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Sierra Valley Irrigation Review & LEPA Irrigation Efficiency Demonstration Program

Sierra Valley, Sierra and Plumas County California

Prepared for:

Sierra Valley Groundwater Management District
PO Box 88
Chilcoot, CA 96105

Draft
September 30, 2022

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1. EXECUTIVE SUMMARY

This report summarizes an evaluation of irrigation practices and potential water savings opportunities that could have direct impact on reduction in groundwater pumping magnitudes in Sierra Valley, Plumas and Sierra Counties, CA. Three types of irrigation take place in Sierra Valley. Flood irrigation occurs over the largest areas in the valley, using diversion from primary stream sources and imported Little Truckee River water, managed under a Decree for Middle Fork of the Feather River. Groundwater is pumped for irrigation to center pivot and wheel line irrigation systems. In 2021 and 2022, approximately 50 center pivots were in operation, and an estimated 20 wheel line systems. Some pivot and wheel line irrigated fields rely solely on groundwater, while others have a combined surface water and groundwater source. It is estimated that there is currently about 5,000 acres under groundwater sources irrigation, and about 3,400 acres under a combined groundwater and surface water irrigation source. Groundwater pumping for irrigation over the past two decades has averaged about 8,500 acre-feet per year, but has varied between approximately 5,000 to 14,000 acre-feet per year, depending on wetness of the water-year, and availability of surface water.

Almost all center pivots in Sierra Valley use traditional mid-elevation sprinkler application (MESA) systems. Potential improvements to irrigation efficiency on the MESA systems provides an opportunity to lower groundwater pumping in the valley. Low elevation precision application (LEPA) systems and low elevation sprinkler application (LESA) systems have been shown to reduce water use by 15-20% as demonstrated in other western US agricultural areas, and have been demonstrated to be suitable for alfalfa irrigation in similar climate valleys. The LEPA systems require a retrofit from ~9 ft spaced 4 ft height MESA sprinklers to close-spaced (~30 inches) sprinkler emitters (bubblers) suspended approximately 1-1/2 ft above the ground. LEPA systems run on 6 to 10 psi pressures, and significant reduction to pressures required for MESA operation (~35 psi). LESA systems use spray emitters rather than bubblers, typically operating on 15 psi. The advantage provided by LEPA and LESA is reduced wind drift water losses, and lowered evaporation losses. Subsidiary advantages to water savings, LEPA and LESA systems have been shown to reduce electrical power costs, potentially improve crop yields, and for LEPA, potentially lower gopher problems by land surface flooding. Combined with soil moisture monitoring technology, deep percolation losses due to over application of water and non-uniform application can also be reduced. LEPA may however cause issues with ponding and runoff due to the reduced application time as well as sloping ground or clay-rich soils, and LESA systems may be more effective for use in some fields in Sierra Valley.

Other notable areas that could further irrigation efficiency improvements include:

- conversion of wheel lines to linear or center pivot systems,
- soil moisture monitoring to adjust water application to better match crop water demands,
- VFD pump control implementation to minimize over-watering in the spring when the water table is higher
- minimize water conveyance piping leaks and conveyance losses, where possible, and
- soils moisture holding capacity improvements.

A goal for Sierra Valley of achieving a 20% irrigation efficiency improvement for ~90% of the groundwater irrigated fields is estimated would save approximately 1,500 acre-feet per as a long-term average. This magnitude of groundwater pumping reduction would be a significant advancement toward achieving groundwater sustainability in the valley, where it is estimated that the long-term pumping reductions, or enhanced aquifer recharge, will need to overcome at least a 2,500 acre-feet per year deficit that is resulting in long-term groundwater level declines.

2. INTRODUCTION

2.1 Purpose of this Document

This document summarizes existing agricultural irrigation practices in Sierra Valley, with a concentration on groundwater sourced irrigation and potential irrigation efficiency improvements to reduce groundwater pumping. Details of a demonstration program for irrigation efficiency improvement using a LEPA sprinkler system are presented. Guidelines for data collection for the LEPA demonstration program are contained within this document.

This technical document can serve as guide for continued evaluations, demonstration programs, and advancement of implementation of projects and management actions related to agricultural water use efficiency improvement to help achieve groundwater use reductions over the forthcoming years, a necessity in order to meet the requirements of the Groundwater Sustainability Plan (GSP) for Sierra Valley. The GSP document is available at the Sierra Valley Groundwater Management District website, https://www.sierravalleygmd.org/sierra-valley-groundwater-sustainability-plan.

This evaluation has been funded by a grant from the California Department of Water Resources (DWR) for development of the Sierra Valley GSP, made to the Sierra Valley Groundwater Sustainability Agency (GSA) with managing member organizations being the Sierra Valley Groundwater Management District (SVGMD) and Plumas County.

2.2 GSP Projects and Management Actions

Chapter 4 of the GSP provides details on identified potential Projects and Management Actions to advance toward the goal of sustainable groundwater use in Sierra Valley. Specially, Tier II Projects and Management Actions relate to potential future actions, whereas Tier I actions are on-going. Under the identified GSP Tier II Projects and Management Actions, *Agricultural Efficiency Improvements* is a component and goal. Details of this proposed Project and Management Action are contained in Section 4.3.1 of the GSP, and is described as follows:

> *Project Description*: Achieving increases in irrigation efficiency through equipment improvements is anticipated to reduce overall water demand. This management action would include development of work plans tailored to individual ranches based on identifying viable alternatives for existing practices and initially conducting pilot projects to evaluate their effectiveness.

2.3 Acknowledgements

The McGinley team responsible for this evaluation and document would like to thank the Sierra Valley Groundwater Management District (SVGMD) and Plumas County for the opportunity to provide professional services on the important component of the newly adopted Groundwater Management Plan (GSP) for Sierra Valley. This project has been funded through a grant received from CA Department of Water Resources (DWR), and we are thankful to the State for making it a priority to assist the Sierra Valley residents with funding necessary to advance sustainable groundwater management in the valley. We would like to acknowledge the Sierra Valley DWR representative Ms. Debbie Spangler for being an active and accessible resource over the course all work related to the GSP development, and initial implementation steps.

The McGinley team would like to acknowledge to assistance of Mr. Jay Huebert, the SVGMD "meter guy" for taking us through the valley on multiple occasions, driving to all active wells and farms/ranching that utilize groundwater, and for gladly sharing his local knowledge with us. We would also like to thank the SVGMD Board members (Mr. Einen Grandi, Mr. Don Wallace, Mr. Dave Goioechea, Mr. Greg Ramelli, Mr. Paul Roen, Mr. Jim Roberti, and Mr. Dwight Ceresola) and local farmers that have helped to educate us on local farming and irrigation practices over the course of this study, and shared observations and ideals openly. Appreciation is also extended to Ms. Jenny Gant, SVGMD Board Clerk for her day-to-day assistance and coordination.

We appreciate the input of all the GSP planning committee members during development of the GSP projects and management actions, and through the course of development of this document, including Judie Talbot, Kristi Jamason, Tracey Ferguson, and Laura Foglia and Betsy Elzofon from the Larry Walker and Associates GSP development team. We also appreciate the efforts and input of the GSP Technical Advisory Community members during initial discussions on potential implementation projects and management actions.

We would like to thank Ms. Tracy Schohr, UC Cooperative Extension, Livestock and Natural Resources Advisor for Plumas and Sierra Counties for soil moisture sensors information, and review of this document.

We would like to thank Mr. David Wagstaff, the regional Senninger representative for sharing information on types and models of LEPA and LESA products, and offering an initial conversion design for the Roberti Ranch Pivot #13. We further thank Ms. Megan Thomason with Agri-Lines for refining the LEPA conversion design and sharing ideas for an effective LEPA retrofit effort.

Lastly, we would like to thank Mr. Jim Roberti and the Roberti Ranch for agreeing to be the first participant in the LEPA Demonstration Program, an important first step to defining viable ways to improve irrigation efficiency and lessen groundwater pumping for agriculture in the valley.

3. BACKGROUND

3.1 Historical Irrigation Practices in Sierra Valley

Sierra Valley has been a ranching valley since the initial settlement of the region in the 1850s and 1860s. Streams tributary to the Middle Fork of the Feather River were diverted to irrigate pastures and meadows, providing hay, dairy products, and beef to regional markets. An account of the settlement of Sierra Valley is presented in GSP Appendix 2-2.

Ranching and farming practices continued into the 20th century. In the period from the 1940s to 1950s, artesian wells were drilled to valley to supplement surface water sources, and high-capacity irrigation wells were drilled in the 1960s and 1970s, concentrated on the east side of the valley. Concurrent with development of the wells, groundwater levels began declining in the valley. Many artesian wells on the valley floor ceased to flow in the mid-1960s (DWR, 1983).

In 1980, the Sierra Valley Groundwater Management District (SVGMD) was formed under statutory authority of SB 1391 to oversee the management of groundwater pumping in the valley. SVGMD has limited drilling of new high-capacity wells in the valley, monitored volumes pumped, and monitored groundwater levels in the valley.

In 1981, water use in Sierra Valley was reported as 12,400 acre-feet (AF) pumped for agriculture, and 2,100 AF pumped for municipal and industrial uses (DWR, 1983). An estimated 63,200 AF of surface water was used for agriculture, and 50 AF for municipal and industrial. Crops grown in 1981 were primarily alfalfa and grains, but also included modest amounts of potatoes, safflower, garlic, and turf grass (DWR, 1983).

3.2 Current Irrigation Practices in Sierra Valley

Since the 1980s, the use of groundwater has continued generally in a similar status to present day. Alfalfa became both a crop to support local livestock, and also for export to dairy operations in the Central Valley. Pasture and hay grasses continue to support the local cattle industry.

The short growing season and harsh winter conditions in this inter-mountain Sierra Nevada valley limit the crops that are suitable to grow. The valley has proven to be well suited to grow high-quality alfalfa. As defined in the GSP and by Bachand et al (2020a), groundwater use for agriculture has ranged between approximately 5,050 to 13,600 acre-feet per year (AFA) over the past 20 years, with a long-term average of 8,500 to 8,600 AFA. Variability in groundwater usage relates to both climate variability, moisture received in the spring, and availability of surface water into the summer. It is presently estimated in the GSP that overdraft of groundwater is a minimum of 2,500 AFA, as a long-term average, in excess of a sustainable groundwater yield.

Today, approximately 95% of groundwater pumped from wells in Sierra Valley is used for agriculture, with the remaining being used for municipal supply in Loyalton and Sierra Brooks, along with smaller domestic, stock watering, industrial and commercial uses. Existing agriculture in Sierra Valley continues to produce forage crops for cattle and the dairy industry, which includes flood-irrigated pasture, cultivated alfalfa, grass hay, and grains as rotation crops.

Irrigated land areas presented in the GSP are derived in part using 2013 satellite imagery, and supported development of a numerical flow model for the 2003 to 2020 timeframe. Estimated groundwater pumping in this timeframe averaged 8,460 AFA for agriculture and 490 AFA used for municipal purposes.

Updated irrigated areas have been developed based on June 2021 satellite imagery, with 2021 areas under irrigation summarized in **Table 3.1.** Irrigated lands total approximately 33,350 acres, of which approximately 24,950 acres are interpreted to be surface water irrigated fields, meadow and pasture. The estimated area irrigated by groundwater or a combined surface water and groundwater source is 8,400 acres. Irrigation areas, partitioned by interpreted sources of water (surface water, groundwater, or combined surface and groundwater) and apparent type of irrigation (center pivot, wheel line, or flood) for year 2021 are shown in **Figure 3.1**.

In Sierra Valley, most groundwater is pumped to center-pivot irrigation systems of wheel lines. Almost all center pivots use mid-elevation spray application (MESA) sprinkler heads. MESA sprinkler head spacing is ~9 ft, and sprinkler height is ~4 ft above land surface. Some center-pivots are equipped with end-guns to expand the irrigated area. These end-guns are high-capacity impact sprinkler heads located at the top of the pivot line. One pivot at the Green Gulch Ranch in the northern part of the valley operates using a low-elevation spray application (LESA) system. Single spans of two MESA pivot systems were convert to LESA systems on the Grandi Ranch and Goodwin Ranch for testing done by Bachand et al (2020b). In 2021, it is estimated that 4,085 acres were irrigated using center-pivot systems.

Wheel line irrigation systems typically have one impact sprinkler head located on each span between the wells. The lines are moved across the field, in increments of approximately 40 to 60 ft, on a daily to several day frequency. In 2021, it is estimated that 728 acres were irrigated using wheel line systems.

Only a small amount of pumped groundwater is used for flood irrigation, estimated at 229 acres in 2021. A majority of flood irrigation in Sierra Valley is conducted using surface water resources. These include Little Last Chance and Smithneck Creeks on the east side of the valley, Cold Stream and imported Little Truckee River water to the southwest end of the valley, and number streams feeding the west side of the valley (West Side Group) including Fletcher, Berry, Hamlin, and Bonta Creeks. Surface water diversion and irrigation deliveries are regulated by a state appointed Water Master under the Middle Fork of the Feather River Decree (1939).

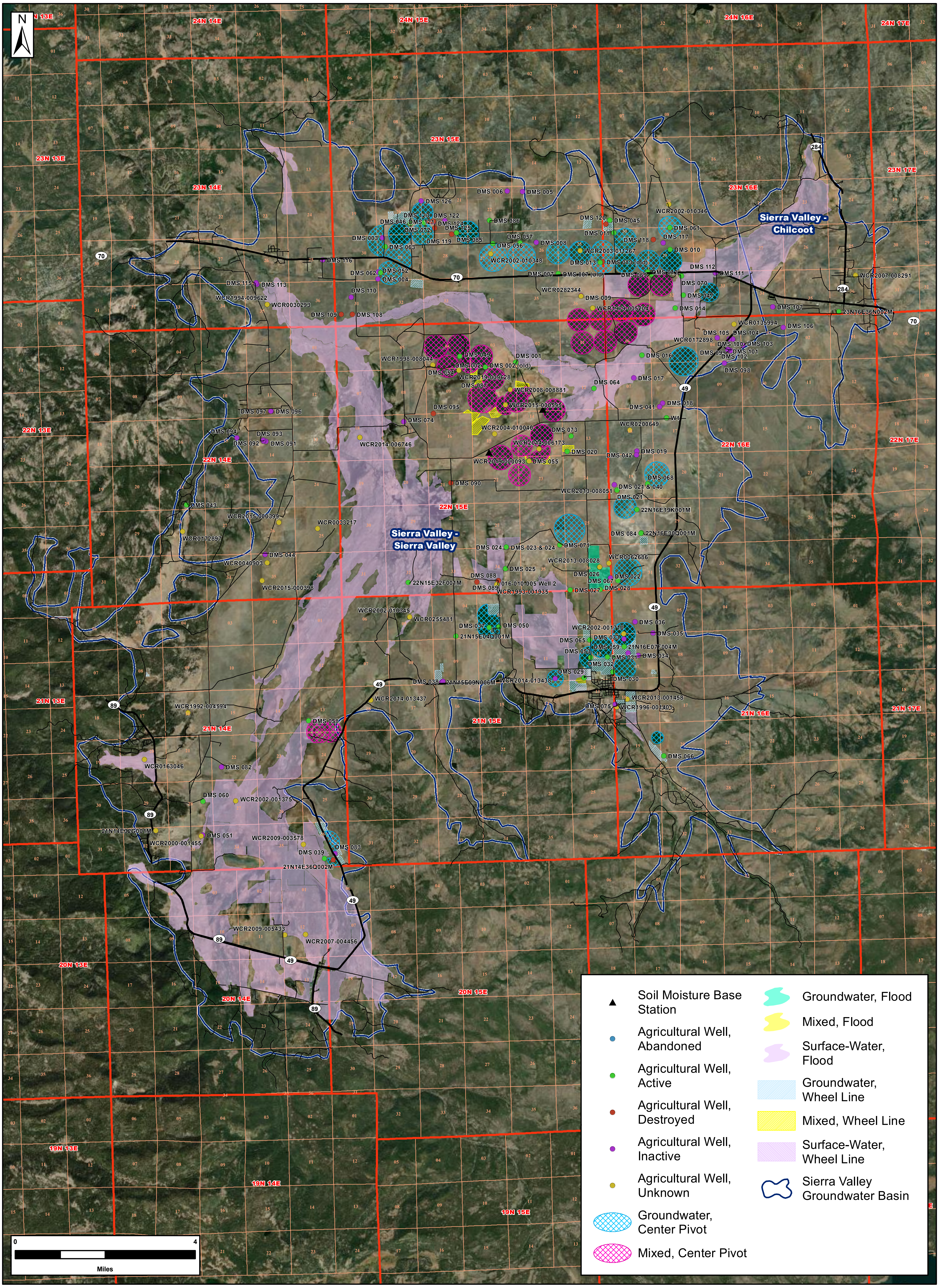
Approximately sixty high-capacity wells are currently in use, and approximately 25 high-capacity wells are registered as inactive with SVGMD, as shown in **Figure 3.1**. In 2021, approximately 51 center-pivots were in operation, 8 of which were half or partial pivots (operating over a half or part of a circular area). The remaining pivots are full circle with irrigation areas ranging from as small as 36 acres to as large as 217 acres, and the majority covering approximately 125 acres.

It is estimated that at least twenty wheel line irrigation systems were in use in 2021, irrigating fields of varying sizes, but typically areas that are smaller than those being irrigated under center pivots. The wheel lines are generally used to irrigated rectangular fields, and in some instances, to irrigate corners outside the footprint of the center pivots.

In 2022, irrigation practices were observed to be similar to 2021, with approximately 50 center-pivots in operation, using mostly MESA sprinkler systems, as described above.

Table 3.1 – Summary of Estimated 2021 Irrigated Area in Sierra Valley

Irrigation Method	Water Source	Irrigated Area (Acres)
Center Pivot	Groundwater	4,085
Wheel Line	Groundwater	728
Flood	Groundwater	229
Center Pivot	Mixed Surface Water and Groundwater	3,174
Wheel Line	Mixed Surface Water and Groundwater	183
Flood	Surface Water	24,950



FIGURE

TITLE:

SITE MAP
-SHOWING-
Irrigation Water Sources
Sierra Valley, California

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FILE: Fig Irrigation Water Sources_11x17

COORDINATE SYSTEM: NAD 1983 UTM Zone 10N

JOB NO.:	DATE:	REF.					REVISION:
SVGMD001	9/28/2022		DESIGNED	HC	CHECKED	DS	-
			DRAWN	HC	APPROVED	DS	

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4. IRRIGATION METHODS

4.1 General Irrigation Types

There are three different types of irrigation methods currently utilized in Sierra Valley; flood irrigation, wheel line irrigation, and center pivot irrigation. Flood irrigation, also known as surface irrigation, consists of rapidly applying water directly to the ground surface and allowing the water to flow along the ground and among the crops. This traditional irrigation method is inexpensive and requires very little technology and equipment while also limiting water lost to evaporation. However, flood irrigation may lead to excessive use of water above that required by the crop, due to runoff at the edges of the irrigated areas and excessive deep percolation past the root zone.

Wheel line irrigation, also known as side-roll or wheel-move irrigation, is an irrigation method which consists of applying water through sprinklers that are mounted to a long lateral pipe that is connected to a water source. The lateral pipe moves water from the source to the sprinkler heads during irrigation. This lateral pipe is mounted on a row of wheels that will be periodically moved across a field during irrigation in order to evenly irrigate the crop.

Center pivot systems are mechanized irrigation systems used to irrigate a circular field. This method utilizes a center pivot point located in the center of a circular field which all other components of the system rotate around during irrigation. Overhead sprinklers are hung from a horizontal pipe via drop hoses. The sprinkler heads which hang from the overhead pipe are rotated about the center pivot point via drive units at certain distance increments from the center. As everything rotates about the center pivot point, the sprinklers irrigate the crops below.

4.2 Center Pivot Irrigation Sprinkler Types

Mid-Elevation Spray Application, or MESA, is a commonly used irrigation technique when employing a center pivot system and in wide use throughout Sierra Valley. Sprinkler heads are evenly spaced apart and suspended approximately halfway between the overhead pipeline and the ground surface by drop hoses. Water is applied to the crops below through these suspended sprinkler heads while the main line and sprinklers rotate about the center pivot point via the drive unit in between each span.

The Low Elevation Sprinkler Application (LESA) and Low Energy Precision Application (LEPA) are both alterations to the traditional MESA configuration of sprinklers used on center pivot irrigation systems (Peters et al., 2016b). A comparison of MESA, LESA and LEPA sprinklers is illustrated in **Figure 4.1**. The LESA configuration is very similar to the MESA configuration but the sprinkler heads are suspended at a lower elevation, approximately 1 to 1-1/2 foot off the surface of the ground, and are more closely spaced. **Figures 4.3a and 4.3b** show examples of LESA sprinkler heads. The lower sprinkler heads help reduce the amount of water lost to evaporation and wind drift.

LEPA sprinkler emitters are similar to the LESA sprinklers; however, it utilizes bubbler heads rather than sprinkler heads which applies water directly onto the soil surface at very low pressure by bubblers that operate at or just above ground level (Neibling et al., 2014) (**Figures 4.2a and 4.2b**). LEPA systems further minimize wind drift, droplet evaporation and canopy evaporation.

While LESA and LEPA are general sprinkler styles, various vendors have different LEPA and LESA sprinkler emitters that may be tailored for field conditions. Field-scale testing of these differing LEPA and LESA products would be beneficial under expansion of the LEPA Demonstration Program that is being established in Sierra Valley.

Figure 4.1 – Illustration of MESA, LESA and LEPA Sprinkler Irrigation (Peters, et al, 2015)

Figure 4.2a – Illustrations of LEPA sprinkler emitters (nelsonirrigation.com)

Figure 4.2b – Illustration of wide-spray (30”-60”) LEPA Sprinkler emitter (senninger.com)

Figure 4.3a – Illustrations of LESA sprinkler emitter (nelsonirrigation.com)

Figure 4.3b – Illustration of LESA low drift sprinkler emitter (senninger.com)

5. IRRIGATION EFFICIENCY

5.1 Definition of Irrigation Efficiency

The term *irrigation efficiency*, as used in this document, is synonymous with the term *water application efficiency*. Simply stated, the irrigation efficiency is that percentage of applied irrigation water that satisfies the crop water demand (evapotranspiration).

Irrigation efficiency is affected by multiple factors including irrigation system management, water distribution methods, crop use rates, weather conditions, and soil characteristics. Additional water application over the crop water demand is also required in order to prevent salt buildup in the root zone and sustain agriculture (leaching fraction). The more efficient that an irrigation system applies water that provides water to the crop root zone, while avoiding losses to other variables, the higher the irrigation efficiency. Irrigation efficiency can approach 100%, but cannot achieve 100% due to variables the necessary leaching fraction outlined above.

5.2 Key Variables Affecting Irrigation Efficiency

Key variables of irrigation water loss are as follows, and as illustrated in **Figure 5.1**.

- Droplet evaporation
- Wind drift
- Canopy evaporation
- Runoff
- Deep Percolation

Irrigation efficiency can be improved by accomplishing more uniform distribution of water to soils, reducing losses to wind drift, minimizing droplet evaporation, minimizing canopy interception and evaporation, minimizing deep percolation past the root zone in excess of a necessary leaching fraction, and preventing runoff from the irrigated area, with a goal of applying just the right amount of water to meet the crop evapotranspiration (ET) requirement. Due to non-uniformity of applied water and natural soils variability, achieving perfect efficiency is not possible, and when approached, will result in some percentage of the crop experiencing distress and crop loss or lowered yield. The highest practical limit to irrigation efficiency is approximately 90-95%. Common irrigation efficiency for flood irrigation is 50-60%, for linear wheel line sprinkler systems 60-70%, and for center-pivot sprinkler systems 75-85%.

Every farm and plot irrigated has it unique characteristics and irrigation efficiency ranges can vary. For flood irrigation practices, canopy evaporation and wind drift become negligible, however, uniformity of water application can be challenging, resulting in significant deep percolation or runoff. Wheel lines generally have one high-pressure impact sprinkler head on each piping span between the wheels. Because the water is sprayed further through the air as compare with a center pivot system, irrigation water is exposed to greater droplet evaporation and wind drift, and the uniformity of irrigation water application may be lower than a center pivot system with more closely spaced sprinkler heads. But wheel lines generally have improved uniformity of water application over flood irrigation.

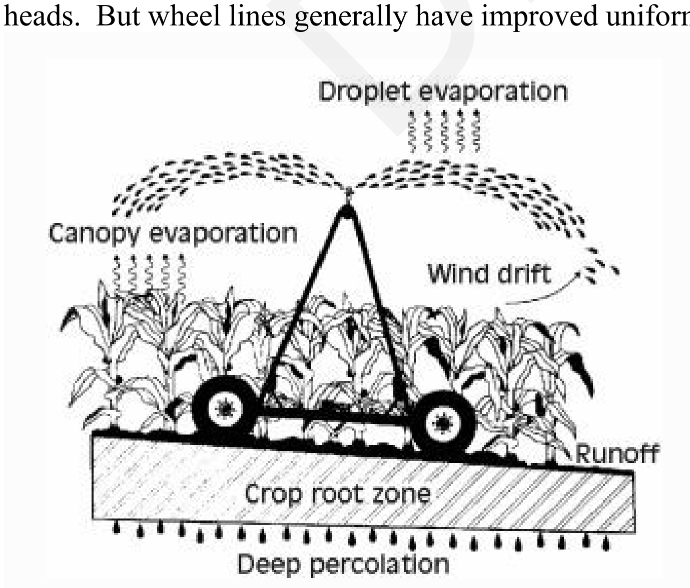


Figure 5.1 - Components of applied irrigation water loss (from Kranz, 2022)

5.3 Irrigation Timing and Water Application Management

Irrigation timing and rate of application are managed by the farmer, commonly using physical inspections of the soils. Soils moisture sensors can aid in understanding of moisture retention and irrigation requirements, and have the advantage of gaining rapid information on water content up the depth of placed moisture sensors. For alfalfa, a relatively deep-rooted crop, soil moisture sensor depths between 12" to 30" is common.

5.3.1 Pump Control Systems

A current limitation to water application management in Sierra Valley is the use of conventional pump control systems, rather than variable frequency drive (VFD) pump controls. When well pumps are turned on in the spring, groundwater levels in the aquifer are shallower than later in the summer levels. The seasonal variability of pumping water levels affects the rate of flow being produced by the pumps. When the pump is lifting water a greater distance to get to land surface, the volume produced will be lower. The result is that the irrigation wells produce higher flow rates in the early season, when the required water by the crop is not as a great, as contrasted with summer crop requirements, when aquifer water levels have dropped and the well pumps are producing lower volumes of water. This dynamic tends to result in over-application of water in the spring.

The over-application early in the irrigation season can be overcome by frequent adjustments to flow regulation valves, but partially closing a valve creates back-pressure and is a waste of electrical power (pump operating against unnecessary head). Manual adjusting is also an imprecise approach to flow regulation.

VFD pump controls allow for modulation of the pump motor speed to match the desired flow rate to be produced from the pump, without valving and unnecessary power waste. In the early season, when water levels are shallower, the VFD will operate the pump motor at a lower speed, programed to deliver the desired flow rate from the well. As additional lift is required through the irrigation season, the VFD will increase the motor speed to maintain the desired water delivery. VFD control systems can thereby improve management of water delivery to the fields to be in sync with crop water requirements, minimizing waste of water and electrical power.

5.3.2 Deep Percolation Management

Deep percolation occurs in all irrigated agriculture, when a portion of applied water seeps downward past the crop root zone. As mentioned previously, sustained agriculture requires leaching of accumulated salts from the root zone (leaching fraction), and therefore some deep percolation is beneficial and necessary.

In Sierra Valley, deep percolation is not a lost water resource, rather it constitutes a source of shallow water table recharge, especially over the areas which are flood irrigated with surface water. Increasing irrigation efficiency for sprinkler systems will likely reduce this component of water table recharge, but is necessary to lessening pumping water demands from the deeper aquifers tapped by irrigation wells.

Improving uniformity in irrigation water application, and use of soil moisture sensors to guide the timing and volume of water being applied are two approaches that can result in managing deep percolation. To the extent that the use of soil moisture sensors can be encouraged and supported in Sierra Valley, water savings and irrigation efficiency improvements can be realized for center pivot and wheel line systems.

5.3.3 Soil Moisture Retention

Improving soil health can reduce irrigation water demand over time, by improving moisture retention in the root zone, and minimizing excessive deep percolation or runoff. Soil health is judged by a combination of physical, chemical, and biological characteristics. Some of the characteristics important for water conservation are (1) improving soil organic matter, (2) improving available water holding capacity, and (3) improving or maintaining soil structure (GAO, 2019). Increasing organic matter in soils and potential use of soil conditioners such as polyacrylamide could be considered for improved soil moisture retention in Sierra Valley, perhaps conducted on a pilot / demonstration scale, and under guidance of a soil agronomist.

6. REVIEW OF LEPA IRRIGATION TECHNOLOGY

6.1 Studies and Implemented Systems

LEPA systems are not new technology. Bordovsky (2018) reported that LEPA technology was developed in the late 1970s to address the depletion of irrigation water from the Ogallala Aquifer and the sharp increase in energy needed for pumping in the Texas High Plains. Lyle and Bordovsky published an evaluation of LEPA systems in 1983 (Lyle and Bordovsky, 1983). In their evaluation they determined that the LEPA system had superior application efficiency, distribution efficiency, water use efficiency and energy savings potential as contrasted with furrow and traditional sprinkler systems.

Buchleiter (1992) reported on effectiveness of LEPA systems on center pivots to realized potential energy and water savings, reporting on water application depth and uniformity. He noted that LEPA systems experience runoff issues for slopes greater than 3%, but performed well on fields with less than 1% slope.

Schneider (2000) reviewed published research on LEPA systems, generally observing that "*with negligible runoff and deep percolation, reported application efficiencies are in the 95 to 98% range for the LEPA sprinkler method*."

Peters, et al (2015) reported on LEPA and LESA systems from testing on six different pivots in Nevada, Idaho, and Washington. Crops being grown included alfalfa, mint, grass seed, beans, wheat, oats, and silage corn. As part of their studies, one span on each pivot was converted from MESA to LESA/LEPA technology. The spray heads were placed at 12 inches above the ground surface, and the spacing was less than or equal to 5 ft apart. Soil moisture sensors at multiple depths in both the LESA and MESA portions of the pivot were compared. As reported in their paper, "*the data clearly demonstrate that the LESA was much more efficient and more water reached the soil*" and "*all of the farmers expressed enthusiasm for the technology and plans to convert entire pivots to LESA*".

As summarized in Peters, et al (2016a, 2016b), "*LEPA and LESA are alterations on a center pivot where the sprinklers are moved much closer to the ground, the spacing between sprinklers is reduced* *(more sprinklers), and water is emitted at very low pressures. It saves water (18%), it saves energy (less water pumped and pumped at a lower pressure), and it helps growers get better yields especially in areas where water is limiting. However, it has an increased propensity for runoff, and the sprinklers operating below the top of the canopy can require some management changes."*

In a two-year irrigation study, Molaei, et al (2020) report using 15% less water under LEPA/LESA systems to grow equal yields of spearmint and peppermint in eastern Washington, as compared with traditional MESA systems. Likewise, Sarwar, et al (2019) report 21% more water reaching the ground using LESA as compared with MESA, with a 16% increase in water application efficiency, in an eastern Washington study. The effectiveness of the LESA method was field tested in 2013 in the Pacific Northwest, with results indicating a 15% to 20% reduction in total water usage as well as a 30% reduction in electrical energy consumption (Stroh, 2018).

Farmers in Diamond Valley, Nevada have been testing LEPA systems, and are targeting a 20% water use reduction by converting from MESA to LEPA systems (Wharton, 2021). Diamond Valley provides a good proxy for Sierra Valley, with a valley floor elevation of approximately 5,800 ft above mean sea level (amsl) and a principal crop of alfalfa grown for the California dairy industry. Diamond Valley has a serious groundwater overdraft condition and has implemented a 30-year basin-wide groundwater management plan to reduce groundwater pumping by one-half over recent conditions. Irrigation efficiency improvements are an important component of plan implementation, along with establishing a progressive reduction in the duty of water right shares over the plan horizon.

Two farmers in Fish Lake Valley, located on the California-Nevada Stateline (Mono County and Esmeralda County) were contacted to discuss wide-scale conversions from MESA to LEPA that have been made in over the past 10-years (D. Smith, 2022 personal communications, Ralph Keys and John Maurer). There are approximately 110 active pivots operating in Fish Lake Valley, for production of alfalfa, in a climate that shares similarities with Sierra Valley (valley floor elevation of ~4900 ft amsl). It is reported that approximately 80% of the active pivots in Fish Lake Valley have now been converted to LEPA systems, with the following benefits being observed:

- reduced water use,
- reduced electrical power,
- increased crop yields,
- decreased problems with gophers.

Other programs are ongoing throughout the western US to both evaluate and implement conversion from traditional MESA pivot irrigation to LESA and LEPA systems, for the purposes of conserving groundwater resources where crop irrigation uses center pivots. During our research we have found information on efforts ongoing in Utah (Southern Utah University, 2021), Idaho, Oregon (supported by the Bonneville Power Administration), New Mexico, Washington, and Nevada.

6.2 2018-2019 LESA Irrigation Efficiency Study in Sierra Valley

Bachand et al (2020) conducted a test of low elevation spray application (LESA) sprinkler systems on two irrigated fields in Sierra Valley in 2018 and 2019, one in the south at the Grandi Ranch, and the other in the north part of the valley on the Goodwin Ranch. In this study, one span of a MESA equipped pivot was converted to close-spaced LESA sprinklers. Soil moisture, alfalfa yield, and crop quality were measured at the test plots. As summarized in their presentation to the SVGMD Board in June, 2020, the following observations were reported from this study.

Standard (MESA) Irrigated Fields:

- Used slightly more water (7%)
- Soil moisture declined less throughout the season
- Appeared to have more operational flexibility (can catch up)
- Yields were similar
- Hay yield quality tended towards, premium at both fields

LESA Irrigated Fields:

- Used slightly less (7%) water
- Soil moisture declined more throughout the season
- Appeared to have less operational flexibility (more difficult to catch up)
- Yields were similar
- Hay quality tended towards lower, though still good to premium

Additional operational observations were as follows.

- System maintenance important for irrigation efficiency
- Nozzle emitters clog easily, can severely affect irrigation uniformity
- Pump rates decrease during irrigation and throughout season in response to local groundwater level declines
- Pivot operation affects water distribution and irrigation uniformity
- Higher pivot speeds likely lead to greater ET losses (could not be measured here)
- Changing pivot speeds affects irrigation uniformity
- On half- and quarter-field pivot systems, pivots stop at the end of the run but continue pumping
- Affects irrigation uniformity
- Automatic pump switch would increase uniformity and water use efficiency

The following conclusions and recommendations regarding LESA sprinkler systems were made:

- May provide slight decrease in irrigation water use
- Can reduce crop quality
- May be more likely to lead to greater soil moisture declines throughout the growing season
- May be less effective in overcoming soil moisture deficits due to higher design efficiencies
- Valves are more likely to stray from design specifications
- Anecdotal information suggests LESA systems require greater maintenance

Other general observations regarding irrigation practices in Sierra Valley were as follows:

- Groundwater levels (short-term and long-term) affect pumping rates
- Effective pivot system maintenance is required for optimum irrigation system performance
- Pivot systems design and operation affect their performance
- Slower pivot speeds more likely to reduce transpiration losses
- Slower pivot speeds could lead to greater water losses past the root zone
- Alfalfa is considered deep rooted crop so may be able to recover deeper water if trained
- Changes in operation (e.g., pivot speed, clogging) affect water distribution and likely irrigation use efficiencies
- Improvements in irrigation water use may be achievable with improved pivot operation and appropriate soil moisture monitoring (including to depth), and may be more cost effective than transitioning from Standard irrigation systems to LESA systems.

The LEPA Demonstration Program being initiated for Sierra Valley will provide larger-scale (field-scale) testing of LEPA technology. The LEPA bubbler emitters have larger apertures as compare with LESA sprinklers, which may lessen emitter clogging issues observed by Bachand et al (2020). The model of Nelson LEPA emitter also has easy flush functions, which should aid in clogging prevention.

6.3 LEPA vs. LESA Comparative Overview

The drawbacks to the MESA systems include water losses due to wind drift and evaporation as well as increased energy due to high water pressures needed for operation (~35-40 psi) and additional volume of water being pumped to meet crop water demands (Peters et al., 2016b). Both LESA and LEPA aim to mitigate these drawbacks by increasing the efficiency of the center pivot or linear-moving irrigation system.

LEPA and LESA involve applying water directly onto the soil surface at very low pressure by sprinklers or bubblers operating just above ground level (Neibling et al., 2014). The goal of the LEPA method is to maximize the efficiency of center pivot or linear-movement irrigation systems by limiting water losses to evaporation and wind drift while also reducing the amount of energy and water needed for pumping and operation. The low operating pressure (~6-10 psi) significantly reduces the energy needed for pumping and operation while the direct application of water to the soil surface limits the possibility of water losses to evaporation and wind drift.

LEPA can cause issues with ponding and runoff due to the reduced application time, notable for sloping ground or clay-rich soils (Peters et al., 2016b). There are multiple mitigation techniques that can be employed to address this issue. Furrow diking is an effective way to hold water locally until it can infiltrate into the soil (Bouchardt and Jones, 2003). Employing tilling methods to loosen the soil in order to increase water storage and promote quicker and deeper infiltration will also help mitigate ponding and runoff (Peters et al., 2016b).

LESA involves applying water very close (~1 to 1-1/2 ft) to the soil surface through suspended sprinklers or spray heads. This irrigation method has the same goal as LEPA to maximize the efficiency of center pivot or linear-moving irrigation systems by limiting water losses to evaporation and wind drift while also reducing the amount of energy and water needed for pumping and operation. However, while similar to the LEPA method, LESA applies water more uniformly across the soil surface than LEPA (Peters et al., 2016b). This is due to the slight spreading of the water from the sprinkler head above the soil surface. The greater degree of uniformity leads to fewer issues with crop germination, ponding, and runoff than LEPA (Peters et al., 2016b). It also negates the need for furrow dikes throughout the field which allows for more flexibility with a wide variety of crops, row orientations, and tillage methods (Peters et al., 2016b).

LEPA and LESA are very similar irrigation methods and ultimately have the same end goal of maximizing efficiency and reducing excessive electricity and water usage. Hesitation to switch over from MESA may come from a reluctance to purchase additional sprinklers and hoses (Peters et al., 2016b). However, savings originating from energy and water use reduction can cover the costs of the additional equipment. The largest potential for profit is the ability maintain or improve crop yields in areas that are water short or have large losses to wind drift or evaporation (Peters et al., 2016b). In the case of Sierra Valley, however, the objective is to reduce use of groundwater for irrigation, and any energy savings or crop yield improvements are subsidiary to the primary goal of achieving water savings.

In summary, the data clearly demonstrate that the LESA and LEPA are much more efficient with more water reaching the soil as contrasted with traditional MESA systems in use in Sierra Valley. LEPA and LESA systems can help Sierra Valley farmers achieve the goal of increasing irrigation efficiency from center pivot systems by limiting water lost to evaporation and wind drift while also reducing the amount of energy and water needed for pumping and operation. Water application using the LEPA method is more precise and concentrated than either LESA or MESA due to the water being applied with the bubbler dribbles at a low pressure rather than being misted or sprayed over a broader area through the LESA or MESA methods. While this irrigation method increases the efficiency of the system, LEPA may cause issues with ponding and runoff due to the reduced application time as well as sloping ground or clay-rich soils, and LESA systems may be more effective for use in some fields in Sierra Valley. Field soils and slope conditions should be reviewed before considering which type of system may be more effective for MESA conversions. Additional testing of the various available LEPA and LESA sprinkler emitters and spacing is recommended for the Demonstration Program to aid in guiding future MESA conversations.

7. CROP TYPES AND WATER USE

Also, for consideration for reducing groundwater consumption on Sierra Valley ranches are crop types being grown. Conversion to economical alternative crops that have lower water requirements could reduce pumping in the valley while maintaining a viable agricultural community. However, the climate in Sierra Valley, including freezing spring and early summer nighttime temperatures, limits potential of alternative crops that are economically viable. Also, many of the ranches engage in farming of forage crops to in part support cattle ranching operations.

Hemp has been tested on the Roberti Ranch, and there has been modest production of other crops, such as potatoes, garlic, and safflower, as reported for year 1981 by DWR (1983). The University of Nevada, Reno is researching sorghum as a low water use crop for northern Nevada, which tends toward a more similar climates as Sierra Valley, although with a somewhat longer growing season. Some northern Nevada producers have also begun to grow teff, a low water use crop which can be used as forage, and harvested as a gluten-free grain.

As opportunities may be identified for alternative crops, willing ranches can conduct tests to further gage the variability of alternative crops. Working with agricultural extension groups of universities in the region (California and Nevada) should continue to be pursued.

8. SUMMARY - POTENTIAL IRRIGATION EFFICIENCY IMPROVEMENTS FOR SIERRA VALLEY

All ranches in Sierra Valley can improve upon existing irrigation efficiencies, thus reducing groundwater pumping. Identified areas for improvement are as follows.

- Convert MESA sprinkler systems to LEPA or LESA sprinklers.
- Use of soil moisture sensors to aid in adjustment of applied water amounts and minimize deep percolation (percolation beyond the root zone).
- Avoid, if possible, irrigation during excessively windy conditions.
- Irrigation system automation for improved water delivery to match crop water requirements, including monitoring of pivot motor speed and flow rates.
- Use of Variable Frequency Drive (VFD) pump controls systems to modulate pumping rates from wells to meet crop water demand more effectively, minimizing over-application of water.
- Reduce use of high-capacity end-guns, which are not as efficient in irrigating peripheries of the fields.
- Convert wheel line irrigation to center-pivot irrigation, where possible.
- Minimize use of groundwater for use in low-efficiency flood irrigation of pastures.

- Improve water holding capacity of soils.
- Reduce leakage from water conveyance pipelines, and unlined open ditches, where used for groundwater conveyance.
- Conversion to low water use crops, as opportunities are identified.

Center pivot irrigation technology is generally considered the most efficient means for irrigation water application. However, there are many variables of center pivot systems that effect how efficiently they are operated. Sprinkler modifications to existing MESA equipped pivots presents opportunities to increase irrigation efficiency and reduce groundwater pumping by conversion to LEPA and LESA equipment. Operations of all types of irrigation systems (pivot and wheel line) can also benefit from use of soil moisture monitoring equipment and VFD systems for pump control and flow regulation from wells.

Based on the research of other communities producing alfalfa in similar climate regions, we suggest that a goal of 20% improvement in irrigation efficiency be targeted for Sierra Valley. To achieve this goal will require:

- wide-spread conversion of MESA systems to LEPA and LESA,
- improved equipment and use of technology to monitor soil moisture to refine water application, and
- improved pump controls to regulate pumping rates and avoid early-season over-pumping and over-application of water.

Funding to support this ambitious but necessary transition to irrigation practices should be sought from available DWR implementation grant funding. With sufficient funding, this implementation component could be accomplished over the next 5 years. Assuming 90% of groundwater irrigated fields can implement irrigation efficiency improvements as recommended, about one-half of the probable magnitude in groundwater pumping reduction required to achieve long-term sustainable groundwater conditions could be realized. While irrigation efficiency improvements alone are not anticipated to be the entire solution to achieve groundwater pumping sustainability, it can be a significant contribution and is an approach that will help preserve the historical culture of agriculture in the valley.

9. LEPA DEMONSTRATION PROGRAM

A LEPA demonstration program has been initiated in Sierra Valley. One MESA pivot retrofit has been completed at the Roberti Ranch Pivot #13. Roberti Ranch Pivot #10 is also equipped for monitoring of water use as a baseline for a comparable MESA system. The locations of Roberti Pivots #13 and #10 are shown in **Figure 9.1**. The baseline field was selected based on the Roberti's expectation of a similar crop yield as compared with yield from Pivot #13, under normal MESA irrigation conditions. OpenET (2022) reports the evapotranspiration (ET) water use by field utilizing satellite imagery and a number of published methods to convert vegetation indexes to estimate crop water consumption (ET). Contrasting ET for 2019, 2020, and 2021 are summarized in **Table 9.1**. ET curves for years 2019 to 2021 reflect a similar shape and magnitude, supporting similarity in irrigation practices for the two pivots (**Figure 9.2**). Field sizes are 124.0 acres and 145.8 acres for Pivots #10 and #13, respectively. The differences in field size will need to be accounted in crop yield comparisons during the demonstration study.

Soils types under each pivot are generally comparable sandy loam and loamy sand soils, with approximately 31 acres of clay soils at Pivot #10. The NRCS (2022) mapped soil types are shown in

Figure 9.3a and **Figure 9.3b**.

The initiated demonstration program varies from the testing in 2018 and 2019 by Bachand et al (2020b) in that it: 1.) uses a LEPA rather than a LESA system, 2.) is set up to run for multiple years, 3.) is based on field-scale crop production rather than assessment on small test plots, 4.) will have primary data collection being made by the farmer, and 5.) will have a primary metric of metered water use. In the demonstration program, the farmer is expected to adjust and test operations of the LEPA pivot such as motor speed and number of irrigation days per cycle between cuttings, with the objective of producing similar field-scale crop yield while lowering applied water, made possible by improving the irrigation efficiency. It is hoped that the demonstration program initiated at the Roberti Ranch can be expanded, subject to additional funding, to include other geographic locations in the valley, other models of LEPA and LESA sprinkler emitters, and other potential styles of water saving irrigation equipment and practices (soils moisture sensor, soil moisture holding capacity improvements, VFD pump motor control systems, etc.).

Table 9.1 – Computed Annual Crop ET in OpenET (2022)

Year	Roberti Pivot #10 Computed ET (inches per season)	Roberti Pivot #13 Computed ET (inches per season)
2019	36	34
2020	33	34
2021	34	33

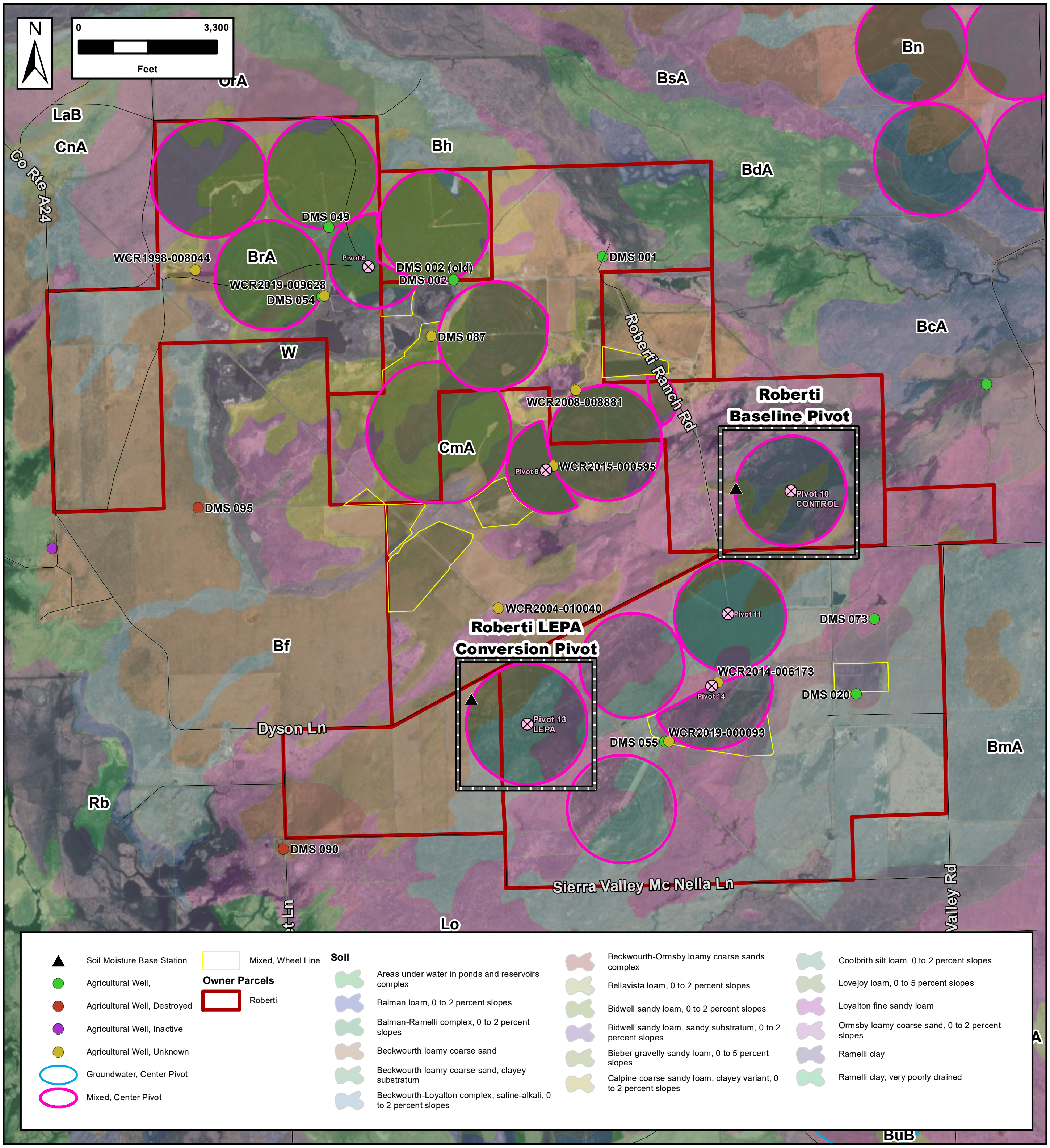


FIGURE	McGinley & Associates A Universal Engineering Sciences Company
TITLE: SITE MAP -SHOWING- Roberti Ranch Irrigation, Soils, and Property Boundaries Sierra Valley, California	FILE: Roberti Ranch Property - Soil
	COORDINATE SYSTEM: NAD 1983 UTM Zone 10N
JOB NO.: SVGMD001	DATE: 9/28/2022
REF. DESIGNED HC, CHECKED DS	REVISION: -
DRAWN HC, APPROVED DS	

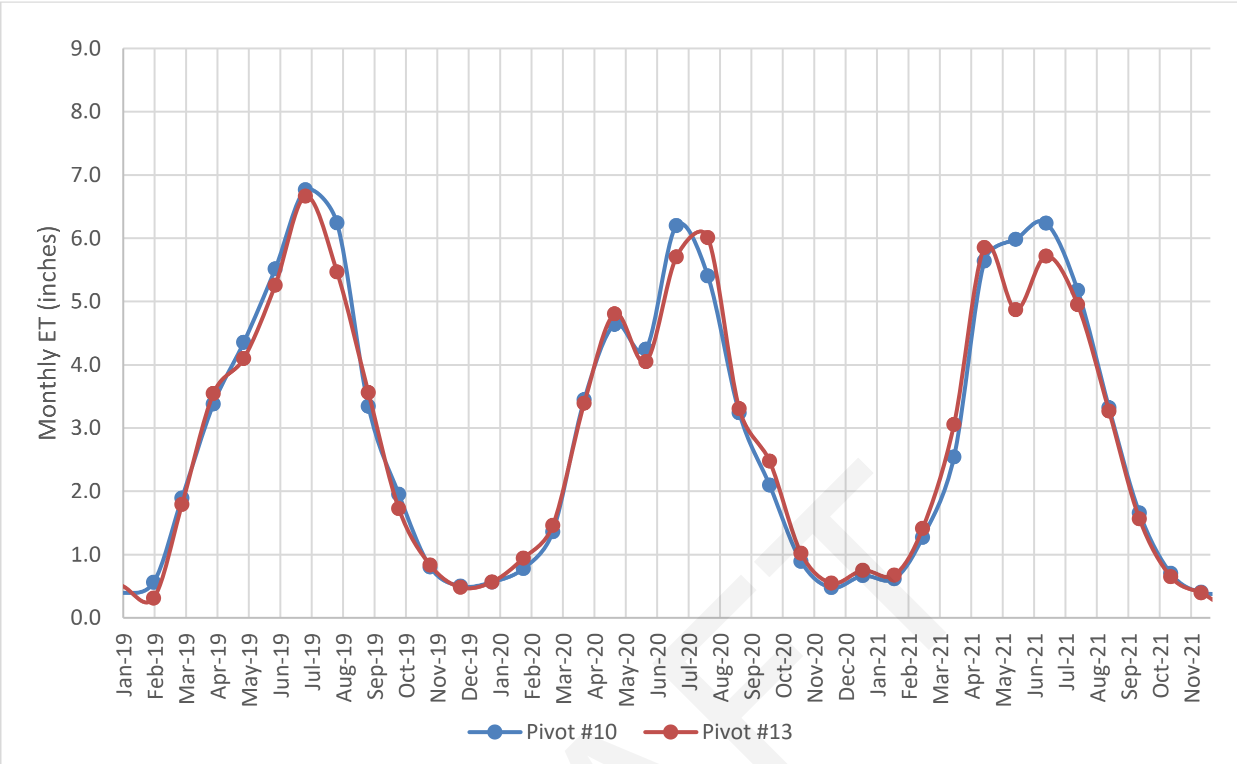
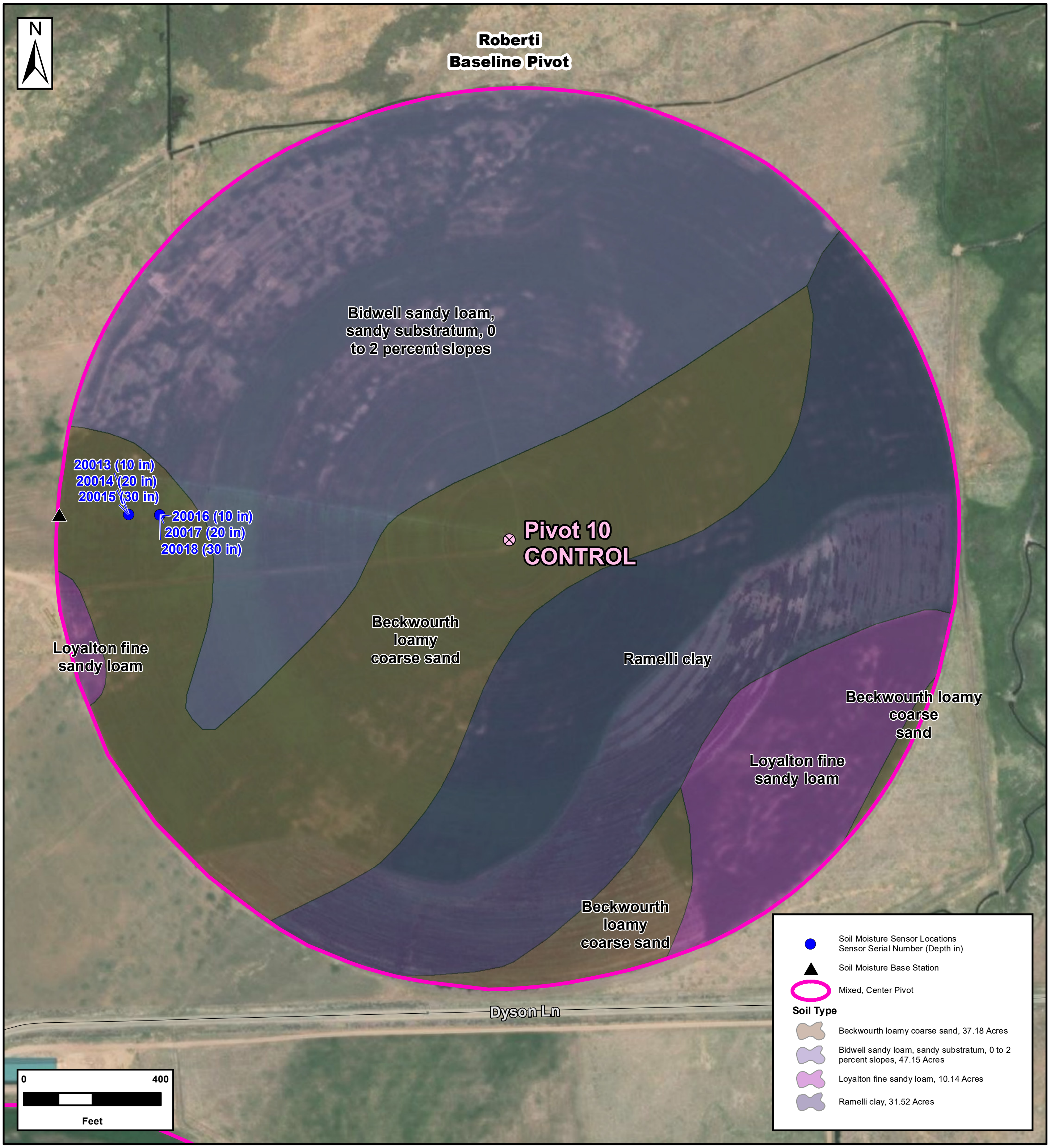


Figure 9.2 – Plot of 2019 to 2021 ET from Roberti Ranch Pivots #10 and #13



FIGURE

TITLE:

PIVOT 10 SITE MAP

-SHOWING-

Roberti Ranch
Baseline Pivot
Sierra Valley, California

McGinley & Associates
A Universal Engineering Sciences Company

FILE: **Roberti Ranch Baseline Pivot (10) - Soil**

COORDINATE SYSTEM: **NAD 1983 UTM Zone 10N**

JOB NO.:	DATE:	REF.					REVISION:
SVGMD001	9/29/2022		DESIGNED	HC	CHECKED	DS	-
			DRAWN	HC	APPROVED	DS	

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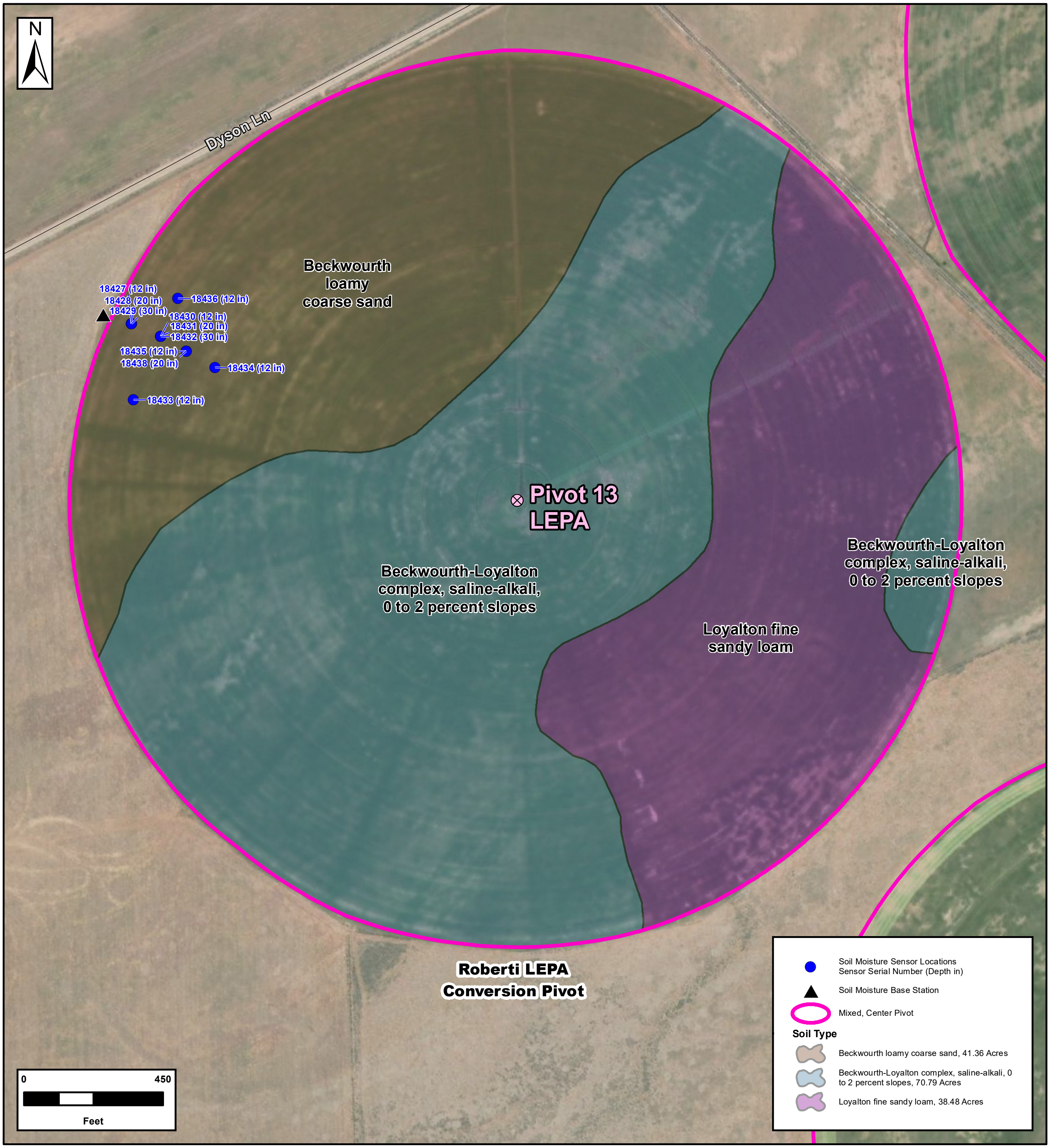

FIGURE

TITLE:

PIVOT 13 SITE MAP

-SHOWING-

Roberti Ranch LEPA Conversion Pivot

Sierra Valley, California

JOB NO.:	DATE:
SVGMD001	9/29/2022

McGinley & Associates
A Universal Engineering Sciences Company

FILE:
Roberti Ranch LEPA Conversion Pivot (13) - Soil

COORDINATE SYSTEM:
NAD 1983 UTM Zone 10N

REF.					REVISION:
	DESIGNED	HC	CHECKED	DS	-
	DRAWN	HC	APPROVED	DS	

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9.1 LEPA Conversion – Roberti Ranch Pivot #13

On October 17-19, 2022, Roberti pivot #13 was converted from a conventional MESA system to a close-spaced LEPA system. The equipment was provided by Agri-Lines, Winnemucca, Nevada. LEPA system design details are provided in **Appendix A**. Additional drops were added to accomplish an approximate 30-inch spacing. Sprinkler nozzles are Nelson 3030 Series Multi-Function 3NV LEPA (see cut-sheet in **Appendix A**). To avoid over watering on the first span from the pivot point, Nelson Orbitor series nozzles were installed (**Appendix A**). The conversion was made in preparation for the 2023 irrigation season. Photographs of the LEPA installation are included below, and in **Appendix A**.

Complimenting the LEPA conversion, an inline totalizing flow meter was installed at the pivot point to accurately measure pivot water use. The flow meter is a Seametrics AG3000 magnetic meter, and flow meter documentation is provided in **Appendix B**.

Soil moisture sensors have been installed at several locations at the in the 6^{th} and 7^{th} spans of the pivot, with senor depths at 12, 24 and 30 inches. Locations of sensors are shown in **Figure 9.3a**. The soil moisture system is a wire-less Soil Scout Hydra100, which communicates to a base station at the edge of the field, and has telemetry data reporting to the vendor managed website. Soils moisture data can be view and recorded by operator via the website. Soil moisture equipment details are contained in **Appendix C**.

Insert pictures of equipped Pivot #13

9.2 Baseline Conditions Monitoring – Roberti Ranch Pivot #10

The baseline MESA pivot system on the Roberti Ranch (Pivot #10) was equipped with the same models of totalizing flow meter and soil moisture equipment to provide baseline data to compare with water use, soil moisture, and crop yield with the LEPA equipped field. The locations of the soil moisture sensers are shown on **Figure 9.1**, and photographs of equipment are provided below.

Insert photographs of Pivot #10

9.3 Field Parameters to be Measured

Throughout the LEPA Demonstration Program, various data regarding groundwater pumping, soil moisture, and operation of the center pivot irrigation systems is to be recorded in order to closely track the potential effectiveness of the LEPA systems at increasing the irrigation efficiency in Sierra Valley.

The data to be recorded includes the total gallons of water used for irrigating between cuttings, soil moisture profile, number of pivot hours and days operated between cuttings, the speed of the pivot motors and adjustments made during the irrigation season to improve water application and soil moisture, the tonnage of crop yield from each cutting, and notes of the general quality of the crop if measured. Data are to be collected and reported for each irrigation season, and it is expected that the demonstration program will continue for 2 to 3 subsequent irrigation seasons to better define water use and LEPA system effectiveness over a range of climatic conditions. Data are to be collected from both the retrofitted pivot (Roberti Pivot #13) and the baseline MESA point (Roberti Pivot #10) so that effectiveness of the LEPA system may contrasted with a standard MESA equipped center pivot. **Appendix D** contains a check list and format for data collection.

9.4 LEPA Data Reporting

After each irrigation season, a report will be drafted with a focus on the intended testing parameters for the following irrigation season. The report will include intended pivot motor speed adjustments and the planned number of irrigation days. The ultimate goal of the LEPA Demonstration Program is to verify that the utilization of the LEPA irrigation system will results in the use of less groundwater water while maintaining an equivalent crop yield from year to year.

10. RECOMMENDATIONS FOR SIERRA VALLEY IRRIATION EFFICIENCY IMPROVEMENTS

The following recommendations are made to improve irrigation efficiency and reduce agricultural water use in Sierra Valley.

- Continue LEPA Demonstration Program over the next 2-3 irrigation seasons at the Roberti Ranch Pivot #13, and any other locations added to the Demonstration Program.
- Expand the LEPA Demonstration Program to include additional locations to test alternatives sprinkler types, and help define optimal irrigation system operations, and define the variability in expectations due to farming practices, weather variability, soils and land slope variations, and crop conditions. As initiated at the Roberti Ranch, LEPA or LESA conversions for testing purposes should be paired with comparable baseline MESA field monitoring, so the performances may be adequately contrasted.
- As an initial recommendation, three addition center pivots can be retrofitted with LEPA systems to better define variances and expectations, and test different models of LEPA sprinkler heads.
- As an initial recommendation, convert an additional three MESA pivots to an approximate 4 to 5-ft spaced modified LEPA or LESA system to contrast to the 30-inch close-spaced LEPA packages. Some fields may not be suitably level and flat for LEPA, and these LESA systems may be better suited for field conditions.
- If possible, convert one or more wheel line irrigation systems to LEPA in a demonstration program. Details of this type of conversion as less clear, and may require some trial-and-error testing.
- Support implementation of soil moisture monitoring systems to aid in refining the timing and volume of irrigation water application for all types of irrigation systems.

- Support implementation of VFD pump controls to minimize early season over-watering due to higher pumping rates (shallower groundwater levels resulting in less lift).
- Support conversions of pump systems (motors / horsepower reductions) concurrent with LEPA conversions to benefit from lower pressure requirements, for electrical power savings.
- Support improvements that can be made to water conveyance losses, including fixing piping leaks and leaks in irrigation system piping.
- When possible, promote avoidance of MESA and wheel line irrigation during the highest wind periods.
- Conduct community outreach targeted to the farming community to convey information on irrigation efficiency methods, the LEPA Demonstration Program, and opportunities to improve irrigation efficiency and reduce groundwater pumping.
- Pursue funding opportunities to implement irrigation efficiency improvements on farms.

11. FUNDING & BUDGET ESTIMATES FOR IRRIGATION EFFICIENCY IMPROVEMENTS IN SIERRA VALEY

The following irrigation efficiency projects and management actions summarized in **Table 11.1** are specific to the GSP Irrigation Efficiency Improvement management action. Preliminary estimated funding requirements and potential implementation timing, subject to funding, is outlined. Primary funding for this component of GSP implementation is hoped can be secured from DWR GSP implementation funding, to the extent made available to Sierra Valley.

As summarized in Table 11.1, in order to fully implement the irrigation efficiency improvements outlined herein, it is estimated that approximately $1.6 million will be required for equipment conversions and installations. This does not factor costs of like-kind services of the farms for LEPA/LESA equipment installations, and does not provide for all costs to convert to VFD pump control systems. Nor do the estimates account for any significant inflation on costs of equipment and materials. Professional services for implementation are preliminarily estimated at $380,000, and administrative services costs at $100,000. It is envisioned that subject to funding availability, and the anticipation of extensive farmer participation, the irrigation efficiency improvement components could be implemented in years 2023 to 2026.

Other funding opportunities may be pursued, as potentially available from agencies like the US Department of Agriculture (USDA), and other state and federal programs targeted to assist in agricultural improvements, agricultural security, improved water use efficiency, and energy savings. These programs are competitive, and it is difficult to assess to what extent SVGMD or Plumas County might be successful in securing USDA grants, and many grants are only for partial funding, or low-interest loans made to individual farmers.

Table 11.1 – Irrigation Efficiency Improvement Project Component and Preliminary Budget Estimates

Proposed Project / Management Action	Notes	Implementation Years	Preliminary Budget Estimate Equipment	Preliminary Budget Estimate Professional Services	SVGMD and Plumas County Administration
Expand LEPA Demonstration	a) 3 additional center pivot fields, variations of LEPA equipment types, with 2 additional baseline field. b) 2 or 3 farm volunteers. c) Equipment: 3 LEPA systems installed, 5 flow meters at pivot heads, 5 soils moisture systems	2023-2024	$150,000	$60,000	$10,000
LESA Demonstration	a) 2 additional center pivots, variations of spacing and LESA equipment type, with 1 baseline field. b) 1 or 2 volunteer farms c) Equipment: 2 LESA systems, 3 flow meters, 3 soils moisture systems	2023-2024	$80,000	$30,000	$10,000
Wheel Line LEPA Conversion Demonstration	a) 1 wheel line motorized and converted to LEPA b) 1 volunteer farm	2023-2024	$70,000	$30,000	$10,000
Soil Conditioning Demonstration	a) One volunteer farm, implement various soils amendments to improvement water holding capacity b) Farm to provide equipment and manpower c) Equipment: amendment materials compounds, three soils moisture monitoring stations	2023-2024	$70,000	$30,000	$10,000

Proposed Project / Management Action	Notes	Implementation Years	Preliminary Budget Estimate Equipment	Preliminary Budget Estimate Professional Services	SVGMD and Plumas County Administration
LEPA Equipment Fund	a) Make equipment available to all interested farms b) Farm contributes like-kind services for installation c) Sufficient to fund an additional ~40 retrofits of MESA systems to LEPA or LESA, depending on most appropriate system from Demonstration Program	2024-2026	$700,000	$100,000	$30,000
Soil Moisture Implementation Fund	a) Make equipment available to all interested farms, with up to ~15 systems made available, or partial funding for ~40 field installations b) Farm contributes like-kind services for installation	2024-2026	$160,000	$30,000	$10,000
Pump VFD Implementation Fund	a) Make equipment available to all interested farms, with up to ~15 systems made available, or partial funding assistance for up to ~40 wells	2024-2026	$400,000	$100,000	$20,000

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APPENDIX A
LEPA – Sprinkler Head Specs and Data Sheets

APPENDIX B
Soil Moisture Probe Manuals/Instructions

APPENDIX C
Flow Meter Manual/Instructions for Data Download

APPENDIX D
Data Collection List (Roberti Ranch)