SECTION 3: PUMPING MANAGEMENT AND GROUNDWATER CONDITIONS

2019-20 PUMPING PLAN AND GROUNDWATER CONDITIONS

In accordance with the Water Agreement, Los Angeles Department of Water and Power prepares an Operations Plan each April for the ensuing 12-month runoff year spanning April 1 to March 31. The 2019-2020 plan included projected amounts for runoff, pumping, water used in the Owens Valley, water exported to Los Angeles, and an update of the groundwater mining calculations. Also, the plan must comply with the pumping well On/Off provisions of the Agreement based on soil water and vegetation measurements. The Inyo County Water Department (ICWD) reviews LADWP's proposed operations plan, performing an analysis of the effects of LADWP operations on groundwater levels in the Owens Valley. Following a Technical Group meeting to resolve concerns raised by the County, LADWP finalizes the plan.

Predicted runoff from the Owens River watershed during the 2019-20 runoff-year is forecast to be 554,000 acre-feet (ac-ft) or 137% of the 50-year (1966-2015) average. The actual runoff value will be available in 2020 when all the surface water measurements that constitute the sum have been verified and tabulated. Figure 3.1 compares LADWP's forecasted runoff with the ensuing, actual runoff for each year. Planned pumping for 2019-20 is in a range of 50,330-73,710 ac-ft. LADWP is predicting 103,100 ac-ft of water will be used in the Owens Valley, 54,000 of which is planned for irrigation. The 2019-20 water exports from the Eastern Sierra (Inyo and Mono Counties) is planned to be 374,300 ac-ft (66% of LADWP anticipated annual need). A more detailed discussion of the 2019-20 Operations Plan is presented in the "2019-20 Pumping" subsection that follows.

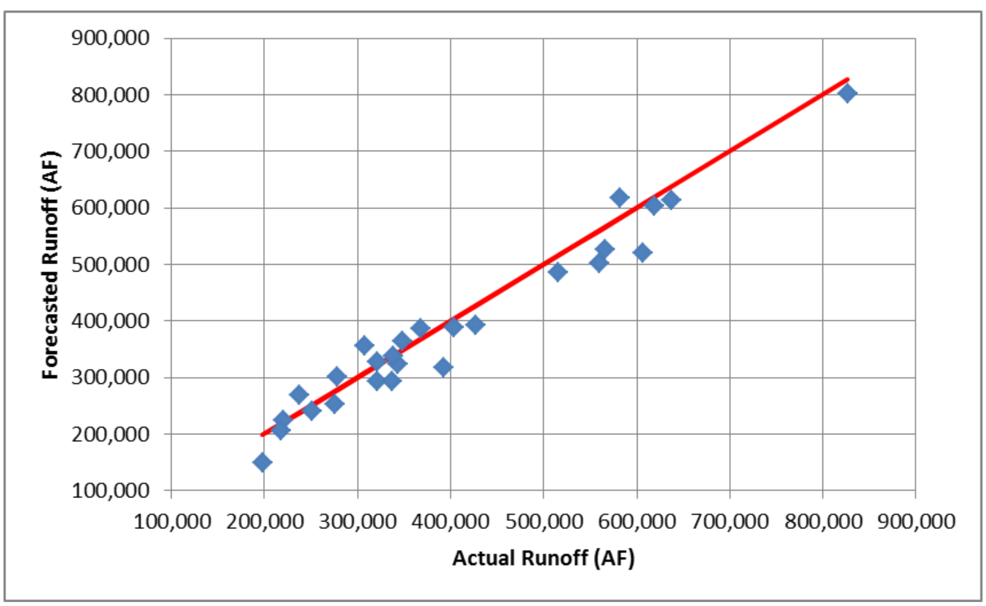

Figure 3.1. Comparison of actual and forecasted runoff 1994-2018 runoff years with one-to-one correspondence (100% accuracy between forecast and actual runoff) in red. The 2018 actual runoff was 393,000 ac-ft; forecasted runoff was 317,500 ac-ft.

Looking at actual totals from 2018-19, runoff was 393,000 ac-ft, approximately 97% of the 1966-2015 long-term average. Total pumping within the Owens Valley from Laws to Lone Pine for 2018-19 was 84,821 ac-ft, which was only 88% of LADWP's planned pumping amount of 96,230 ac-ft (Table 3.1). Owens Valley water uses for 2018-19 were 95,000 ac-ft, and Eastern Sierra water exports were approximately 287,000 ac-ft.

Table 3.1. Planned and LADWP actual pumping by wellfield for the 2018-19 runoff-year. Estimated minimum pumping prepared by Inyo County for sole source uses is included for reference.

Wellfield	Estimated Minimum Pumping (ac-ft)	Planned Pumping (ac-ft)	Actual Pumping (ac-ft)	Percent Actual vs. Planned
Laws	6,300	13,900	10,714	88%
Bishop	10,400	11,280	12,221	95%
Big Pine	20,550	26,010	23,105	89%
Taboose-Aberdeen	300	18,080	14,458	80%
Thibaut-Sawmill	8,160	9,000	8,412	93%
Ind.-Oak	5,990	13,230	11,640	88%
Symmes-Shepherd	1,200	960	1,073	112%
Bairs-Georges	500	2,880	2,281	79%
Lone Pine	1,035	890	917	103%
Total	**54,195**	**96,230**	**84,821**	**88%**

ICWD uses groundwater levels from a suite of key monitoring wells (Indicator Wells) located throughout the Owens Valley near LADWP wellfields to both track and predict (using regression models) the effects of groundwater pumping on water tables. The effect of pumping and runoff in 2018-19 on water levels in the Indicator Wells is shown in Table 3.2. Water levels in a larger set of monitoring wells are discussed below.

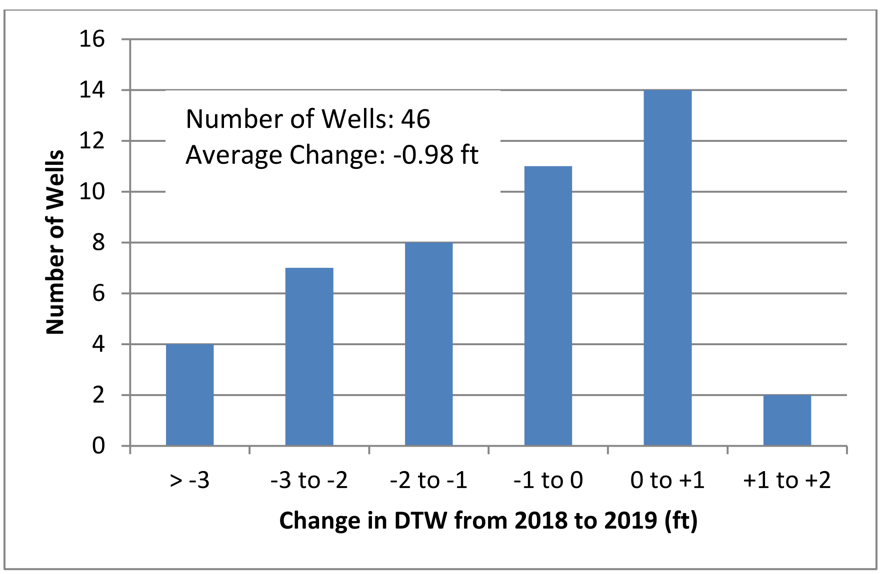

Figure 3.2. Histogram of change in DTW between April 2018 and April 2019 for 46 Indicator test wells. Positive changes indicate rising (shallowing) water tables.

Groundwater levels fell in 30 of the 46 non-dry monitoring wells (Figure 3.2); the average change in DTW in the 46 wells from 2018 to 2019 was a decline of 0.98 feet, with a median decline of 0.67 feet. Groundwater levels remain below levels of the mid-1980's vegetation baseline period in about half of the indicator wells. A more detailed discussion of groundwater levels in Indicator wells and other monitoring wells at well-field locations across the Owens Valley is presented in the "Summary of Hydrologic Conditions" subsection that follows.

Table 3.2. Depth to Water (DTW) at Indicator wells, April 2019. All data are in feet. Negative values denote a decline in water level. Depths are from reference point on the test well. Baseline elevation at monitoring sites is the April average of water levels from years 1985-87. Baseline was predicted from monitoring site/indicator wells regression models if the test well was not present from 1985-87.

Station ID, Monitoring site	DTW April 2019	Change from April 2018	Deviation from Baseline in 2019
Laws			
107T	28.15	-4.70	-3.88
434T	6.81	-0.68	0.79
436T	7.51	-1.29	0.59
438T	10.35	-2.35	-0.75
490T	10.8	-0.64	2.27
492T	28.72	-5.07	4.08
795T, LW1	9.56	-1.39	3.73
V001G, LW2	18.92	-4.82	0.70
574T, LW3†	12	-1.85	1.08
Big Pine			
425T	17.27	-0.12	-2.37
426T	13.43	0.35	-1.86
469T	22.06	-0.31	-0.39
572T	11.39	-2.80	0.51
798T, BP1	14.64	-2.74	1.41
799T, BP2	19.11	0.21	-0.60
567T, BP3	16.1	-1.08	-2.14
800T, BP4	15.61	0.40	-2.02
Taboose Aberdeen			
417T	25.88	-2.66	1.09
418T	7.68	0.47	0.55
419T, TA1	4.87	-0.20	1.76
421T	35.26	-1.99	-0.91
502T	10.03	-0.92	-2.54
504T	9.02	-0.66	1.75
505T	17.72	-2.69	0.88

Station ID, Monitoring site	DTW April 2019	Change from April 2018	Deviation from Baseline in 2019
586T, TA4	6.62	0.49	1.70
801T, TA5	14.25	0.56	-0.73
803T, TA6	7.4	-2.54	1.30
Thibaut Sawmill			
415T	10.82	-1.35	7.68
507T	3.48	1.19	1.19
806T, TS2	9.11	0.49	4.07
Independence Oak			
406T	5.49	-0.05	-3.92
407T	12.58	0.53	-5.28
408T	5.47	-0.37	-2.34
409T	10.43	-2.73	-8.83
546T	5.25	-0.74	-1.82
809T, IO1	12.21	-1.64	-5.64
Symmes Shepherd			
402T	10.13	0.23	-2.10
403T	7.69	0.50	-2.36
404T	5.78	0.73	-2.21
447T	39.26	0.88	-17.39
510T	6.43	0.77	-1.43
511T	7.11	0.92	-2.48
V009G, SS1	20.93	1.43	-14.10
Bairs George			
398T	4.82	-1.25	1.53
400T	6.32	-0.92	-0.02
812T, BG2	14.67	-4.50	-1.21

The Water Agreement and Green Book include procedures to calculate a pumping limit to prevent groundwater mining to ensure that there is no long-term decline in aquifer storage; these calculations are summarized in the 2019-20 Operations Plan and are used to predict the pumping limit through September of 2019. Unlike the annual reporting periods which are based on runoff year (April to March), the annual period for the groundwater mining calculation is based on the water-year (October 1 through September 30). The mining calculation is a comparison of LADWP pumping and recharge for each wellfield on a water-year basis for the most recent 20-year period. The 2017-18 water-year groundwater recharge in the Owens Valley from the mining calculations was approximately 163,650 ac-ft compared to 73,384 ac-ft of pumping, and no wellfield was in violation of the groundwater mining provision in water-year 2017-18.

The 19.5-year total of pumping (pumping through April 2019) is subtracted from 20 years of recharge (recharge estimated through September 2019) to arrive at an April to September 2019 pumping limit for each wellfield and the Owens Valley as a whole. The 2018-19 water-year estimate of groundwater recharge in the Owens Valley from the mining calculations was approximately 211,305 ac-ft compared to 32,207 ac-ft of estimated pumping, and no wellfield is projected to be in violation of the groundwater mining provision in 2019.

The Big Pine wellfield is the only wellfield close to its mining provision limit with pumping at 88% of the total recharge thru water-year 2018-19. Pumping exceeded recharge during the five-year period of the recent drought (2012-2016). This does not constitute a violation of the groundwater mining provision, but ICWD has suggested that pumping in this wellfield be curtailed to include only sole source in-valley uses. Despite the significant amount of water spread into the Big Pine Wellfield in 2017, the narrow difference between recharge and pumping in the Big Pine wellfield (less than 62,000 ac-ft) is concerning and will continue to be monitored carefully.

For the Owens Valley, the percentage of pumping to recharge through water-year 2018-19 is projected to be 15%. Runoff (as an inflow) and pumping (as an outflow) are two of the components of the Owens Valley groundwater budget. It is important to note that evapotranspiration (evaporation and plant transpiration of groundwater primarily by native vegetation along the valley floor) is another primary component (as an outflow) of the groundwater budget; one that is implicitly protected by the Water Agreement. Therefore, looking at groundwater levels which track change in storage of the Owens Valley groundwater system and availability of groundwater to phreatophytic plants is of primary importance.

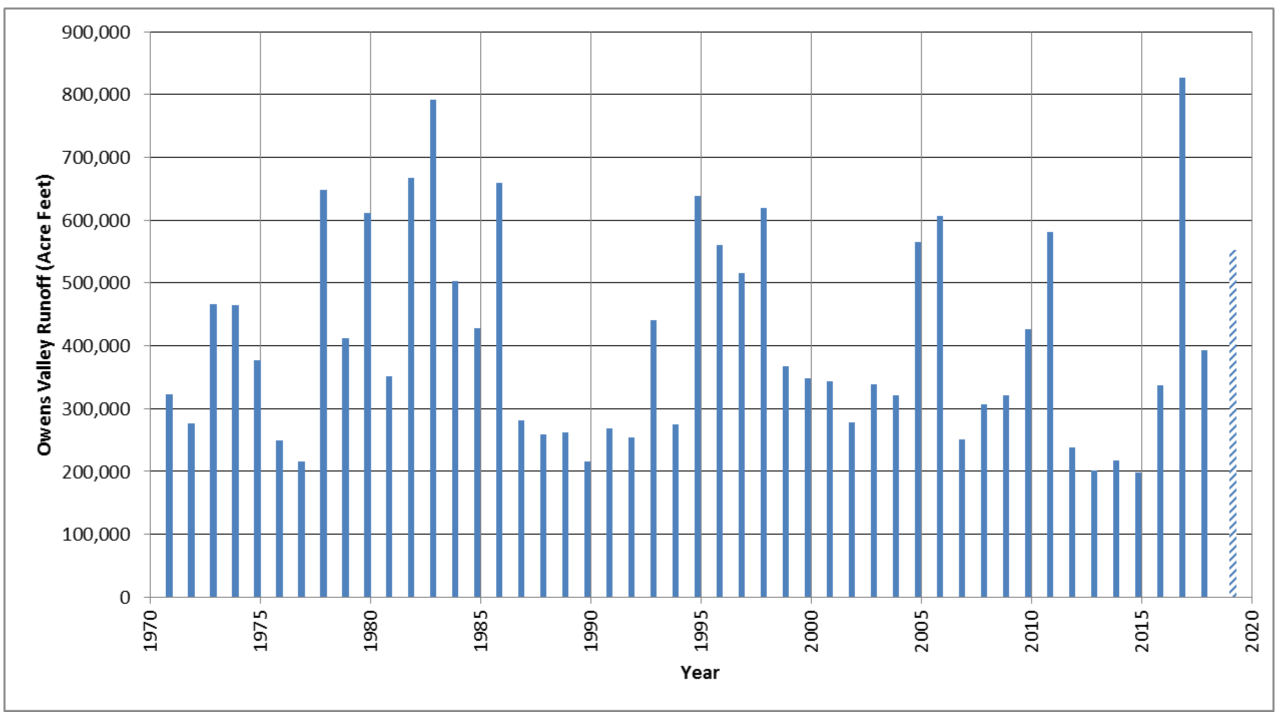

Figure 3.3. Measured Owens Valley runoff since 1970. Values are for the runoff year (e.g. runoff year 2017 includes April 1, 2017 through March 31, 2018). Dash line is current runoff year estimate.

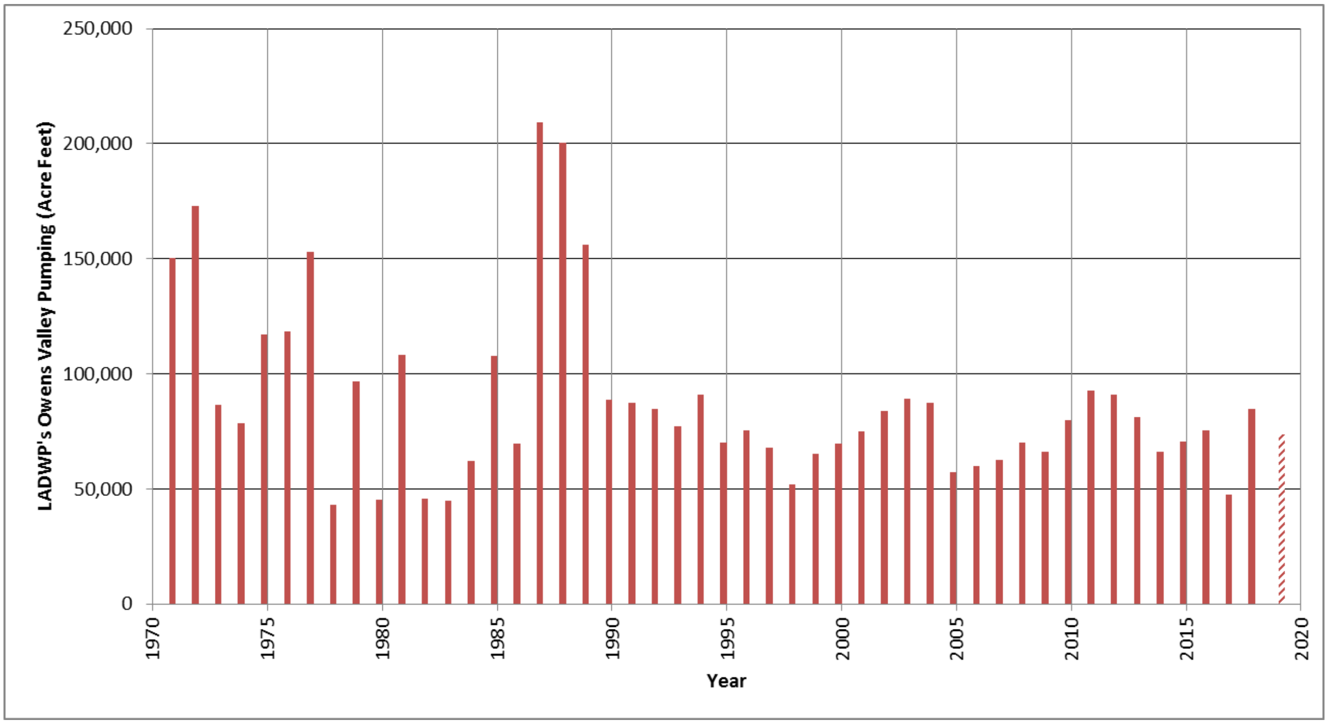

Figure 3.4. Total LADWP pumping in the Owens Valley since 1970 by runoff *year. Dash line is anticipated pumping for current runoff year.*

Summary of Hydrologic Conditions

The history of Owens Valley pumping and runoff since 1970 are presented in Figures 3.3 and 3.4. Since the Water Agreement was adopted and implemented (1992), annual pumping has averaged 73,000 ac-ft and runoff 399,000 ac-ft.

Groundwater data is collected from several hundred monitoring wells located throughout the Owens Valley each spring and fall. Most wells are also visited on more frequent (weekly-monthly schedules). Data presented in this section are depth-to-water (DTW) below ground surface (bgs) measured in feet.

Water levels in most wellfields in the valley declined in 2018-19 (Figure 3.5). Average declines in Laws, Big Pine, Taboose-Aberdeen, Independence-Oak and Bairs-Georges ranged from 0.7 to 2.5 feet. Water levels rose in the Thibaut Sawmill area near the Blackrock Waterfowl project and also in the Symmes-Shepherd well field. Water levels in west Bishop were in the range of their historic norms. During the span of 2015-2017 west Bishop experience extremely shallow or perched groundwater likely due to increased seepage from area ditches and ponds. This situation appears to be resolved.

One method of analyzing hydrologic conditions in the Owens Valley is to compare recent groundwater levels with historic conditions. The LTWA uses the vegetation conditions documented from surveys conducted from 1984 to 1987 as its baseline for comparison of ecologic change (see Section V for details). Therefore, ICWD uses the average April groundwater levels from 1985 to 1987 as a hydrologic “baseline.” While this hydrologic baseline is not specifically proscribed in the LTWA, it is a

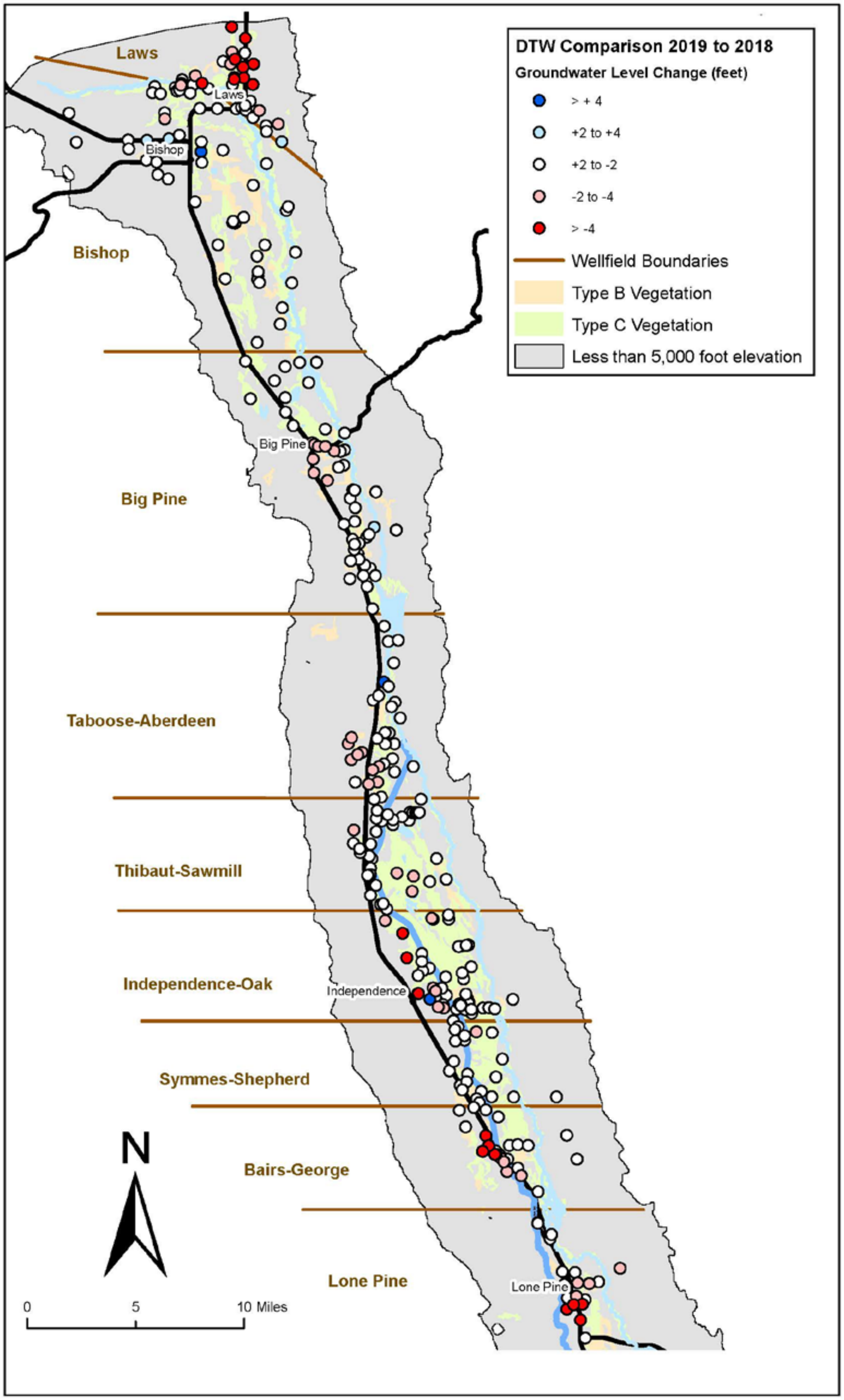

Figure 3.5. Change in water levels in Owens Valley monitoring wells from 2018 to 2019.

comparison point between the hydrology and the ecology of the baseline period. Also, the April time-frame roughly coincides when DTW is typically shallowest each year. The hydrologic baseline DTW usually is an adequate indicator of better soil water and vegetation conditions, but should be considered a guide rather than a specific threshold that determines whether vegetation conditions are above or below baseline in the immediate vicinity of a monitoring well. Unlike the vegetation baseline, maintaining baseline DTW is not a requirement of the Water Agreement.

The record winter of 2017 assisted in allowing water levels to recover from the recent 5-year drought. As of April 2019, DTWs in many wellfields were at or above baseline levels. However, certain wellfields were below baseline (Figure 3.6), including southern Big Pine, Independence-Oak, and Symmes-Shepherd. Hydrographs plotting DTW for selected wells are provided in the following discussions of conditions for each wellfield. The hydrographs presented below were selected to provide insight on water level changes over time.

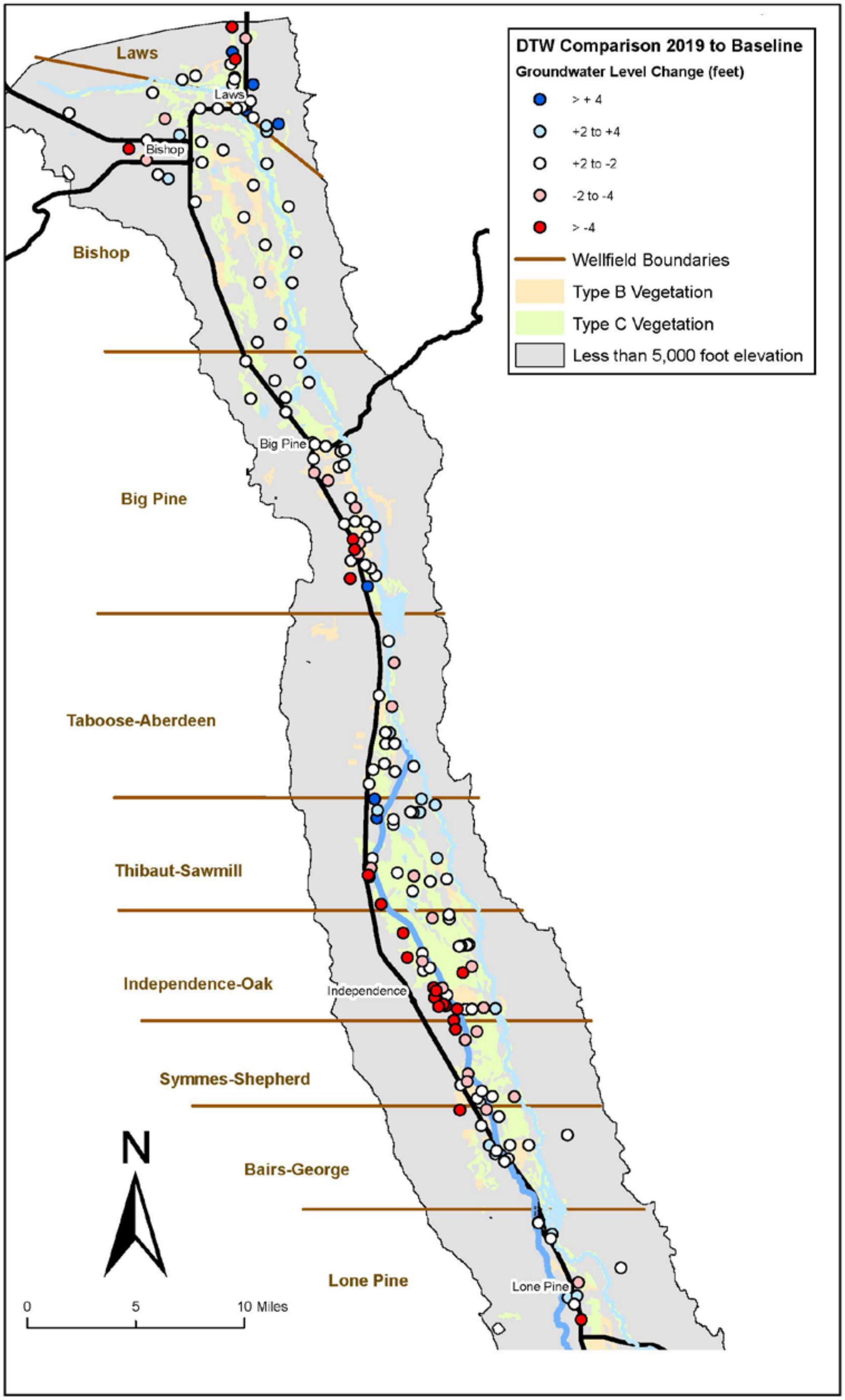

Figure 3.6. April 2019 groundwater levels wells compared with April average water level in 1985-87.

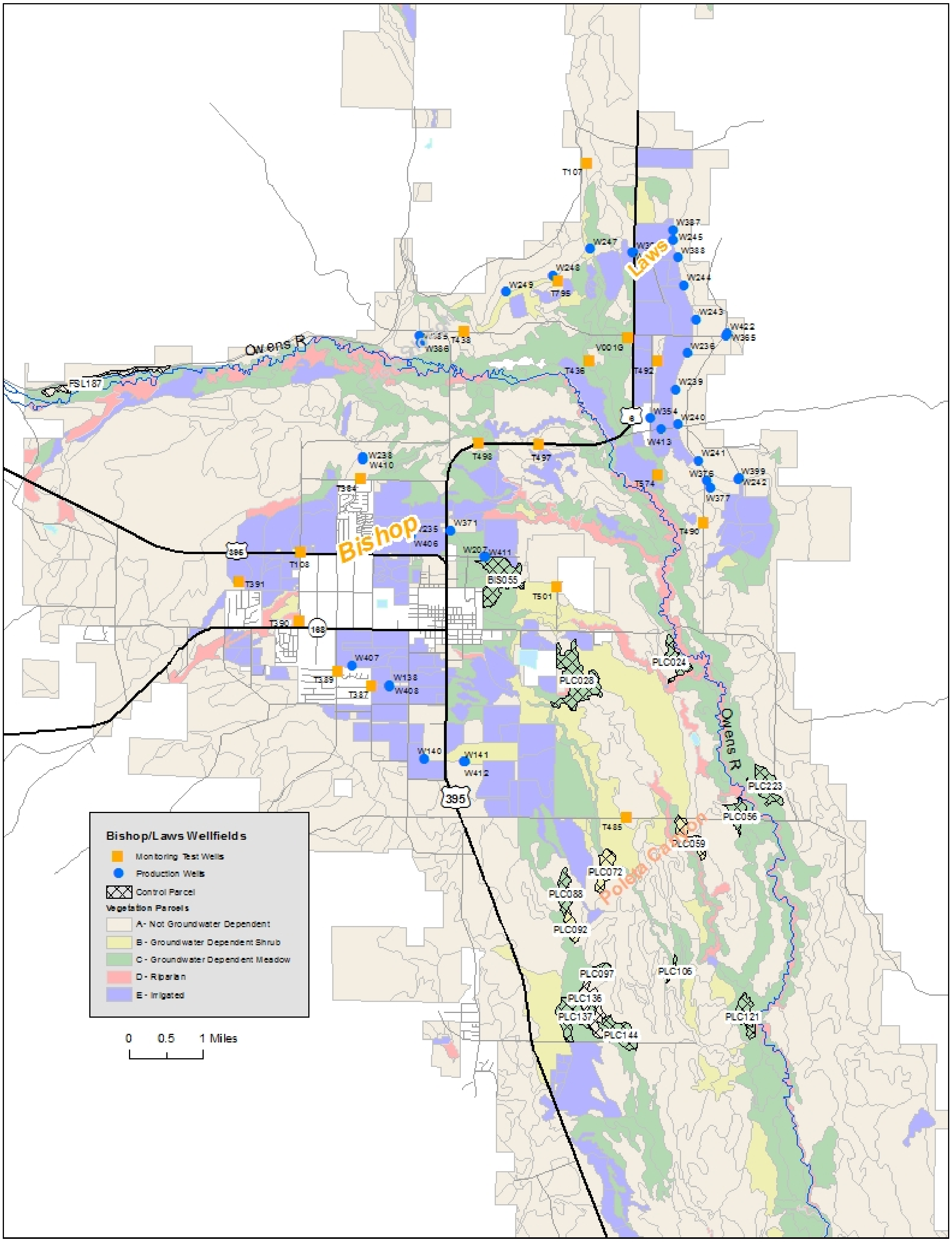

Figure 3.7. Map of monitoring wells and LADWP production wells in Laws and Bishop wellfields.

Laws Wellfield

In the 1970's and 80's, pumping along with irrigation and spreading from the Owens River via the McNally canals in Laws varied greatly year-to-year causing large fluctuations in the water table (Figures 3.8 and 3.9). This was especially true for T107 and T492 because of their proximity to the McNally canals and LADWP pumping wells. Heavy pumping and low recharge in the late 1980's caused severe groundwater level decline in Laws. Under the Water Agreement pumping has remained considerably below the maximum wellfield capacity. As a result, water levels rose, and beginning in 2000, water table fluctuations have been largely driven by pumping for local uses in the surrounding area and by water spreading following heavy snow winters (2005, 2006, 2011, 2017, 2019). In 2018-19, groundwater levels fell in all indicator test holes; however seven of the nine test holes remained above baseline water levels as of April 2019 (Table 3.2).

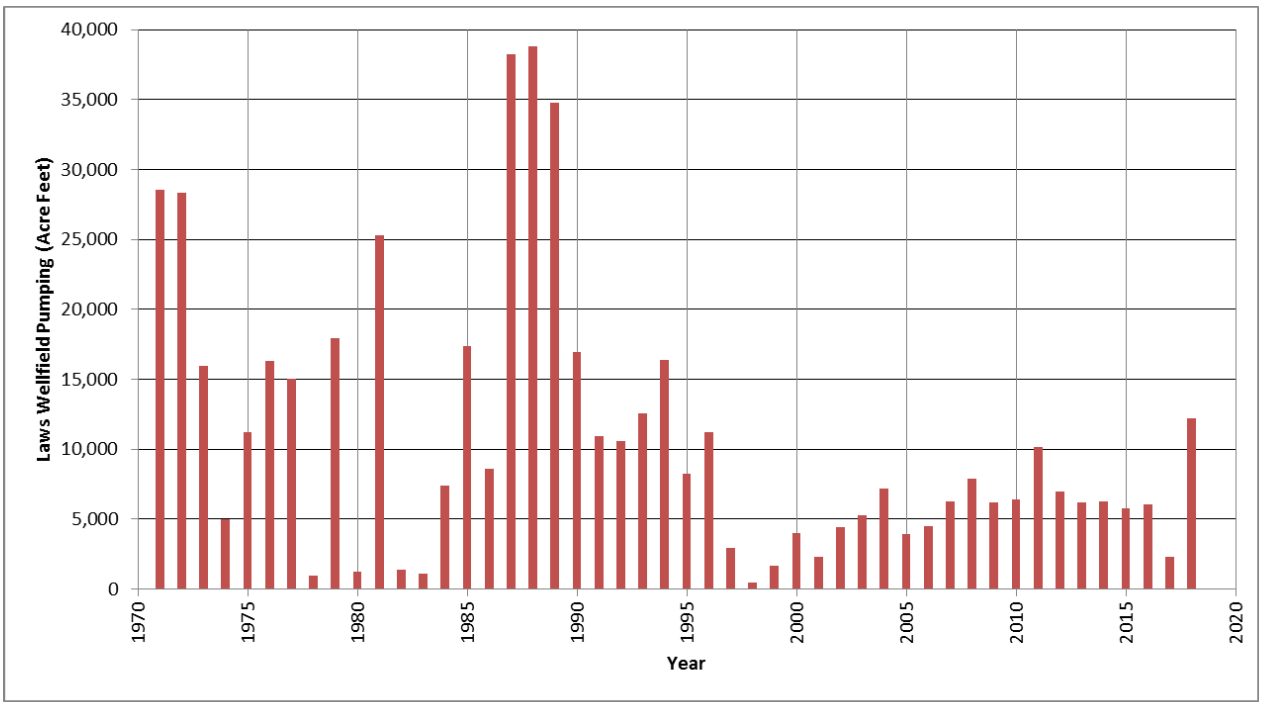

Figure 3.8. Pumping totals for the Laws wellfield.

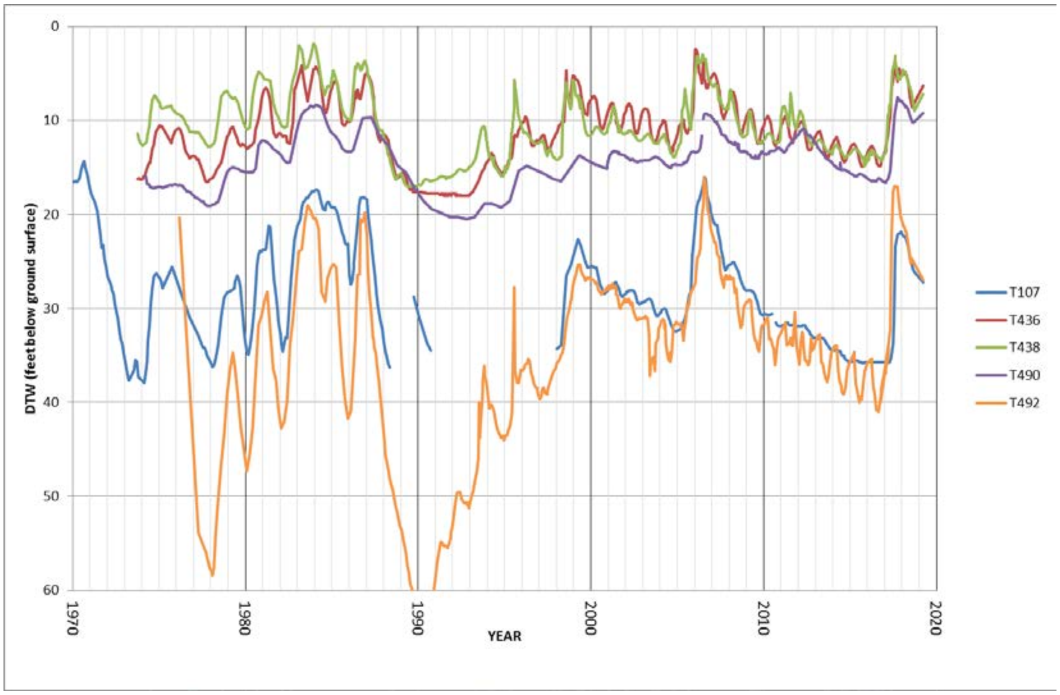

Figure 3.9. Hydrographs of indicator wells in the Laws wellfield. Well T492 is dry if DTW is below 60 ft, and well T107 is dry if DTW is below 37 feet.

Bishop Wellfield

Groundwater pumping in the Bishop Wellfield is managed differently than other wellfields due to additional legal requirements governing LADWP operations. The environmental protections and goals of the Water Agreement still apply, however. The Water Agreement requires Inyo and Los Angeles to prepare an annual audit of pumping and uses on the Bishop Cone to demonstrate compliance with the Hillside Decree (the Decree itself does not contain audit procedures). The Hillside Decree is a 1940 Inyo County Superior Court stipulation and order under which LADWP groundwater extractions from pumped and uncapped flowing wells cannot exceed the annual amount of water used on LADWP owned land on the Bishop Cone.

It is important to understand that the Bishop Cone Audit is not an accounting of the water balance for the groundwater aquifer. Rather, it is an accounting based on the surface water applications (for irrigation and stockwater) to the Bishop Cone compared to groundwater pumping and flowing wells. Water supplied for irrigation in west Bishop upstream of LADWP pumping wells consists of surface water diverted primarily out of Bishop Creek and the Owens River. Pumped water from the center of the cone is also conveyed for irrigation using the same ditches and canals as the surface water, and most lands are supplied with combined pumped and surface water. Because it is impossible to separate surface and groundwater once they are combined in a canal or ditch, the most reliable method to assess compliance with the Hillside Decree is to compare the sum of pumping and flowing water against the sum of water uses applied on the cone.

Uses in the Bishop Cone Audit are calculated as the amount of water applied to a parcel minus the amount of water flowing off the parcel back into the canal or ditch system. In some cases several parcels are grouped into a single account and several monitoring stations are used to measure the water delivered to and exiting from the account. The accounts as well as the individual deliveries/uses are only included in the Bishop Cone Audit following a field inspection and Technical Group approval to ensure that appropriate monitoring is in place. Not all lands supplied with water or all water uses are included in the Audit.

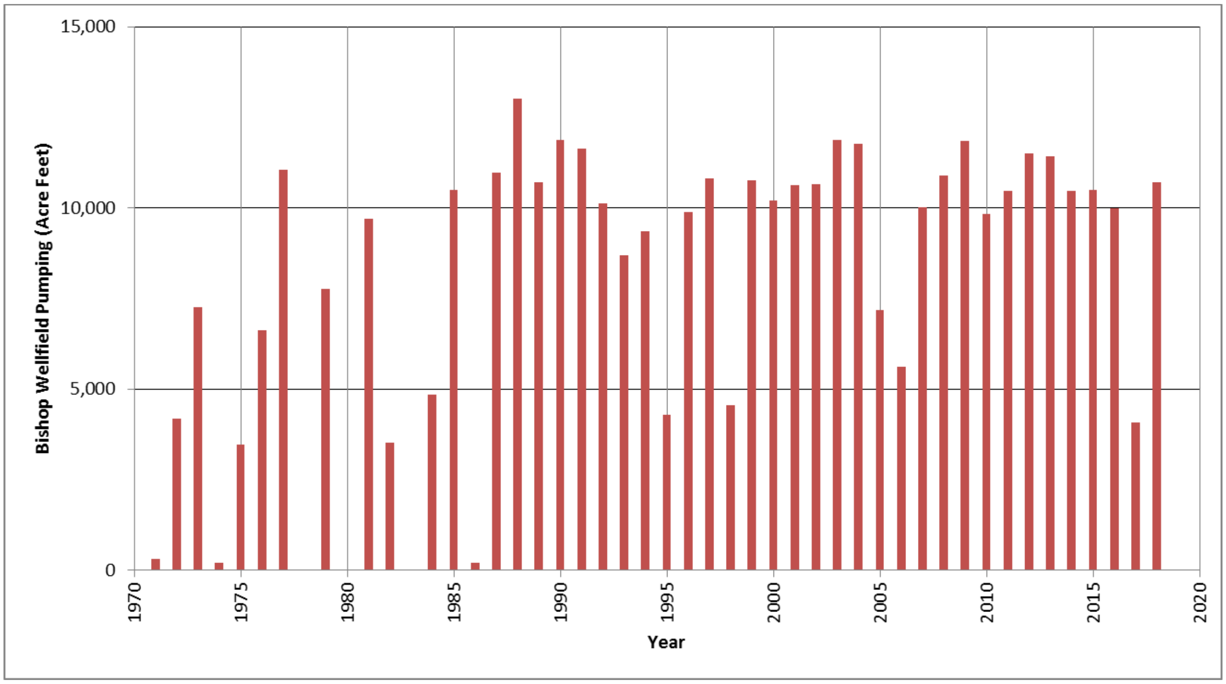

Figure 3.10. Pumping totals for the Bishop wellfield.

The most recent Bishop Cone Audit examined conditions for the 2017-18 runoff year. Total groundwater extraction (pumping and flowing wells) on the Bishop Cone was 9,972 ac-ft compared with 46,440 ac-ft of recorded uses. Therefore, uses on the Bishop Cone exceeded extractions by approximately 36,468 ac-ft. If extractions had exceeded the amount of recorded uses, all groundwater could not have been used on the Bishop Cone and LADWP would be out of compliance with the Hillside Decree. That situation has not occurred since the audit procedures were implemented as part of the Water Agreement.

Pumping in the Bishop Wellfield has been relatively constant for the past 25 years except in above-normal runoff years when pumping decreased, for example 1998, 2006, 2017 and possibly 2019 (Figure 3.10). Because of the Hillside Decree and relatively constant pumping, ICWD does not routinely use indicator wells to analyze LADWP's annual operations plan for this wellfield. Water levels in west Bishop typically peak after the summer irrigation season. Groundwater levels from 1980 to 2018 at several test wells located west, north, and east of the city of Bishop are presented in Figures 3.11.a -c. Constant pumping and consistent recharge from irrigation has historically resulted in relatively stable water levels in the Bishop Cone Wellfield. However, the effects of the 2012 to 2016 drought can be seen in the recent water levels from Bishop Cone wells, especially wells in the western and northern portions of the wellfield.

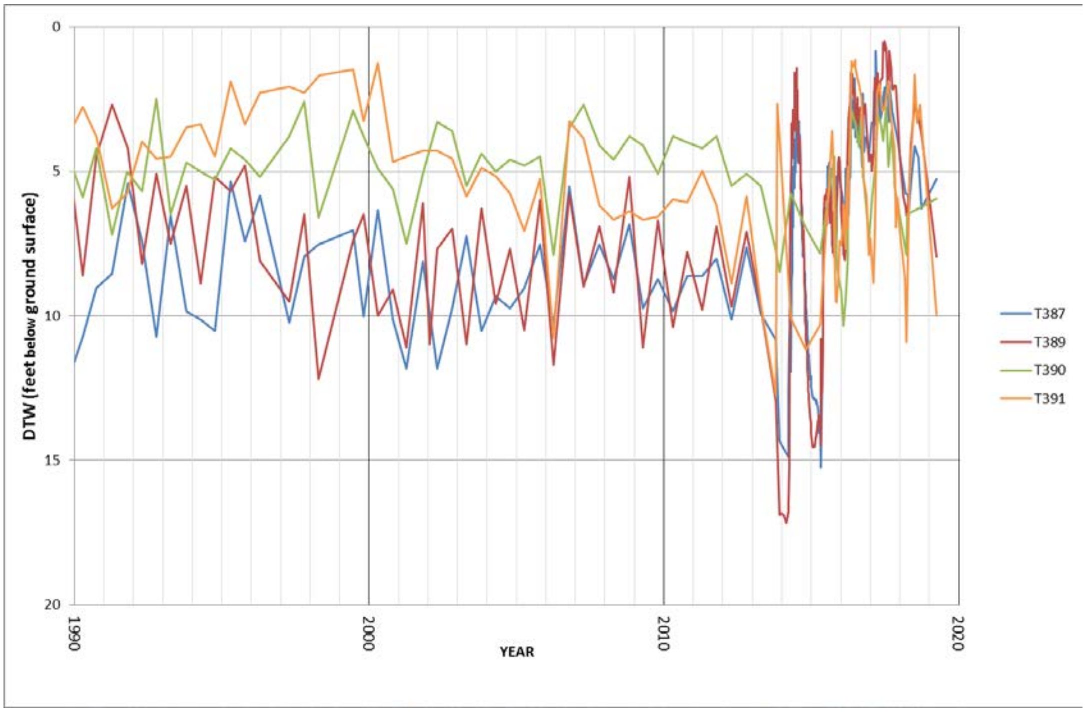

Figure 3.11.a. Hydrographs of selected monitoring wells in the western Bishop wellfield. Locations of the wells are shown in Figure 3.7.

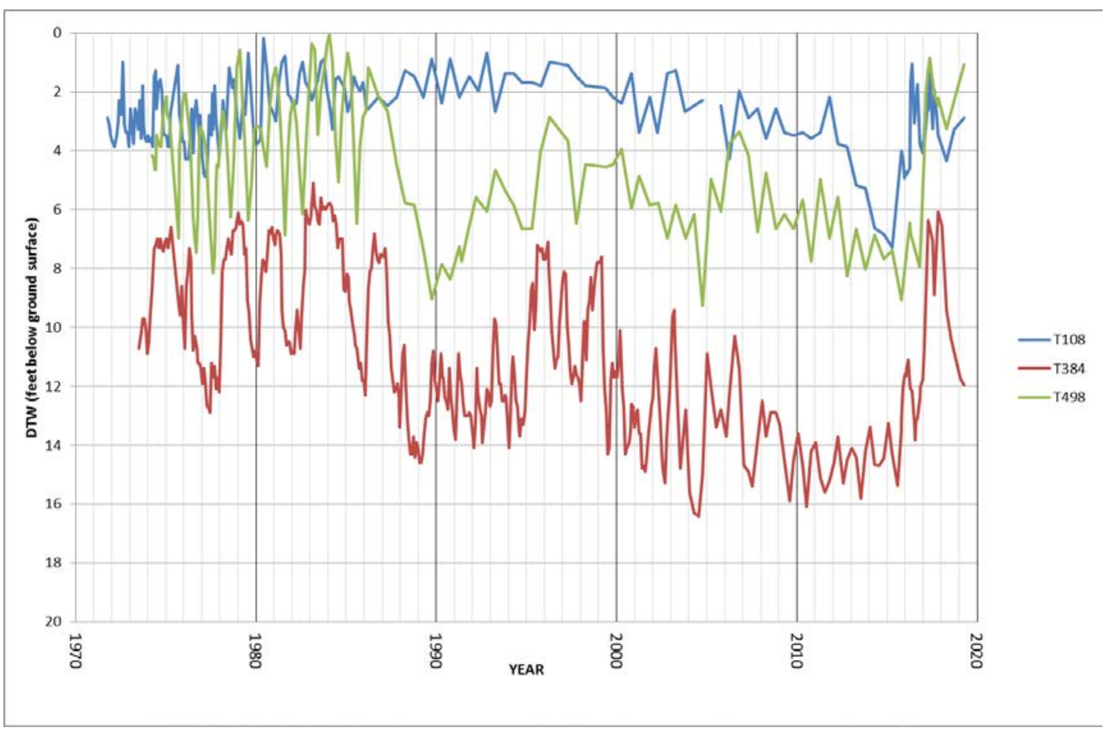

Figure 3.11.b. Hydrographs of selected monitoring wells in the northern Bishop wellfield. Locations of the wells are shown in Figure 3.7

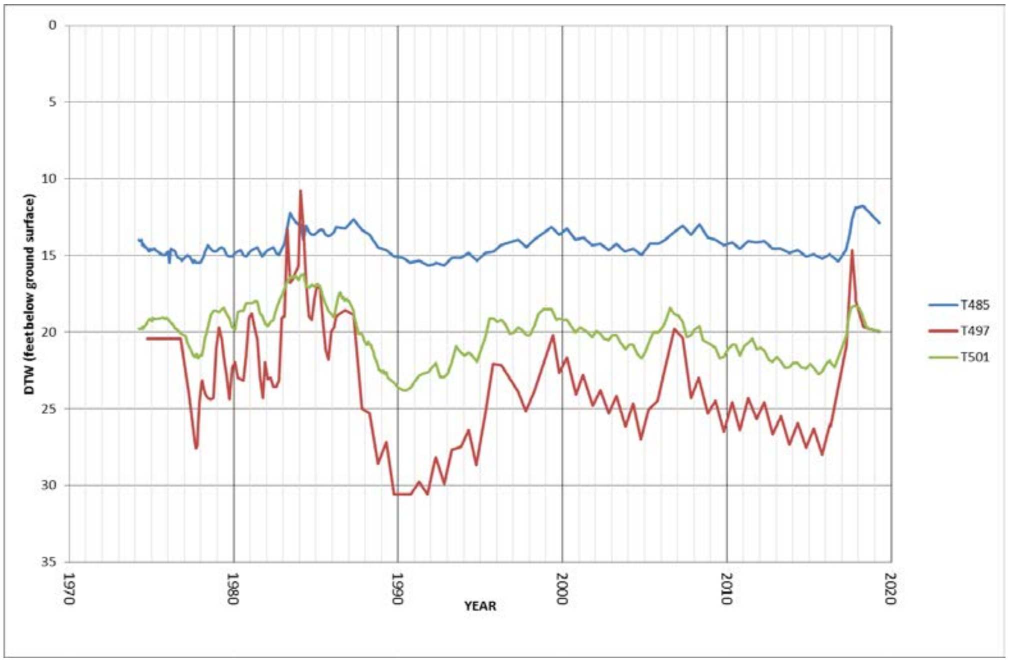

Figure 3.11.c. Hydrographs of selected monitoring wells in the eastern Bishop wellfield. Locations of the wells are shown in Figure 3.7

It is likely that a combination of diminished surface water flows caused by the 2012-2016 drought and the change in timing of Bishop Creek surface flows negatively affected shallow groundwater levels in west Bishop from the fall of 2013 through the winter of 2014. Groundwater levels in this area dropped precipitously, in some cases to their lowest recorded levels. Several domestic wells went dry. Hydrographs of these groundwater levels declines can be seen in Figure 3.12. The declining groundwater levels prompted both ICWD and LADWP to increase the frequency of their monitoring on the western half of the Bishop Cone in order to more fully understand the changes in groundwater levels during the prolonged drought.

From the water table lows in fall and winter of 2013-14, groundwater levels recovered. During this recovery, several west Bishop residents noticed extremely shallow or perched water at their properties. It is theorized that once creek and ditch flows returned to the area in 2014, increased seepage of surface water led to the oversaturation of the near surface sediments. Additional investigations were conducted in 2016, including a report issued by the Department of Water Resources.

Since summer/fall of 2017, fewer problems with shallow groundwater were noted and it is hoped that the natural sealing caused by decaying biomass in ditches and ponds has decreased seepage amounts to their pre-2013 rates, and that the west Bishop hydrologic system is moving back towards it historic equilibrium.

Due to another significant winter, for 2019-20 the forecasted flows in Bishop Creek are expected to exceed the Chandler Decree minimums through September 2019 with enough water retained in storage to keep 2019-20 fall and winter flows at or above historic norms.

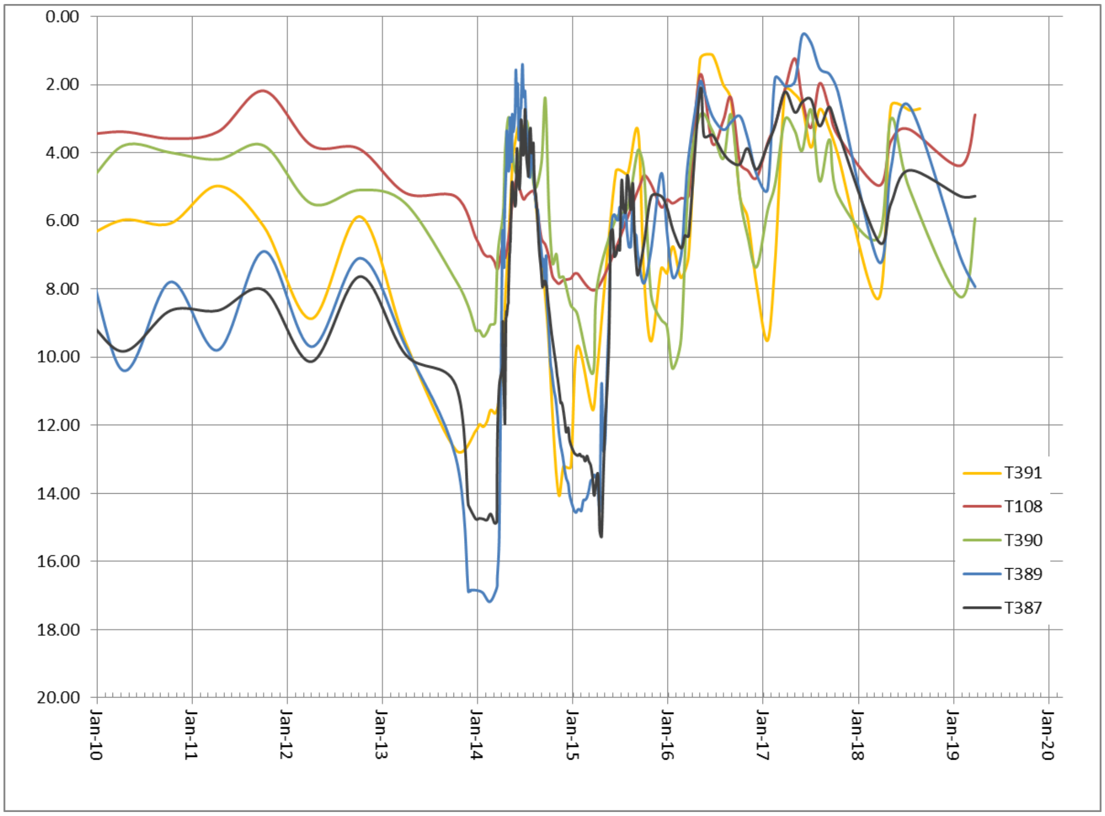

Figure 3.12. Recent hydrographs of selected monitoring wells in western Bishop wellfield. Locations of the wells are shown in Figure 3.7

Important takeaways from recently observed Bishop Cone conditions:

- Surface water flows play an integral role in recharging shallow groundwater levels in west Bishop; and the interaction between surface water and groundwater recharge is very sensitive to changes in equilibrium conditions
- Semiannual monitoring in spring and fall does not capture the full range of groundwater fluctuations in the Bishop area
- Thoughtful water management of Bishop Creek flows and the associated diversion and ditch flows should be used during drought and/or low runoff years to maintain some flow in area ditches
- In west Bishop there is a delicate balance between enough surface water seepage to recharge area groundwater and too much seepage to overwhelm infiltration rates, leading to undesirable, extremely shallow or perched water levels
- Many of the private wells in west Bishop are shallow and, therefore, more vulnerable to impacts associated with deepening groundwater levels
- Conservative pumping practices should be used on LADWP wells W407 and W408 during drought and/or low runoff years
- Information gathered in west Bishop during the past several years should be taken into consideration in regards to LADWP's potential new wells B2 and B5.

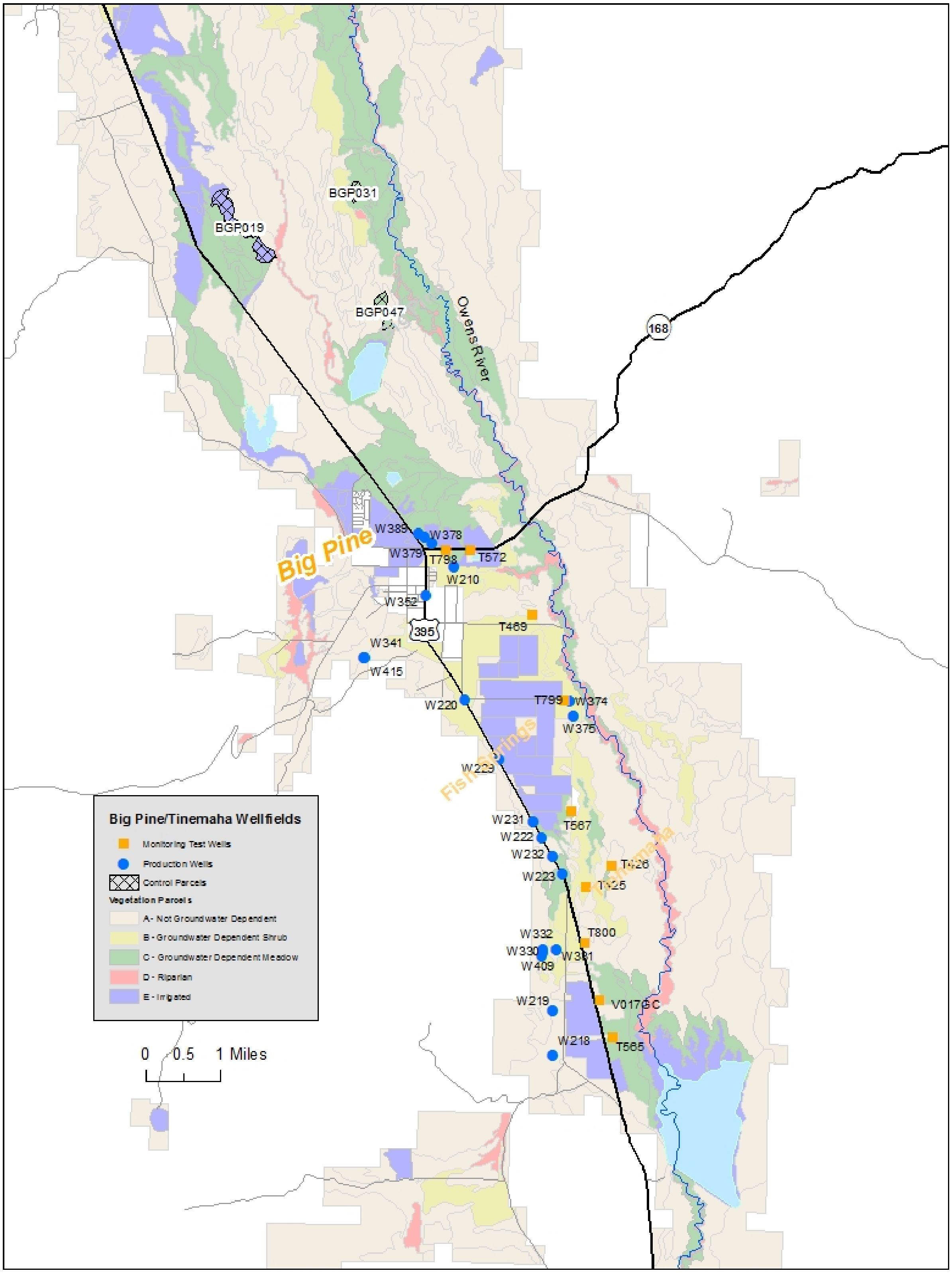

Figure 3.13. Map of monitoring wells and LADWP production wells in Big Pine wellfield.

Big Pine Wellfield

Since 1974, pumping in the Big Pine wellfield (Figure 3.14) has been consistently higher than other wellfields (Figure 3.13). Minimum pumping to supply uses in this wellfield include the Fish Springs Hatchery (approximately 19,500 ac-ft per year) and Big Pine town supply (500 ac-ft per year). Pumping under the Water Agreement has largely been to supply these uses. It should be noted that most of the hatchery pumped water also reaches the aqueduct.

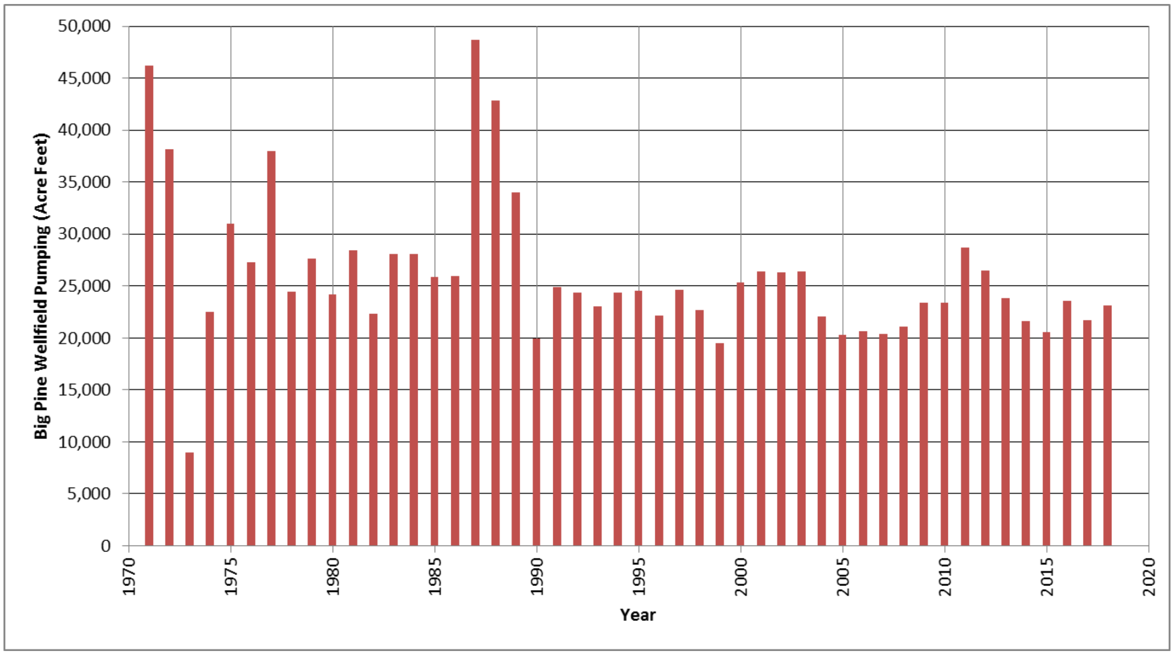

Figure 3.14. Pumping totals for the Big Pine wellfield

DTW in indicator and monitoring site wells fell in five of eight wells in 2019 (Figure 3.15, Table 3.2). Six of the eight indicator wells remain below, but within 2.5 feet, of baseline. The two indicator wells above baseline (T572 and T798) are in the northern part of the wellfield in close proximity to and strongly influenced by the Big Pine Canal. ICWD also examined two test wells located just east of U.S. 395 near W218 and W219 to assess possible impacts from the additional export pumping of recent years (Figure 3.16). Both V017GC and T565 are located in or adjacent to groundwater dependent vegetation. Water levels declined in response to drought and pumping from 2012 to 2016. In 2017, LADWP actively spread water into the Big Pine wellfield, notably south of town along the Red Mountain cinder cone. Both V017GC and T565 have recovered significantly since 2017 and remained above baseline levels as of April 2019.

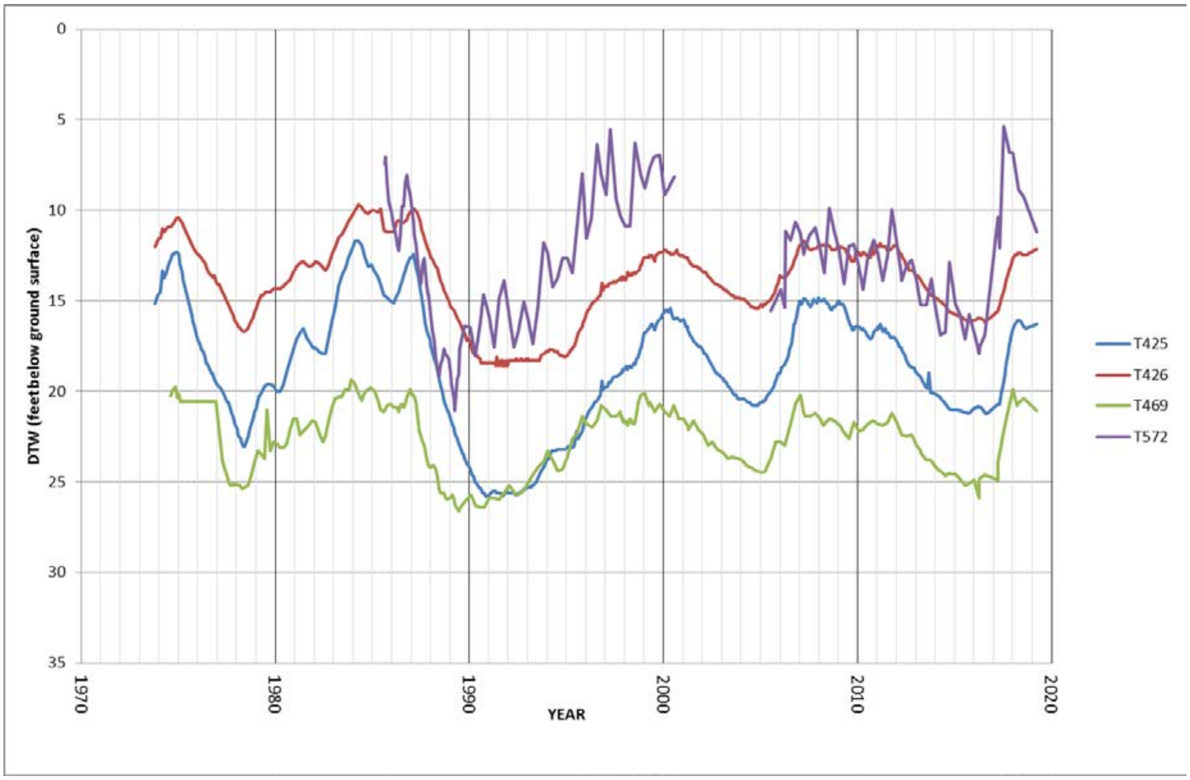

Figure 3.15. Hydrographs of indicator wells in the Big Pine wellfield. Periods of missing data for T572 occurred when the well was plugged and in need of repair.

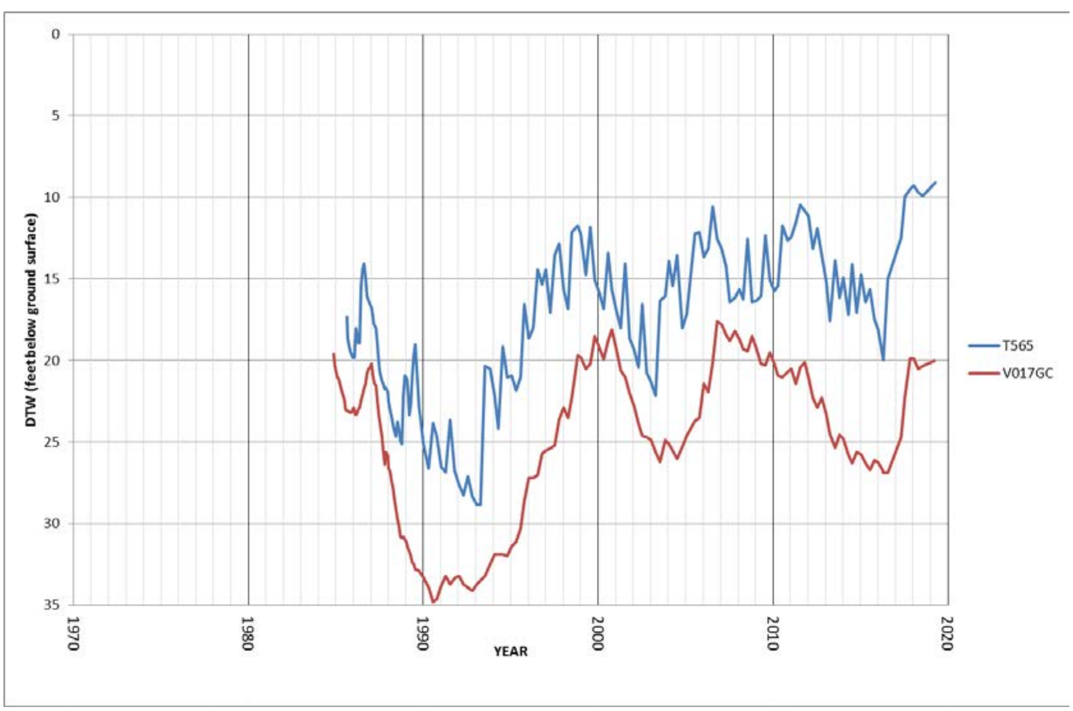

Figure 3.16. Hydrographs of monitoring wells in the southern Big Pine wellfield near pumping wells W218 and W219.

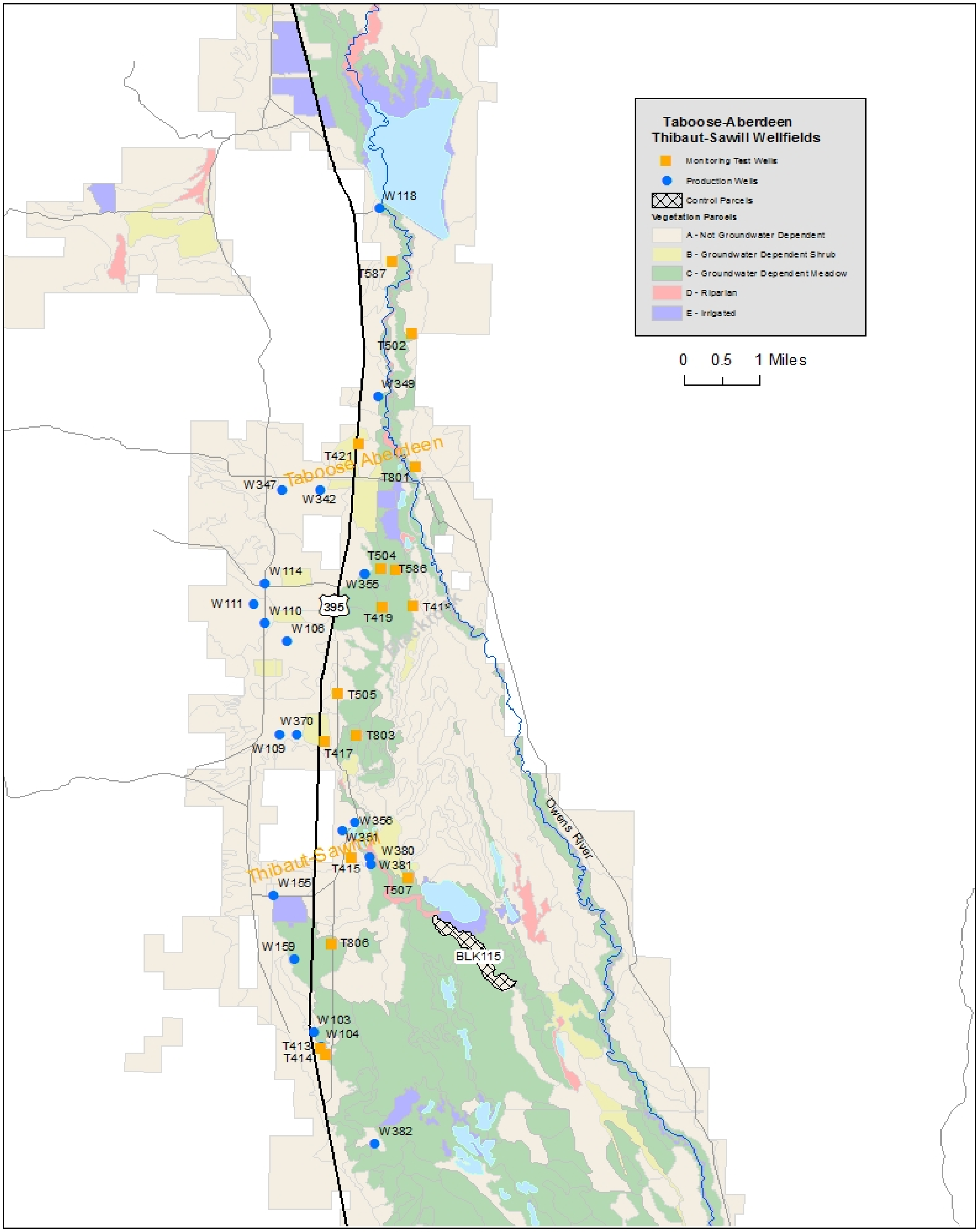

Figure 3.17. Map of monitoring and LADWP production wells in the Taboose-Aberdeen and Thibaut-Sawmill wellfields.

Taboose-Aberdeen Wellfield

Since 1990 under the Water Agreement, pumping in the Taboose-Aberdeen Wellfield (Figure 3.17) has remained much below the wellfield capacity (Figure 3.18). Minimum pumping for this wellfield is approximately 300 ac-ft to supply one mitigation project at Big Seeley Spring, and nearly all of the pumping since 2010 has been for aqueduct supply. LADWP pumped more than 14,000 ac-ft of water from the wellfield in 2018-19; the most pumping since 1989.

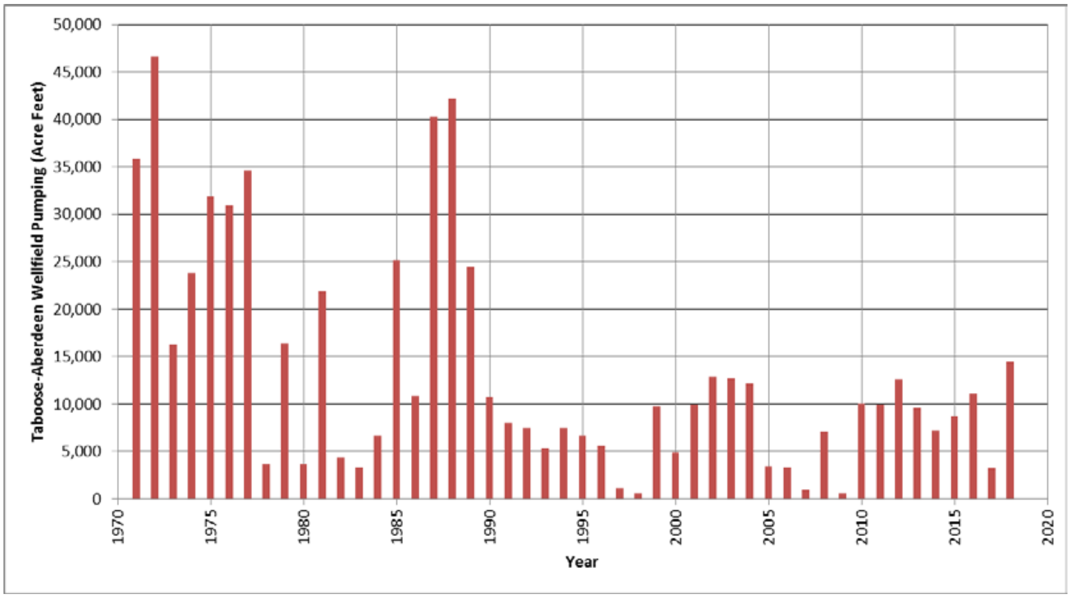

Figure 3.18 Pumping totals for the Taboose-Aberdeen wellfield.

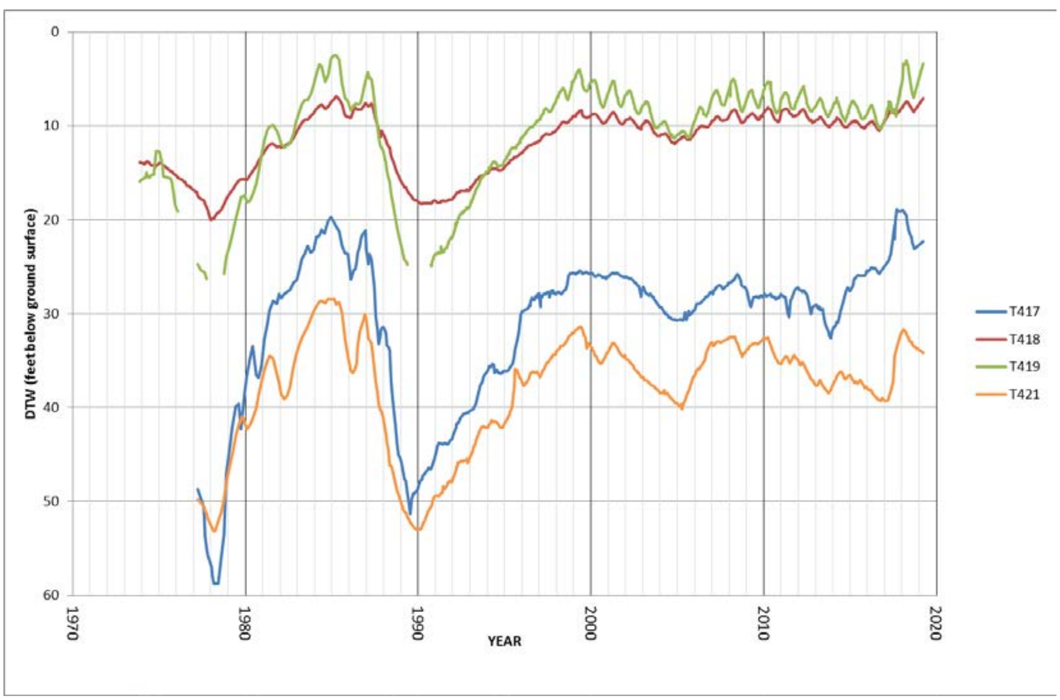

Figure 3.19. Hydrographs of indicator wells in the Taboose-Aberdeen wellfield. Periods of missing data denote when the test well was dry.

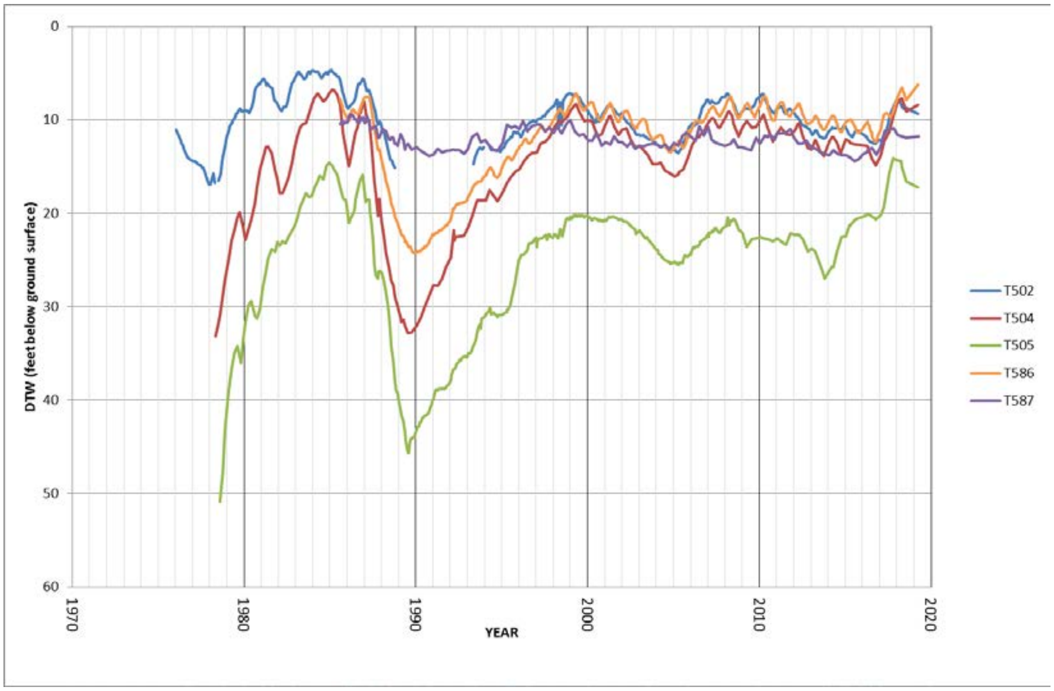

Figure 3.20. Hydrographs of indicator wells in the Taboose-Aberdeen wellfield. Periods of missing data denote when the test well was dry.

Groundwater levels in 2018-2019 declined in seven out of 10 indicator or monitoring site wells (Table 3.2). However, water levels remained above baseline levels in seven on the 10 wells. Depth to water in all wells varied between three feet below to two feet above baseline in April 2019 (Table 3.2).

Hydrographs for the indicator wells exhibit similar response to fluctuations in pumping and runoff (Figures 3.19 and 3.20). Most of the recent pumping has been from well W349 and W118 located in the northern portion of the wellfield. Well 118 has been operated consistently from 2011 to 2016, was off for the majority of the 2017-18 runoff year, but was pumped through most of 2018-19. Data from monitoring well T587 (a non-indicator well) is included because it is located adjacent to groundwater dependent vegetation near W118 and is used to assess the impacts of recent pumping.

Thibaut-Sawmill Wellfield

Historically, most pumping in the Thibaut-Sawmill Wellfield has been to supply approximately 12,200 ac-ft annually to the Blackrock Fish Hatchery (Figure 3.21). In 2014, Inyo and Los Angeles agreed to reduce hatchery pumping to approximately 8,300 ac-ft as p[art of the settlement to the Black Rock dispute.

Hydrographs of five test wells used to track water levels in Thibaut-Sawmill have exhibited different responses due to local water management within the wellfield (Figure 3.22). Wells T415 and T806, responding to reduced hatchery pumping, have exhibited a continuing rising trend since 2014.

Wells T413, T414 and T507 located in the southern portion of the wellfield have recovered several feet since the end of the recent drought. However, the reduction in the hatchery pumping is not nearly as evident in these wells.

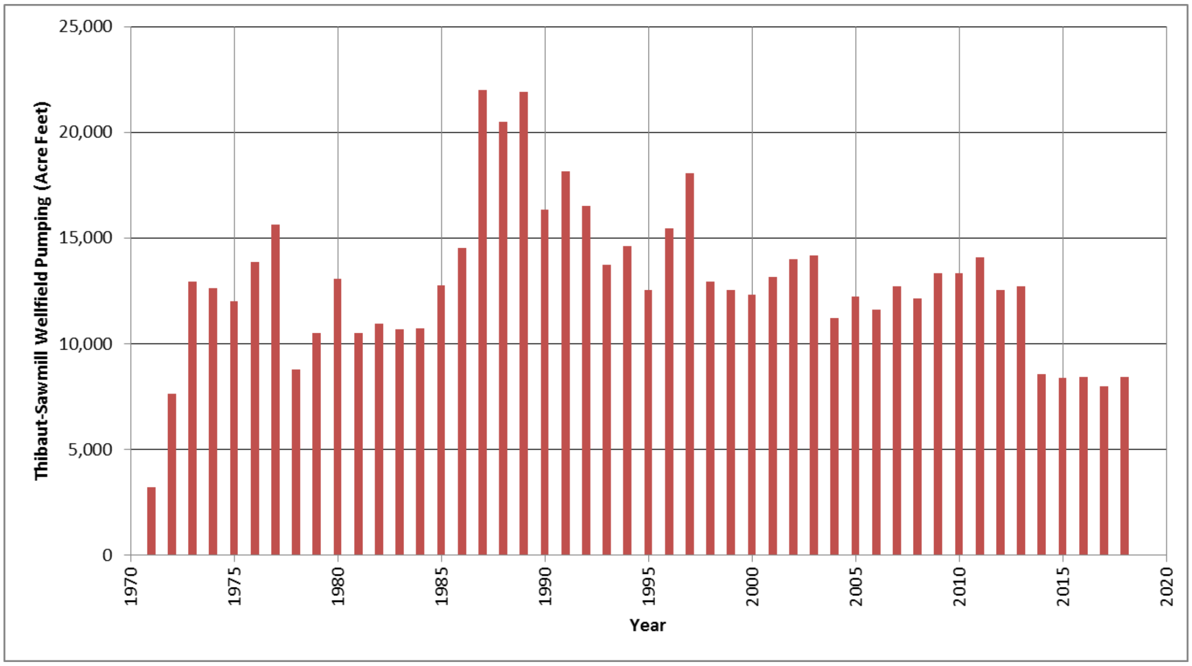

Figure 3.21. Pumping totals for the Thibaut-Sawmill wellfield.

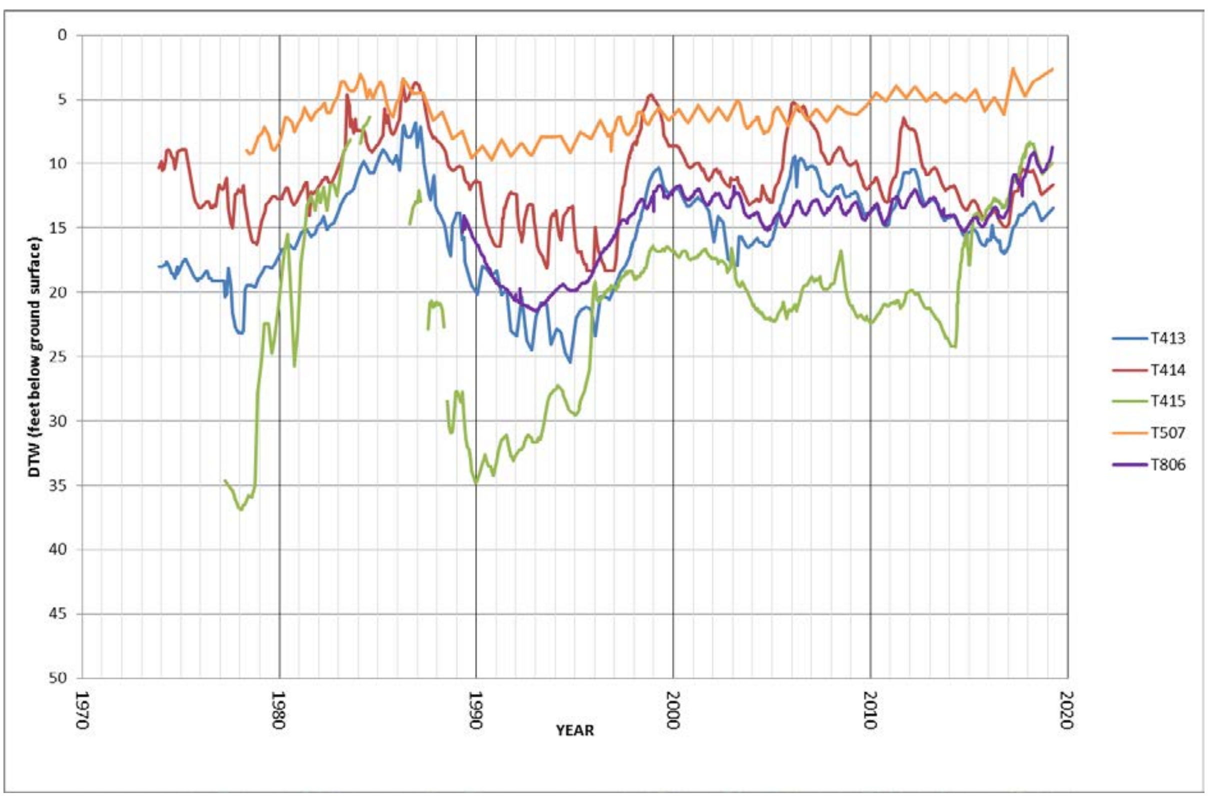

Figure 3.22. Hydrographs of selected test wells in the Thibaut-Sawmill wellfield.

Following nearly ten years of stable water levels, T507 began to respond in 2009 to the establishment of wetlands in the Blackrock Waterfowl Management Area (BWMA). The rotational flooding of BWMA affects groundwater levels in this well. Groundwater levels in the five wells were stable (DTW change +/- 1.5 feet) in 2019 compared to 2018. And all three indicator wells for Thibaut-Sawmill are at or above baseline level.

Independence-Oak Wellfield

Pumping in this wellfield (Figure 3.23) is required to supply approximately 6,700 ac-ft annually for irrigation projects surrounding Independence and for town supply (Figure 3.24). LADWP pumped between 8,600-9,600 from 2011 through 2016; however, with heavy 2017-18 runoff, this wellfield was only pumped for irrigation (approximately 6,000 ac-ft). In 2018-19 pumping for export resumed with the wellfield total at approximately 11,600 af.

Water levels had been stable through the first decade of 2000 in wells located in the center of the wellfield (T406, T407, T408, T409), but have declined in response to the increased pumping during the past decade. In 2017, the combination of reduced pumping for export and increased recharge from heavy runoff allowed water levels to rebound somewhat. Groundwater levels in these wells ranged between three feet of decline to one-half foot of recovery (Table 3.2 and Figures 3.25 and 3.26) as of April 2019.

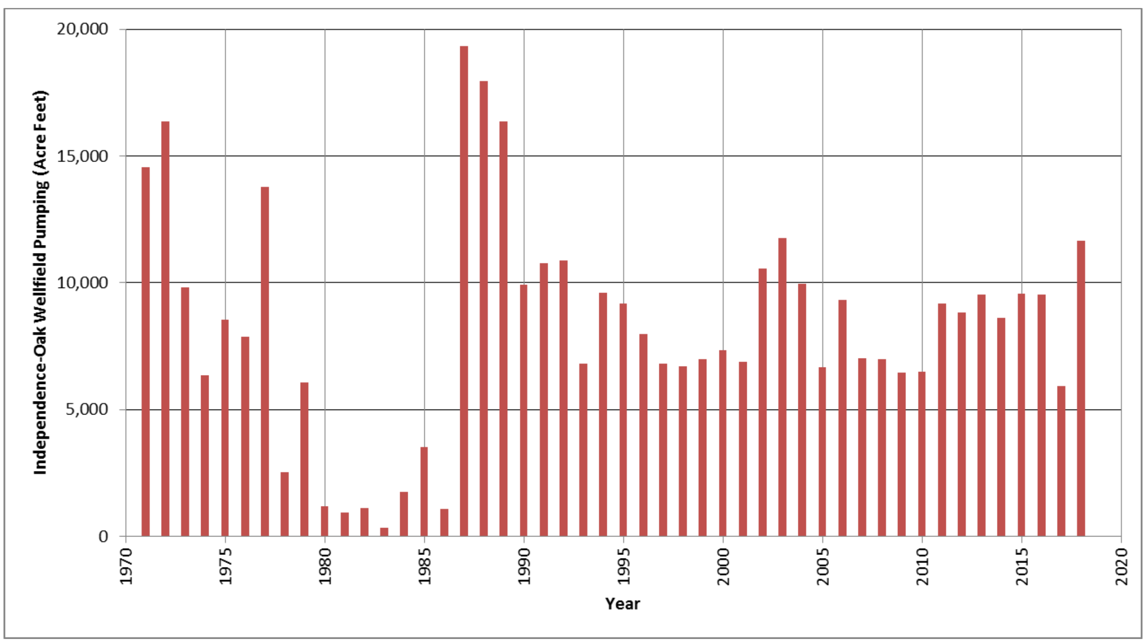

Figure 3.24. Pumping totals for the Independence-Oak wellfield.

All of the indicator wells in the Independence-Oak Wellfield were below the baseline in April 2019 by one to nine feet (Table 3.2). Due to the declines in groundwater levels as compared to the baseline period in these wells ICWD staff has recommended to LADWP that pumping for export be minimized in this wellfield.

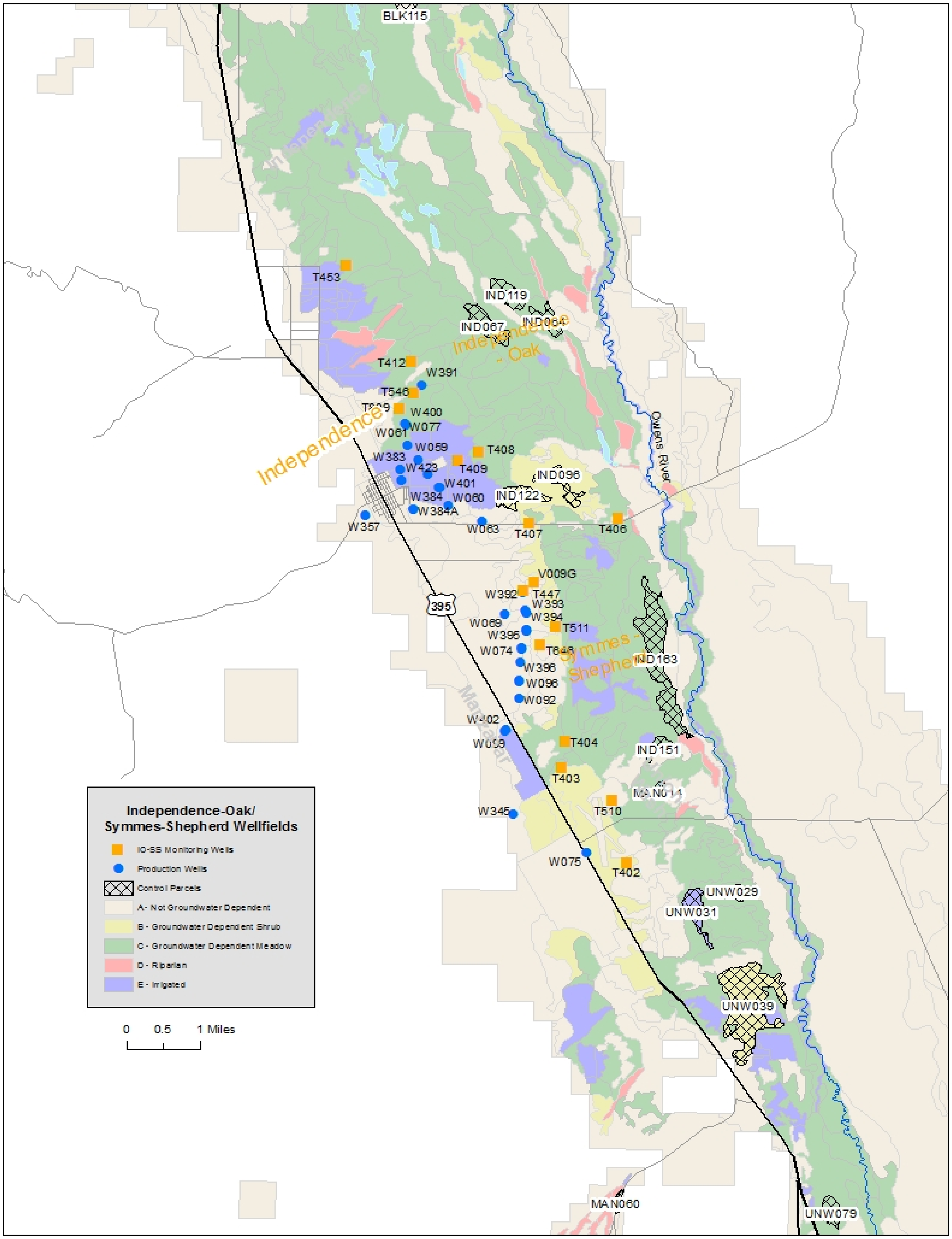

Figure 3.23. Map of monitoring and LADWP production wells in the Independence-Oak and Symmes-Shepherd wellfields.

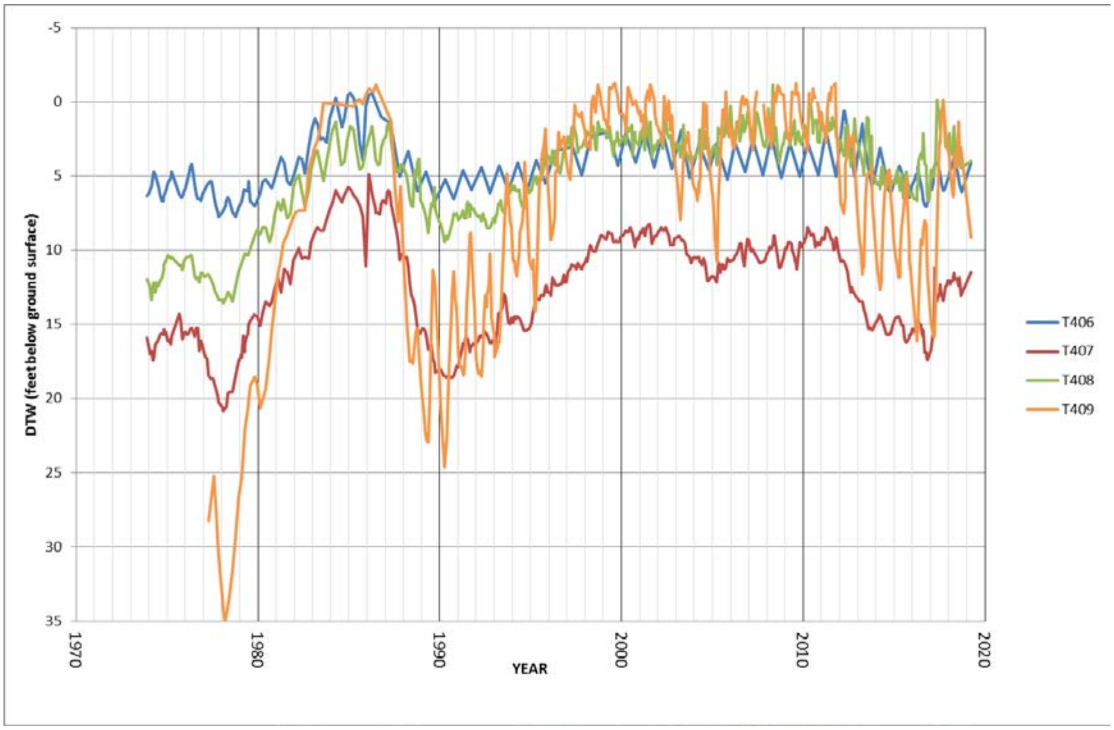

Figure 3.25. Hydrographs of selected test wells in the Independence-Oak wellfield

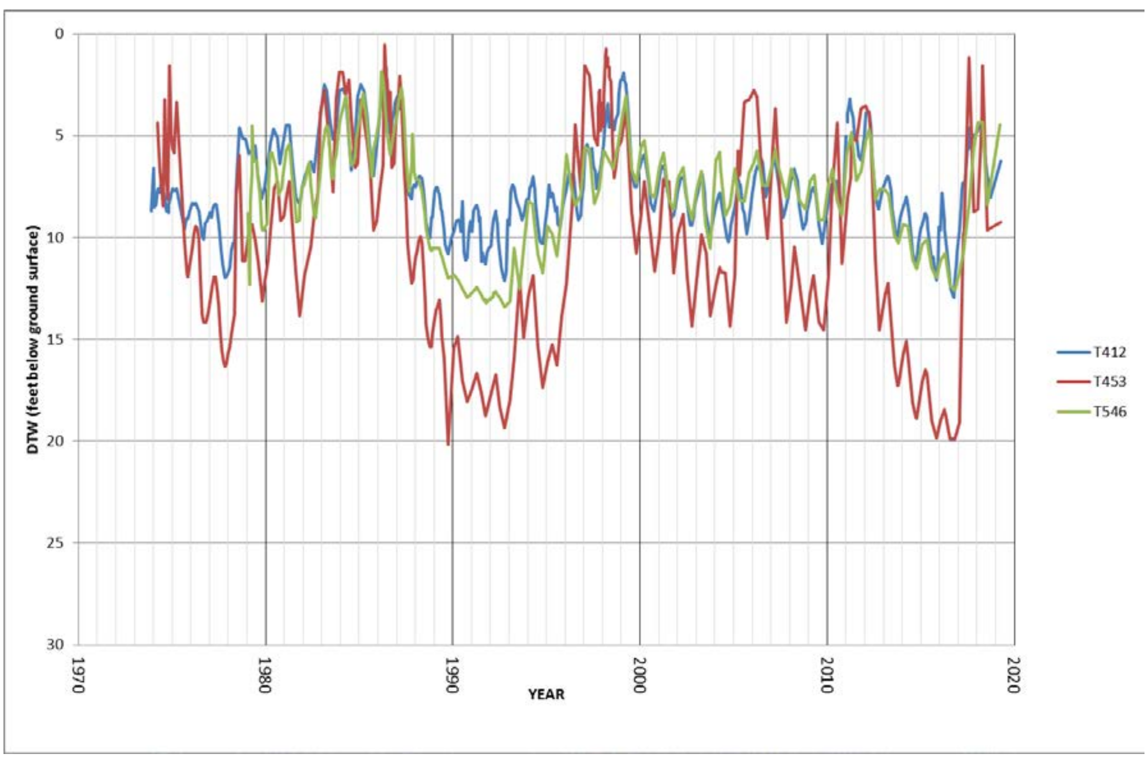

Figure 3.26. Hydrographs of selected test wells in the Independence-Oak wellfield

Symmes-Shepherd Wellfield

In the 1970's and 80's, pumping in the Symmes-Shepherd Wellfield varied considerably (Figure 3.27). Under the Water Agreement, pumping was reduced. Approximately 1,200 ac-ft of pumping is required to supply one mitigation project (irrigated agriculture); however, pumping for aqueduct supply has increased since 2010, primarily in the northern part of the wellfield.

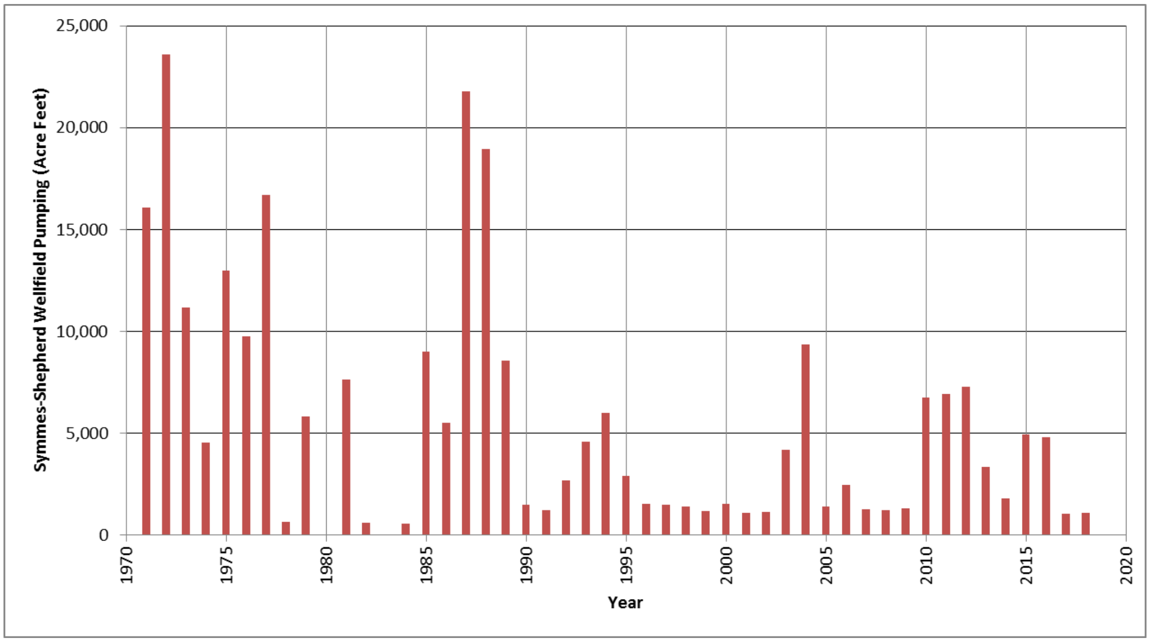

Figure 3.27. Pumping totals for the Symmes-Shepherd wellfield.

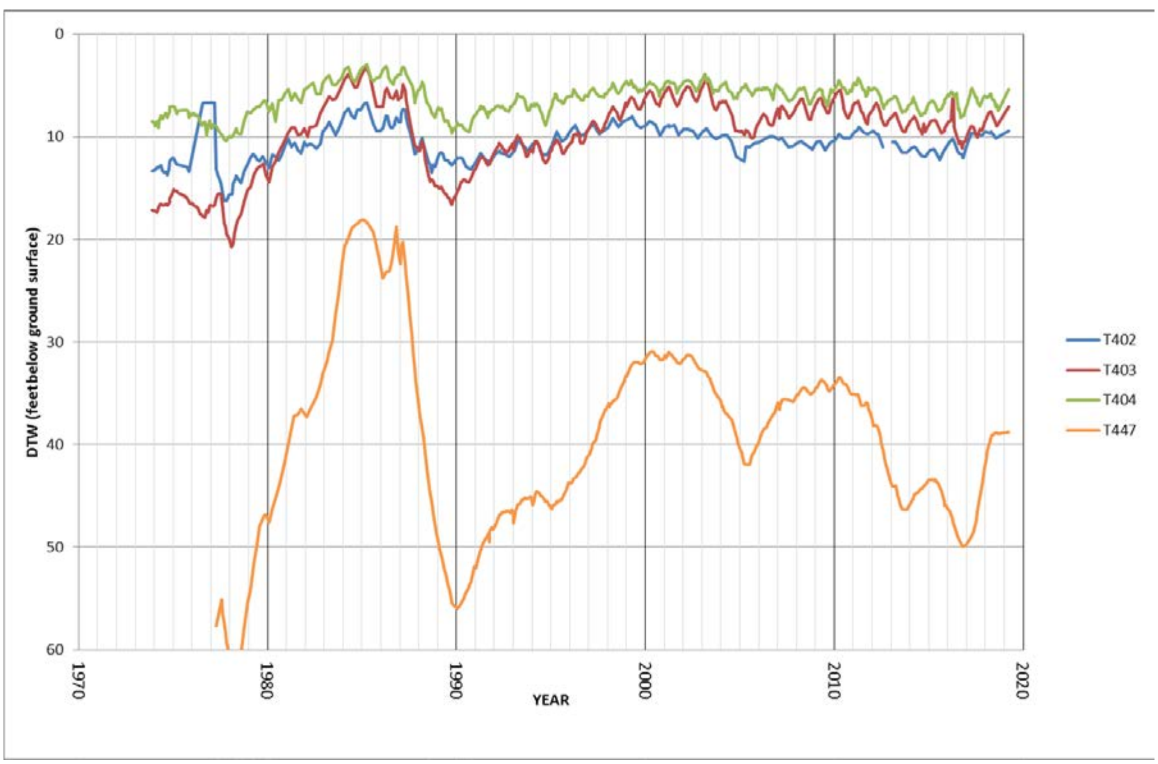

Figure 3.28 Hydrographs of indicator wells in the Symmes-Shepherd wellfield.

LADWP has only pumped the minimum amount of water for use on the irrigated field the past two years, and groundwater levels have risen in all seven on the indicators wells from 2018 to 2019 in a range of zero to 2.5 feet (Table 3.2). Some test wells are buffered to a degree by their proximity to the Los Angeles Aqueduct (T402-404 and T510-511), and groundwater levels are relatively stable (Figures 3.28 and 3.29). Test wells T447 and V009G are located near pumping wells in the northwestern portion of the wellfield and responded by rising dramatically (seven to nine feet) due to the reduction in pumping in 2017-18. Although groundwater levels have recovered somewhat, water levels in all monitoring wells continue to be below baseline in 2019 (Table 3.2).

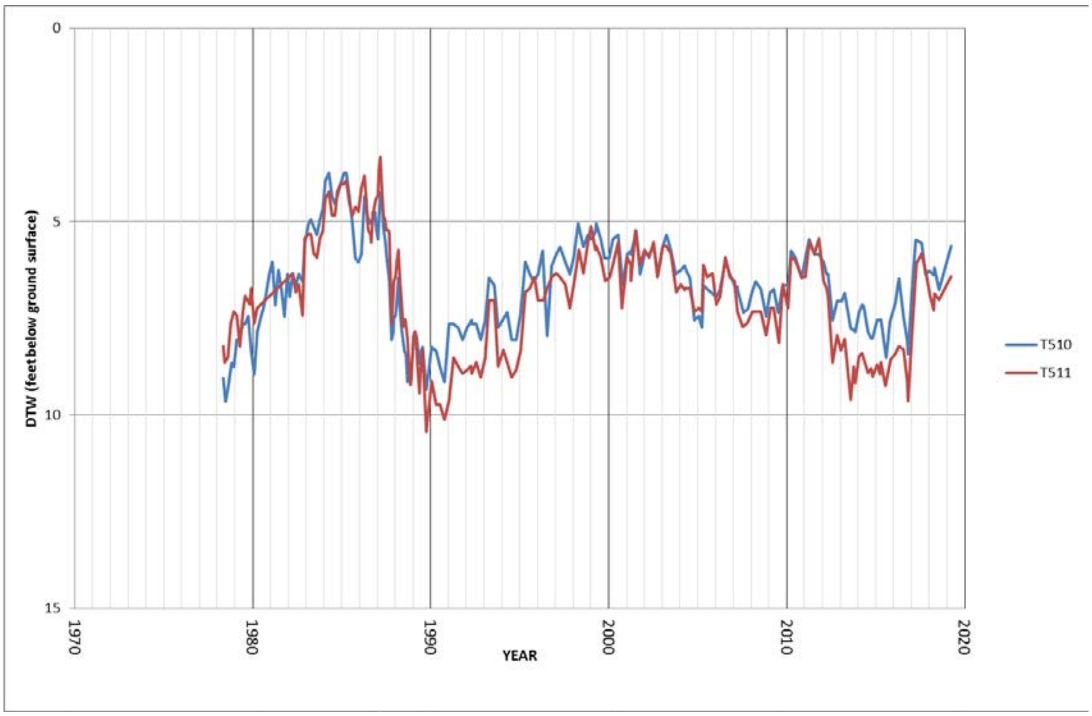

Figure 3.29 Hydrographs of indicator wells in the Symmes-Shepherd wellfield

Due to the declines in groundwater level caused by pumping in this wellfield combined with the recent drought, Inyo County monitoring wells at the Independence landfill were dry or within a few feet of becoming dry in spring 2017. Cessation of pumping in 2017 combined with recharge has allowed water levels to recover more than 15 feet in these wells; however, ICWD continues to be concerned with water levels in Symmes-Shepherd that are between one to 17 feet below baseline levels as of 2019.

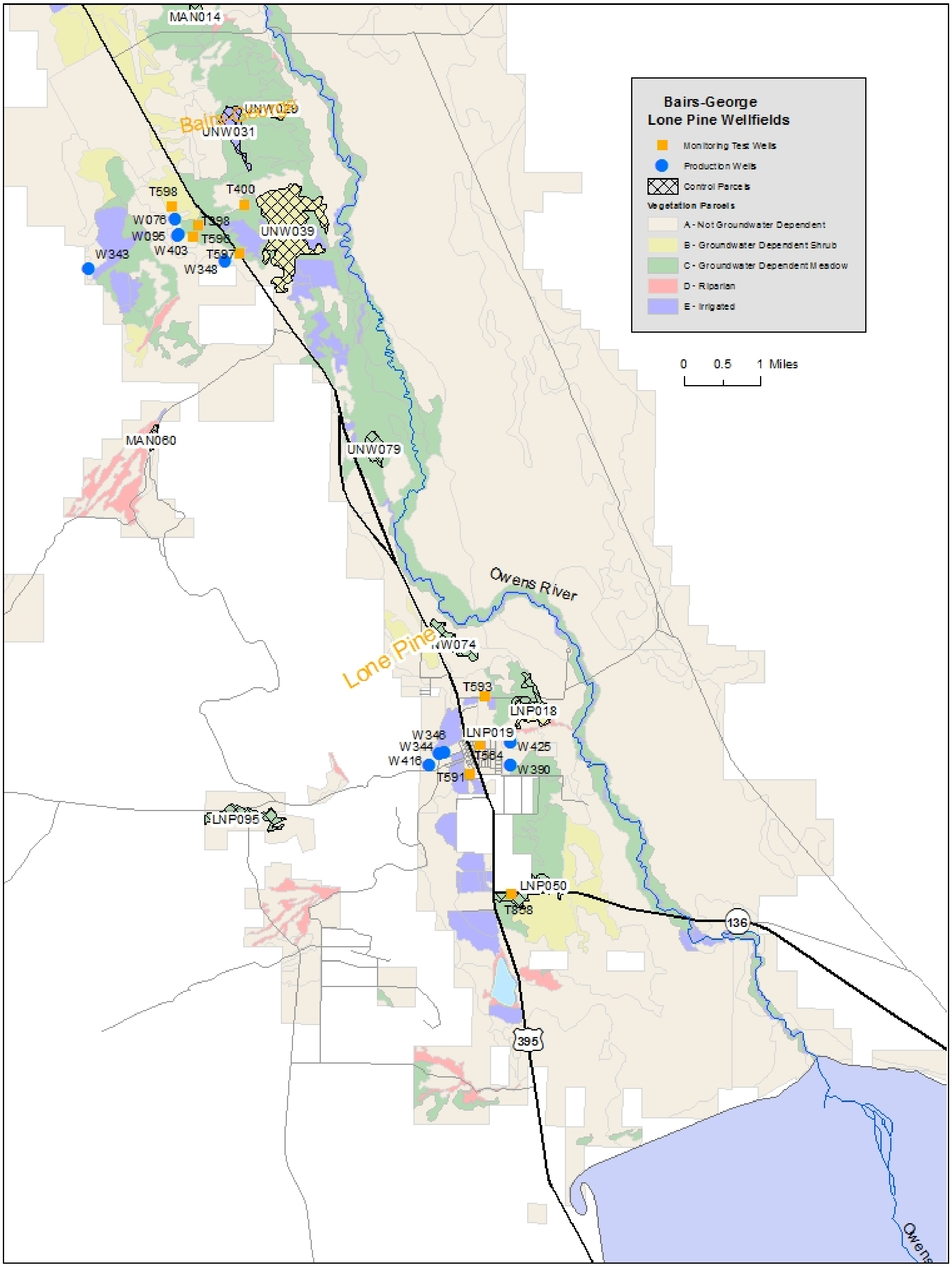

Figure 3.30. *Map of monitoring and LADWP production wells in the Bairs-George and Lone Pine wellfields.*

The Bairs-Georges Wellfield

In the 1970's and 80's, pumping and water levels in the Bairs-George wellfield (Figure 3.31) varied considerably, but under the Water Agreement, pumping has been reduced substantially. In dry years when surface flows decline, one well is exempt (W343) and can be operated to supply irrigated pastures. As in other wellfields, pumping for aqueduct supply increased in 2010-2016 compared with the small amounts during the five preceding years. Since the mid 1990's groundwater levels in the three indicator wells have been relatively stable. In 2018-2019, LADWP pumped approximately 2,280 ac-ft from the wellfield; the most pumping since 1989. Water levels in 2018-2019 declined by one to four feet. However, the three wells were all at or near baseline in 2019 (Table 3.2).

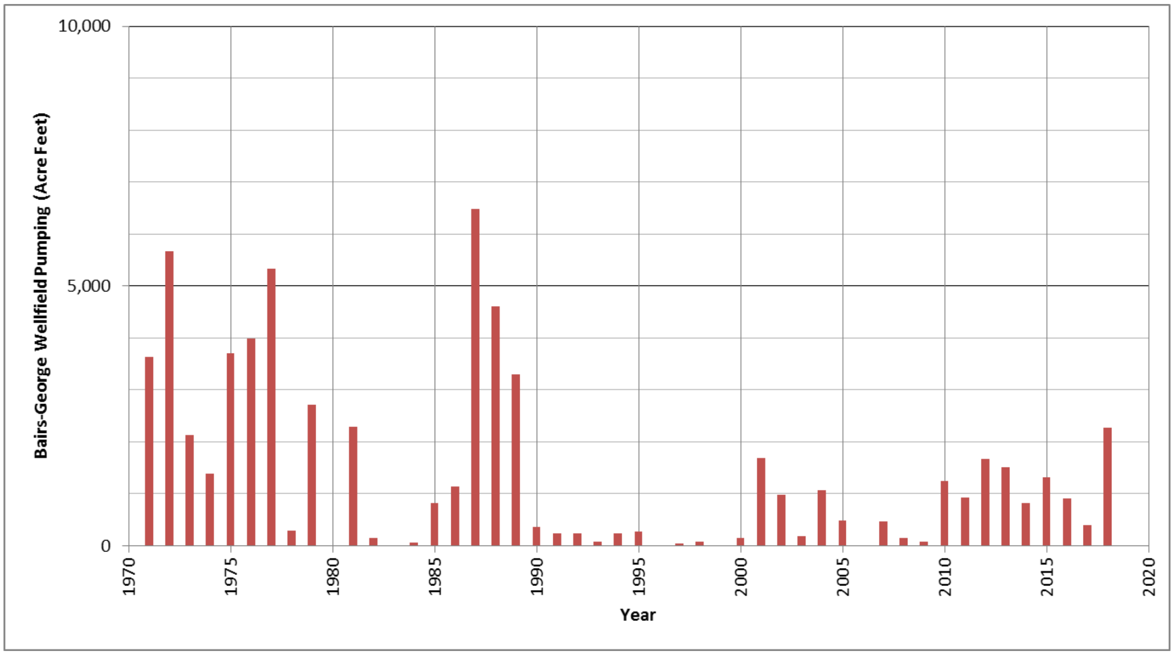

Figure 3.31. Pumping totals for the Bairs-Georges wellfield.

The pumping wells are located west of the Los Angeles Aqueduct. Monitoring wells T597 and T398 (Figure 3.32) are in the immediate vicinity of the aqueduct and well T400 is east of the aqueduct. Water table fluctuations in these wells are buffered by the infiltration from the aqueduct, though the effect of the increase in pumping since 2010 coupled with the 2012-2016 drought is plainly evident in T398 and T597. Pumping effects are less evident in T400. Monitoring wells T598 and T596 are located west of the aqueduct, and they exhibit larger fluctuations due to pumping (Figure 3.33).

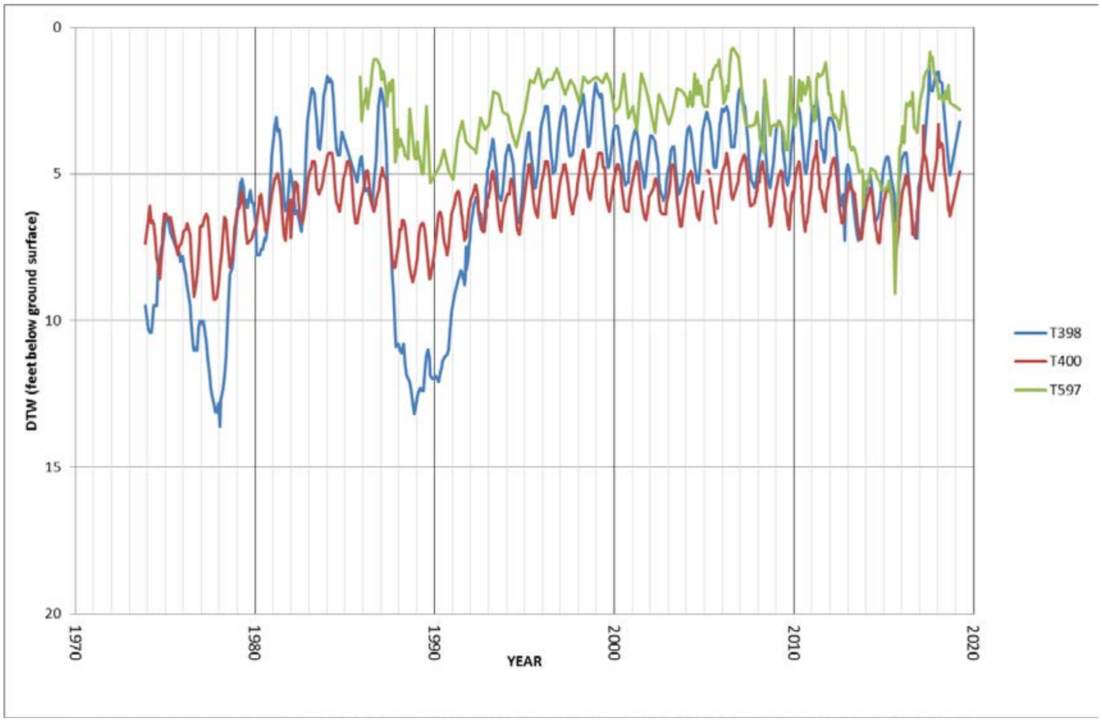

Figure 3.32. Hydrographs of indicator wells and 597T in the Bairs-Georges wellfield.

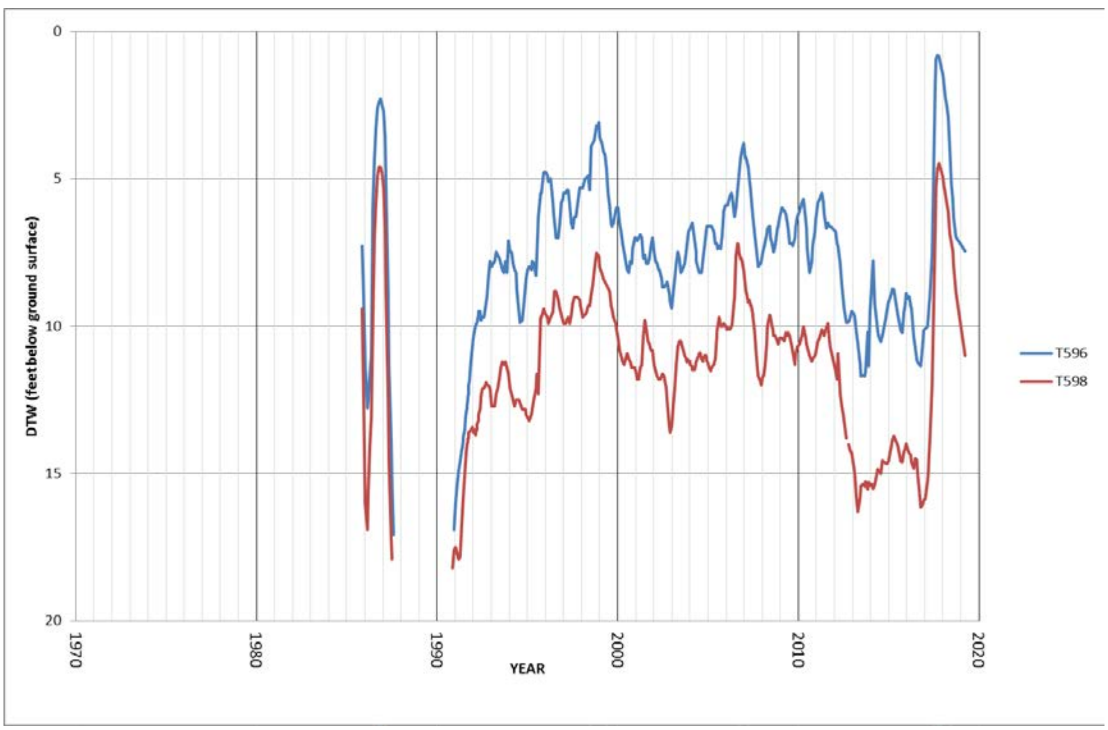

Figure 3.33. Hydrographs of selected wells in the Bairs-Georges wellfield.

The Lone Pine Wellfield

Most pumping in the Lone Pine Wellfield (Figure 3.30) has been to supply the town of Lone Pine and one mitigation project (approximately 1,300 ac-ft annually for irrigated agriculture). Pumping increased occasionally (e.g. in 2000) to offset aqueduct water previously supplied to Diaz Lake (Figure 3.34). In 2015, pumping also increased largely due to the operation of a new well to supply Van Norman field. The previous well (W390) degraded and production declined noticeably in 2008. The new well (W425) has capacity to fully supply the project. Because of the relatively constant pumping for sole-source uses, ICWD does not routinely use indicator wells to analyze the annual operations plan for this wellfield.

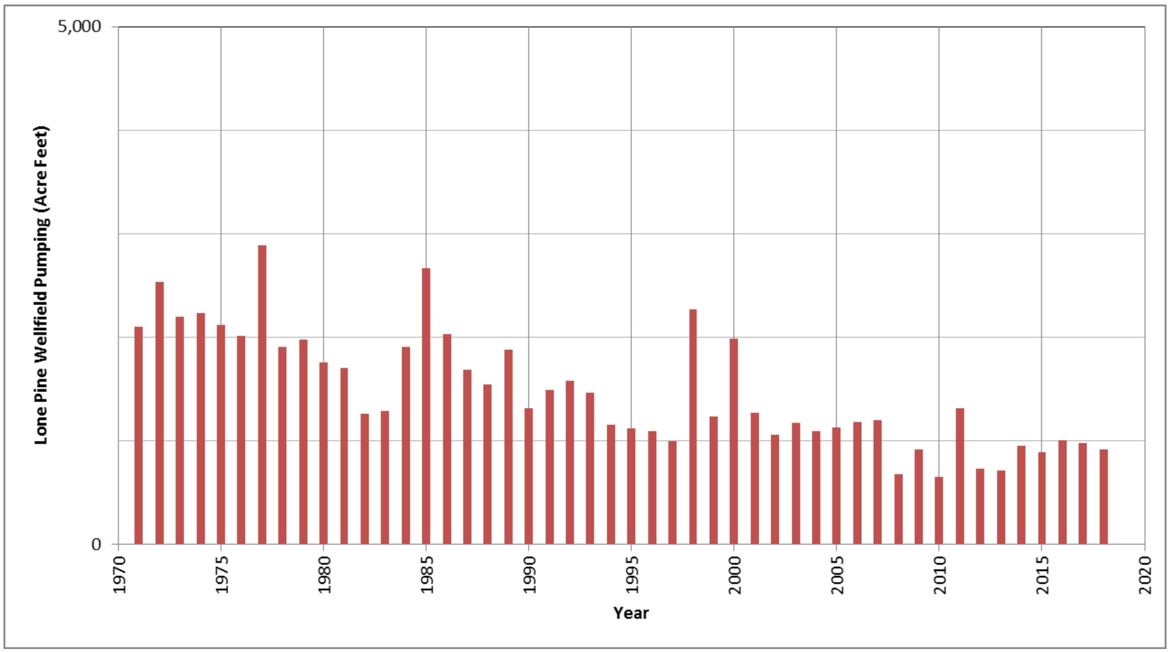

Figure 3.34. Pumping totals for the Lone Pine wellfield.

Hydrographs for test wells T564 and T591 are presented in Figure 3.35 to represent water levels near the town of Lone Pine where the LADWP pumping wells are located. Monitoring wells T593 and T858 are located in groundwater dependent vegetation north and south of Lone Pine, respectively. All wells exhibit seasonal fluctuations as well as water table response to decreased recharge due to drought. Pumping effects are not as evident. Water levels rose in 2017 due to heavy runoff. With less runoff and spreading in 2018, water levels declined.

In early 2010, LADWP tested a new production well, W416, installed to increase aqueduct supply. This new production well has been modified and initial tests to determine well capacity and performance have been completed. However, details of the operational monitoring have yet to be agreed upon by the Technical Group.

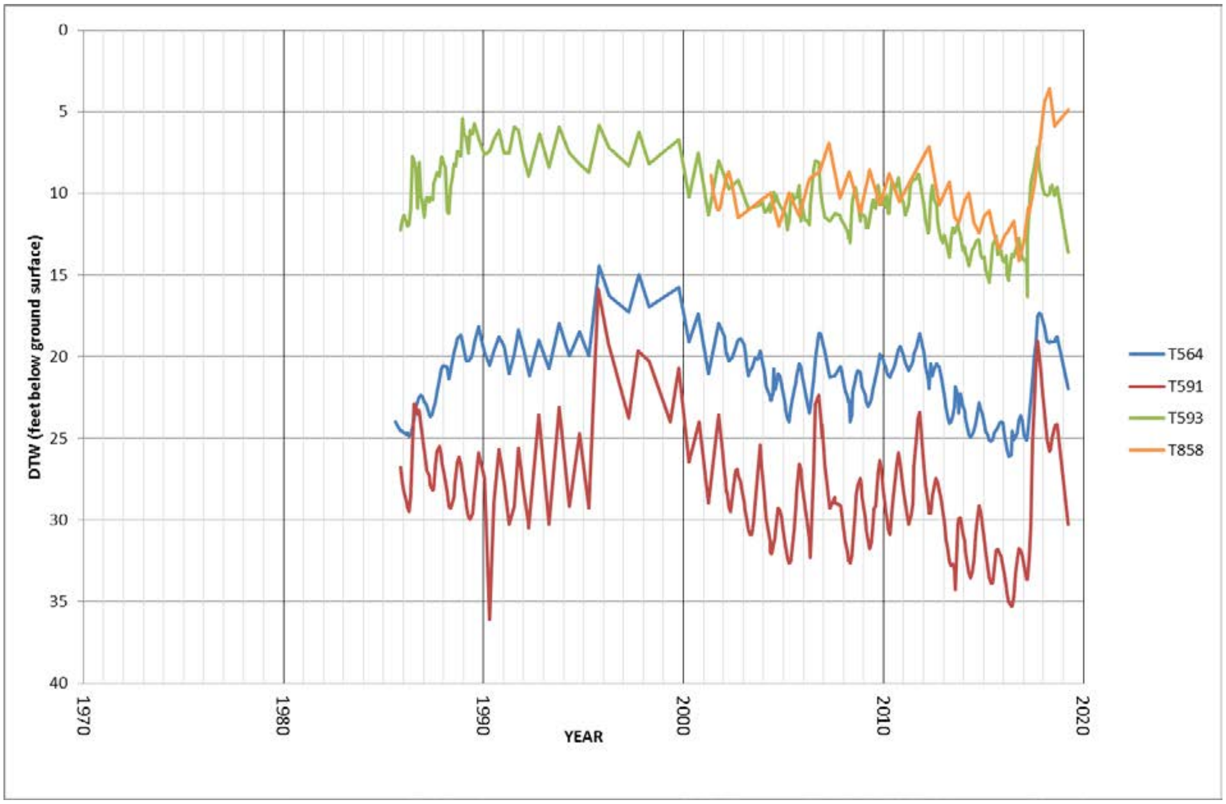

Figure 3.35. Hydrographs of selected test wells in the Lone Pine wellfield.

2019-20 Pumping Plan

LADWP issued its annual operations plan for the 2019-20 runoff year on April 19, 2019. The forecasted runoff for the Owens River watershed runoff is 554,000 ac-ft (137% of normal). LADWP provided a large range of planned pumping for the year between 50,330 and 73,710 ac-ft (Table 3.3). The majority of this pumping is for sole-source (in valley) uses; however, under LADWP's high pumping scenario a significant amount of pumping for export in planned (appx. 20,000 ac-ft).

Wellfield	Minimum Pumping	LADWP proposed (max)	Inyo Recommended
	Ac-ft/year	Ac-ft/year	Ac-ft/year
Laws	4,380	8,220	8,220
Bishop	6,120	11,280	11,280
Big Pine	21,000	22,910	21,000
Taboose-Aberdeen	2,580	8,820	7,750
Thibaut-Sawmill	8,000	9,160	9,160
Independence-Oak	6,420	8,880	6,420
Symmes-Shepherd	960	960	960
Bairs-George	0	2,610	500
Lone Pine	870	870	870
Sum	50,330	73,710	66,160

Table 3.3. Planned LADWP pumping by wellfield for 2019-20 and ICWD proposed pumping.

The Water Department analyzed the effect of the operations plan on groundwater levels in the Owens Valley using regression models for several monitoring wells (Table 3.4). Most models rely on measured depth to water in April 2019, planned wellfield pumping for the entire runoff year and Owens Valley runoff, to predict water levels next April. For several wells, Owens Valley runoff was not a statistically significant variable in the regression model. Water levels in those wells are correlated with pumping, and the models are still useful for evaluating the pumping plan. Also, models in Laws use the amount of water diverted from the Owens River into the McNally canals as the variable associated with recharge instead of runoff. Water spreading is planned for Laws in 2019-20 (Table 2.5 of the Draft Plan), so operation of the McNally Canals was assumed in the Laws regression models.

The models used by the Water Department to analyze the annual operations plan predict water levels one year in the future (e.g. April 2019 to 2020) based on annual pumping for each wellfield. Since LADWP began presenting a range of pumping amounts, the final annual pumping total has most often been just below the proposed upper limit.

Table 3.4. Predicted water level changes at indicator wells and monitoring sites for LADWP's proposed annual operations plan, for minimum pumping, and for pumping proposed by Inyo County. Negative DTW values denote a decline.

Station ID, Monitoring site	LADWP Proposed 73,710 ac-ft 2020 vs 2019	LADWP Proposed 73,710 ac-ft 2020 vs Baseline	LADWP Minimum 50,330 ac-ft 2020 vs 2019	LADWP Minimum 50,330 ac-ft 2020 vs Baseline	ICWD Recomended 66,160 ac-ft 2020 vs 2019	ICWD Recomended 66,160 ac-ft 2020 vs Baseline
	(DTW change ft)	(DTW change ft)	(DTW change ft)	(DTW change ft)	(DTW change ft)	(DTW change ft)
Laws						
107T	3.69	-0.19	4.97	1.09	3.69	-0.19
434T	0.38	1.17	0.93	1.72	0.38	1.17
436T	0.98	1.57	1.53	2.12	0.98	1.57
438T	1.07	0.32	1.53	0.78	1.07	0.32
490T	0.80	3.07	1.04	3.31	0.80	3.07
492T	1.70	5.78	3.75	7.83	1.70	5.78
795T	-4.00	-0.27	-2.18	1.55	-4.00	-0.27
V001g	3.50	4.20	4.56	5.26	3.50	4.20
574T	0.19	1.27	0.76	1.85	0.19	1.27
Big Pine						
425T	1.17	-1.20	1.50	-0.87	1.50	-0.87
426T	0.79	-1.07	0.98	-0.88	0.98	-0.88
469T	0.28	-0.11	0.46	0.07	0.46	0.07
572T	1.11	1.62	1.47	1.98	1.47	1.98
798T, BP1	0.02	1.43	0.33	1.74	0.34	1.74
799T, BP2	0.49	-0.10	0.66	0.06	0.66	0.06
567T, BP3	1.16	-0.97	1.46	-0.68	1.46	-0.68
800T, BP4	0.70	-1.32	1.09	-0.93	1.09	-0.93
Taboose Aberdeen						
417T	-0.32	0.76	1.31	2.40	-0.04	1.04
418T	0.28	0.84	1.00	1.54	0.40	0.96
419T, TA1	-0.07	1.69	1.61	3.38	0.22	1.98
421T	0.61	-0.30	2.31	1.41	0.90	-0.01
502T	0.82	-1.72	1.60	-0.94	0.95	-1.58
504T	-0.27	1.47	1.82	3.56	0.09	1.83
505T	-0.21	0.67	1.45	2.33	0.07	0.95
586T, TA4	-0.38	1.32	1.01	2.71	-0.14	1.56
801T, TA5	-0.12	-0.85	0.26	-0.46	-0.05	-0.78
803T, TA6	-0.58	0.72	0.97	2.27	-0.31	0.99
Thibaut Sawmill						
415T	1.85	9.53	2.74	10.42	1.85	9.53
507T	0.07	1.26	0.26	1.45	0.07	1.26
806T, TS2	1.29	5.36	1.52	5.59	1.29	5.36
Ind. Oak						
406T	0.53	-3.40	0.70	-3.23	0.70	-3.23
407T	-0.39	-5.67	0.45	-4.83	0.45	-4.83
408T	-0.25	-2.59	0.30	-2.03	0.30	-2.03
409T	0.71	-8.12	2.42	-6.41	2.42	-6.41
546T	-0.34	-2.16	0.02	-1.80	0.02	-1.80
809T, IO1	1.29	-4.35	2.14	-3.50	2.14	-3.50
Symmes Shep.						
402T	0.64	-1.46	0.64	-1.46	0.64	-1.46
403T	1.27	-1.09	1.27	-1.09	1.27	-1.09
404T	0.44	-1.78	0.44	-1.78	0.44	-1.78
447T	4.51	-12.88	4.51	-12.88	4.51	-12.88
510T	0.28	-1.15	0.28	-1.15	0.28	-1.15
511T	0.35	-2.12	0.35	-2.12	0.35	-2.12
V009G, SS1	2.97	-11.13	2.97	-11.13	2.97	-11.13
Bairs George						
398T	-2.88	-1.35	0.67	2.20	-0.01	1.52
400T	-0.44	-0.46	0.22	0.20	0.09	0.07
812T	-1.31	-2.51	1.78	0.57	1.19	-0.02

†: Values in this table are significant to 0.1 ft. Extra digits are presented for rounding transparency.

Three pumping scenarios are presented in Table 3.4: minimum pumping, the upper limit of pumping proposed in the Draft Plan, and ICWD's recommended pumping. The analysis of water level changes if minimum pumping were conducted for specific uses in the Owens Valley is included as a basis for comparison with the higher levels of pumping in LADWP's proposed and Inyo County's recommended pumping amounts. Minimum pumping is not a constant and varies depending on runoff availability to supply irrigation or mitigation projects with surface water instead of groundwater where possible. This year LADWP's minimum pumping amount of 50,330 ac-ft was similar to ICWD's minimum estimate and was, therefore, used to analyze the lower pumping amount.

The upper limit of the pumping proposed in the Draft Plan is used to evaluate LADWP's proposed pumping because (1) it represents the maximum impact on the water table that the Draft Plan could have, and (2) except in high runoff conditions, LADWP has generally pumped near the upper end of the proposed range.

ICWD's analysis of the Draft Plan and recommendations for pumping are based on the goals and principles of the Water Agreement, the status of individual pumping wells according to Green Book soil water triggers, groundwater dependent vegetation conditions monitored by the Technical Group, water table conditions in each well field, and groundwater uses within each wellfield. ICWD recommends 66,160 ac-ft of pumping for 2019-20.

Average groundwater levels are expected to rise in all wellfields except Taboose-Aberdeen and Bairs-Georges under LADWP's 2019-20 maximum proposed pumping (Table 3.4). The average groundwater level change in the 46 indicator wells is predicted to be a rise of 0.5 ft under maximum pumping scenario, 1.3 ft with minimum pumping, and 0.9 ft with the ICWD recommended pumping amount. By April 2020, under LADWP's maximum pumping scenario, average predicted water levels will be at or within 3" inches of baseline in all well fields except Independence, Symmes-Shepherd and Bairs-Georges. Average water levels are predicted to be more than 4 feet below baseline in Independence-Oak and Symmes Shepherd, and within 1.5 ft of baseline in Bairs-Georges.

Concerns and recommendations to LADWP's proposed 2019-20 pumping plan were made by Inyo County in the Water Department's April 29, 2019 letter to LADWP. A summary of these comments are presented as follows.

The extraordinarily high amount of the 2017-2018 runoff-year promoted substantial rise in the water table in most areas of the Owens Valley; however, some areas remain below the water levels that prevailed during the mid-1980s when the baseline vegetation mapping was done. ICWD's analysis and recommendations are based on water table conditions in each well field relative to baseline water levels, groundwater uses within each wellfield, and groundwater dependent vegetation conditions.

Although 2017 was an exceptional year for runoff and 2018 runoff was nearly average, these two years come on the heels of an exceptional drought with runoff values below 60% for four consecutive years. The negative effects of this drought on vegetation were evident in 2016 perennial cover values. Increased cover was noted in most parcels in 2017; however, in 2018 perennial cover and grass cover remained below baseline in many vegetation parcels across the valley, notably in Laws. Maintaining a shallow water table in areas of groundwater-dependent vegetation in 2019 is necessary to encourage further recovery to baseline values, especially given the feast-or-famine pattern of precipitation observed during the past 30 years. Shallow groundwater levels are particularly important to maintain perennial grasses which have seen more substantial declines than overall cover. Preventing conversion of meadows to shrub communities is one of the components of the LTWA.

In 2018, LADWP pumped approximately 85,000 ac-ft of groundwater and water levels across the valley fell by about 1 foot. The upper range of pumping in the Draft Plan (Table 3.3) would be near the average pumping since the implementation of the LTWA.

ICWD's recommend pumping amount is a more prudent recommendation which allows the multiple goals of the Water Agreement to be met with a more responsible and sustainable approach: a significant amount of groundwater would be pumped for use in Owens Valley and export to Los Angeles, while maintaining hydrologic conditions conducive to vegetation recovery.

ICWD has expressed concerns to LADWP about pumping and water level declines in three wellfields during the recent drought: southern Big Pine, Independence-Oak, and Symmes-Shepherd. Pumping for aqueduct supply has been concentrated from exempt and On-status wells located in these wellfields. Groundwater levels in several wells in Independence-Oak and Symmes-Shepherd wellfields are predicted to remain several feet below baseline. In addition, the groundwater mining limit calculation for the Big Pine wellfield shows a relatively small amount of recharge in excess of pumping over the past 20 year period. ICWD recommended that pumping in these wellfields and Bairs-Georges be limited to sole source uses to allow for maximum water level recovery in this above-average runoff year.

The Water Department's comment letter can be found on the inyowater.org website.

Evaluation of 2018 DTW predictions

As noted in the previous sub-section, ICWD routinely uses linear regression models to predict the effects of pumping on DTW as part of its analysis of LADWP's annual operations plans. Periodically, ICWD staff examines the accuracy of these models by comparing the predictions with DTW measurements collected the following year on April 1. The regression models were constructed from historical data for wellfield pumping, Owens Valley runoff, and current water levels. The models in Laws rely on an estimate of the diversions into the McNally canals instead of Owens Valley runoff as the variable related to groundwater recharge. For four of the permanent monitoring sites, a second model was used that relies on predicted DTW in a nearby indicator well that responds similarly to pumping and runoff. The models were originally developed by Harrington (1998) and Steinwand and Harrington (2003). These reports are available on the Water Department website.

This analysis of the predictions includes uncertainty in the input variables (runoff forecast and planned pumping) as well as uncertainty in the models. Model uncertainty includes all management actions and environmental conditions not captured in the regression model e.g. atypical recharge or pumping operations near one of the test wells. Predictions for 46 indicator wells made in April 2018 were compared to actual 2019 DTWs for this report.

The predicted DTW values were based on the higher pumping amount planned by LADWP in their 2018-19 pumping plan (96,230 ac-ft). Actual pumping was approximately 88% (84,821 ac-ft) of the planned amount (Table 3.1). Wellfield pumping totals for the year differed by as much as 3,600 acre feet of the planned amounts in wellfields with indicator wells. The discrepancies in planned and actual pumping decrease the accuracy of predictions. The model predictions also rely on forecasted Owens Valley runoff and unavoidably include the uncertainty in that prediction. The LADWP runoff forecast has tracked actual runoff with accuracy since 1994, and therefore that contribution to model uncertainty is small.

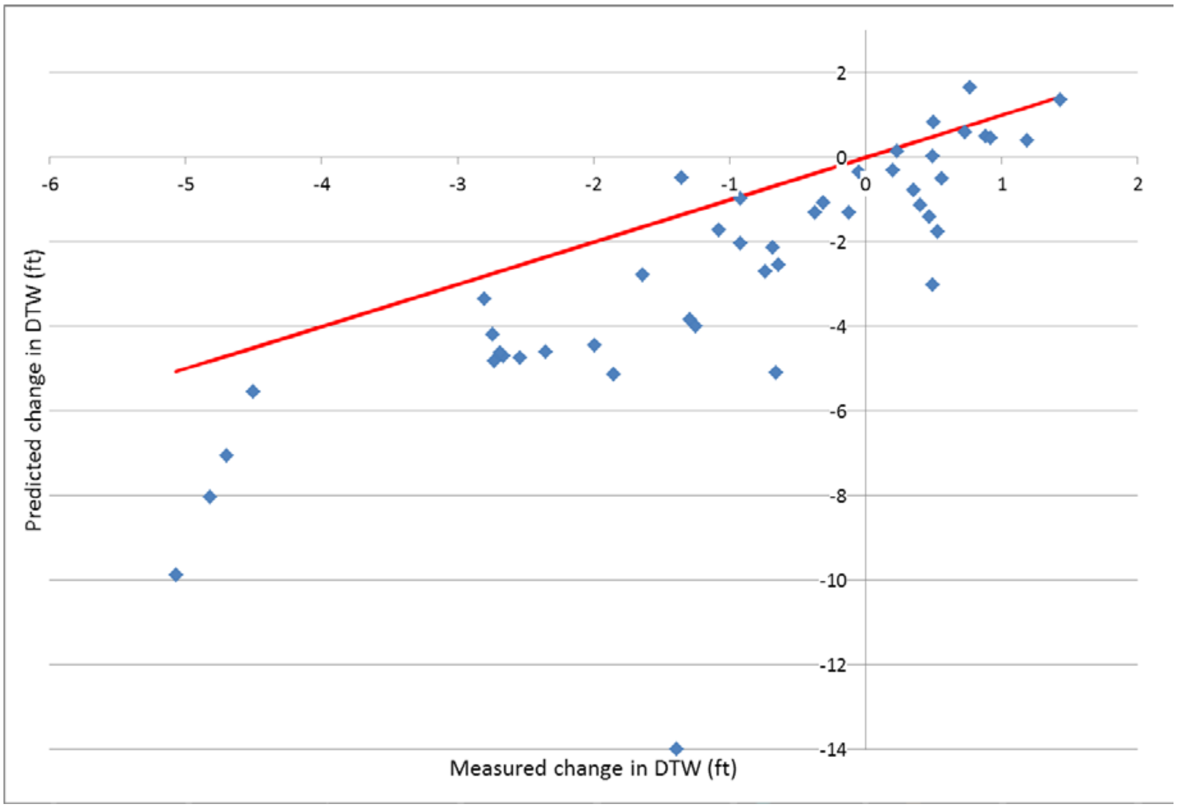

Figure 3.36. Measured and predicted change in DTW from April 2018 to April 2019 for 46 indicator wells. The sold line is the 1:1 line. Negative values denote decline in water level.

The forecasted 2018-19 runoff was below average (78%) but well within the standard range of common runoff amounts. However, the 96,230 ac-ft of planned LADWP pumping was at the upper edge of pumping for the past 25 years. Model performance in 2018-19 was less accurate than previous years due to a combination of less pumping than planned, more surface water spreading in the McNally canals, and greater runoff than predicted.

Measured versus predicted change in DTW are plotted in Figure 3.36. If the models were perfect predictors, the points would fall on the 1:1 line between the lower left and upper right quadrants. Of the 46 wells, actual and predicted DTW in 17 wells differed by less than 1 foot, and a total of 25 wells differed by less than 1.5 feet. The average of the actual deviation for all monitoring wells was 1.8 ft.

Five wells in Laws, three in Taboose-Aberdeen and one in Bairs-Georges had notable deviations. At these nine wells, the models over-predicted drawdown by 2.5 to 12.6 feet. In these nine cases, the actual water level decline was much less than predicted due to several factors. In Laws, due to the below-normal forecasted runoff for the 2018-19, the wellfield model predictions assumed that LADWP would not run the McNally canals. However, heavy snowfall in early 2019 prompted LADWP to run surface water in the McNallys, leading to increased infiltration and, therefore, less water table decline than predicted. Also, the actual pumping in the wellfield was about 90% of the planned amount. In both Taboose-Aberdeen and Bairs Georges, actual pumping was only 80% of the planned amount. This also led to less actual drawdown than predicted.

Although, model predictions were less accurate than past years, the principal sources of error in the 2018 predictions lie with reduced actual pumping and increased surface water spreading but not with the regression models themselves. For confirmation purposes, the 2018 models were re-run with actual runoff, McNally spreading, and pumping values. The models performance was good, with the average difference between predicted and modeled DTWs approximately 1.0 feet, and 31 of 46 models having an absolute difference of less than 1.5 feet from predicted.

References

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