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1995 LEVEL HYDROLOGY FOR THE CENTRAL VALLEY OF CALIFORNIA (Excluding Tulare Basin)

Hydrology HYD-C-01
for
Department of Water Resources
Simulated Operation Studies

INTRODUCTION

The Department of Water Resources' Division of Planning has recently completed the development of a 1995 level hydrology, titled HYD-C-01, for use in planning studies. The hydrology is based on agricultural land use projections made for the upcoming Bulletin 160-93, and outdoor irrigated urban projections from Bulletin 160-83 corrected for later surveys. Urban projections for Bulletin 160-93 were not available.

The purpose of this report is to:

- o give a general description of hydrology development
- o summarize the previous hydrologies developed to date
- o summarize the land use and water supply available to the Delta

HYDROLOGY DEVELOPMENT

The main objective of developing a hydrology is to provide input to the Department's reservoir simulation model DWRSIM. The hydrology represents the water supply of the Central Valley (excluding Tulare Basin) available to the SWP and CVP systems at some specified level of development assuming that the historical measured precipitation would occur during the study period in the same pattern and quantity. The study period for the Department's latest hydrology is the period October 1922 through September 1991, in monthly time steps.

The Central Valley is divided into drainage and service areas from which water supplies and demands can be more easily evaluated. The individual areas are called depletion areas. The lowest elevation on the main river in the depletion area is called an "outflow point". The Central Valley has been divided into 37 depletion study areas as shown in Figure 1 (Depletion Area 55 shown represents the Delta Uplands and Delta Lowlands). Boundaries used to define each area are based on drainage area lines in the mountain areas, and a combination of drainage and water service area lines in the valley floor areas. Table 1 is a list of Depletion areas grouped by their geographical location in Central Valley, beginning with the northern-most area.

Development of a hydrology for use in the Department of Water Resources Operation Studies consists of carrying out three types of studies in sequence as shown in the schematic of Figure 2.

Consumptive Use Studies evaluate 70 years of historic and future water use by depletion study areas using:

- o historic agricultural and urban acreages (vary with time)
- o projected agricultural and urban acreages (constant with time)
- o monthly evapotranspiration rates
- o monthly precipitation rates
- o soil moistute storage criteria

Output from the CU studies becomes input to the depletion analysis studies described next.

Depletion Analysis Studies are used to determine the effect of future water demands and future storage and diversion regulation on the historical flows of the river systems tributary to the delta. Historic outflow for any depletion area usually begins with flow data that is measured at a gage located at the outflow point. The depletion analysis method computes the future outflow of a depletion area by adjusting the historic outflow for any changes in water use occuring upstream from the outflow point.

A depletion analysis for the most upstream area is computed first. The depletion program basically computes the projected outflow of the area by adjusting its historic outflow for any changes in depletion, local reservoir regulation, imports and exports that are expected to occur above the outflow point. Differences in projected and historic outflow for the area represent the total change made above the outflow point. These differences are called "upstream area modification". The upstream area modification table is input into the next downstream area and the projected outflow for the area is computed.

Reservoirs are separated into system and local reservoirs. System reservoirs are those reservoirs which are to be operated in the DWR simulation model DWRSIM. They include Shasta, Whiskeytown, Oroville, Folsom and New Melones reservoirs. System diversions include Trinity River imports to J.F. Carr power plant and American River diversion by Folsom South Canal. In the Depletion Analysis the historic effects of system reservoirs and diversions are removed from the historic supply. Projected effects for system reservoirs are limited to "project water". "Project Water" is the water needed from the system reservoir storage to supply future diversion requirements in the area. For non-system reservoirs (local reservoirs), the historic effects are removed, and a projected operation built back into the analysis.

Consumptive use and depletion studies are performed on those depletion study areas which are considered to have a significant change between historic and future demands and storage regulation.

Preparing Input to DWRSIM is the final step in the hydrology development. Consumptive use and depletion analysis data is converted to local inflows (IN's) and diversions (YD's) for the control points in the DWRSIM network.

YD's include such items as:

- o projected exports
- o direct diversions
- o diversion to ground water storage (above historic values)
- o consumptive use (depletion)
- o projected imports

IN's are local accretions and represent runoff from local precipitation less unaccounted losses.

For a given operation study, DWRSIM incorporates the depletion study results (IN's and YD's) and regulates the water supply available to meet D-1485 (or any prespecified) standards, exports outside of the DElta service area, flood control, fish/wildlife requirements, and navigation criteria.

SUMMARY OF PREVIOUS HYDROLOGIES

Since the late 1970's three main hydrologies have been developed each with variations as shown in Table 2. They differ mainly in the land use projections used to develop the hydrology, and the length of the historic period included. Hydrlogy series A is based on land use projections from Bulletin 160-74 for the 1980 and 2000 levels of development. The 1990 level is a hybrid of the 1980 and 2000 levels. Hydrology series B was based on land use projections from Bulletin 160-83. Hydrology series C is based on Bulletin 160-93 projections for irrigated crop acreages and Bulletin 160-83 projections for outdoor urban acreages corrected for later surveys. Hydrology HYD-C-01 is the latest hydrology developed for use by DWRSIM.

HYDROLOGY HYD-C-01

The latest hydrology developed for DWRSIM planning studies began with the previous hydrology (HYD-B-01a) as a base and updated the land use projections.

Land Use Projections: For irrigated crop acreages the values used were those estimated from the 1990 normalized land use surveys for use in Bulletin 160-93. These acreages are expected to remain relatively constant throughout the 1990s. Since urban projections for Bulletin 160-93 were not yet available, projections for the year 1995 from Bulletin 160-83 were used. The urban projections, however, were corrected with data available from recent surveys. Table 3 lists the crop and urban acreages used for the valley floor depletion areas (shown in Figure 1). Table 4 summarizes the total agricultural and urban acreages by depletion area and aggregated by basin for actual 1990 historical (surveyed), for the projections used in Hydrology series B, and for the projections used in Hydrology series C. Figure 3 shows a summary of the irrigated land use by basin. Figure 4 shows total land use by depletion area and the increase over the previous hydrology projections (negative value indicates a decrease). Figure 5 shows the various irrigated crop and urban acreages for the Central Valley (excluding Tulare Basin). Figures 6 through 10 are the irrigated crop and urban acreages by basin (shown in Figure 1). Figures 11 through 16 are plots of the historic surveyed and projected land use data for the Central Valley and by basin. As shown in Figure 3 the latest hydrology compared to the previous hydrology has a net decrease in

overall land use by about 267,000 acres (agricultural acreage less by 366,000 acres while urban acreage increased by 100,000 acres).

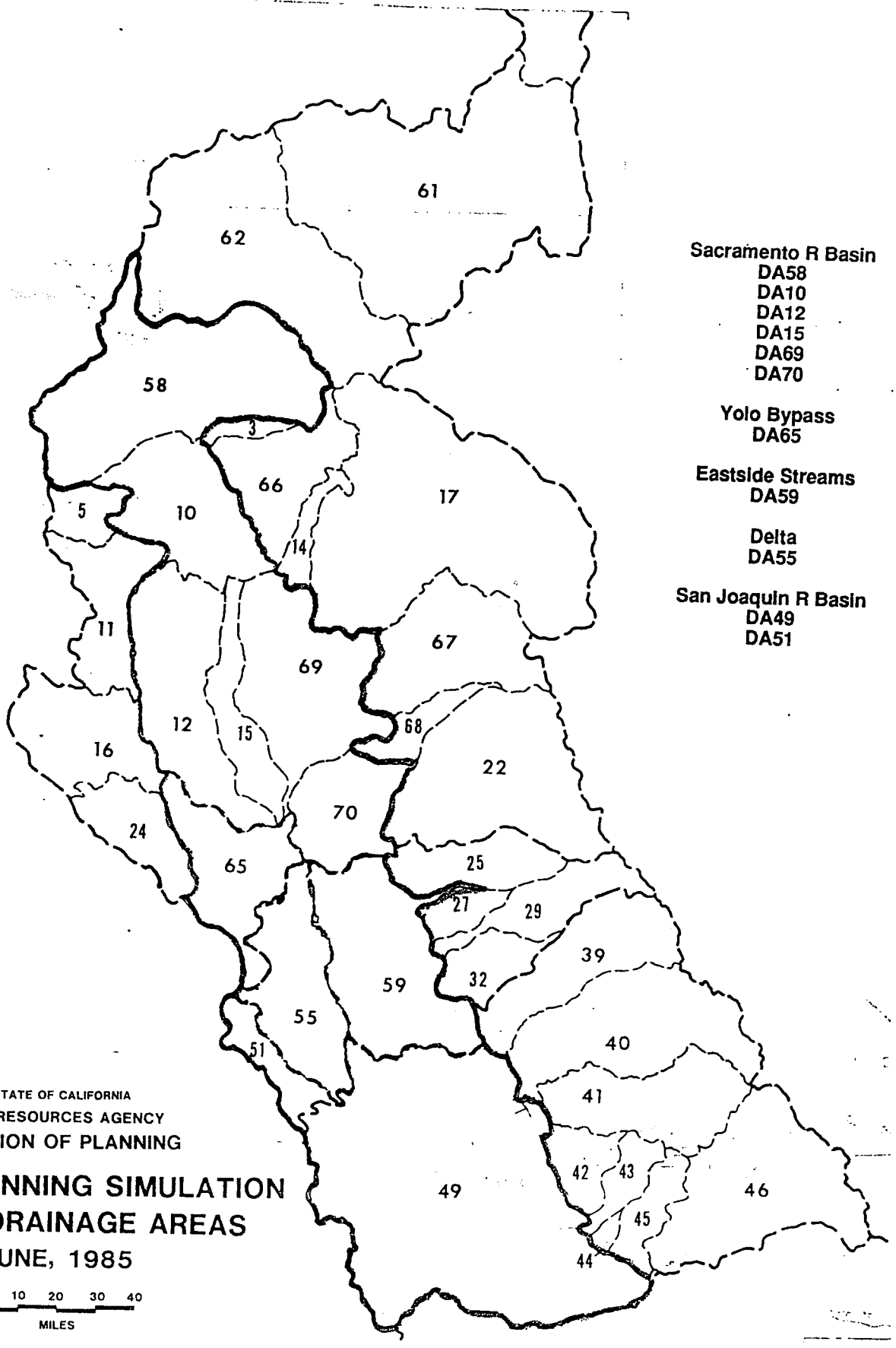
Water Supply to the Delta: Compared to the previous hydrology there is an overall increase in the amount of water reaching the Delta (unregulated for system reservoirs). The values are summarized for various periods in Table 5. For example, for the period 1922-1991 the average annual supply at the Delta is 20,796 TAF per year; an increase of 783 TAF per year compared to hydrology HYD-B-01a. For the critical period of 1928-1934 the increase was 525 TAF per year.

Valley Floor Depletions: Average annual depletions for the 1922-91 period are 12,480 TAF; 5,542 TAF Sacramento Valley Floor, 909 TAF Yolo Bypass, 975 TAF Eastside Streams, and 5,054 TAF for the San Joaquin River Basin.

Ground Water Storage Operation: The additional storage requirements (above historical) are 103 TAF for DA10, 7058 TAF for DA12, 340 TAF for DA15, 9414 TAF for DA49, 1655 TAF for DA59, and 868 TAF for DA65.

The back-up data for the hydrology development including input files and output files to the Consumptive Use Model, the Depletion Analysis Model, and the program to prepare input for DWRSIM is extensive requiring several megabytes of storage electronically. All information, however, is available for review.

Figure 1



Sacramento R Basin
DA58
DA10
DA12
DA15
DA69
DA70

Yolo Bypass
DA65

Eastside Streams
DA59

Delta
DA55

San Joaquin R Basin
DA49
DA51

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DIVISION OF PLANNING

D.W.R. PLANNING SIMULATION MODEL DRAINAGE AREAS

JUNE, 1985

0 10 20 30 40
MILES

Consumptive Use and Depletion Analysis Flowchart

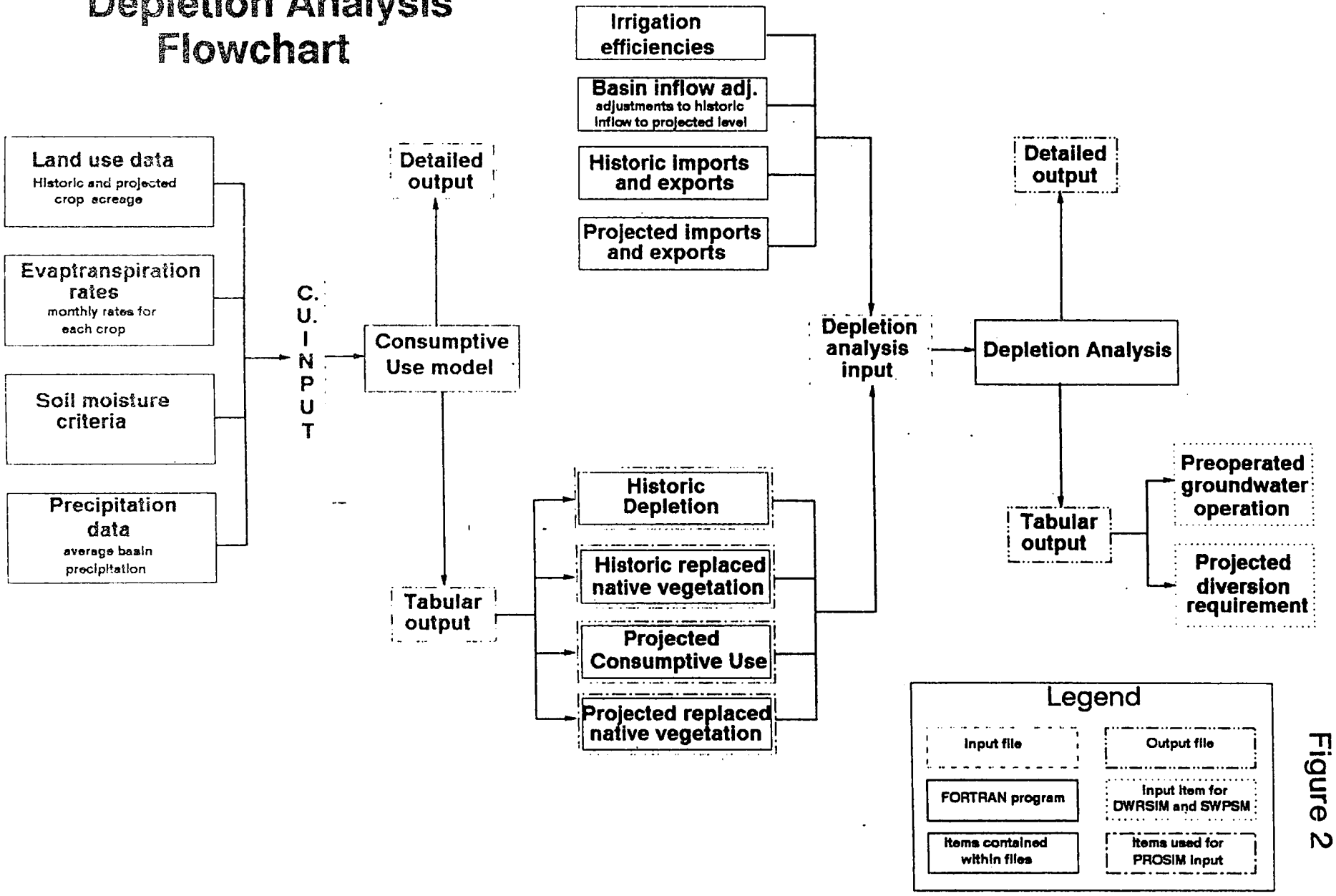
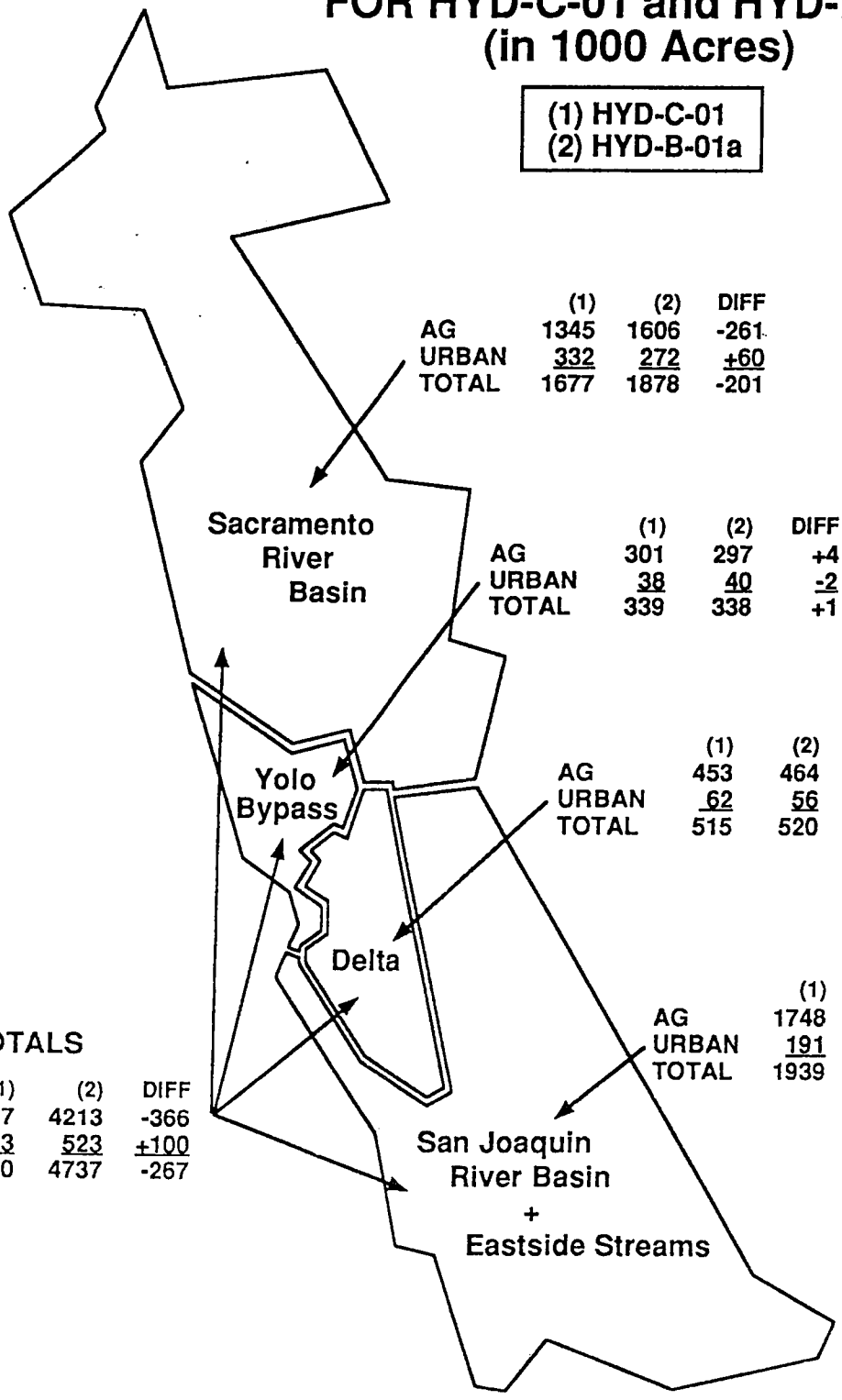


Figure 2

Figure 3

CENTRAL VALLEY FLOOR AREA PROJECTED LAND USE BY BASIN FOR HYD-C-01 and HYD-B-01a (in 1000 Acres)



	(1)	(2)	DIFF
AG	1345	1606	-261
URBAN	332	272	+60
TOTAL	1677	1878	-201

	(1)	(2)	DIFF
AG	301	297	+4
URBAN	38	40	-2
TOTAL	339	338	+1

	(1)	(2)	DIFF
AG	453	464	-11
URBAN	62	56	+6
TOTAL	515	520	-5

	(1)	(2)	DIFF
AG	1748	1846	-98
URBAN	191	156	+35
TOTAL	1939	2001	-62

TOTALS

	(1)	(2)	DIFF
AG	3847	4213	-366
URBAN	623	523	+100
TOTAL	4470	4737	-267

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Figure 4

CENTRAL VALLEY FLOOR AREA PROJECTED LAND USE BY DEPLETION AREA FOR HYD-C-01

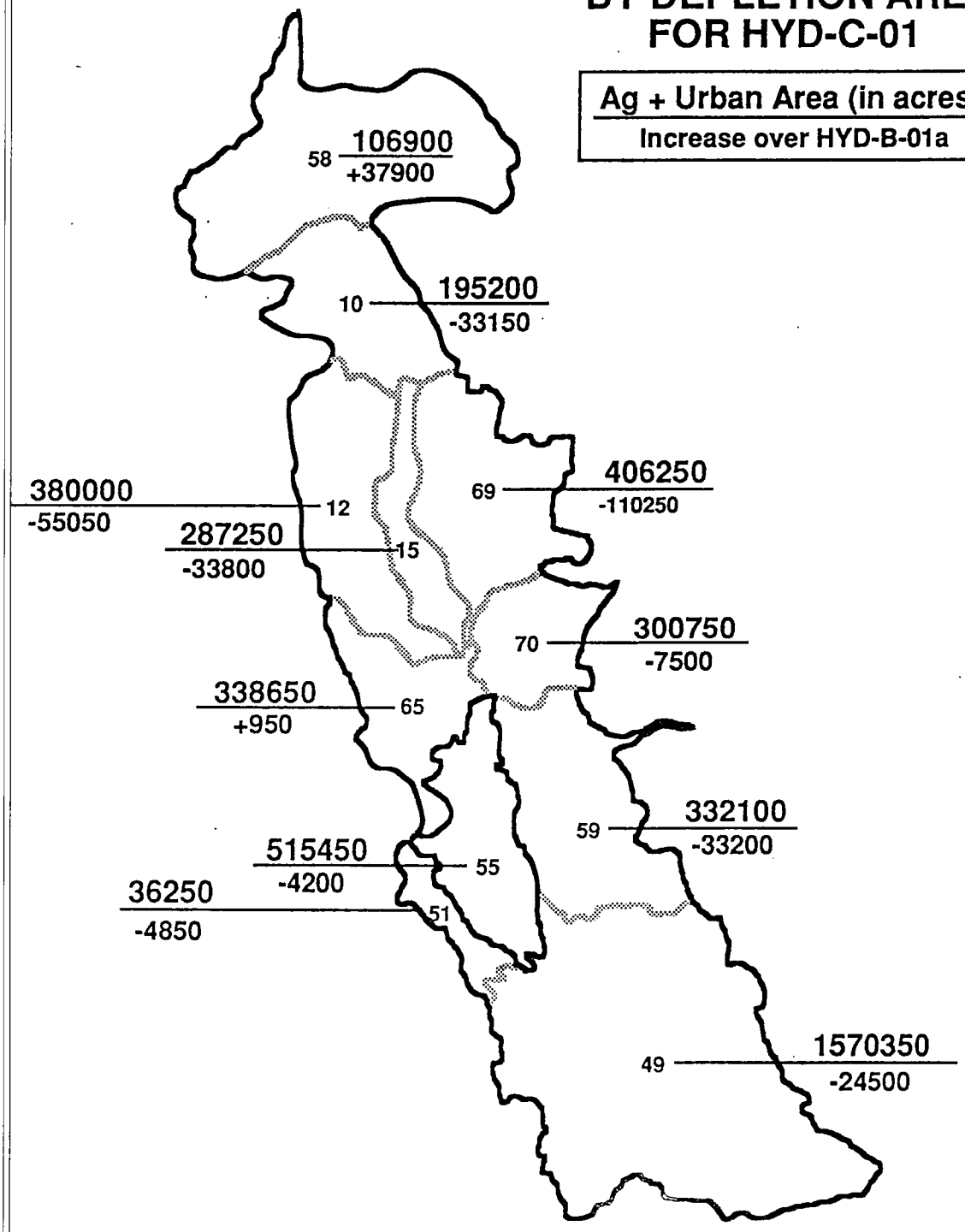

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Figure 5
CENTRAL VALLEY FLOOR AREA CROP AND URBAN ACREAGES
FOR HYD-C-01 AND HYD-B-01a

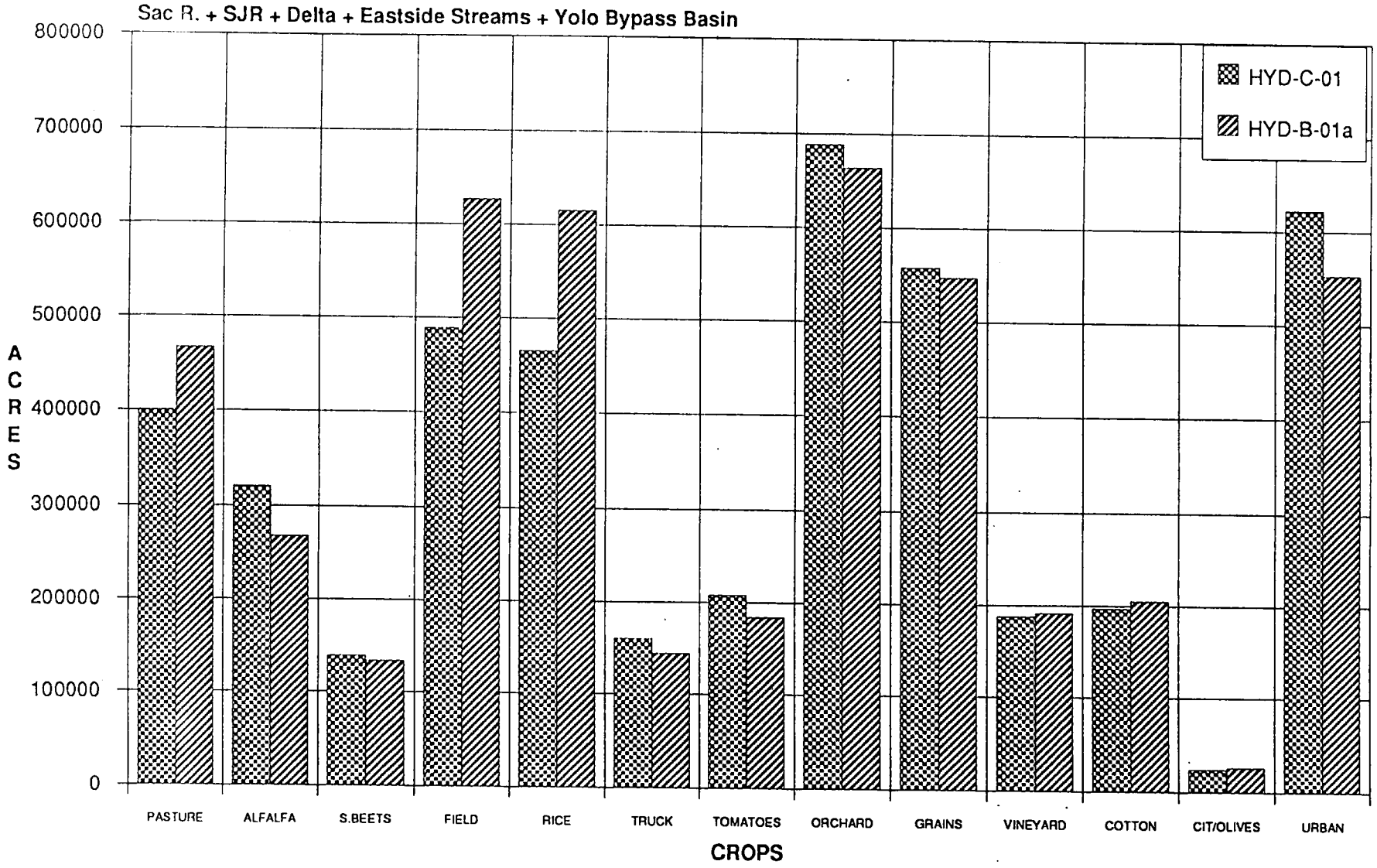

Figure 6
SACRAMENTO RIVER BASIN CROP AND URBAN ACREAGES
FOR HYD-C-01 AND HYD-B-01a

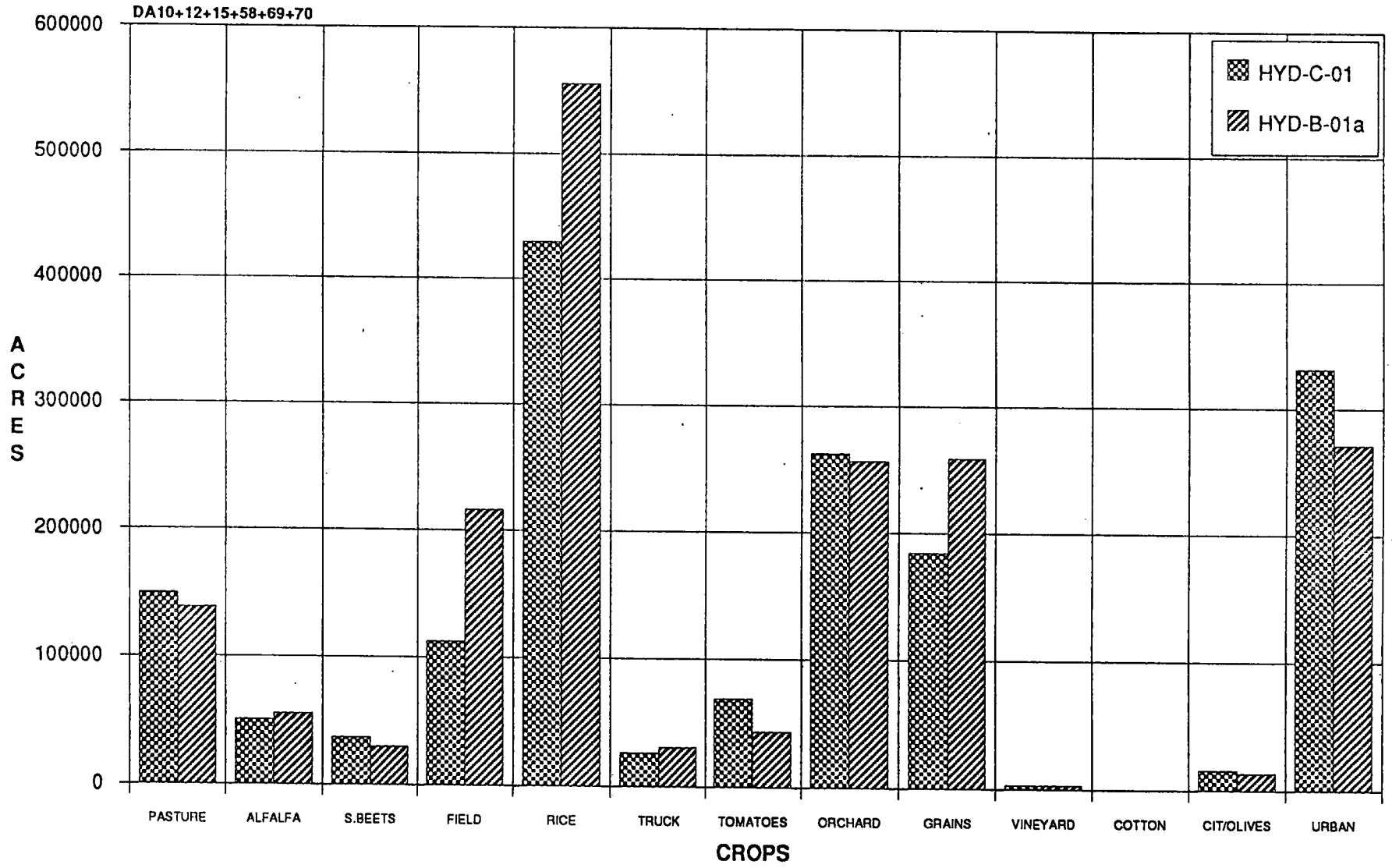

Figure 7
SAN JOAQUIN RIVER BASIN CROP AND URBAN ACREAGES
FOR HYD-C-01 AND HYD-B-01a

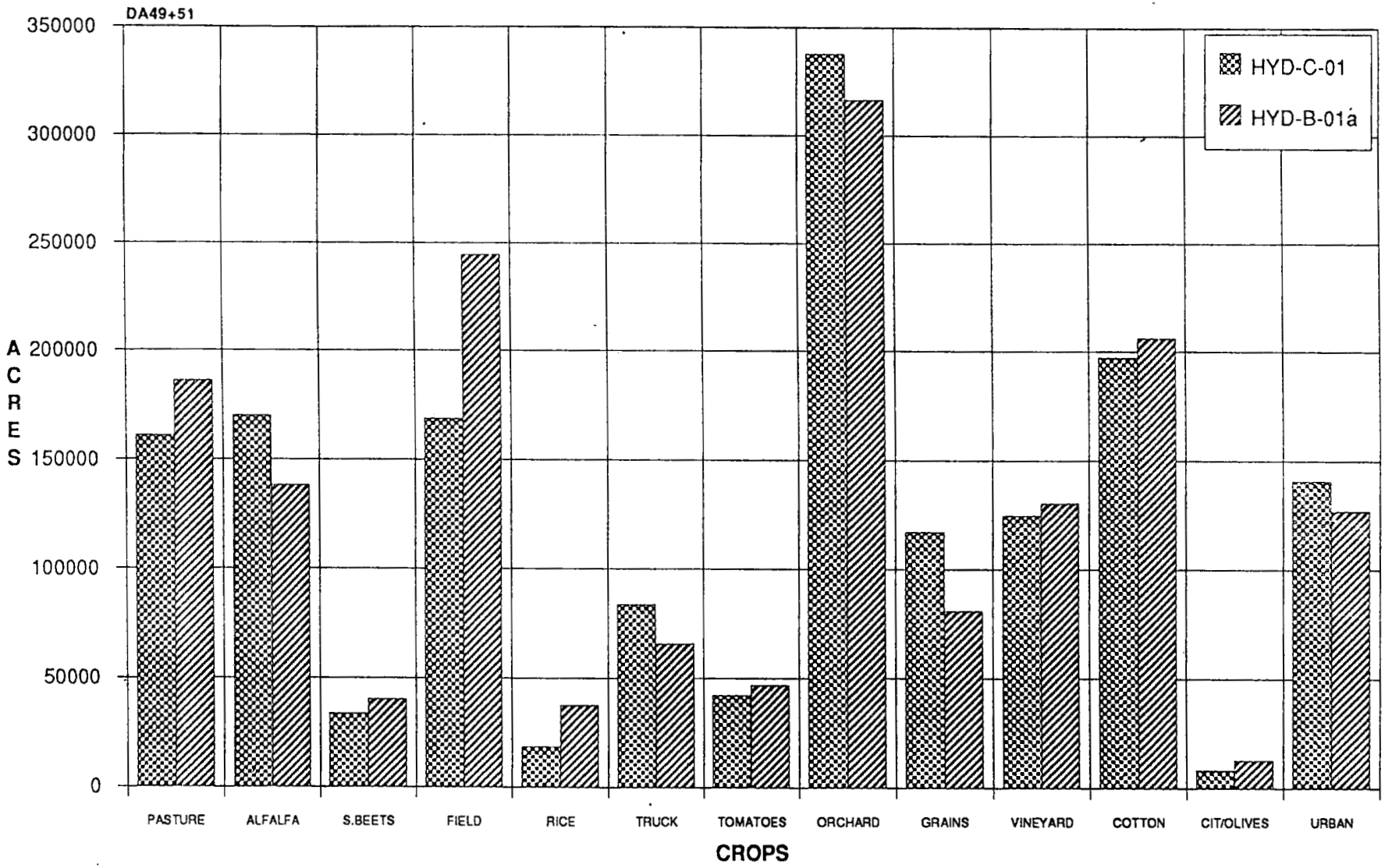

Figure 8
DELTA CROP AND URBAN ACREAGES
FOR HYD-C-01 AND HYD-B-01a

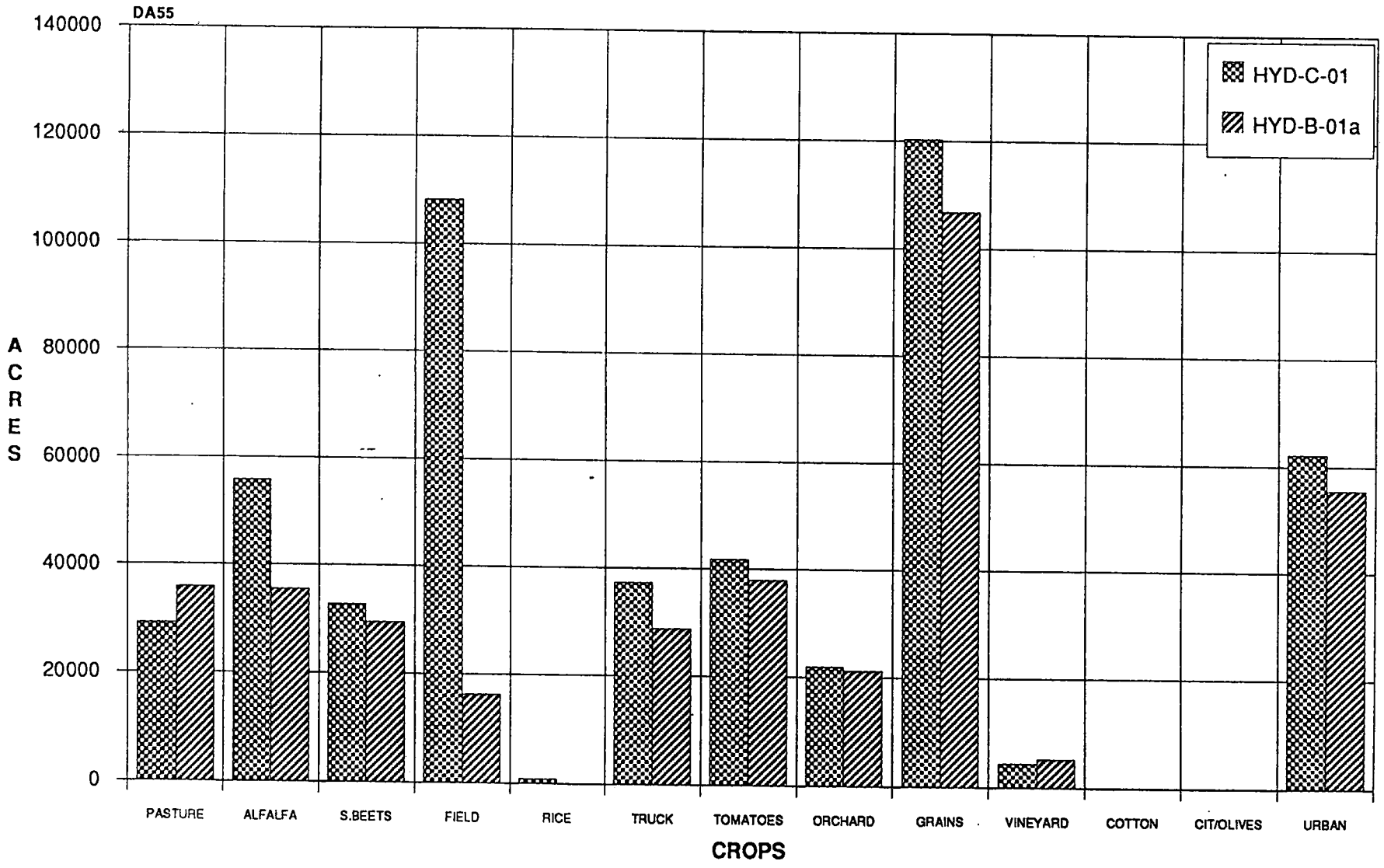

Figure 9
EASTSIDE STREAMS BASIN CROP AND URBAN ACREAGES
FOR HYD-C-01 AND HYD-B-01a

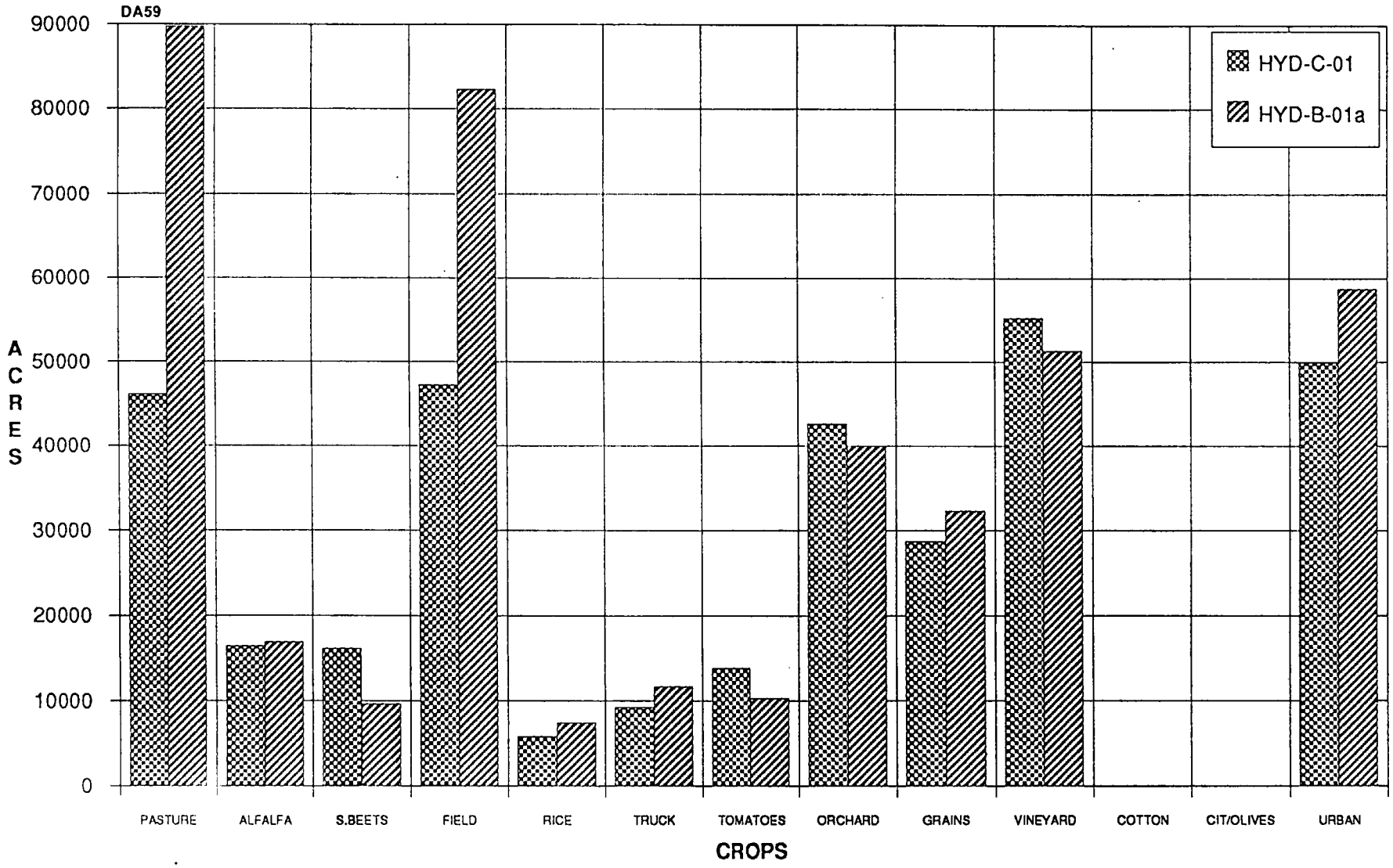

Figure 10
YOLO BYPASS BASIN CROP AND URBAN ACREAGES
FOR HYD-C-01 AND HYD-B-01a

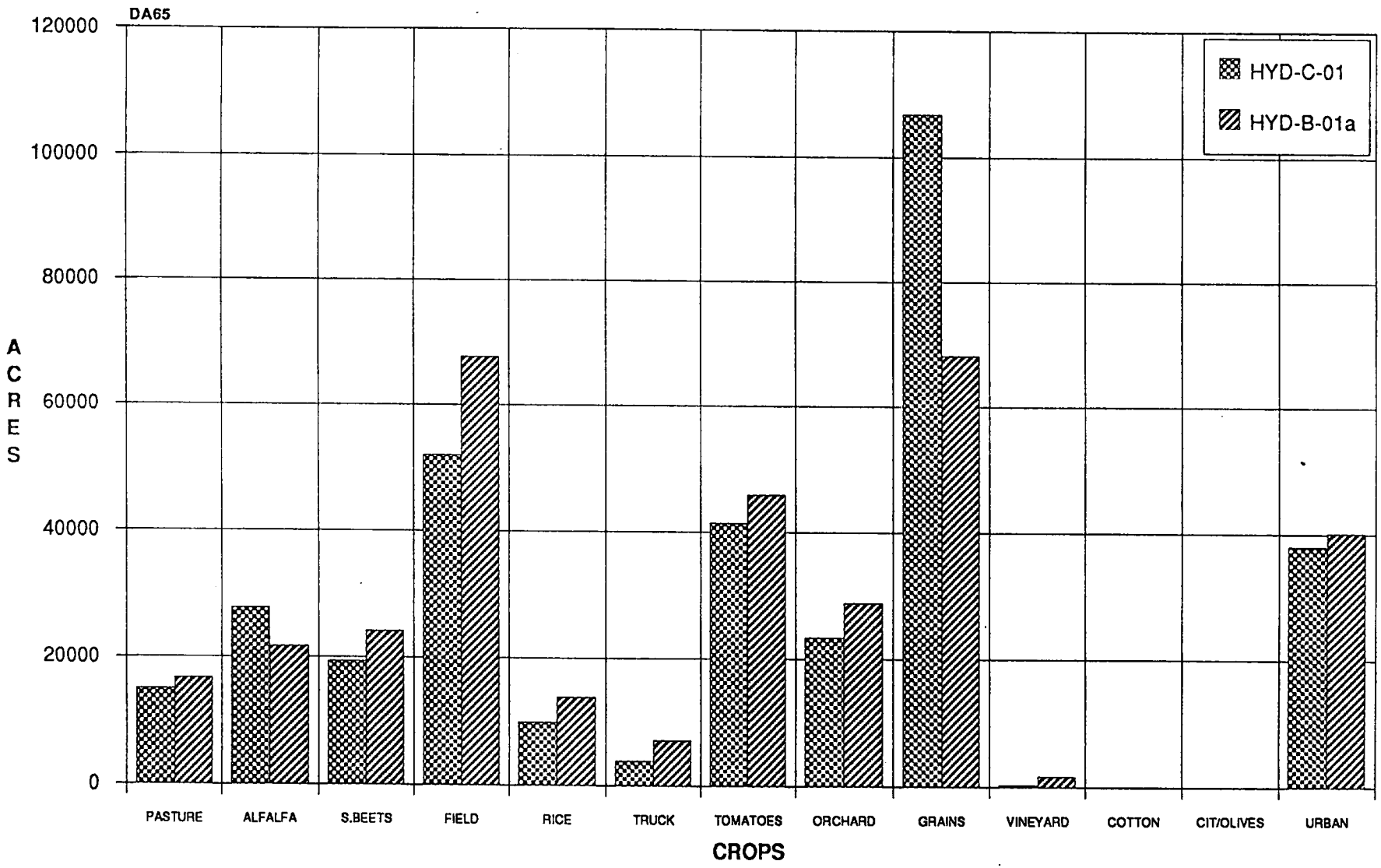

Figure 11

CENTRAL VALLEY FLOOR AREA LAND USE FOR HYD-C-01
(Excluding Tulare Basin)

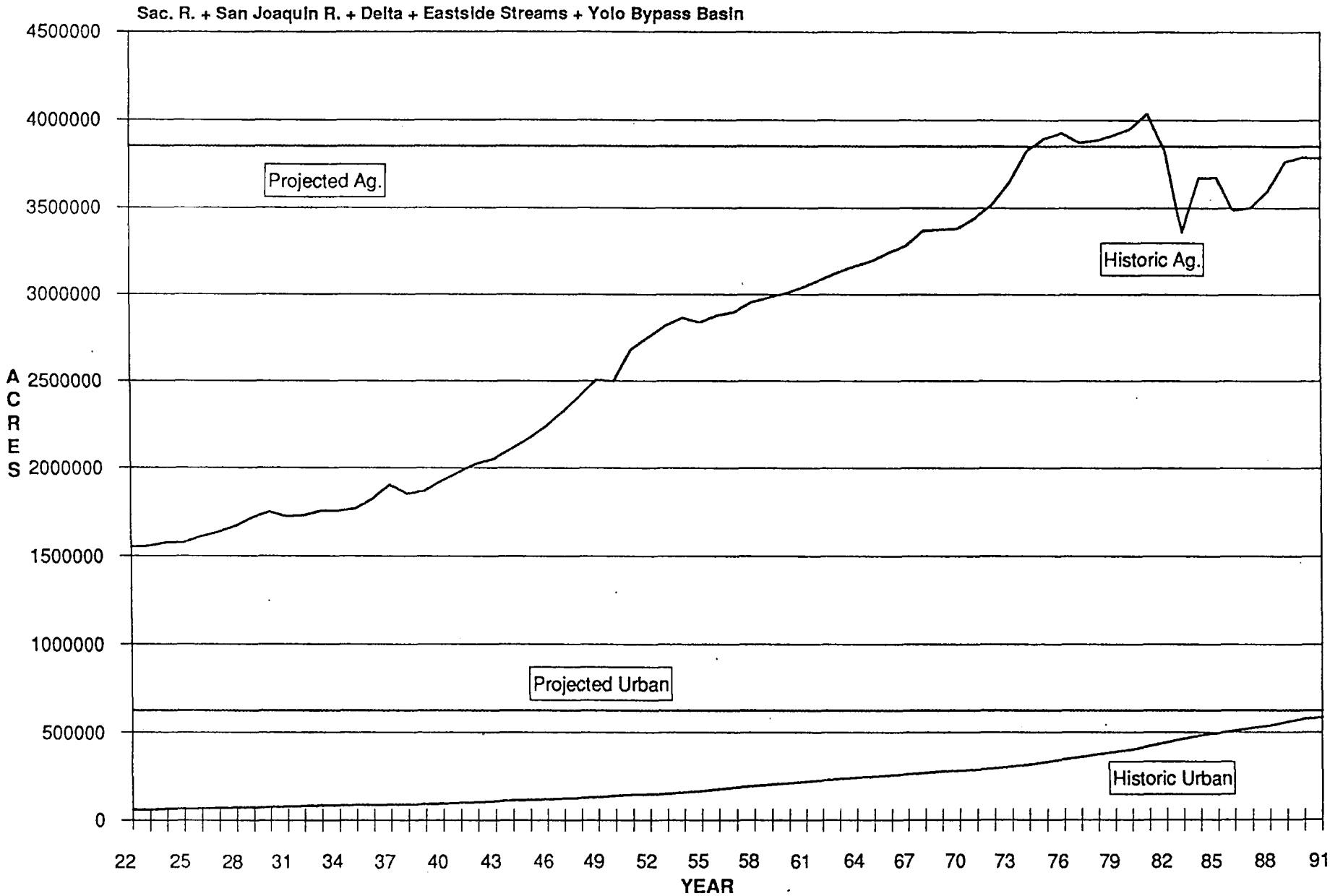

Figure 12

SACRAMENTO RIVER BASIN LAND USE FOR HYD-C-01

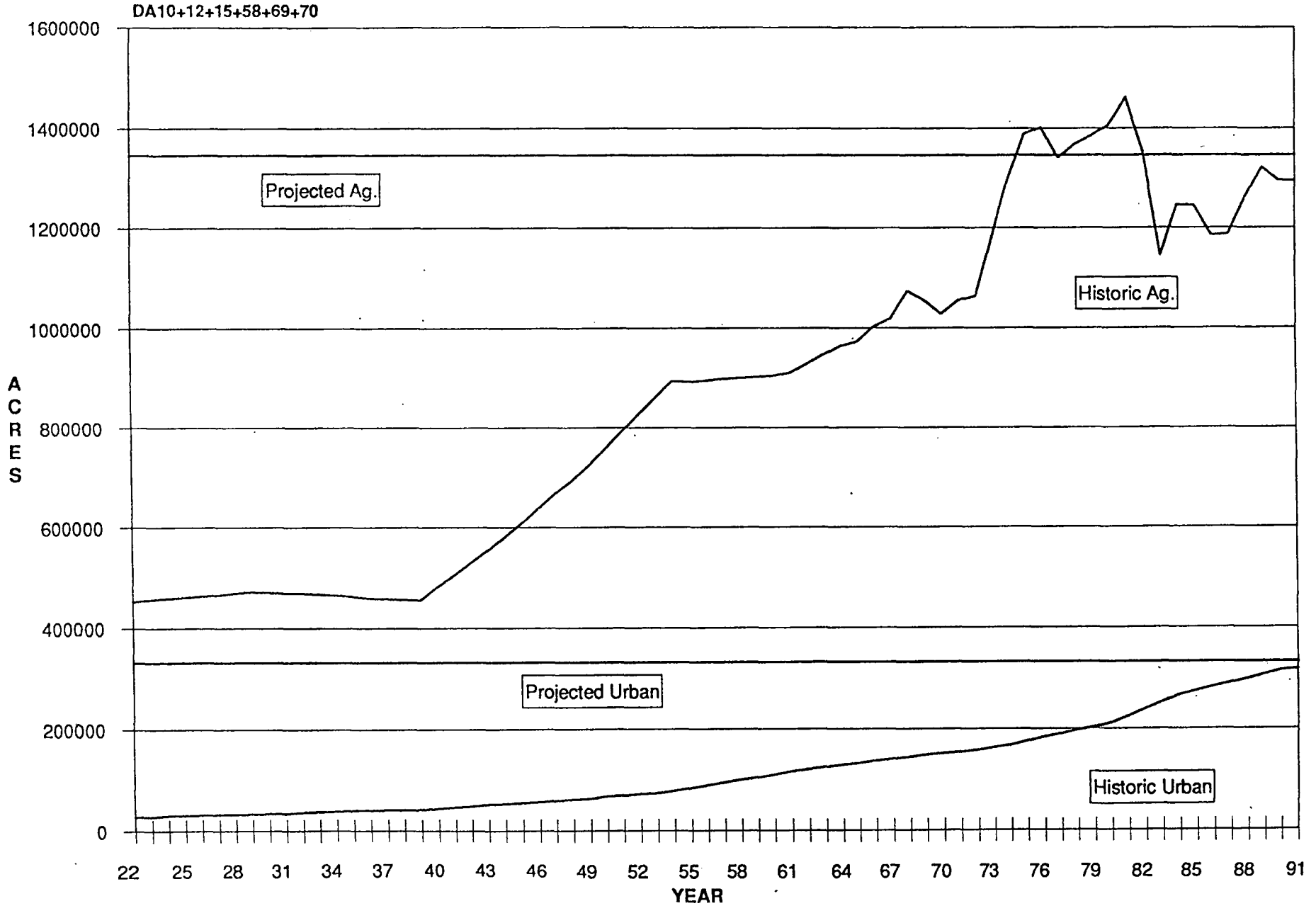

Figure 13

SAN JOAQUIN RIVER BASIN LAND USE FOR HYD-C-01

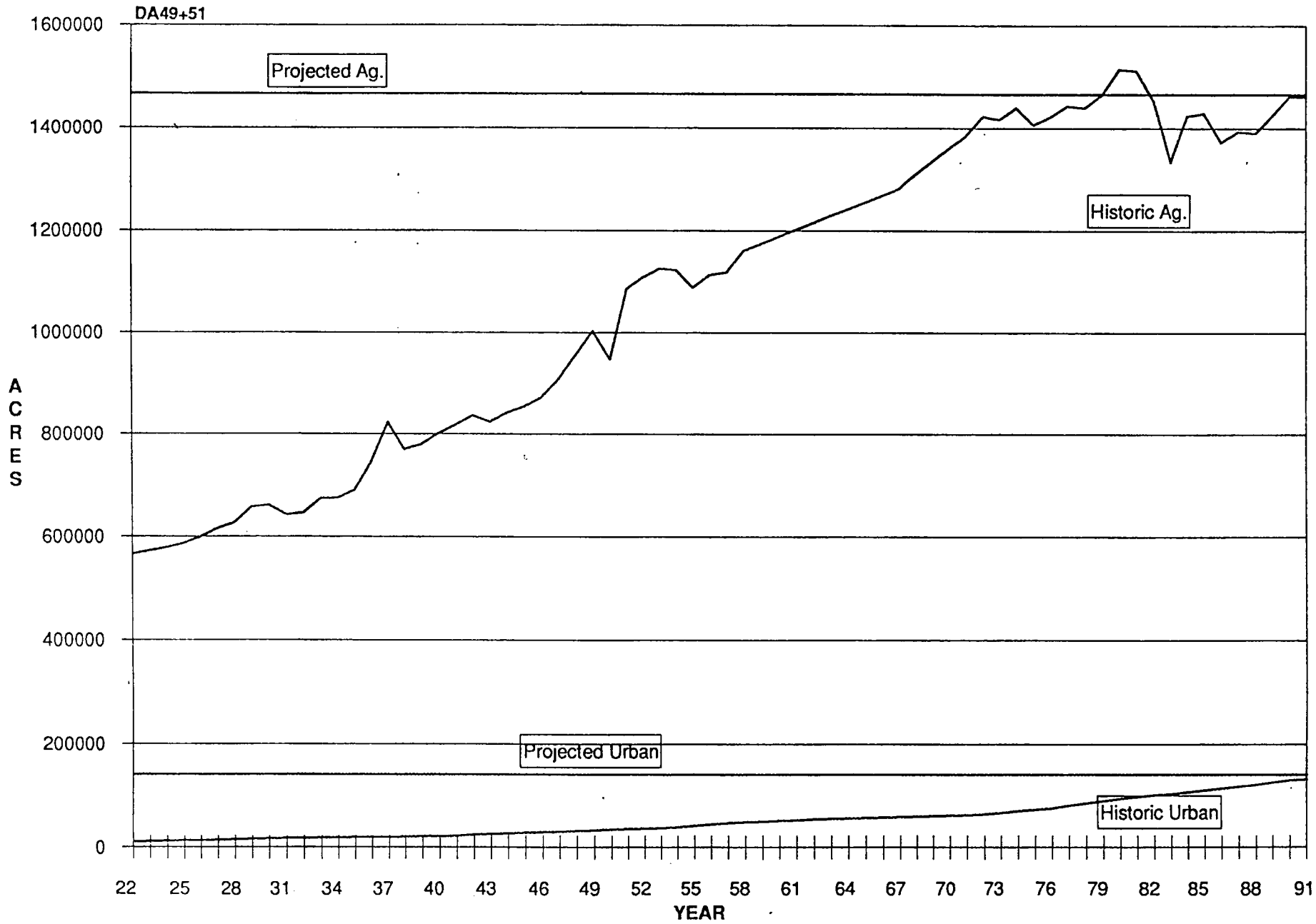

Figure 14

DELTA LAND USE FOR HYD-C-01

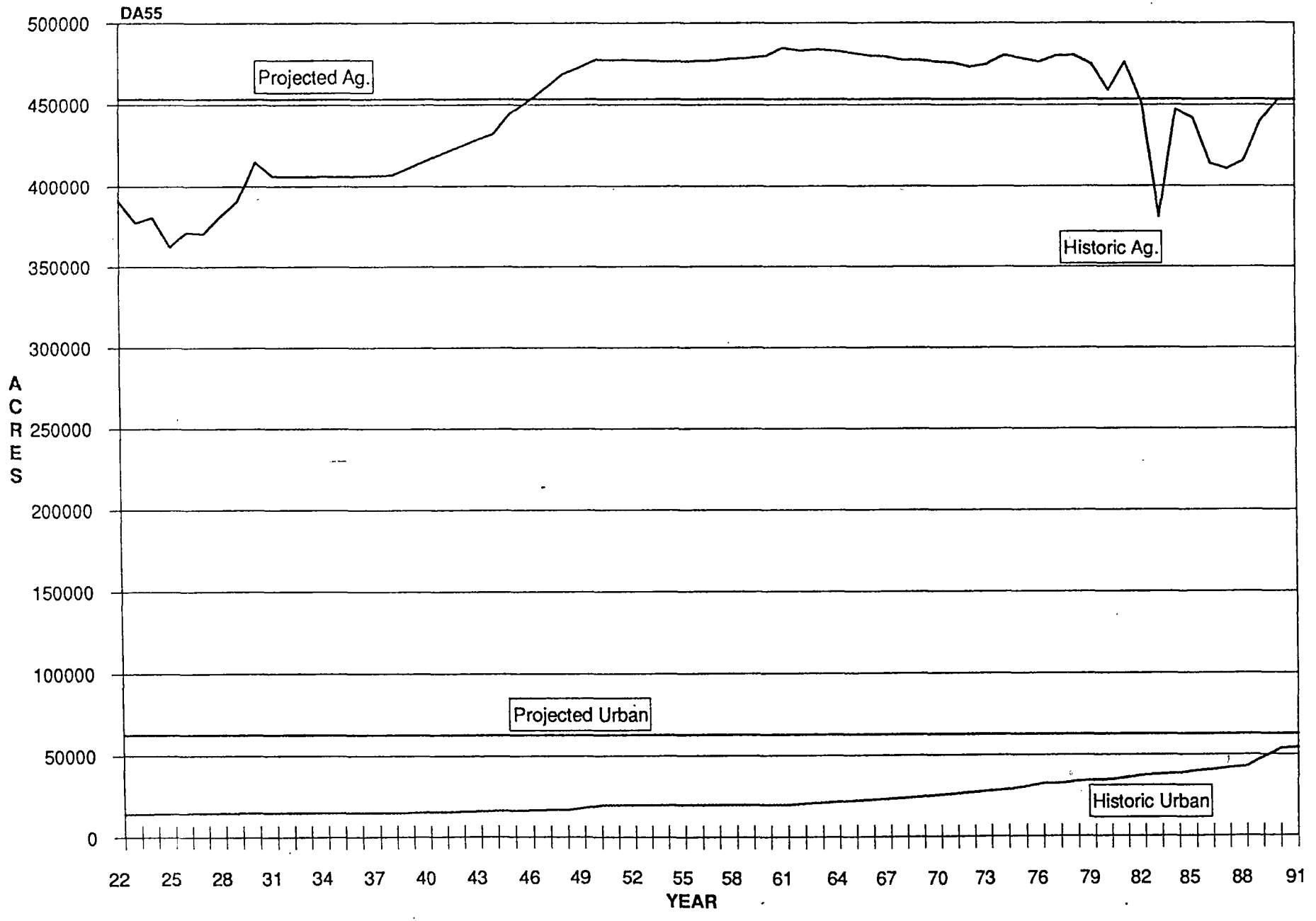

Figure 15
EASTSIDE STREAMS BASIN LAND USE FOR HYD-C-01

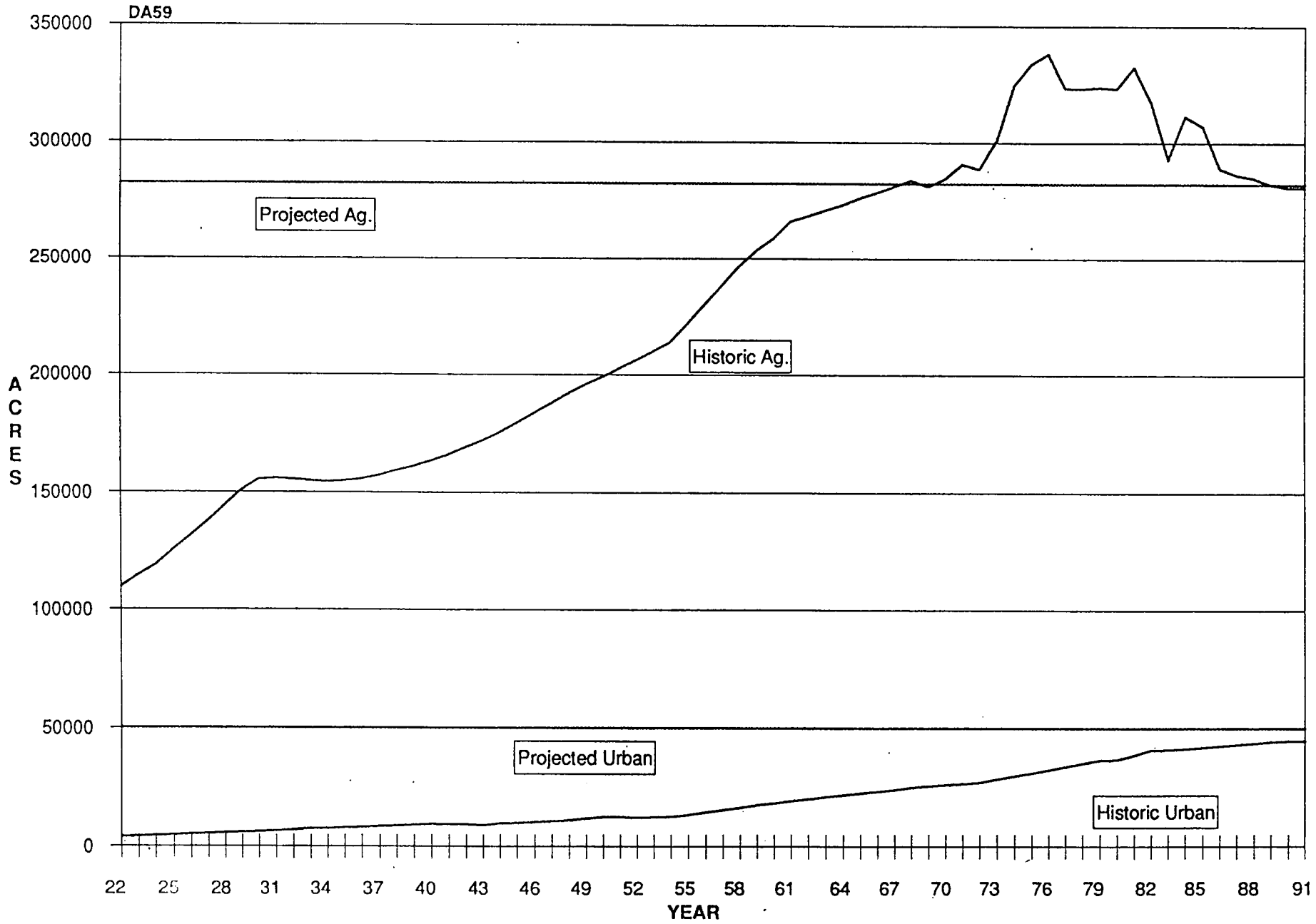

Figure 16

YOLO BYPASS BASIN LAND USE FOR HYD-C-01

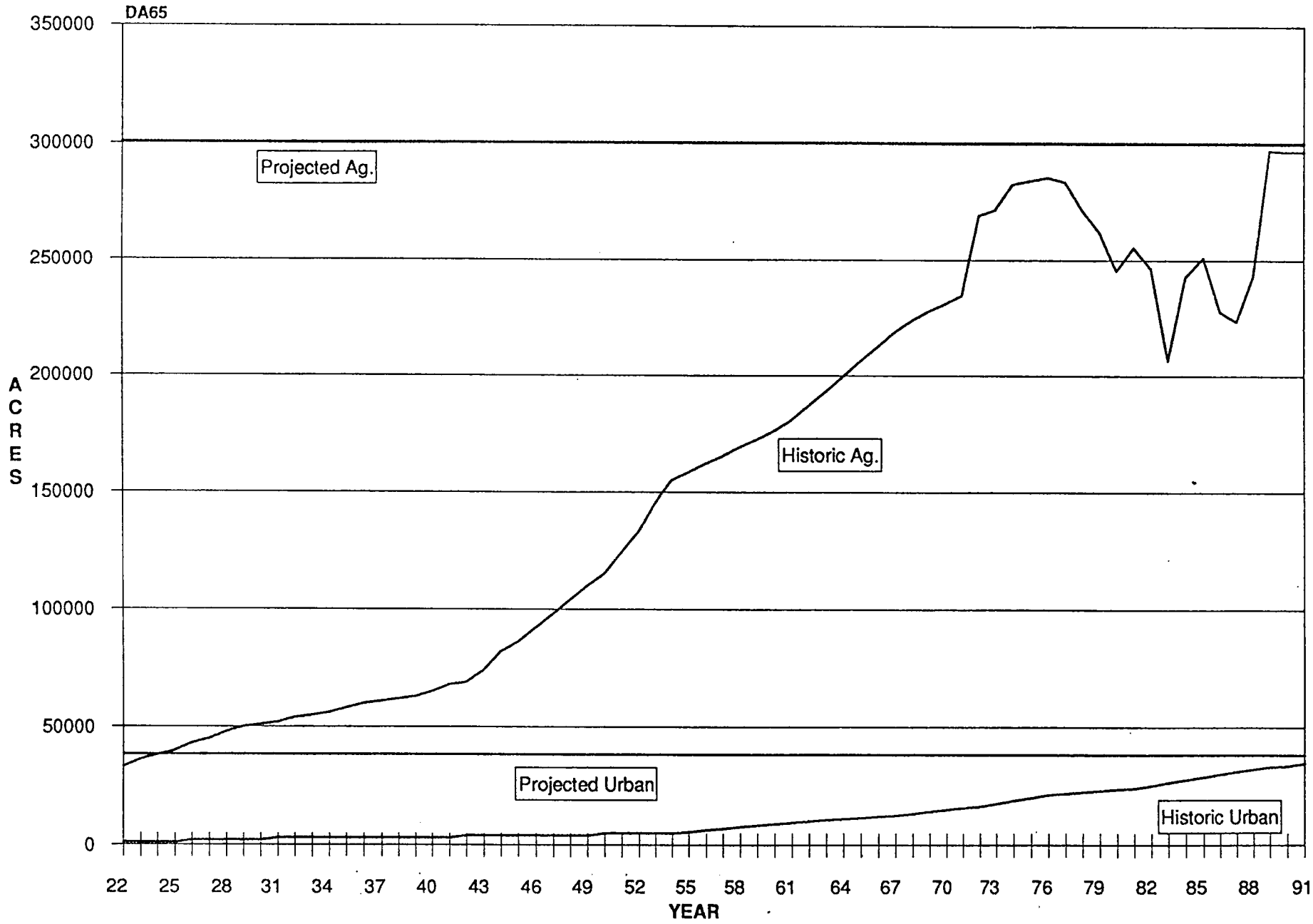

Table 1
DWR DEPLETION STUDY AREAS

AREAS	DESCRIPTION	UPSTREAM AREAS
UPPER SACRAMENTO RIVER BASIN		
61	Pit River above Fall River	none
62	Sacramento River at Shasta Res.	61
3	Paynes Creek Group (*)	none
58	Sacramento River at Red Bluff	62 and 3
5	Thomes and Elder Creeks	none
66	Northeast tributaries: Antelope, Mill, Deer and Big Chico Creek Groups	none
10	Sacramento River at Ord Ferry	58, 5, and 66
15	Sacramento River at Knights Landing	10
12	Sacramento Valley westside above Colusa Basin Drain	none
FEATHER RIVER		
17	Feather River at Oroville	none
14	Butte and Big Chico Creeks	none
67	Upper Yuba River including Deer and Dry Cks	none
68	Bear River at Camp Far West Res.	none
69	Lower Feather to mouth	17, 14, 67,and 68
LOWER SACRAMENTO RIVER BASIN		
22	American River at Folsom Res.	none
70	Lower Sacramento River to the Delta	12, 15, 69, and 22
CACHE, PUTAH, AND YOLO BYPASS		
16	Cache Creek above Rumsey	none
24	Putah Creek near Winters	none
65	Yolo Bypass and westside miner streams inflow to the north Delta	16 and 24
DELTA EASTSIDE STREAMS		
25	Cosumnes above Michigan Bar	none
27	Dry Creek at Galt	none
29	Mokelumne above Camanche Res.	none
32	Calaveras above Jenny Lind	none
59	Eastside Streams to the Delta	25, 27, 29, and 32
DELTA WESTSIDE TRIBUTARIES		
51	Westside minor streams inflow to the south Delta	none
SAN JOAQUIN RIVER		
39	Stanislaus River at Melones Res.	none
40	Tuolumne River above La Grange Dam	none
41	Merced River at Exchequer	none
42	Bear Creek Group	none
43	Chowchilla River above Buchanan Damsite	none
44	Berenda Creek	none
45	Fresno River	none
46	San Joaquin at Friant	none
49	San Joaquin River at Vernalis	39 thru 46
DELTA		
54	Delta Lowlands	55
55	Delta Uplands	49, 51, 59, 65, 70

Consumptive Use and Depletion Studies were not made for the Tulare Basin, area 60.

(*) The term 'Group' indicates that in addition to the named creek some unmeasured local runoff has been added.

Table 2. SUMMARY OF HYDROLOGIES DEVELOPED FOR USE IN PLANNING STUDIES

	Basis for Land Use Projections	Level	Simulation Period	Year Developed	Comments
HYD-A-01	160-74 Ag 160-74 Ur	1980	1922-1978	1979	
HYD-A-02	160-74 Ag 160-74 Ur	2000	1922-1978	1979	
HYD-A-01a	160-74 Ag 160-74 Ur	1980	1922-1978	1981	HYD-A-01 with new estimates for Delta water requirements by George Sato (Central District) and Gordon Lyford (USBR)
HYD-A-02a	160-74 Ag 160-74 Ur	2000	1922-1978	1981	HYD-A-01 with new estimates for Delta water requirements by George Sato (Central District) and Gordon Lyford (USBR)
HYD-A-03	160-74 Ag 160-74 Ur	1990	1922-1978	1983	Use HYD-A-01a plus two thirds difference between HYD-A-01a and HYD-A-02a
HYD-A-03a	160-74 Ag 160-74 Ur	1990	1922-1978	1985	Modify HYD-A-03 to include HEC models for Yuba and Bear rivers
HYD-B-01	160-83 Ag 160-83 Ur	1995	1922-1991	1991(Mar)	Extend historic period through Feb91 & forecast thru Sep91 Introduce HEC-3 on American River. Use modified HEC-3 on Yuba River. New reservoir operations on Cache, Putah, Mokelumne, and New Melones. New definitions for Delta IN and YD. Import in DA49. Millerton study 13B replaced by USBR 1984 study. DA12 imports limited. Project water definition changed. Black Butte re-operated. DA17 outflow modified. Some historic land use based on 1980 160-83. No 1981-91 county adjustments. No deficiencies taken (95de). o 95df (impose deficiencies) o 95dg (imposed Misc SJR and Eastside Streams modifications) o 95dh
HYD-B-01a	160-83 Ag 160-83 Ur	1995	1922-1991	1991(Aug)	Finalize 160-83 estimates. Still forecasted data for Mar91-Sep91. (95di)
HYD-B-01b	160-83 Ag 160-83 Ur	1995	1922-1991	1991(Nov)	Finalize historic flows and precip. Reduce rice acreage. (95dm)
HYD-C-01	160-93 Ag 160-83 Ur(mod)	1995	1922-1991	1992(May)	Updated historic land use using additional surveys and county adjustments. Four hydrologic corrections (Oroville, Whiskeytown Folsom, Yolo Bypass). Constant ET's for Delta. (95dn)

Table 3
DWR 1995 Level Hydrology for the Central Valley (HYD-C-01)
1995 Crop and Urban Acreages Based on Bulletin 160-93*
(in acres)

	DA10	DA12	DA15	DA49	DA51	DA55	DA58	DA59	DA65	DA69	DA70	Total
Pasture	42400	15300	2000	160800	200	29200	32300	46200	15000	25900	31700	401000
Alfalfa	7200	26300	9100	166800	3300	56000	1100	16500	27800	5200	2000	321300
S.Beets	3100	14600	12600	33800	200	32800	0	16200	19400	2300	4700	139700
Field	15400	25600	49400	166300	2600	108300	1500	47300	52100	16000	5100	489600
Rice	2100	140300	86100	19100	0	900	0	5900	10000	153000	48800	466200
Truck	1200	10600	9100	83800	100	37300	400	9300	3900	4900	500	161100
Tomatoes	0	35200	31400	42400	100	41800	0	13900	41500	1100	1400	208800
Orchard	70300	32200	24000	332200	5600	22000	3800	42700	23500	121700	10900	688900
Grains	18700	67900	60000	115300	2100	120400	3300	28800	106900	20600	14400	558400
Vineyard	200	2700	0	124200	700	4500	200	55300	400	0	400	188600
Cotton	0	0	0	197400	0	0	0	0	0	0	0	197400
Cit/Olives	10300	0	0	8500	0	0	900	0	0	5100	0	24800
Urban	24300	9300	3550	119750	21350	62250	63400	50000	38150	50450	180850	623350
Total	195200	380000	287250	1570350	36250	515450	106900	332100	338650	406250	300750	4469150

* The 1995 Urban is actually Bulletin 160-83 projections for 1995 corrected for later surveys since Bulletin 160-93 urban projections are not yet available

Table 4
SUMMARY OF LAND USE DATA IN DEVELOPMENT OF VARIOUS HYDROLOGIES
Central Valley Floor Drainage Areas
(in acres)

Basin	Depletion Area	1990 (historical)			1995 (HYD-B-01a)			1995 (HYD-C-01)		
		Ag	Urban	Total	Ag	Urban	Total	Ag	Urban	Total
	DA58	34200	62400	96600	44000	25000	69000	43500	63400	106900
	DA10	169300	25000	194300	205950	22400	228350	170900	24300	195200
Sacramento River	DA12	345900	9100	355000	428300	6750	435050	370700	9300	380000
Basin	DA15	268610	3400	272010	318800	2250	321050	283700	3550	287250
	DA69	352900	45800	398700	466550	49950	516500	355800	50450	406250
	DA70	122600	168800	291400	142750	165500	308250	119900	180850	300750
	Total	1293510	314500	1608010	1606350	271850	1878200	1344500	331850	1676350
Yolo Bypass	DA65	296900	33600	330500	297450	40250	337700	300500	38150	338650
Eastside Streams	DA59	280800	44900	325700	336800	28500	365300	282100	50000	332100
Delta (54+55)	DA55	452749	53850	506599	464000	55650	519650	453200	62250	515450
San Joaquin River	DA51	14700	20500	35200	16500	24600	41100	14900	21350	36250
Basin	DA49	1446500	109800	1556300	1492250	102600	1594850	1450600	119750	1570350
	Total	1461200	130300	1591500	1508750	127200	1635950	1465500	141100	1606600
Overall Totals		3785159	577150	4362309	4213350	523450	4736800	3845800	623350	4469150

Note: HYD-B-01a based on projections from Bulletin 160-83
HYD-C-01 based on projections from Bulletin 160-93 for Ag
and Bulletin 160-83 for urban, corrected for later surveys

Table 5. SUMMARY OF THE PROJECTED WATER SUPPLY FOR HYD-C-01

Averages Annual Flows (TAF/YR)

	1922-78	1928-34	1976-77	1981-91	1987-91	1922-91
1. Rim flows	21138	13150	8958	***	***	***
2. Inflow to Delta:						
a. Sacramento River	15460	9078	5398	15644	8861	15496
b. Yolo Bypass	1913	251	134	3029	78	2115
c. Eastside Streams	733	355	184	1328	270	835
d. San Joaquin River	2031	1160	753	3701	839	2350
Total	20137	10844	6299	23703	10048	20796
3. Net Delta use(constant ET's)	904	1033	1225	854	1084	892

Increase Over HYD-B-01a (TAF/YR)

	1922-78	1928-34	1976-77	1981-91	1987-91	1922-91
1. Rim flows	153	37	-25	***	***	***
2. Inflow to Delta:						
a. Sacramento River	595	546	305	456	529	573
b. Yolo Bypass	23	4	56	487	-10	96
c. Eastside Streams	1	-31	-19	191	-30	32
d. San Joaquin River	-14	6	68	514	44	82
Total	605	525	410	1648	532	783
3. Net Delta use(constant ET's)	-6	-8	-5	-4	-14	-7

Note: Some rim flows for the 1981-91 period were same as historic requiring no upstream area modification. They are not reported in this table.