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**COUNTY OF INYO  
WATER DEPARTMENT**

April 4, 2014

TO: Inyo/Los Angeles Technical Group  
Arbitration Panel (JAMS Arbitration Case Ref. No. 1110016067)

FROM: Inyo County Water Department

SUBJECT: Inyo County Reply to 'The Los Angeles Department of Water and Power's  
Closing Report to the Technical Group Regarding Vegetation Changes in  
Blackrock 94, March 27, 2014

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## Executive Summary

LADWP presented the County with a report on the premise that it needed to respond to “*vast amounts of new data relating to satellite imagery analysis, soil moisture analysis, groundwater modeling, and hypothetical scenarios*” that were in the County’s February 14, 2014 response to LADWP’s December 18, 2014 evaluation of attributability and significance of vegetation change in parcel Blackrock 94. In the LADWP Report, we found no identification of or discussion of any new data; instead, LADWP revisited a broad range of issues that had already been extensively analyzed and briefed between the two parties.

In this reply, we address the most substantive and determinative issues raised in the LADWP Report: the alleged change to the County’s conclusions, the applicability and use of groundwater models in determining attributability, soil water conditions at monitoring sites, determination of whether the measured vegetation change would have occurred without pumping, effects of surface water spreading, utility of satellite-derived vegetation cover, and choice of control areas. Here, and in previous work, the County relied on two primary independent modes of investigation to ascertain whether groundwater pumping or varying runoff conditions since baseline contributed to the change in vegetation; modeling of groundwater and vegetation conditions in the absence of groundwater pumping and comparison of Blackrock 94 with control. The County’s investigation of attributability included all factors prescribed by the Water Agreement and Green Book. Recognizing that all data sets have inherent strengths and weaknesses, the County endeavored to include and analyze all relevant data.

The County reached its conclusions based on careful analysis of the relative effects of groundwater pumping, wet/dry cycles, and other factors on the hydrology, soil water, and vegetation in Blackrock 94 and neighboring Blackrock 99. The County showed that:

- The water table in 1986 was shallow enough to support the baseline groundwater dependent meadow vegetation.
- Groundwater modeling results show pumping since in the late 1980's caused much greater declines than drought and associated reduced surface water diversions alone.
- The groundwater decline resulted in lack of available soil water in plant root zone at Blackrock 94.
- A decline in vegetation cover was first evident in 1991 and a change in vegetation composition from Type C to Type B is occurring but has not yet crossed the threshold between the Water Agreement Vegetation Types.
- Groundwater modeling results suggest that in the absence of pumping, the water table fluctuations would have been of similar magnitude as observed at control parcels unaffected by pumping.
- Groundwater and vegetation modeling and simple interpretation of soil water measurements show that in the absence of pumping, the water table would have remained shallow enough to supply groundwater to the plant rooting zone and the decline in vegetation cover would not have occurred.
- A neighboring meadow affected by the same drought conditions but little affected by pumping did not experience water table decline, lack of available soil water, or vegetation decline.

Over the course of this dispute, LADWP argued that groundwater modeling, DTW estimates, interpretations of soil water measurements, line-point vegetation data, most statistical methods, satellite-derived SMA cover, data from permanent transects, photographs of vegetation condition, the use a neighboring parcel as a control, and vegetation modeling by the County should be discounted. The County has shown each and every one of these arguments to be lacking in substance. In LADWP's Closing Report, it was argued that the Technical Group should eschew model results, estimates, and simulations in favor of actual data. The County concurs that actual data are valuable and essential for the task set for the Technical Group, as shown by the County's inclusion of all relevant data sets. However, to fulfill the Water Agreement's requirement that the Technical Group determine whether a change in vegetation would not have occurred but for groundwater pumping or changes in surface water management, it is necessary to examine hypothetical no-pumping or constant climatic scenarios. That can only be done using models or comparison with controls. Despite LADWP's voluminous comments critical of the County's analysis and LADWP's own multiple analyses, LADWP has not provided substantive reasons why the County's conclusions are incorrect nor adequately addressed the attributability standard required by the Water Agreement.

The County concluded that while both runoff-driven recharge and pumping contribute to water table fluctuations in Blackrock 94, the water table decline, lack of available soil water, and coincident vegetation decline would not have occurred but for LADWP groundwater pumping.

LADWP's conclusion that the vegetation decline was caused by reduced surface water diversions caused by lower runoff conditions alone is inaccurate and thoroughly refuted by the multiple lines of evidence developed by the County. Because the County's analysis relied on multiple independent data sets, and two corroborating independent lines of investigation, the County has shown to a reasonable scientific certainty that a significant decline in vegetation cover has occurred and a trend toward a change from Type C to Type B is occurring, and that the vegetation change is attributable to LADWP groundwater pumping and significant.

## Introduction

LADWP has submitted a report to the Technical Group and Arbitration Panel titled “The Los Angeles Department of Water and Power’s Closing Report to the Technical Group Regarding Vegetation Change in Blackrock 94,” hereafter referred to as “LADWP Closing Report.” According to its “Response to Motion for Procedural Order,” of March 18, 2014, LADWP’s need to prepare its Closing Report arises because the County “*elected to substantively change the question posed to the Panel in the initial dispute, and to include vast amounts of new information to support wholly new arguments that were not properly raised in the initial dispute*” and “*the County has submitted vast amounts of new data relating to satellite imagery analysis, soil moisture analysis, groundwater modeling, and hypothetical scenarios*” in the County’s February 14, 2014 response (hereafter referred to as “County Response”) to LADWP’s December 18, 2013 assessment of attributability and significance of effects in Blackrock 94 (hereafter “LADWP Evaluation”). We also refer to a number of attachments to the County’s Initial Brief and Response Brief to the Arbitration Panel, numbered as provided to the Panel (e.g., County Attachment 1).

Despite this premise, in its Closing Report, LADWP does not identify any data used by the County that were not available to LADWP while it was preparing its Evaluation attributability and significance of vegetation change in Blackrock 94 . Instead, rather than moving forward with discussions with the County to resolve the dispute, LADWP “*convened an internal scientific team to address the new information raised by the County*” and forestalled any attempts at resolving the dispute for six weeks while it worked on its report. LADWP revisited a number of issues that have been thoroughly discussed in previous documents, and made a number of false claims concerning the analysis contained in the County response, as well as made numerous claims that contradict claims made elsewhere in the Closing Report or in other materials LADWP has submitted to the Technical Group and the Arbitration Panel. Below, we respond to LADWP’s contentions concerning groundwater modeling, the effects of groundwater pumping, water table depth, surface water management, soil water, ground-based and satellite-based measurements of vegetation, utility of Blackrock 99 as a control parcel, and LADWP’s characterization of how the County has changed its conclusion and/or the question submitted to dispute resolution.

The Water Agreement’s dispute resolution process requires that the Technical Group report to the Standing Committee on areas of agreement and subjects of disagreement and each party’s arguments in favor of its position along with supporting data and background. In their Closing Report, LADWP identified a number of areas of agreement and disagreement, as did the County in its County Response. Based on the parties’ respective discussions of agreements and disagreements, it is clear that the Technical Group will need to conduct further discussions to determine the areas of agreement and disagreement and to develop a joint statement of agreements and disagreements. This would be best preceded by meetings between LADWP and Water Department staff as suggested by the Panel, so we leave further discussion of those issues for a later time. However, the absence of further discussion of this topic should not be construed as agreement with LADWP’s characterizations of agreements and disagreements.

## **Alleged changes in the County's conclusions**

LADWP now alleges that the County has changed its conclusions since 2011, because in 2011, the County claimed that “*a significant change is occurring*,” in 2012 “*a significant change has occurred...*”, and in 2014 “*a significant decrease or change in vegetation has occurred or is occurring*.”

In 2011, the County concluded “*the degree of change is significant*” and “*changes in species composition suggest a change in Type is occurring*” (County Attachment 10, pp. 65-66). The concern that the County brought to the Technical Group in 2011 included both changes that had occurred in live perennial cover and changes that were occurring in species composition. That conclusion has not changed. This is certainly a point that could have been clarified easily at the Technical Group or among staff, had LADWP ever expressed this concern.

LADWP also claims that the County changed its attributability determination from “*...reduced surface water diversions into the vicinity of Blackrock 94*” to “*...changes in surface water management practices*” (LADWP Closing Report, p. 5). There is no inconsistency: changing (e.g., reducing) diversions in a given area is a change in surface water management practice. The first statement describes an activity that is included as a one of the activities described in the second statement.

## **Hydrology**

### **Groundwater modeling and the effects of pumping**

LADWP and the County both presented the results of groundwater modeling exercises in their respective analyses of attributability (LADWP Evaluation, pp. 41-44; County Response, pp. 11-18). These modeling exercises are important to resolving this dispute, because these are the only analyses that address what depth to water (DTW) would have been but for pumping. Both the County's and LADWP's modeling exercises showed clearly that pumping had a greater influence on changes in water table elevation (and hence depth to water) than other factors such as recharge, and that the effect of pumping has been significant. Comparison of the model results with observed drawdown (LADWP Evaluation, p. 36; County Response, p. 11-19) shows that both models somewhat underestimated water table declines from the mid-1980's to the early-1990's, indicating that the County's evaluation of whether the vegetation decline would have occurred but for pumping is conservative (i.e., it is that likely effects were greater than estimated).

The groundwater modeling results quantitatively describe the relative contributions of recharge (from runoff, precipitation, water spreading, irrigation, etc.) and pumping on water table decline and fluctuations under the parcel and at permanent monitoring sites. The County estimated that water table decline due to drought was approximately 3 to 4 feet whereas during the same

period the decline caused by pumping was about 10 feet (ICWD 2011, pp. 51-52). A decline of 3 to 4 feet due to the late 1980's drought is comparable to that experienced by control parcels unaffected by LADWP pumping wells. Both LADWP and the County classify parcels into control and wellfield groups based on criteria derived from groundwater drawdown measurements during the period of maximum pumping rate and drought that occurred between 1987 and 1993 (LADWP Attributability Report, p. 88 and various ICWD annual reports cited therein). Parcels that experienced less than 1 m (~3 feet) of water table decline are considered unaffected by pumping (controls). The USGS model results are consistent with observed fluctuations due to drought elsewhere in the valley (see Inyo Initial Brief, Attachment 22, Figure 10, p. 33).

## **Use of the USGS Model**

LADWP claims that the USGS model used by the County was applied inappropriately to assess pumping effects at Blackrock 94. LADWP's claim is based on three assertions: (1) that the model is designed for addressing regional questions (LADWP Closing Report, p. 34), (2) that the County did not account for spring flow and recharge correctly in the model (LADWP Closing Report, pp. 34-35), and (3) that the model has uncertainty in it and could be improved (LADWP Closing Report, p. 34).

The volume of pumping involved in this dispute (see County Response, p. 13, Figure 1), the spatial extent of the wellfields, and the period of time over which pumping has occurred make this dispute a regional-scale problem, and the USGS regional model is appropriate for this analysis. The County showed that the USGS model was the more accurate than the LADWP groundwater model in reproducing historic water table changes relevant to this dispute (County Response, p. 15, Table 1). As described below, the Technical Group has recognized the usefulness of the USGS model in addressing groundwater management questions.

## **LADWP's rejection of the USGS model is contrary to its past use of the model at the Technical Group and in Court**

Although LADWP claims that the USGS model is inappropriate for addressing the Blackrock 94 issues, the Technical Group has agreeably and successfully applied the USGS model to a number of analyses required by the Water Agreement where the model was used to evaluate pumping effects at the scale of a single well field. LADWP has used these Technical Group analyses conducted by the County to comply with CEQA. In 2001, LADWP completed a CEQA negative declaration for the Big Pine Northeast Regreening Project, which included an analysis of potential effects of groundwater pumping to supply the project (LADWP, 2011). In their CEQA environmental analysis, LADWP concluded:

*...the Inyo County Water Department Director/senior hydrologist Dr. Robert Harrington , performed a modeling analysis on potential effects of groundwater pumping to supply*

*the Big Pine Northeast Regreening Project. A description of this work is included in Appendix B.*

*To evaluate the effects of different pumping locations on the water table, the regional groundwater model for the Owens Valley was used to examine the effect of project pumping on water table elevations in the Big Pine area. This groundwater model was originally developed by the United States Geological Survey (USGS) as part of a larger program to evaluate the relationship of groundwater pumping and vegetation (USGS Water Supply Paper 2370-H, 1998)....*

*Groundwater models have inherent limitations because they are generalizations of the groundwater system. **Nevertheless, they represent the best-available tools to analyze long-term effects of groundwater pumping.***

...

*Based on field results from the operational testing (Appendix C), and groundwater modeling analysis (Appendix B), pumping 150 acre-feet per year from Well W375 will have a less than significant impact to the hydrology of the area and phreatophytic vegetation.*

LADWP's CEQA analysis of the Big Pine Northeast Regreening Project was challenged by the Sierra Club, the Big Pine Paiute Tribe, and the Owens Valley Committee (a local environmental group) (Case No. SI CV PT 1253541). LADWP relied in part on the County's groundwater modeling, and the Court found in favor of LADWP, stating that:

*Respondents [LADWP] rely on the fact ... that groundwater modeling by Dr. Robert Harrington in 2010 led him to conclude that a drawdown of water from No. 375 for project make-up water is too small to "measurably affect the shallow aquifer dependent vegetation..."*

In case of the Big Pine Regreening Project, LADWP considered the USGS model among the "best-available tools to analyze the effects of long-term groundwater pumping" and appropriate to perform an analysis that was more local in scale than the questions involved in the Blackrock 94 issue. Similarly, LADWP has also used an analysis performed by the County using the USGS model in a CEQA analyses for the "Irrigation Project in the Laws Area."

## **Effect of Blackrock Hatchery pumping on Blackrock 94**

LADWP reasserts that hatchery pumping has been constant and uses this to argue that groundwater pumping could not have caused change in vegetation since the mid-1980's (LADWP Closing Report, p. ES-3). LADWP's reasoning fails on two counts. First, although pumping from the Hatchery has been sustained and somewhat constant, it peaked in the late-1980's, exactly when severe vegetation decline occurred in Blackrock 94 (County Response, pp. 18-19). Second, throughout this dispute, the County has concluded that groundwater

declines at Blackrock 94 are a result of both the supply wells for the hatchery and other LADWP wells. Groundwater observations, groundwater pumping records, and groundwater modeling results all corroborate this fact. Attachment 22 (pp. 33-34, Figure 10) to the County's Reply Brief to the Panel shows the contrast between pumping-affected and non-pumping affected hydrographs, and shows that Blackrock 94 is clearly affected by pumping. The County has repeatedly pointed out the importance of non-hatchery pumping in this analysis (Attachment 10, pp. 51-53; Attachment 22, p. 29; County Response, pp. 11-17), a stress on the aquifer system and vegetation that LADWP largely ignores.

## **Amount of Hatchery Pumping that should be included in the Groundwater Models**

LADWP's method of modeling pumping from the Black Rock Hatchery is faulty. Their claim that "*ICWD ignored the reduction in discharge from Blackrock Spring prior to 1972*" is completely false. The USGS model uses the MODFLOW "drain package" to simulate spring flow, where if groundwater levels are sufficiently high, groundwater discharges from the spring. In the USGS model, Blackrock Spring flows prior to 1972, but is dry thereafter due to the effect of the Black Rock Hatchery supply wells. In this respect, the USGS model is consistent with actual observations of spring flow. It should be noted that the model used by LADWP simulates the period subsequent to 1985, so it cannot be determined if their model renders Black Rock Springs in a manner consistent with observations.

LADWP's net discharge concept produces an erroneous water balance. Their concept is that since the spring was discharging approximately 7,000 acre-feet per year prior to 1972, and now it is discharging 0 acre-feet per year, that volume of water should be subtracted from the amount pumped from Hatchery supply wells. Groundwater models (and hydrologic analysis in general) require that a water budget be developed for the aquifer system being analyzed, in order to account for inputs and outputs of water to the system. At the Black Rock hatchery, groundwater that previously discharged from the spring now discharges from the supply wells. Subtracting the spring flow from the pumpage from the supply wells forces the LADWP model to retain that amount water in the aquifer when in reality it exits the aquifer through the wells or would flow out the springs if the pumps were turned off. By using net discharge instead of the larger value of actual discharge, the water budget is unrealistic which explains why the LADWP model predicts that hatchery pumping only has a small effect on the water table. Performing this model scenario as described by LADWP puts incorrect information into the model, producing incorrect output.

LADWP's suggested method proposes that discharge does not occur from either the supply wells or from the spring, which is a faulty water balance since it does not reflect reality. There may be merit to accounting for water infiltrating back to the shallow aquifer, but LADWP's arbitrary subtraction of historic spring flow has no basis. Despite this flaw in LADWP's modeling analysis, their results still show significant drawdown from non-hatchery wells (LADWP



Evaluation, p. 43, Figure 5.1). As discussed in the County Response, LADWP's modeling likely would have been more accurate had it correctly accounted for pumping at the hatchery.

Overall, despite disagreement over how to characterize Black Rock hatchery pumping in groundwater models, the groundwater modeling results from both the County and LADWP show substantial effects of pumping (County Response, pp. 13-14). These results are wholly consistent with the statement made by the USGS quoted in the County Response (p. 16) and in the LADWP Closing Report (p. 33). Further, both parties' groundwater models show that water table fluctuations due to variations in recharge are smaller than fluctuations due to pumping, which is wholly consistent with the observed comparison between areas affected and unaffected by pumping (County Response, pp. 13-14; Inyo Brief Attachment 22, p. 33, Figure 10).

### **Depth to water in Blackrock 94**

LADWP claims that the County's estimate of 1986 depth to the water table (DTW) in Blackrock 94 of 3.1 feet is wrong, and faults the County for omitting a number of deep wells north and upslope of the parcel. LADWP claims that it used '*all relevant data*' to produce an estimate of 13.2 feet for the parcel. The County omitted the deep upslope wells based on systematic criteria already explained in Attachments 22 and 24 of the County's Brief. In LADWP's Closing Report, it emphasizes the need to rely on '*actual data*' rather than estimates or models. In this vein, we point out that the only actual measurement of depth to water within Blackrock 94 in April 1986 that we are aware of is well T582, which had a depth to water 3.9 feet from land surface measured by LADWP on April 16, 1986 - far closer to the County's estimate than LADWP's. LADWP estimates that 1986 depth to water at T807 at the west edge of the parcel is 8.47 feet (LADWP Evaluation, p. 36). LADWP correctly points out in their Closing Report (p. 43, Figure 10) that depth to water is greater at the western upslope edge of the parcel; however, their estimate that the maximum DTW in the parcel is in the range of 8.47 feet conflicts with their contention that the average DTW is 13.2 feet (i.e., mathematically, the average cannot exceed the maximum). The available evidence shows that the water table depth in 1986 was sufficiently shallow to supply groundwater to meadow vegetation.

### **Soil water**

To refute the County's Response, LADWP relied on a correlation analysis of soil water data contained in the LADWP Evaluation. LADWP restated that surface water, precipitation, and runoff were the primary factors affecting soil water at TS1 and TS2. LADWP elsewhere concedes, however, that vegetation declined at the monitoring sites in the late 1980's due to drought and elevated groundwater pumping (LADWP Closing Report, p. 92). The statements are difficult to reconcile and represent an example of the varying and often contradictory conclusions in LADWP briefs and reports. LADWP again asserts that the comparison of TS1 and TS2 with TS3 is invalid because TS3 has a shallower and more stable water table (see Inyo Brief, Attachment 11 for LADWP's previous statements). LADWP did not evaluate soil water

data presented in the County's Response or present new lines of evidence. As a result, in this section, the County reiterates its conclusions and corrects false assertions put forth in LADWP's Closing Report.

In its February 2011 report, the County concluded that soils at TS1 and TS2 in Blackrock 94 were dry by the early 1990's. The surface layer contains almost no available soil water except after precipitation. The soil at TS1 has been dry since baseline, and groundwater rarely has replenished soil water except after surface water spreading in 1995 and 1996. Soil water at TS2 was replenished below 2 m by groundwater when the water table rose in the late 1990's, but the soil above 2 m remained dry. Based on its analysis, the County concluded in 2011 that, *"Vegetation degradation (in Blackrock 94) is primarily attributable to changes in water availability resulting from groundwater pumping and reduced surface water diversions into the vicinity of Blackrock 94."* Both factors contributed to the water table decline coincident with the measured vegetation decline. The County Response corroborated these conclusions.

In its Closing Report, LADWP asserted that water spreading, runoff-driven recharge, and precipitation explain variation in soil water amounts. The fatal flaw in LADWP's logic was to conclude that detecting soil water fluctuations due to precipitation and spreading explains the lack of available soil water and decline in groundwater dependent vegetation since baseline. Furthermore, LADWP only examined data collected since 1996, and therefore can conclude nothing regarding the water table and soil water decline coincident with the vegetation decline measured in 1991.

LADWP's results provide no insight as to why the soil is dry and no information about the groundwater/soil water relationship that links the amount of pumping to changes in vegetation. Essentially, LADWP sidestepped these seminal questions. At TS1, LADWP's results simply reflect the situation where groundwater has been too deep to recharge soil water above 4 m for most of the period since 1996. Likewise, groundwater has not contributed appreciably to soil water above 2 m at TS2. Understandably, if the water table is too deep due to pumping for it to contribute groundwater to a particular soil layer, precipitation and spreading become the only important factors that can affect soil water. LADWP's conclusion that the surface soil layer gets wet when it rains is not in dispute. Similarly, the temporary effects of isolated spreading events on soil water and vegetation at TS1 were thoroughly described in the County's Closing Response. We agree with the LADWP result that water table depth is weakly related to soil water in the grass root zone at TS1 and TS2. However, this is due to the fact that for most of the time since 1991, the water table has been decoupled from the root zone as a consequence of LADWP's pumping. Accordingly, the County cannot and does not agree that the soil water and vegetation conditions resulted from natural wet/dry cycles. Reasons supporting the County's position are discussed below.

LADWP offered the following new hypothesis in support of its December 2013 conclusions. LADWP surmised that the soil water trends at TS1 and TS2 must be similar if groundwater were the cause of variability in the soil water between TS1 and TS2. Variability between sites is not the issue, and the premise is false because it ignores that water spreading directly affects TS1,

but not TS2, and that the sites have different water table depths. LADWP's analysis does not address the standard for attributability that decreases in vegetation (and in this context the lack of available soil water) shall be considered attributable if the decrease or change would not have occurred but for groundwater pumping.

LADWP asserts that the County did not examine the effect of runoff, water spreading, and precipitation in its February 2014 report. That assertion is demonstrably false. Soil water response to water spreading and precipitation were discussed at length in the County's Closing Response (pp. 27-37). The relative effects of runoff and pumping were evaluated by preparing groundwater models for actual pumping and no-pumping scenarios. Both scenarios were based on actual runoff values, only the pumping amounts differed. Those model results were combined with water table measurements to estimate what the water table depth would have been without pumping. Fluctuations due to varying runoff over time are plainly visible in the no-pumping water table estimates at TS1 and TS2 (County Response, Figures 6 and 8). Water table declines due to varying runoff and associated spreading are not large enough to decouple groundwater from the rooting zone. Because the estimated water table in the absence of pumping was within or just below the rooting zone for all or most of the period since baseline, the County concluded that the effect of varying runoff conditions and drought alone were *"...insufficient to lower the water table sufficiently to eliminate soil water recharge from the water table at either site."* In other words, but for LADWP's groundwater pumping, the water table would have provided groundwater recharge to the vegetation rooting frequently since baseline even in the western portion of the parcel. LADWP has not presented contrary evidence.

LADWP again contends that the comparison of TS1 and TS2 with TS3 is invalid because groundwater depth and fluctuations at TS3 were buffered from pumping effects by surface water (irrigation, flowing wells, and LA Aqueduct). Elsewhere in its Closing Report, LADWP argues strenuously that the comparison is invalid because both parcels are affected by pumping and classified as wellfield parcels. The County cannot reconcile those contradictory lines of reasoning.

Blackrock 99 was classified by the County and LADWP as a wellfield parcel affected by pumping. This means that the water table decline in the late 1980's due to drought and elevated groundwater pumping was larger than declines observed at control parcels. Monitoring site TS3 is a wellfield site established by the Technical Group to manage groundwater pumping because it can be affected by pumping. Thus, any suggestion that Blackrock 99 and TS3 are inappropriate controls because the water table was shallower and fluctuated less than at other control sites due to surface water or flowing wells in the parcel is indefensible (LADWP Closing Response p.25 and p.95).

Contrary to LADWP's assertion, the estimated water table depth at TS1 and TS2 in the absence of pumping was similar or shallower than the actual water table depth measured at TS3. Since TS3 had adequate soil water and exhibited no vegetation decline, there is no evidence that variation in runoff, which would have produced similar or even more favorable water table conditions at TS1 and TS2, caused the lack of available soil water and vegetation decline

evident at those sites. We agree that the water table beneath TS3 was buffered from the effects of groundwater pumping more than at TS1 and TS2. Rather than invalidate the comparison between the water table conditions at TS1, TS2 and TS3, however, that observation supports the County's contention that the different water table conditions due to LADWP pumping caused the differences in soil water availability and change in vegetation since baseline.

In summation, the County's interpretation of the soil water monitoring results in Blackrock 94 and near Blackrock 99 is:

- Sites TS1 and TS2 in Blackrock 94, experienced water table depths well below the rooting zone of groundwater dependent vegetation due to elevated groundwater pumping and drought during the 1987-1990 period. Vegetation cover declined.
- The available water in the soil above 4m was nearly exhausted by 1994 (except for precipitation) coincident with the period of decline in vegetation cover.
- Vegetation cover increased at TS1 when available soil water increased temporarily following water spreading. At TS2, grass cover remained depressed but shrub cover increased when available soil water increased due to a rising water table only in the deeper portion of the shrub root zone.
- Site TS3 did not experience as severe of water table decline due to pumping allowing frequent groundwater contribution to available soil water in the grass root zone, and vegetation cover has been maintained or increased (even after fire).
- In the absence of pumping, water table fluctuations at TS1 and TS2 would have been similar to those at TS3, and variations in runoff and precipitation alone would not have caused sufficient water table decline to prevent groundwater recharge to the rooting zone for extended periods.

## Vegetation

The primary disagreement between the County and LADWP concerning causes of vegetation change in Blackrock 94 is that LADWP believes the decline in vegetation cover was caused solely by natural climate cycles, while the County believes the additional drawdown of the water table caused by pumping, superimposed on natural climatic variability, contributed significantly to the observed decline in vegetation. Because pumping influences water table depth, which in turn influences soil water available to vegetation, the linkage between water table depth and vegetation cover needed to be quantified. Therefore, the County arrived at its conclusion by first quantifying the relative change in vegetation cover associated with changes in DTW and precipitation using linear regression. Both the County and LADWP found water spreading correlated to precipitation and thus both the County and LADWP excluded spreading from their respective vegetation models. Second, because the attributability analysis requires that the

effect of pumping on vegetation be quantified while controlling for the influence of natural climate variability, the County used the USGS groundwater model to provide an estimate of DTW for the scenario that pumping had not occurred under observed climate conditions. Finally, because DTW is embedded in the County's vegetation model, the vegetation cover that would have been realized solely due to natural climatic variability could be computed by using the DTW values predicted from the USGS model from the no pumping scenario as input to the County's vegetation model. The differences in the actual vegetation cover and the modeled vegetation cover influenced solely by climate variability is the change in vegetation cover that can be attributed to pumping-induced drawdown of the water table.

LADWP raised several issues with the way that the County addressed the problem of estimating a vegetation change attributable to pumping. First, LADWP doesn't believe DTW should be included in the vegetation model. In its modeling, LADWP uses a model that does not include DTW to show that DTW has no effect on vegetation. Second, LADWP doesn't believe the USGS model should be used to estimate DTW fluctuations associated with natural climate variability and pumping. LADWP's contention that the County has ignored effects of wet/dry cycles and changes in water diversions is false. The USGS model (and LADWP's model) include recharge fluctuations driven by changes in runoff, which in turn (as shown in LADWP's Evaluation) largely dictates water spreading management.

LADWP is forceful in their assertion that:

*“Real-world analysis or management decisions cannot be based on simulated vegetation cover in this hypothetical set of circumstances constructed by ICWD” (LADWP Closing Report, p. ES-12)*

The Water Agreement requires that the Technical Group determine if vegetation changes would not have occurred but for groundwater pumping and/or changes in surface water management. This inherently requires that the Technical Group employ analytical tools to model or estimate how vegetation would have responded had pumping or surface water management changes not occurred. From this statement it would appear that LADWP believes computing an estimate of vegetation cover under the no pumping scenario for some reason should not be allowed, thus evading their Technical Group responsibilities under the Water Agreement. However, the County's approach is the logical way to conduct the required attributability analysis: determine the effect of pumping on the water table, and then determine the effect of the water table on soil water and vegetation. The real failing of LADWP's analysis is that despite the abundant material presented on vegetation conditions, surface water management, and soil water, LADWP never addresses the standard for attributability set in the Water Agreement: would vegetation not have changed but for pumping and/or changes in surface water management?

## **Discussion of LADWP contentions related to the County's vegetation model**

In its attempt to reduce the quantitative rigour of the attributability analysis, LADWP, manufactures several illogical arguments for; 1) dismissal of DTW as a variable in the vegetation model, 2) dismissal of SMA data used in the County's vegetation model, 3) dismissal of DTW estimates derived from the County's kriging, and 4) dismissal of the relevancy of vegetation-DTW relationships in neighboring parcel Blackrock 99 that maintained a shallower water table than Blackrock 94. In the following sections we first readdress why DTW is a critical variable to include in a vegetation model that is a key component in the evaluation of the effect of pumping on DTW and the effect of DTW on vegetation. To do this, we must again revisit LADWP's vegetation model and their justification for including a 5-year moving average runoff variable instead of DTW. Second we address LADWP's argument that SMA should be discounted because the line point data and SMA values are different. Third, we again identify the flaws in LADWP's argument that data from neighboring parcel Blackrock 99 can't be used in the attributability analysis.

### **LADWP's vegetation model**

In the February 2014 County Response to the LADWP Evaluation, the County pointed out problems with LADWP's vegetation regression modeling, specifically their model selection method and the appropriate variables to include in their 'best' vegetation model.

LADWP and the County have identified that DTW and precipitation are the two primary hydrologic variables that directly affect vegetation cover. However, LADWP used precipitation and the 5-yr moving average of Sawmill Creek runoff to explain vegetation cover in Blackrock 94. Annual runoff and DTW are related; both the County and LADWP routinely use regression models to predict DTW year to year as a function of pumping, runoff, and the present DTW. Annual runoff is correlated with precipitation and so it cannot legitimately be included in the same regression model as precipitation. However, 5-yr moving average runoff is not correlated with precipitation, but it is related to DTW. By using the 5-yr moving average runoff variable, LADWP is implicitly modeling DTW without calling it DTW.

In its February 2014 County Response, the County pointed out that since the 5-year moving average of runoff is correlated with and implicitly represents DTW, it is illogical to use the 5-yr moving average rather than the DTW of the parcel which directly affects vegetation cover. The County also demonstrated that LADWP's justification for not including DTW in their model in favor of the 5-yr moving average runoff variable was based on a mistake. LADWP excluded DTW because when included alongside the 5-year moving average runoff variable in the same model, the estimated effect (sign of the regression coefficient) of DTW turned out to be positive. However, with increasing DTW (deeper water table), vegetation cover should decline, so the sign of the regression coefficient should be negative instead of positive. When two variables that are highly correlated are included in the same model, the regression coefficient of one of them often has the wrong sign. This is an indication of multicollinearity problems in a regression model. Rather than recognizing the statistical problem, LADWP made the argument that this result justified excluding DTW in favor of the 5-yr moving average runoff in explaining vegetation

cover. In response to the County's point that this was a mistake, in LADWP's Closing Report, it stated that it is safe to include collinear independent variables in regression models if the variance inflation factor (VIF) is less than 10 (LADWP closing report, p. 45). However this is wrong. Such an assertion abuses a common rule of thumb to justify an incorrectly specified model in which case the VIF is irrelevant. Even with correctly specified models, a VIF greater than 2.5 can indicate multicollinearity problems. The VIF LADWP calculated was about 4. LADWP should have examined the bivariate correlations between their independent variables as the first step in guarding against multicollinearity problems. From the plot of DTW vs. 5-yr moving average runoff, it is clear the two variables are correlated (Fig. 1); and we expect them to be as recharge from runoff influences DTW, especially when averaged over a 5-yr period.

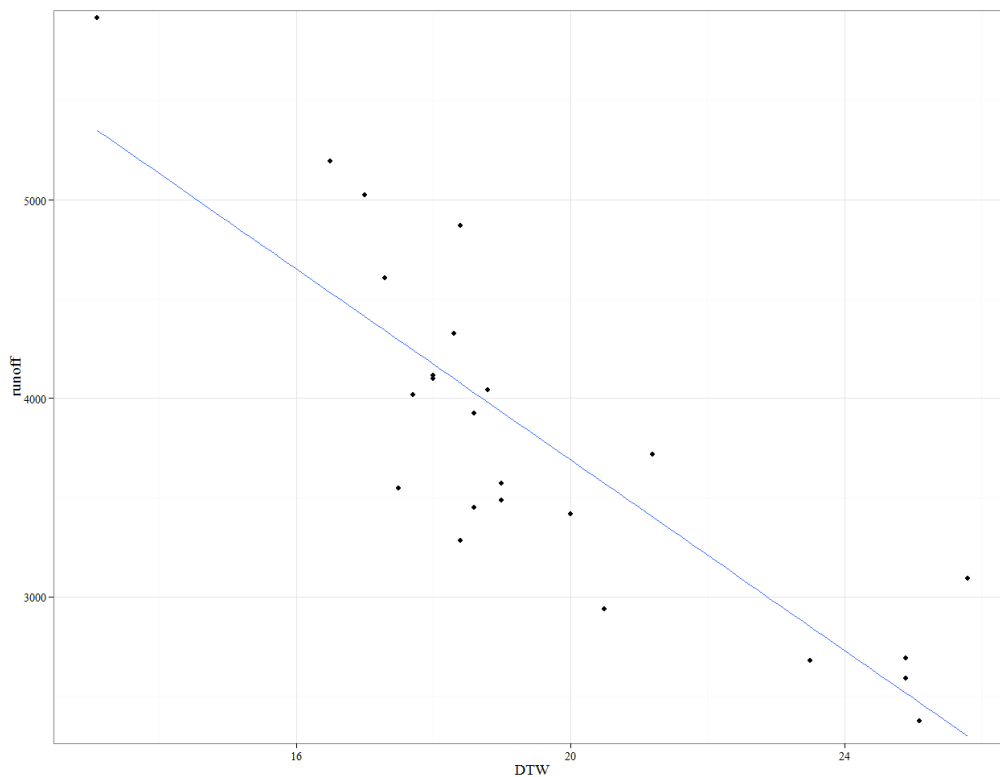


Figure 1. The linear relationship between the 5-yr moving average Sawmill Creek runoff (ac-ft) and DTW (ft) ( $R^2=0.7089$ ,  $p < 0.0001$ ) is expected because runoff influences DTW through recharge of groundwater and the 5-yr average of runoff implicitly is modeling the antecedent DTW values. The 5-yr moving average runoff variable is representing DTW without calling it DTW. LADWP's Closing Response does not recognize this correlation.

LADWP, in its Closing Response, attempted another justification for its use of a moving average runoff variable instead of DTW in their vegetation model. It conducted a partial regression analysis intended to show that the runoff variable “*..remains significant even after taking account of the influence of other variables...*” (p. 46). LADWP states that when the influence of DTW was removed, the relationship between runoff and cover remained almost unchanged. This is exactly the County's point--the two variables, DTW and five-year moving average runoff

are redundant when included in the same model, so they should not be included in the same model. Runoff (flow in Sawmill Creek as measured through a stream gauge) is related to recharge through stream bed infiltration, recharge is related to DTW, and DTW is related to cover of groundwater dependent vegetation. When given the choice of two redundant variables in a regression model, sound modeling practice is to choose the variable that has an actual physical connection to the response variable, in this case DTW. Additionally, use of 5-year-average runoff arbitrarily and unnecessarily degrades the resolution of this input variable. LADWP's attempt to demonstrate the significance of one variable that is a surrogate for the other, while statistically controlling for the other, is a convoluted approach that could be avoided by direct use of the physically related variable. LADWP goes on to conclude from this illogical analysis that "*the relationship between vegetation cover and DTW disappears or becomes positive after removing the influence of runoff.*" As previously stated by the County, this is because LADWP includes redundant variables in its model. LADWP goes on to reach the nonsensical conclusion that:

*"The influence of DTW on vegetation is explained by runoff, **but the influence of runoff on vegetation cannot be explained by DTW**" (LADWP Closing Report, p. 45).*

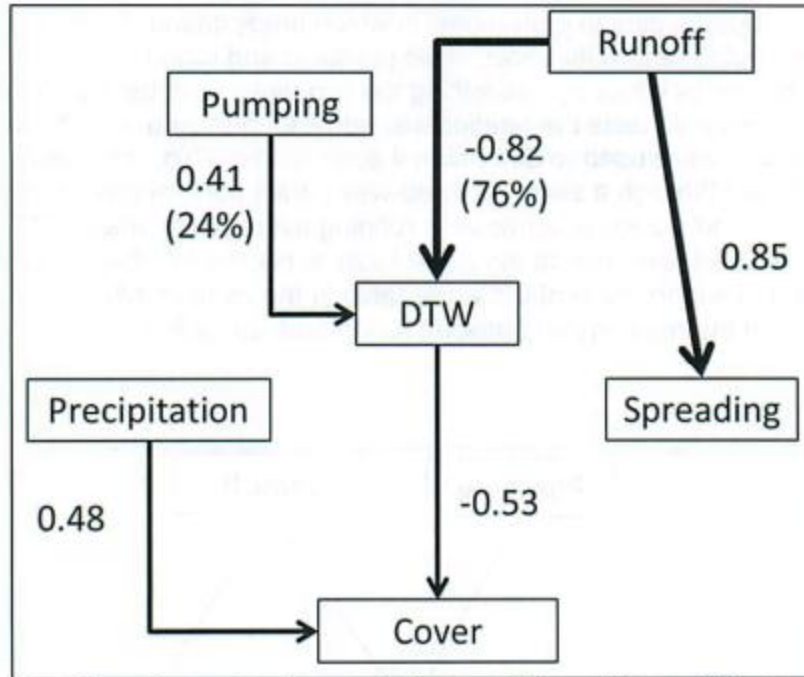
This statement is nonsensical because runoff influences vegetation through DTW. Immediately following this statement LADWP presents results from its new path analysis which (correctly) contradict the stated conclusion:

*"The results show precipitation and DTW were the only variables that directly influence perennial cover, while **runoff and pumping indirectly influence perennial cover through DTW**" (LADWP Closing Report, p. 47).*

To summarize, LADWP believes on one hand "*the influence of runoff on vegetation cannot be explained by DTW*" (p. 45) and on the other hand "*runoff and pumping indirectly influence perennial cover through DTW*" (p. 47). In fairness, it is possible these analyses were conducted by two different people who did not coordinate their stories. Regardless of the origin of the discrepancy, the County agrees with the latter statement that "*runoff and pumping indirectly influence perennial cover through DTW.*" The County's groundwater modeling was done to assess the effect of different pumping regimes while accounting for variation in runoff-driven recharge. The County also agrees with LADWP's conclusion that "*precipitation and DTW were the only variables that directly influence perennial cover*" (LADWP Closing Response, p. 47).

In light of LADWP's most recent discovery in its path model analysis, it is odd that LADWP prefers the indirect runoff variable over DTW which it found to influence perennial cover directly. However given LADWP's stance that pumping didn't affect vegetation, it is understandable that LADWP preferred not to include DTW in its vegetation model because DTW is the link between pumping and vegetation (Fig. 2). Unfortunately, that decision precluded LADWP from examining the standard for attributability of whether the vegetation change would not have occurred but for groundwater pumping.





Note - The values next to the arrow indicate partial correlation coefficients, and thickness of each arrow is adjusted to the value of partial correlation (stronger the correlation, thicker the line). The number in the parentheses under correlation coefficient indicates relative importance of runoff and pumping on DTW.

Figure 2. LADWP’s path model quantifies the indirect and direct influence of hydrological variables on vegetation cover with DTW and precipitation being the only variables that directly influence vegetation cover. LADWP concludes the effect of runoff and pumping influences cover through their respective influence on DTW (reproduced from LADWP Closing Report Fig. 12, p. 48)

To summarize, the County disagrees with LADWP that the the 5-yr moving average runoff variable is “...*the ideal variable to model vegetation change.*” The preferred approach would be to model vegetation cover with the two variables that LADWP found directly influence perennial cover in its path analysis.

To demonstrate why the vegetation model should have DTW in it and not a climatic index such as the 5-yr moving average of Sawmill Creek runoff, the County Response applied LADWP’s vegetation model to Blackrock 99 that has a shallower water table. This was a ‘toy example’ to demonstrate the obvious fact that LADWP’s model omits a critical hydrological variable, DTW. LADWP writes in defense of the obvious shortcoming of its model:

*“The Blackrock 94 vegetation regression model was not designed to be applied to Blackrock 99, which experiences totally different hydrologic and ecological processes and had a distinctly different initial environmental condition” (LADWP closing report, p. ES-11).*

It is unclear what LADWP means by “totally” different. The adjacent parcels are actually quite similar. Regardless, LADWP’s statement further advances the County’s point. If LADWP’s model cannot be applied to an alternate hydrologic scenario such as a shallower water table, what is its value in estimating the vegetation condition under the no pumping scenario that has an even shallower water table? It is evident that LADWP’s model cannot be used to fulfill the Water Agreement’s requirement that the Technical Group assess whether the measurable change would not have occurred but for groundwater pumping. In comparison, the County’s model can predict vegetation cover in both Blackrock 94 and Blackrock 99 accurately because it includes DTW and is applicable over a range of DTW.

## County’s vegetation model

The importance of depth to water on groundwater dependent vegetation is well established. ICWD included DTW and precipitation in its regression model and, contrary to LADWP’s assertion that this is a ‘new model’ developed by the County (LADWP closing report, p. ES-12), this model was presented in the County’s 2011 report:

*To determine the relative effect of water-year precipitation versus depth to groundwater (DTW) on perennial vegetation in Blackrock 94, a multiple linear regression of both live cover from the Green Book program and SMA data were conducted against DTW and precipitation (ICWD report 2011, p. 44)*

The only difference in the County’s most current version of its model is that DTW values were grouped into different depths and thus considered a categorical variable rather than a continuous variable. This is a reasonable way to structure the DTW variable because the response of vegetation to DTW is not linear owing to rooting depth limits. In other words, there are non-linear thresholds in the potential cover of groundwater vegetation as depth to water increases.

To estimate the regression coefficients for the shallow DTW levels, the County used vegetation-DTW relationships from neighboring Blackrock 99 in addition to Blackrock 94. LADWP disagrees with the validity of this approach because it believes this adjacent parcel is hydrologically dissimilar. The County agrees that Blackrock 99 is hydrologically dissimilar. It is because Blackrock 99 was ecologically similar during baseline and hydrologically dissimilar since baseline that it was used to estimate the vegetation response over the range of DTW that was largely missing from the Blackrock 94 dataset owing to rapid drawdown in the late 1980s.

The line point vegetation data for Blackrock 94 are missing key years (1987-1990) when the water table was shallower. The line point data set only contains a single vegetation estimate with DTW shallower than 3.7 m. The SMA data set is a complete record since baseline allowing the DTW-vegetation relationship under a shallower water table to be quantified. In Fig. 3, the two data points for Blackrock 94 in the 0.0-1.8 m range correspond to 1985 and 1986. The

single data point in the 1.8-3.1 m range corresponds to 1987; and by 1988 DTW had fallen to 3.9 m, after which the water table never recovered to shallower depths.

Without pumping, the DTW under Blackrock 94 was estimated to not exceed on average 2.5 meters. Since there was only a single vegetation estimate in the 1.8 to 3.1 m DTW range in Blackrock 94, the County supplemented vegetation estimates at these shallow DTW levels from Blackrock 99. When DTW values were similar between Blackrock 94 and Blackrock 99, vegetation conditions were also similar. It is justified to parameterize the vegetation model using DTW-vegetation relationships from all relevant data. To contest this approach, LADWP writes:

*Combining two vegetation parcels, Blackrock 94 and Blackrock 99 to estimate DTW, is wrong because two of the most important assumptions are violated. The first assumption that the similar vegetation condition observed in two parcels was solely due to similarity in the water table condition is not satisfied as DTW conditions of two parcels would have been completely different. The second assumption, that the mechanism or process of groundwater recharge must be similar is not satisfied either because these two parcels do not share the same recharge mechanism.*(LADWP Closing Report, p. 49)

LADWP's contention that data from Blackrock 99 should not be used for comparison to Blackrock 94 has already been addressed extensively in the County Response (pp. 55-72). Here LADWP expounds on the same arguments and the County again points out its inconsistencies. LADWP's understanding of what the County did is wrong. The County did not combine two parcels to "estimate DTW". The parcel average DTW was estimated from kriging of nearby water table measurements. What the County did do was use SMA data and the DTW values from the two parcels to develop its regression model for each DTW level. Importantly, this facilitated quantification of the relationship between vegetation cover and DTW at the DTW levels that would have occurred without groundwater pumping.

LADWP proposes what it calls the "two most important assumptions" that must be satisfied to quantify the relationship between DTW and vegetation. The first of these assumptions LADWP states as "that the similar vegetation condition observed in two parcels was solely due to similarity in the water table conditions". The County would rephrase this to make it clearer to the reader.

What LADWP probably means is that the County assumes that the response of vegetation to DTW is similar across the two parcels. Circumstances where this would not apply would be different vegetation communities, which may respond differently to changes in DTW. However, these two parcels were ecologically similar, composed of the same species as would be expected given they neighbor one another. Blackrock 94 and Blackrock 99 were both mapped in the baseline vegetation inventory as alkali meadow, Type C, vegetation. Type C vegetation is defined in the Water Agreement as "comprised of grasslands/meadow vegetation communities with evapotranspiration greater than precipitation. The communities comprising this classification exist because of high groundwater conditions, natural surface water drainage, and/or surface water management practices in the area, i.e., conveyance facilities, wet year

*water spreading, etc*” (Water Agreement, p. 9). LADWP has presented evidence that water has been spread on both Blackrock 94 and 99 (e.g., LADWP Closing Report, pp. 39 and 73, and elsewhere). The County does not dispute that both parcels have been subject to episodic and variable inputs of surface water; however, this is a similarity, not a contrast, between the parcels and cannot explain the divergent trends in vegetation.

The generalizability of the County’s model is supported by the observation that cover values are similar when DTW values are similar (Fig. 3). LADWP on the other hand asserts this assumption is not satisfied “*as DTW conditions of the two parcels would have been completely different.*” The assumption does not, however, require that DTW level between the two parcels mirror one another over time, but rather that the relationship between vegetation and DTW is consistent over time. These are important differences and critical to analysis of LADWP contentions.

LADWP’s second proposed assumption actually does not need to be met to quantify the DTW-vegetation relationship. LADWP states “*The second assumption, that the mechanism or process of groundwater recharge must be similar is not satisfied either because these two parcels do not share the same recharge mechanism*”. Regardless of the specific mechanisms or sources of recharge that buffered Blackrock 99 from the effects of groundwater pumping, DTW is DTW and vegetation responds to DTW not the specific groundwater recharge mechanism. There is no physiological reason and no explanation given by LADWP why plants would respond differently to recharge from Sawmill Creek versus the LA Aqueduct versus flowing wells in Blackrock 99. The contrast between the parcels that affects vegetation condition is DTW.

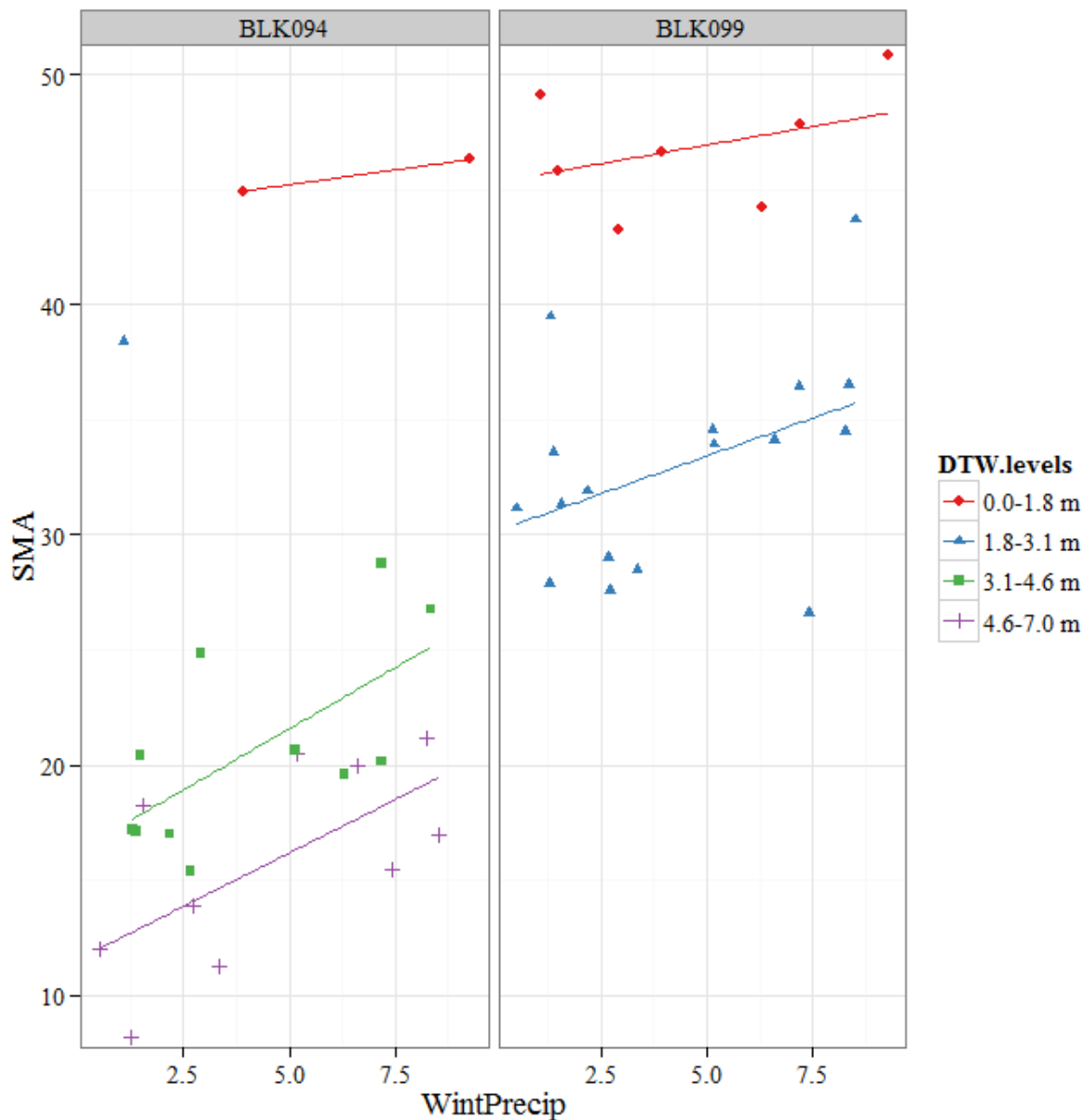


Figure 3. Effect of DTW on vegetation cover and the relatively smaller effect of precipitation. During baseline Blackrock 94 and Blackrock 99 DTW and cover were similar. By the 1990s DTW increased in Blackrock 94 and cover declined in association. Blackrock 99 DTW only increased to the 1.8-3.1 m level, which is the level that would have been maintained in Blackrock 94 under the no pumping scenario (reproduced from the County Response, Fig. 15, p. 46)

In the summary of LADWP's Closing Response on p. 77, it states that:

*ICWD's most recent attempts in ICWD, 2014 to corroborate its theory that vegetation conditions in Blackrock 94 were due to high groundwater levels in 1986 and have permanently and irreversibly changed from those described during the initial inventory*

*fail for many reasons. In these attempts, ICWD ignored the effects of water spreading during the 1978-1986 and 1995-1998 wet periods and discarded analysis based upon actual field data in favor of simulated outputs from models that utilize the simulated outputs of other models as the basis of their conclusions.*

LADWP's assertion that ICWD ignored spreading is false. If LADWP had investigated its data closer, as the County has repeatedly pleaded, it would find that spreading and precipitation are highly related as expected (Fig. 4). Spreading occurs in years of high runoff and precipitation, an association that LADWP has identified. Inclusion of the spreading variable in addition to precipitation would introduce redundant information into the vegetation model similar to LADWP's error of including DTW and the 5-yr moving average runoff variable in the same model during its model selection routine. The modeled effect of precipitation on vegetation cover represented by the slopes in Figure 3 accounts for the statistical effect of spreading because according to LADWP's data, water is not available for spreading when precipitation is less than 6 inches (Fig. 4). The effect of this covariance between spreading and precipitation is to accentuate the statistical effect of the included precipitation variable on vegetation cover. It is worthy to point out that LADWP challenges the County for not considering the influence of spreading while at the same time, it chose to exclude a spreading variable from its vegetation model.

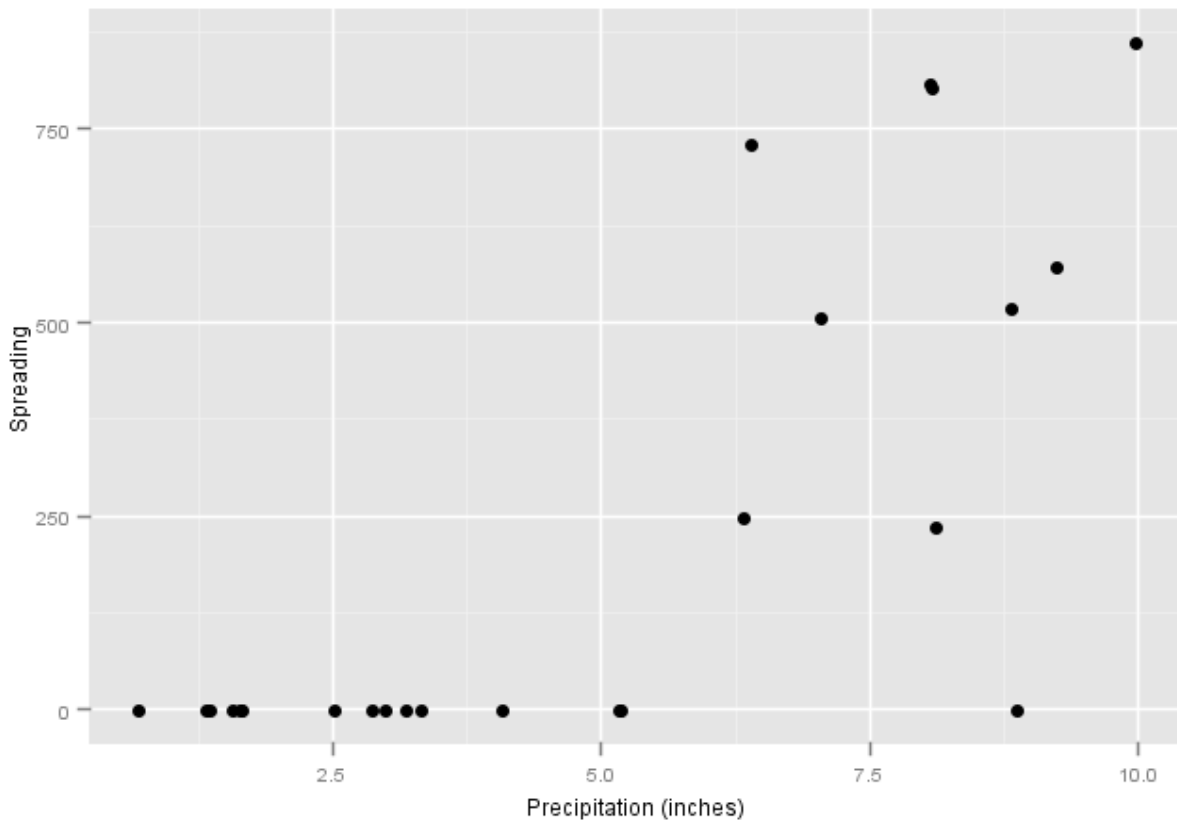


Figure 4. Relationship between spreading and precipitation from LADWP's data set provided in LADWP Evaluation (Table 17, page 76).

Precipitation is one of two variables included in the County's model. As already stated in the County Response, the change in vegetation cover is small as precipitation varies from 0 to 10 inches compared to the change in vegetation cover as DTW moves from 0-1.8 m to greater than 4.6 m (Fig. 3). Given the relatively weak effect of precipitation and spreading on vegetation cover compared to the effect of DTW on cover, the notion that spreading is more important than DTW in controlling vegetation cover is unsupported.

Further, the County did not discard analyses based upon 'actual field data' in favor of simulated outputs from models. The County has made extensive use of 'actual field data' in its analysis. It was LADWP, based on a number of scientifically-flawed arguments that sought to exclude the County's line point data showing the vegetation change in Blackrock 94. Now in its current attempt to discount the peer-reviewed SMA method of Elmore *et al.* (2000), LADWP makes an about face and asserts the line point data are accurate and any difference shown in these different cover measures is now due to the inherent inaccuracies in cover estimates derived from satellite-borne imagery. The County's assessment of vegetation using both techniques yielded similar conclusions.

### **LADWP's critique of spectral mixture analysis (SMA)**

LADWP spends a considerable amount of time arguing that the fractional cover variable derived from Landsat TM satellite imagery does not perfectly match the average parcel perennial cover estimated from a sample of line point transects at an earlier point in the growing season. It is well known that the SMA fractional cover derived from imagery in late summer, when annuals have mostly senesced, is a different measure than the average cover computed from a random sample of line point transects in early July. Previously, LADWP concluded that *"Based on this assessment, the quality of data collected in BLK094 since 1991 and its usefulness in accurately assessing vegetation change in the Owens Valley should be called into question. Any analyses and conclusions reached from those data should be viewed cautiously."* (Attachment 11 p. 5, Inyo County Initial Brief). Now LADWP uses those data to attempt to discredit the County's analysis based on available satellite data. In both instances, the County disagreed with LADWP's assessment and made appropriate interpretations from available data cognizant of the strengths and weaknesses of each data set. A main reason that the line point data and SMA values are not expected to correspond are due to differences in the timing of when the line point sampling was conducted and when satellite imagery was acquired. LADWP dedicates a discussion to this effect, so it is a bit perplexing why it takes issue with the fact that SMA data representing perennial cover in late summer doesn't match line point data from peak growing season.

Importantly, regardless of the reasons why these two different methods differ in their cover estimates, LADWP's argument for why the SMA data should not be given consideration is based on the premise that cover estimates from SMA must replicate the line point data estimate

to be a relevant and valid. That premise is false. There is no evidence that the SMA data are an inaccurate representation of the perennial vegetation conditions at the time the image was taken. What matters is that SMA data are internally consistent; in other words, SMA data can be compared to SMA data. An advantage of the SMA is that it is based on an image of the entire parcel and therefore the average fractional cover of all the grid cells within the parcel can be used to make legitimate comparisons that are internally consistent. LADWP used this desirable feature of the SMA data set in their own report to depict vegetation patterns and hypothesized spreading effects within Blackrock 94 (LADWP Closing Report, p. 69-72). Baseline vegetation cover is higher than all following years, and the relative change over time is a valid measure of vegetation change. The direction of changes in SMA and the line point data are similar because they are both adequate for change detection (Fig. 25, p. 84, LADWP Closing Report). A large advantage of the SMA dataset with respect to this particular evaluation is that the most important change occurred during a period not represented by the line point data set (1987-1990). This period is represented in the SMA dataset, thus it is absolutely relevant to the evaluation of attributability.

Lastly, in a bizarre attempt to expunge the SMA dataset from consideration by the Technical Group, LADWP makes a claim that SMA should not be used outside of the 33 monitoring sites that were used to assess its accuracy in Elmore *et al.* (2000). The recommendation is misguided because the advantage of remote sensing is to obtain spatially extensive data beyond what LADWP calls the 'intended design parameter' (LA Closing Report, p. 67). If the 'intended design parameter,' to use LADWP's terminology, was solely the 33 monitoring sites, remote sensing is a hypercomplex solution to a simple problem (i.e., field personnel could just measure vegetation at these 33 sites, as Inyo and LADWP actually do).

In the County's view, SMA vegetation cover derived from satellite imagery, line-point measurements by the County and LADWP, permanent transects at monitoring sites, and photographs of vegetation condition are all relevant data to the question at hand, and each data set has strengths and weaknesses. Throughout this process, LADWP has attempted to limit the data under consideration by the Technical Group, but this is contrary to scientific collaboration and the advancement of knowledge.

Interestingly, immediately following its argument for why the County's analysis using SMA data should not be considered, LADWP decides to use the SMA data itself in its own analysis. In support of their contention that baseline vegetation cover was supported not by shallow groundwater in combination with surface water but rather solely by surface water spreading LADWP states:

*"The 1986 SMA map provides an incredibly clear picture of the processes affecting vegetation in the parcel in 1986 (LA Closing Report, p. 70)"*

The County agrees with LADWP that SMA provides *an incredibly clear picture of the processes affecting vegetation in the parcel*; and that is one of many reasons the County uses SMA in its analyses.



## Control Parcels

LADWP, on page 79, states:

*“...ICWD left out the most important criteria for selecting a control parcel when attempting to control for the effects of pumping: the control parcel should not be affected by pumping!”*

Elsewhere, and in conflict with the statement above, LADWP argues that Blackrock 99 is different from Blackrock 94 because Blackrock 99 is hydrologically buffered by the effects of flowing well return ditches, the LA Aqueduct, and topographic position. We agree that this concept is applicable. These hydrologic features maintained a high water table in Blackrock 99, but Blackrock 94 does not have such features, so it is affected by pumping. Other relevant factors such as soils, precipitation, and baseline vegetation condition are similar between the two parcels, a necessary requirement for a control/response pair that is not met by the parcels chosen by LADWP.

LADWP apparently believes that an effect cannot be measured unless the ‘treatment’, in this case the effect of pumping, is either present or absent. But the effect of different treatment levels is a common experimental design. The objective has always been to elucidate the effect of pumping on vegetation. Put simply, Blackrock 94 has been affected by pumping more than Blackrock 99, and the vegetation has changed in Blackrock 94 more than in Blackrock 99. LADWP would have the reader believe that this effect cannot be measured.

LADWP also defends its comparison to its ‘control’ parcels that have different initial DTW values, vegetation conditions and soil characteristics than Blackrock 94. LADWP provides a ‘mini tutorial’ on what it views a control is in a statistical sense on pp. 78-81 in their Closing Report. On p. 81, LADWP states that its controls are appropriate controls because “*they contain similar vegetation cover/communities.*” LADWP’s assertion in this regard is completely false. Despite this misinformation, it is a fact that the line point data show grass cover in LADWP’s ‘control parcels’ was half that of Blackrock 94 during baseline (County Response, p. 58-59). LADWP criticizes the County’s comparison to Blackrock 99 because it was classified as a wellfield parcel, lower in elevation, receives irrigation, and receives direct infiltration from ditches and the Los Angeles Aqueduct. The elevation of Blackrock 99 is closer to Blackrock 94 than any of LADWP’s controls. Moreover, LADWP’s latest argument is that Blackrock 94 vegetation is driven by direct infiltration from ditches. Thus, its complaint that Blackrock 99 is influenced in the same way would support its use as a control site to evaluate pumping effects not invalidate its use.

## Surface Water Spreading

The clearest statement of LADWP’s assessment of attributability of vegetation decline in Blackrock 94 is, “*As a result, the alleged decline in vegetation cover is mainly due to the*

*presence or absence or quantity of surface water spreading.*” (LADWP Closing Report, p. 69). Evidence put forth by LADWP to support its conclusion that vegetation change was due to reduction in spreading and lower runoff since baseline; 1) included a correlation analysis relating vegetation cover to precipitation and the 5-year moving average of Sawmill Creek runoff, 2) examples of spreading events since baseline, and 3) speculation that spreading in 1986 was responsible for baseline conditions, not shallow groundwater. The County’s evaluation of the correlation analyses was discussed above. Points 2 and 3 are discussed in this section.

LADWP described several instances of surface water entering Blackrock 94 since baseline as evidence that spreading affects vegetation. However, the LADWP Closing Report simultaneously argues that Blackrock 99 is an inappropriate control because, *“Blackrock 99 is irrigated, Blackrock 94 is not”* (LADWP Closing Report , p. 23) creating another example of contradictory statements and situational reasoning in LADWP’s briefs and reports. LADWP’s observations of spreading since baseline are of little value because it is unlikely that water spreading in Blackrock 94 since baseline caused the loss of cover and grasses. What is evident is that spreading locations and amounts since baseline have varied considerably and that the areas of Blackrock 94 affected by spreading visible on the satellite images and air photos were small. LADWP failed to note that water spreading in amounts similar to 1986 (estimated at 861 ac-ft, LADWP Evaluation) occurred in 2005 and 2006 (precipitation was above average and similar to 1986) when the water table was deeper. Vegetation in the parcel in those years did not recover to baseline. Apparently, in the absence of a shallow water table, spreading since baseline only increased cover in areas where water was directly applied which comprised a small portion of the parcel (Inyo County, February 3, 2011 report, Appendix A, pp. 88-89). Under those conditions, the effect was localized because most of the parcel was not directly affected, and the groundwater recharge from spreading was insufficient to raise the water table to depths that could contribute to available soil water. Whereas, in 1986, spreading when the water table was shallower likely provided sufficient recharge to raise the water table to depths sufficient to benefit a large portion of the parcel. Based on the localized effect when amounts similar to baseline were spread in recent years, that hypothesis is more plausible than the speculative, parcel-wide spreading now proffered in LADWP’s Closing Report.

LADWP’s Closing Report has introduced new unsubstantiated and unverifiable information on ditches and water flow paths in Blackrock 94 that existed in 1986 (LADWP, Closing Response, Figure 20). The source of those data is unknown and the data have not been provided to the Technical Group or the County. Ironically, to identify spreading locations in 1986, LADWP relied on indirect evidence from the County’s satellite data (SMA) which it characterizes as unreliable and inaccurate. LADWP acknowledged that, *“...direct water accounting data for spreading on Sawmill Creek has only been available from 1989 through the present.”* (LADWP Evaluation, p. 194). No independent or actual evidence to demonstrate what water conveyances were active in 1986 and the amount of water conveyed were provided. The County recognized that spreading occurred before, during and after baseline period, but refrained from speculating on the effects of surface water spreading in 1986 for which data are lacking. LADWP’s assertion that high cover areas on the SMA map are coincident with pathways of hypothesized water

spreading cannot be corroborated, and the related suggestion by LADWP that vegetation cover in Blackrock 94 in 1986 was not supported by a higher water table was shown above to be demonstrably false.

LADWP dedicated much of their Closing Response to demonstrating that “... *all conclusions, results and inferences based on the SMA data are flawed and should be discounted. Modeled SMA-estimated cover cannot be used as a substitute for physical line-point measurements of vegetation cover.*” (LADWP Closing Report , p. ES-14). In its examination of the conditions and spreading in 1986 , LADWP further states, “*First of all, SMA-estimated cover is not accurate or reliable, and cannot detect any change in species composition.*” and “*Although the overall predictive capabilities of ICWD's SMA model are unreliable.....The 1986 SMA map provides an incredibly clear picture of the processes affecting vegetation in the parcel in 1986 because it shows which parts of the parcel were wet or dry even though absolute values of SMA-estimated cover are unreliable.*” (LADWP Closing Report, p. 69-70). On the one hand LADWP discounts the SMA entirely, and yet, on the other hand uses that data to analyze attributability. Such contradictory statements are seemingly inserted when it is convenient for LADWP in order to discount the County’s results and conclusions, rather than provide a cogent scientific analysis. Concerning detecting species composition from SMA, no claim was ever made by the County or by Elmore et al. (2000) that SMA detects species composition; it clearly does not.

LADWP has previously argued that the baseline vegetation conditions documented in 1986 for the Long Term Water Agreement were inappropriate because the preceding period of high runoff resulted in unusually high vegetation cover (LADWP Response Brief, p. 24, lines 13 to 21, page 25, lines 1 to 10.) That sentiment has surfaced again in the Closing Response in the form of a speculative evaluation of spreading that occurred in 1986 to ascribe the vegetation decline in Blackrock 94 to runoff variability or wet/dry cycles.

In its Closing Report LADWP postulated that, “...*the parcel (Blackrock 94) cannot support a “meadow community” because “meadow” has been maintained by surface water spreading (and direct precipitation when available), and not because of a high water table.*” (LADWP Closing Report, p. 76-77). The false statement regarding the water table depth during 1986 was addressed above. Soil properties and classification for most of Blackrock 94 and nearly all of Blackrock 99 suggest that they formed under and would naturally support grass vegetation (County Closing Response, p. 62-65). The soils also indicate their formation was influenced by a shallow water table; the meadow present during baseline was not an artifact of LADWP’s management of Sawmill Creek. Blackrock 94 was mapped and classified in the LTWA as Type C grassland/meadow vegetation. The LTWA recognized that these communities “...*exist because of high groundwater conditions, natural surface water drainage and /or surface water management practices in the area, i.e., conveyance facilities, wet year water spreading.*” (LTWA Sec II. C). It is not entirely clear if LADWP is now arguing the parcel was classified incorrectly. In that case, a solution would be for the Technical Group to modify the LTWA to redesignate Blackrock 94 and 99 as Type E, areas where water is provided to City-owned lands. Neither party has brought such a proposal forward to the Technical Group. Regardless, the Panel’s

Findings and Partial Interim Award defined the purpose and proper consideration of the baseline data in this dispute (p. 10):

*“Both the LTWA and the Green Book clearly express that the 1984-87 vegetation inventory performed by LADWP staff is the baseline for comparisons with vegetation data gathered after 1991. Both parties to the LTWA knew how the 1984-87 vegetation inventory was done and under what climatic conditions it was made. Knowing this and the uncertainties and risks involved, the parties established the 1984-87 inventory without adjustments or modifications for how it was made, or for the climatic conditions under which it was made. To modify or adjust the 1984-87 inventory as baseline would require modification as provided for in Section XXV of the LTWA. Neither party has submitted evidence that the baseline has been so modified. The 1984-87 vegetation inventory is the baseline. This Panel will not consider any changes to the baseline to take into consideration how it was made, or for the climatic conditions under which it was made.”*

The question that must be addressed by an attributability analysis under the LTWA is, *“..if the decrease, change or effect would not have occurred but for groundwater pumping and/or a change in past surface water management practices.”* (Sec. IV.B). Because groundwater pumping as well as variation in runoff and associated water diversions for spreading can affect vegetation in Blackrock 94, a credible attributability analysis must attempt to partition the effect of runoff and groundwater pumping on the water table, soil water, and vegetation conditions. LADWP has provided no credible quantitative estimate of the relative magnitude of runoff and pumping on change in water table depth in Blackrock 94. Simply pointing out that runoff, spreading and vegetation cover have varied over time is insufficient evidence to rule out the effect of groundwater pumping on the vegetation. Regardless of how the parcel got wet in 1986, the County has shown that the water table would not have dropped severely and the soil probably would have stayed wet if pumping had not affected the parcel since baseline. Coupled with the continued sporadic spreading events and shallow water table in or just below the rooting zone, it is reasonable to suspect the present vegetation would resemble baseline conditions (even after natural disturbances such as fire). The County’s hydrological and vegetation modeling, and comparison of Blackrock 94 with Blackrock 99, support that contention.

## Summary

LADWP presented the County with a report on the premise that it needed to respond to *“vast amounts of new data relating to satellite imagery analysis, soil moisture analysis, groundwater modeling, and hypothetical scenarios”* that was in the County Response to the LADWP Evaluation. In the LADWP Report, we found no identification of or discussion of any new data; instead, LADWP revisited a broad range of issues that had already been extensively analyzed and briefed between the two parties.

In this reply, we addressed the most substantive and determinative issues raised in the LADWP Report: the alleged change to the County's conclusions, the applicability and use of groundwater models in determining attributability, soil water conditions at monitoring sites, determination of whether the measured vegetation change would have occurred without pumping, effects of surface water spreading, utility of satellite-derived vegetation cover, and choice of control areas. Here, and in previous work, the County relied on two independent modes of investigation to ascertain whether groundwater pumping or varying runoff conditions since baseline contributed to the change in vegetation; modeling of groundwater and vegetation conditions in the absence of groundwater pumping and comparison of Blackrock 94 with a control. The County's investigation of attributability included all factors prescribed by the Green Book. Recognizing that all data sets have inherent strengths and weaknesses, the County has endeavored to include and analyze all relevant data.

The County reached its conclusions based on careful analysis of the relative effects of groundwater pumping, wet/dry cycles, and other factors on the hydrology, soil water and vegetation in Blackrock 94 and neighboring Blackrock 99. The County has shown:

- The water table in 1986 was shallow enough to support the baseline groundwater dependent meadow vegetation.
- Groundwater modeling results show pumping in the late 1980's caused much greater declines than drought and associated reduced surface water diversions alone.
- The groundwater decline resulted in lack of available soil water in the plant root zone at Blackrock 94.
- A decline in vegetation cover was first evident in 1991 and a change in vegetation composition from Type C to Type B is occurring but has not yet crossed the threshold between the vegetation Water Agreement Types.
- Groundwater modeling results suggest that in the absence of pumping, the water table fluctuations would have been of similar magnitude as observed at control parcels unaffected by pumping.
- Groundwater and vegetation modeling and straightforward interpretation of soil water measurements show that in the absence of pumping, the water table would have remained shallow enough to supply groundwater to the plant rooting zone and the decline in vegetation cover would not have occurred.
- A neighboring meadow affected by the same drought conditions but little affected by pumping did not experience water table decline, lack of available soil water, or vegetation decline.

Over the course of this dispute, LADWP argued that groundwater modeling, DTW estimates, interpretations of soil water measurements, line-point vegetation data, most statistical methods, satellite-derived SMA cover, data from permanent transects, photographs of vegetation condition, the selection of a control parcel, and vegetation modeling by the County should be disregarded. The County has shown each and every one of these arguments to be lacking in substance. In LADWP's Closing Report, it was argued that the Technical Group should eschew model results, estimates, and simulations in favor of actual data. The County concurs that

actual data are valuable and essential for the task set for the Technical Group, as shown by the County's inclusion of all relevant data sets. However, to fulfill the Water Agreement's requirement that the Technical Group determine whether a change in vegetation would not have occurred but for groundwater pumping or changes in surface water management, it is necessary to examine hypothetical scenarios of no-pumping or constant surface water management. That can only be done using models or comparison with controls.

The County concluded that while both runoff and pumping contributed to water table fluctuations in Blackrock 94, the water table decline, lack of available soil water, and coincident vegetation decline would not have occurred but for LADWP groundwater pumping. LADWP's conclusion that the vegetation decline was caused by reduced surface water diversions caused by lower runoff conditions alone is inaccurate and thoroughly refuted by the multiple lines of evidence developed by the County. Because the County's analysis relied on multiple independent data sets, and two corroborating independent lines of investigation, we have shown to a reasonable scientific certainty that a significant decline in vegetation cover has occurred and a trend toward a change from Type C to Type B is occurring, and that the vegetation change is attributable to LADWP groundwater pumping and significant.

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