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EXHIBIT

194

Report of Lee G. Bergfeld entitled "Consumptive Use of Applied Water of Alfalfa in Mason Valley" dated February 14, 2013

Consumptive Use of Applied Water of Alfalfa in Mason Valley

PROFESSIONAL ENGINEER-STATE OF NEVADA
LEE G. BERGFELD
Exp. 12/31/14
CIVIL
2/14/13
No. 19536

Prepared by

MBK ENGINEERS
1771 Tribute Road, Suite A
Sacramento, CA 95815
916.456.4400
916.456.0253 (fax)

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I. EXECUTIVE SUMMARY

This report details the data, methods, and assumptions used to calculate consumptive use of applied water (CUAW) of alfalfa in the Mason Valley. Alfalfa was selected because it is the principal crop grown in the Mason Valley (State of Nevada, 2011), has been used in legal rulings such as U.S. v. Alpine Land & Reservoir Co. and Nevada State Engineer Ruling #6035, and has a CUAW higher than other crops commonly grown in the Mason Valley (Huntington and Allen, 2010). The analysis involved use of weather data from stations located in the Mason Valley to calculate a reference evapotranspiration (ET). The American Society of Civil Engineers (ASCE) Standardized Reference ET Equation was used to calculate a daily reference ET which was multiplied by crop coefficients. A dual crop coefficient method and daily soil water balance approach were applied to calculate daily potential crop ET and the portions of daily potential crop ET met from precipitation and applied water.

Results of this analysis were compared to three recent studies: (1) conducted by Nevada Division of Water Resources (NDWR) and the Desert Research Institute (DRI) (State of Nevada, 2011), (2) NDWR's 2010 report "Evapotranspiration and Net Irrigation Water Requirement for Nevada" (NDWR's 2010 Report or Huntington and Allen), and (3) a U.S. Geological Survey (USGS) study from 2005 through 2007 (Allander et. al., 2009). Based on comparisons with these studies, review of aerial images of the Mason Valley, and recommendations from the Irrigation Training & Research Center at California Polytechnic State University (ITRC, 2003), potential crop ET was reduced by 8% to better represent field conditions and actual CUAW of alfalfa.

The average March through October CUAW of alfalfa in the Mason Valley for approximately the last 10 years is 3.0 feet. CUAW was calculated for the March through October period because this is the diversion season for natural flow rights under the Walker River Decree, and because these dates approximately define the alfalfa growing season in the Mason Valley. This number represents the CUAW of alfalfa, assuming the crop has access to an adequate supply of water.

II. BACKGROUND

The purpose of this analysis is to determine the CUAW of alfalfa in the Mason Valley. This analysis was performed using the ASCE Standardized Reference Evapotranspiration Equation (ASCE Equation). The ASCE Equation was developed by the Evapotranspiration in Irrigation and Hydrology Committee – Environmental and Water Resources Institute (the Committee). Reference ET is a function of local weather and represents the crop water use from a defined vegetated surface (ASCE Task Committee, 2005). Reference ET serves as an evaporative index by which engineers, hydrologists, water managers, and other technical professionals can predict ET for a range of conditions by applying crop coefficients for agricultural and landscape use (ASCE Task Committee, 2005).

The ASCE Equation was developed to define a benchmark reference ET equation to standardize the calculation of reference ET. The equation was designed to be acceptable to the U.S. scientific community, engineers, policy makers, and end users (ASCE Task Committee, 2005). The Committee also provided guidelines for assessing the integrity of weather data used for estimating ET.

NDWR's 2010 Report states Nevada has adopted the daily time-step grass reference ASCE Equation as the basis for computing ET and the net irrigation water requirement (NIWR) (Huntington and Allen, 2010). Net irrigation water requirement is synonymous with CUAW. Analysis conducted for NDWR's 2010 Report was based on the ASCE Equation.

The first step in my approach is to review and assess the quality of available weather station data. Weather station data at two stations in the Mason Valley required adjustment because the stations are not located in irrigated areas. Second, a reference ET is calculated from available weather station data. The third step is to develop a crop coefficient. A dual crop coefficient method was used in this analysis as described in Food and Agriculture Organization of the United Nations Irrigation and Drainage Paper 56 (FAO 56). A daily soil water balance was developed to calculate crop coefficients, water stress, and to simulate irrigations. The daily soil water balance included weather data to determine growing seasons and cutting cycles, daily soil moisture accounting to determine irrigation requirements, and calculation of daily crop ET and the portion met from precipitation and the portion met from applied irrigation water, referred to here as CUAW. This approach follows the methods described in NDWR's 2010 Report. Modifications to methods in NDWR's 2010 Report are described in this report.

III. MASON VALLEY WEATHER STATIONS

The analysis utilized weather data from three stations located in the Mason Valley. Table 1 is a summary of these stations and periods of available data. Figure 1 shows the approximate locations of the stations.

Station Name	Latitude	Longitude	Elevation (feet)[1]	Period of Available Data	
				Start	End
Yerington	38° 58' 57"	119° 10' 55"	4,395	Sep. 2002	Dec. 2012
Campbell Ranch	39° 03' 46"	119° 12' 15"	4,340	Jan. 2002	Dec. 2012
Mason Valley	39° 06' 24"	119° 08' 50"	4,320	May 2010	Dec. 2012

Table 1. Mason Valley Weather Station Information

[1] Approximate elevation based on NAVD 88.

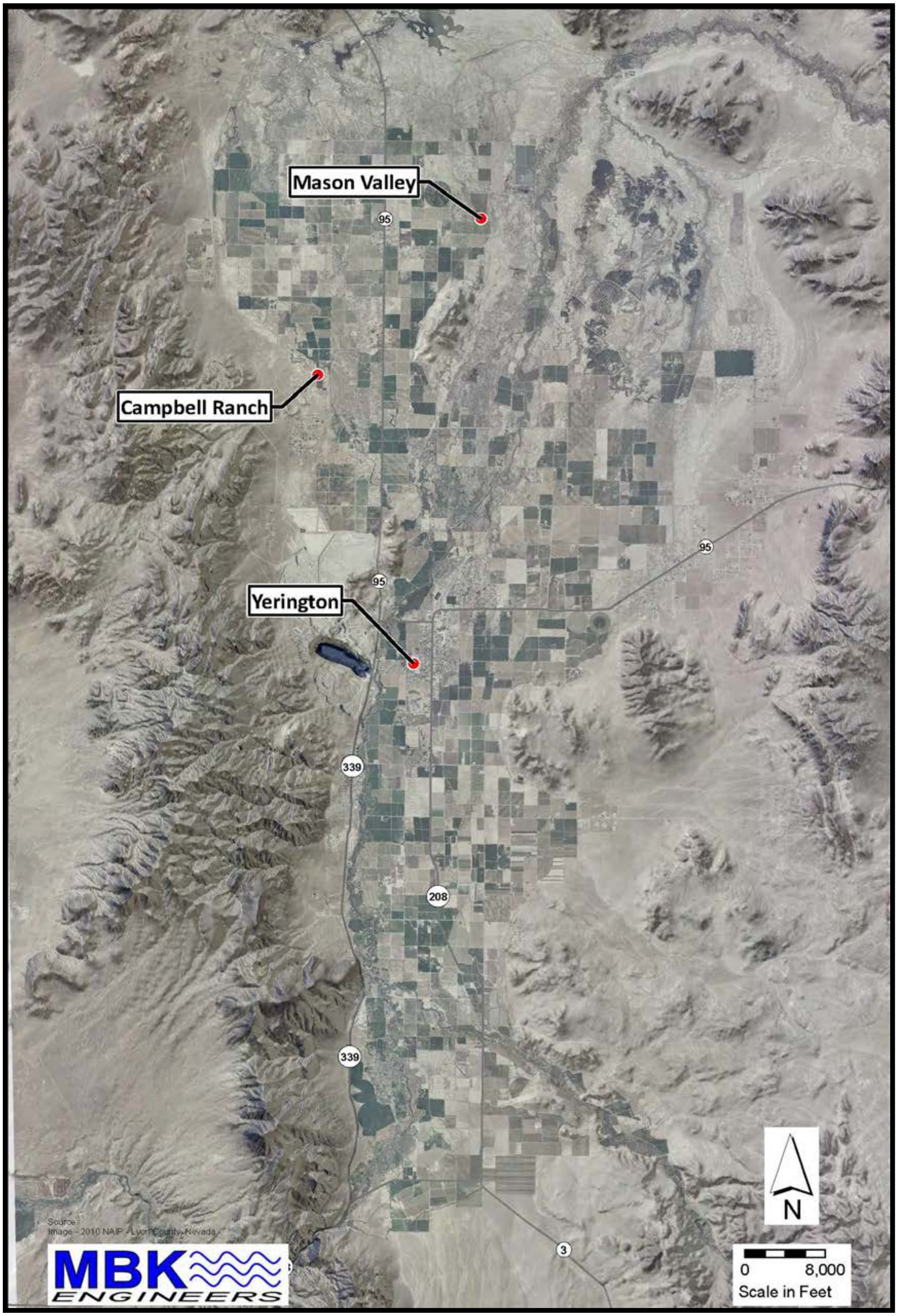

Figure 1. Mason Valley Weather Station Locations

IV. WEATHER DATA QUALITY CONTROL

The quality of weather data collected at automatic weather stations can vary. Therefore, all weather data used in this analysis were reviewed following the procedures outlined in the ASCE Task Committee on Standardization of Reference Evapotranspiration, Appendix D (ASCE Task Committee, 2005). This review included discussion with Mr. Greg McCurdy at Desert Research Institute (DRI) who collects data at the stations.

According to Mr. McCurdy, DRI generally observes weather station data on a weekly basis to determine if the station is operational, performs maintenance on the stations twice each year, and calibrates the sensors annually. Only limited quality assurance/quality control procedures are applied, such as removing obviously erroneous or missing periods, prior to posting the data on the Western Regional Climate Center website.

The Yerington station is located in the town of Yerington in a primarily urban area south of Bridge Street and west of Main Street. The Campbell Ranch station is located on the northwest side of the Mason Valley in a non-vegetated, non-irrigated lot. Agricultural fields are located to the north, east, and south sides of the lot though these fields may not be irrigated every year. The Mason Valley station is located in the north central part of the Mason Valley in a field of irrigated alfalfa. The Mason Valley station is the only station that appears to be located in a nearly ideal site, defined as centrally located over a dense, actively transpiring crop of grass or alfalfa extending at least 100 meters in all directions (ASCE Task Committee, 2005). However, the location of the Yerington and Campbell Ranch stations in non-ideal settings does not preclude their use in estimating reference ET. Adjustments to data from non-ideal settings were made as described in subsequent sections.

Solar radiation data were screened by plotting measured values against the theoretical clear-sky solar radiation envelope for the station location. Measured solar radiation should approach the clear-sky solar radiation envelope on cloud-free days, but should never exceed the clear-sky solar radiation envelope that is the theoretical maximum radiation. The clear-sky solar radiation envelope was calculated using the detailed procedures recommended in ASCE Appendix D (ASCE Task Committee, 2005). These plots illustrated an inconsistency with the measured solar radiation at the Mason Valley station. Measured solar radiation routinely exceeded the clear-sky solar radiation envelope, see Figure 2. These data were replaced with the data for the same days from the Campbell Ranch station, see Figure 3. Measured solar radiation data at the Yerington station were acceptable, per ASCE Appendix D.

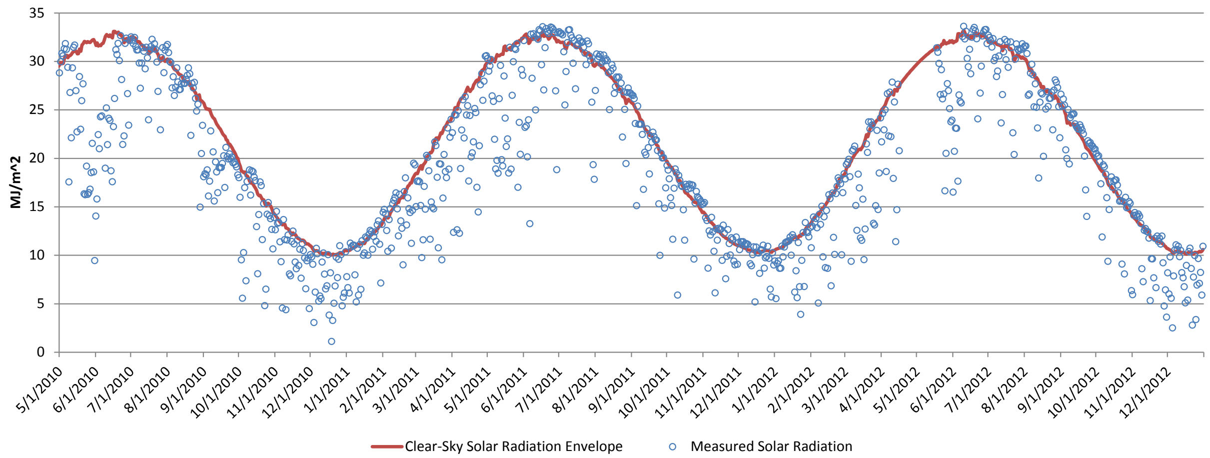

Figure 2. Measured Solar Radiation and Clear-Sky Solar Radiation Envelope at Mason Valley Station

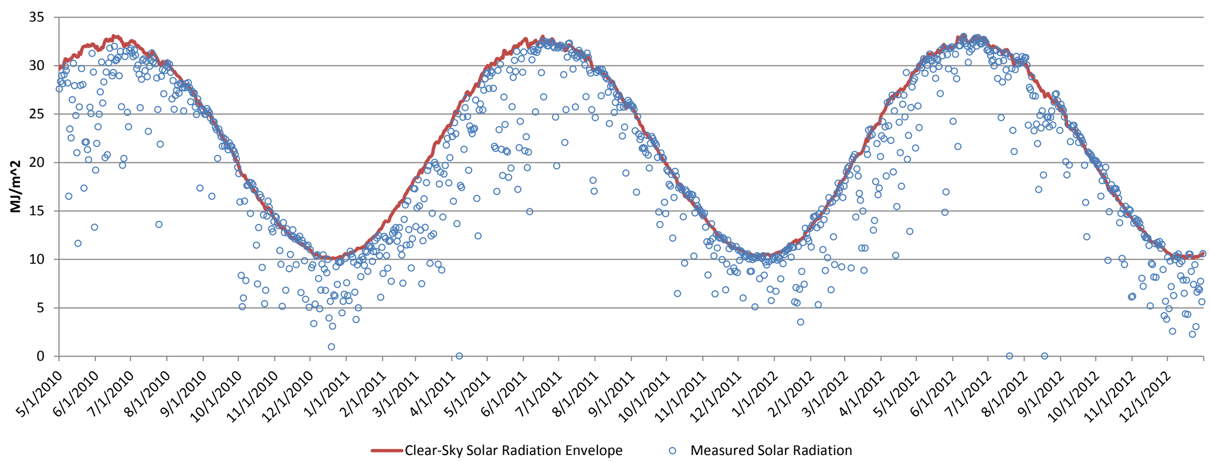

Figure 3. Measured Solar Radiation and Clear-Sky Solar Radiation Envelope at Campbell Ranch Station

Maximum relative humidity data were screened for values greater than 100%. Measured relative humidity exceeded 100% on less than five days each at the Yerington and Campbell Ranch stations and did not exceed 100% at the Mason Valley station. All values exceeding 100% were set to 100% for use in calculations, per the recommendation in ASCE Appendix D (ASCE Task Committee, 2005).

Daily mean wind speed data were plotted at each station as described in ASCE Appendix D (ASCE Task Committee, 2005). The wind speed measured at each station appeared to be well distributed and with ranges similar to nearby stations. Gust factors, the ratio of maximum to mean daily wind speeds, were plotted over time and the ratio did not appear to increase, which indicates no bearing contamination in the anemometers. Wind speeds at the Campbell Ranch station typically exceed wind speed at the Mason Valley station. This may be because the Campbell Ranch station is located on the western edge of the irrigated portion of the

Mason Valley. Additionally, wind speeds at the Yerington station were typically lower than at the Mason Valley station. This may be due to interference from nearby buildings.

Maximum and minimum temperature data were compared to historical monthly maximum and minimum records at the Yerington Airport National Weather Service station. Temperature data were within the range of historical maximum and minimum values on all days at the Yerington station, all but one day at the Mason Valley station, and all but four days at the Campbell Ranch station. Temperature data for all three stations were plotted together for comparison and were typically similar.

Solar radiation, wind speed, temperature, humidity, and precipitation data were reviewed by plotting each variable at all three stations on a single plot. This provided an understanding of the correlation between the stations, as well as identified additional anomalies in the data for review and correction.

If data were missing or determined to be erroneous using the procedures described above and recommended by ASCE Appendix D, the data were replaced using the calculated daily median historical value at that station. The calculated daily median historical value was determined by calculating the monthly median of the station's historical data, and linearly interpolating daily values using the monthly medians. Precipitation data were replaced using data from a nearby weather station.

The period of available data at the Yerington station began in September 2002. The period of analysis for this station was limited to calendar years 2003 through 2012. The period of available data at the Mason Valley station began April 30, 2010. In order to make use of this data and estimate the CUAW for 2010 at this station, data for January 1 through April 29 were estimated. Temperature and precipitation data from the Yerington station were used for this period at the Mason Valley station. All other parameters were estimated from daily median historical values for the station. Table 2 summarizes the period of analysis at each station.

	Period of Analysis	
Station Name	**Start**	**End**
Yerington	Jan. 2003	Dec. 2012
Campbell Ranch	Jan. 2002	Dec. 2012
Mason Valley	Jan. 2010[1]	Dec. 2012

Table 2. Period of CUAW Analysis at Mason Valley Weather Stations

[1] January through April analysis based on median monthly values for 2011 and 2012 and Yerington station data.

V. ADJUSTMENTS FOR STATIONS IN NON-IDEAL SETTINGS

Weather station data for the Campbell Ranch and Yerington stations were adjusted to account for non-ideal conditions below and around each station. Equipment at these two stations is located over and near non-irrigated, arid areas. Comparisons of 10-day average maximum and minimum air temperature (see Figure 4) and maximum and minimum relative humidity (see Figure 5) between all three stations illustrate effects of aridity at these two stations. Arid conditions tend to increase temperatures and decrease relative humidity compared to data collected from stations located in irrigated expanses of actively growing grass or alfalfa. Calculation of reference ET using data from stations in arid locations has been shown to overestimate reference ET (Allen, et al, 1982). Therefore, it is important to adjust data for the effects of site aridity before calculating reference and crop ET.

The availability of data from a station located in a nearly ideal setting at Mason Valley provides a basis for making aridity adjustments to data at Campbell Ranch and Yerington. This approach is similar to that followed by Allen, Brockway, and Wright (1982). Daily data were used to calculate time-series of average monthly maximum and minimum air temperature and relative humidity for comparison between the stations for the period of available data at Mason Valley. Average differences between Campbell Ranch and Mason Valley, and Yerington and Mason Valley were calculated by month. Average monthly adjustment values for each station are summarized in Table 3. Linear interpolation was used between average monthly values to adjust daily data. Adjustments were applied only during the March through October irrigation season.

Temperature Adjustments (^{o}C)								
Station	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**
Yerington	-1.3	-1.4	-1.9	-2.3	-2.6	-3.2	-3.2	-2.7
Campbell Ranch	-0.7	-0.9	-1.2	-1.4	-1.5	-2.0	-1.7	-1.3
Relative Humidity Adjustment (%)								
Station	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**
Yerington – Max.	8.8	10.8	13.9	16.6	18.1	21.3	23.9	18.9
Yerington – Min.	3.0	3.3	6.6	5.5	4.3	5.3	5.0	7.0
Campbell Ranch – Max.	3.5	6.6	8.3	11.6	15.9	19.8	20.3	14.6
Campbell Ranch – Min.	0.2	0.3	3.6	3.0	2.2	3.5	2.5	4.4

Table 3. Aridity Adjustments for Temperature and Relative Humidity Data

No adjustments were made to wind speed data at either Campbell Ranch or Yerington stations. It should be noted that studies have shown that wind speeds on the edge of irrigated areas can be higher than within irrigated areas due to local advection (Hanks et. al., 1971; Burman et. al., 1975; Hashemi and Habibian, 1979). Higher wind speeds will increase

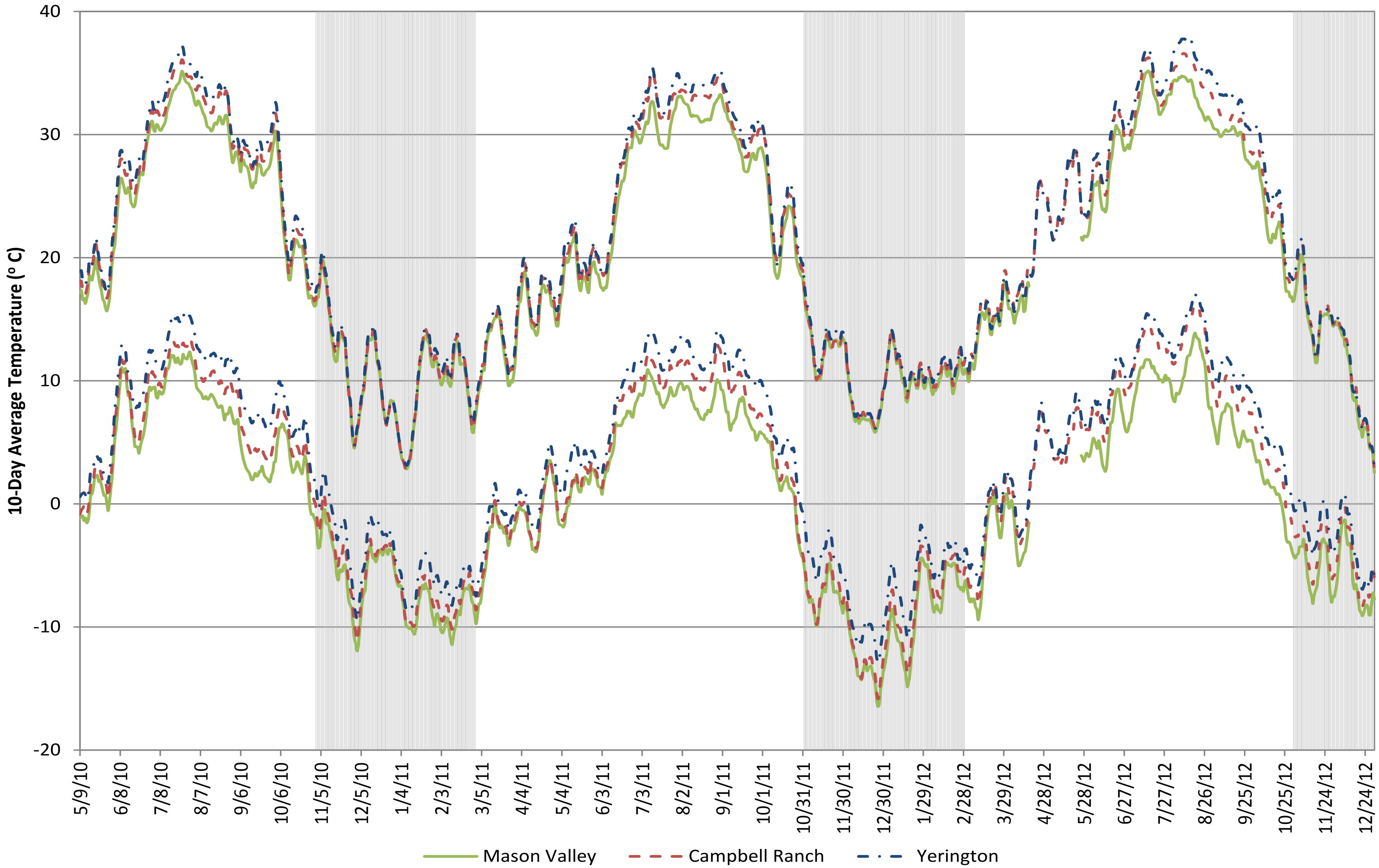

Figure 4. Comparison of 10-Day Average Maximum and Minimum Air Temperature at all Mason Valley Stations

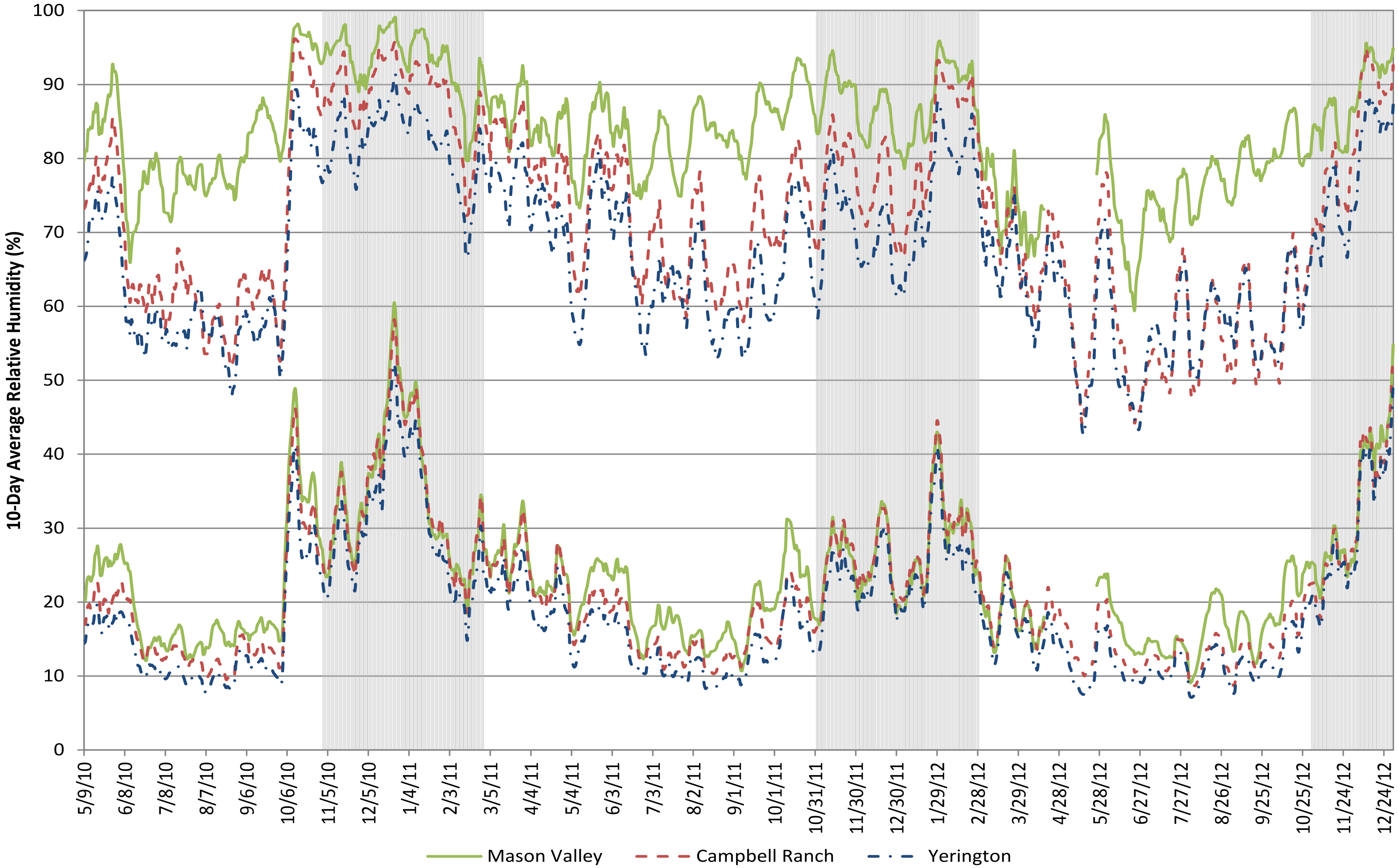

Figure 5. Comparison of 10-Day Average Maximum and Minimum Relative Humidity at all Mason Valley Stations

calculated reference ET. Likewise, low wind speeds at Yerington will decrease calculated reference ET. These localized effects were considered in analysis of results.

VI. CALCULATION OF REFERENCE ET

The ASCE Equation can be used for both a short reference crop (similar to clipped grass) and a long reference crop (similar to alfalfa) (ASCE Task Committee, 2005). NDWR's 2010 Report states Nevada has adopted the daily time-step grass reference ASCE Equation as the basis for computing ET and the net irrigation water requirement (Huntington and Allen, 2010).

The calculation of reference ET was performed on a daily time-step in the manner described in the ASCE Report (ASCE Task Committee, 2005). The ASCE Standardized Reference Evapotranspiration Equation for a short reference crop is:

$$ET_{os} = \frac{0.408\Delta(R_n - G) + \gamma \frac{C_n}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + C_d u_2)}$$

where

ET_{os} = standardized reference crop evapotranspiration for short surfaces (mm/day)
R_n = calculated net radiation at the crop surface ($MJ/m^2/day$)
G = soil heat flux density at the soil surface ($MJ/m^2/day$)
T = mean daily air temperature at 1.5 to 2.5 meters height (^oC)
u_2 = mean daily wind speed at 2 meters height (m/second)
e_s = saturation vapor pressure at 1.5 to 2.5 meters height (kPa), calculated as the average of saturation vapor pressure at maximum and minimum air temperature
e_a = mean actual vapor pressure at 1.5 to 2.5 meters height (kPa)
Δ = slope of the saturation vapor pressure-temperature curve ($kPa/^oC$)
γ = psychrometric constant ($kPa/^oC$)
C_n = numerator constant, varies by reference crop and calculation time-step
C_d = denominator constant, varies by reference crop and calculation time-step

The use of the reference ET equation requires numerous preceding calculations for some of the listed variables. The reader is referred to the ASCE Task Committee Report for a thorough review and discussion of these methods and sub-calculations.

One adjustment was made to the wind speed data because at all three stations the anemometers are located at a height of three meters, while the reference equation is based on wind speed at two meters. Wind speed was adjusted to the two meter height by the following equation from the ASCE Task Committee Report (ASCE Task Committee, 2005):

$$u_2 = u_z \left(\frac{4.87}{\ln(67.8 z_w - 5.42)} \right)$$

where

u_2 = mean daily wind speed at 2 meters height (m/second)

u_z = measured wind speed at z_w above ground surface (m/second)

z_w = height of measurement above ground surface (m)

VII. GROWING SEASON AND CUTTING CYCLES

The growing season and cutting cycles for alfalfa in Mason Valley were estimated by use of the cumulative growing degree days (CGDDs) approach, as described in NDWR's 2010 Report, (Huntington and Allen, 2010). Growing degree days are calculated for each day as the maximum of the average daily temperature or zero. Growing degree days are accumulated from January 1 each year. Weather station temperature data were adjusted for aridity prior to calculation of CGDD.

Table 4 contains the CGDDs used for greenup or start of the growing season, effective full cover or first cutting, and each subsequent cutting of alfalfa in the Mason Valley. Cuttings were limited to a maximum of four for the analysis based on common practices in the Mason Valley (Snyder and Fulstone, 2013).

Growth Stage or Cutting Cycle	CGDDs from Jan. 1 (°C)
Greenup or start of growing season	300
Effective full cover or first cutting	880
Second cutting	1,620
Third cutting	2,360
Fourth cutting	3,100

Table 4. Cumulative Growing Degree Days for Alfalfa Growth Stage and Cutting Cycles

Daily temperature data available from the National Weather Service (NWS) station at the Yerington Airport for 64 years, from 1949 through 2012, were analyzed to estimate typical growing season lengths in the Mason Valley. These data were used to provide a longer record of data that is likely more representative of the range of potential temperatures and therefore growing seasons. NWS temperature data at the Yerington Airport indicate the median date for greenup, when the CGDD meets or first exceeds 300, is approximately March 21, see Figure 6 at 50%. The first killing frost of -7.0° C or less was used to determine the end of the growing season (Huntington and Allen, 2010). The median date for the first killing frost at the Yerington Airport NWS station is November 9. Figure 3 illustrates the probability of exceedance for the start and end of the alfalfa growing seasons and cutting cycles based on CGDDs in Table 4 and

NWS temperature data at the Yerington Airport from 1949 through 2012. Temperature data at the Yerington Airport were adjusted for aridity prior to calculation of CGDDs per Huntington and Allen (2010).

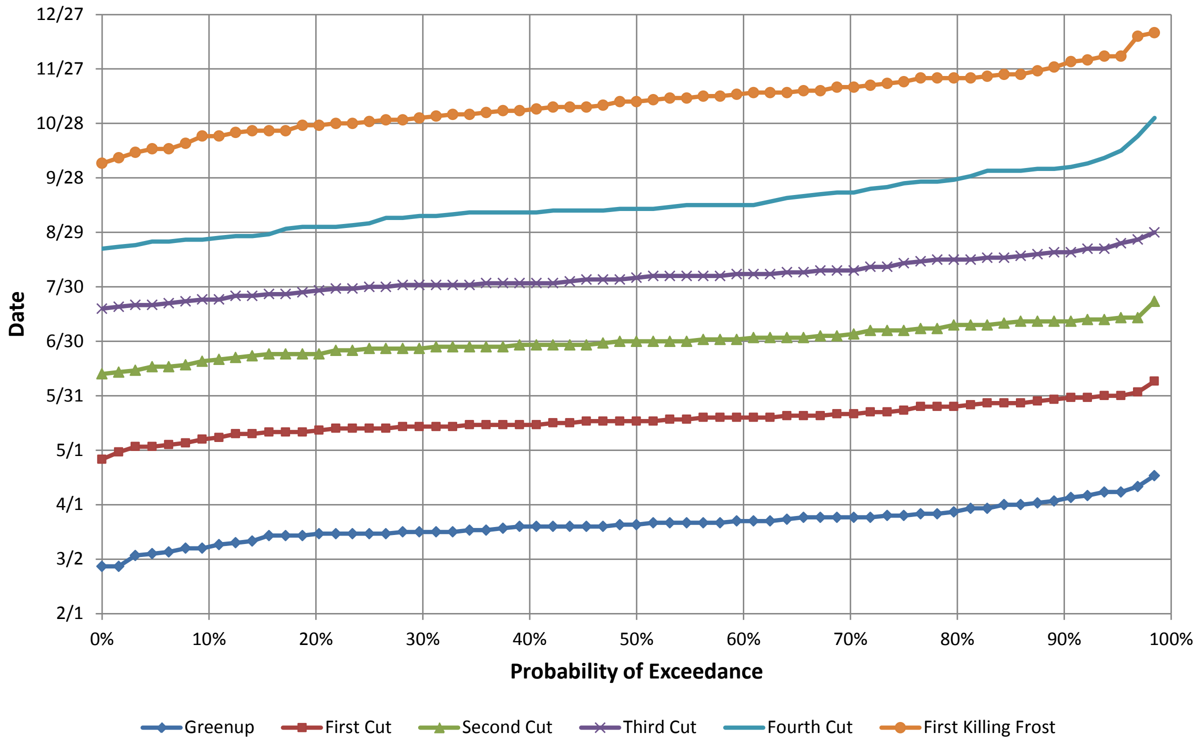

Figure 6. Probability of Exceedance for Alfalfa Growing Season and Cutting Cycles based on NWS data at Yerington Airport

Dates presented in Figure 6 were calculated to better understand growing seasons and cutting cycles determined for each of the three weather stations with shorter periods of record in the context of long-term records for the Mason Valley. These data also indicate that the alfalfa growing season for Mason Valley and the Walker River Decree diversion season of March through October are generally aligned.

VIII. CROP COEFFICIENTS AND DAILY SOIL WATER BALANCE

The ASCE equation accounts for the meteorological influences on ET for an actively growing reference crop with adequate water supply, at full cover and peak height. The resulting reference ET is then multiplied by a crop coefficient that accounts for the differences in ET from an actual crop that grows to full cover and is harvested over the course of an irrigation season. The crop coefficient also accounts for differences in the crop surface and geometry from the specified reference crop. Reference ET is combined with crop specific information such as growing season and crop coefficients to calculate a total potential crop ET, ET_{crop}.

Crop coefficients, K_c, are identified for various stages of the crop growth cycle, such as the initial, development, middle, and late growth stage. Alfalfa is harvested several times during the growing season and these periodic cuttings affect the K_c throughout the growing season. A dual crop coefficient method and a daily soil water balance were used in this analysis to develop daily crop coefficients to represent various stages of crop growth and alfalfa cutting cycles. The dual crop coefficient method separates K_c into a basal crop coefficient, K_{cb}, representing the ET of the crop with a dry soil surface, and a soil evaporation coefficient, K_e (Allen et. al., 1998; Allen et. al. 2005). Potential crop ET, ET_{crop}, under the dual crop coefficient approach with consideration of crop water stress is then,

$$ET_{crop} = (K_s * K_{cb} + K_e) * ET_{os}$$

where

ET_{crop} = potential crop evapotranspiration (mm/day)
K_s = crop water stress coefficient (unitless)
K_{cb} = basal crop coefficient (unitless)
K_e = soil evaporation coefficient (unitless), adjusted based on water available at the soil surface
ET_{os} = standardized reference crop evapotranspiration for short surfaces (mm/day)

Basal crop coefficients for alfalfa were taken from Huntington and Allen (2010), Figure 22, reproduced below as Figure 7.

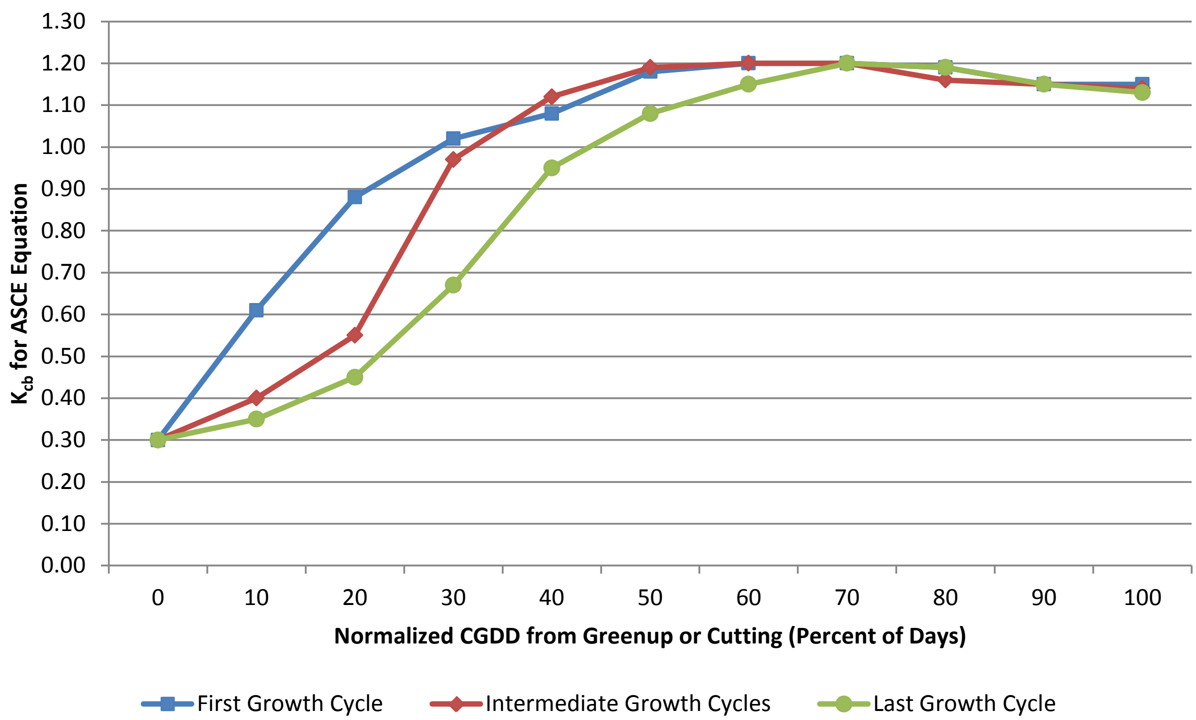

Figure 7. Alfalfa K_{cb} Curve for First, Intermediate, and Last Growth Cycles from Huntington and Allen (2010)

Normalized cumulative growing degree days were calculated for each growth cycle based on weather station data and used to interpolate between points illustrated in Figure 7 to develop daily K_{cb} values for the period of analysis at each weather station. A K_{cb} value of 0.12 was used outside of the growing season (Huntington and Allen, 2010). Following the first day when temperature dropped below -3.0^{o} C, K_{cb} values were reduced by 0.005 multiplied by the number of days since the temperature went below -3.0^{o} C based on Allen and Robinson (2007) and Huntington and Allen (2010).

A daily soil water balance was used to estimate the K_e value and determine any potential water stress at the soil surface. The daily soil water balance and daily values for K_e were calculated as described in Allen et. al. (2005). Daily K_e values were based on daily water balance in the upper 0.1 meter of the soil column.

The daily water balance included calculation of runoff and infiltration of precipitation. Runoff of precipitation was calculated daily using the Natural Resources Conservation Service (NRCS) curve number approach (USDA-NRCS, 2004). Curve numbers were calculated based hydrologic soil group data from the NRCS Soil Survey Geographic (SSURGO) database for the Mason Valley and antecedent soil conditions calculated in the daily soil water balance. The NRCS SSURGO database contains soils data collected by the National Cooperative Soil Survey (NRCS, 2013). Details on the adjustment of curve numbers based on soil types and antecedent soil moisture is contained in Huntington and Allen (2010). Daily infiltration of precipitation was calculated as measured precipitation minus runoff. Precipitation that infiltrates may evaporate from the soil surface, be stored in the root zone, or percolate past the root zone.

The daily soil water balance relied on an estimate of the available water holding capacity (AWC) of soils in the Mason Valley. AWC was estimated based on data in the NRCS SSURGO database. Based on NRCS data, the area weighted average available water holding capacity for the Mason Valley is 136 millimeters per meter of soil depth. Therefore, the maximum available water holding capacity within a 1.8 meter root zone for alfalfa is 244.8 millimeters. AWC of the root zone is a function of rooting depth. A root growth function following Borg and Grimes (1986) and used in Huntington and Allen (2010) was used as part of the daily soil water balance. The total available water (TAW) on any given day was calculated as the AWC multiplied by the rooting depth.

The daily soil water balance was used to simulate irrigations to avoid crop water stress. Simulated irrigations occur when the readily available water (RAW) is depleted from the root zone. RAW was calculated per Huntington and Allen (2010) as,

$$RAW = TAW * \frac{MAD}{100}$$

where

RAW = readily available water (mm)
TAW = total available water (mm)
MAD = maximum allowable depletion before stress occurs (percent)

A MAD value for alfalfa of 60% was used from Huntington and Allen, Appendix 5 (2010). Simulated irrigations were calculated as the depth of water needed to refill the TAW for the entire root zone. Simulated irrigations began each year on March 5. This is prior to greenup but consistent with practice in the Mason Valley (Snyder and Fulstone, 2013). Simulated irrigations ended after the fourth cutting each year.

Results from the daily soil water balance were used to determine the portion of daily crop ET met from precipitation and applied water. This was done by tracking the portion of water in the root zone from each source separately and assuming daily crop ET was met from both precipitation and applied water based on the proportion of each stored in the root zone on the previous day.

Crop coefficients, adjusted for any water stress, were multiplied by the calculated daily reference ET calculated with the ASCE Equation to calculate the daily potential crop ET. Daily potential crop ET of applied irrigation water was aggregated to monthly potential CUAW.

IX. POTENTIAL CONSUMPTIVE USE OF APPLIED WATER

The growing season total potential CUAW is calculated as the sum of the daily potential crop ET of applied irrigation water from March 1 through October 31 for each year analyzed (see Tables 5 through 7). These values represent the potential CUAW under pristine crop conditions with no water stress and should be considered an upper limit of the actual CUAW in the Mason Valley (Huntington and Allen, 2010).

Year	**Month** (inches)								
	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Season
2003	1.5	2.7	5.5	7.4	7.2	5.8	4.0	3.3	37.3
2004	1.6	4.2	5.7	7.9	7.9	5.4	4.0	2.5	39.1
2005	1.1	2.6	4.8	5.9	7.5	5.6	5.2	1.6	34.3
2006	1.0	2.7	5.5	7.8	7.7	5.8	3.9	1.4	35.9
2007	1.9	4.5	6.2	8.5	7.9	6.3	3.8	2.3	41.5
2008	0.9	3.3	5.7	6.7	7.5	6.3	4.9	1.0	36.3
2009	1.2	4.0	6.6	6.2	7.3	6.0	4.5	2.6	38.4
2010	1.1	2.8	4.9	6.2	7.6	6.5	5.1	2.2	36.4
2011	1.1	3.0	5.8	6.6	7.1	6.7	5.0	2.0	37.2
2012	1.7	4.6	6.3	8.4	7.5	5.9	3.9	2.7	40.9
Avg.	**1.3**	**3.4**	**5.7**	**7.2**	**7.5**	**6.0**	**4.4**	**2.2**	**37.7**

Table 5. Monthly and Seasonal Potential CUAW at the Yerington Station

Year	**Month** (inches)								
	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Season
2002	0.7	2.2	6.4	7.9	9.0	6.6	5.5	0.7	38.9
2003	2.3	4.5	7.0	9.0	8.8	6.2	3.9	1.6	43.4
2004	1.8	5.7	7.1	9.5	8.9	6.0	3.6	1.1	43.7
2005	1.3	3.4	6.0	7.3	9.2	6.4	5.7	1.7	40.9
2006	1.1	2.6	5.9	8.9	8.8	6.4	4.6	2.4	40.4
2007	1.8	5.2	7.1	10.0	9.1	7.4	2.7	0.9	44.1
2008	1.0	4.0	7.0	7.4	8.6	7.3	5.5	0.9	41.6
2009	1.1	4.1	7.2	6.7	8.4	6.6	5.3	2.6	42.1
2010	1.1	3.3	5.8	7.0	8.8	7.6	6.0	2.3	41.9
2011	1.3	3.0	6.5	6.9	8.5	7.5	5.6	1.7	41.0
2012	1.6	5.4	7.3	9.9	8.9	7.1	4.2	3.2	47.6
Avg.	**1.4**	**3.9**	**6.7**	**8.2**	**8.8**	**6.8**	**4.8**	**1.7**	**42.3**

Table 6. Monthly and Seasonal Potential CUAW at the Campbell Ranch Station

Year	**Month** (inches)								
	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Season
2010	0.8	2.5	5.0	6.4	8.4	6.3	5.5	2.2	37.2
2011	1.2	2.8	6.2	6.5	7.4	7.0	4.9	2.0	38.0
2012	1.1	3.5	7.1	7.4	8.3	6.4	5.2	1.9	40.9
Avg.	**1.0**	**2.9**	**6.1**	**6.8**	**8.0**	**6.6**	**5.2**	**2.1**	**38.7**

Table 7. Monthly and Seasonal Potential CUAW at the Mason Valley Station

Potential CUAW based on the Campbell Ranch station data is higher than at the other two stations. This is due, at least in part, to higher wind speeds at this location. Potential CUAW based on the Yerington station data is lower than at the other two stations. This is due, at least in part, to lower wind speeds. It is recognized that wind speed data at each location affects these results, but data were not adjusted because of a lack of basis for making adjustments. Effects are partially offset by averaging results from all three stations.

The average potential CUAW of alfalfa in the Mason Valley during the March through October irrigation seasons of all available years at all three stations is calculated to be 39.6 inches or 3.3 feet. The average monthly pattern of potential CUAW for all available years and at all three stations is illustrated below as Figure 8.

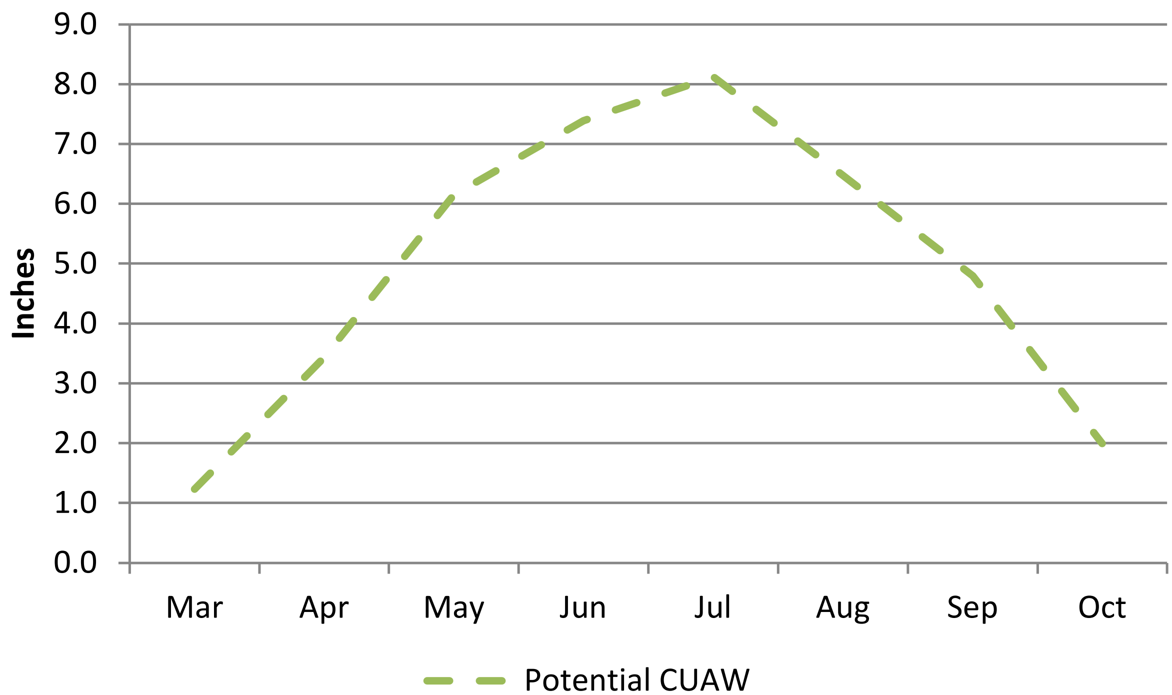

Figure 8. Average Monthly Potential CUAW of Alfalfa in Mason Valley

X. COMPARISONS WITH OTHER STUDIES

NDWR's 2010 Report includes estimates of total ET and net irrigation water requirement (NIWR) for alfalfa in the Mason Valley. Estimates were calculated using NWS data at Yerington Airport, the ASCE Equation, regional wind speeds, estimated solar radiation, and detailed soil water balance accounting. NDWR's 2010 Report calculated average annual total ET and NIWR based on 30 years of available data between 1965 and 2006. Total ET represents ET from both precipitation and applied water. Results of the study for the Mason Valley are summarized and compared to results for this report in Table 8.

	Average Annual Total ET of Alfalfa (feet)	Average Annual NIWR or Potential CUAW of Alfalfa (feet)
NDWR's 2010 Report	3.5[1]	3.1[2]
Average Annual Value for this Report	3.7	3.4
Percent Difference	+6%	+10%

Table 8. Comparison of Mason Valley Total ET and Net Irrigation Water Requirement

[1] Appendix 11a, Huntington and Allen, 2010.
[2] Appendix 12a, Huntington and Allen, 2010.

Differences between calculated values in this report and NDWR's 2010 Report are at least partially explained by differences in the periods of analysis. Other differences are that NDWR's 2010 Report used regional, average wind speeds, and estimates of solar radiation based on temperatures.

The USGS published Scientific Investigation Report 2009-5079 titled "Evapotranspiration from the Lower Walker River Basin, West-Central Nevada, Water Years 2005-07," to provide estimates of total and net ET for areas in the Lower Walker River Basin. This study included estimates for the total ET of alfalfa. The Bowen-ratio energy-budget method was used to calculate total ET of alfalfa at two locations in the Mason Valley, station B11 near the Mason Valley station used in this report, and station B1 near the town of Wabuska. Total ET of alfalfa was calculated at station B1 for one year from April 1, 2005 to March 31, 2006, and for two years from March 1, 2005 to February 28, 2007 at station B11. USGS results are summarized in Table 9 and compared to the same period as calculated using methods described in this report.

	Station B1[1] (feet)	Station B11[2] (feet)
USGS Total ET of Alfalfa	3.3	4.1
Calculated Total ET for this Report	3.7	3.6
Percent Difference	+12%	-12%

Table 9. Comparison with USGS Mason Valley Total ET of Alfalfa

[1] Table 9, Allander et. al., 2009 for period April 2005 through March 2006.
[2] Table 9, Allander et. al., 2009 average for period March 2005 through February 2007.
[3] Total ET of alfalfa, averaged for Yerington and Campbell Ranch Stations for same period as USGS study.

Differences between USGS estimates and this report may be the result of differences in the methods used to calculate ET. The USGS report does not provide explanation for the 0.8 foot difference between estimates at stations B1 and B11.

NDWR processed Landsat satellite data for the 2010 and 2011 seasons using Mapping Evapotranspiration at High Resolution with Internalized Calibration (METRIC) to develop actual ET maps of the Mason Valley (State of Nevada, 2011). METRIC was used to calculate total ET as the residual of the surface energy balance, calibrated using a ground-based reference evapotranspiration from the Mason Valley station used in this analysis. Table 10 is a comparison of average total ET of alfalfa in the Mason Valley as calculated by METRIC and the method described in this report for the same period of May through October of 2010 and 2011.

	May – Oct. 2010 (feet)	**May – Oct. 2011** (feet)
Average METRIC Total ET of Alfalfa	2.7	2.9
Calculated Total ET for this Report	3.07	3.04
Percent Difference	+14%	+5%

Table 10. Comparison with METRIC Total ET of Alfalfa

The consumptive use of alfalfa for areas downstream of Lahontan Reservoir was determined during U.S. v. Alpine Land and Reservoir Co. (503 F. Supp. 877, 1980). Lands downstream of Lahontan Reservoir are approximately 40 miles northeast of Mason Valley and approximately 500 feet lower in elevation. A total actual consumption of 3.25 acre-feet per acre (or feet) was determined and then reduced by 0.26 feet of effective rainfall to arrive at total actual CUAW of 2.99 feet.

XI. ADJUSTMENT FOR NON-PRISTINE CONDITIONS

Total ET and potential CUAW calculated as described above is for a well-managed crop that has uniform cover and vigor across the field and is not short of water. These are referred to as pristine conditions. Aerial images of Mason Valley agricultural areas were collected for years 1994 (USGS, 2013), 2006, and 2010 (USDA, 2013). Review of aerial images of irrigated lands in the Mason Valley show that uniform cover and vigor is not typical. These figures are included as Appendix 1. Therefore, an adjustment to calculated potential CUAW is necessary to estimate the actual CUAW of alfalfa in the Mason Valley.

Research by the Irrigation Training & Research Center (ITRC) concluded that for average cropping conditions in California, calculated crop ET (potential CUAW in this report) should be reduced 7% to 8% when calculating water balances (ITRC, 2003). Additionally, comparison of results of this analysis to METRIC results for 2010 and 2011 in Table 10, indicate total ET of alfalfa using METRIC is an average of approximately 10% less than potential ET calculated for this report. Based on this comparison and research by ITRC, potential ET and CUAW calculated and presented above should be reduced by 8% to estimate actual CUAW of alfalfa in the Mason Valley.

XII. CONCLUSION

Based on the calculations described above, the average March through October CUAW of alfalfa in the Mason Valley is 36.4 inches or approximately 3.0 feet. The average monthly CUAW of alfalfa is illustrated in Figure 9 and provided in Table 11.

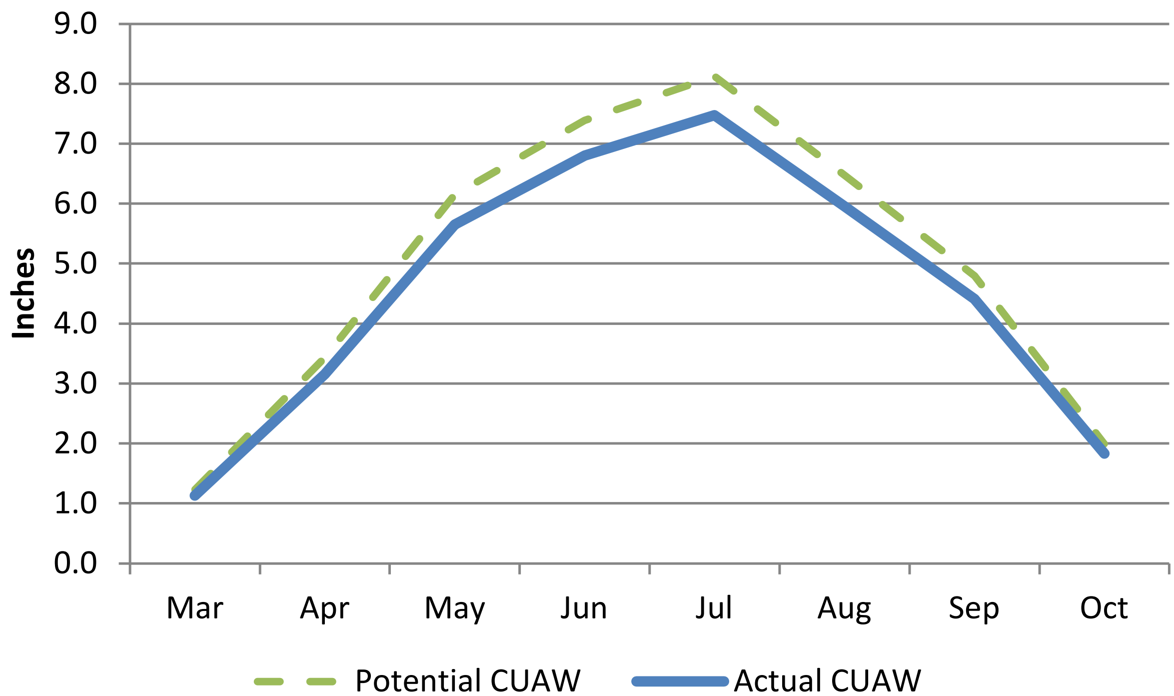

Figure 9. Monthly Pattern of CUAW of Alfalfa in Mason Valley

Month (inches)								**Season**	**Season**
Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	(inches)	(feet)
1.1	3.2	5.6	6.8	7.5	6.0	4.4	1.8	36.4	3.0

Table 11. Average Monthly and Seasonal CUAW of Alfalfa in Mason Valley

An approximate daily pattern of CUAW of alfalfa was developed from the average monthly CUAW by interpolation between monthly values and extrapolation to the beginning of March and end of October. The approximate daily pattern is presented as Figure 10.

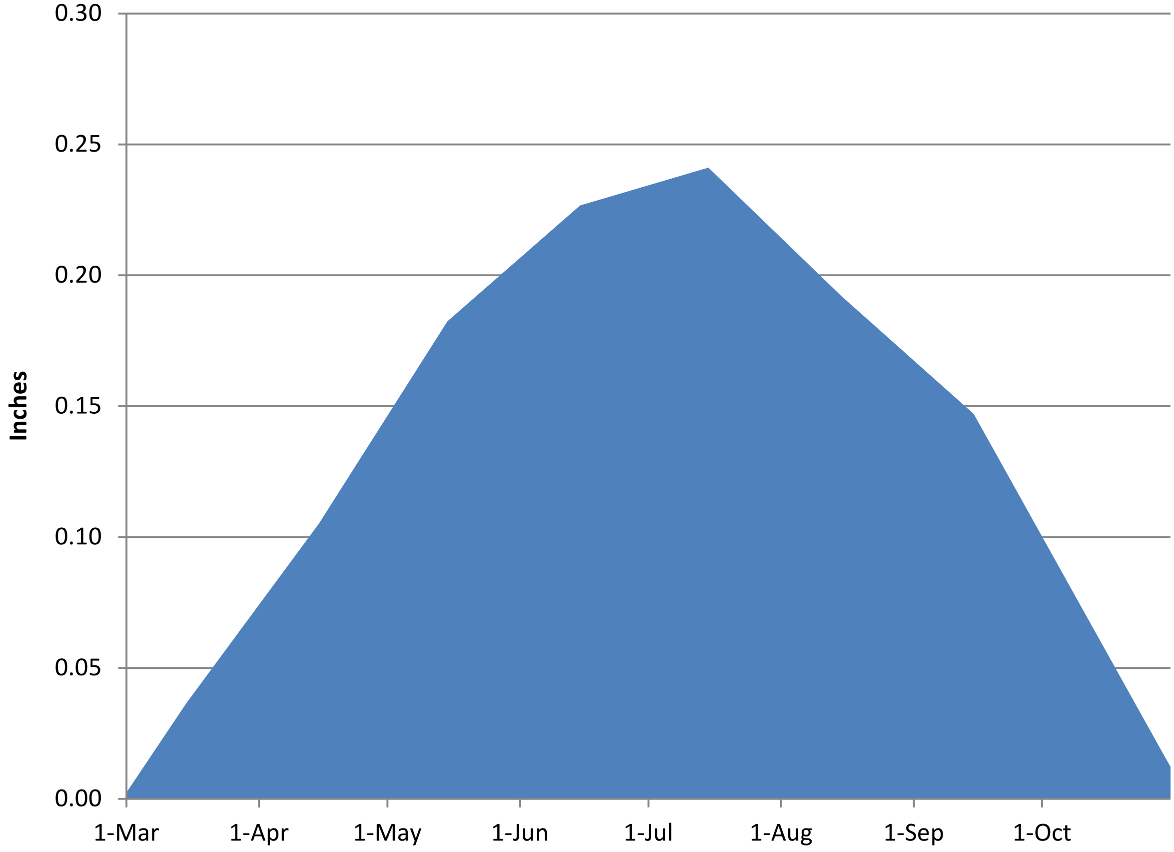

Figure 10. Average Daily Pattern of CUAW of Alfalfa

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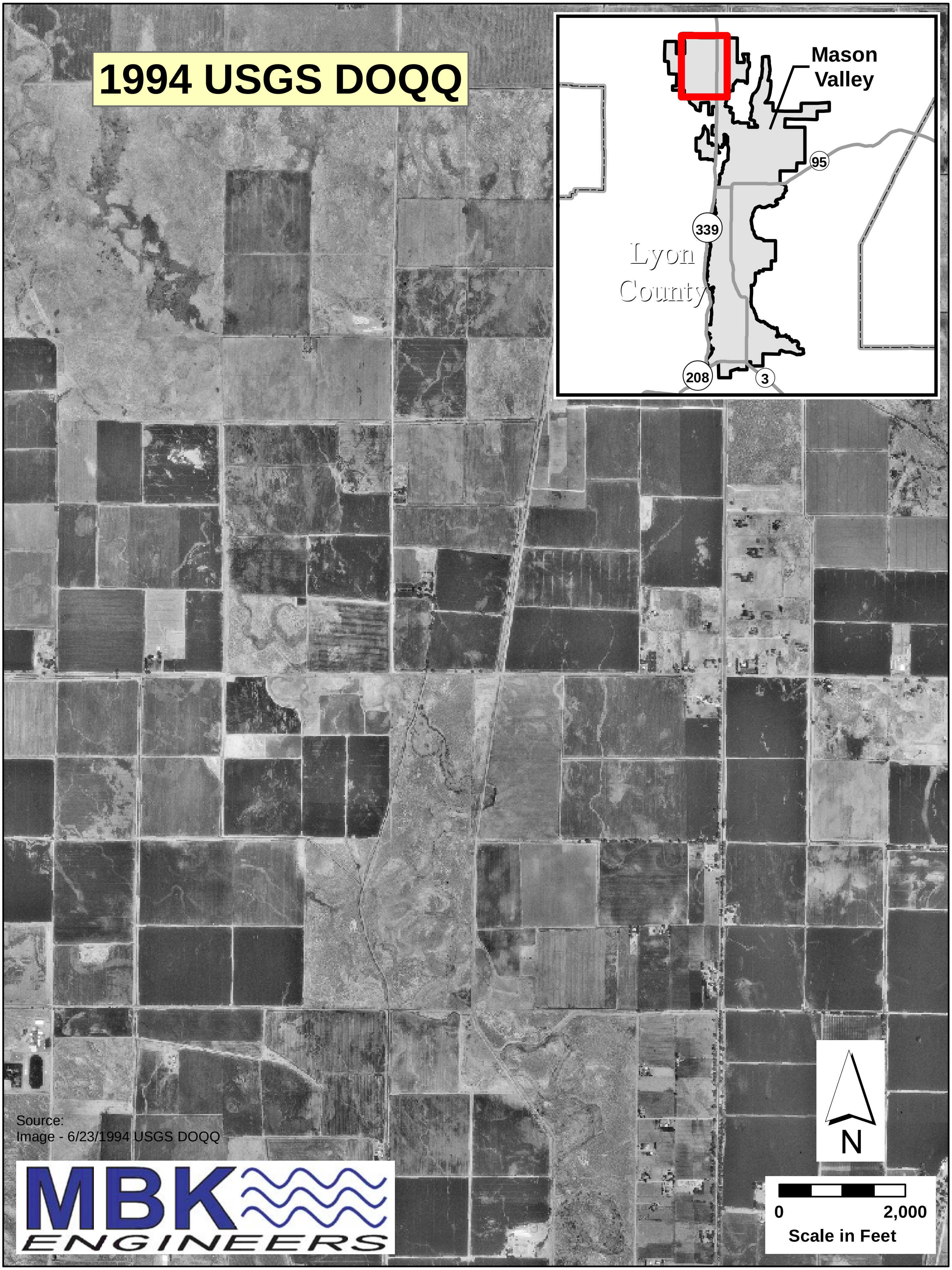
APPENDIX 1

AERIAL IMAGES OF MASON VALLEY AGRICULTURAL AREAS FOR 1994, 2006, AND 2010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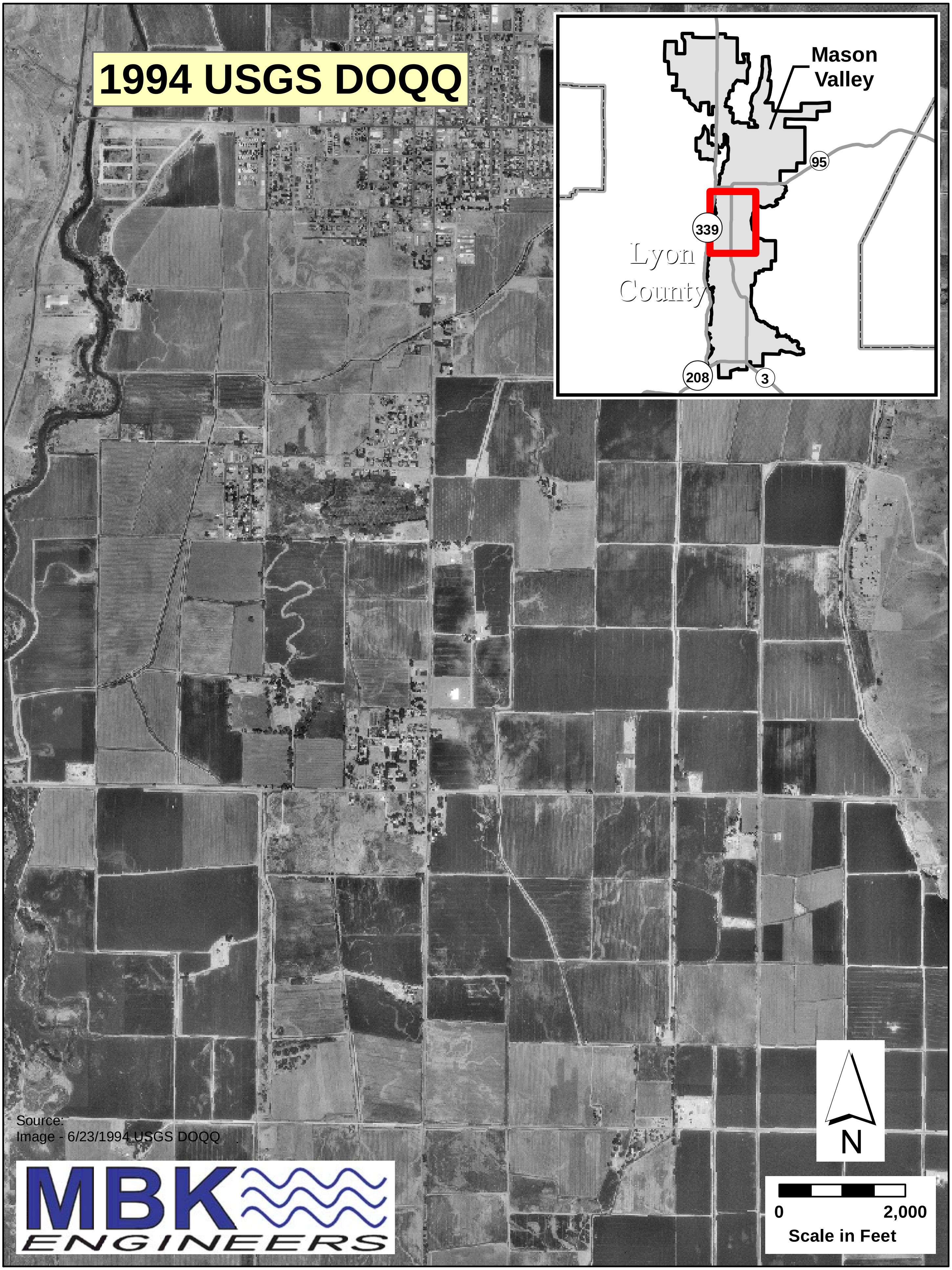

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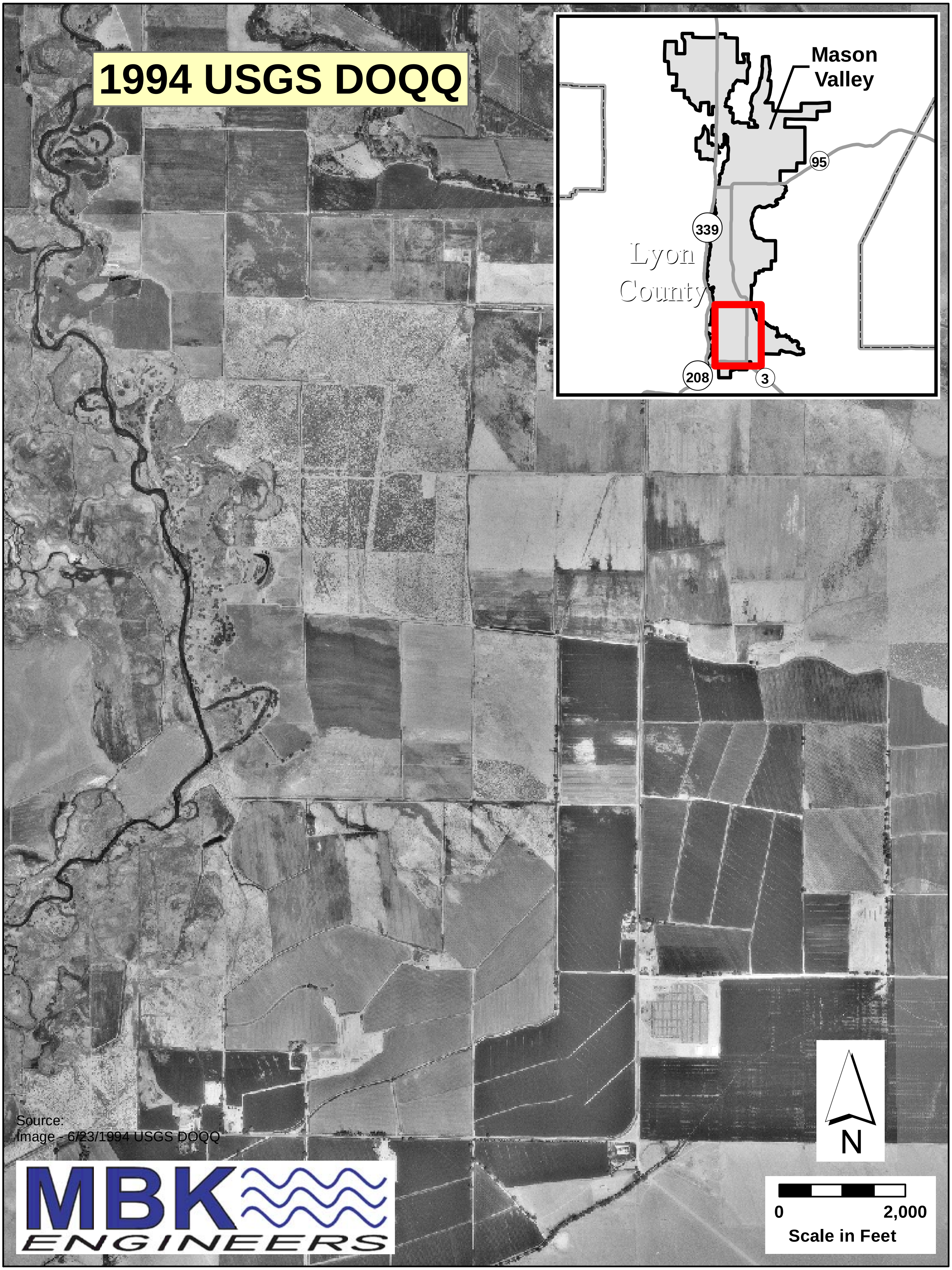

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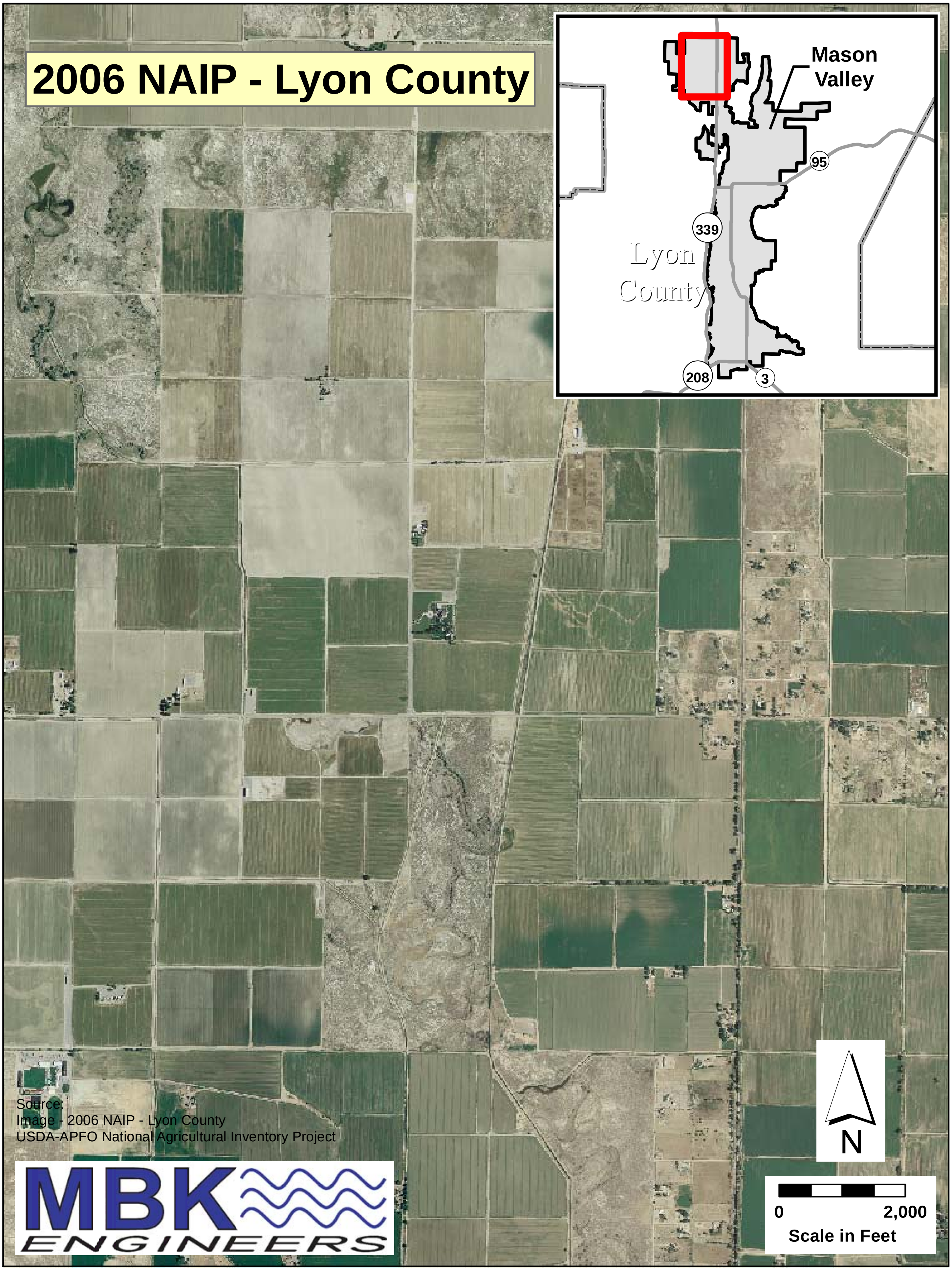
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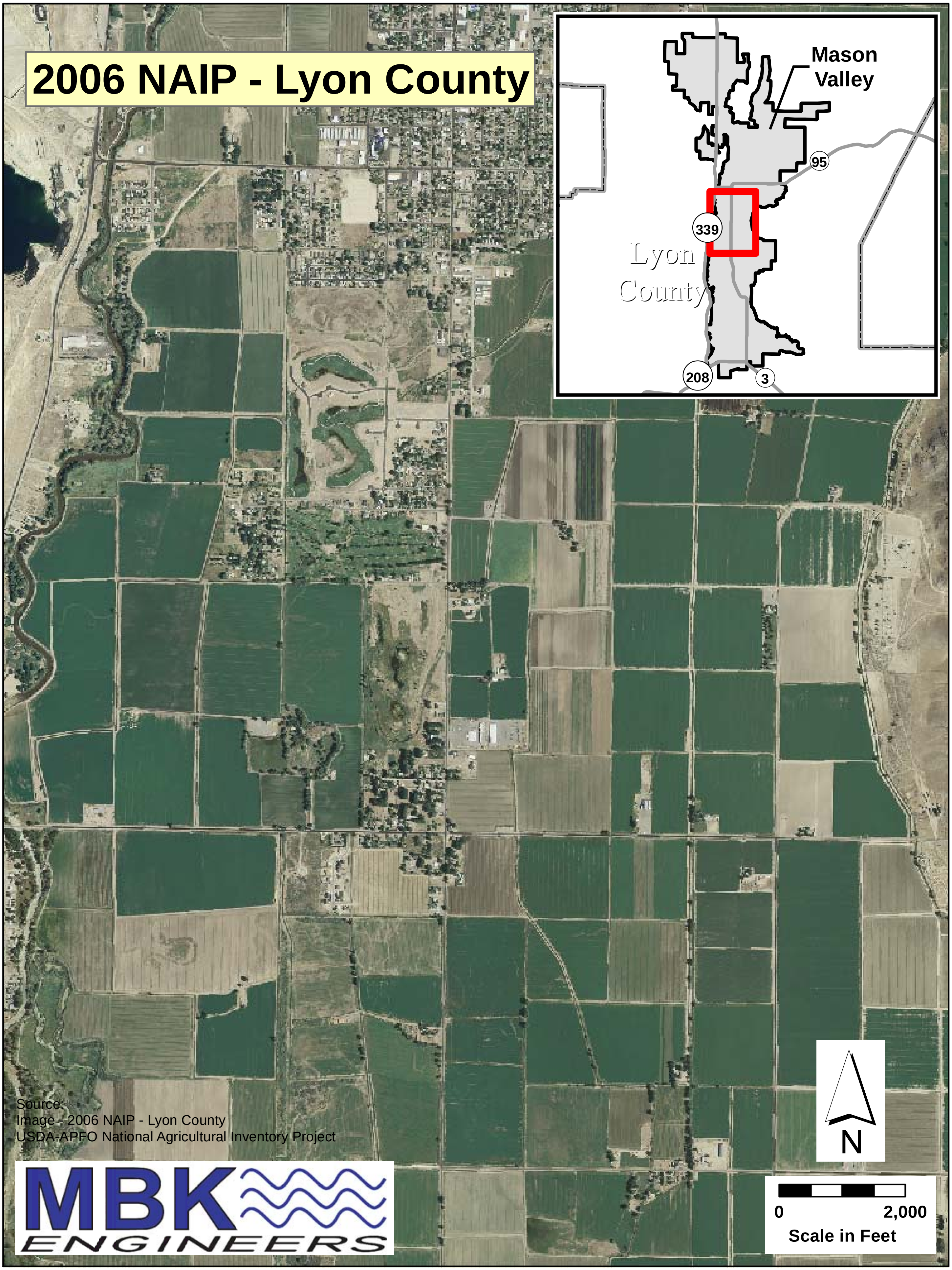
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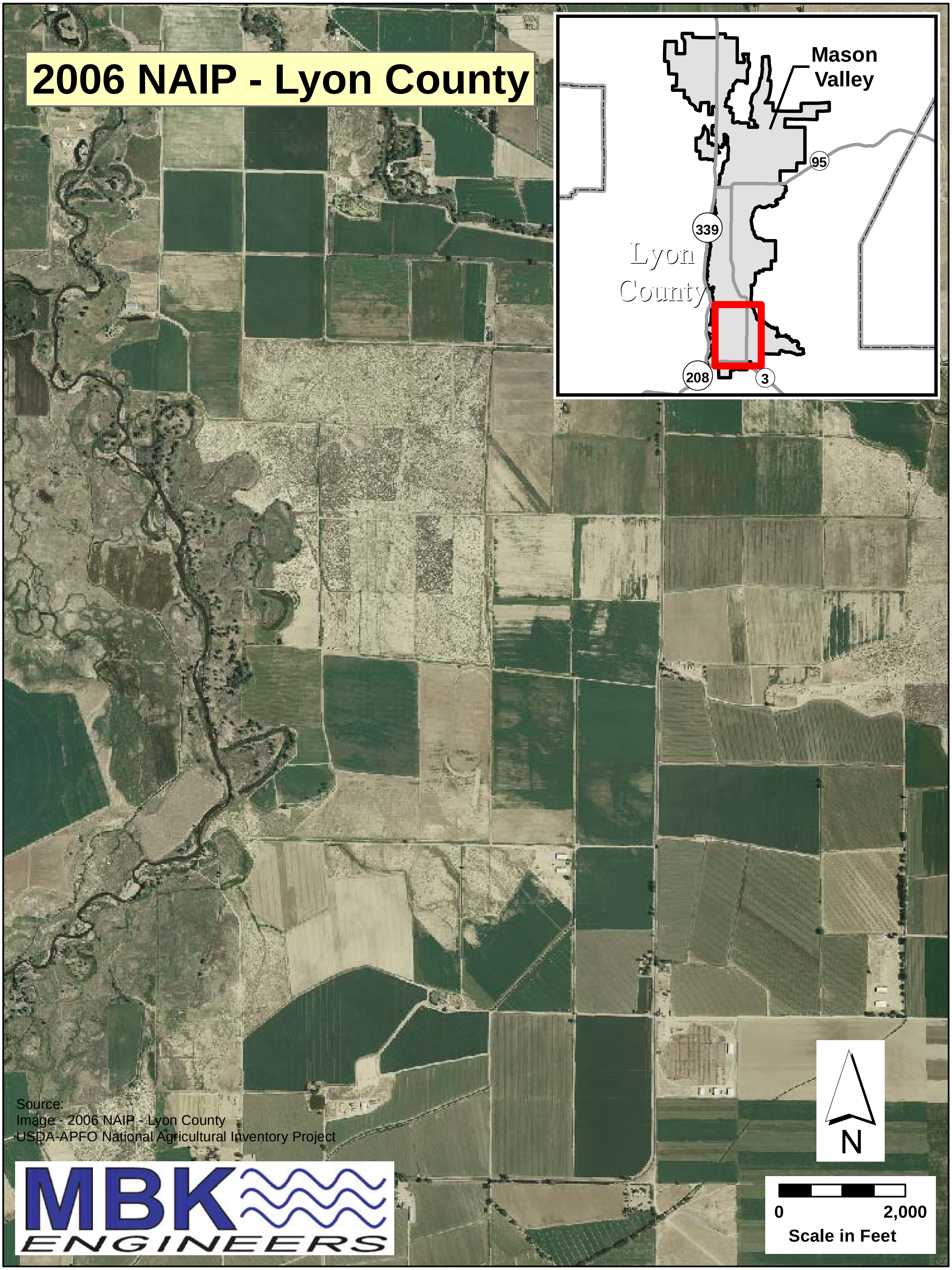

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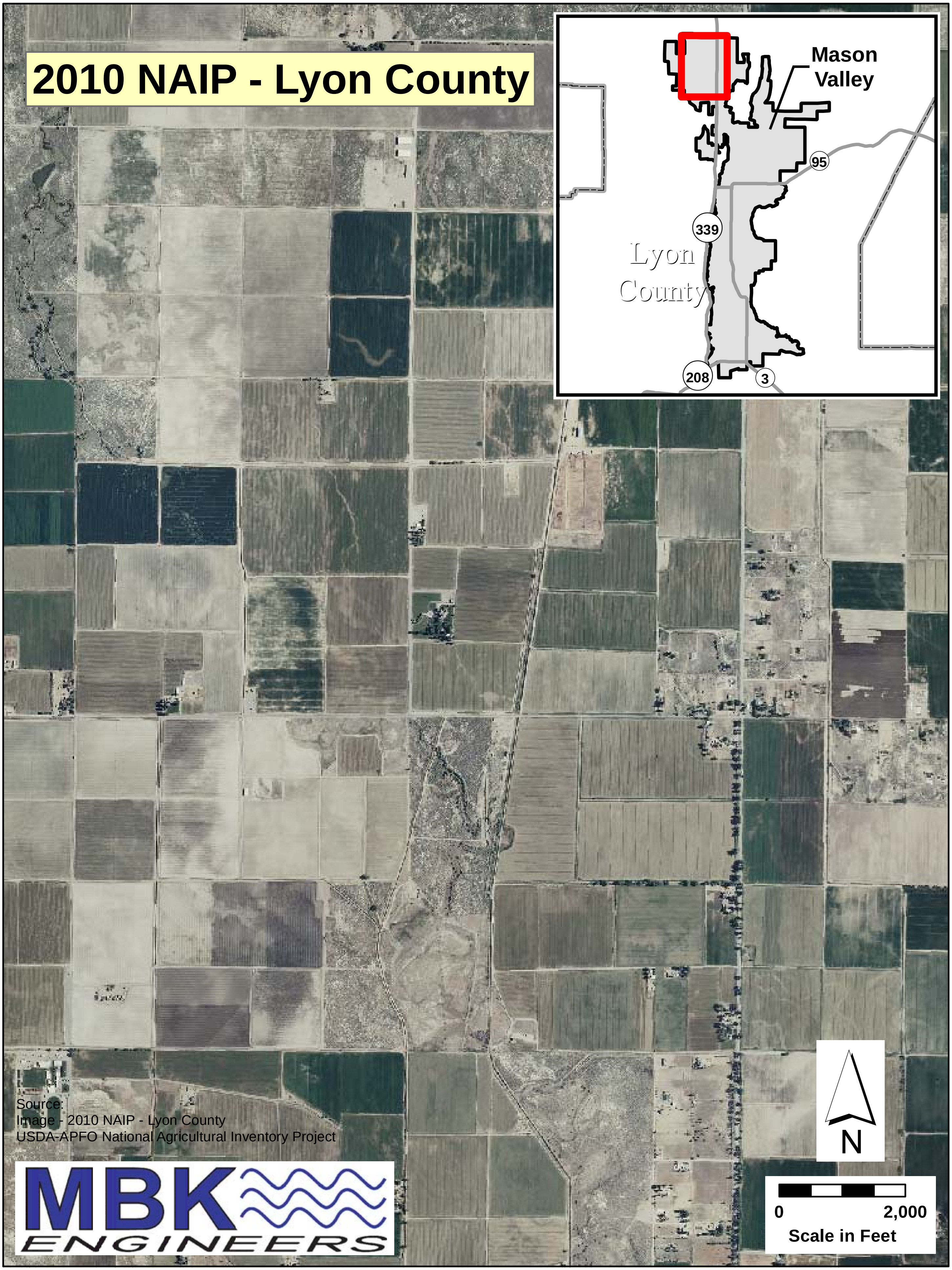

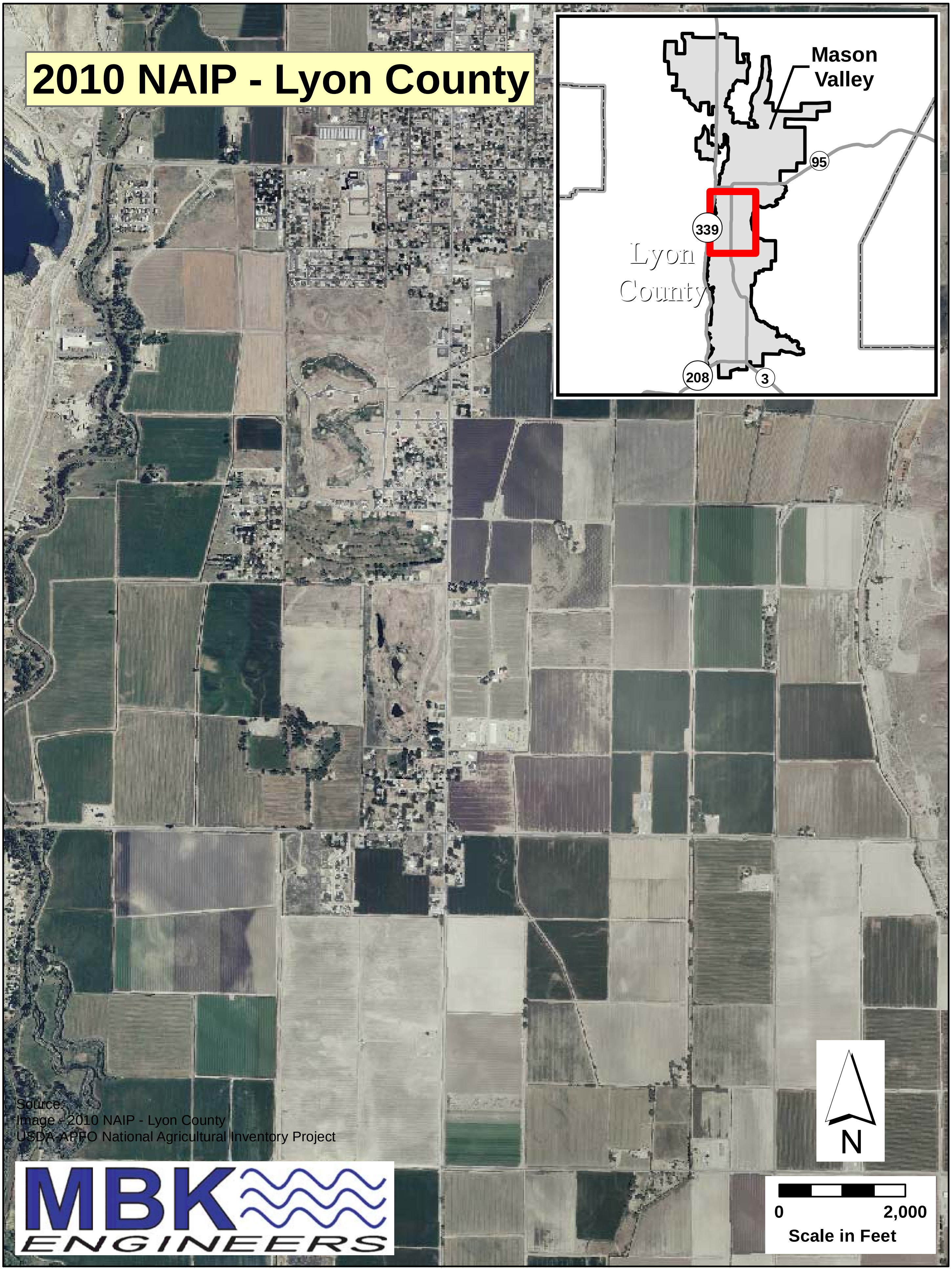
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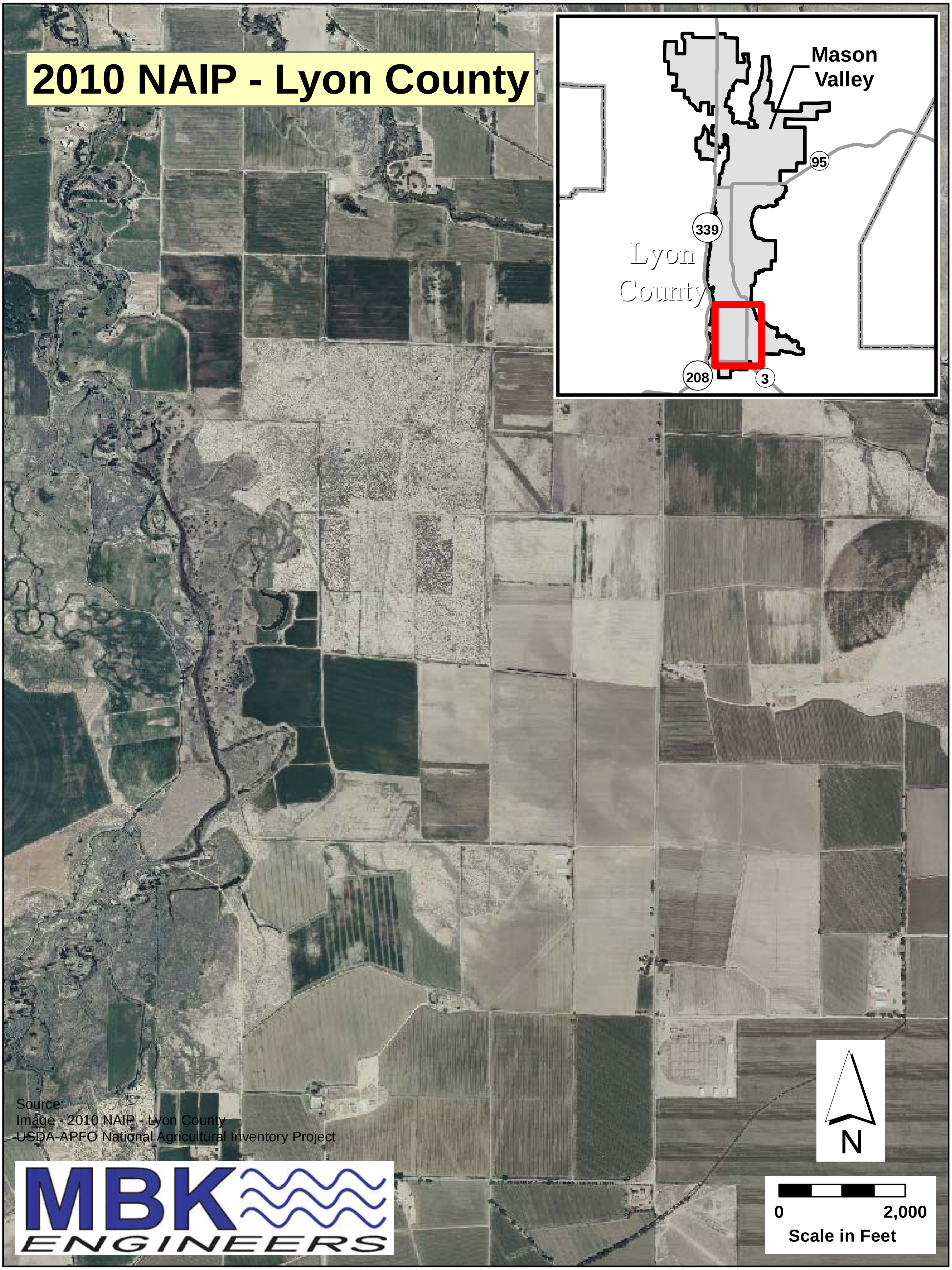
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