2011-12 Inyo County Water Department Annual Report: Pumping Management and Groundwater Conditions

Annual Pumping Plans

LADWP prepares an operations plan each April for the twelve month runoff year beginning April 1 in accordance with the Water Agreement. The plan includes projected amounts for runoff, pumping, reservoir storage, water used in the Owens Valley, and water exported to Los Angeles. Also, the plan must comply with the pumping well On/Off provisions of the Agreement based on soil water and vegetation measurements. Inyo County reviews the proposed operations plan which usually includes performing an analysis of the effects of LADWP operations on groundwater levels in the Valley. Following a Technical Group meeting to resolve concerns raised by the County, LADWP finalizes the plan.

2011-12 Pumping Plan

Total pumping within the Owens Valley for 2011-12 was 91,728 acre-feet (ac-ft), which was slightly greater than the 91,000 ac-ft planned (Table 1). Pumping amounts for each wellfield are provided in Table 1. In most wellfields, actual pumping was within approximately 200 ac-ft of the anticipated amount. Notable deviations from the plan include Bishop (+2075 ac-ft), Independence-Oak (-1815 ac-ft), and Lone Pine (+351 ac-ft) wellfields. Positive values denote more pumping than planned. Runoff from the Owens River watershed during the 2011-12 was forecast to be 616,900 ac-ft or 150% of normal (the average during the 50 year period, 1961-2010). It was the second consecutive year of above normal runoff. The actual runoff value will be available later in 2012 when the all the surface water measurements have been are tabulated. The effect of pumping and runoff in 2011-12 on water levels in several test wells is discussed below.

The Water Agreement and Green Book include procedures to calculate groundwater mining to ensure no long term decline in aquifer storage has occurred. The mining calculation is a comparison of pumping and recharge for each wellfield on a water year basis (October 2010 through September 2011). The estimate of groundwater recharge in the Owens Valley from the mining calculations was approximately 208,139 ac-ft compared to 82,614 ac-ft of pumping for the 2011 water-year, and no wellfield was in violation of the groundwater mining provision.

Table 1. LADWP actual pumping by wellfield for the 2011-12 runoff-year and planned pumping for the 2012-13 runoff-year.

Wellfield	2011-12 Actual Pumping (ac-ft)	2012-13 Planned Pumping (ac-ft)
Laws	10,158	7,400
Bishop	10,475	12,000
Big Pine	28,654	21,400-28,400
Taboose-Aberdeen	10,027	2,550-12,600
Thibaut-Sawmill	14,064	12,000-13,200
Independence-Oak	9,175	7,200-9,800
Symmes-Shepherd	6,935	1,750-7,000
Bairs-Georges	929	500-1,800
Lone Pine	1,311	800
Total	91,728	65,600-93,000

Evaluation of 2011 Indicator Well Predictions

The Water Department routinely uses linear regression models to predict the effects of pumping on depth to water table (DTW) as part of its analysis of LADWP's annual operations plans. Periodically, we examine the accuracy of our models by comparing the predictions with 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. For twelve permanent monitoring sites, a second model is 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) and have been updated annually. These reports are available on the Water Department website. The set of test wells for which predictions were made in 2011 included 46 wells in 2011 (Table 2).

In most years DWP's projected and actual pumping are similar, and this source of uncertainty in the predictions is small. It would be appropriate to include it in the assessment of overall accuracy of our evaluation of LADWP pumping. After the 2011-12 pumping plan was finalized, however, pumping was revised in several wellfields in response to Inyo County's objections over the plan. Simply comparing 2011 predictions with the DTW measured in 2012 would include both management changes and model uncertainty and would not be an informative examination of model performance. For this analysis, the 2011 predictions were recalculated using the same models, runoff forecast, and initial DTW conditions available in April 2011, but actual pumping in the 2011-12 runoff year was simulated instead of the amount proposed by LADWP. 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. The 2011-12 predictions were based on LADWP's projected amount of spreading in Laws included in their 2011 annual report. LADWP released approximately 11,000 ac-ft less than projected in our original analysis. The 2011 model predictions were recalculated using the actual value of 5,465 ac-ft for comparison with the original predictions and measured DTW.

Overall, the models performed well in 2011-12. The average deviation (absolute value) for all 46 wells was 1.24 ft (Table 2). For 27 test wells, the actual and predicted values differed by less than 1 foot, and for 38 comparisons the values differed by less than 2 feet. As mentioned previously, for fourteen monitoring sites, two regression models were used sequentially to predict DTW which introduced an additional source of uncertainty in predictions for those wells. The average deviation for the monitoring sites (14 test wells) and indicator wells (32 test wells) were comparable, 1.21 ft and 1.25 ft. Given the similar accuracy of the two sets of wells, relying on the paired regressions was not a large source of error.

The average deviation (actual value) for all wells was slightly negative (-0.77 ft) suggesting a slight tendency in 2011 to predict larger increases or smaller declines than were observed. The input data for this analysis included actual pumping and measured DTW, both of which contribute negligible error. The largest remaining sources of uncertainty are the runoff estimate and model error. Model error lumps 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). If the actual runoff was less than forecasted, the average difference would be negative as observed. Unfortunately, actual runoff values are not available until later in 2012, but generally, LADWP runoff forecasts are accurate (±28,106 ac-ft) or underestimate actual runoff in wet years (Figure 2). Forecasted runoff in 2011-12 was much above normal, and the systematic error evident in Figure 2 would not account for the small negative deviation.

Table 2. Predicted and measured change in DTW for 2011-12. A negative value indicates a water table decline; negative deviation from baseline indicates the water table is below baseline.

Wellfield and test well	Predicted change, (McNally=16.5K)	Predicted change, (McNally =5.4K)	Measured change	Absolute deviation
	(ft)	(ft)	(ft)	(ft)
Laws				
107T	3.06	0.16	-0.22	0.38
436T	0.96	-0.53	-0.46	0.07
438T	0.39	-1.24	-0.77	0.47
490T	0.68	-0.58	2.36	2.94
492T	0.57	-2.12	-0.80	1.32
795T, LW1	1.87	-0.77	-0.03	0.74
V001G, LW2	2.23	-0.09	-0.85	0.76
574T, LW3	1.81	0.76	0.36	0.4
Big Pine				
425T		0.93	-1.03	1.96
426T		0.64	-0.37	1.01
469T		0.30	-0.34	0.64
572T		1.94	0.22	1.72
798T, BP1		0.61	0.20	0.41
799T, BP2		0.15	-0.34	0.49
567T, BP3		1.37	-1.23	2.6
800T, BP4		1.13	-1.22	2.35
Taboose-Aberdeen				
417T		1.37	0.5	0.87
418T		0.60	0.79	0.19
419T		0.98	0.41	0.57
421T		1.02	-0.75	1.77
502T		0.86	-1.25	2.11
504T		0.55	0.24	0.31
505T		1.33	0.47	0.86
586T, TA4		0.13	-0.18	0.31
801T, TA5		-0.50	-1.97	1.47
803T, TA6		1.52	0.77	0.75
Thibaut-Sawmill				
415T		2.50	0.84	1.66
507T		-0.34	-0.01	0.33
806T, TS2		0.03	0.63	0.6
Independence-Oak				
406T		-0.04	1.33	1.37
407T		-0.44	-2.12	1.68
408T		-0.42	-2.37	1.95
409T		1.10	-4.51	5.61

Wellfield and test well	Predicted change, (McNally=16.5K)	Predicted change, (McNally =5.4K)	Measured change	Absolute deviation
546T		-0.19	0.21	0.4
809T, IO1		-0.77	1.00	1.77
Symmes-Shepherd				
402T		0.10	-0.39	0.49
403T		-0.58	-0.09	0.49
404T		-0.24	-0.90	0.66
447T		0.85	-2.97	3.82
510T		-0.21	-0.78	0.57
511T		-0.42	-1.05	0.63
V009G, SS1		-0.29	-2.97	2.75
646T, SS2		1.36	-2.39	3.75
Bairs-George				
398T		-0.43	-0.91	0.48
400T		-0.27	-0.30	0.03

Measured and predicted change in DTW were compared to examine if systematic trends were present in the model results (Figure 1). If the models were perfect predictors, the points in Figure 1 would fall on a 1:1 line between the lower left and upper right quadrants. Most of the points fall into these quadrants (28 of 46) indicating that the direction of water table change (rise or fall) was predicted correctly for the majority of wells. Of the remaining 18 wells, 14 fell into the upper left quadrant indicating a propensity to predict water table increases that did not occur. Most of the these 14 wells were located in the Symmes-Shepherd and southern portion of the Big Pine wellfields. It is likely that the cool spring in 2011 allowed aqueduct operations to accommodate the peak runoff without spreading as much water in wellfields as in previous years that had similar runoff.

Model predictions for Laws would have been substantially in error due to the inability to accurately forecast McNally spreading operations (compare columns 1 and 3 in Table 2). When the actual values for the input variables were modeled, however, the predictions agreed with the measured DTW values. For Laws, both the pumping and recharge amounts are managed quantities, and accurate input values are essential for accurate evaluations of the annual operations plan. These results are not evidence that revisions to the Laws models are necessary.

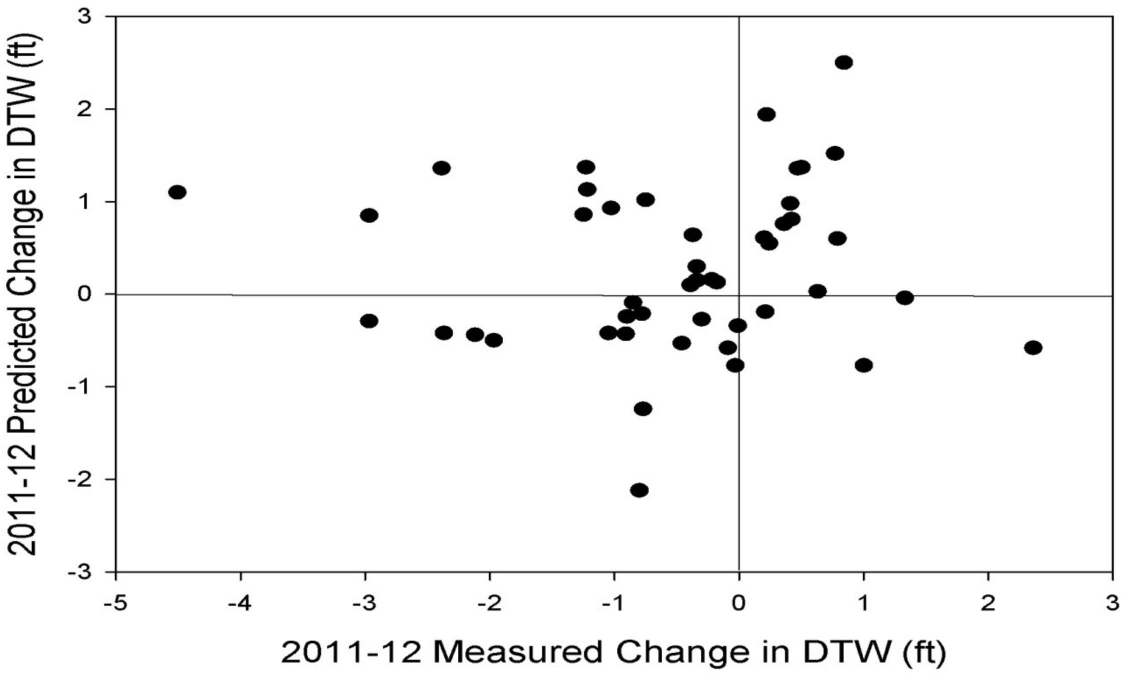


Figure 1. Measured and predicted change in DTW from April 2011 to April 2012. Negative values denote a decline in water level.

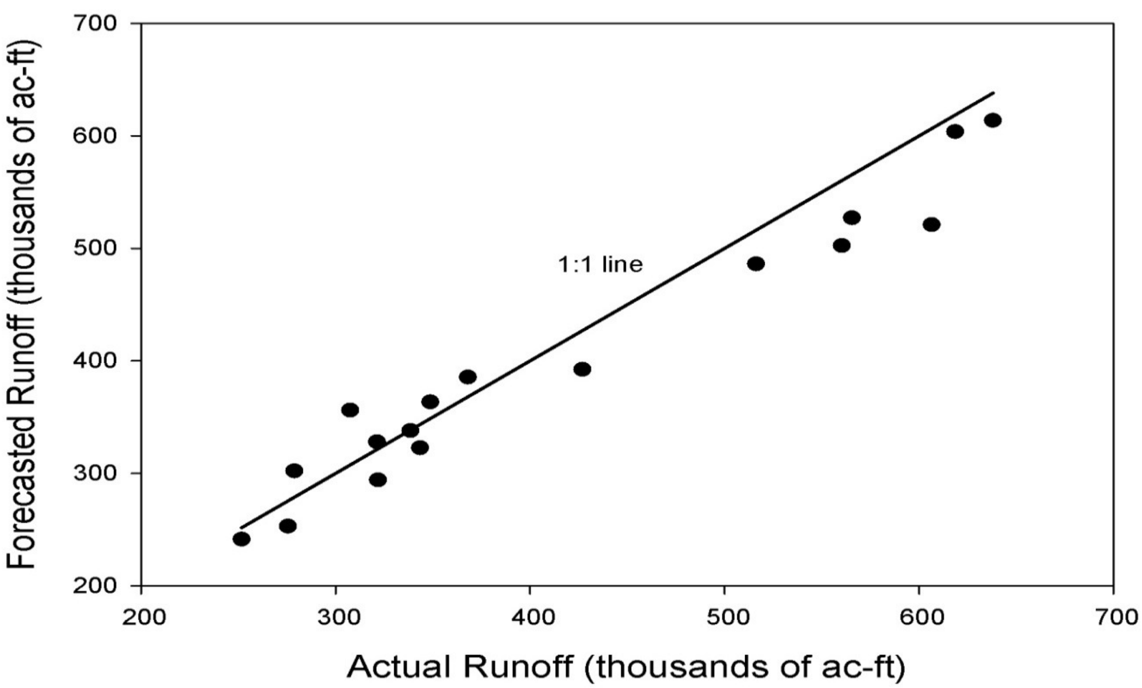


Figure 2. Comparison of actual and forecasted runoff since 1994. During this period, LADWP has revised the method to forecast runoff, but there was no discernible trend (better or worse) in the accuracy of the forecasts over time.

Table 3. Predicted water level changes at indicator wells and monitoring sites for LADWP's final annual operations plan for 2012-13. Negative DTW values denote a decline.

Station ID, Monitoring Site	2012-13 Predicted Change in DTW, Maximum Pumping†	2012-13 Predicted Change in DTW, Minimum Pumping††	2013 Predicted dev. From Baseline, Maximum Pumping
	(ft)	(ft)	(ft)
Laws			
107T	-0.04	-0.04	-8.47
436T	-0.65	-0.65	-3.80
438T	-1.36	-1.36	-4.40
490T	-1.60	-1.60	-1.02
492T	-1.87	-1.87	-3.24
795T, LW1	-1.06	-1.06	-10.34
V001G, LW2	-1.02	-1.02	-6.34
574T	1.24	1.24	-0.73
Big Pine			
425T	-1.91	-0.79	-5.62
426T	-1.27	-0.62	-3.41
469T	-0.95	-0.26	-2.56
572T	-1.61	-0.32	-3.30
798T, BP1	-2.50	-1.42	-2.76
800T, BP4	-1.23	-0.20	-5.11
567T, BP3	-2.06	-1.14	-5.96
799T, BP2	-1.15	-0.44	-2.65
Taboose-Aberdeen			
417T	-2.33	0.07	-6.48
418T	-1.03	0.07	-1.73
419T, TA1	-2.48	0.16	-3.31
421T	-2.56	0.11	-4.49
502T	-1.10	0.13	-4.08
504T	-3.10	0.18	-3.48
505T	-2.27	0.20	-6.49
803T, TA6	-2.31	0.09	-6.48
586T, TA4	-1.83	0.39	-2.41
801T, TA5	-0.16	0.45	-0.55
Thibaut-Sawmill			
415T	-1.16	-0.43	-3.61
507T	-0.26	-0.06	-0.44
806T, TS2	-1.93	-1.55	-1.88
Independence- Oak			
406T	-0.68	-0.37	-1.15
407T	-0.69	0.17	-5.32
408T	-0.43	0.15	-2.40

Station ID, Monitoring Site	2012-13 Predicted Change in DTW, Maximum Pumping†	2012-13 Predicted Change in DTW, Minimum Pumping††	2013 Predicted dev. From Baseline, Maximum Pumping
409T	-2.28	-0.55	-9.46
546T	-1.96	-1.54	-4.01
809T, IO1	-4.15	-3.48	-6.46
Symmes- Shepherd			
402T	-0.69	-0.10	-3.02
403T	-1.41	0.26	-3.40
404T	-0.23	0.39	-2.41
510T	-0.22	0.37	-2.28
511T	-0.28	0.35	-3.04
447T	-3.21	0.54	-20.06
646T, SS2	-1.72	1.22	-15.74
V009G, SS1	-3.36	-0.07	-17.05
Bairs George			
398T	-1.90	-0.23	-0.57
400T	-0.43	-0.11	-0.02

†: Values in this table are only significant to 0.1 ft. Extra digits are presented for transparency before rounding.
††: Minimum pumping contained in the final LADWP operations plan (Table 1).

2012-13 Pumping Plan

LADWP issued a final operations plan for the 2012-13 runoff year on May 21, 2012. Forecasted runoff for the Owens River watershed was much below normal at 268,400 ac-ft (65% of normal). LADWP's plan provided a range of planned pumping for most wellfields; often the range between the lower and upper limit was several thousand acre-feet (Table 1). The Water Department analyzed the effect of the operations plan on groundwater levels in the valley using regression models for several test wells (Table 3). Most models rely on measured depth to water in April 2012, planned wellfield pumping, 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. The quantity of water diverted into the McNally canals was estimated from LADWP's annual estimated spreading in Laws provided in Chapter 3 of their 2012 annual report. No spreading is planned for 2012-13 which is not unusual given the low runoff forecast.

Given the relatively low runoff and uncertainty over the pumping amounts, the Water Department recommended pumping in wellfields be managed to protect the vegetation or be limited to amounts near the lower limit in Table 1. The draft and final operations plans and recommendations provided by Inyo County are available from the Water Department.

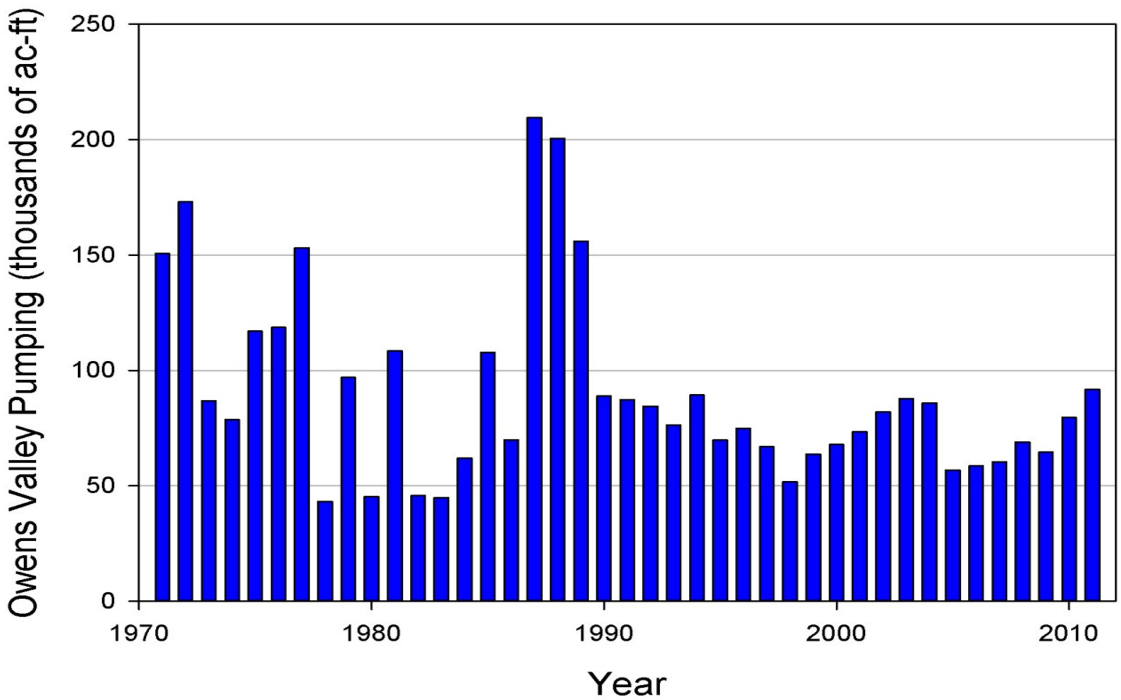


Figure 3. Total LADWP pumping in the Owens Valley since 1970. Values are for the runoff year (e.g. runoff year 2011 includes pumping from April 2011 through March2012).

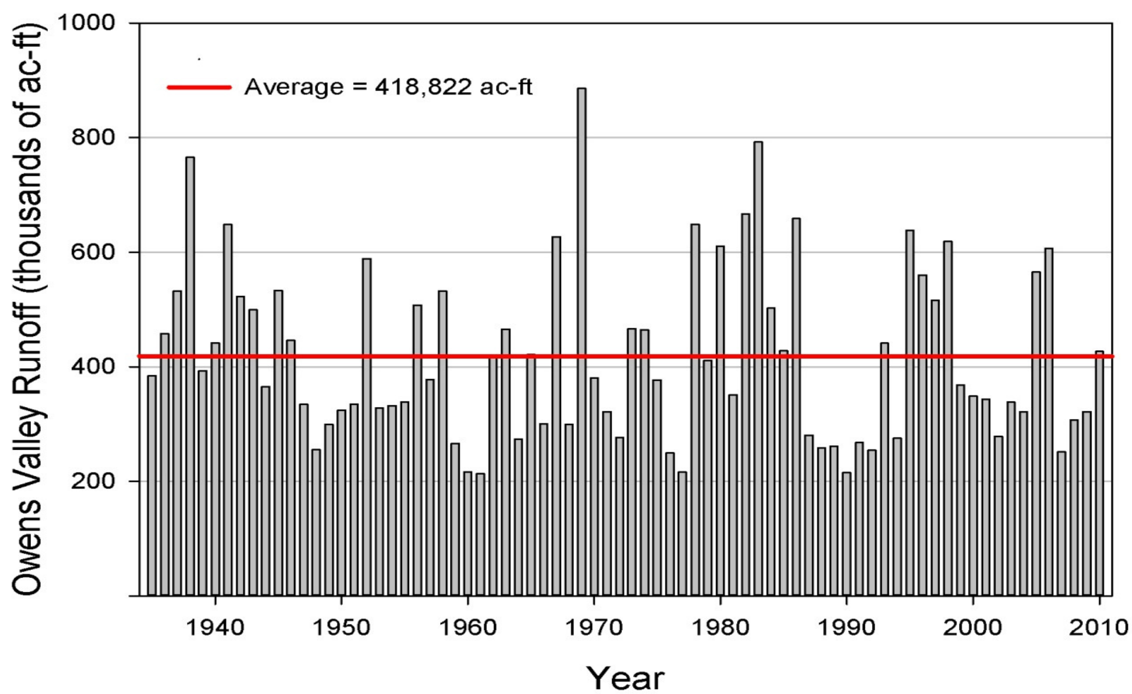


Figure 4. Measured Owens Valley runoff since 1935.

Table 4. Depth to Water (DTW) at indicator wells and monitoring sites, April 2012. All data are in feet. A negative change from April 2011 indicates a water table decline; negative deviation from baseline indicates the water table was below baseline. Depths are from reference point on the test well. Baseline elevation at monitoring sites was predicted from monitoring site/indicator wells regression models unless the test well was present in 1985-87.

Well ID	DTW, April 2012	Change from April 2011	Deviation from Baseline in 2012††
Laws			
107T	32.70	-0.22	-8.43
436T	11.25	-0.46	-3.15
438T	12.64	-0.77	-3.04
490T	12.49	-2.36	0.58
492T	34.17	-0.80	-1.37
795T, LW1	23.84	-0.03	-9.28
V001G, LW2	24.95	-0.85	-5.32
574T, LW3†	15.08	0.36	-1.98
Big Pine			
425T	18.61	-1.03	-3.71
426T	13.70	-0.37	-2.13
469T	22.28	-0.34	-1.61
572T	13.60	0.22	-1.70
798T, BP1	16.44	0.20	-0.26
799T, BP2	19.87	-0.34	-1.49
567T, BP3	17.85	-1.23	-3.90
800T, BP4	17.40	-1.22	-3.88
Taboose Aberdeen			
417T	31.12	0.50	-4.15
418T	8.93	0.79	-0.70
419T	7.47	0.41	-0.84
421T	36.28	-0.75	-1.93
502T	10.48	-1.25	-2.99
504T	11.15	0.24	-0.38
505T	22.82	-0.47	-4.22
586T, TA4	8.79	-0.18	-0.59
801T, TA5	15.31	-1.97	-0.38
803T, TA6	12.61	0.77	-4.17
Thibaut Sawmill			
415T	20.95	0.84	-2.45
507T	4.63	-0.01	0.04
806T, TS2	12.47	0.63	0.05
Independence Oak			
406T	2.03	1.33	-0.46
407T	11.93	-2.12	-4.63
408T	5.10	-2.37	-1.97
409T	8.78	-4.51	-7.18
546T	5.48	-0.21	-2.05

Well ID	DTW, April 2012	Change from April 2011	Deviation from Baseline in 2012††
809T, IO1	8.29	1.00	-2.31
Symmes Shepherd			
402T	10.36	-0.39	-2.33
403T	7.32	-0.09	-1.99
404T	5.75	-0.90	-2.18
447T	38.72	-2.97	-16.85
510T	7.06	-0.78	-2.06
511T	7.40	-1.05	-2.77
V009G, SS1	19.64	-2.97	-13.69
646T, SS2	26.73	-2.39	-14.02
Bairs George			
398T	5.02	-0.91	1.33
400T	5.89	-0.30	0.41

†: The new test well at LW3, 840T, tracks 574T except during active spreading on the site, and depth to water is on average 1.23ft deeper.

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

Summary of Hydrologic Conditions

The history of Owens Valley pumping and runoff are presented in Figures 3 and 4. Despite the much above normal runoff in 2011-12, pumping also increased slightly resulting in relatively stable water levels with small (<1ft) increases and decreases in the measured DTW in most indicator wells and monitoring sites (Table 4). In only one well did the water table rise more than 1 ft; 406T in the Independence-Oak wellfield. Water levels declined more than 2 ft in six wells in the Independence-Oak (407T, 408T and 409T) and Symmes-Shepherd (646T, V009g, and 447T) wellfields. Water levels generally remain below the levels of the mid-1980’s (average 1985-87) with a few exceptions in Laws (1 well), Thibaut-Sawmill (2 wells), and Bairs-George (2 wells). Hydrographs for the indicator wells are provided in following discussions of conditions in each wellfield; hydrographs for the permanent monitoring sites are included in the Soil Water section of the annual report. All data presented in the hydrographs are DTW below the ground surface.

Laws Wellfield

In the 1970’s and 80’s, pumping and spreading in Laws varied greatly year to year causing large fluctuations in the water table (Figures 5 and 6). This was especially true for 107T and 492T because of their proximity to the McNally canals and LADWP pumping wells. Heavy pumping and low recharge in the late 1980’s caused severe declines in the water table in Laws. Under the Water Agreement pumping has remained well 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 uses in the wellfield and by water spreading in 2005 and 2006. In 2011-12 DTW declined in all but one test hole (574T), and all except 490T were below baseline water levels in April 2012 (Table 4).

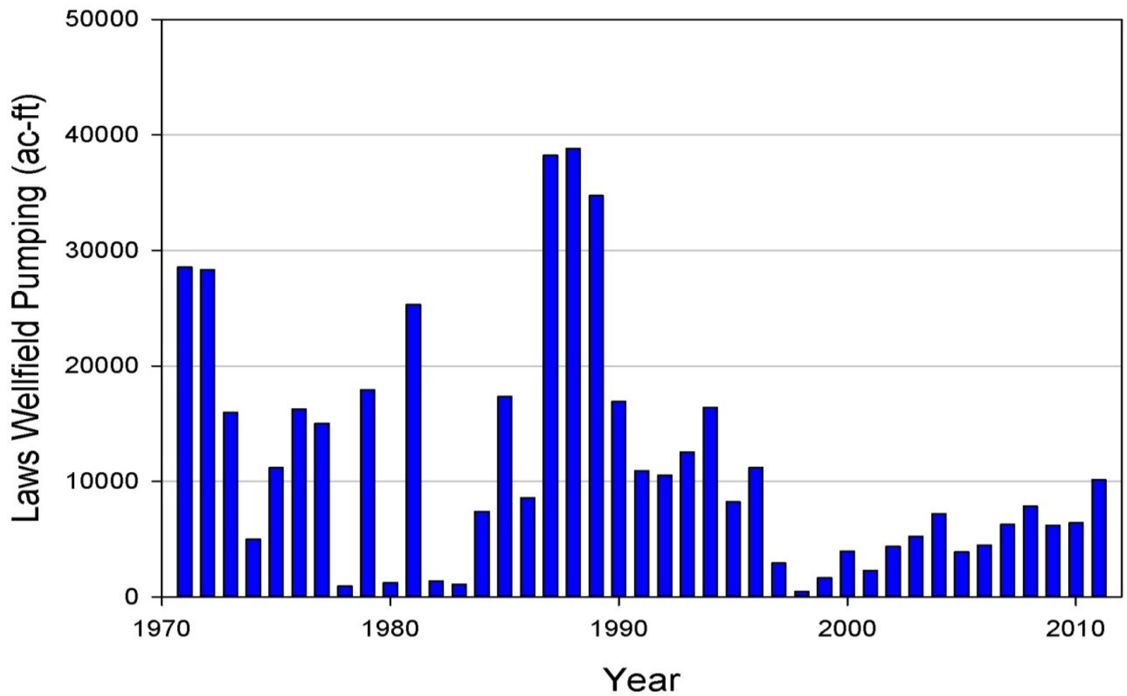


Figure 5. Pumping totals for the Laws wellfield.

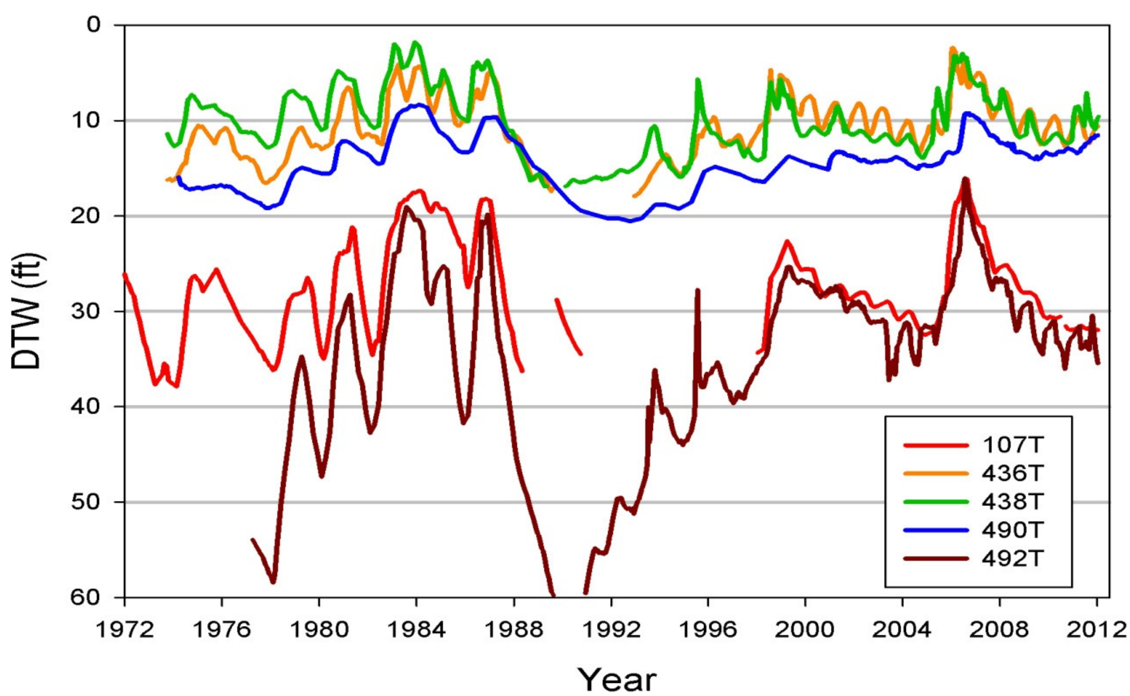


Figure 6. Hydrographs of indicator wells in the Laws wellfield. Well 492T is dry if DTW is below 60 ft. Missing data for well 107T reflect when the wells was dry.

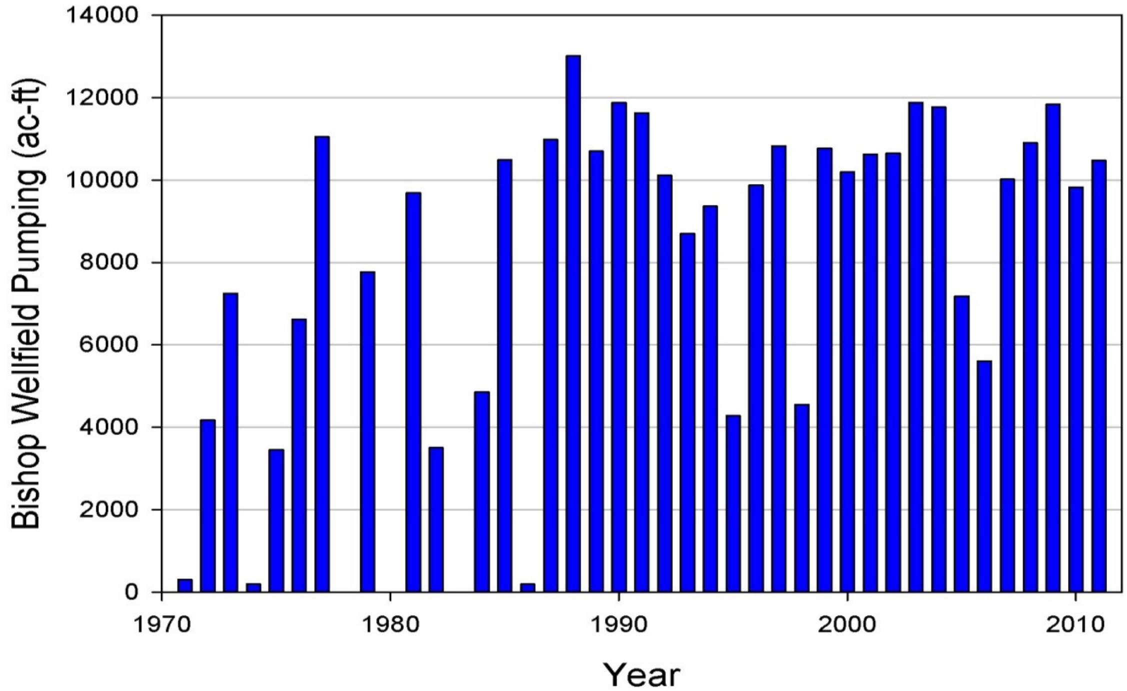


Figure 7. Pumping totals for the Bishop wellfield.

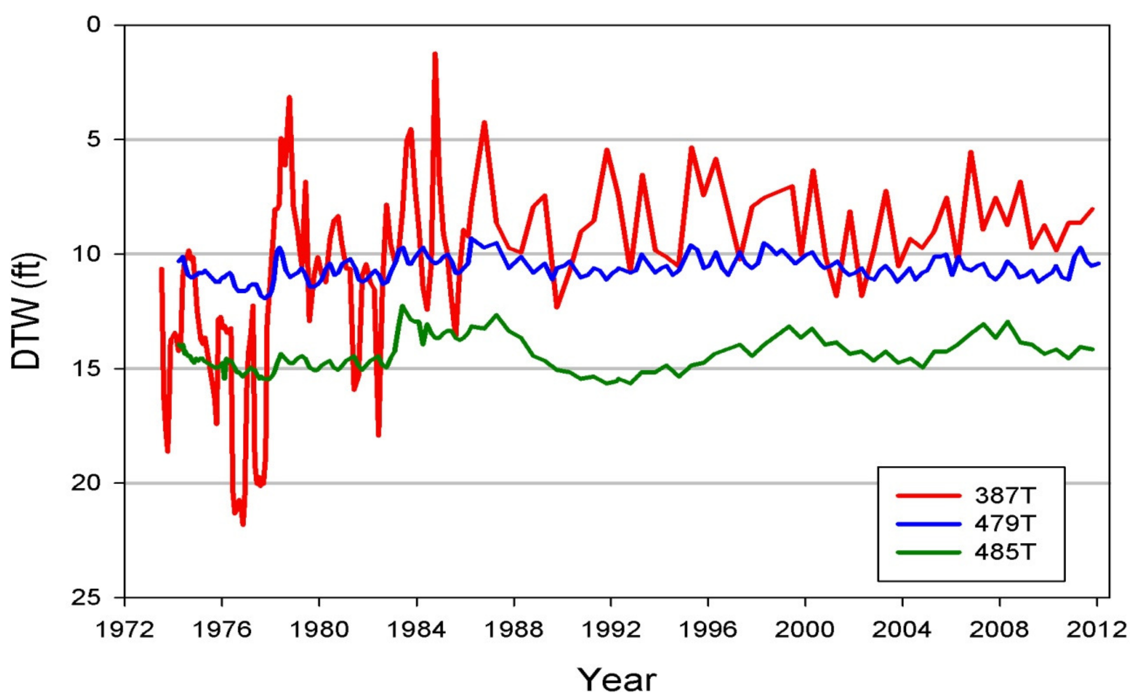


Figure 8. Hydrographs of selected test wells in the Bishop wellfield.

Bishop Cone Wellfield

Pumping on the Bishop Cone has been relatively constant for the past 25 years with above normal runoff when pumping decreased, for example 2005 and 2006 (Figure 7). The Water Agreement requires Inyo and Los Angeles prepare an annual audit of pumping and uses on the Bishop Cone to demonstrate compliance with the Hillside Decree. The Hillside Decree is a 1940 Inyo County Superior Court stipulation and order under which LADWP pumping and water from uncapped flowing wells cannot exceed the annual total of water used to supply irrigation in the Bishop area. The most recent Bishop Cone Audit examined conditions for the 2010-11 runoff year. Total water extraction on the Bishop Cone was 14,727 ac-ft compared with 25,764.9 ac-ft of recorded uses.

Because of the Hillside Decree and relatively constant pumping, we do not routinely use indicator wells to analyze the annual operations plan for this wellfield. The three wells in Figure 8 are located near the locus of pumping and irrigation adjacent to the city of Bishop (387T) and at intermediate (485T) and larger (479T) distances from the city. Constant pumping as well as recharge from Bishop Creek and the extensive network of canals and ditches to supply irrigated lands produce relatively stable water levels in the Bishop wellfield. (Figure 8).

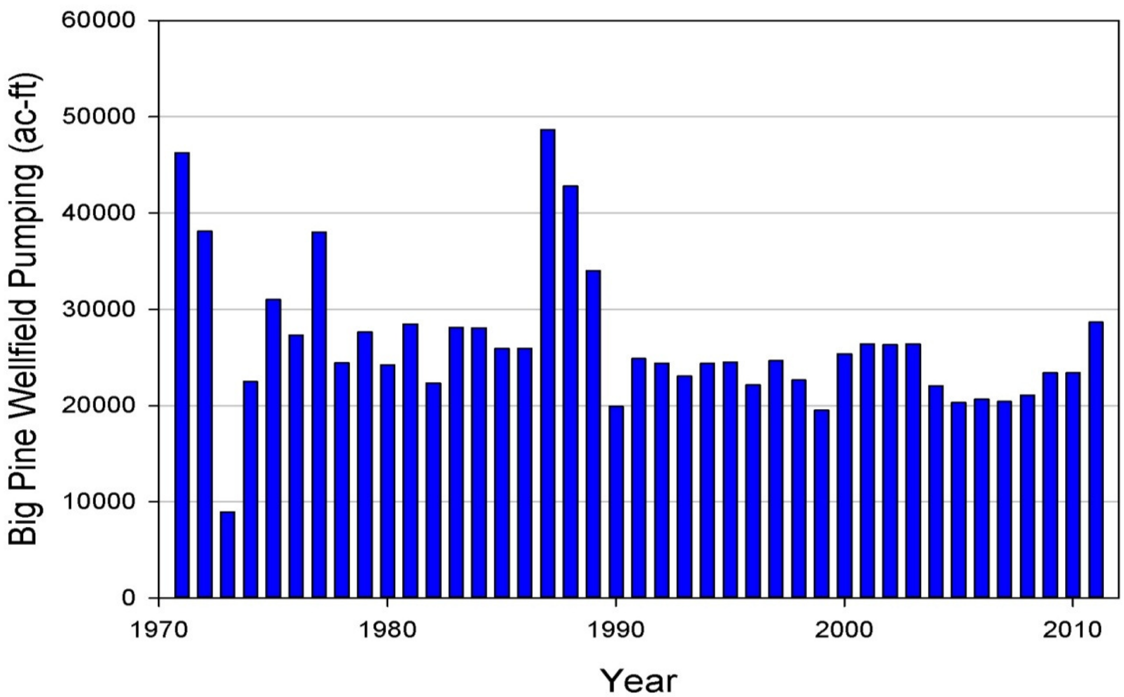


Figure 9. Pumping totals for the Big Pine wellfield.

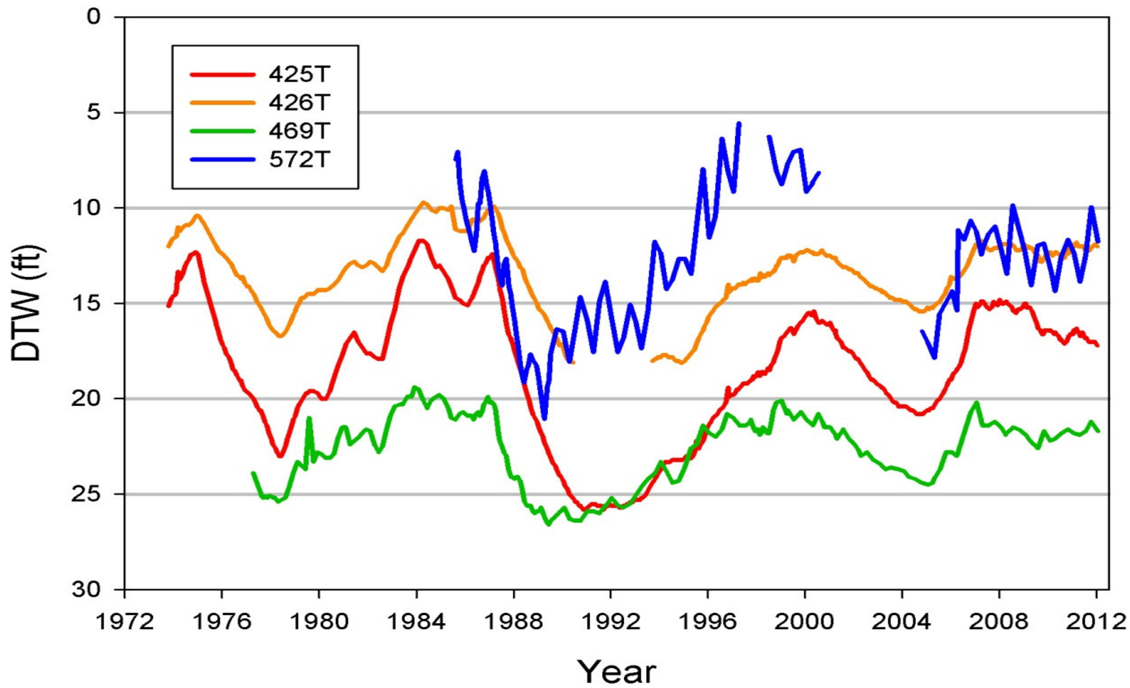


Figure 10. Hydrographs of indicator wells in the Big Pine wellfield. Periods of missing data for 572T occurred when the well was plugged and in need of repair.

Big Pine Wellfield

Pumping in the Big Pine wellfield since 1974 has been relatively large compared with other wellfields (Figure 9). Minimum pumping to supply uses in this wellfield include the Fish Springs Hatchery (approximately 19,500 ac-ft) and Big Pine town supply (500 ac-ft). Pumping under the Water Agreement largely has been to supply these uses. In 2009 and 2010, wellfield pumping increased to approximately 8000 ac-ft above the minimum. The increase in pumping was primarily for aqueduct supply although it should be noted that most of the hatchery pumped water also reaches the aqueduct. Despite the increase in export pumping, DTW in four indicator wells during the last three years have been relatively stable (Figure 10). Groundwater levels in 2011-2012 rose slightly in two wells north of Big Pine but declined 0.3-1.25 ft in all other wells. All wells remain below baseline levels in April 2012, usually by more than 1-3 ft (Table 4).

Taboose-Aberdeen Wellfield

Pumping in the Taboose-Aberdeen wellfield since 1990 under the Water Agreement has remained much below the wellfield capacity (Figure 11). Minimum pumping for this wellfield is approximately 300 ac-ft to supply one mitigation project , and nearly all pumping in 2011-12 was for aqueduct supply.

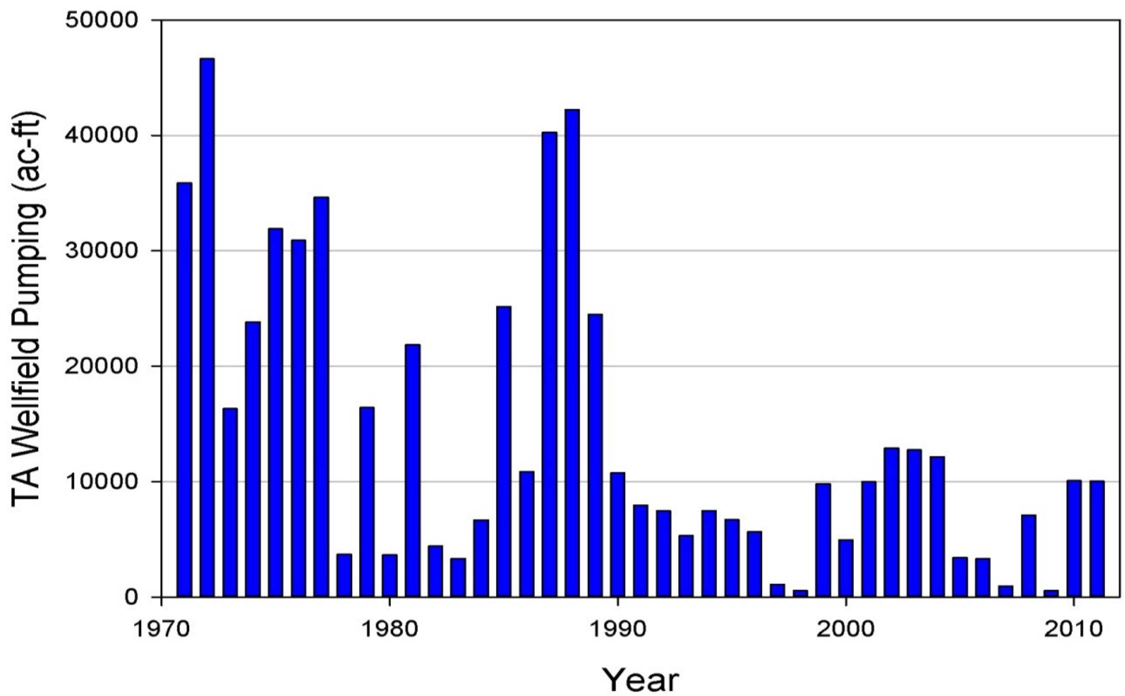


Figure 11. Pumping totals for the Taboose-Aberdeen wellfield.

Hydrographs for the indicator wells exhibit similar response to fluctuations in pumping and runoff (Figure 12). Despite the above normal runoff during 2010 and 2011, pumping also increased, and water levels were stable or declined slightly. Most of the recent pumping has been from well 349W, and the three indicator/monitoring site wells in the northern portion of the wellfield, 421T, 502T, and 801T have declined approximately 2 ft since 2010. DTW in other parts of the wellfield have changed less than 1 ft over this period. Groundwater levels in 2011-2012 declined in five test wells and rose in five test wells. Depth to water in all wells was below baseline in April 2012 (Table 4).

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 13). In 2011-12, approximately 1,800 ac-ft was pumped from this wellfield for aqueduct supply. The four test wells used to track water levels in Thibaut-Sawmill exhibit differing patterns due to local water management within the wellfield (Figure 14). Wells 413T and 414T are not used as indicator wells but they are included as examples from the southern portion of the wellfield. Both wells respond to spreading during high runoff years (e.g. 2006) and then decline gradually in response to pumping and reduced runoff. The overall trend in these wells has been stable or slightly increasing since the late 1990's. Following nearly ten years of stable water levels, 507T began to respond in 2009 to the establishment of wetlands in the Blackrock Waterfowl Management Area. Well 415T has declined slightly from the recent peak water level in 2008. Groundwater levels in 2011-2012 increased in 415T and 806T and were essentially unchanged in 507T. One well remained below baseline in April 2012 (Table 4).

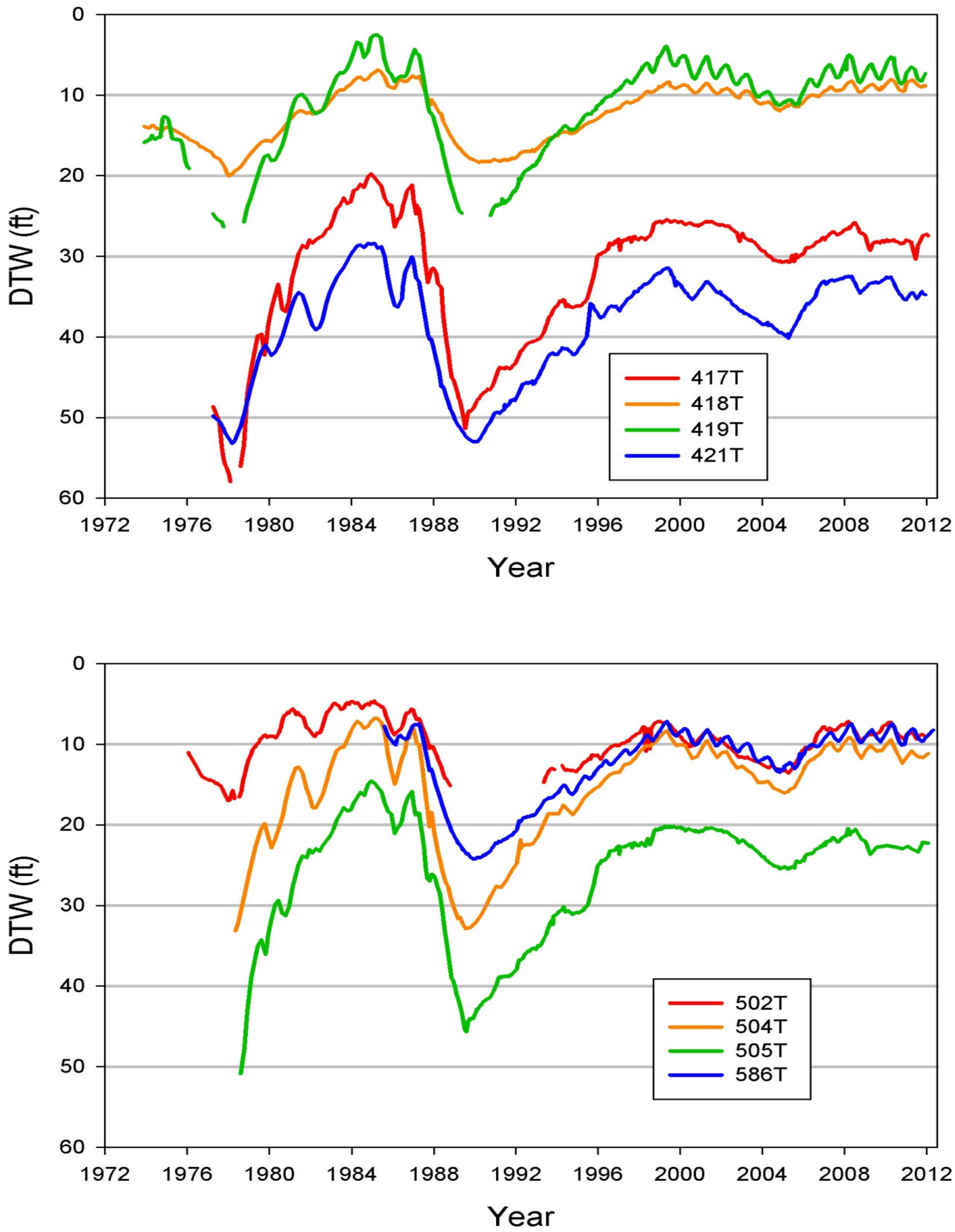


Figure 12. Hydrographs of indicator wells in the Taboose-Aberdeen wellfield. Periods of missing data denote when the test well was dry.

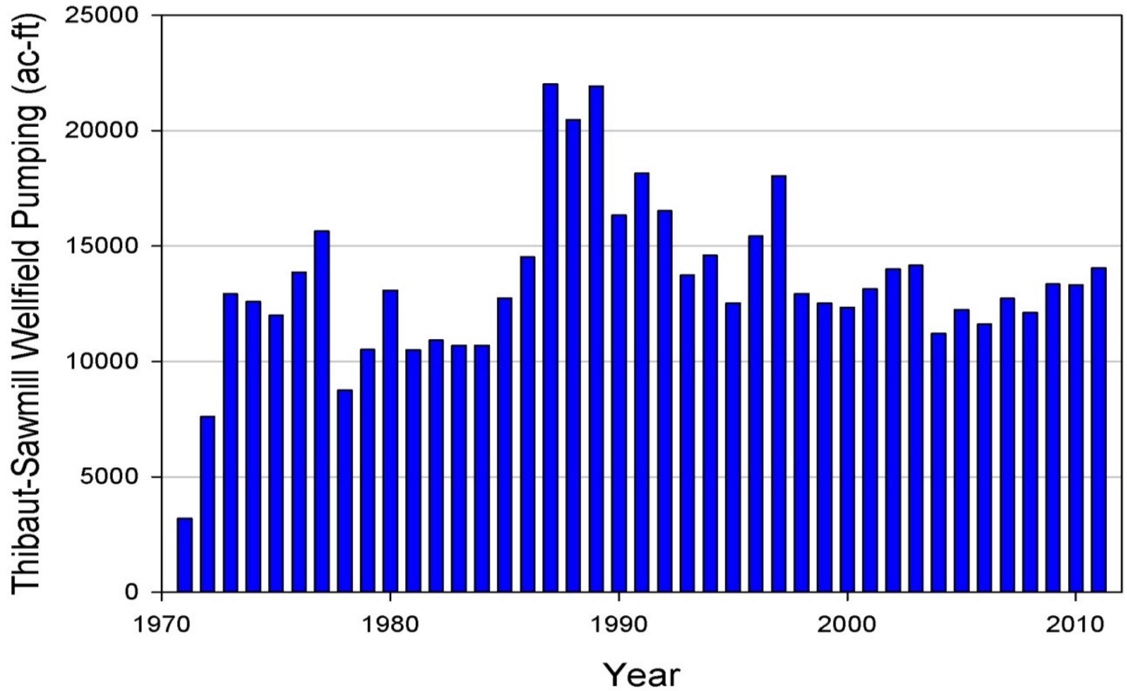


Figure 13. Pumping totals for the Thibaut-Sawmill wellfield

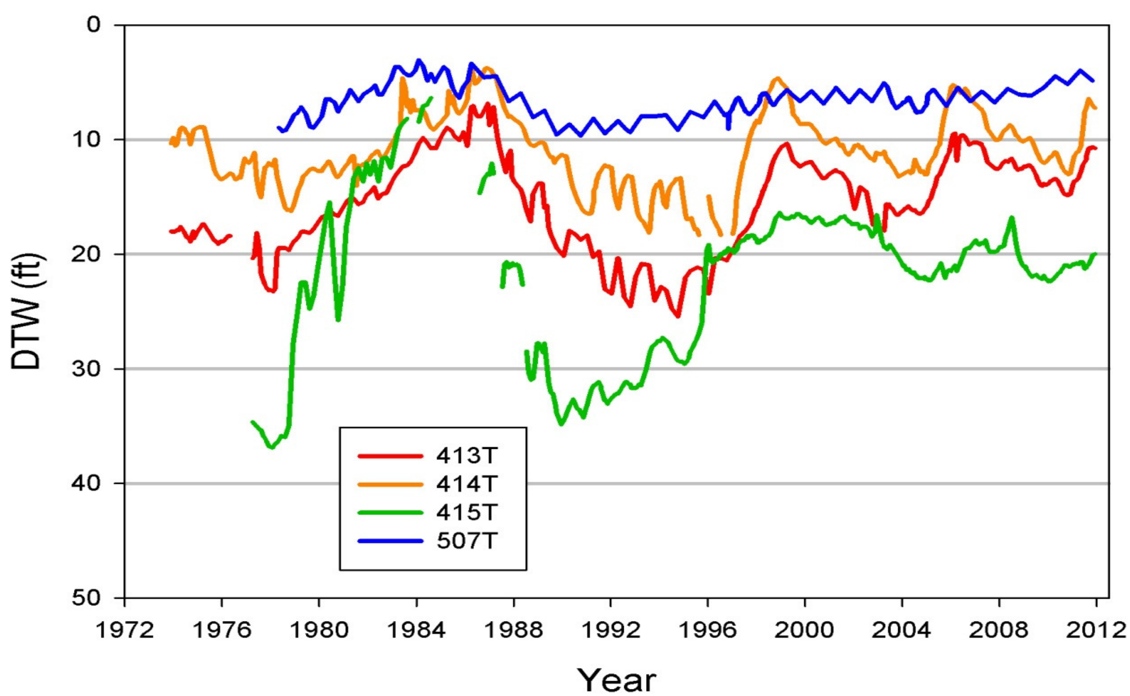


Figure 14. Hydrographs of selected test wells in the Thibaut-Sawmill wellfield.

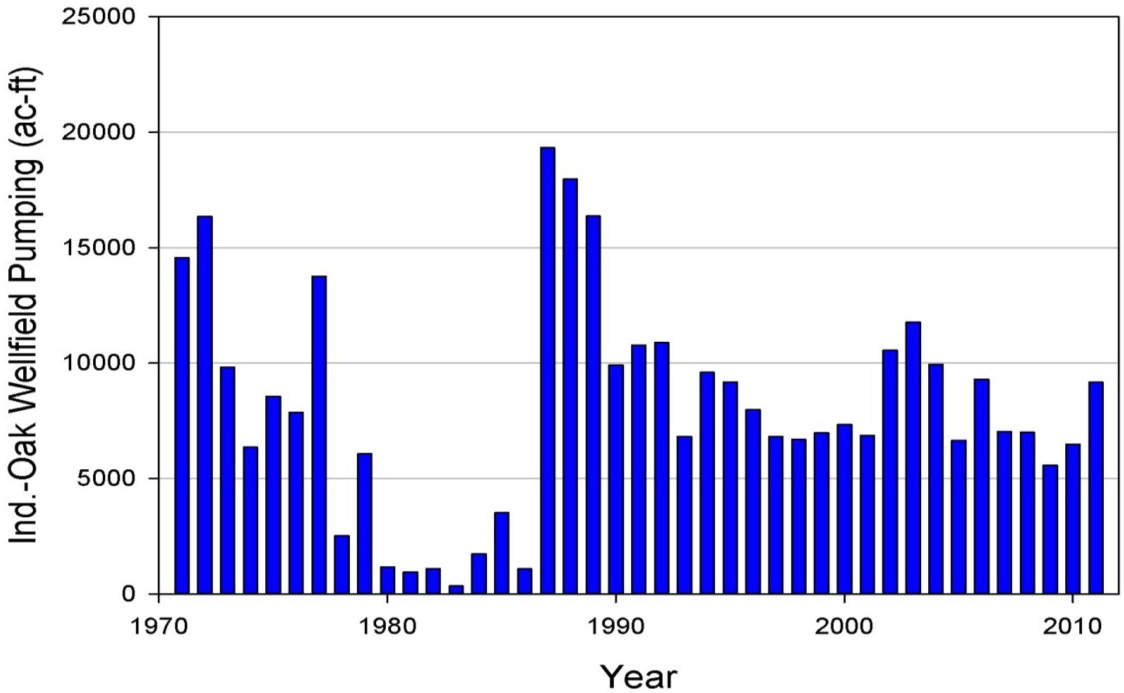
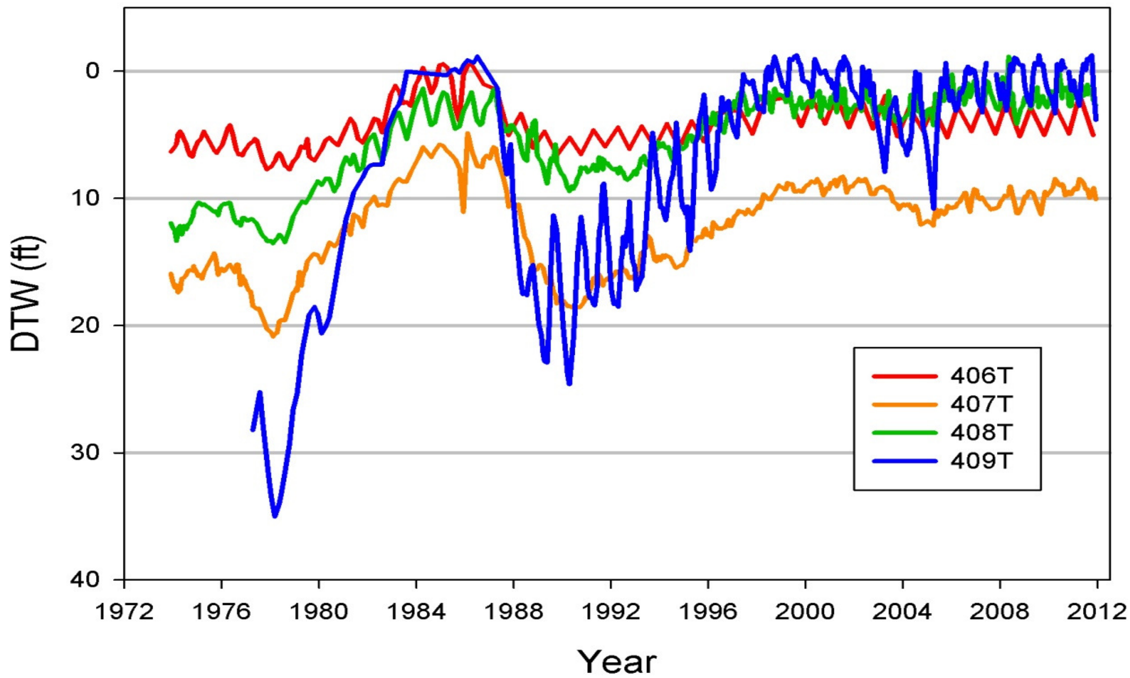


Figure 15. Pumping totals for the Independence-Oak wellfield.

Independence-Oak Wellfield

This wellfield has experienced annual pumping of approximately 6,700 ac-ft for irrigation projects surrounding Independence and for town supply (Figure 15). Following four years of near minimum pumping, LADWP increased pumping for the 2011-12 runoff-year to 9,175 ac-ft. Water levels had been stable for several years in wells located in the center of the wellfield (407T, 408T, 409T), but they declined in response to the increased pumping last year (Table 4). The other indicator wells located east and north of Independence have continued to exhibit stable or rising water levels (Figure 16 and Table 4). Wells 412T and 453T are not used as indicator wells, but they are included as examples of water levels in the northern portion of the wellfield. All of the indicator wells test in the Independence-Oak wellfield were below the baseline in April 2012 (Table 4).



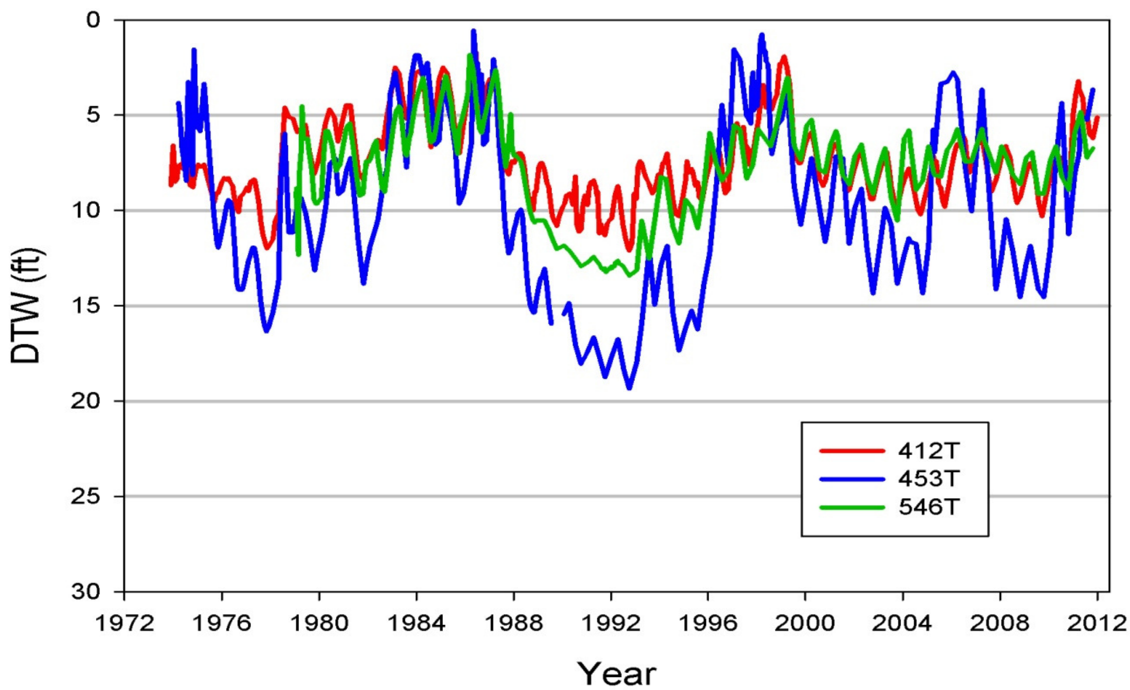


Figure 16. Hydrographs of selected test wells in the Independence-Oak wellfield

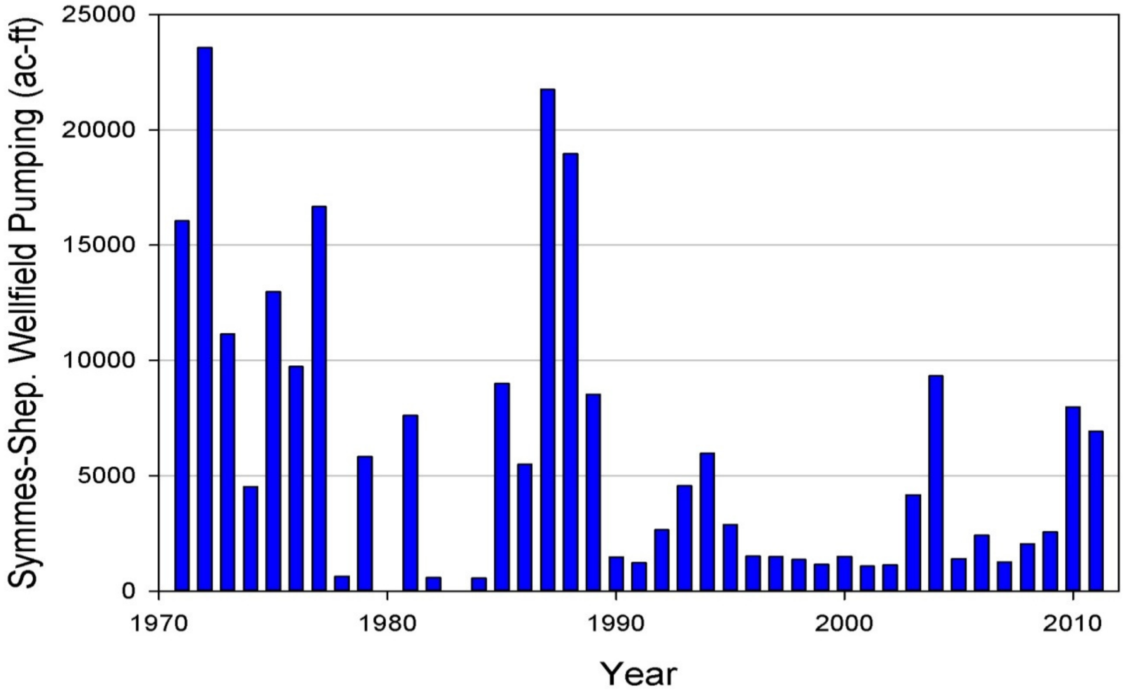
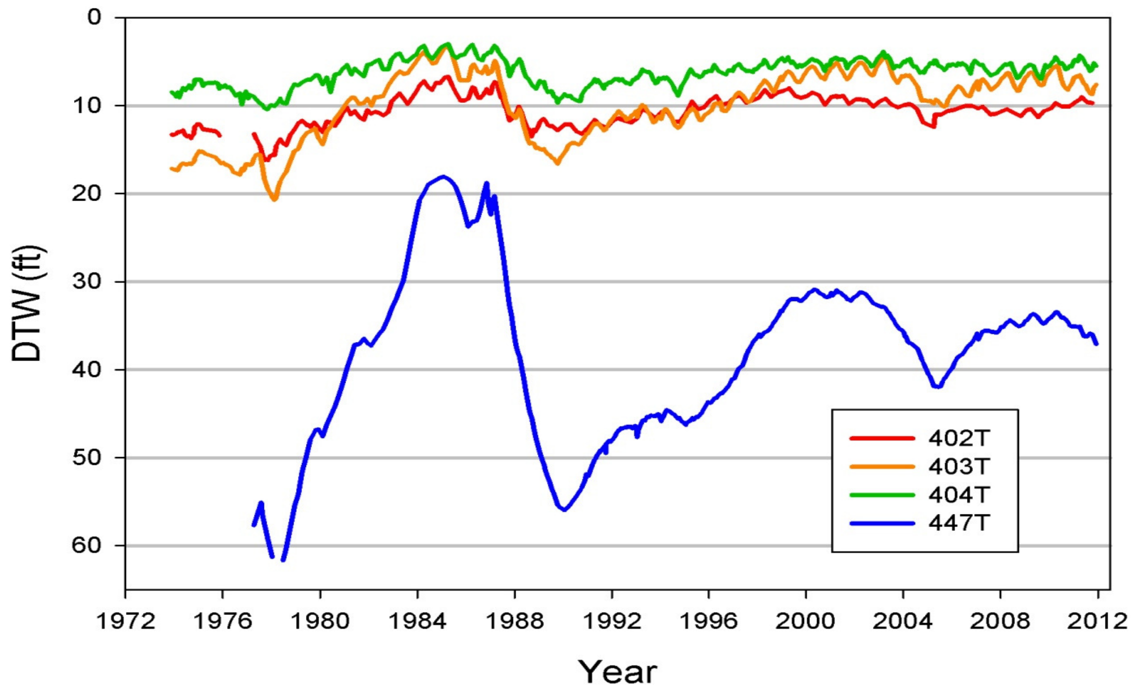
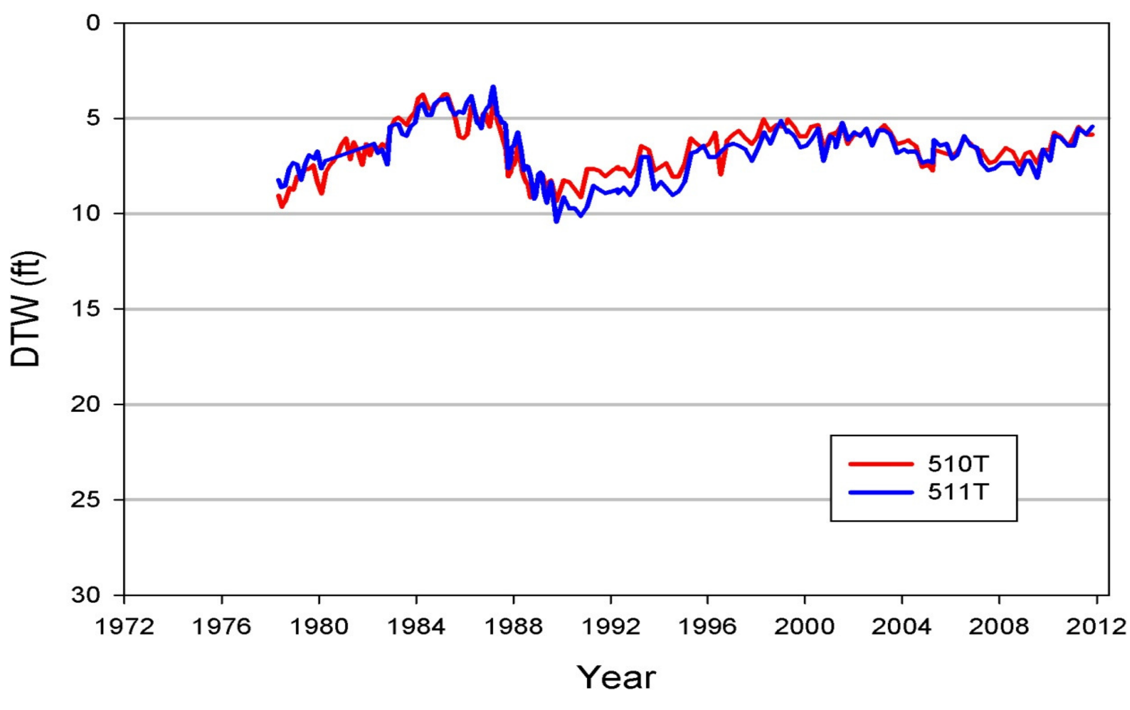


Figure 17. Pumping totals for the Symmes-Shepherd wellfield

The Symmes-Shepherd Wellfield

In the 1970's and 80's, pumping in the Symmes-Shepherd wellfield varied considerably (Figure 17). Under the Water Agreement, pumping has been reduced to approximately 1200 ac-ft to supply one mitigation project in most years; howver, pumping for aqueduct supply increased considerably in the 2010 and 2011 runoff years. Groundwater levels in 2011-2012 declined and were below baseline in all test holes (Table 4). The largest DTW declines occurred in 447T and the monitoring site wells located near the northern portion of the wellfield where most of pumping in 2011 occurred. The other test wells are located further from the pumping wells (403T) or are buffered somewhat by their proximity to the LAA (402T, 404T, 510T, and 511T).   Water levels in these wells has been relatively stable, but decreased small amounts in 2011-12.





Figures 18. Hydrographs of indicator wells in the Symmes-Shepherd wellfield.

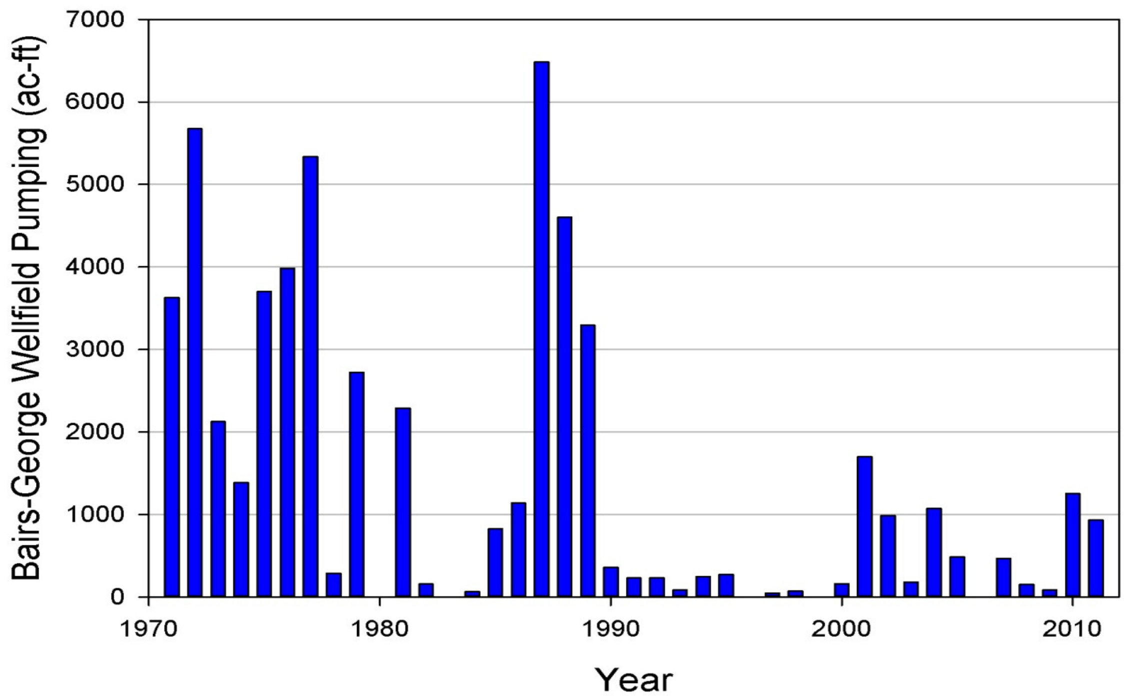


Figure 19. Pumping totals for the Bairs-Georges wellfield.

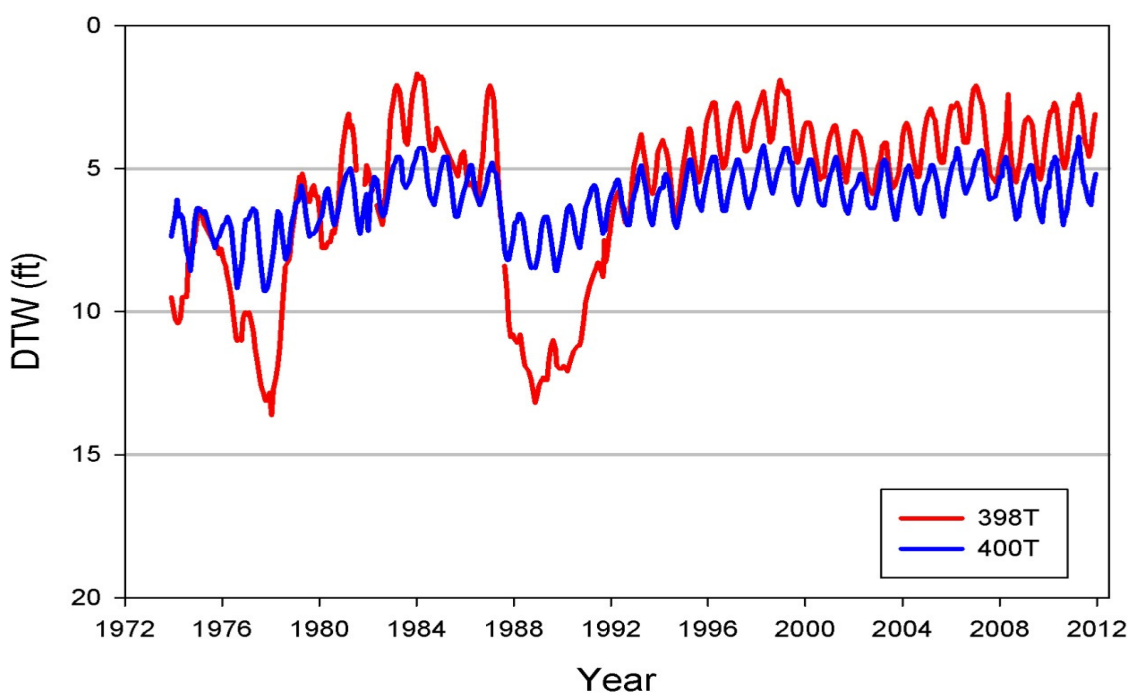


Figure 20. Hydrographs of indicator wells in the Bairs-Georges wellfield.

The Bairs-Georges Wellfield

In the 1970's and 80's, pumping in the Bairs-George wellfield varied considerably (Figure 19), but under the Water Agreement, pumping has been reduced substantially. There are no projects supplied by groundwater in this wellfield, but in dry years one well can be operated to supply irrigated pastures. As in other wellfields, pumping for aqueduct supply increased considerably in 2010 and 2011 runoff years compared with the small amounts during the five preceding years. Since the mid 1990's groundwater levels in the two indicator test wells have been relatively stable (Figure 20). Water levels in 2011-2012 declined, but both wells remain above baseline in April 2012 (Table 4).

The Lone Pine Wellfield

Most pumping in the Lone Pine wellfield has been to supply the town of Lone Pine and one mitigation project (approximately 1,300 ac-ft annually). Pumping increased occasionally (e.g. 2000) to offset LAA water previously supplied to Diaz Lake. Because of the relatively constant pumping for sole source uses, we do not routinely use indicator wells to analyze the annual operations plan for this wellfield. Hydrographs for test wells T564 and T591 are presented in Figure 22 to represent water levels near the town of Lone Pine where the LADWP pumping wells are located. Both wells exhibit seasonal fluctuations as well as water table response to increased recharge in wet year. In early 2010, LADWP and ICWD tested a new production well installed to increase aqueduct supply. Additional testing may be performed during the 2012-13 runoff year, subject to the analysis of the results from the previos test.

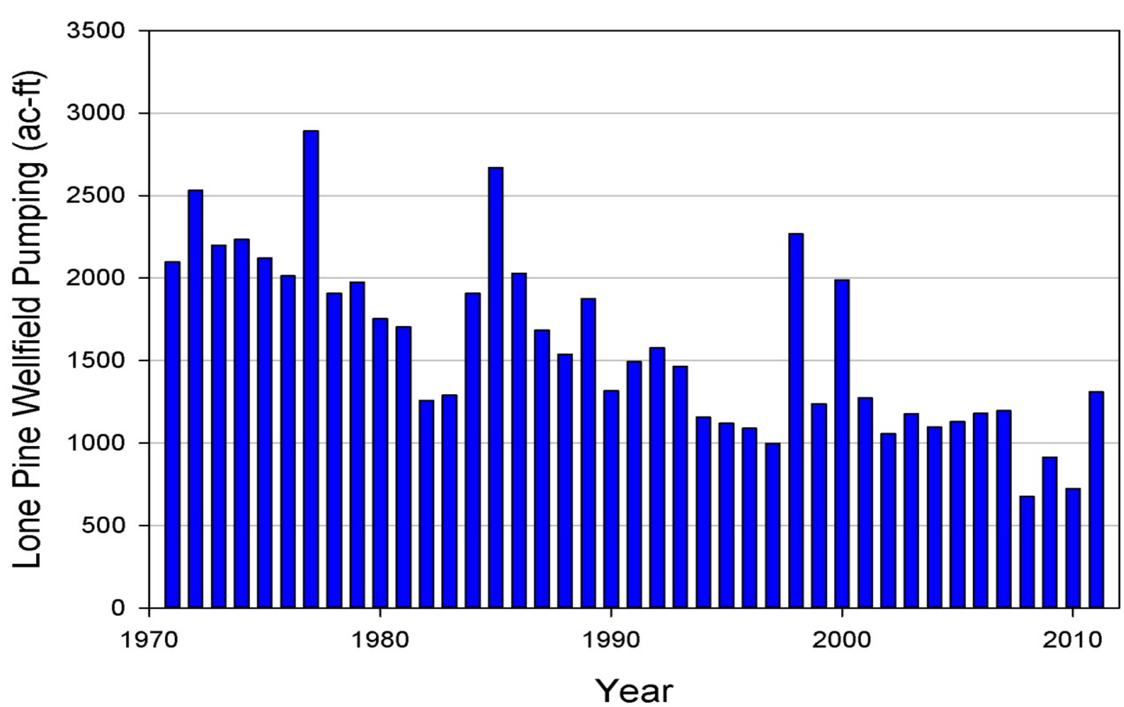


Figure 21. Pumping totals for the Lone Pine wellfield.

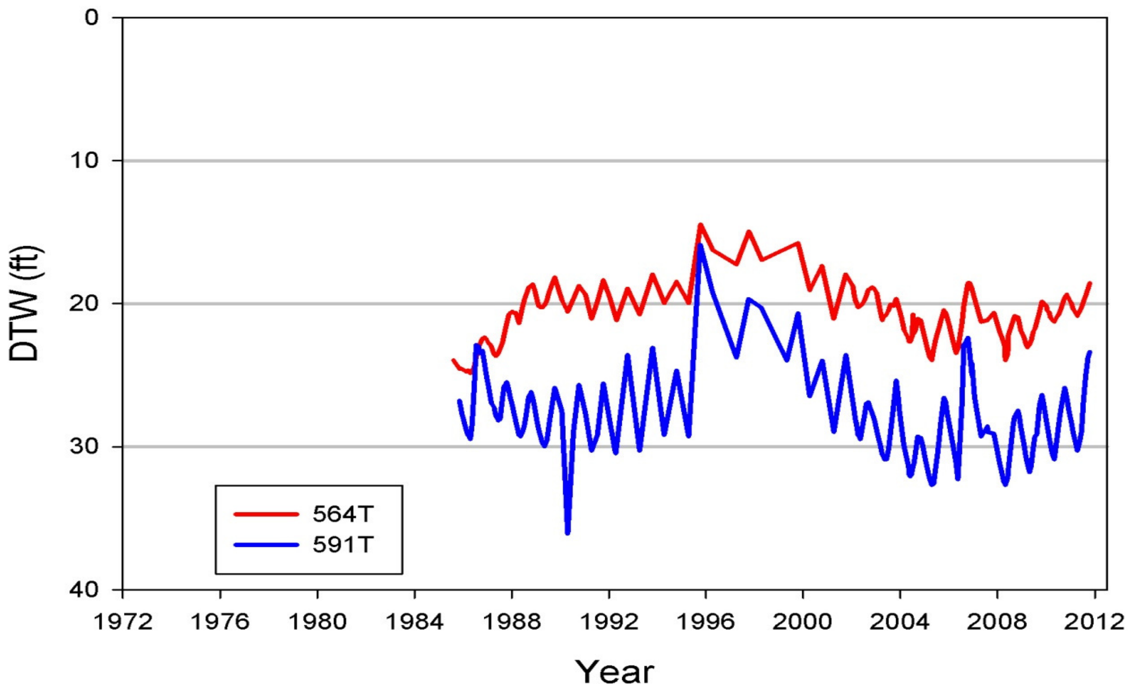


Figure 22.Hydrographs of selected test wells in the Lone Pine Wellfield.

Shallow Groundwater Adjacent to the Lower Owens River Project (LORP)

Base flows of 40 cubic feet per second were established in the lower Owens River in the 2007-2008 runoff-year. Four periods of higher flows to promote habitat have also been released down the Owens River channel. The effect of rewatering the LORP channel on the adjacent aquifer was monitored to gain information on the surface-groundwater interaction as the project is implemented. A selected number of test wells along with the distance from the river channel are listed in Table 5. Two test wells are adjacent to a previously dry reach of the river and two are adjacent to the reach previously wetted by diversions from LAA or from groundwater discharge (Figure 23). Shallow groundwater levels rose quickly in 2007 in response to the establishment of base flows in the Lower Owens River. The increase in water levels due to the LORP has resulted in groundwater levels near or above the highest levels experienced since 1972. Not surprisingly, the largest increases occurred in wells adjacent to previously dry channel. Water levels continue to rise in all of the wells suggesting the aquifers adjacent to the river have not yet reached equilibrium.

Table 5. Selected Shallow Test Holes Adjacent to the Lower Owens River Project.

Test Well	Pre-LORP channel condition	Distance from River Channel
		(ft)
T467	Dry	700
T463	Dry	1070
T446	Wet	142
T448	Wet	457

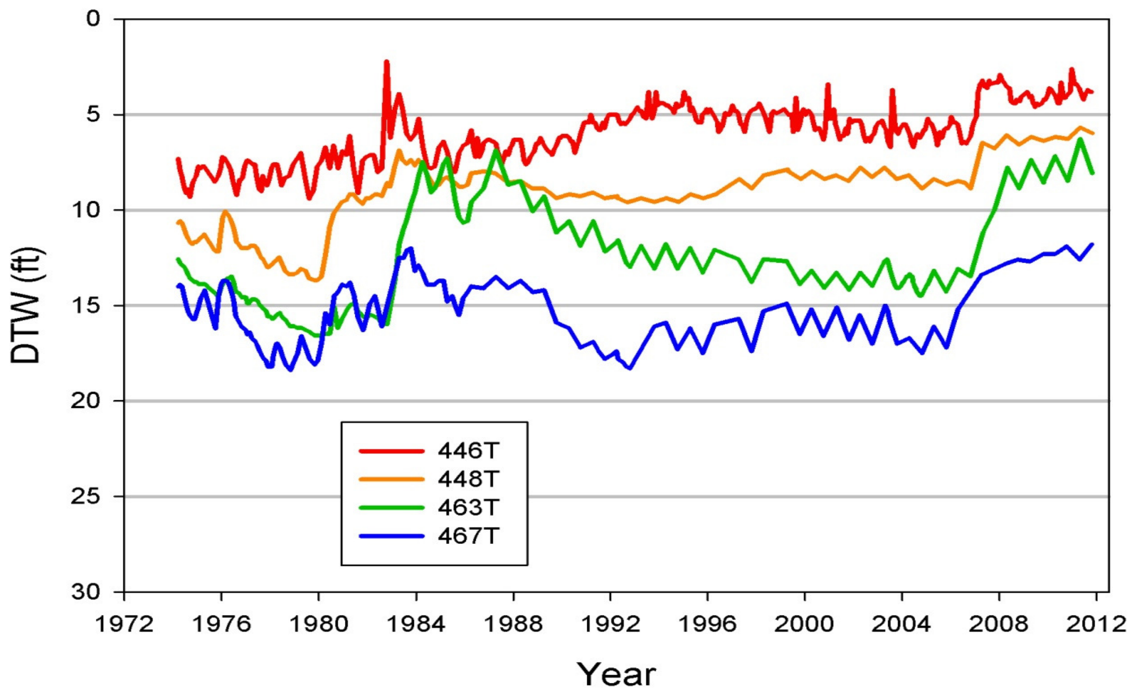


Figure 23. Hydrographs of selected test holes adjacent to the Lower Owens River Channel

References

Harrington, R. F., Multiple regression modeling of water table response to groundwater pumping and runoff, Inyo County Water Department report, 1998.

Steinwand, A.L, and R.F. Harrington. 2003. Simulation of water table fluctuations at permanent monitoring sites to evaluate groundwater pumping. Report to the Inyo/Los Angeles Technical Group, February 25, 2003.