

3 Monitoring Programs

3.1 Climatological Monitoring Program

3.1.1 Program Description

The Zone 7 Climatological Monitoring Program network consists of seven rainfall stations, two pan evaporation stations, and one California Irrigation Management System (CIMIS) station located within the approximate 400-square-mile watershed of the Valley. The Zone 7 network stations provide high quality data for long-term studies, basin recharge calculations, and water management decisions. The boundary of the watershed, the location of the climatological stations, and the lines of equal annual rainfall (isohyets) are shown in Figure 3.1-1. Table 3.1-1 lists the stations and provides basic station information including the station ID, name, location, and mean annual precipitation or evaporation.

There are two basic types of rainfall stations used in Zone 7's climatological monitoring program: daily record stations and recorder stations. A daily record station, which is used to determine multi-day storm totals, consists of a rain gage at which, once-a-day, the observer measures and records the depth of rain that has fallen during the preceding 24 hours. A recorder station, which provides rainfall intensity for periods of less than 24-hours, consists of a computerized-tipping-bucket rain gage and a data recorder. These semi-continuous-reading rain gages generally provide rainfall totals on a 15-minute frequency.

Zone 7's climatological monitoring program contains both reference evapotranspiration (ET_o) and pan evaporation stations to determine water transfer to the atmosphere. Station 191 (CIMIS) is a reference evapotranspiration station, which is an estimated value of the water used by a well-watered, full-cover grass surface, whereas the pan evaporation stations at Lake Del Valle (LDV) and Livermore Water Reclamation Plant (LWRP) measure evaporation directly. LDV and LWRP pan evaporation data is converted to ET_o using a conversion factor ($ET_o = \text{Pan Evap} \times 0.6402$). Zone 7 uses ET_o to calculate evaporation from the mining ponds as well as in its applied water recharge model. The CIMIS Stations' ET_o is also used as part of Zone 7's Water Conservation program to help regulate weather-based irrigation ("SMART") controllers.

3.1.2 2012 Results

The 2012 Water Year rainfall in the Valley was below average at 68% of normal. Rainfall totals from individual stations ranged from 7.39 inches (57% of normal) at Station 24 (Patterson Pass Water Treatment Plant) to 19.93 inches (83%) at Station 44 (Mt. Hamilton). Evaporation was 73.23 inches (110% of normal) at the Lake Del Valle Station. Evapotranspiration was 50.14 inches (the station is too new to have established a "normal") at the CIMIS station.

The monthly precipitation totals for each of Zone 7's precipitation stations for the 2012 Water Year are shown in Table 3.1-2. Table 3.1-3 shows historical monthly data from Station 15E in Livermore, the station with the longest historical record (1871-2012). Daily and 15-minute data are archived in Zone 7's database. Figure 3.1-2, a graph of cumulative rainfall from Station 15E, presents data for the 2012 Water Year, along with the driest water year (1977), the calculated average water year, the wettest year (1983), and the 2011 Water Year for comparison.

Table 3.1-4 provides the monthly evapotranspiration (ET_o) for each of the three monitoring stations during the 2012 Water Year, and Table 3.1-5 shows monthly pan evaporation measured at Lake Del Valle (LDV-EV) data going back to the 1969 Water Year.

There were some data confidence issues with the LWRP pan evaporation data for the 2012 Water Year. This station had multiple days of zero pan evaporation while the other two program stations recorded ET_o/evaporation values of up to 0.16" on the same days. The City of Livermore operates this monitoring station, but Zone 7 will continue to monitor its integrity in the 2013 Water Year.

3.2 Groundwater Elevation and Quality Monitoring Program

3.2.1 Program Description

The Groundwater Elevation and Quality Monitoring Program includes the measurement of groundwater levels in monitoring and production wells, and the collection and analyses of groundwater samples. These hydrologic data are needed to assess groundwater supplies (i.e., quantity, quality, and trends). The program focuses on the Main Basin, where groundwater is pumped for municipal uses. Other Zone 7 programs utilize the data collected in this program, and the results are used in water resources management planning and decision making.

There were a total of 239 wells in the Zone 7 groundwater monitoring program during the 2012 Water Year (shown on Figure 3.2-1). Each well in the program was monitored and/or sampled to fulfill one or more specific objectives. Table 3.2-1 lists all of the wells in the program, the objective(s) of each monitoring well, and the frequency of monitoring or sampling for each objective. The objectives are summarized below:

Zone 7's Water Level Monitoring – groundwater level measurements are made twice per year during seasonal extremes (i.e., spring highs and fall lows) for storage tracking. Water level measurements are also measured monthly in some wells to monitor subsidence, adjust recharge operations, and identify when semi-annual water level measurements should be scheduled.

Zone 7's Water Quality Sampling –sampling of groundwater is performed annually from each of the wells in the program. Sampling is performed in some wells more frequently if required for an additional program described below. Also, some of the wells in the program are sampled and tested by an outside contractor or property owner, and the results are supplied to Zone 7 staff.



**TABLE 3.1-1
CLIMATOLOGICAL STATIONS
2012 WATER YEAR**

PRECIPITATION NETWORK

Alameda County STATION	Computer SITE ID	STATION NAME	LOCATION	OBSERVER	ELEVATION	STATION ESTABLISHED		MEAN ANNUAL PRECIPITATION INCHES
						DAILY RECORD	15 MIN RECORD	
15E	CM_STA 15E	NOAA LIVERMORE	WELLINGHAM DRIVE LIVERMORE	MR. RON HAFNER	480	1871	-	14.51
17	CM_STA 17	DEL VALLE PLANT	VALLECITOS ROAD LIVERMORE	ZONE 7 STAFF	640	1974	1978 to Present	15.96
24	CM_STA 24	PATTERSON PLANT	PATTERSON PASS ROAD LIVERMORE	ZONE 7 STAFF	680	1963	1969 to Present	13.01
34	CM_STA 34	MOCHO WELL FIELD	SANTA RITA ROAD PLEASANTON	ZONE 7 STAFF	340	1968	1970 to Present	17.86
44	CM_STA 44	MT HAMILTON	LICK OBSERVATORY MT HAMILTON	LICK OBSERVATORY	4209	1881	-	24.05
101	CM_STA 101	TASSAJARA	CAMINO TASSAJARA ROAD DANVILLE	MRS. JOAN HANSEN	800	1912	-	19.59
170	CM_STA 170	ZONE 7 OFFICE	PARKSIDE DRIVE PLEASANTON	ZONE 7 STAFF	330	1986	1986 to 2005	20.78
191	CM_STA 191	CIMIS STATION	ALAMEDA COUNTY FAIRGROUNDS PLEASANTON	DWR STAFF	335	-	2004 to Present	16.99

EVAPORATION NETWORK

STATION ID	SITE ID	STATION NAME	LOCATION	OBSERVER	ELEVATION	STATION ESTABLISHED	MEAN ANNUAL ET _o INCHES *
LDV	CM_STA LDV-EV	LAKE DEL VALLE	ARROYO ROAD LIVERMORE	DWR STAFF	760	1969	42.45
LWRP	CM_STA LWRP-EV	LIVERMORE WATER RECLAMATION PLANT	JACK LONDON DRIVE LIVERMORE	LWRP STAFF	410	1974	45.88
191	CM_STA 191-ETO	CIMIS STATION	ALAMEDA COUNTY FAIRGROUNDS PLEASANTON	DWR STAFF	335	2004	50.14

* Stations LDV and LWRP record evaporation using pan evaporation equipment. ET_o is derived using : ET_o= Pan Evaporation x 0.6402



**TABLE 3.1-2
MONTHLY PRECIPITATION DATA
2012 WATER YEAR**

MONTHLY PRECIPITATION IN INCHES

	STATION NUMBER								Network Average	% Average of Network
	15E	17	24	34	44	101	170	191		
OCT	1.06	1.17	1.08	0.95	2.15	1.29	1.25	0.98	1.24	122.9%
NOV	0.93	0.92	0.75	1.20	1.88	1.07	1.45	1.30	1.19	59.3%
DEC	0.04	0.06	0.02	0.08	0.35	0.14	0.12	0.10	0.11	3.9%
JAN	1.52	1.60	1.17	2.32	3.15	2.41	2.64	2.39	2.15	64.6%
FEB	0.52	0.28	0.40	0.91	2.07	1.09	1.10	0.88	0.91	28.1%
MAR	2.57	3.19	2.01	3.38	6.07	4.21	4.09	4.11	3.70	124.4%
APR	2.01	1.99	1.89	2.83	3.92	2.83	3.89	2.46	2.73	199.4%
MAY	0.02	0.00	0.00	0.00	0.00	0.02	0.00	0.05	0.01	1.9%
JUN	0.12	0.15	0.07	0.00	0.32	0.00	0.00	0.00	0.08	65.7%
JUL	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.01	23.6%
AUG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0%
SEP	0.01	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.01	2.4%
TOTAL	8.80	9.37	7.39	11.67	19.93	13.11	14.54	12.27	12.14	
% AVG	61%	59%	57%	65%	83%	67%	70%	72%	68%	

DISTRIBUTION OF DAILY PRECIPITATION

Number of days with precipitation greater than given rainfall total

Rainfall (inches)	STATION NUMBER								Network Average
	15E	17	24	34	44	101	170	191	
TRACE	49	42	43	47	57	46	48	47	47
0.1	19	22	18	24	39	29	24	25	25
0.5	4	5	5	6	12	8	11	8	7
1	1	2	1	2	5	2	3	3	2
2	0	0	0	0	0	0	0	0	0



TABLE 3.1-3
HISTORICAL MONTHLY PRECIPITATION
MONITORING STATION 15E, LIVERMORE (INCHES)
1871 to 2012 WATER YEARS

Water Year	OCTWY	NOVWY	DECWY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL OCT-SEP	TOTAL JULY-JUNE	% NORMAL OCT-SEP
1871	0.00	0.00	0.00	1.42	1.93	0.36	1.25	0.02	0.00	0.00	0.00	0.00	4.98	4.98	34%
1872	0.00	1.13	11.69	2.15	2.69	0.65	0.43	0.00	0.32	0.00	0.00	0.00	19.06	19.06	131%
1873	0.00	1.22	3.87	1.04	3.73	0.68	0.15	0.00	0.00	0.00	0.00	0.00	10.69	10.69	74%
1874	0.42	0.70	4.48	2.96	1.03	1.34	0.95	0.32	0.06	0.00	0.00	0.30	12.56	12.26	87%
1875	1.67	2.03	0.20	5.40	1.20	0.35	0.00	0.00	0.52	0.00	0.00	0.00	11.37	11.67	78%
1876	0.00	7.23	1.62	2.68	3.01	4.39	0.73	0.33	0.00	0.00	0.00	0.00	19.99	19.99	138%
1877	1.26	0.10	0.00	2.47	0.56	1.10	0.13	0.39	0.00	0.00	0.00	0.00	6.01	6.01	41%
1878	1.27	1.29	0.73	4.61	6.73	2.01	0.96	0.06	0.00	0.00	0.00	0.00	17.66	17.66	122%
1879	0.24	0.31	0.17	2.83	1.78	2.49	0.75	1.34	0.20	0.00	0.00	0.00	10.11	10.11	70%
1880	0.83	1.06	1.94	1.48	1.80	1.45	6.51	0.91	0.00	0.00	0.00	0.00	15.98	15.98	110%
1881	0.00	0.65	7.75	2.40	2.62	1.06	1.93	0.00	0.04	0.00	0.00	0.00	16.45	16.45	113%
1882	0.08	0.78	1.97	1.07	1.72	4.85	1.03	0.20	0.00	0.00	0.00	0.34	12.04	11.70	83%
1883	1.52	1.48	0.38	2.38	0.63	3.45	1.50	2.18	0.00	0.00	0.00	0.35	13.87	13.86	96%
1884	1.52	0.57	0.44	4.03	5.29	5.92	2.70	0.20	1.73	0.00	0.10	0.30	22.80	22.75	157%
1885	1.14	0.02	6.22	1.72	0.36	0.78	1.29	0.08	0.00	0.00	0.00	0.05	11.66	12.01	80%
1886	0.00	6.20	1.94	4.20	0.24	1.18	2.36	0.00	0.00	0.40	0.00	0.00	16.52	16.17	114%
1887	0.30	0.70	0.81	0.90	6.23	0.23	1.60	0.00	0.00	0.00	0.00	0.80	11.57	11.17	80%
1888	0.00	0.61	3.51	3.20	0.94	2.51	0.60	0.66	0.30	0.00	0.00	0.76	13.09	13.13	90%
1889	0.00	3.80	2.21	0.46	0.67	5.15	0.51	2.25	0.00	0.00	0.00	0.00	15.05	15.81	104%
1890	3.94	2.95	8.63	5.24	3.71	2.85	0.86	0.48	0.00	0.00	0.00	1.20	29.86	28.66	206%
1891	0.00	0.00	3.31	0.54	4.18	2.50	1.88	0.40	0.15	0.00	0.00	1.32	14.28	14.16	98%
1892	0.05	0.38	4.42	0.84	1.08	3.96	0.90	1.30	0.00	0.00	0.00	0.45	13.38	14.25	92%
1893	1.65	4.97	7.27	3.02	3.12	3.68	1.40	0.73	0.00	0.00	0.00	0.00	25.84	26.29	178%
1894	0.00	1.59	2.14	4.97	5.36	0.81	0.58	1.19	0.52	0.00	0.00	1.45	18.61	17.16	128%
1895	1.15	0.50	8.56	6.83	1.56	1.81	1.26	1.25	0.00	0.00	0.00	0.22	23.14	24.37	159%
1896	0.83	1.69	1.28	7.16	0.17	1.50	3.11	0.39	0.00	0.00	0.73	0.55	17.41	16.35	120%
1897	1.48	3.02	1.71	1.89	3.54	4.04	0.24	0.00	0.08	0.00	0.00	0.06	16.06	17.28	111%
1898	1.43	0.52	1.31	1.47	1.78	0.78	0.45	0.96	0.35	0.00	0.00	0.95	10.00	9.11	69%
1899	0.74	0.25	1.61	2.60	0.08	4.81	0.35	0.15	0.22	0.00	0.00	0.00	10.81	11.76	75%
1900	2.52	2.49	2.07	2.44	0.34	1.11	0.86	1.10	0.00	0.00	0.00	0.18	13.11	12.93	90%
1901	1.93	4.48	1.06	2.69	5.15	0.95	1.80	1.58	0.00	0.00	0.00	0.68	20.32	19.82	140%
1902	0.70	1.99	0.74	0.99	3.62	2.69	0.75	0.32	0.00	0.00	0.13	0.00	11.93	12.48	82%
1903	0.47	2.07	0.87	3.19	0.94	5.65	0.81	0.12	0.00	0.00	0.00	0.00	14.12	14.25	97%
1904	0.00	2.16	0.59	0.89	4.18	3.71	1.56	0.24	0.00	0.00	0.32	1.62	15.27	13.33	105%
1905	1.00	0.78	1.42	2.43	2.30	3.12	0.93	1.89	0.00	0.00	0.00	0.00	13.87	15.81	96%
1906	0.00	1.01	1.18	5.56	2.67	5.18	0.95	1.61	0.56	0.00	0.00	0.20	18.92	18.72	130%
1907	0.03	1.34	6.45	3.22	1.86	8.85	0.47	0.16	0.56	0.00	0.00	0.00	22.94	23.14	158%
1908	0.81	0.04	3.90	2.27	1.35	0.73	0.28	0.53	0.00	0.00	0.00	0.03	9.94	9.91	69%
1909	0.27	0.60	1.55	10.18	3.96	1.94	0.00	0.00	0.05	0.00	0.00	0.62	19.17	18.58	132%
1910	0.75	1.68	5.77	2.50	1.14	1.90	0.10	0.00	0.04	0.00	0.00	0.10	13.98	14.50	96%
1911	0.29	0.10	1.32	12.60	1.42	4.45	0.69	0.24	0.07	0.00	0.00	0.00	21.18	21.28	146%
1912	0.43	0.29	1.71	2.66	0.20	1.99	0.73	0.94	0.65	0.00	0.00	0.48	10.08	9.60	69%
1913	0.71	0.44	0.81	2.63	0.38	1.65	0.54	0.58	0.01	0.27	0.02	0.00	8.04	8.23	55%
1914	0.00	2.47	3.17	7.10	2.11	0.66	0.76	0.45	0.19	0.00	0.00	0.00	16.91	17.20	117%
1915	0.45	0.33	3.96	4.16	5.79	1.50	0.66	2.66	0.00	0.00	0.00	0.00	19.51	19.51	134%
1916	0.00	0.76	4.41	11.35	2.17	1.47	0.21	0.05	0.00	0.00	0.00	0.44	20.86	20.42	144%
1917	0.50	0.68	3.28	1.06	3.37	1.08	0.15	0.02	0.00	0.00	0.00	0.04	10.18	10.58	70%
1918	0.00	0.43	0.66	0.59	3.08	3.32	0.61	0.00	0.00	0.00	0.00	5.72	14.41	8.73	99%
1919	0.39	2.38	1.51	1.03	4.58	2.33	0.05	0.00	0.00	0.00	0.00	0.48	12.75	17.99	88%
1920	0.15	0.33	2.21	0.22	0.71	3.52	1.07	0.00	0.13	0.00	0.00	0.00	8.34	8.82	57%
1921	2.03	1.43	3.81	3.38	0.59	0.83	0.16	1.05	0.00	0.00	0.00	0.05	13.33	13.28	92%
1922	0.15	1.17	3.38	1.51	5.46	1.83	0.23	0.27	0.00	0.00	0.00	0.00	14.00	14.05	96%
1923	0.54	2.86	5.43	1.80	0.65	0.15	2.15	0.00	0.02	0.00	0.00	0.82	14.42	13.60	99%
1924	0.25	0.76	0.87	1.40	0.93	0.65	0.28	0.07	0.00	0.00	0.00	0.00	5.21	6.03	36%
1925	1.30	1.53	2.63	1.02	3.74	1.14	1.75	1.41	0.04	0.00	0.00	0.00	14.56	14.56	100%
1926	0.00	0.97	1.14	2.44	3.58	0.16	3.11	0.11	0.00	0.00	0.00	0.00	11.51	11.51	79%
1927	0.93	2.83	0.78	1.74	3.49	1.54	1.73	0.10	0.18	0.00	0.00	0.03	13.35	13.32	92%
1928	1.71	1.43	2.00	1.46	0.89	3.43	1.43	0.45	0.00	0.00	0.00	0.00	12.80	12.83	88%
1929	0.00	2.57	2.76	1.26	0.87	1.07	0.70	0.03	0.83	0.00	0.00	0.00	10.09	10.09	70%
1930	0.01	0.00	1.81	3.64	1.91	1.88	1.14	0.43	0.00	0.00	0.00	0.20	11.02	10.82	76%
1931	0.58	1.15	0.26	3.45	1.67	0.57	0.36	0.93	0.11	0.00	0.00	0.00	9.08	9.28	63%
1932	0.27	1.89	5.63	1.29	3.15	0.19	0.41	0.37	0.00	0.00	0.00	0.00	13.20	13.20	91%
1933	0.00	0.51	2.03	4.51	0.44	2.09	0.13	0.70	0.03	0.00	0.00	0.01	10.45	10.44	72%
1934	0.75	0.00	3.69	1.29	2.86	0.00	0.13	0.60	0.53	0.00	0.00	0.27	10.12	9.86	70%
1935	0.62	2.71	2.32	3.53	0.52	3.16	3.28	0.00	0.00	0.00	0.04	0.00	16.18	16.41	112%
1936	0.79	0.21	1.53	3.28	6.76	0.71	0.63	0.46	0.10	0.00	0.00	0.00	14.47	14.51	100%
1937	0.40	0.02	3.26	3.38	4.13	5.07	0.68	0.17	0.20	0.00	0.00	0.00	17.31	17.31	119%
1938	0.55	2.46	4.57	2.40	6.14	4.09	0.90	0.02	0.00	0.00	0.00	0.00	21.13	21.13	146%
1939	1.00	1.08	0.52	2.40	1.57	2.18	0.53	0.18	0.00	0.00	0.00	0.16	9.62	9.46	66%
1940	1.23	0.15	0.78	8.13	5.14	2.60	0.35	0.14	0.00	0.00	0.00	0.25	18.77	18.68	129%
1941	0.50	0.43	4.63	3.24	4.19	2.07	2.76	0.23	0.00	0.00	0.03	0.00	18.08	18.30	125%
1942	0.72	0.89	5.34	3.89	1.68	1.42	3.10	1.00	0.00	0.00	0.00	0.09	18.13	18.07	125%
1943	1.08	3.05	1.73	4.48	1.68	2.39	1.14	0.00	0.06	0.00	0.00	0.00	15.61	15.70	108%
1944	0.30	0.53	1.23	2.36	4.89	1.01	0.94	0.73	0.00	0.00	0.00	0.00	11.99	11.99	83%



TABLE 3.1-3
HISTORICAL MONTHLY PRECIPITATION
MONITORING STATION 15E, LIVERMORE (INCHES)
1871 to 2012 WATER YEARS

Water Year	OCTWY	NOVWY	DECWY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL OCT-SEP	TOTAL JULY-JUNE	% NORMAL OCT-SEP
1945	0.77	3.41	2.03	0.87	3.68	3.19	0.20	0.17	0.00	0.00	0.02	0.00	14.34	14.32	99%
1946	1.07	2.07	2.98	0.76	1.23	1.69	0.02	0.61	0.00	0.24	0.00	0.02	10.69	10.45	74%
1947	0.02	2.93	2.07	0.69	1.45	2.34	0.53	0.17	0.36	0.00	0.00	0.00	10.56	10.82	73%
1948	1.84	0.85	0.51	0.20	1.11	2.79	2.50	1.03	0.16	0.03	0.00	0.00	11.02	10.99	76%
1949	0.46	0.34	2.71	1.39	2.47	3.38	0.02	0.34	0.00	0.03	0.16	0.05	11.35	11.14	78%
1950	0.08	1.20	1.21	4.65	1.54	1.44	0.85	0.59	0.01	0.00	0.00	0.08	11.65	11.81	80%
1951	1.84	5.95	4.95	2.23	1.81	1.82	0.55	0.35	0.06	0.00	0.00	0.00	19.56	19.64	135%
1952	1.04	3.01	6.07	7.60	1.40	2.36	2.20	0.16	0.04	0.00	0.00	0.10	23.98	23.88	165%
1953	0.01	2.11	6.33	2.07	0.05	1.12	1.42	0.61	0.59	0.00	0.15	0.00	14.46	14.41	100%
1954	0.21	1.33	0.64	2.19	2.27	3.00	0.73	0.16	0.27	0.00	0.00	0.04	10.84	10.95	75%
1955	0.00	1.68	3.33	2.45	1.69	0.38	1.28	0.65	0.00	0.00	0.01	0.01	11.48	11.50	79%
1956	0.01	1.31	10.15	5.49	1.15	0.14	1.92	0.63	0.00	0.00	0.00	0.63	21.43	20.82	148%
1957	0.79	0.03	0.48	2.65	2.23	1.30	1.14	2.65	0.04	0.00	0.00	0.05	11.36	11.94	78%
1958	1.06	0.37	1.62	3.16	5.37	4.44	3.74	0.66	0.41	0.00	0.00	0.02	20.85	20.88	144%
1959	0.09	0.14	0.86	2.45	3.59	0.29	0.35	0.00	0.00	0.00	0.07	1.89	9.73	7.79	67%
1960	0.00	0.00	0.75	2.98	4.12	0.60	0.48	0.42	0.00	0.02	0.00	0.01	9.38	11.31	65%
1961	0.05	2.92	1.25	2.08	1.04	1.92	1.03	0.69	0.19	0.00	0.13	0.16	11.46	11.20	79%
1962	0.15	2.24	0.82	0.73	5.61	1.82	0.22	0.00	0.00	0.00	0.00	0.00	11.59	11.88	80%
1963	3.64	0.28	1.55	1.40	4.50	2.60	3.47	0.70	0.00	0.00	0.00	0.33	18.47	18.14	127%
1964	0.93	3.18	0.19	2.37	0.08	1.57	0.21	0.48	0.32	0.00	0.12	0.04	9.49	9.66	65%
1965	0.85	2.44	4.91	2.11	0.59	1.73	1.53	0.00	0.00	0.00	0.21	0.00	14.37	14.32	99%
1966	0.03	4.22	3.23	1.05	1.17	0.17	0.33	0.10	0.12	0.17	0.00	0.11	10.70	10.63	74%
1967	0.00	3.43	2.35	6.14	0.29	4.15	4.65	0.19	0.48	0.00	0.00	0.02	21.70	21.96	150%
1968	0.24	0.88	1.62	3.93	0.90	2.40	0.43	0.15	0.00	0.00	0.00	0.00	10.55	10.57	73%
1969	0.43	2.48	3.04	6.28	4.76	0.55	1.24	0.08	0.00	0.00	0.00	0.00	18.86	18.86	130%
1970	1.10	0.49	2.34	5.38	1.18	1.42	0.40	0.07	0.32	0.00	0.00	0.00	12.70	12.70	88%
1971	0.41	5.24	5.27	1.19	0.33	1.75	1.37	0.54	0.00	0.00	0.00	0.13	16.23	16.10	112%
1972	0.04	0.46	3.27	0.90	0.79	0.14	0.64	0.00	0.04	0.00	0.00	0.58	6.86	6.41	47%
1973	2.98	4.91	2.22	5.50	3.38	2.63	0.29	0.03	0.00	0.00	0.00	0.08	22.02	22.52	152%
1974	2.08	3.71	3.80	1.50	0.71	2.69	1.62	0.00	0.00	0.00	0.00	0.00	16.11	16.19	111%
1975	0.50	0.66	1.98	0.84	3.65	5.24	1.42	0.00	0.06	0.10	0.35	0.00	14.80	14.35	102%
1976	1.27	0.08	0.21	0.30	1.46	0.48	0.39	0.00	0.18	0.00	0.91	0.95	6.23	4.82	43%
1977	0.50	0.50	0.73	1.15	0.83	0.82	0.16	1.01	0.00	0.10	0.00	0.22	6.02	7.56	41%
1978	0.13	1.34	3.07	5.44	2.95	3.07	2.49	0.01	0.00	0.00	0.00	0.04	18.54	18.82	128%
1979	0.00	2.16	0.58	4.52	3.19	1.86	0.88	0.34	0.00	0.06	0.00	0.00	13.59	13.57	94%
1980	1.51	1.13	2.66	4.16	4.24	1.36	1.32	0.48	0.00	0.70	0.00	0.00	17.56	16.92	121%
1981	0.04	0.28	1.18	3.97	1.11	2.94	0.61	0.11	0.00	0.00	0.00	0.06	10.30	10.94	71%
1982	2.07	3.44	2.57	5.29	2.16	5.58	1.50	0.00	0.28	0.00	0.01	1.48	24.38	22.95	168%
1983	2.24	3.72	2.80	6.28	5.56	6.14	3.51	0.21	0.00	0.00	0.50	1.02	31.98	31.95	220%
1984	0.27	5.44	3.44	0.33	1.87	1.00	0.53	0.01	0.03	0.00	0.00	0.04	12.96	14.44	89%
1985	1.25	4.71	1.51	0.48	1.25	2.62	0.32	0.07	0.22	0.00	0.03	0.13	12.59	12.47	87%
1986	0.89	2.69	1.97	2.04	7.11	4.09	0.40	0.14	0.00	0.01	0.00	0.45	19.79	19.49	136%
1987	0.04	0.08	0.92	1.83	3.47	2.30	0.16	0.09	0.00	0.00	0.00	0.00	8.89	9.35	61%
1988	0.87	1.40	2.30	1.78	0.38	0.26	1.15	0.45	0.10	0.00	0.00	0.00	8.69	8.69	60%
1989	0.11	1.92	2.03	0.81	0.95	2.94	0.88	0.08	0.10	0.00	0.00	1.33	11.15	9.82	77%
1990	1.13	1.02	0.10	1.54	2.46	0.87	0.37	1.78	0.00	0.02	0.00	0.06	9.35	10.60	64%
1991	0.08	0.39	1.45	0.31	2.20	5.87	0.34	0.35	0.08	0.00	0.21	0.04	11.32	11.15	78%
1992	1.65	0.31	1.19	1.39	4.61	1.97	0.43	0.00	0.09	0.00	0.00	0.00	11.64	11.89	80%
1993	0.90	0.15	4.99	6.41	4.53	2.91	0.63	0.51	0.30	0.00	0.00	0.00	21.33	21.33	147%
1994	0.57	2.00	1.81	0.94	3.33	0.15	1.20	1.78	0.04	0.00	0.00	0.00	11.82	11.82	81%
1995	0.58	3.08	1.36	6.64	0.33	6.66	1.02	0.92	0.70	0.00	0.00	0.00	21.29	21.29	147%
1996	0.00	0.01	5.37	5.17	4.10	2.34	1.91	1.05	0.00	0.00	0.00	0.00	19.95	19.95	137%
1997	1.08	2.55	4.43	5.81	0.15	0.06	0.15	0.29	0.17	0.00	0.42	0.00	15.11	14.69	104%
1998	0.28	4.23	1.95	5.47	7.30	2.37	1.37	2.00	0.13	0.00	0.00	0.18	25.28	25.52	174%
1999	0.54	2.48	0.73	3.23	3.33	1.67	0.99	0.08	0.01	0.00	0.03	0.04	13.13	13.24	90%
2000	0.15	1.26	0.25	4.61	4.87	1.25	0.59	0.69	0.18	0.00	0.01	0.24	14.10	13.92	97%
2001	1.97	0.49	0.45	1.92	2.89	1.22	1.80	0.00	0.12	0.00	0.00	0.09	10.95	11.11	75%
2002	0.37	1.92	5.09	0.72	0.62	1.65	0.16	0.68	0.00	0.00	0.00	0.00	11.21	11.30	77%
2003	0.00	2.65	7.01	0.66	1.31	1.07	3.09	0.95	0.00	0.00	0.29	0.00	17.03	16.74	117%
2004	0.02	2.02	3.57	2.19	4.01	0.39	0.18	0.11	0.00	0.00	0.00	0.58	13.07	12.78	90%
2005	2.77	0.89	3.01	2.81	3.55	3.41	1.53	1.03	0.05	0.00	0.00	0.25	19.30	19.63	133%
2006	0.17	0.65	5.40	2.22	1.32	4.79	2.60	0.34	0.00	0.00	0.00	0.00	17.49	17.74	121%
2007	0.20	1.68	2.25	0.52	3.92	0.33	0.44	0.11	0.00	0.00	0.00	0.21	9.66	9.45	67%
2008	1.12	0.71	2.05	4.79	1.89	0.10	0.02	0.00	0.00	0.00	0.00	0.00	10.68	10.89	74%
2009	0.33	1.40	1.56	1.34	3.31	2.29	0.23	0.51	0.11	0.00	0.00	0.31	11.39	11.08	78%
2010	2.79	0.21	2.02	3.53	2.36	1.57	2.10	0.24	0.00	0.00	0.00	0.00	14.82	15.13	102%
2011	1.00	2.02	3.87	0.78	2.69	4.10	0.22	0.46	1.07	0.00	0.00	0.00	16.21	16.21	112%
2012	1.06	0.93	0.04	1.52	0.52	2.57	0.00	0.02	0.12	0.00	0.00	0.01	8.80	8.79	61%
MAXIMUM	3.94	7.23	11.69	12.60	7.30	8.85	6.51	2.66	1.73	0.70	0.91	5.72	31.98	31.95	220%
MINIMUM	0.00	0.00	0.00	0.20	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.98	4.82	34%
MEAN	0.71	1.62	2.62	2.92	2.48	2.19	1.08	0.47	0.12	0.02	0.04	0.24	14.51	14.49	100%



TABLE 3.1-4
MONTHLY REFERENCE EVAPOTRANSPIRATION (ET_o)
2012 WATER YEAR

MONTHLY EVAPORATION (E_{to}) IN INCHES

	Monitoring Station			2102 Network Average	% Historic Network Average
	LDV	LWRP	191		
OCT	3.03	2.61	3.26	2.97	88.0%
NOV	1.47	0.96	1.84	1.43	83.6%
DEC	1.88	2.39	1.97	2.08	169.4%
JAN	1.59	2.45	1.75	1.93	160.4%
FEB	1.82	1.95	2.34	2.03	130.4%
MAR	2.22	1.82	3.04	2.36	84.6%
APR	3.53	3.05	4.65	3.75	94.6%
MAY	5.66	4.71	6.56	5.64	103.2%
JUN	6.52	5.50	7.13	6.38	100.7%
JUL	7.22	5.70	7.51	6.81	95.9%
AUG	6.77	5.58	6.79	6.38	100.2%
SEP	5.17	4.37	5.14	4.90	96.7%
TOTAL	46.88	41.09	51.98	46.65	
% AVG	110%	90%	104%	101%	

1) E_{to} values for LDV and LWRP were approximated using : E_{to}= Pan Evaporation x 0.642

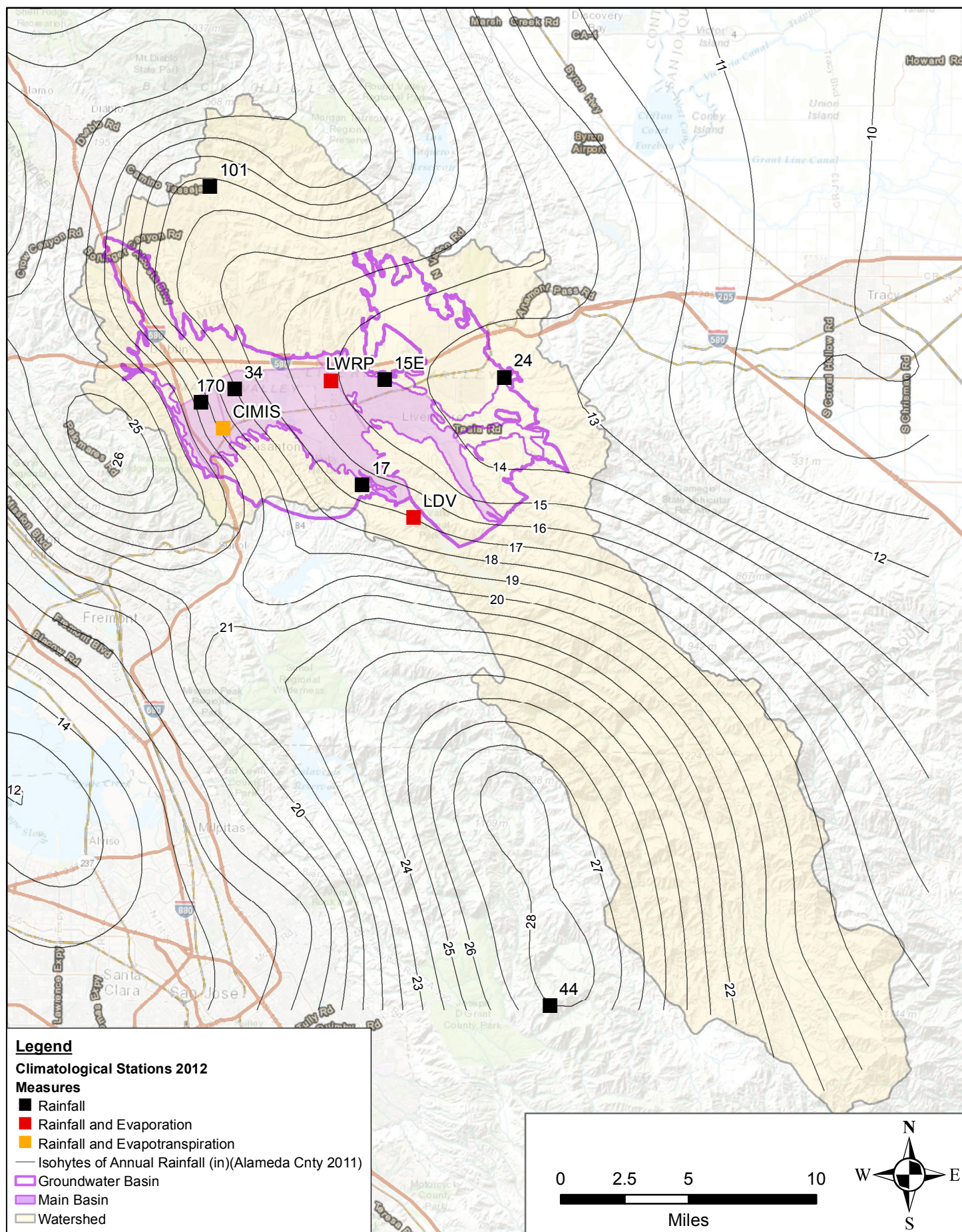
2) LWRP data was provided by City of Livermore; however, there were unresolved accuracy issues concerning the LWRP dataset for WY2012 .



TABLE 3.1-5
HISTORICAL MONTHLY PAN EVAPORATION
MONITORING STATION LAKE DEL VALLE, LIVERMORE
(INCHES)
1969 to 2012 WATER YEARS

Water Year	OCTWY	NOVWY	DECWY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL OCT-SEP	TOTAL JULY-JUNE	% NORMAL OCT-SEP
1969	3.20	2.50	1.54	0.66	1.08	4.89	5.92	9.99	7.84	11.38	11.77	8.32	69.09	NA	104%
1970	4.04	2.94	1.12	1.23	2.29	4.96	5.83	8.88	8.88	11.52	9.92	9.16	70.77	71.64	107%
1971	5.07	2.14	1.05	1.33	2.12	3.67	5.17	6.54	8.91	10.92	10.30	9.12	66.34	66.60	100%
1972	5.91	3.01	1.49	1.53	2.01	4.74	6.52	8.84	10.03	11.63	10.40	7.12	73.23	74.42	110%
1973	3.67	1.30	0.93	1.14	1.20	2.98	6.36	8.69	10.59	10.89	10.21	7.33	65.29	66.01	98%
1974	4.70	1.86	0.85	1.40	1.73	2.40	4.16	7.31	9.14	9.68	9.73	7.94	60.90	61.98	92%
1975	5.52	2.15	1.44	1.73	1.99	3.01	3.64	8.27	8.63	9.45	9.39	7.45	62.67	63.73	95%
1976	3.72	2.28	1.58	2.45	1.96	3.94	5.56	8.47	9.85	9.80	7.05	6.80	63.46	66.10	96%
1977	4.82	2.75	2.59	1.08	2.12	3.84	7.15	5.48	9.28	11.24	8.89	6.74	65.98	62.76	100%
1978	5.12	2.70	1.37	0.99	1.43	2.57	3.73	8.69	8.91	10.52	10.24	7.90	64.17	62.38	97%
1979	5.80	2.24	1.51	1.25	1.29	2.29	4.80	8.36	11.02	10.40	9.23	9.47	67.66	67.22	102%
1980	4.14	1.85	1.95	1.66	1.40	3.82	4.78	6.22	8.18	9.41	9.17	7.16	59.74	63.10	90%
1981	5.86	3.30	1.79	1.08	2.18	2.83	5.80	8.11	11.82	11.34	10.23	7.72	72.06	68.51	109%
1982	4.43	2.10	1.14	1.23	2.10	2.25	4.59	7.55	7.31	10.34	10.58	6.83	60.45	61.99	91%
1983	4.53	1.50	1.54	1.72	1.54	2.17	4.05	6.71	8.34	10.44	9.35	7.82	59.71	59.85	90%
1984	4.37	1.86	1.08	1.52	1.79	4.29	5.32	9.04	9.88	11.99	9.80	9.24	70.18	66.76	106%
1985	4.02	1.63	1.11	1.18	2.70	3.09	5.95	7.75	10.40	11.49	9.23	6.38	64.93	68.86	98%
1986	5.05	2.27	1.11	1.11	1.75	3.55	4.96	7.44	8.67	10.20	8.88	6.10	61.09	63.01	92%
1987	4.84	3.47	1.22	1.45	2.08	3.19	6.43	7.90	8.73	8.46	8.97	7.29	64.03	64.49	97%
1988	4.71	1.71	1.50	1.21	2.94	5.17	5.30	7.22	8.92	11.46	8.90	7.90	66.94	63.40	101%
1989	4.81	1.85	1.64	1.39	1.57	2.75	5.75	7.70	9.30	11.30	9.14	6.41	63.61	65.02	96%
1990	4.86	2.95	1.75	1.57	1.83	3.64	5.74	7.86	9.18	10.19	9.21	7.09	65.87	66.23	99%
1991	6.56	3.48	1.95	1.86	2.44	2.63	5.00	6.42	8.50	10.25	8.00	7.61	64.70	65.33	98%
1992	6.45	3.03	1.71	0.96	1.65	2.84	5.91	8.87	8.23	10.01	10.76	7.82	68.24	65.51	103%
1993	5.12	2.79	1.19	1.21	1.42	2.83	4.93	6.61	9.64	10.23	10.02	8.18	64.17	64.33	97%
1994	4.65	3.27	1.22	1.49	1.36	4.12	5.23	6.38	10.01	10.03	10.31	7.44	65.51	66.16	99%
1995	4.94	1.66	0.76	0.73	1.61	2.33	4.75	5.22	8.18	10.06	10.39	7.65	58.28	57.96	88%
1996	6.23	2.80	0.88	1.33	1.66	3.85	6.38	8.12	9.68	12.03	11.13	7.48	71.57	69.03	108%
1997	5.44	2.05	1.04	1.02	2.67	4.82	6.45	8.95	9.40	10.32	8.78	8.52	69.46	72.48	105%
1998	5.25	1.82	1.60	1.19	0.96	2.80	4.36	4.13	7.10	9.91	10.57	7.51	57.20	56.83	86%
1999	4.51	1.63	1.41	1.32	1.58	2.93	5.25	7.04	8.70	10.51	8.58	7.53	60.99	62.36	92%
2000	6.86	2.73	2.51	1.57	1.55	3.91	5.48	7.16	9.66	9.23	9.82	7.86	68.35	68.06	103%
2001	3.84	1.84	1.68	1.45	2.20	4.14	4.86	10.05	10.92	9.78	9.75	7.98	68.49	67.89	103%
2002	6.56	2.56	1.47	1.97	2.56	4.63	5.65	7.82	9.87	11.08	9.87	9.13	73.17	70.60	110%
2003	5.64	3.23	1.73	1.26	2.31	4.04	4.05	7.62	9.78	12.14	9.23	8.84	69.87	69.74	105%
2004	6.71	1.72	1.12	1.08	2.22	4.99	7.38	8.66	9.46	10.16	9.88	8.76	72.14	73.55	109%
2005	4.86	2.21	1.54	1.14	1.54	3.20	4.93	6.60	8.37	11.13	10.65	7.41	63.58	63.19	96%
2006	5.19	2.50	1.50	1.52	2.47	3.04	3.81	8.54	9.82	12.43	9.37	8.42	68.61	67.58	103%
2007	5.27	2.09	2.22	1.98	1.71	4.34	5.86	8.58	9.59	9.814	10.45	7	68.90	71.86	104%
2008	4.45	3.25	1.68	1.37	2.14	4.60	6.65	8.66	10.37	10.54	10.54	8.42	72.67	70.43	110%
2009	6.27	2.40	1.35	2.04	1.95	3.90	6.24	8.52	9.09	11.053	10.12	8.63	71.566	71.26	108%
2010	4.84	3.00	1.28	1.20	1.61	3.91	4.65	6.40	9.52	10.2	9.08	8.26	63.95	66.21	96%
2011	4.98	2.43	1.13	1.53	2.46	2.64	5.64	7.13	8.22	10.25	9.62	8.46	64.49	63.70	97%
2012	4.73	2.30	2.93	2.49	2.84	3.46	5.52	8.84	10.19	11.27	10.58	8.08	73.23	70.84	110%
MAXIMUM	6.86	3.48	2.93	2.49	2.94	5.17	7.38	10.05	11.82	12.43	11.77	9.47	73.23	74.42	110%
MINIMUM	3.20	1.30	0.76	0.66	0.96	2.17	3.64	4.13	7.10	8.46	7.05	6.10	57.20	56.83	86%
MEAN	5.06	2.39	1.48	1.40	1.91	3.55	5.37	7.71	9.28	10.60	9.73	7.82	66.30	66.26	100%

ETo can be approximated using: $ETo = \text{Pan Evaporation} \times 0.6402$



ZONE 7 WATER AGENCY
100 North Canyons Parkway
Livermore, CA 94551

DRAWN: TR/MG

REVIEWED: MK/MG

File: E:\MONITOR\IPR\2012WY\Fig3.1-1-CMPProg2012.mxd

Scale: 1" = 5 miles

Date: Mar 29, 2013

Figure 3.1-1
Climatological Monitoring
Stations with
Average Rainfall (in)



**FIGURE 3.1-2
ZONE 7 WATER AGENCY
GRAPH OF LIVERMORE RAINFALL (Station 15E NOAA)
2012 WATER YEAR**

