Section 2

Water Resources Inventory

WATER SUPPLY

Unlike water agencies with more abundant supplies, Westlands must allocate (ration) water to its farmers, even in the wettest years. Its annual Contract entitlement from the Bureau's Central Valley Project (CVP) is 1,150,000 AF. The annual safe yield of the confined underground aquifer adds about another 135,000 AF to 200,000 AF. The total water available is about 15 percent (215,000 AF) short of the 1.5 million AF required to water the entire irrigable area in the District.

The surface water supply is allocated to more than 535,000 acres eligible to receive Project water. (An additional 33,000 acres farmed in the District ineligible to receive Project water must rely solely on pumped groundwater.) The District has three separate priority areas of water allocation. During periods of drought, deficiencies are applied as an equal percentage of the Contract entitlement of each priority area.

The original Westlands entered into a 40-year water supply Contract with the Bureau in 1963, providing for the delivery of 900,000 AF annually. In 1965 the Bureau committed an additional 250,000 AF annually to the District, although the Bureau and Westlands recognized that amount was insufficient for the additional irrigable acreage.

The Merger Agreement between the original Westlands and Westplains Water Storage District was codified by California Water Law in 1965. It specifies that the original Westlands area has a priority right to the 1963 Contract water. The 900,000 AF delivered under the 1963 Contract, therefore, is allocated first to about 337,000 eligible acres in Priority Area I (the original Westlands area), providing about 2.6 AF/Ac.

The 250,000 AF allocation for Priority Area II (former Westplains area) provides only about 1.3 AF for each of the 187,000 acres eligible to receive Project water. An additional 18,000 eligible acres annexed to the District after the merger (Priority Area III) does not receive any allocation until and unless Priority Areas I and II have been allocated about 2.6 AF/Ac.

The 1963 Contract allows Westlands to purchase additional (interim) water from the Bureau when it is available, which is usually allocated to Priority Area II. Between 1975 and 1988, the District purchased a total of more than 1 million acre-feet of additional water to boost average annual deliveries from 1.15 to 1.23 million AF. Since 1988, interim water has not been available. In addition to the Project water supply, since 1989 the District has been actively engaged in water marketing and conjunctive use with other agencies and purchases from the State Water Bank. While providing neither firm, abundant, nor economical water, these sources have provided insurance against well failures and higher than anticipated crop water needs.

GROUNDWATER SUPPLY

Farming in the Westlands area was originally developed through the use of groundwater for irrigation. The groundwater basin underlying Westlands is comprised generally of two water-bearing zones: (1) an upper zone above a nearly impervious Corcoran Clay layer containing the Coastal and Sierran aquifers and (2) a lower zone below the Corcoran Clay containing the Sub-

Corcoran aquifer. The location of these water-bearing zones is depicted on a generalized cross section of the District shown on Figure 3. These water-bearing zones are recharged by subsurface inflow from the east and northeast, the compaction of water-bearing sediments, percolation of pumped groundwater, and percolation from imported and natural surface water. Land subsidence due to groundwater overdraft ranged from 1 to 24 feet between 1926 and 1972 (U.S. Geological Survey (USGS), 1988). Surface water deliveries from the San Luis Unit (SLU) began in 1968 and largely replaced groundwater for irrigation. However, extensive pumping occurred in 1977, a drought year when deliveries of CVP water amounted to only 25 percent of the District's entitlement. In response to the surface water shortfall, farmers reactivated old wells and constructed new wells, pumping groundwater to irrigate their crops. During 1977, groundwater pumping rose to nearly 500,000 AF and the piezometric surface declined about 90 feet, resulting in localized subsidence of about 4 inches according to USGS officials.

Groundwater pumping increased to about 300,000 AF in 1989-90 because of decreased CVP water supplies caused by the drought. Pumping during 1990-91 and 1991-92 is estimated to be about 600,000 AF annually. This increase in pumping has resulted in a piezometric water surface decline of about 91 feet from 1988 through 1991, but had recovered by 1997.

A study by the Bureau, USGS, and Westlands estimated the safe yield of the deep confined aquifer underlying Westlands to be between 100,000 and 135,000 AF annually (Westlands Water District, 1980). Westlands does not supply groundwater to District farmers nor does the District regulate or control groundwater pumping; individuals pump their own groundwater. The District does, however, survey the static water levels in the wells and the water quality and quantity of the pumped groundwater, as part of the Groundwater Management Plan completed under provisions of AB3030 in 1996, see Appendix E. More recent district analysis of these data indicate that a better estimated safe yield may be between 135,000 and 200,000 AF.

The irrigable area and amount of Project water and groundwater used each crop year are shown in Table 8.

Table 9

District Water Supply

Crop Year [1]	Irrigable Area Ac	Project Water AF	Groundwater Water AF	Total AF
1978	565,585	665,895	159,000	824,895
1979	565,506	1,084,386	140,000	1,224,386
1980	566,101	1,138,994	106,000	1,244,994
1981	563,301	1,244,446	99,000	1,343,446
1982	563,862	1,236,639	105,000	1,341,639
1983	567,184	1,090,888	31,000	1,121,888
1984	571,219	1,473,883	73,000	1,546,883
1985	568,554	1,315,548	228,000	1,543,548
1986	568,986	1,194,113	145,000	1,339,113
1987	566,844	1,309,252	159,000	1,468,252
1988	568,083	1,270,213	160,000 [2]	1,430,213
1989	567,817	1,157,908	175,000 [2]	1,332,908
1990	568,083	920,681	300,000 [2]	1,220,681
1991	568,470	376,733	600,000 [2]	976,733
1992	570,552	375,535	600,000 [2]	975,535
1993	567,390	665,901	225,000 [2]	890,901
1994	563,563	859,492	325,000 [2]	1,184,492
1995	563,781	918,643	150,000 [2]	1,068,643
1996	563,881	1,403,965	50,000 [2]	1,453,965
Average	566,502	1,161,757	144,615	1,244,774

[1] October 1 to September 30
[2] District Estimate

OTHER WATER SUPPLIES

On a year by year basis flood flows from the San Joaquin and Kings Rivers are available to Westlands. These water supplies flow into the Mendota Pool on a seasonal basis and are available to the District through the 7-1 Pumping Plant. No water was taken from this source in the 1996-97 water year. The upper limit, due to pumping plant limitations, of water delivered from this source would be approximately 20,000 AF.

RESTRICTIONS ON THE DISTRICT'S WATER SOURCES

Westlands long term outlook for project water deliveries shows an expectation of about 70 percent of contract delivery, while the most recent years have seen near full contract deliveries due to abundant precipitation conditions experienced in California.

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Restriction	Agency Imposing Restriction	Effect on District Operations
District is not receiving its full-contract supply because of implementation of the CVPIA.	Department of Interior, U.S. Bureau of Reclamation.	The CVPIA reallocated 800,000 AF of the CVP yield away from traditional uses for environmental purposes. It is not clear yet whether this amount of water can be "double-counted" and serve both restoration purposes as well as those required under the ESA, as it should. It also is not clear whether this water can be used more than once, i.e., used for temperature control upstream, but still be available for pumping to users south of the Delta; again, as it should.
District is not receiving its full contract supply because of implementation of the ESA.	Department of Interior, Fish and Wildlife Service; Department of Commerce, National Marine Fisheries Service.	Because of the listing of the winter-run chinook salmon and the Delta smelt, as well as the potential listings of several other native species, Project operations have been drastically altered to meet requirements of the ESA. Consequently, to date, both Services have chosen to sharply restrict pumping at both the state and federal pumps in the southern Delta as their only course of implementation. This has resulted not only in a reduction of water supplies, but also has created an unfair and inequitable burden on those users south of the Delta.
District may not receive its full contract supply because of proposed water quality and salinity standards in the Delta.	U.S. Environmental Protection Agency (EPA)	With the EPA announcing proposed standards, it is unclear exactly what the impact will be. However, it is clear that there will be an impact, both in terms of water supply reductions and water costs. It will be some months before the precise effects can be quantified.

SOURCE WATER QUALITY MONITORING PRACTICES

The District does not deliver any potable or treated water. Water is delivered directly from the California Aqueduct or the Mendota Pool on the San Joaquin River. Any requirements for drinking water uses of the water are the water user's responsibility, the water quality monitoring is accomplished by the individual water user. In general, biological monitoring and treatment are a necessity for any public water supplier.

Several sources for raw water quality are available to District water users:

1. Non-agricultural water users, to satisfy requirements of the Safe Drinking Water Act, use information from a Raw Water Representative Sampling Program. This program provides annual Title 22 sampling and analysis at 10 locations in the District during August. The results are reported to all non-agricultural water users and the Fresno County Department of Health Services. Similar analysis is obtained when water is pumped from the Mendota Slough.

2. The Distribution Integration Program allows a water user to pump groundwater into the district distribution system that meets drinking water standards. Verification sampling is conducted when this program is in operation.

3. The District receives monthly Water Quality Reports from Checks 13, 18, and 21 on water delivered from the California Aqueduct. These reports document electrical conductivity(EC), Temperature and Turbidity on a hourly basis.

4. The annual groundwater monitoring program conducted under the Groundwater Management Plan analyzes water from running wells in December for EC. The results are consolidated into a District groundwater quality map for the Groundwater Management Plan.

CROP PRODUCTION

Westlands' farmers work some of the most fertile and productive land in the world, producing vital food and fiber products and economic wealth from renewable natural resources. More than 60 different crops are grown commercially in the District with the potential for scores of others. And, unlike many other key growing areas of California, urbanization is not a direct threat to productivity.

Westlands' farmers have combined generations of family tradition with state-of-the art advances in modern agricultural practices. They provide California and the United States an irreplaceable asset producing the three-way benefit of (1) superior crop yields, (2) high crop value, and (3) low water use.

The Crop Production Report, Table 9, lists the acreage devoted to each crop, the average yield, and the crop value produced. Crop acreage trends from 1978-1996 are shown in Table 10. Prior to the delivery of Project water, Westlands' farmers primarily grew cotton and grain crops, such as wheat and barley, and some vegetables. However, between 1980 and 1996, the acreage devoted to vegetables increased to more than 220,000 acres, while grains declined by some 100,000 acres. Figure 6 shows the acreage of grains, safflower, and vegetable crops grown in the District during this period. Crops classified as grain and vegetable are indicated in Crop Production Reports. Part of the increase in vegetable production is attributed to the fact that traditional "salad bowl" growing areas, such as the Salinas-Monterey area and the Central Coastal counties of California, are becoming urbanized and water more scarce. In addition, some coastal areas are faced with groundwater pumping limitations brought about by sea water intrusion.

As the District's farmers devote more resources to raising vegetable crops (some of which are double-cropped) and to growing more than 34,000 acres of trees and vines, they are recognizing the need to produce growing high-quality marketable products that meet the consumer's increasingly high standards. Therefore, in addition to meeting crop water requirements for normal growth, significant amounts of water are used on plants for cultural practices such as weed control, climate control, holding tomatoes for harvest, and ensuring a tight head of lettuce or swelled garlic bulbs. Because of the continuing changes in water management due to cultural practices, Westlands' farmers now require more water on acreage where low water use crops, such as wheat and barley, were previously grown.

Table 10

WESTLANDS WATER DISTRICT
1996 Crop Acreage Report

Crop	Acres [1/]
Alfalfa-Hay	3,525
Alfalfa-Seed	6,531
Almonds	14,561
Apples	1,445
Apricots	341
Asparagus	803
Barley	3,843
Beans-Dry	2,786
Beans-Garbanzo	15,245
Beans-Green	294
Broccoli	3,332
Cabbage	141
Cantaloupes	18,452
Carrots-Bulk	717
Cherries	40
Corn-Field	1,138
Corn-Sweet	2,018
Cotton-Lint-Acala	214,579
Cotton-Lint-Pima	57,782
Cucumbers	104
Eucalyptus	24
Garlic	22,665
Grains-Sorghum	394
Grapes-Juice	491
Grapefruit	38
Grapes-Table	661
Grapes-Wine	5,095
Honeydews	2,483
Jojoba	11
Lettuce-Fall	6,438
Lettuce-Spring	10,708
Melons-Mixed	976
Milo	290
Nectarines	108
Oats	96
Olives	504
Onions-Dehy.	8,706
Onions-Fresh	1,883
Oranges	156
Parsley	70
Pasture	2,009
Peaches	374
Peppers-Misc.	2,229
Pistachios	5,747
Pomegranates	904
Potatoes-Sweet	94
Prunes	164
Pumpkins	20
Radicchio	28
Safflower	4,925
Seed Crop-Misc.	917
Spinach	6
Squash	3
Sugar Beets	4,708
Tangerines	50
Tomatoes-Fresh	4,484
Tomatoes-Proc.	88,095
Walnuts	506
Watermelons	758
Wheat	20,316
NB Trees & Vines [2/]	3,327
Fallow	26,754
Nonharvested [3/]	566
Subtotal	576,458
Double Crop	12,577
Total [4/]	563,881

[1/] USDA-CFSA net cropped acreages
[2/] Nonbearing trees and vines
[3/] Includes experimental and nursery crops
[4/] Total net cropped acreage in Westlands, excluding feed lots, commercial, residential, and industrial areas

Crop Acres [1/]

Table 11

CROP ACREAGE TRENDS
1978 – 1991

Crop	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Alfalfa-Hay	13,771	13,450	10,182	11,438	6,256	10,887	11,136	10,768	10,134	8,738	10,042	11,482	10,716	7,812
Alfalfa-Seed	17,337	14,162	18,925	15,103	17,552	10,832	15,235	14,486	19,130	17,839	14,321	13,453	13,049	8,942
Almond	6,531	6,991	7,738	8,038	8,116	7,586	7,940	7,959	8,301	7,972	7,363	8,381	7,159	8,016
Apple	63	15	15	18	18	18	17	18	14	70		411	360	554
Apricot								122	122	135	151	172	236	236
Asparagus	54					483	412	352	382	443	477	642	547	744
Barley	126,862	78,840	76,547	54,206	45,818	21,004	22,674	24,901	22,996	12,866	10,678	15,953	8,587	3,094
Bean-Dry	1,873	1,090	2,149	2,755	4,033	101	3,872	7,545	6,074	3,740	8,691	10,052	4,382	2,958
Bean-Green	2,370	4,739	3,735	4,730	2,368	7,869		477		2,282		2,070	3,004	408
Broccoli	38	261	25			259	1,307	2,308	4,130	6,413	5,137	2,175	1,003	2,180
Cantaloupe	19,929	19,467	18,037	16,641	17,237	21,523	21,008	20,190	25,345	23,152	18,603	21,310	20,402	17,489
Carrot			585	120		706	946	1,176	1,990	2,412	2,749	1,930	1,262	760
Cauliflower	193	436	100	477			338	155	229	435	1,136	170		473
Corn-Field	298	598	1,896	152	1,175	980	7,803	7,153	6,926	791	94		665	
Corn-Silage		595	400	3,822	5,133	5,665	171				70			
Corn-Sweet								871	2,757	3,471	1,900	1,977	973	899
Cotton-Acala	272,061	300,563	284,688	300,309	277,064	230,307	297,174	286,169	231,142	266,483	290,062	241,995	235,290	177,102
Cotton-Pima													5,786	30,840
Cucumber				155	106		26			20			234	
Eucalyptus												53	280	57
Garlic	1,856	2,670	3,427	4,602	7,510	9,118	8,132	8,670	9,011	11,583	11,345	12,338	14,500	14,466
Grape-Raisin			100	80	77	155				40		61	131	
Grape-Table									155	70	248	314	253	337
Grape-Wine	4,566	4,924	4,782	5,603	6,247	5,262	6,767	6,633	6,208	6,306	5,548	5,446	5,483	5,208
Honeydew	100	150				399	348	225	624	1,881	1,198	1,582	1,825	1,840
Jojoba										10	10	11	11	11
Lettuce-Spring	7,358	8,876	6,123	3,529	3,100	5,870	6,420	8,813	7,308	8,107	10,037	9,497	8,602	3,725
Lettuce-Fall			1,367	3,801	3,391	5,640	1,551	5,879	6,118	6,496	6,075	5,734	4,209	5,588
Nectarine								72	242	171	193	193	248	197
Oat	677				174			255	942		446	1,853		
Olive	423	423	412	423	423	423	423	423	422	413	413	413	583	471
Onion	2,433	4,320	3,803	6,393	8,772	9,070	8,921	9,954	11,357	12,230	12,704	12,839	11,442	8,835
Orange	157	157	157	157	157	157	182	163	168	167	167	190	207	158
Pasture	1,697	227	210	254	501	382	344	261	355	540	631	1,697	474	711
Peaches								54	20		20	126	190	283
Peas-Green	1,157	1,372	1,259	299	617	1,535	2,320	231	301			2,009	1,109	1,039
Pepper	532	877	972	1,321	1,110	1,498	1,039	1,392	2,320	2,202	2,253	547	993	917
Pistachio	565	584	572	886	2,243	1,968	2,102	2,252	2,534	3,215	2,403	3,365	3,120	4,715
Pomegranate	669	724	722	580	547	473	504	521	499	542	594	700	797	707
Rice	1,080	638	1,649	1,676	435	291	388	37	153	84				
Safflower	9,393	14,550	9,982	7,219	10,507	9,573	8,161	3,846	13,447	4,127	4,776	8,531	13,541	4,424
Seed Crop-Misc.	631	1,098	412	467	665	106	2,584	434	543	745	1,196	1,448	1,234	1,395
Sorghum-Milo	5,813	555	635	442	2,680	276	1,060		323					
Sugar Beet	6,746	9,901	11,194	11,455	7,046	5,203	5,699	8,841	11,880	9,730	8,337	7,806	7,393	3,182
Tomato	30,224	37,504	27,857	29,656	45,000	56,949	59,817	54,211	60,816	60,095	65,040	80,903	95,1591	100,707
Walnut	38	21	82	133	124	137	33	150	248	252	250	252	264	309
Watermelon								63	390	109	25	65	120	278
Wheat	1,591	16,051	55,637	60,507	62,528	49,045	50,314	49,989	36,118	26,595	24,641	23,399	26,407	8,399
N/B Trees/Vines		533	275	128	617	1,286	15	558	821	236	2,497	1,647	6,361	5,423
Fallow-Idle Land	36,335	25,743	16,527	18,203	26,128	93,773	16,340	30,579	67,829	66,236	45,632	64,579	52,544	125,082
Nonharvested		609	347	707	3,278	1,464	773	3,245	821	449	1,578	743	4,530	6,673
Miscellaneous	129	405		167	242	931	871	352	931	1,328	1,663	1,459	1,118	3,947
Subtotal	575,496	574,119	573,525	576,497	578,889	578,721	574,729	582,401	582,039	580,678	580,659	579,738	575,458	570,442
Double Crop	<9,021>	<8,202>	<8,806>	<13,196>	<14,850>	<11,537>	<6,532>	<13,847>	<13,053>	<13,834>	<12,576>	<11,921>	<7,069>	<1,972>
Total	566,475	565,917	564,719	563,301	564,039	567,184	568,197	568,554	568,986	566,844	568,083	567,817	568,389	568,470

NOTE: Source of these acreages is the District's Annual Crop Production Report

Table 10, Continued

CROP ACREAGE TRENDS 1991 – 1996

Crop	1992	1993	1994	1995	1996
Alfalfa-Hay	5,350	3,958	4,775	3,815	3,525
Alfalfa-Seed	6,297	3,896	4,600	6,825	6,531
Almond	11,817	11,843	12,202	13,877	14,561
Apple	1,095	1,348	972	1,118	1,445
Apricot	301	326	308	490	341
Asparagus	675	627	709	735	803
Barley	10,297	8,226	6,632	5,423	3,843
Bean-Dry	6,836	3,112	2,148	2,633	2,786
Bean-Garbanzo		5,785	9.091	10,539	15,245
Bean-Green	231	1,810		820	294
Broccoli	2,733	3,209	2,761	3,337	3.332
Cabbage			203	26	141
Cantaloupe	15,997	19,775	20,873	18,998	18,452
Carrot	638	1,078	332	606	
Cauliflower	71	150			
Casabas			40		
Cherry		20	20	40	40
Corn-Field				114	1,138
Corn-Silage					
Corn-Sweet	1,082	1,793	1,875	1,461	2.018
Cotton-Acala	195,658	213,057	214,314	226,601	214,579
Cotton-Pima	29,237	27,806	25,315	42,105	57,782
Crenshaws			57		
Cucumber	80	80		127	104
Eggplant		10			
Eucalyptus	2	54	46	21	24
Garlic	14,647	16,239	18,419	21,469	22,665
Grain-Sorghum/Milo					684
Grapefruit				38	38
Grape-Juice					491
Grape-Raisin	109	255	155		77
Grape-Table	309	345	544	700	661
Grape-Wine	5,072	5,587	4,847	5,479	5,095
Honeydew	1,323	1,758	2,099	2,706	2,483
Jojoba	11	11	11	11	11
Lettuce-Spring	8,747	8,610	9,751	9,079	10,708
Lettuce-Fall	9,021	6,130	7,967	9,369	6,438
Melons-Mixed			435	1,340	976
Nectarine	174	342	149	148	108
Oats			153	505	96
Olive	549	421	312	487	504
Onion-Dehy	6,749	8,453	10,124	8,516	8,706
Onion-Fresh	1,510	1,868	2,458	2,183	1.883
Orange	168	213	156	156	156
Parsley					70
Pasture	485	927	298	604	2,009
Peaches	428	292	367	334	374
Peas-Green	55			1,237	
Pepper-Misc.	1,640	1,433	1,169	1,597	2,229
Pistachio	3,892	4,153	3,861	4,399	5,747
Pomegranate	750	830	722	865	904
Potatoes-Sweet			85	75	94
Plums		130	110		
Prune	169	149	75	149	164
Pumpkins					20
Radicchio					28
Safflower	19,055	15,356	7,306	8,982	4,925
Seed Crop-Misc.	670	554	381	692	917
Spinach					6
Squash			32		3
Sugar Beet	5,045	6,445	9,539	5,485	4,708
Tangerines				50	50
Tomato-Fresh	2,959	3,335	4,220	4,375	4,484
Tomato-Proc.	75,811	74,964	85,768	83,693	88,095
Watermelons			349	350	758
Walnut	310	304	340	260	506
Wheat	12,628	14,428	12,207	13,334	20,316
N/B Trees/Vines	1,593	2,773	3,201	2,576	3,327
Fallow-Idle Land	112,718	90,413	75,732	43,528	26,754
Nonharvested	3,638	1,449	2,170	678	566
Subtotal	580,666	576,529	572,723	575,160	576,458
Double Crop	<10,114>	<9,139>	<9,160>	<11,379>	<12,577>
Total	570,552	567,390	563,563	563,781	563,881

NOTE: Source of these acreages is the District's Annual Crop Production Report

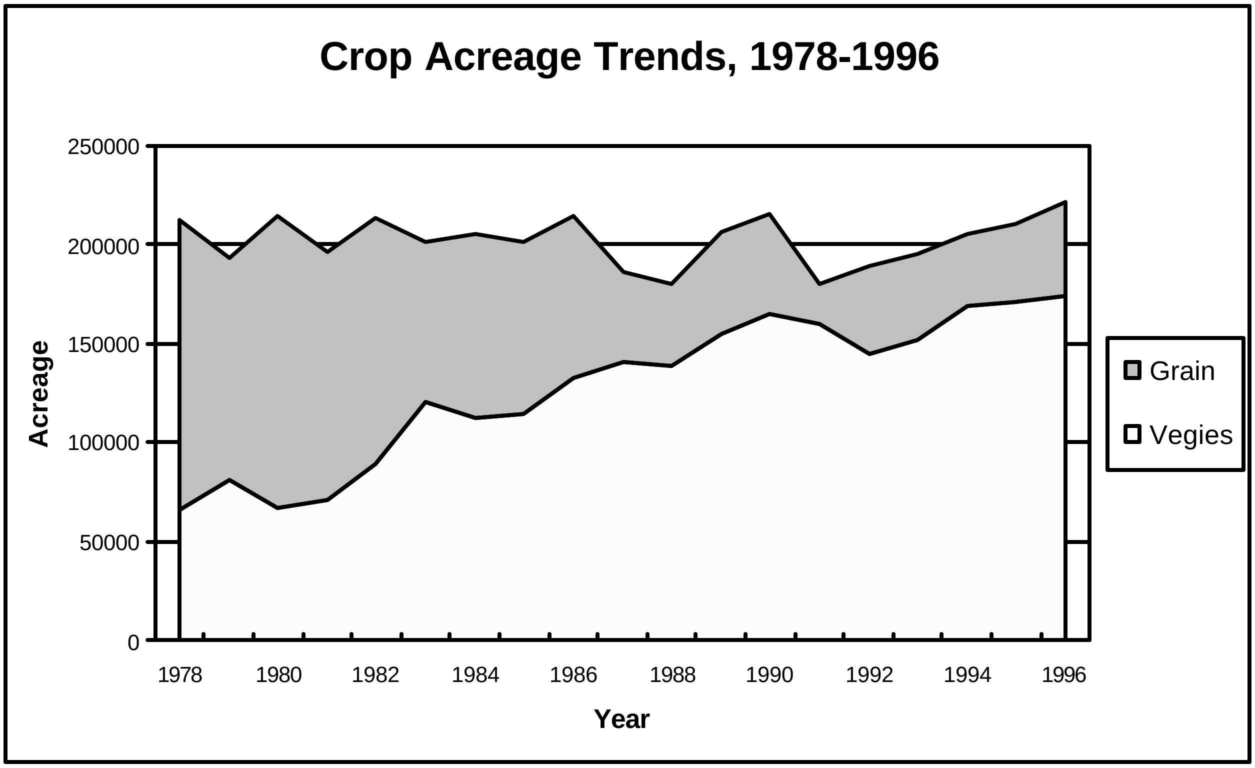

Figure 6. Grain and Vegetable Acreage Trends

Figure 7 shows the variable planting, growing, and harvest seasons and historical seasonal evapotranspiration (ET) of the major crops grown in Westlands during the year. This figure shows that the growing season is year round. Therefore, no single fixed annual crop water use requirement can be established for the same crop that may be planted and harvested several different times during the year or used for different purposes. Examples are: fresh market corn, grain, or silage; fresh market or processing tomatoes; onions and garlic for fresh market or dehydration; and various vegetables planted in either the spring or fall.

Crop	ET(in)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
ETP (In)	77.0	5.7	3.1	1.9	1.8	2.8	4.4	7.1	10.2	11.4	11.2	10.0	7.4	5.7	3.1	1.9	1.8
Alfalfa Hay	46.9	-C--	----	C---	----	----	---C	----C	----C	----C	----C	----C	----	--C-	----	-C--	----
Alfalfa Seed	36.5	----	----	----	----	----	----	CC--	----	----	----	HHHH	----	----	----	----	----
Almond	33.5	HH--	----			B--	----	----	----	----	----	--HHH	HHHHH	HH--	----		
Asparagus	NA	----	----	----	----	----	----	----	HHHHH	HHHH	----	----	----	----	----	----	----
Barley	14.7		PPP	PPPPP	PPPP	----	----	----	--HHH	HH					PPP	PPPPP	PPPP
Beans, Dry	22.2							PPPP	----	----	----	HHHHH	HHHH				
Beans, Fresh	NA	HHHH						PPPP	PPPPP	PPPPP	PPPP	HHHHH	HHHHH	HHHH		PPPP	----
Broccoli,Spr.	NA			PPPPP	PPPP	----	---HH	HHHH									
Broccoli,Fall	NA	----	-HHHH	HHHHH	HH							PPP	----	----	-HHHH	HHHHH	HH
Cantaloupes, Early	11.5					PPP	PPPP	----	----	HHHHH	HHH						
Cantaloupes, Late	12.0	-HHH							PPPP	PPPP	----	----	----	-HHH			
Cauliflower, Spring	NA			PPPPP	PPP-	----	---HH	HHHH								PPPPP	PPP-
Cauliflower, Fall	NA	----	-HHHH	HHH								PPPP	----	----	-HHHH	HHH	
Carrot	NA				PPPP	PPPP	----	----	----	----	HHHHH	H					PPP
Corn, Field	27.0						PPP	PPPPP	P---	----	----	---HH	HHH				
Corn, Silage	20.0	HHHH							PPP	PPPP	----	----	-HHHH	HHHH			
Cotton	26.2	D---	HHHH				PPPP	PPPPP	P---	----	----	----	----	D---	HHHH		
Garlic	15.0	PPPPP	PPPP	----	----	----	----	----	----	----	HHHHH	HHH		PPPPP	PPPP	----	----
Grapes	24.2	----	----				B--	----	----	----	----	---HH	HHHH	----	----		
Lettuce, Fall	4.9	--HHH	H									PP	PP--	--HHH	H		
Lettuce, Spring	4.0		PPP	PPPPP	PP--	----	---HH	HHHH							PPP	PPPPP	PP--
Olives	36.5	HHH-	----	----	----	----	----	----	----	----	----	----	----	HHH-	----	----	----
Onions, Fresh	16.4		PPPP	----	----	----	----	----	----	--HHH	HHHHH	HHHH			PPPP	----	----
Onions, Dehyrator	23.5	PPP	PPPPP	PPPPP	PP--	----	----	----	----	----	--HHH	HHHHH	HH	PPP	PPPPP	PPPPP	PP--
Peppers	25.0	HH					PPP	PP--	----	----	----	----	HHHHH	HH			
Pistachios	35.3	----	----					B---	----	----	----	----	HHHH	----	----		
Pomegranate	30.7	----	----	----	----	----	----	----	----	--HHH	HH--	----	----	----	----	----	----
Rice	41.0	HHHH							PPPP	P---	----	----	----	HHHH			
Safflower	26.9					PPP	PPPPP	PP--	----	----	---HH	HHHH					
Sugar Beets, Fall	36.0	PPPPP	PPPPP	PPP-	----	----	----	----	----	----	---HH	HHHH			PPPPP	PPP-	----
Sugar Beets, Spring	37.0	HHHH				PPPPP	PPPP	----	----	----	----	----	HHHHH	HHHH			
Tomato,Frsh, Fall	16.3	HHHHH	H									PPPP	----	HHHHH	H		
Tomato,Frsh, Spring	NA						PPPPP	PPPPP	P---	-HHHH	HHHH						
Tomato,Processor	18.9					EEEE	EEEEE	EEEE	----	----	-HHHH	HHHHH	HHHH				
Wheat	19.3		PPP	PPPPP	PPPP	----	----	----	--HHH	HH					PPP	PPPPP	PPPP

Legend: P=Planting   E=Emergence   B=Bloom   C=Cutting   -=Growing   D=Defoliate   H=Harvest

Figure 7. Crop Planting, Growing and Harvest Season, and Historical Seasonal Evapotranspiration

ON-FARM IRRIGATION SYSTEMS

Each year District farmers are surveyed to determine the types of irrigation systems used during the crop year as part of the annual crop production report survey. Several trends become apparent when this information is compared to a similar survey conducted in 1985, as shown in Table 11. In 1985, 63 percent of the District was irrigated exclusively by surface irrigation (furrow or border strip). In 1990 this figure decreased to 43 percent and by 1996 it decreased to 34 percent. The acreage irrigated only by sprinkler systems decreased from 21 to 16 to 15 percent. The acreage irrigated by a combination of sprinkler and furrow almost tripled, from 15 to 43 percent. The drip/trickle acreage increased from 1 to 6 percent.

Table 11

On-Farm Irrigation Systems

Type of System	Percentage of Land Irrigated		
	1985	1990	1996
Surface			
Furrow	60	38	34
Border Strip	3	5	2
Combination sprinkler/furrow	15	38	43
Pressurized			
Sprinkler	21	16	15
Drip/Trickle	1	3	6
Total	100	100	100

The 1987 through 1989 *Irrigation Improvement Program (IIP)* data were analyzed to determine the use of on-farm tailwater reuse systems in the District. The analysis shows that 62 percent of the 451 fields irrigated by surface irrigation had tailwater systems. This is an increase from 54 percent in the 1985 survey. The 1989 Program data show 16 percent of those fields utilizing tailwater systems returned the water to the same field while only 11 percent of the fields with tailwater systems returned the water to the same field as reported in the 1985 survey.

Various factors may account for these trends. The District has experienced a decrease in its water supply during the drought which began in 1986. Project water supplies declined by over 100,000 AF annually for the five-year period ending in 1990 when compared to the previous five-year period. In 1990 the District received only 50 percent of its Contract allocation. To cope with these reductions and to continue farming their land, the farmers had to reduce field applications or pump additional groundwater. The pumped groundwater is more expensive than the surface water, and in most cases is of poorer quality.

The *IIP* data indicates sprinkler preirrigations followed by regular season furrow irrigations produce the highest irrigation efficiencies. Also, tailwater reuse systems, when used with furrow irrigation, increased distribution uniformity, thus facilitating better irrigation efficiencies. These findings were shared with the Program participants through their program advisors and with the rest of the District water users through workshops and Profitable Practices. Undoubtedly, some farmers adopted recommendations from the *IIP* to stretch their supplies in response to supply cutbacks.

Shallow-rooted vegetable crops are difficult to irrigate efficiently with surface systems and are best irrigated by sprinklers during the early portion of the growing season when small applications of water are desirable. Well-managed furrow irrigation will suffice during the remainder of the season, especially on those crops which are susceptible to mildew caused by mid-to-late season sprinkler irrigations.

The irrigation systems used on the major crops grown in the District are shown in Table 12. High-value, shallow rooted crops such as tomato, garlic, and onion are most likely irrigated by a combination of sprinklers and furrow during the season. Lower-valued, deeper rooted crops such as alfalfa and wheat are more likely to be surface irrigated. Moderate valued crops such as cotton have about one-half the fields irrigated by sprinklers for at least a portion of the season. Trees and vines such as almonds and grapes tend to be irrigated by pressurized systems and new plantings are almost exclusively drip/trickle irrigated.

Table 13

Crop Irrigation Systems [1/]

	Border (%)	Furrow (%)	Sprinkler (%)	Spr/Fur [2/] (%)	Drip (%)
Almond		2	14	6	78
Cotton	1	51	16	32	
Garlic		8	12	80	
Grape	26	6			68
Melon	2	11	1	85	
Onion-Dehy			59	41	
Onion-Fresh			10	90	
Tomato-Fresh				10	90
Tomato-Process		6	3	90	
Wheat	7	45	28	20	

[1/] 1997 farmer survey

[2/] Combination of sprinkler and furrow irrigation used during the season

WATER USE

Seasonal Application Efficiency

The Seasonal Application Efficiency (SAE) is the ratio of the crop water requirements to applied water and is used to determine District-wide water use efficiency.

The District-wide SAE averaged 83 percent during the period 1978 through 1996 and is shown in Table 13. The SAEs vary from a low of 72 percent to a high of 94 percent. The high SAE of 94 percent during the 1978 crop year was due to the high rainfall that occurred during December 1977 through April 1978. This eliminated the need for preirrigations and the applied water requirements for all winter crops. Differences in the SAE may be attributed to (1) alternative water management practices and irrigation systems used due to changes in cropping patterns, (2) weather variations, and (3) the increased use of water for the cultural practices required to produce high quality vegetable crops.

Table 14
District-Wide Seasonal Application Efficiency

Crop Year [1]	Area Ac	ET AF	EP AF	LRD [2] AF	CP [3] AF	CWR AF	AW AF	SAE Percent
1978	565,585	1,038,432	313,759	40,260	10,000	774,933	824,895	94
1979	565,506	1,063,783	43,781	56,667	10,000	1,086,669	1,224,386	89
1980	566,101	1,110,665	80,939	57,207	10,000	1,096,933	1,244,994	88
1981	563,301	1,200,511	48,200	64,017	10,000	1,226,328	1,343,446	91
1982	563,862	1,092,494	44,669	58,213	10,000	1,116,038	1,341,639	83
1983	567,184	991,784	67,654	51,341	11,000	986,471	1,121,888	88
1984	571,219	1,219,669	36,124	65,753	11,000	1,260,298	1,546,883	81
1985	568,554	1,137,016	30,286	61,485	12,000	1,180,215	1,543,548	76
1986	568,986	1,063,689	95,168	53,807	12,000	1,034,328	1,339,113	77
1987	566,844	1,050,545	47,952	55,700	13,000	1,071,293	1,468,252	73
1988	568,083	1,095,899	55,181	56,702	13,000	1,110,420	1,430,213	78
1989	567,817	1,063,991	65,249	54,468	14,000	1,067,210	1,332,908	80
1990	568,389	1,062,302	74,386	49,100	14,000	1,037,268	1,220,681	85
1991	568,470	930,480	110,554	43,063	14,000	876,989	976,733	90
1992	570,552	942,959	151,541	39,011	14,000	844,429	975,535	87
1993	567,390	958,847	241,475	35,932	14,000	767,304	890,901	86
1994	563,563	970,136	47,225	37,839	15,351	976,101	1,184,492	82
1995	563,781	993,328	179,851	28,766	15,823	858,066	1,068,642	80
1996	563,881	1,157,630	79,587	41,311	15,999	1,135,353	1,453,965	78
Average	566,639	1,060,224	95,452	50,034	12,588	1,027,394	1,238,585	83

1/ October 1 to September 30
2/ LRD figured at four percent for all years prior to 1988
3/ CP estimated

Ac - Acre
AF - Acre-foot
ET - Evapotranspiration
EP - Effective Precipitation
LRD - Leaching Requirement Depth
CP - Cultural Practices
CWR - Crop Water Requirement
AW - Applied Project and groundwater
SAE - Seasonal Application Efficiency

The difference between the amount of applied water and the amount of crop water requirement is the water loss due to all factors. This loss can be attributed to both on-farm distribution and irrigation system losses. Individual on-farm irrigation system losses will depend upon the type of irrigation system. These losses can generally be classified into two categories, evaporation and deep percolation. Deep percolation is water which infiltrates into the soil but becomes unavailable for crop use because it moved below the root zone. Deep percolation on all District irrigable land averaged about 0.47 feet during the period 1977 through 1996 as shown in Table 14. The depth of deep percolation shown in Table 14 is about 10 percent less than the depth that would occur when only the land actually irrigated is considered.

Data from Westlands' 1987-89 *Irrigation Improvement Program (IIP)* (described later) shows that deep percolation is about 0.1 foot in areas where the shallow groundwater is less than 6 feet below the soil surface. This is substantially less than the San Joaquin Valley Drainage Program's recommended goal.

Table 15

District Deep Percolation

Crop Year[1]	Irrigable Area Ac	Applied Water AF	ML+CP[2] AF	ET AF	EP AF	ETAW AF	Deep Percolation AF	Deep Percolation FT.
1978	565,585	824,895	19,797	1,038,432	313,759	724,673	80,425	0.14
1979	565,506	1,224,386	29,385	1,063,783	43,781	1,020,002	174,999	0.31
1980	566,101	1,244,994	29,880	1,110,665	80,939	1,029,726	185,388	0.33
1981	563,301	1,343,446	32,243	1,200,511	48,200	1,152,311	158,892	0.28
1982	563,862	1,341,639	32,199	1,092,494	44,669	1,047,825	261,615	0.46
1983	567,184	1,121,888	26,925	991,784	67,654	924,130	170,833	0.30
1984	571,219	1,546,883	37,125	1,219,669	36,124	1,183,545	326,213	0.57
1985	568,554	1,543,548	37,045	1,137,106	30,286	1,106,730	399,773	0.70
1986	568,986	1,339,113	32,139	1,063,689	95,168	968,521	338,453	0.60
1987	566,844	1,468,252	35,238	1,050,545	47,952	1,002,593	430,421	0.76
1988	568,083	1,430,213	34,325	1,095,899	55,181	1,040,718	355,170	0.63
1989	567,817	1,332,908	31,990	1,063,991	65,249	998,742	302,176	0.53
1990	568,389	1,220,681	29,296	1,062,302	74,386	987,916	203,469	0.36
1991	568,470	976,733	23,442	930,480	110,554	819,926	133,365	0.30
1992	570,552	975,535	23,413	942,959	151,541	791,418	160,704	0.35
1993	567,390	890,901	21,382	958,847	241,475	717,372	152,147	0.32
1994	563,563	1,184,492	28,428	970,136	47,225	922,911	233,153	0.48
1995	563,781	1,068,642	25,647	993,328	179,851	813,477	229,518	0.44
1996	563,881	1,453,965	34,895	1,157,630	79,587	1,078,043	341,027	0.63
Average	566,639	1,238,585	29,726	1,060,224	95,452	964,772	244,452	0.47*

[1] October 1 to September 30
[2] Evaporative losses estimated at 2.4% of Applied Water

Ac -	Acre	ETAW -	ET of Applied Water
AF -	Acre-foot	ML -	Minor Losses (evaporative losses only)
EP -	Effective Precipitation	CP -	Cultural Practices
ET -	Evapotranspiration		*DP based on irrigated area not irrigable area.

Distribution Uniformity

The attainable Distribution Uniformity (DU) limits the irrigation efficiency of any irrigation system unless the crop is underirrigated. As its name implies, DU is the measure of how evenly the water is infiltrated into the soil profile. DU is a ratio of the average depth of water infiltrated into the soil in the quarter of the field infiltrating the least amount, to the average depth of total irrigation water infiltrated, in percent:

$$DU = \frac{Infiltration, AverageLowQuarterDepth}{Infiltration, AverageFieldDepth} X100$$

This method of determining DU based on the low quarter infiltration depth was developed by the U.S. Department of Agriculture, Soil Conservation Service and has become the standard for comparing alternative conditions (ASAE, 1980). It should be emphasized that this equation does not account for the possibility that one half of the low quarter, or 12.5 percent of the field, could be underirrigated. This results in inadequate leaching and a reduction in crop yield in this part of the field.

When an irrigation system operates at 80 percent DU, a farmer needs to apply an additional 25 percent of crop water requirement to adequately irrigate those parts of the field to which the system infiltrates the least amount of water. This over application results in losses to deep percolation below the crop root zone. A farmer can improve the system's DU through proper design and management, but no irrigation system's efficiency can exceed its attainable DU unless the field is intentionally underirrigated which reduces crop yields.

Average DU values for various irrigation systems measured by field evaluations, along with estimates of potential DU, are shown in Table 15. The table includes DU values for Westlands compiled from the 1987-1989 *IIP* and for drip/trickle irrigation systems evaluated throughout California by the Resource Conservation Districts' Mobile Laboratory Programs (Little, 1989).

Table 16

Distribution Uniformities

	Potential		Measured		
Irrigation System	Tanji & Hanson	Merriam & Keller	Little	IIP [1]	Attainable
	(%)	(%)	(%)	(%)	(%)
Furrow	85	80	N.A.	79	80
Border	77	77	N.A.	N.A.	80
Basin	92	72	N.A	N.A.	80
Sprinkler	75	75	N.A.	71	75 [2]
Drip/Trickle	85	82	74	74	80

[1] 1987-89 *Irrigation Improvement Program*
[2] A DU of 80 percent is attainable when alternate sets can be used.

The potential DU for each irrigation system is based on the mid-point of a range of values provided by Merriam and Keller, 1978, and Tanji and Hanson, 1990. Potential DUs for each irrigation system will vary from field to field depending on field specific conditions such as topography, soil texture, wind conditions, and water quality. The attainable DUs that can currently be achieved during the life of the system are based on the best commercial irrigation systems in the District and analysis of the measured DUs within Westlands. The absolute maximum attainable appears to be 85 percent, and that level would require a significant investment for technology and management to achieve and sustain this level, possibly with microirrigation and linear move systems.

After studying the differences in DU for the irrigation systems used in the District, it is evident that there is more variation in DUs within system categories than between categories. Therefore, it is concluded that proper system design for each field, along with good management, has a greater impact on DU and thus on irrigation efficiency than the type of system being used.

It is estimated from 1987-1989 *IIP* data that the average annual DU for current irrigation systems and management is approximately 74 percent. Irrigation efficiency values greater than the DU are the result of underirrigation; these high irrigation efficiency values occur at the cost of lower yields since parts of the field are underirrigated. The lower irrigation efficiencies noted for crops such as vegetables are due to difficulties in applying the precise amounts of water necessary to refill the shallow root zones.

FUTURE WATER REQUIREMENTS

It is anticipated that cropping patterns in Westlands will change in the future. Current and projected cropping patterns based on trends during the past several years are shown in Table 16. Future cropping patterns will be influenced by (1) decreases in average farm size, (2) increases in water costs, (3) increases in acreage of high-value crops, (4) increases in double cropping, (5) lands taken out of production, (6) substantially reduced subsidies for crops and water, and (7) no fallow acreage. The projected acreages are determined by water need rather than availability.

Table 17

Present and Projected Cropping Patterns

Crop	1996 Present Ac	2010 Future Ac
Alfalfa Hay	3,525	5,000
Cotton	272,361	180,000
Field Crops	16,951	25,000
Grain	41,322	5,000
Trees	28,289	50,000
Vegetables	181,009	300,000
Vines	6,247	10,000
Fallow	26,754	0
Out of Production	0	30,000
Subtotal	576,458	605,000
Double Crop	<12,577>	<67,000>
Total	563,881	538,000

The information presented in Table 16 assumes no fallow land in 2010 due to the increased double cropping required to pay for increased farming costs and the need for higher production from fewer small farm acres. Some land will be used for alternative purposes and will be voluntarily removed from production. The water currently used on these lands will be used elsewhere within the District.

The projected water requirement for Westlands in the year 2010 is expected to be approximately 1.52 million acre-feet as shown in Table 17. This projection is based on the expectation that irrigation systems will be designed and operated to apply water more frequently, which should improve yields.

Crop ET will increase due to the more frequent irrigations, distribution uniformity will increase to 85 percent, and alternative water management practices will ultimately allow the seasonal application efficiency to improve to 80 percent without underirrigation. Some newly installed irrigation systems have distribution uniformities greater than 85 percent. However, regardless of the system, it is expected that production agriculture DU will, at best, average no greater than 85 percent over the course of the system's service life. Proper management is essential to achieve high efficiencies, even for systems which have potentially high DU.

The District's firm water supply consists of 1.15 million AF of Project water and 0.15 million AF of groundwater for a total of 1.3 million AF. This supply is about 0.22 million AF less than the amount required by the farmers to keep ahead of the rising costs to produce the food and fiber needed by the state's ever increasing population.

Table 18

Projected 2010 Water Requirement

Crop	Area	Evapotranspiration		Effective Precipitation		Leaching* Requirement		Cultural Requirement		Crop Water Requirement		Seasonal Application Efficiency	Water Use	
	Ac	AF / Ac	AF	AF / Ac	AF	AF / Ac	AF	AF / Ac	AF	AF / Ac	AF	Percent	AF / Ac	AF
Alfalfa hay	5,000	5.1	25,500	0.2	1,000	0.3	1,500	0.0	0	5.2	26,000	80	6.50	32,500
Cotton	180,000	2.4	432,000	0.1	18,000	0.1	18,000	0.0	0	2.4	432,000	80	3.00	540,000
Field crops	25,000	2.9	72,500	0.2	5,000	0.1	2,500	0.0	0	2.8	70,000	80	3.50	87,500
Grain	5,000	1.8	9,000	0.2	1,000	0.1	500	0.0	0	1.7	8,500	80	2.13	10,625
Trees	50,000	3.0	150,000	0.2	10,000	0.1	5,000	0.0	0	2.9	145,000	80	3.63	181,250
Vegetables	300,000	1.6	480,000	0.1	30,000	0.1	30,000	0.1	30,000	1.7	510,000	80	2.13	637,500
Vines	10,000	2.3	23,000	0.1	1,000	0.1	1,000	0	0	2.3	23,000	80	2.88	28,750
Fallow	0	0	0	0	0	0	0	0	0	0	0	80	0	0
Out of production	30,000	0	0	0	0	0	0	0	0	0	0	80	0	0
Subtotal	605,000													
Double crop	(67,000)													
TOTAL	538,000		1,192,000		66,000		58,500		30,000		1,214,500	80		1,518,125

* Five percent of ET

WATER AND SALT BALANCE

Water and salt balances are simply defined as the amount of each that enters the root zone and its final destination. Water available for use in the root zone comes from four main sources: effective precipitation, groundwater wells, the San Luis Canal, and the Mendota Pool. Water leaves the root zone by crop evapotranspiration, surface evaporation, and deep percolation. Farmers are prohibited from moving Project water outside the farm or District boundaries without prior approval. Subsurface drainage water is not exported from or imported into Westlands. District and other studies show subsurface lateral inflow and outflow estimates to be nil and will not be considered in the water balance calculation. Also, a small amount of shallow groundwater may be present in the root zone. This is not considered a renewable water source since once it is used, it can only be replaced by subsequent overirrigation.

Since its inception, Westlands has been analyzing its irrigation water use. Water use, measured at each delivery, is compiled on an annual basis. Annual estimates of groundwater pumpage have been provided by the U.S. Geological Survey, and more recently verified by the District's in-house groundwater monitoring program. District-wide crop evapotranspiration is calculated using computer models which are field verified with soil moisture data measured with a neutron probe. Effective precipitation is calculated from rainfall data collected at three weather stations. Leaching Requirement Depth (LRD) is the quantity of water required to leach salts below the crop root zone to maintain crop production.

The seasonal application efficiency is estimated for each crop year. After minor evaporative losses are considered, the quantity of water that percolates below the root zone is also estimated.

Water Balance

The water balance equation states that the sum of the water brought into the root zone, minus the sum of the water taken out of the root zone, must be equal to the change in storage of water. Since no Project water is taken out of the District, evapotranspiration, evaporation, and deep percolation are assumed to be the ultimate destination of all applied water.

Applied water is primarily surface water, supplemented by pumped groundwater. Pumped groundwater for 1996, the most recent year when near 100 percent of the Contract water supply was available (95%), was 50,000 AF. The ET, leaching component of deep percolation, and water for cultural practices are considered to be of beneficial use. The deep percolation in excess of the LRD is considered lost since most of Westlands overlies saline shallow groundwater, and cannot be recovered for reuse.

Table 18 shows the District's average water balance in the root zone for the period 1978 through 1996, using data from tables 8, 13, and 14.

Table 19

Average Root Zone Water Balance [1/]

	Inflow (AF)	Outflow (AF)
Project Water	1,161,757	
Effective Precipitation	100,859	
Pumped Groundwater	144,615	
Crop ET		1,062,329
Evaporation (ML+CP)		29,874
Deep Percolation includes LRD		253,430
	1,345,633	1,345,633

[1/] Average of 1978 to 1996 Water Years

Shallow groundwater observations are made in October of each year for about 200,000 acres where the depth to shallow groundwater is 10 feet or less. These indicate a stable situation and only minor changes in water storage. Fluctuations in shallow groundwater levels indicate that local overirrigation in or immediately adjacent to a field, rather than lateral subsurface flow, is the main cause of changes during the irrigation season.

Salt Balance

A root zone salt balance is achieved when the amount of salts added to the root zone and the amount removed by leaching are equal. The inflow of salts to the root zone in Westlands from irrigation with Project water and groundwater is presented in Table 19.

Table 20
Root Zone Salt Balance

	Inflow	Outflow
Project Water [1/]	454,000 Tons	
Groundwater [2/]	251,000 Tons	
Fertilizers and Amendments	Unknown	
Deep Percolation		Unknown
Total	Unknown	Unknown

[1/] Average Project Water EC = 0.45 dS/m for 1978 thru 1996
[2/] Average Groundwater EC = 2.0 dS/m

The generalized buildup of salts in Westlands' soil cannot be determined using standard procedures such as those described in Food and Agricultural Organization, Irrigation and Drainage Paper No. 29, *Water Quality for Agriculture*. These procedures assume the average salts in the applied water are equal to the average amount leached fom the root zone. Such steady state conditions seldom exist. Furthermore, when this procedure is applied to a district or region, the average or steady state salt inflow/outflow can appear to be in balance, while leaching remains inadequate or excessive in specific localities. Inadequate leaching results in excessive root zone salinity and reduced crop production. Excessive leaching can result in increased deep percolation and rising shallow groundwater levels, which can also reduce crop production.

Westlands' actual root zone salt balance cannot be calculated because salts from mineral dissolution, soil amendments, and fertilizers are unknown as is the salt removed from the root zone by deep percolation and added from fluctuating shallow groundwater levels.

Also, 1976 research by Drs. Kaddah and Rhoades identified the difficulty with attempting to determine district-wide salt balance of an irrigation district. Their work in the Imperial Valley indicates that naturally occurring salts laid down during soil formation still have a significant effect on salinity and salt balance distribution. Specific field leaching values were also difficult to identify because typical leaching fraction analysis assumes a steady state condition of root zone salinity. In this condition, only those salts added to the field are concentrated and removed through deep percolation without considering other salt inputs or outflows.

MUNICIPAL AND INDUSTRIAL USES

Municipal and Industrial (M&I) water uses are provided from the basic agricultural contract, under provisions that allow for M&I uses. True M&I uses should be differentiated from incidental agricultural uses. Incidental agricultural uses, provided for in the contract, are those on-farm support uses that are necessary to the conduct of agricultural activities, such as dust control on roads, wash racks, and water for on farm water treatment plants. True M&I uses are those non-agricultural production uses within the District that support agricultural production, but are not on-farm operations, such as cotton gins, tomato processing plants, motels and restaurants. Westlands provides conveyance services to cities and governmental agencies, but does not provide any treated water.

GROUNDWATER RECHARGE

Westlands does not have any groundwater recharge facilities within the District. Except for the western portion of the district, Westlands is generally considered to be sitting above a saline salt sink, the upper unconfined aquifer or shallow groundwater. Recharge for the lower confined aquifer comes generally from east of the District, below the Corcoran clay. Recharge of the confined aquifer might possibly occur in areas on the western edge of the District, near the coast range, where the boundary of the Corcoran clay is irregular.

WATER TRANSFERS

Water transfers have become an important component in Westlands water supply. Transfers from other districts are pursued each year to supplement reduced contract deliveries when the price is reasonable. Transfers within the District are used to supplement a water user's allocation from supplies currently available. Table 20 has a consolidated list of transfers into Westlands from other districts in the 1996-97 water year. Due to the shortage of supply, no water is transferred out of Westlands.

Table 21

Consolidated Transfer List for Water Year 1996-97

Agency	Transfer In (AF)	Transfer Out (AF)
215/Kern County WA	63,128	
Banta Carbona ID	14,250	
Berenda/KCWA	24,000	
Broadview WD	2,470	
CCID	1,050	
City of Avenal	1,000	
City of Tracy	1,430	
Clarksfield Co.	30,000	
Coelho Trust	1,768	
Del Puerto WD	14,425	
Fresno Slough WD	1,500	
Jim Nichol/BRAVO	10,000	
KCWA	42,632	
KCWA		(10,443)
Kings River WA	3,297	
Lower Tule &Pixley ID	2,500	
Madera ID/KCWA	21,287	
Mercy Springs WD	1,400	
Panoche WD	8,339	
Patterson WD	6,200	
Plain View WD	6,000	
San Luis WD	5,527	
TLBWSD	4,000	
Tranquillity ID	2,885	
Tranquillity ID		(743)
West Stanislaus ID	6,000	
Widren WD	65	
Transfer/Exchanges Total	275,153	(11,186)

Intra-District water transfers between water users are too numerous to list. Citing information from a recent water marketing study, it was found that in the 1994-95 water year a total of over 380,000 AF was transferred in over 3,500 transactions.

WATER ACCOUNTING

The intent of this section is to arrange quantified water supplies, uses and losses discussed earlier and arrange it in a water accounting form. These tables are intended to assist when analyzing best management practices, the water savings resulting from an individual practice can be estimated based on the water inventory. The water accounting is broken down into several tables, Surface Water Supply, Ground Water Supply, Water Supplies, Conveyance System Losses, Crop Water Needs, and Overall Water Budget.

Table 22
1996-Surface Water Supply
(Crop Year)

Month	USBR, Ag	State Project	Local Water	Upslope Drain	Total
	AF	AF	Supply, AF	Water, AF	AF
October, 95	21,934				21,934
November	36,586				36,586
December	62,599				62,599
January, 96	121,236				121,236
February	79,324				79,324
March	47,425				47,425
April	76,900				76,900
May	130,680				130,680
June	157,410				157,410
July	205,468				205,468
August	173,080				173,080
September	23,983				23,983
TOTAL	1,136,625				1,136,625

Table 22
1996-Ground Water Supply
(Crop Year)

	Pumped by District		Pumped by District Water Users		
Month	Basin 1	Basin 2	Basin 1	Basin 2	Total
	AF	AF	AF	AF	AF
October, 95			0		0
November			0		0
December			0		0
January, 96			0		0
February			0		0
March			0		0
April			0		0
May			10,000		10,000
June			10,000		10,000
July			10,000		10,000
August			10,000		10,000
September			10,000		10,000
TOTAL			50,000		50,000

Table 24
1996-Water Supplies
(Crop Year)

Month	Surface Water	Ground Water	Effective Precipitation	Reclaimed Water	Total
	AF	AF	AF	AF	AF
October, 95	21,934	0	16,766		38,700
November	36,586	0	5,128		41,715
December	62,599	0	19,527		82,126
January, 96	121,236	0	25,937		147,173
February	79,324	0	2,564		81,889
March	47,425	0	6,410		53,835
April	76,900	0			76,900
May	130,680	10,000	3,254		143,934
June	157,410	10,000			167,410
July	205,468	10,000			215,468
August	173,080	10,000			183,080
September	23,983	10,000			33,983
TOTAL	1,136,625	50,000	79,587		1,266,212

Table 25
1996-Conveyance System Losses
(Crop Year)

Lateral or Res.	Length	Seepage	Evaporation	Operational Spills	Total Losses
	miles	AF	AF	AF	AF
7-1 Inlet Canal	7.4	275	75	0	350
Regulating Res.		196	31	0	227
TOTAL	7.4	471	107	0	578

Table 26
1996-Crop Water Needs
(Crop Year)

Crop	Area	Planting	Harvest	Crop ET	Leaching Requirement	Cultural Practices	Water Needs
	Acres	Month	Month	AF/Ac	AF/Ac	AF/Ac	AF
Alfalfa Hay	3,525	Perennial	------	4.93	0.31	0.00	18,440
Alfalfa Seed	6,531	Perennial	Sep	3.78	0.24	0.00	26,210
Almonds	14,561	Perennial	Aug	3.26	0.27	0.00	51,313
Barley	3,843	Nov	May	1.35	0.02	0.00	5,256
Beans	18,325	May	Sep	1.89	0.16	0.00	37,503
Cantaloupe	18,452	Apr	Aug	1.02	0.05	0.00	19,710
Cotton	272,361	Apr	Oct	2.31	0.04	0.00	638,967
Garlic	22,665	Nov	Aug	1.46	0.14	0.10	38,465
Grapes	6,247	Apr	Sep	2.29	0.19	0.00	15,466
Lettuce, Spr	10,708	Dec	Apr	0.33	0.03	0.08	4,704
Lettuce, Fall	6,438	Sep	Oct	0.38	0.04	0.13	3,535
Onions	10,589	Nov	Aug	2.36	0.25	0.10	28,648
Pistachios	5,747	Perennial	Aug	3.41	0.29	0.00	21,228
Safflower	4,925	Mar	Aug	2.50	0.05	0.00	12,538
Sugar Beets	4,708	Feb	Sep	3.50	0.06	0.00	16,732
Tomatoes, Fr	4,484	Apr	Jun	1.47	0.07	0.00	6,894
Tomatoes, Pr	88,095	Mar	Aug	1.82	0.09	0.13	179,410
Wheat	20,316	Nov	Jun	1.73	0.03	0.00	35,696
Field, Misc	5,410			2.00	0.06	0.00	11,126
Truck, Misc	13,782			1.50	0.09	0.00	21,876
T&V, Misc	7,992	Perennial		2.50	0.16	0.00	21,223
TOTAL	549,704						1,214,939

Table 27
1996-Overall Water Budget
(Crop Year)

Step 2 A 1996 Water Supply		From Table 23	1,266,212	AF
District Beneficial Uses				
2A2e Environmental Consumptive Use		minus	28	AF*
2C3 Ground Water Recharge	(planned)	minus	0	AF
2C4 Water Exchanges or Transfers		plus or minus	267,340	AF
		Water Supply Available for Use	1,533,524	AF
District Non-Beneficial Uses				
2A2a Conveyance System Seepage*	Table 24	minus	471	AF**
2A2a Conveyance System/Reservoir Evaporation**	Table 24	minus	107	AF***
2A2a Conveyance System Spills	Table 24	minus	0	AF
2A2d Consumptive Use by Riparian Vegetation	(estimate)	minus	0	AF
		Available Water Supply	1,532,946	AF
		Quantity of Water Actually Delivered to Customers	1,532,946	AF
2C1 Crop Water Needs	Table 25	minus	1,214,939	AF
2D On-farm Drain/Spill Water Leaving the District	(estimate)	minus	0	AF
2D Deep Percolation, in excess of Leaching Requirement		EQUALS	318,007	AF

* Wetlands mitigation on lateral 14
** Mendota Pool inlet canal plus regulating reservoirs on pumped laterals.
*** Canal evaporation and misc. evaporation losses from on-farm surface irrigation systems.

Table 28
1996-Deep Percolation and Conveyance Seepage
(Crop Year)

Deep Percolation (Table 26)	AF	318,007
Conveyance Seepage (Table 24)	AF	471
Total of Deep Percolation plus Conveyance Seepage	AF	317,536
Irrigated acres	Ac	563,881
Irrigated acres over a perched water table, 5 feet or less.	Ac	139,450
Irrigated acres over a salt sink, 20 feet or less.	Ac	293,300
Portion of Deep Percolation/Conveyance Seepage flowing to a perched water table		25%
Portion of Deep Percolation/Conveyance Seepage flowing to a salt sink		52%
Total flowing to a perched water table or saline sink, AF		165,119

Table 29
Annual Water Quantities Delivered Under Each Right or Contract
(Water Year)

Year	USBR	USBR (CL II)	SWP Contract	Transfers	Total
1987	1,150,300			6,069	1,156,369
1988	1,215,000			15,959	1,230,959
1989	1,152,118			108,599	1,260,717
1990	694,491			18,502	712,993
1991	404,102			88,447	492,549
1992	488,083			124,143	612,226
1993	788,871			231,441	1,020,312
1994	606,392			146,368	752,760
1995	1,210,061			138,428	1,348,489
1996	1,173,028			264,142	1,437,170
Total	8,882,446			1,142,098	10,024,544
Average	888,245			114,210	1,002,454

Table 30-M&I Water Delivered in Westlands in 1998

Customer Type	# of Connections	1998 use (AF)
Single Family		
Multifamily		
Commercial	5	271
Industrial	35	778
Institutional	12	224 / 2,598**
Landscape Irrigation		
Wholesale		
Reclaimed		
Other, Incidental Ag	188	1061
Unaccounted for		
TOTAL	240	2,334 / 4,708**

** Note: 2,374 AF was conveyed to NAS Lemoore, but is not considered as M&I waterdelivered for purposes of the USBR criteria for preparing an Urban plan.There is no wastewater collection & treatment systems or recycling of M&I water in the District.