period from 1975 through 2000. By including root zone deficit accounting in the estimates for groundwater recharge from deep percolation over native vegetation, the cumulative change in groundwater storage over the study period is -18,060 AF. This is an increase in deficit of 12,300 AF.

The last year in the study period, year 2000, is a dry year which results in an end of year soil deficit in both the native trees and shrubs and the grasses. The root zone deficit at the end of year 2000 is 1,700 AF for the trees and shrubs and 1,020 AF for the grasses, a total of 2,720 AF. Because it was assumed that there was no deficit in the root zone at the start of the study period (1975), the root zone deficit can be added to the cumulative deficit at the end of study period to show the total change in groundwater storage and root zone moisture. If this is done, the cumulative change in groundwater storage and root zone moisture over the study period is 20,780 AF.

MEMORANDUM

ATTORNEY WORK PRODUCT
CONFIDENTIAL AND PRIVILEGED

TO: R. G. Beeby

FROM: Mark Bandurraga

RE: Assumptions Used in Safe Yield Calculations for NMMA Hydrologic Inventory

DATE: August 1, 2002

This memo provides a summary of the assumptions used in calculating safe yields from the hydrologic inventory results for the Nipomo Mesa Management Area (NMMA) The assumptions used to provide the hydrologic inventory results are summarized in other detailed memos (See Hydrologic Inventory Memo contained in Summary Binder).

1. Production Safe Yield and Consumptive Safe Yield Calculations

Current and projected Production and Consumptive Safe Yields were estimated using three different conditions to revise portions of the hydrologic inventory as follows:

Condition 1: 1996 Safe Yield Calculations Using Study Period Average Water Supply and 1996 Land Uses, Consumptive Uses, and Groundwater Production

1. Applied 1996 land uses for the 1975 through 2000 study period to calculate the net deep percolation of precipitation over the study period based on 1996 cultural practices.
2. Used the study period average subsurface inflow and subsurface and surface outflow from the hydrologic inventory results.
3. Applied 1996 consumptive use of production and groundwater production estimates.

Condition 2: 1996 Safe Yield Calculations Revised to Account for the Drier Long-Term Average

1. Adjusted the results from Condition 1 to reflect that the average rainfall from 1975 through 2000 was greater than the period of record average rainfall from the Nipomo CDF gage used in the inventory. The average annual rainfall from available gage data from 1959-2000 is approximately 92.8 percent of the average annual rainfall during the study period 1975-2000. The drier long-term average was evaluated by multiplying the

Condition 1 study period average deep percolation of precipitation, subsurface inflow, surface outflow and groundwater outflow by 0.928 for use in the Safe Yield calculations.

2. Used 1996 consumptive use of production and groundwater production. The maximum change in consumptive use of groundwater due to a 7.2 percent reduction in rainfall is estimated to be an increase of 7.2 percent, or approximately 400 acre-feet. This would affect the safe yield calculations.

<u>Condition 3: Safe Yield Calculations Using 2020 Data Revised to Reflect Drier Long-Term Average Conditions</u>

1. 2020 urban water groundwater production data obtained from water service agencies in NMMA. Consumptive use of urban production assumed to be 56% of production consistent with hydrologic inventory approach.

2. Reduced the long-term average study period subsurface inflow and subsurface and surface outflow as described for Condition 2 to reflect drier long-term average conditions.

3. Applied projected 2020 land uses for the 1975 through 2000 study period to estimate the net deep percolation from rainfall, and reduced the resultant net deep percolation by 7.2 percent to reflect drier long-term average conditions.

4. Assumed the 2020 consumptive use of production and groundwater production for agriculture was the same as year 2000. Used golf course consumptive use of production and groundwater production calculated for 2020 conditions.