INYO COUNTY WATER DEPARTMENT

2015-2016 ANNUAL REPORT

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SECTION 1: EXECUTIVE SUMMARY

To protect the County's environment, citizens, and economy from adverse effects caused by activities relating to the extraction and use of water resources and to seek mitigation of any existing or future adverse effects resulting from such activities.

The Water Department's efforts during 2015-2016 were directed toward our core mission of assisting in the implementation of the County's water resources policies through the Inyo/Los Angeles Long-Term Water Agreement. Our work consists of four main activities: joint management with LADWP of LADWP water-related activities through the Inyo/Los Angeles Technical Group and Standing Committee; environmental monitoring to assess impacts of LADWP activities and compliance with Water Agreement goals; planning, monitoring, implementation, and enhancement of mitigation measures associated with the Water Agreement; and disseminating information and fostering public knowledge and involvement in County water policy.

The 1997 MOU between LADWP, Inyo County, California Department of Wildlife, California State Lands Commission, the Sierra Club, and the Owens Valley Committee requires that "*DWP and the County will prepare an annual report describing environmental conditions in the Owens Valley and studies, projects, and activities conducted under the Los Angeles Agreement and this MOU.*" This requirement has customarily been fulfilled by two reports, one issued by LADWP and one issued by the Water Department. In addition to fulfilling this MOU requirement, the Water Department's Annual Report is a vehicle for disseminating information to the public about conditions and activities related to the Inyo/Los Angeles Long-Term Water Agreement. The Water Agreement contains a number of provisions for collecting and sharing data, analyzing data, managing groundwater pumping, and mitigating negative effects of LADWP water management. We strive to make this report informative broadly for those wishing an overview of conditions and trends, and also to provide detailed data and analysis for those desiring to look more closely at conditions in Owens Valley. In general, this report covers the 2015-16 runoff year (April 1, 2015 through March 31, 2016), but also contains material pertaining to LADWP's planned pumping for the 2016-17 runoff year.

An important benefit that the Inyo/Los Angeles Water Agreement (Agreement) provides to the Owens Valley is the continuation of water deliveries to Los Angeles-owned lands for irrigation, habitat, and recreation. Maintaining water on these lands provides economic opportunities for ranching and growing crops, makes habitat for wildlife, provides recreational opportunities (fishing, hunting, ice skating), controls dust, and positively affects the Valley's aesthetics. The Water Agreement classifies Los Angeles's land into five vegetation types: Type A lands are native vegetation that is not groundwater dependent, Type B lands are groundwater dependent shrub lands, Type C lands are groundwater dependent meadows, Type D lands are riparian vegetation, and Type E lands are lands supplied with water. Water supply for irrigation has received considerable discussion in the past two years. In runoff-year 2015, LADWP proposed to drastically reduce irrigation without having approval from the Inyo/Los Angeles Standing Committee, and this year, the Standing Committee considered proposals from both LADWP and the County to reduce irrigation and enhancement/mitigation water supply without coming to agreement. The Water Department wrestles with a number of issues concerning LADWP irrigated lands, including declining trends in stock water supply to lessees, unilateral reductions in irrigation water by LADWP, terms of ranch leases affecting water related uses, water use on Owens Lake, compliance monitoring of irrigated lands, and challenges in supplying water to mitigation projects.

Total pumping within the Owens Valley for 2015-16 was 70,334 AF which was slightly less than the planned pumping of 75,285 AF. The Water Agreement and Green Book include procedures to calculate a pumping limit to prevent groundwater mining to ensure no long term decline in aquifer storage. The mining calculation is a comparison of pumping and recharge for each wellfield on a water year basis (October 1st through September 31st) for a 20 water year period. The 19.5 year total of actual pumping is subtracted from 20 years of estimated recharge to arrive at an estimated April-September pumping limit for each wellfield and Owens Valley as a whole. The estimate of groundwater recharge in the Owens Valley was 101,546 AF compared to 64,573 AF of pumping for the 2016 water year, and no wellfield was in violation of the groundwater mining provision.

The Bishop Cone well field required special attention in the last few years because of a perplexing combination of groundwater declines impacting private domestic wells and high water tables causing saturated soil conditions negatively affecting homes, landscaping, and roads. 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. Many of the private wells in west Bishop are shallow and, therefore, more vulnerable to impacts associated with deepening groundwater levels. This sensitivity should be considered in planning and managing new groundwater wells that LADWP has proposed on the Bishop Cone.

Groundwater elevations have declined in all well fields as compared to the 1984-87 baseline levels by an average magnitude of several feet. Inyo County commented to LADWP that we did not feel that it is appropriate to pump groundwater for export to Los Angeles in well fields that are significantly below baseline levels. Although the Water Agreement's process for Annual Operations Plans is based on planning for one year at a time, the Water

Department recommended that the Technical Group consider multi-year planning to address the need to maintain or raise the water table to meet the Water Agreements native vegetation goals.

Since 2012 California and the western U.S. has experienced severe drought resulting in reduced runoff into the Owens Valley from the Sierra Nevada. As a consequence, less water has been available for irrigation in the valley and for natural and artificial groundwater recharge. These changes to hydrology due to drought are accompanied by groundwater pumping for export and for use in the valley. The current ongoing drought has had the lowest average runoff over its first four years of any droughts in the period since the period of operation of the second LA Aqueduct. In terms of cumulative runoff deficit, it is exceeded only by the drought of 1987-1992, which persisted for six years. Groundwater levels recovered to baseline or near baseline in over half of the indicator wells and monitoring site wells examined for this annual report. Twenty-seven of forty-six wells have recovered to baseline at some time since 1991 when water tables were at a low point and another nine wells have been within one foot of baseline. Present water tables are generally higher than when the Water Agreement was signed in 1991. Water table declines during the current drought are due to the combined effects of groundwater pumping and diminished recharge. In most areas, the effect of diminished recharge had greater effect on the water table than discretionary pumping, except in the Taboose-Aberdeen well field where discretionary pumping has been a relatively large fraction of the overall pumping in the well field.

The Water Agreement's ON/OFF method of managing LADWP pumping wells is based on monitoring sites where vegetation cover, soil water, and depth to the water table are measured, and the vegetation's water needs are compared to the available soil water. Pumping wells are linked to a monitoring site, and if sufficient soil water is present for vegetation at a site, then wells linked to that site may be pumped. As part of the monitoring effort, each month the Water Department measures depth to groundwater and soil water at 25 monitoring sites in wellfields and 8 sites in control areas (areas unaffected by pumping). At the beginning of the 2015-16 runoff year, six sites of 25 were in On-status, and remained so throughout the runoff year. No sites went into On-status during the winter 2015-16.

One of the roles of the Water Department is to monitor and report on the status of environmental mitigation projects in the Owens Valley. Approximately 60 projects, spread throughout the Valley, mitigate for a range of environmental impacts due to abandonment of irrigated agriculture and groundwater pumping in the Owens Valley. These improvements range in size from single-acre spring restoration projects to the 78,000-acre Lower Owens River Project (LORP). The majority of these projects are described in the Water Agreement and associated 1991 EIR (titled Water from the Owens Valley to Supply the Second Los Angeles Aqueduct), and in the 1997 MOU (which resolved conflicts and concern over the 1991 EIR), which can be found on the Water Department website (www.inyowater.org). As part of our tracking of these projects, the Water Department gave qualitative rankings of 'implemented or completed with no outstanding issues (green),' 'implemented but not fully reaching goals or implemented but in need of mitigation plan revision (yellow),' and 'project not implemented or completed or implemented but far short of reaching goals (red).' Our evaluation indicated 66% of projects were 'green,' 20% were 'yellow,' and 14% were 'red.'

Each year the Water Department monitors selected vegetation parcels within the valley to ensure that the Water Agreement's vegetation goals are met. The primary goal of this monitoring, according to the Green Book are to detect any *"significant decreases and changes in Owens Valley vegetation from conditions documented in 1984 to 1987"*. Vegetation live cover and species composition documented during the 1984-87 mapping effort were adopted as the baseline for comparison with each annual reinventory according to the Water Agreement. From September 1984 to Nov 1987, LADWP inventoried and mapped vegetation on 2126 vegetation parcels (223,168 acres). In the summer of 2015, the Water Department and LADWP resampled a subset of the parcels sampled in 1984-1987 (141 parcels) using the line-point protocol described in the Green Book. At the valley-wide scale we evaluated plant community cover and composition in parcels affected by groundwater pumping and for parcels that were generally further east of the wellfields. Parcels are classified as either control or wellfield based on criteria derived from groundwater drawdown during the period of maximum pumping rate that occurred between 1987 and 1993. At the individual parcel scale, we quantified the change in perennial vegetation cover since baseline, assessed whether the relative proportion of shrubs, grass, and herbaceous vegetation has changed compared to baseline, and quantified the temporal trends of grass and shrub proportion for each parcel. In general, wellfield parcels have been below baseline measurements while control parcels have maintained baseline conditions but in 2014 and 2015 control parcels on average were below baseline perennial cover presumably owing to the ongoing drought. Vegetation conditions following the 2015-monitoring season can be summarized by four main findings. First, during the time period 1992-2015, the change profile of the wellfield parcel group was different from the control parcel group, with the decrease in wellfield group cover below that of the control group. Second, overall perennial cover and grass cover in 2015 for both wellfield and control parcel groups was significantly below baseline. Third, within the wellfield parcel group, the relative proportion of shrub cover has significantly increased and grass cover has decreased. Finally at the individual parcel level of analysis, 46 out of 73 (63%) wellfield parcels were significantly below their baseline cover values.

This Annual Report is a requirement of the 1997 MOU, which is one of the governing documents of the Inyo/Los Angeles Long-Term Water Agreement, so the focus of the Annual Report is on Water Department activities related to the LADWP and the Water Agreement. The Water Department is involved in a number of activities unrelated or indirectly related to the Water Agreement, including participation in the Inyo-Mono Integrated Regional Water Management Group, assistance to other County departments needing hydrologic analysis on projects they are working on (e.g., environmental analysis for permitting of solar, industrial, or residential developments), monitoring and management of projects permitted under Inyo County's groundwater ordinance, implementation of the Sustainable Groundwater Management Act of 2014, and development of a County-wide groundwater elevation monitoring network to meet State mandates. These activities are not covered in this Annual Report, but information on their status may be found on our web site http://www.inyowater.org.

SECTION 2: TYPE E – LOS ANGELES LAND IN THE OWENS VALLEY SUPPLIED WITH WATER

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An important benefit that the Inyo/Los Angeles Water Agreement (Agreement) provides to the Owens Valley is the continuation of water deliveries to Los Angeles-owned lands for irrigation, habitat, and recreation. Maintaining water on these lands provides economic opportunities for ranching and growing crops, makes habitat for wildlife, provides recreational opportunities (fishing, hunting, ice skating), controls dust, and positively affects the Valley's aesthetics. The Water Agreement classifies Los Angeles's land into five vegetation types: Type A lands are native vegetation that is not groundwater dependent, Type B lands are groundwater dependent shrub lands, Type C lands are groundwater dependent meadows, Type D lands are riparian vegetation, and Type E lands are lands supplied with water. Water supply for irrigation has received considerable discussion in the past two years. Figure 2.1 shows the location of Type E lands in Owens Valley. In runoff-year 2015, LADWP proposed to drastically reduce irrigation without having approval from the Inyo/Los Angeles Standing Committee, and this year, the Standing Committee considered proposals from both LADWP and the County to reduce irrigation and enhancement/ mitigation water supply without coming to an agreement. This Director's Report identifies the Water Agreement requirements for Los Angeles lands supplied with water, provides some background and history, and discusses various associated issues.

Background

Type E lands are defined in the Agreement as areas where water is provided to city owned lands (Agreement, Section II.E, p. 9):

> *Type E Classification. This classification is comprised of areas where water is provided to City-owned lands for alfalfa production, pasture, recreation uses, wildlife habitats, livestock, and enhancement/ mitigation projects. This classification is shown as blue on the management maps and includes approximately 18,830 acres.*

Although the baseline management maps show 18,830 acres of Type E land, irrigated lands are considerably less – 11,600 acres plus 2,600 acres irrigated for

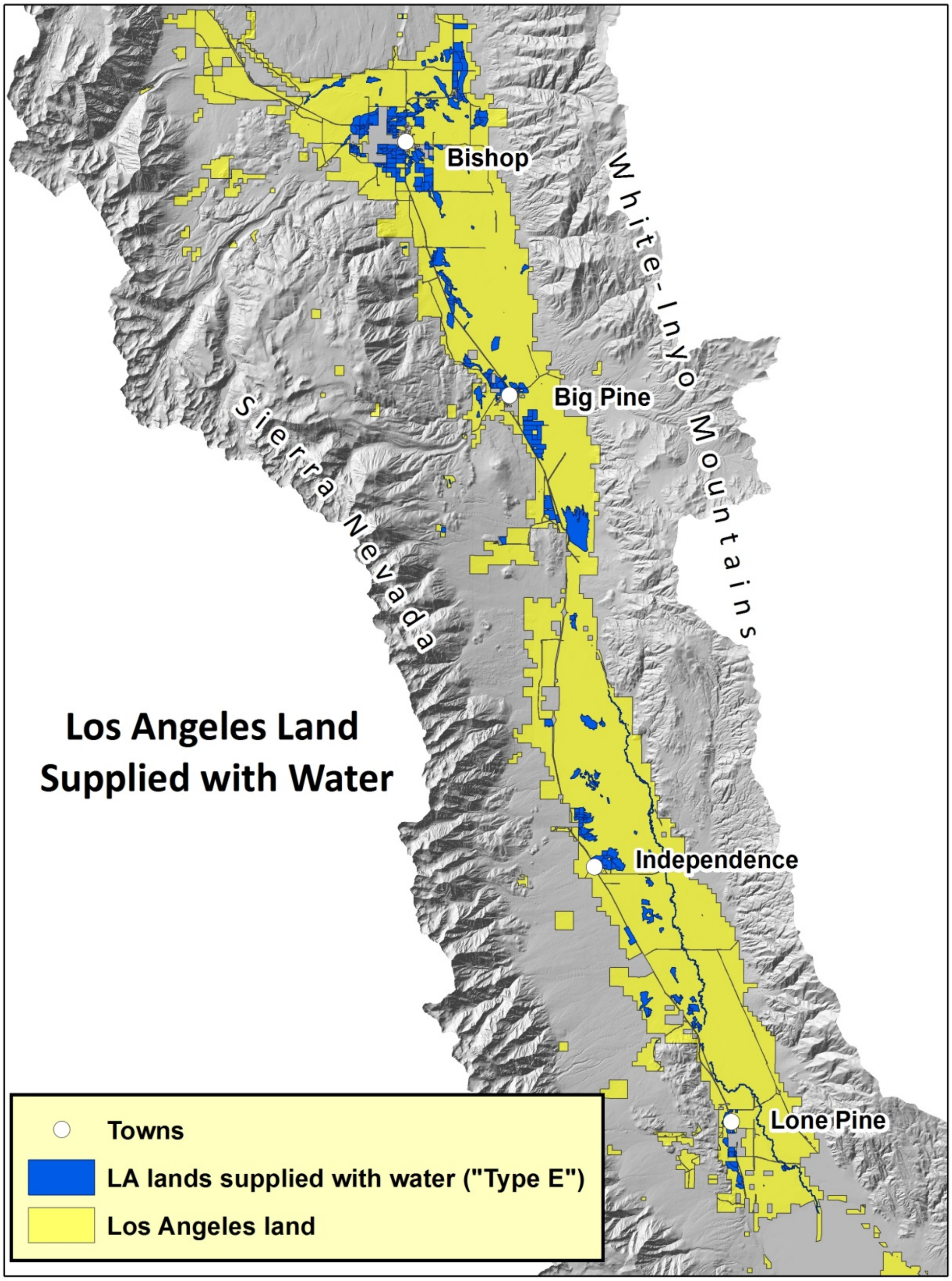

Figure 2.1. Locations of Type E lands in the Owens Valley.

enhancement/mitigation projects. In addition to irrigated agriculture and pasture, Type E lands include water bodies (e.g., Tinemaha Reservoir), rush sedge meadows, and wildlife areas (e.g., Buckley Ponds).

The Agreement sets several goals for managing Type E vegetation: significant decreases or changes from the conditions that existed in runoff-year 1981-1982 should be avoided, Los Angeles will provide water such that water-related uses that were present in 1981-1982 can continue, and recreation and habitat dependent on water supplied by LADWP should not decrease. Here are the goals for Type E land (Agreement, pp. 16-18):

> *Type E Vegetation Classification (Lands supplied with water). These lands will be supplied with water and will be managed to avoid causing significant decreases and changes in vegetation from vegetation conditions which existed on such lands during the 1981-82 runoff year. Significant decreases and changes in vegetation will be determined as set forth in the management goals for Type B, C, and D vegetation; however, conversion of cultivated land be the Department or its lessee to other irrigated uses shall not be considered a significant decrease or change. Another primary goal is to avoid significant decreases in recreational uses and wildlife habitats that in the past have been dependent on water supplied by the Department.*

Though the Agreement requires that water supply to Type E land be maintained to meet these goals, it is also recognized that during successive dry years, there may be insufficient water to meet all needs. In these circumstances, LADWP and the County may agree to reduce irrigation or water supplied to enhancement/mitigation projects. Importantly, such reductions can only take place with the concurrence of the Inyo Board of Supervisors (Agreement, IV.A, p. 17):

> *The Department shall continue to provide water for Los Angeles-owned lands in Inyo County in an amount sufficient that the water related uses of such lands that were made during the 1981-82 runoff year can continue to be made. The Department shall continue to provide water to Los Angeles-owned lands in the Olancha/Cartago area such that the lands that have received water in the past will continue to receive water. Additionally, the Department shall provide water to any enhancement/mitigation projects added since 1981-1982, unless the Inyo County Board of Supervisors and the Department agree to reduce or eliminate such water supply.*
>
> *It is recognized that successive dry years could result in insufficient water to meet all needs. During periods of dry year water shortages, the Technical Group will evaluate existing conditions. A program providing for reasonable reductions in irrigation water supply for Los Angeles-owned lands in the Owens Valley and for enhancement/mitigation projects may be implemented if such a program is approved by the Inyo County Board of Supervisors and the Department, acting through the Standing Committee.*

The Green Book (the technical appendix to the Agreement) gives a number of factors to consider in determining whether to implement reductions to irrigation or enhancement/ mitigation projects which include (1) water use, supply and conservation in Los Angeles, (2) flows in the Los Angeles Aqueduct system, (3) surface water runoff conditions, (4) level of groundwater extractions, and (5) extent of well turn-offs implemented for purposes of environmental protection (Green Book, I.B.4.a, p. 19).

The 1991 Environmental Impact Report (1991 EIR) on the Water Agreement explains that in the 1960's, as Los Angeles planned and constructed the second Los Angeles Aqueduct, irrigated acreage of Los Angeles's land was reduced from 21,800 acres to 11,600 acres, and that the reduced acreage would receive a firm allocation of 5 acre-feet per acre (1991 EIR, p. 4-13):

> *The reduction in irrigated acres began with the modification of leases of Los Angeles-owned land in the mid-1960s. The total leases acreage classified as irrigated by Los Angeles was reduced from a maximum of 21,800 acres to 11,600 acres. The leases for the remaining 11,600 acres of irrigated land were provided with a reliable source of water instead of the "feast or famine" approach that had previously existed. The new leases provided that, even in dry years, "firm" allocation (generally five acre-feet per acre) of water would be provided, subject to physical availability. Irrigated leased lands solely dependent on diversion from a creek for irrigation water receive the full allotment only when sufficient water was available from the natural flow in the creek to supply this amount.*

This reduction in irrigated acreage was identified in the 1991 EIR as a potentially significant impact, but it was concluded that no mitigation was required due to the firm allocation of water provided to the remaining irrigated lands (1991 EIR, pp. 4-14 – 4-18):

> *Impact 14-1 – In anticipation of the proposed project, by 1968 LADWP reduced the amount of land classified as irrigated in Owens Valley from 21,800 to 11,600 acres.*
>
> *As part of the proposed project, LADWP irrigated acreage was reduced and ranch leases were modified to provide a firm allocation of five acre-feet per acre. Irrigated leased lands solely dependent on diversions from a creek for irrigation water would receive the full allotment only when sufficient water was available from the natural flow in the creek. Other irrigated leased lands would receive pumped groundwater, where available, to stabilize water supply during drought years.*
>
> *Figure 14-4 shows that as a result of the modification of ranch leases, water deliveries to ranches were stabilized. The land that was removed from irrigation was mainly poor quality pasture and the higher quality lands that remained irrigated benefited from the firm allotment of water. Alfalfa production in the Valley also increased as a result of the consistent water supply.*
>
> *Mitigation Measure 14-1 – None required.*

The implementation of enhancement/ mitigation projects increased irrigated acreage to 14,200 acres. The 1991 EIR also concluded that the Water Agreement's terms for continued irrigation would not have significant negative impacts:

> *Impact 14-2 – LADWP will continue to provide water for irrigation of Los Angeles-owned land in Inyo County. Under the terms of the Agreement, LADWP will provide water to irrigate Los Angeles-owned lands that were irrigated during the 1981-*

82 runoff year. LADWP will continue to provide water for irrigation of Los Angeles-owned lands in the Olancha/Cartago area in accordance with past practices. In addition, water will continue to be provided to any enhancement/mitigation projects implemented since 1981-82. This will result in a total of 14,200 irrigated acres under the Agreement; however, in the event of successive dry years, a program providing for reasonable reductions in irrigation water supply for Los Angeles-owned lands and for enhancement/mitigation projects may be implemented if such a program is approved by LADWP and the Inyo County Board of Supervisors.

Mitigation Measure 14-2 – None required.

The Water Agreement uses vegetation maps produced from 1984-1987 as a baseline standard by which to assess future change. To address concerns that there was insufficient baseline data in these maps for Type E land, the 1997 MOU provided for additional survey of extant vegetation conditions on Type E lands, which would provide a baseline condition for management of Type E land. Field work for this survey was conducted in 1998 and 1999, and the results were approved by the Inyo/Los Angeles Standing Committee on February 23, 2000.

Status and issues

Los Angeles's water use in Owens Valley has great importance to Inyo County because of the economic, environmental, and social benefits that it provides to the County. It is also watched closely by LADWP because water used in the Valley is water that is not exported to Los Angeles. The severe drought conditions of the past few years brought out a number of issues and disagreements over water use in Owens Valley.

<u>Trends in water supply to lessees.</u> Figures 2.2 and 2.3 show trends in irrigation supply and stockwater supply over time (source: LADWP 2016 Annual Owens Valley Report). Although there has been a decrease in irrigation over the past four years of drought, annual irrigation has generally been in the 40,000 – 60,000 acre-feet per year range since the baseline year of 1981. Stockwater has declined since its peak in the mid-1990s, and is on a gradual downward trend, last year reaching its lowest amount on record (since 1981). Since the Water Agreement's requirements for Type E lands are related to vegetation condition and maintaining water-related uses, valleywide water supply volumes may not directly indicate a water agreement violation; however, the steady decline in stockwater availability affects vegetation condition and water-related uses.

<u>Unilateral withholding of water by LADWP.</u> LADWP's draft 2015 Annual Operations Plan called for 16,500 acre-feet of irrigation – an unprecedented reduction – and LADWP notified most ranch lessees that their irrigation water would be terminated on May 1. This would have crippled ranchers to the point that some likely would not have stayed in business. Since reductions in irrigation require the concurrence of the Inyo County Board of Supervisors, soon after the County became aware of Los Angeles's intentions, the Board of Supervisors notified Los Angeles that "LADWP's unilateral discontinuation of irrigation in the Owens Valley is a clear violation of the Agreement" and requested that LADWP immediately rescind its discontinuation of irrigation. As a result, LADWP continued irrigation, and LADWP, the County, and others worked together to identify

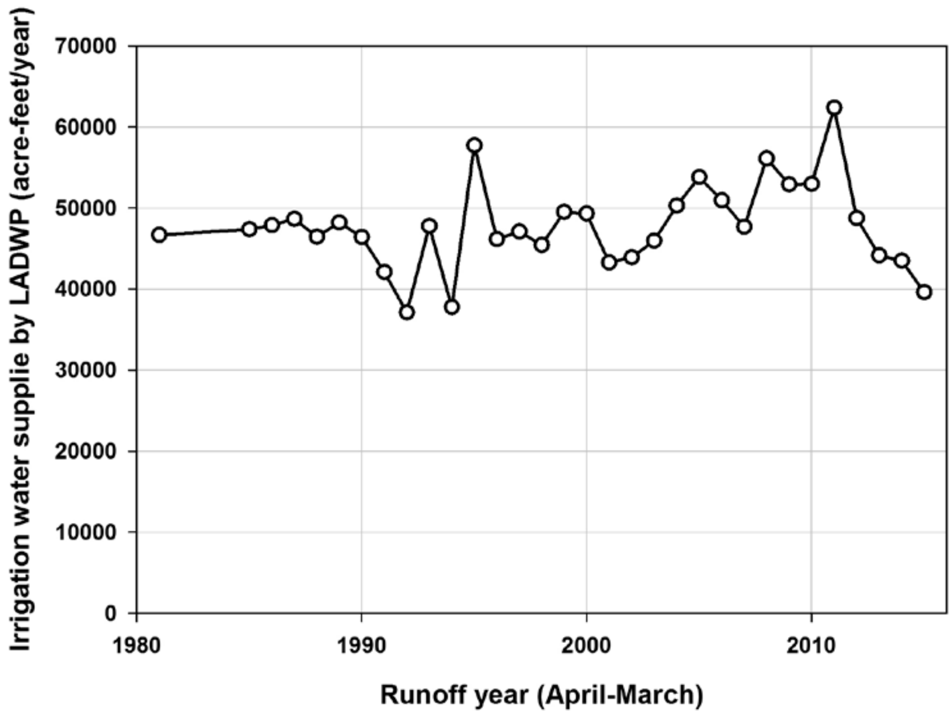

Figure 2.2. Amount of irrigation water supplied to Los Angeles owned lands in the Owens Valley.

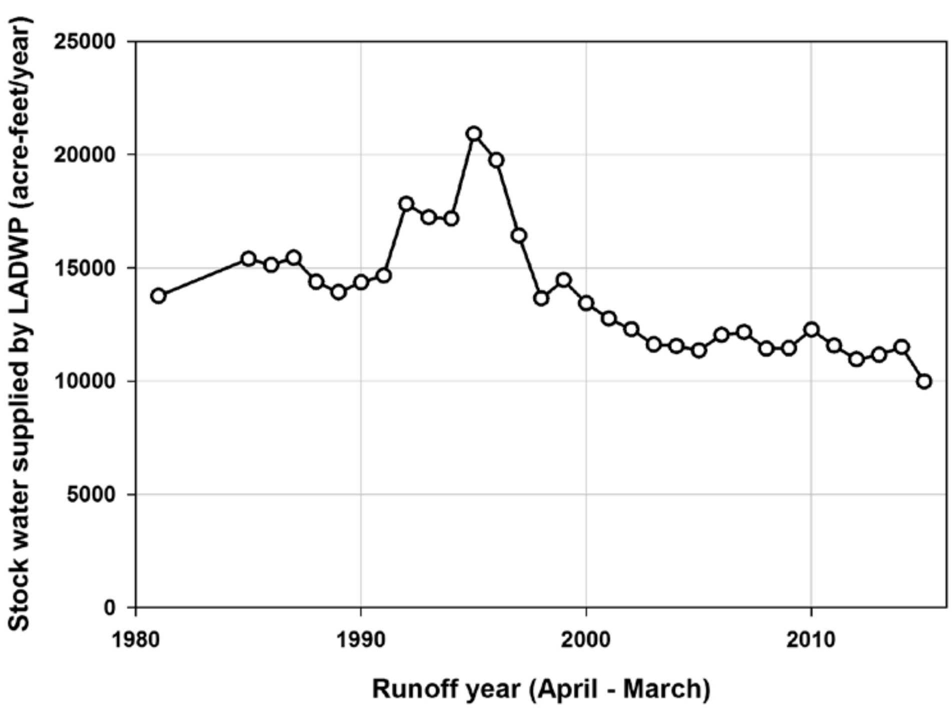

Figure 2.3. Amount of water supplied for livestock on Los Angeles owned lands in the Owens Valley.

less-drastic reasonable reductions to irrigation. Irrigation for 2015-2016 was 39,600 acre-feet.

Ranch lease terms play a role in maintaining the conditions of Type E lands. The 1991 EIR considers the Water Agreement's effects on ranch leases:

> *Ranch Leases 1970-1990 – Impact 14-5 Ranch leases in Owens Valley were modified as a result of the project.*
>
> *When LADWP reduced the amount of land it classified as irrigated in Owens Valley, it modified the leases to provide a firm allocation of water. The term of the leases, however, continued to be five years, as it was prior to the modification. The number of LADWP lessees also remained the same, while the number of leases decreased slightly so that there were fewer leases of larger acreage.*
>
> *In 1978, LADWP reduced the term of the leases to one, two or three years in response to the litigation filed by Inyo County against Los Angeles. All other conditions of the leases remained the same.*
>
> *Mitigation measure 14-5 – None required.*

Under the Water Agreement, the 1991 EIR states that "LADWP ranch leasing policies will remain as they have been during 1970-1990." Over the past few years, Los Angeles has developed new leases which potentially conflict with the Water Agreement due to a number of issues including the amount of water provided, use of stock water, unilateral withdrawal of irrigation by LADWP, and lease charges. These issues remain unresolved.

Water use on Owens Lake. Since 2002, LADWP has used water diverted from the LA Aqueduct to implement dust control measures. Water use on Owens Lake has been as high as 75,500 acre-feet and may increase due to additional dust control requirements. Inyo County has consistently supported LADWP's activities aimed at reducing water use on the lake, along with requesting that LADWP retain a portion of any water conserved for use in Owens Valley. LADWP has succeeded in reducing water use on the lake in the past few years; however, Los Angeles has not committed to retaining a portion of the water for use in Owens Valley. It seems likely that Los Angeles will not make such a commitment, and the most effective path for the County to retain some portion of the conserved water is to carefully monitor and enforce the Water Agreement's requirements for water use in the valley.

Compliance monitoring for Type E land. The Technical Group does not have a program for monitoring Type E land. Requirements for Type E are that there shall be no significant decreases or changes in vegetation, and that sufficient water be supplied such that the water-related uses present in 1981-1982 can be continued. The water-related uses that existed in 1981-1982 are generally poorly documented. Air photos from that irrigation season exist, and recently the Water Department digitized them so they can be analyzed with other geographic data. The air photos do not provide quantitative measures of baseline vegetation cover, but they can be used to identify whether a given parcel was fully irrigated, partially irrigated, or unirrigated during the baseline period, and compared to contemporary air photos.

Lack of baseline data. Baseline data for Type E vegetation is either non-quantitative or incomplete. No field measurements exist for the baseline irrigation season of 1981. Air photos from 1981 show where irrigation was occurring, but they do quantitatively document the baseline vegetation condition. The 1999 study that was conducted to document conditions on Type E land for the purpose of setting baseline conditions did not survey all Type E parcels.

Unilateral reductions to enhancement/ mitigation project water supply – McNally Ponds. The Water Agreement allows for reduced water supply to irrigated lands and enhancement/mitigation projects during prolonged drought conditions. A number of times in the past, the County has agreed to such reductions when low-runoff conditions reasonably merited such reductions. One project that has been subject to such reductions is the McNally Ponds and Pasture Enhancement/Mitigation Project. This project entails irrigation of pastures during the summer irrigation season and filling ponds for water fowl during the fall and winter. The project is in the Laws area and can be supplied either by diverting surface water into the McNally Canals or by groundwater wells. A problem that has repeatedly arisen during dry years is that the nearby groundwater wells that feasibly could supply the project are in Off-status under the Water Agreement's well management rules, and LADWP does not want to incur the conveyance losses resulting from routing water from the Owens River through the Lower McNally Canal to the project. Recognizing these problems, the County has agreed to reduce the water supply to the project a number of times. In spring of 2015, due to the severe drought, the County agreed to reduce the water supply to the project. LADWP however did not agree to a Standing Committee motion to reduce the supply, contending that they could unilaterally reduce the water supply to the project because (1) the project was never intended to receive water during dry years, and (2) to divert water into the Lower McNally Canal during a dry year would be a violation of the Water Agreement's requirement canals be operated consistent with LADWP's past practices. The County served LADWP with a notice initiating a dispute as to whether LADWP could unilaterally decide to reduce the water supply to the project, and the dispute was resolved by LADWP agreeing at a subsequent Standing Committee meeting that the water supply would be reduced. The issue was not whether the supply for the project should be reduced – both Inyo and LADWP agreed that it would be appropriate to reduce the supply. Rather, the issue was whether LADWP could take that action without the County's approval. Although it would seem that this disagreement was resolved last year, this year LADWP again intends to reduce the supply to the project without Standing Committee approval.

Other water obligations. This report addresses a number of issues related to lands that Los Angeles historically has supplied water to, which are identified in the Water Agreement as Type E lands. Los Angeles has a host of other water obligations in Owens Valley, including water supplied to tribes under a 1938 agreement between Los Angeles and the Bureau of Indian Affairs, obligations to the Bishop Creek Water Association, the Big Pine Water Association, and the Big Pine Irrigation and Improvement District; maintenance of fish flows in streams covered by California Department of Fish and Wildlife regulations; water use to control dust on Owens Lake; supply for the towns of Lone Pine, Independence, Big Pine, and Laws; and a number of mitigation projects requiring water. Each of these obligations has its own set of controversial and difficult issues.

The Water Agreement's requirements for water use in Owens Valley are complex and fraught with conflict, and are a central part of the Water Department's work in monitoring and enforcing the Water Agreement.

SECTION 3: PUMPING MANAGEMENT AND GROUNDWATER CONDITIONS

LADWP prepares an operations plan each April in accordance with the Water Agreement. The plan describes runoff conditions, wellfield pumping, water uses in the Valley, and export to Los Angeles.

ICWD and LADWP each monitor groundwater levels throughout the Valley.

2015-16 Pumping Plan and Groundwater Conditions

In accordance with the Water Agreement, LADWP prepares an operations plan each April for the twelve month runoff year beginning April 1st. In the event of two consecutive dry years when actual and forecasted Owens Valley runoff for the April to September period are below normal and average less than 75 percent of normal, LADWP prepares two six-month plans. The 2015-16 runoff year qualified under the consecutive drought year provision. The first plan described operations from April 1st to September 30th, and the second plan covered October 1st to March 31st. Each plan included projected amounts for runoff, pumping, reservoir storage, water used in the Owens Valley, and water exported to Los Angeles. Also, the plans must comply with the pumping well On/Off provisions of the Agreement based on soil water and vegetation measurements. The Inyo County Water Department reviews LADWP's proposed operations plans, 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 plans.

Runoff from the Owens River watershed during the 2015-16 runoff year was forecast to be 148,600 ac-ft or 36% of normal. This forecasted runoff smashed the previous driest year on record. Fortunately, it seems the preliminary estimates of runoff was substantially higher (approximately 48% normal), but still a record. The final runoff value will be available later in 2016 when the all the surface water measurements that constitute the sum have been verified and tabulated.

Total pumping within the Owens Valley for 2015-16 was 70,334 acre-feet (ac-ft), which was slightly less than the planned pumping of 75,285 ac-ft (Table 3.1). In most wellfields, actual pumping was within 500 ac-ft of the planned amount except for Big Pine, Taboose-Aberdeen, and Bairs-Georges wellfields where pumping was 1000-2000 ac-ft less than planned.

The effect of pumping and runoff in 2015-16 on water levels in key test wells is shown in Table 3.2. The County uses data from 46 test wells to predict the effect of pumping on the water table depth (DTW). Four wells were dry in April 2016 preventing evaluation.

Table 3.1. Planned and LADWP actual pumping by wellfield for the 2015-16 runoff-year. Estimated minimum pumping prepared by Inyo County for sole source uses is included for reference although in an extremely dry year minimum pumping would be insufficient to supply all uses.

Wellfield	Estimated Minimum Pumping (ac-ft)	Planned Pumping (ac-ft)	Actual Pumping (ac-ft)
Laws	6,300	5,806	5,742
Bishop	10,400	10,352	10,505
Big Pine	20,550	22,909	20,578
Taboose-Aberdeen	300	10,543	8,706
Thibaut-Sawmill	8,160	8,305	8,358
Ind.-Oak	5,990	9,135	9,561
Symmes-Shepherd	1,200	5,683	4,682
Bairs-Georges	500	1,670	1,323
Lone Pine	1,035	882	888
Total	54,435	75,285	70,334

Water tables declined in 26 of the 42 non-dry test wells; the average change in DTW in the 42 wells was a decline of 0.36 feet (Figure. 3.1). Water levels rose in four wells near the Blackrock Fish Hatchery (415T, 417T, 505T, 803T) by one to two feet in continued response to the reduction in pumping at the hatchery resulting from the 2014 settlement of the Blackrock 94 dispute. Water levels remain below the levels of the mid-1980's (average 1985-87) in nearly all wells.

The Water Agreement and Green Book include procedures to calculate a pumping limit to prevent groundwater mining to ensure no long term decline in aquifer storage. The mining calculation is a comparison of pumping and recharge for each wellfield on a water year basis (October 1 through September 30) for a 20 year period. The 19.5-year total of actual pumping is subtracted from 20 years of estimated recharge to arrive at an estimated April-September pumping limit for each wellfield and the Owens Valley as a whole. The estimate of 2015 groundwater recharge in the Owens Valley from the mining calculations was approximately 101,546 ac-ft compared to 64,573 ac-ft of pumping for the 2015 water year, and no wellfield was in violation of the groundwater mining provision.

Summary of Hydrologic Conditions

The history of Owens Valley pumping and runoff are presented in Figures 3.2 and 3.3. 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 in feet.

Laws Wellfield

In the 1970's and 80's, pumping and 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 3.4, 3.5, and 3.6). 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

Table 3.2. Depth to Water (DTW) at indicator wells, April 2016. All data are in feet. Depths are from reference point on test well. A negative change indicates a water table decline. Baseline elevation at monitoring sites was predicted from monitoring site/indicator well regression models if the test well was not present 1985-87.

Wellfield Well ID	**DTW** **April 2016**	**Change from April 2015**	**Change from April 2011**	**Deviation from Baseline in 2016**
Laws				
107T	Dry			
436T	13.95	-0.29	-3.16	-5.85
438T	16.99	-0.81	-5.12	-7.39
490T	18.08	-0.58	-3.23	-5.01
492T	37.17	-0.64	-3.8	-4.37
795T, LW1	Dry			
V001G, LW2	Dry			
574T, LW3	17.44	-0.14	-1.84	-4.22
Big Pine				
425T	21.87	0.16	-4.29	-6.97
426T	17.28	-0.09	-3.95	-5.71
469T	25.92	-0.43	-2.98	-4.25
572T	18.13	-2.08	-4.31	-6.23
798T, BP1	22.50	-2.08	-5.8	-6.32
799T, BP2	22.32	0.15	-2.82	-3.94
567T, BP3	21.13	0.50	-4.53	-7.16
800T, BP4	20.26	0.00	-4.06	-6.71
Taboose Aberdeen				
417T	28.80	1.13	2.82	-1.83
418T	10.16	-0.06	-0.44	-1.93
419T	9.32	-0.25	-1.44	-2.69
421T	39.45	-0.90	-3.92	-5.10
502T	12.57	-0.23	-3.34	-5.08
504T	13.36	-0.37	-1.97	-2.59
505T	20.67	1.18	2.62	-2.07
586T, TA4	10.68	-0.25	-2.08	-2.39
801T, TA5	16.27	0.45	-3.07	-0.17
803T, TA6	10.30	1.42	3.00	-2.04
Thibaut Sawmill				
415T	13.70	1.16	8.09	4.80
507T	5.69	-0.66	-1.07	-1.02
806T, TS2	13.85	0.82	-0.75	-1.41
Independence Oak				
406T	6.38	-0.51	-3.02	-4.81
407T	16.20	-0.55	-6.39	-8.90
408T	8.17	-1.14	-5.44	-5.04
409T	17.42	-4.23	-13.15	-15.82
546T	11.62	-0.77	-5.93	-8.19
809T, IO1	16.87	-1.05	-7.57	-1.75

Wellfield Well ID	**DTW** **April 2016**	**Change from** **April 2015**	**Change from** **April 2011**	**Deviation from** **Baseline in 2016**
Symmes Shepherd				
402T	11.00	1.02	-1.03	-2.97
403T	9.05	-0.02	-1.82	-3.72
404T	6.17	0.84	-1.32	-2.60
447T	47.81	-4.84	-12.06	-25.94
510T	7.41	0.98	-1.13	-2.41
511T	8.99	0.72	-2.79	-4.36
V009G, SS1	28.05	-2.91	-11.05	-22.64
646T, SS2	Dry			
Bairs George				
398T	5.95	0.09	-1.84	0.40
400T	6.75	0.38	-1.16	-0.45
812T	18.84	-0.16	-3.46	-5.59

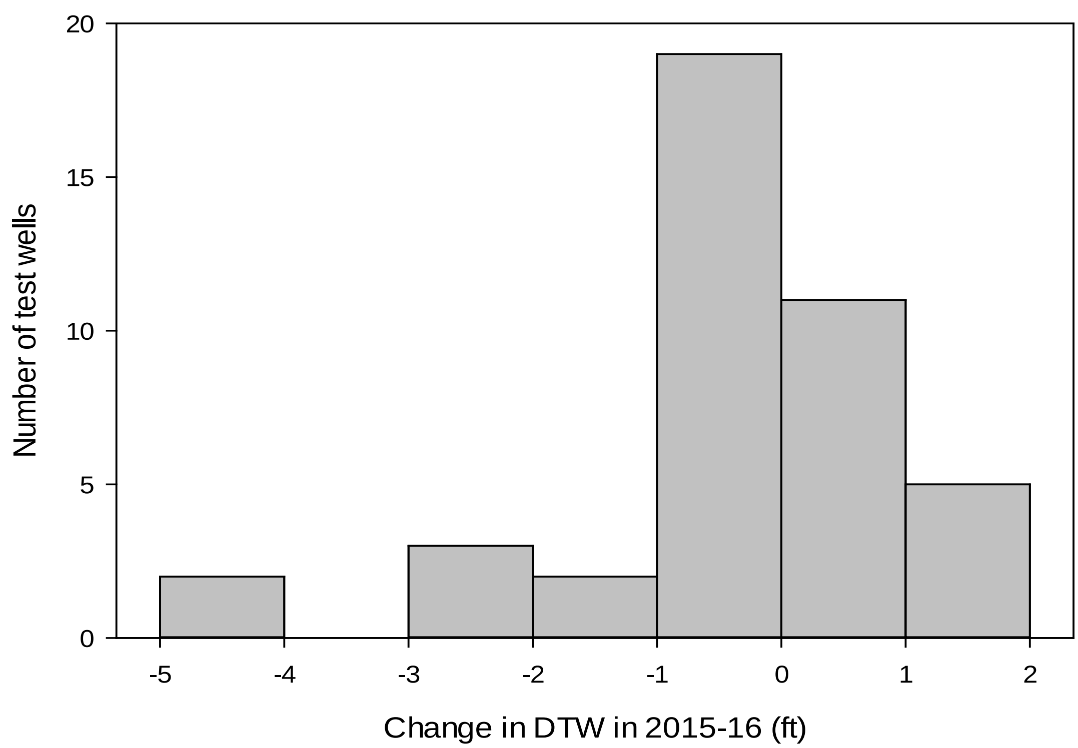

Figure 3.1. Histogram of change in DTW between April 2015 and April 2016 for 42 test wells.

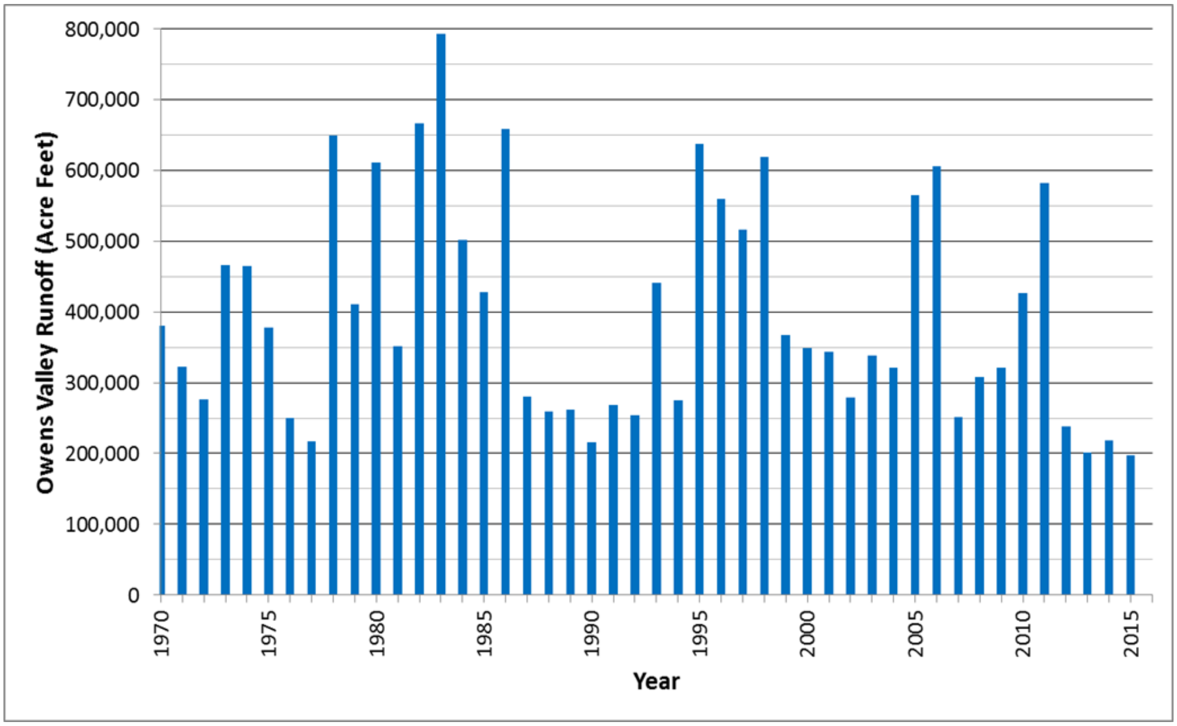

Figure 3.2. Measured Owens Valley runoff since 1970. Values are for the runoff year (e.g. runoff year 2015 includes pumping from April 2015 through March 2016).

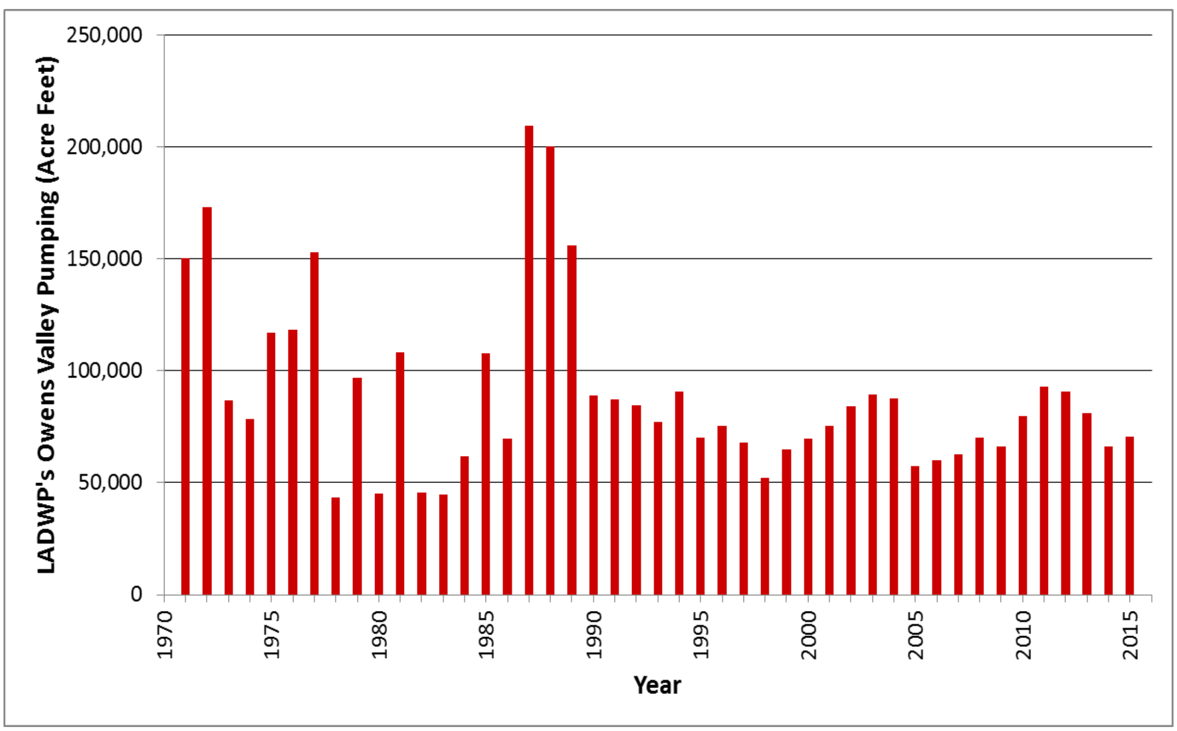

Figure 3.3. Total LADWP pumping in the Owens Valley since 1970 by runoff year.

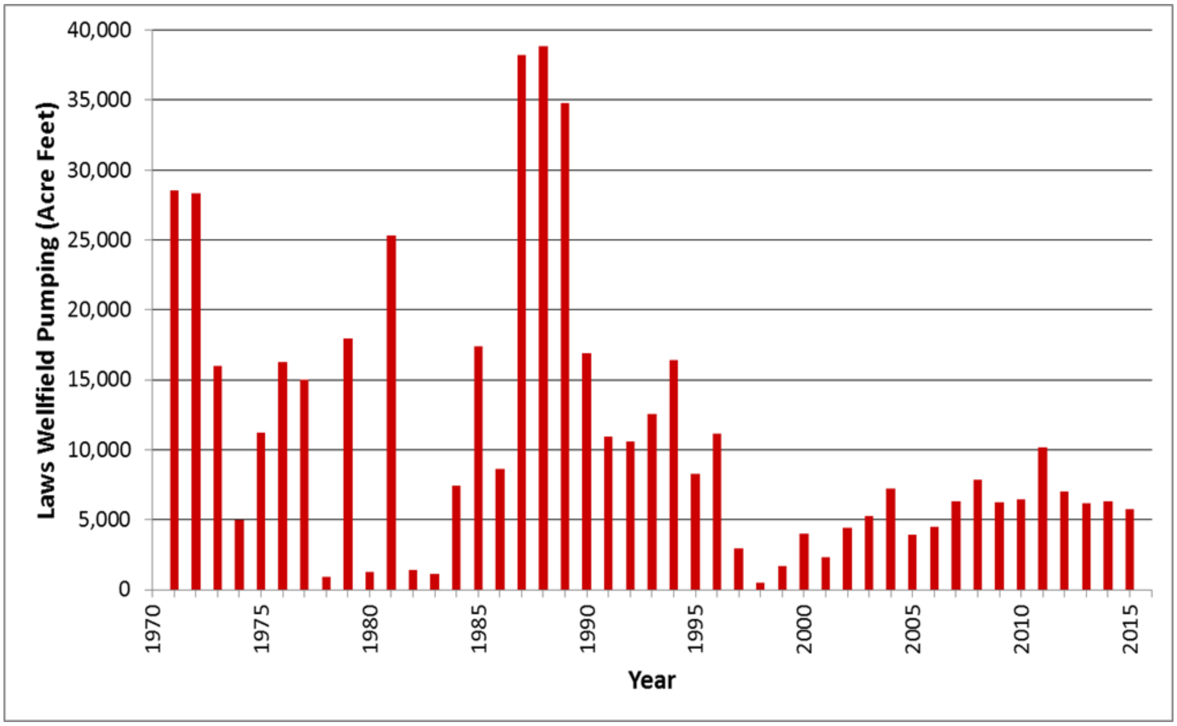

Figure 3.4. Pumping totals for the Laws wellfield.

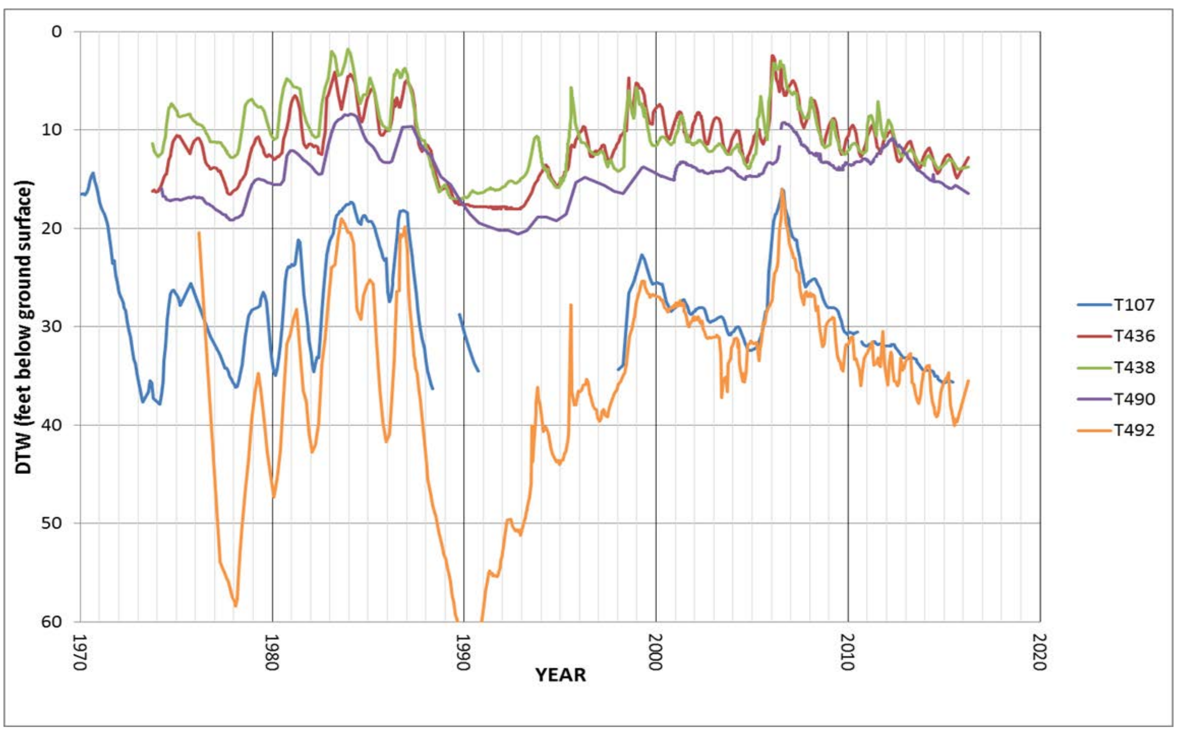

Figure 3.5. Hydrographs of indicator wells in the Laws wellfield. Well 492T is dry if DTW is below 60 ft. Missing data for well 107T reflect when the well was dry.

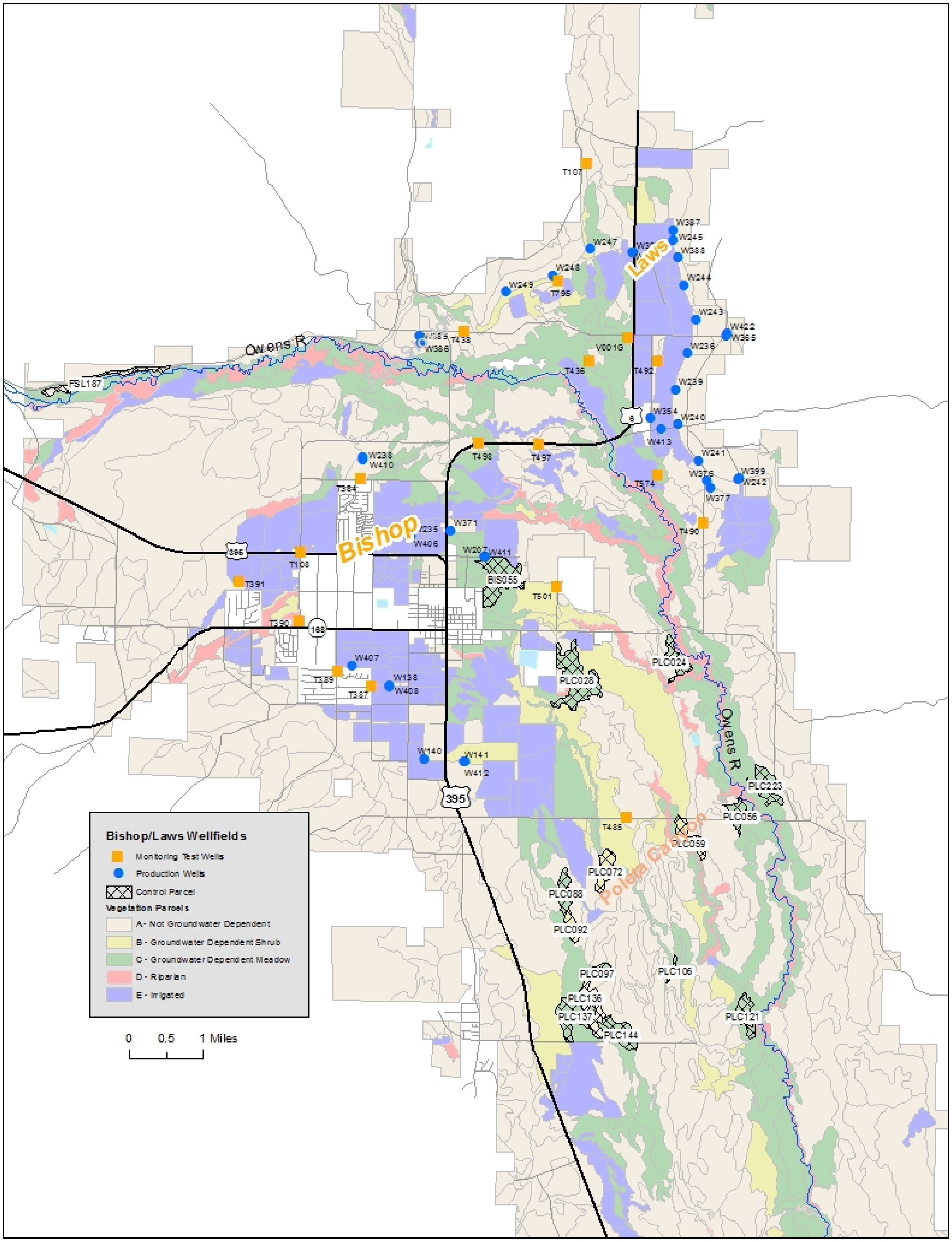

Figure 3.6. Map of monitoring wells and LADWP production wells in Laws and Bishop wellfields.

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 uses in the wellfield and by water spreading in 2005 and 2006. In 2015-16, DTW declined in all test holes, and all test holes were below baseline water levels in April 2016 (Table 3.2).

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 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 water balance of the system of canals and ditches that convey water for irrigation. Water supplied for irrigation in west Bishop upstream of LADWP pumping wells consists of surface water alone diverted primarily out of Bishop Creek and the Owens River. Pumped water is conveyed for irrigation using the same ditches and canals that convey 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 with the sum of uses.

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.

The most recent Bishop Cone Audit examined conditions for the 2014-15 runoff year. Total groundwater extraction (pumping and flowing wells) on the Bishop Cone was 15,229 ac-ft compared with 20,452 ac-ft of recorded uses. Therefore, uses on the Bishop Cone exceeded extractions by approximately 5,223 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, also called the Bishop Cone, has been relatively constant for the past 25 years except in above normal runoff years when pumping decreased, for example 1998 and 2006 (Figure 3.7). 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. Water levels in west Bishop typically peak after the summer irrigation

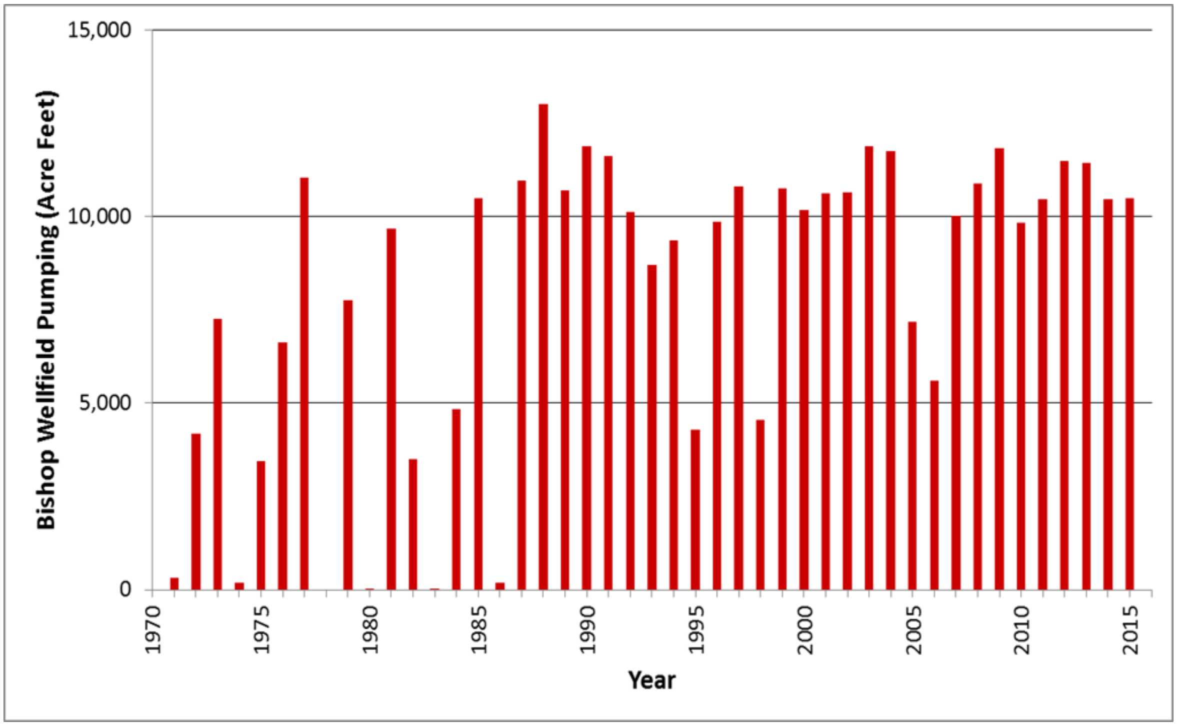

Figure 3.7. Pumping totals for the Bishop wellfield.

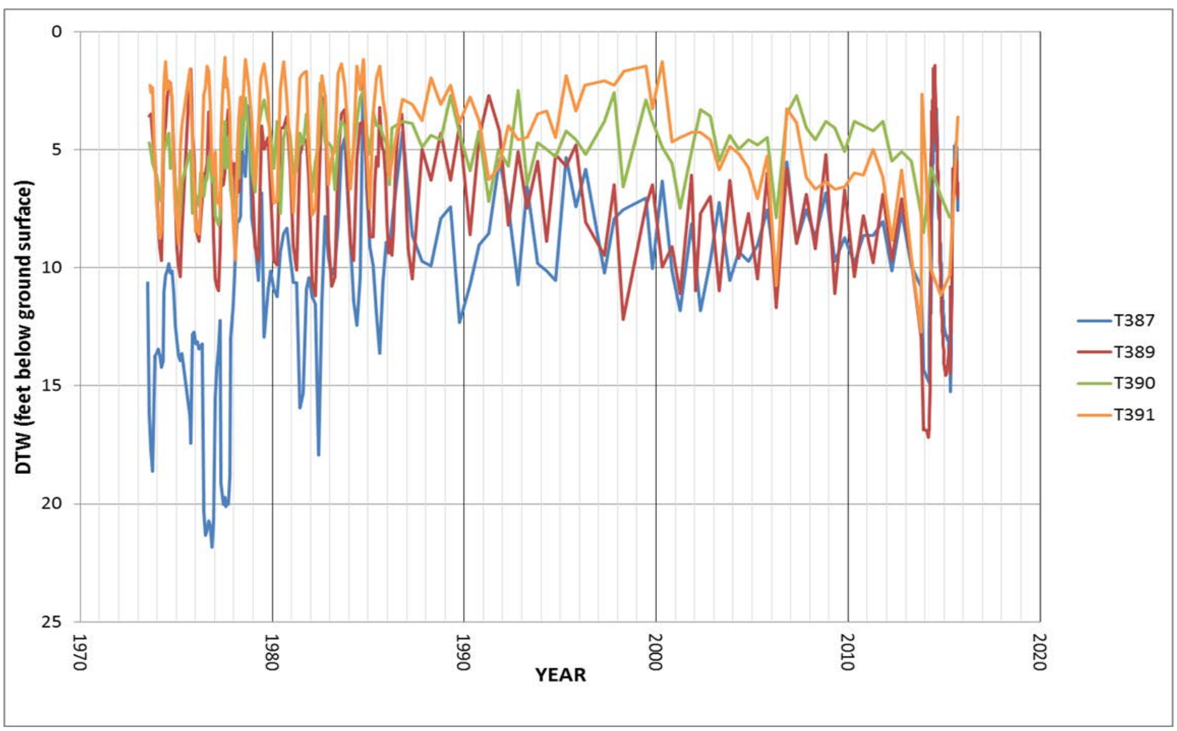

Figure 3.8a. Hydrographs of selected monitoring wells in the western Bishop wellfield. The wells are located in west Bishop in a northwest to southeast line roughly from the northern end of the McLaren Lane development to the eastern end of Sunrise Drive.

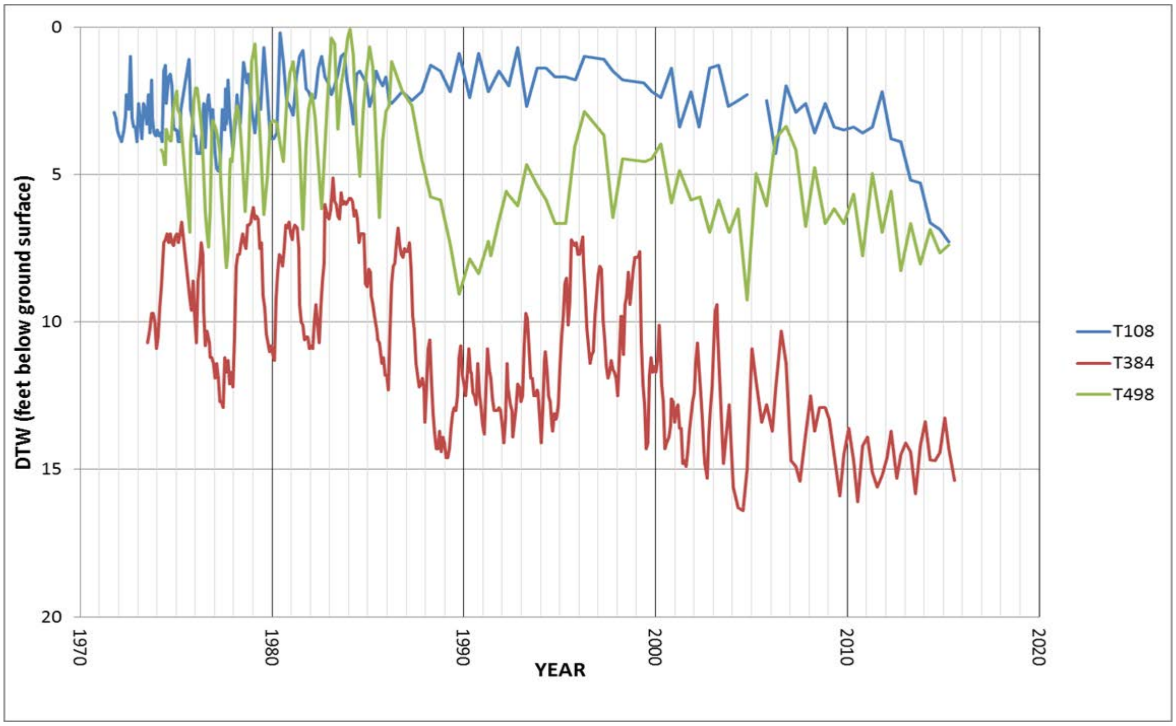

Figure 3.8b. Hydrographs of selected monitoring wells in the northern Bishop wellfield. The wells are located in a southwest-northeast line from Brockman corner, Dixon Lane, to U.S. 6

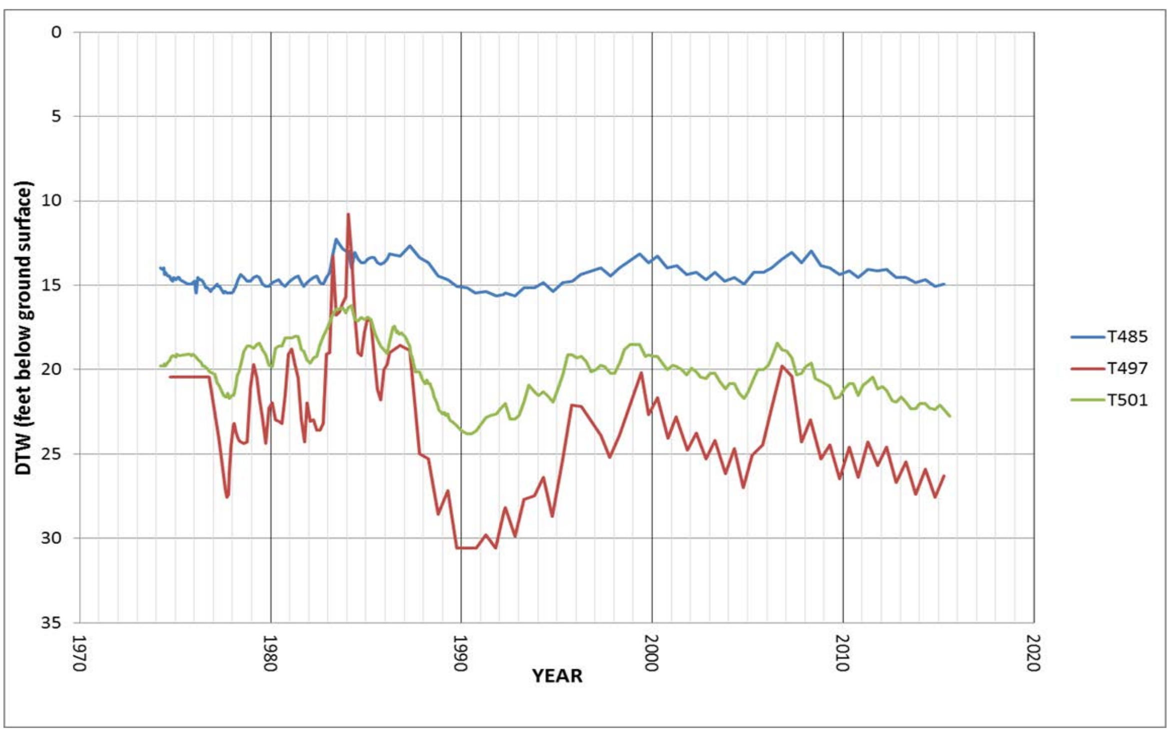

Figure 3.8c. Hydrographs of selected monitoring wells in the eastern Bishop wellfield. The wells are located in a north-south line from U.S. 6, Bishop airport, to Warm Springs Road. The wells are separated from the Bishop pumping wells by a series of north-south trending faults.

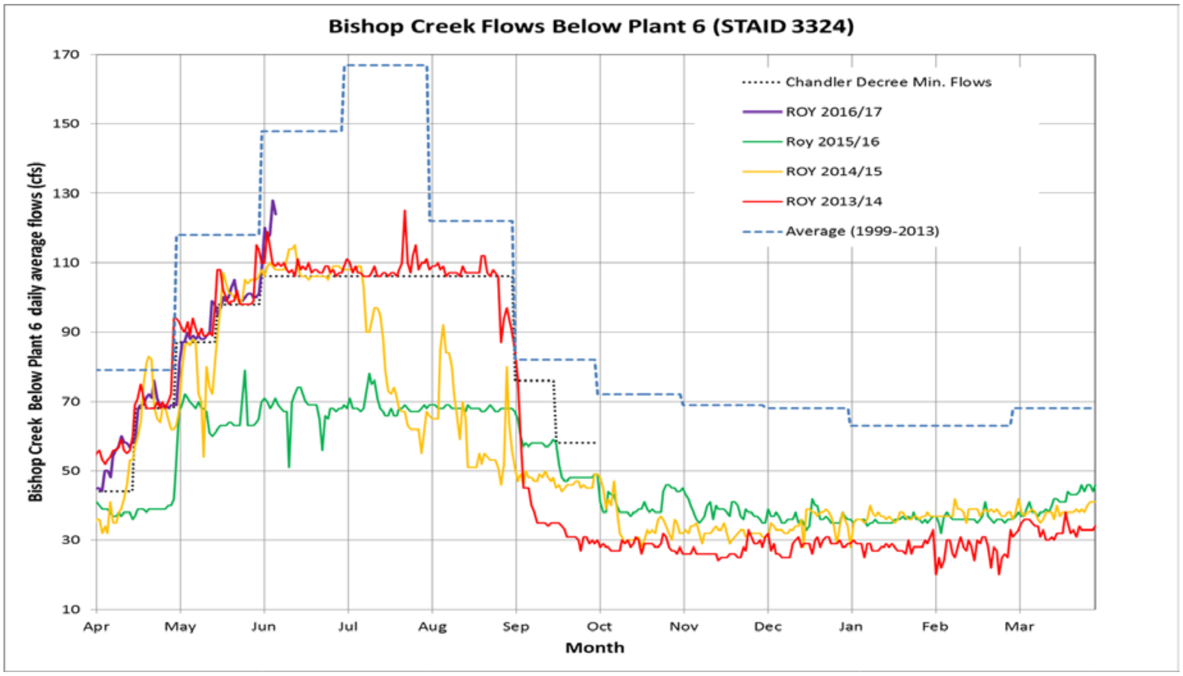

Figure 3.9.a. Hydrographs of Bishop Creek daily average flows below Plant 6 (in cubic feet per second) for runoff years 2013 to date. Also shown are the average flows in Bishop Creek and the Chandler Decree minimum flows for Bishop Creek. Note the low flows in the fall/winter of 2013.

season. Groundwater levels from 1980 to 2014 at several test wells located west, north, and east of the city of Bishop are presented in Figures 3.6 and 3.8a -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 ongoing (2012 to date) drought, along with other factors discussed below, can be seen in the recent water levels from Bishop Cone wells, especially wells in the western and northern portions of the wellfield.

In 2013-14, prolonged and severe drought conditions resulted in reduced flow in Bishop Creek and, therefore, reduced surface water flows onto the Bishop Cone (Figure 3.9a and 3.9b). Changes to the historic management practices of upstream reservoirs and Bishop Creek flows also occurred in 2013, allowing more runoff to flow into Bishop Creek in the spring with less runoff stored in the reservoirs for use later in the season. This change contributed to a lack of available surface water for irrigation in fall of 2013. Due to the reduced irrigation supplied by surface water diversions from Bishop Creek, dry ditches occurred in the west Bishop area in fall of 2013.

In addition to reduced surface flows in west Bishop, LADWP pumped a record amount of groundwater from Well 407 (Figure 3.9.c). Traditionally, LADWP pumps groundwater from W407 from April through September during a given year. In 2013, W407 pumped groundwater from April into December, pumping an additional 279 acre feet of groundwater during the October through December period. The total amount of groundwater pumped from W407 in 2013 was

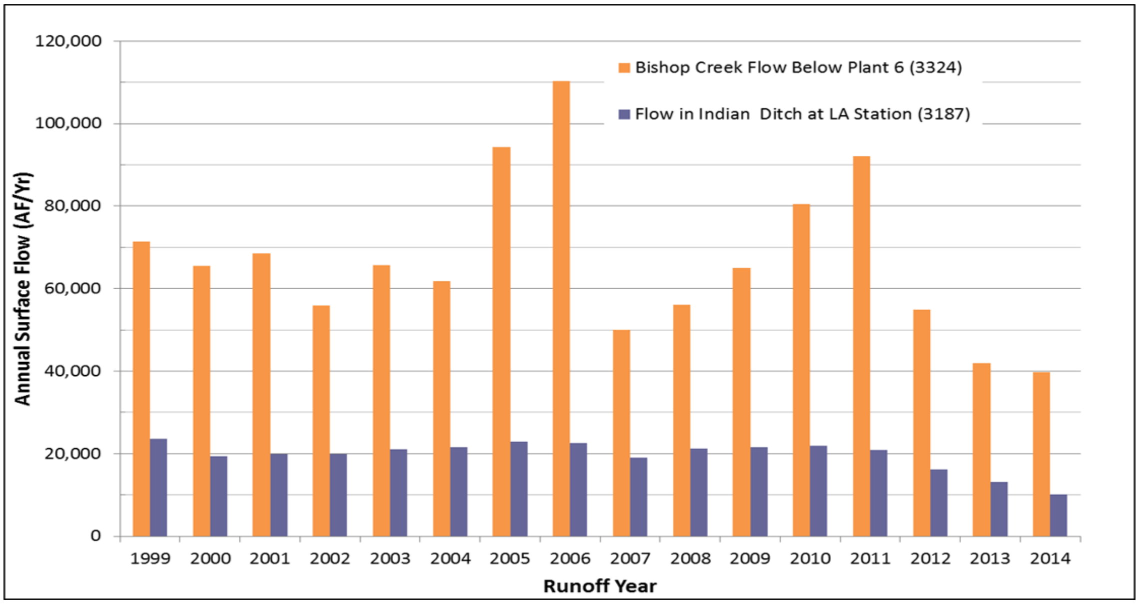

Figure 3.9b. Hydrographs of surface flows totals (in acre feet per year) in Bishop Creek at Plant 6 and in the North and South Indian Ditch at LA Station just east of Plant 6.

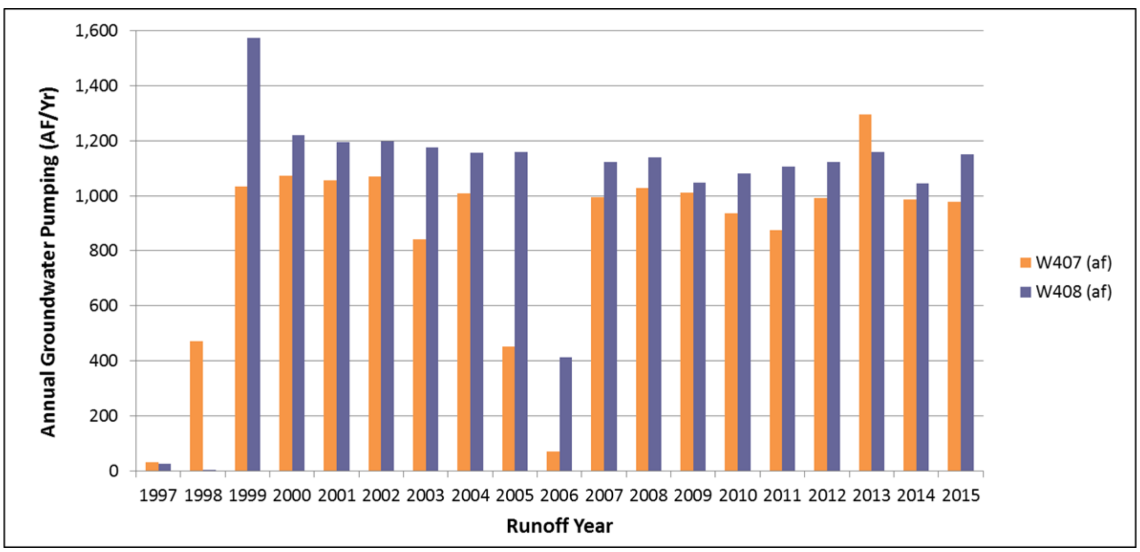

Figure 3.9c. Pumping totals for Bishop wellfield wells W407 and W408. These two wells are located south of Line Street and east of Barlow Lane. Note the amount of water pumped from W407 in 2013.

1,295 acre feet, 200 acre feet more (20%) than the next highest year (2000). This increase in pumping appears to have contributed to localized drawdown in the surrounding area.

It is likely that a combination of diminished surface water flows caused by ongoing drought, the change in timing of Bishop Creek surface flows, and the additional pumping of Well 407 negatively affected shallow groundwater levels

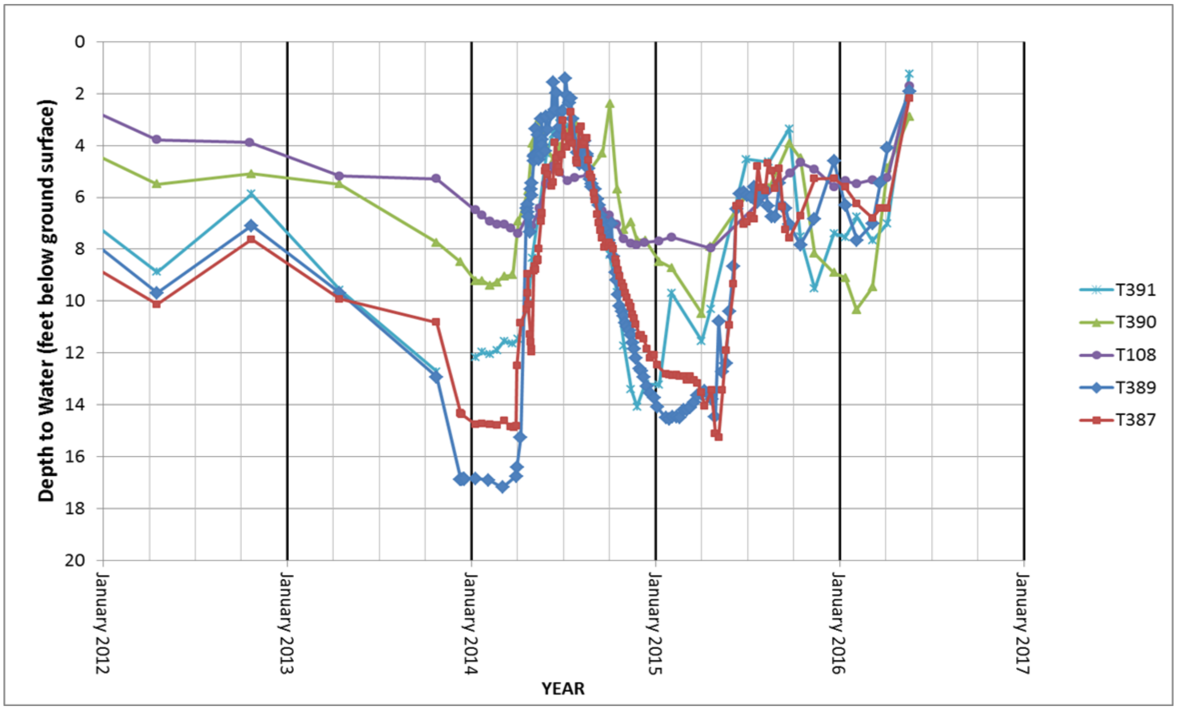

Figure 3.10. Recent hydrographs of selected monitoring wells in western Bishop wellfield.

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. Hydrographs of these groundwater levels declines can be seen in Figure 3.10. 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 this prolonged drought.

From the water table lows in fall and winter of 2013-14, groundwater levels recovered during summer of 2014 in west Bishop in the range of 7 to 16 feet (T390 to T389, respectively). During the fall and winter of 2014-15, worsening drought conditions with associated lowered runoff amounts contributed to persistent low groundwater levels in west Bishop. In 2014-15, LADWP managed Bishop Creek surface flow distributions and peak flow timing, as well as pumping in the west Bishop area in a manner more consistent with historic practices, with Well 407 turning off in early October 2014. However, due to the cumulative effects of the drought, groundwater table lows in fall and winter 2014-15 were similar to 2013-14.

However, increased surface flows in Bishop Creek (and the associated west Bishop ditches) during the fall and winter of 2015-16 have led to a rebound of the water table as compared to 2013-14 with depths-to-groundwater as much as 5 feet closure to the surface. For 2016-17, the forecasted flows in Bishop Creek are expected to comply with the Chandler Decree minimums through September 2016 with enough water retained in storage to keep 2016-17 fall and winter flows above 2015-16 flows.

Important takeaways for the Bishop Cone:

- 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 west Bishop
- Many of the private wells in west Bishop are shallow and, therefore, more vulnerable to impacts associated with deepening groundwater levels
- Thoughtful water management of Bishop Creek flows and the associated diversion and ditch flows should be used during drought and/or low runoff years
- 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.

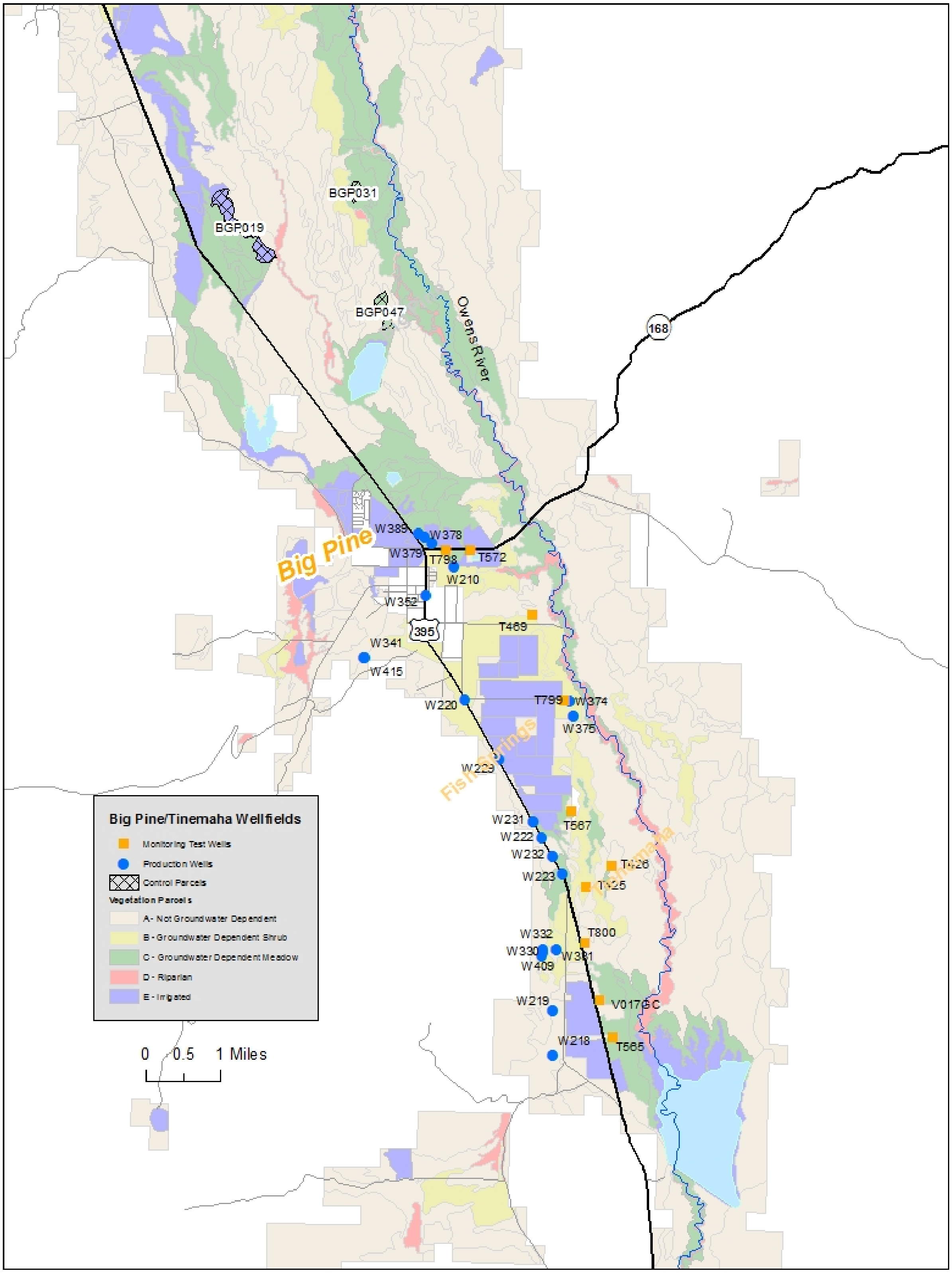

Figure 3.11. Map of monitoring wells and LADWP production wells in Big Pine wellfield.

Big Pine Wellfield

A map of the indicator and production wells for Big Pine is presented in Figure 3.11. Pumping in the Big Pine wellfield since 1974 has been relatively large compared with other wellfields (Figure 3.12). 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 2015, pumping also included approximately 99 ac-ft from well 375W to replace surface water supplied to the Big Pine northeast regreening project.

From 2009 to 2016, wellfield pumping has been greater than the minimum for required uses, although pumping has declined slightly each year since 2011. The increase in pumping was primarily for aqueduct supply from exempt well 219W located in the southern portion of the wellfield, west of the irrigated pastures along U.S. 395. It should be noted that most of the hatchery pumped water also reaches the aqueduct.

DTW in indicator and monitoring site wells in the southern of the wellfield declined or rose slightly; water levels declined in wells in the northern portion of the wellfield (572T and 798T; Figure 3.13 and Table 3.2). All wells remain between 3 to 7 feet below baseline levels in April 2016 (Table 3.2) . Two test wells located just east of U.S. 395 near 218W and 219W were examined to assess possible impacts from the additional export pumping of recent years (Figure 3.14). Both V017GC and 565T are located in or adjacent to groundwater dependent vegetation. Water levels have declined in response to drought and pumping since 2012 when they were above their 1985-87 baseline. Well V017GC continues to decline, and is approximately four feet below baseline; 565T is approximately one foot baseline.

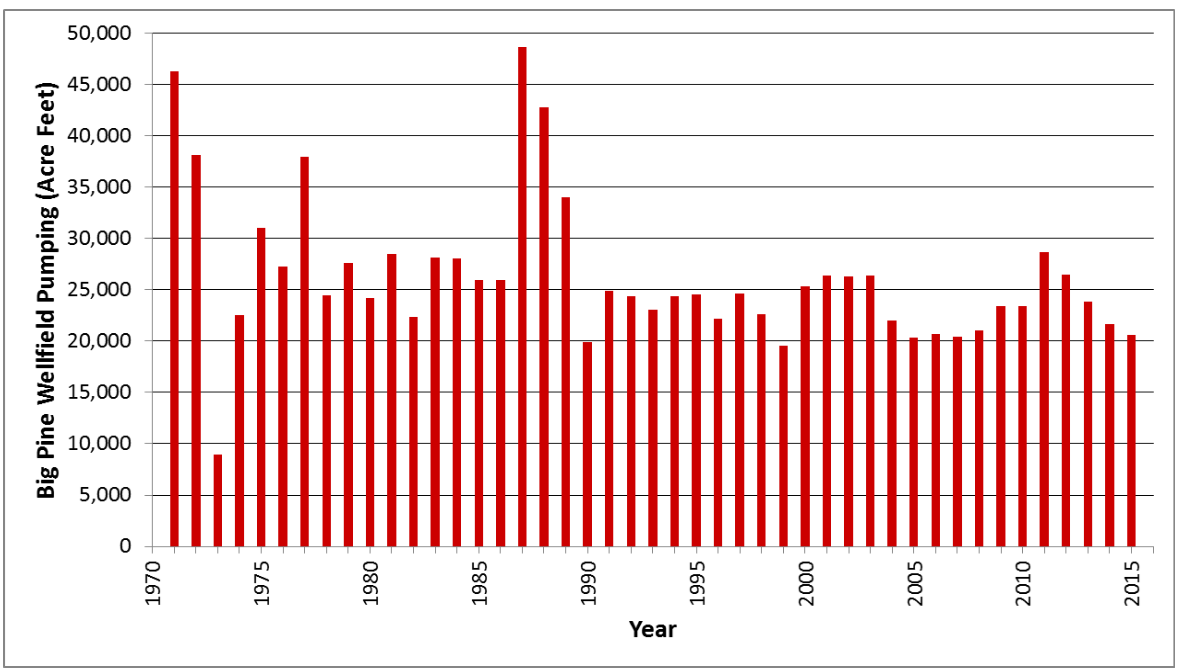

Figure 3.12. Pumping totals for the Big Pine wellfield.

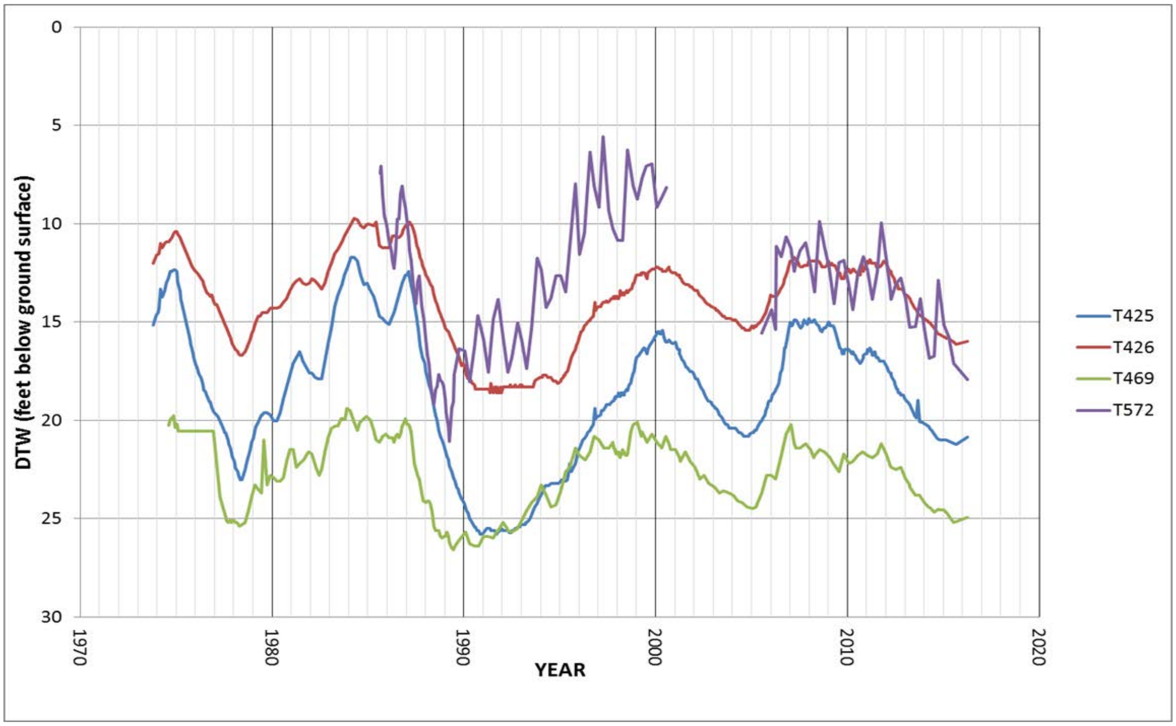

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Figure 3.13. Hydrographs of indicator wells in the Big Pine wellfield. Periods of missing data for 572T occurred when the well was plugged and in need of repair.

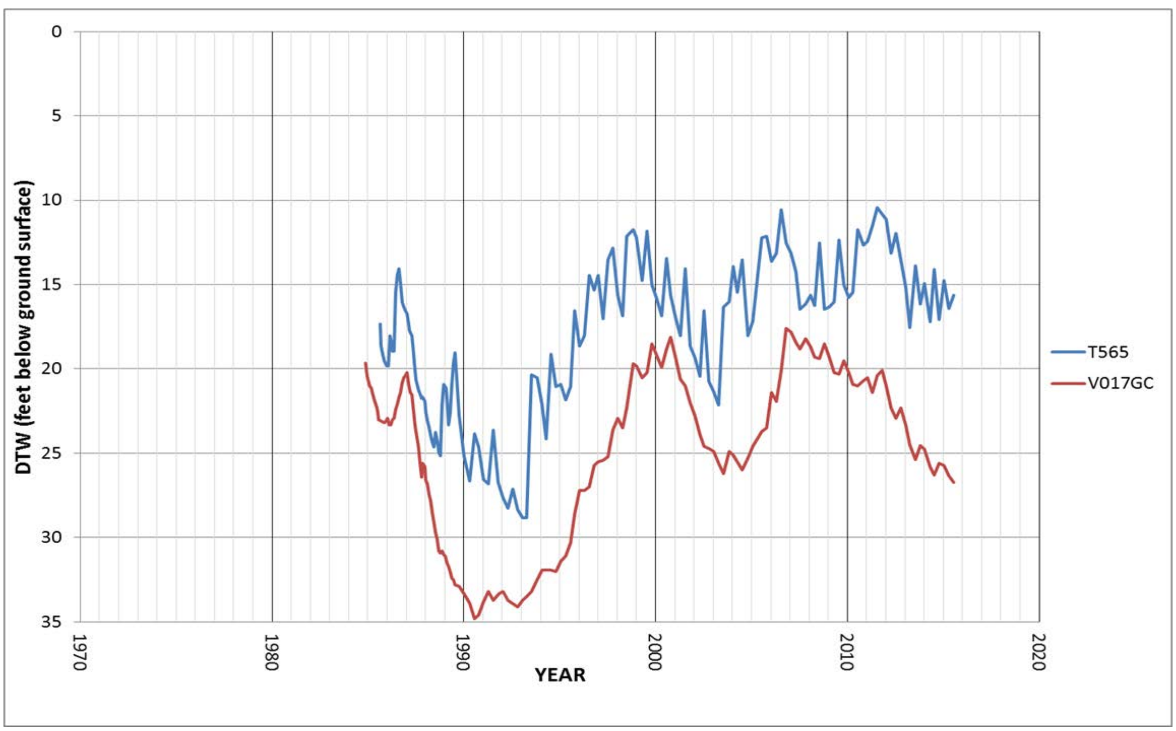

Figure 3.14. Hydrographs of monitoring wells in the southern Big Pine wellfield near pumping wells 218W and 219W.

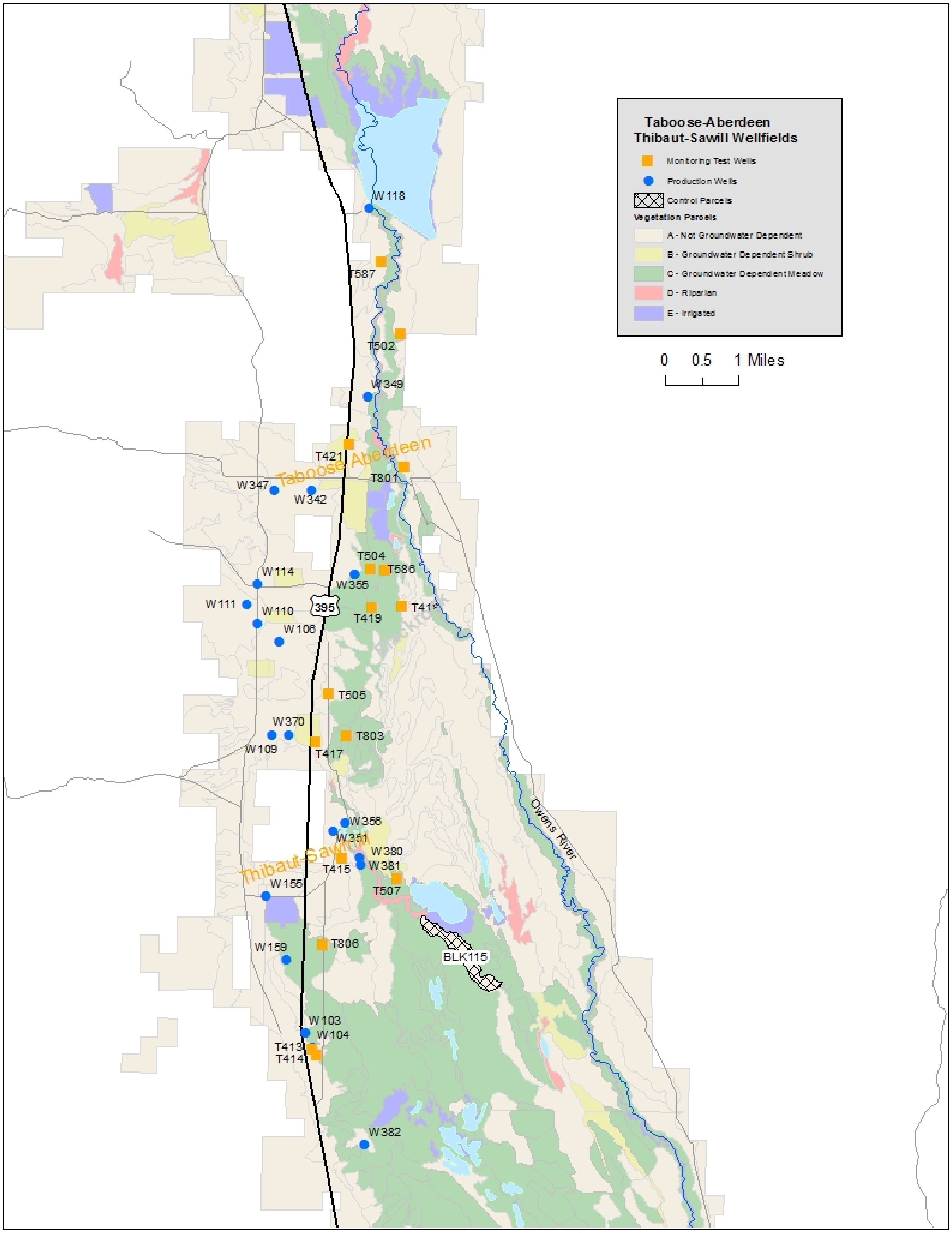

Figure 3.15. Map of monitoring and LADWP production wells in the Taboose-Aberdeen and Thibaut-Sawmill wellfields.

Taboose-Aberdeen Wellfield

A map of the Taboose-Aberdeen wellfield is presented in Figure 3.15. Pumping in the Taboose-Aberdeen Wellfield since 1990 under the Water Agreement has remained much below the wellfield capacity (Figure 3.16). 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.

Hydrographs for the indicator wells exhibit similar response to fluctuations in pumping and runoff (Figures 3.17 and 3.18). 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 118W located in the northern portion of the wellfield. Well 118W has been operated almost constantly since 2011. Data from well 587T was included because it is located adjacent to groundwater dependent vegetation near 118W to assess the impacts of recent pumping. Water level declines in this well since 2011 have been approximately two feet (Figure 3.15). Groundwater levels in 2015-2016 declined in six out of ten indicator or monitoring site test wells (Table 3.2). The declines were less than one foot. Water levels in three wells in the southern portion of the wellfield increased one to two feet due to a reduction in pumping to supply the Blackrock fish hatchery. These monitoring wells were previously affected by well 370W which was granted a temporary exemption in 2013 to supply water for fish in the Blackrock Ditch and at the Blackrock Hatchery. Water levels have fully recovered from operation of 370W during that temporary exemption. Depth to water in all wells was 0.1-5.5 feet below baseline in April 2015 (Table 3.2).

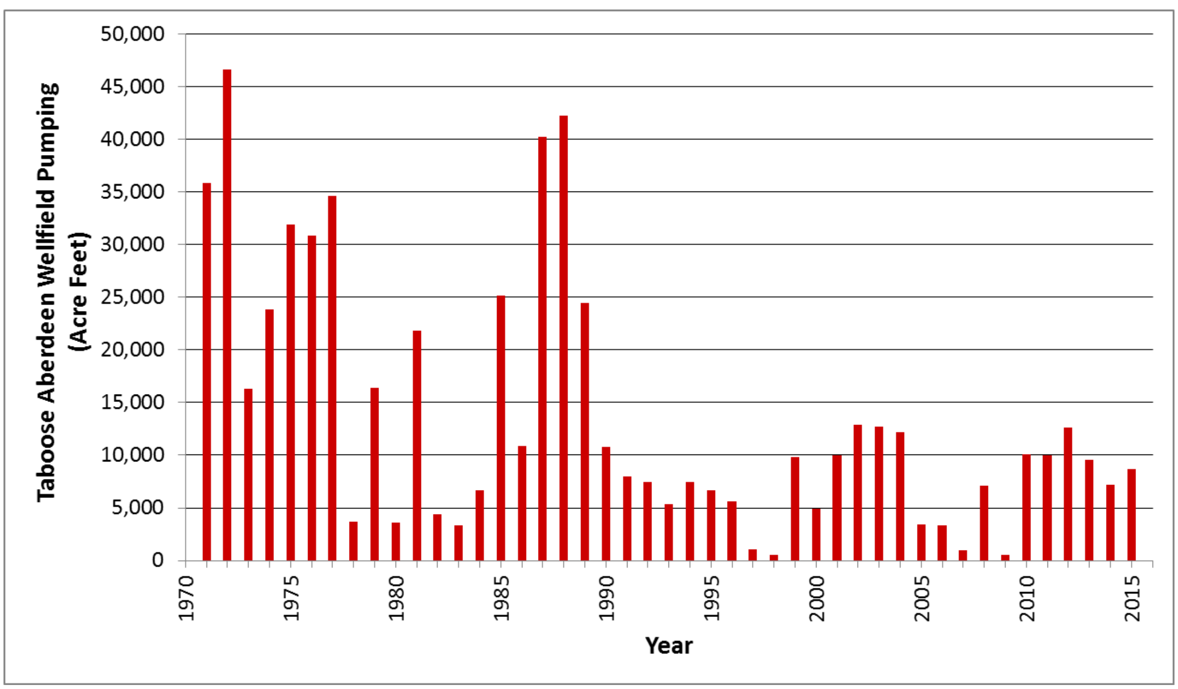

Figure 3.16. Pumping totals for the Taboose-Aberdeen wellfield.

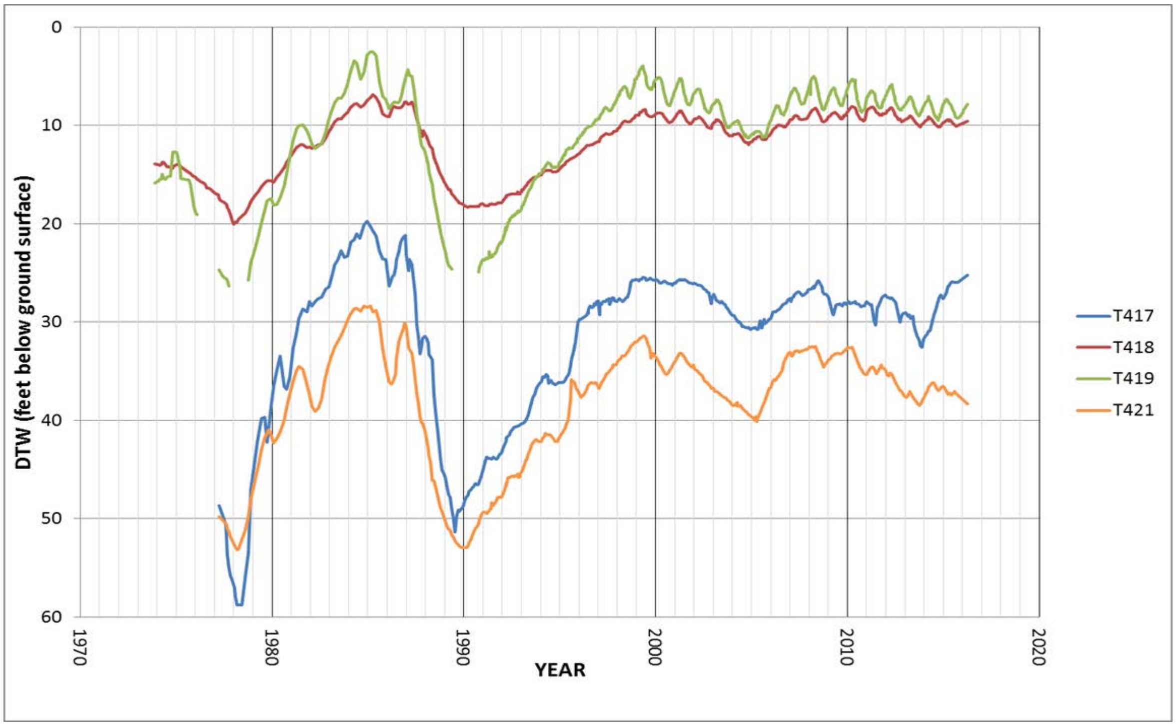

Figure 3.17. Hydrographs of indicator wells in the Taboose-Aberdeen wellfield. Periods of missing data denote when the test well was dry.

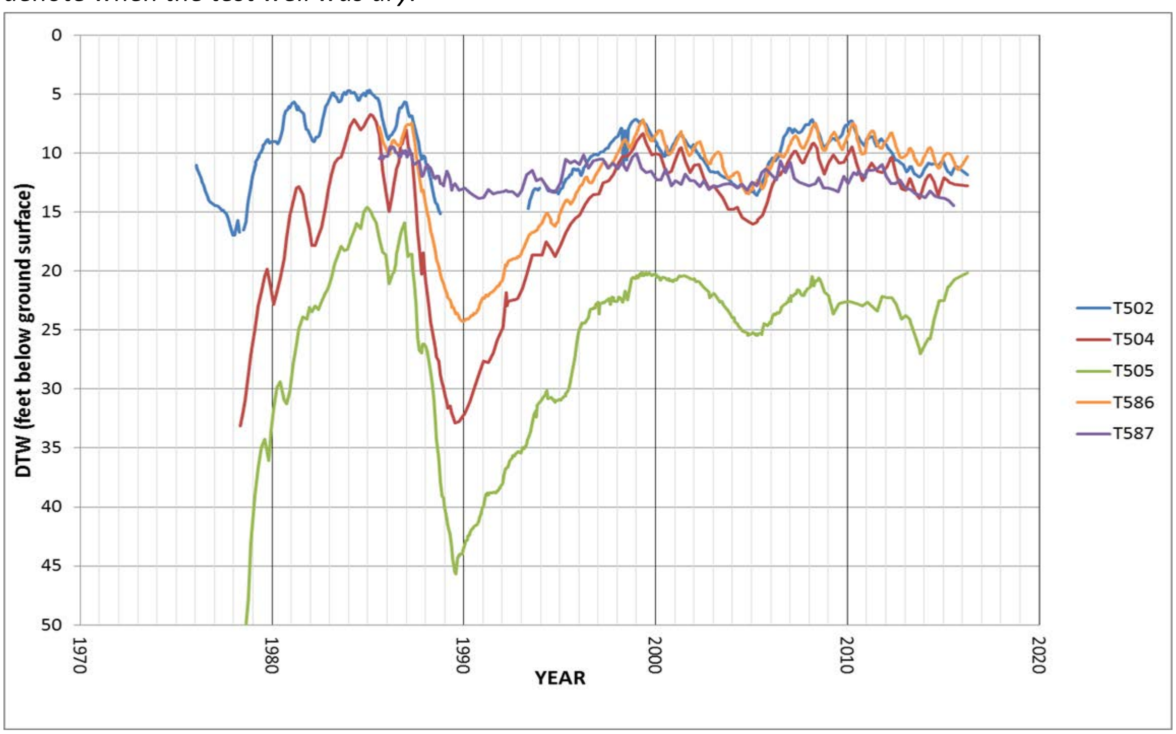

Figure 3.18. Hydrographs of indicator wells in the Taboose-Aberdeen wellfield. Periods of missing data denote when the test well was dry.

Thibaut-Sawmill Wellfield

A map of the Thibaut-Sawmill wellfield is presented in Figure 3.15 Historically, most pumping in Thibaut-Sawmill has been to supply approximately 12,200 ac-ft annually to the Blackrock Fish Hatchery (Figure 3.19). In 2011-12, approximately 1,800 ac-ft was pumped from this wellfield for aqueduct supply; since then, all pumping has been for hatchery or local irrigation uses. In 2014, Inyo and Los Angeles agreed to reduce hatchery pumping to approximately 8300 ac-ft.

The four test wells used to track water levels in Thibaut-Sawmill exhibited different response due to local water management within the wellfield (Figure 3.20). Well 415T exhibited a substantial water level rise of over 10 ft and is now 4.8 ft above the 1985-87 baseline level. 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/or reduced runoff. In 2015-2016, a downward trend since the onset of drought continued due to low runoff. The reduction in the hatchery pumping is not evident in these wells. 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. That trend persisted through 2014-15, but is reversed in 2015-2016 with the drying of the Drew Slough unit in 2015.

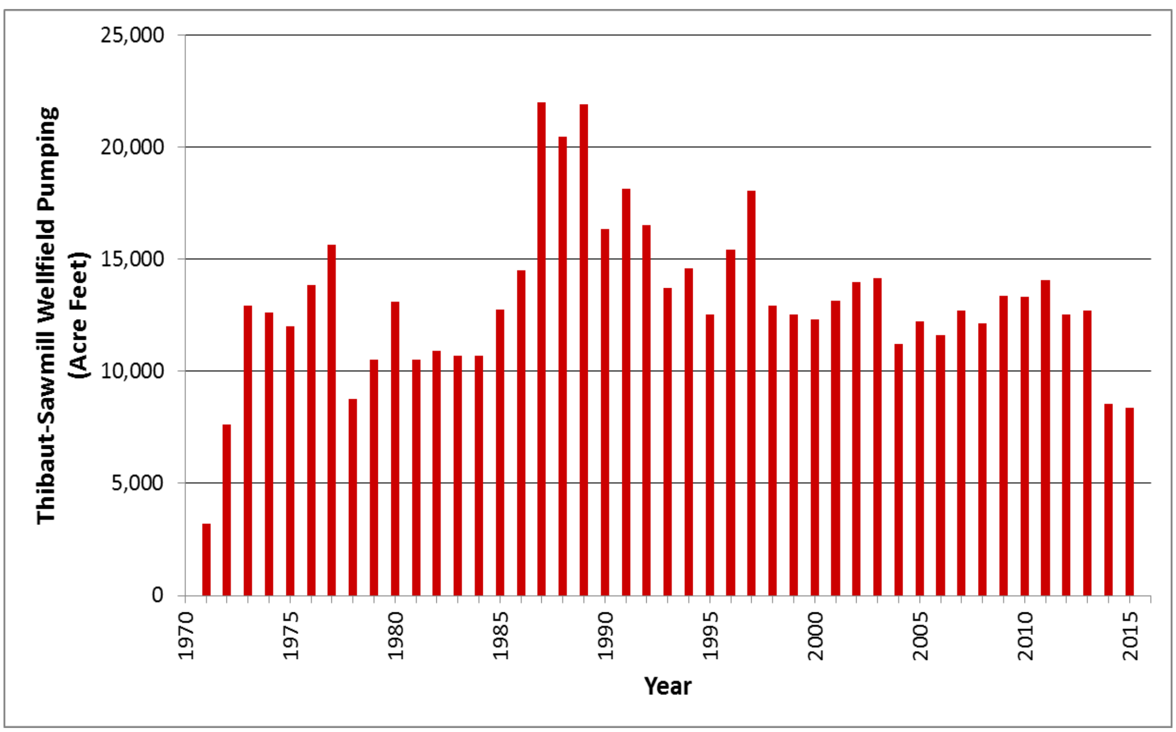

Figure 3.19. Pumping totals for the Thibaut-Sawmill wellfield.

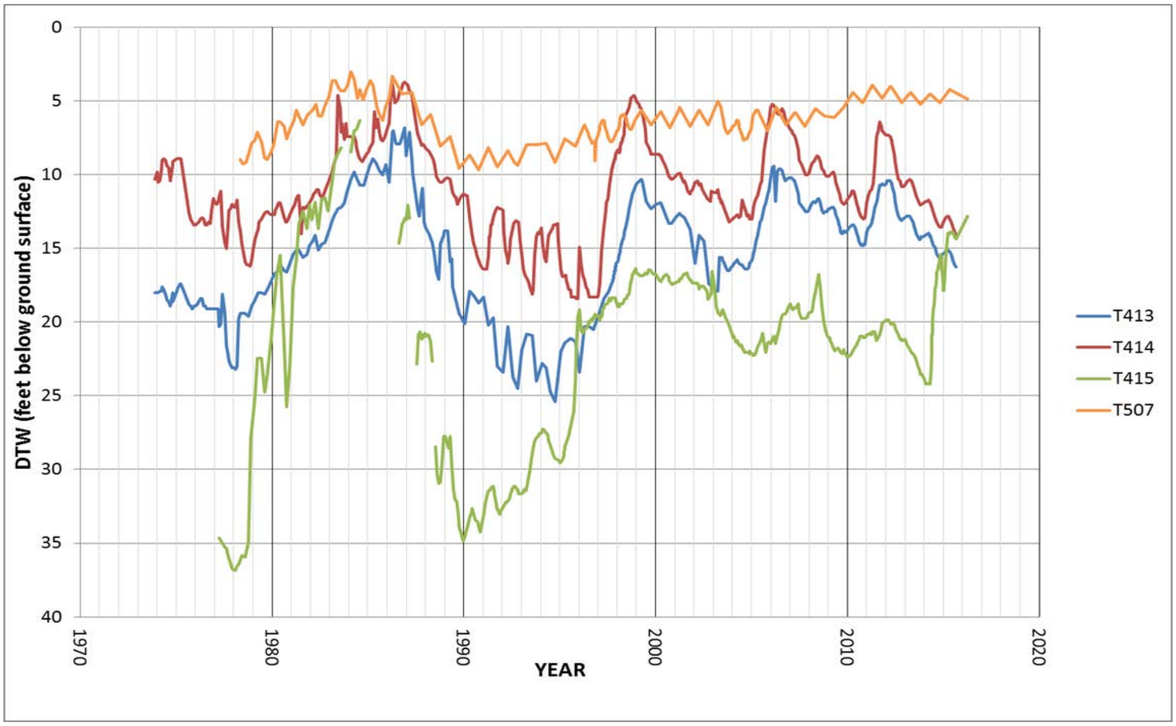

Figure 3.20. Hydrographs of selected test wells in the Thibaut-Sawmill wellfield.

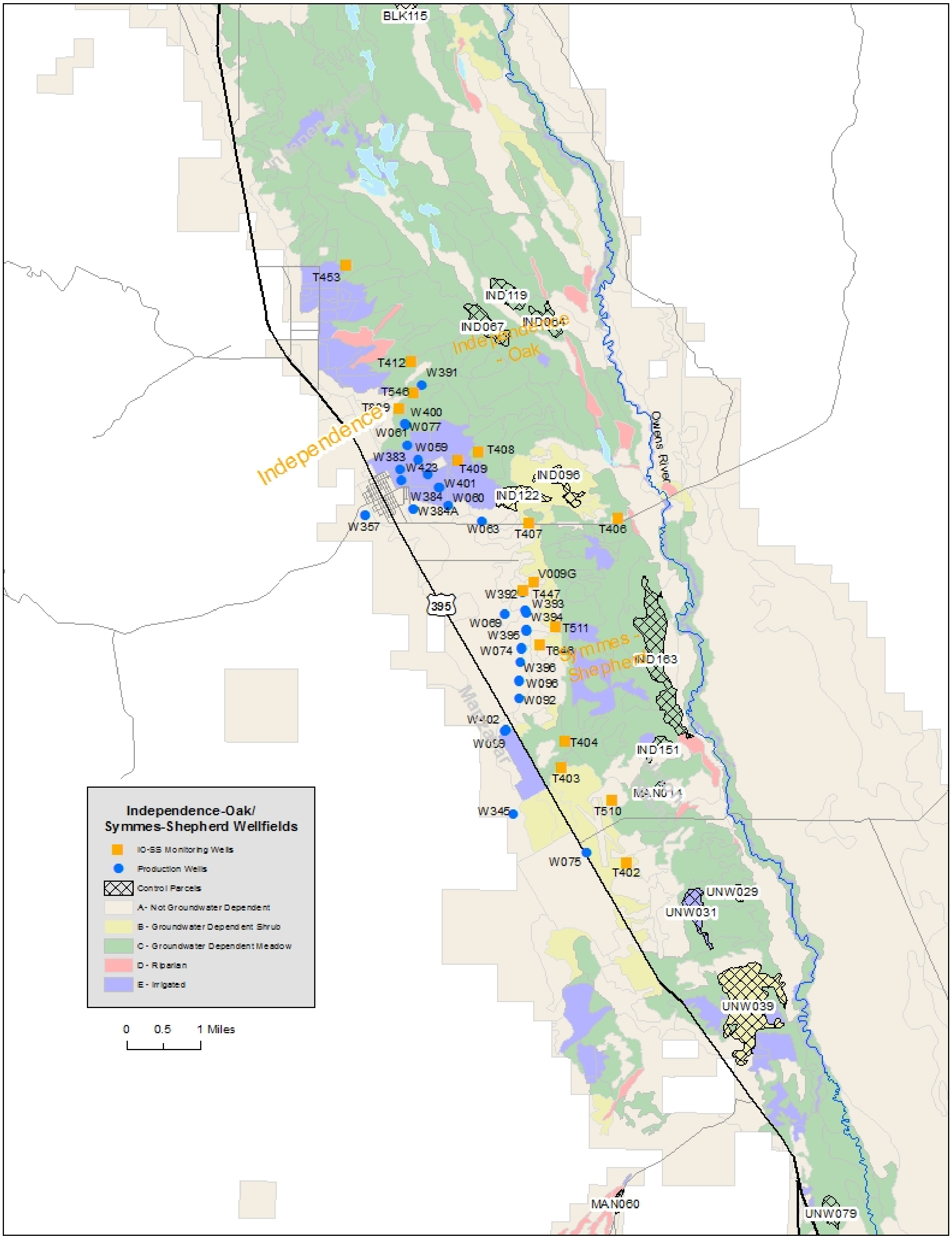

Figure 3.21. Map of monitoring and LADWP production wells in the Independence-Oak and Symmes-Shepherd wellfields.

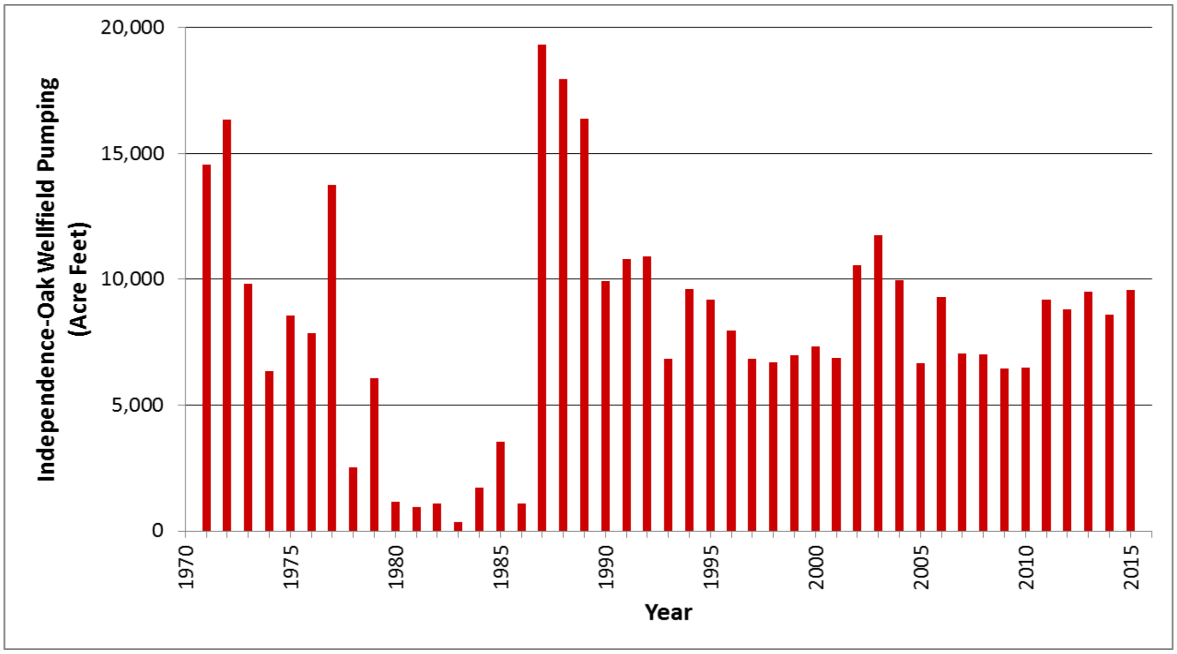

Figure 3.22. Pumping totals for the Independence-Oak wellfield.

Independence-Oak Wellfield

A map of the Independence-Oak wellfield is presented in Figure 3.21. Pumping in this wellfield is required to supply approximately 6,700 ac-ft annually for irrigation projects surrounding Independence and for town supply (Figure 3.22). Following four years of near minimum pumping, LADWP increased pumping to between 8, 600-9,600 each year since 2011.

Water levels had been stable for several years in wells located in the center of the wellfield (407T, 408T, 409T), but they have declined in response to the increased pumping of the last four years. With the continued pumping in 2015-16, water levels in these three wells declined from 0.5 to 4 feet (Table 3.2 and Figure 3.23). The other indicator wells located east and north of Independence exhibited declining water levels again last year (406T in Figure 3.23, and Figure 3.24). All of the indicator wells in the Independence-Oak Wellfield were below the baseline in April 2014 (Table 3.2).

Symmes-Shepherd Wellfield

A map of the Symmes-Shepherd wellfield is presented in Figure 3.21. In the 1970's and 80's, pumping in the Symmes-Shepherd Wellfield varied considerably (Figure 3.25). Under the Water Agreement, pumping has been reduced, in most years, to approximately 1200 ac-ft to supply one mitigation project; however, pumping for aqueduct supply increased considerably in the 2010-12 and 2015 runoff years.

In three of the seven indicator wells, groundwater levels in 2015-2016 declined, but in four wells groundwater increased up to 1 foot (Table 3.2). Some test wells are buffered somewhat by their proximity to the Los Angeles Aqueduct (402T, 404T, 510T, and 511T), and water levels are relatively stable (Figures 3.26 and 3.27). Test wells 447T and V009G are

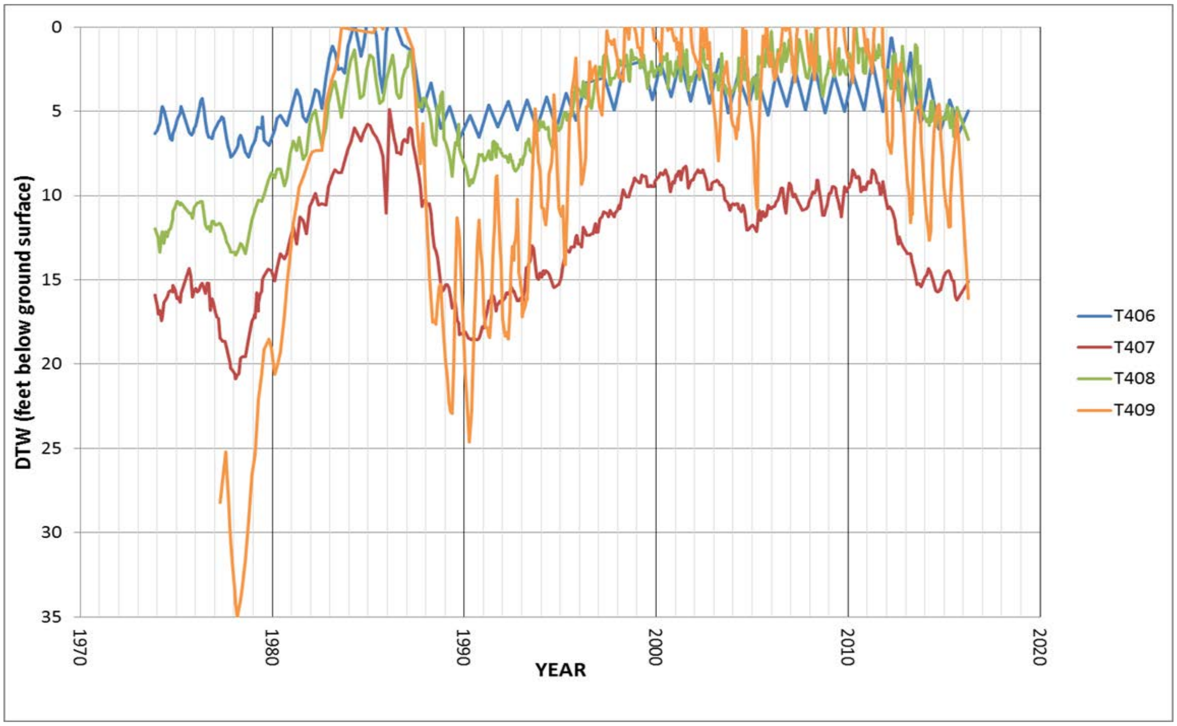

Figure 3.23. Hydrographs of selected test wells in the Independence-Oak wellfield

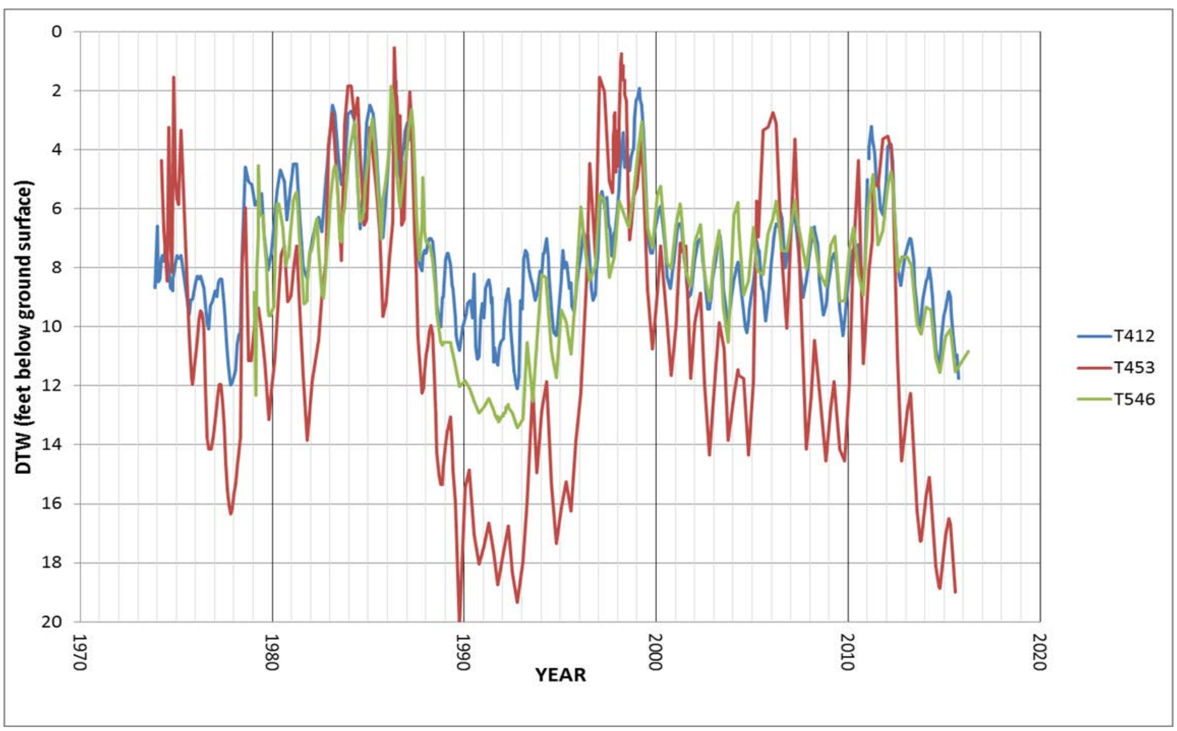

Figure 3.24. Hydrographs of selected test wells in the Independence-Oak wellfield.

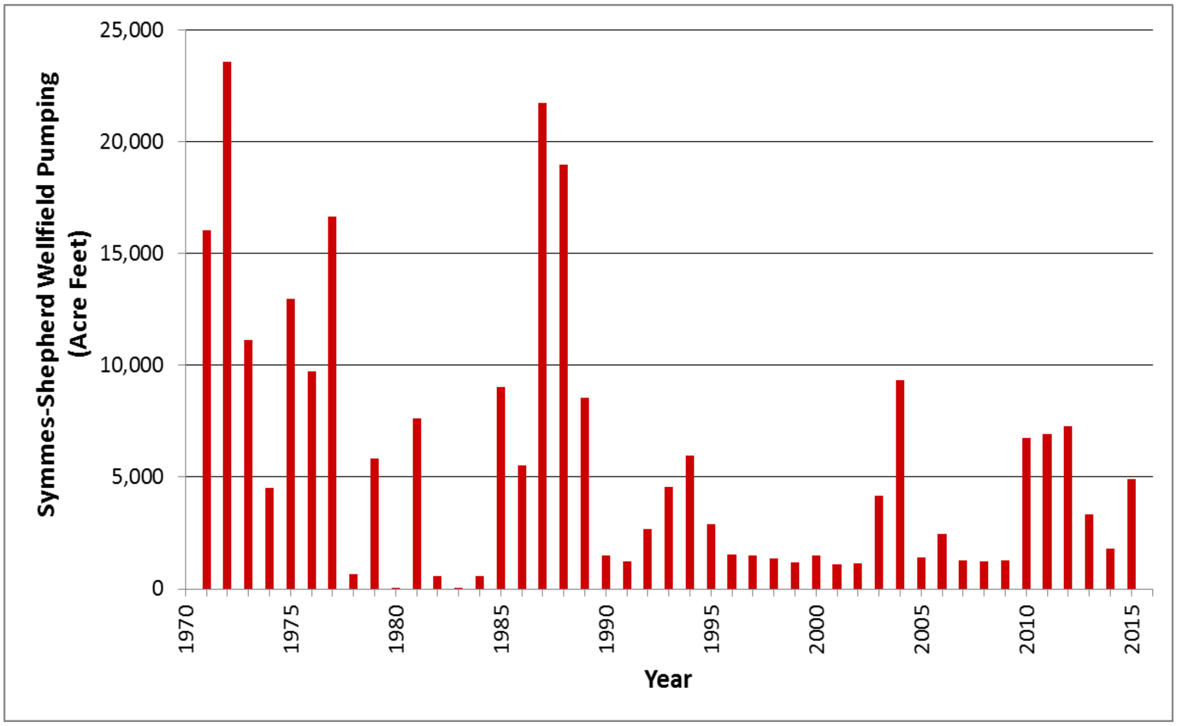

Figure 3.25. Pumping totals for the Symmes-Shepherd wellfield.

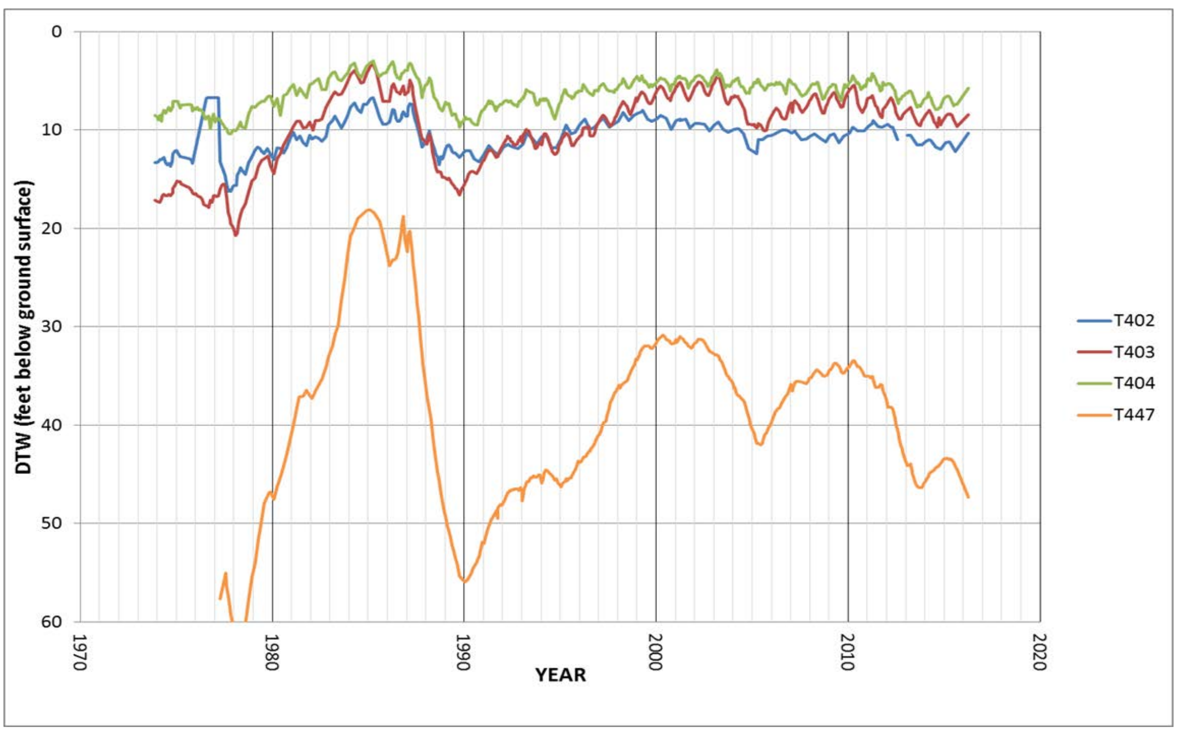

Figure 3.26 Hydrographs of indicator wells in the Symmes-Shepherd wellfield.

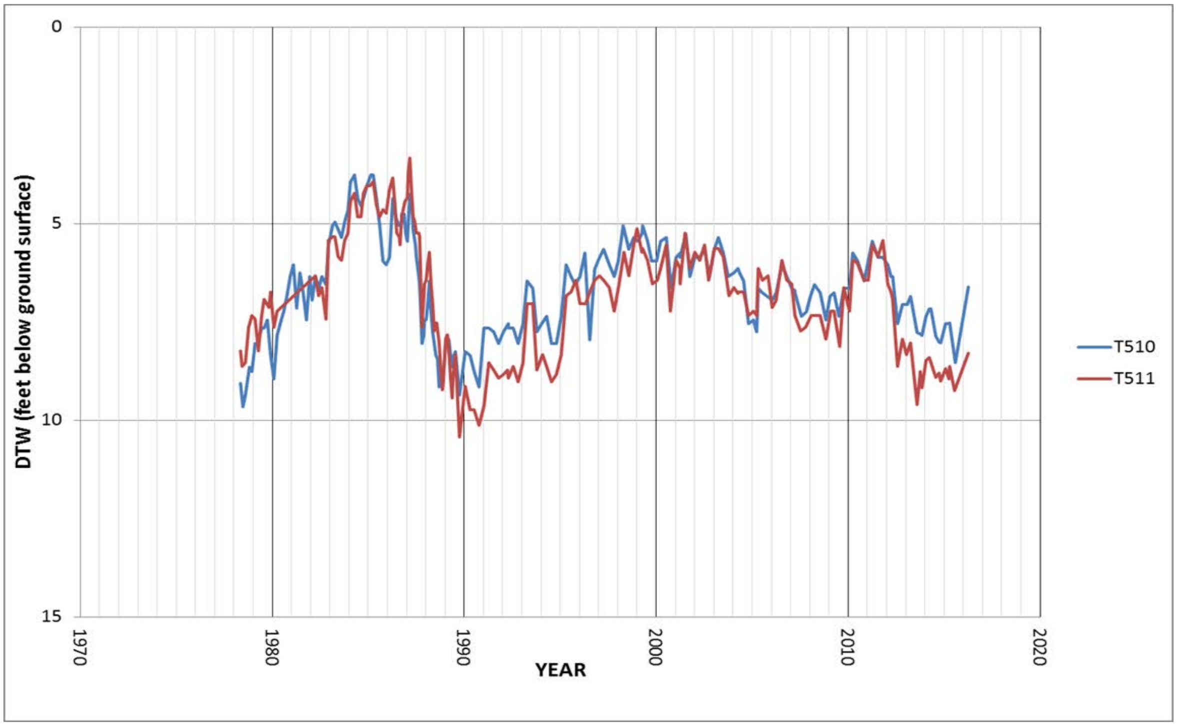

Figure 3.27 Hydrographs of indicator wells in the Symmes-Shepherd wellfield.

located near pumping wells in the northwestern portion of the wellfield and responded to the increased pumping in 2015-16. Water levels in all monitoring wells were below baseline (Table 3.2).

Bairs-George Wellfield

A map of the Bairs-George wellfield is presented in Figure 3.28. In the 1970's and 80's, pumping and water levels in the Bairs-George wellfield varied considerably (Figure 3.29), 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 is exempt (343W) and can be operated to supply irrigated pastures. As in other wellfields, pumping for aqueduct supply increased in 2010-2015 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 3.30). Water levels in 2015-2016 were stable; one well is above baseline and one less than a foot below baseline (Table 3.2).

The pumping wells are located west of the Los Angeles Aqueduct. Monitoring wells 597T and 398T (Figure 3.30) are in the immediate vicinity of the aqueduct and well 400T 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 drought since 2012 is plainly evident in 398T and 597T. Pumping effects are less evident in 400T. Wells 598T and 596T are located west of the aqueduct, and they exhibit larger fluctuations due to pumping (Figure 3.31).

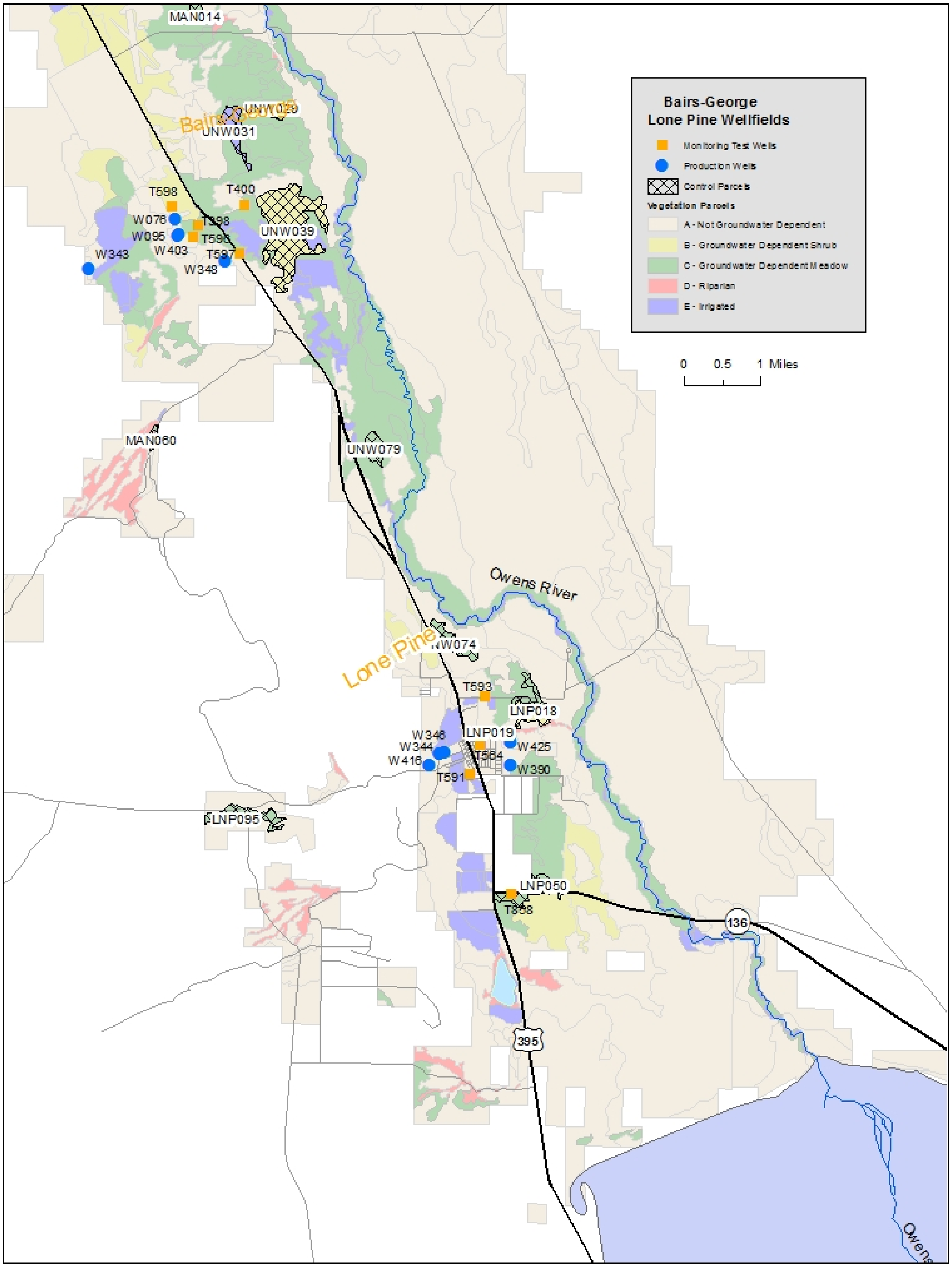

Figure 3.28. Map of monitoring and LADWP production wells in the Bairs-George and Lone Pine wellfields.

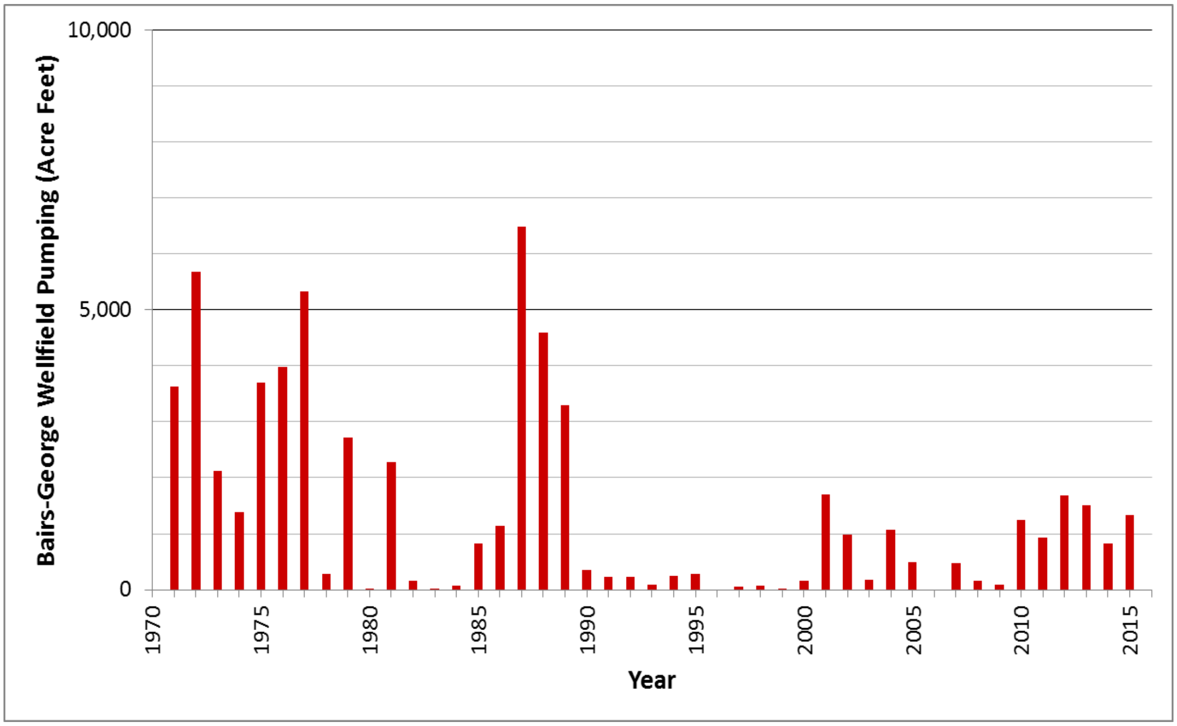

Figure 3.29 Pumping totals for the Bairs-Georges wellfield.

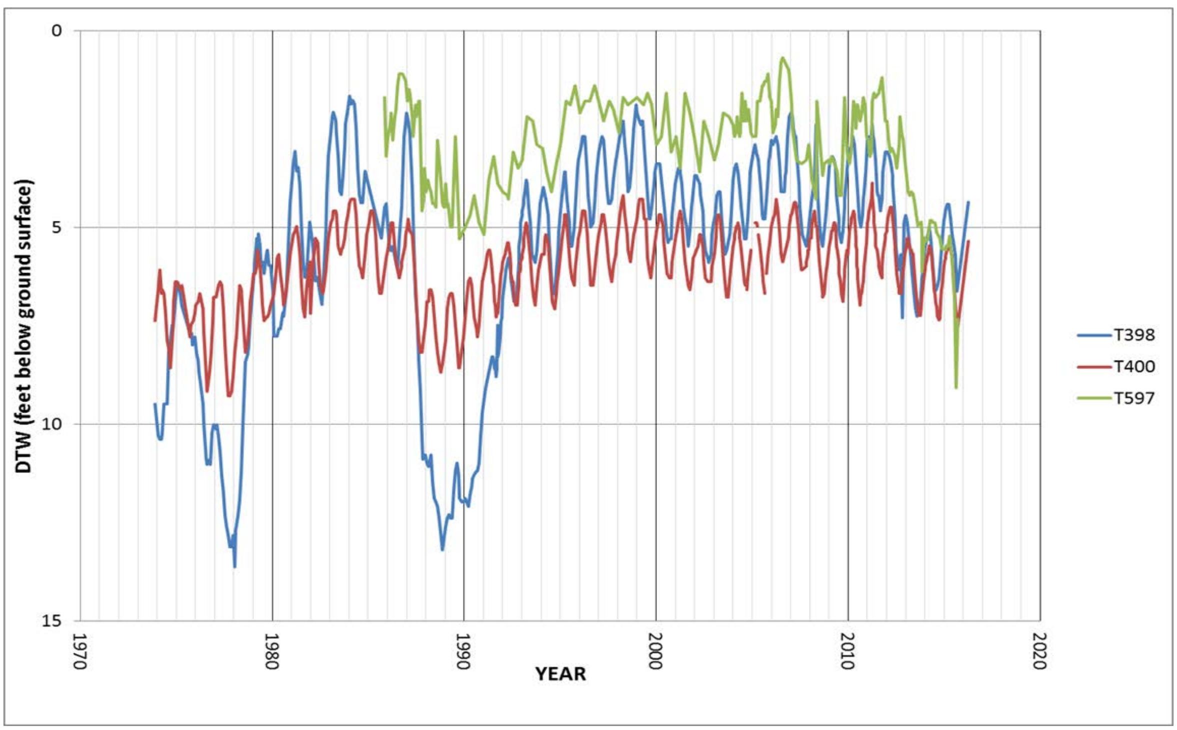

Figure 3.30. Hydrographs of indicator wells and 597T in the Bairs-Georges wellfield.

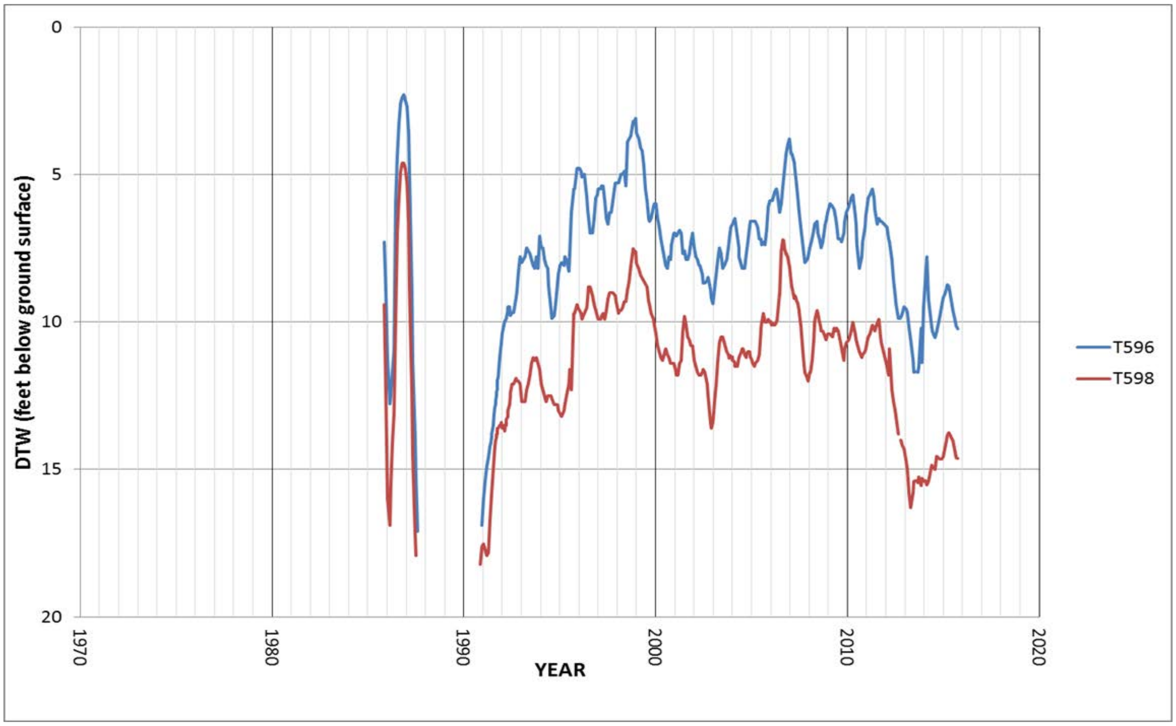

Figure 3.31. Hydrographs of selected wells in the Bairs-Georges wellfield.

Lone Pine Wellfield

A map of the Lone Pine wellfield is presented in Figure 3.28. 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 aqueduct water previously supplied to Diaz Lake (Figure 3.32). in 2015, pumping also increased largely due to the operation of a new well to supply the E/M Van Norman field. The previous well (390W) degraded and production declined noticeably in 2008. The new well (425W) has capacity to fully supply the project. 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 564T and 591T are presented in Figure 3.33 to represent water levels near the town of Lone Pine where the LADWP pumping wells are located. Monitoring well 593T and 858T 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. In early 2010, LADWP and ICWD tested a new production well, 416W installed to increase aqueduct supply. This new production well has been modified and initial tests to determine well capacity and performance have been completed. The initial operation may occur in 2016-17.

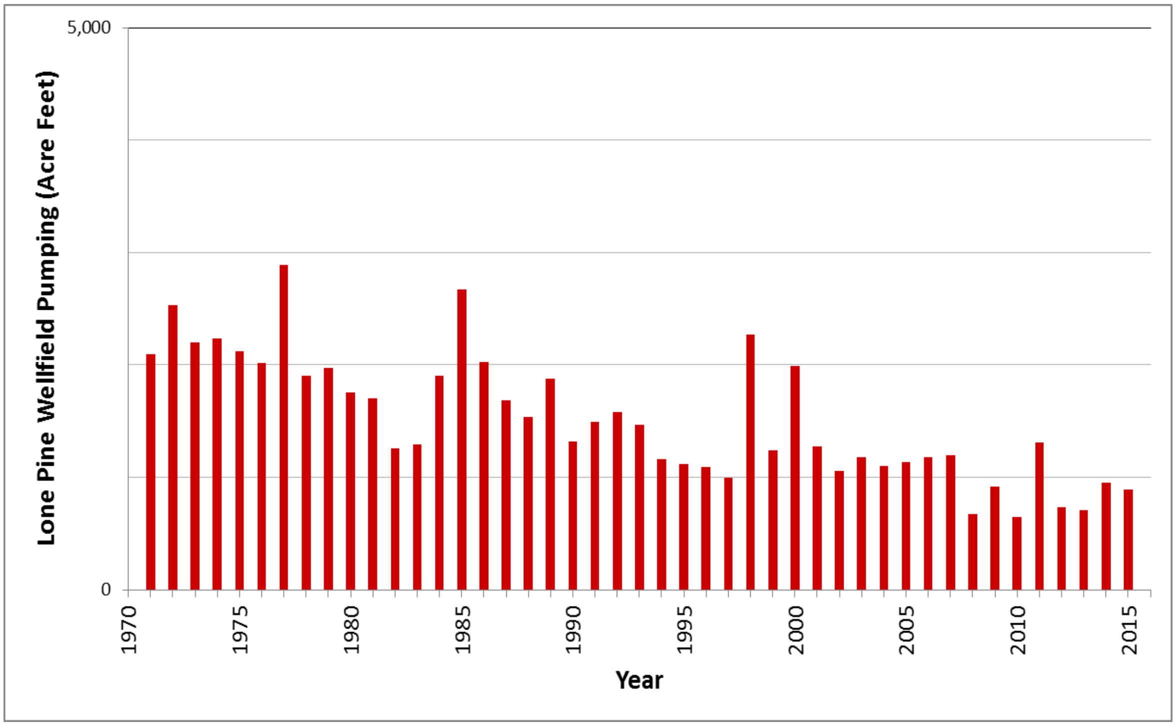

Figure 3.32. Pumping totals for the Lone Pine wellfield.

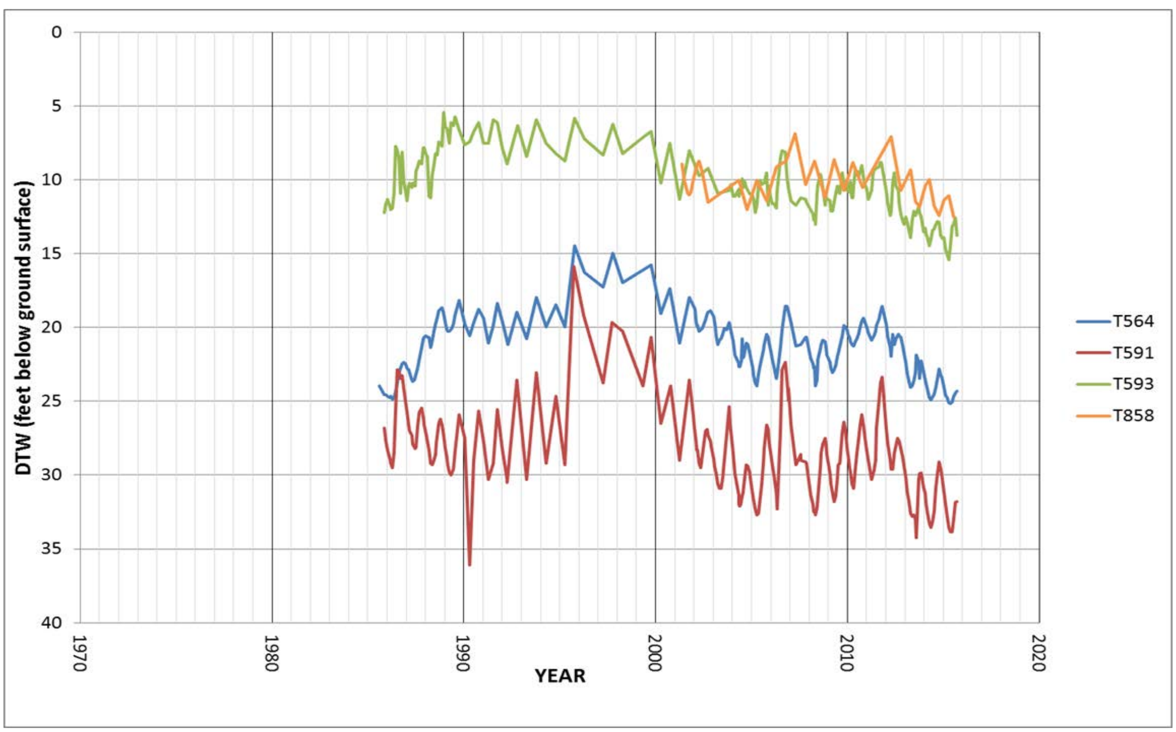

Figure 3.33. Hydrographs of selected test wells in the Lone Pine wellfield.

Evaluation of 2016 DTW 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 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 nine 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. In 2015-16, LADWP prepared operations plans for the April-September period and a final plan for the October-March period. The regression models operate on an annual time step and the County's analysis of LADWP's operations plan in April unavoidably included estimates of LADWP's distribution of the annual pumping amounts among wellfields. When LADWP's final proposed pumping amounts were available in October, the County revised its DTW predictions. Predictions for 38 wells made in October 2015 were examined for this report; three wells in the Taboose-Aberdeen wellfield were excluded because the are known to be affected by reduction in pumping in neighboring wellfield. Analysis of the October predictions isolates the evaluation of model accuracy from the uncertainty in the April estimates of annual pumping.

The predicted DTW values were based on the high pumping amount planned by LADWP in the October 2015-16 pumping plan. Wellfield pumping totals for the year were within 500 acre feet of the planned amounts in the wellfields with indicator wells; discrepancies in planned and actual pumping should be a small factor in the accuracy of model predictions. Actual and planned pumping differ by 1000-2000 ac-ft in the Big Pine, Taboose-Aberdeen, and Symmes-Shepherd wellfields. Prediction inaccuracy due to differences between planned and actual pumping was included in the estimates of model error. 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 well since 1994 (Figure 3.34). The average absolute deviation is approximately 27,000 ac-ft (mean runoff is 397,394 ac-ft for the period).

Model performance in 2015-16 was satisfactory and comparable to previous years. Measured and predicted change in DTW are plotted in Figure 3.32. If the models were perfect predictors, the points in Figure 3.35 would fall on the 1:1 line between the lower left and upper right quadrants. Most points were in the correct quadrant and of the 38 wells, actual and predicted DTW in 19 wells differed by less than 1 ft, and 28 differed by less than 1.5 ft.

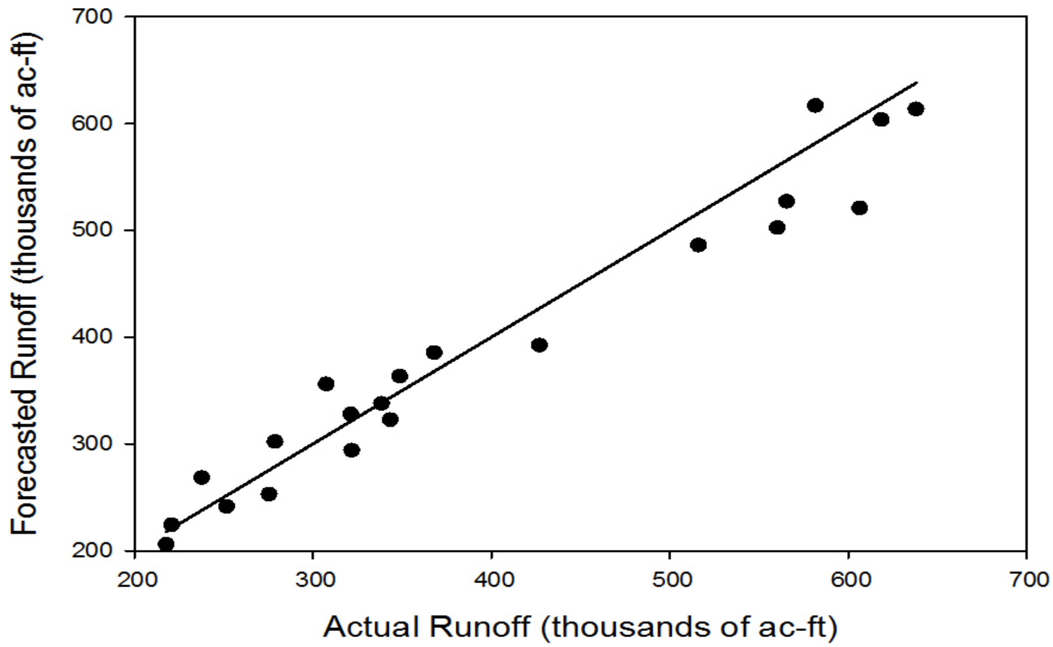

Figure 3.34. Comparison of actual and forecasted runoff 1994-2014 runoff years. During this period, LADWP has revised the method to forecast runoff, but there has been no discernible trend (better or worse) in the accuracy of the forecasts over time. The 2014 datum is the point with the lowest actual runoff on the graph.

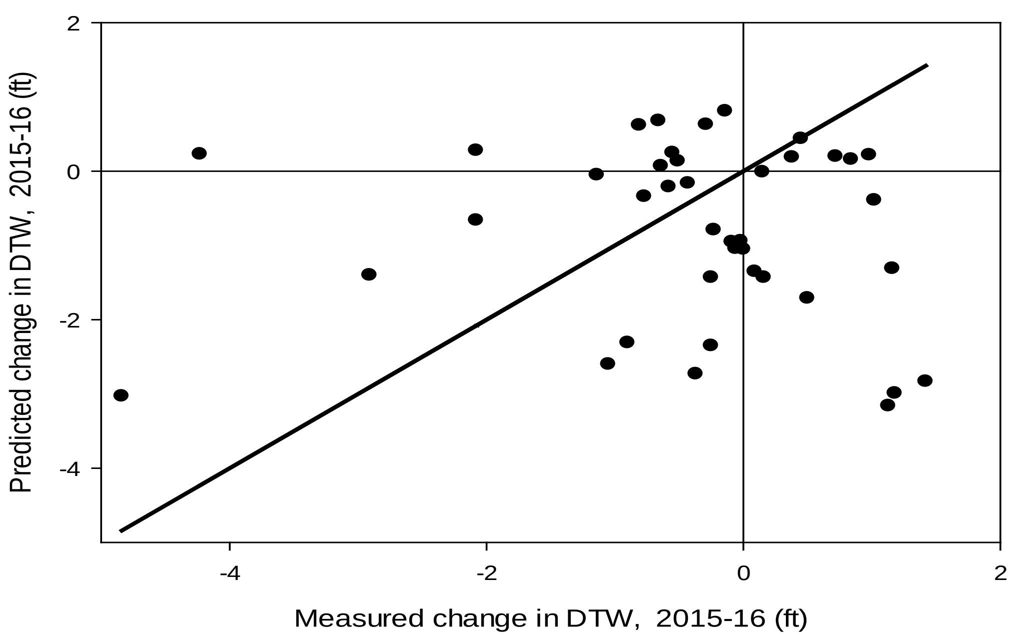

Figure 3.35. Measured and predicted change in DTW from April 2015 to April 2016 for 38 indicator and monitoring site wells. The solid line is the 1:1 line. Negative values denote a decline in water level.

Table 3.3. Planned LADWP pumping by wellfield for April-October 2016. Minimum pumping for sole-source (in-valley)uses and 2016-17 annual total estimated by Inyo County to evaluate the plan also included.

Wellfield	LADWP Planned Pumping for Apr-Sept. 2016-17 (ac-ft)	Inyo Estimate Minimum Annual Pumping (ac-ft)	Inyo Estimate Annual Pumping (ac-ft))
Laws	6,600	6,300	6,780
Bishop	9,000	10,400	11,100
Big Pine	10,995-12,345	20,550	24,020
Taboose-Aberdeen	2,500-6,500	300	8,000
Thibaut-Sawmill	4,380	8,160	8,460
Ind.-Oak	6,910	5,990	9,345
Symmes-Shepherd	3,975	1,200	5,110
Bairs-Georges	960	500	1,150
Lone Pine	840	1,035	1,035
Total	46,160-51,510	54,435	75,000

The average of the actual deviation for all wells was 1.2 ft. For nine wells at 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 absolute deviation for the predictions based on one model and two models were 1.24 ft and 1.14 ft, respectively. Given the similar accuracy of the two sets of wells, relying on the paired regressions was not a large source of additional uncertainty.

2016-17 Pumping Plan

LADWP issued a six-month operations plan for the 2016-17 runoff year on April 20, 2016. The forecasted runoff for the Owens River watershed runoff is 293,800 ac-ft (71% of normal) and is the fifth year of record or near record drought. LADWP's plan provided a range of planned pumping for the first half of the year; the range between the lower and upper limit was up to several thousand acre-feet in some cases (Table 3.3). In LADWP's plan, projected total pumping for the entire runoff year of 2016-2017 was estimated to be 75,000 ac-ft. For the first six months of 2016-17, the LADWP estimates pumping amounts to total between 46,160-51,510 ac-ft. The actual planned pumping amount for the year will not be known with certainty until LADWP's second six-month pumping plan is released in October 2016.

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 2016, planned wellfield pumping for the entire runoff year (which is an estimate for this 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, but the models are still useful for evaluating the pumping plan. Models in Laws use the amount

Table 3.4. Predicted water level changes at indicator wells and monitoring sites for LADWP's proposed annual operations plan for 2016 and estimated minimum pumping required for sole source uses. Negative DTW values denote a decline.

Wellfied Well ID and Mon. Site	Minimum 54,435 ac-ft	Maintain 2016 75,000 ac-ft	Inyo Recommended 75,000 ac-ft
	(ft)	(ft)	(ft)
Laws			
436T	0.53	0.46	0.46
438T	0.82	0.76	0.76
490T	-0.20	-0.23	-0.23
492T	0.11	-0.15	-0.15
574T	0.35	0.32	0.32
Big Pine			
425T	0.19	-0.56	-0.39
426T	0.05	-0.37	-0.27
469T	0.69	0.25	0.35
572T	1.89	1.05	1.24
798T, BP1	2.61	1.89	2.06
799T, BP2	0.30	-0.14	-0.04
567T, BP3	0.02	-0.62	-0.47
800T, BP4	0.53	-0.16	0.00
Taboose Aberdeen			
418T	0.70	-0.02	-0.15
419T, TA1	1.78	0.02	-0.28
421T	2.23	0.44	0.13
502T	1.41	0.59	0.45
504T	2.23	0.05	-0.33
586T, TA4	1.57	0.10	-0.15
801T, TA5	0.9	0.48	0.40
Thibaut Sawmill			
415T	1.14	0.91	0.91
507T	0.78	0.73	0.73
806T, TS2	3.34	3.24	3.24
Independence Oak			
406T	0.24	-0.03	0.02
407T	1.34	-0.03	0.20
408T	0.83	-0.10	0.06
409T	3.93	0.54	1.12
546T	0.81	0.52	0.62
809T, IO1	0.62	-1.01	-0.85
Symmes Shepherd			
402T	0.14	-0.22	-0.28
403T	0.82	-0.20	-0.38
404T	0.47	0.08	0.01
510T	2.76	0.32	-0.11
511T	0.44	0.07	0.00

Wellfied Well ID and Mon. Site	Minimum 54,435 ac-ft	Maintain 2016 75,000 ac-ft	Inyo Recommended 75,000 ac-ft
447T	0.49	0.08	0.01
V009G, SS1	2.29	0.15	-0.23
Bairs George			
398T	0.65	-0.24	-0.23
400T	0.27	0.11	0.11
812T	1.25	0.48	0.48

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

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 2016 annual report. No spreading is planned for 2016-17 which is not unusual given the low runoff forecast.

The models used by the Water Department to analyze the annual operations plan predict water levels one year in the future (e.g. April 2016 to 2017) based on annual pumping for each wellfield. The models cannot be used to analyze changes over a shorter period. However, as discussed below, the information provided in the pumping plan allowed the Water Department to estimate annual pumping with sufficient accuracy to apply the models.

The Water Agreement and Green Book include procedures to calculate a pumping limit to prevent groundwater mining to ensure no long term decline in aquifer storage. The mining calculation is a comparison of pumping and recharge for each wellfield on a water year basis (October 1st through September 30th) for a 20-year period. The 19.5 year total of actual pumping is subtracted from 20 years of estimated recharge to arrive at an estimated April-September pumping limit for each wellfield and Owens Valley as a whole. The preliminary recharge estimate for the 2016 water year is 127,169 ac-ft and planned pumping in each wellfield is not expected to violate the groundwater mining provision. In the Big Pine wellfield, however, pumping has exceeded recharge each of the previous four years. Pumping has been relatively constant at a high level, and the start of the deficit coincides with the onset of the severe drought. This does not constitute a violation of the groundwater mining provision, but the Water Department has suggested that pumping in this wellfield be curtailed to include only sole source uses. The growing deficit between recharge and pumping in the Big Pine wellfield is concerning and will be monitored carefully.

LADWP plans to pump between 46,160-51,510 ac-ft during the first six months of 2016. The estimated minimum pumping for sole-source, in-valley uses during the second six months of 2016-17 is approximately 17,905 ac-ft. This minimum pumping estimate consists of town and hatchery supply and stockwater and environmental project supply on the Bishop Cone in the fall and winter. It assumes there will be no extension of irrigation reliant on pumped water into October. The sum of the low range of LADWP's initial six-month pumping and the minimum pumping during the second six months is 64,065 ac-ft. The sum of the high range of proposed pumping and the minimum fall/winter pumping is 69,415 ac-ft, approximately 5,585 ac-ft less than the annual total anticipated by LADWP. To permit analysis of the pumping plan using ICWD's models, this additional amount of pumping must be apportioned among wellfields with On-status or exempt wells. Until the LADWP releases the second operations plan for 2016-17 in October, this modeling procedure is unavoidably subjective which makes the analysis of LADWP 2016 operations and water table predictions for some wellfields somewhat uncertain. However, the list of available wells to pump the additional 5,585 ac-ft is small and will likely be similar to last year. Therefore, while actual pumping distributions among wellfields may differ slightly from the modeled values, the assumptions to derive the values in Table 3.3 are reasonable enough to utilize the models to evaluate LADWP's proposal.

Table 3.4 presents predicted groundwater level changes from April 2016 to 2017 at indicator wells in seven wellfields under two scenarios: the minimum (sole-source) pumping amount (54,435 ac-ft) and LADWP's proposed annual amount of (75,0000 ac-ft). For the Laws wellfield using LADWP's proposed pumping amounts, water levels are predicted to remain stable (rise or fall less than one foot) in all monitoring wells in 2016-17. In Big Pine, water levels are predicted to remain stable with small declines in most indicator wells with the exception of 1-2 foot increases in the northern part of the wellfield. In Taboose-Aberdeen, water levels are predicted to remain stable in all wells. In the Thibaut-Sawmill wellfield, water levels are predicted to increase 0.5 to 3 feet, largely in response to the continuing reduction in pumping at the Blackrock Fish Hatchery. In Independence-Oak, Symmes-Shepherd and Bairs-George wellfields, water levels are expected to remain stable in all wells.

Under the minimum pumping scenario of 54,435 ac-ft, in Laws, Big Pine, Thibaut Sawmill and Bairs George, groundwater levels would rise an additional 0.5-1 feet. In Taboose Aberdeen, Independence Oak and Symmes Shepherd, groundwater levels would rise an additional 1-4 feet under the minimum pumping scenario.

As noted above, the County evaluated the annual estimated pumping contained in LADWP's draft plan (75,000). The predicted changes in DTW will be reanalyzed in October when LADWP's second six-month pumping plan is released and annual pumping amounts become more certain. The draft and final operations plans are available on the Water Department website.

Concerns and recommendations to LADWP's proposed 2016-17 pumping plan were raised by Inyo County in the Water Department's April 29, 2016 letter to LADWP. The Water Department did not object to LADWP's 2016-17 operations plan given the low runoff conditions, relatively low proposed pumping, and predicted stable groundwater levels in most wellfields. However, ICWD expressed concern with the cumulative, declining water table elevations throughout the Owens Valley. Depth to water and water level changes since April 2015 in selected shallow monitoring wells are shown in Table 3.2. Also shown are water level changes since the current drought began in 2011 and water table change since the vegetation baseline mapping was done in the mid-1980s. Despite the relative conservatism of the 2016-17 pumping plan, the cumulative effect of five years of drought has resulted in a substantial decline in the water table and in the condition of groundwater dependent native vegetation (as shown in Section 5).

Groundwater elevations have declined in all well fields as compared to the 1984-87 baseline levels by an average magnitude of several feet. Inyo County commented to LADWP that we did not feel that it is appropriate to pump groundwater for export to Los Angeles in well fields that are significantly below baseline levels. Although the Water Agreement's process for Annual Operations Plans is based on planning for one year at a time, the Water Department recommended that the Technical Group consider multi-year planning to address the need to maintain or raise the water table to meet the Water Agreements native vegetation goals. The Water Department's comment letter can be found on the inyowater.org website.

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/LosAngeles Technical Group, February 25, 2003.

SECTION 4: EFFECTS OF THE 2012-16 DROUGHT

The 2012-16 drought has been the dominant story pertaining to water in California . Drought stresses the hydrology and ecology of the Owens Valley and confronts Inyo and Los angeles with difficult management problems.

Introduction

Since 2012 California and the western U.S. has experienced severe drought resulting in reduced runoff into the Owens Valley from the Sierra Nevada. As a consequence, less water has been available for irrigation in the valley and for natural and artificial groundwater recharge. These changes to hydrology due to drought are accompanied by groundwater pumping for export and for use in the valley. Winter precipitation on the valley floor has also been below normal during the drought which compounds the stress on native vegetation resulting from declining groundwater levels. This section compares conditions during the present drought with previous droughts and assesses the effects of LADWP pumping and drought on water levels since 2012. The focus of this section is hydrology, but vegetation conditions will be mentioned briefly. More detailed vegetation data and analyses are included in the Vegetation Conditions section of this report.

Background

The response of Owens Valley hydrology and vegetation to the 2012-16 drought partly depended on the conditions in 2012 at the onset of the drought. Water levels and vegetation conditions in 2016 are best understood in the context of previous disturbances from pumping and drought.

The 1987-92 period was the most severe stress on the hydroecology of the valley since wide scale pumping commenced in 1970 to provide water for the second aqueduct. A vegetation map created in 1984-87 was adopted as a baseline for measuring compliance with the goals of the Water Agreement. Shortly after the map was prepared and before pumping management under the Water Agreement was implemented, a severe drought coupled with multiple years of high pumping severely lowered water tables and negatively affected phreatophytic vegetation. Water levels typically were deepest between 1990-92 (Figure 4.1). For the purpose of comparison, 1991 will be used here to represent the worst case for water levels. In response to the drought and depressed water levels, Inyo and Los Angeles agreed in 1991 to reduce pumping to raise water levels and used the average of April 1985-87 depth to water (DTW) measurements as a target for water table recovery. The DTW baseline roughly coincides with the vegetation mapping, and April is when water levels are typically shallowest each year. Unlike the vegetation baseline, maintaining baseline DTW is not a requirement of the Water Agreement. The baseline water table usually is an

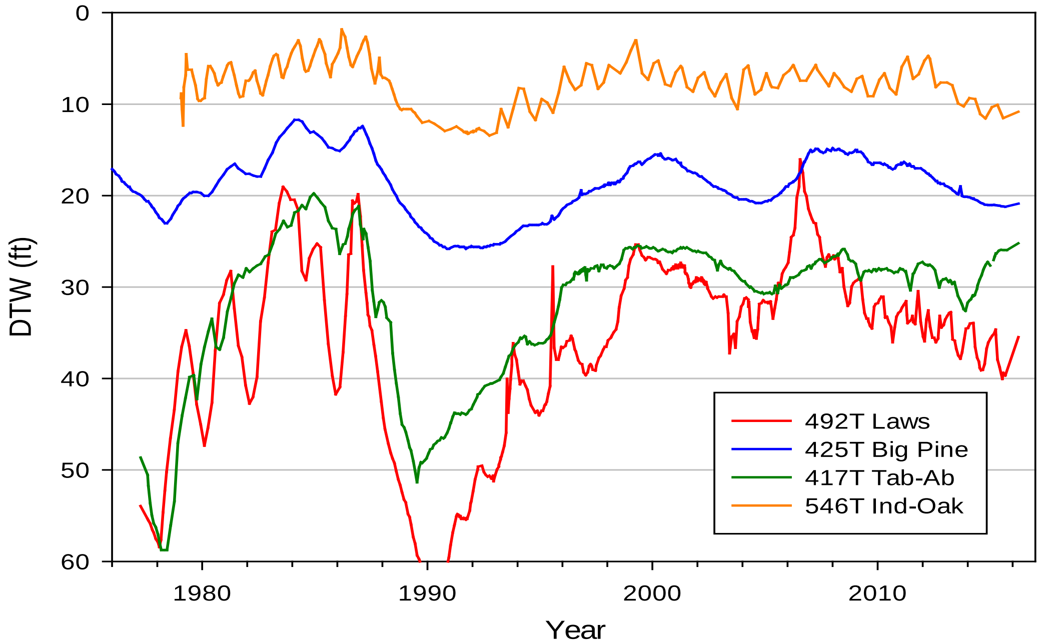

Figure 4.1. Selected hydrographs of for wells in Laws, Big Pine, Taboose-Aberdeen, and Independence Oak wellfields showing the effect of the drought and very high pumping in 1987-92. The effects of pumping and reduced runoff on water levels are also apparent for the 1975-77, 1999-04, 2007-10, 2012-16 droughts. Hydrographs for additional wells are included in Section 3 of this report.

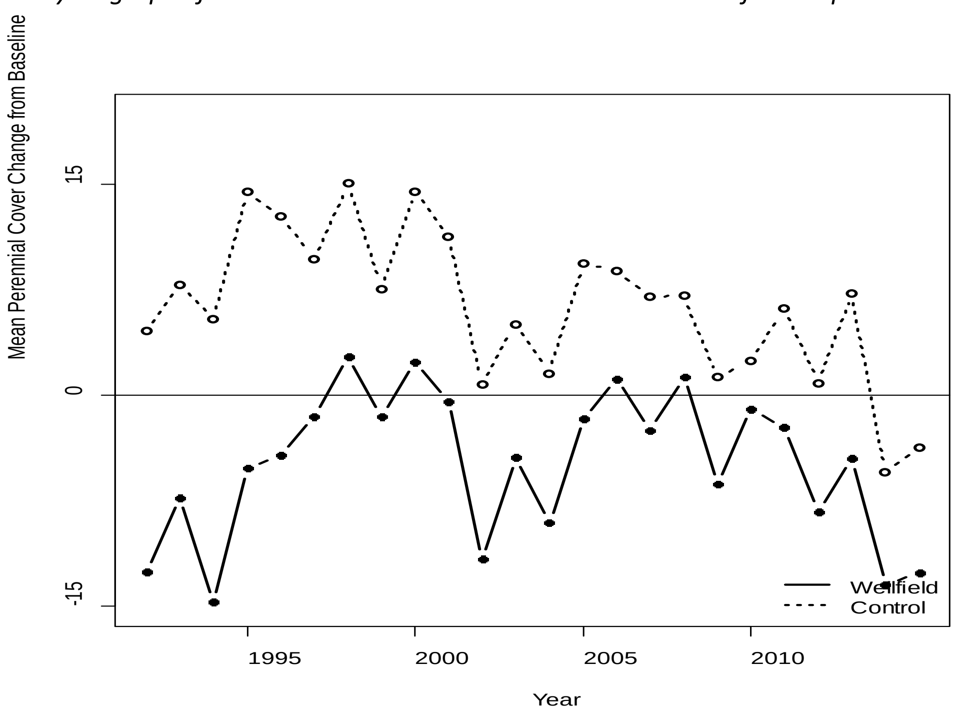

Figure 4.2. Average perennial cover of all wellfield and control parcels sampled each year between 1992 and 2014. Points above the zero line are above baseline

Table 4.1. Years when DTW in indicator wells and vegetation cover in nearby parcels attained baseline. Vegetation parcels near or surrounding the test well and the recent year cover was at or above baseline (p<0.05). Maps of the monitoring wells and parcels are included in the Groundwater and Vegetation sections of this report.

Wellfield Monitoring Well	**Year DTW at baseline, and 1 ft below baseline**	**Nearby parcels**	**Recent Year cover at or above baseline†**	**Notes**
Laws				
107T	2007, 2007	LW30 LW35	2014 1987	 Cover always below baseline
436T	2008, 2008	LW107 LW78 LW109	2014 2008 2013	
438T	2007, 2011	FSL123	2011	
490T	2012, 2013	LW122 LW137	2013 2013	
492T	2011, 2011	LW82 LW52 LW43	2008 1987 1987	Cover usually below baseline Cover always below baseline Cover always below baseline
795T, LW1	2007, 2007	LW63 LW65 LW62 LW70 LW72	2011 2008 1999 1987 1987	 Cover always below baseline
V001G, LW2	2008, 2008	LW85	1987	Cover always below baseline
574T	2007, 2008	LW120 LW112	2014 2014	
Big Pine				
425T	1987, 2008	TIN28	2013	
426T	1987, 1987	FSP4 FSP6	2014 2011	DTW 1.5 ft below baseline in 2007 and 2011
469T	2007, 2011	BP162	2000	Cover usually below baseline
572T	2011, 2012	BP154 BP157	2013 2013	
798T, BP1	2014, 2014	BP154 BP86	2013 2013	
799T, BP2	2011, 2012	BP162	2000	
567T, BP3	2011, 2011	FSP4 FSP6	2014 2011	
800T, BP4	<1989, 2009	TIN28	2013	
Tab- Ab				
417T	1987	BLK44	2015	DTW was 2 ft below baseline in 2001
418T	1985, 2012	BLK21	2006	Cover usually below baseline
419T, TA1	2008, 2012	BLK16	2015	
421T	2010, 2010	BLK2 TIN64	2015 2011	

Wellfield Monitoring Well	**Year DTW at baseline, and 1 ft below baseline**	**Nearby parcels**	**Recent Year cover at or above baseline†**	**Notes**
502T	1987, 2010	TIN50	2013	
504T	2010, 2012	BLK9	2011	
505T	1987	BLK24	2015	DTW was 2.5 ft below baseline in 2008 and 2 ft in 2016
803T, TA6	<1989	BLK44 BLK33 BLK39	2015 2015 2015	DTW was 2 ft below baseline in 2016, BLK33 cover usually below baseline
586T, TA4	2010, 2012	BLK9	2011	
801T, TA5	2014, 2015	TIN68 TIN50	2015 2015	
Thib-Saw.				
415T	2016, 2016	BLK77 BLK75	2011 2008	Cover usually below baseline
507T	2011, 2016	BLK74 BLK69	2013 2010	
806T, TS2	2012, 2016	BLK93 BLK94	2015 2000	Cover usually below baseline
Ind.-Oak				
406T	1985, 2012	IND96	2013	
407T	1986	IND106	2015	DTW was 2.5 ft below baseline in 2011
408T	2013, 2013	IND122	2015	
409T	2011, 2011			
546T	1987, 1999	IND11 IND111	2015 2013	
809T, IO1	<1989	IND111 IND205	2013 2015	DTW was 2.1 ft below baseline in 2012
Sym-Shep.				
402T	1987, 1999	MAN7	2011	
403T	2003, 2010	MAN6 MAN7	2015 2011	
404T	1986, 2003	IND139	2010	
510T	1987, 2001			
511T	1987			DTW was 2 ft below baseline in 2011
447T	1987, 1987	IND132 IND133	2010 2013	
646T, SS2	<1987, <1987	IND231	2015	Baseline cover very low
V009G, SS1	1985, 1987	IND132 IND133	2010 2013	Baseline DTW <4 ft. Rooting zone 13ft

Wellfield Monitoring Well	**Year DTW at baseline, and 1 ft below baseline**	**Nearby parcels**	**Recent Year cover at or above baseline†**	**Notes**
Bairs-Geo.				
398T	2013, 2014	MAN37	2000	Cover usually below baseline
400T	2012, 2014	UNW39	2013	
812T	2007, 2007	MAN37	2000	DTW was 2 ft below baseline in 2011

†: Perennial cover was considered at or above baseline if it was not significantly below ($p<0.05$) baseline. For parcels with no baseline data, cover was considered at baseline if the baseline variance overlapped with measured cover

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.

Following the 1987-92 period, water levels and vegetation conditions improved following a lengthy period of relatively low pumping and average or above average runoff (Figures 4.1 and 4.2). Many areas attained DTW and vegetation cover baseline values (Table 4.1). A brief description of water levels and vegetation cover for each wellfield is provided below based on the information in Table 1. Detailed vegetation and associated hydrologic data are included in the Vegetation Conditions section of this report.

Laws: Water levels in most wells recovered to baseline between 2007-2013; wells south of the town of Laws (574T, 490T) attained baseline between 2011-2013. Vegetation cover in parcels near the Owens River or south of Laws attained baseline between 2008-14, but cover in several parcels west of US 6 between Jean Blanc Road and the Lower McNally Canal have usually or always been below baseline.

Big Pine: Water levels in wells in Big Pine recovered to baseline or nearly to baseline (<1 ft below) between 2008-2014. Cover in all parcels except BP162 were above baseline sometime between 2011-13.

Taboose-Aberdeen: Water levels in wells recovered to baseline or nearly to baseline (<2 ft below) between 2010-2015. Most parcels attained baseline sometime between 2008-2015; cover in one parcel BLK21 has usually been below baseline.

Thibaut-Sawmill: Water levels in all wells have risen sharply since 2014. Water levels were at baseline in April 2016. One parcel at the Blackrock fish hatchery (BLK75) and BLK94 have usually been below baseline; cover at other parcels attained baseline between 2008-2015.

Independence-Oak: Water levels in most monitoring wells recovered to baseline or nearly to baseline (approximately <2 ft) 2011-2013. All parcels attained baseline between 2013-2015.

Symmes-Shepherd: Water levels in several wells rose in the late 1990-00's, but only one well has nearly recovered.

Table 4.2. Depth to Water at indicator wells, April 2011. All data are in feet. A negative deviation from baseline indicates the water table is below baseline. Depths are from reference point. Monitoring site baseline depth predicted from monitoring site/indicator wells regression models unless test well was present 1985-87.

Wellfield Monitoring Well	**April 2011 DTW**	**Deviation from Baseline in 2011**	**Deviation from Baseline in 2012**
Laws			
107T	32.48	-7.14	-8.43
436T	10.79	-2.56	-3.15
438T	11.87	-2.27	-3.04
490T	14.85	-1.78	0.58
492T	33.37	-0.50	-1.37
V001G, LW2	17.89	-5.78	-5.32
574T, LW3	16.66	-3.31	-1.98
Big Pine			
425T	17.58	-2.68	-3.71
426T	13.33	-1.76	-2.13
469T	22.94	-1.21	-1.61
572T	13.82	-1.70	-1.70
798T, BP1	16.78	-0.43	-0.26
799T, BP2	19.53	-1.11	-1.49
567T, BP3	16.62	-2.67	-3.90
800T, BP4	16.18	-2.75	-3.88
Taboose Aberdeen			
417T	31.62	-4.65	-4.15
418T	9.72	-1.59	-0.70
419T	7.88	-1.31	-0.84
421T	35.53	-1.26	-1.93
502T	9.23	-1.80	-2.99
504T	11.39	-0.66	-0.38
505T	23.29	-4.72	-4.22
586T, TA4	8.61	0.64	-0.59
801T, TA5	13.35	0.93	-0.38
803T, TA6	13.33	-4.61	-4.17
Thibaut Sawmill			
415T	21.79	-3.33	-2.45
507T	4.62	0.05	0.04
806T, TS2	13.1	-0.45	0.05
Independence Oak			
406T	9.81	-2.28	-0.46
407T	3.36	-1.83	-4.63
408T	2.73	0.40	-1.97
409T	4.27	-2.65	-7.18
546T	5.69	-2.06	-2.05
809T, IO1	9.29	-2.76	-2.31

Wellfield Monitoring Well	April 2011 DTW	Deviation from Baseline in 2011	Deviation from Baseline in 2012
Symmes Shepherd			
402T	9.97	-1.94	-2.33
403T	7.23	-1.90	-2.18
404T	4.85	-1.3	-2.18
510T	6.28	-1.25	-2.06
511T	6.35	-1.72	-2.77
447T	35.75	-14.3	-16.85
V009G, SS1	16.6	-10.77	-13.69
646T, SS2	24.3	-11.7	-14.02
Bairs George			
398T	4.11	2.23	1.33
400T	5.59	0.71	0.41
812T, BG2	14.8	-2.12	-2.72

Bairs-George: Water levels recovered to baseline between 2007-2013, but cover in MAN37 has not recovered fully from pumping and a 2002 fire.

to baseline recently (403T). All parcels attained baseline between 2010-2015

In general, water levels in most test wells attained baseline sometime between 2007-2015, and cover in 42 of 57 parcels located near the indicator wells attained baseline since 2011 (Table 4.1). Wellfield vegetation generally has and can attain baseline levels, but does not sustain cover above baseline compared with parcels in control areas (Figure 4.2). Undoubtedly the continued disturbance from pumping is largely responsible, but the effect of droughts with below normal precipitation on the valley floor on both control and wellfield parcels is apparent as well in Figure 4.2. Several parcels have been persistently or usually below baseline since monitoring began in 1991; six in Laws, one parcel in Big Pine, two parcels in Taboose-Aberdeen, one parcel in Thibaut-Sawmill, and one in Bairs-George. These parcels are candidates to evaluate whether a significant impact to vegetation persists since the 1987-92 pumping and drought.

Blackrock 94 has already been the subject of a dispute on vegetation conditions. That dispute was settled in 2014 (see ICWD 2014 Annual Report, Directors Report).

In the years immediately preceding the current drought, water levels were typically highest in 2011. Water levels in the indicator and monitoring site wells were usually between 1-3 feet below baseline in 2011 (Table 4.2). Pumping and runoff were relatively high in 2011 and water levels typically stayed the same or declined less than 1 ft between 2011 and 2012. Notable exceptions were the 2-3 ft declines in the central Independence-Oak (409T) and northern Symmes-Shepherd (447T, V009g, 646T) wellfields. Water levels in 2012 at the beginning of the current drought relative to 1985-87 baseline are shown in Table 4.2 and Figure 4.3.

Comparison of Droughts

LADWP has compiled extensive records of stream flow and other hydrologic measurements within the Owens River

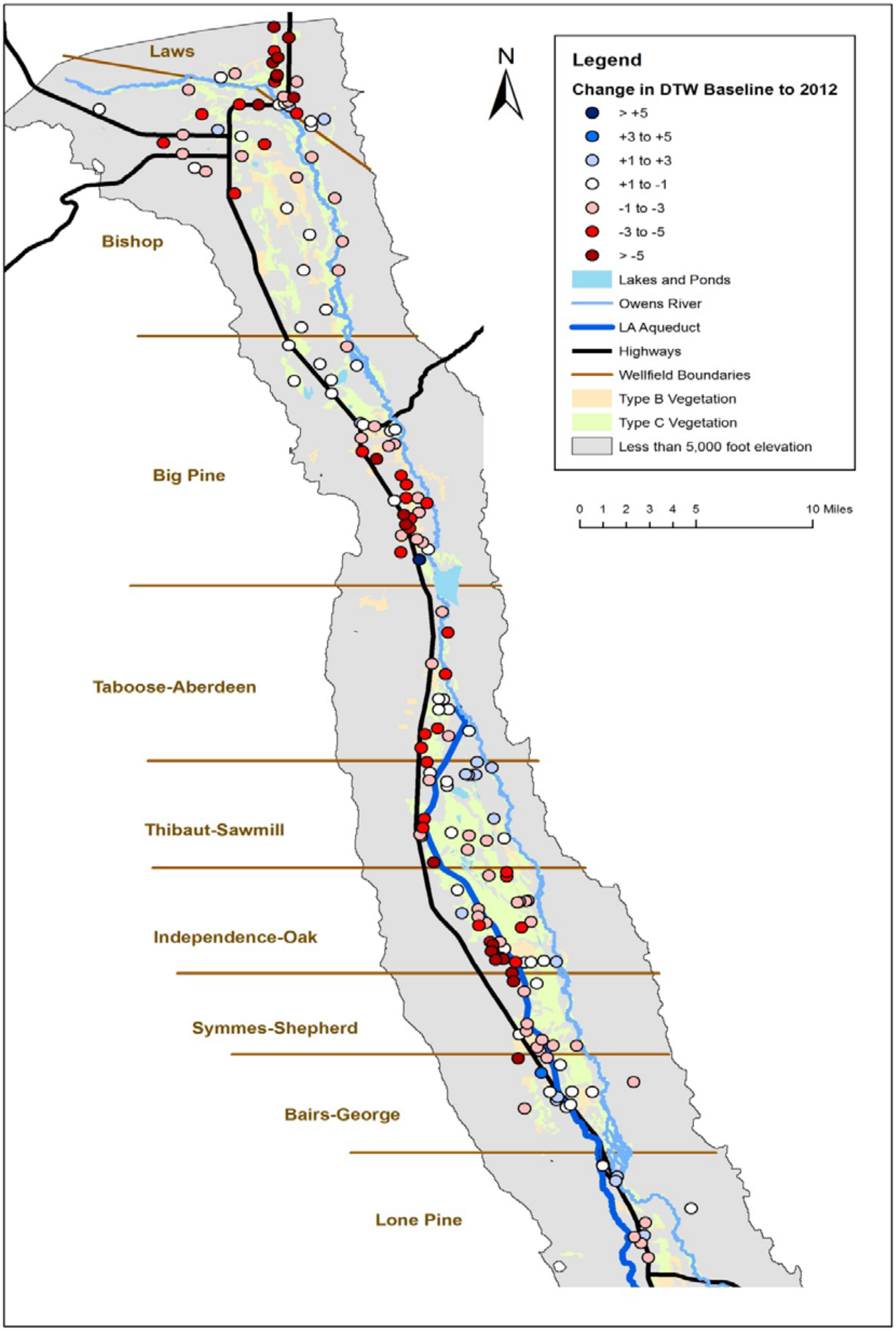

Figure 4.3. Water levels in 2012 relative to the 1985-87 baseline. Negative values denote water levels were below baseline.

Table 4.3. Comparison of runoff and pumping for multiyear droughts since 1970. The total runoff deficit is the sum of the difference between actual runoff and normal runoff for each year of the drought. Normal runoff was average of 1935-2014 (413,651 ac-ft).

Drought	Duration	Average Pumping	Average Runoff	Average Runoff	Total Runoff Deficit
	(Years)	(Ac-ft)	(Ac-ft)	% normal	(Ac-ft)
1970-72	3	119,491	326,483	79	261,504
1975-77	3	129,509	281,184	68	397,400
1987-92	6	137,773	256,441	62	943,261
1999-04	6	78,472	333,076	81	483,450
2007-09	3	66,363	293,613	71	311,362
2012-16	4	77,807	219,436	53	776,860

watershed to track and manage its water sources. A primary measurement produced by LADWP is Owens Valley runoff (OVR) which is a summation of gauged creek flows derived from precipitation, melting snowpack, and groundwater discharge (springs and creek baseflow). Quantitative records of OVR have been compiled since 1935; average annual OVR for the period is 413,651 ac-ft including several droughts. For the purposes of this discussion, drought was defined as consecutive years of below average runoff; isolated years of below average runoff were not examined.

Previous studies have shown that the relative effects of pumping on shallow water levels are much greater than that caused by fluctuations in OVR and recharge (Danskin, 1998). Comparing the effects of drought without considering pumping effects would not adequately explain differences in observed groundwater or vegetation conditions during different periods of low OVR. Before the completion of the second Los Angeles aqueduct in 1970, annual pumping was small and increased only during droughts. After completion of the second aqueduct, annual pumping was increased for export and for in valley uses. Because of the importance of pumping management on the hydrologic system, this comparison focuses on the droughts since 1970.

Six multiyear droughts have occurred since 1970 (Figure 4.4). Average runoff and the accumulated deficit in runoff (to reflect the length of the drought) is presented in Table 4.3. Lowest average runoff occurred during the present drought, and the accumulated deficit in 2012-16 is second only to 1987-92. Four other droughts since 1970 were shorter and less severe. During the droughts of the 1970's and 80's, LADWP increased pumping to make up shortfalls in surface water supplies for export. The Water Agreement management provisions were just being instituted in 1989 after most of the pumping during that drought had occurred. Pumping was reduced by approximately 50% during 1990-92. Pumping during the droughts that occurred after implementation of the Water Agreement including the current one has been substantially less than earlier droughts (Table 4.3).

Lower pumping during the current drought compared with 1987-92 despite similar or worse runoff conditions has resulted in relatively higher DTW conditions in 2016 compared to 1991 (Figure 4.5). Water levels in unpumped areas (e.g. between Bishop and Big Pine and east of the aqueduct) are similar to

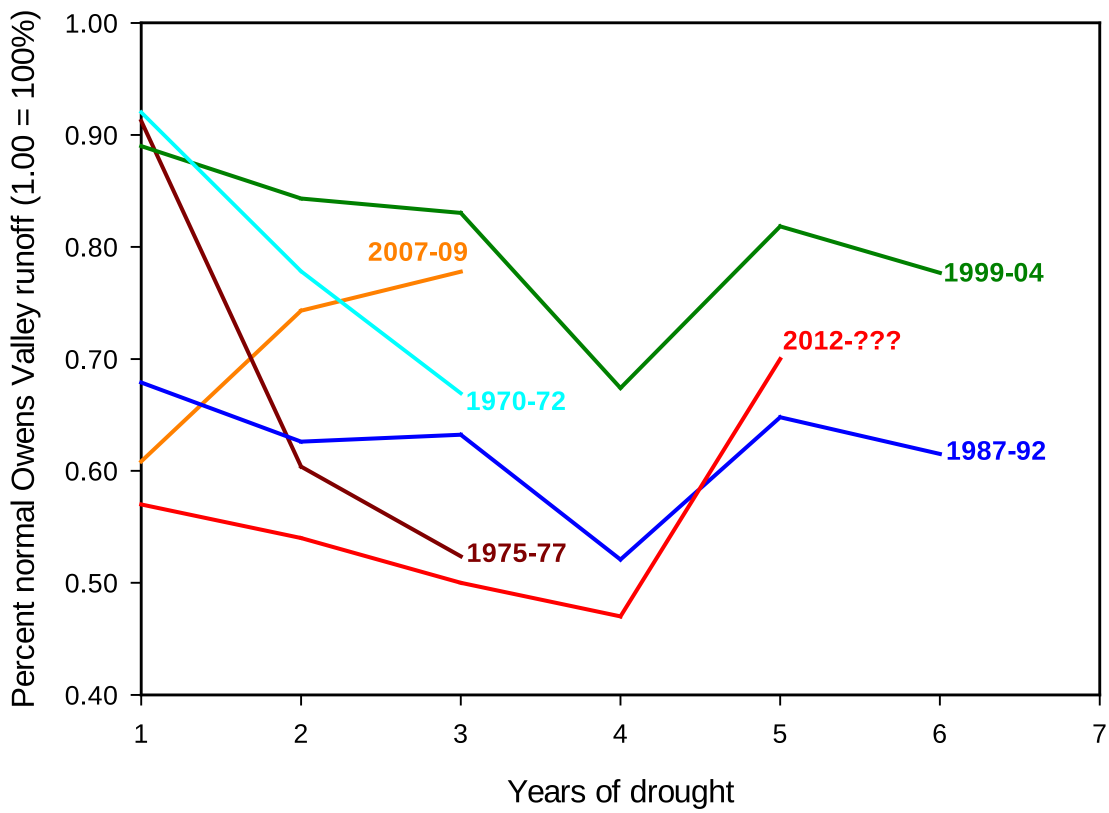

Figure 4.4. Comparison of present drought 2012-??? with previous multiyear droughts since 1970. Normal runoff was average of 1935-2014 (413,651 ac-ft).

1991 conditions consistent with drought being the principal factor controlling water levels.

Water levels in Laws, southern Big Pine, Taboose-Aberdeen, and Thibaut-Sawmill wellfields are generally 1 to more than 5 feet above the 1991 levels. Southern Symmes-Shepherd and Bairs-George range between 1-5 ft shallower than 1991 DTW. These areas have experienced much lower pumping since 2012 than in 1987-92. Water levels in Independence-Oak and northern Symmes-Shepherd are 0-3 ft shallower than 1991. Overall, pumping has been less during the present drought, but water levels in IO and SS are approaching the 1991 levels because nearby On-status and exempt wells located north and south of Mazourka Canyon Road have been operated. Curiously, water levels in the northern portion of the Big Pine wellfield also are approximately at 1991 levels despite the fact that pumping has not occurred in this portion of the wellfield since 1997. Water levels were at or near baseline as recently as 2011 and 2014 in that area, so the decline is recent and not indicative of a persistently depressed water table (798T and 572T, Table 4.1).

Pumping in Bishop and Lone Pine has varied little since 1987. Water levels compared to 1991 in west Bishop are variable, but in 2016 some wells are slightly below levels experienced

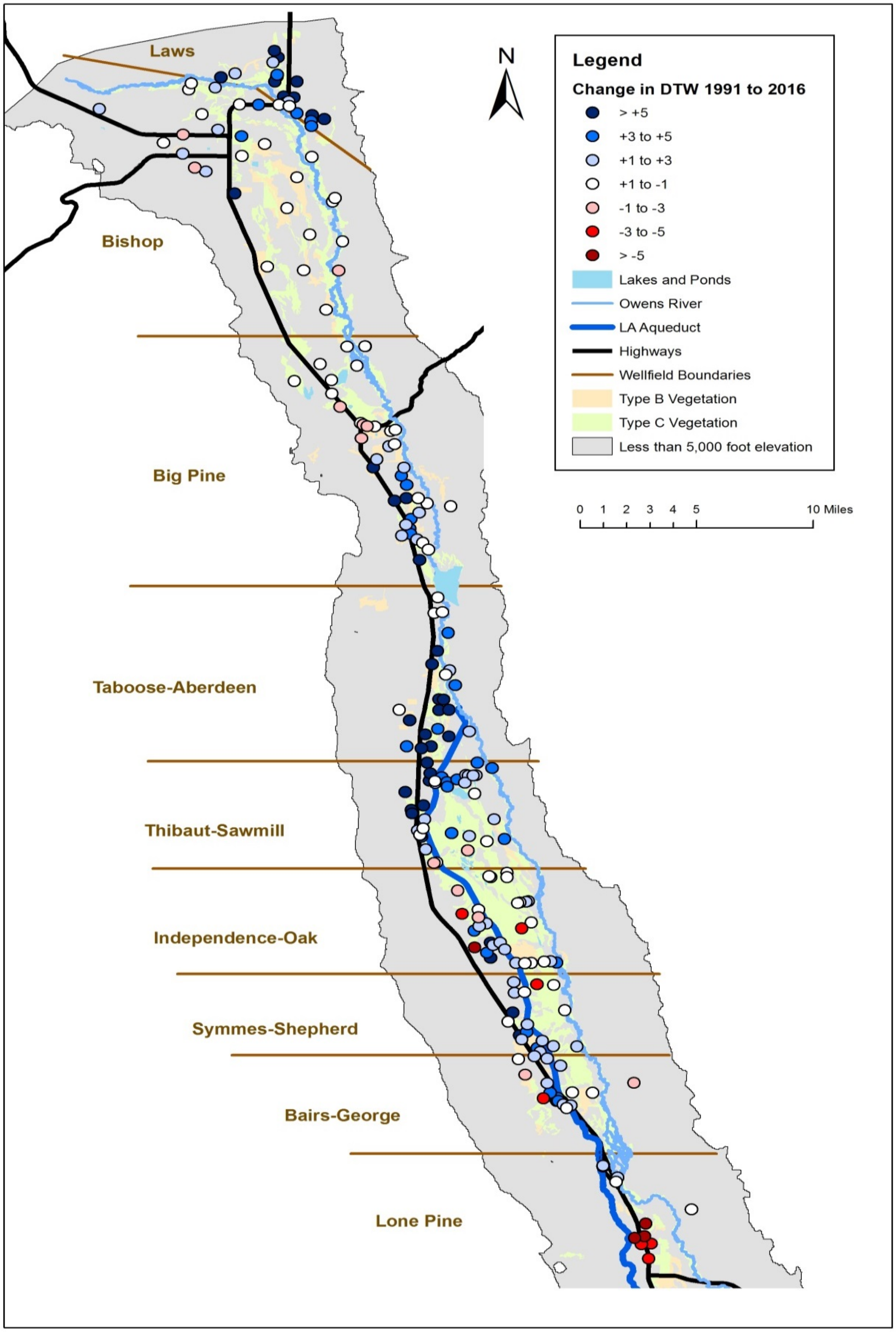

Figure 4.5. Comparison of 1991 and 2016 water levels for shallow monitoring wells in the Owens Valley. Positive values denote shallower water levels in 2016.

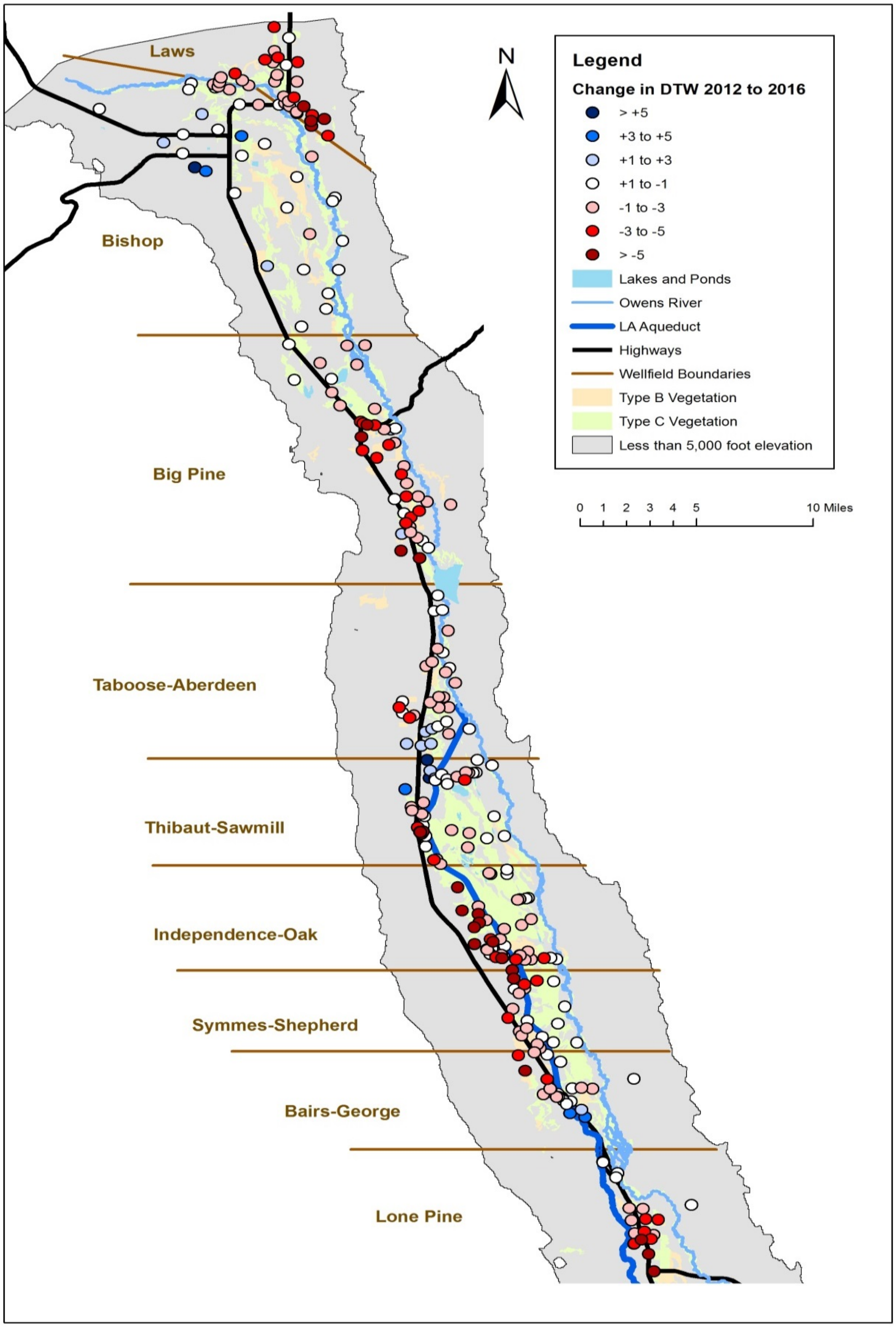

Figure 4.6. Change in water levels between April 2012 and April 2016 for most shallow monitoring wells in the Owens Valley. Negative values denote a decline in water level.

in 1991. Differences in water levels are probably due to localized changes in irrigation management. The Lone Pine wellfield is a curious outlier with water levels consistently 3 to 5 or more feet below the 1991 levels. Historically, water levels in Lone Pine fluctuate little compared to other wellfields due to the relatively low pumping stress (typically ~1100 ac-ft/year, 1990-2008) and extensive irrigated acreage supplied by creek water. Wellfield pumping was reduced 2008-14 due to well failure, and the recent decline in water levels began in 2012 coincident with drought. Pumping increased slightly after the failed well was replaced in 2015, but wellfield pumping still remains below the historic average. Reduced pumping and lack of correspondence in the timing of changes in pumping and water levels suggest pumping was not responsible for the decline since 2012. The declines in Lone Pine were likely due to depressed creek flow and/or associated irrigation.

Pumping and Drought effects 2012 to 2016

Measured water level changes since 2012 for shallow monitoring wells in the Owens Valley are presented in Figure 4.6. Water levels in unpumped areas (e.g. areas between Bishop and Big Pine and east of the Los Angeles aqueduct) have declined between 0-3 ft similar to observations in previous droughts and consistent with water level changes due solely to reduced recharge. Water levels in Bishop have generally increased small amounts (<5 ft) since 2012, probably in response to efforts to manage ditches and irrigation to correct a decline in water levels that occurred in 2013. The only other areas of water level recovery during the present drought are north and south of the Blackrock fish hatchery on the boundary between the Taboose-Aberdeen and Thibaut-Sawmill wellfields and several wells in the southern Bairs-George wellfield. Water levels near the hatchery have risen sharply since 2014 when pumping was reduced following settlement of dispute resolution over BLK94. The wells in Bairs-George are near the Los Angeles aqueduct and rose sharply in 2015-16 despite the drought and increased wellfield pumping. The water level rise was probably caused by leaks in the aqueduct.

Water levels in most wellfields have declined 3 to >5 ft since 2012 (Figure 4.6). Most wells in Laws declined 1-3 ft which is slightly more than in unpumped areas. Several wells, however, near Jean Blanc road and in the southeast portion of the wellfield have declined 3 to >5 ft. Water levels in most wells in Big Pine have declined 1 to 5 ft. Declines greater than 5 ft were observed in the southern portion near exempt wells operated for hatchery and export and curiously also near U.S. 168 with no nearby pumping. The northern half of Taboose-Aberdeen experienced 0-3 ft declines comparable to unpumped areas; the remainder of the wellfield experienced shallower water levels due to reduced hatchery pumping discussed above. Notable declines since 2012 have occurred in Independence-Oak and northern Symmes-Shepherd wellfields. Declines in these wellfields correspond with pumping for export and irrigation through the drought from exempt and On-status wells. Southern Symmes-Shepherd and Bairs-George experienced 1-3 ft of decline in most wells, slightly more than in unpumped areas east of the Los Angeles aqueduct. Possible causes for water level changes in Lone Pine were discussed above.

The observed water level changes shown in Figure 4.6 include both pumping and drought effects. Compared to unpumped areas, declines greater than 3 ft in wellfields can be interpreted as pumping effects. To better

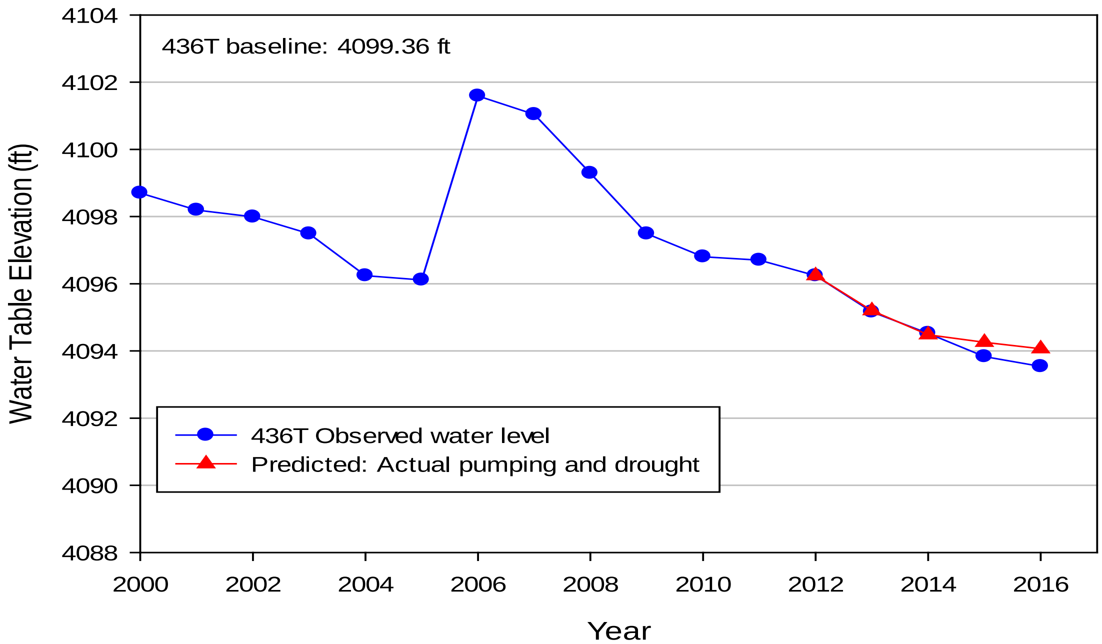

Figure 4.7: Observed water level for monitoring well 436T in the Laws wellfield and predicted water levels 2013-2016 using indicator well models for actual runoff and pumping. Scenario 1 is in red.

discriminate the relative effects of drought and pumping, simulations using the indicator and monitoring site models were completed. Three scenarios were modeled: 1) actual pumping and drought, 2) minimum pumping and drought, and 3) actual pumping and no drought. The first scenario evaluates how well the model performed compared to actual water levels. For these simulations, minimum pumping is the pumping necessary to supply sole source uses such as town supply, fish hatcheries, irrigation, and mitigation projects. Scenarios 2 and 3 estimate the water levels if LADWP had reduced pumping to minimum through the drought and water levels if runoff had remained 100% of normal. Water levels in some of the indicator wells are not correlated with runoff and could not be used for Scenario 3. Three models in Taboose-Aberdeen wellfield are inaccurate because the monitoring wells are affected by the reduction in pumping from the neighboring Thibaut-Sawmill wellfield. Simulations were not performed for these wells. The simulations begin in April 2012 coincident with the onset of below normal runoff. Water levels were simulated for each April 2013-2016, and the simulated DTW at the end of each year was used as input for the following year. Accuracy of the models in a given year is generally ±1.25 ft (this report p. 3-44)

Example hydrographs of the simulation results are presented in Figures 4.7 through 4.13. Graphs of most wells within wellfields were visually similar and only one representative example from each wellfield is presented. Results for all indicator wells included in the modeling analysis are included in Table 4.4.

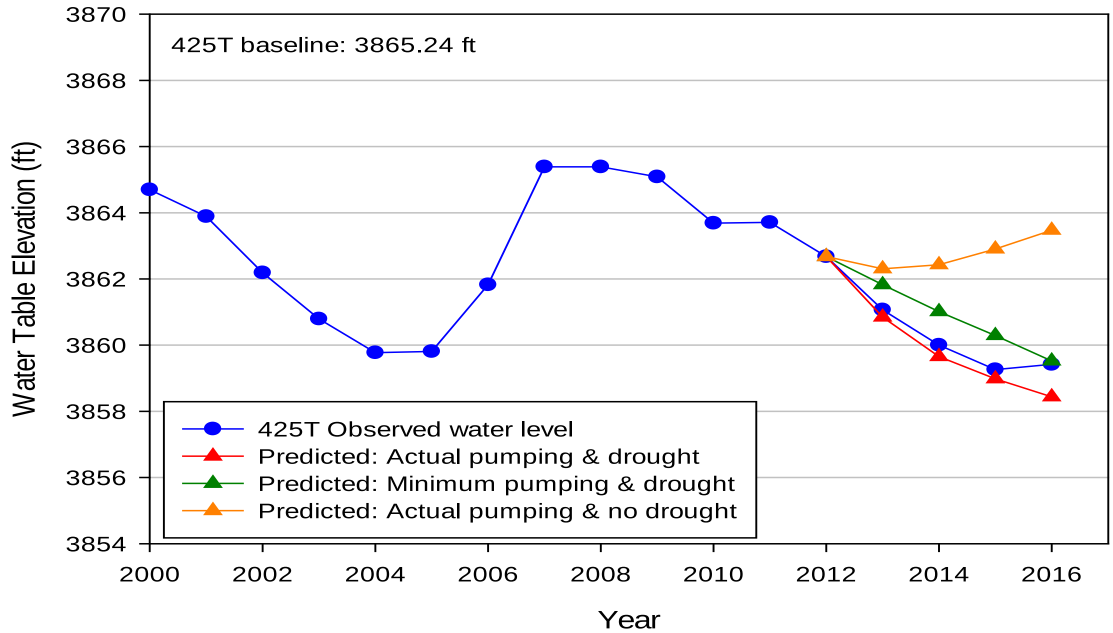

Figure 4.8: Observed water level for monitoring well 425T in the Big Pine wellfield and predicted water levels 2013-2016 using indicator well models for actual and two alternate runoff and pumping scenarios . Scenario 1 is in red, Scenario 2 is in green, and Scenario 3 is in orange.

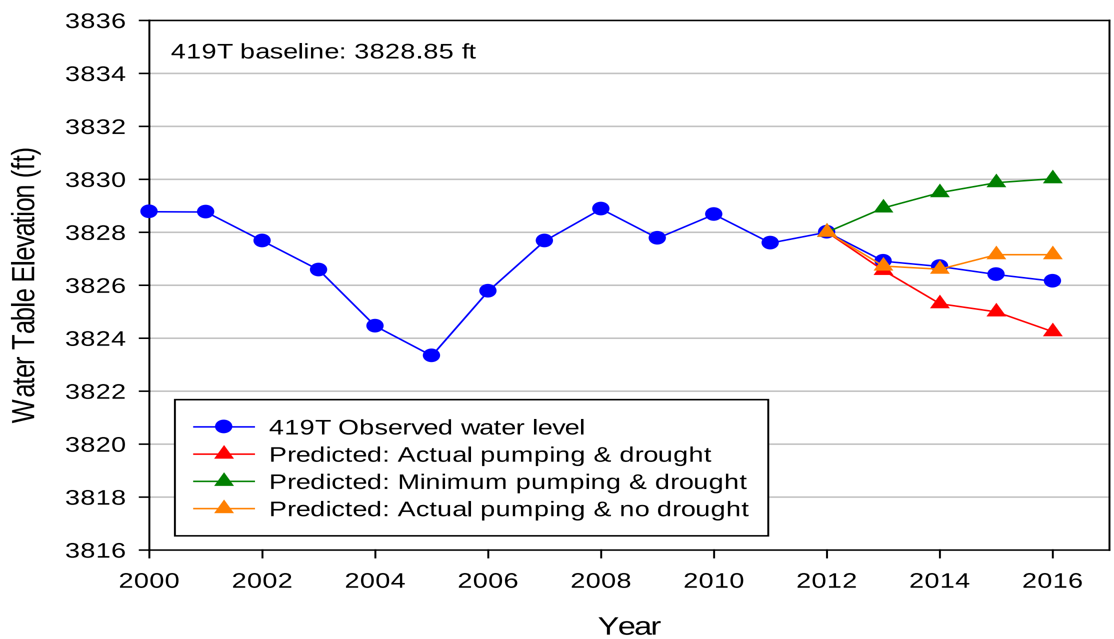

Figure 4.9: Observed water level for monitoring well 419T in the Taboose Aberdeen wellfield and predicted water levels 2013-2016 using indicator well models for actual and two alternate runoff and pumping scenarios. Scenario 1 is in red, Scenario 2 is in green, and Scenario 3 is in orange.

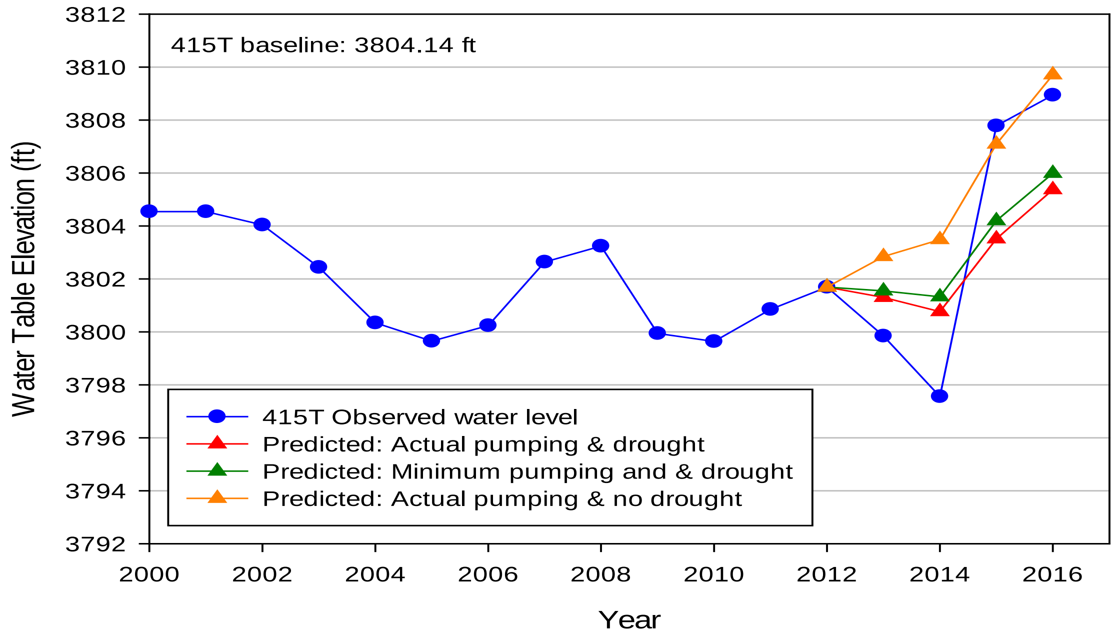

Figure 4.10: Observed water level for monitoring well 415T in the Thibaut-Sawmill wellfield and predicted water levels 2013-2016 using indicator well models for actual and two alternate runoff and pumping scenarios. Scenario 1 is in red, Scenario 2 is in green, and Scenario 3 is in orange.

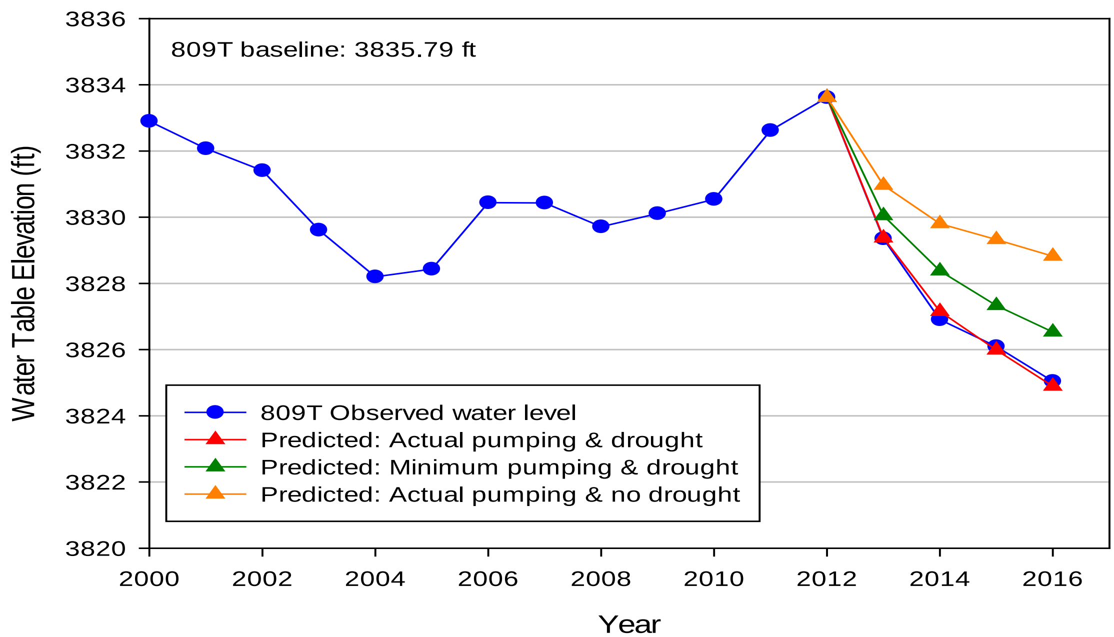

Figure 4.11: Observed water level for monitoring well 809T in the Independence-Oak wellfield and predicted water levels 2013-2016 using indicator well models for actual and two alternate runoff and pumping scenarios. Scenario 1 is in red, Scenario 2 is in green, and Scenario 3 is in orange.

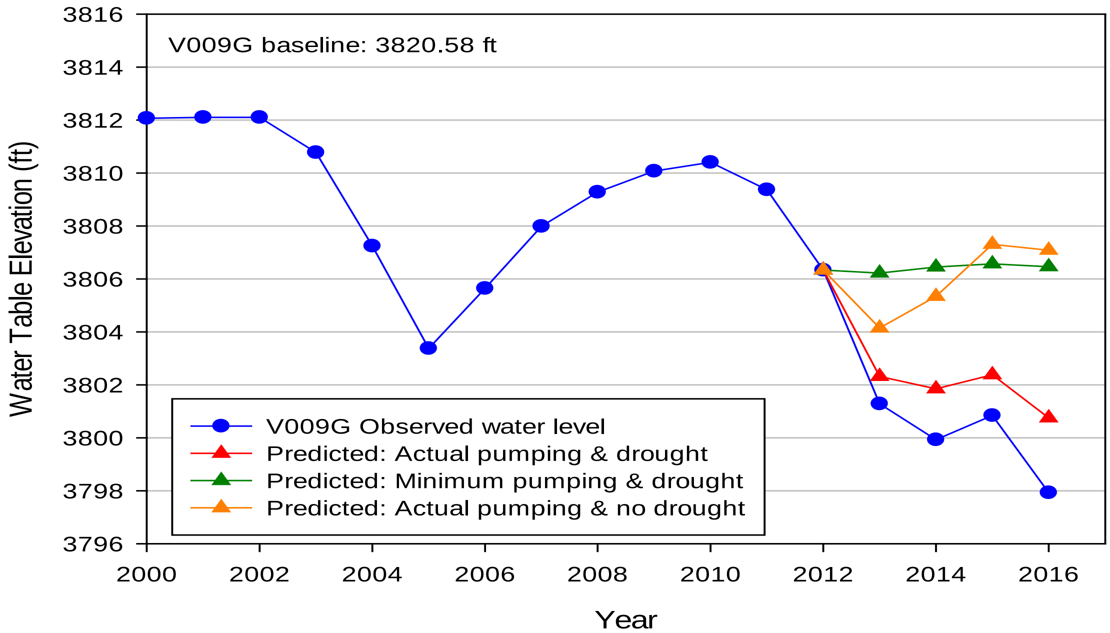

Figure 4.12: Observed water level for monitoring well V009g in the Symmes-Shepherd wellfield and predicted water levels 2013-2016 using indicator well models for actual and two alternate runoff and pumping scenarios. Water levels in 2010 were below baseline but sufficient to substantially wet the plant root zone. Scenario 1 is in red, Scenario 2 is in green, and Scenario 3 is in orange.

The models in Laws commonly used for analysis of the annual pumping plan rely on diversions from the Owens River into the McNally canals as the variable correlated with recharge instead of OVR. No water has been diverted into the canals since 2011, and under current aqueduct operations it is unlikely that LADWP would divert much water into the canals even in normal runoff years. Models based on OVR were developed to simulate the effect of reduced natural recharge related to drought when no canal recharge is expected (Scenario 1, Table 4.4). Since 2012, pumping in Laws has been for irrigation and town supply only and results for the Scenarios 1 and 2 are the same. Neither the models with OVR or McNally variables were valid for simulating Scenario 3. The McNally models do not reflect the reduced natural runoff in dry years when no water is diverted into the canals. Before about 1999, OVR and diversions into the McNally canal were correlated, and normal runoff years were usually associated with substantial diversion of river water into the canals. This is no longer the case, and OVR models drastically overestimates the probable recharge that would have occurred since 2012 if runoff were normal.

The model results for other wellfields were much more straightforward compared to Laws. Most indicator well models adequately simulated trends in the observed water levels during the drought. The average of the absolute deviation between the 2016 measured water level and Scenario 1 results for all wells was ±1.2 ft; most were less than 1 ft. This is

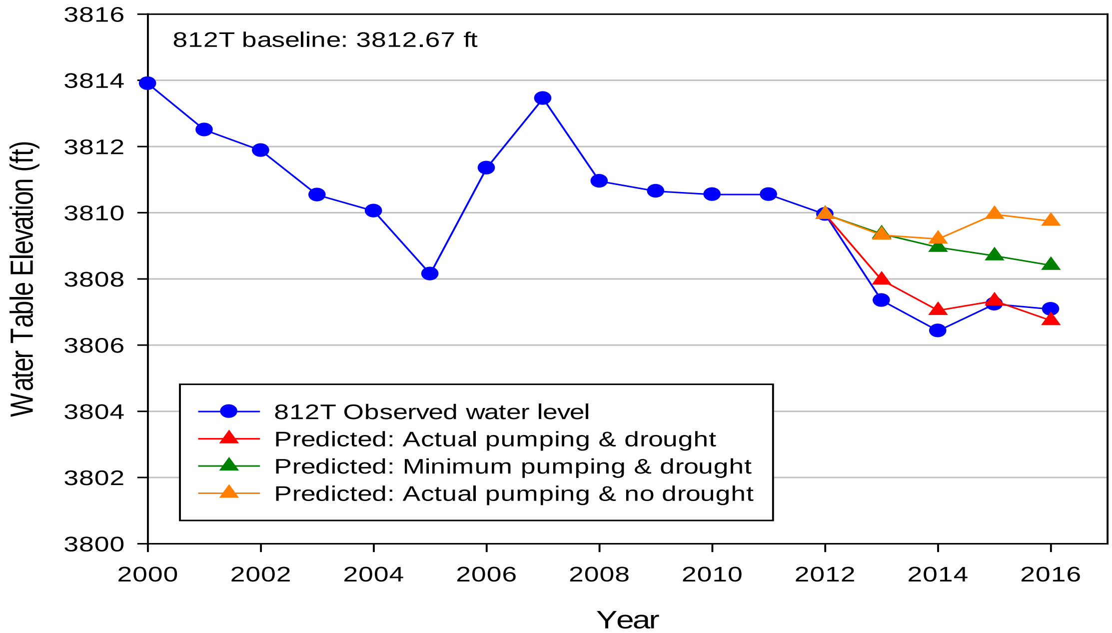

Figure 4.13: Observed water level for monitoring well 812T in the Bairs-George wellfield and predicted water levels 2013-2016 using indicator well models for actual and two alternate runoff and pumping scenarios. Scenario 1 is in red, Scenario 2 is in green, and Scenario 3 is in orange.

comparable to model error. A few observations were noted where the model systematically differed from measured values. Actual water levels in Taboose-Aberdeen wells in the central portion of the wellfield (e.g. 418T, 421T, 586T and 419T, Figure 4.9) tended to be consistently shallower than predicted in Scenario 1 (actual pumping and drought, Table 4.4). Reduced pumping at the Blackrock Hatchery may be having a small effect on these wells that is not included in the Taboose-Aberdeen models because the hatchery wells are in the neighboring Thibaut-Sawmill wellfield. Accurate predictions for 502T and 801T in the northern portion of the wellfield farthest from the hatchery supports that interpretation. Models for 447T and V009g in Symmes-Shepherd predicted shallower water levels than observed. Pumping in this wellfield in recent years has been concentrated near these monitoring wells; in the past pumping occurred from wells throughout the wellfield. If this is the case, simulated water levels for Scenario 3 (Table 4.4) for these wells were probably about three feet too shallow as well. Water levels in Thibaut-Sawmill are still responding to the reduction in hatchery pumping and water levels increased in all scenarios. Since 2014 Thibaut-Sawmill pumping has been less than the range of historic pumping contributing to relatively poor model simulation of the trends (Figure 4.10).

The relative effects of pumping more than the wellfield minimum and drought can be gleaned by comparing Scenario 1 with Scenario 2 (pumping) and Scenario 1 with Scenario 3

Table 4.4. Summary of modeling results for three scenarios of drought and pumping 2012-2016. Data are change in DTW since 2012.

		Predicted DTW change 2012-2016		
Wellfield Well	Measured Change 2012-2016	Scenario 1: Actual pumping & drought	Scenario 2: Min. pumping & drought	Scenario 3: Actual pumping & no drought
Laws				
436T	-2.70	-2.18	-2.18	NA
438T	-4.35	-3.60	-3.60	NA
490T	-5.59	-6.26	-6.26	NA
492T	-3.00	-4.13	-4.13	NA
574T, LW3	-2.36	-2.38	-2.38	NA
Big Pine				
425T	-3.26	-4.25	-3.16	0.79
426T	-3.58	-3.53	-2.86	0.10
469T	-2.64	-1.59	-1.19	0.39
572T	-4.53	-2.20	-1.65	1.81
798T, BP1	-6.06	-3.08	-2.61	0.35
799T, BP2	-2.45	-1.78	-1.37	0.24
567T, BP3	-3.28	-4.96	-4.12	0.57
800T, BP4	-2.86	-3.40	-2.41	1.19
Taboose Aberdeen				
417T†	2.32	NA	NA	NA
418T	-1.23	-2.33	0.82	-0.28
419T	-1.85	-4.11	2.01	-0.85
421T	-3.17	-4.41	1.34	-0.54
502T	-2.09	-2.07	0.30	0.43
504T	-2.21	-4.63	2.30	-1.43
505T	2.15	NA	NA	NA
586T, TA4	-1.89	-3.03	2.64	-1.33
801T, TA5	-0.96	-0.78	0.45	0.52
803T, TA6	2.31	NA	NA	NA
Thibaut Sawmill				
415T	7.25	3.68	4.30	8.02
507T	-1.06	0.65	0.80	NA
806T, TS2	-1.38	-0.08	0.19	1.80
Independence Oak				
406T	-4.35	-3.05	-2.43	-1.63
407T††	-4.27	-1.82	1.32	NA
408T	-3.07	-1.27	1.01	NA
409T	-8.64	-5.88	-0.06	-2.48

		Predicted DTW change 2012-2016		
Wellfield Well	Measured Change 2012-2016	Scenario 1: Actual pumping & drought	Scenario 2: Min. pumping & drought	Scenario 3: Actual pumping & no drought
546T	-6.14	-5.06	-3.99	-2.50
809T, IO1	-8.58	-8.72	-7.09	-4.80
Symmes Shepherd				
402T	-0.64	-1.46	-0.66	-0.05
403T	-1.73	-1.91	0.51	-0.35
404T	-0.42	0.15	1.13	NA
510T	-0.35	-0.51	0.21	0.11
511T	-1.59	-0.15	1.11	NA
447T	-9.09	-5.72	0.79	1.49
V009G, SS1	-8.41	-5.59	0.13	0.75
Bairs George				
398T	-0.93	-1.53	-0.01	-0.97
400T	-0.86	-0.64	-0.43	NA
812T	-2.87	-3.21	-1.54	-0.21

†: Wells 417T, 505T, and 803T are affected by reduction in pumping in the neighboring TS wellfield.
††: Wells in the Independence-Oak, Symmes-Shepherd and Bairs-George wellfields with no results for Scenario 2 and 3 are not significantly correlated with runoff (p>0.10) and not applicable to this analysis.

(drought). Water levels would be on average 2 ft shallower (average of subtracting Scenario 1 from Scenario 2 in Table 4.4). The similarity in 2016 water levels for the two scenarios in most wellfields is due to reductions in pumping in 2013-16 (Table 4.1 and Figure 3.3 this report). In several wellfields actual pumping has been minimum (Laws) or slightly above (Big Pine, Thibault-Sawmill) and Scenario 1 and 2 results differ by about a foot or less. Minimum pumping in Taboose-Aberdeen is only 300 ac-ft, and amount of discretionary pumping was greatest in this wellfield (Figure 3-16, this report). Water levels in Taboose-Aberdeen for the minimum pumping scenario were substantially above Scenario 1 (e.g. Figure 4.9). Reducing pumping in this wellfield during the drought could have stabilized or even raised water levels slightly instead of the 1-3 ft declines actually experienced. Reducing pumping to minimum levels during the drought would not have prevented DTW declines in Laws, Big Pine, portions of Independence-Oak and Bairs-George (Table 4.4, Scenario 2). In contrast, water levels for Scenario 3 (no drought) were on average 3 ft shallower than Scenario 1 (drought). In almost all wells, the relative effect of drought was greater than the effect of pumping above the minimum value. Exceptions were the wells in Taboose-Aberdeen where most of the discretionary pumping during the drought has occurred. In that wellfield, the drought effect is substantial, 1-4 feet, but still less than what a reduction in pumping to minimum pumping could have attained 1-6 ft.

Summary and Conclusions

This section examined groundwater and vegetation response to the current ongoing drought in the context of past droughts and in the context of the Water Agreement's goals for vegetation conditions. To summarize:

- The current ongoing drought has had the lowest average runoff over its first four years of any droughts in the period since the period of operation of the second LA Aqueduct. In terms of cumulative runoff deficit, it is exceeded only by the drought of 1987-1992, which persisted for six years.
- Groundwater levels recovered to baseline or near baseline in over half of the indicator wells and monitoring site wells examined for this chapter. Table 1 shows that 27 of 46 wells have recovered to baseline at some time since 1991 when water tables were at a low point (e.g., Figure 1), and another 9 wells have been within one foot of baseline. Present water tables are generally higher than when the Water Agreement was signed in 1991.
- At some time since 2011, 42 of 57 vegetation parcels near the indicator and monitoring site wells have had perennial vegetation cover statistically the same as baseline cover. Notable vegetation declines in numerous parcels have occurred since 2013 (see Vegetation Conditions section).
- During the present drought, water tables have declined, but not as much as during pre-Water Agreement droughts because pumping was higher during droughts of the 1970's and 80's.

Water table declines during the current drought are due to the combined effects of groundwater pumping and diminished recharge. In most areas, the effect of diminished recharge had greater effect on the water table than discretionary pumping, except in the Taboose-Aberdeen well field where discretionary pumping has been a relatively large fraction of the overall pumping in the well field.

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SECTION 5: 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 2016 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 5.1. Comparison of DTW preceding the growing seasons in 2015 and 2016. Data compare measurements taken near April 1 of each year except for BP1 and BP3 where the minimum DTW is in the fall. Hydrographs for the sites are provided in Appendix A. Depths are below ground surface.

Wellfield Site	2015 DTW (m)	2016 DTW (m)	DTW Change 2015-16† (m and ft)
Laws			
L1	Dry at 8.28	Dry at 8.28	--
L2	Dry at 7.53	Dry at 7.53	--
L3	5.54	5.92	-0.05 (-0.17)
Bishop Control			
BC1	3.32	3.30	-0.02 (0.06)
BC2	4.60	4.56	0.03 (0.11)
BC3	1.83	1.83	0.00
Big Pine			
BP1	4.76	5.77	-0.99 (-3.25)
BP2	6.40	6.60	-0.15 (-0.12)
BP3	6.27	6.42	0.50 (0.15)
BP4	6.02	6.02	0.0
Taboose Aberdeen			
TA1 & 2	2.27	2.37	-0.10 (-0.32)
TA3	5.58	5.13	0.45 (1.48)
TA4	3.11	3.20	-0.09 (-0.30)
TA5	5.03	4.90	0.13 (0.42)
TA6	3.44	3.01	0.44 (1.43)
TAC	1.40	1.52	-0.12 (-0.39)
Thibaut Sawmill			
TS1	6.01	5.65	0.36 (1.16)
TS2	4.33	4.10	0.23 (0.76)
TS3	2.91	3.02	-0.11 (-0.36)
TS4	2.27	2.10	0.16 (0.54)
TS6	5.91	6.32	-0.53 (-1.72)
TSC	1.32	1.62	-0.30 (-0.99)
Independence Oak			
IO1	4.68	5.00	-0.32 (-1.04)
IO2	9.92	11.27	-1.35 (-4.43)
IC1	1.15	1.21	-0.06 (-0.20)
IC2	2.50	2.55	-0.05 (-0.17)
Symmes Shepherd			
SS1	6.75	7.60	-0.85 (-2.78)
SS2	Dry at 8.41	Dry at 8.41	--
SS3	4.36	4.44	-0.08 (-0.25)
SS4	6.61	6.65	-0.03 (-0.10)
Bairs George			
BG2	5.35	5.39	-0.05 (-0.15)
BGC	2.97	2.93	0.04 (0.13)

†: positive values denote a rise in the water table.

Table 5.2. Soil depth below ground surface replenished by groundwater in 2015-2016 at control sites. Values are provided for each monitoring location within a site. Minimum DTW before the 2016 growing season 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	3.30	2.9, 1.9, 2.6
BC2	rabbitbrush, saltgrass	2	4.56	<1.3†, 2.7, <1.1, 1.1
BC3	rabbitbrush, saltgrass, saltbush	2	1.83	<0.3,< 0.3, <0.5
TAC	saltbush, rye grass, saltgrass, alk. sacaton	2	1.52	<0.9,< 0.9, <0.7, <0.7
TSC	alk. sacaton, rabbitbrush, greasewood.	2	1.62	0.9, 0.9, 1.7
IC1	saltbush, saltgrass, rabbitbrush	2	1.21	1.3, 1.1, <0.9
IC2	rabbitbrush, alk. sacaton	2	2.55	2.1, 2.5, >3.7
BGC	saltbush, saltgrass	4	2.93	1.1, 1.5, >3.3

†: Less than symbols (<) denote locations where both infiltration and groundwater recharge contribute to increasing soil water content above the depth indicated

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 contained in Appendix A. (The graphs in Appendix A are periodically updated and available at Technical Group meetings and on the ICWD website.) At the beginning of the 2015-16 runoff year, six sites were in On-status, and remained so throughout the runoff year. No sites went into On-status during the winter 2015-16. The six sites in On-status as of May, 2016 were: L2, BP4, TA5, TS2, SS1, and BG2.

Hydrographs for the permanent monitoring sites are presented in Appendix A, and the DTW measured during the fall and winter preceding the 2015 and 2016 growing seasons are presented in Table 4.1. At most sites, the minimum DTW occurs in the spring, near April 1. At sites BP1 and 3 in Big Pine, 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. For these three sites, the amount and depth of soil water recharge during the winter are related to the minimum water table depth in the fall. Of the 33 monitoring sites, TA1 and TA2 rely on a single monitoring well, and the monitoring wells at LW1, LW2, and SS2 were dry in 2015 and 2016 preventing evaluation of water table changes. Water table changes were examined at 29 sites; 21 in wellfields and eight outside wellfields.

Table 5.3. Soil depth below ground surface replenished by groundwater in 2015-2016 at wellfield sites. Values are provided for each monitoring location within a site unless the identification of a specific depth was uncertain. Minimum DTW before the 2016 growing season was measured in the associated test well.

Site	Dominant plant species	Root Zone (m)	Minimum DTW (m)	Groundwater recharge depth (m)
L1	greasewood	4	Dry at 8.28	>3.9, >3.7, >3.7
L2	alk. sacaton, greasewood, saltbush	2	Dry at 7.53	>3.9 at all five locations
L3	alk. sacaton, saltgrass	2	5.92	0.9, 1.9, 0.9, 0.9, 1.1, 0.9
BP1	saltbush, greasewood	3	5.77	>3.7, >3.3,>3.7, >3.9, >3.9
BP2	saltbush, rabbitbrush	4	6.60	>5.3, >3.9, >3.9
BP3	greasewood, rabbitbrush	4	5.83	3.7, 3.5, >3.9
BP4	saltbush, greasewood	4	6.02	2.1†, 2.3†, 2.1†
TA1	alk. sacaton, saltbush	2	2.37	1.3
TA2	alk. sacaton, saltbush, greasewood, rabbitbrush	2	2.37	1.1
TA3	saltbush, alk. sacaton, sagebrush	2	5.13	3.1, 2.1, 2.5
TA4	rabbitbrush, alk. sacaton	2	3.20	>3.3 ,>2.1, >1.9
TA5	greasewood, alk. sacaton	2	4.90	
TA6	saltbush, rabbitbrush	2	3.01	2.1, 2.3, 2.1
TS1	weeds, alk. sacaton	2	5.65	>3.9 at all five locations
TS2	sagebrush, saltbush, alk. sacaton	2	4.10	3.3, 1.7, >3.3
TS3	saltgrass, alk. sacaton	2	3.02	1.5, 1.7, 1.1, 1.1, 0.9, 0.9
TS4	greasewood, alk. sacaton, saltbush, saltgrass	2	2.10	<0.9††, <0.9, 1.1, 0.9
TS6	alk. sacaton, saltbush, saltgrass	2	6.32	0.9 to 2.5†
IO1	rabbitbrush, alk. sacaton, saltbush	2	5.00	2.1-2.7†, 1.9-2.3†, 1.5-2.5†
IO2	saltbush	4	11.27	>5.5, >3.9, >3.9
SS1	saltbush, greasewood	4	7.60	>5.5, >3.9, >3.9
SS2	saltbush	4	Dry at 8.41	>5.5, >3.9, >3.9
SS3	saltbush	4	4.44	>3.9, 2.3-2.7†, >3.9
SS4	saltbush	4	6.65	>3.9, >3.9, 3.1-3.5†
BG2	inkweed, saltbush	4	5.39	>3.9, >3.5, >3.7

†: Soil water content at these depths increases slightly during winter well above the limit of capillarity above the water table suggesting that another recharge mechanism is operating.

††: Less than symbols (<) denote locations where both infiltration and groundwater recharge contribute to increasing soil water content above the depth indicated.

The average water table depth declined -0.15 m (6in.) in wellfields and -0.02m (less than 1 in) in control areas. Groundwater pumping in 2015-16 was reduced, so stable or slightly declining water levels were expected despite the severity of the ongoing drought (see the Groundwater section of this report). Five control and 15 wellfield sites experience water table declines. Sites near the Blackrock fish hatchery were the only wellfield sites that exhibited rising water table due to the reduction in pumping to supply the Blackrock fish hatchery that began in 2014 as a result of the settlement of the dispute over conditions in Blackrock 94.

At most sites it was possible to discriminate groundwater recharge from surface infiltration because of the dry winter in 2015-16 (Tables 4.2 and 4.3). Infiltration was limited to depths within 0.5-0.7 m of the surface at most sites and resulted in negligible increase in soil water. 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. Two wellfield and four 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. Three control and three wellfield sites occur in this category. The control sites and L3, TA2, and TS3 have ample soil water stored in the soil profile.

3. Disconnected: No recharge from groundwater occurred in the root zone. Twenty wellfield sites and one control site occur in this category. The control site and L2, BP4, TA4, TA5, TS6, IO1, SS3, and BG2 had retained soil water available to vegetation, but the water table at the beginning of the 2016 growing season is too deep to recharge the root zone. Soil at the other sites is dry.

Only one site was placed in a different category in 2016 compared with 2015. Site BC2 changed from well connected to weakly connected despite the nearly same water table conditions. Soil water changes at this site are difficult to interpret, and the soil depth wetted by groundwater at two tubes is just below the 1m threshold necessary to classify as well connected. All control sites still had ample retained water in the soil above the water table. At the beginning of the 2016 growing season, the water table was capable of supplying water to the root zone at five wellfield monitoring sites (Figure 5.1). Twenty wellfield sites were classified as disconnected Eight sites in the disconnected category still retain soil water following water table decline (L2, BP4, TA4, TA5, TS6, IO1, SS3, and BG2) or because the plant cover is low and the soil is always moist (TA5). The remaining 12 sites have dry soil throughout the root zone. As in previous years, interpretations for TA5 were atypical. Soil at this site was moist at lower depths but relatively unchanging. Plant uptake during the summer was not evident below two meters, and soil water recovery when plant uptake ceased in the fall or related to water table fluctuations was not evident. The DTW at TA5 is much below the 2m root zone, and the site was classified as disconnected as it was in 2015.

Monitoring locations at BP4, TS6, IO1, SS3, and SS4 exhibited increasing soil water content at certain depths well above the water table while lower depths showed no change in water

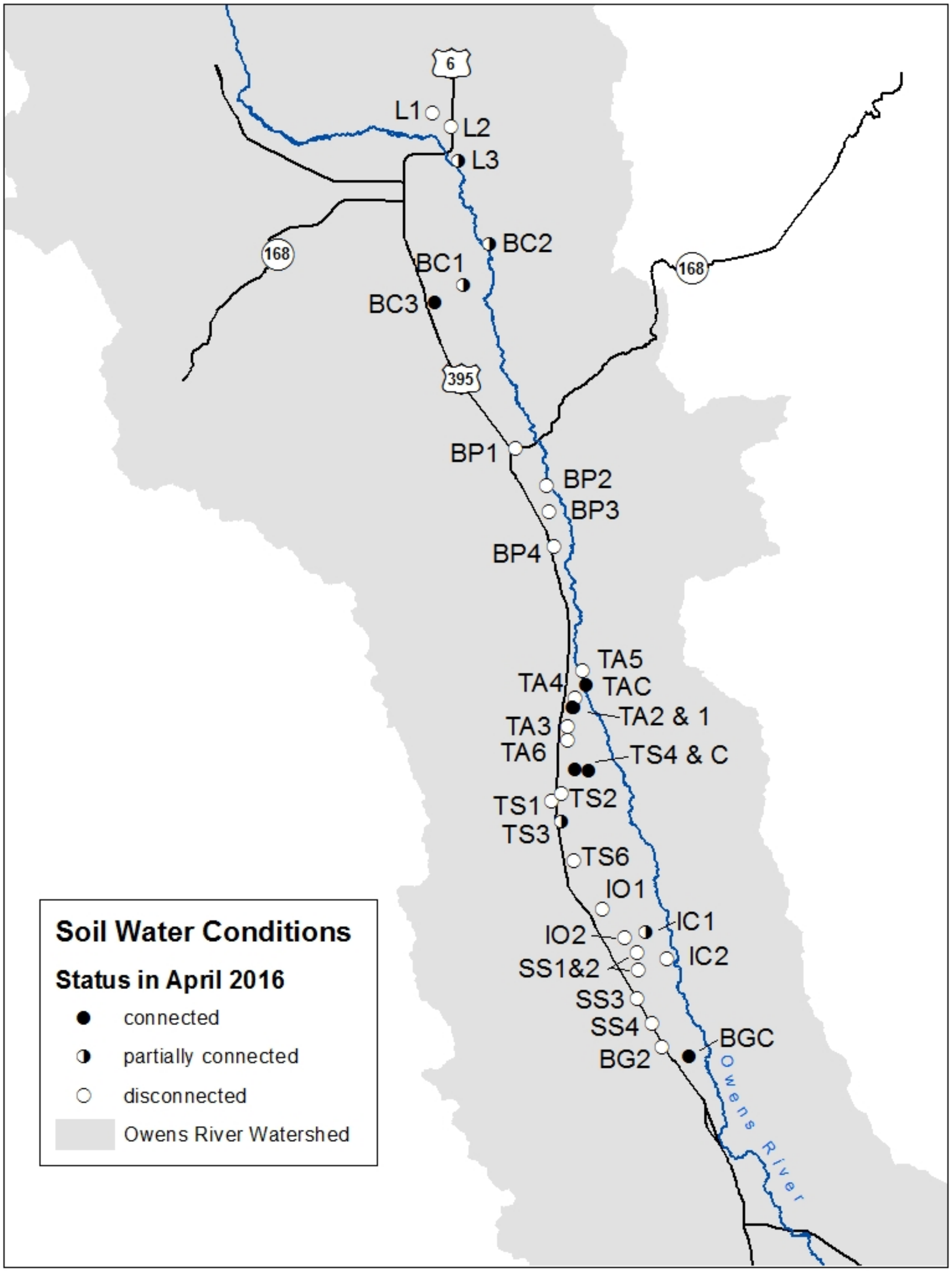

Figure 5.1. Owens Valley permanent monitoring sites and groundwater recharge classes. It is difficult to distinguish TA1 and TA2 on this map because of their proximity to one another. TA1 is partially connected; TA2 is connected.

unsaturated soil just above the water table is unusual. 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; Jackson et al., 2000) but without additional information, assigning that cause is speculative. The increase in water content was small and barely detectable, usually about 3%. 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.

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Available Soil Water Graphs

July 1 and October 1 2016 On/Off calculation table for the permanent monitoring sites and graphs containing the soil-plant water balance and groundwater data. No sites changed status in April 2015-April 2016

June 2015 monitoring site status and July 1, 2015 soil/vegetation water balance calculations according to Green Book, Section III.

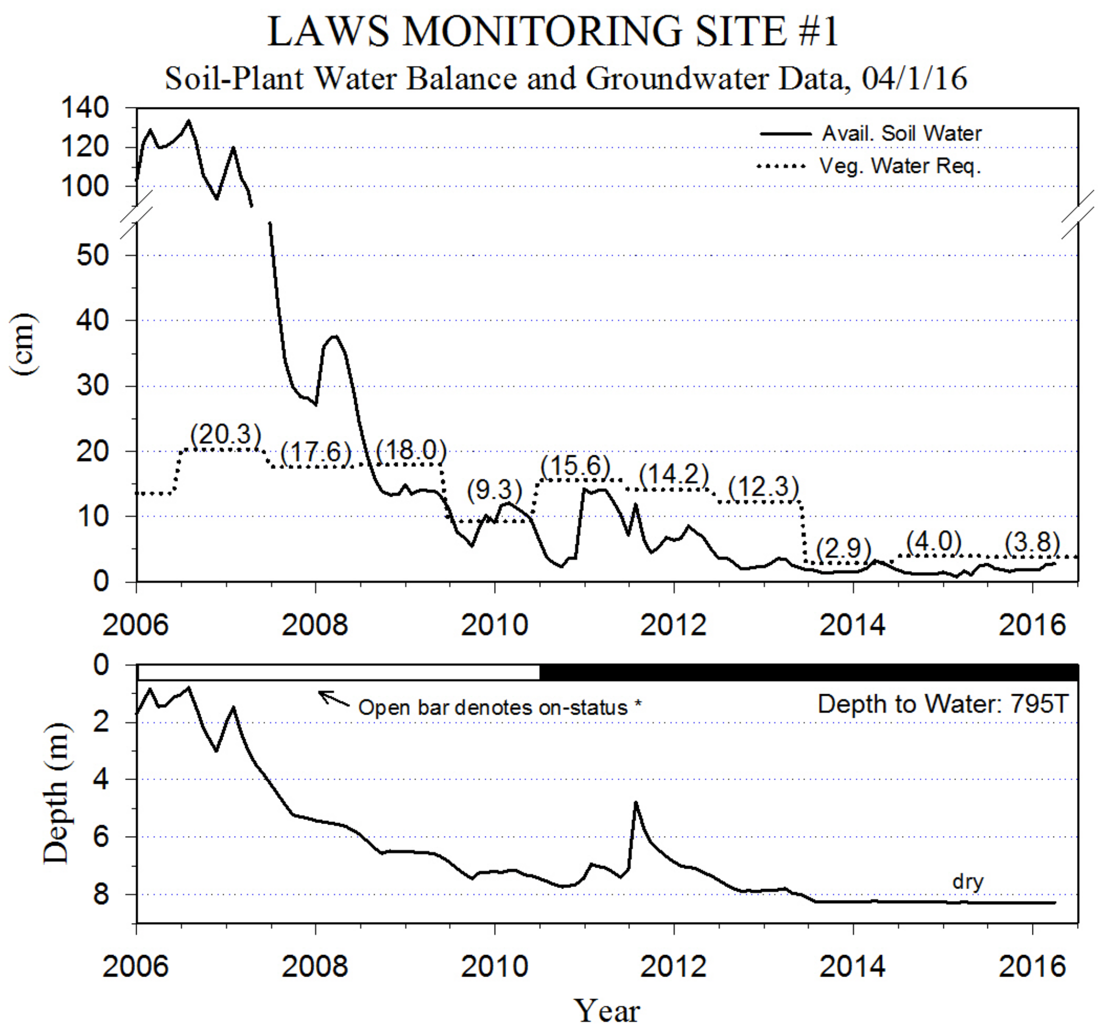
Site	June, 2015 Status	July, 2015 Veg. Water Req./ Soil AWC for turn-on	July 2015 soil AWC	July 2015 Status	Soil AWC required. for well turn-on
		(cm)	(cm)		(cm)
L1	OFF	2.2/15.6	2.7	OFF	15.6, OFF 7-10
L2	ON	3.9/NA	10.3	ON	NA
L3	OFF	6.7/25.2	9.5	OFF	25.2, OFF 10-11
BP1	OFF	1.2/22.9	1.4	OFF	22.9†, OFF 10-97
BP2	OFF	2.6/28.4	1.6	OFF	28.4, OFF 7-98
BP3	OFF	2.4/10.6	3.8	OFF	10.6. OFF 7-12
BP4	ON	4.2/NA	39.8	ON	NA
TA3	OFF	7.6/26.0	6.5	OFF	26.0, OFF 10-11
TA4	OFF	4.7/23.3	14.7	OFF	23.3, OFF 10-11
TA5	ON	2.2/NA	21.8	ON	NA
TA6	OFF	5.8/17.6	9.3	OFF	17.6, OFF 10-11
TS1	OFF	1.7/20.4	1.2	OFF	20.4†, OFF 10-96
TS2	ON	4.9/NA	6.8	ON	NA
TS3	OFF	7.0/32.9	18.6	OFF	32.9, OFF 10-12
TS4	OFF	15.1/55.9	37.6	OFF	55.9, OFF 10-11
IO1	OFF	18.8/42.2	14.1	OFF	42.2, OFF 10-98
IO2	OFF	1.8/18.9	4.3	OFF	18.9, OFF 7-11
SS1	ON	2.6/NA	12.3	ON	NA
SS2	OFF	0.8/25.6	3.1	OFF	25.6, OFF 7-11
SS3	OFF	3.2/33.8	18.7	OFF	33.8, OFF 10-11
SS4	OFF	2.6/15.9	7.3	OFF	15.9, OFF 7-05
BG2	ON	0.9/NA	23.60	ON	NA

†: These values of soil water required for well turn-on were derived using calculations based on % 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.

Monitoring site status and soil/vegetation water balance calculations for Oct. 1, 2015 according to Green Book, Section III.

Site	July 1, 2015 Status	October, 2015 Veg. Water Req./Soil AWC for turn-on	October 2015 soil AWC	+30% annual ppt.	October 1 2015 Status	Soil AWC req. for well turn-on
		(cm)	(cm)	(cm)		(cm)
L1	OFF	3.8/15.6	1.6	NA	OFF	15.6, OFF 7-10
L2	ON	7.0/NA	7.3	7.3 + 4.7 = 12.0	ON	NA
L3	OFF	12.4/25.2	7.5	NA	OFF	25.2, OFF 10-11
BP1	OFF	2.1/22.9	0.9	NA	OFF	22.9†, OFF 10-97
BP2	OFF	4.9/28.4	1.3	NA	OFF	28.4, OFF 7-98
BP3	OFF	4.2/10.6	2.6	NA	OFF	10.6. OFF 7-12
BP4	ON	7.5/NA	35.3	35.3 + 4.9 = 40.2	ON	NA
TA3	OFF	14.2/26.0	6.3	NA	OFF	26.0, OFF 10-11
TA4	OFF	8.8/23.3	13.4	NA	OFF	23.3, OFF 10-11
TA5	ON	3.9/NA	21.4	21.4 + 4.9 = 26.3	ON	NA
TA6	OFF	10.7/17.6	8.8	NA	OFF	17.6, OFF 10-11
TS1	OFF	3.1/20.4	1.3	NA	OFF	20.4†, OFF 10-96
TS2	ON	9.1/NA	6.0	6.0 + 4.4 = 10.4	ON	NA
TS3	OFF	12.8/32.9	16.5	NA	OFF	32.9, OFF 10-12
TS4	OFF	27.7/55.9	33.2	NA	OFF	55.9, OFF 10-11
IO1	OFF	35.0/42.2	11.1	NA	OFF	42.2, OFF 10-98
IO2	OFF	3.4/18.9	4.5	NA	OFF	18.9, OFF 7-11
SS1	ON	4.8/NA	11.7	11.7 + 3.9 = 15.6	ON	NA
SS2	OFF	1.5/25.6	2.9	NA	OFF	25.6, OFF 7-11
SS3	OFF	5.9/33.8	18.9	NA	OFF	33.8, OFF 10-11
SS4	OFF	4.8/15.9	4.8	NA	OFF	15.9, OFF 7-05
BG2	ON	1.7/NA	23.0	23.0 + 4.0 = 27.0	ON	NA

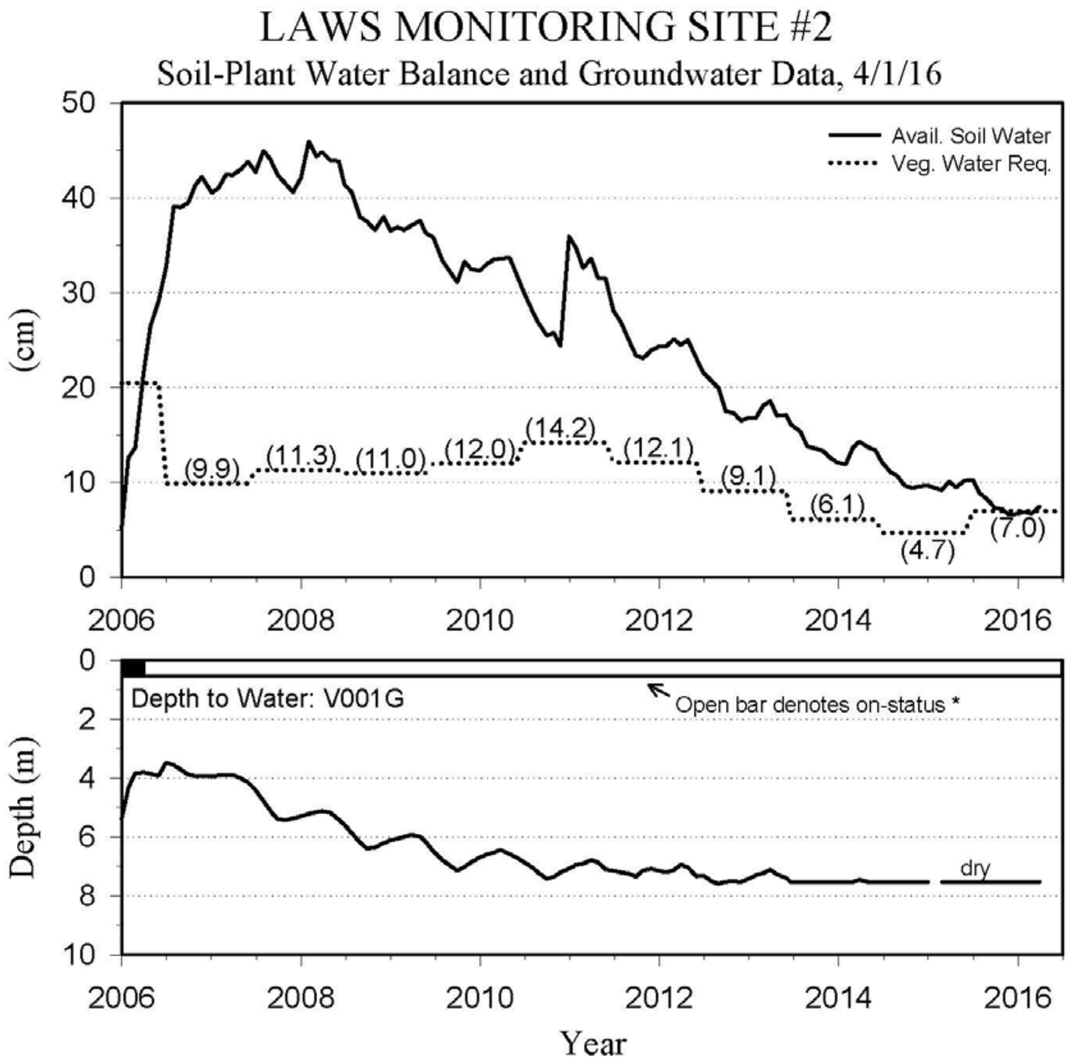
†: These values of soil water required for well turn-on were derived using calculations based on percent cover that were routinely performed in the past. The values have not been updated to conform with the Greenbook equations in section III.D.2, p. 57-59



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells- 247, 248, 249, 398

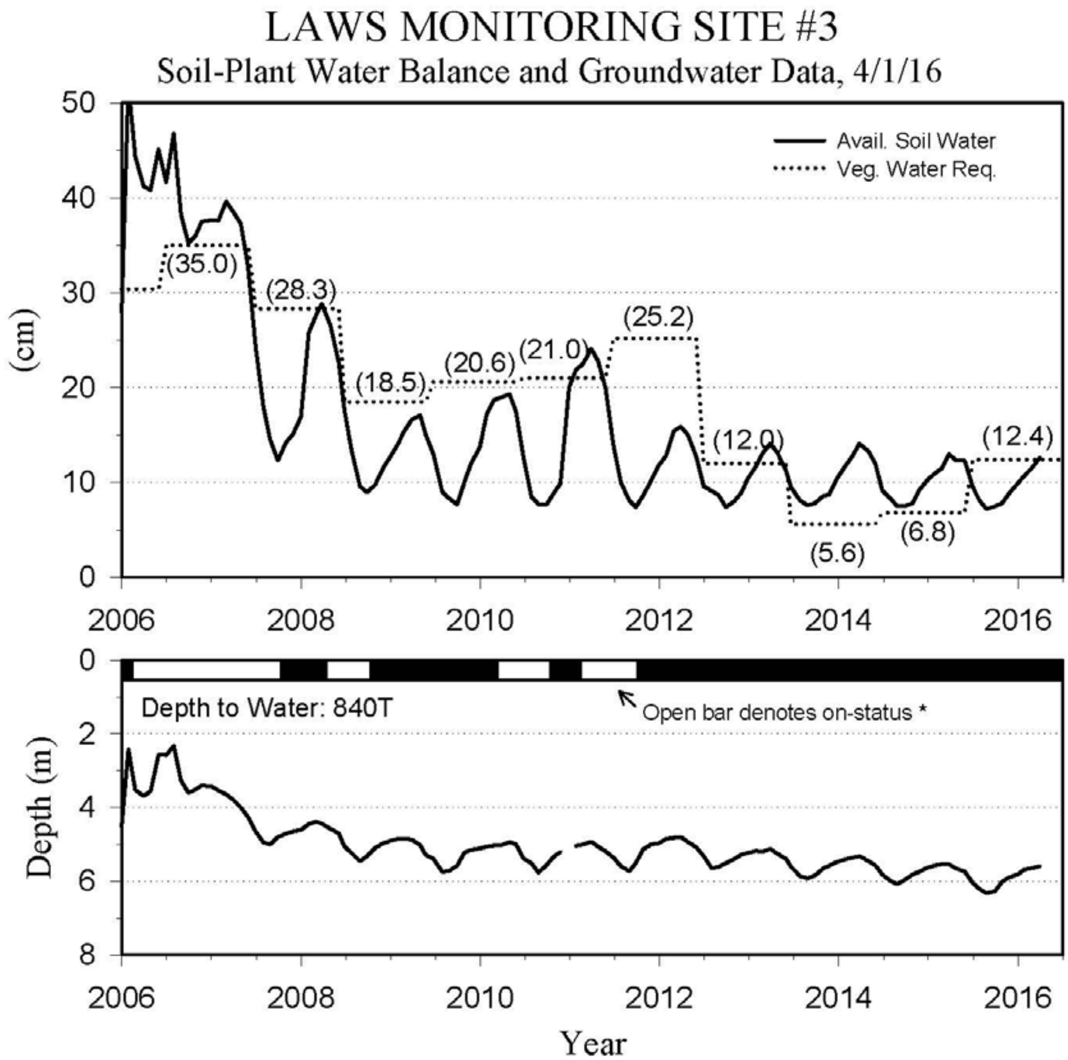
Soil water required for turn on (15.6 cm)



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 236, 239, 243, 244

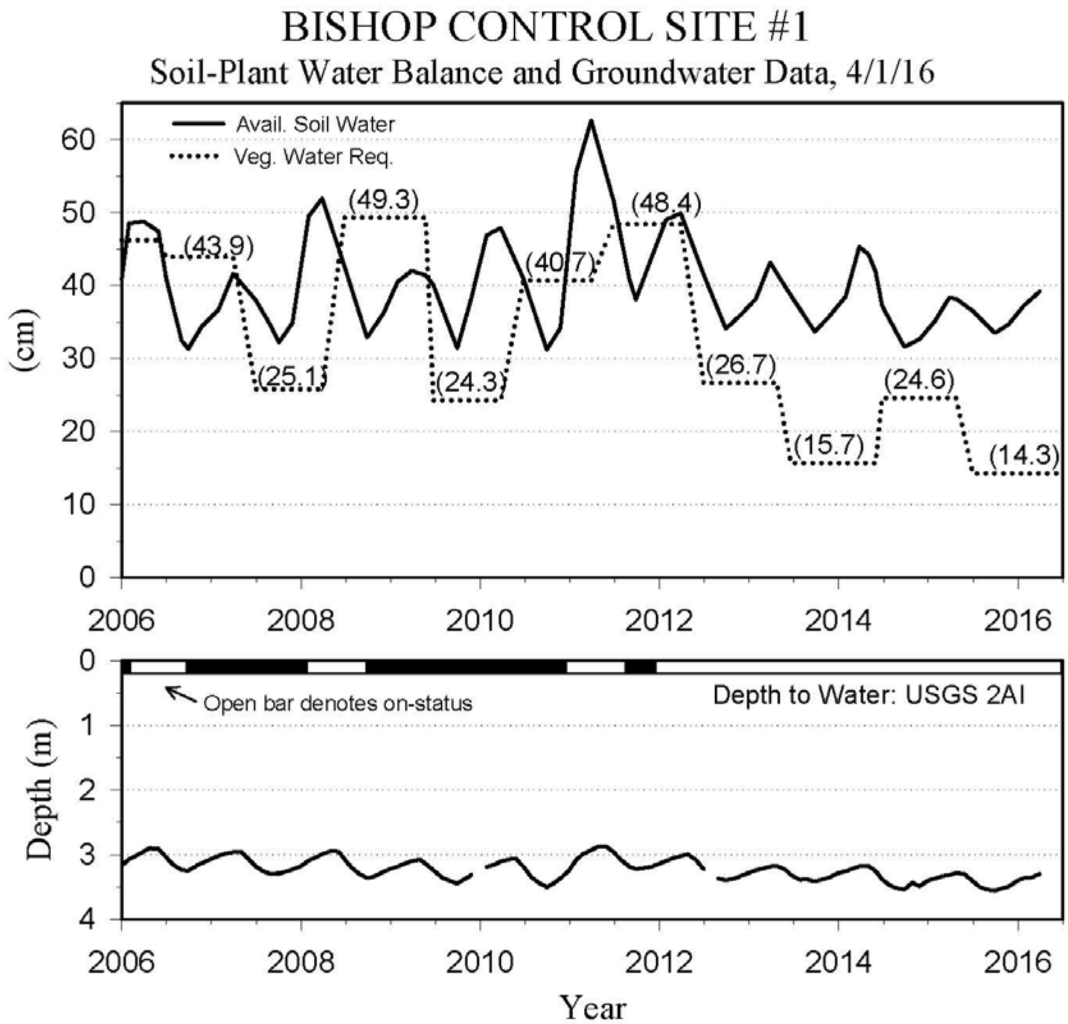
Soil water required for turn on (--)



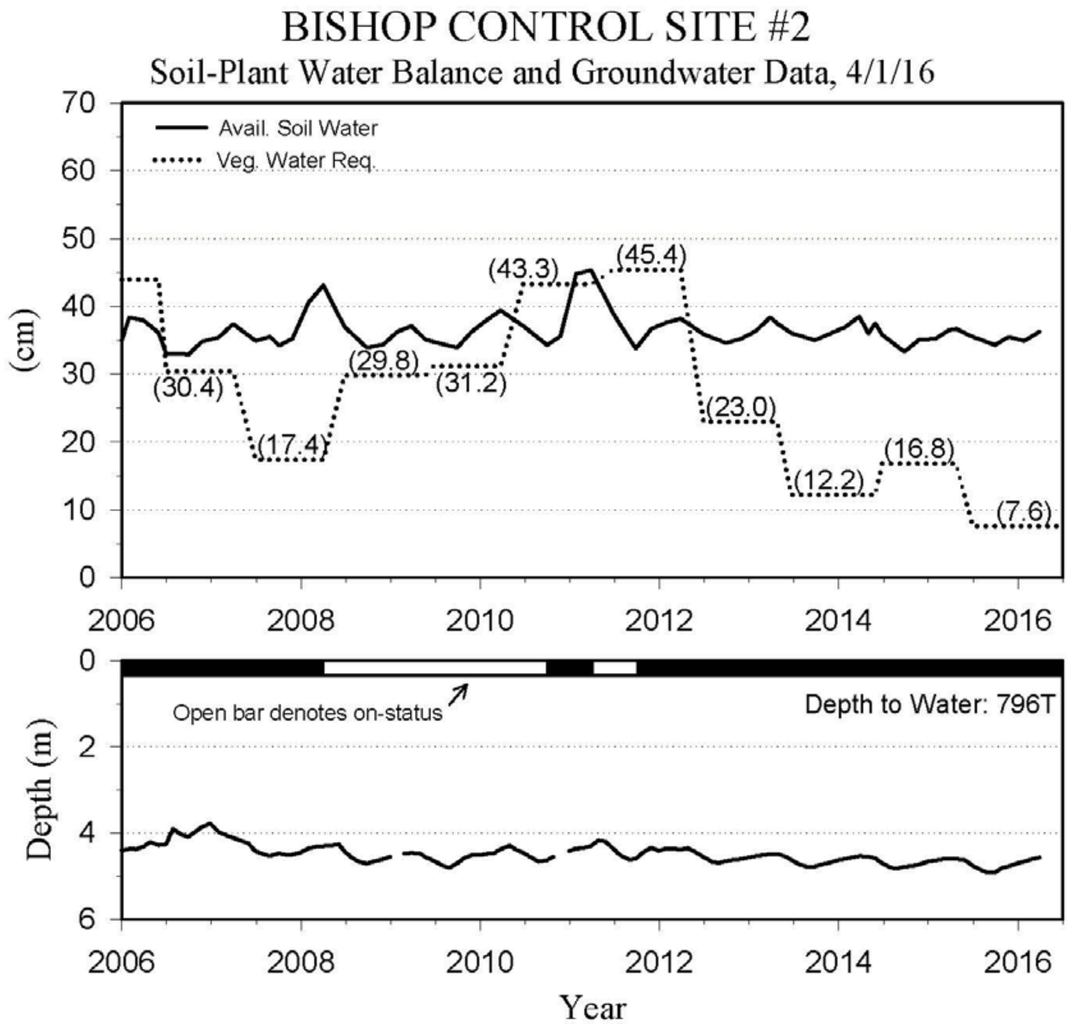
* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 240, 241, 399, 376, 377

Soil water required for turn on (25.2 cm)

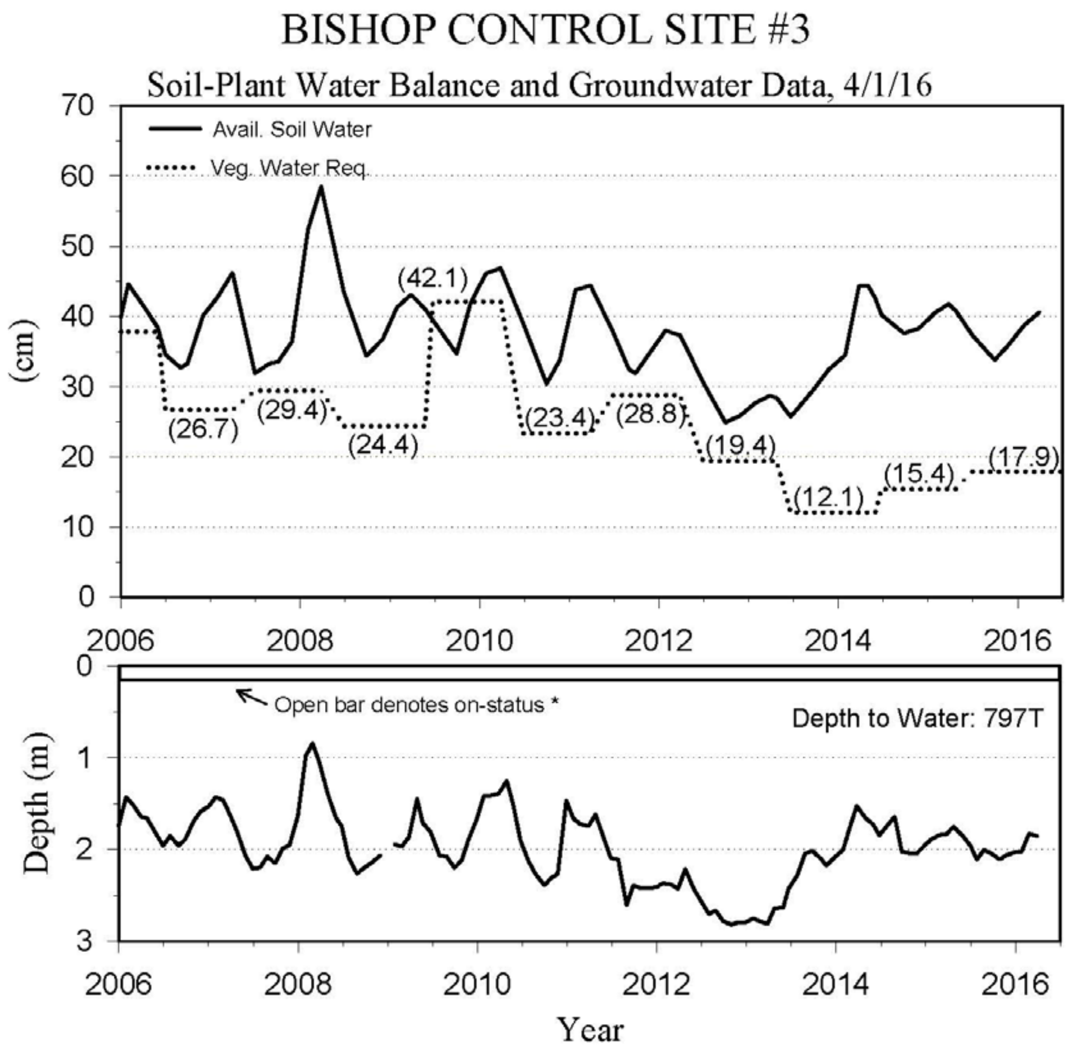


*On/off according to the Green Book Section III values for Veg. Water Req.
Soil water required for turn on (--)



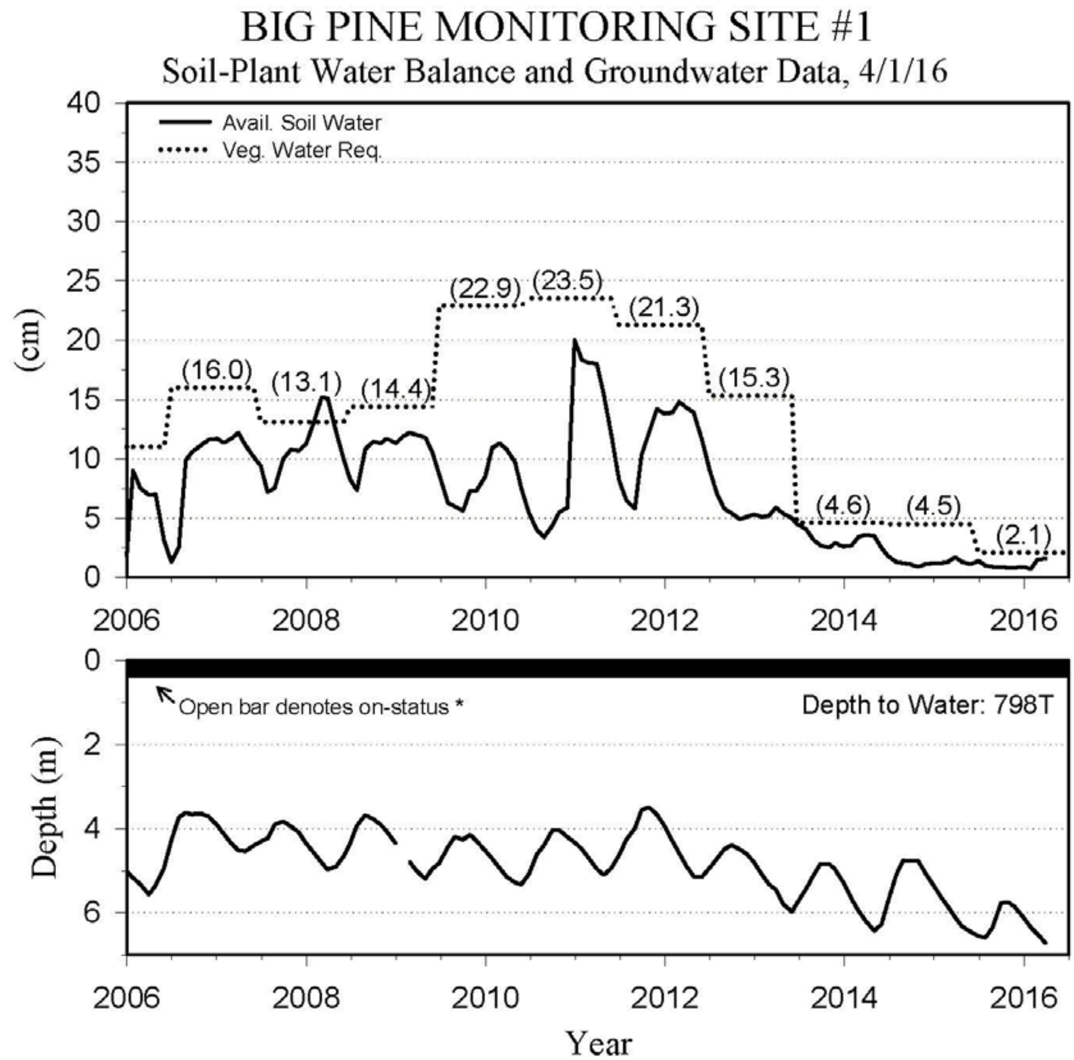
*On/off according to the Green Book Section III values for Veg. Water Req.

Soil water required for turn on (--)



*On/off according to the Green Book Section III values for Veg. Water Req.

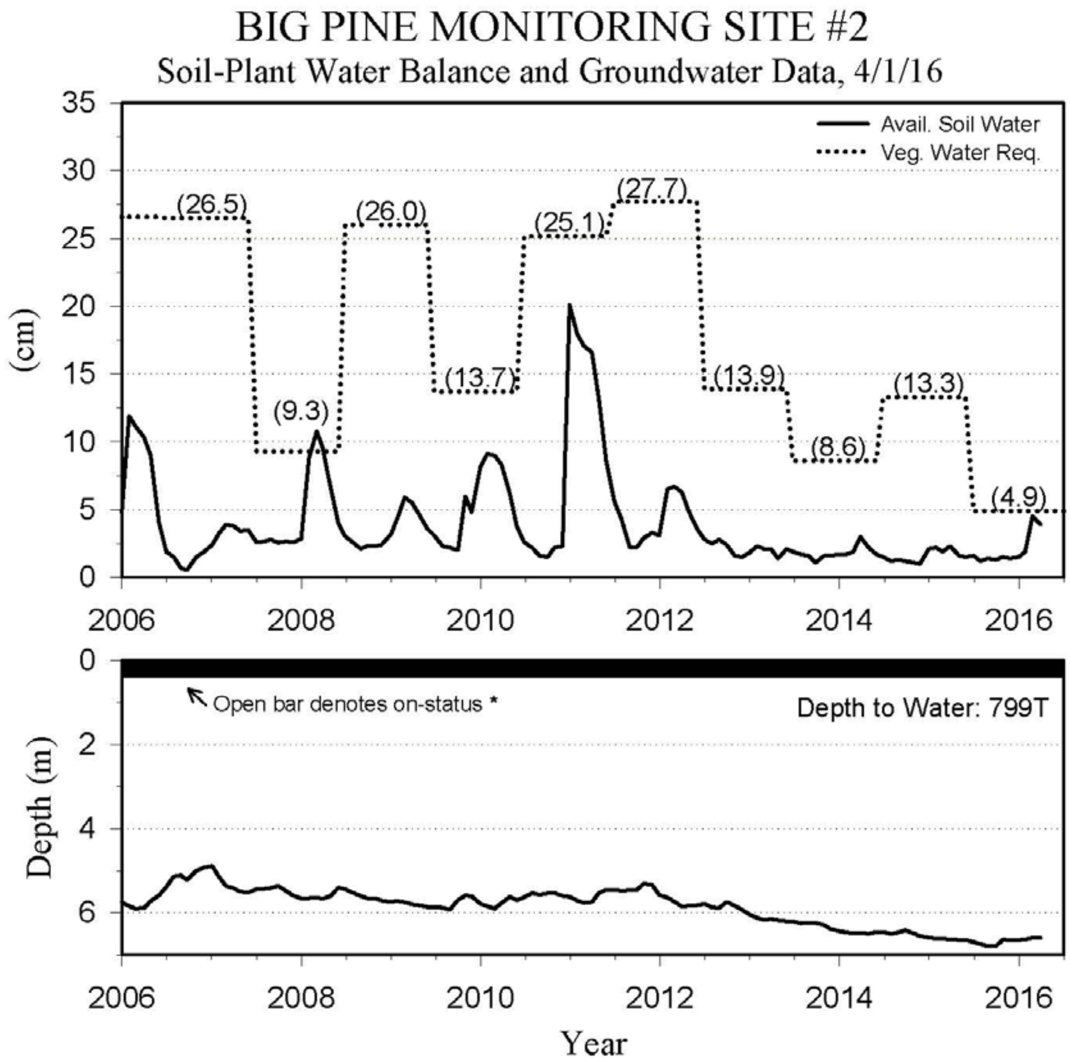
Soil water required for turn on (--)



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 210, 378, 379, 389

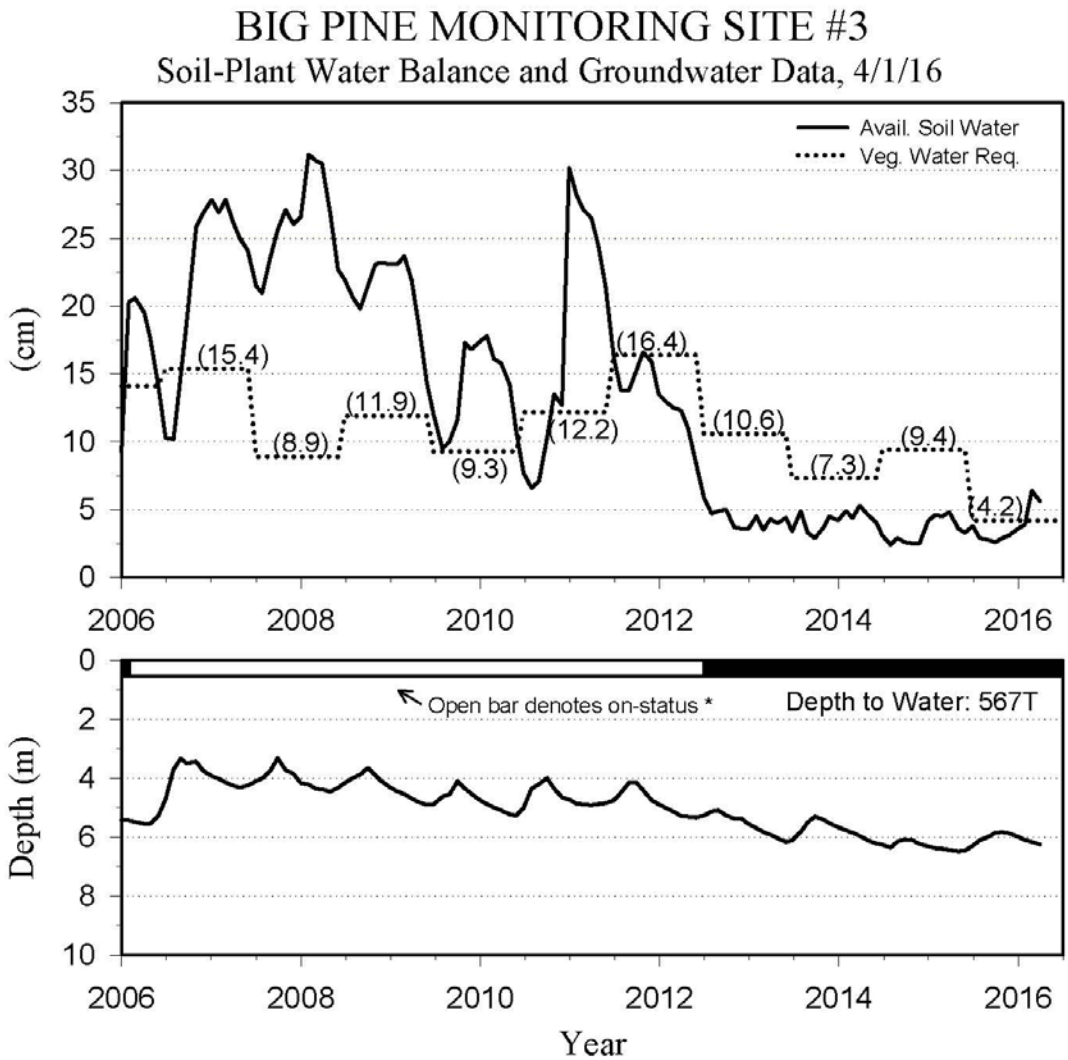
Soil water required for turn on (22.9 cm)



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 220, 229, 374, 375

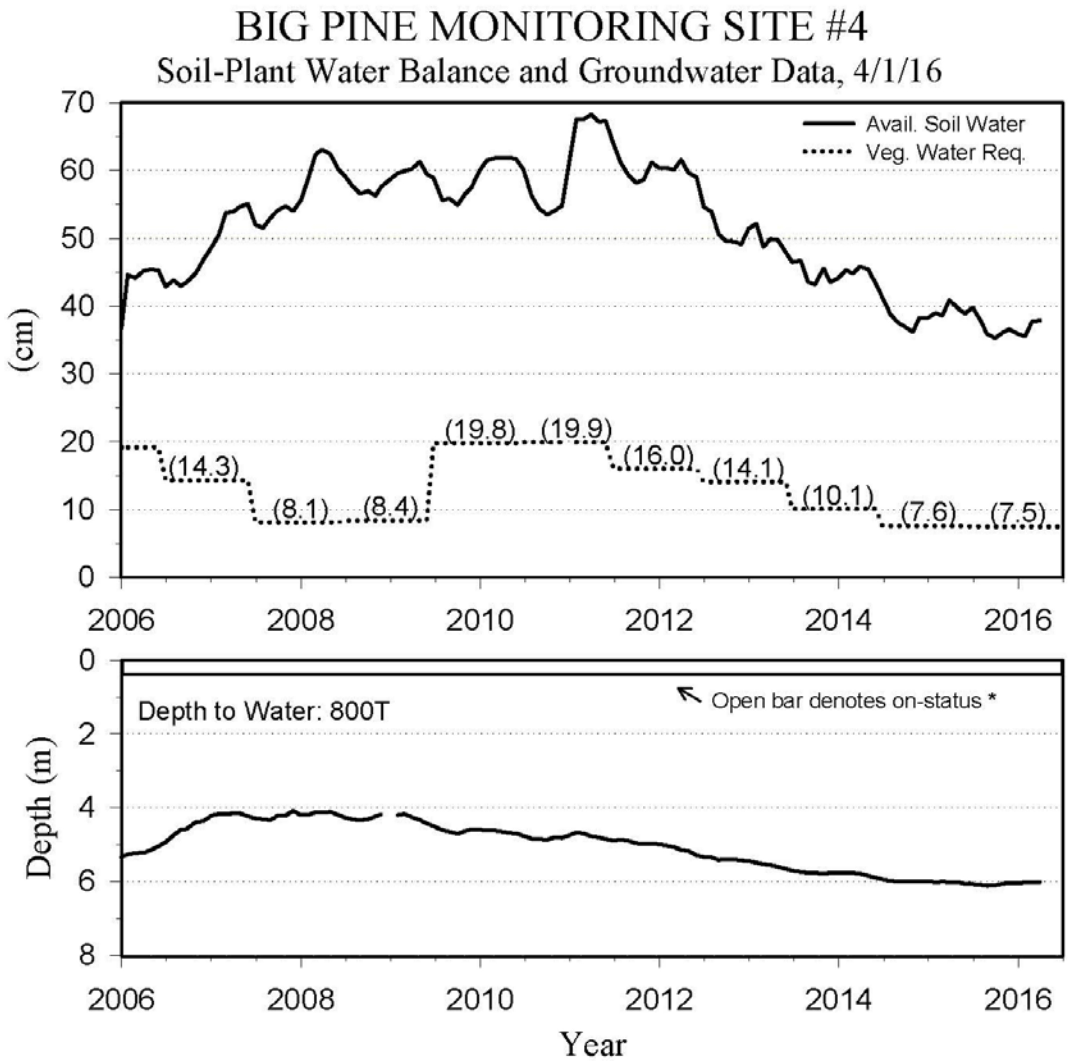
Soil water required for turn on (28.4 cm)



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 222, 223, 231, 232

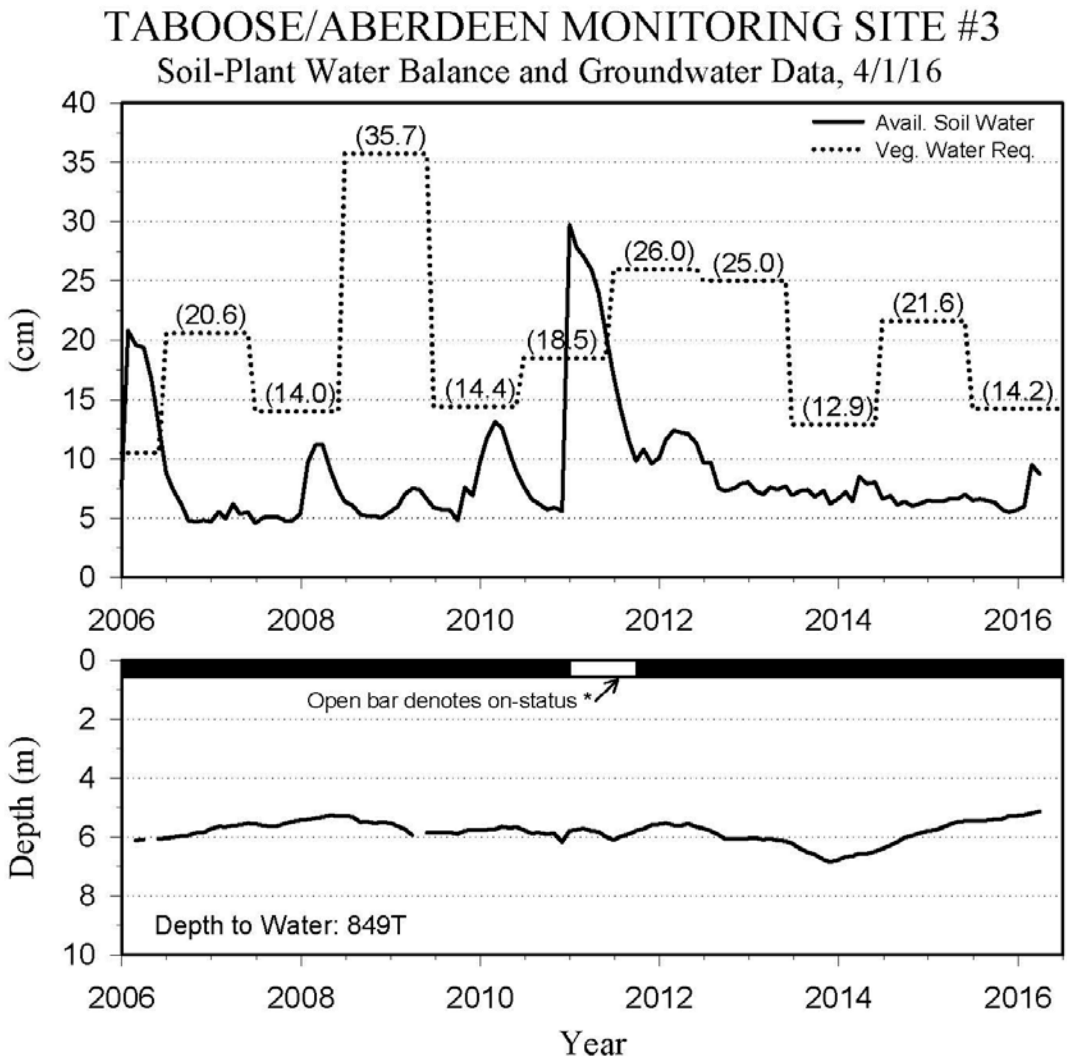
Soil water required for turn on (10.6 cm)



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping well - 331

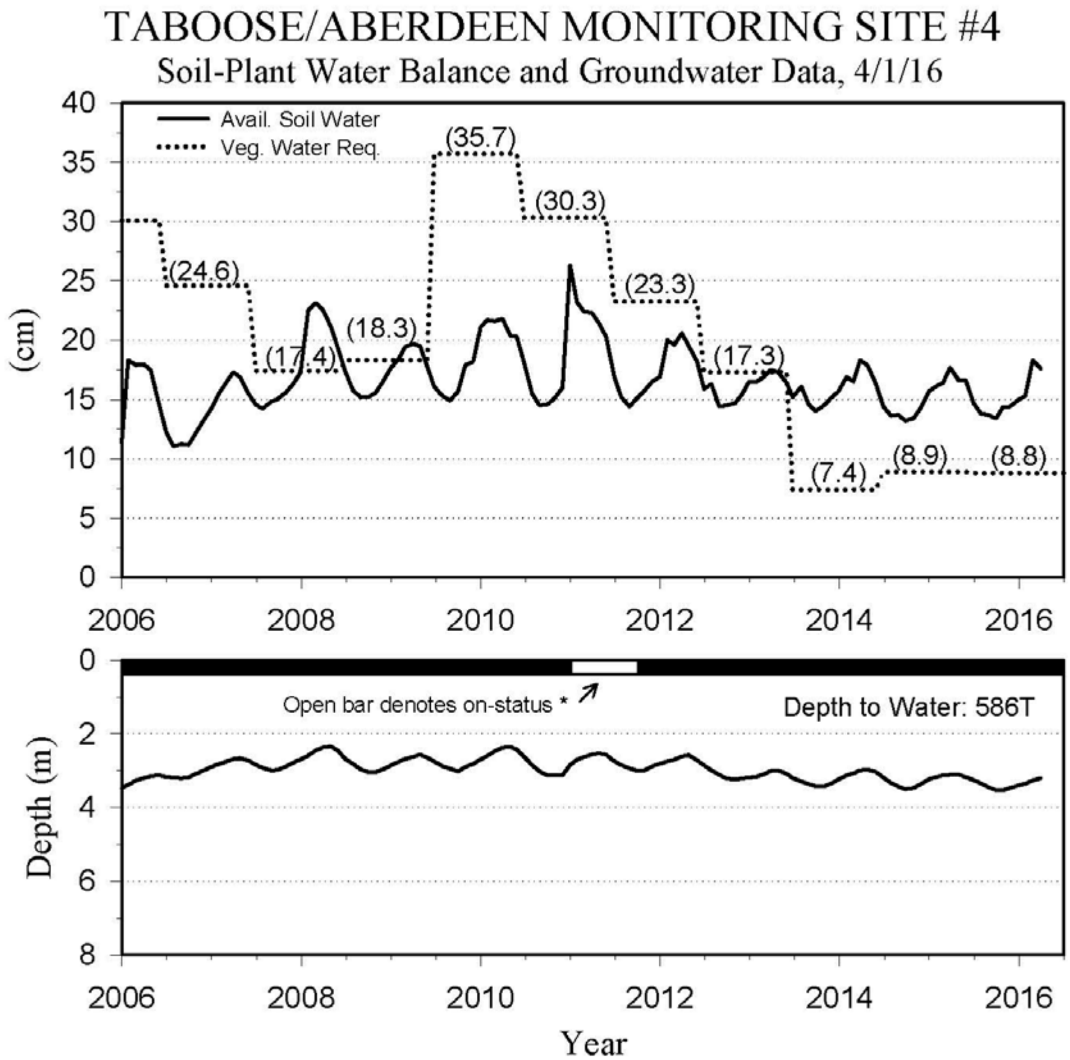
Soil water required for turn on (--)



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 106, 110, 111, 114

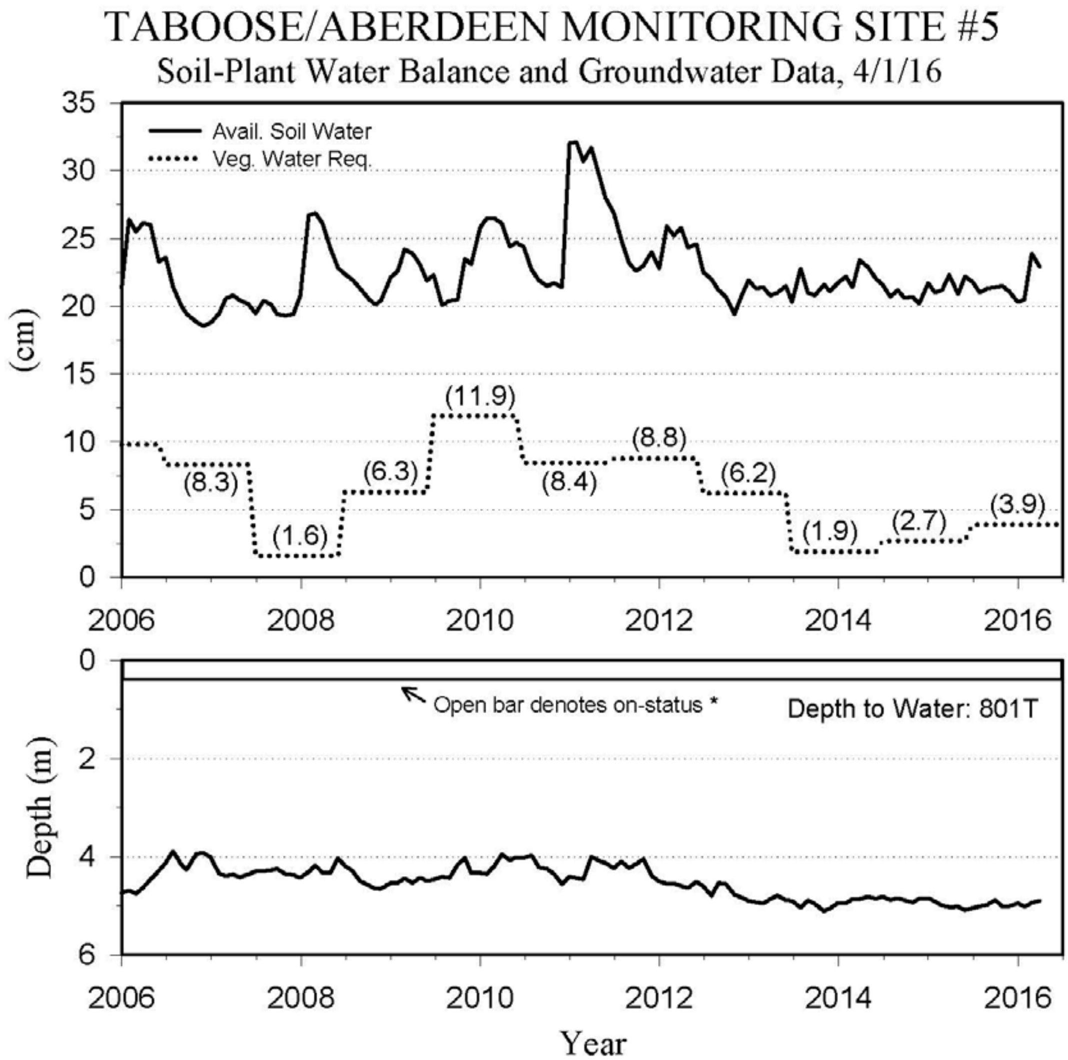
Soil water required for turn on (26.0 cm)



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 342, 347

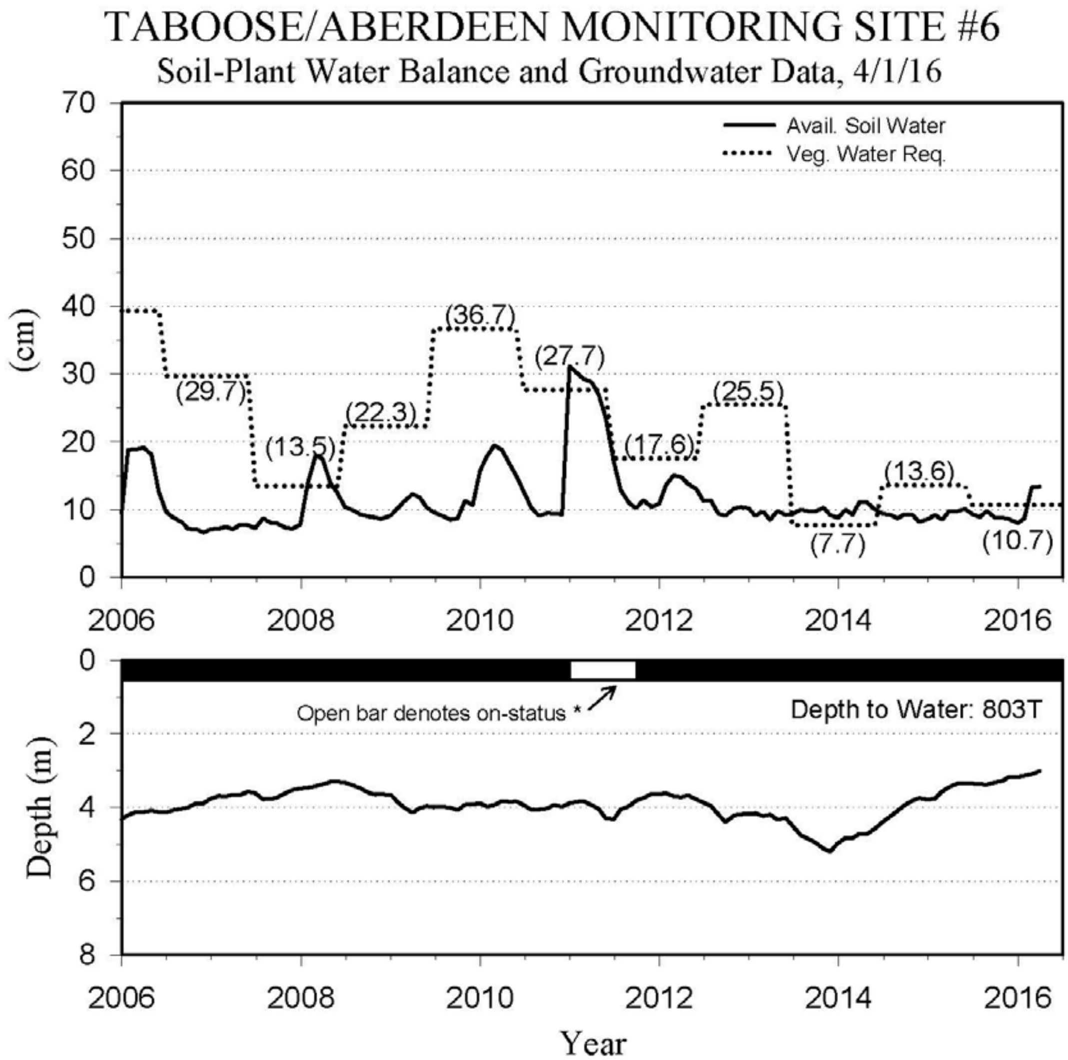
Soil water required for turn on (23.3 cm)



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III value for Veg. Water Req.

Linked pumping well - 349

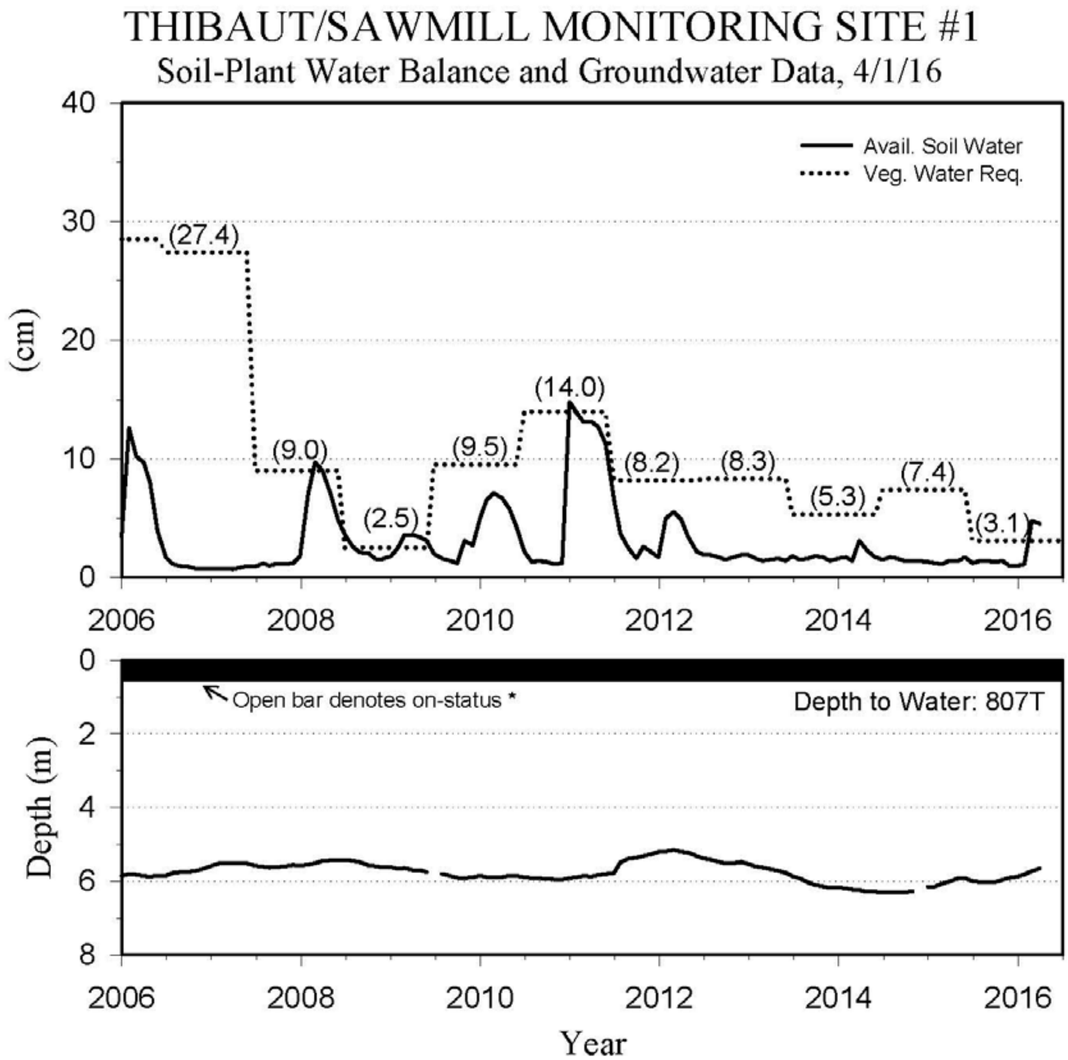
Soil water required for turn on (--)



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 109, 370

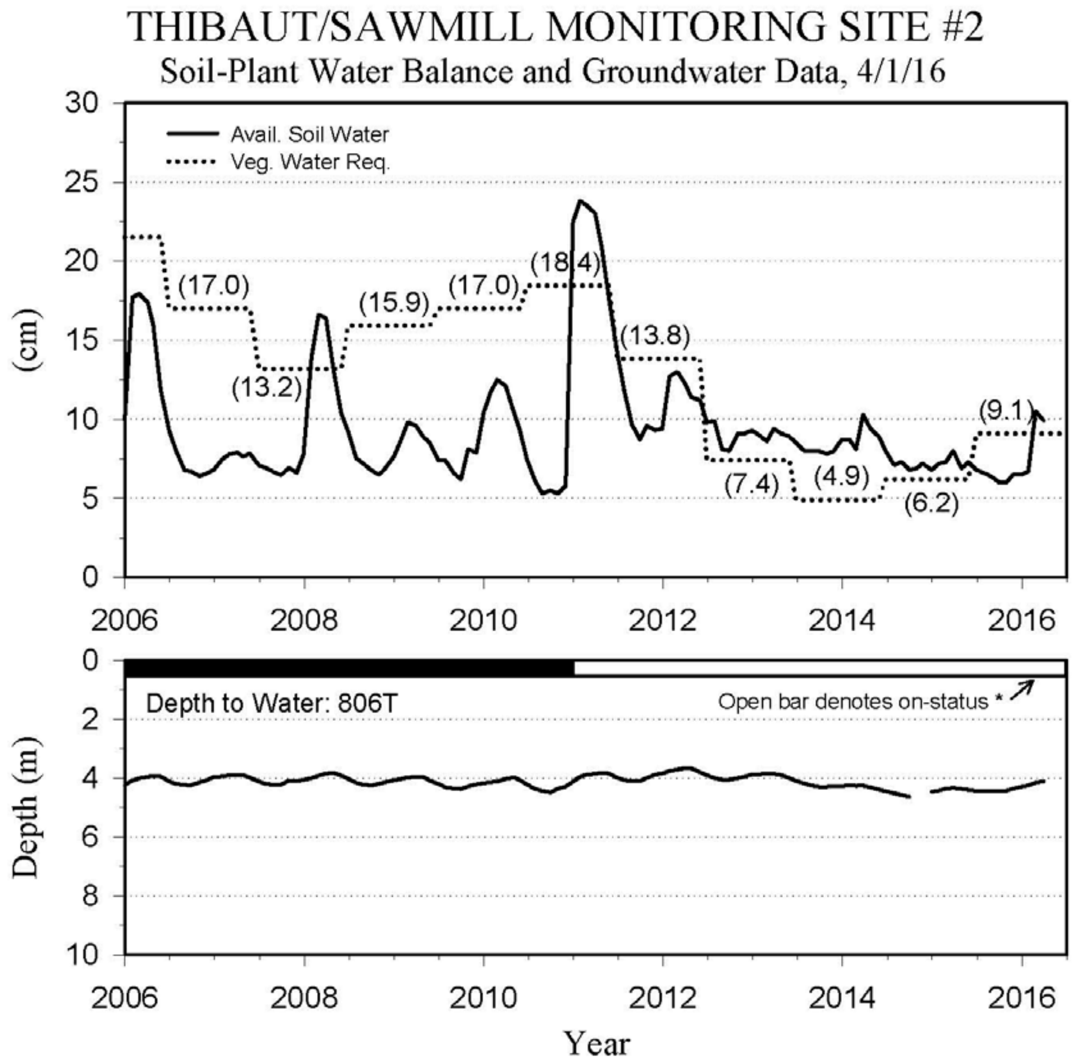
Soil water required for turn on (17.6 cm)



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping well - 159

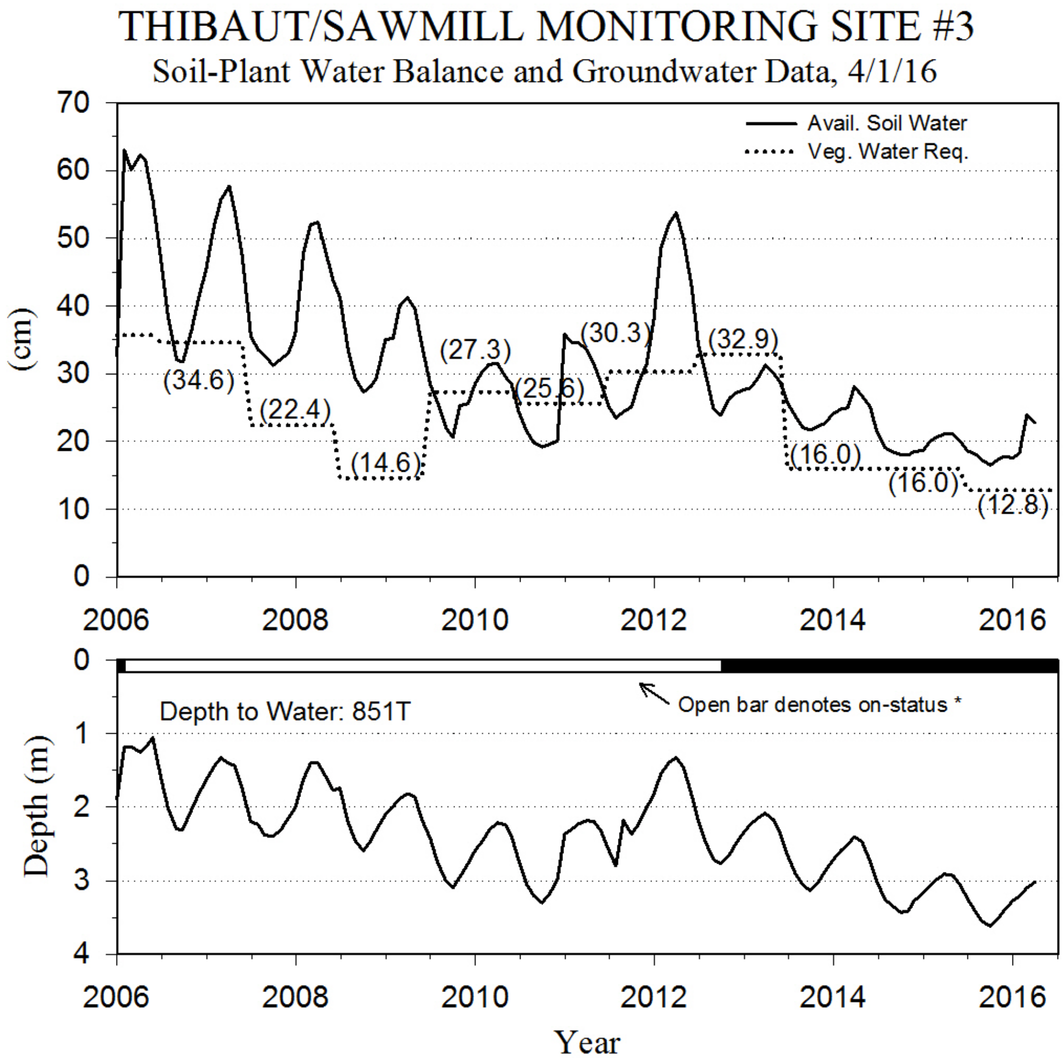
Soil water required for turn on (20.4 cm)



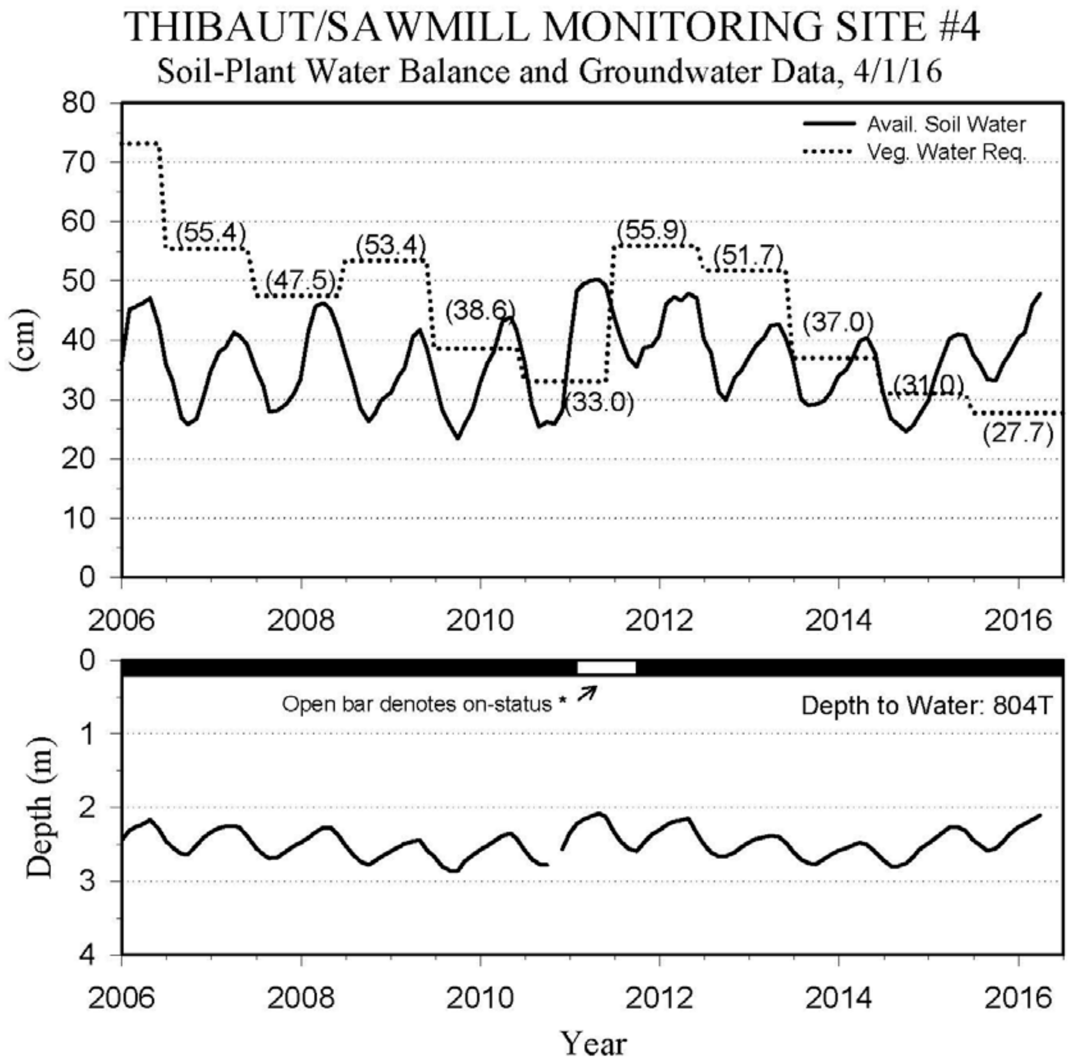
* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping well - 155

Soil water required for turn on (--)



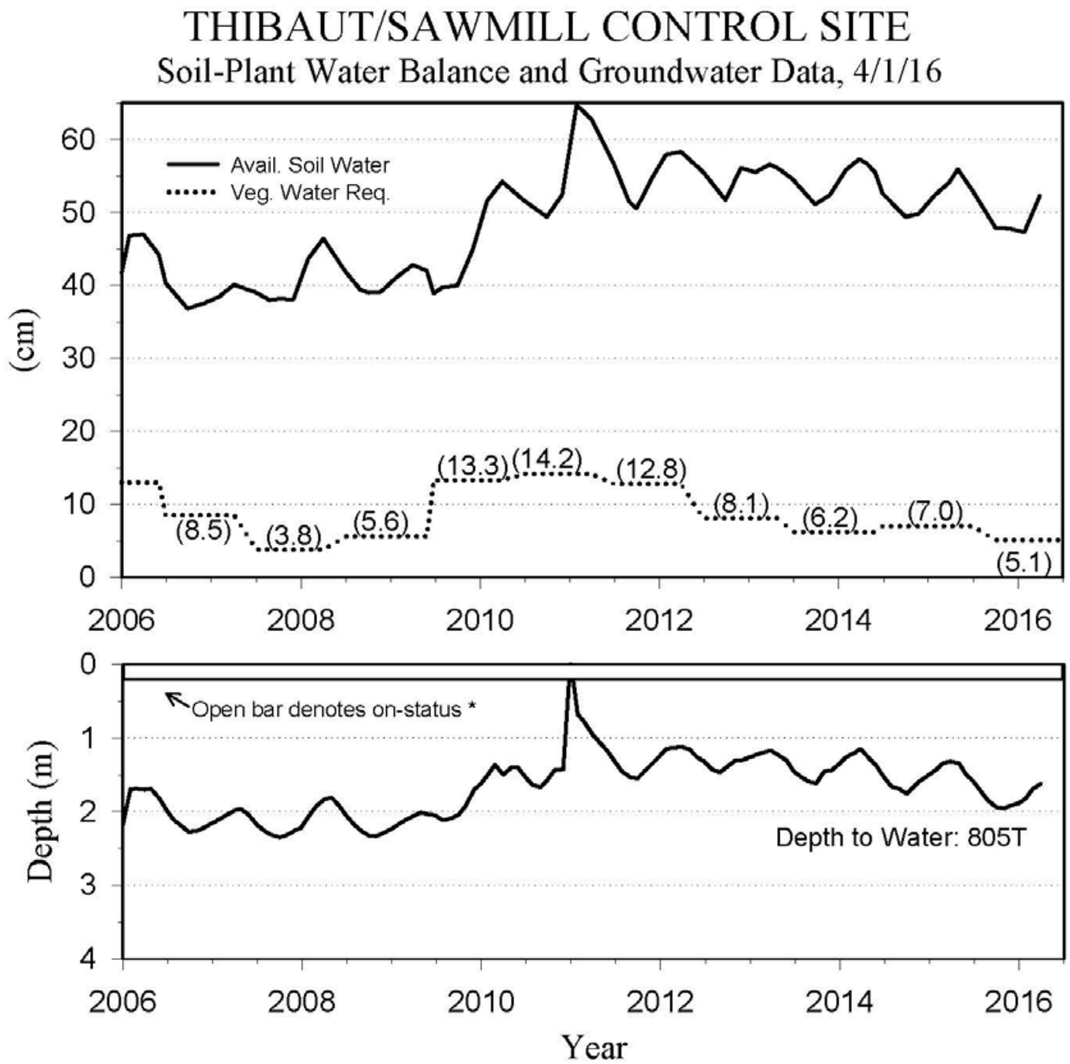
* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.
Linked pumping wells - 103, 104, 382
Soil water required for turn on (32.9 cm)



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

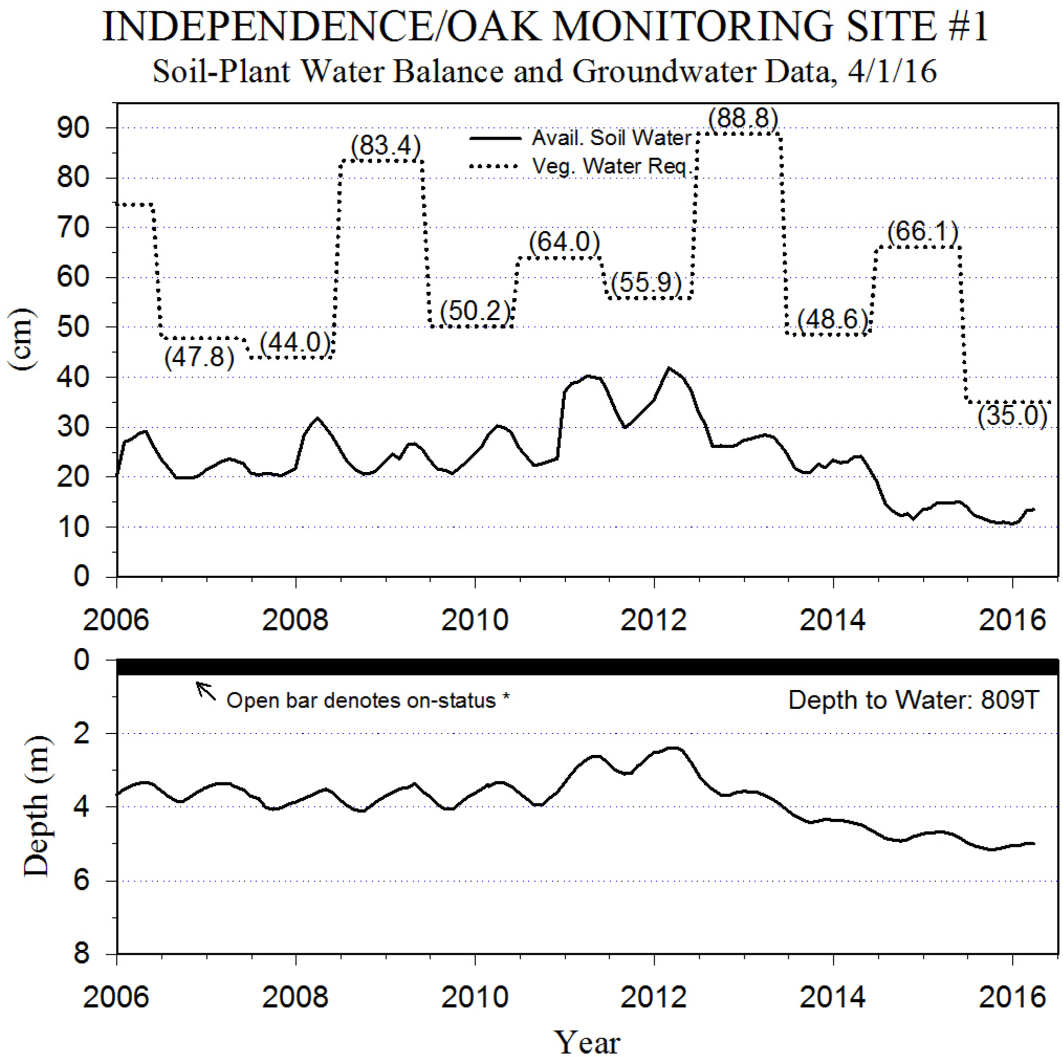
Linked pumping wells - 380, 381

Soil water required for turn on (55.9 cm)



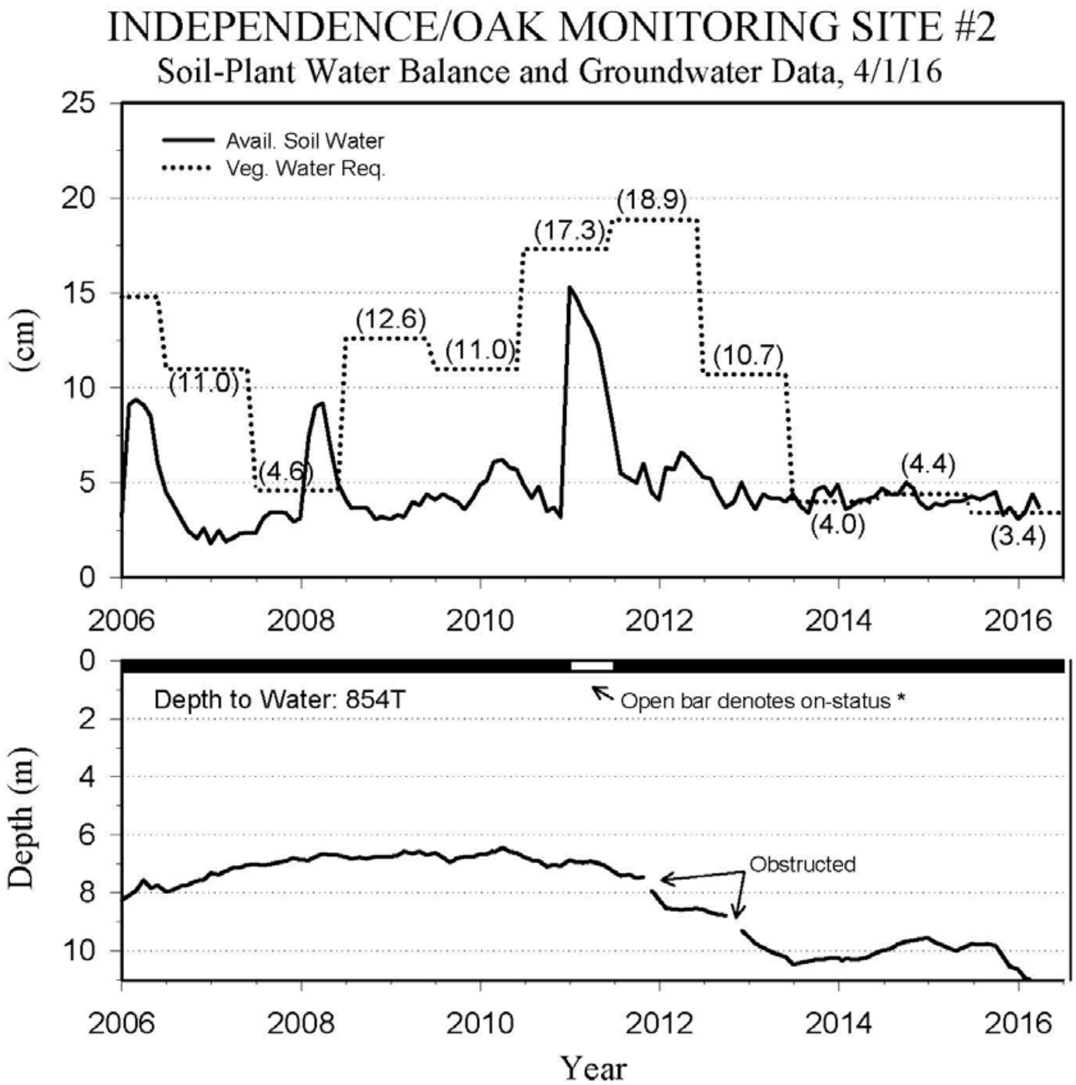
* On\off according to the Green Book Section III values for Veg. Water Req.

Soil water required for turn on (--)



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.
Linked pumping wells - 61, 391, 400

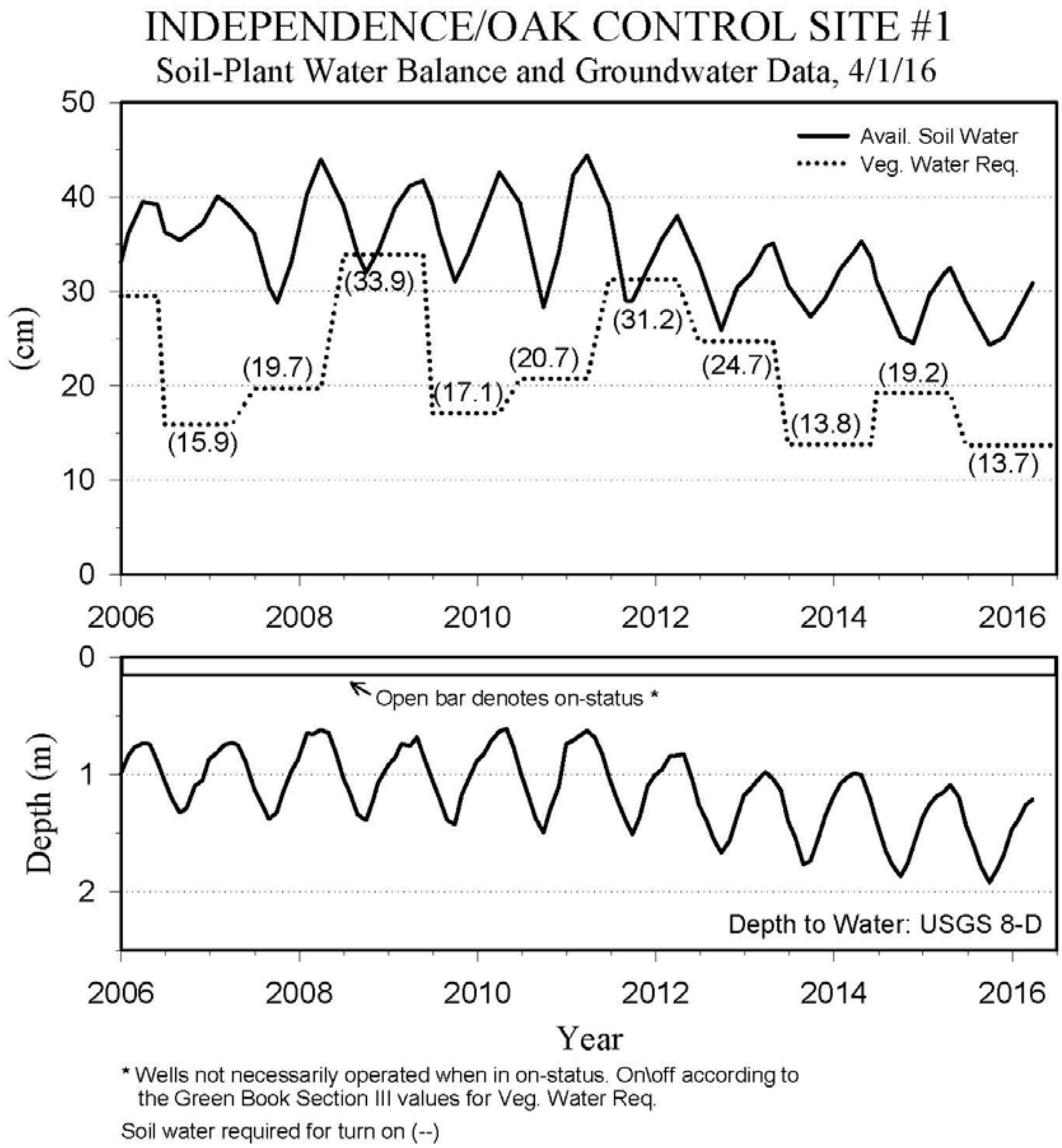
Soil water required for turn on (42.2 cm)

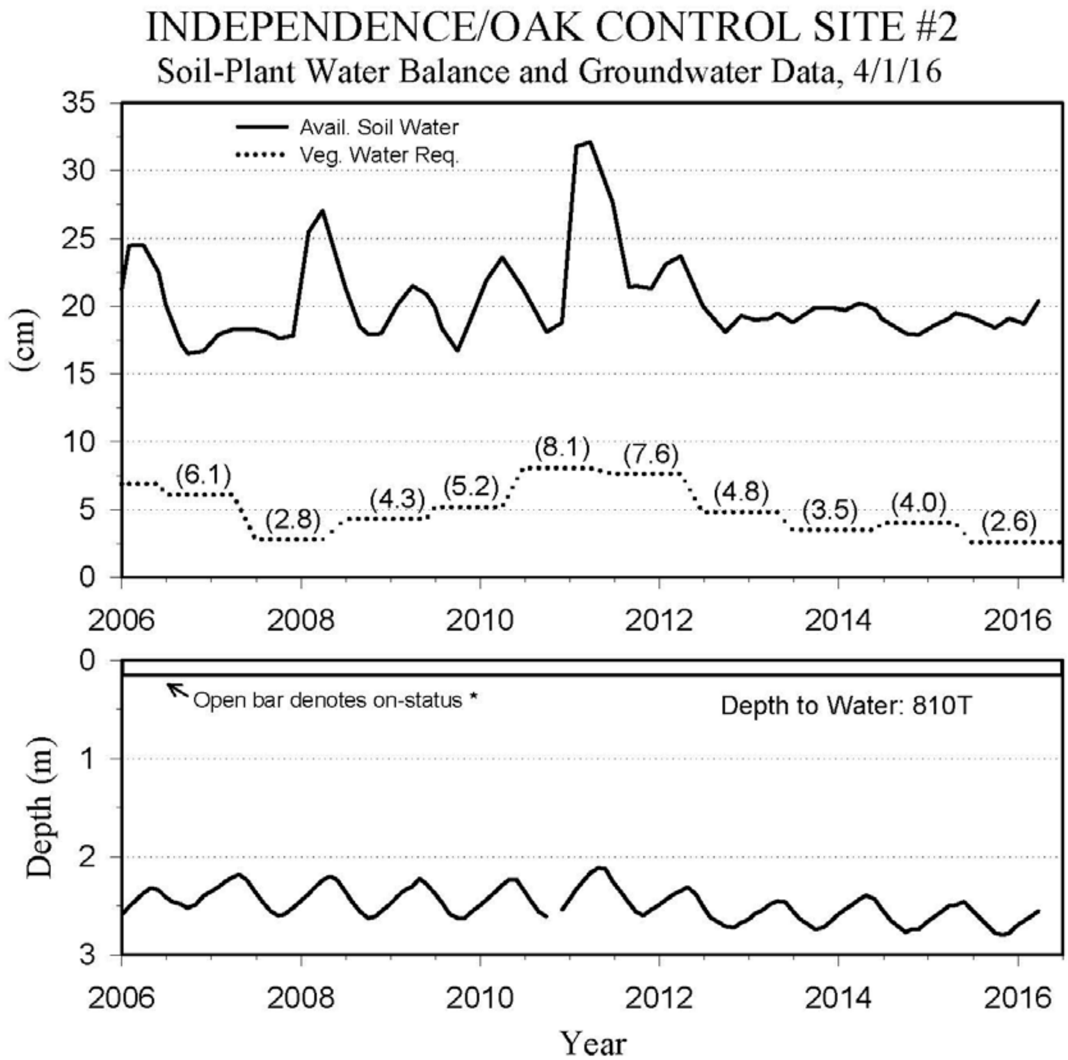


* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping well - 63

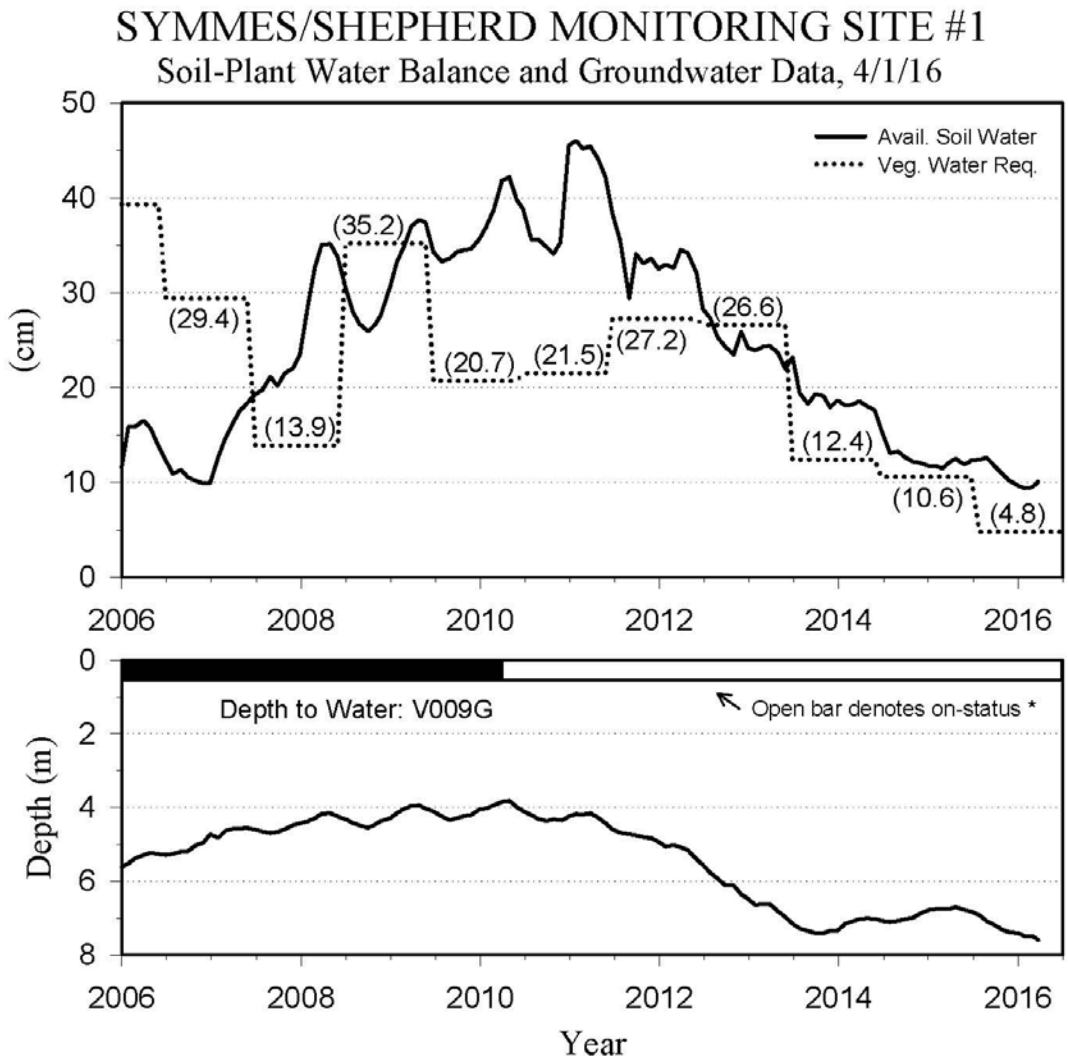
Soil water required for turn on (18.9 cm)


INDEPENDENCE/OAK CONTROL SITE #1
Soil-Plant Water Balance and Groundwater Data, 4/1/16
Avail. Soil Water
Veg. Water Req.
(cm)
(15.9)
(19.7)
(33.9)
(17.1)
(20.7)
(31.2)
(24.7)
(13.8)
(19.2)
(13.7)
Open bar denotes on-status *
Depth (m)
Depth to Water: USGS 8-D
Year
* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.
Soil water required for turn on (--)



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

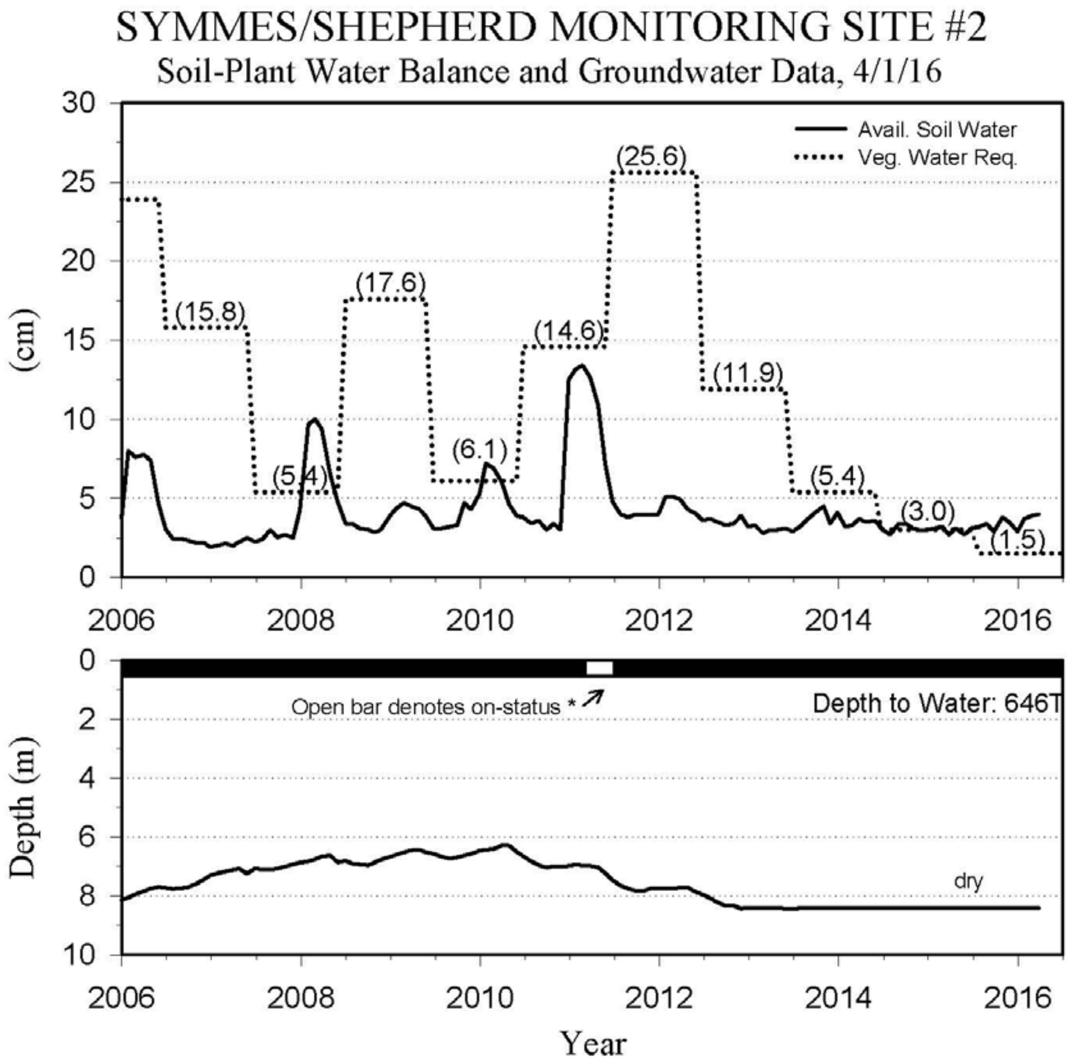
Soil water required for turn on (--)



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping wells - 69, 392, 393

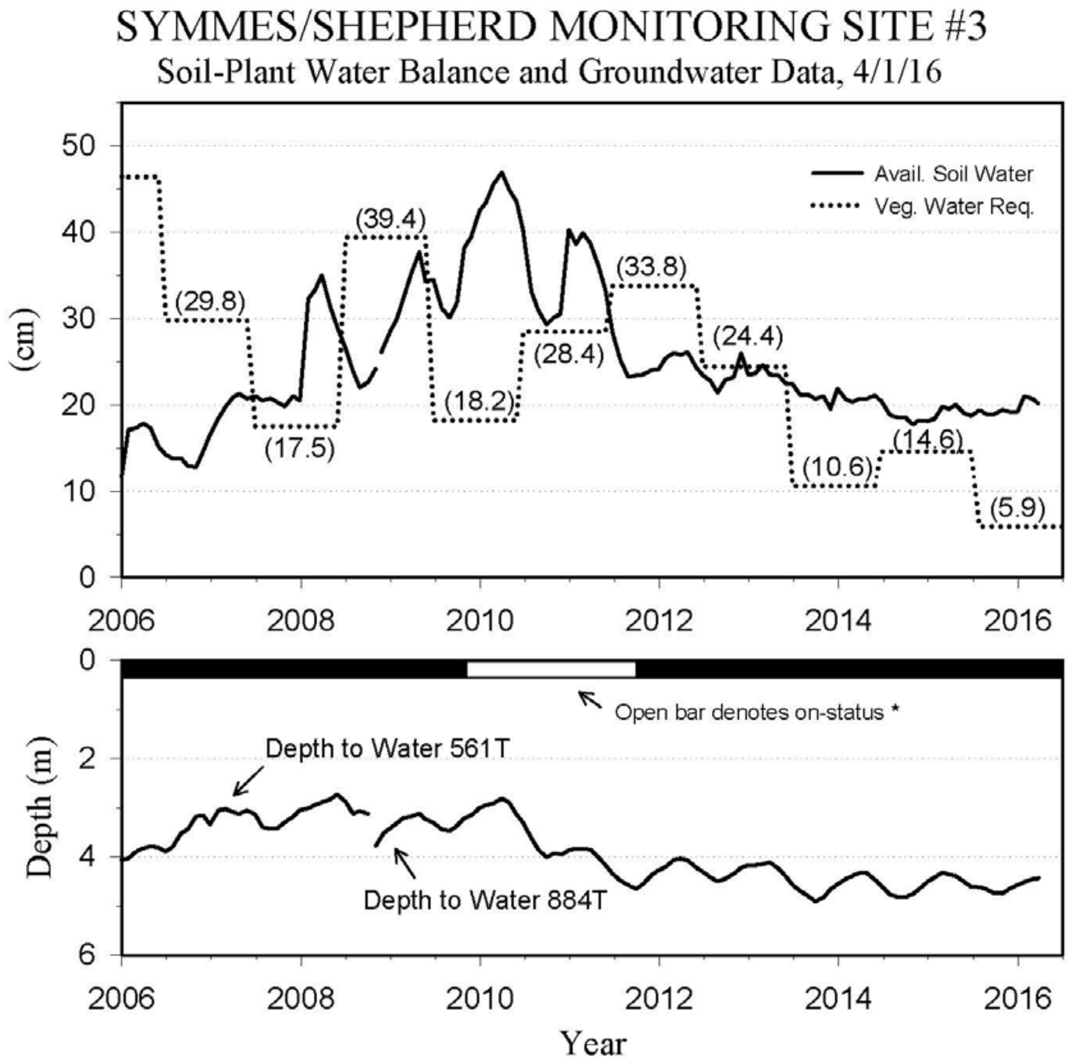
Soil water required for turn on (--)



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping wells - 74, 394, 395

Soil water required for turn on (25.6 cm)

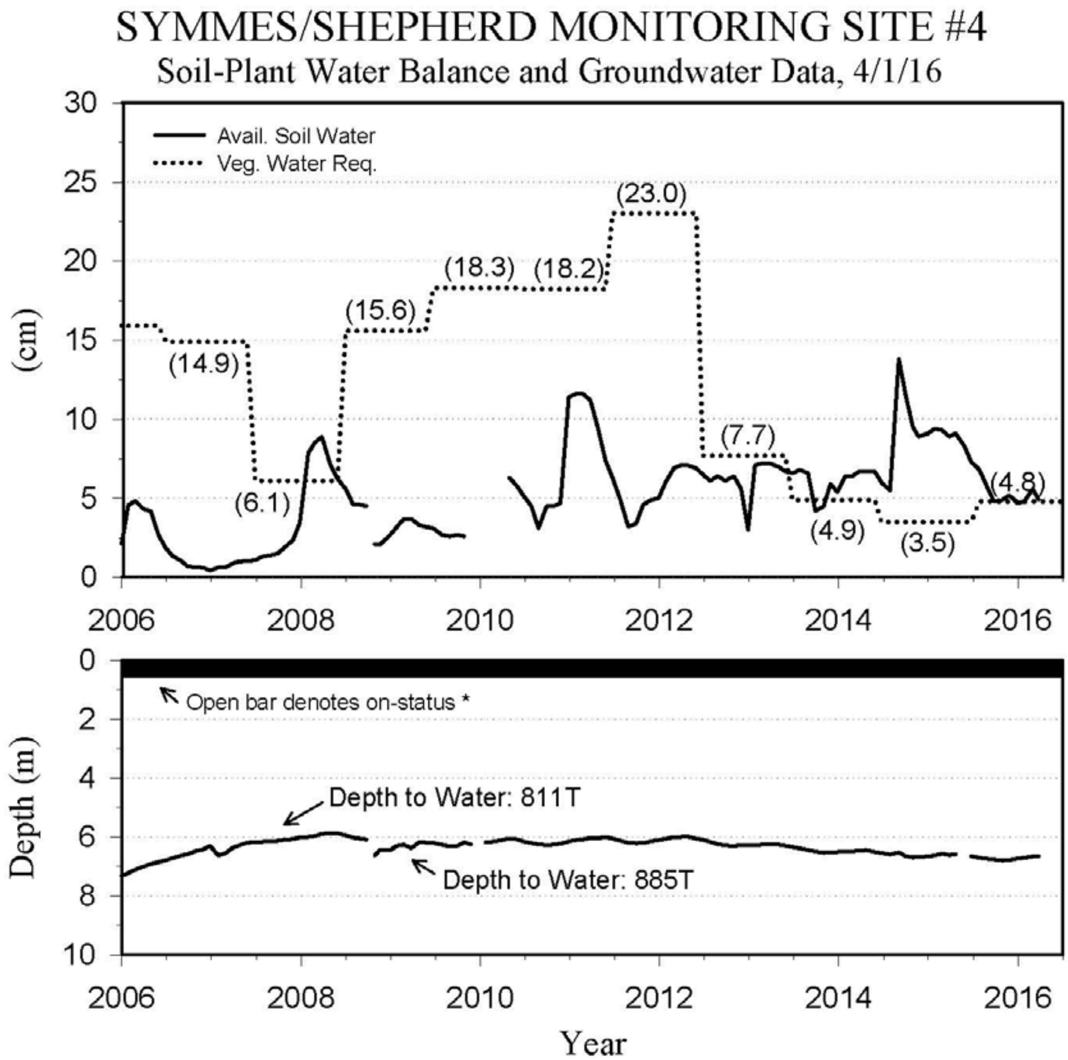


* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping wells - 92, 396

Soil water required for turn on (33.8 cm)

New soil water monitoring locations established Dec 1, 2008

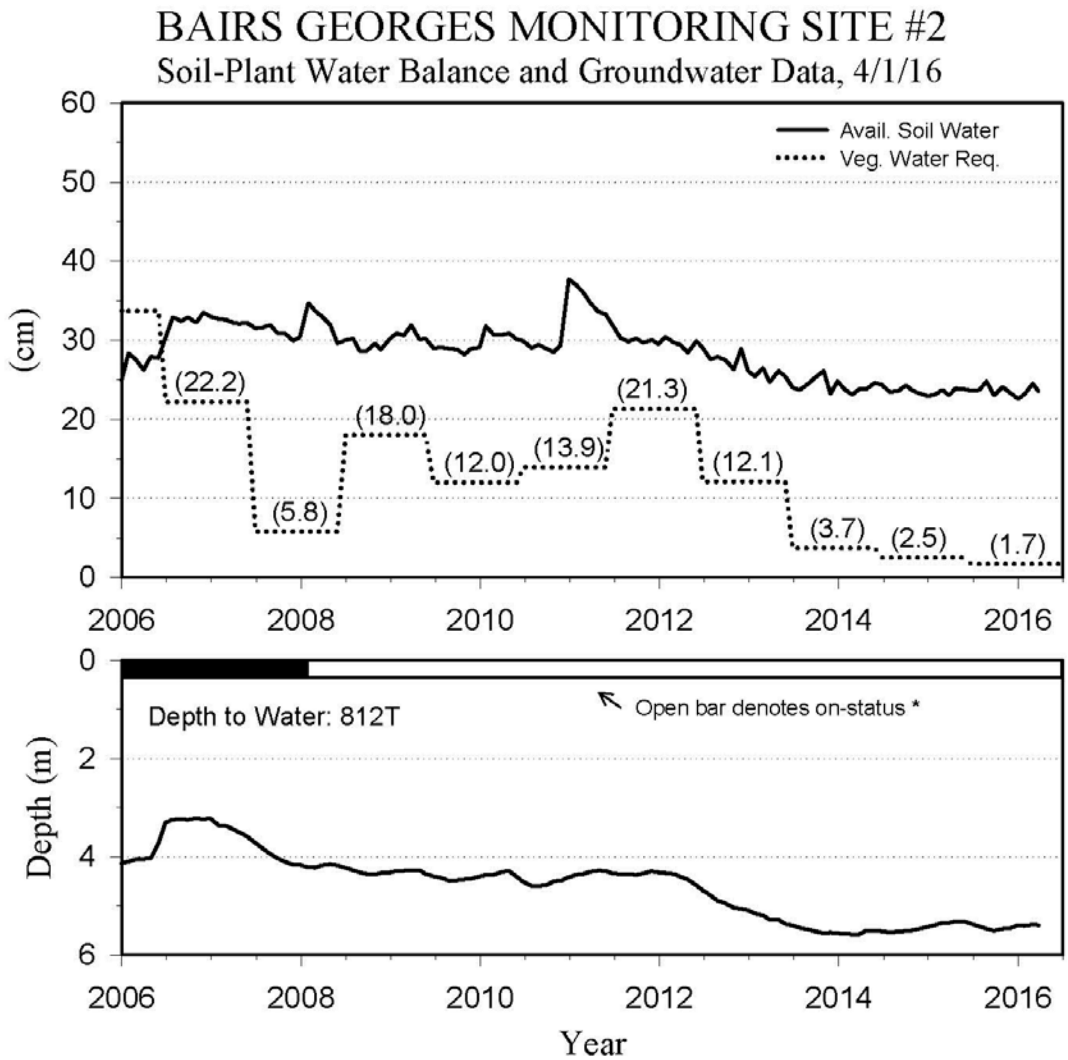


* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping wells - 75, 345

Soil water required for turn on (15.9 cm)

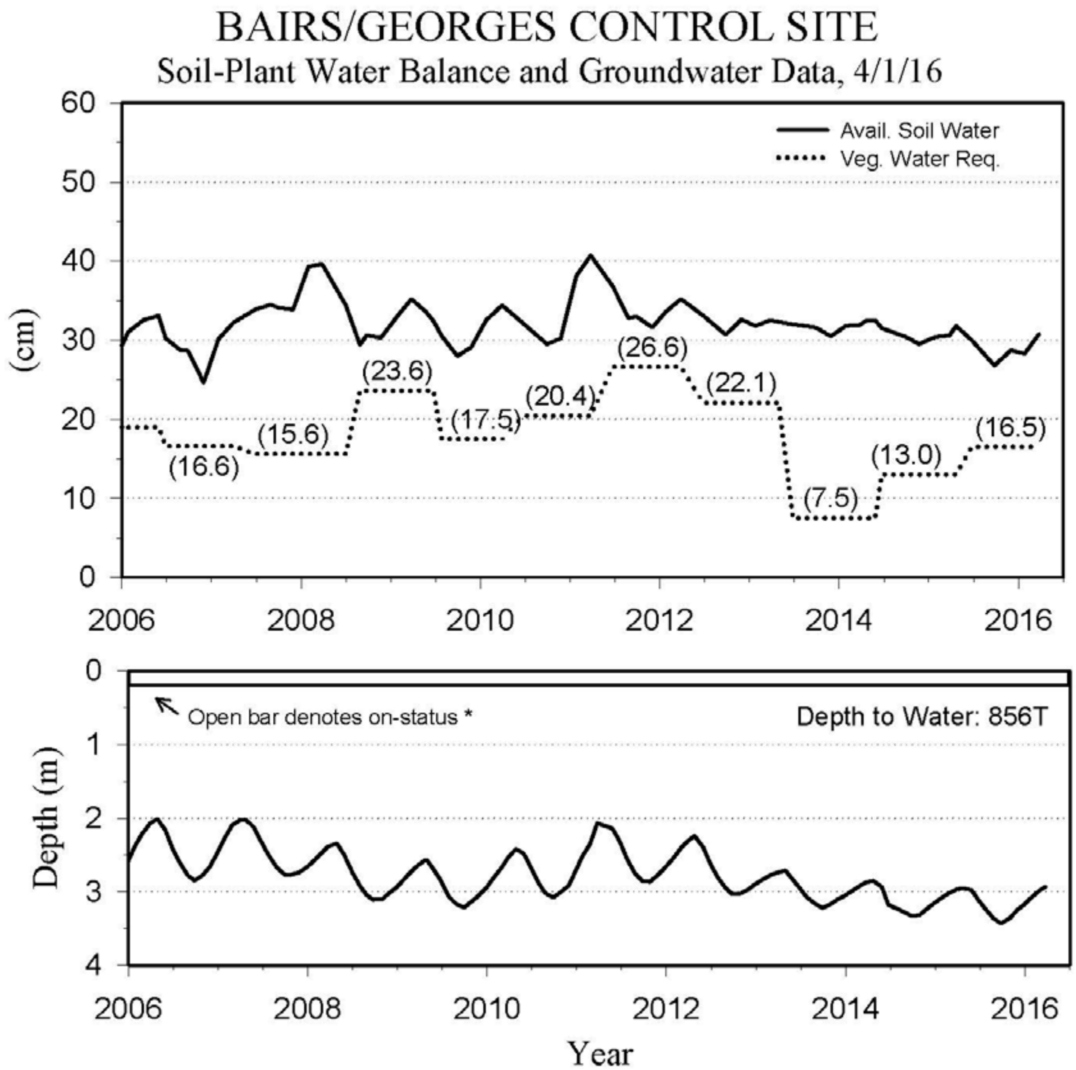
New soil water monitoring locations established Nov 1, 2008 and May 1, 2010



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping wells - 76, 403, 343, 348

Soil water required for turn on (--)



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Soil water required for turn on (--)

SECTION 6: VEGETATION CONDITIONS

A primary goal of the Water Agreement is to manage groundwater and surface water while maintaining healthy groundwater-dependent plant communities in the Owens Valley.

This section presents an analysis of the 2015 vegetation conditions

Abstract

A primary goal of the Long Term Water Agreement is to maintain the hydrological conditions compatible with the persistence of groundwater-dependent ecosystems mapped on LADWP lands in the Owens Valley during the 1984-1987 (baseline) period. Each year the Inyo County Water Department and Los Angeles Department of Water and Power measure plant cover and composition, in areas mapped as groundwater dependent during the baseline period, to quantify vegetation change over time. This report provides estimates for: (1) changes in vegetation cover and composition for parcels influenced by pumping (wellfield parcels) and parcels not influenced by pumping (control parcels), and (2) changes in cover over time for individual vegetation parcels. In general, wellfield parcels have been below baseline measurements while control parcels have maintained baseline conditions but in 2014 and 2015 control parcel on average were below baseline perennial cover. In 2015, 63% of wellfield parcels (46 out of 73) reinventoried were below baseline perennial cover estimates. Thirty of these 46 parcels dropped below baseline in 2014 and 2015, while seven parcels have been below baseline for four years and nine parcels have been persistently below baseline for 7-19 years.

Introduction

This report presents an analysis of the 2015 vegetation conditions based on the joint monitoring efforts by the Inyo County Water Department (ICWD) and Los Angeles Department of Water and Power (LADWP). Each year, ICWD and LADWP monitor vegetation conditions on the floor of the Owens Valley. The purpose of this monitoring is to detect any

Significant decreases and changes in Owens Valley vegetation from conditions documented in 1984 to 1987.

Vegetation live cover and species composition documented during the 1984-87 mapping effort were adopted as the baseline from which current conditions are compared.

The technical appendix to the Agreement (Green Book) details certain decreases and changes in vegetation community types that must be avoided under the Agreement. Baseline vegetation communities in which parcel scale evapotranspiration estimates exceeded annual precipitation were classified as Types B (shrub dominated), C (grass dominated), and D (riparian). These groundwater-dependent communities are maintained with shallow water table, as precipitation alone is inadequate to meet transpiration water demand required by species in these locations (Sorensen et al. 1991, Steinwand et al. 2006). For these parcels, according to the Green

Book, the goal is to manage groundwater pumping and surface water management practices so as to avoid causing significant decreases in live vegetation cover and to prevent a significant amount of vegetation from changing to a vegetation type that precedes it alphabetically (for example, Type C meadow changing to Type B, shrub meadow, or Type B changing to Type A, non-groundwater dependent vegetation).

To determine whether significant decreases and/or changes in vegetation have occurred, three criteria need to be met that are described in the Green Book: (1) measurability of vegetation change, (2) attributability of vegetation change to LADWP groundwater pumping or surface water management and (3) degree of significance defined by the magnitude, extent, duration and permanency of the change along with other factors including air quality, human health, impact to species of concern, etc. In the Green Book, the term "measurability" is synonymous with statistical significance. The primary objective of the vegetation annual report is to evaluate the statistical significance (measurability) of vegetation change compared to baseline, however significance levels (i.e. Type I error rates) and sample sizes were not specified in the Green Book nor were specific statistical tests specified. The second criterion, evaluating whether a statistically significant change in vegetation is caused by water management (attributability), is beyond the scope of this report but will be evaluated in separate reports. Another source of confusion may arise with the third criterion which is the "degree or significance" of environmental change. For this criterion to be met, statistical significance is necessary but not sufficient. As described above, there are several other factors in addition to statistical significance that must be demonstrated to evaluate the degree of significance for the third criterion. For an example of a an evaluation of all three criteria for an individual parcel, see the report " in Vegetation Parcel Blackrock 94" and the various reports associated with the arbitration concerning this vegetation parcel (available at www.inyowater.org).

A large proportion of groundwater-dependent parcels were mapped during baseline as Type C alkali meadows (61%), and the Agreement seeks to prevent these meadows from changing to shrub-dominated communities (Type B), a change that can be associated with increased depth to groundwater. Alkali meadows are of special concern because small increases in depth to groundwater can decouple the groundwater from the root zone of grass species (Naumberg *et al.* 1996, Elmore *et al.* 2006). Alkali meadow comprises 0.1% of the vegetation community types in California and 80% of alkali meadow communities are located within the Owens Valley (Davis *et al.* 1998). Local management of these ecosystems influences the likelihood these ecosystems persist within California in a changing environment.

Vegetation change across the Owens Valley was evaluated at both the valley scale and for each of 141 individual parcels sampled in 2015. First, at the valley-wide scale we evaluated perennial plant cover and composition in parcels affected by groundwater pumping and for parcels that were relatively unaffected by groundwater pumping during the period of maximum pumping rate (1987-1993). Second, we assessed whether perennial plant cover differed over time for locations influenced by pumping compared to locations not influenced by groundwater pumping. Third, we quantitatively assessed the divergence of these groups of parcels from the baseline cover values recorded from 1984 to 1987. Fourth, we assessed whether vegetation composition in wellfield or control groups had changed from baseline values. Lastly, for individual parcels, we (a) quantified the magnitude of change in perennial vegetation cover over the 25 year reinventory period, (b) assessed whether the relative proportion of woody vegetation (hereafter shrub), gramminoid vegetation (hereafter grass) and non-gramminoid herbaceous vegetation (hereafter herb) has changed compared to baseline and (c), quantified the temporal trends of vegetation composition for each parcel.

Methods

The Owens Valley is located in east-central California, entirely within Inyo County. The valley is bounded by the Sierra Nevada to the west and the White/Inyo Mountains to the east. Runoff from the Sierra Nevada maintains a shallow water table in the valley that historically supported phreatophytic vegetation communities including alkali meadow, Nevada saltbush meadow and rabbitbrush meadow. Perennial grasses dominate the alkali meadow vegetation communities, while shrubs and grasses co-dominate mixed meadows (Manning, 1997).

From September 1984 to Nov 1987, LADWP inventoried and mapped vegetation on 2126 vegetation parcels (223,168 acres). Many of these parcels are characterized by nonphreatophytic plant communities or are distant from pumped areas. In the summer of 2015, ICWD and LADWP resampled 141 parcels using the line point protocol described in the Greenbook (a complete list is contained in Appendix 1). Parcels were initially selected based on meeting one or more of the following criteria: (1) parcel contained a permanent monitoring site; (2) baseline data was collected for the parcel; (3) parcel was in close proximity to a pumping well; (4) information of past and current land use for parcel was available; (5) parcel was representative of one of the plant communities originally mapped during baseline; (6) soil characterization was available for the parcel; (7) characterization of the landscape position was available for the parcel (Manning 1994).

Criteria for control or wellfield groups

Parcels were classified as either control or wellfield based on criteria derived from groundwater drawdown during the period of maximum pumping rate that occurred between 1987 and 1993. Two water table estimation methods were used to provide numerical criteria for these parcel classifications: (1) ordinary kriging, a geostatistical approach that relies on the spatial correlation structure of the test well data for weighting in order to interpolate groundwater depth for an entire parcel, and (2) groundwater-flow modeling estimates of groundwater drawdown contours shown on the baseline maps (Danskin 1998, Agreement Exhibit A: Management Maps, Harrington and Howard 2000, Harrington 2003). Parcels were designated as either wellfield or control depending on whether drawdown estimates from both kriged test well data and groundwater modeling were above or below critical values. Parcels were assigned wellfield status if (1) kriged DTW estimates exceeded 1-m water-table drawdown during 1987-1993 (2) they were located at sites corresponding to modeled drawdown contours greater than 10 ft. Parcels were assigned control status if (1) kriged DTW estimates were less than 1-m and (2) they were located at sites corresponding to modeled drawdown contours less than 10 ft. If the kriged DTW estimates were not reliable owing to inadequate test well coverage near vegetation parcels (Harrington 2003), then the groundwater-flow model estimate of the 10-ft drawdown contour was used as the sole criteria to designate parcels as either wellfield or control. An exception to the above criteria was applied to parcels associated with drawdown contours greater than 10-ft yet located near a surface water source (specifically, a canal, sewer pond, creek, river, or a ground water seepage source) that would lessen local drawdown effects—these parcels were classified as control. Some parcels assigned the wellfield designation currently have higher water tables than during 1987 to 1993, but they retain the wellfield designation owing to their proximity to pumping wells and potential for pumping-induced drawdown.

Statistical Analyses

Changes in vegetation cover and composition from baseline were evaluated at the valley-wide scale via comparisons of parcel groups (wellfield vs. control) and at the individual parcel scale using multi-year transect data for each parcel.

All statistical analyses were performed using R Version 3.1.1 (R Core Team 2014). The following R packages were used: 'plyr' (Wickham 2011), 'reshape' (Wickham 2007), 'multcomp' (Hothorn et al. 2008), 'nlme' (Pinheiro *et al.* 2013), and 'car' (Fox and Weisberg 2011). Statistical significance was declared at the $\alpha = 0.05$ level. The County recognizes the arbitrary dichotomization of the p scale, however for compliance monitoring a dichotomization is necessary. Cover values are rounded to the nearest integer in reporting.

Analysis Variables

At the transect level, the data represent the counts of vegetation cover 'hits' from a 50-m line-point-intercept transect sampled every 0.5 m yielding 100 possible hits per transect. Perennial cover was chosen for analysis because annual species are not dependent on ground water. Perennial cover was further categorized by the life-form categories grass, herb, and shrub.

In order to analyze the changes in the composition of total perennial cover, the proportion of shrub, herb and grass cover in comparison to total perennial cover was calculated at the transect level. Transect data are summarized for each year using the arithmetic average, creating a history of cover over time for each parcel. Other measurements taken each year at the parcel level include depth to water (DTW) and fraction of photosynthetic vegetation cover derived from spectral mixture analysis (SMA) of Landsat TM imagery (Elmore 2001). SMA values were not available for 2011-2016 due to discontinuation of Landsat 7 data use in previous years. However Landsat 8 data is now available and a new SMA processing tool has been developed yet the crosswalk between Landsat 5/7/8 endmembers needs to be completed before continuation of the time series. This project is the topic of separate report due out in fall 2016.

A change profile for each parcel in the continuous parcel data was computed as the change in mean perennial cover for each reinventory year from baseline perennial cover. Each parcel is classified by its Holland plant community type and by its status as either wellfield or control.

Analysis Data Sets

The number of parcels sampled each year as well as the number of transects sampled per parcel has varied due to fluctuations in annual staffing. Thus, some parcels have varying numbers of transects sampled across time. Other parcels have not been sampled continuously during the entire monitoring period. In 2015, 141 parcels were sampled. For determinations of change from baseline, several subsets of the entire data set were used as follows:

1. **Parcels missing baseline transect data** ($n = 15$): The set of parcels resampled in 2015 for which baseline transect data is unavailable. BGP091, BGP093, BLK044, BLK069, BLK074, FSP006, IND099, IND106, IND132, IND133, IND205, IND231, LAW085, PLC106, TIN006. These parcels cannot be evaluated statistically from the reinventory data.
2. **Parcels with a single transect at baseline** ($n = 7$): IND019, IND021, IND026, IND029, IND087, IND124,

IND156 (not sampled in 2015). These parcels cannot be evaluated statistically from the reinventory data but change is calculated using the single transect.

3. **Full transect data** (*n* = 123): The set of parcels with transect data from both the current year (2015) and at least one associated transect conducted during the baseline monitoring period (1985-1987). These parcels were further identified as belonging to the control or wellfield parcel group. Parcels with only a single transect from cannot be evaluated statistically.
   a. Wellfield (*n* = 78); 73 can be evaluated statistically
   b. Control (*n* = 45); 43 can be evaluated statistically
4. **Continuous parcel data** (*n* = 36): The subset of full transect data that was sampled in every year from 1992 to the present. The year 1992 was chosen for the continuous parcel data because the sample size was greater than the set of parcels sampled each year from 1991 to the present. The baseline year was assigned to the nominal value of 1986 for these data. These data were further identified as either control or wellfield and by alkali meadow.
   a. Wellfield (*n* = 24)
      i. Continuous transect data – alkali meadow wellfield (*n* = 15)
   b. Control (*n* = 12)
      i. Continuous transect data – alkali meadow control (*n* = 10)
5. **Regression data set** (*n* = 106): The subset of full transect data with at least 10 years of data including the nominal baseline year. This set also includes parcels that were not sampled in 2015 if the time series contained at least 10 years of data.
   a. Wellfield (*n* = 67)
   b. Control (*n* = 39)

Analysis of parcel groups: wellfield vs. control

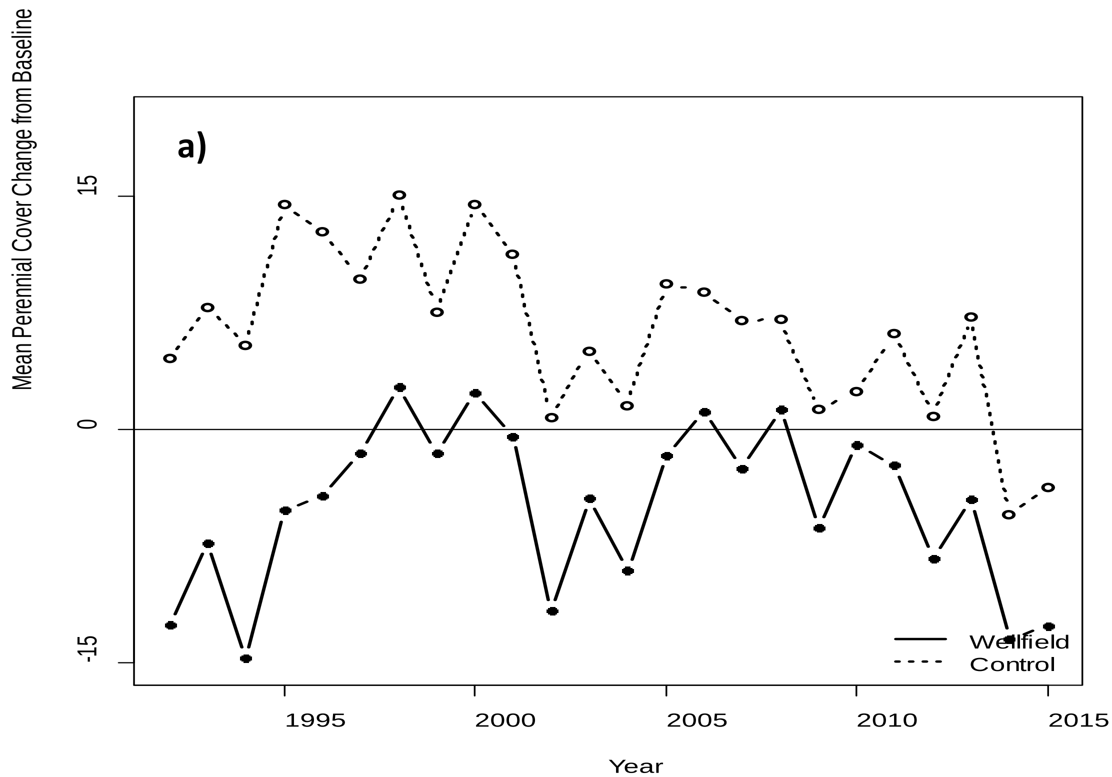
MANOVA was used to assess whether there was a difference in level or shape of the change profile over time between wellfield and control parcels. This allowed a direct evaluation of the effects of parcel status (wellfield or control) and time (1992-2015) on changes from baseline. The change profile was defined as the difference between the mean annual cover for each year and baseline. To allow for arbitrary changes in variance from year to year, and also for arbitrary dependence between errors from year to year, a fully unstructured correlation matrix was used. To avoid confounding the evaluation of change over time with the potential effects of varying the sample size between years, analyses were performed only on the continuous parcel data and on the alkali meadows subset of the continuous parcel data. Model fit was assessed using graphical analysis of residuals.

To assess directly whether there was a change from baseline across parcels in mean perennial cover or mean grass cover, a paired t-test was used. Tests were performed using the full parcel data. Wellfield and control parcels were analyzed separately.

Analysis of covariance (ANCOVA) was used to assess whether there were differences in the linear trend of total perennial, grass cover, herb cover and shrub cover wellfield and control parcels. This analysis was performed using the continuous parcel data (1986, 1992-2015 = 25 years). The grouping variable was parcel status (wellfield or control), and the continuous variable was cover regressed on time. Linear trends were subsequently estimated using simple linear regression. Model fit was assessed using graphical analysis of residuals.

Individual parcel analyses

To evaluate in which parcels and in which year(s) total perennial cover has significantly



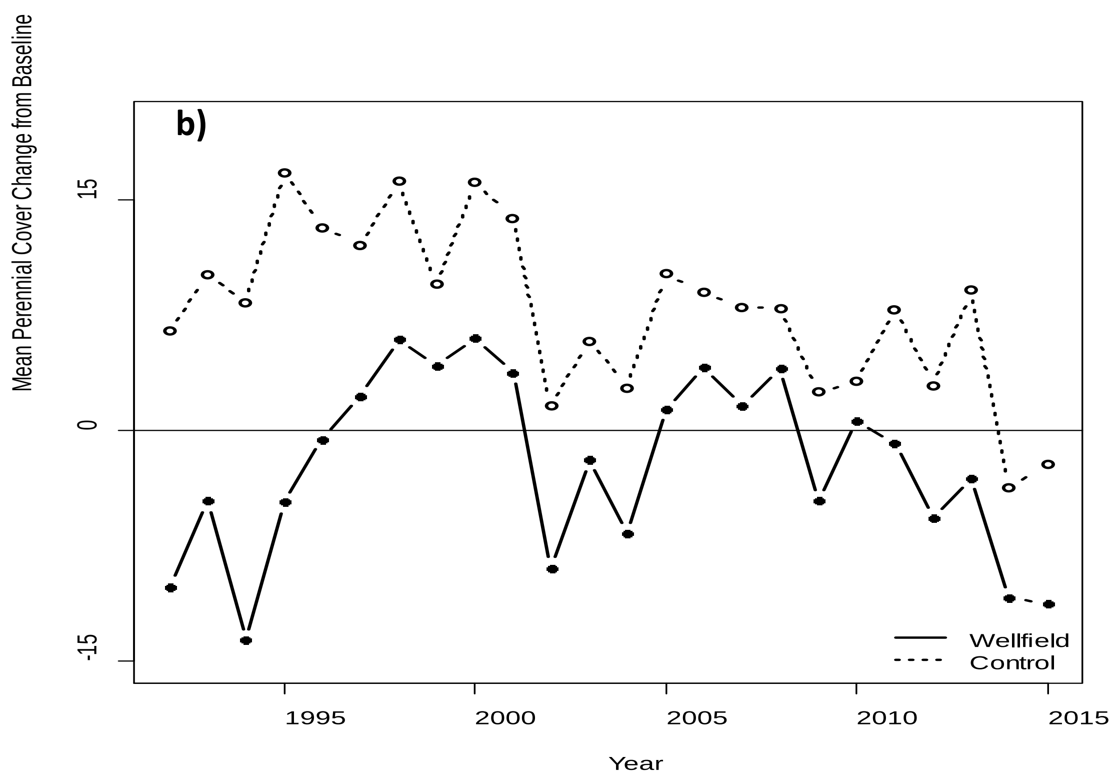


Figure 6.1. The mean change from baseline of mean perennial cover for the parcels sampled each year between 1992 and 2015. (a) All parcels with continuous annual sampling (n = 36). (b) Alkali meadow parcels with continuous annual sampling (n = 25).

differed from baseline, Welch's t-test for unequal variance was used to evaluate significant changes compared to baseline for each year that the parcel was sampled. Weighted ANOVA with Dunnet's method for multiple comparisons has been used for these comparisons in the past; however, Welch's t-test is appropriate and there is no need to correct for multiple comparisons in a monitoring context when the comparison is always the most recent sample estimate vs. the baseline value (ICWD Annual report 2014, p. 172). This method could only be used for parcels in which baseline data contained more than one transect. The results were grouped into three categories: significantly below baseline, no difference from baseline, and significantly above baseline.

To assess whether composition had changed within each vegetation parcel, a regression of shrub proportion (shrub cover/total perennial cover), grass proportion, and herb proportion over time was performed for all parcels in the full transect data with at least 10 years of vegetation data including baseline (regression data set).

Results

Analysis of Parcel Groups: Wellfield vs. Control

Comparison of change profiles between wellfield and control groups–MANOVA results

Figure 6.1 displays the change profiles for wellfield and control parcels that were continuously sampled, as well as for the alkali meadow subset of these parcels. Figure 6.2 breaks out the overall cover by each lifeform category.

The change from baseline of mean perennial cover of wellfield parcels (n = 24) differed from the change from baseline of mean perennial cover of control parcels (n = 12) (n = 24 yrs (1992-2015), p = 0.028, Figure 6.1a). Inter-annual trends or the shape of the change profile in the two groups have been similar during the reinventory period, thus the significant difference is attributable to the level of the difference between the change profiles. In 2014 both groups dropped below baseline and continued below baseline in 2015. For the alkali meadow parcel group sampled each year during this same time period (1992-2014), the general pattern and level of difference were similar; however, the comparison between wellfield (n = 15) and control (n = 10) parcels was not significant (n = 24 yrs, p = 0.73, Figure 6.1b).

Difference between baseline and 2015 cover in wellfield and control parcel groups

Mean perennial cover in wellfield parcels calculated from the 2015 full transect data set (n = 123) was 18%, compared to 34% mean baseline cover (n = 78, p < 0.001, Figure 6.3a). Mean perennial cover in control parcels calculated from the full data set in 2015 was 25%, compared to 34% mean baseline cover (n = 45, p < 0.001, Figure 6.3b).

In 2015, mean perennial grass cover in wellfield parcels calculated from the full transect data set was 7%, compared to 22% mean baseline grass cover (n = 78, p < 0.001, Fig 6.3a). Mean perennial grass cover in control parcels calculated from the full data set in 2015 was 12%, compared to 24% mean baseline grass cover (n = 45, p < 0.001, Figure 6.3b).

Differences in rates of composition change for wellfield vs. control groups

Formal tests for difference in slope using analysis of covariance (ANCOVA) over time (n = 25 years) between control and wellfield parcel groups were not significant for total perennial cover (p = 0.25) or grass cover (p = 0.58). Herb cover (p=0.12) and shrub cover (p = 0.11) approached significance at alpha 0.05. Parcel-level responses in opposing directions within groups yield wide variance when aggregated at this level.

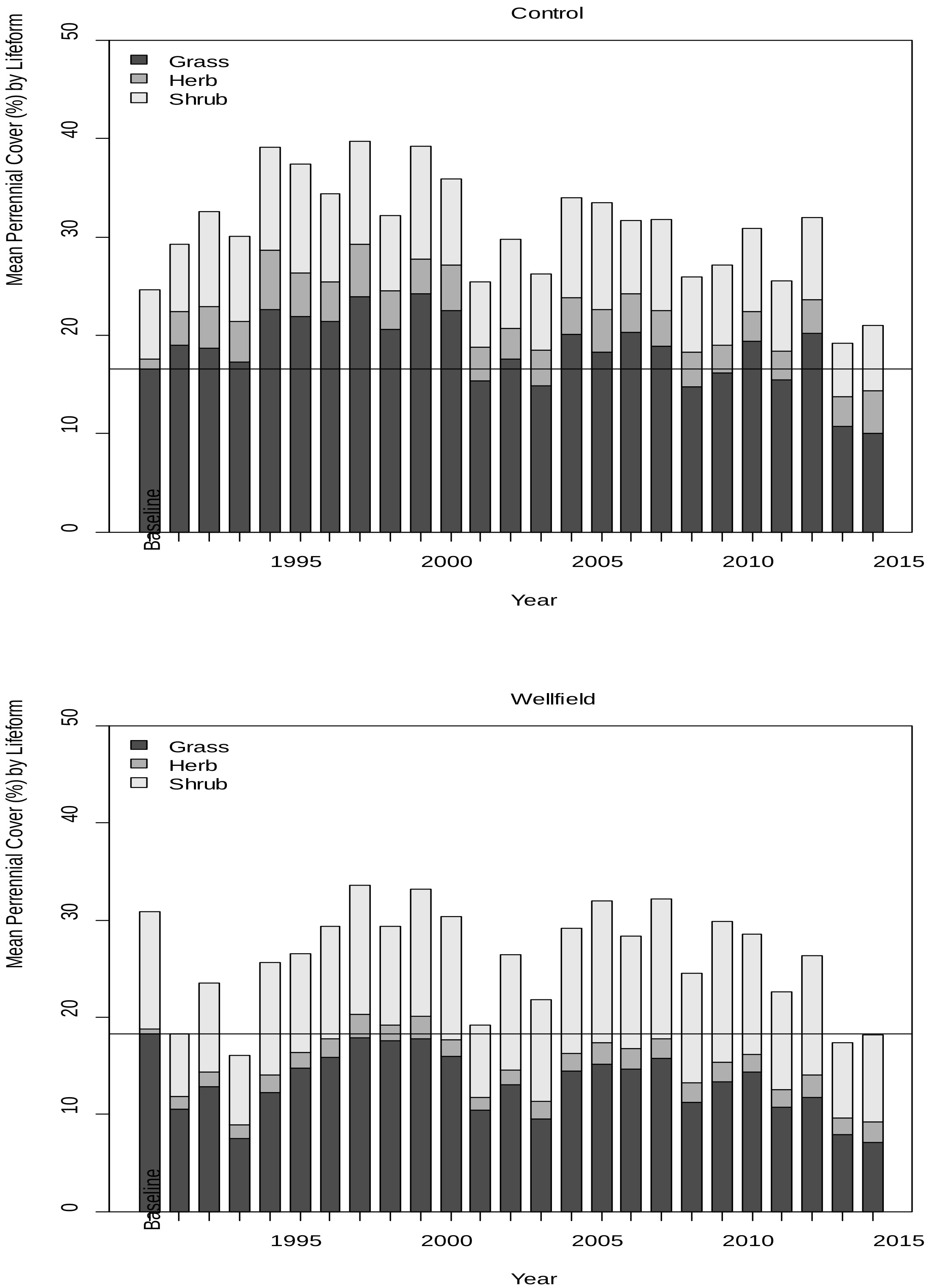
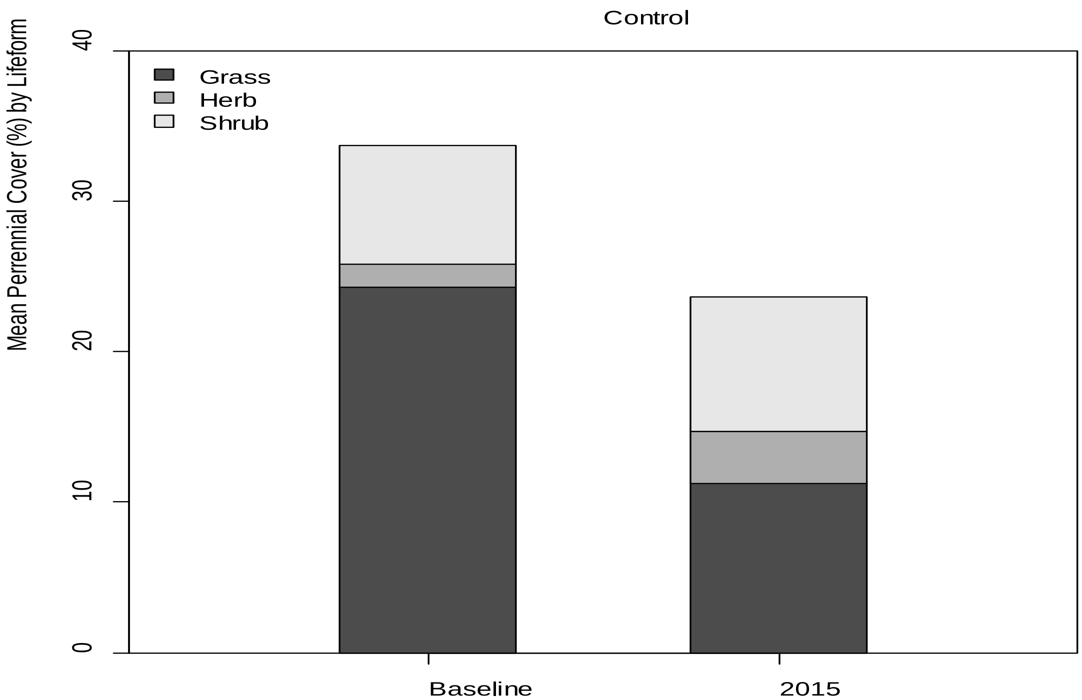


Figure 6.2. Time profile of grass, herb and shrub cover for baseline and each reinventory year for the continuously sampled control and wellfield parcels, sampled each year between 1992 and 2015 (n = 24 wellfield parcels, n = 12 control parcels, n = 25 yrs including nominal baseline year). Horizontal line shows the mean baseline grass cover value.



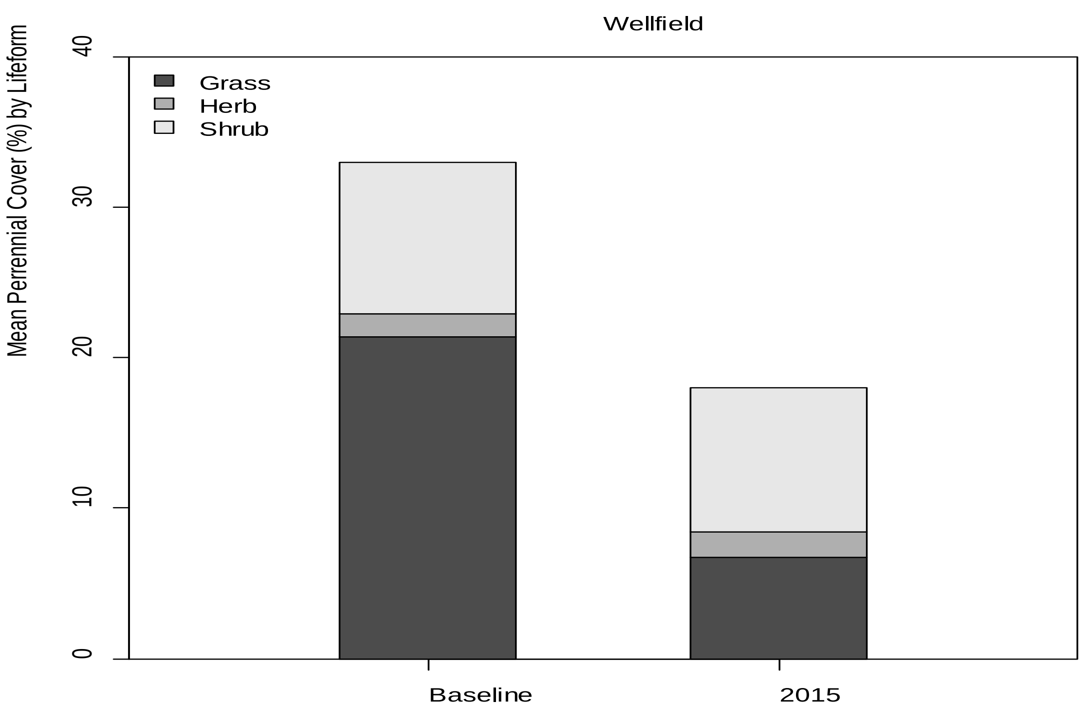


Figure 6.3. Mean perennial cover partitioned by lifeform for baseline and 2015 calculated for all parcels sampled in 2015 that have baseline transect data (n = 45 for control parcels, n = 78 for wellfield parcels).

Composition change for wellfield and control groups

Using the 25-yr continuous data (1992-2015) (n = 24 wellfield parcels, n = 12 control parcels), simple linear regression was used to graphically illustrate linear trends in plant functional groups over time (Figure 6.4). Mean total perennial cover in this limited wellfield parcels set was above 31% during baseline and below 18% in 2015 but the slope over time was not statistically different from a slope of zero owing to the variability in cover values between baseline and 2015. Control parcel cover for the wellfield continuously sampled set during baseline was about 25%; and all years following were above this level except 2014 and 2015 where the current estimate is 18%. Grass cover has declined in both wellfield and control parcels; the primary decline in grass cover over the last 30 years was in the late 1980s and early 1990's associated with decreased recharge due to drought and groundwater drawdown due to pumping. The reinventory time series of parcel cover and composition suggests 1994 was the lowest cover year before rebounding with the higher runoff years in the late 1990s. In most reinventory parcels, the 2014-15 cover estimates are approaching 1994 conditions. 2015 declined below the 1994 lowest grass cover on record (Figure 6.4). Wellfield non-gramminoid herbaceous perennial cover has increased over time associated with an increase in ruderal species but represents a small component of overall cover (less than 3%).

Individual parcel analysis

In 2015, perennial cover in 46 out of 73 sampled wellfield parcels (63%) with more than one baseline transect were significantly below baseline. Thirty of these 46 parcels dropped below baseline in 2014 and 2015, seven parcels have been below baseline for four years and nine parcels have been persistently below baseline for 7-19 years.

Appendix 2 contains all parcels sampled at least one year between baseline and 2015 (n = 190) and associated results of (1) Welch's unequal variances t-test on cover for the entire time period (baseline-2015) (2) SMA cover values for baseline through 2011 and (3) DTW values for baseline through April 2016.

Individual parcel changes in shrub and grass proportion

For 66 wellfield parcels with at least 10 years of data, woody shrub proportion increased in 28 and grass proportion decreased in 30 ($p < 0.05$). Decreasing grass proportion of the total cover can occur with either increasing shrub cover, decreasing grass cover, and even increasing grass cover with concomitant but comparatively larger increases in shrub cover. Declines in grass cover don't necessitate a decline in grass proportion either, when shrub cover also declines in the same proportional amount, yielding static composition with lower total cover.

Discussion

There have been statistically significant changes in cover and composition at the wellfield group level and at the level of individual parcels. The majority of the individual parcels that had statistically significant change were from the wellfield group.

Analysis of parcel groups: wellfield vs. control

Comparison of change profiles between wellfield and control groups

The change from baseline of mean perennial cover of wellfield parcels from 1992-2015 differed significantly from the change from baseline of mean perennial cover of control parcels. The finding of statistical significance for this test could in theory be due to either shape or level differences between the change profile of wellfield and control parcels. The shape of the change profile was quite similar for both parcel groups and thus the significance may be interpreted as being due to differences in overall level, with the wellfield

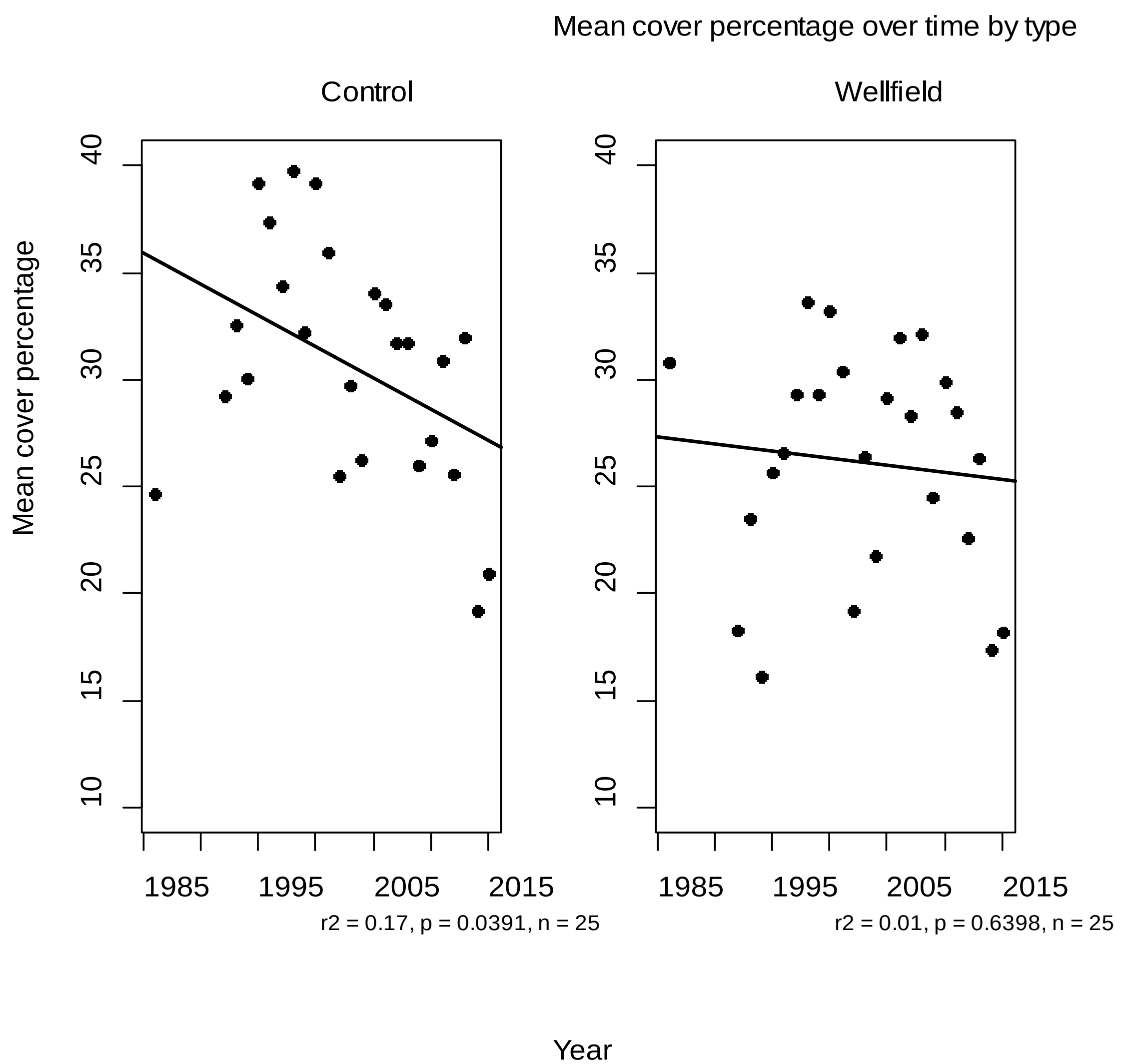


Figure 6.4a. Total cover over time in wellfield and control parcels computed from parcels in the continuous transect data set (n = 24 wellfield parcels, 12 control parcels, n = 25 years including nominal baseline year).

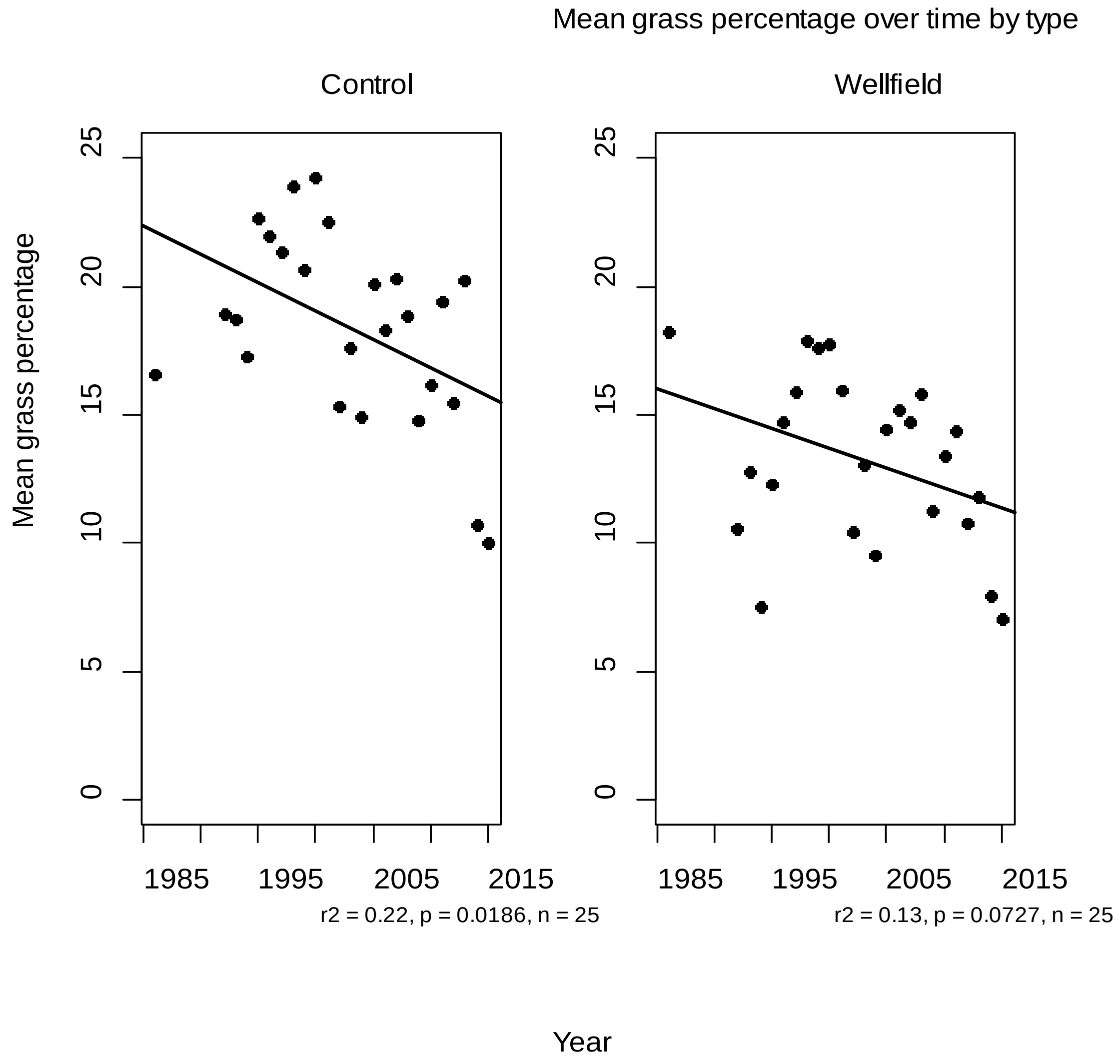


Figure 6.4b. Total grass cover over time in wellfield and control parcels computed from parcels in the continuous transect data set (n = 24 wellfield parcels, 12 control parcels, n = 25 years including nominal baseline year).

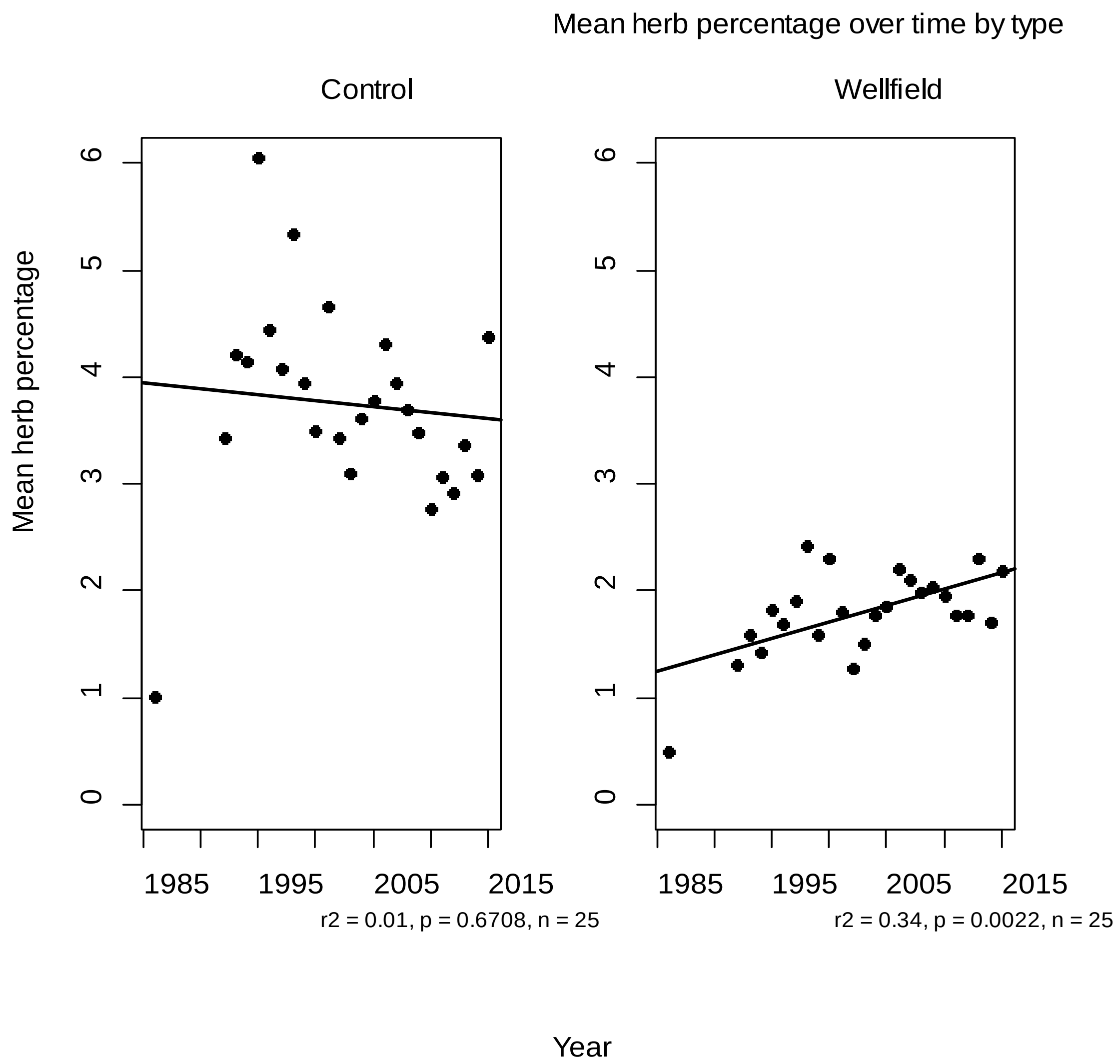


Figure 6.4c. Total herbaceous cover over time in wellfield and control parcels computed from parcels in the continuous transect data set (n = 24 wellfield parcels, 12 control parcels, n = 25 years including nominal baseline year).

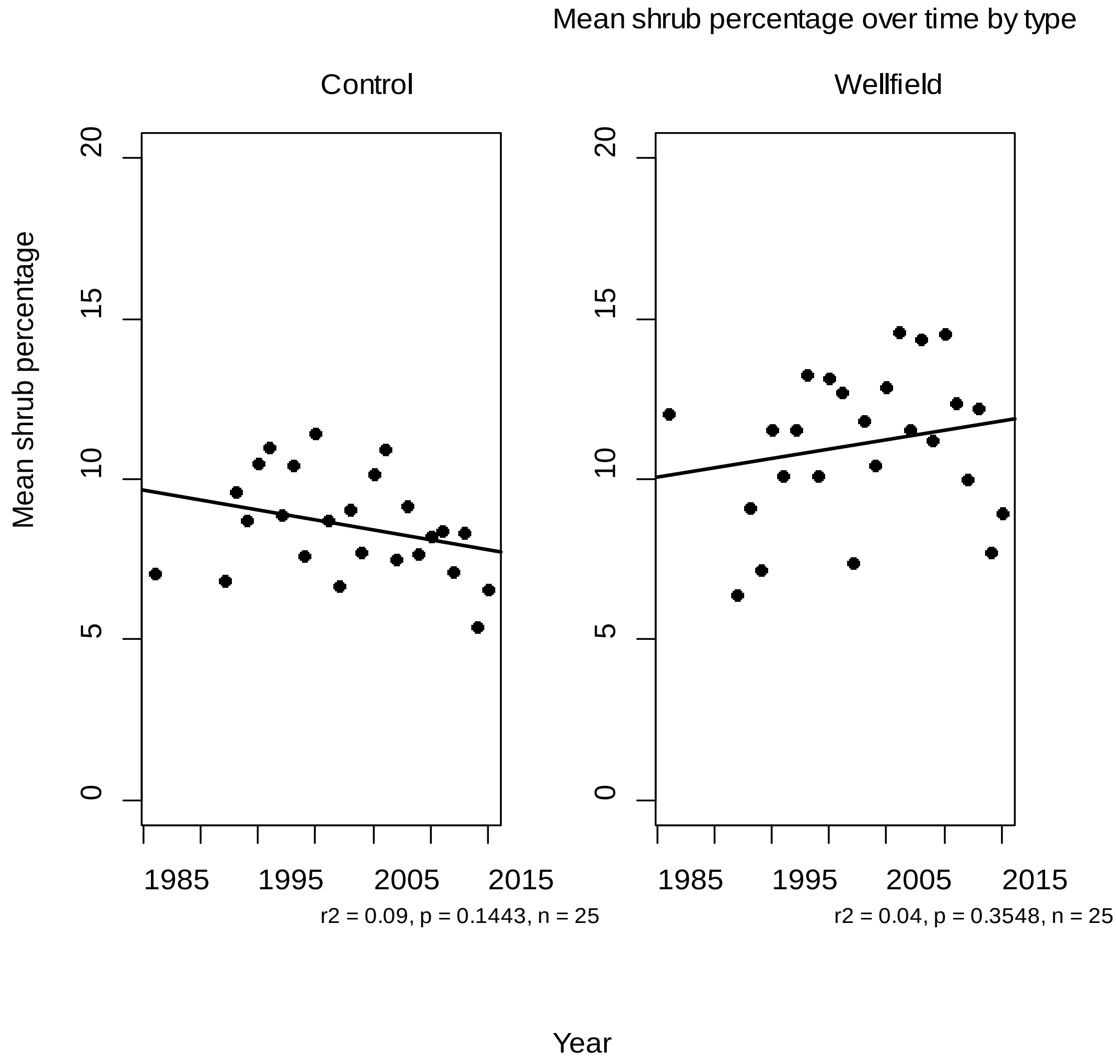


Figure 6.4d. Total shrub cover over time in wellfield and control parcels computed from parcels in the continuous transect data set (n = 24 wellfield parcels, 12 control parcels, n = 25 years including nominal baseline year).

group change from baseline, significantly below that of the control group.

<u>Difference in 2015 vs. baseline cover for wellfield and control groups</u>

Total perennial cover in 2015 for the wellfield group was 14.4% lower than baseline and grass cover was 11.8% below baseline (n=53). Total perennial cover for the control parcel group in 2014 was 8.5% below baseline and grass cover was 9.2% below baseline.

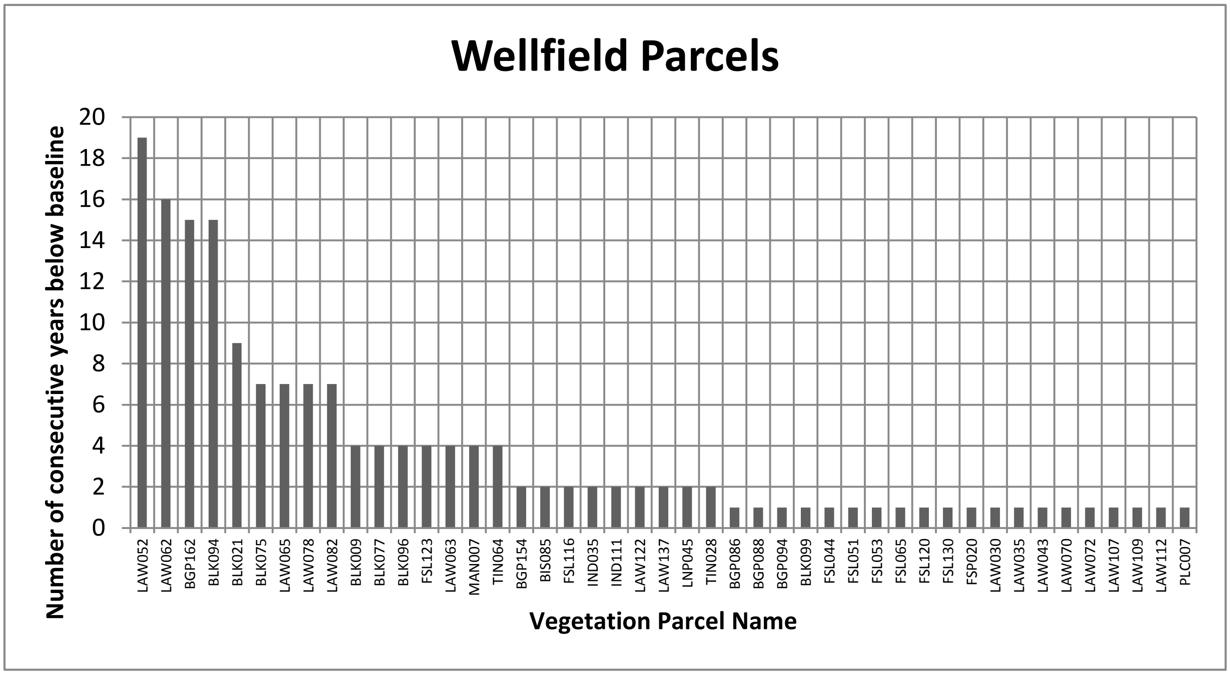


Figure 6.5. Number of consecutive years below baseline prior to and including 2015 for wellfield parcels. Statistical significance was determined based on Welch's unequal variances t-test with significance declared at α = 0.05.

Composition change for wellfield and control group

Using the continuous data set, simple linear regression showed shrub and herb cover in wellfield parcels increased significantly and grass cover decreased (Figure 6.4). Control parcels showed a decreasing trend in grass cover also with 2014 and 2015 being influential data points associated with the third and fourth year of consecutive drought and the lowest values recorded for control parcels since 1994 for this subset of parcels (Figure 6.4).

Individual parcel analysis

Difference in 2015 vs. baseline cover for individual parcels

Figure 6.5 shows four parcels that have been statistically below baseline for the past 15 consecutive years or more. The causes of cover decline in one of these four parcels, BLK094, was the subject of several years of analysis by Technical group members and a dispute resolution process; and ultimately a management resolution was agreed upon that included reduced pumping in the vicinity and off-site prescribed burns intended to reduce woody vegetation with the aim of maintaining higher gramminoid cover. The post-baseline decline in cover for LAW052 and LAW062 and other LAWS parcels is likely symptomatic of the cessation of water conveyance through the McNally Canals and pumping.

The 2015 reinventory data show that 63% of wellfield parcels reinventoried are below baseline perennial cover measurements. Over half of these parcels dropped below baseline from 2013-2015 during the ongoing drought.

Dominant species in these meadow communities require more water than is available via precipitation and obtain needed water within a zone of soil that is saturated with groundwater, or immediately above this zone in the capillary fringe. Reduction in water table beyond a maximum rooting depth of 2-2.5 m is incompatible with shallow-rooted species of meadow ecosystems (Elmore et al. 2006). With water-table decline, establishment and dominance of deep-rooted woody species over herbaceous species is predicted based on deeper rooting depth of shrubs (Stromberg et al. 1996; Cooper et al. 2006; Trammell et al. 2008; Goedhart and Pataki, 2010). In alkali soils, reductions in the groundwater table reduce dissolved salt content that accumulates via wicking to the surface via capillary action (Cooper et al. 2006; Patten et al. 2008). In addition to a lack of salt replenishment to the soil surface with water table reductions, subsequent precipitation events further leach remaining salts to deeper horizons. The consequent decreases in soil salt content could increase site-suitability for non-halophytic species (Patten et al. 2008) and reduce site-suitability for halophytes (plants adapted to saline environments). *Distichlis spicata*, or saltgrass, a native halophytic dominant of alkali meadow, could be expected to decrease in distribution and abundance in association with both decreases in the groundwater table and consequent decreases in soil-surface salt content. To allow long-term persistence of meadow ecosystems and alkali meadow in particular, water management in the Owens Valley requires maintenance of a shallow saturated zone of soil necessary to maintain populations of meadow species.

Trends in individual parcel composition change

The decrease in grass cover and increase in shrub cover in the wellfield parcels is consistent with the causal link between water table reductions beyond the 2 to 2.5-m grass root zone, favoring deeper-rooted woody species. In some control parcels, however, shrub cover also increased and grass cover decreased. Since control parcels are outside the influence of ground-water pumping, the mechanism underlying this effect could be due to altered water management, or disturbance regimes (i.e. grazing, fire, and drought) or a combination of these factors influencing local population demographic rates and succession to increased dominance of woody vegetation (Brown and Archer 1999, Van Auken 2000, Berlow *et al.* 2002, Eldridge *et al.* 2011).

For parcels influenced by groundwater management, repeated drawdown below the maximum rooting depth of grasses may result in establishment and dominance of shrubs. Depending on the degree of grass decline, water management alone may be inadequate to recover the former grass component without additional management such as prescribed fire and reseeding. Land and water management practices, including reduced pumping in impacted areas, in combination with water spreading, prescribed burning (to reduce woody vegetation) and revegetation of alkali meadow species where appropriate may allow recovery of ground-water dependent meadows at sites already transitioning to woody-dominated communities. Lack of action in arresting these transitions during early warning signs of composition shifts, will require more intensive action later on with the likelihood of success shrinking rapidly as the local species pool is reduced.

Conclusions

Vegetation conditions following the 2015-monitoring season can be summarized by four main findings. First, during the time period 1992-2015, the change profile of the wellfield parcel group was different from the control parcel group, with the decrease in wellfield group cover below that of the control group. Second, overall perennial cover and grass cover in 2015 for both wellfield and control parcel groups was significantly below baseline. Third, within the wellfield parcel group, the relative proportion of shrub cover has significantly increased and grass cover has decreased. Finally at the individual parcel level of analysis, 46 out of 73 (63%) wellfield parcels were significantly below their baseline cover values.

Acknowledgments

Field data collection was conducted by ICWD and LADWP staff during the reinventory period covered in this report (1991-2015). Vegetation Program Manager, Jerry Zatorski managed ICWD's field crew, handled logistics of field data collection, data QA/QC and post processing. Ron Tucker managed the data collection and data processing for LADWP. Meredith Jabis and Jerome Braun developed some of the R scripts used in analyses. Andrew Elmore provided the spectral mixture analysis on Landsat TM data. ICWD Hydrologist, Keith Rainville, developed the 2011-2016 kriged DTW gridded surfaces that I used to summarize parcel scale hydrographs.

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Section 6 Appendices

Appendices are on the Water Department's web site: http://www.inyowater.org in the section containing Inyo County Water Department Annual Reports.

Appendix 1. Parcels sampled in 2015. Column headings indicate: baseline management *type (A,B,C,D,E), plant community* type based on Holland (1986), and *location* based on proximity to production wells.

Appendix 2. Figures 1-169 show mean perennial vegetation cover plotted over time for the 169 vegetation parcels sampled since 1991 using the Green Book Line Point monitoring program, and SMA average cover data (through 2011), and depth to water (through 2010). Asterisks depict years that perennial cover is significantly different from the baseline period (sampled between 1984 and 1987) using Welch's t-test for unequal variances. Thirteen parcels do not have raw baseline transect data and thus could not be analyzed with statistics based on the variance. In these cases, the baseline cover value is shown without error bars.

Appendix 3. Grass, shrub, and herb proportion regressed against time in parcels with baseline transect data and at least 10 years of line point data. Columns indicate: wellfield or control parcel status, *W/C*; sample size, *n*; coefficient of determination, R^2; p-value, *p*; slope parameter estimate, *slope*; upper and lower 95% confidence interval for the slope parameter, *95% Confidence Interval*; direction (positive or negative) of the relationship, *Slope direction*. Bold text in p-value column, indicates significant regressions at $\alpha = 0.05$. Rows were sorted by grass slope direction to highlight changes in grass proportion.

Appendix 4. Map of parcels sampled in 2015 and coded by the comparison to baseline perennial cover: significantly below, above or no change.

SECTION 7: MITIGATION

Introduction

The Inyo County Water Department monitors and reports on the staus of environmental mitigation projects in the owens Valley.

Inyo County is also a partne in funding and implementing the Lower Owens River Project.

One on the roles of the Inyo County Water Department (ICWD) is to monitor and report on the status of environmental mitigation projects in the Owens Valley. More than 62 projects, spread throughout the Valley, mitigate for a range of environmental impacts due to abandonment of irrigated agriculture and groundwater pumping in the Owens Valley. These improvements range in size from single-acre spring projects to the 78,000-acre Lower Owens River Project (LORP). The majority of these projects are described in the Water Agreement and associated 1991 EIR (*Water from the Owens Valley to Supply the Second Los Angeles Aqueduct*), and in the 1997 MOU (*Resolving conflicts and concern over the 1991 EIR*), which can be found on the ICWD website (www.inyowater.org).

ICWD participates in the development of new projects, evaluates the effectiveness of ongoing mitigation, and oversees modifications of existing projects that have been changed by the Inyo/LADWP Standing Committee or the courts.

This report provides background and status on all mitigation projects.

This section includes tables of all the projects described in the 1991 EIR and MOU and water supplied to these projects. Information In Table 8.1 includes the project origin, impact being addressed, management prescription, development stage, and project status.

Mitigation Projects Origins and Background

The Los Angeles Department of Water and Power (LADWP) is legally obligated to implement mitigation projects to enhance recreation, diversify land use, improve or create habitat for wildlife and vegetation, and mitigate for a range of impacts in the Owens Valley. Descriptions of mitigation projects are found in the collection of documents that govern the activities of the LADWP in the Owens Valley. These documents were developed over time and include the 1991 Long Term Water Agreement and associated EIR, the 1997 MOU, and other court stipulations and orders.

Although the environment of the Owens Valley had begun to suffer the effects of large-scale water diversions to supply water to Los Angeles Aqueduct beginning in 1913, all of the mitigation projects described in this report mitigate for impacts after 1970 that resulted from the operation of the second Los Angeles Aqueduct. These mitigation projects will to a certain degree repair, restore and compensate for adverse impacts from the operation of the second aqueduct.

More than 58,000 acres of groundwater dependent vegetation is found in the Owens Valley. Between 1970 and 1990, increased groundwater pumping, and the resulting fluctuations in groundwater table, has had a significant effect on more than 1,000 acres; 655 acres of groundwater dependent vegetation has entirely died-off. Most of the mitigation projects include goals to improve vegetation in the Owens Valley.

Mitigation Alternatives

With respect to mitigation, the Water Agreement generally follows the framework of the California Environmental Quality Act (CEQA), which allows several alternative forms of mitigation. These are generally considered in sequence (i.e., with preference given to avoidance first and compensation last). These actions include:

- **Avoiding the impact altogether by not taking a certain action or parts of an action.**
  Local example: Well on/off provisions. When soil water and projected contribution from precipitation is inadequate to maintain vegetation, wells are not operated.
- **Minimizing impact by limiting the degree or magnitude of the action and its implementation.**
  Local example: Shutting down pumping wells, as was done at Five Bridges when groundwater drawdown degraded nearby vegetation.
- **Rectifying the impact by repairing, rehabilitating, or restoring the impacted environment.**
  Local example: Revegetation and regreening projects, which compensate for the effects of the abandonment of irrigated agriculture leading to areas of blowing dust and dirt.
- **Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action. Local example: Salt cedar control, ongoing irrigation of fields**
- **Compensating for the impact by replacing or providing substitute resources or environments.**
  Local example: Lower Owens River Project, civic projects, recreational

facilities, habitat enhancement projects, and fish hatcheries

Origin of Mitigation Efforts

Mitigation planning, development, and implementation are ongoing activities that are undertaken cooperatively with LADWP; however, the majority of mitigation projects in the Owens Valley were developed by the two parties during three discrete periods of time in response to judgments or potential legal and administrative actions:

Environmental Projects (EP), 1970-1984

Between 1970 and 1984, LADWP committed about 10,000 acre-feet of water annually to implement twelve environmental projects. The primary purpose of these projects was to restore habitat that had been negatively affected or lost due to water gathering. These areas may have exhibited vegetation changes, or reduction in wildlife using a particular habitat. The goal was to provide a regular water supply to habitats such as ponds, lakes, sloughs, springs, and the Lower Owens River (LOR). Objectives differed between the projects, depending on the type of the impact that had occurred, but the overall goal of the environmental projects was to improve wildlife, forage, fisheries, and public recreation facilities.

In many instances it was impractical to mitigate at the original impact site, or the affected area was not well defined, or the impact was sporadic. In these cases a project was constructed at a site that would best accommodate the goals of the mitigation.

- **Farmer's Ponds**: Water is provided each fall to offer habitat for migrating waterfowl; two miles north of Bishop.
- **Buckley Ponds:** Water is provided for a warm-water fishery and waterfowl area; three miles southeast of Bishop.
- **Saunders Pond:** Water is provided to a warm-water fishery and waterfowl area; five miles southeast of Bishop.
- **Mill Pond:** Water is provided to a pond at a recreation area, either by creek flow or a well at the site; four miles northwest of Bishop; five miles west northwest of Bishop.
- **Klondike Lake:** Water is provided for permanent wildlife habitat area now incorporated in Klondike Lake E/M Project; 2 mile north of Big Pine.
- **Tule Elk Field:** Water is provided to irrigate a pasture heavily used in summer by tule elk; between U.S. Highway 395 and Tinemaha Reservoir.
- **Seeley Spring:** Maintained by an LADWP well adjacent to Owens River to provide waterfowl and shorebird habitat larger than had existed at Seeley Spring; two miles south of Tinemaha Reservoir.
- **Calvert Slough:** Water is provided to maintain habitat; small pond and marsh area near LADWP Aqueduct Intake.
- **Little Blackrock Spring:** Water is diverted from ditch to maintain wetland area at original spring site; west of the aqueduct intake.
- **Lone Pine Pond:** Water is provided by natural seep or spring flow in river with supplemental releases from Alabama Gates (now incorporated in the Lower Owens River E/M Project); north of Lone Pine Narrow Gauge Road.
- **Lower Owens River:** Water releases began in 1975 to provide year-long minimal flows along the lower Owens River, as well as releases to Twin Lakes, Billy Lake, and Thibaut Ponds. The goal is to maintain waterfowl, marsh, shorebird, and upland gamebird habitat, as well as provide for a warm-water fishery. The project has now been replaced by the

Lower Owens River E/M Project, which provides water to all of the formerly dry stretch of the Owens River; the 78,000 acre project site is located east of the towns of Aberdeen, Independence, and Lone Pine.

- **Diaz Lake:** A supplemental water supply is provided to Diaz Lake recreational area. The accounting of water supplied to this project has been revised as part of the MOU 1600 ac-ft. projects described below. The lake is three miles south of Lone Pine.

Enhancement/Mitigation Projects 1985-1991

The Enhancement Mitigation (E/M) projects are environmental projects that were implemented prior to adoption of the 1991 EIR. The Water Agreement required that all E/M project continue. Some of these projects were included in the 1991 EIR as mitigation for impacts due to LADWP's water gathering activities. The amount of water allocated to these projects, along with the water used is reported in Table 8.1.

These projects addressed a number of environmental impacts and filled community needs. Projects include the revegetation of abandoned agricultural lands and lands that experienced vegetation loss due to groundwater pumping, delivery of water for public parks, improved wildlife habitat, and a partial rewatering of the lower Owens River. For each project, specific goals and objectives were established and environmental documentation was prepared in accordance with CEQA.

- **Millpond Recreation Area Project:** Located west of Bishop, was the first E/M

- **Laws-Poleta Native Pasture Project:** Provides water for irrigation of 220 acres

measure to be completed. Since October 1985, funds have been provided to operate the recreation area's sprinkler irrigation system that waters 18 acres of the community park, including two softball fields.

- **Shepherd Creek Alfalfa Lands Project:** Revegetated 198 acres of abandoned cropland adjacent to U.S. Highway 395 with sprinkler-irrigated alfalfa and windbreak trees. The property between Lone Pine and Independence had only sparse annual vegetation since 1976, and was a source of blowing dust creating a traffic hazard.
- **Klondike Lake Project:** Previously, the 160-acre lake located north of Big Pine had been filled only during above-normal runoff years. Now, less than 1,700 af of water maintains the lake year-round. Benefits include nesting and feeding areas for waterfowl, and recreation including skiing, windsurfing, and other water sports in summer months. Due to the shape and size of the Klondike lakebed, the full volume of water (2,200 af) allocated to the project was more than the lake required, so the project was modified to permanently reduce the water allotment. The balance of this unused water allocation was apportioned the Big Pine Ditch System and the Klondike South Shore Habitat Area.
- **Laws Historical Museum Project:** Provides a regular water supply to improve the native vegetation on a 21-acre parcel, provide for irrigated pasture on 15 acres, and establish windbreak trees, all adjacent to the museum.
- **640 acres near Laws:** Revegetate with non-groundwater dependent native plants (potential project that would require Standing Committee approval to implement).

of sparsely vegetated land to reestablish native vegetation on abandoned pasturelands and increase livestock grazing capabilities.

- **McNally Ponds and Pasture:** Provides a regular water supply to existing ephemeral ponds (60 acres) in the Laws area to create waterfowl habitat, and to provide spring and summer irrigation to enhance and maintain existing vegetation on 300 acres of pastureland.
- **Independence Pasture Lands/and Spring Field Projects:** Provides approximately 910 acres of abandoned croplands and sparsely vegetated land with irrigation to create native pasturelands and provide water to native vegetation. Flood irrigation converted sparsely vegetated land east of Independence into productive native pasture. The project mitigated a source of blowing dust and stabilized soil previously affected by severe wind erosion.
- **Lone Pine Riparian Park:** Provides a continuous water supply to a ditch running through Russell Spainhower Park then easterly to supply water to Lone Pine Woodlot and Richards and Van Norman Fields projects.
- **Van Norman Field (160 acres) and Richards Field (160 acres):** Provides surface and pumped water to establish pastureland and increase livestock grazing capabilities on abandoned agricultural land.
- **Lone Pine Sports Complex:** At the request of the community, portions of the Lo-Inyo Elementary School and vacant LADWP property were converted to an outdoor sports complex consisting of baseball fields, soccer fields, and related parking, picnic and park areas.
- **Independence and Lone Pine Woodlots:** Two irrigated projects in Lone Pine and Independence provide a greenbelt and are harvested as sustainable source of firewood for those in need.
- **Independence Roadside Rest:** This project consisted of planting shade and windbreak trees and grass, installation of an irrigation system, and placement of picnic table on a 1/2-acre site south of the town of Independence. The project is an aesthetic improvement over the previously blighted area.

  Eastern California Museum: This project enhanced the appearance of the Eastern California Museum grounds in Independence. It consisted of a small pond, trees, expanded lawn areas, and installation of an irrigation system.
- **Town Regreening Projects:** Three projects designed to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the towns of Big Pine, Independence, and Lone Pine. Lone Pine has been implemented; Big Pine and Independence should come into operation in 2014.
- **Lower Owens River Rewatering E/M Project:** This project provided up to 18,000 AFY of continuous flow of water in the previously dry (1913-1986) portion of the river channel, creating a warm water fishery and wildlife habitat in the southern Owens Valley. The project also supplies water to five small lakes along the river route providing improved waterfowl habitat in the region. This project has been superseded by the Lower Owens River Project, which was fully implemented in December 2006.
- **Hines Springs:** Create 1-2 acres of aquatic, riparian, and marshland habitats. Project will serve as a research project on how to reestablish a damaged aquatic habitat.

Additional Mitigation Projects, 1997 MOU and 2004 Amended Stipulation and Order

The 1997 MOU identifies *Additional Commitments* that include studies, evaluations and commitments to specific issues (Section III.A). One of the issues brought forward in the MOU in Section III.A.3. is *Additional Mitigation* that requires a total of 1,600 acre-feet of water per year to be supplied by Los Angeles Department of Water and Power (LADWP). This water is to be used for the implementation of on-site mitigation measures at Hines Springs that were identified in the 1991 EIR and on-site or off-site mitigation that is in addition to the mitigation measures identified in the EIR for impacts at Fish Springs, Big and Little Seeley Springs and Big and Little Blackrock Springs.

- **Yellow-Billed Cuckoo (YBC) Enhancement Mitigation Project:** These projects located near Big Pine on Baker Creek and Hogback Creek near Lone Pine were designed to enhance vegetation conditions and direct land management actions to enlarge and enhance existing YBC habitat.
- **1600 acre-feet of water:** Commits 1600 acre-feet of water at seven sites. The initial project recommended by the MOU consultant was replaced by seven projects prepared by an Ad Hoc group of Inyo, LADWP, and CFG staff, local lessees, and representatives of the Owens Valley Committee and the Sierra Club. A report describing these projects can be found on the ICWD website.

Current Project Status

Enhancement Mitigation Water Use

In 2015-2016, the total water supplied E/M projects was 9,208 acre-feet (Table 7.1). This is 36% less water than would be applied based on the total normal year water allocation described in the 1991 EIR (14,420 acre-feet). Most of the difference between the allocation and the supply can be attributed to having not supplied the McNally Ponds in the Laws area.

Revegetation projects in the 1991 EIR and Irrigation in the Laws Area (ILA) MND

Revegetation projects mitigate for environmental damages due to groundwater pumping and/or discontinuation of agriculture The Environmental Impact Report (EIR) pertaining to the second Los Angeles aqueduct identified land that had become barren due to changes in surface or groundwater management (Figure 7.1). A mitigation plan prepared by the Inyo/Los Angeles Technical Group for these projects dates was submitted to the Standing Committee in 1999 (www.inyowater.org).

The majority of these projects have not met goals, and none of the abandoned agricultural revegetation projects are near meeting targeted goals. To date, the only revegetation efforts to have succeeded were those that came back naturally once the water table was allowed to recover. In these instances no improvements other than fencing and the elimination of grazing were needed. Table 7.2 shows the status of the performance of revegetation projects relative to prescriptions found in the *Revegetation Plan for Impacts Identified in the LADWP, Inyo County EIR for Groundwater Management*.

Table 7.1. Water Supplied to E/M Projects 2004-2015 (from values provided in LADWP's Owens Valley Report).

Project	Normal Year Water Supply (EIR)	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	11-Year Average *Supplied*	11-Year *Actual*	12-Year EIR Total
McNallyLaws/Poleta Native Pasture Lands	660	1,682	1,269	1,241	1,396	1,320	1,764	1,267	2,306	1,460	1,149	1,376	1,259	**1,457**	**17,489**	**7,920**
McNally Ponds	4,000	0	1,522	1,491	0	0	0	368	857	0	0	0	0	**353**	**4,238**	**48,000**
Laws Historical Museum	150	32	59	99	147	63	131	152	105	138	112	119	101	**105**	**1,157**	**1,800**
Klondike Lake	1,700	1,278	1,203	314	1,201	1,195	1,169	1,195	1,086	1,144	1,515	1,600	1,411	**1,193**	**12,900**	**20,400**
Big Pine NE Regreening	150	0	0	0	0	0	0	0	0	0	0	103	75	**15**	**103**	**1,800**
Independence Pasture Land	2,350	2,489	3,330	2,785	3,272	2,588	1,962	2,397	2,545	2,324	1,852	1,932	1,731	**2,434**	**27,476**	**28,200**
Independence Springfield	1,500	280	519	1,850	1,962	1,554	1,530	1,356	1,136	1,188	958	1,427	1,569	**1,277**	**13,760**	**18,000**
Independence Ditch System	725	451	356	359	380	515	446	497	496	165	129	343	65	**350**	**4,137**	**8,700**
Independence Woodlot	120	276	190	226	237	335	220	569	175	334	150	186	64	**247**	**2,898**	**1,440**
Independence East Regreening	150	0	0	0	0	0	0	0	0	0	0	63	71	**11**	**63**	**1,800**
Shepherd Creek Alfalfa Lands	990	1,072	1,152	1,206	1,100	1,183	1,166	1,212	1,073	1,019	884	980	872	**1,077**	**12,047**	**11,880**
Lone Pine Park/Richards Field	1,230	916	1,085	870	570	1,012	1,037	1,037	1,194	481	416	429	344	**783**	**9,047**	**14,760**
Lone Pine Woodlot	120	76	100	120	78	51	58	123	120	156	70	74	55	**90**	**1,026**	**1,440**
Lone Pine Van Norman Field	480	337	474	512	306	28	147	102	116	97	79	343	426	**247**	**2,541**	**5,760**
Lone Pine Regreening	95	238	180	107	232	228	283	257	298	223	216	233	211	**226**	**2,495**	**1,140**
Total	**14,420**	**9,127**	**11,439**	**11,180**	**10,881**	**10,072**	**9,913**	**10,532**	**11,507**	**8,729**	**7,530**	**9,208**	**8,254**	**10,011**	**110,118**	**173,040**
[1] Scoped at 2,200, but in 2004 reduced to 1,500 af																
Klondike Lake SSHA	200	0	0	0	96	89	80	92	200	**37**				**557**	**1,000**	
Big Pine Ditch	300	0	0	276	372	303	332	424	683	**632**	**604**	**534**	**441**		**1,800**	
	500	**0**	**0**	**276**	**468**	**392**	**412**	**516**	**883**	**258**				**2,564**	**3,000**	

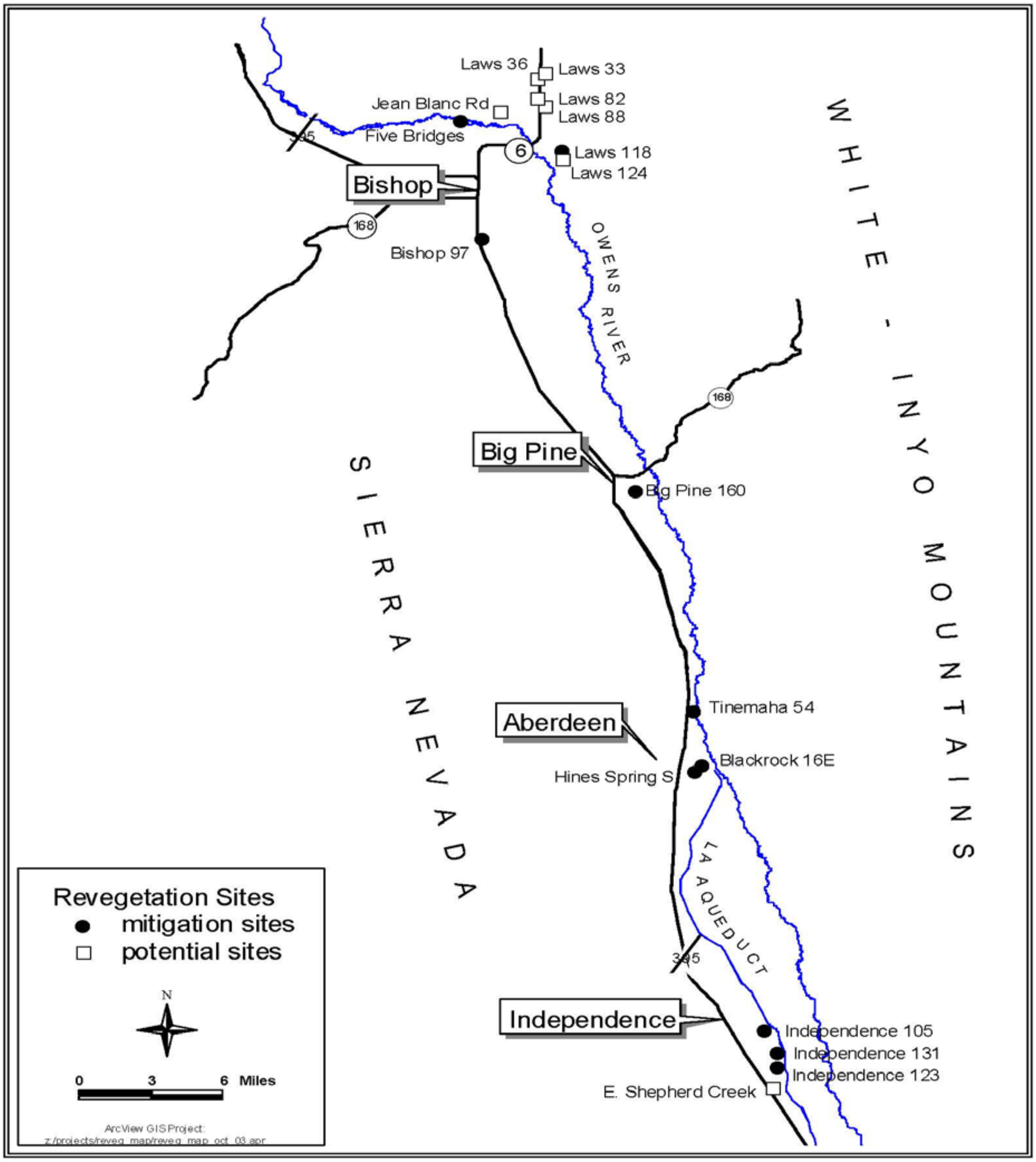

Figure 7.1. Locations of revegetation projects in the Owens Valley described in the 1991 EIR.

Table 7.2. Status of revegetation projects.

Guiding	Project name	Acres	Impact[3]	Met	Percent Live Native Cover: Goal %	Percent Live Native Cover: Reported %	Number of Species: Goal	Number of Species: Reported
91 EIR/97 MOU	LAWS 118	107	ABAG	NO	11.5	2.0	11	Not reported
91 EIR/97 MOU	BISHOP 97	124	ABAG	NO	15.0	4.8	12	Not reported
91 EIR/97 MOU	FIVE BRIDGES	300	GP	NO	60.0	47.0/74.0 (2 sites)	4	5/6 (2 sites)
91 EIR/97 MOU	BIG PINE 160	211	ABAG	NO	17.7	3.0	10	Not reported
91 EIR/97 MOU	TINEMAHA 54	0.4	GP	NO	33.0	2.1	3	Not reported
91 EIR/97 MOU	BLACKROCK 16E	7.5	GP	YES	34.0	37.0	6	14
91 EIR/97 MOU	HINES SOUTH	11.5	GP	NO	33.0	–	TBD	–
91 EIR/97 MOU	INDEPENDENCE 105	42	GP	YES	25.0	>25.0	4	>4
91 EIR/97 MOU	INDEPENDENCE 123	42	GP	YES	17.0	>17.0	4	>4
91 EIR/97 MOU	INDEPENDENCE 131 N	23	GP	YES	17.0	16.2	4	5
91 EIR/97 MOU	INDEPENDENCE 131 S	50	GP	NO	17.0	6.2	4	Not reported
ILA*	LAWS 90	94	ABAG	NO	10.0	Not surveyed	10	Not surveyed
ILA	LAWS 94	47	ABAG	NO	10.0	Not surveyed	10	Not surveyed
ILA	LAWS 95	44	ABAG	NO	10.0	Not surveyed	10	Not surveyed
ILA	LAWS 118/129	50	ABAG	NO	10.0	Not surveyed	8	Not surveyed
ILA	LAWS 27 (SEED FARM)	118	ABAG	NO	10.0	Not surveyed	8	Not surveyed

YES	Meeting Goals
YES	Reported by LADWP to have met goals in 2012, but cover is below goal
NO	Not meeting goals

*ILA, Irrigation in the Laws Area MND

Mitigation Table (projects arranged north to south)

The table below contains general information about mitigation projects identified in the 1991 Final Impact Report (1991 EIR) including their origin, description, impact mitigated, plan, development stage and status as of April 2016.

The Mitigation Origin column lists the project starting point and any subsequent consideration of the project over time. Many of the Enhancement Mitigation projects (E/M) that were implemented prior to the 1991 EIR were continued. Some of the pre 1985 Environmental Projects (EP) are identified as mitigation in the EIR. The Impact Number, if provided, is from Section 7 of the 1991 EIR, and associates the mitigation measure with the pre-project setting and type of environmental impact being mitigated; it also describes the significance of the environmental impact. Projects developed subsequent to the 1991 EIR are not included. These projects are certain "additional mitigation" projects included in the 1997 MOU, projects associated with Owens Lake, and the Laws Area Irrigation project.

The *Impact* column summarizes the environmental impact being mitigated. The *Prescription* column describes the activities and goals from the associated mitigation plan or other agreement. The project's state of development, relative to the project's goals, is reported in the *Development Stage* column. The *Status* column summarizes recent project activity. Color codes have been added to provide a quick reference as to the current status of the project.

Project implemented or completed as scoped. No outstanding issues.

Project implemented but not fully reaching goals, or project implemented but in need of a mitigation management plan or plan revision.

Project not implemented or completed, or implemented and far short of reaching goals.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Laws/Poleta Native Pasture (north and southeast of Laws) (216 acres)	E/M 1985-1990[1] 1991 Owens Valley EIR Impact No. 10-16	The Laws area has lost all or part of its vegetation cover due to increased groundwater pumping, abandonment of irrigated agriculture to supply water to the second aqueduct, livestock grazing and drought.	Annually provide water to approx. 216 acres in two locations to enhance and maintain existing vegetation and increase livestock grazing capacities while continuing the activity that caused the impact. (First implemented 1988).	Implemented and ongoing.	The pasture, 2.5 miles north of Laws and just east of Hwy. 6 (160 acres, parcel 44) has achieved good pasture cover on 65-70% of the eastern half of the parcel. Irrigation methods and effectiveness should be investigated. The 60 acre pasture 2 miles southeast of Laws (parcel 138) adjoins the McNally Ponds and Pasture project. Only a fraction of the pasture can be effectively irrigated. LADWP had reported that they couldn't separate this project's water accounting from adjacent irrigated parcels. LADWP reports these projects were supplied a combined 1,259 acre-feet in 2015-2016.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
McNally Ponds and Native Pasture (348 acres)	E/M 1985-1990 1991 Owens Valley EIR Impact No. 10-18	The Laws area has lost all or part of its vegetation cover due to increased groundwater pumping, abandonment of irrigated agriculture to supply water to the second aqueduct, livestock grazing, and drought.	Create waterfowl habitat by annually filling ponds Sept-Jan. Enhance and maintain vegetation and increase livestock grazing capacities by irrigating 107 acres of native vegetation and ~200 acres of native pasture. (First implemented 1986-1987).	Implemented and ongoing.	In a number of past years, the Inyo Board of Supervisors has approved water reductions due to drought conditions. LADWP currently describes the water supply to the ponds as provided only when water is diverted from the Owens River to the McNally canals. The adjacent 100-acre pasture has low patchy grass cover. The other pasture located 1 ½ miles SE of Laws (200 acres) was irrigated and maintaining grass cover. In 2013-14, to compensate for not irrigating the ponds pasture, approximately 100 acres of pasture adjacent to Bishop Creek Canal was irrigated. During the 2015-16 runoff year, neither the ponds or pond-adjacent pasture received any water.
640 acre potential revegetation near Laws	E/M 1985-1990 1991 EIR Impact No. 10-18	The Laws area has lost all or part of its vegetation cover due to increased groundwater pumping, abandonment of irrigated agriculture to supply water to the second aqueduct, livestock grazing and drought.	Standing Committee to consider revegetating with non-groundwater dependent native plants and continuing the activity that caused impact.	In progress.	The Standing Committee has not evaluated the need for mitigation of this area. Desert Aggregates expanded gravel mine operation includes at least 174 acres in the western part this potential mitigation site.
Five Bridges area revegetation (300 acres)	1991 Owens Valley EIR Impact No. 10-12	Between 1987 and 1988, two wells in the Five Bridges area that were pumped to supply water to enhancement mitigation projects	Manage pumping to restore water table levels, supply surface water, and restore meadow and riparian vegetation through active revegetation	In progress.	Water has been spread over the affected area since 1988. By the summer of 1990, revegetation of native species had begun on

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
		contributed to a lowering of the water table under riparian and meadow areas along Owens River. Approximately 300 acres of vegetation were affected, and within this area, approximately 36 acres lost all vegetation due to a wildfire. EIR v1 (10-58).	efforts. Inyo and LA are responsible for plan development and implementation.		approximately 80 percent of the affected area. The Technical Group developed a plan for all of the revegetation projects in 1999, including this project. An effort to revise the plan stalled in 2003 and has not proceeded beyond a draft. Providing surface water to the site has increased cover in some areas. The area north of the river that was originally in the impact area appears to have declined in cover and requires attention but his area was not addressed in the draft mitigation plan. In March 2005, LADWP informed the Water Department that limited grazing in some enclosures had resumed. The project is affected by a widely fluctuating water table, invasive weeds, herbicide, fire, soil compaction, and irregular water deliveries. The Technical Group needs a revise mitigation plan for the area. In 2015-16, no water was released into the project area during the growing season (383 acre-feet was released into the area in October).

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Farmers Pond	EP 1970-1984 1991 EIR Impact No. 10-18	The Laws area has lost all or part of its vegetation cover due to increased groundwater pumping, abandonment of irrigated agriculture to supply water to the second aqueduct, livestock grazing and drought.	Water provided in fall of each year to offer increased habitat for migrating waterfowl; two miles north of Bishop.	Implemented and ongoing.	Implemented and ongoing.
Revegetation near Laws (160 acres)	Non-E/M Project 1991 EIR Impact No. 10-18	The Laws area has lost all or part of its vegetation cover due to increased groundwater pumping, abandonment of irrigated agriculture to supply water to the second aqueduct, livestock grazing and drought. EIR v1 (10-66).	Native plant revegetation. Mitigated Negative Declaration (MND) allows approx. 32 acres to be converted to flood irrigated pasture.	Incomplete.	The Technical Group implemented a 10-acre study plot in 2001 in lieu of initiating the planting of container plants as required in the Mitigation Plan. The mitigation project area has decreased in size due to inclusion of part of Laws 118 parcel in the Laws Irrigation project.
Laws Historical Museum Project	E/M 1985-1990	Improve aesthetics on LADWP lands near towns.	Provides a regular water supply to improve the native vegetation on a 21-acre parcel, establish irrigated pasture on 15 acres and establish windbreak trees, all adjacent to the museum.	Implemented and ongoing.	Implemented and ongoing.
Laws Museum Pastures (21 and 15 acres)	E/M 1985-1990 1991 EIR Impact No. 10-18	Significant adverse vegetation decrease and change have occurred in the Laws area due to a combination of factors, including abandoned agriculture, groundwater pumping, water spreading in wet years, livestock grazing, and drought.	Enhance the museum grounds by irrigating pastures east and west of the museum. This project was revised in the Laws reirrigation MND.	Implemented and ongoing.	Both museum pastures had a cover of weedy species in the recent past, but seem to be improving. The west pasture was reseeded in 2015. The condition of project and irrigation system will be monitored. LADWP reports that the project was supplied 101 acre-feet of water in

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					2015-2016.
Laws area	1991 EIR Impact No. 10-18	Significant adverse vegetation decreases and changes have occurred in the Laws area due to a combination of factors, including abandoned agriculture, groundwater pumping, water spreading in wet years, livestock grazing, and drought.	Monitor and reduce groundwater pumping where suspected impacts have occurred. Mitigate according to the Agreement, if necessary.	Incomplete.	County and LADWP are in disagreement over the need to operate the McNally canals to avoid impacts to vegetation. Monitoring of select vegetation parcels is ongoing.
Millpond Recreation Area	EP 1970-1984; E/M 1985-1990	Non-specific compensation.	Pay for costs of running well to provide water to pond and thus create wet habitat.	Implemented and ongoing.	Implemented and ongoing.
Buckley Ponds	EP 1970-1984 1991 EIR Impact No. 11-1	Non-specific compensation.	Provide habitat for warm-water fishery and waterfowl by maintaining a year-round pond.	Implemented and ongoing.	Implemented and ongoing.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Bishop Area Revegetation Project (Bishop 97, 120 acres)	Non-E/M Project 1991 EIR Impact No. 10-16	Non-specific compensation.	Revegetate with non-groundwater dependent native vegetation.	In progress.	In progress, but behind schedule. LADWP estimates that successful revegetation could take a decade or longer. Fencing to eliminate disturbance has been installed. The Mitigation Plan (MP) provided that test plots would be implemented if the area did not demonstrate vegetation recovery. Vegetation cover was re-sampled in 2003 to compare with 1999 baseline cover. Results showed little to no change. Another survey is planned for 2012. The MP provides that revegetation efforts would be expanded in 2009, five years after implementation of test plots. In 2011-12 drip irrigation was expanded and about 2,180 containerized plants were planted. The parcel was surveyed in 2012 and found to have attained a 4.8% native perennial cover.
Saunders Pond	EP 1970-1984	Non-specific compensation.	Provide wet habitat by maintaining operation of year-round pond.	Implemented and ongoing	Implemented and ongoing.
Klondike Lake	EP 1970-1984; E/M 1985-1990 1991 EIR Impact No.	Non-specific compensation.	Improve waterfowl habitat and provide recreation in the Big Pine area. The Big Pine Ditch MND (2004) reduced the water supply to 1,700 acre-feet, provided maintenance of native pasture and wetland habitats adjacent	In progress.	Motorized recreation on the lake has been limited to prevent the introduction of the freshwater quagga mussel. LADWP reports runoff year 2015-16

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
	11-1		to Lyman ditch, and committed LADWP to maintain a described a lake level. Up to 200 acre-feet/year would be used for a native habitat area. (First implemented 1987).		water supplied was 1,411 acre-feet.
Klondike South Shore Waterfowl Management Area (160 acres)	1991 EIR Impact No. 11-1 Addition to Klondike Lake project 2005	Compensation for the inability to supply water to the Klondike Lake Project.	When initiated, the Klondike Lake Project was expected to use 2,200 AF, but the project requires less than 1,500 AF. South Shore project was initiated to create waterfowl habitat just south of the lake with water that could not be delivered to Klondike Lake. Two hundred AF was allocated for this purpose.	In progress. Needs Management Plan	The elevation between the Lake and the Project is minimal and sediment in the water conveyance limited flow to the project. A new water gate was installed and from the 2011-12 runoff year to present, a full 200 af allocation was supplied. With the use of the new water gate new habitat has been created and is being used by desired species; however the original project area receives little water and is almost completely tule chocked. A habitat management plan needs to be prepared for this project. It has been the practice of LADWP to release water to the project area during waterfowl migration season, usually beginning releases in late winter, but as of April 2013 water had not been supplied to the project, and in 2014 only 52 acre-feet was delivered, in 2016 the ponds were dry in mid-June.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Big Pine Northeast Regreening (30 acres)	E/M 1985-1990 1991 EIR Impact No. 10-19	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Manage pumping in accordance with the Agreement and establish irrigated crop.	In progress.	The Inyo County/ LADWP Technical Group approved an amended mitigation plan in the spring of 2010. Modifications include a change in water source. The Big Pine Canal will serve as a source of project water. Replacement water, (equal to or less than 150 AFY) will be supplied by Well 375. The new project scope allows sprinkler irrigation as well as flood irrigation. It is estimated that sprinklers will reduce the project's water use from 150 AFY to 90 AFY. In April 2012, a lawsuit was filed by the Owens Valley Committee, Sierra Club, and Big Pine Paiute Tribe seeking to declare the ND inadequate and asking that a full EIR be developed was presented. The Court found that the CEQA document was adequate and the case was dismissed in 2013. Although the pasture was planted with a native pasture seed mix, the cover in 2015-16 is largely composed of weedy species. This can be expected given the preexisting seedbank. It is expected that, given time, desirable pasture vegetation will predominate. Weeds were raked and burned in the spring of

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					2016. 75 acre-feet of water was provided the project in 2015-16.
Big Pine Ditch System	Non-E/M Project 1991 EIR Impact No. 10-19	Non-specific compensation.	Establish/restore ditch system through Big Pine.	Implemented and ongoing.	This project was completed in the summer of 2010. LADWP reports that water use exceeds allowances; however, there are questions about how the water is being measured. This has not been resolved. It is planned that the Bell Canyon Well, providing replacement water, will be sited and drilled in 2016.
Big Pine Revegetation (East Big Pine) (20 acres)	E/M 1985-1990 1991 EIR Impact No. 10-19	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	This is an undefined potential enhancement/mitigation (E/M) project that will become a native plant site if permanent irrigation is infeasible Establish an irrigated crop while continuing the activity that caused the impact.	Incomplete and ongoing.	Portion of parcel 160 to west of BP Canal. LADWP reports "The site was fenced in 2007 to eliminate disturbances and encourage natural revegetation. If this area does not revegetate naturally, it will be included with LADWP's ongoing revegetation efforts." LADWP reports that they drill seeded 3.2 acres in February of 2014 and 17

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					acres in the winter of 2015-2016.
Revegetation near Big Pine (Big Pine 160) (160 acres)	Non-E/M Project	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Revegetate with non-groundwater dependent native species while continuing the activity that caused the impact.	Incomplete and ongoing.	LADWP reports, "The site has been fenced. Permanent transects were run in 2006. In the spring of 2011 approximately 20 acres were drill seeded with locally collected seed." Transects run in August 2012 show 3% native perennial cover. LADWP reports that they drill seeded 28 acres in February of 2014. The native seed was installed in time for a 1.35" rain event. 155 acres were drill seeded in the winter of 2015-2016. LADWP, in their 2015 annual report, mentioned that irrigation is being designed for part of the site and, and irrigation construction should begin in 2016.
Steward Ranch	Non-E/M Project 1991 Owens Valley EIR Impact No. 9-14	Compensation for loss of well.	Compensation agreement with ranch owner.	Implemented and ongoing.	Mitigation agreement is in place.
Fish Springs Hatchery	EP 1970-1984; Non-	CDFG fish hatchery and the LORP serve as compensatory mitigation.	No on-site mitigation will be implemented at Fish Springs; however, the CDFG fish hatcheries at these	Implemented and ongoing.	Implemented.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
	E/M Project 1991 Owens Valley EIR Impact No. 10-14		locations serve as mitigation of a compensatory nature by producing fish that are stocked throughout Inyo County.		
Tule Elk Field	EP 1970-1984	Non-specific compensation.	Provide water in summer to field used by tule elk between U.S. Highway 395 and Tinemaha Reservoir.	Implemented and ongoing.	The water supply to this project has been reduced since 2002. ICWD does not believe the project water provided is sufficient in all years to meet project goals, especially in the area east of highway 395.
Fish Springs, Big and Little Seeley, and Big and Little Blackrock	1991 EIR Impact No. 10-14	Ground water pumping has lowered depth to water to a level where springs and seeps no longer flow. Associated riparian and wetland vegetation is lost.	Monitor and maintain vegetation to avoid significant change or decrease as provided in the Agreement and the Green Book.		The Technical Group does not have a plan for monitoring flows or vegetation at springs and seeps. Ecosystem Sciences has developed an inventory of springs and seeps. According to the MOU, the inventory should provide baseline data adequate for monitoring change.
Big and Little Seeley Springs	EP 1970-1984 1991 Owens Valley EIR Impact No. 10-14	Non-specific compensation.	Two miles south of Tinemaha Reservoir LADWP well number 349 discharges water into a pond approximately one acre in size. This pond provides a temporary resting place for waterfowl and shorebirds when the pumps are operating or Big Seeley Spring is flowing. Riparian vegetation has become established around this pond.	Implemented and ongoing.	Implemented and ongoing.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
			EIR v1, 10-62).		
Calvert Slough	EP 1970-1984	Non-specific compensation.	Water provided to maintain habitat for a small pond and marsh area near LADWP Aqueduct Intake.	Inactive.	This project has not been receiving a regular water supply since 1998. LADWP reported that low flows in the creek do not allow supplying the project because of high ditch losses and the off status of the two wells upstream of the project. No water was supplied to this project for seven years (1998-2004). The enhancement of the Calvert Slough wetland was a as a possible Additional Mitigation measure, but was not selected as one of the final 1600 acre-foot projects.
Hines Spring (1,600 af project)	E/M 1985-1990; 1997 MOU; 204 and 2010 Stipulation and order. 1991 EIR Impact No. 10-11	Ground water pumping has lowered depth to water to a level where springs and seeps no longer flow. Associated riparian and wetland vegetation is lost.	The Hines Spring vent and its surroundings will receive on-site mitigation. Water will be supplied to the area from an existing, but unused, LADWP well at the site. As a result, approximately one to two acres will either have ponded water or riparian vegetation. Hines Spring will serve as a research project on how to re-establish a damaged aquatic habitat and surrounding marshland. Riparian trees and a selection of riparian herbaceous species will be planted on the banks.	In progress.	The initial concept, to provide water at the spring vent, proved impractical. MOU Parties entered into an ad hoc process and agreed to build two projects at the spring site; 1) water from Well 355 now supplies water to a small pond used by livestock. The solar power source designed to power Well 355 would be insufficient, so the project was modified to include a new above-ground power line to the project; 2) Aberdeen Ditch. A 2700' pipeline now supplies water to a ditch

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
			The area will be fenced. (EIR) v.1 10-62)		just southeast of the former spring that will be used by livestock.
Taboose/Hines Spring – Blackrock Areas Revegetation Project (80 acres)	Non-E/M Project 1991 EIR Impact No. 10-11	Ground water pumping has lowered depth to water to a level where springs and seeps no longer flow. Associated riparian and wetland vegetation is lost.	Manage pumping and revegetate with native species. These lands will not be permanently irrigated, but will be revegetated with native Owens Valley vegetation not requiring irrigation except during initial establishment.	In progress.	This mitigation measure consists of 3 sites that total approx. 115 acres. Hines Spring. A mitigation plan and schedule for will be developed by March 8, 2015; 3 years after the Hines Spring mitigation project had been completed. Tin 54 (0.3 acres) 108 alkali sacaton plants were planted in 1999. A drip irrigation system has been utilized. Blk 16E 7.2 acres. LADWP reports that based on 2010 transects the project has attained the cover and composition goals in the revegetation plan. The cover goal is 35%
Little Blackrock Springs	EP 1970-1984 1991 EIR Impact No. 10-14	Ground water pumping has lowered depth to water to a level where springs and seeps no longer flow. Associated riparian and wetland vegetation is lost.	LADWP will continue to supply water from Division Creek to the site of the former pond at Little Blackrock Springs, to maintain marsh vegetation at this site will thus be maintained.	Implemented and ongoing.	An operations plan is needed. LADWP had reported that the Goodale Bypass Ditch that supplies the project normally runs all year at less than 1 cfs, providing approx. 700 acre feet a year.
Big Blackrock Springs	Non-E/M Project 1991 EIR	Ground water pumping has lowered depth to water to a level where springs and seeps no longer flow. Associated riparian and wetland	No on-site mitigation will be implemented at Big Blackrock Springs; however, the CDFG fish hatcheries at these locations serve as mitigation of a	Implemented and ongoing	The fish hatchery is in place. ICWD calculates runoff year 2009-10 water use was 13,354 acre-feet.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
	Impact No. 10-14	vegetation is lost.	compensatory nature by producing fish that are stocked throughout Inyo County.		
Thibaut/Sawmill marsh habitat	Non-E/M Project 1991 EIR Impact No. 10-20	Ground water pumping has lowered depth to water to a level where springs and seeps no longer flow. Associated riparian and wetland vegetation is lost.	The Blackrock Waterfowl component of the LORP will provide compensatory and some on-site mitigation. Vegetation impacts will be mitigated under the Agreement.	Implemented and ongoing.	Implemented under the LORP.
Independence Roadside Rest	E/M 1985-1990	Improve aesthetics on LADWP lands near towns.	This consists of planting of shade and windbreak trees and grass, installation of an irrigation system, and placement of picnic tables on a 1/2-acre site south of the town of Independence. The project is an aesthetic improvement over the previously blighted area.	Implemented and ongoing.	Implemented.
Eastern California Museum	E/M 1985-1990	Non-mitigation E/M project (community project to improve aesthetics on LADWP lands near towns).	This project enhanced the appearance of the Eastern California Museum grounds in Independence. It consists of a small pond, trees, expanded lawn areas, and installation of an irrigation system.	Completed.	Implemented.
Independence Pasture Lands (610 acres)	E/M 1985-1990 1991 EIR Impact No.	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and	Develop and irrigate pasture or alfalfa fields (first implemented 1987-1988).	Implemented and ongoing.	Site topography prevents flood irrigation from reaching some portions of the project. LADWP reports runoff year 2015-2016

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
	12-1	maintain vegetation.			water use was 1,569 af.
Billy Lake	EP 1970-1984 1991 EIR Impact No. 11-1	Non-specific compensation.	Maintain wet habitat to provide waterfowl habitat in the region.	Implemented and ongoing.	Included in the LORP. Billy lake is managed under the LORP Monitoring, Adaptive Management, and Reporting Plan as an Off River Lake.
Independence East Side Regreening (30 acres)	E/M 1985-1990 1991 EIR Impact No. 12-1	Regreening projects implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the towns of Big Pine, Independence, and Lone Pine. Water is supplied from LADWP to promote and maintain vegetation.	Manage pumping and establish irrigated crop.	In Progress.	The Technical Group evaluated and approved a new well at the site, and CEQA was completed. LADWP has drilled the new well and put out a request for proposals to identify a lessee. The project was fully implemented in 2014. The project is receiving regular water during the growing season; however, although the pasture was planted with a native pasture mix, the cover crop is in large part composed of weedy species. This can be expected given the preexisting weedy seedbank. It is expected that over time the weedy species will be replaced by desirables. 71 acre-feet of water were supplied the project in 2015-2016.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Independence Woodlot (21 acres)	E/M 1985-1990 1991 EIR Impact No. 10-11	Fluctuations in water tables due to groundwater pumping have caused approximately 655 acres of groundwater dependent vegetation to die-off. Loss of vegetation cover has occurred on these lands. Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	As part of the Independence Springfield and woodlot enhancement/mitigation projects, approximately 317 acres of barren or near-barren ground have been revegetated with either native pasture or alfalfa. This area was affected by groundwater pumping and surface diversions of water.	Implemented and ongoing.	Lone Pine FFA is managing the project, with some wood going to Independence residents and other wood being sold in Lone Pine to support FFA activities. An operations plan is needed based on management guidelines agreed to by Inyo Co. and LADWP. The project was supplied 64 af water during 2015-2016.
Independence Springfield (283 acres)	E/M 1985-1990 1991 EIR Impact No. 12-1	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Manage pumping and establish native pasture or alfalfa (first implemented 1988).	Implemented and ongoing.	Water supply during runoff year 2015-2016 was 1,569 acre-feet.
Additional regreening w/in Independence Springfield (40 acres)	E/M 1985-1990 1991 EIR Impact No. 12-1	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Revegetate with native pasture.	Not Implemented.	LADWP in their 2014 annual report said they are "currently planning to irrigate an additional 40; however LADWP staff state that, an internal review of the projects in the Independence area found that the Independence Springfield is approximately 300 acres in area and has an irrigation allotment of approximately 1,500 acre-feet per year, which meets the goals of the

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					project.
Independence Ditch System	E/M 1985-1990	Non-mitigation E/M project (community project).		Completed.	This project was supplied 65 acre-feel of water in 2015-2016. This represents 80% less water than last year.
Independence Roadside Rest	E/M 1985-1990	Non-mitigation E/M project (community project to improve aesthetics on LADWP lands near towns).	This consists of planting of shade and windbreak trees and grass, installation of an irrigation system, and placement of picnic tables on a 1/2-acre site south of the town of Independence. The project is an aesthetic improvement over the previously blighted area.	Completed.	Implemented.
Symmes/Shepherd wellfield revegetation (60 acres)	Non-E/M Project 1991 EIR Impact No. 10-13	Increased groundwater pumping from wells in the Symmes-Shepherd area has caused a substantial reduction of vegetation cover in approximately 60 acres in three areas immediately to the east of the pumping wells. The affected	A revegetation program will be implemented for these effected areas utilizing native vegetation of the type that that has died off. Water may be spread as necessary in these areas to accomplish the revegetation. EIR v1 (10-59).	Implemented and ongoing.	Two of the four sites included in this mitigation measure are behind schedule. The 3 sites total approx. 115.2 acres. Ind 123 (28.4 acres) did not have test plots implemented in 2002 as scheduled in the Mitigation Plan. In

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
		vegetation was previously supplied by shallow groundwater and surface seeps. EIR v1 (10-59).			2011 LADWP reports that goals had been attained. Ind 131, north and south (73.2 acres). The Technical Group implemented revegetation test plots in Dec. 2001. A final report from the consultant was received in Nov. 2003. LADWP's consultant conducted additional revegetation studies, and reports on methods and results from this effort have not been made available. The schedule in the Mitigation Plan called for expanding revegetation efforts for Ind 123 and 131 in 2007. LADWP reports in 2015 that the north plot is not attaining goals. The south plot was drilled with native seed in 2011, which hasn't yet germinated. Ind 105 (13.6 acres) cover data increased from 1999 to 2001, thus no active revegetation activities are planned. The initial cover of 8.1% increased to 13.5%. The goal for the site is 17% perennial native cover. The site has attained prescribed cover and composition goals.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Shepherd Creek Alfalfa Field (200 Acre)	E/M 1985-1990 1991 EIR Impact No. 12-1	Dust mitigation .	Manage pumping and establish irrigated crop on approx (first implemented 1986).	Implemented and ongoing.	Alfalfa planted and maintained on approx. 185 acres. LADWP reports that water supply for runoff year 2015-16 was 872 acre-feet.
Expand Shepherd Creek Alfalfa (60 acres)	E/M 1985-1990 1991 EIR Impact No. 12-1	Dust mitigation.	Expand E/M project to east of Hwy 395 if vegetation cover in that area remains sparse.	Monitor.	The Technical Group does not have mitigation or monitoring plans for this mitigation measure. LADWP has conducted vegetation transects and concluded that vegetation cover has increased from baseline and thus the mitigation is not necessary.
Lone Pine Riparian Park (Spainhower Park)	E/M 1985-1990 1991 EIR Impact No. 10-16	The park is a non-mitigation E/M project. Water conveyed through the park provides irrigation to lands formerly removed from irrigation.	This project provides a conduit of water through a town park for the Lone Pine Regreening E/M projects, including the Lone Pine Wood Lot and projects to reestablished abandoned pasture land. Water conveyed provides irrigation to approximately 320 acres of native vegetation lands to allow increased livestock grazing capability.	Completed.	LADWP, in their annual Owens Valley Report, lists water use for this project and Richards Field together. In 2015-16, water use reported for these projects was 344 acre-feet. For the park, water use is conveyance loss.
Reinhackle Spring	Non-E/M Project 1991 EIR Impact No. 16-11	Increased groundwater pumping has periodically reduced the flow from Reinhackle Spring. This spring is the source of water for a large pasture area and supports many large tree willows. EIR v1 (10-61).	Manage groundwater pumping to avoid reductions in flow, and monitor and maintain vegetation to avoid significant change or decrease as provided in the Agreement and the Green Book.	Under investigation.	A 2004 study concluded that the water flowing from Reinhackle Spring is similar in composition to aqueduct water and not similar to the deep aquifer samples or up-gradient shallow aquifer wells. Testing to

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					monitor the effect of pumping conducted May 2010 to April 2011. Data from these tests are being analyzed. A draft management plan is under consideration by the Technical Group, but has not been approved.
Lone Pine Ponds	EP 1970-1984; E/M 1985-1990 1991 EIR Impact No. 11-1	Non-specific compensation.	Wildlife enhancement. Similar to Buckley Ponds and Saunders Pond; water provided by natural seep or spring flow in river with supplemental releases from Alabama Gates (now incorporated in lower Owens River E/M Project); north of Lone Pine Station.	Implemented and ongoing.	Included in the LORP. The Lone Pine Ponds are managed under the LORP Monitoring, Adaptive Management, and Reporting Plan as a component of the River-Riverine system.
Lone Pine East Side Regreening (11 acres)	E/M 1985-1990 1991 EIR Impact No. 10-16	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Create irrigated pasture. One of the Lone Pine Regreening E/M projects.	Implemented and ongoing.	Pasture appears to be receiving water and is in good condition. LADWP did not break out water use for this project in runoff year 2015-2016.
Lone Pine Woodlot (12 acres)	E/M 1985-1990 1991 EIR Impact No. 10-16	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Revegetate and provide irrigation.	Implemented and ongoing.	Lone Pine FFA irrigates the woodlot and distributes wood according to plan developed by the Technical Group LADWP reports water use was 55 af for runoff year 2015-2016(~50% of allocation). The project appears to not be receiving

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					adequate water. As of 2015, forty-five percent of the project area is without live canopy due to die off of locust in the middle and eastern side of the project area and lack of replanting of harvested trees on the north and west end of the project area. LADWP cleaned up the area in the fall and winter of 2015-16 and plan to replant bare areas in the spring of 2016. LA proposes to plant cottonwood. The County has requested black locust replace the black locust lost.
Richards Field (189 acres)	E/M 1985-1990 1991 EIR Impact No. 10-16	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Create irrigated pasture or alfalfa field (first implemented 1987). One of the Lone Pine Regreening E/M projects.	Implemented and ongoing.	This project had been modified without Standing Committee approval. During the non-irrigation season, water normally flows to the project after flowing through Lone Pine Riparian Park. LADWP informed the Water Dept. that the project will no longer receive water during the non-irrigation season. Water to this project is not measured separately from the park supply. LADWP reports water use for Richards Field and Lone Pine Park was 344 af for runoff year 2015-2016.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Van Norman Field (160 acres)	E/M 1985-1990 1991 EIR Impact No. 10-16	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Create irrigated pasture or alfalfa field. One of the Lone Pine Regreening E/M projects.	Implemented and ongoing	LADWP reports water use was 426 acre-feet for runoff year 2015-2016. The project is allocated 480 afy. A replacement well was drilled in the fall of 2012 and began production in April 2014. The new well is located in a position that should allow the establishment of additional acres of pasture. In 2013, as part of an E/M evaluation, Inyo County and LADWP agreed to expand the project to include irrigating an adjacent 10 acre parcel operated as a school farm by Lone Pine High School. On April 29, 2014 the Standing Committee agreed to The Standing Committee agreed to: "Modify the Van Norman Field Enhancement/Mitigation (E/M) Project by adding approximately ten acres of the Lone Pine High School Farm to the Van Norman Field E/M Project. The total acreage of the modified Van Norman Field E/M Project will be approximately 170 acres. The approximately ten additional acres will be irrigated pasture. The total annual water supply for the project will remain at 480 acre-feet per year, which will result in an annual water distribution within the project boundaries of approximately 2.8 acre-

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					feet per acre.”
Lone Pine West Side Regreening (7 acres)	E/M 1985-1990 1991 EIR Impact No. 10-16	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Create irrigated pasture. One of the Lone Pine Regreening E/M projects.	Implemented and ongoing.	Pasture looks to be in good condition. LADWP reports water use was 211 af for runoff year 2015-2016.
Lone Pine Sports Complex	E/M 1985-1990	Non-mitigation E/M project (community project).	Lone Pine Sports Complex: At the request of the community, portions of the Lo-Inyo Elementary School and vacant LADWP property were converted to an outdoor sports complex consisting of baseball fields, soccer fields, and related parking, picnic and park areas.	Completed	Includes 3 irrigated ball fields and two multipurpose fields, with an irrigated area totaling 12.5 acres Asphalt replaced the former dirt parking area in 2013. 139 parking spaces were delineated.
Diaz Lake	EP 1970-1984	Non-specific compensation.	Provide supplemental water to recreation area and create wet habitat.	Implemented and ongoing.	Under the Additional Mitigation project description, Diaz Lake will be supplied a secure source of water, which reduces dependence on water pumped by Inyo County up to 250 afy. LADWP’s lease with Inyo County (Lease No. 1494, in effect until June 30, 2015) has been updated to reflect these additional water supply commitments and accounting requirements of this project agreed to by LADWP.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Lower Owens Rewatering Project	E/M 1985-1990 1991 EIR Impact No. 10-14	The Lower Owens Rewatering Project was initiated in 1986 by the LADWP and Inyo County to improve habitat for shorebirds, waterfowl, and fish in the river corridor and at the Delta. The project was one of 25 Enhancement/Mitigation Projects jointly implemented between 1985 and 1990.	Re-water the Owens River to create wet habitat for wildlife. Project includes off-river lakes and ponds. Under the project, 18,000 acre-feet of water per year were to be released from the Blackrock spillgate to maintain continuous flow in the Lower Owens River from the Blackrock area to the Owens River Delta (first implemented, step 1, 1986).	Replaced.	Superseded by the LORP. Billy lake is managed under the LORP Monitoring, Adaptive Management, and Reporting Plan as an Off River Lake.
Lower Owens River Project	1991 DEIR; MOU 1997 1991 EIR Impact No. 10-14	The LORP is an in-kind compensatory mitigation for impacts related to LADWP's groundwater pumping that are difficult to quantify or mitigate directly such as the drying up of springs, seeps and loss of wetlands.	The Lower Owens River Project settles more than 24 years of litigation between the Department and Inyo County over groundwater pumping and water exports. The project is intended to mitigate for a host of lost environmental values in the reach of the Owens River from the Los Angeles Aqueduct Intake to Owens Lake, and associated springs and seeps and off-river lakes and ponds. 64 miles of the Owens River channel will be rewatered. The project includes the Delta Habitat Area, Off-river Lakes and Ponds, and a 1500 acre Blackrock Waterfowl Management Area.	Implemented and ongoing.	Project implemented. In December 2006, when a 40 cfs baseflow was established. A permanent base flow of 40 cfs was established on February, 20, 2007. In February 2008, Los Angeles initiated the first seasonal habitat flow. Adaptive management requires ongoing monitoring, which is described in the Monitoring, Adaptive Management, and Reporting Plan. Additional information about the status of the LORP can be found at www.inyowater.org. Goals pertaining to water quality, avian habitat indicator species, and willow and cottonwood tree recruitment, have not been fully met.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Meadow/riparian vegetation dependent on agricultural tailwater	1991 EIR Impact No. 10-14	Decrease in irrigated land resulted in reduction or withdrawal of tailwater and associated loss of dependent vegetation.	LORP serves as compensatory mitigation.	Replaced.	LORP serves as compensatory mitigation.
Salt Cedar Control Program	1991 EIR Impact No. 10-6	Between 1970 and 1990, LADWP continued to spread surplus water in wet years in the spreading areas created by the dikes east of Independence between the aqueduct and the river. This activity increased soil moisture and water tables, but also fostered conditions favorable to the spread of salt cedar, which was established prior to 1970. (91 EIR)	Implement salt cedar control program in accordance with the Agreement.	Ongoing implemented.	The program also monitors and maintains cleared areas. The current program is focused on clearing saltcedar thickets in water spreading basin adjacent to the Lower Owens River and burning slash. In 2013-14, program staff cut 176 acres, burned about 120 slash piles, and treated 106 miles of Owens River bank and floodplain.
Irrigated fields, including Cartago and Olancha	1991 EIR Impact No. 10-16	Decrease in irrigated land resulted in reduction or withdrawal of tailwater and associated loss of dependant vegetation.	Continue irrigation practices since 1981-82 and thereafter.		Ongoing. Irrigated lands are not directly monitored; lessees are relied upon to indicate if there are changes in water for irrigation.
Town Regreening Projects	E/M 1985-1990	Non-mitigation E/M project. These projects were implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the towns of Big Pine, Independence, and Lone Pine. Water was supplied from LADWP facilities to promote and maintain vegetation.	Maintain trees and vegetation.	Implemented and ongoing.	Many trees have died in Lone Pine, Big Pine, Independence, and Bishop due to reductions or elimination of irrigation during recent years of drought.

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