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September 6, 2011

Dr. Robert Harrington, Director
Inyo County Water Department
P.O. Box 337
Independence, CA 93526-0337

Dear Dr. Harrington:

Subject: Los Angeles Department of Water and Power Review of the Inyo County Water Department Analysis of Conditions of Vegetation Parcel Blackrock 94

In July 2007, the Technical Group received a letter from the California Native Plant Society (CNPS) stating that vegetation degradation was proceeding rapidly in vegetation parcel Blackrock 94 (BLK094) in the Thibaut-Sawmill Wellfield. Based on an examination of vegetation and hydrologic data, the CNPS concluded that serious negative trends in ecosystem condition are occurring at BLK094. The CNPS consequently recommended that the pumping management in the area be altered to avoid an impact by reducing groundwater pumping at the Blackrock Fish Hatchery from its present level of about 12,000 acre-feet per year to 8,000 acre-feet per year. In response to this letter, in mid-year 2009, the Technical Group agreed to examine the issue based on the *Agreement Between the County of Inyo and the City of Los Angeles and its Department of Water and Power on a Long Term Groundwater Management Plan for Owens Valley and Inyo County* (Water Agreement) provisions for determination of a significant effect on the environment.

The Water Agreement (Section IV.B.) provides a three-step evaluation for determining whether an impact to the environment will or has occurred. First, the effect must be measurable. Second, if an effect is measurable, its causes are evaluated as to whether the effect is attributable to LADWP groundwater pumping and/or a change in past surface water management practices. Third, if the effect is due to groundwater pumping and/or a change in past surface water management practices, its degree of significance is evaluated. On February 2, 2011, the staff of the Inyo County Water Department (ICWD) completed a report that in part focused on evaluation of physical factors relevant to vegetation in the parcel and how BLK094 compared to other areas. This report concluded that there was a measurable change in the vegetation of BLK094 from the initial vegetation inventory.

The City of Los Angeles Department of Water and Power (LADWP) staff has reviewed the analysis provided in the ICWD Analysis of Conditions in Vegetation Parcel Blackrock 94 and finds that in many instances there is inadequate information provided in the report to complete a thorough analysis. LADWP still has many questions regarding how and why many of the analyses were performed. Staff will continue to work on an evaluation and will likely have more comments and questions forthcoming. However, at this time please find enclosed LADWP's report in response to the ICWD Vegetation BLK094 Analysis which is our initial thoughts regarding the ICWD analysis and conclusion that there has been a measurable change in the vegetation from the initial vegetation inventory, as well as the data collection methodology and analyses performed to arrive at ICWD's findings.

If you would like to have your technical staff meet with LADWP staff, or have any questions, please contact Mr. Robert P. Prendergast, of my staff, at (760) 873-0209.

Sincerely,

Clarence E. Martin
Assistant Aqueduct Manager

DWM:bs:src
Enclosure
c w/enc: Mr. Robert P. Prendergast

LADWP Response to ICWD Vegetation BLK094 Analysis

City of Los Angeles
Department of Water and Power
August 31, 2011

1. Background

In July 2007, the Technical Group received a letter from the California Native Plant Society (CNPS) stating that vegetation degradation was proceeding rapidly in vegetation parcel Blackrock 94 (BLK094) in the Thibaut-Sawmill wellfield. Based on an examination of vegetation and hydrologic data, the CNPS concluded that serious negative trends in ecosystem condition are occurring at BLK094. The CNPS consequently recommended that pumping management in the area be altered to avoid an impact by reducing groundwater pumping at the Blackrock Fish Hatchery from its present level of about 12,000 acre- feet per year to 8,000 acre-feet per year. In response to this letter, the Technical Group agreed to examine the issue based on the Inyo-Los Angeles Long-Term Water Agreement's (LTWA or the Agreement) provisions for determination of a significant effect on the environment.

The LTWA (Section IV.B.) provides a three-step evaluation for determining whether an effect is significant. First, the effect must be measurable. Second, if an effect is measurable, its causes are evaluated as to whether the effect is attributable to LADWP groundwater pumping and/or a change in past surface water management practices. Third, if the effect is due to groundwater pumping and/or a change in past surface water management practices, its degree of significance is evaluated. On February 2, 2011, the staff of the Inyo County Water Department (ICWD) completed a report that in part focused on evaluation of physical factors relevant to vegetation in the parcel and how BLK094 compared to other areas. This report concluded that there was a measurable change in the vegetation of BLK094 from the initial vegetation inventory.

The City of Los Angeles Department of Water and Power (LADWP) staff has reviewed the analysis provided in the ICWD *Analysis of Conditions in Vegetation Parcel Blackrock 94* and disagree with the conclusion that there has been a measurable change in the vegetation from the initial vegetation inventory, as well as the data collection methodology and analyses performed to arrive at ICWD's findings.

2. BLK094 Site Description

BLK094 is located south of Big Pine and north of Independence, California on both sides of Highway 395 (Figures 1 and 4). This parcel is directly south and southeast of 8 Mile Ranch and west of the Blackrock Fish Hatchery and the Los Angeles Aqueduct. BLK094 is quite heterogeneous with regard to vegetation cover across its landscape. This is due to several factors, but primarily because this vegetation parcel encompasses three Ecological Sites derived from 3 distinct soil types (NRCS, 1993). The north end of the parcel is classified by the National Resources Conservation Service (NRCS) as a Gravelly Loamy Sand Ecological Site (MLRA 29-18). If the remainder of the parcel were divided in half, the western half is classified as a Saline Meadow Ecological Site (MLRA 29-2) and the eastern half of the parcel is classified as a Saline Bottom Ecological Site (MLRA 29-7) (Figure 1).

Gravelly Loamy Sand Ecological Site soils are typically very deep and well-drained to somewhat excessively well-drained. They are formed in alluvium from granitic sources. Surface textures are sands and loamy sands. The dominant plant species for this ecological site are shadscale (*Atriplex confertifolia*) and Indian ricegrass (*Achnatherum hymenoides*). Approximate vegetative cover (basal and crown) for this Ecological Site is 20 to 35 percent.

Saline Meadow Ecological Site soils are very deep and range from well-drained to poorly-drained. They are formed in mixed alluvium and lacustrine sediments. Surface textures are loamy sands, sandy loams, loams, and silt loams. The dominant plant species for this site are alkali sacaton (*Sporobolus airoides*), inland saltgrass (*Distichlis spicata*), saltbush (*Atriplex sp.*), and rabbitbrush (*Ericameria sp.*). Approximate vegetative cover (basal and crown) for this Ecological Site is 40 to 80 percent.

Saline Bottom Ecological Site soils range from very deep and poorly drained to well-drained. They are formed in mixed alluvium and lacustrine sediments. Surface textures are sands, sandy loams, loamy sands, and loams. This division has hardpan from 14 to 20 inches. The dominate vegetation at this site is Alkali sacaton, inland saltgrass, black greasewood (*Sarcobatus vermiculatus*), shadscale, and Parry saltbush (*Atriplex parryi*). Approximate vegetative cover (basal and crown) for this Ecological Site is 20 to 40 percent.

Vegetation cover also varies due to annual surface water availability, as the parcel receives irrigation water from 8 Mile Ranch along its north end (Figure 6). In addition, there was a large wildfire that burned a majority of the parcel in the spring/early summer of 2007 known as the Inyo/Complex Fire. This fire burned at such intensities that entire vegetation stands were removed (LADWP Staff Observation, 2008).

3. Issues Associated with ICWD Vegetation Re-inventory

ICWD Sampling Methods

The Green Book for the Long-Term Groundwater Management Plan for the Owens Valley and Inyo County (Green Book) describes the methodology of the Initial Vegetation Inventory conducted in 1984-1987 below:

"Transects were located visually by choosing lines that appeared to cover the representative units of vegetation within the parcel. With regard to the parcel area, transect locations were generally toward the center of the parcels in order to avoid transitional areas at the parcel edges."(Green Book Section II.A.2.vi)

In addition, areas of disturbance were avoided as they were not representative of the vegetation. Ditches, roads, livestock supplement and bedding areas and other areas of disturbance were omitted as sampling areas (as personally observed by LADWP staff while assisting in the initial vegetation inventory).

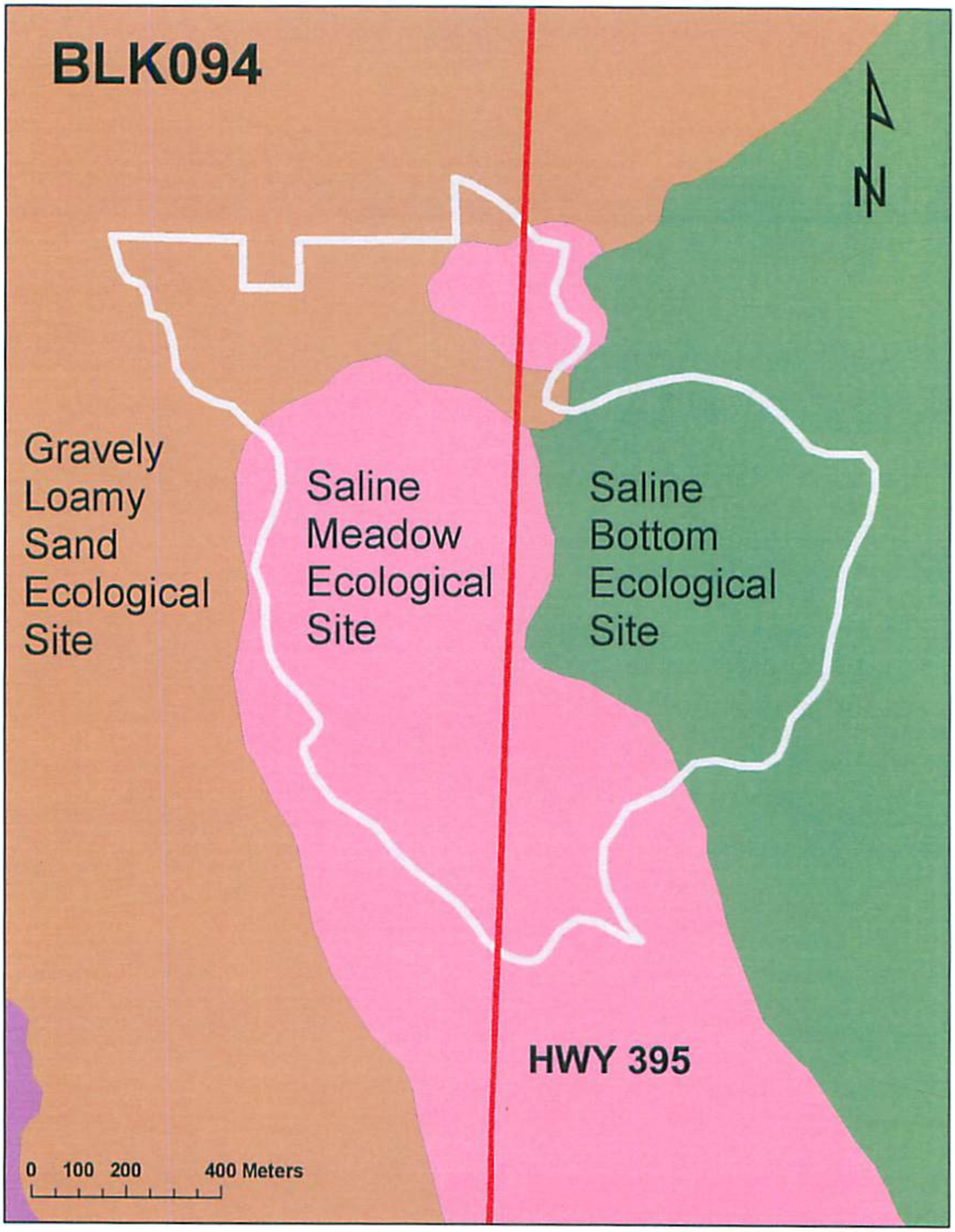

Figure 1. Ecological Site locations within the boundaries of BLK094.

The first re-inventory by ICWD staff occurred in 1991. The first parcels selected for re-inventory were conducted jointly by ICWD and LADWP. All parcels with monitoring sites and other parcels classified as Type B or Type C vegetation (under the Green Book) located inside and outside wellfields were selected for data collection. The first claims of vegetation change were made by ICWD in November of that year, the second in March of 1992. Both times LADWP expressed concern and questioned the methods as well as the results. LADWP objected to annual randomly selected transects and stated that to monitor change over time, transects should be permanently located. In addition, LADWP stated that the Green Book discussed permanent changes in vegetation and, therefore, accurate conclusions about vegetation change could not be made when significant drought conditions were persisting.

ICWD unilaterally began selecting parcels for monitoring and continued to run randomly located transects without agreement from the Technical Group. The Technical Group was not consulted regarding where or how the sampling or analyses were conducted, despite repeated attempts for more involvement from LADWP staff. (Documented by letters from Robert Wilson of LADWP to Greg James of ICWD, 1991 and 1992.)

In October 2000, ICWD filed a dispute over the operations of the McNally Canals. One line of evidence presented was an ICWD assertion of vegetation change again relying on data that was solely collected and analyzed by ICWD. During that time, LADWP staff observed ICWD running transects across areas cleared by heavy equipment, roadways, ditches, cattle trails, bedding and supplement areas, and areas with other disturbances. Therefore, vegetation change, if present, could not be proven to be solely related to changes in water management practices because data were being collected inappropriately. Further, water management activities cannot be isolated as the cause of vegetation change (if present) based on data collected in this manner, as other anthropogenic influences should not be dismissed as possible cause. (Documented by LADWP July 2001 response to ICWD October 2000 Request for Dispute Resolution.) Consequently, LADWP staff continued to request more involvement in the monitoring being unilaterally collected and analyzed by ICWD between 1991 and 2001.

In 2001, LADWP had ICWD's vegetation sampling methods evaluated by an outside ecological consultant whose findings indicated that:

> *"-ICWD does not appear to have maintained sufficiently high data quality standards in all aspects of the application of the technique. This has resulted in larger than expected variation in the data and has made reasonable repeatability of the results (a major aspect of the scientific method) difficult, if not impossible.*
>
> *-The annual randomization of transect locations within each parcel is a serious flaw in the ICWD methodology. One result of this annual randomization is that it combines temporal and spatial variation, and therefore makes it impossible to attribute annual changes in the vegetation to environmental changes (e.g., groundwater pumping).*

-No attempt is made by ICWD to account for obvious anthropogenic disturbances when placing transects. These disturbances include cattle bedding areas, heavily-grazed areas, trails, and mechanically-cleared areas. Including these disturbed areas in the sampling results is a serious source of sampling error because it includes the variation in vegetation from these factors with temporal variation.

-ICWD increase the bias in their data by selective placement of the direction of transects to avoid thick stands of shrubs. This is a serious source of bias in their data.

-Statistical comparisons of the within-parcel variability between the baseline and monitoring data indicate that, for the four major plant species, the variability of the ICWD monitoring data is significantly greater than the variability of the baseline data. This increase in variability could be the result of a combination of factors, two of which are the effects of spatial variability in the ICWD sampling and poor field technique relative to data collection." (MWH 2004)

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. As a consequence, LADWP staff has also reinventoried vegetation conditions in the Owens Valley annually since 2004 using methods specified in the Green Book (Attachment 1).

Figure 2 shows the magnitude of discrepancies in ICWD and LADWP perennial cover data collected at all control sites from 2004-2010. ICWD's data was collected using annual rerandomization of transects. LADWP's data was collected using methods used in the initial vegetation inventory. These transects begin at the same GPS point annually and are run in the same cardinal direction to eliminate sampling bias. As shown in Figure 2, there is as large as a 15% difference in perennial cover values between ICWD and LADWP's sampling of the same control parcels. Further, Figure 3 shows these notable differences in ICWD and LADWP perennial cover data collected in the Thibaut-Sawmill Wellfield, where BLK094 occurs. Discrepancies in cover data collected by both agencies are apparent in both examples. There is a small element of error in all vegetation sampling due to different individuals performing the work; however, a difference as large as 15% is likely also due to sampling methods used. Using ICWD's data alone to guide LADWP's wellfield management in the Owens Valley could be problematic, especially when the agencies vary so much in data collected in the same vegetation parcels (and seemingly the same vegetation communities).

<u>Live Cover vs. Perennial Cover</u>

The goal of the LTWA is to manage groundwater pumping and surface water management practices so as to avoid causing significant decreases in <u>live vegetation</u>

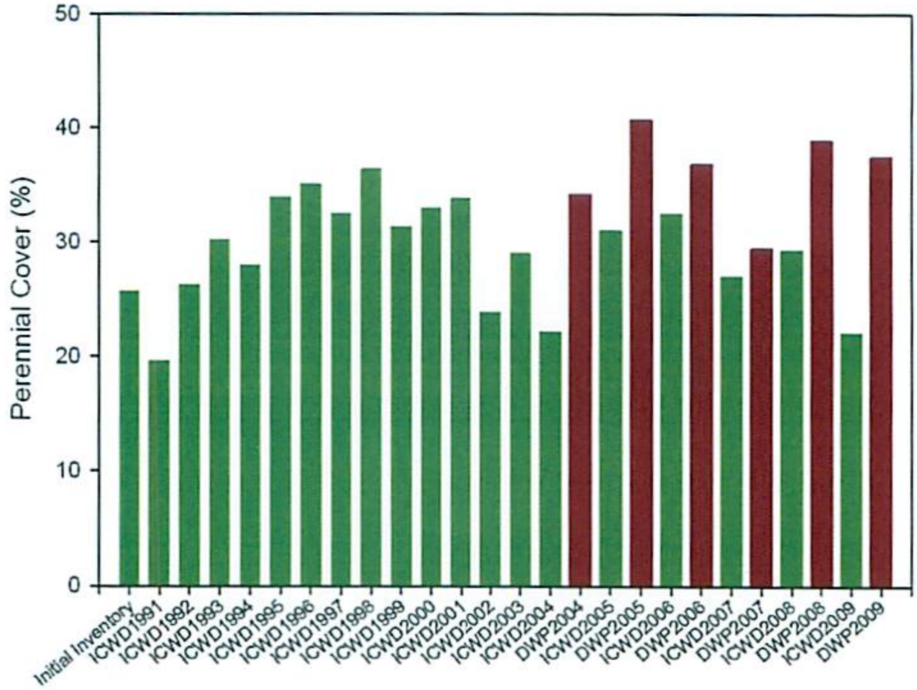

Figure 2. Perennial cover values collected across all control sites by ICWD (green) in the initial inventory and 1991-2009 using annual rerandomization methods. Red bars show LADWP's data for the same parcels from 2004-2009 using methods described in the Green Book for the initial inventory.

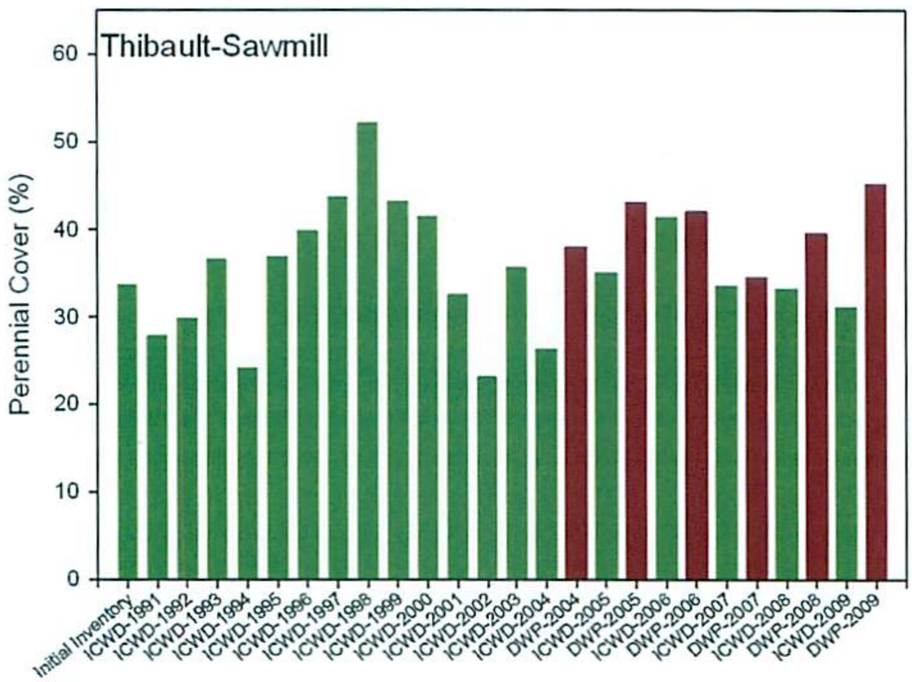

Figure 3. ICWD and LADWP's perennial cover data collected in the Thibaut-Sawmill wellfield from the initial inventory to 2009.

cover, and to avoid causing a significant amount of vegetation comprising either the Type B, C, or D classification to change to vegetation in a classification type which precedes it alphabetically (Agreement IV.A).

There are several assumptions that are made by ICWD in their analysis of the conditions of vegetation parcel BLK094. The first is that there has been a decrease in vegetation cover within vegetation parcel BLK094. In their analysis, ICWD presents data on mean perennial cover within the parcel. However, the Agreement specifies that changes in live cover, not perennial cover, is the goal. (Live cover can include both perennial and annual vegetation cover). In that regard, ICWD has not demonstrated that there has been a change in live cover within vegetation parcel BLK094.

Table 1 contains the average live cover of vegetation within vegetation parcel BLK094 as sampled at permanent transects established within the parcel since 2004 by LADWP staff. These data and subsequent analysis indicates that there has been no change in the vegetation as compared to baseline conditions.

Table 1. Total live cover in vegetation parcel BLK094.

Year	% Live Cover	Std. Err
Initial Inventory	43	1.3
2004	42	4.9
2005	42	4.7
2006	37	3.9
2007	26	3.1
2008	29	3.3
2009	40	4.2
2010	37	4.0

Vegetation Type Conversion

An additional contention of ICWD is that the vegetation within parcel BLK094 is converting from Type C to Type B. As described previously, the goal of the LTWA is to manage groundwater pumping and surface water management practices so as to avoid causing significant decreases in live vegetation cover, and to avoid causing a significant amount of vegetation comprising either the Type B, C, or D classification to change to vegetation in a classification type which precedes it alphabetically (for example, Type D changing to either Type C, B, or A vegetation) (Agreement Section IV).

Section II.B and Section II.C describe Type B and C vegetation classification types.

> *Type B Classification. This classification is comprised of scrub dominated communities, including rabbitbrush and Nevada saltbush communities with evapotranspiration greater than precipitation.*

Type C Classification. This classification is 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.

As mentioned previously, BLK094 is quite heterogeneous with regard to vegetation cover across its landscape. BLK094 cannot be classified as simply a grassland community. In fact during the baseline mapping, 10% of the vegetation identified were shrub species (Table 2).

Table 2. Vegetation cover by life form for parcel BLK094.

	Percent Cover by Life Form		
	Grass	Shrub	Forb
Initial Inventory	29.1	10.4	1.7
2004	16.9	19.0	3.0
2005	19.5	17.3	2.5
2006	17.9	15.4	2.7
2007	10.4	14.8	0.9
2008	11.3	11.6	2.8
2009	19.7	14.8	3.1
2010	15.5	15.8	2.1

Further, the apparent decrease in grass cover from the baseline period to present is likely an artifact of the line point sampling technique. First contact line point sampling does not indicate there is a decrease in grass occurrence within the parcel. It can only indicate that there has been a decrease in first contacts of grasses (Figure 4). First contact line point sampling only documents the presence of the tallest species with no documentation of any understory species that are present. In areas with trees, trees will be documented where present because they are the tallest species. In areas where shrubs are the tallest vegetation, shrubs will receive the first contact. Lower stature species growing under taller stature species are not recorded. This does not necessarily mean that they are not present, but may not be documented due to the sampling method. To state that the lower stature species are decreasing is not accurate if the only data being utilized is first contact line point sampling. Assumptions of changes in community composition based solely upon first contact line point sampling simply cannot be made and any analysis conducted using these data are inappropriate and conclusions reached are seriously flawed.

Therefore, ICWD has provided an inadequate factual basis for its conclusion that there may be a conversion of vegetation parcel BLK094 from Type C to Type B. Further, Section I.D. of the Agreement recognizes vegetation composition and density varies for reasons other than groundwater pumping from period to period, depending upon weather, precipitation, and other factors.

As plant ecology developed, it was recognized that very diverse sites, such as grasslands and forests, underwent similar stages of development from the initial barren conditions to the mature stages of vegetation (Clements 1910, 1916, 1928; Sampson 1914; Weaver 1914; Bergman, H.F. and H. Stallard 1916; Shantz 1917; Cooper 1926a; Stallard 1929; Weaver and Clements 1938). Although the species involved in the stages at diverse ecological sites were generally different, and many characteristics of the ultimate stages differed, there were many similarities in this process of vegetation development or redevelopment.

This natural process of directional vegetation change was termed succession. It is now recognized as occurring, in one form or another, on all sites (Clapham 1973:124). The rate of vegetation change may be rapid, as in the case of recently disturbed sites, or the rate of change may be very slow, as in the case of mature plant communities. But in all cases, successional change is occurring.

Examples of First- vs. Multiple-Species Contacts

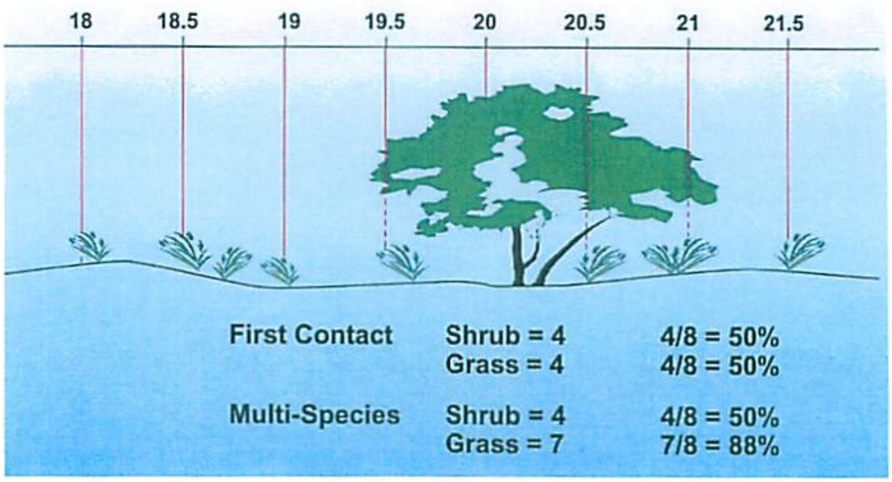

Figure 4. Illustration of how first contact line point sampling procedures can lead to the erroneous conclusion that grass cover is decreasing along the transect.

As succession progresses on a site, short-lived perennials tend to replace annuals and longer-lived perennials tend to replace the short-lived perennials (McLendon and Redente 1991, Samuel and Hart 1994, Paschke et al. 2000). Perennial grasses often form the major plant group during the middle stages of succession, followed by shrubs. If there is sufficient moisture at the site, and fire and high wind are not significant factors, trees will eventually dominate the site, relatively fast-growing mid-successional species at first, followed by slower-growing but larger species. Shrub encroachment into grass dominated biomes is occurring globally (Knapp et al 2011, Eldridge et al 2011).

Comparison of BLK094 with Blackrock 99 (BLK099)

In their February 2011 analysis, ICWD conducts a comparison of BLK094 with an adjacent parcel, BLK099 and contends that this clearly demonstrates that a lowered water table caused by pumping and a decrease in recharge were factors largely responsible for the vegetation decreases and changes in BLK094.

The Green Book discusses comparing wellfield parcels to control parcels when trying to determine the effects of groundwater pumping. ICWD has decided instead to compare two wellfield parcels. Comparing BLK094 to BLK099 is like comparing apples to oranges. BLK099 is located both east and west of the Los Angeles Aqueduct (Figure 5). The portion of the parcel BLK099 that lies to the east of the unlined aqueduct receives sub-irrigation from the water conveyance structure. BLK094 does not receive this supplemental water as it is located solely west and upslope from the aqueduct. In addition, the lessee for BLK099 irrigates the parcel when water is available. This is an unauthorized activity that LADWP has asked the lessee to discontinue. This irrigation is obvious on the 2005 aerial photo of this parcel. A ditch that parallels Highway 395 can be seen carrying water to the majority of BLK099 (Figure 5). BLK094 was receiving much less water in 2005. Figure 6 shows that there was a small release of water near the ranch headquarters in the north part of the parcel and some water coming off of BLK099 onto BLK094 in the southern part of the parcel. This is drastically different than the amount of water being spread in BLK099. The water spreading activities noted on the 2005 aerial photos was not a one- time event but has occurred on numerous occasions.

ICWD's report also states that "With the groundwater levels above 3 meters, groundwater supplied by capillarity was potentially within reach of grass roots and well within the reach of shrub roots in Blackrock 99". Groundwater levels are being artificially altered by unauthorized water spreading in BLK099. Comparing these conditions to BLK094 is not appropriate. ICWD states that "a comparison with an adjacent parcel clearly demonstrates that a lowered water table caused by pumping and a decrease in recharge were factors largely responsible for the vegetation decreases and changes in Blackrock 94". Comparing BLK099 and BLK094 is not a valid comparison and should not be used to support ICWD's conclusion.

4. LADWP's Statistical Reanalysis of ICWD's BLK094 Assessment

Background on Statistical Tests used in Vegetation Analyses

2-sample Test

Due to the inherent variability of plant structure and composition across the landscape, randomly placed transects will more often than not yield a different cover value (For example: Trans 1 = 10%, Trans 2 = 60%, and Trans 3 = 20%). If this method is employed again on the same day at 3 new randomly located transects three new values would also result (For example: Trans 1a = 12%, Trans 2a = 62%, and Trans 3a = 40%).

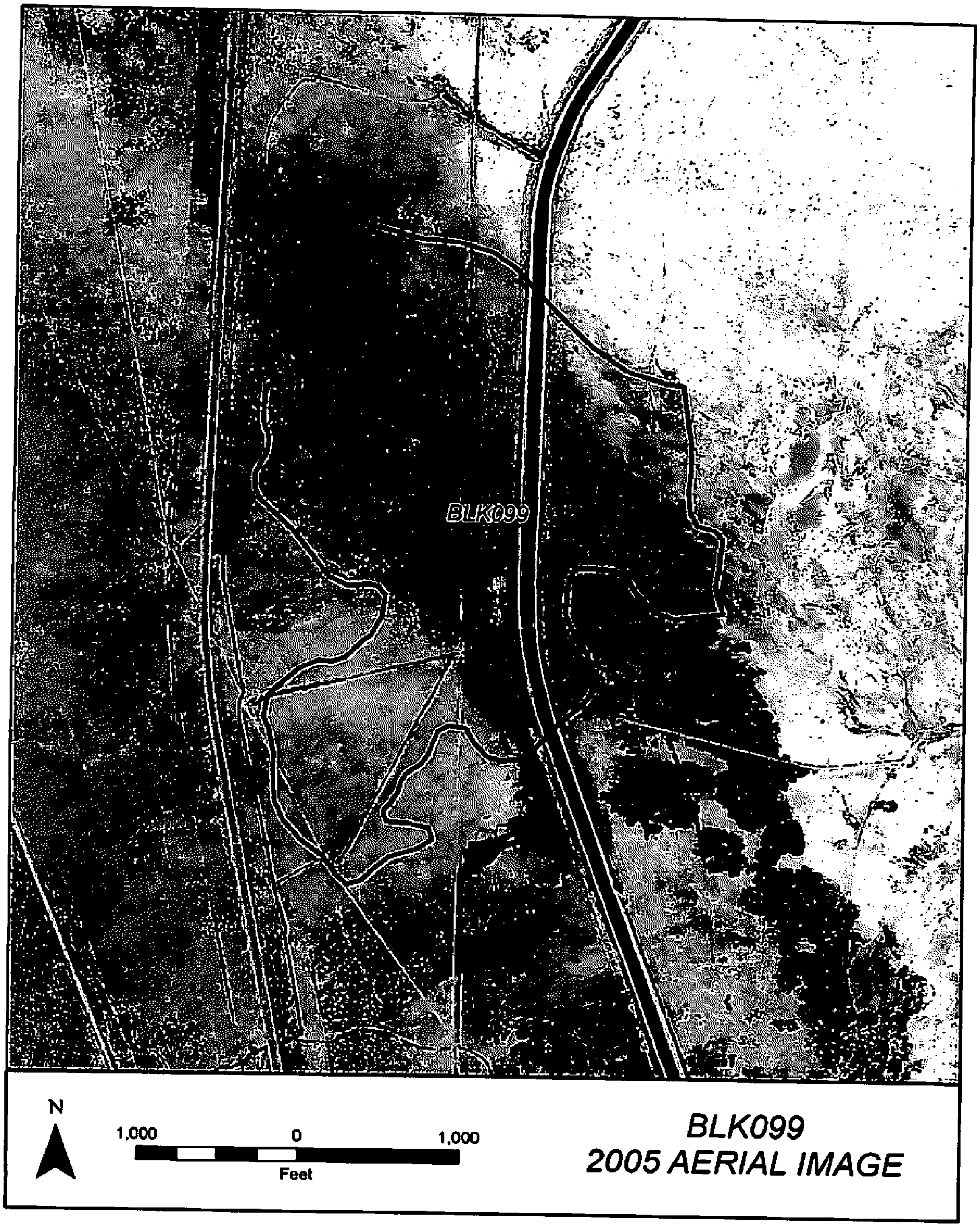

Figure 5. BLK099 in 2005 receiving irrigation over the majority of the parcel.

Figure 6. BLK094 in 2005 receiving minor surface water near the ranch headquarters in the north portion of the parcel and some irrigation in the southern part of the parcel from BLK099.

This is again due to the fact that landscapes are not homogeneous with regard to plant structure and composition.

To ascertain if these two sets of numbers are statistically the same, the following discussion is provided. The average of the first three transects (1, 2, 3) equals 30% (10 + 20 + 60 = 90; 90/3 x 100 = 30%) and the average of the second set of three transects (1a, 2a, 3a) equals 38% (12 + 62 + 40 = 114; 114/3 x 100 = 38%). Although these two values are different, they are not significantly different because they came from the same population, were sampled on the same day, and differences are within the error of the analysis. To determine if these two numbers are the same or different from one another, the variation about the mean or "standard error" for each will need to be analyzed. Standard error is a way of quantifying and dealing with the inherent variability of ecological measurements. The standard error for sample one (Ave cover = 30%) is 15.28 and the standard error of sample two (Ave cover = 38%) is 14.47. These two error values represent the variation of the two sampled means. For the two sample means to be different from each other (30% vs. 38%) the confidence interval of one value plus and minus its standard error must not encompass the confidence interval of the second value plus and minus its standard error (For example: 30 ± 15.28 = 14.72 to 45.28 and 38 ± 14.47 = 23.53 to 52.47). For the above example, the two confidence intervals around both sample means overlap from 23.53 to 45.28. Therefore, it can be concluded that the two means are statistically the same value. This makes sense due to the fact that both samples were taken from the same population on the same day.

If the confidence intervals of the two sampled means (based on standard error) did not overlap, it could then be concluded that too few samples (3 each in the above examples) were taken to represent the entire landscape in question. For example, half of a unit of vegetation (i.e. parcel) was comprised of dense vegetation and the other half was comprised of sparse vegetation and again, like the above example, two samples of three transects apiece were randomly placed on the same day. However, if the first three transects randomly fell within the densely vegetated area and the other three randomly fell within the sparsely vegetated area, the resulting average plant cover values would be very different from one another. In this case, the two samples would be characterized as two different populations when in fact they are one.

Further, consider both samples being taken one year apart rather than on the same day. One may erroneously conclude that there had been a drastic change in vegetation when in fact there was not. To prevent this type of error, is best to randomly locate a sufficient number of transects each year so that both the high and low cover areas are sampled and averaged as one community.

Analysis of Variance (ANOVA) Test

When making comparisons of the same population across several years, it is not appropriate to apply a 2-sample test (as above) to all possible pairs of samples (Zar, 1999, Sokal and Rohlf 1969). This type of testing greatly increases the chance of wrongly concluding a difference between one or more of the sample means with each comparison made (See Zar, 1999 for more details). The appropriate test for this type of analysis is a single-factor analysis of variance (ANOVA). This test compares the variation within each sample to all possible pairs of samples when the purpose is to determine the significance of differences over the entire sampling period. If a particular sample variation is greater than the group's variation (no overlap in values) it is said that it is not part of the population. For example, consider vegetation cover that was sampled at a particular area for 3 years using 3 transects per year to characterize the vegetation and concluding from this data that all three years were significantly different from one another. These differences could be due to two main reasons: (1) there was an appreciable landscape scale change each year that effected the vegetation in such a way that it was different each year (i.e. drought year, wet year, insect infestation), or (2) like the two sample example above, too few transects were used to adequately characterize the vegetation. Using only three transects within a large area sets the stage for the possibility of sampling a different plant community each year with an inadequate sample size. If more transects were sampled per year, all plant communities contained within the vegetation parcel would be sampled and surmised as one community each year. The latter method would provide a more accurate representation of the plants within the parcel.

Parametric and Nonparametric ANOVA Explained

Data analysis using any parametric statistical model first requires a set of assumptions that apply to the population being sampled. These assumptions are based on the constraints of the equations used in a statistical model. If the assumptions set forth for a particular test are not met by the sampled population, the results of that test may not be valid.

When comparing several groups or samples based on one variable, a widely- accepted method used to test for significance in differences between the group means is a parametric test known as single-factor (or one-way) ANOVA (Zar, 1999,Sokal and Rohlf, 1969). The main assumptions for this test are the population being sampled should be normally distributed and the variance of data in groups should be equal. However, according to Zar (1999) the ANOVA is robust in respect to the assumption of the underlying populations' normality and the validity of the analysis is affected only slightly by even considerable deviations of normality (in skewness and/or Kurtosis). Zar (1999) further states that the ANOVA is also robust, operating well even with considerable heterogeneity of variances as long as all n_i are equal or nearly equal. If the data deviates severely from the underlying assumptions, nonparametric procedures should be used.

Nonparametric ANOVA does not depend upon the sampled populations being distributed normally and is only slightly influenced by difference in populations' dispersions (Zar, 1999). In this test, the values from the sampled values are ranked and analysis is performed on the medians.

Statistical Analysis of ICWD/LADWP Vegetation Data

The Green Book specifies that "Statistical analysis will be used to determine the measurability (statistical significance) of vegetation changes from the 1984-1987 inventory maps" (Green Book Box I.C.1.a.ii pgs 22-23). A major goal of statistical analysis is to draw inferences about a population by examining a sample or series of samples from that population because it is almost always impossible to sample an entire population. A very common example of this is the desire to draw conclusions about one or more population means (Zar, 1999).

Before any statistical analysis can be undertaken a sampling protocol must be implemented. The Green Book specifies that plant cover will be characterized by utilizing the "line point" method of sampling the population (Box I.C.1.a.ii pgs 22-23). This method utilizes transects, fifty meters in length, that are randomly located throughout a vegetation parcel. Each vegetation transect is read every half meter and live plant cover is tallied as intercepts/100 possible intercepts x 100 = percent cover (For example: 25 intercepts/100 x 100 = 25% cover).

For this reanalysis, vegetation data collected by both the ICWD and the LADWP were analyzed with Sigma Plot 11.0 (SigmaPlot 2008). While the goal of the Agreement is to manage groundwater pumping and surface water management practices to avoid causing significant decreases in live vegetation cover, ICWD conducted their analyses using perennial vegetation cover. Therefore, to provide an adequate comparison, LADWP conducted the reanalysis using perennial vegetation cover data also.

To test for significance, using both the ICWD and the LADWP vegetation data sets, a standard one way ANOVA (Zar, 1999) was chosen and significance was declared upon $P < 0.05$. When a particular data set did not meet the assumptions required for a one way ANOVA (i.e. normal distribution or equal variance), a nonparametric Kruskal-Wallis (1952) single factor ANOVA was used and significance was also declared at $P < 0.05$. These two tests were chosen based on their wide acceptance and use throughout the scientific community (Zar, 1999,Sokal and Rohlf, 1969, Kruskal and Wallis, 1952).

ICWD Analysis of BLK094 (Anderson 2001), Statistical Perspective

ICWD utilized a relatively new statistical model to analyze both the ICWD and LADWP vegetation data sets. This model developed by Anderson (2001) uses a permutation to calculate a pseudo F-statistic. Anderson claims that because the F-statistic is derived from a permutation of row values contained in the original data set that it is a nonparametric test. However, this model does not yield similar results to those found using traditional parametric or nonparametric statistical models.

Using the Anderson (2001) model, ICWD found vegetation cover at BLK094 to be significantly lower than the initial inventory for 14 out of 19 sample years (Figure 7). Upon re-analysis by LADWP, this data set was found to be normally distributed, but did not make the assumption of equal variance for parametric analysis. However, due to the robustness of the ANOVA to differences in sample variances, parametric analysis was still performed. Using a parametric single factor ANOVA to re-analyze the ICWD data, 7 years were found to be significantly lower than baseline (also Figure 7). To test if the unequal variance had an affect on the previous results, a nonparametric model was also used (Kruskal and Wallis, 1952). The nonparametric single-factor ANOVA found the same 7 years to be significantly lower than baseline and verifies that the unequal variance did not affect the results of the parametric ANOVA. These results from here on will be referred to as parametric results.

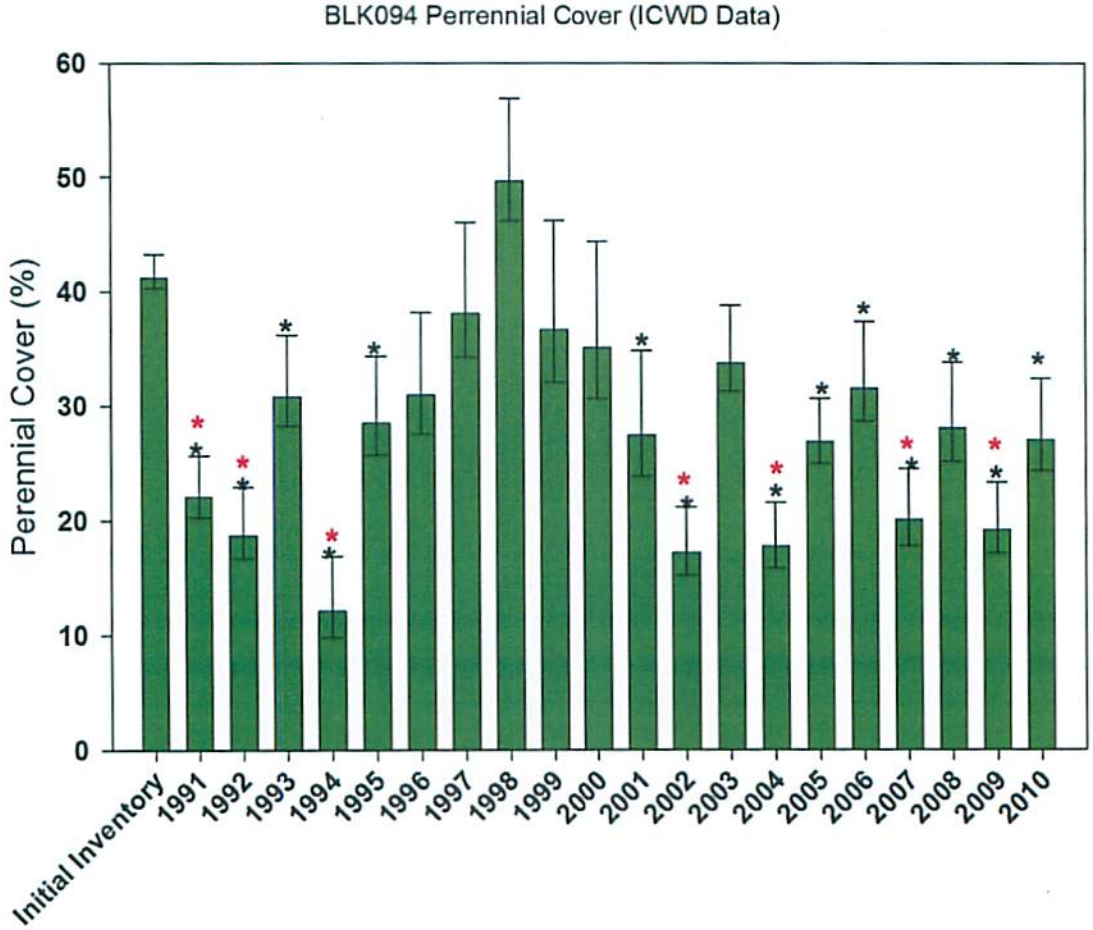

Figure 7. ICWD vegetation data showing significant differences from the initial inventory using the Anderson (2001) method (black asterisks) and significant differences from the initial inventory using traditional parametric statistics (red asterisks). Error bars represent the 95% confidence intervals.

Analysis of LADWP Data using Anderson 2001

Of the 7 years vegetation was sampled by LADWP at BLK094 (2004-2010), ICWD reported that 2004, 2007, and 2008 were significantly lower than baseline using (Anderson 2001) (Figure 8). Within the results of Anderson (2001), 2007 and 2008 can be arguably attributed to the Inyo/Complex Fire and 2004 can be attributed to data error. According to the graph provided within the ICWD report, in 2004 the perennial cover for that year was approximately 31 percent. This value is 7.9 percent less than the perennial cover value of the ICWD dataset as calculated by LADWP, indicating perhaps that some perennial species were not included in the ICWD calculations. This difference would make 2004's perennial cover value almost that of 2005's perennial cover value of 39.3 percent. When making this change to the data set, 2004 would no longer be significantly lower than baseline.

Analysis of LADWP Data using Zar 1999

The LADWP vegetation cover data for BLK094 failed both the normality and equal variance test therefore standard parametric analysis were not performed. To determine if any deviations from baseline had occurred during the sampling period (2004 to 2010) a nonparametric Kruskal-Wallis (1952) test was utilized. Re-analysis of this 7 year data set (2004 – 2010) using traditional statistics revealed no significant differences from baseline (Figure 8).

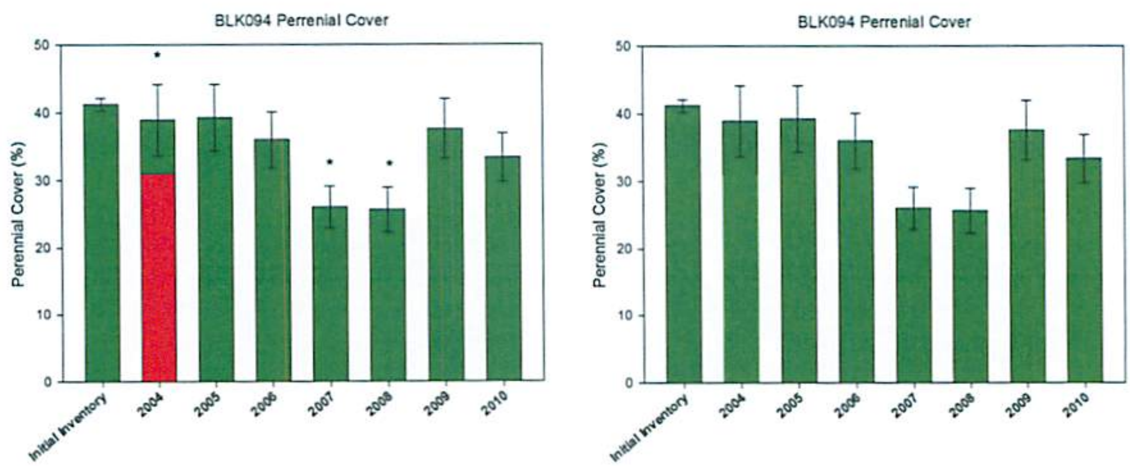

Figure 8. Graph on left shows significant differences (black asterisk) in LADWP data from the initial inventory using the Anderson (2001) method. Red bar represents the value calculated by the ICWD (data error). Graph on right shows no significant differences in LADWP data from the initial inventory using traditional statistics. Error bars indicate the standard error of each mean.

Multivariate Analysis-NMS Ordination

While NMS is the ordination technique of choice for community datasets (Kruskal and Wish 1978, Mather 1976) each NMS run can yield different results with the same data depending on the input parameters due to local minima (Clarke 1993). It is important to note that different results may be found depending on the configuration, starting point, and number of axis used for this iterative ordination. Therefore it is imperative that the author reveal important parameters used and discuss why certain outputs were chosen for interpretation (McCune and Grace 2002).

In their report, ICWD presents information regarding the use of NMS ordination in analyzing community composition. There are several concerns with the analysis performed, how the data was used, and conclusions presented that result from ICWD's multivariate analysis. ICWD should provide the species matrix used. Data transformations are commonly used and data are often screened to remove outliers. Many questions remain, for example was there any other data screening than removing non-perennial species? Was raw percent live cover used? If there are outliers and rare species that only occasionally occur, how these issues are handled can inflate differences in communities and obscure patterns.

Additional questions exist regarding the distance measure used and the number of dimensions of the results. Euclidean distance is not appropriate for most community data sets because it further enhances the role of dominant species so the ordination displays relationships of differences of the dominant species at the expense of the community composition. For example, a sample with 20% of species A and 20% of species B has the same composition as a sample with 5% of species A and 5% of species B but the Euclidean distance would actually measure a third sample with 20% of species A and 0% of species B as more similar.

The amount of variation explained by Axis 2 in ICWD Figure 7a is not given. SPAI, which is a grass, plays the biggest role in the ordination on Axis 2 (-0.801) but there is only one shrub ARTR (0.399) that drives the relationship in sampling in post baseline years. A positive correlation with saltgrass (DISP) actually separates the baseline sampling from many years of subsequent sampling in Axis 1. This indicates that the ordination sees saltgrass as more abundant on years post-baseline. Furthermore, negative correlation with cover of a shrub (ATTO) separates baseline average cover from most post-baseline transects. Therefore the ordination results indicate ATTO should have higher cover on initial vegetation transects. The main component of the ordination axis 2 in ICWD Figure7a is that SPAI is less common on most of the re-inventory transects sampled. SPAI was the most dominant species on baseline transects. Due to choices in how data are used in the ordination, SPAI is much more highly weighted than other less dominant species. Therefore the significance testing is actually testing to see if the same species are dominant in each sampling effort.

Two wetland shrubs are more common on re-inventory sampling, although still less than 1% of average cover each year based on LADWP's sampling. Woods' rose (wetland status facultative, estimated probability 34%-66% occurrence in a wetland) and coyote willow (obligate wetland plant). As ICWD notes, both of these did not occur during initial vegetation inventory. This is also true of PSPO, ATCA, and EPNE, which are shrubs that are highly correlated with the ordination of LADWP's data that separate later years sampling from the initial vegetation inventory.

For these reasons, testing of the NMS ordinations used by ICWD is inappropriate, which leads these statistical tests on community composition to be interpreted incorrectly. The tests for differences in community composition (more appropriately species dominance) rely on only 60% of the original variation in the data. Additionally, since transect locations have varied through the years, the test may be more realistically interpreted as testing for differences in community composition on the transects sampled than on the parcel as a whole over time, since the parcel is in no way homogeneous and baseline transect locations were generally toward the center of the parcel in order to avoid transitional areas at the parcel edges (Greenbook Section II.A.2.vi). This test also inflates the Type I error rate of falsely concluding a difference when there is none by not correcting for multiple comparisons. This is analogous to doing multiple t-tests on different years of data. While this test does not rely on assumptions of normal distribution it does require that the cloud of data points have similar dispersion, which may not be true. The fact that this ordination and NPMANOVA test is comparing differences among different communities sampled along different transects is further exemplified by the ordination of LADWP's linepoint data in ICWD Figure 7c. Since these transects are run in the same area (within the accuracy of gps) it is more likely for them to clump together since they are in the same community sampled every year than the baseline transect that was sampled in different and unknown areas.

5. LADWP's Spatial Analysis of ICWD's Vegetation Data in BLK094

The ICWD randomly chooses placement of their vegetation transects each year and compares the average vegetative cover value to that of baseline. This method was chosen because the locations of the nine baseline vegetation transects were never recorded and therefore impossible to revisit. Unfortunately, this poses two problems. The first is that without knowing where the original nine transects were located, subsequent sampling each year thereafter may not accurately represent stasis or a departure from conditions recorded during baseline. Second, due to different vegetation types that occur across the landscape of BLK094, annual re-randomization of transects may inadvertently describe a different community each year. This method could also result in an inaccurate perennial vegetation cover estimate each year when compared to earlier years. This becomes increasingly apparent considering that the potential plant canopy cover for BLK094 can range from 20 to 80 percent depending on the proportion of transects located among the three ecological sites on the parcel (Figure 1).

Spatial Analysis Methods

To determine if there was an effect of re-randomization of vegetation transects on reported perennial cover values at BLK094, an in depth spatial analysis was performed using ArcMap 9.3. To ascertain the effects of re-randomizing transect location an accurate vegetation coverage map of the parcel would be required. It was determined that the most objective way to construct this map would be to use the actual data that was collected over the last 19 years. To do this, ICWD data was kriged by plotting all 436 transects (using their unique UTMs) and corresponding cover values as a new GIS layer. The resulting map was then used to delimit areas of high, medium, and low cover. Lastly, LADWP quantified how random placement each year captured the actual percentage of the three cover classes.

Before plotting all 436 transects it was necessary to first account for temporal change in vegetation. To block for year effect on vegetation cover, each transect was either scaled up or down to reflect the long term average. To do this, all 19 years of transects were arranged in columns and an average perennial vegetation cover was calculated for each year. Then the average of all 19 cover averages was calculated (28.03% = 19 year average). The average value for a particular year was then divided by the long-term average of 28.03 to calculate a multiplier. This value was then multiplied across all transects of that same year to scale up or down the average to 28.03. For example, in 1991 the average of all 18 transects ran that year was 22.05. To calculate 1991's "scaling" multiplier the long term average was divided by the 1991 average 28.03/22.05 = 1.27. This value (1.27) was then multiplied across all 18 transects so that the 1991 average would be the same as the long-term average of 28.03. This procedure was performed on all 19 years worth of transects. This adjusted for temporal differences without undermining the integrity of the original data set.

All 436 transects with their adjusted values were then plotted as a GIS layer (Figure 9). Transects were separated into 3 cover classes, low, medium, and high. Values for each class were calculated using equal quartiles. Other classification methods were tried, however, it seemed they afforded too many inclusions and did provide adequate clustering. The low cover class ranged from 0 to 22 percent, the medium cover class from 23 to 34 percent, and the high cover class from 35 to 100 percent. To determine the percentage of transects that fell within each class, the sum of transects within each class (low, medium, high) was divided by the total number of transects. The low cover class captured 32.6 percent of transects. The medium cover class captured 34.6 percent of transects. And the high cover class captured 32.8 percent of transects. To validate these values ArcMap was again utilized. All 436 transects were kriged using Inverse Distance Weighted. A fixed search distance of 100 meters was chosen and a new raster data set was created (Figure 10). This layer was reclassified into the three cover classes as before: low 0 to 22 percent, medium 23 to 34 percent, and high 35 to 100 percent. This reclassified layer was then exported as a shape file and the acreages of the three classes were then summed and divided by the total acreage to calculate relative coverage. The low cover class represented 32.6 percent of the total acreage. The medium cover class represented 33.9 percent of the total acreage. And the high cover class represented 33.5

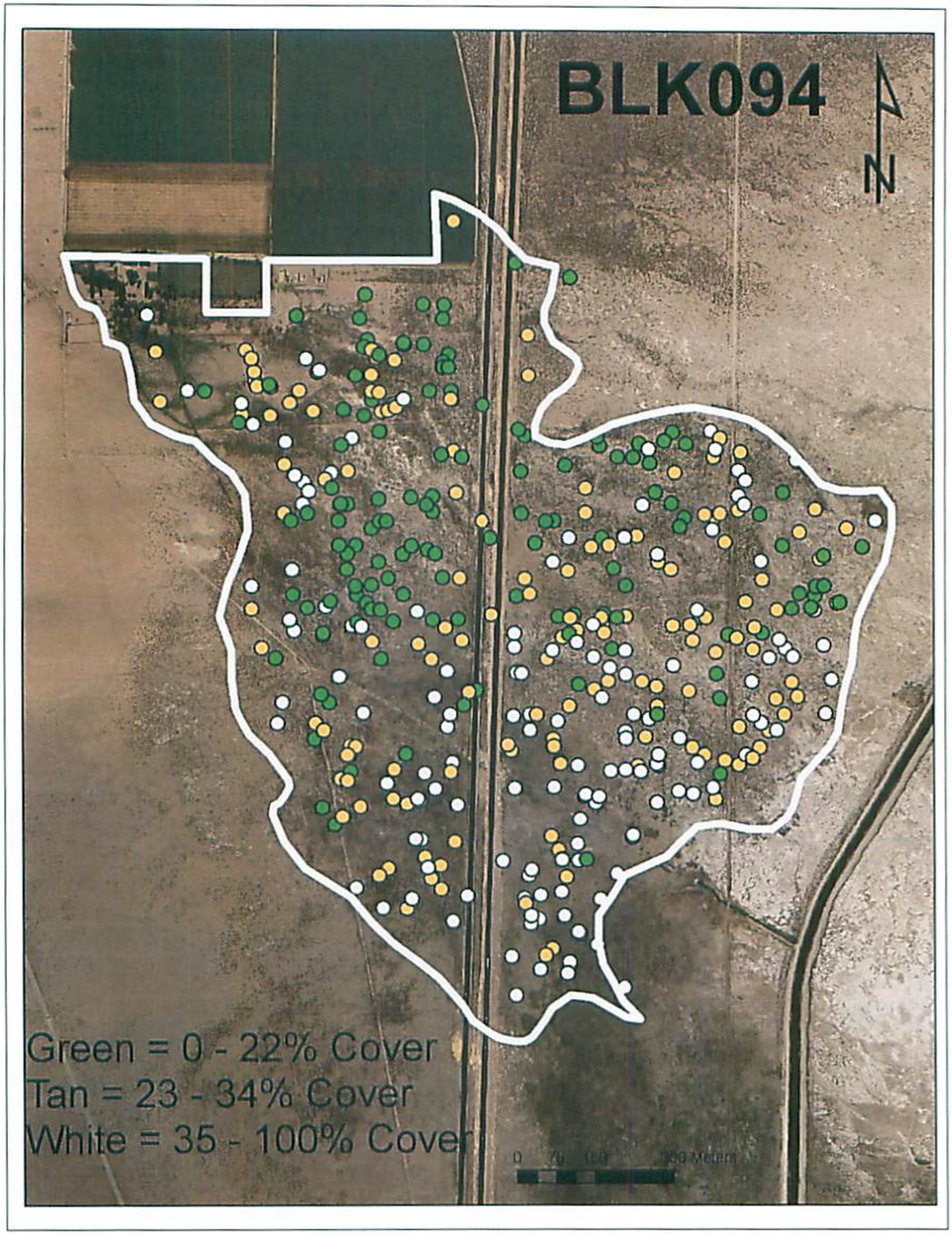

Figure 9. Distribution and cover class of all ICWD vegetation transects at BLK094 collected from 1991-2010.

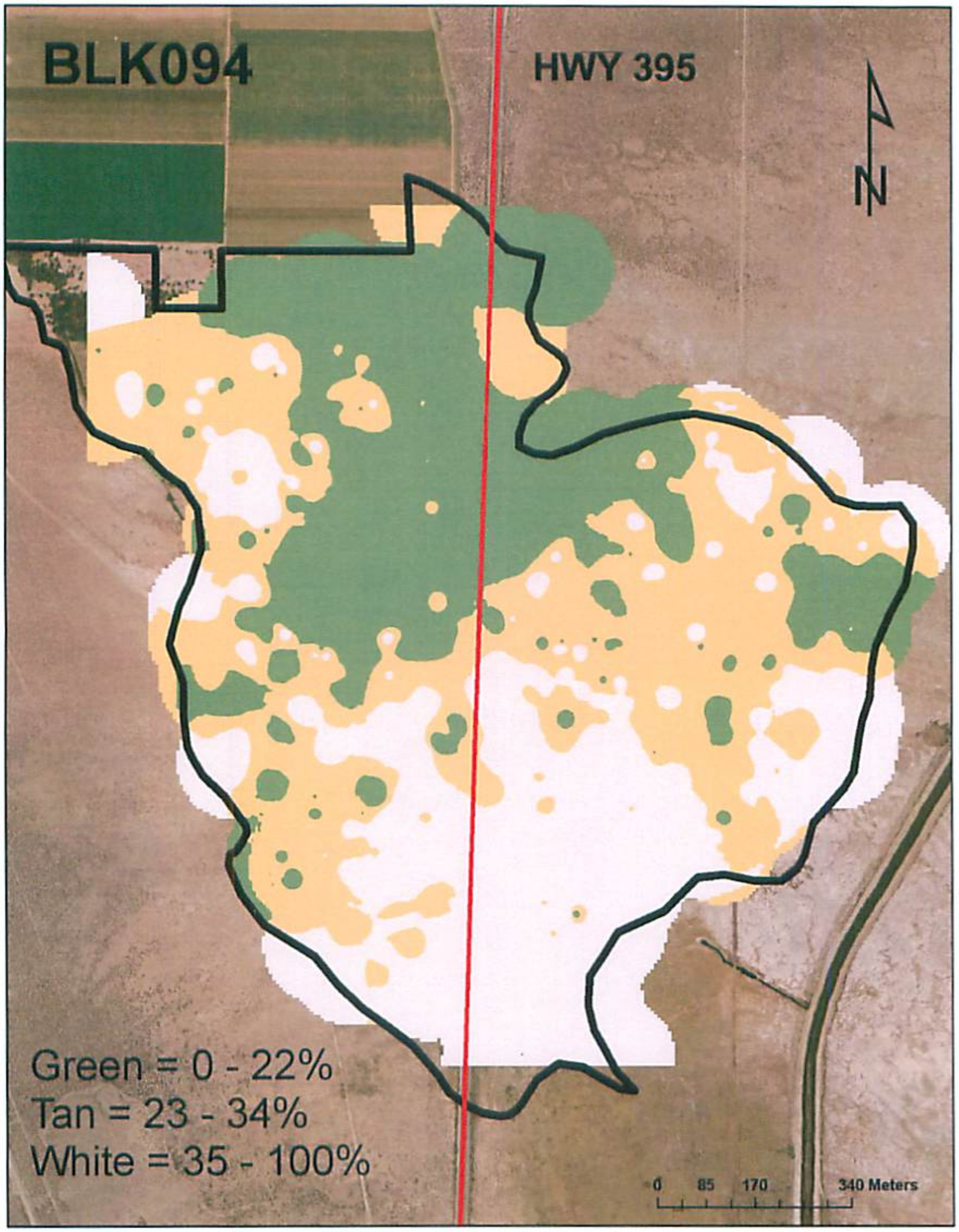

Figure 10. Raster layer of kriged ICWD transects at BLK094. Map based on transect data collected from 1991-2010.

percent of the total acreage. The results of both methods yielded very similar values and analysis of how random transect placement actually reflected this practically 1/3, 1/3, 1/3 split of cover class across the landscape of BLK094 could proceed.

Spatial Analysis Results

This analysis utilized the actual ICWD transect data, collected each year from 1991 to 2010, in conjunction with the new coverage map to determine the effects of annual transect re-randomization . For each year sampled, the total number of transects were summed by cover class. For example in 1991, 11 transects fell into the low cover class, 7 fell into the medium cover class, and zero fell into the high cover class for a 61, 39, 0 percent three-way split respectively. The target values based on spatial analysis were 33, 35, and 33 percent for the low, medium, and high classes respectively. This means that the low cover class was over sampled by 50 percent, the medium class was over sampled by 4 percent, and the high cover class was under sampled by 33 percent. Of the 19 years sampled, each of the cover classes was either over or under sampled and only a few years came close to representing the target percentages. In some cases both the high and low classes were over sampled and the middle class was under sampled or vice-versa, both the high and low classes were under sampled and the middle class was over sampled (i.e., Low = 40%, Med = 20%, High = 40% vs. Low = 20%, Med = 60%, High = 20%). In these two cases, the average of all transects should negate the error in sampling. However, too many or too few transects run in the low or high classes will result in a skewed perennial cover value for the year sampled and may lead to a Type 1 error.

ICWD Data (Anderson 2001) Revisited, Spatial Perspective

Of the 19 years vegetation was sampled by the ICWD at BLK094, the ICWD declared 14 of them to be significantly lower than baseline (using Anderson 2001) (Figure 7). Of those 14 years, spatial analysis of transect placement suggest that 10 years were spatially biased. In nine of the ten years, low cover areas were over sampled, and in one of the ten years, high cover areas were under sampled. This means that approximately 71% of the years that were declared significantly lower than baseline may have been due to sampling error alone.

ICWD Data (Zar, 1999) Revisited, Spatial Perspective

Parametric re-analysis of the ICWD vegetation data performed by LADWP in this report declared the following 7 years to be significantly lower than baseline: 1991, 1992, 1994, 2002, 2004, 2007, and 2009 (Figure 7). Spatial analysis suggests that all 7 years where subject to sample bias. In six of these years, the low cover class was over sampled and the high cover class was under sampled, and one of the years sampling bias was skewed toward the high cover class.

6. Conclusions in LADWP's Statistical and Spatial Analyses

Through re-analysis of the BLK094 vegetative data sets collected by both the ICWD and the LADWP it was determined that the impacts to the vegetation at BLK094 are not significant using traditional parametric and nonparametric statistics (Zar, 1999 and Kruskal-Wallis, 1952). The first reason for this declaration begins with the statistical model (Anderson 2001) that was chosen by the ICWD. The results using Anderson are very different as compared to the results using traditional statistics. The Anderson (2001) model being fairly new has yet to receive the same amount of peer review and wide acceptance from the scientific community as compared to both the parametric and nonparametric models, developed by Fisher (circa 1934) (Zar, 1999) and Kruskal and Wallis (1952) respectively. Therefore, the Anderson (2001) model may not have been the best choice for this analysis.

Second, using spatial analysis it was found that of the 14 years the ICWD significantly declared lower than baseline conditions, approximately 71% (10 years) were subject to inadvertent sample bias caused by annual re-randomization of transects. Re-analysis, using traditional statistics, found 7 years were to be significantly lower than baseline. Furthermore, it was determined that all 7 of the years that were significantly lower than the initial inventory were subject to sample bias.

Thirdly, the ICWD using the Anderson (2001) method of analysis on the LADWP data set found 3 years to be significantly lower than baseline. Under these results it was determined that two of the years were due to fire and one was due to a data calculation error. Re-analysis using traditional nonparametric analysis on the same 2004-2010 LADWP data set found no significant differences from baseline.

7. Review of ICWD's Spectral Mixture Analysis (SMA)

In their February 2011 report, ICWD uses the results of spectral mixture analysis (SMA) of remotely sensed imagery to confirm a decline in vegetation in BLK094. Therefore, it is important to determine exactly how that analysis was performed and how the accuracy of the results was determined. An initial review of the SMA methodology as described in Elmore et al., 2000, raised several technical issues that require further examination. The following list of issues center on ICWD's SMA method and require independent verification prior to the acceptance of ICWD's results:

1. **Field data not well suited for a remote sensing application were used to quantify the accuracy of the SMA results, leading to uncertainty in the reported accuracy of 88%.** Validation of the Elmore et al. (2000) SMA results was completed using field transect data collected by ICWD. Transects do not adequately characterize spatial and spectral variability present in pixel-based sample areas in the imagery. These scaling issues, along with difficulties in relating a transect to specific pixels in the imagery and registration differences between images, all contribute to uncertainty in the use of this field data for

assessment of the SMA accuracy. Questions as to the quality and consistency of the field data collected by ICWD that is used for validating the SMA results imposes an additional element of doubt on the reported accuracy of the SMA.

2. **Correlation and reporting of SMA results against field measurements of vegetation cover were completed and reported for only a small subset of years analyzed.** The 88% accuracy of the SMA results reported by Elmore et al. (2000) is based on statistical comparison of SMA estimates versus field measures of vegetation cover for only 43% of available data (i.e. only 6 of the 14 years actually analyzed). Furthermore, ICWD's BLK094 report presents the results of an expanded SMA analysis for the years 1998-2009 with no documentation of validation or assessment of accuracy for these additional years. Independent verification of SMA accuracy across the entire timeframe should be completed and is more appropriate than using a small subset of years.

3. **Imagery selected for the SMA must be examined in more detail to determine if fluctuations in vegetation cover or condition caused by variability in climatic conditions or other environmental factors that could lead to detection of "false-positive" cover changes have been ruled out.** Fluctuations in climatic and environmental conditions can significantly change vegetation composition and cover and influence the phenological growth stage development curve of the vegetative community from year to year (and within a single growing season). These factors which impact biophysical parameters of the vegetation must be examined for each date of imagery selected for the SMA analysis to ensure that the potential for detection of "false-positive" cover changes has been eliminated.

4. **Unnecessary and/or atypical image correction methods were used that could have reduced spectral quality and introduced unnecessary error.** In the Elmore et al. study, three separate geometric corrections were performed, each of which slightly degraded the spectral quality of the imagery due to resampling. In addition, there are questions about the type of resampling algorithms used for the multiple geometric corrections. A weighted resampling algorithm was described as being used for at least one of the geometric corrections. This type of averaging of the data is generally avoided by the use of a nearest neighbor resampling algorithm for projects involving numerical analysis of the imagery. It is not known what overall impact these processes had on the integrity of the image data values.

5. **Further evaluation of the endmembers used for spectral mixture analysis in Elmore et al. (2000) and the quantification of effect on accuracy produced by deviating endmembers is needed.** The SMA approach requires selection of endmembers, which are used to identify and quantify the surface components (i.e., vegetation, soil, water, etc.) mixed within the spectral signature of an image pixel. Differences in the results obtained by Elmore et al. and Smith et al. (1990) (who performed SMA on the Owens Valley using earlier dates of imagery), as

well as tests performed by Elmore with alternative endmembers, indicate that SMA results can vary significantly with the selection of different endmembers. Thus the endmembers selected and used by Elmore et al. for analysis of imagery from 1984-1997 bear further scrutiny and justification. Likewise, investigation of the endmembers used for the additional years of SMA results (1998-2009) is required.

Based on the issues raised above, the SMA methods utilized by ICWD to confirm a decline in vegetation in the BLK094 parcel need further examination and explanation. The field data used in this exercise is not well suited for this type of analysis, ICWD used only a portion of the available dataset, and the correction methods used by ICWD could have introduced unnecessary error. Therefore, the results of this type of analysis are not suitable for drawing the conclusions made by ICWD.

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Attachment 1

LADWP Vegetation Monitoring Methods

METHODS and MATERIALS

Experimental Design

In response to inconsistencies found in the Inyo County perennial cover monitoring data the Los Angeles Department of Water and Power (LADWP) developed and initiated a new monitoring program in 2004 that could be used to better compare vegetation cover values within vegetation parcels throughout the value across years. Using aerial imagery and Arcview 3.2 fifty transects of 50 meters in length were randomly placed within each of the vegetation parcels previously monitored by Inyo County. To prevent transects from crossing parcel boundaries a 100-foot buffer was placed within the outer perimeter of each parcel prior to transect placement. Transects that crossed each other, crossed roads, or crossed noticeably disturbed areas were removed. If necessary, transects continued to be added and removed until the maximum number of transects that had ever been run by Inyo County were obtained for each parcel. Maps (Figure 1) containing the location of each parcel and corresponding transects were generated using 2000 imagery and transect coordinates were uploaded to field crew GPS units. Lastly, data sheets were created for each parcel containing the Universal Transverse Mercator (UTM) and unique compass bearing for each transect (Figure 2). Each 50-meter vegetation transect is assessed using the line point method outlined by Bonham (1989) to characterize vegetation cover.

Field Protocol

After navigating to a transect, one end of a 50-meter tape measure is staked to the ground using a 3/8 inch piece of rebar with a hook on one end. A compass bearing for that particular transect (designated on the data sheet) is then taken. To assist in maintaining a constant bearing a permanent structure/landform is identified along the bearing. A measurement of 50 meters is paced out along the bearing. Again using a compass a back shot along the bearing is then taken to verify that the transect did not wander off bearing. A second piece of rebar is then used to stake the other end of the tape to the ground. The tape is kept as taunt as possible using the reel.

If at any time it is found that a transect crosses man caused disturbance that was not visible on the air photo the transect is to be moved slightly to avoid the impact. Record the new UTM and new bearing (hold bearing if possible) and restring the transect. Once the tape has been staked, stand at the zero meter end of the tape and take a photo (zoomed all the way out) of the entire transect.

Beginning at the 0.5 meter mark the tape is read at every 0.5 meters and the first live species hit (canopy cover only) is then recorded directly under this point. To qualify as a "hit" the plant must be a green transpiring plant part, or an obviously living stem. When recording a hit, the plant must be directly under the point. The reader should have their field of view centered over the tape as close to 90 degrees (perpendicular to tape) as possible (Figure 3). If a plant part is not directly under that point, no matter how close it comes, it does not count as a hit. Each 0.5 meter point is read along the 50-meter tape achieving a total of 100 possible hits for each transect.

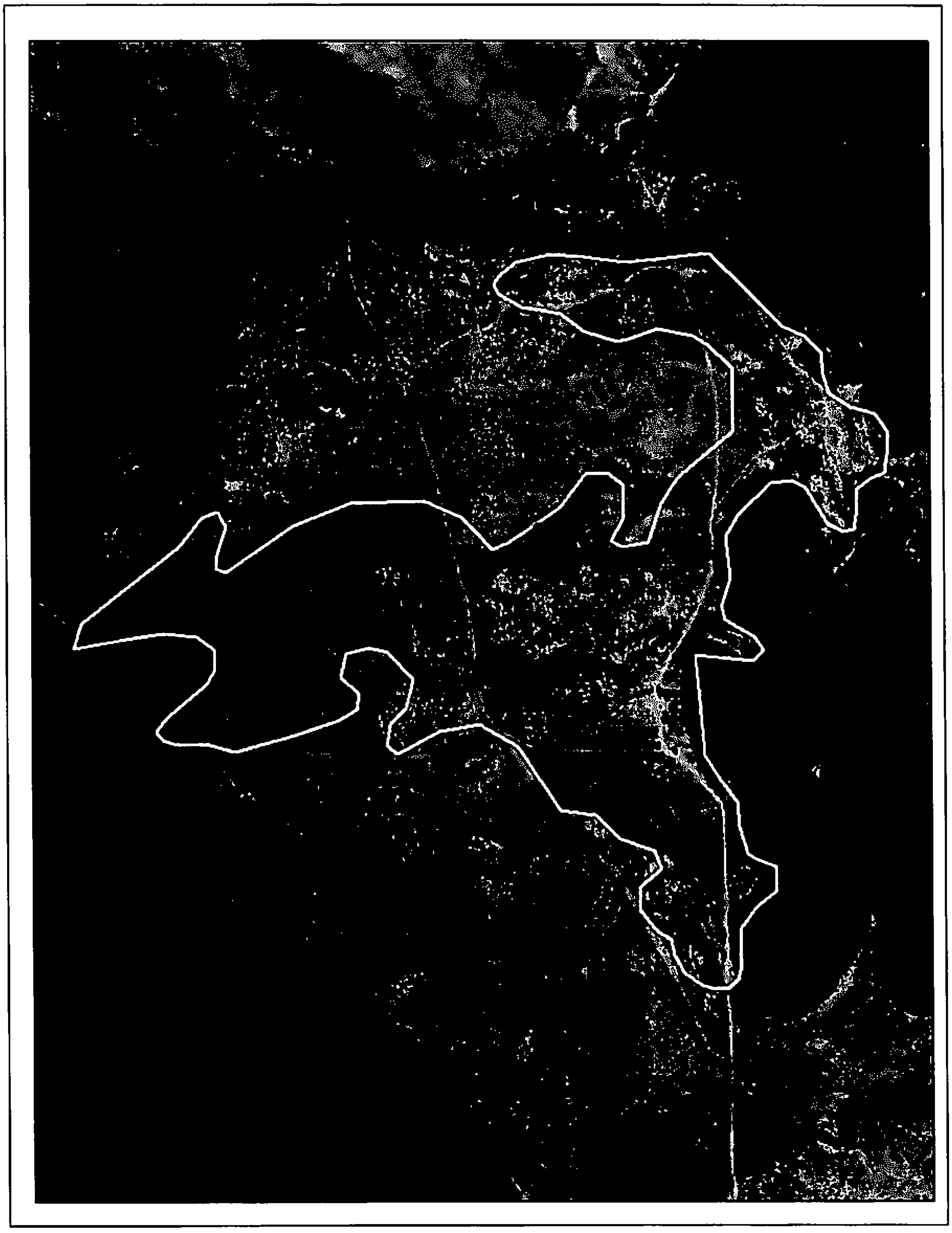

Figure 1. Example of Map Used to Locate Vegetation Parcel and Corresponding Transects (BGP088 = Big Pine, Parcel 88).

	Date:				Surveyors							
Parcel	BGP088	BGP088	BGP088	BGP088	BGP088	BGP088	BGP088	BGP088	BGP088			
Transect	1	2	3	4	5	6	7	8	9			
Beg Easting	387260	387190	386969	386749	386639	386859	387100	387060	387190			
Beg Northing	4115874	4115712	4115721	4115703	4115650	4115614	4115587	4115408	4115229			
Bearing	359	244	190	359	170	138	194	67	302			

Figure 2. Example of the Data Sheet Used to Record Vegetative Cover Data.
Species is recorded along the left side of data sheet and vegetation hits are recorded under their respective transect designation.

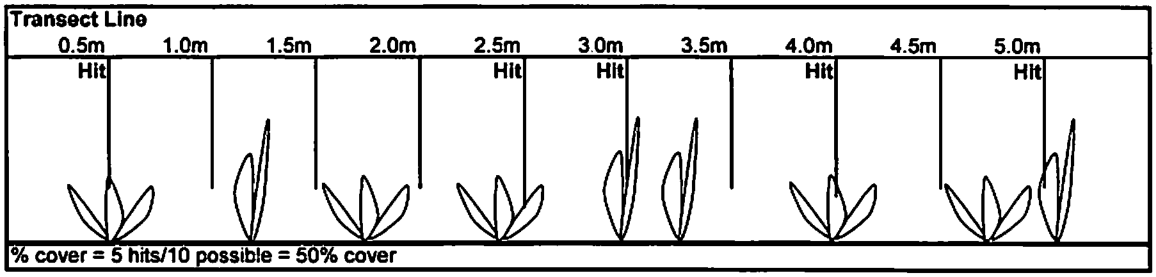

Figure 3. Point Intercept Method of Measuring Cover.

Data Analysis

To calculate total perennial cover (TPC) for a particular parcel all perennial hits are summed and then divided by the total number of transects. For example 128 hits out of a possible 800 hits from 8 transects (128/800 = 0.16 * 100 = 16% perennial cover). Due to the fact that each transect has the possibility of 100 hits and the final answer requires multiplication by 100 to calculate percent, the equation can be shortened by dividing total hits 128 by total transects 8 (128/8 = 16%). Once all the calculations are made each parcel will have one cover value.

Within the Owens Valley, 110 parcels were chosen for vegetation monitoring. Within those 110 parcels, 1,211 transects were established (Table 1). Parcels were divided into 11 geographic locations (based on the name of the quadrangle map) and given a unique prefix for each, for example BGP088 = Big Pine, Parcel 88 and UNW079 = Union Wash, Parcel 79.

Table 1. Vegetation Parcels and Corresponding Transects Being Monitored in the Owens Valley.

Parcel	Transects	Parcel	Transects	Parcel	Transects
BGP031	14	IND011	12	PLC107	4
BGP088	9	IND019	12	PLC121	14
BGP094	11	IND029	6	PLC137	16
BGP154	12	IND035	11	PLC210/LAW137	20
BGP157	15	IND064	9	PLC223	15
BGP162	17	IND096	12	TIN028/FSP022/FSP019	16
BGP182/FSP006	7	IND106	15	TIN030	24
BGP188/FSP004	16	IND111	13	TIN050	14
BIS055/FSL214	8	IND119	8	TIN053	16
BIS060	9	IND124	5	TIN064	8
BIS085	12	IND132	10	TIN068	9
BLK002/TIN061	21	IND133	8	UNW029	5
BLK009	15	IND139/MAN005	24	UNW039	23
BLK011	10	IND163/BEE017	20	UNW079	9
BLK016	16	IND205	8		
BLK021	11	IND231	9		
BLK024	15	LAW030	9		
BLK033	8	LAW035	8		
BLK039	10	LAW043	9		
BLK044	6	LAW052	5		
BLK069	15	LAW062	9		
BLK074	14	LAW063	9		
BLK075	11	LAW065	5		
BLK077	8	LAW070	5		
BLK094	17	LAW078	8		
BLK095	10	LAW082	8		
BLK096	8	LAW085	4		
BLK099	16	LAW105	15		
BLK115	17	LAW107	5		
BLK143	7	LAW108/FSL047	19		
FSL044	6	LAW112	4		
FSL051	8	LAW120	9		
FSL053	8	LAW122	12		
FSL054	18	LNP018	12		
FSL065	12	LNP045	7		
FSL116	14	MAN006/IND229	12		
FSL118	10	MAN007	22		
FSL123	8	MAN014	6		
FSL124	9	MAN034	6		
FSL125	3	MAN037	14		
FSL126	3	MAN042	16		
FSL128	8	MAN060	4		
FSL129	10	PLC007	18		
FSL130	11	PLC024	8		
FSL138	10	PLC070	12		
FSL166	8	PLC072	12		
FSL172	9	PLC097	6		
FSL187	12	PLC106	6		

Some vegetation parcels have been given two prefixes, for example BLK002/TIN061 = Blackrock, Parcel 2/Tinemaha, Parcel 61. Even though two parcels are represented they are analyzed as one "vegetation" parcel. This was done to be consistent with the baseline vegetation mapping efforts that occurred in the mid-1980s (Green Book, 1990). In the end the "vegetation parcel" represents the sample unit "n" for analysis.

Each geographic area contains a different number of parcels ranging from 2 in the Lone Pine (LNP) area to as many as 18 in the Blackrock (BLK), Fish Slough (FSL), and LAWS (LAW) areas (Table 2). Each year after percent cover for each parcel has been calculated, a one way ANOVA ($P < 0.05$) will be used to test for differences between sampling years (including baseline 1986). If a difference is found, a mean separation will be performed. Sometimes called "multiple comparisons", mean separations are comparisons of every pair of means. Since the ANOVA test will only show if at least one mean differs from the others, the objective is to identify where and how many differences exist (ZAR, 1984). Three main comparisons are to be made each year. All parcels vs. all parcels (valley wide), geographic area vs. geographic area (parcel prefix grouping), and wellfield vs. wellfield (Table 3). The last comparison has the parcels grouped according to their proximity to LADWP production wells. There are 9 wellfield groupings and one control group. Groundwater is pumped at differing levels throughout the year in the wellfields. There is no groundwater pumping in the control field. A one way ANOVA will also be use for this test, however to test for differences an ANOVA will need to be performed on the wellfield parcels as well as on the control parcels. Some vegetation parcels are located in two wellfields or in a wellfield and control field. In this case the vegetation parcel will have multiple designations, for example Thibault-Sawmill/Control. When performing analysis the perennial cover value for that parcel is used for both the wellfield ANOVA and the control field ANOVA. In the event of a difference being detected, a mean separation will be performed to determine the wellfield or wellfields that are driving the change. Furthermore, to determine measurability, a comparison of vegetation cover and composition at the affected area with vegetation data from one or more control sites located in areas which have similar vegetation, soil, and precipitation conditions will need to be performed. This will include a comparison of the ratio of recently decreased vegetation in the affected area with other areas not affected by pumping with similar vegetation cover and composition, soil, and precipitation (Green Book, 1990).

Table 2. Vegetation Parcels and Respective Transects Based on Geographic Designation.

Geographic Area	Parcel Prefix	Parcels (n)	Number of Transects
Big Pine	BGP	8	101
Bishop	BIS	3	29
Blackrock	BLK	18	235
Fish Slough	FSL	18	167
Independence	IND	16	182
Laws	LAW	18	143
Lone Pine	LNP	2	19
Manzanar	MAN	7	80
Poleta Canyon	PLC	10	131
Tinemaha	TIN	7	87
Union Wash	UNW	3	37

Table 3. Parcel Grouping By Wellfield

Parcel	Well Field	Parcel	Well Field	Parcel	Well Field
MAN034	Bairs-Georges	LAW107	Laws	IND119	Control
MAN042	Bairs-Georges	LAW108	Laws	IND163	Control
BGP088	Big Pine	LAW112	Laws	PLC007	Control
BGP094	Big Pine	LAW137	Laws	PLC024	Control
BGP154	Big Pine	IND124	Symmes-Shepard	PLC070	Control
BGP157	Big Pine	IND133	Symmes-Shepard	PLC072	Control
BGP162	Big Pine	IND139	Symmes-Shepard	PLC097	Control
BGP182	Big Pine	IND231	Symmes-Shepard	PLC106	Control
FSP004	Big Pine	MAN005	Symmes-Shepard	PLC107	Control
FSP006	Big Pine	MAN007	Symmes-Shepard	PLC121	Control
FSP019	Big Pine	BLK002	Taboose Aberdeen	PLC137	Control
FSP022	Big Pine	BLK009	Taboose Aberdeen	PLC210	Control
TIN028	Big Pine	BLK011	Taboose Aberdeen	PLC223	Control
TIN030	Big Pine	BLK016	Taboose Aberdeen	UNW039	Control
FSL044	Bishop	BLK021	Taboose Aberdeen		
FSL047	Bishop	BLK024	Taboose Aberdeen		
FSL051	Bishop	BLK033	Taboose Aberdeen		
FSL053	Bishop	BLK039	Taboose Aberdeen		
FSL054	Bishop	BLK044	Taboose Aberdeen		
FSL065	Bishop	TIN050	Taboose Aberdeen		
FSL116	Bishop	TIN053	Taboose Aberdeen		
FSL118	Bishop	TIN061	Taboose Aberdeen		
FSL123	Bishop	TIN064	Taboose Aberdeen		
FSL125	Bishop	TIN068	Taboose Aberdeen		
FSL126	Bishop	BLK075	Taboose Aberdeen/Thibault-Sawmill		
FSL128	Bishop	BLK077	Thibault-Sawmill		
FSL129	Bishop	BLK094	Thibault-Sawmill		
LAW120	Bishop Cone	BLK095	Thibault-Sawmill		
LAW122	Bishop Cone	BLK096	Thibault-Sawmill		
IND205	Independence Oak	BLK099	Thibault-Sawmill		
IND011	Independence-Oak	BLK143	Thibault-Sawmill		
IND019	Independence-Oak	IND029	Thibault-Sawmill		
IND106	Independence-Oak	IND035	Thibault-Sawmill		
IND111	Independence-Oak	BLK069	Thibault-Sawmill/Control		
IND132	Independence-Oak/Symmes Shepard	BLK074	Thibault-Sawmill/Control		
LAW030	Laws	BGP031	Control		
LAW035	Laws	BIS055	Control		
LAW043	Laws	BIS060	Control		
LAW052	Laws	BIS085	Control		
LAW062	Laws	BLK115	Control		
LAW063	Laws	FSL130	Control		
LAW065	Laws	FSL138	Control		
LAW070	Laws	FSL166	Control		
LAW078	Laws	FSL172	Control		
LAW082	Laws	FSL187	Control		
LAW085	Laws	IND064	Control		
LAW105	Laws	IND096	Control		

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