SECTION 4: SOIL WATER CONDITIONS

The purpose for monitoring soil water and the On/Off procedures is to manage pumping to protect plant communities that require periodic access to the water table for long-term survival.

Introduction

The Water Agreement established procedures to determine which LADWP pumping wells can and cannot be operated based on soil water and vegetation measurements (On/Off status). As part of the monitoring effort for the Agreement, the ICWD regularly measures depth to groundwater (DTW) and soil water content at 25 sites in wellfields and eight sites in control areas. Three of the wellfield sites are not used to determine the operational status of nearby pumping wells but are monitored to continue the data record. Each site is equipped with 1 to 6 soil water monitoring locations. Soil water measurements are collected using a neutron gauge calibrated for each site (Dickey, 1990; Steinwand, 1996).

The purpose for the On/Off procedures is to manage pumping to protect plant communities that require periodic access to the water table for long-term survival. Generally, the sites with On-status have wet soil and shallow water tables, and sites in Off-status have dry soil and deep water tables.

To assist the evaluation of LADWP pumping proposals, the Water Department examined the DTW and soil water data to determine whether groundwater is accessible to plants at the permanent monitoring sites at the beginning of the 2018 growing season.

How well plants can access groundwater depends on the vegetation type as well as water table depth. In similar soils, a shallower water table is necessary to supply groundwater to grasses than shrubs because of the shallower roots of the grasses. For management purposes in the Water Agreement, shrub-dominated sites are assigned a root zone of 4 m (13.1 ft.); grass-dominated or mixed grass and shrub assemblages are assigned a root zone of 2 m (6.6 ft.). These approximate values are not the actual rooting depth at a particular monitoring site, but they are useful to compare with the soil depth that received recharge from groundwater.

Soil water in the root zone can be supplied by infiltration from the surface (rain or irrigation) or from contact with the water table. It is usually possible to discriminate deeper soil affected by groundwater from soil near the surface affected by infiltration based on the depth and timing of the measured changes in soil water content. Plant roots can utilize groundwater directly, and if the water table is within the root zone it is reasonable to conclude that groundwater is available. A rising water table can progressively wet the root zone from below and provide water to plants. Plant roots can also tap groundwater that is drawn into the soil above the water table by capillarity where it is held in soil pores or adsorbed to soil particles. Plant uptake during the summer depletes soil water, and when transpiration ceases in the fall,

Table 4.1 June 2018 monitoring site status and July 1, 2018 soil/vegetation water balance calculations according to Green Book, Section III. These values of soil water required for well turn-on were derived using calculations based on percent cover that were routinely performed in the past. The values have not been updated to conform to the Green Book equations in section III.D.2, p. 57-59.

Site	June 2018 On/Off Status	July 2018 Vegetation Water Requirement	July 2018 Required Soil AWC For Turn-On	July 2018 Actual Soil AWC	July 2018 On/Off Status
LW 1	ON	6.7	NA	69.4	ON
LW 2	ON	7.5	NA	45.4	ON
LW 3	ON	12.5	NA	31.6	ON
BP 1	ON	10.6	NA	22.3	ON
BP 2	OFF	5.7	28.4	2.2	OFF (7/98)
BP 3	ON	6.6	NA	21.4	ON
BP 4	ON	4.9	NA	49.9	ON
TA 3	OFF	5.7	28.4	11.6	OFF (10/17)
TA 4	ON	6.7	NA	19.6	ON
TA 5	ON	2.9	NA	22.5	ON
TA 6	ON	5.9	NA	34.4	ON
TS 1	OFF	9.3	28.9	6.9	OFF (7/17)
TS 2	OFF	3.5	23.4	14	OFF (7/17)
TS 3	ON	6.3	NA	19.7	ON
TS 4	OFF	19.8	53.5	44.6	OFF (10/17)
IO 1	OFF	20.5	42.2	21.6	OFF (10/98)
IO 2	ON	0.6	NA	5.1	ON
SS 1	OFF	2.6	34.0	7.3	OFF (7/17)
SS 2	OFF	0.3	25.6	3.5	OFF (7/11)
SS 3	OFF	8.2	33.8	20.7	OFF (10/11)
SS 4	OFF	1.5	15.9	3.8	OFF (7/05)
BG 2	ON	6.9	NA	42.8	ON

Table 4.2. Monitoring site status and soil/vegetation water balance calculations for Oct. 1, 2018 according to Green Book, Section III. These values of soil water required for well turn-on were derived using calculations based on percent cover that were routinely performed in the past. The values have not been updated to conform with the Green book equations in section III.D.2, p. 57-59.

Site	July 1, 2018 On/Off Status	October 2018 Vegetation Water Requirement	October 2018 Required Soil AWC For Turn-On	October 2018 Actual Soil AWC	Soil AWC +50% Annual Precip.	October 1, 2018 On/Off Status
LW 1	ON	11.8	NA	33.2	41.1	ON
LW 2	ON	13.5	NA	42.4	50.3	ON
LW 3	ON	22.9	NA	15.3	23.2	ON
BP 1	ON	19.1	NA	20.9	28.8	ON
BP 2	OFF	10.6	28.4	1.3	NA	OFF (7/98)
BP 3	ON	11.7	NA	19.1	26.7	ON
BP 4	ON	8.8	NA	46.8	55.0	ON
TA 3	OFF	10.7	28.4	11.0	NA	OFF (10/17)
TA 4	ON	12.4	NA	17.8	25.1	ON
TA 5	ON	5.2	NA	20.9	29.1	ON
TA 6	ON	11.0	NA	23.7	31.0	ON
TS 1	OFF	17.4	28.9	5.5	NA	OFF (7/17)
TS 2	OFF	6.5	23.4	12.7	NA	OFF (7/17)
TS 3	ON	11.7	NA	16.9	24.2	ON
TS 4	OFF	36.0	53.5	36.2	NA	OFF (10/17)
IO 1	OFF	38.1	42.2	18.9	NA	OFF (10/98)
IO 2	ON	1.1	NA	3.1	9.6	ON
SS 1	OFF	4.6	34.0	5.6	NA	OFF (7/17)
SS 2	OFF	0.6	25.6	3.3	NA	OFF (7/11)
SS 3	OFF	15.3	33.8	19.4	NA	OFF (10/11)
SS 4	OFF	2.7	15.9	3.5	NA	OFF (7/05)
BG 2	ON	12.7	NA	36.4	43.0	ON

Table 4.3. Monitoring site status on April 1, 2019 according to Green Book, Section III. All values in cm.

Site	October 2018 Soil AWC	50% Annual Precipitation	Projected Soil AWC	Oct. 2018 Vegetation Water Requirement	Oct. 2018 Required Soil AWC For Turn-On	October 1, 2018 On/Off Status	April 2019 Soil AWC	April 2019 Required Soil AWC For Turn-On	April 2019 On/Off Status
LW 1	33.2	7.9	41.1	11.8	NA	ON	101.6	NA	ON
LW 2	42.4	7.9	50.3	13.5	NA	ON	45.1	NA	ON
LW 3	15.3	7.9	23.2	22.9	NA	ON	32.2	NA	ON
BP 1	20.9	7.9	28.8	19.1	NA	ON	26.7	NA	ON
BP 2	1.3	NA	1.3	10.6	28.4	OFF	12.4	28.4	OFF (7/98)
BP 3	19.1	7.6	26.7	11.7	NA	ON	26.5	NA	ON
BP 4	46.8	8.2	55.0	8.8	NA	ON	61.1	NA	ON
TA 3	11.0	NA	11.0	10.7	28.4	OFF	27.3	28.4	OFF (10/17)
TA 4	17.8	7.3	25.1	12.4	NA	ON	27.3	NA	ON
TA 5	20.9	8.2	29.1	5.2	NA	ON	29.4	NA	ON
TA 6	23.7	7.3	31.0	11.0	NA	ON	38.3	NA	ON
TS 1	5.5	NA	5.5	17.4	28.9	OFF	16.0	28.9	OFF (7/17)
TS 2	12.7	NA	12.7	6.5	23.4	OFF	28.1	NA	ON
TS 3	16.9	7.3	24.2	11.7	NA	ON	31.8	NA	ON
TS 4	36.2	NA	36.2	36.0	53.5	OFF	58.2	NA	ON
IO 1	18.9	NA	18.9	38.1	42.2	OFF	30.0	42.2	OFF (10/98)
IO 2	3.1	6.5	9.6	1.1	NA	ON	8.9	NA	ON
SS 1	5.6	NA	5.6	4.6	34.0	OFF	9.5	34.0	OFF (7/17)
SS 2	3.3	NA	3.3	0.6	25.6	OFF	8.3	25.6	OFF (7/11)
SS 3	19.4	NA	19.4	15.3	33.8	OFF	30.6	33.8	OFF (10/11)
SS 4	3.5	NA	3.5	2.7	15.9	OFF	8.3	15.9	OFF (7/05)
BG 2	36.4	6.6	43	12.7	NA	ON	35.3	NA	ON

Table 4.4. Comparison of DTW preceding the growing seasons in 2018 and 2019. Data compare measurements taken near April 1 of each year except for and BP3 where the minimum DTW is in the fall. Depths are below ground surface. Positive values denote a rise in the water table.

Wellfield	2018 DTW	2019 DTW	DTW Change 2018-19	
Site	(m)	(m)	(m)	(ft)
Laws				
L1	2.29	2.984	-0.694	-2.28
L2	3.64	5.8	-2.16	-7.09
L3	3.15	4.378	-1.228	-4.03
Bishop Control				
BC1	2.29	2.623	-0.333	-1.09
BC2	4.03	4.262	-0.232	-0.76
BC3	1.13	1.333	-0.203	-0.67
Big Pine				
BP1	3.45	4.511	-1.061	-3.48
BP2	5.67	5.847	-0.177	-0.58
BP3	3.19	4.932	-1.742	-5.72
BP4	4.72	4.78	-0.06	-0.20
Taboose Aberdeen				
TA1	0.95	1.467	-0.517	-1.70
TA3	3.5	4.755	-1.255	-4.12
TA4	2.09	2.025	0.065	0.21
TA5	4.42	4.417	0.003	0.01
TA6	1.36	2.313	-0.953	-3.13
TAC	0.85	1.125	-0.275	-0.90
Thibaut Sawmill				
TS1	3.77	4.406	-0.636	-2.09
TS2	2.82	2.802	0.018	0.06
TS3	2.53	3.06	-0.53	-1.74
TS4	1.86	1.957	-0.097	-0.32
TS6	3.34	4.686	-1.346	-4.42
TSC	1.19	0.933	0.257	0.84
Independence Oak				
IO1	3.08	3.74	-0.66	-2.17
IO2	8.26	9.507	-1.247	-4.09
IC1	1.19	1.291	-0.101	-0.33
IC2	2.2	2.538	-0.338	-1.11
Symmes Shepherd				
SS1	5.95	6.447	-0.497	-1.63
SS2	Dry at 8.41	7.906	> 0.504	> 1.65
SS3	4.03	4.301	-0.271	-0.89
SS4	6.18	6.768	-0.588	-1.93
Bairs George				
BG2	2.77	4.49	-1.72	-5.64
BGC	2.15	2.949	-0.799	-2.62

water from the moist soil above the water table will replenish the drier soil in the root zone via capillarity or through inactive plant roots even if the water table is stable or declining. This is a slow process and usually provides much less soil water recharge than a rising water table.

Results

Monitoring results for available soil water, vegetation water requirement, water table depth, and the On/Off status for all sites are presented in the figures that are periodically updated and available at Technical Group meetings and on the ICWD website. At the beginning of the 2018-19 runoff year 12 sites were in On-status: L1, L2, L3, BP1, BP3, BP4, TA4, TA5, TA6, TS3, IO2, and BG2 (Table 4.1). Sites TS2 and TS4 went into On-status in April 2019 (Table 4.3), and a total of 14 sites were in On-status as of April 2019.

Hydrographs for the permanent monitoring sites are presented on the ICWD website, and the DTW measured during the fall and winter before the 2018 and 2019 growing seasons are presented in Table 4.4. At most sites, the minimum DTW occurs near April 1. At sites BP1 and 3 in Big Pine, usually the water table rises during the summer and reaches a minimum in the fall coinciding with the timing of diversions into the Big Pine canal for irrigation.

In 2018-19, the water table declined on average 2.4 ft in wellfields and 1.3 ft in control areas. This was expected due to a below-average runoff year combined with above average groundwater pumping. Three wellfield and one control sites experienced minor water table gains (< 1 ft). See the Groundwater section of this report for an assessment of water level changes using a larger set of monitoring wells.

At most sites it was easy to discriminate groundwater recharge from surface infiltration because of the vertical gap between the deeper groundwater recharge and the shallow infiltration from the notable January thru March 2019 precipitation (Tables 4.5 and 4.6). Infiltration due to precipitation from 2019 was primarily limited to the top 50 or 100 cm of the soil.

Most sites experienced groundwater recharge into the root zone in 2018-19. The monitoring sites were grouped into simple categories to summarize the connection between soil water in the root zone and the water table. Brief descriptions of the three categories and the results are given below:

1. Connected: Water table fluctuations resulted in soil water recharge in the top half of the root zone at most monitoring locations within a site. Thirteen wellfield and seven control sites were placed in this category.

2. Partially connected: Water table fluctuations resulted in soil water recharge in the bottom half of the root zone at most monitoring locations within a site. Nine wellfield and one control sites were placed in this category.

3. Disconnected: No recharge from groundwater occurred in the root zone. Three wellfield sites and no control sites were in this category (southern Independence and northern Symmes-Shepard).

At some monitoring locations, BP2 and SS4 for example, soil water content exhibited increasing amounts at certain depths well above the water table while lower depths showed little or no change. Water can be transported during winter from wetter, deeper soil layers through plant roots to recharge dry soil at shallower depths (Horton and Hart, 1998;

Table 4.5. Soil depth below ground surface replenished by groundwater in 2018-2019 at control sites. Values are provided for each monitoring location within a site. Minimum DTW was measured in the associated test well.

Site	Dominant plant species	Root Zone (m)	Minimum DTW (m)	Groundwater recharge depth (m)
BC1	rabbitbrush, saltbush, greasewood, alk. sacaton	4	2.3	2.1, 2.4, 2.4
BC2	rabbitbrush, saltgrass	2	4.0	0.3, 0.3, 0.3, 0.6
BC3	rabbitbrush, saltgrass, saltbush	2	1.1	0.9, 0.9, 0.7
TAC	saltbush, rye grass, saltgrass, alk. sacaton	2	0.9	0.9, 1.1, 0.9, 0.3
TSC	alk. sacaton, rabbitbrush, greasewood.	2	0.8	0.3, 0.3, 0.6
IC1	saltbush, saltgrass, rabbitbrush	2	1.1	0.9, 0.9, 0.5
IC2	rabbitbrush, alk. sacaton	2	2.2	2.1, 2.1, 1.8
BGC	saltbush, saltgrass	4	2.0	1.3, 1.3, 1.8

Jackson et al., 2000), but without additional information, assigning that cause is speculative. The increase in water content was small and barely detectable. Regardless of the exact mechanism causing the increase in soil water, the monitoring and On/Off management was able to measure and account for that source of water. At the beginning of the 2019 growing season, the water table had supplied or was capable of supplying water to the root zone at 21 of the 25 wellfield monitoring sites (Figure 4.1), continuing or sustaining the trend from the exceptional 2017 winter. Most sites except BP2, IO2, SS1, and SS2 had ample retained water in the soil.

References

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Table 4.6. Soil depth below ground surface replenished by groundwater in 2018-2019 at wellfield sites. Values are provided for each monitoring location within a site unless the identification of a specific depth was uncertain. Minimum DTW was measured in the associated test well. ND is groundwater not recharging soil.

Site	Dominant plant species	Root Zone (m)	Minimum DTW (m)	Groundwater recharge depth (m)
L1	greasewood	4	1.9	0.9, 0.6, 0.9
L2	alk. sacaton, greasewood, saltbush	2	3.8	0.3 at all five locations
L3	alk. sacaton, saltgrass	2	3.4	0.6, 0.9, 0.3, 0.3, 0.5, 0.3
BP1	saltbush, greasewood	3	3.0	ND, ND, ND,ND, ND
BP2	saltbush, rabbitbrush	4	5.3	3.3, 2.5, 3.7
BP3	greasewood, rabbitbrush	4	4.0	3.7, 3.5, 3.5
BP4	saltbush, greasewood	4	4.6	2.1, 2.1, 2.9
TA1	alk. sacaton, saltbush	2	1.0	0.3
TA2	alk. sacaton, saltbush, greasewood, rabbitbrush	2	1.0	0.3
TA3	saltbush, alk. sacaton, sagebrush	2	3.6	3.7, 3.5, 3.9
TA4	rabbitbrush, alk. sacaton	2	2.0	1.9, 1.7, 1.5
TA5	greasewood, alk. sacaton	2	4.0	3.1, 3.3, 3.5
TA6	saltbush, rabbitbrush	2	1.6	1.7, 1.5, 1.7
TS1	weeds, alk. sacaton	2	3.8	2.3, 2.7, 3.6, 3.5, 3.3
TS2	sagebrush, saltbush, alk. sacaton	2	2.7	1.7, 2.1, 1.9
TS3	saltgrass, alk. sacaton	2	2.5	1.7, 1.7, 1.9, 1.9, 1.3, 2.1
TS4	greasewood, alk. sacaton, saltbush, saltgrass	2	1.8	1.5, 1.3, 1.7, 1.3
TS6	alk. sacaton, saltbush, saltgrass	2	3.5	1.9
IO1	rabbitbrush, alk. sacaton, saltbush	2	3.1	2.9, 2.5, 3.1
IO2	saltbush	4	8.2	5.3, >3.9. >3.9
SS1	saltbush, greasewood	4	5.5	4.9, >3.9, >3.9
SS2	saltbush	4	7.5	5.3, >3.9, >3.9
SS3	saltbush	4	3.6	2.5, 1.9, 1.9
SS4	saltbush	4	6.1	2.9, 2.7, 2.9
BG2	inkweed, saltbush	4	3.0	3.1, 2.2, 2.3

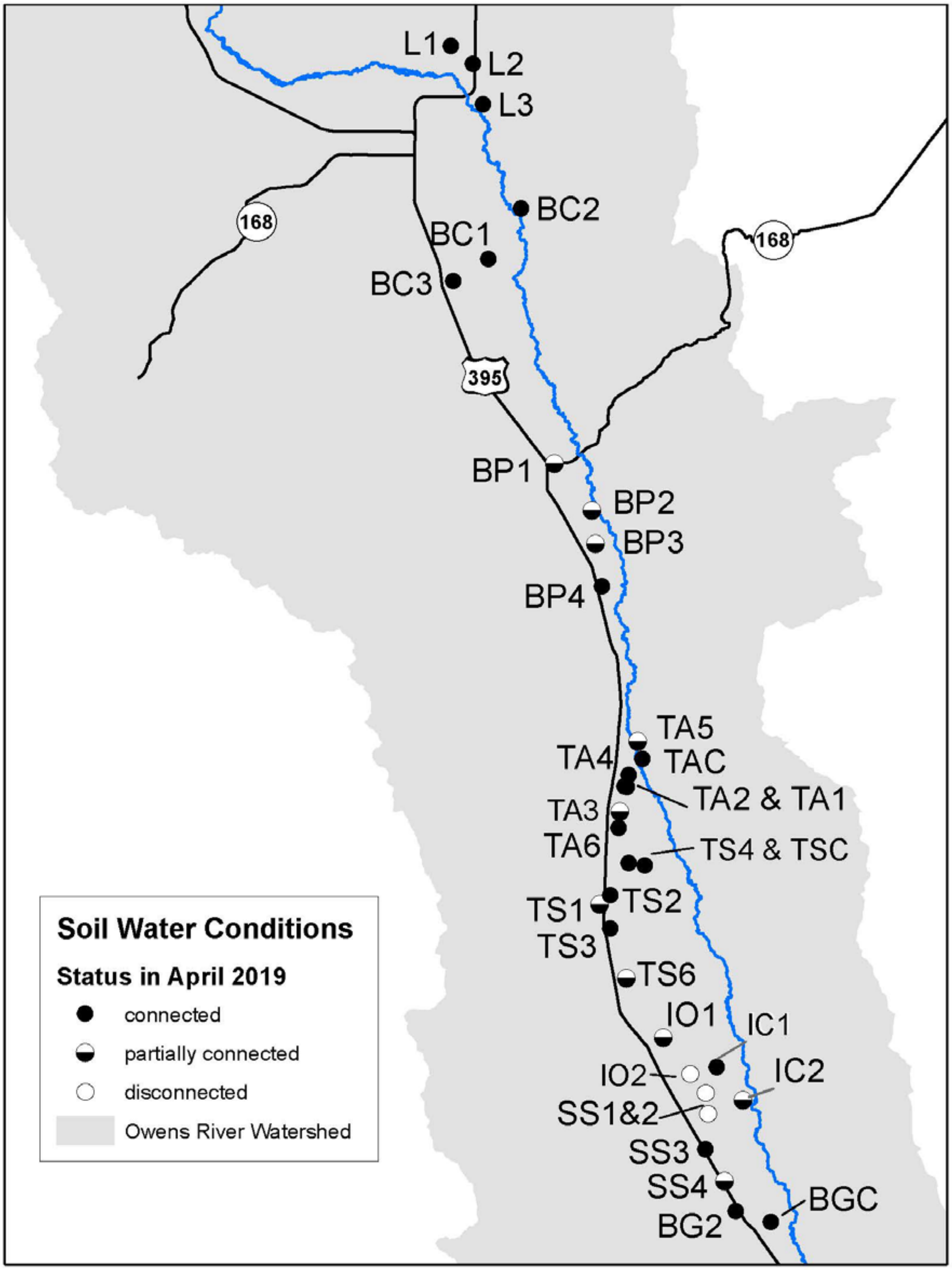

Figure 4.1. Owens Valley permanent monitoring sites and groundwater recharge classes. It is difficult to distinguish TA1 and TA2 on this map because of their proximity to one another. TA1 and TA2 are connected.