Rock Creek
Reclamation District

Infiltration Feasibility Study

October 2023

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A Butte County Reclamation District Operating Under Division 15 of the California Water Code

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1.0 INTRODUCTION AND PURPOSE

Wood Rodgers Inc. (Wood Rodgers) has been contracted by the Rock Creek Reclamation District to provide a conceptual groundwater recharge/infiltration analysis for assessing the potential for increasing aquifer recharge from surface water in the Sand Creek watershed north of the City of Chico, California. This report is intended to document the literature review of previously available analysis, new data collection methodology, hydrological and hydraulic analyses, and the method adopted to analyze baseline and proposed condition infiltration through the potential groundwater recharge site(s) within the Sand Creek watershed.

The Sand Creek watershed is located north of Rock Creek and east of State Route 99 (SR99) in Butte County, California. Twenty potential infiltration areas were identified within the Sand Creek watershed by the RCRD as part of the scoping effort for this study. **Figure 1** shows the location of the area studied and the initial 20 potential infiltration sites.

The purpose of this study is to determine locations and potential structural measures that may be constructed to increase groundwater recharge and assess their effectiveness. This will be achieved by analyzing the existing (baseline) condition infiltration volume through the site(s) and then analyzing the proposed infiltration enhancement scenarios to demonstrate how they could increase the recharge capacity of the respective basins. This study provides a feasibility-level assessment of the infiltration volume for existing and proposed conditions in the project area. Alternatives that could be implemented to improve/increase the infiltrated volume are described, as well as the approach and methodology used to evaluate the alternatives. Further study would be needed to identify a preferred and implementable alternative.

2.0 BACKGROUND

2.1. General Background

An aquifer is a geological formation that consists of underground layers of permeable rock, sediment, or soil capable of storing and transmitting water. These natural underground “reservoirs” play a crucial role in groundwater storage and supply. Infiltration refers to the process by which water from precipitation or surface sources penetrate into the ground, recharging aquifers and replenishing underground water resources. Together, these formations and processes are essential components of the Earth's hydrological cycle, sustaining ecosystems and providing a vital source of freshwater for human consumption and various other uses. Aquifers, their physical structure, infiltration capacity, and percolation processes are closely interconnected and occur simultaneously, necessitating comprehensive joint study. The quantity of water that can be infiltrated is inherently reliant on the specific characteristics of the aquifer and the soil layers it must pass through to reach it. Therefore, relying solely on hydrological (surface) analysis is insufficient for drawing conclusions; a combined approach that includes geological analysis is essential for a thorough understanding of these processes. However, the quantification of storage underground cannot be well defined in sufficient detail in many areas because measurements of pore spaces within underground sediments is very limited and expensive to collect, forcing analysis to rely on interpolations and projections of data.

Relying solely on a desk evaluation and analysis can yield imprecise results for such studies, which demand on-site visits and accurate data collection for more precise results. Our team conducted a field visit to assess hydromorphic conditions and evaluate infiltration conditions in Sand Creek. This fieldwork serves as a reference point to validate the feasibility of proposed alternatives and the results simulated by the feasibility study model.

2.2. Previous Studies and Existing Modeling Information

The Rock Creek watershed, situated in Butte and Tehama counties in California, is part of the larger hydrological unit known as Big Chico Creek – Sacramento River. Originating in the Sierra Nevada Mountains, this watershed experiences runoff that flows in a southwest direction until it reaches the confluence of Rock Creek and Mud Creek. Mud Creek then continues for approximately two miles before joining the Sacramento River. The northeastern section of this watershed encompasses foothills and mountainous terrain, with elevations ranging from around 200 to 3,900 feet. In contrast, the southwestern part lies within foothills and valleys, with elevations spanning from approximately 560 to 135 feet. The primary watercourse in this watershed is Rock Creek, which has two named tributaries, Keefer Slough and Sand Creek. In the upper reaches of the watershed, Rock Creek spills into the upstream end of Keefer Slough, which ultimately merges with Rock Creek in the lower part of the watershed. Additionally, there are several small, unnamed tributaries that contribute to the Rock Creek watershed.

The Northern Region Office of the California Department of Water Resources (DWR) conducted hydrological modeling for the Rock Creek watershed in November 2021. They utilized the Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) developed by the United States Army Corps of Engineers (USACE) for this purpose. The hydrologic model used in this study was initially provided to Butte County by DWR and subsequently employed by Wood Rodgers as part of the Rock Creek Nord Feasibility Study, which assessed flooding alternatives affecting greater Rock Creek and Keefer Slough. The primary focus of the new infiltration study centers on the Sand Creek portion of the watershed. As the original DWR model and subsequent feasibility study lacked the required level of detail for the infiltration study, Wood Rodgers subdivided the Sand Creek watershed at a specific point of interest, where more detailed streamflow estimates were essential. No modifications were made to the remainder of the Rock Creek model. The necessary hydrologic parameters were then computed for this newly delineated Sand Creek Sub-Watershed. Refer to **Figure 2** for a visual representation of the revised Sand Creek watershed delineation.

The DWR incorporated publicly-available rainfall frequency projections from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 into its simulation, to assess flooding. It is important to note that the NOAA Atlas 14 dataset is a statistical analysis that does not encompass all rainfall gauges within Butte County, or directly represent historical data. The primary objective of the current study is to simulate long-term historical hourly conditions and corresponding infiltration rates/volumes at the subject sites. In order to accurately represent the local rainfall conditions and to generate long-term hourly flow data, Wood Rodgers replaced the NOAA dataset (hypothetical rainfall) with historically measured (observed) gauge data collected from February 2000 to August 2023.

Wood Rodgers utilized the HEC-RAS 2D model for the previous feasibility study effort that covers a larger watershed area, including Rock Creek, which results in longer model run time. A separate baseline model was developed with a specific focus on the Sand Creek Watershed and the subject sites. This model is utilized for the purpose of identifying long-term hourly infiltration patterns across the sites in baseline. This focused HEC-RAS model was utilized to generate rating curve information required for evaluating the proposed conditions. The modeling methodologies, data sources, and underlying assumptions within the workflow are elaborated upon in subsequent sections of this report.

3.0 FEMA EFFECTIVE FIRM

Basins $D_{1\&2}$ and E_1 are currently mapped within a Federal Emergency Management Agency (FEMA) Special Flood Hazard Area that is designated Zone A on the Flood Insurance Rate Map (FIRM) 06007C0575E (dated January 6, 2011). Since the site is located within the FEMA's currently mapped floodplain, a Letter of Map Change Request (LOMR) would be necessary to change the flood limits after any flood-limits altering project. The request should be made through detailed hydrological and hydraulic analyses which shows modeling results performed in accordance with FEMA criteria. This mapping change can be a separate study after any construction is completed. **Figure 3** shows the FIRM information. Any proposed increases in flooded areas outside of the published EMA Special Flood Hazard Area due to impounding water would need to be assessed by Butte County or map revision requirements. If there are no existing structures to insure under the National Flood Insurance Program (NFIP), and the zoning and land use prohibit future development, there may be no need to define the flood hazard with FEMA in order to assign flood insurance rates.

4.0 GROUND SURFACE ASSESSMENTS

The purpose of this study is to quantify the baseline infiltration volume and explore various alternatives for increasing the infiltration capacity of the subject basins. The primary option is to construct a dam to retain water for a specific duration. Once retention and infiltration can be quantified, future studies will need to assess environmental constraints, historical preservation issues, and water rights issues. It's important to note that subsurface conditions have only preliminarily been evaluated in this study, any findings presented here are subject to modification once they are evaluated. The decision to move forward with additional analysis depends on qualifying for available funding, the State's and Butte County's ordinances and requirements, and RCRD's willingness to oversee onsite efforts.

GeoSystem Analysis, Inc. (GSA) supported the analysis by performing onsite identification of potential surface infiltration rates within the Sand Creek watershed. GSA and its subconsultant performed an aboveground Frequency Domain Electro-Magnetic (FDEM) survey to assess long term infiltration within the Sand Creek Watershed. FDEM is a surface-based electromagnetic tool used to detect variations in subsurface electrical conductivity (or its inverse, resistivity) using electromagnetic induction principles. Over twenty sites were assessed and five of them have been identified as potential sites, namely, Sites $D_{1\&2}$, E_1, E_2, J_1, and J_2, as shown on **Figure 4**. GSA's primary focus was to identify the potential infiltration rates and locations within the site, and they concluded that these five areas demonstrate greater infiltration potential. A maximum constant infiltration rate of 0.7 ft/day was determined for the five identified areas, as provided by GSA. Further details and explanations can be found in GSA's report, provided in **Appendix A**.

In addition to the FDEM surveys, Wood Rodgers performed a site visit to document the geomorphic stream conditions within much of the project area. **Figure 5** shows the locations of all of the photographs taken to depict the bank and bed conditions at key locations. At the onset of the project, it was assumed that the primary infiltration potential would be located along stream bed areas, where looser sediments accumulate over time, in locations where water naturally collects already, and where structures to retain water could easily be constructed. **Appendix B** provides all of the photographic documentation.

The qualitative findings from the site visit show that bank scour conditions are naturally created, given the slope/terrain characteristics of the watershed, as the existing meandering channels are subjected to periodic higher flows. It is assumed that any proposed dam-like features that may be constructed to impound water will not worsen erosion stream conditions downstream of the impoundment, as long as the impounding structure is designed for overtopping during high-flow conditions. Dam-like structures serve to reduce peak flow downstream while they are filling, which will reduce bank erosion during smaller storm events. During larger storm events, the dam passes flows downstream identical to pre-structure conditions after the peak has passed.

The main impacts to geomorphic stream conditions that are created by impounding water are from trapping sediment upstream of dams and thereby starving the downstream reaches of sediment that would have otherwise migrated. Removing upstream sediment will require some degree of routine maintenance. It will not likely detract from the infiltration capacity of the basin, but if allowed to accumulate it will deplete surface storage and potentially block low-flow discharges from the dam outlet. Sediment management will be an important consideration for design and implementation, and will require more in-depth analysis to quantify any long term impacts.

5.0 HYDROLOGIC DATA COLLECTION AND USE

This section of the report provides the information regarding the hydrologic data necessary to conduct the study. Mainly spatial data, temporal data and topographic data have been used for the analysis.

5.1. Rainfall Data

In California, numerous organizations have been actively collecting rainfall data. For this particular project, Wood Rodgers conducted an extensive review of data sources, including Day-met, UC-IPM, CIMIS, CDEC, CA-WC, and NOAA. Among these sources, the California Data Exchange Center (CDEC) stood out for its long-term rainfall data collection and preservation. No measured rainfall data was identified directly within the Sand Creek watershed. However, within the Sand Creek vicinity, there is an array of rain gauges available. The CDEC database identifies rainfall collection sites by a three-letter ID, such as **CRG**, CST, DES, CHI, PED, BLW, BIC, MUC, LCH, BKC, BPD, CES, and more. Wood Rodgers gathered and analyzed data from all of these stations before deciding on their suitability for hydrological rainfall runoff modeling. The main characteristics of the data were the measured time interval for data collection, the length of the period of record, and the continuity/completeness of the data set. Given the size of the watershed, it was important to obtain a maximum interval of hourly rainfall data. While daily and monthly data is more prevalent, it does not provide enough detail to understand how storms realistically fill and drain during a single day. Our analysis revealed that **CRG** possessed high-quality hourly data, with minimal instances of missing values recorded over an extended period. While the location of the CRG gauge is approximately 17 miles northwest of the Sand Creek watershed, the elevations and climate conditions for each location are similar. Due to the lack of long-term data and the prevalence of missing values in other stations, only the CRG gauge was used for this study as the best representation of historical rainfall in the watershed.

The CRG gauge has hourly rainfall recorded from February 2000 to August 2023, and CRG data up to August 2023 has been used in the study. Wood Rodgers utilized the hourly data to calculate both annual and monthly average rainfall values. The analysis revealed that annual rainfall ranged from 5.13 inches to 32.22 inches throughout the twenty-four-year observation period, with an average annual rainfall of 19.33 inches, averaged according to calendar year. **Table 1** provides a summary of annual rainfall values throughout this time frame, while **Chart 1** visually illustrates the variations in rainfall over the mentioned period.

Table 1: Annual Rainfall Observed at Station CRG

Calendar Year	Rainfall-Inch
2000	13.15
2001	26.98
2002	19.49
2003	27.35
2004	22.62
2005	27.93
2006	22.2
2007	10.46
2008	15.36
2009	19.27
2010	28.85
2011	18.46
2012	23.31
2013	5.13
2014	23.51
2015	8.62
2016	26.27
2017	22.78
2018	16.41
2019	32.22
2020	6.84
2021	15.7
2022	10.57
2023	20.54
Avg. annual rainfall	19.33

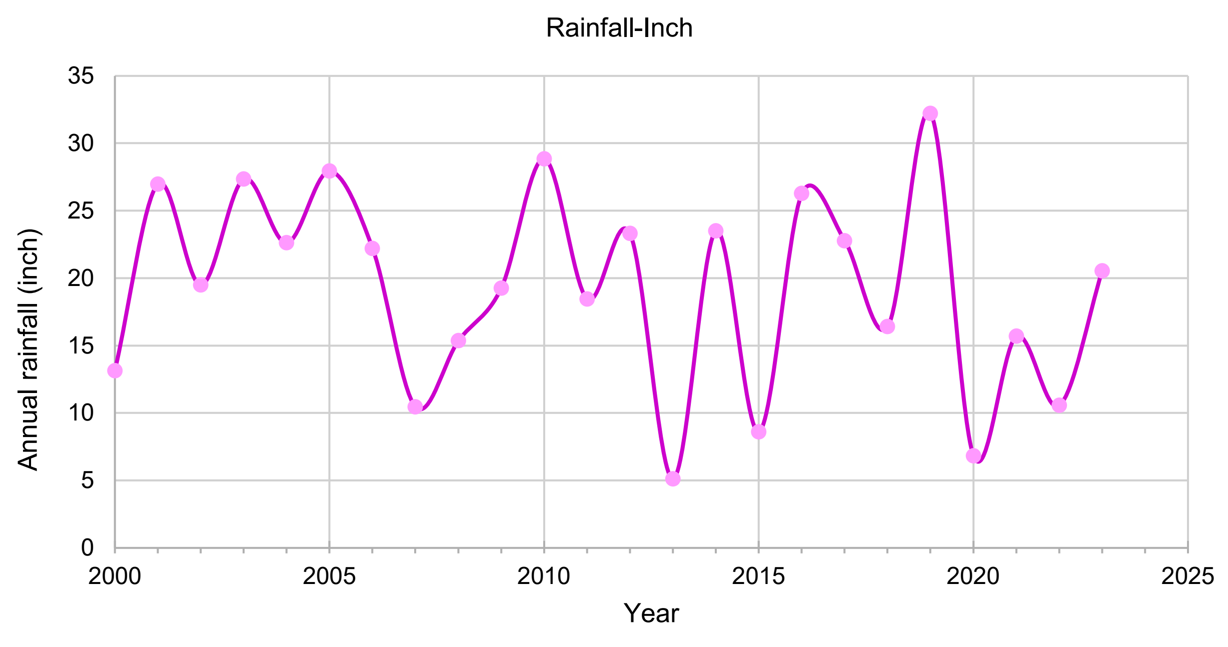


Chart 1: - Annual (Calendar Year) Rainfall Variation Graph

Monthly average rainfall from twenty-four years of recorded data was calculated which shows May to September months having very low rainfall. The maximum average monthly rainfall occurred in December which is 4.29 inches. **Table 2** provides a summary of average monthly rainfall values for this time frame, while **Chart 2** visually illustrates the monthly variations in rainfall over the recorded period.

Table 2: - Monthly average rainfall measured at station CRG.

Month	Rainfall-Inch
Jan	3.74
Feb	3.16
Mar	2.62
Apr	1.26
May	0.94
Jun	0.24
Jul	0.02
Aug	0.04
Sep	0.27
Oct	1.12
Nov	2.12
Dec	4.29

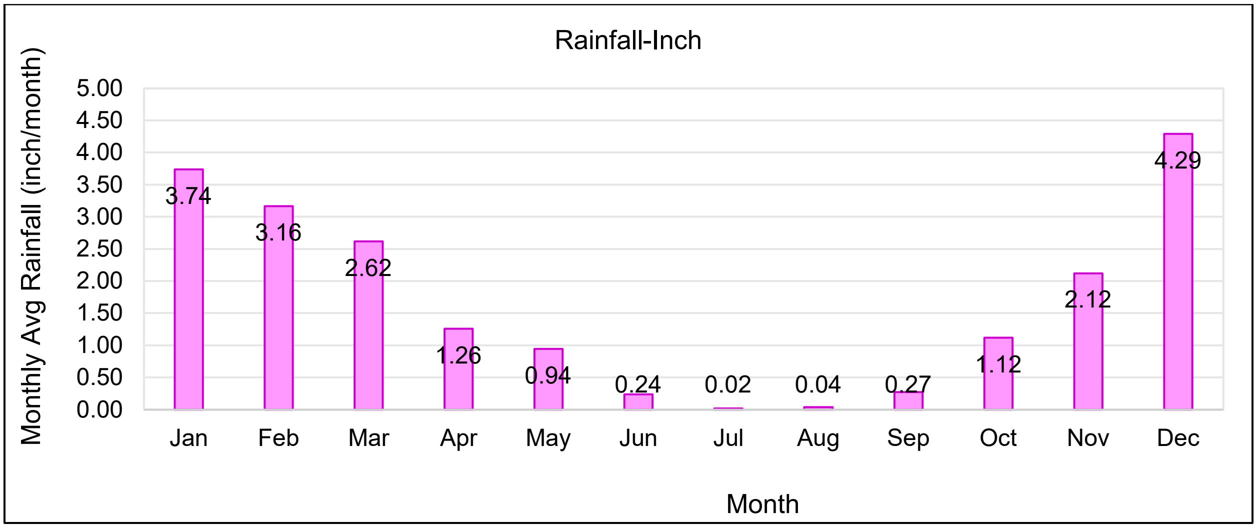


Chart 2: - Historical average monthly rainfall at CRG

5.2. Topographic Data

A one-meter Digital Elevation Model (DEM) was acquired from the United States Geological Survey (USGS) via The National Map website (USGS, 2021). To prepare the data for analysis, various essential tasks such as unit conversion, projection definition, clipping, and mosaic were performed using the ArcGIS Pro software. **Figure 6** Shows the topographic data. The horizontal datum utilized for the project evaluations is the North American Datum of 1983 (NAD 83) State Plane California Zone II Federal Information Processing Standard (FIPS) 0402 (US Feet). The vertical datum utilized is the North American Vertical Datum 1988 (NAVD 88).

5.3. Soil Data

Wood Rodgers retrieved Gridded Soil Survey Geographic Data (USDA-NRCS, 2020) from the Natural Resources Conservation Service (NRCS) and employed Geographic Information System (GIS) Pro software to identify the prevailing soil types within the Sand Creek Watershed. The watershed is predominantly characterized by NRCS soil types C and D. C type soils are most abundant in the northwest region of the basin and primarily consist of clay. These C class soils exhibit a high available water capacity and are classified with a high runoff potential. Conversely, D type soils are dominant across the majority of the basin and primarily consist of gravelly loam. The D class soils, in contrast, possess a low available water capacity but are also classified with a high runoff potential. The soil properties serve as the basis for assessing watershed runoff upstream and feeding into the infiltration basin areas.

6.0 MODELING APPROACH

6.1. Baseline Modeling Approach

To estimate the existing infiltration volume, extensive hydrological and hydraulic modeling, as well as GIS analysis, were performed. Infiltration is a vital component of the water cycle or water balance, and to isolate infiltration from the cycle, it's essential to consider areas and durations of inundation. The HEC-RAS 2D model was used to identify the area of inundation across each infiltration area for a wide range of flow conditions to develop a flow/area relationship. This study considered five recharge zones, and the ArcPy programming approach was used to calculate the inundation area for each flow value within each polygon. To estimate the volume of infiltration, the inundated area was multiplied by the assessed constant infiltration rate of 0.7 feet per day (0.35 inches/hour). This calculation resulted in an infiltration volume versus inflow rating curve. The updated Sand Creek hydrologic modeling in HEC-HMS was utilized to simulate historic hourly runoff values as inflow entering each infiltration polygon, and the previously developed volume rating curve was used to calculate the infiltration volume for each recharge zone with respect to hourly simulated historical runoff.

6.1.1.Hydrological (Surface Runoff) Modeling

As previously explained, the previously developed HEC-HMS model with modifications was utilized for this analysis. The study focuses on Sand Creek and its watershed. Modifications and calculations of watershed and hydrological parameters were adjusted exclusively for the Sand Creek Watershed. Hourly rainfall data from the selected rain gauge were used to estimate historical runoff. The upstream flow entering each recharge zone was computed and considered as basin inflow in the calculations. The flow entering recharge zones J_1 and J_2 is the same, as is the case with E_1 and E_2. However, the infiltration volume through each of these zones would differ according to their distinct inundation areas. The main update in the rainfall-runoff modeling is related to the historical rainfall input. Most of the information remains consistent with Wood Rodgers' previous analysis conducted for the Rock Creek Nord Feasibility Study.

6.1.2.Hydraulic Modeling

The available HEC-RAS model covers Sand and Rock Creek; however, it has a significantly longer run time. To reduce this extended runtime, Wood Rodgers decided to develop a new truncated model focused only on the area of interest. HEC-RAS version 6.3.1 was used for model development, with the river and bank areas using finer/denser mesh sizes. A significant number of break lines were added to enforce cell alignment along the creeks, including streets and roads. The upstream boundary condition is a hypothetical flood hydrograph, with stepped flows, while the downstream boundary condition is normal depth. The previously described land and soil data were used to define the surface characteristics. This hydraulic analysis was employed to establish the rating curve relationship between inundation area and flow at each of the five sites.

6.2. Baseline Modeling Results

After conducting Rainfall Runoff modeling for the period of 2000-2023, and developing a rating curve through hydraulic modeling, Wood Rodgers calculated the hourly infiltration volume for all five recharge zones over a span of twenty-four years. These results were subsequently analyzed on both a monthly and annual/average basis. The monthly analysis reveals that Basin $D_{1\&2}$ provides the largest infiltration potential, consistently demonstrating higher monthly infiltrated volumes compared to the other basins. Basin J_1 exhibits the lowest potential under baseline conditions. The wettest months from October to May are favorable in terms of generating substantial infiltration volume, while the period from June to September records significantly lower levels of infiltration volume. The volume of realized historical infiltration is influenced by the amount of inflow being applied as well as the vertical dimensions and slopes of each potential recharge area. The D1&2 area is the most downstream of the potential sites with the largest contributing tributary area and inflow, and it is also the infiltration area with the flattest and widest natural configuration to allow for most infiltration area under the same flow conditions. The J1 basin is located in steeper terrain with a smaller tributary area and inflow.

Table 3 provides data on the average monthly infiltration volume, while **Chart 3** visually represents the monthly variations in infiltration volume for all months. The rating curve and time series data is attached to **Appendix D**.

Table 3: - Monthly Average Infiltration Volume (acre-feet) through each basin under Baseline Condition

Month	BasinD1&2	Basin_E1	Basin_E2	Basin_J1	Basin_J2
Jan	8.19	2.75	4.14	0.12	4.07
Feb	6.71	2.28	3.42	0.10	3.30
Mar	6.49	2.14	3.32	0.10	3.15
Apr	3.51	1.12	1.78	0.04	1.70
May	2.66	0.83	1.30	0.04	1.34
Jun	0.83	0.25	0.42	0.01	0.40
Jul	0.05	0.02	0.03	0.00	0.02
Aug	0.13	0.04	0.07	0.00	0.05
Sep	0.93	0.28	0.45	0.01	0.47
Oct	2.97	0.95	1.48	0.04	1.45
Nov	5.38	1.75	2.70	0.07	2.68
Dec	8.86	3.00	4.49	0.15	4.39

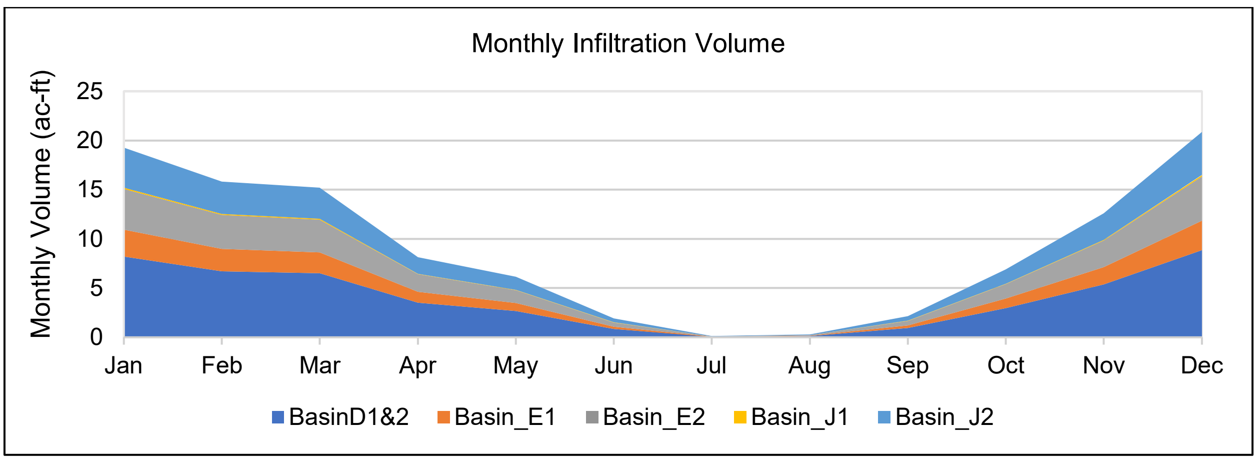


Chart 3: - Monthly Infiltration Volume through each Basin

Annual analysis shows that the average annual infiltration volume through recharge zone $D_{1\&2}$ is 45.63 acre-feet, and through basin J_1 is 0.66 acre-feet. The baseline analysis shows that basin $D_{1\&2}$ has a larger realized infiltration volume. Improvement is needed for increasing infiltration in basin J_1. **Table 4** shows the baseline condition annual capacity of each basin, and **Charts 4 to 8** graphically illustrate the values presented in the table.

Table 4: - Annual Infiltration Volume (acre-feet) through each Basin under baseline Condition

Year	BasinD1&2	Basin_E1	Basin_E2	Basin_J1	Basin_J2
2000	33.28	10.83	16.99	0.40	15.93
2001	64.82	21.82	33.31	0.85	32.15
2002	44.41	14.96	22.22	0.69	21.72
2003	60.71	20.10	29.99	1.17	30.28
2004	50.67	16.89	25.82	0.71	25.17
2005	63.96	21.06	32.16	1.24	31.48
2006	53.24	17.15	27.00	0.80	25.84
2007	28.46	9.42	14.71	0.30	13.90
2008	27.65	9.30	13.92	0.45	13.51
2009	45.15	15.10	23.24	0.61	21.99
2010	69.28	23.07	35.42	0.90	34.02
2011	47.14	15.23	23.42	0.60	23.44
2012	51.22	17.29	26.00	0.73	25.57
2013	13.78	4.28	7.14	0.15	6.49
2014	54.77	18.27	27.18	0.89	27.10
2015	21.57	6.79	10.85	0.28	10.57
2016	65.72	21.47	32.93	0.89	32.44
2017	54.52	17.76	27.46	0.73	27.29
2018	39.27	12.96	20.11	0.53	19.19
2019	67.89	22.92	34.21	1.06	33.53
2020	21.16	6.47	10.86	0.22	10.08
2021	38.26	12.42	19.30	0.53	18.56
2022	27.77	8.80	13.71	0.37	13.68
2023	50.44	16.76	25.20	0.76	25.54
Average	45.63	15.04	23.04	0.66	22.48

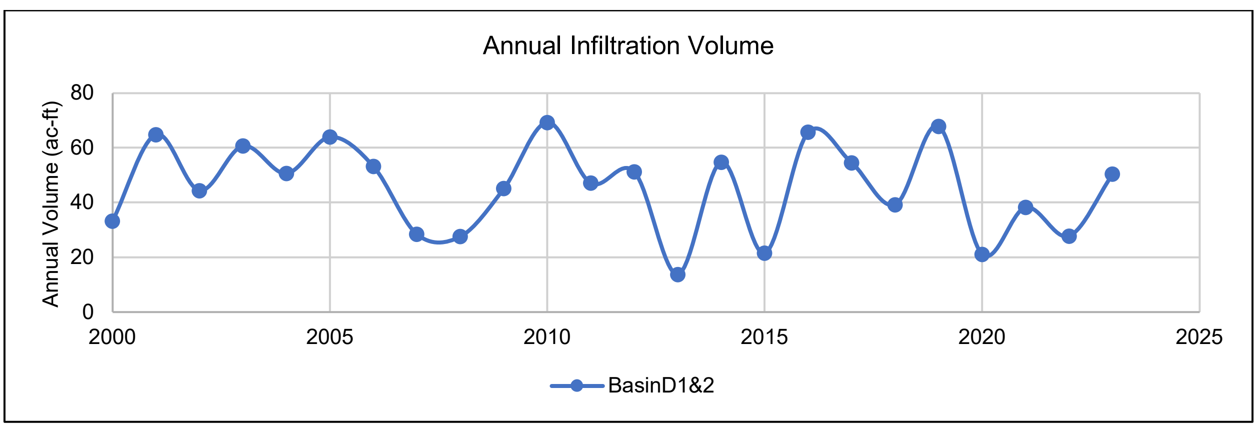


Chart 4: - Estimated Infiltration Volume through Basin $D_{1\&2}$

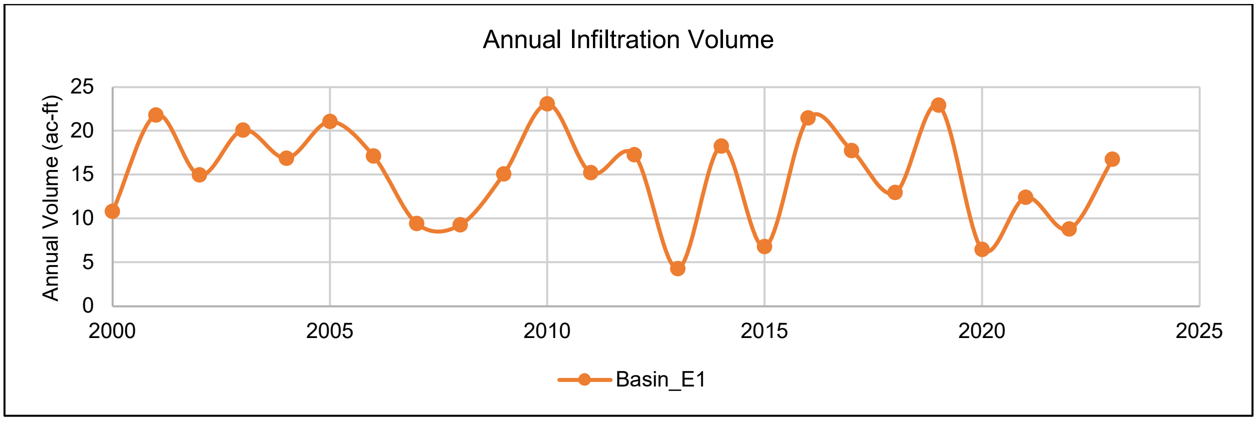


Chart 5: - Estimated Infiltration Volume through Basin E_1

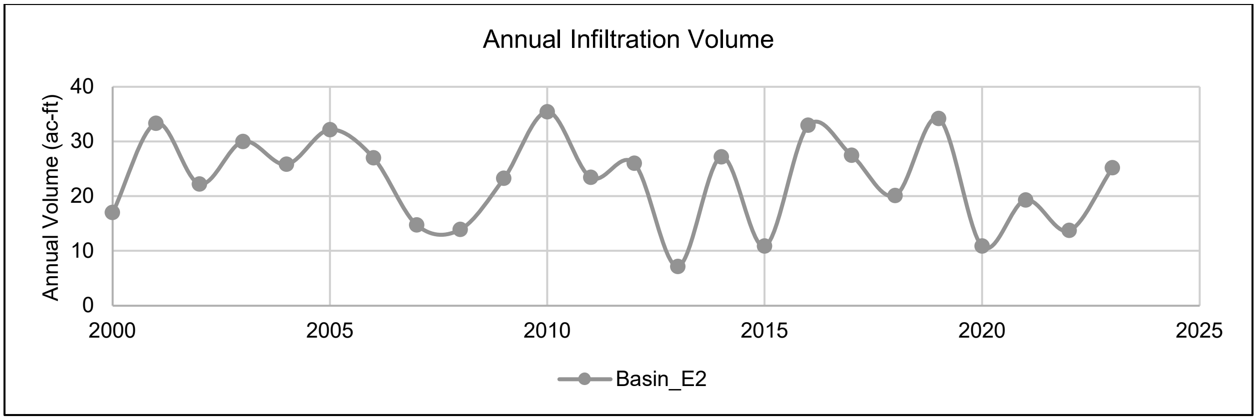


Chart 6: - Estimated Infiltration Volume through Basin E_2

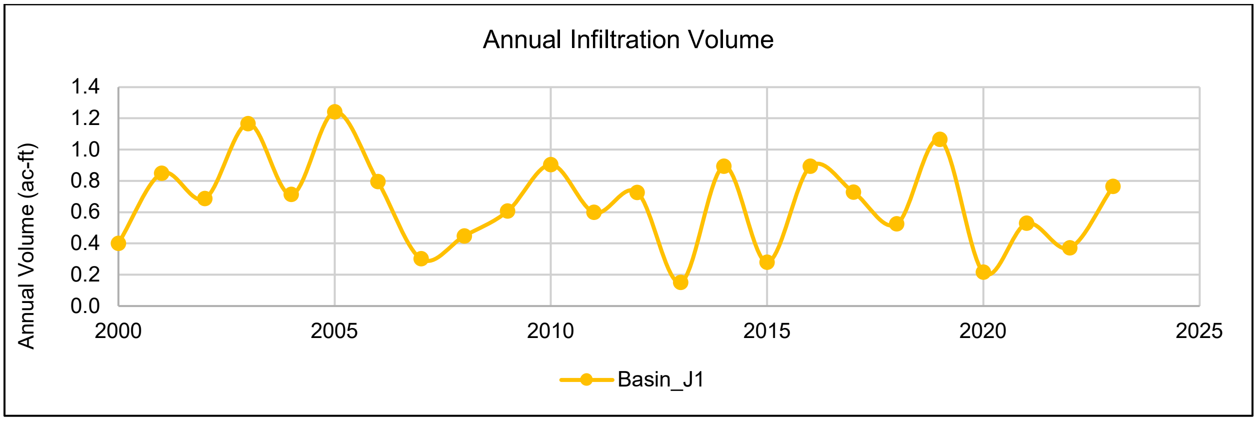


Chart 7: - Estimated Infiltration Volume through Basin J_1

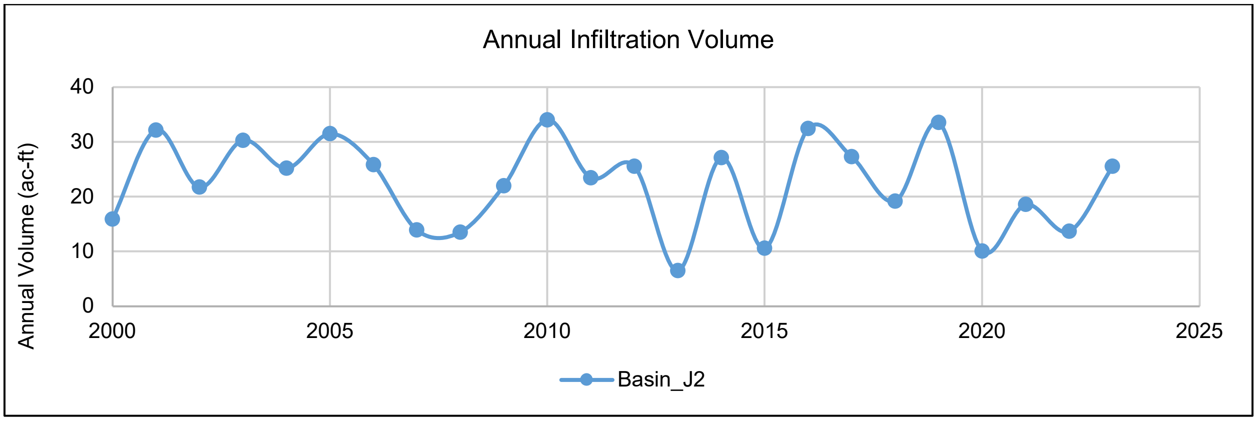


Chart 8: - Estimated Infiltration Volume through Basin J_2

6.3. Proposed Condition Modeling Approach

For the proposed condition, where dams or other structures are developed to impound more recharge water, Wood Rodgers utilized a Linear Programming concept to account for water entering, storing and exiting (piped outflow, infiltration and overtopping) each basin. Wood Rodgers conducted spreadsheet-based calculations to quantify time-series infiltration over the specified time period (2000-2023). The HEC-HMS historical runoff was considered as the inflow for each recharge zone within the basin. A one-foot diameter circular culvert was assumed to maintain low-flow continuity downstream, which is counted as water that passes downstream before it can infiltrate in the recharge zone. After deducting the pipe flow, the remaining water can be calculated, stored and infiltrated for each time increment. The incremental and maximum basin storage capacity was determined using the ArcGIS Pro tool, which provides elevation data, corresponding volume, and area measurements from topographic data. This is referred to as the Elevation-Storage-Area (**E-S-A**) Curve. E-S-A curves were developed for each recharge area using the proposed dam locations and alignments shown on **Figure 7**. This figure also displays the approximate inundated (flooded) areas behind each proposed structure. These areas correspond to the maximum assessed height of each proposed structure and indicate how FEMA floodplain mapping might be impacted should any of the five recharge locations be constructed. An extensive assessment of flood frequencies and volumes was not part of this study, however, given the number of times the detention basins filled and overtopped within the assessed historical record (2000-2023) for infiltration, it is not likely that there will be any significant reduction in the 100-year flood downstream. Very large flood events will quickly fill the basin early in the storm, as these infiltration basins are configured to capture smaller flood events, and will pass the peak of such a flood event downstream relatively unattenuated.

By referencing the E-S-A curve, we calculated the storage elevation corresponding to the volume of water entering the basin. HEC-RAS software was also utilized to create the rating curve for quantifying the flow through the pipe in relation to a specified water surface elevation in the reservoir, i.e., the recharge basin. Using the rating curve and the initial water surface elevation in the basin due to inflow, we calculated the pipe flow. The remaining volume in the basin is obtained by subtracting the flow leaving the basin through the pipe from the initial inflow volume. Once again referencing the E-S-A curve and the remaining volume in the basin, we calculated the elevation corresponding to this remaining volume. Using this elevation, we identified the inundation area within the basin . This step yields the intermediate inundation area before infiltration. After multiplying the inundation area by a constant infiltration rate, we can calculate the infiltrated volume for each time increment. Finally, for each time step, the final (residual) volume is determined after pipe outflow and infiltration are accounted for. This volume is then carried over to the next time increment and added to the new inflow volume for the next time increment. The HEC-RAS rating curve developed for each culvert and the E-S-A curves are provided in **Appendix C**.

6.4. Proposed Condition Scenarios and Results

For the purposes of this study, the full capacity of each basin is considered to be achieved in relation to the proposed dam height. A series of dam heights were assessed for each Basin to determine the impact of varying dam heights on recharge. For example, in the case of basin J_1, the full capacity dam height is 10 feet, with 20% dam height at 2 feet, 40% dam height at 4 feet, 60% dam height at 6 feet, and 80% dam height at 8 feet. The same concept applies to all recharge basins. The maximum assessed dam heights for Basins $D_{1\&2}$, E_1, E_2, J_1, and J_2 are 17 feet, 8 feet, 14 feet, 10 feet, and 18 feet, respectively. All calculations in this study have been based on these reference dam heights. The following section explains the results of each scenario.

6.4.1. 20% Dam Height

This alternative involves installing a dam height at 20% of the maximum dam height in each recharge basin. No changes to the pipe diameter have been made, meaning that the same diameter pipe has been retained for all scenarios. Similar to what was observed in the baseline scenario, the infiltration volume is notably lower from June to September. In the baseline condition, a two-dimensional calculation was carried out using HEC-RAS 2D with a sloped floodplain area. However, in the proposed condition, a linear calculation was performed, which assessed ponded storage levels and does not fully account for the volume when considering a shorter dam height. Therefore, because of the limitation in capturing the 20% volume over the baseline condition, and the limited benefit of a dam at 20% of maximum height, this step in the incremental analysis was omitted for the remaining basins. **Table 5** displays the monthly average capacity corresponding to a 20% dam height for each basin, while **Chart 9** provides a graphical representation of these results.

Table 5: Monthly Average Infiltration Volume (acre-feet) under 20% Dam Height

Month	Basin_D1&2	Basin_E1	Basin_E2	Basin_J1	Basin_J2	All Basins
Jan	5.93	2.06	2.49	3.34	1.21	15.03
Feb	4.80	1.67	2.03	2.67	0.96	12.13
Mar	5.00	1.93	2.25	2.77	1.04	12.99
Apr	2.75	1.17	1.29	1.54	0.61	7.36
May	2.05	0.80	0.91	1.17	0.45	5.38
Jun	0.70	0.37	0.38	0.39	0.17	2.02
Jul	0.04	0.03	0.03	0.02	0.01	0.13
Aug	0.11	0.09	0.08	0.06	0.03	0.37
Sep	0.74	0.30	0.33	0.43	0.17	1.98
Oct	2.25	0.90	1.04	1.24	0.46	5.89
Nov	4.03	1.53	1.77	2.29	0.86	10.47
Dec	6.33	2.25	2.69	3.58	1.31	16.16
Ann. Total	34.74	13.09	15.28	19.52	7.27	89.91

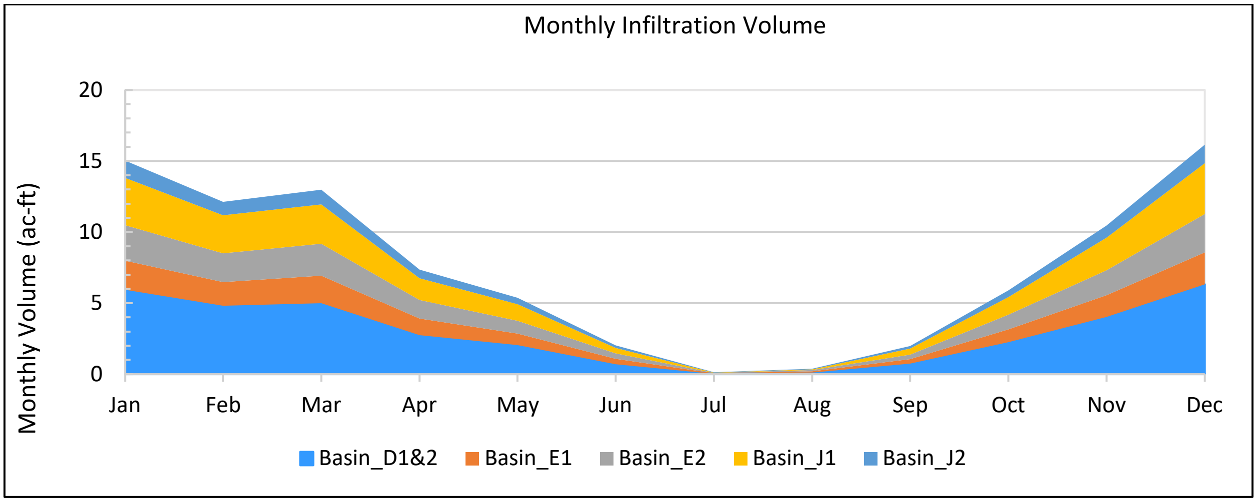


Chart 9: - Average Monthly Infiltration Volume With 20% Dam Height

Similarly, the annual recharge volume was estimated and compared to baseline data, which shows that the annual volume decreased in each basin ($D_{1\&2}$, E_1, E_2, and J_2) by 25%, 14%, 35%, and 68%, respectively, except for basin J_1. This difference is primarily due to the methodologies used, and indicates negligible benefit at this dam height. **Table 6** shows the annual infiltration volume, and **Charts 10 to 14** show the annual infiltration volume for each basin.

Table 6: - Annual infiltration volume (acre-feet) Under 20% Capacity Dam Height Scenario

Year	Basin_D1&2	Basin_E1	Basin_E2	Basin_J1	Basin_J2
2000	25.89	10.26	11.82	14.28	5.45
2001	48.49	16.35	20.14	27.24	9.74
2002	31.54	10.49	12.92	17.68	6.27
2003	43.85	15.80	18.59	24.84	9.21
2004	36.70	13.62	16.06	20.77	7.57
2005	48.00	17.45	20.54	26.69	9.80
2006	39.76	17.59	19.38	22.30	8.69
2007	22.43	9.39	10.40	12.81	5.04
2008	19.56	7.61	8.75	10.83	4.14
2009	33.85	13.04	15.21	18.95	7.22
2010	52.28	20.06	23.14	29.48	11.10
2011	36.22	13.75	15.97	20.31	7.66
2012	37.03	12.91	15.71	20.87	7.53
2013	10.66	5.64	5.77	6.04	2.57
2014	39.93	13.57	16.57	22.29	7.93

2015	16.62	7.36	7.97	9.25	3.60
2016	49.76	18.03	21.51	27.63	10.16
2017	40.00	15.01	17.56	22.71	8.39
2018	29.37	11.64	13.39	16.61	6.18
2019	47.48	17.77	20.92	27.01	10.07
2020	17.39	8.47	8.88	9.67	4.08
2021	29.67	11.63	13.29	16.45	6.32
2022	20.90	7.94	9.20	11.91	4.39
2023	37.10	11.85	14.75	20.92	7.44
Annual Avg.	33.94	12.80	14.94	19.06	7.11

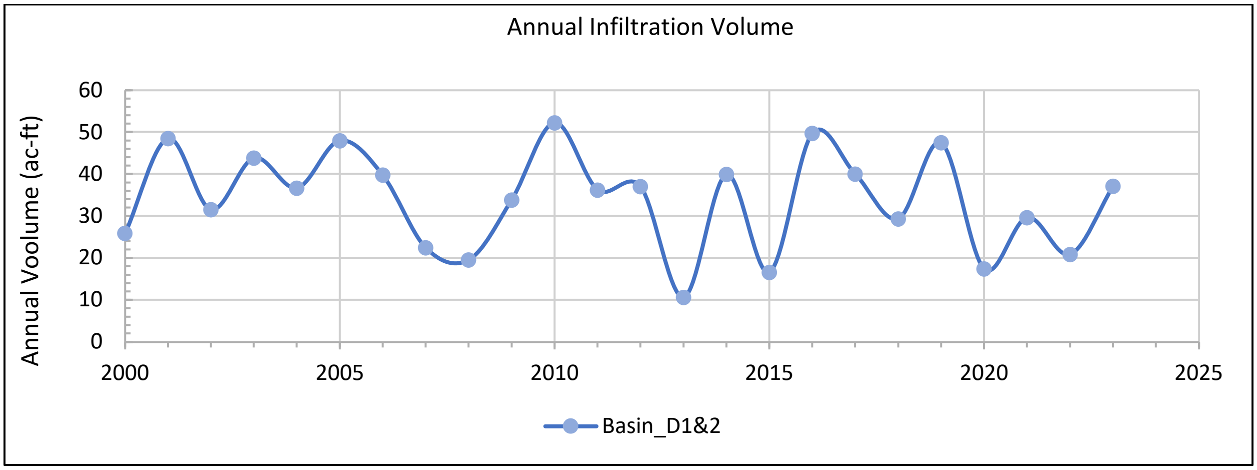


Chart 10: Total annual infiltration volume in basin $D_{1\&2}$

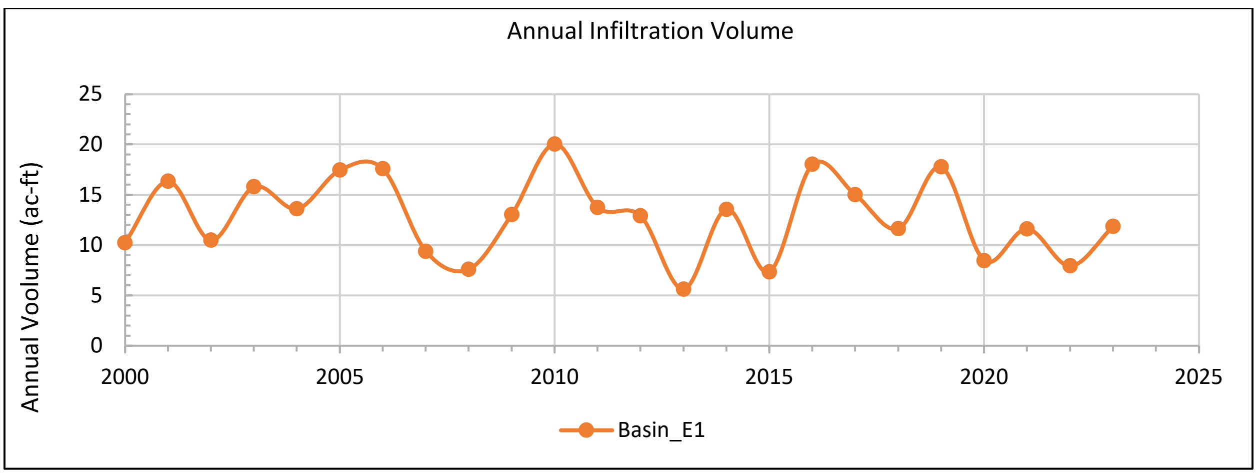


Chart 11: Total annual infiltration volume in basin E_1

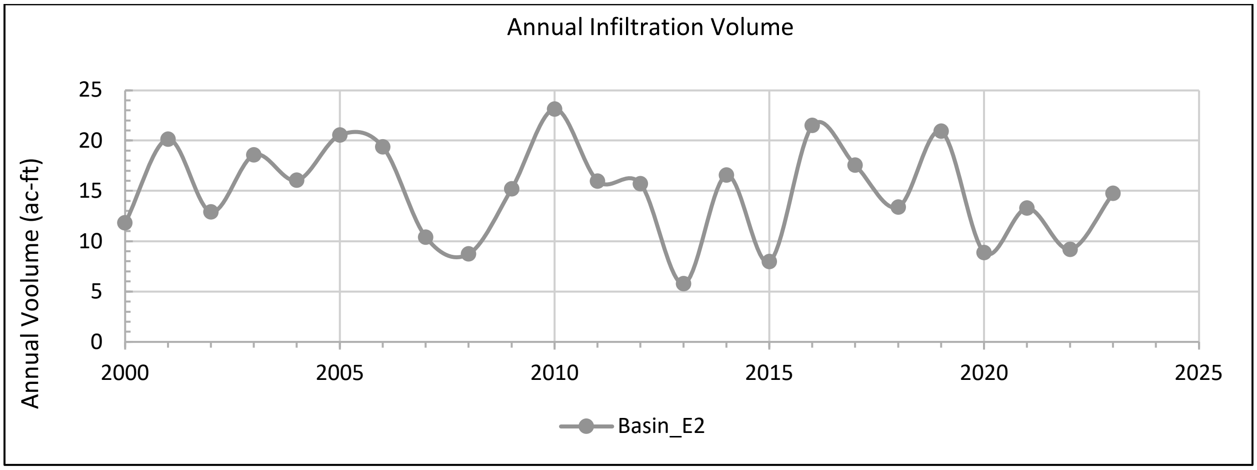


Chart 12: Total annual infiltration volume in basin E_2

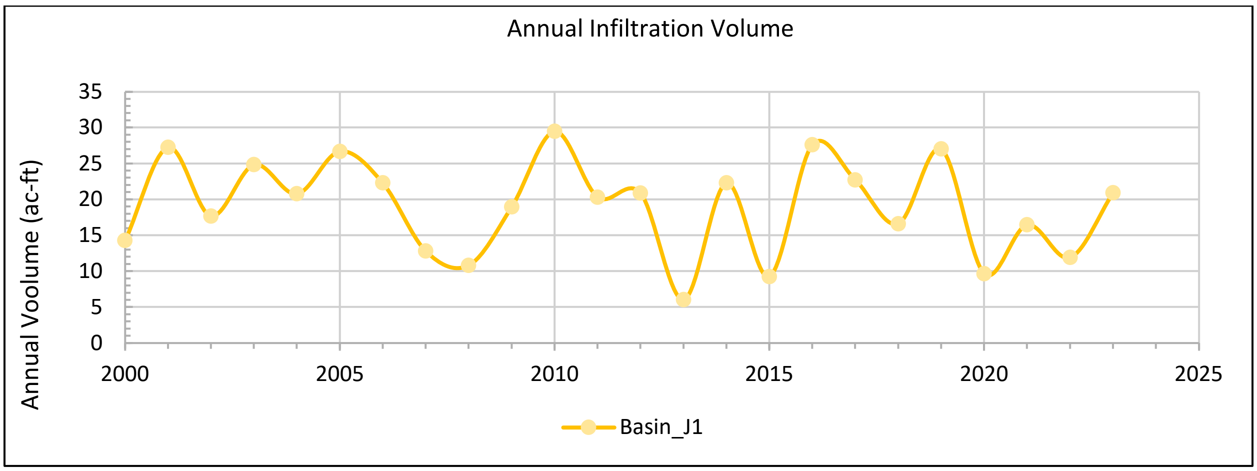


Chart 13: Total annual infiltration volume in basin J_1

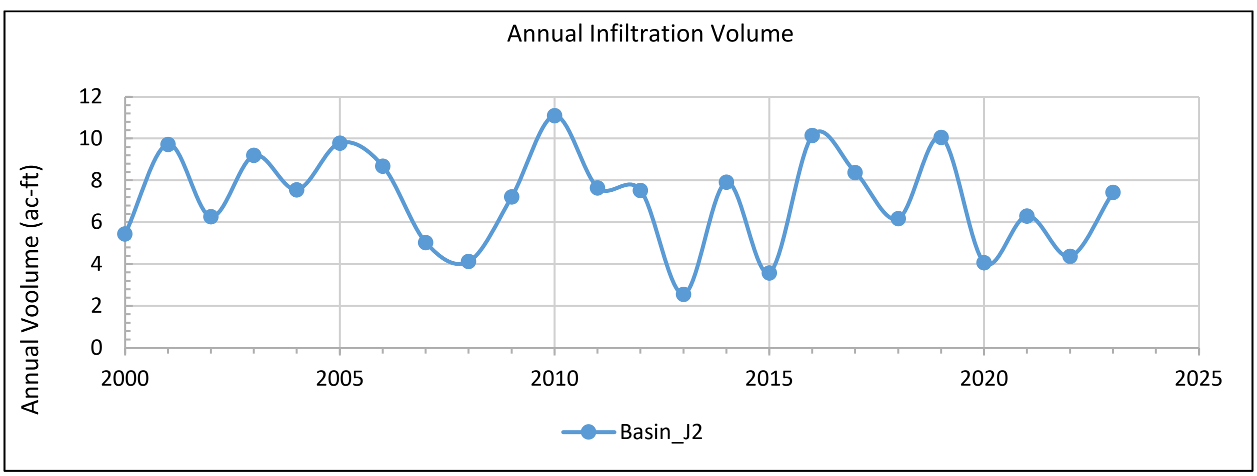


Chart 14: Total annual infiltration volume in basin J_2

6.4.2.40% Dam Height

At 40% of the total dam height, the infiltration volume in all basins increases dramatically. **Table 7** displays the average monthly volume. All volumes are presented in acre-feet (ac-ft). **Chart 15** illustrates the monthly average volume in each recharge zone across all twelve months. The colors represent each individual recharge basin volume. This same pattern applies to all months and basins.

Table 7: - Average monthly infiltration volume (acre-feet)

Month	BasinD1&2	Basin_E1	Basin_E2	Basin_J1	Basin_J2	All Basins
Jan	24.030	4.404	9.813	6.259	7.570	52.077
Feb	19.749	3.581	8.027	5.047	6.143	42.547
Mar	20.786	3.946	8.453	5.117	6.064	44.366
Apr	11.487	2.286	4.689	2.825	3.370	24.656
May	8.882	1.608	3.445	2.176	2.640	18.751
Jun	2.956	0.664	1.241	0.685	0.793	6.339
Jul	0.188	0.046	0.080	0.043	0.054	0.411
Aug	0.460	0.137	0.204	0.098	0.106	1.006
Sep	2.974	0.598	1.216	0.752	0.866	6.406
Oct	9.010	1.806	3.733	2.265	2.633	19.447
Nov	16.782	3.126	6.730	4.275	5.163	36.076
Dec	26.198	4.766	10.556	6.731	8.234	56.485
Ann. Total	143.503	26.967	58.188	36.274	43.635	308.568

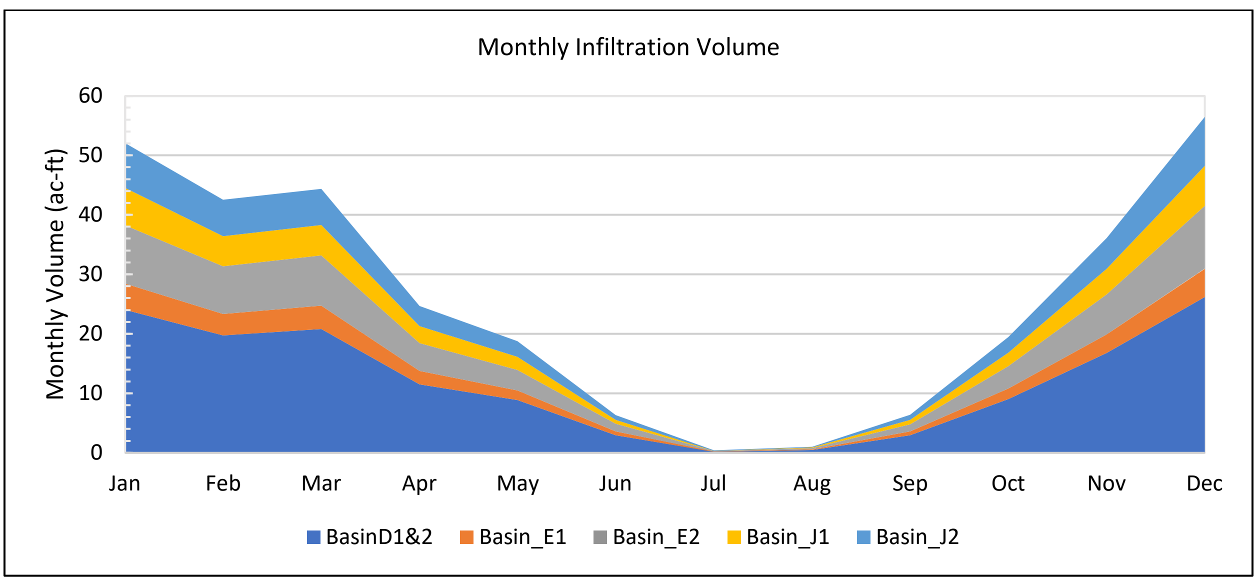


Chart 15: Monthly average Infiltration Under 40% Dam Height

Likewise, the annual volume has increased in each basin ($D_{1\&2}$, E_1, E_2, J_1, and J_2) by 207%, 75%, 146%, 5261%, and 89%, respectively. The annual volume infiltrated under the 40% dam height condition is tabulated in **Table 8**. **Charts 16 to 20** show the annual volume (acre-feet) variation in each basin for the years 2000 to 2023.

Year	BasinD1&2	Basin_E1	Basin_E2	Basin_J1	Basin_J2
2000	107.30	20.76	43.65	26.09	31.13
2001	203.98	35.68	81.51	51.66	63.60
2002	121.41	22.93	50.88	32.96	39.78
2003	177.61	33.01	72.04	46.34	56.00
2004	152.53	28.18	61.77	39.15	48.27
2005	195.58	36.56	80.45	49.57	59.76
2006	167.96	33.74	67.76	40.98	48.70
2007	95.30	18.53	38.91	23.60	28.44
2008	81.37	15.47	32.83	20.24	24.17
2009	137.06	26.85	56.74	34.51	40.49
2010	216.53	40.96	88.73	54.77	66.71
2011	155.08	28.08	60.43	37.51	45.03
2012	154.35	27.63	62.16	39.51	47.89
2013	44.43	10.15	18.48	10.70	12.80
2014	160.65	29.24	65.56	41.72	50.03
2015	73.15	14.01	28.96	17.20	20.25
2016	208.95	37.87	83.27	51.91	62.78
2017	168.40	30.94	66.57	42.41	51.20
2018	119.27	23.49	49.61	30.84	36.02
2019	186.49	36.81	77.62	49.33	59.24
2020	74.66	15.69	30.11	17.01	20.15
2021	125.94	23.51	50.84	30.66	35.92
2022	84.74	16.17	34.42	21.97	26.36
2023	152.31	26.26	61.18	39.65	48.04
Annual Avg.	140.21	26.35	56.85	35.43	42.62

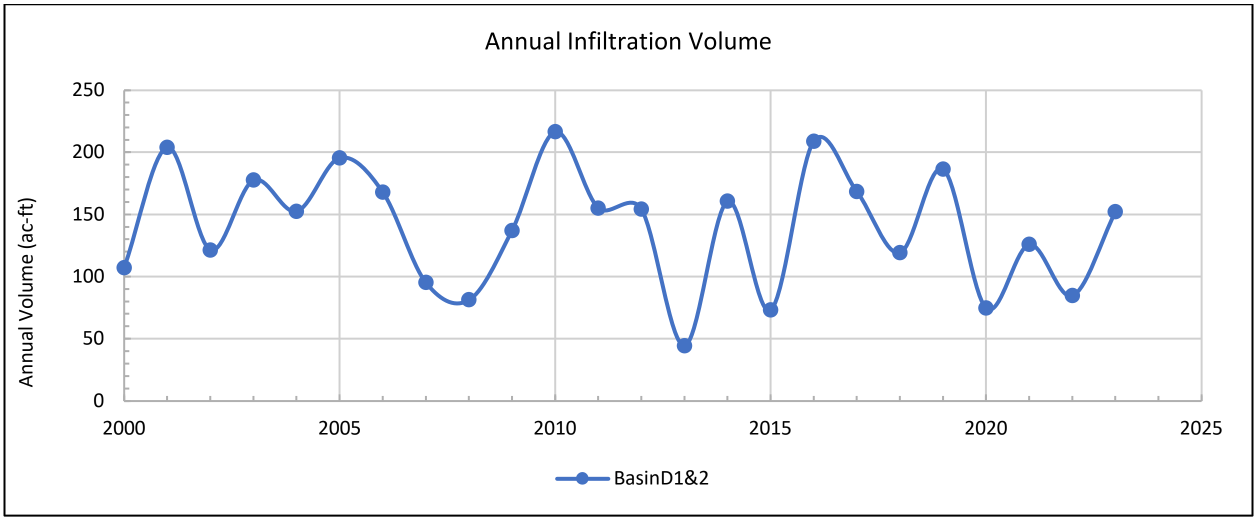


Chart 16: - Annual infiltration volume in basin $D_{1\&2}$

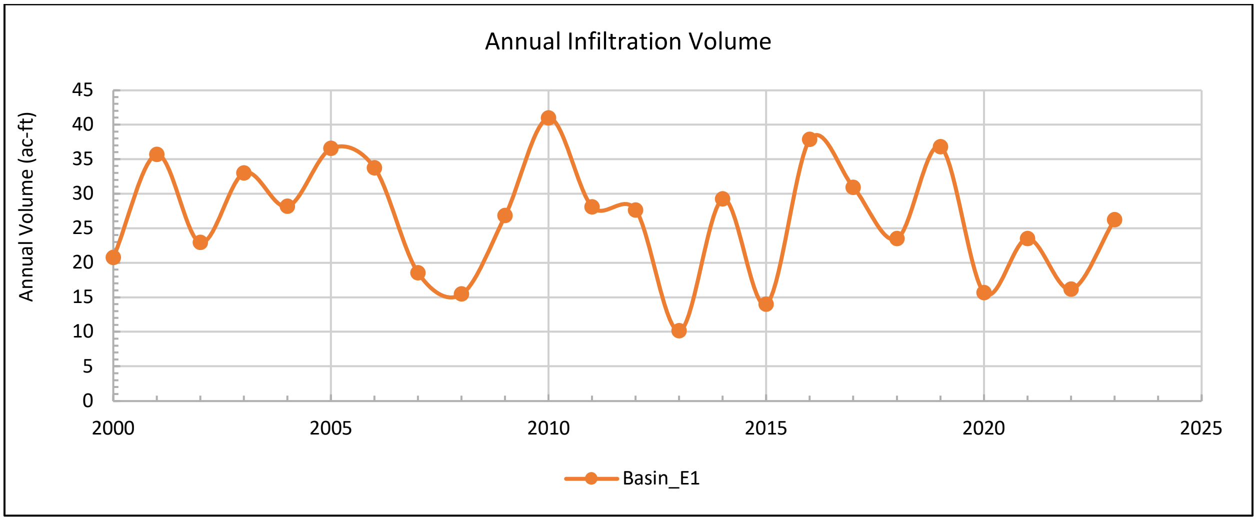


Chart 17: - Annual infiltration volume in basin E_1

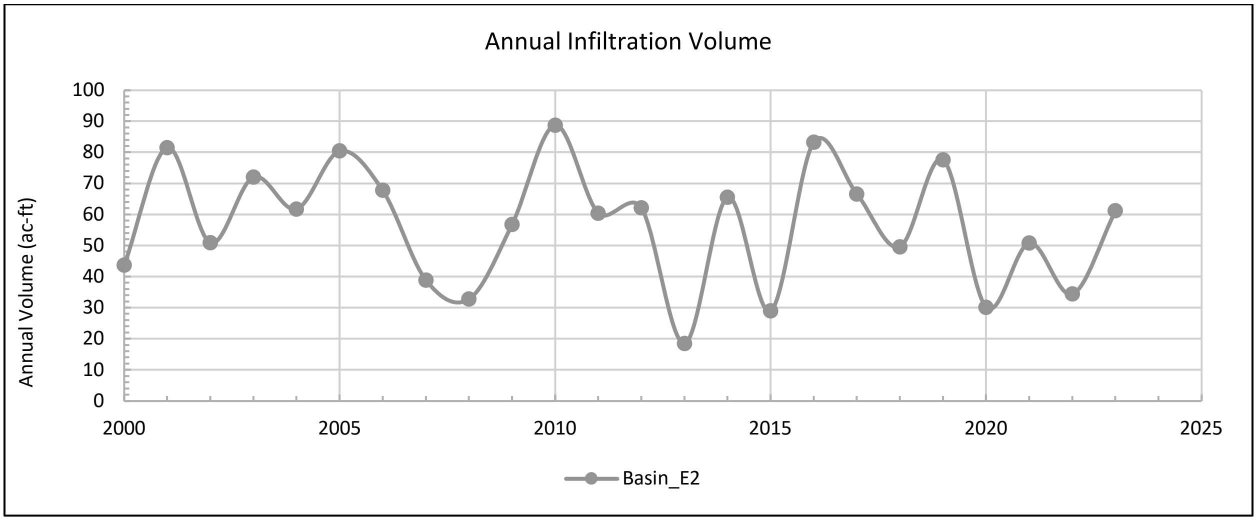


Chart 18: - Annual infiltration volumein basin E_2

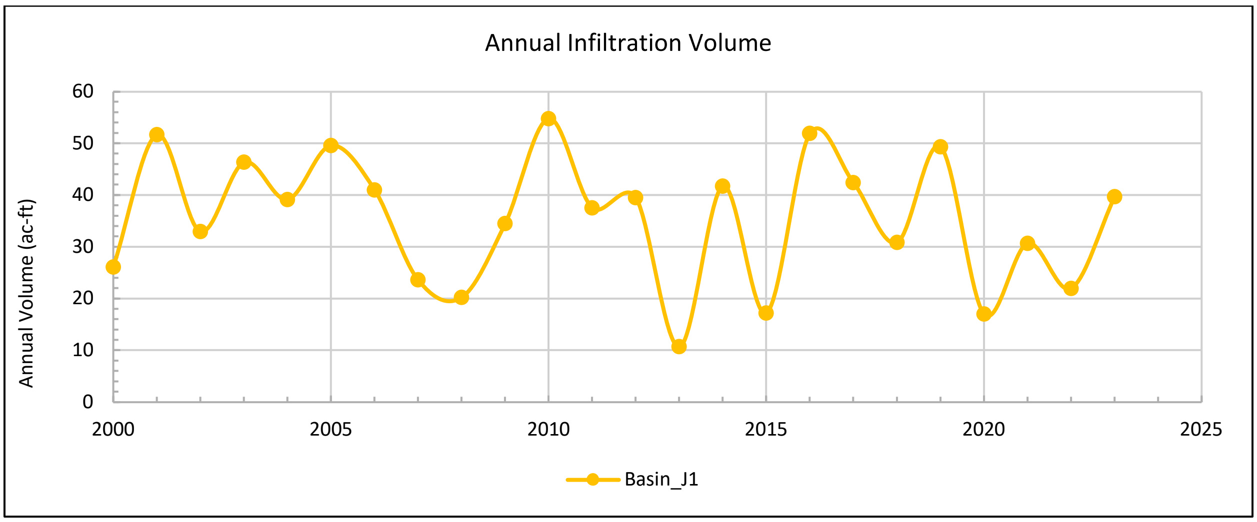


Chart 19: - Annual infiltration volume in basin J_1

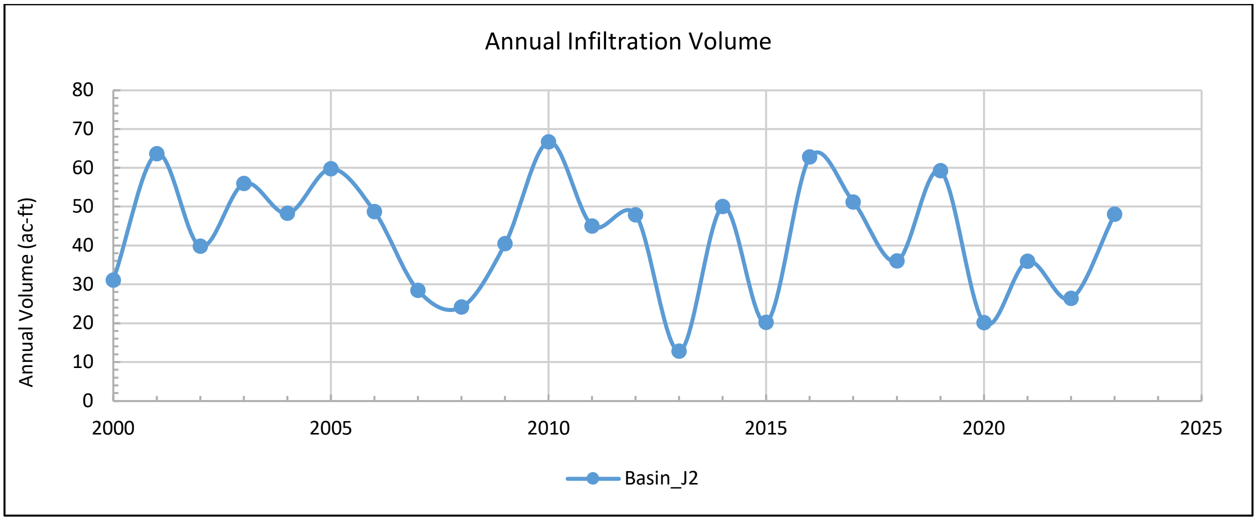


Chart 20: - Annual infiltration volume in basin J_2

6.4.3.60% Dam Height

In this alternative approach, Wood Rodgers considered sixty percent of the total height to estimate the inundated area and the volume infiltrating through each recharge zone. Logically, as the dam height increases, the infiltration volume also increases. The amount (volume and duration) of water stored in the recharge zone is affected by the size of the outflow pipe. The diameter of the outflow pipe was set as small as was considered feasible, to maintain low-flow downstream of the recharge basin, to maximize infiltration. If other constraints force the pipe size to increase, like environmental or downstream water rights considerations, the infiltration benefits will lessen.

Table 9 presents the estimated water volume that has infiltrated through each basin. **Chart 21** illustrates the infiltration volume through each basin. When examining individual values from the table, it becomes apparent that the percentage increase is dramatic, even though the absolute values are not exceptionally large.

Table 9: - Average monthly infiltration volume (acre-feet)

Month	BasinD1&2	Basin_E1	Basin_E2	Basin_J1	Basin_J2	All Basins
Jan	44.57	8.82	19.89	14.05	25.06	112.38
Feb	35.95	7.17	16.47	11.47	20.11	91.18
Mar	39.20	7.71	17.27	11.43	19.80	95.41
Apr	22.23	4.35	9.72	6.44	11.37	54.11
May	17.68	3.14	7.44	5.08	9.32	42.65
Jun	5.99	1.21	2.52	1.54	2.82	14.08
Jul	0.42	0.08	0.18	0.11	0.22	1.00
Aug	0.76	0.21	0.40	0.21	0.21	1.80
Sep	5.68	1.15	2.39	1.64	2.99	13.86
Oct	16.57	3.45	7.43	4.98	8.79	41.23
Nov	32.20	6.11	14.00	9.70	17.50	79.51
Dec	50.28	9.50	21.97	15.47	28.25	125.46

Ann. Total	271.54	52.91	119.67	82.10	146.45	672.66

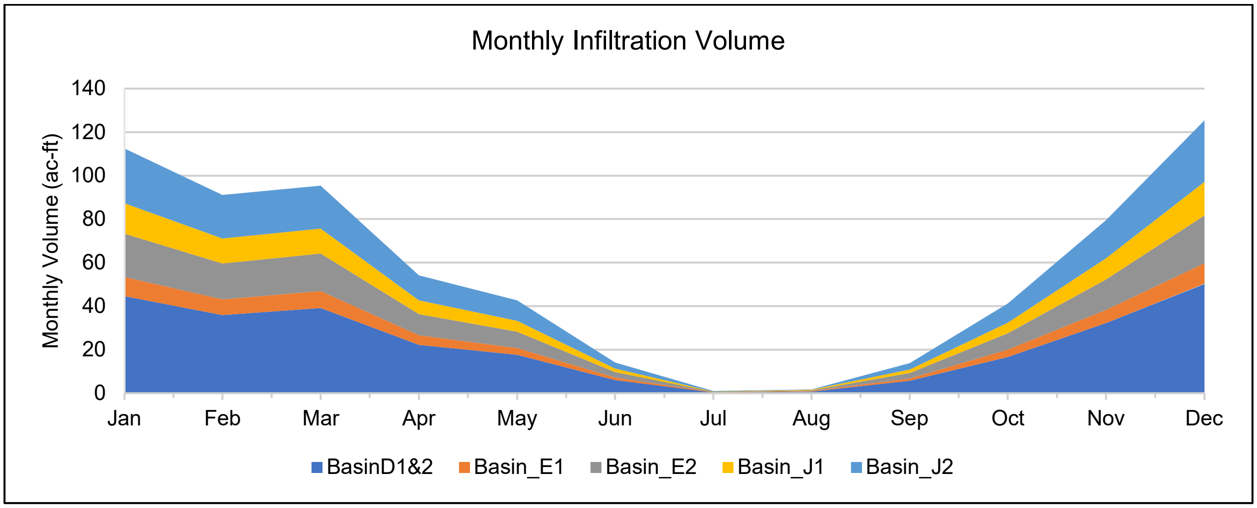


Chart 21: - Average monthly infiltration Volume with 60% dam height

Table 10 shows the annual infiltration volume from each basin. The average annual volume for each basin ($D_{1\&2}$, E_1, E_2, J_1, and J_2) is 265, 51, 116, 80, and 143 ac-ft, respectively. In each project, it is important to understand the impact of implementing the proposed scenarios compared to baseline data. **Charts 22 to 26** show the annual infiltration trend. All units are presented in ac-ft.

Table 10: - Annual infiltration volume corresponding to 60% Dam height.

Year	BasinD1&2	Basin_E1	Basin_E2	Basin_J1	Basin_J2
2000	206.85	40.09	91.04	59.16	102.26
2001	391.68	72.31	171.73	120.11	221.09
2002	217.16	45.79	99.20	71.33	124.14
2003	329.47	65.30	145.72	104.11	181.31
2004	287.60	55.54	127.31	89.09	159.33
2005	357.49	72.81	162.76	113.18	194.31
2006	315.59	63.05	141.17	91.60	158.02
2007	186.05	35.63	81.69	53.72	94.23
2008	148.79	29.94	66.90	44.65	79.93
2009	264.16	52.35	114.78	76.73	139.41
2010	417.96	80.71	182.91	125.06	226.04
2011	312.70	55.31	131.67	88.27	166.13
2012	290.86	55.34	128.65	89.93	162.62
2013	94.44	18.23	39.29	25.23	46.52
2014	297.83	58.89	131.60	93.57	168.93
2015	136.06	26.89	61.00	38.78	67.51
2016	394.68	74.73	174.62	119.14	214.15
2017	317.71	60.30	139.70	97.67	179.50
2018	218.68	45.55	97.29	66.61	118.24

2019	343.81	71.48	152.93	108.34	189.25
2020	153.97	28.84	64.71	40.02	70.41
2021	232.79	46.29	104.78	68.51	115.94
2022	159.22	31.40	70.17	50.02	89.40
2023	292.00	54.03	124.86	89.78	163.44
Annual avg.	265.31	51.70	116.94	80.19	143.00

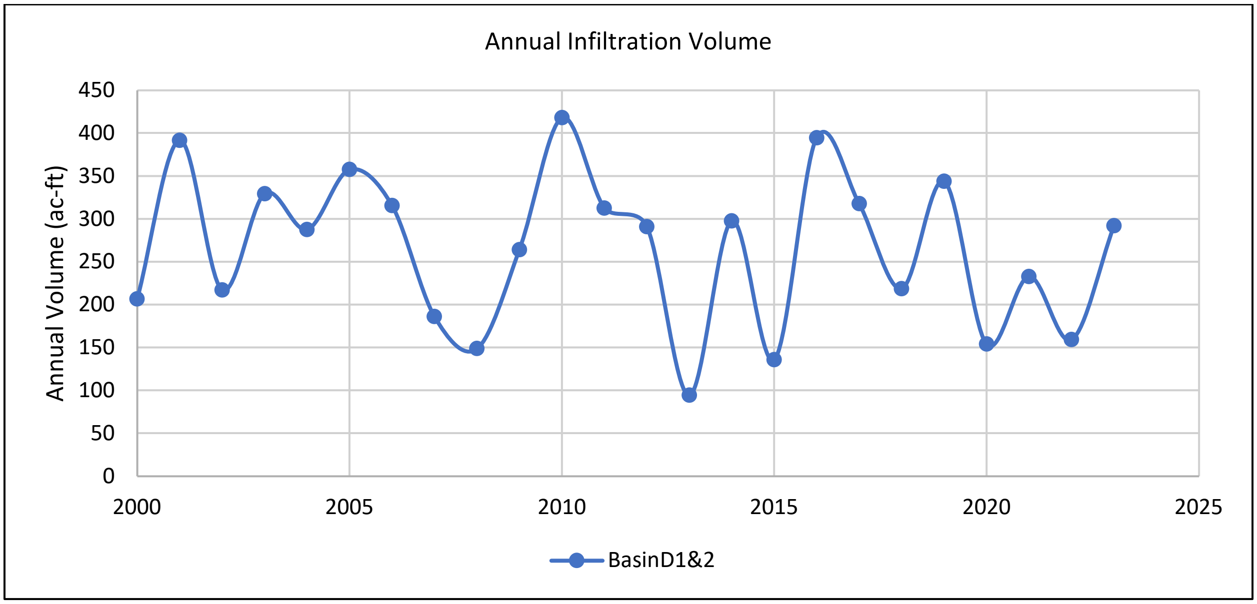


Chart 22: - Annual Infiltration Volume in Basin D1&2 with 60% Dam Height

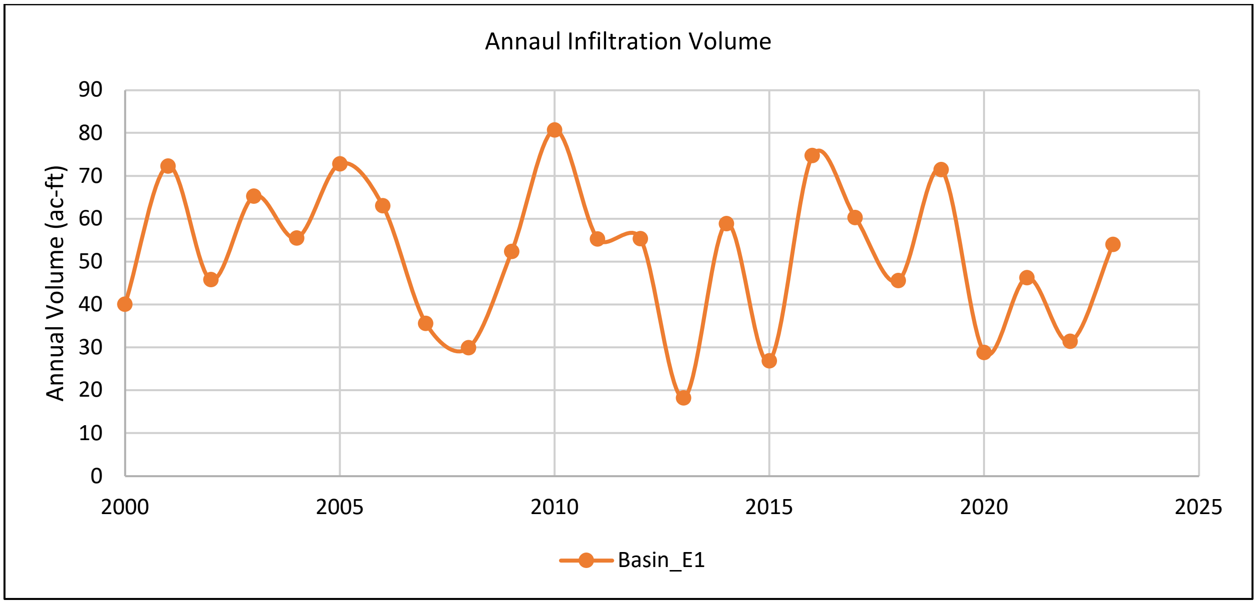


Chart 23: - Annual Infiltration Volume in Basin E1 with 60% Dam Height

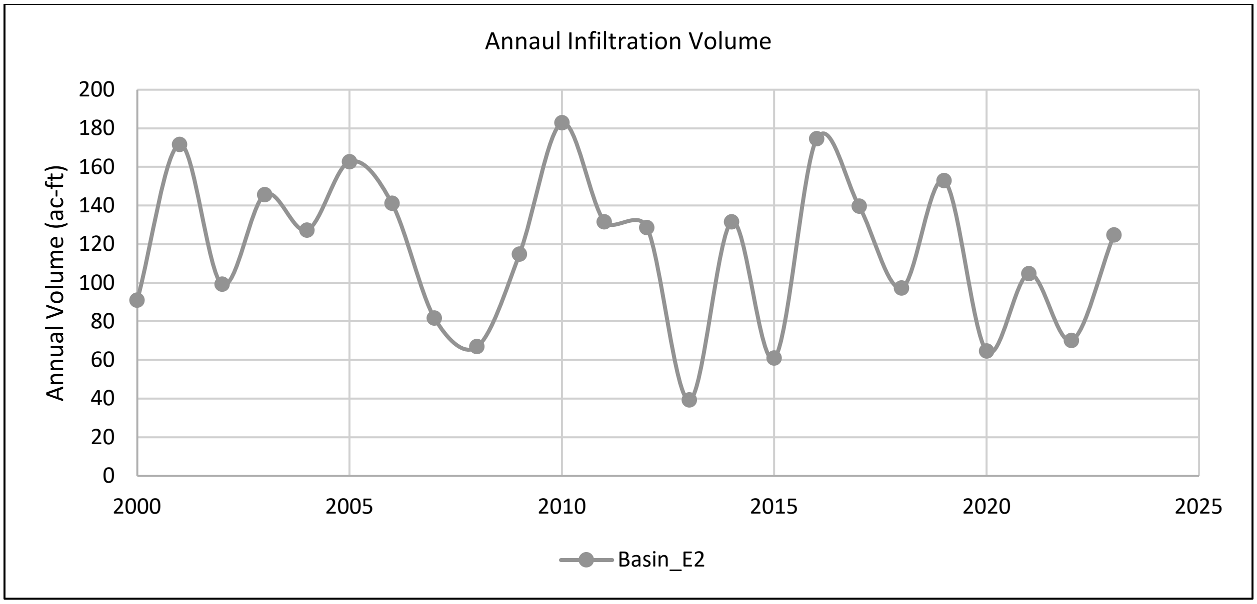


Chart 24: - Annual Infiltration Volume in Basin E2 with 60% Dam Height

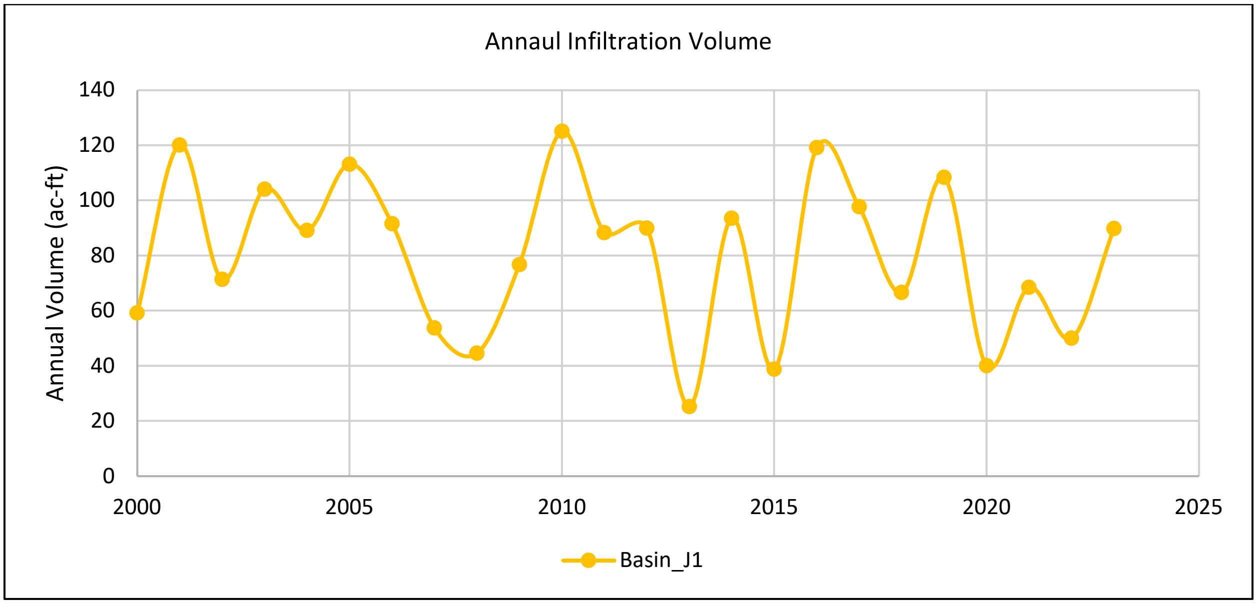


Chart 25: - Annual Infiltration Volume in Basin J1 with 60% Dam Height

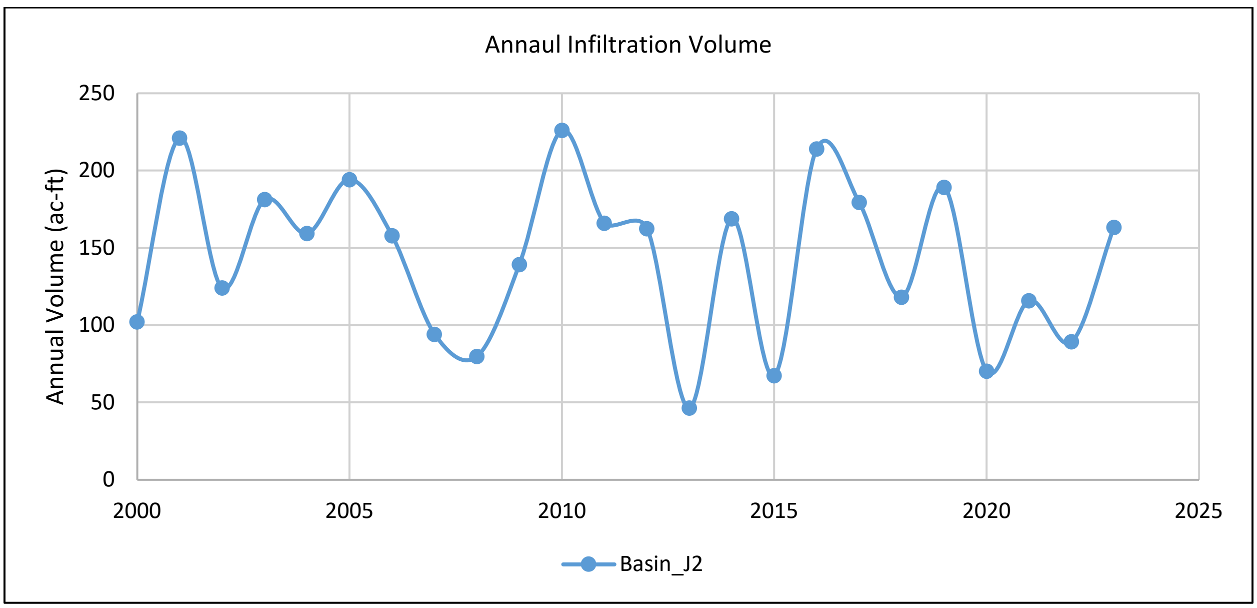


Chart 26: - Annual Infiltration Volume in Basin J1 with 60% Dam Height

6.4.4.80% Dam Height

In this scenario, the dam heights used in recharge zones ($D_{1\&2}$, E_1, E_2, J_1, & J_2) are as follows: 13.5 feet, 6.5 feet, 11 feet, 8 feet, and 14.5 feet, respectively. This alternative analysis and the accompanying data clearly demonstrate that increasing the dam height significantly enhances the infiltration volume. **Table 11** provides a breakdown of the monthly average infiltration volume. **Chart 27** graphically represents the data presented in the table.

Table 11: - Monthly average infiltration volume with 80% dam height

Month	BasinD1&2	Basin_E1	Basin_E2	Basin_J1	Basin_J2	All Basins
Jan	58.05	14.93	32.28	22.60	42.95	170.81
Feb	45.90	12.26	25.86	18.19	33.57	135.77
Mar	50.96	13.04	28.98	18.34	34.42	145.74
Apr	30.06	7.33	16.60	10.44	20.74	85.15
May	23.61	5.42	13.10	8.47	16.35	66.94
Jun	8.18	1.98	4.58	2.62	4.72	22.09
Jul	0.64	0.13	0.35	0.20	0.42	1.74
Aug	0.76	0.34	0.55	0.25	0.21	2.11
Sep	7.95	1.87	4.20	2.74	5.72	22.48
Oct	21.58	5.68	12.09	8.00	15.52	62.87
Nov	43.13	10.42	23.79	15.85	31.93	125.11
Dec	66.60	16.21	36.96	25.35	50.06	195.18
Ann. Total	357.40	89.61	199.33	133.04	256.61	1035.98

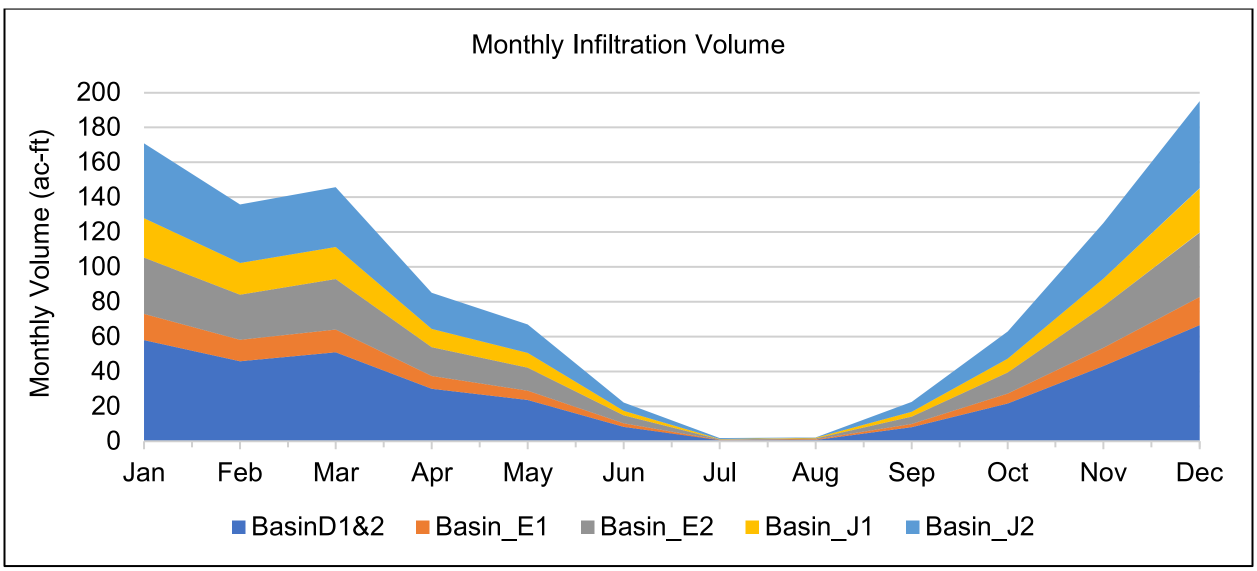


Chart 27: Monthly Variation in infiltration volume with 80% dam height

Table 12 presents the annual infiltration volumes for each basin for this scenario. The average volumes for basins $D_{1\&2}$, E_1, E_2, J_1, and J_2 are 349, 87, 194, 129, and 250 acre-feet respectively. When comparing the increase from 60% capacity to 80% capacity, there is an increase of 31%, 69%, 66%, 62%, and 75% in these respective basins. It's worth noting that this increase is somewhat constrained when compared to the earlier increase from 40% to 60% capacity. In the previous transition, from 40% to 60% capacity, the percentage increase exceeded 100% for each basin. However, the increase from 60% to 80% capacity now remains below 75% for all basins. This is a result of the dam increasing the overall inundation area, **Chart 28** illustrates the annual infiltration trend. The annual volume data for each basin is presented in the same graph.

Table 12: - Annual infiltration volume with 80% Dam Height

Year	BasinD1&2	Basin_E1	Basin_E2	Basin_J1	Basin_J2
2000	264.21	67.72	153.52	94.94	179.70
2001	510.15	125.33	285.52	198.45	388.91
2002	275.32	76.50	155.08	111.64	208.97
2003	431.90	109.87	238.39	164.47	323.96
2004	383.40	94.68	210.30	144.15	275.66
2005	465.22	122.83	258.28	177.49	318.92
2006	416.56	106.42	234.88	146.55	277.94
2007	255.97	60.57	140.10	87.76	162.01
2008	197.40	51.25	109.19	72.20	141.23
2009	345.13	86.62	196.49	127.37	219.25
2010	557.79	136.68	308.29	204.56	399.90
2011	419.08	94.83	233.40	151.03	300.92
2012	380.15	95.24	212.95	145.96	279.11
2013	128.87	29.50	72.61	42.99	85.08
2014	392.80	99.44	216.90	151.09	306.08
2015	179.37	45.90	100.94	62.44	120.97
2016	519.56	128.58	287.78	193.46	380.56
2017	421.26	103.71	232.31	160.87	325.79
2018	287.05	75.38	161.18	107.20	198.80
2019	452.88	117.61	250.79	172.01	341.00
2020	198.26	48.48	116.18	66.88	124.65
2021	296.84	79.16	168.93	107.73	198.94
2022	212.31	52.43	116.11	80.53	162.14
2023	388.88	92.81	214.43	146.56	291.90
Annual Avg	349.18	87.56	194.77	129.93	250.52

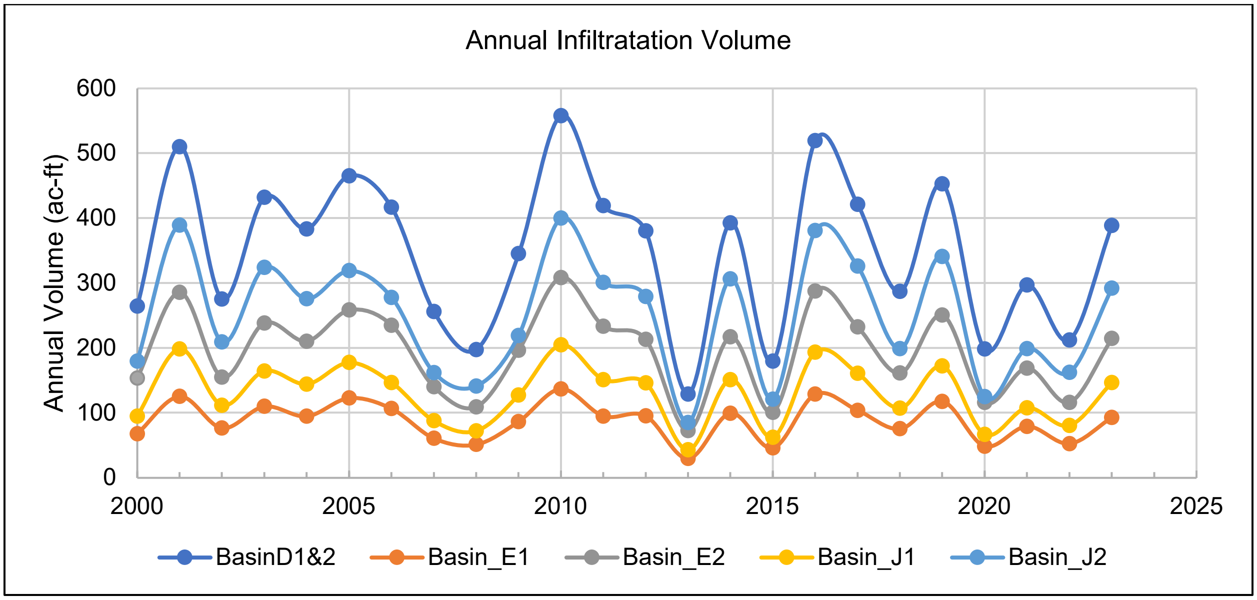


Chart 28: - Annual infiltration with 80% dam height

6.4.5.100% Dam Height

This is the maximum alternative considered for quantifying the infiltration volume. Taller dams necessitate a more robust (and costly) construction and may also introduce additional regulatory oversight on operation and maintenance. In this preliminary analysis, the maximum dam heights for each basin ($D_{1\&2}$, E_1, E_2, J_1, & J_2) are 17, 8, 14, 10, and 18 feet, respectively. **Table 13** below presents the average monthly infiltration volume. In conclusion, increasing dam height can enhance infiltration area and volume, but it inevitably leads to greater design and construction costs. **Chart 29** shows the graphical representation of the tabular data. In contrast to other months, from June to September, all basins exhibit lower capacity.

Table 13: - Monthly Average Infiltration Volume with 100% Dam Height

Month	Basin_D1&2	Basin_E1	Basin_E2	Basin_J1	Basin_J2	All Basins
Jan	76.12	20.73	43.14	30.98	58.81	229.79
Feb	59.46	17.07	33.50	24.75	44.96	179.74
Mar	65.55	18.13	38.64	25.12	47.26	194.70
Apr	40.42	10.25	23.01	14.86	27.99	116.52
May	30.70	7.79	17.81	11.79	22.07	90.16
Jun	10.17	2.73	6.31	3.68	5.16	28.05
Jul	1.04	0.19	0.57	0.32	0.42	2.54
Aug	0.76	0.45	0.55	0.25	0.21	2.22
Sep	10.89	2.57	6.13	3.97	8.39	31.96
Oct	28.01	7.82	15.99	11.21	21.10	84.12
Nov	58.27	14.64	32.85	22.27	44.82	172.85
Dec	88.27	22.82	49.74	35.39	68.68	264.90
Ann. Total	469.65	125.19	268.23	184.60	349.89	1397.55

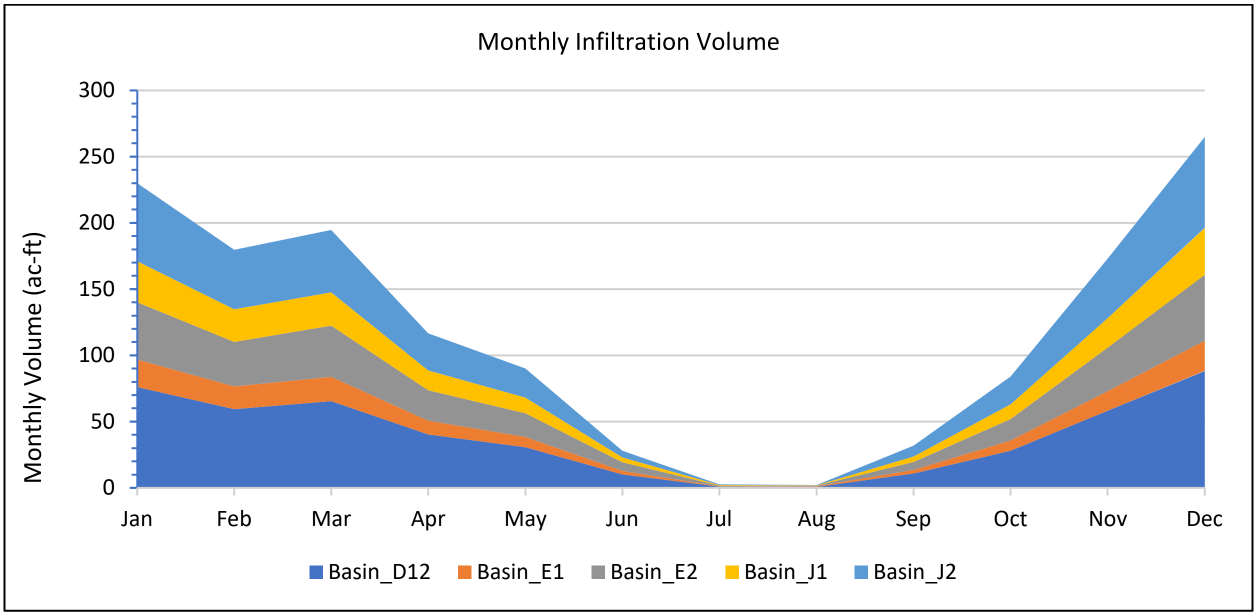


Chart 29: Monthly Average Infiltration Volume with 100% Dam Height

The average annual infiltration volumes projected under 100% capacity alternatives for each basin ($D_{1\&2}$, E_1, E_2, J_1, and J_2) are 458, 122, 262, 180, and 340 acre-feet respectively. The percentage increase in comparison to the baseline condition is dramatic, with values of 905%, 713%, 1037%, 27180%, and 1419% respectively. The increase in annual average volume from 80% to 100% capacity was also quantified, showing a percentage change in each basin of 31%, 39%, 34%, 38%, and 36% respectively. In contrast, the capacity, i.e., the volume increase from 20% to 40% capacity, 40% to 60% capacity, and 60% to 80% capacity, was considerably high. **Table 14** shows the annual trend of infiltration volume in each basin, and **Chart 30** illustrates the data presented in the table graphically.

Table 14: - Annual infiltration Volume with 100% Dam Height

Year	Basin_D1&2	Basin_E1	Basin_E2	Basin_J1	Basin_J2
2000	342.10	95.57	200.99	129.59	243.27
2001	675.37	177.42	376.89	275.20	540.74
2002	360.27	103.38	200.81	150.81	275.48
2003	578.81	152.53	318.51	227.48	454.25
2004	500.76	132.45	288.90	198.42	383.71
2005	598.20	169.73	346.51	238.84	428.74
2006	537.74	148.98	315.51	205.04	394.99
2007	332.15	85.90	199.28	121.62	203.14
2008	262.99	70.30	147.54	102.52	198.41
2009	430.69	120.55	263.55	169.16	279.88
2010	738.09	191.31	417.98	288.67	548.76
2011	556.43	137.63	318.68	214.99	401.70

2012	495.43	133.23	283.04	200.26	370.00
2013	170.47	42.32	101.02	62.11	100.40
2014	525.00	137.07	290.62	213.52	434.20
2015	234.99	64.44	137.07	87.54	176.89
2016	687.46	181.57	390.77	270.66	517.43
2017	560.55	145.55	313.29	228.35	445.53
2018	374.31	102.73	217.33	146.52	264.54
2019	605.71	160.55	337.79	238.35	488.83
2020	256.90	69.24	152.29	90.64	156.12
2021	385.02	110.27	222.45	146.53	263.93
2022	283.83	73.48	157.57	112.47	232.68
2023	516.68	129.74	291.26	207.18	392.01
Annual Avg.	458.75	122.33	262.07	180.27	341.48

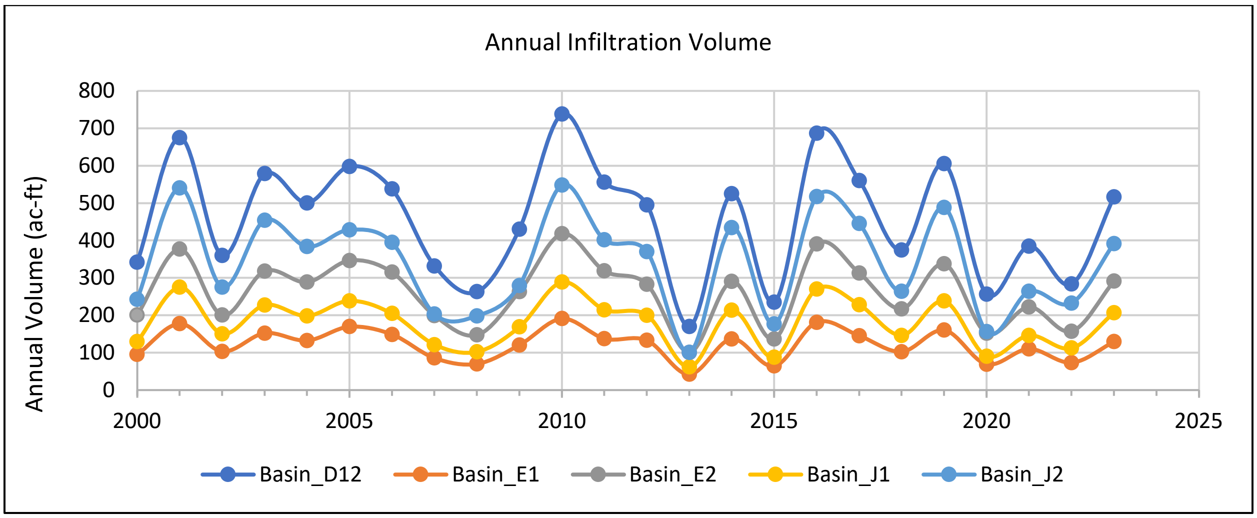


Chart 30: Annual Infiltration Volume in all Basins with 100% Dam Height

7.0 AQUIFER ASSESSMENT

The surface and near surface assessments described above indicate a significant potential for groundwater recharge can be realized within the Sand Creek watershed. As part of this initial assessment, Wood Rodgers conducted a review of available data/reports defining underground aquifers and subsurface geology below Sand Creek and down gradient of the potential recharge areas to determine if the underlying geology will likely have the capacity to receive and store the increase infiltration volumes. The review of the subsurface data indicates that permeable material likely exists to depths ranging from 300 feet to 350 feet below ground surface (bgs). Applied water is anticipated to migrate vertically into the subsurface to a depth between 60 to 90 feet, where it is reasonable to anticipate the water will flow horizontally following both the regional dip of the geologic formations, or where saturated, the general groundwater gradient.

The supporting analysis for this aquifer assessment is provided in **Appendix C**.

8.0 CONCLUSION AND SUMMARY

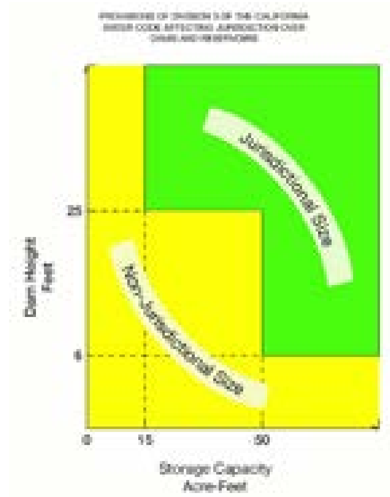
Five potential groundwater recharges areas were identified within the Sand Creek watershed through evaluations supported by field surveys, including Frequency Domain Electro-Magnetic surveys. The estimated long term maximum infiltration rate was determined to be 0.7 feet/day (0.35 inches/hour). These five recharge areas were evaluated for the historical period of 2000-2023 using rainfall data from the nearest comparable hourly gauge for existing conditions. These same areas were then evaluated with inline dam structures of varying heights, to impound natural runoff for longer periods of time over these areas, in order to increase infiltration. The following table summarizes the average expected infiltration.

Scenario	Groundwater Recharge Basin				
	D1&2	E1	E2	J1	J2
	Average Annual Infiltrated Volume (acre-feet)				
Baseline	45.63	15.04	23.04	0.66	22.48
20% Dam Height	33.94	12.8	14.94	19.06	7.11
40% Dam Height	140.21	26.35	56.85	35.43	42.62
60% Dam Height	265.35	51.7	116.94	80.19	143
80% Dam Height	349.18	87.56	194.77	129.93	250.52
100% Dam Height	458.75	122.33	262.07	180.27	341.48

Ecological/environmental benefits can be realized by detaining and infiltrating runoff. Qualitatively, if there is an increase in inundation and saturated soils in portions of the project area, there would be an increased opportunity for creation of seasonal wetland and riparian/vegetated areas to grow naturally over time. Subsequently, the increase in newly available seasonal wetlands and riparian habitats would be expected to provide new wildlife corridors, and potentially suitable areas for a wide range of plants and wildlife species. Some ecological/habitat benefits would be provided quickly (such as those for seasonal waterfowl), but most would develop over time as functionality of the new system is repeatable year after year. If a much more in-depth quantitative analysis about specific outcomes in specific areas is required, creating a "Water Budget Analysis" to determine exact locations and potential species composition based on the water budget results is recommended.

Waterfowl habitat benefits are a potential ancillary benefit that may be better realized by configuring outlet structures to further limit water releases in order to maximize ponding, however, these benefits may be limited if higher infiltration rates are realized and ponding areas/times are significantly reduced. It is important to note that if all low-flow runoff is captured to potentially enhance waterfowl conditions upstream of a dam it can reduce water reaching downstream channels and potentially impact existing downstream habitat areas. A more comprehensive analysis that identifies existing habitat would be required to assess the relative benefits and impacts of specific design options. The location of the smaller recharge ponds within the surrounding Sand Creek watershed and their suitability for visually attracting migrating waterfowl (during migration flights) and maintaining populations without extensive food supplies may be limited but would be best assessed by a waterfowl expert during design. Enhancing waterfowl habitat is not expected to change the infiltrative performance.

The installation of inline dam structures is the most effective means of impounding water within the natural terrain features. Within the state of California, small dams are allowed to be constructed without state oversight if they fall below the jurisdictional size thresholds defined by the Division of Safety of Dams (DSOD). These thresholds allow unlimited volumes of storage if the dam height is below six feet. Once the dam height exceeds six feet, the maximum storage volume that can be stored without triggering DSOD jurisdictional design oversight is 50 acre-feet, up to a dam height of 25 feet. Once the dam height exceeds 25 feet, the maximum volume that can be stored below the jurisdictional threshold is 15 ac-ft.



Given these jurisdictional constraints, the proposed D1&2 basin area, which infiltrates the most water, can be constructed up to a height of approximately 12.1 feet before becoming a jurisdictional dam, which is between the 60% and 80% dam height evaluated. This equates to an annual average recharge of between 265 and 349 ac-ft annually. The E1, E2, and J1 basins never reach the jurisdictional threshold at 100% dam height. The J2 basin reaches 50 ac-ft of storage at elevation 240.5 feet, which is just above the 80% dam height of 14.4 feet evaluated. For the J2 basin area approximately 250 ac-ft of groundwater recharge can be accomplished annually below jurisdictional thresholds. The E2 basin area can infiltrate approximately 262 ac-ft annually with a non-jurisdictional dam height of 14 feet. The following table provides a summary of each basin's surface storage volume with respect to dam height.

Dam Height (ft)	Basin				
	D1&2	E1	E2	J1	J2
	Volume (acre-feet)				
0	0	0	0	0	0
1	0.02	0.05	0.05	0.2	0.02
2	0.21	0.27	0.34	0.63	0.11
3	0.77	0.91	0.8	1.42	0.29
4	1.91	2.02	1.55	2.95	0.54
5	3.71	3.91	3.02	5.5	1.05
6	6.38	6.86	5.46	9.24	1.94
7	10.71	10.65	8.7	13.88	3.45

8	16.16	15.17	12.7	19.44	6.23
9	22.77		17.57	25.87	10.06
10	30.51		23.06	32.93	15.2
11	39.31		28.76		21.7
12	48.37		34.7		29.01
13	57.7		41.03		36.86
14	67.52		47.88		45.37
15	78.18				54.45
16	89.68				63.93
17	102.14				73.69
18	115				83.74

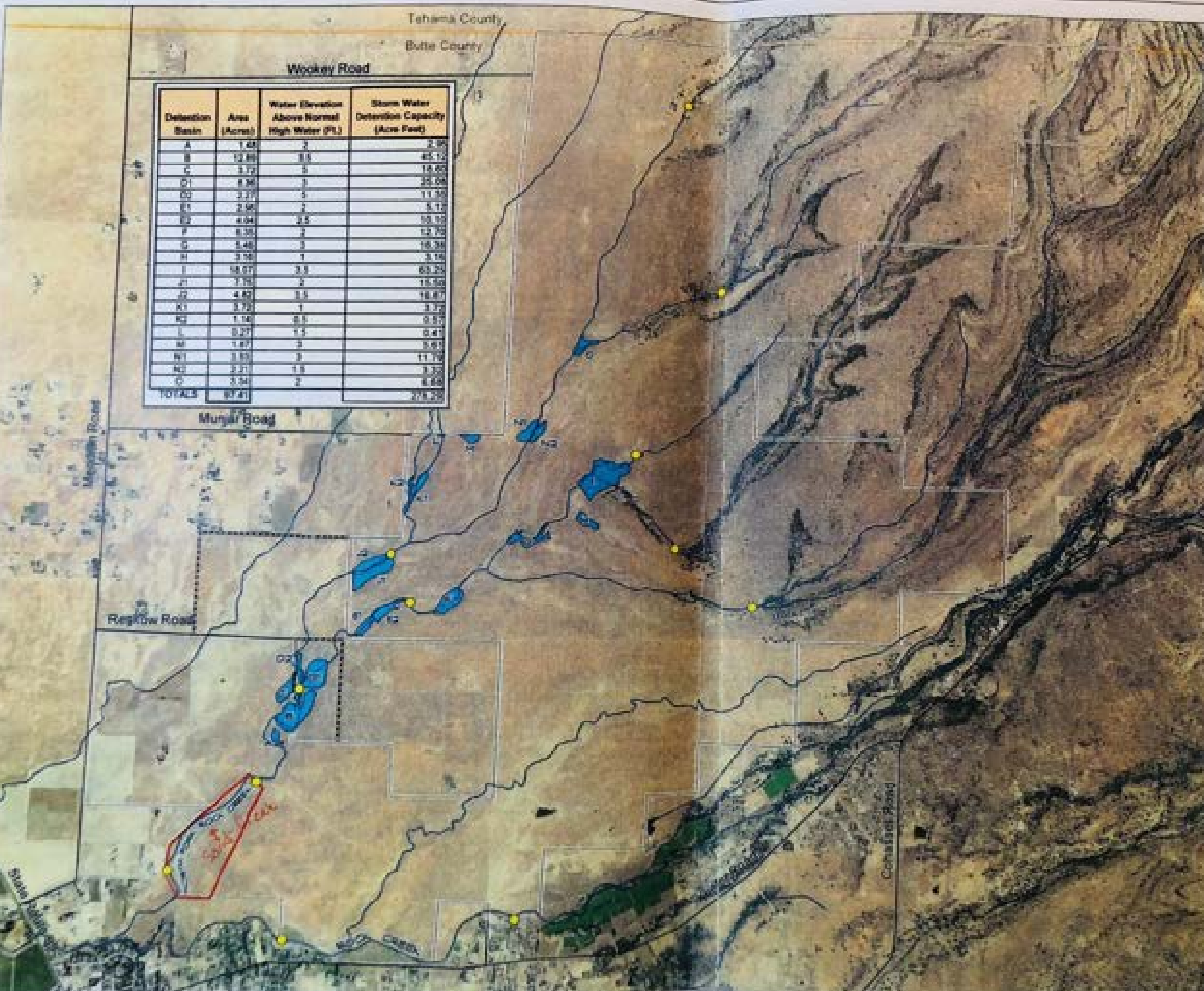
The D1&2 and J2 basins infiltrate the most water. Given the evaluated rainfall period, it appears that the watershed can generate sufficient runoff to realize the scenarios that were evaluated. The length and height of the dam required for the D1&2 basin will require more cost to realize the infiltrative benefits, with a longer dam length, along an existing paved roadway alignment. The costs of construction go up dramatically once the dam structure becomes jurisdictional.

If further analysis is justified, based on the findings of this report, Wood Rodgers recommends evaluating the J2 area first, perhaps in combination with the J1 area, then the D1&2 area, and then the E2 and E1 areas. With more detailed assessments of environmental constraints, historical preservation, water rights and construction costs, the benefits of constructing aquifer recharge facilities can be better understood and justified to apply for grant funding and implementation in the future.

A streambed alteration agreement is typically required to be processed and completed through the California Department of Fish and Wildlife for any structure constructed within any streambed (ephemeral or perennial) in California, to ensure earthwork and erosion protection measures occur properly without introducing sediment into downstream receiving waters and negatively impacting aquatic species.

The Sand Creek system is outside of the jurisdiction of the Central Valley Flood Protection Board. The State Water Resources Control Board and its regional arm will require a permit to allow recharging groundwater from surface water sources related to the State's adjudication of water rights.

Most of the proposed recharge sites are within a conservation easement held by the Natural Resources Conservation Service and will require extensive coordination with this agency and the property owner to ensure compliance with the intent of the easement or agreement that benefits will outweigh impacts.



Detention Basin	Area (Acres)	Water Elevation Above Normal High Water (Ft.)	Storm Water Detention Capacity (Acre Feet)
A	1.48	2	2.96
B	12.89	3.5	45.12
C	3.72	5	18.60
D1	8.36	3	25.08
D2	2.27	5	11.35
E1	2.56	2	5.12
E2	4.04	2.5	10.10
F	6.35	2	12.70
G	5.46	3	16.38
H	3.16	1	3.16
I	18.07	3.5	63.25
J1	7.75	2	15.50
J2	4.82	3.5	16.87
K1	3.72	1	3.72
K2	1.14	0.5	0.57
L	0.27	1.5	0.41
M	1.87	3	5.61
N1	3.93	3	11.79
N2	2.21	1.5	3.32
O	3.34	2	6.68
TOTALS	97.41		278.29

Butte Conservation Properties

Unit 1

Proposed Water Detention Basins

Butte County, California

Legend

- BCP Unit 1 Boundary
- Conservation Easement: Unit 1A
- Additional Survey Properties
- Local Roads
- BCP Unit 1 Drainages
- Proposed Water Detention Basins
- Flow Monitoring Stations

0 1,250 2,500 5,000 Feet

1:14,000

DRAWN BY: LPRR
REVIEWED BY: RSWPT
DATE: 3.2.1

RESTORATION RESOURCES

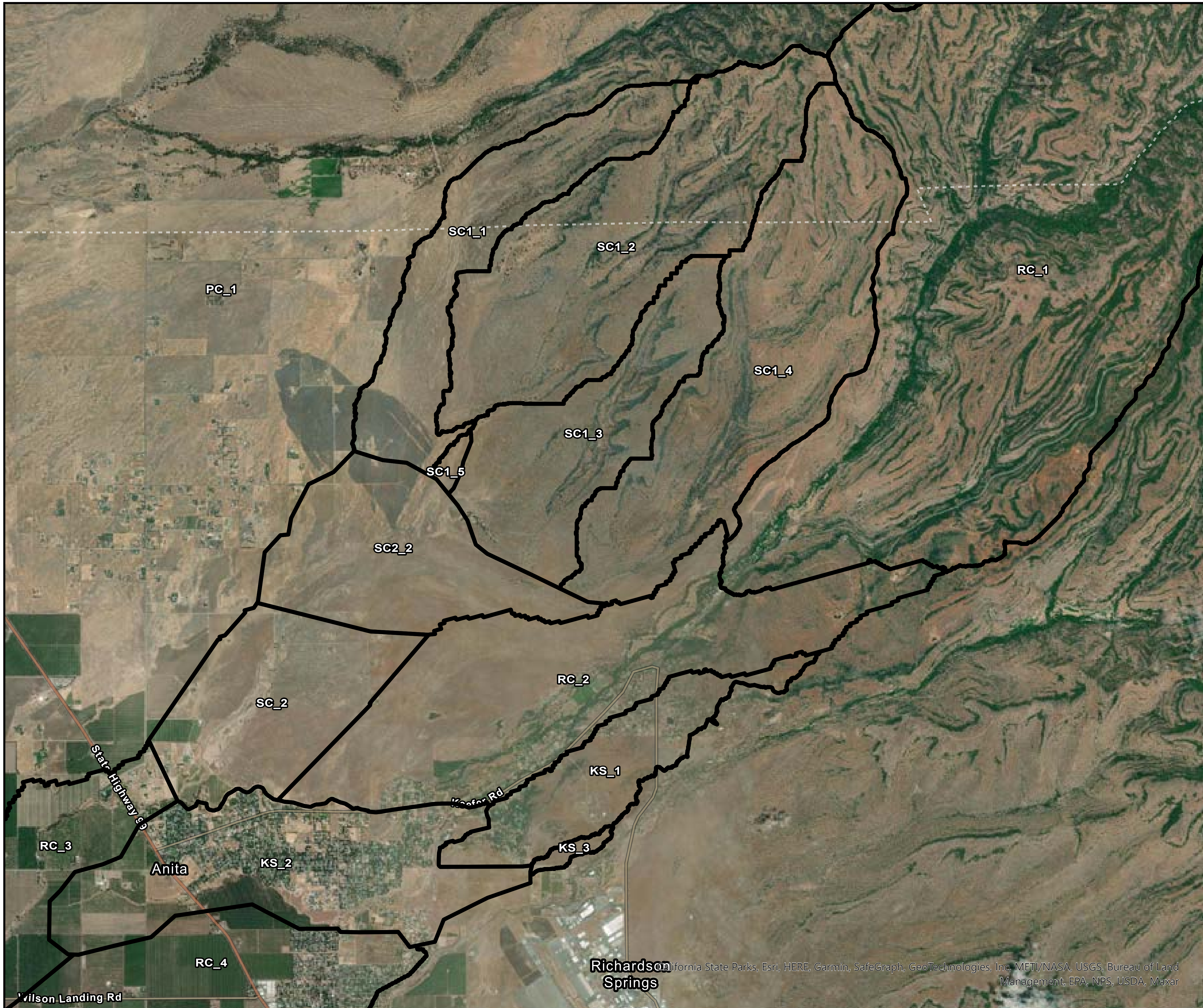
FIGURE 2

SAND CREEK WATERSHED

INFILTRATION ANALYSIS IN FIVE RECHARGE ZONES

BUTTE, CALIFORNIA

AUGUST 2023



Legend

HMS SubBasins

0 2,000 4,000 8,000

Feet

NORTH

WOOD RODGERS

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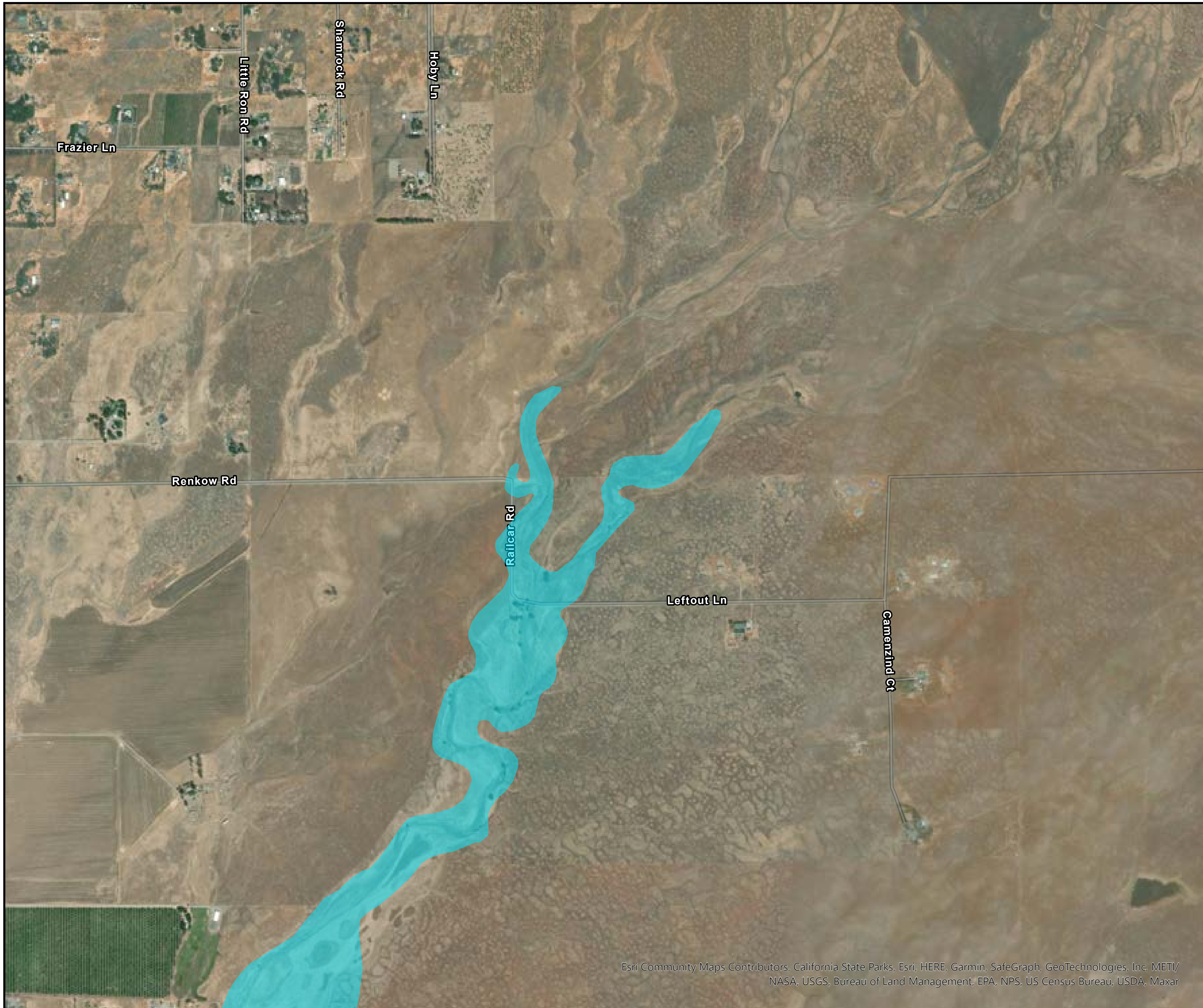
FIGURE 3

FIRM MAP

INFILTRATION ANALYSIS IN FIVE RECHARGE ZONES

BUTTE, CALIFORNIA

SEPTEMBER 2023



Legend

1% Annual Chance Flood Hazard

0 500 1,000 2,000

Feet

NORTH

WOOD RODGERS

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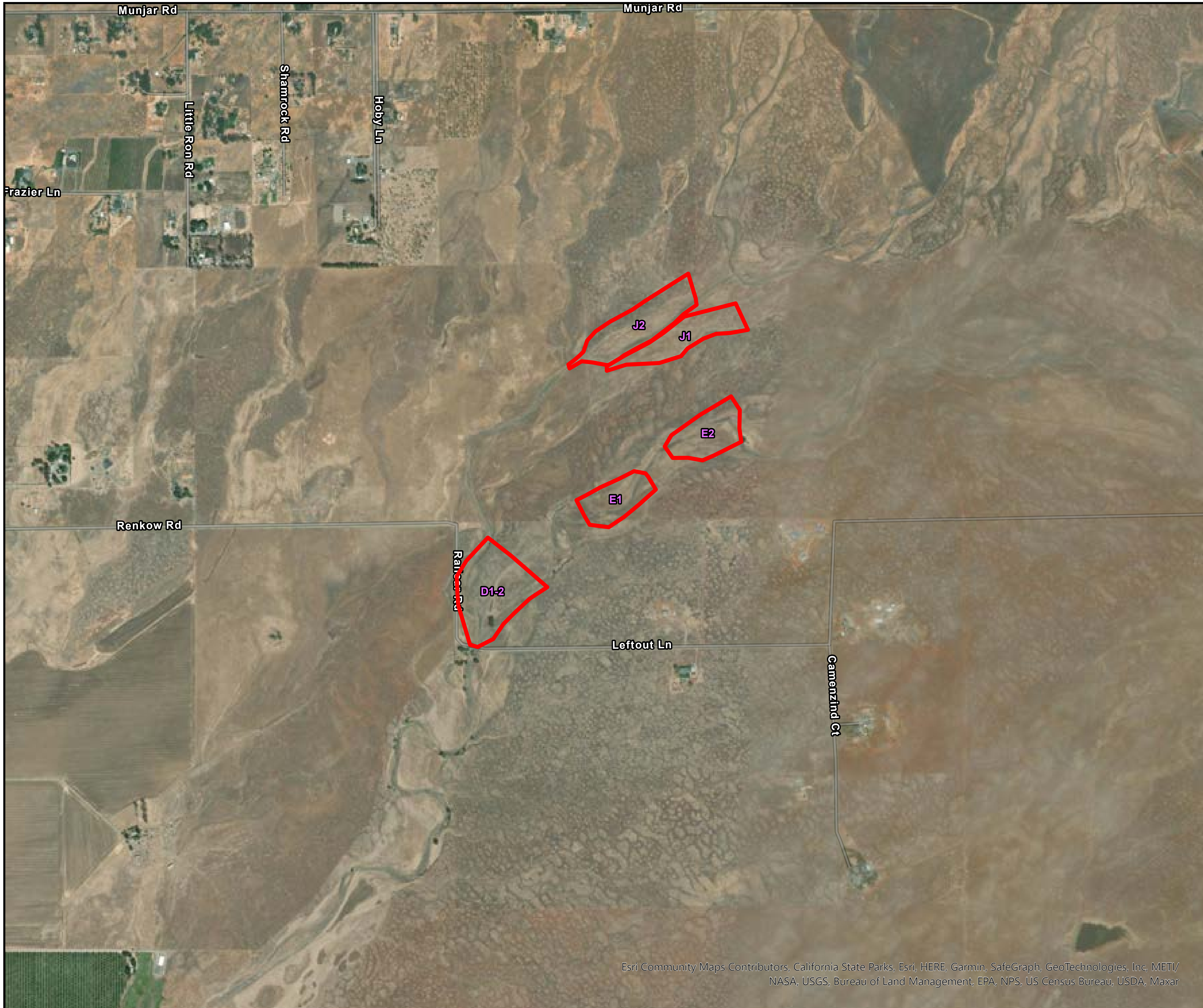

FIGURE 4

POTENTIAL RECHARGE AREAS

INFILTRATION ANALYSIS IN FIVE RECHARGE ZONES

BUTTE, CALIFORNIA

SEPTEMBER 2023

WOOD RODGERS

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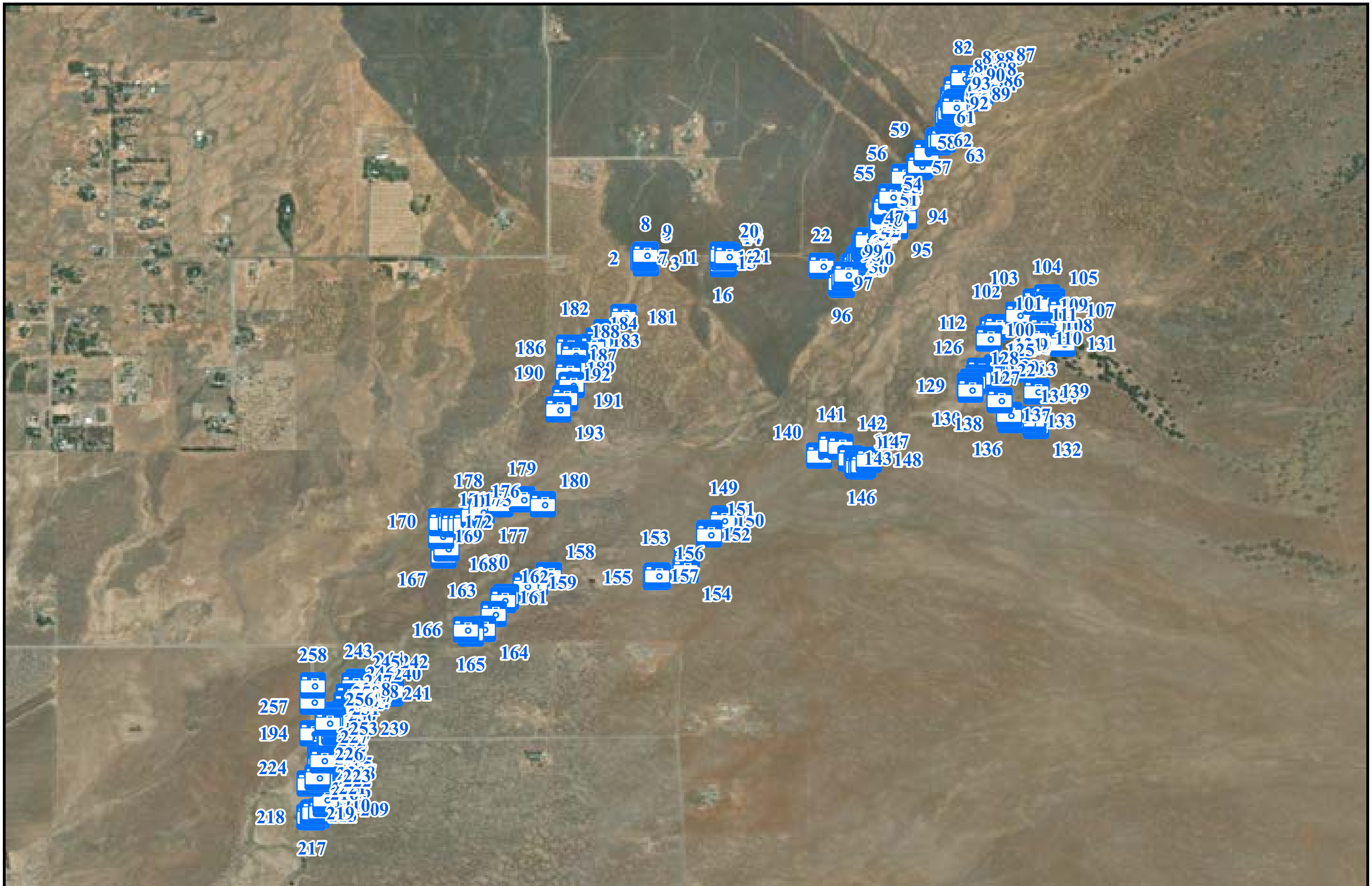

Rock Sand Field Visit 06062023

Location Map
Photos collected 06/06/2023

Photo Location

NORTH

0 500 1,000

Feet

Service Layer Credits: World Imagery: Maxar
World Boundaries and Places: Esri, HERE, Garmin, iPC

WOOD RODGERS

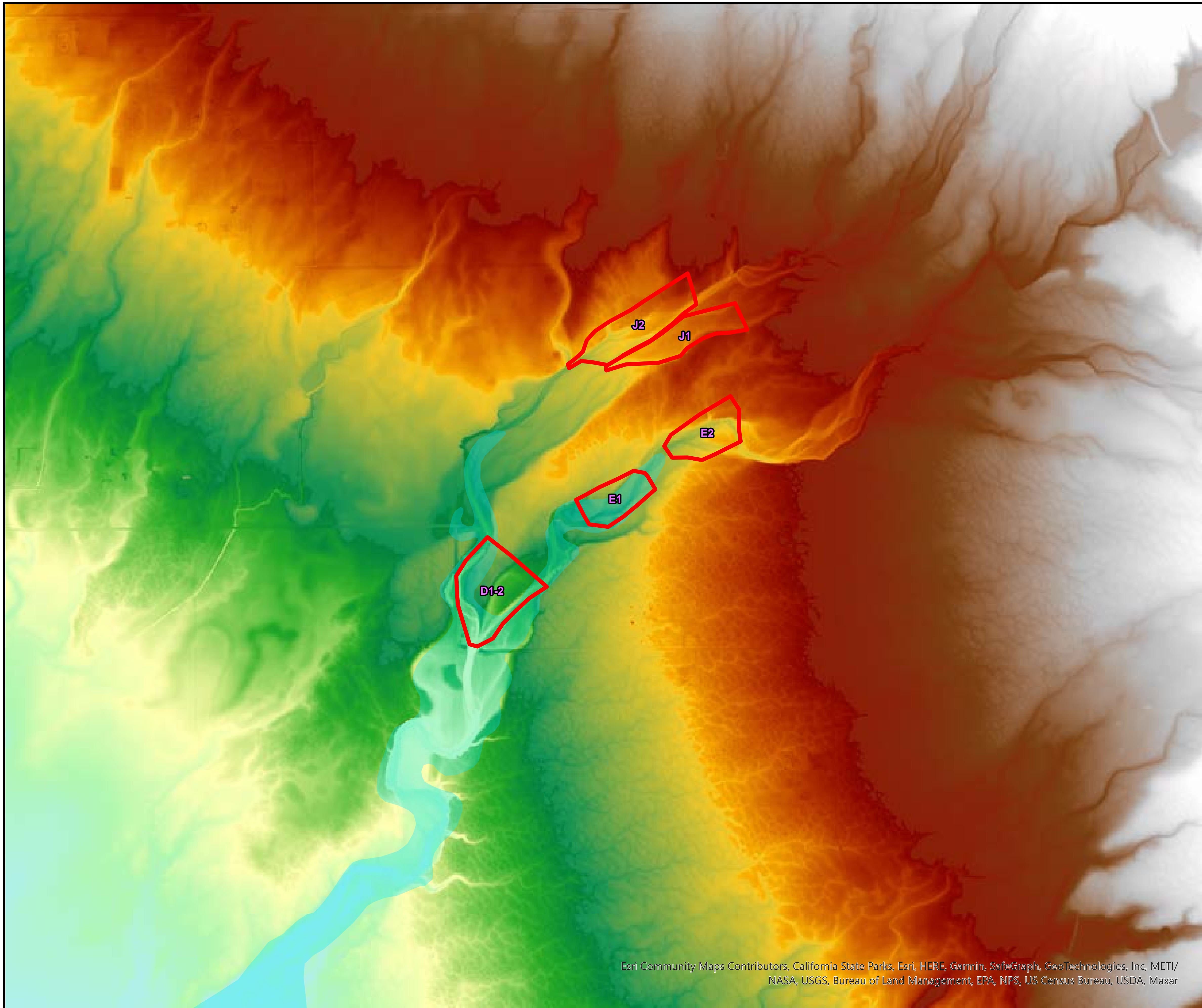

FIGURE 6

TOPOGRAPHIC MAPPING

INFILTRATION ANALYSIS IN FIVE RECHARGE ZONES

BUTTE, CALIFORNIA

SEPTEMBER 2023

Legend

Potential Recharge Areas

0 500 1,000 2,000

Feet

NORTH

WOOD RODGERS

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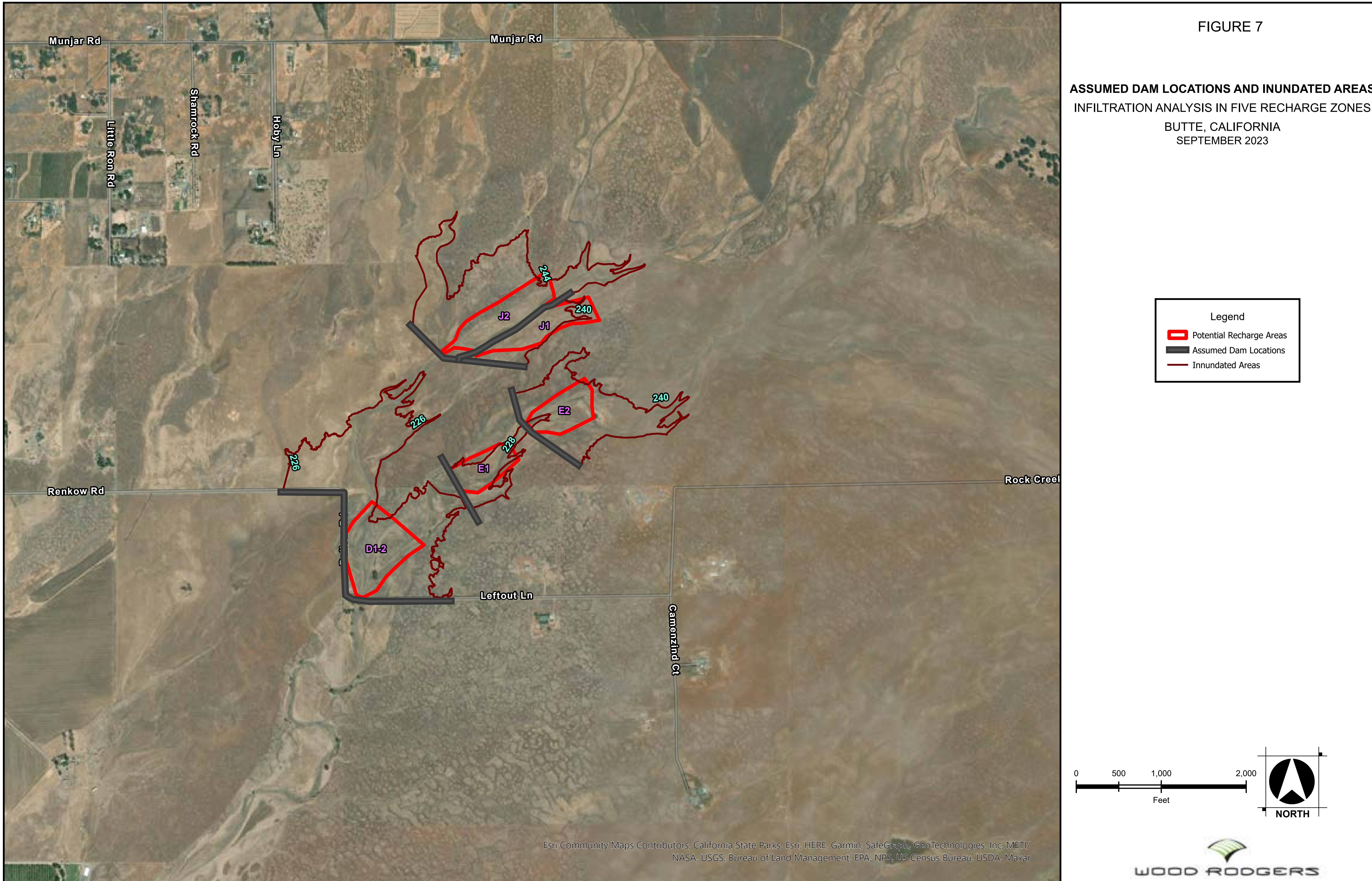
FIGURE 7

ASSUMED DAM LOCATIONS AND INUNDATED AREAS

INFILTRATION ANALYSIS IN FIVE RECHARGE ZONES

BUTTE, CALIFORNIA

SEPTEMBER 2023



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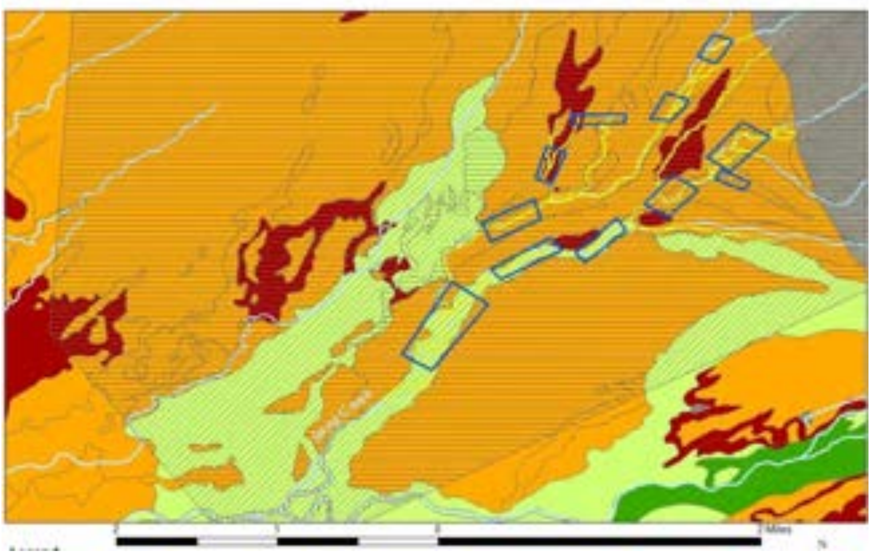
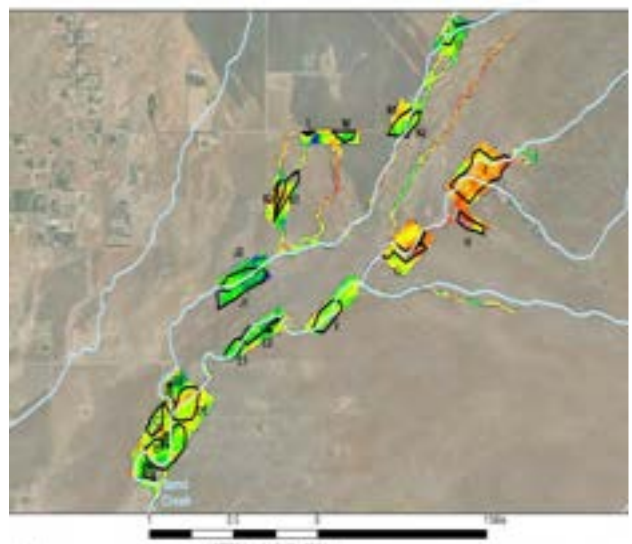
APPENDIX A



GSA GeoSystems Analysis, Inc.
Innovations in Hydrology

Sand Creek Geophysical Characterization Report
September 15, 2023

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DOCUMENT CONTROL SUMMARY

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<tr><td>Author(s):</td><td colspan="3">Meg Buchanan, Lindsey Bunting</td></tr>
<tr><td>Revision Number:</td><td colspan="3">2</td></tr>
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1.0 INTRODUCTION

GeoSystems Analysis, Inc. (GSA) was contracted by Wood Rodgers, Inc. (Wood Rodgers) to provide project support in the Sand Creek potential flood mitigation area located near Chico, CA for the Rock Creek Reclamation District (RCRD). Due to surface disturbance constraints associated with the NRCS Conservation Easements located within the investigation area, the scope of the field investigation was modified from the initially proposed test pitting and infiltration testing approach to instead utilize low disturbance geophysical survey techniques. The geophysical survey was used as a preliminary screening tool to identify areas within the proposed potential detention basin areas provided by RCRD that appear to have shallow subsurface materials favorable for stormwater capture and recharge.

The RCRD proposed potential detention basin areas and FDEM survey area are shown in Figure 1. FDEM survey locations were designed to encompass RCRD's potential detention basin areas as well as major drainages of Sand Creek. The geophysical field investigation was conducted by Collier Geophysics (Collier) from June 27-29, 2023 and utilized a hand-carried frequency-domain electromagnetic (FDEM) survey approach. The FDEM survey was designed to provide a preliminary assessment of surface soil and vadose zone conditions up to approximately 20 feet below ground surface (ft bgs). Results of the geophysical survey as well as publicly available soils data were used to estimate potential infiltration rates and identify areas to target for further investigation as potential stormwater storage and recharge basins.

Section 2.0 of this report provides background information including a conceptual model for successful managed aquifer recharge (MAR), site geology, soil properties, and groundwater conditions and aquifer properties. Section 3.0 provides an interpretation of the geophysical conditions, and Section 4.0 provides recommendations for areas of further investigation as stormwater recharge facilities as well as potential design considerations.

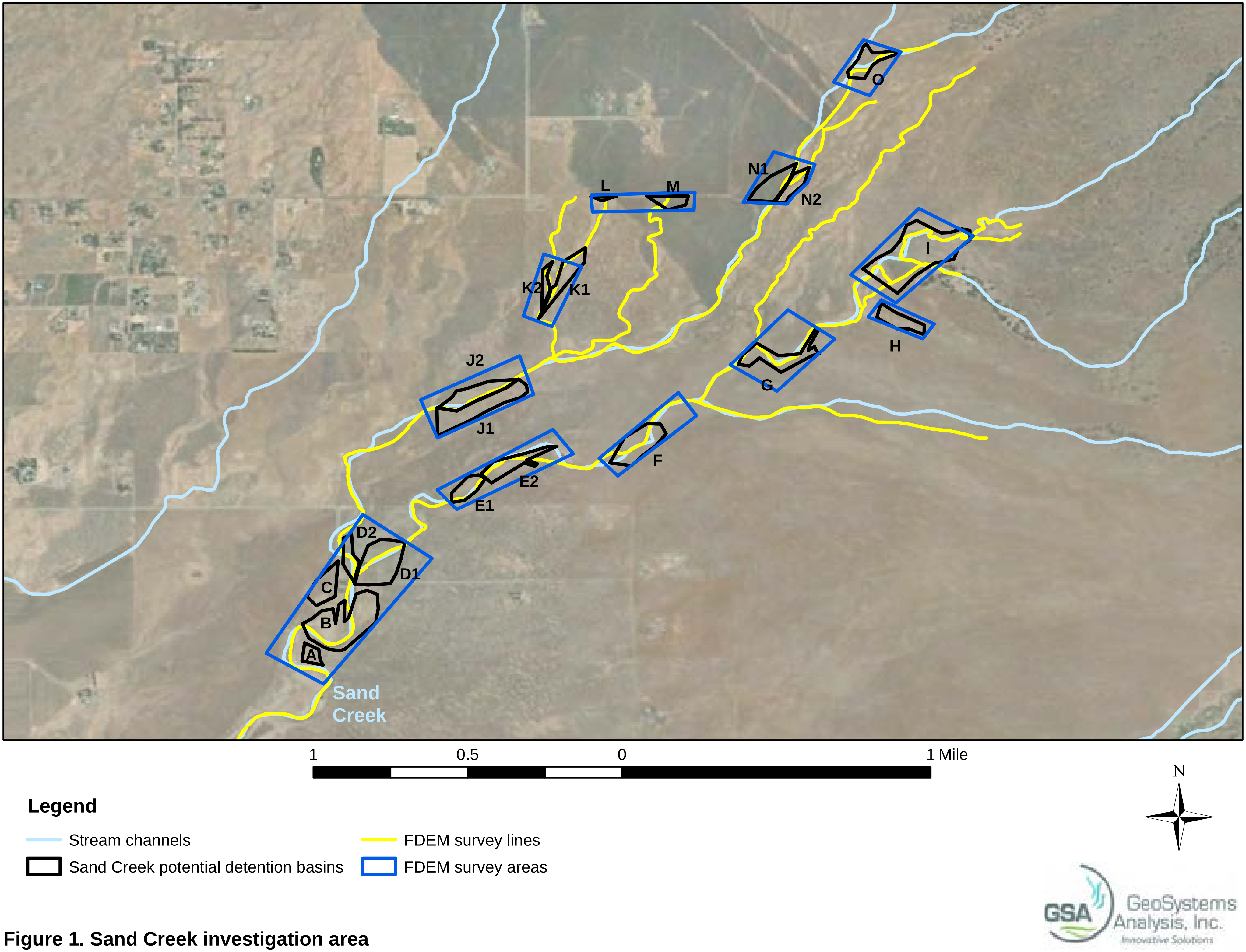


Figure 1. Sand Creek investigation area

2.0 BACKGROUND

2.1 Conceptual Model

MAR is the intentional harvesting and infiltrating of a water source at the surface (e.g. stormwater runoff) to recharge depleted aquifer storage, and can be an essential tool for achieving compliance with the California Sustainable Groundwater Management Act (SGMA). MAR can include the use of injection wells (e.g. aquifer storage and recovery wells), surface spreading infiltration (i.e. in-channel structures, recharge basins), Flood MAR (where agricultural fields are flooded), and low impact development (decreasing impermeable surfaces, using passive rainwater harvesting). The focus of this study is the capture of stormwater runoff for surface spreading MAR, particularly through the use of in-channel detention structures to detain and infiltrate water in basins and surface water channels.

The suitability of a site for surface spreading MAR is highly dependent on a number of variables including the distribution and infiltration properties of near-surface and deeper vadose zone sediments, available storage and recharged water recovery, water quality, and conveyance systems (if needed) to deliver water to the spreading area.

In most alluvial basins, such as the study area, the near-surface and subsurface sediments consist of variable and inter-bedded layers resulting from changing fluvial processes over the basin's depositional history. The hydraulic capacity of the vadose zone is ultimately determined by the lateral extent and vertical inter-connectivity of the subsurface sedimentary layers. Groundwater recharge site investigations must therefore determine whether infiltration rates of near surface materials are sufficiently high to meet project needs and whether laterally extensive low-permeability layers exist within the shallow vadose zone (Milczarek et al., 2003). Soil infiltration rates and permeability are correlated to soil texture and bulk density, with coarser textured soils having greater permeability and finer textured soils having lower permeability.

Site suitability for MAR is also dependent on available vadose zone storage, which is a function of the depth to groundwater, and the hydrogeologic properties of the subsurface materials. Sufficient vadose zone storage must be available to prevent mounding to shallow depths below the basin, which can result in decreased infiltration rates. Vadose zone and aquifer properties will also determine how quickly mounding dissipates to allow for continued recharge. Designs for stormwater capture and MAR facilities must also consider stormwater detention and sedimentation structures to reduce surface clogging that can occur in detention basins which will reduce infiltration and groundwater recharge rates.

2.2 Site Geology

The project area is located within the Great Central Valley of California which is an alluvial plain approximately 50 miles wide and 400 miles long in the central part of California. The northern portion, where the study area falls, is within the Sacramento Valley and drained by the Sacramento River. The Great Valley consists of an elongated trough in which sediments have been deposited since the Jurassic period. The majority of rocks and deposits in this area are sedimentary, with ages ranging from upper Jurassic (154-135 million years ago) to recent. Surface geology in Butte County, California is comprised of a variety of geologic units, including predominantly quaternary alluvium and marine deposits of Pleistocene to Holocene age, mesozoic granitic rocks, tertiary pyroclastic and volcanic mudflow deposits, and 18 other geologic units (USGS, https://mrdata.usgs.gov/geology/state/fips-unit.php?code=f06007).

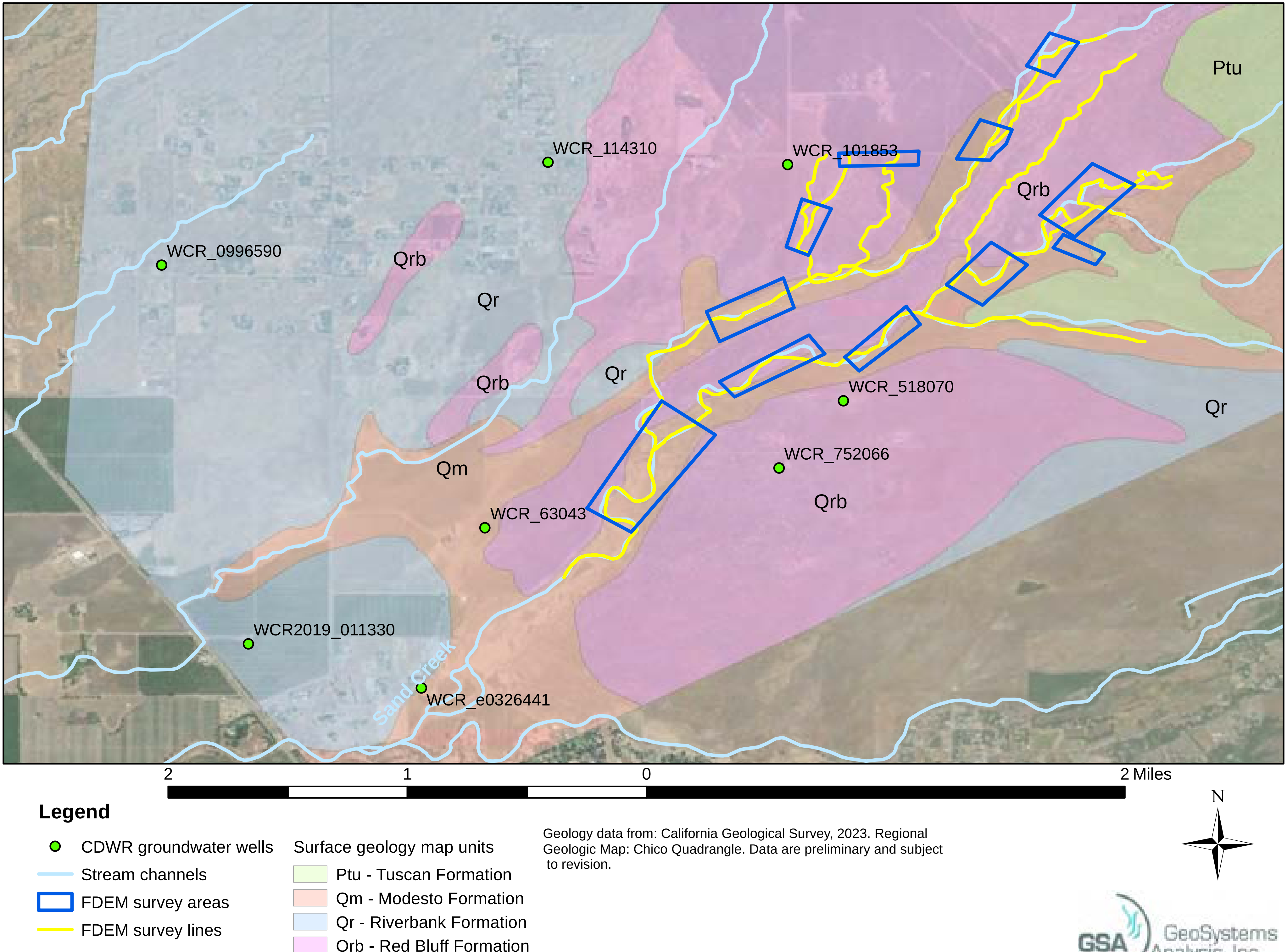
Figure 2 shows the surface geology at the Sand Creek site (Saucedo and Wagner, 1992). Surficial geologic units in this area include the Pleistocene Modesto, Riverbank and Red Bluff formations, with the Pliocene Tuscan Formation units underlying these below the Sand Creek site and exposed at its eastern edge. The Tuscan Formation (P_{tu}) east of the investigation area is described by Helley and Harwood (1985) as comprised of interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. This formation is the primary hydrogeologic unit and groundwater source in the Vina Subbasin of the larger Sacramento Valley Groundwater Basin (Geosyntec Consultants, 2021). The "B" unit of the Tuscan formation present at the Sand Creek site is approximately 425 feet thick, with conglomerate layers approximately 50 feet thick (Helley and Harwood, 1985). It contains fresh groundwater, as confirmed by a California Department of Water Resources (CDWR) analysis of geophysical and water quality parameters in the early 2000s (CDWR, 2014).

The Red Bluff Formation (Q_{rb}), which underlies a portion of the geophysical survey area polygons located in high elevation upland areas, contains well-weathered, bright red, sandy gravel, sand, and silt, is between 3 and 33 feet thick, and may contain groundwater, indicating a perched aquifer (Helley and Harwood, 1985, CDWR, 2014). The Red Bluff consists of a gravel sediment above a rock pediment (Helley and Harwood, 1985). It overlies and is derived from the Tuscan Formation on the eastern edge of the valley and underlies the Riverbank and Modesto formations (CDWR, 2014). Geosyntec (2021) describes Red Bluff deposits as cemented and not transmitting water.

The Riverbank Formation (Q_r), which does not appear to coincide with any geophysical survey areas, is composed of reddish gravel, sand, and silt and forms alluvial terraces and fans (Helley and Harwood, 1985). Near the investigation area, the Riverbank overlies the Tuscan and Red Bluff formation and underlies the Modesto Formation. It may contain small amounts of clay

(Helley and Harwood, 1985). Groundwater may be present under unconfined conditions (CDWR, 2014) and water-bearing capacity is limited by deposit thickness, although deposits range from poorly to highly permeable and this unit supplies groundwater to some shallow wells in the region (Geosyntec, 2021).

The Modesto Formation (Q_m), which underlies all geophysical survey areas, is the youngest of the Pleistocene alluviums, forming stream deposits of gravelly sand, silt, and clay (Helley and Harwood, 1985). It includes an upper layer, present in the investigation area, which forms low-elevation terraces and alluvial fans and is generally less than 10 feet thick at valley edges (Helley and Harwood, 1985, CDWR, 2014). Modesto Formation deposits are considered to be moderately to highly permeable (Geosyntec Consultants, 2021).



Geology data from: California Geological Survey, 2023. Regional Geologic Map: Chico Quadrangle. Data are preliminary and subject to revision.

Figure 2. Surface geology

2.3 Soil Properties

Soils data for the investigation area were obtained from the U.S. Natural Resource Conservation Service's Web Soil Survey (NRCS, 2023). Figure 3 shows soil map units occurring within the investigation area as well as presence of a restrictive layer in the shallow subsurface. Geophysical survey areas in the downstream portion of the Sand Creek channel and southern lower fork fell predominantly within the Redsluff gravelly loam soil map unit (Figure 3), which is characterized by moderately well drained gravelly loam materials with a gravelly clay loam horizon occurring from 5-12 inches bgs and no observed depths to a restrictive layer. Most of the northern upper fork of Sand Creek falls within the Wafap-Hamslough soil map unit. These soils are characterized by shallow gravelly loam materials overlying cobbly to extremely cobbly clay loams with restrictive layers occurring between 20-40 inches bgs. Redtough-Redswale map units occurred in the upper fan terrace areas adjacent to channel systems and are characterized by loam to very cobbly loams overlying cemented gravelly material at 10-20 inches bgs. Anita gravelly duripan map units underlie a subset of the upstream investigation areas in fan terraces adjacent upper Sand Creek tributaries. This map unit is characterized by gravelly clay overlying cemented gravelly material between 10-20 inches bgs. Based on NRCS soils data for the area, locations overlying the Redsluff gravelly loam soil map units are most likely to have physical properties favorable for groundwater recharge due to the absence of a restrictive layer in the top 80 inches.

Figure 4 shows the Soil Agricultural Groundwater Banking Index (SAGBI) which provides a qualitative estimate of suitability for groundwater recharge on agricultural land. This index is based on five factors critical to success including deep percolation, root zone residence time, topography, chemical limitations, and soil surface condition. The SAGBI for the area indicates good to very poor suitability for groundwater recharge (Figure 4). FDEM investigation areas falling within the downstream portion of the Sand Creek channel investigation area and southern tributary of Sand Creek had good ratings; upstream areas and those in the northern tributary of Sand Creek had poor to very poor ratings.

Figure 4 also shows near-surface soil permeability estimates determined from depth-weighted harmonic mean estimated saturated hydraulic conductivity (K_{sat}) calculated from the U.S. Natural Resource Conservation Service soil survey map unit horizon K_{sat} ranges (NRCS, 2023). GSA's experience is that NRCS-estimated soil permeability rates are typically 5X to 10X greater than the long-term potential infiltration at the near-surface. As a result, the NRCS K_{sat} values were reduced by a factor of 10 to approximate achievable, long-term infiltration rates for groundwater recharge operations. Multiple soil units exist in the study area, and therefore the mean K_{sat} weighting was based on the area and depth of each soil unit within the study area. These data indicate that most of the study area has expected near-surface infiltration rates of less than 0.2 feet/day, with other areas primarily in the Sand Creek channel that could be in excess of 0.6 feet/day (Figure 4).

Driller logs for nearby wells shown on Figure 2 and presented in Appendix B, also indicate the presence of interbedded hardpan and restrictive layers occurring at depths as shallow as 2 ft bgs (WCR-114310, WCR-518070). With the exception of WCR-752066 and WCR-011330, all nearby wells with available drill logs noted cemented material or rock within the top 10 ft.

Areas with limited expected infiltration rates primarily have hard pan or restrictive layers within 0-6.5 ft bgs (Figure 3). Depending on the stormwater capture volumes, basins with hardpan layers may still be suitable for recharge, if the layer is deep enough or can be broken up via excavation or deep ripping. Conversely, potential basin areas with shallow (i.e. <10 ft bgs) restrictive layers may be suitable for temporary storage, and recovery via drains for gradual discharge into more favorable recharge areas downstream.

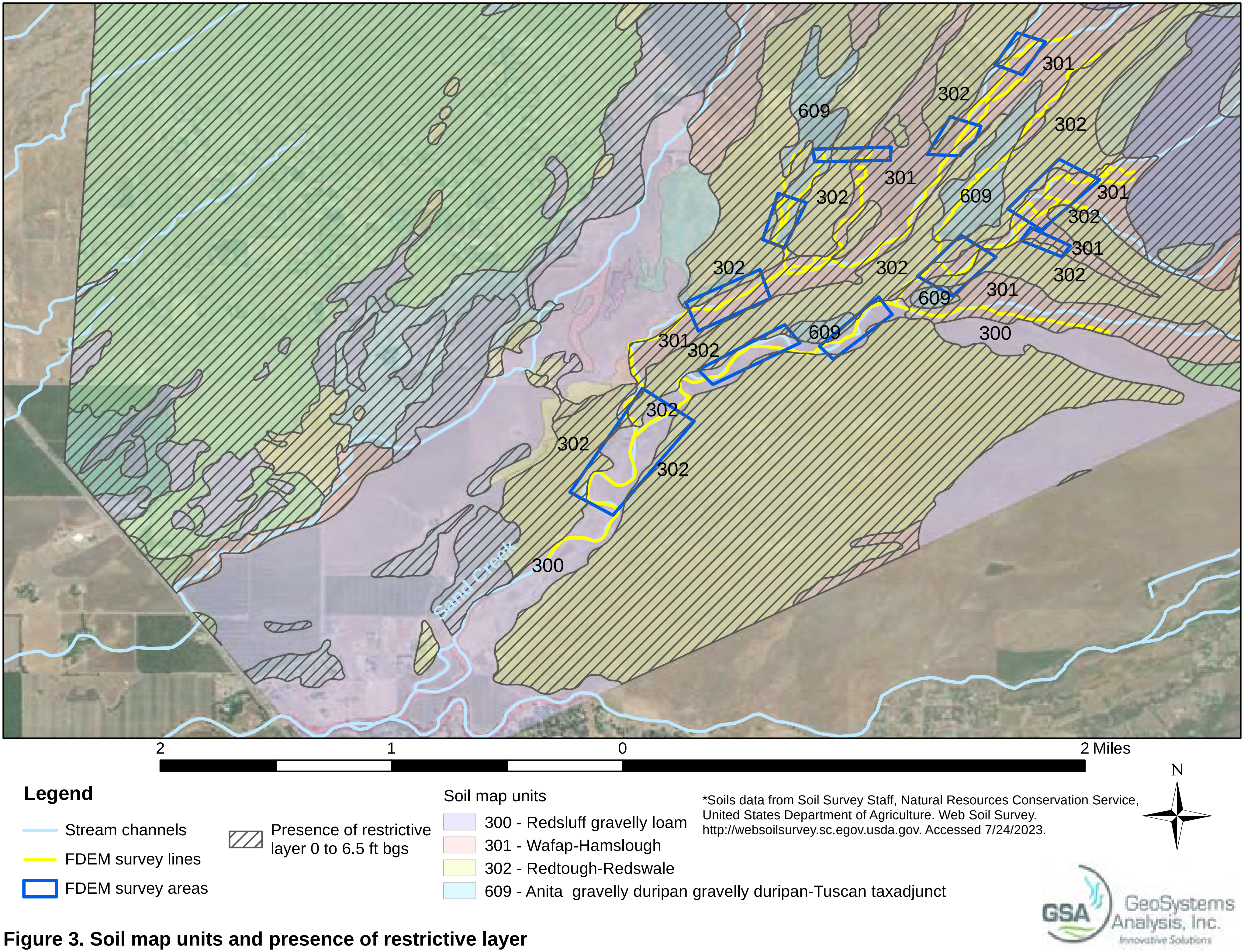


Figure 3. Soil map units and presence of restrictive layer

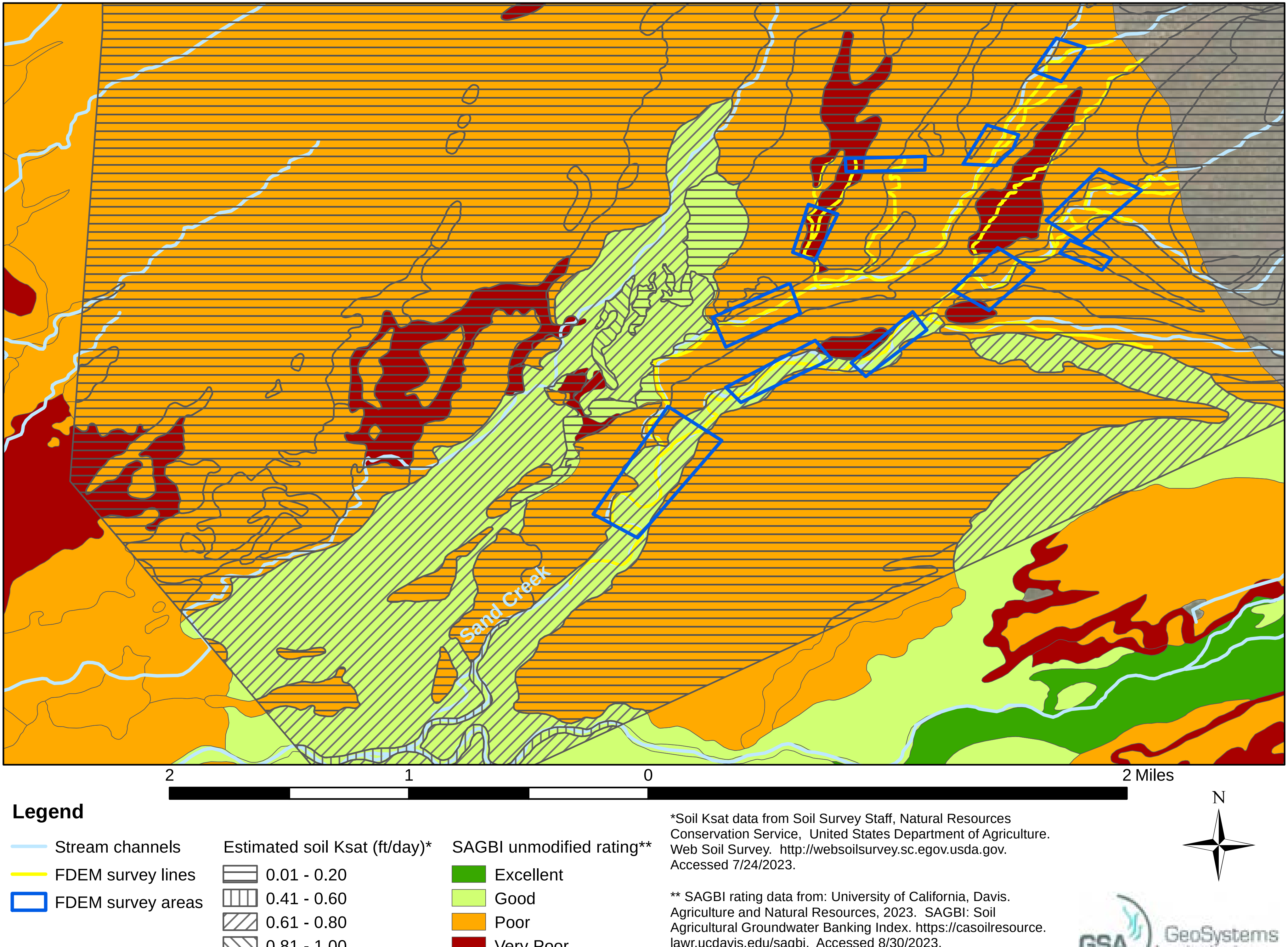


Figure 4. SAGBI recharge suitability index and estimated soil permeability

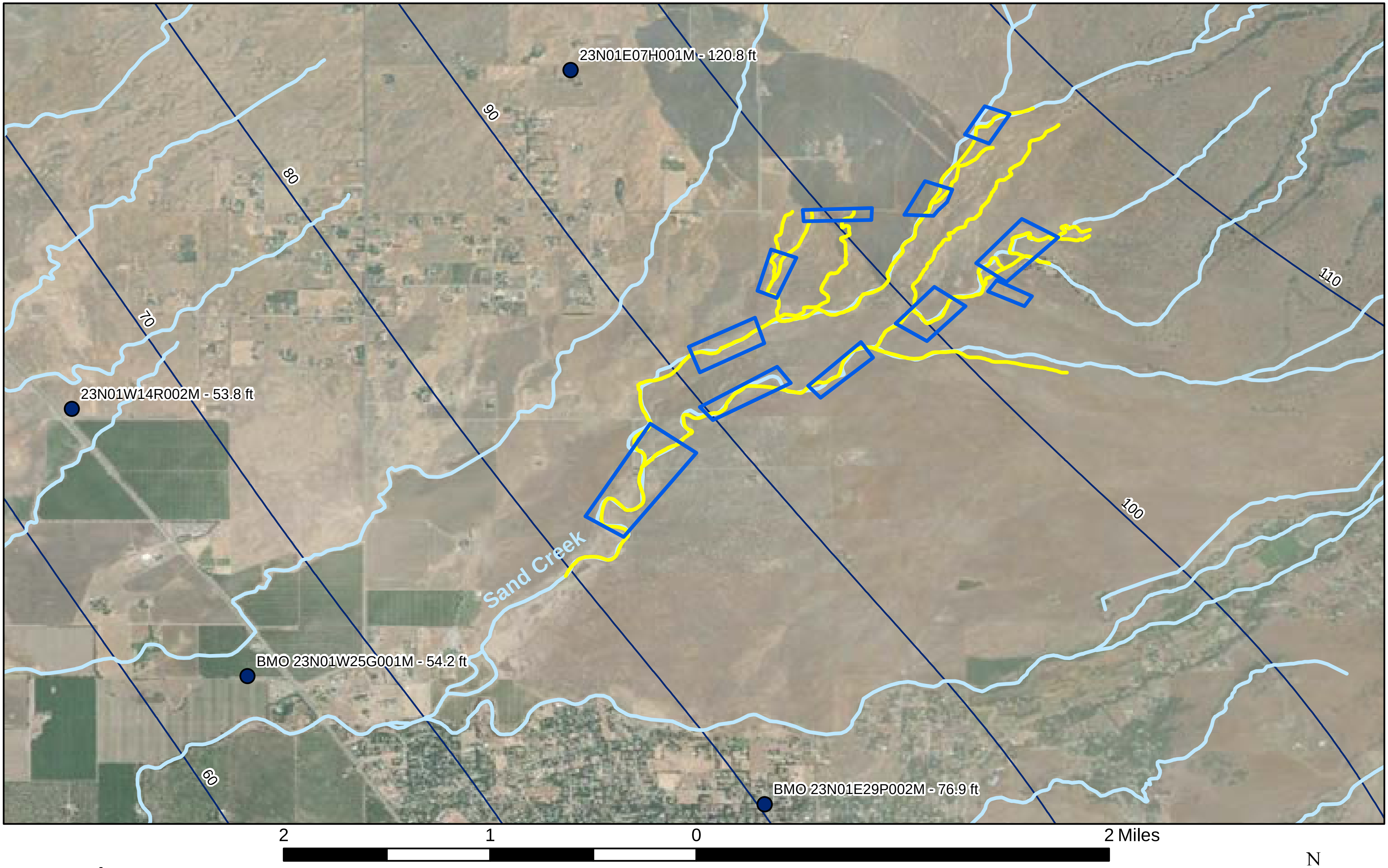
2.4 Groundwater Elevation and Aquifer Properties

The ephemeral Sand Creek drainage falls within the Vina North Management Area of the Vina Groundwater Sustainability Agency, and the investigation area overlies the Tuscan aquifer. To assess the available storage within the vadose zone and groundwater flow characteristics, the depth and flow direction of groundwater below the study area were estimated from California Department of Water Resources (CDWR) October 2022 depth to groundwater and groundwater elevation data (Figure 5, Figure 6). Depth to water and elevation contours indicate that groundwater occurs between 60 and 110 feet below ground surface and groundwater elevation between 130 and 160 feet above mean sea level. These data indicate that in the absence of perched water, the study area should have sufficient vadose zone storage for stormwater capture and MAR.

A stable isotope study conducted in the area indicated that groundwater recharge from precipitation occurs within the Valley Floor area and the ephemeral streams traversing the Lower Foothills, where the study area is located (Brown and Caldwell, 2017; Geosyntec Consultants, 2021). Rainfall in this area percolates directly into the Tuscan Formation at the outcrop or percolates into small alluvial fans or other sedimentary deposits in the area. This also supports the potential for increased groundwater recharge through the recent alluvial deposits located in the Sand Creek ephemeral drainages.

The Tuscan Formation is the main hydrogeologic unit and source of groundwater in the area, is comprised of volcanic sediments, and occurs under unconfined and semi-confined conditions and varying vertical conductivity (Geosyntec Consultants, 2021). Ranges in estimates of Lower Tuscan aquifer parameters for three sites in the Vina Subbasin of the Sacramento Valley Basin (Geosyntec Consultants, 2021), in which the Sand Creek site is located were:

- Specific yield: 5.9 – 7.1 percent
- Transmissivity: 2,322 – 23,650 square feet/day
- Horizontal hydraulic conductivity: 66 – 5,712 feet/day



Legend

Stream channels

FDEM survey lines

FDEM survey areas

SGMA wells with October 2022 depth to groundwater (ft bgs)

SGMA October 2022 depth to water contours (ft bgs)

Groundwater data from: California Department of Water Resources, 2023. SGMA Data Viewer, https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#gwlevels

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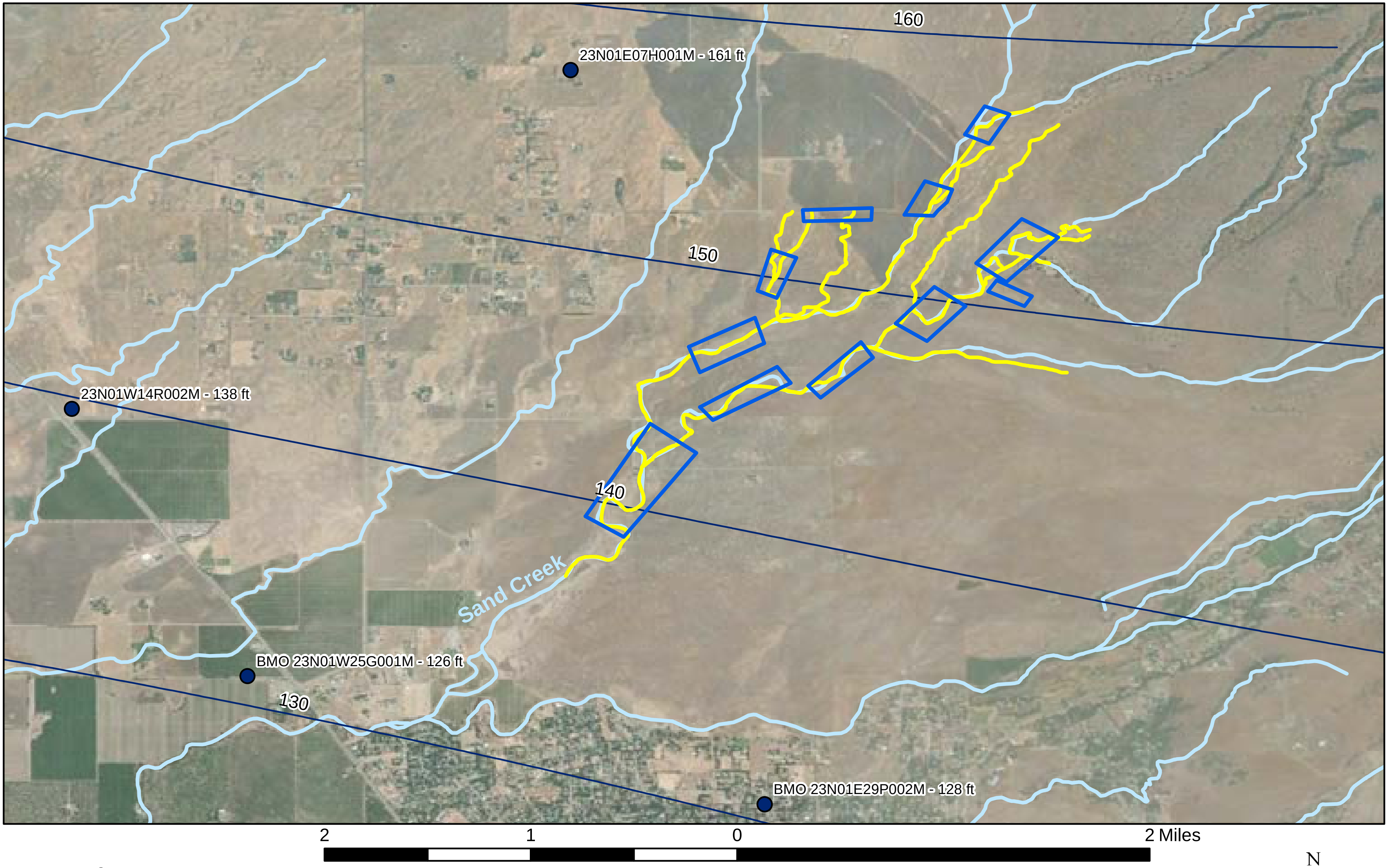
Figure 5. Estimated October 2022 depth to groundwater



Legend

- Stream channels
- FDEM survey lines
- FDEM survey areas
- SGMA wells with October 2022 groundwater surface elevation (ft amsl)
- SGMA October 2022 groundwater elevation contours (ft amsl)

Groundwater data from: California Department of Water Resources, 2023. SGMA Data Viewer, https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#gwlevels

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Figure 6. Estimated October 2022 groundwater elevation

3.0 GEOPHYSICAL INTERPRETATION

The geophysical survey report prepared by Collier is provided in Appendix A and provides a detailed discussion of survey methods and results. Collier mapped the apparent conductivity results for three coil depths, which represent increasing subsurface depth ranges of 5-7 ft bgs (coil 1), 9-14 ft bgs (coil 2), and 15-22 ft bgs (coil 3) (Appendix A). Lower conductivity areas are typically representative of coarse-grained sand and gravel, but can also indicate the presence of conglomerate, igneous and metamorphic rock, or other consolidated sedimentary materials. Higher conductivity areas are indicative of fine-grained clay materials but can also indicate increased water and salt content. Because of these uncertainties associated with geophysical surveys, confirmation testing via test pitting and/or an exploratory borehole investigation will be an essential step in the site screening process.

Geophysical survey results indicate that the extent of coarse-grained (low conductivity) sediments decreases with increasing depth below ground surface (Appendix A). As a result, low conductivity sediments are extensive within the top 5-7 ft bgs, decrease by 9-14 ft bgs, with a further decrease in extent from 15-22 ft bgs (Appendix A). Based on adjacent drill logs and area soils data (Section 2.3), this is likely a result of encountering finer-grained and potentially cemented materials at deeper depths. Areas with low conductivity values at the deepest investigation depth (15-22 ft bgs) also had low conductivity values above this depth (5-7 and 9-14 ft bgs) suggesting that material properties in these areas are most favorable for aquifer recharge.

Figure 7 shows FDEM results from 15-22 ft bgs. The FDEM 15-22 ft level results were selected for comparison to the shallow (0-6.5 ft bgs) soil survey results as the lower limit for estimated conductivity observed in the FDEM data. Potential detention basins A through F lie within the portion of Sand Creek with greater estimated K_{sat} values of 0.6-0.8 ft/day (Figure 4) and comprised of the Redsluff gravelly loam soil map unit, which is known to have deeper soils lacking a restrictive layer in the top several feet (Section 2.3). Of the potential basins occurring within the Redsluff soil map unit, basins E1 and E2 had the lowest apparent conductivity (coarsest material) values at 15-22 ft bgs. Basins A through D and basin F showed slightly higher, though similar conductivities at each depth (Appendix B). Although potential detention basins J1 and J2 fall outside of the Redsluff gravelly loam, portions of the basins were also identified as having low conductivity (coarse-grained materials) to a depth of up to 22 ft bgs. The remaining basins east of basins A through F, with the exception of basin O, showed much higher estimated conductivity values, indicating finer grained materials at all FDEM survey levels.

The FDEM data was also compared to lower resolution geophysical data from the California Airborne Electromagnetic (AEM) Surveys (CDWR, 2023). The AEM data interpretations were downloaded from the CDWR SGMA Data Viewer (https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#hcm) for the study area. Figure 8 shows the Hydrologic Conceptual Model for the average percent coarse grained material within 0-50 ft bgs, along the AEM survey lines within the study area. The average percent coarse-grained material estimates are based on integrating the AEM data with well logs in the general area. These data predict that basins A through D have greater percent coarse materials (30-40%) than basins to the east of basins F and J (20-30%) in the 0 to 50 ft bgs depth interval. The AEM flight path did not cover basins E1/E2 and J1/J2, so comparison between AEM and FDEM data is not possible for these potential detention basins. Where available, these data are generally consistent with the higher resolution FDEM data.

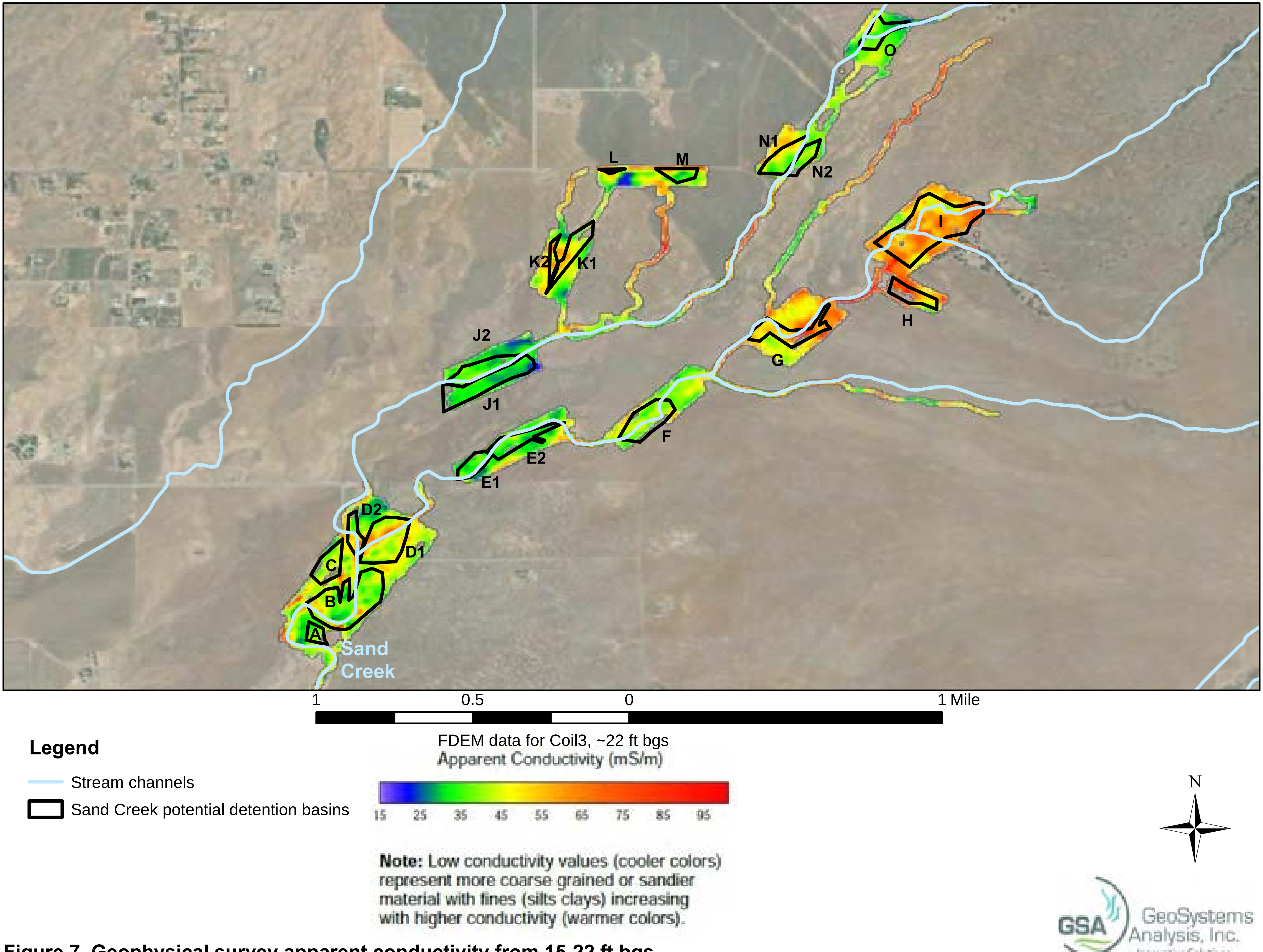

Figure 7. Geophysical survey apparent conductivity from 15-22 ft bgs

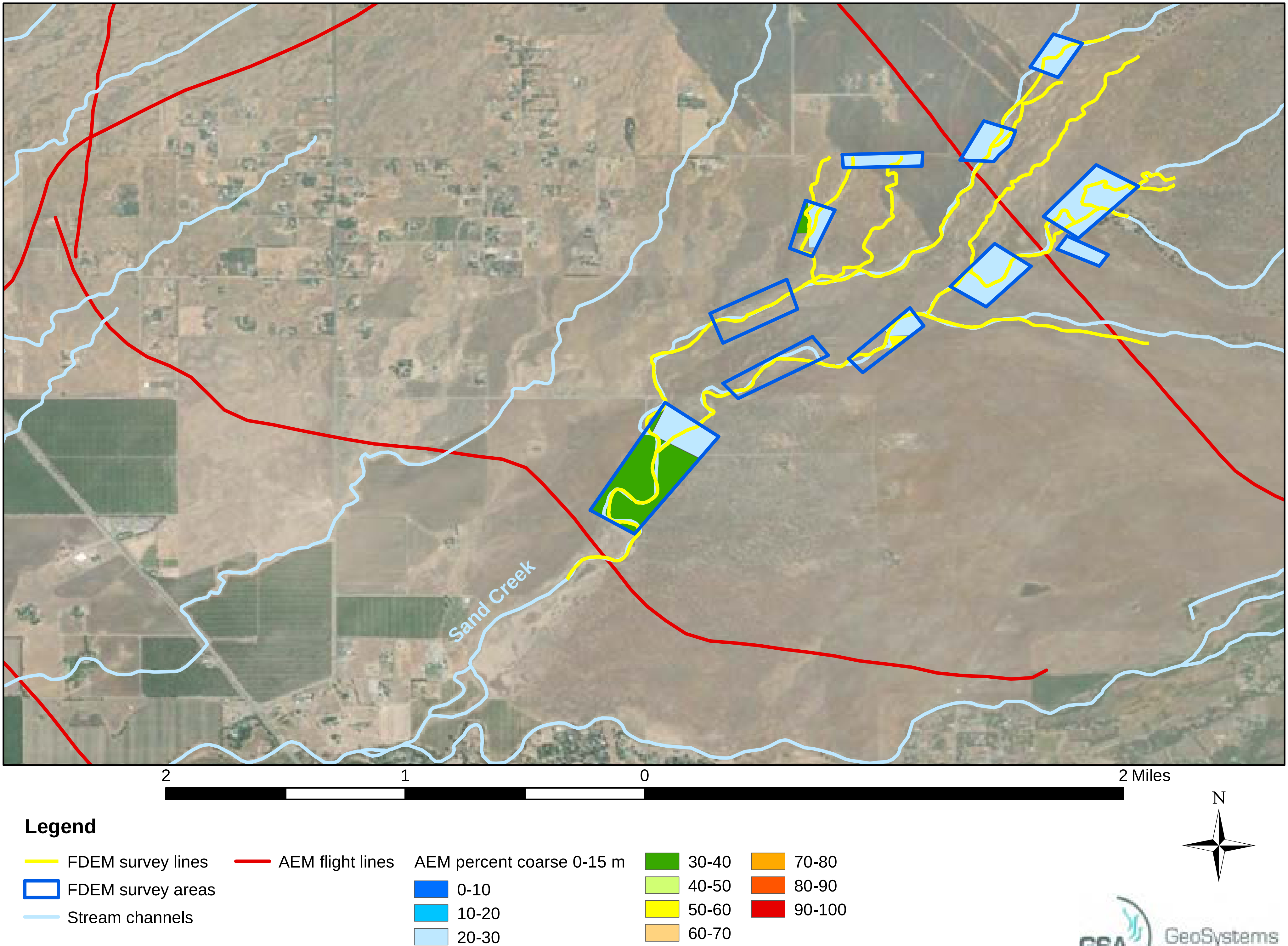

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Figure 8. AEM survey data

4.0 RECOMMENDATIONS

Based on careful review of findings from the geophysical survey and review of publicly available geologic and soils data, GSA recommends the following potential detention basin areas be considered for further evaluation for suitability as stormwater capture and recharge locations:

- E1 and E2 (greater K_{sat} and estimated coarse-grained materials)
- J1 and J2 (greater estimated coarse-grained materials)

Basins A-D, F, and O may also be suitable for investigation as secondary options in the event that greater total storage is required and/or confirmation testing indicates unsuitable vadose zone properties at E1/E2 and J1/J2. In ephemeral drainages such as Sand Creek, the amount of water available for capture and recharge is highly dependent on rainfall-runoff dynamics in the contributing watershed. MAR facility design must be guided by water availability and seasonality (e.g. months per year of water availability and estimated average, min and max flow volumes), the amount and duration of planned detention, as well as surface infiltration rates, and vadose zone and aquifer properties. If the infiltration rates are limited, or the vadose zone is limited in thickness and total storage due to restrictive layers, larger basins or treatment (i.e. ripping) may need to be designed to meet project objectives.

Because the basins to the east of the E and J basins generally appear to be less favorable to groundwater recharge, these areas could be used for upstream retention structures to capture and serve as sedimentation basins that slowly meter water to improve the water quality reaching downstream detention basins. The upstream basins essentially become sacrificial, while increasing water residence time in the channel and downstream basins which will increase overall recharge and reduce maintenance required in downstream basins to remove accumulated sediment.

While no estimate of potential capture volumes is yet available, we used a volume range of 50 to 300 acre feet per year (afa) as an example to illustrate the required basin size(s) required under different estimated infiltration rates. Depending on the estimated recharge volumes, and assuming an infiltration rate of 0.2 to 0.7 ft/day, recharge occurring over two months of the year could be achieved with overall basin sizes between approximately 1 to 25 acres in size (Table 1). Note that this estimate does not include additional recharge that will occur due to increased channel infiltration or the retention characteristics needed to retain water for two months. Based on GSA's experience, increased channel infiltration can be as high as 50% of the total volume recharged in stormwater capture systems.

Table 1. Estimated recharge basin area required for MAR

Estimated Periods of Water Availability	Desired Average Annual Recharge Rates (AFA)	Estimated Basin Infiltration Rate (Feet/day)	Acres of Basins Needed
2 months/year	50	0.2	4.2
		0.7	1.2
	100	0.2	8.3
		0.7	2.4
	150	0.2	12.4
		0.7	3.6
	200	0.2	16.5
		0.7	4.7
	300	0.2	24.7
		0.7	7.1

Finally, geophysical investigations are very useful as a screening tool but are subject to numerous constraints which can result in potentially inaccurate results, such as the effects of high water content, high salt content, or consolidated material on predictions of unconsolidated material properties. As a result, physical investigations in the recommended potential detention basin areas to confirm the estimated material properties from the geophysical survey are necessary prior to conducting any further design work. Physical investigations should include: 1) a near-surface (i.e. test pitting) characterization with surface infiltration testing to better approximate the range in effective infiltration rates, and 2) a borehole investigation to determine if any continuous restrictive layers are present which may constrain percolation of recharged water to the aquifer, or result in mounding which limits recharge project effectiveness and/or results in unacceptable daylighting elsewhere in the channel.

More detailed information on subsurface and aquifer properties, in addition to information on channel flow dynamics (frequency, duration, discharge volumes) will allow for improved stormwater capture and MAR facility design.

5.0 REFERENCES

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APPENDIX A

Collier Geophysics FDEM Survey Report

COLLIER GEOPHYSICS
Surface • Marine • Borehole
1205 Sam Bass Rd | Round Rock, Tx 78613 | (254) 968-8725

July 19, 2023

To: Lindsey Bunting
Project Scientist

Geosystems Analysis, Inc.
Tuscan, AZ

VIA Email: lindsey@gsanalysis.com

RE: Geophysical Letter Report – FDEM Sand Creek, CA | Project #230212
FDEM Geophysical Survey
Chico, CA

Collier Geophysics, LLC. (Collier) is pleased to provide GeoSystems Analysis, Inc. (GeoSystems) with this letter report summarizing the results of a frequency-domain electromagnetic (FDEM) survey located off Golden State Hwy in Chico, CA. The main objective of this geophysical investigation was to assist GeoSystems in identifying areas with higher recharge potential based on soil grain size and potential permeability inferred from subsurface conductivity.

The survey was conducted from June 27th to June 29th. Collier Geophysicist Josh Morrison led the survey. The following report presents results from the geophysical investigation and summarizes the site conditions, field methods, data acquisition, and interpretation procedures.

Site Conditions

The 1,000-acre area of investigation is located near the intersection of Renkow Road (Rd) and Meridian Rd in Chico, CA. **Figure 1** shows the general area of the geophysical project. The weather during data collection was sunny, with daily high temperatures around 100 degrees (Fahrenheit). The brush in parts of the survey site was dense and chest-high. The topography was generally flat with surface soils mostly dry. **Inset 1** shows photographs of the site field conditions. The approximate surface elevation of the site ranged from 180-215 feet (ft) above mean sea level (MSL).

Inset 1: Photographs of site conditions and field work.

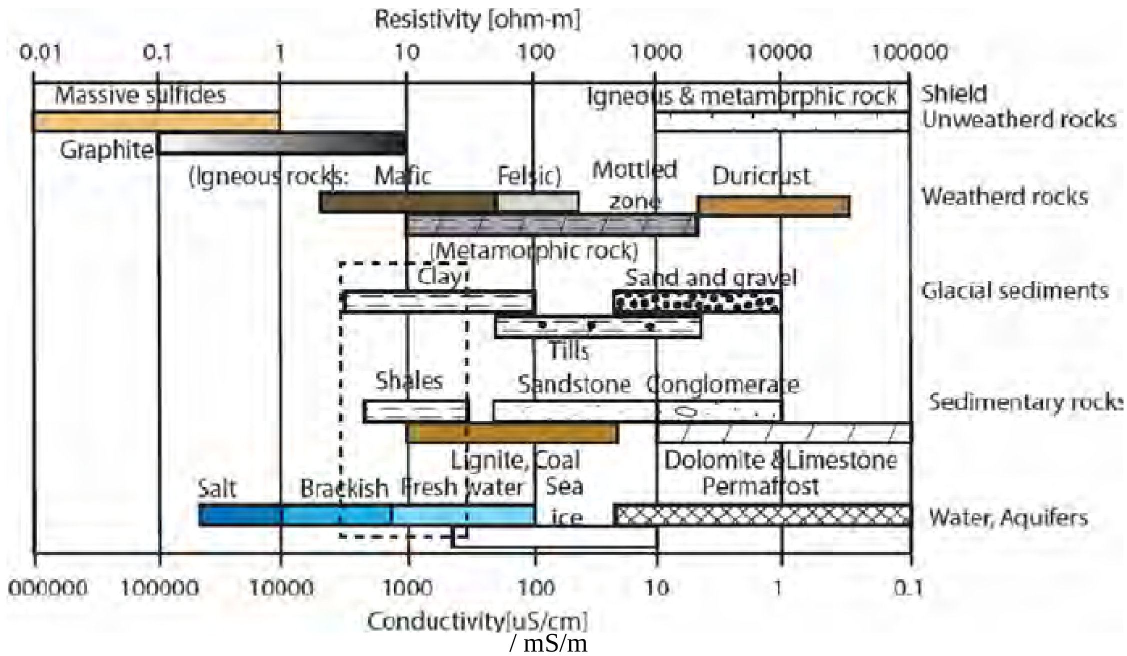
Surface Geology

The project area is located in the Great Valley province of California. This region contains volcanic rock, terrace deposits, as well as marine and nonmarine sedimentary rocks. The survey site lies on deposits described as Pleistocene-age sandstone, shale, and gravel deposits; mostly loosely consolidated (QPc). Pleistocene-Holocene age unconsolidated sedimentary rock, including alluvium, and terrace deposits (Q) is located to the west of the project area. East of the project area lies Tertiary age volcanic rock (Tvp and Tv) as shown in **Figure 2** (California Department of Conservation, California Geological Survey).

Method Overview

The frequency domain electromagnetic survey (FDEM) is used to characterize the subsurface based on conductivity. An FDEM instrument consists of at least one pair of transmitter and receiver coils. A primary magnetic field of a constant frequency is generated using an alternating current in the transmitter coil, and a secondary magnetic field is detected in the receiving coil due to the interaction of the primary field with the subsurface.

The FDEM instrument allows for simultaneous measurements of the secondary magnetic field's quadrature components. The quadrature component is primarily sensitive to the electrical conductivity of subsurface materials due to changes in lithology, moisture content, and/or fines (clay) content. The quadrature response is calibrated and measured as apparent bulk conductivity in millisiemens per meter (mS/m); it is referred to as the conductivity measurement. Electrical resistivity is the inverse of conductivity. Therefore, knowing the conductivity of the subsurface allows an understanding of the resistivity of the subsurface as well. **Inset 2** is a chart that shows the general range of conductivity / resistivity of various soil and rock types.



Inset 2: Chart showing conductivity/resistivity of various soil and rock types from Sikandar, 2009.

Data Acquisition

For this project data was collected using a CMD-Explorer, which is a multi-coil FDEM conductivity meter manufactured by GF Instruments. The instrument consists of a boom with three coil separations of 1.48 m (4.86 ft), 2.92 m (9.58 ft), and 4.49 m (14.73 ft), corresponding to approximate depths of investigation up to 2.2 m (7.2 ft), 4.2 m (13.8 ft), and 6.7 m (22.0 ft), respectively. The FDEM instrument was carried using a neck sling and a GPS mounting backpack. The depth listed for each coil is the approximate depth achievable by the individual coil but not confirmed for this survey.

Data were recorded continuously at a sample rate of 10 Hz (10 measurements per second). A Juniper Geode GPS unit capable of sub-meter precision was used for positioning at a sample rate of 1 Hz. For each record, the apparent conductivity and the in-phase amplitude are stored, comprising six measurements for each record.

The data was acquired along the creek bed within the area of investigation as well as targeted polygons areas. Data inside the polygons were acquired in parallel line paths, spaced approximately 100 feet apart, as shown in **Figure 1**. Obstructions, fences, inaccessible property, and surface features that cause interference were avoided when possible. Data acquisition on a small portion of one of the polygons and creek bed on the west side of the survey was not acquired due to property access.

Data Processing

Raw FDEM data were exported in tabular format using CMD Data Transfer, version 1.6.2, by GF Instruments. Surface locations for each measurement are interpolated for each record from GPS positions using the data transfer software. The data were then processed using Geosoft Oasis Montaj, version 2022.2, which is a processing and data visualization software suite used to analyze geophysical data sets. The data were then filtered to remove erroneous spikes and to mitigate noise from cultural features such as overhead powerlines. The filtered data for each coil were gridded using a minimum curvature method for contouring and presentation of the data.

Results and Discussion

The apparent conductivity (mS/m) results from the FDEM data were gridded and contoured with Golden Software's Surfer contouring program. **Figures 3, 4, and 5** present the conductivity data as two-dimensional (2D) contour maps for each of the coil separations 1-3, respectively. The conductivity data for the site were contoured using a range of 15 mS/m to 100 mS/m. While there were some outliers for this data range it captures a majority of the data from the site. In **Figures 3, 4, and 5**, the conductivity results are color-mapped with cool colors representing low bulk conductivities and warm colors representing high bulk conductivities. The lower conductivities are interpreted to potentially represent sands and sandy clays grading to finer grained materials (silts, clays, and shales) as the conductivity values increase. The lower conductivity areas (15mS/m to 25 mS/m – blue colors) are interpreted to be coarser grained soils that are potentially permeable.

The coil 1 data in **Figure 3** (estimated depth of investigation 5-7 feet) depicts some areas of lower apparent conductivity values (blue colors) present in portions of Areas 1, 2, 3, 4, 5, 6, 8, and 11 of the survey site. Several portions of the creek bed circled and marked as Areas A, B, C, D and E, also show the presence of these lower conductivity values. The majority of Areas 4, 6, 7, 9, and 10 show overall higher apparent conductivity values for all three coil separations. This is interpreted to be due to the presence of lower sand and higher fines content at these locations and depths.

The coil 2 data in **Figure 4** (estimated depth of investigation 9-14 feet) continues to depict some lower apparent conductivity values in portions of Areas 1, 2, 3, 4, 5, 6, 8, and 11. Similarly to the coil 1 data, the creek bed data from coil 2 shows relatively low conductivity values in some portions of the circled areas marked A, B, C, D and E.

Generally, the data from coil 3 in **Figure 5** (estimated depth of investigation 15-22 feet) shows an increase in conductivity, signifying increasing fine-grained materials or potentially moisture at the depth. However, limited portions of Areas 2, 3, 6, and 11 continue to show lower conductivity values and likely represent areas of coarser grained materials at depth. With the exception of Area E, the selected areas of the creek bed from **Figure 3** and **Figure 4** no longer show the presence of lower conductivity values in the deeper coil 3 data.

Based on the data from all 3 coils, it is interpreted that portions of Areas 1, 2, 3, 5, 6, 8, and 11 as well as portions of the creek bed in Areas A, B, C, D and E may have the potential to contain zones of permeable soils due to the presence of relatively lower conductivity zones (<25 mS/m - blue colors). Portions of Areas 2, 3, 11, and E appear to have the highest potential for more permeable soils due to the relative depth and lateral extent of relatively lower conductivity material present in these areas. Additionally, there is one smaller portion of Area 6 on the southwestern side that exhibits low conductivity in all three coil separations and may also have a high potential for the presence of permeable soils. These interpretations are based on the relative change in conductivity at the site. Therefore, it is recommended that select soil borings be placed in areas of interest and compared to the conductivity data for confirmation and a refinement of this interpretation.

Closure

The FDEM geophysical investigation in Butte County near Chico, CA was used to generate 2D plan view maps of apparent conductivity at three different depth ranges. The collected data for this investigation shows relative changes in conductivity, interpreted to be related to changes in the amount of fine- and coarse-grained materials in the near subsurface. The lower conductive areas (< 25 mS/m - blue colors) as presented in **Figures 3, 4, and 5** may have higher potential for permeability based on the interpreted presence of coarser grained materials at these locations and depths.

Overall, the quality of the data yields a high degree of confidence in the results obtained and presented in this report. However, like any non-intrusive investigation method, FDEM mapping requires the subjective interpretation of indirect measurements and therefore an inherent margin of error is unavoidable. Our methods used for data acquisition and interpretation are as complete as is reasonably possible, and we believe them to be a reasonable representation of the subsurface conditions. Due to the subjective nature of any type of interpretation, we cannot guarantee that our results are accurate in all areas or that all subsurface features have been detected. We suggest that key features identified by this survey be confirmed by selective in-situ methods before decisions are based on our findings.

If you have any questions regarding the field procedures, data analysis, or the interpretive results presented in this report, please do not hesitate to contact us. We appreciate working with you and look forward to providing GeoSystems with geophysical services in the future.

Sincerely,

Collier Geophysics, LLC

Josh Morrison

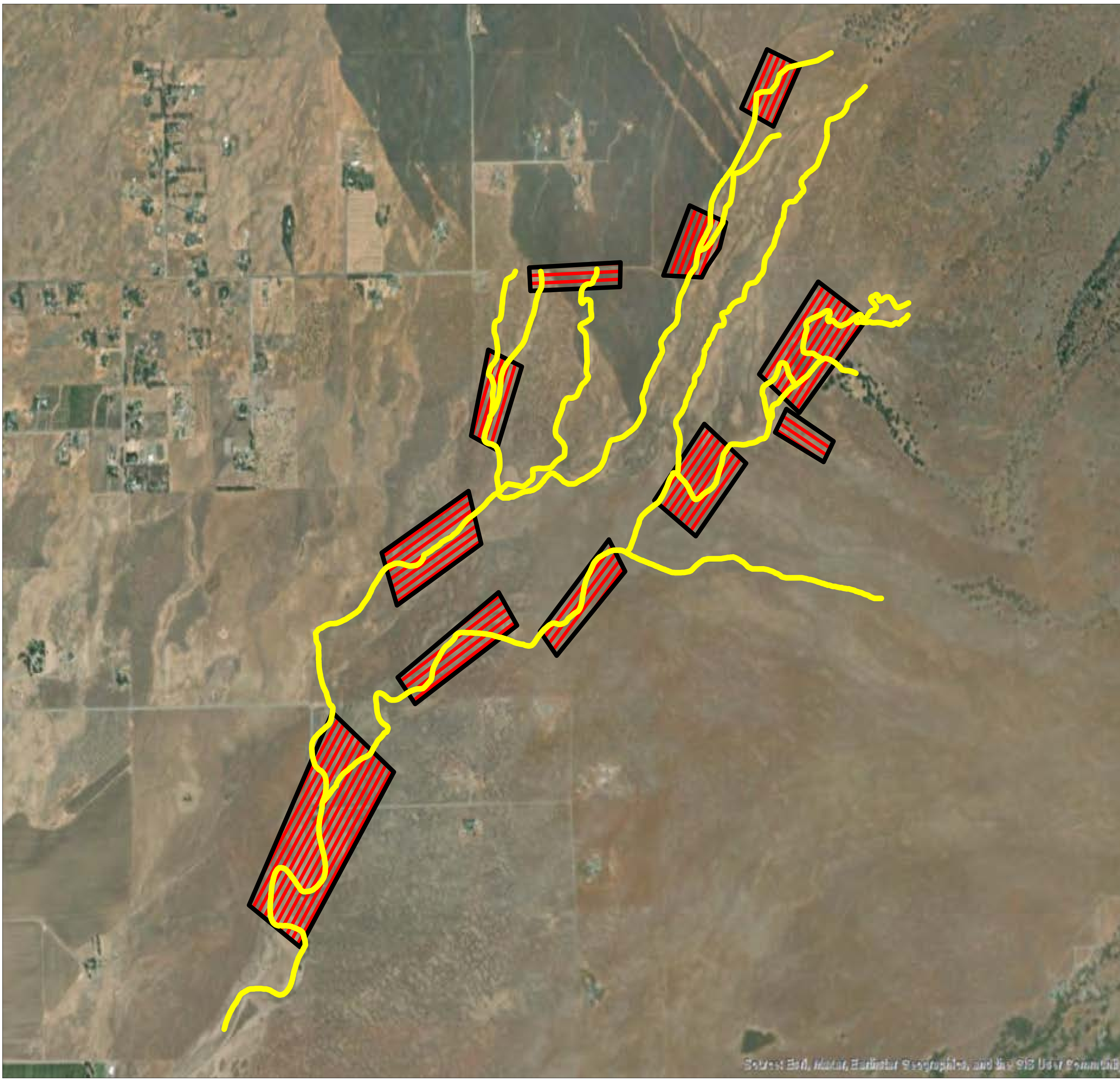
Douglas E. Laymon

Joshua Morrison
Geophysicist

Doug Laymon, P.G.
Principal Geophysicist

Figures

Butte County FDEM Survey



0 1000 2000 3000

Feet

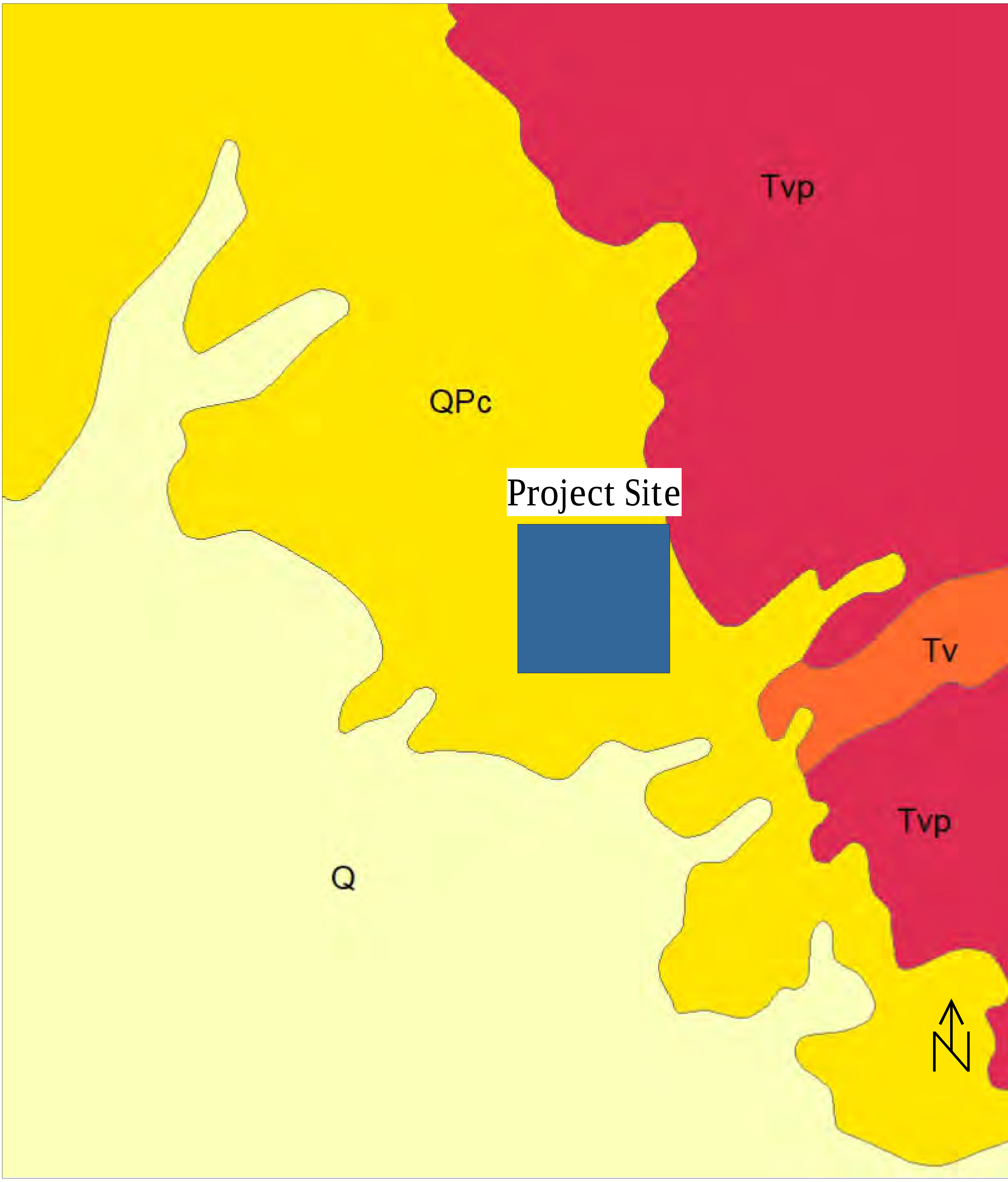
Legend

Surveyed Creek Bed

Surveyed Areas

Survey Lines		
GeoSystems Analysis		COLLIER GEOPHYSICS
Project #: 230212	July 2023	
Drafted by: J. Morrison	Checked by: D. Laymon	Figure 1

Butte County FDEM Survey



*California Department of Conservation, California Geological Survey

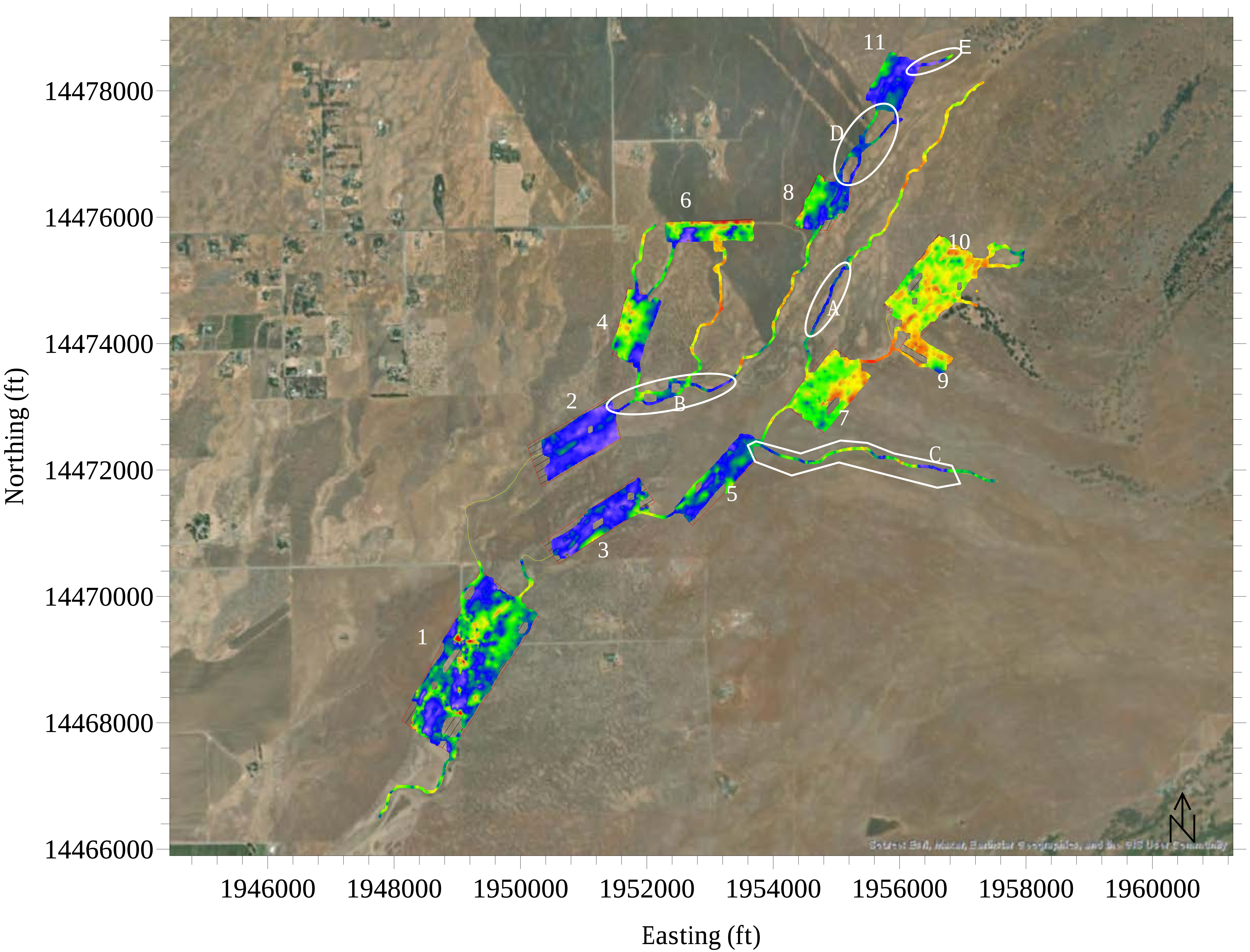
Legend

- Q, Marine and nonmarine sedimentary rocks
- QPc, Nonmarine sedimentary rocks
- Tv, Volcanic rocks
- Tvp, Volcanic rocks

Surface Geology		
GeoSystems Analysis		COLLIER GEOPHYSICS
Project #: 230212	July 2023	
Drafted by: J. Morrison	Checked by: D. Laymon	Figure 2

Coil 1 Separation 4.86 ft (1.48 m)

Measured Conductivity (~Depth 7 ft)



Apparent Conductivity (mS/m)

15 25 35 45 55 65 75 85 95

Note: Low conductivity values (cooler colors) represent more coarse grained or sandier material with fines (silts clays) increasing with higher conductivity (warmer colors).

Depth listed above is the approximate depth achievable by the individual coil but not confirmed.

Legend

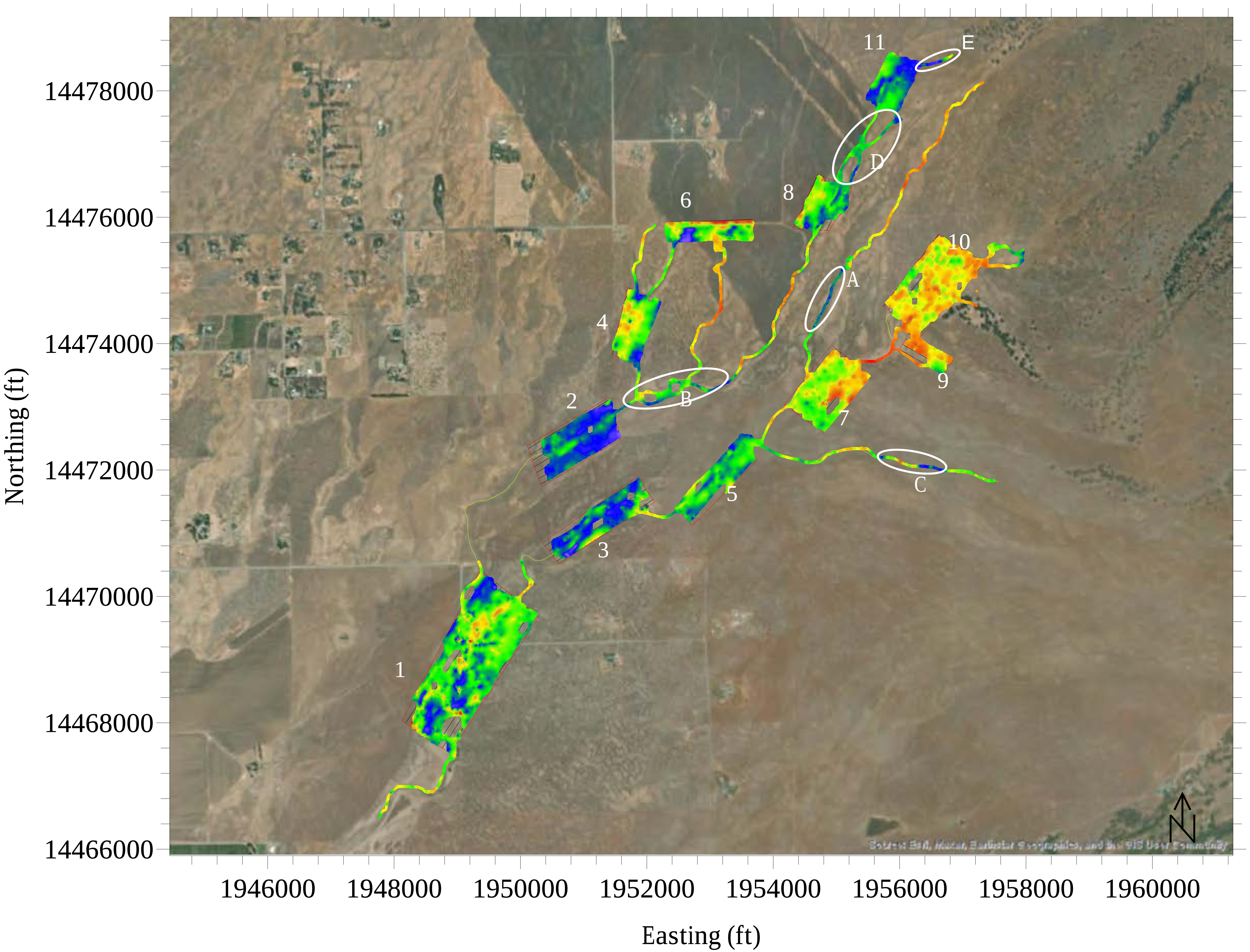
- Creek Bed Locations of Interest
- Surveyed Areas Labeled 1-11

FDEM Survey Butte County FDEM Survey *Chico, CA*		
GeoSystems Analysis		COLLIER GEOPHYSICS
Project #: 230212	July 2023	
Drafted by: J. Morrison	Checked by: D. Laymon	**Figure 3**

Coordinate System: WGS 84 / UTM Zone 10N (ft)

Coil 2 Separation 9.58 ft (2.92 m)

Measured Conductivity (~Depth 14ft)



Apparent Conductivity (mS/m)

15 25 35 45 55 65 75 85 95

Note: Low conductivity values (cooler colors) represent more coarse grained or sandier material with fines (silts clays) increasing with higher conductivity (warmer colors).

Depth listed above is the approximate depth achievable by the individual coil but not confirmed.

Legend

Creek Bed Locations of Interest

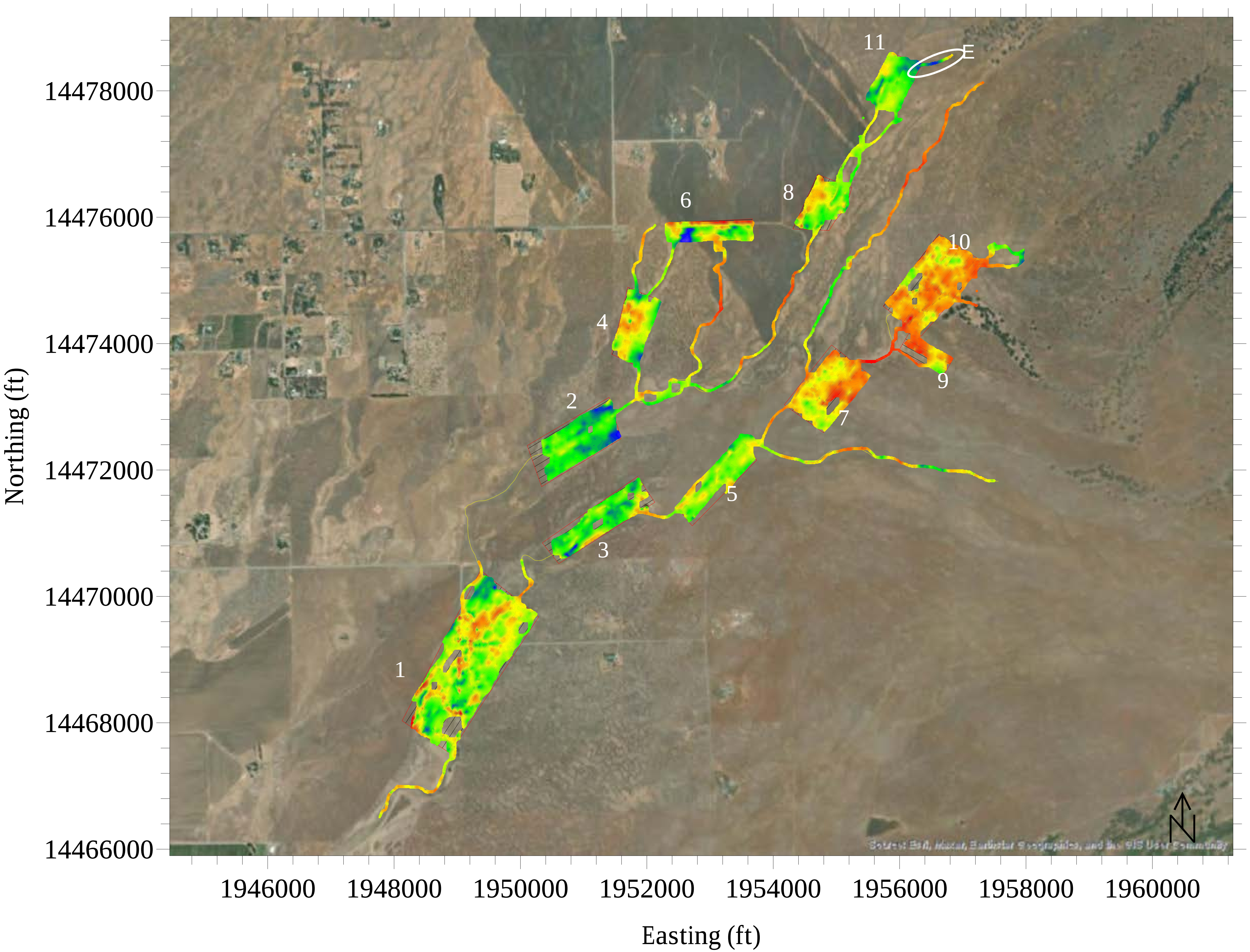
Surveyed Areas Labeled 1-11

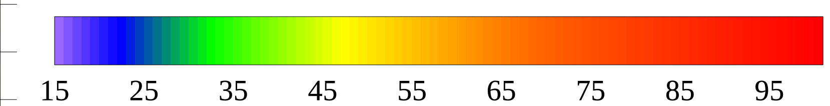
Coordinate System: WGS 84 / UTM Zone 10N (ft)

FDEM Survey Butte County FDEM Survey *Chico, CA*		
GeoSystems Analysis		COLLIER GEOPHYSICS
Project #: 230212	July 2023	
Drafted by: J. Morrison	Checked by: D. Laymon	**Figure 4**

Coil 3 Separation 14.72 ft (4.49 m)

Measured Conductivity (~Depth 22ft)





Note: Low conductivity values (cooler colors) represent more coarse grained or sandier material with fines (silts clays) increasing with higher conductivity (warmer colors).

Depth listed above is the approximate depth achievable by the individual coil but not confirmed.

Legend

Creek Bed Locations of Interest

Surveyed Areas Labeled 1-11

FDEM Survey Butte County FDEM Survey *Chico, CA*	
GeoSystems Analysis	COLLIER GEOPHYSICS
Project #: 230212	June 2023
Drafted by: J. Morrison	Checked by: D. Laymon
Figure 5	

Coordinate System: WGS 84 / UTM Zone 10N (ft)

APPENDIX B

Well Driller Geologic Logs

23N/11E-17 ✓

ORIGINAL

File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
WATER WELL DRILLERS REPORT

Do not fill in

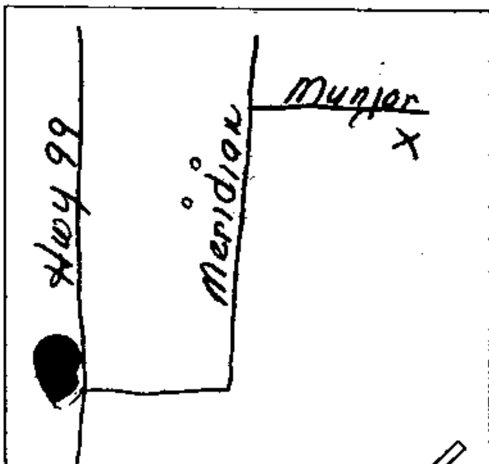
No. 101853

State Well No. CONFIDENTIAL LOG
Other Well No. Water Code Sec. 13752

Not[redacted] Intent No.
Local Permit No. or Date

(1) (
Address
City

(2) LOCATION OF WELL (See instructions):
County Butte Owner's Well Number
Well address if different from above
Township 23 N Range 1E Section 17
Distance from cities, roads, railroads, fences, etc. Munjor Rd. - 8 mi. No. Chico Airport.



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☒
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☐
Other ☐

(5) EQUIPMENT:
Rotary ☐ Reverse ☐
Cable ☒ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☐ No ☒ Size
Diameter of bore
Packed from ___ to ___ ft.

(7) CASING INSTALLED:
Steel ☒ Plastic ☐ Concrete ☐

(8) PERFORATIONS:
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	57	6 5/8	.125			

(9) WELL SEAL: Sanitized
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth ___ ft.
Were strata sealed against pollution? Yes ☐ No ☐ Interval ___ ft.
Method of sealing Clay

(10) WATER LEVELS:
Depth of first water, if known 90 ft.
Standing level after well completion 85 ft.

(11) WELL TESTS:
Was well test made? Yes ☐ No ☒ If yes, by whom?
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ___ ft. At end of test ___ ft
Di[redacted]e ___ gal/min after ___ hours Water temperature
Che[redacted]l analysis made? Yes ☐ No ☒ If yes, by whom?
Was electric log made? Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 230 ft. Depth of completed well 230 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	10	Dirt
10	18	Rock
18	70	Brown Clay
70	85	Hard Red Clay
85	102	Brown Clay
102	117	Layers
117	163	Red Clay
163	165	Gravel
165	187	Brown Clay
187	189	Gravel
189	229	Red Clay
229	230	Gravel

Work started 3/14 1981 Completed 3/15 1981

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

SIGNED (signature)
NAME CHICO WELL DRILLING AND PUMP SERVICE (Person, firm, or corporation) (Typed or printed)
Address CAL. LIC. No. 363175
City RT. 1, BOX 477 CHICO, CA 95926 Zip
License No. ___ Date of this report

23N/1E-17

Do Not Fill In

№ 114310

State Well No.

Other CONFIDENTIAL LOG Water Code Sec. 13752

ORIGINAL
File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

(1) OWNER:

(2) LOCATION OF WELL:

County: Butte — Owner's number, if any:

Township, Range, and Section: T22N R1E Sec 17

Distance from cities, roads, railroads, etc.: 574 Feet South [illegible] 200 Feet E [illegible]

(3) TYPE OF WORK (check):

New Well ☒ Deepening ☐ Reconditioning ☐ Destroying ☐

If destruction, describe material and procedure in Item 11.

(4) PROPOSED USE (check):

Domestic ☒ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(5) EQUIPMENT:

Rotary ☐
Cable ☒
Other ☐

(6) CASING INSTALLED:

STEEL: OTHER:
SINGLE ☒ DOUBLE ☐

From ft.	To ft.	Diam.	Gage or Wall	If gravel packed: Diameter of Bore	From ft.	To ft.
0	70	8"	12Ga.			

Size of shoe or well ring: 8x6x1/2 — Size of gravel:

Describe joint: Elect Butt Weld 8x24x1/4 B.U.

(7) PERFORATIONS OR SCREEN:

Type of perforation or name of screen

From ft.	To ft.	Perf. per row	Rows per ft.	Size in. x in.

(8) CONSTRUCTION:

Was a surface sanitary seal provided? Yes ☒ No ☐ To what depth 50 ft.

Were any strata sealed against pollution? Yes ☐ No ☐ If yes, note depth of strata

From ft. to ft.

From ft. to ft.

Method of sealing: Puddled Clay

(9) WATER LEVELS:

Depth at which water was first found, if known: 91 ft.

Standing level before perforating, if known: ft.

Standing level after perforating and developing: 70 ft.

(10) WELL TESTS:

Was pump test made? Yes ☒ No ☐ If yes, by whom? Bailer

Yield: 30 gal./min. with 0 ft. drawdown after hrs.

Temperature of water — Was a chemical analysis made? Yes ☐ No ☐

Was electric log made of well? Yes ☐ No ☐ If yes, attach copy

(11) WELL LOG:

Total depth 165 ft. Depth of completed well 165 ft.

Formation: *Describe by color, character, size of material, and structure* — ft. to ft.

0--2 Light Rocky Soil
2--21 Hard Pan & Large Rocks
21--34 Yellow Clay
34--63 Coarse Sand & Gravel
63--91 Hard sticky brown clay
91--113 Sandstone
113--127 Coarse sand
127--164 Coarse sand & brown clay
164--165 Coarse sand & gravel

CONFIDENTIAL LOG
Water Code Sec. 13752

Work started 3/15 19 , Completed 3/23/76

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME J. C. Plummer & Co
(Person, firm, or corporation) *(Typed or printed)*

Address 541 West 11 th St.
Chico, Calif

[SIGNED]
(Well Driller)

License No. 279572 Dated 3/31/76, 19

SKETCH LOCATION OF WELL ON REVERSE SIDE

DWR 188 (REV. 9-66)

67199-790 8-72 30M TRIP OSP

ORIGINAL
File Original, Duplicate and Triplicate with the
REGIONAL WATER POLLUTION
CONTROL BOARD No.______
(Insert appropriate number)

WATER WELL DRILLERS REPORT

(Sections 7076, 7077, 7078, Water Code)

STATE OF CALIFORNIA

LOCATION NOT CHECKED
Do Not Fill In
Nº 63043
State Well No.______
Other Well No. 23N/1E-30 19

(1) OWNER:

(2) LOCATION OF WELL:
County Butte Owner's number, if any—
R. F. D. or Street No.
T.23 N. R.1E Sec ~~30~~ 19

(3) TYPE OF WORK (check):
New well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 11.

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☒ Test Well ☐ Other ☐

(5) EQUIPMENT:
Rotary ☐
Cable ☒
Dug Well ☐

(6) CASING INSTALLED:
SINGLE ☒ DOUBLE ☐

From	to	Diam.	Gage or Wall
0 ft.	100 ft.	14	10

If gravel packed: Diameter of Bore ___ from ___ ft. to ___ ft.

Type and size of shoe or well ring 1-14" Shoe
Size of gravel:
Describe joint

(7) PERFORATIONS:
Type of perforator used none
Size of perforations ___ in., length, by ___ in.
From ___ ft. to ___ ft. Perf. per row ___ Rows per ft. ___

(8) CONSTRUCTION:
Was a surface sanitary seal provided? ☐ Yes ☒ No To what depth ___ ft.
Were any strata sealed against pollution? ☐ Yes ☒ No If yes, note depth of strata
From ___ ft. to ___ ft.
Method of Sealing

(9) WATER LEVELS:
Depth at which water was first found 32 ft.
Standing level before perforating ___ ft.
Standing level after perforating ___ ft.

(10) WELL TESTS:
Was a pump test made? ☐ Yes ☐ No If yes, by whom?
Yield: 1420 gal./min. with 231 ft. draw down after ___ hrs.
Temperature of water ___ Was a chemical analysis made? ☐ Yes ☒ No
Was electric log made of well? ☐ Yes ☒ No

(11) WELL LOG:
Total depth 568 ft. Depth of completed well ___ ft.
Formation: Describe by color, character, size of material, and structure.

CONFIDENTIAL LOG Water Code Sec. 13752

From (ft.)	To (ft.)	Formation
0	3	Soil
3	12	Hard Pan
12	30	Gravel
30	47	Clay
47	58	Gravel
58	74	Clay
74	80	Gravel
80	90	Clay
90	95	Gravel
95	155	Clay
155	169	Lava
169	290	Clay
290	310	Lava
310	325	Clay
325	332	Lava
332	345	Hard Pan
345	360	Lava
360	390	Clay
390	410	Hard Pan
410	435	Gravel Cement
435	475	Lava
475	484	Gravel Cement
484	495	Sand stone
495	540	Hard pan
540	560	Gravel
560	568	Sand & Gravel

CONFIDENTIAL
Section 7076.1, Water Code

Work started Mar 21, 1959 Completed Apr. 16, 1959

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Lassen Pump & Motor Works
(Person, firm, or corporation) (Typed or printed)
Address P. O. Box 964
Chico, California

[Signed] *(signature)*
Well Driller
License No. 59223 / 457 Dated June 15, 1959

DWR 188 (REV. 5-54)

DUPLICATE
~~Driller's Copy~~ DWR
Page ____ of ____

Owner's Well No. 1 JUL 0 1999

Date Work Began 6-27-99, Ended 6-28-99

Local Permit Agency Butte

Permit No. 269614 Permit Date 6-1-99

RECEIVED

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 518070

DWR USE ONLY — DO NOT FILL IN
23N/01E-20M
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ✓ VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER 80 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain size, color, etc.
0	2	Soil
2	4	Hard Pan - Cemented
4	20	Hard Pan
20	30	Gravel
30	80	Cobble + Clay
80	85	Gravel
85	160	Red Clay + Cobble
160	180	Sand + Gravel

TOTAL DEPTH OF BORING 180 (Feet)

TOTAL DEPTH OF COMPLETED WELL 180 (Feet)

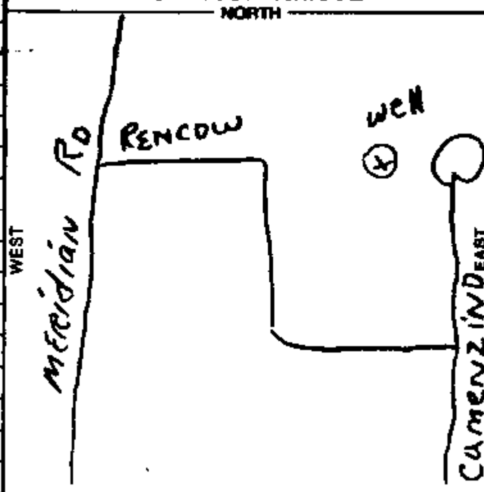
WELL OWNER

WELL LOCATION

Address Camenzind Ct.
City Chico
County Butte
APN Book 047 Page 220 Parcel 096
Township 23N Range 01E Section 20
Latitude ___ DEG. MIN. SEC. NORTH Longitude ___ DEG. MIN. SEC. WEST

LOCATION SKETCH

NORTH



WEST EAST

SOUTH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

✓ NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

___ MONITORING
WATER SUPPLY
✓ Domestic
___ Public
___ Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Air

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 75 (Ft.) & DATE MEASURED 6-28-99

ESTIMATED YIELD* 50 (GPM) & TEST TYPE Air Lift

TEST LENGTH 2 (Hrs.) TOTAL DRAWDOWN ____ (Ft.)

* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	100	9.00	✓				PVC	5.00	CL 200	
100	180	9.00		✓			PVC	5.00	CL 200	.032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	45	✓			
45	180				3/8 Gravel

JUL 14 1999

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ____

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Earl Watson Well Drilling
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

8015 Cohasset Rd. Chico Ca 95973
ADDRESS CITY STATE ZIP

Signed Earl Watson 7-1-99 409780
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

ORIGINAL
File with DWR
Page 1 of 1
Owner's Well No. 67
Date Work Began 11-24-03, Ended 11-26-03
Local Permit Agency BUTTE CO. HEALTH DEPT.
Permit No. 384252 Permit Date 07-29-03

JAN 02 2004

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 752066

DWR USE ONLY — DO NOT FILL IN
23N/01E-20M
STATE WELL NO./STATION NO.
LATITUDE | LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ✓ VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DRILLING METHOD MUD ROTARY FLUID BENTONITE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain size, color, etc.
0	15	COBBLES
15	150	LAVA, CLAY AND GRAVEL
150	165	LAVA
165	250	LAVA AND CLAY

TOTAL DEPTH OF BORING 250 (Feet)
TOTAL DEPTH OF COMPLETED WELL 250 (Feet)

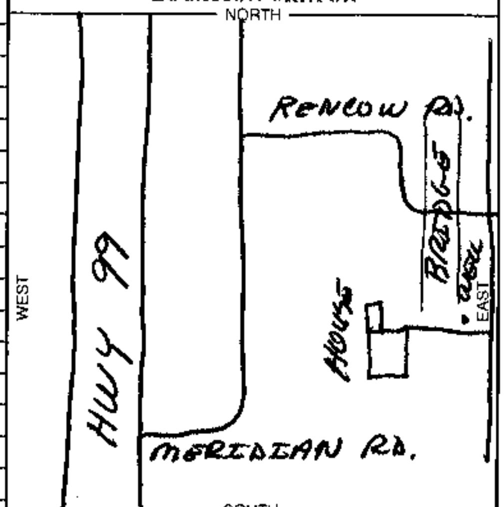
WELL OWNER

N
M
CITY STATE ZIP

WELL LOCATION

Address 14577 CAMENZIND
City CHICO
County BUTTE
APN Book 047 Page 220 Parcel 100
Township 23N Range 01E Section 20
Latitude ___ NORTH DEG. MIN. SEC. Longitude ___ WEST DEG. MIN. SEC.

LOCATION SKETCH



Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. ***PLEASE BE ACCURATE & COMPLETE.***

ACTIVITY (✓)

✓ NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

PLANNED USES (✓)

WATER SUPPLY
✓ Domestic ___ Public
___ Irrigation ___ Industrial
MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 80 (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 80 (Ft.) & DATE MEASURED 11-26-03
ESTIMATED YIELD * 150 (GPM) & TEST TYPE AIR LIFT
TEST LENGTH 1 (Hrs.) TOTAL DRAWDOWN N/A (Ft.)
** May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	150	12"	✓				P.V.C.	6"	CL.200	N/A
150	250	12"		✓			P.V.C.	6"	CL.200	.032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	40	✓			7 SACK
40	250				3/8" PEA GRAVEL

JAN 23

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME NORTH STATE DRILLING
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

#6 FREIGHT LN. CHICO CA. 95973
ADDRESS CITY STATE ZIP

Signed [signature] 12-12-03 812678
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

ORIGINAL
File with DWR

Page 1 of 1

JUL 25 2017

Owner's Well No.

Date Work Began 11-10-16, Ended 11-11-16

Local Permit Agency Butte County Health Dept

Permit No. EHWS16-0100 Permit Date 8-5-16

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 0996590

DWR USE ONLY — DO NOT FILL IN

23N/01W+13

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD Air Rotary FLUID O-Foam

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION (Describe material, grain size, color, etc.)
0	8	Clay & Rock
8	45	Clay
45	53	Gravel & Rock
53	200	Sandstone with Seams of Cemented Gravel

TOTAL DEPTH OF BORING ______ (Feet)

TOTAL DEPTH OF COMPLETED WELL 200 (Feet)

WELL OWNER

WELL LOCATION

Address Will "T" Road

City Chico

County Butte

APN Book 047 Page 100 Parcel 085 202

Township ___ Range ___ Section ___

Lat ___ DEG. MIN. SEC. N Long ___ DEG. MIN. SEC. W

LOCATION SKETCH

NORTH / SOUTH / WEST / EAST

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

XX NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

USES (✓)

WATER SUPPLY
XX Domestic ___ Public
___ Irrigation ___ Industrial

MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER ______ (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 58 (Ft.) & DATE MEASURED 11-11-16

ESTIMATED YIELD * 100+ (GPM) & TEST TYPE Air Lift

TEST LENGTH ______ (Hrs.) TOTAL DRAWDOWN ______ (Ft.)

* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	160	6-5/8					Steel	6	.188	
160	200						PVC	4	Liner	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	24		XX		

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ______

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME W. S. Heitman Drilling (PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

ADDRESS P. O. Box 1010, Red Bluff, CA 96080 CITY STATE ZIP

Signed W S Heitman Co (C-57 LICENSED WATER WELL CONTRACTOR) DATE SIGNED 11-15-16 C-57 LICENSE NUMBER 386577

State of California

Well Completion Report

Form DWR 188 Auto-Completed 10/14/2019
WCR2019-011330

Owner's Well Number ______ Date Work Began 07/17/2019 Date Work Ended 08/13/2019

Local Permit Agency Butte County Public Health

Secondary Permit Agency ______ Permit Number EHWL 19-0009 Permit Date 08/01/2019

Well Owner (must remain confidential pursuant to Water Code 13752)

Name XXXXXXXXXXXXXXXXXXXX

Mailing Address XXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXX

City XXXXXXXXXXXXXXXXXXXX State XX Zip XXXXX

Planned Use and Activity

Activity New Well

Planned Use Water Supply Irrigation - Agriculture

Well Location

Address

City Zip County Butte

Latitude 39 Deg. 49 Min. 32.5199 Sec. N Longitude -121 Deg. 55 Min. 27.12 Sec. W

Dec. Lat. 39.8257 Dec. Long. -121.9242

Vertical Datum Horizontal Datum WGS84

Location Accuracy Location Determination Method

APN 047.100.200

Township 23 N

Range 01 W

Section 25

Baseline Meridian Mount Diablo

Ground Surface Elevation

Elevation Accuracy

Elevation Determination Method

Borehole Information

Orientation Vertical Specify

Drilling Method Other - Reverse Rotary Drilling Fluid Bentonite

Total Depth of Boring 770 Feet

Total Depth of Completed Well 770 Feet

Water Level and Yield of Completed Well

Depth to first water ______ (Feet below surface)

Depth to Static Water Level 55 (Feet) Date Measured 08/13/2019

Estimated Yield* ______ (GPM) Test Type

Test Length ______ (Hours) Total Drawdown ______ (feet)

*May not be representative of a well's long term yield.

Geologic Log - Free Form

Depth from Surface Feet to Feet		Description
0	12	clay
12	45	volcanics with gavel
45	55	clay
55	60	gravel
60	97	clay
97	138	volcanic gravel
138	155	clay
155	177	gravel
177	440	clay
440	465	gravel
465	508	clay
508	600	gravel
600	770	volcanics

Casings

Casing #	Depth from Surface Feet to Feet		Casing Type	Material	Casings Specificatons	Wall Thickness (inches)	Outside Diameter (inches)	Screen Type	Slot Size if any (inches)	Description
1	0	420	Blank	PVC	OD: 17.400 in. | SDR: 17 | Thickness: 1.024 in.	1.024	17.4			
1	420	480	Screen	PVC	OD: 17.400 in. | SDR: 17 | Thickness: 1.024 in.	1.024	17.4	Milled Slots	0.05	
1	480	500	Blank	PVC	OD: 17.400 in. | SDR: 17 | Thickness: 1.024 in.	1.024	17.4			
1	500	770	Screen	PVC	OD: 17.400 in. | SDR: 17 | Thickness: 1.024 in.	1.024	17.4	Milled Slots	0.05	

Annular Material

Depth from Surface Feet to Feet		Fill	Fill Type Details	Filter Pack Size	Description
0	50	Cement	10.3 Sack Mix		
50	770	Filter Pack	6 x 16	6 x 16 and 6 x 12 mix	

Other Observations:

Borehole Specifications

Depth from Surface Feet to Feet		Borehole Diameter (inches)
0	770	28

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name SULLIVAN DRILLING INC
Person, Firm or Corporation

P O BOX 1227 — Address
ORLAND — City
CA — State
95963 — Zip

Signed *electronic signature received* — C-57 Licensed Water Well Contractor
08/13/2019 — Date Signed
656504 — C-57 License Number

DWR Use Only

CSG #	State Well Number	Site Code	Local Well Number

				N

Latitude Deg/Min/Sec

				W

Longitude Deg/Min/Sec

TRS:

APN:

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. e0326441

Page 1 of 1 FEB 2 7 2017

Owner's Well Number ______

Date Work Began 10/05/2016 Date Work Ended 10/13/2016

Local Permit Agency Butte County Public Health

Permit Number EHWL 16-0012 Permit Date 6/20/16

DWR Use Only – Do Not Fill In

23N/01W-30

State Well Number/Site Number

N Latitude W Longitude

APN/TRS/Other

Geologic Log

Orientation ◉ Vertical ○ Horizontal ○ Angle Specify ______

Drilling Method Direct Rotary Drilling Fluid Bentonite mud

Depth from Surface Feet to	Feet	Description (Describe material, grain size, color, etc)
0	3	clay
3	18	rock
18	38	clay
38	42	gravel
42	176	clay
176	185	gravel
185	187	clay and fractured clay
187	196	gravel 192 Hard
196	240	clay and fractured clay
240	246	gravel
246	330	clay
330	335	gravel
335	555	clay
555	650	black gravel
650	692	clay
692	740	black gravel

Total Depth of Boring 740 Feet

Total Depth of Completed Well 270 Feet

Well Owner

Well Location

Address 4684 Kilkare Lane

City Chico County Butte

Latitude ___ Deg. ___ Min. ___ Sec. N Longitude ___ Deg. ___ Min. ___ Sec. W

Datum ______ Dec. Lat. ______ Dec. Long. ______

APN Book 047 Page 330 Parcel 010

Township ______ Range ______ Section ______

Location Sketch

(Sketch must be drawn by hand after form is printed.)

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

◉ New Well

○ Modification/Repair

○ Deepen

○ Other ______

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

◉ Water Supply

☐ Domestic ☐ Public

☑ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

○ Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other ______

Water Level and Yield of Completed Well

Depth to first water ______ (Feet below surface)

Depth to Static Water Level 50 (Feet) Date Measured 10/13/2016

Estimated Yield * ______ (GPM) Test Type ______

Test Length ______ (Hours) Total Drawdown ______ (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet to	Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	160	20	Blank	PVC	SDR-21	10		
160	200	20	Screen	PVC	SDR-21	10	Milled Slots	0.050
200	240	20	Blank	PVC	SDR-21	10		
240	270	20	Fill pipe	PVC	SDR-21	10	Milled Slots	0.050

Annular Material

Depth from Surface Feet to	Feet	Fill	Description
0	20	Bentonite	3/8" chips
20	270	Filter Pack	6 x 16 sand

Attachments

☐ Geologic Log

☐ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other ______

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name Sullivan Drilling, Inc.

Person, Firm or Corporation

6458 County Rd 25 Orland CA 95963

Address City State Zip

Signed [signature] 10/19/2016 656504

C-57 Licensed Water Well Contractor Date Signed C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

APPENDIX B

Rock Sand Filed Visit 06062023

06/06/2023


TH002725.JPG
1: 24 15 CMP


TH002726.JPG
2: erosion 8 x 10 x 12


TH002727.JPG
3: channel 12 ft wide 1 ft deep


TH002728.JPG
4: looking DS


TH002729.JPG
5: looking US


TH002730.JPG
6: ROAD 4 ft above scour hole inv

Rock Sand Filed Visit 06062023

06/06/2023

TH002731.JPG
7: ROAD 4 ft above scour hole inv

TH002732.JPG
8: US PIPE 15 24

TH002733.JPG
9: LOOKING US

TH002734.JPG
10: 24 CMP

TH002735.JPG
11: scour hole 7 x 10 x 6

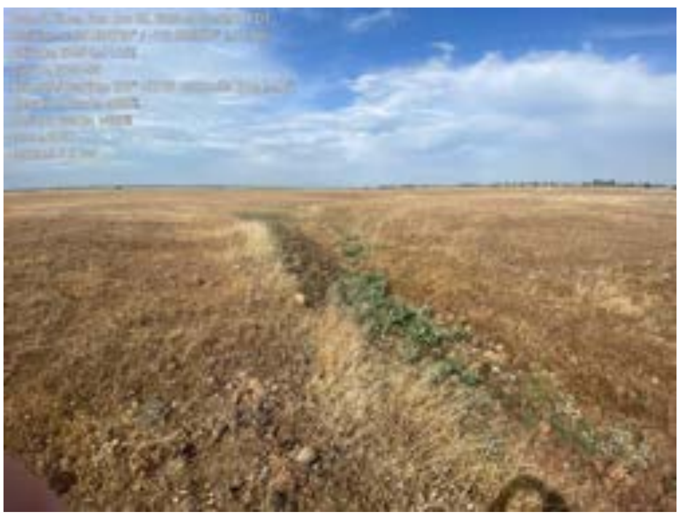
TH002736.JPG
12: road 4 ft above pipe inv

Rock Sand Filed Visit 06062023

06/06/2023

TH002737.JPG
13: overflow around pipe

TH002738.JPG
14: channel constriction



TH002739.JPG
15: channel 4 ft bw

TH002740.JPG
16: looking US

TH002741.JPG
17: looking DS 6 12 in rock

TH002742.JPG
18: looking US

Rock Sand Filed Visit 06062023

WOOD RODGERS

06/06/2023

TH002743.JPG
19: US CULV

TH002744.JPG
20: US CULV

TH002745.JPG
21: DS CULV

TH002746.JPG
22: 15 CULV

TH002747.JPG
23: bridge

TH002748.JPG
24: 20 in scour

Rock Sand Filed Visit 06062023

06/06/2023


TH002749.JPG
25: bridge scour


TH002750.JPG
26: bridge scour


TH002751.JPG
27: bridge scour


TH002752.JPG
28: bridge scour


TH002753.JPG
29: bridge scour


TH002754.JPG
30: bridge scour

Rock Sand Filed Visit 06062023

WOOD RODGERS

06/06/2023


TH002755.JPG
31: 20 ft wide bw us bridge


TH002756.JPG
32: 16 ft between pier and abutment on right


TH002757.JPG
33: from 10 ft deep scour hole


TH002758.JPG
34: from 10 ft deep scour hole


TH002759.JPG
35: from 10 ft deep scour hole


TH002760.JPG
36: from 10 ft deep scour hole

Rock Sand Filed Visit 06062023

WOOD RODGERS

06/06/2023

TH002761.JPG
37: from 10 ft deep scour hole

TH002762.JPG
38: 10 ft deep scour hole

TH002763.JPG
39: 10 ft deep scour hole

TH002764.JPG
40: 10 ft deep scour hole

TH002765.JPG
41: wide channel with deposition

TH002766.JPG
42: 1 ft erosion

Rock Sand Filed Visit 06062023

06/06/2023

TH002767.JPG
43: 3 ft deep erosion

TH002768.JPG
44: 3 ft deep erosion

TH002769.JPG
45: 3 ft deep erosion

TH002770.JPG
46: 3 ft deep erosion

TH002771.JPG
47:

TH002772.JPG
48: 5 ft deep erosion

Rock Sand Filed Visit 06062023

06/06/2023

TH002773.JPG
49: 5 ft deep erosion

TH002774.JPG
50: erosion at bend

TH002775.JPG
51: erosion at bend

TH002776.JPG
52: erosion at bend

TH002777.JPG
53: erosion at bend 3 ft

TH002778.JPG
54: back to natural channel

Rock Sand Filed Visit 06062023

06/06/2023


TH002779.JPG
55: constricted channel


TH002780.JPG
56: erosion


TH002781.JPG
57: scour 4 ft


TH002782.JPG
58: scour 4 ft


TH002783.JPG
59: erosion 3 ft


TH002784.JPG
60: erosion 3 ft

Rock Sand Filed Visit 06062023

WOOD RODGERS

06/06/2023

TH002785.JPG
61: erosion 3 ft

TH002786.JPG
62: erosion 3 ft

TH002787.JPG
63: erosion 3 ft old

TH002788.JPG
64: erosion 3 ft

TH002789.JPG
65: channel

TH002790.JPG
66: excavated material

Rock Sand Filed Visit 06062023

06/06/2023

TH002791.JPG
67: erosion

TH002792.JPG
68: black rock evaporation

TH002793.JPG
69: scour 12 ft deep from bank

TH002794.JPG
70: from top opposite bank

TH002795.JPG
71: from top opposite bank

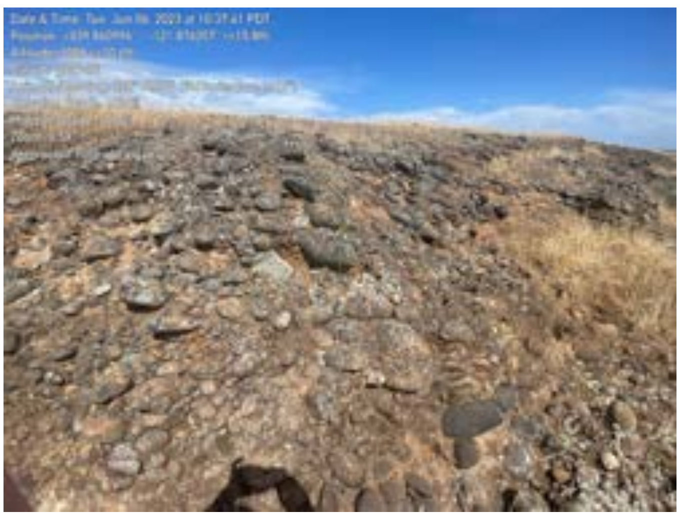
TH002796.JPG
72: deep scour hole

Rock Sand Filed Visit 06062023

06/06/2023

TH002797.JPG
73: deep scour hole

TH002798.JPG
74: deep scour hole



TH002799.JPG
75: deep scour hole old algae

TH002800.JPG
76: deep scour hole old algae veg

TH002801.JPG
77: deep scour hole

TH002802.JPG
78: channel split

Rock Sand Filed Visit 06062023

WOOD RODGERS

06/06/2023

TH002803.JPG

79: erosion of bank

TH002804.JPG

80: erosion of bank

TH002805.JPG

81: natural channel

TH002806.JPG

82: natural channel 50 wide

TH002807.JPG

83: rock

TH002808.JPG

84: bank erosion 3 ft chnl 15 wide

Rock Sand Filed Visit 06062023

WOOD RODGERS

06/06/2023


TH002809.JPG
85: bank erosion 3 ft chnl 20 wide


TH002810.JPG
86: heavy deposition chnl 40 wide


TH002811.JPG
87: bank erosion channel 20 wide


TH002812.JPG
88: bank erosion channel 10 wide


TH002813.JPG
89: bank erosion channel 10 wide


TH002814.JPG
90: left path overflow us bank

Rock Sand Filed Visit 06062023

06/06/2023

TH002815.JPG
91: left path overflow end note deposition

TH002816.JPG
92: left path overflow end note deposition

TH002817.JPG
93: channel 35 wide smaller rocks faster flow

TH002818.JPG
94: 20 channel 1 deep

TH002819.JPG
95: wide shallow channel no erosion

TH002820.JPG
96: bank erosion evaporation

Rock Sand Filed Visit 06062023

WOOD RODGERS

06/06/2023

TH002821.JPG
97: bank erosion evaporation chnl 20 wide

TH002822.JPG
98: heavier deposits chnl 50 wide

TH002823.JPG
99: bridge

TH002824.JPG
100: exist basin

TH002825.JPG
101: exist basin

TH002826.JPG
102: exist basin

Rock Sand Filed Visit 06062023

06/06/2023


TH002827.JPG
103: exist basin us trib


TH002828.JPG
104: erosion old 2 ft


TH002829.JPG
105: meandering channel

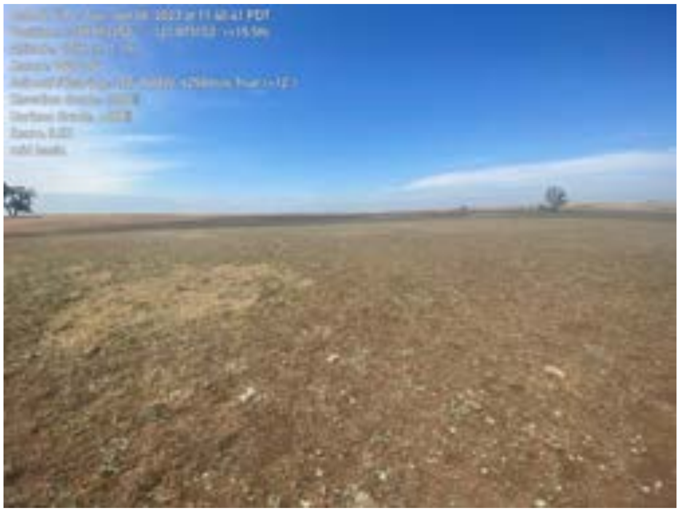

TH002830.JPG
106: meandering channel 10 wide 1 deep


TH002831.JPG
107: meandering channel 10 wide 1 5 deep


TH002832.JPG
108: low point no veg

Rock Sand Filed Visit 06062023

06/06/2023


TH002833.JPG
109: mid basin


TH002834.JPG
110: 12 wide channel leaves


TH002835.JPG
111: 12 wide channel leaves fine material


TH002836.JPG
112: low point ds dam fine material no veg


TH002837.JPG
113: erosion control spillway


TH002838.JPG
114: erosion control spillway fail

APPENDIX C

WOOD RODGERS

September 1, 2023 Job No. 8874.001

Subject: Rock Creek Reclamation District – Flood and Recharge Rock and Sand Creek Flood Mitigation Project

Basin description

The Vina Subbasin is situated in the eastern-central part of the Sacramento Groundwater Basin. It is bounded to the north by Deer Creek, to the west by the Sacramento River, to the south by Big Chico Creek, and to the east by the Chico Monocline. Los Molinos, Corning, and Butte Subbasins, lie to the north, west, and south, respectively. Surface water flows from the Rock Creek and Big Chico Creek and flows southwest from the Sierra Nevada Mountains towards the Sacramento River. Several smaller creeks and ephemeral streams also flow southwest near the project area, including Rock Creek and Keefer Slough. Two ephemeral stream channels traverse the project area and flow southwest with a gradient between one to two percent. The two ephemeral streams confluence into one ephemeral stream and then into Rock Creek. The Chico Monocline acts as a geographic boundary and surface water and groundwater are able to flow from the east.

Groundwater-bearing formations in this region are composed of Tertiary to late Quaternary age continental sediments of the Tehama Formation on the west side of the Sacramento Valley, and the Tuscan Formation on the east-side. The Tuscan Formation is the primary water-bearing formation underlying the project site. The continental formations mark the extent of water-bearing units. The depth ranges of the continental formation are generally from 800 to 1,200 feet below the ground surface (bgs) (VGS GSP 2021).

The Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers (California Department of Water Resources [DWR], 2003). The thickness of the Tuscan Formation reaches approximately 1,250 feet towards the center of the Valley. The geologic formations in the project area generally dip between 2 and 20 degrees to the southwest from the valley towards the Chico Monocline (DWR 2003).The Tuscan Formation is further divided into four separate stratigraphic units (A through D) with tuff or ash separating the different units in some areas (Helley and Harwood 1985). Units A, B, and C reside within the Vina Subbasin (**Table 1**). Each unit is composed of interbedded lahar deposits, volcanic conglomerate, tuffaceous sandstone, volcanic sandstone, and siltstone to varying degrees. Unit C is the shallowest unit in the study area and is overlain with younger alluvial fan deposits.

Near the project area, geologic formations with limited water-bearing capacity include Holocene age younger stream channel and alluvial fan deposits and Pleistocene age deposits, including the Modesto, and Red Bluff Formations (**See Figure 1**). Holocene age stream channel and alluvial fan deposits consist of unconsolidated gravel, sand, silt and clay from the erosion and deposition of the upgradient Tertiary volcanic flow and quaternary stream terrace alluvial deposits. Pleistocene age Modesto Formation deposits consists of unconsolidated, unweathered gravel, sand silt, and clay. Pleistocene age Red Bluff Formation consists of a thin veneer of distinctive, highly weathered bright-red gravels (Halley and Harwood 1985).

Table 1: Stratigraphy and Hydrostratigraphy Beneath the Project Area

AGE	***FORMATION***	***AQUIFER***
Holocene	Alluvium	Stream Channel and alluvial fan Deposits
Pleistocene	Modesto	Unconfined
	Red Bluff	Unconfined
Upper Pliocene	Tuscan	Unit C
		Unit B
		Unit A

Understanding the general structure and composition of the subsurface geologic formations will aide in the understanding of the potential pathway for recharged water to move within the subsurface. In 2018, DWR conducted its Airborne Electromagnetic (AEM) geophysical survey of the Vina Subbasin and the vicinity of the project area,. The AEM survey utilizes an airborne geophysical technology to map depth-specific subsurface conditions by measuring variations in the electrical conductivity and resistivity of the subsurface to depths of approximately 1,000 feet. The vertical resolution varies with depth, with the ability to delineate approximately five to 10 foot thick geologic layers in the shallow subsurface, and a minimum of100 foot thick geologic layers at greater depths. Wood Rodgers utilized the DWR AEM data to create geologic cross-sections which provide a generalization of the subsurface conditions up to a depth of approximately 1,000 feet. In conjunction with the AEM data, lithologic data from domestic and irrigation wells drilled within a 2-mile radius of the project area were used to further understand the subsurface conditions. The lithologic logs from the project area are provided on DWR Well Completion Reports (WCR), which were obtained from the DWR Sustainable Groundwater Management Act (SGMA) Data Viewer website (DWR 2023) and are included in **Attachment A**.

To understand the possible hydraulic connection between the surface soils and subsurface, Wood Rodgers utilized the University of California, Davis Soil Agricultural Groundwater Banking Index (SAGBI) data. The data correlates a suitability index of soil type for groundwater recharge projects with a goal to develop a rating system that could be used to assess the suitability of an area to accommodate recharge activities while maintaining healthy soils. SAGBI data of the project area shows that the younger alluvium which consists of the upper part of the unconfined zone of the aquifer system has a rating ranging from Poor to Good.

Subsurface Geologic and Hydrogeologic Conditions

The proposed recharge basins E1, E2, D1, and D2 are generally located in an area with a higher SAGBI index rating and located in the Redsluff series soil type (**See Figure 2**). The Redsluff series is described by the United States Department of Agriculture (USDA) as very deep, moderately well drained soils that formed in overbank alluvium over channel alluvium from predominantly volcanic rocks. The soil is described as gravelly loam, on a less than 2 percent slope. The drainage and permeability of the Redsluff series is considered moderate. The hydraulic conductivity of the topsoil increases with depth to 80 inches bgs.

Two proposed recharge basins, J1 and J2, are in an area with a lower SAGBI index rating and located in the Wafap series soil type. The Wafap series is described by the USDA as deep, relatively poorly drained soils that formed in the alluvium from volcanic rocks. The soil is described as gravelly loam. The drainage and permeability of the Wafap series is considered poor. The hydraulic conductivity in the topsoil and decreases with depth to 42 inches bgs.

DWR WCRs from domestic and irrigation wells drilled within 2-miles of the project area (**Table 2**) indicate that the soil from ground surface to approximately 20 feet bgs consists of mixed fine and coarse cemented soils that include clay and interbedded gravel, cobbles, and clay soils until volcanic deposits are encountered between 85 and 155 feet bgs. The volcanic deposits, and red/brown clay as described in the available WCRs are presumed to be the upper portion of Unit C of the Tuscan Formation and the threshold between the upper unconfined aquifers and the shallowest portion of the water-bearing formations. The subsurface geologic conditions vary in composition between well sites due to the location of the wells along the alluvial fan and the varying soil descriptions used by the drillers in the WCRs.

Table 2: Wells Drilled Within 2-miles of the Project Area with DWR WCR Lithology Data

Well Name (WCR No.)	*Well Type*	*Total Depth of Well Log (feet bgs)*	*Top of Screen (feet bgs)*	*Bottom of Screen (feet bgs)*
518070	Domestic	180	100	180
752066	Domestic	250	150	250
63043	Irrigation	568	-	-
101853	Domestic	230	-	-
114310	Domestic	165	-	-
E0326441	Irrigation	740	160	270
2019-011330	Irrigation	770	420	770
0996590	Domestic	200	160	200

Generally, the interbedded clays, cobbles, and gravel are indicative of colluvium from the Tuscan Formation and stream terrace alluvial deposits. The lithology data from the WCRs correlates with Cross Section A-A' and B-B' (Figures 3 and 4) from the AEM survey in relation to the relative thickness of the unconfined alluvial deposits. The younger alluvial fan deposits are reported to generally be between 10 and 80 feet in thickness and approximately 60 feet thick near the project area according to the AEM survey.

Cross-section A-A' is located downgradient of groundwater flow from the proposed recharge basins and cross-section B-B' is located upgradient of groundwater flow from the proposed recharge basins. Cross-section A-A' (**Figure 3**) is located southwest of the proposed recharge basins and displays mixed fine and coarse grain material up to approximately 330 ft bgs and comprises the shallower aquifer. Beneath the shallow aquifer in the area is 80 to 160 feet of less permeable fines or clay. Below the clay layer is up to 650 feet of coarse-grained material that comprises the deep aquifer. The hydraulic communication between the upper and lower aquifer in this area is likely to be low but would require further study to quantitate. Cross-section B-B' (**Figure 4**) is located northeast of the proposed recharge basins and displays a thin layer of fine-grained material or clay at the surface up to approximately 30 feet in thickness with up to approximately 30 feet of fine and coarse material below. Coarse grained material is displayed from approximately 60 feet bgs to 500 ft bgs. The AEM data indicates a thickness range of permeable soil in the unsaturated zone between 65 to 143 feet depending on the site-specific subsurface geologic conditions and seasonal fluctuations of groundwater. The geologic formations in the subsurface structurally dip towards the center of the valley to the southwest and generally in the same direction as groundwater flow. Surface water placed in the proposed recharge basins and subsequently infiltrated into the subsurface will likely follow the structural dip of the geologic formation and groundwater flow.

Groundwater Conditions

Groundwater levels in the vicinity of the project area have been declining since the year 2000 (DWR 2023). Groundwater movement is generally to the southwest in the project area. There is no significant change in groundwater direction between fall and spring with groundwater flow bearing 187 degrees in the fall and 210 degrees in the spring with a calculated gradient between 0.13 to 0.14 percent. Water level data from WCR No. 215535, located approximately 2.5 miles west of the project area, shows that over the period of record the average groundwater elevation is 149.5 feet msl (41.4 feet bgs) with seasonal fluctuations ranging from 164.5 to 135.9 ft msl (26.9 to 55.5 feet bgs). The depth to water beneath the proposed recharge basins, based on an average ground surface elevation of 229 feet msl, is estimated to be between 65 and 93 feet bgs over the period of record.

Historical groundwater levels within a 2-mile radius of the project area are illustrated in hydrographs prepared for select wells monitored by DWR in the project area and are shown in **Figure 5** and include seasonal elevation contours from Fall 2022. Groundwater elevations in Fall 2022 were between 150 and 140 feet mean sea level (msl) or approximately 75 to 95 feet bgs near the project area. The hydrographs display groundwater elevation trends within the upper unconfined aquifer (WCR No. 215535, WCR No. 57344, and WCR No. 265103) and the deeper confined aquifer of the Tuscan formation in two deeper wells (WCR No. 513092 and WCR No.

4060). Historical data from hydrographs of the wells within the upper unconfined aquifer exhibit relatively stable groundwater elevations since the early 1990s. Since approximately the year 2000, groundwater elevations began a steady decline with 10 feet of decline from 2000 to 2011 in WCR 57344 and 20 feet of decline from 2000 to 2023 in WCR 265103 and WCR 215535. WCR 393242 has limited historical groundwater elevations with data going back to 2018. The groundwater elevations in WCR 393242 are stable with minor seasonal fluctuations. Data from the WCR 4060 hydrograph exhibits stable groundwater elevations from the mid-1970s to late 2011. Historical data from the WCR 513092 exhibits higher seasonal fluctuations and a steeper decline in groundwater elevation than the other hydrographs from mid-2007 to mid-2023.

The data indicates the available storage capacity in the unsaturated portion of the subsurface ranges from 60 to 90 feet. Recharged water will likely infiltrate vertically until it reaches the saturated portion of the upper aquifer or an impermeable geologic layer, which will likely be the fine-grained material or clay found at depths between 300 feet and 350 feet bgs.

Conclusions

The subsurface data reviewed indicate permeable material likely exists to depths ranging from 300 feet to 350 feet bgs underlying the project site. Applied water is anticipated to migrate vertically into the subsurface to a depth between 60 and 90 feet, where it is reasonable to anticipate the water will flow horizontally following both the regional dip of the geologic formations, or where saturated, the general groundwater gradient. The dip of the geologic formations and groundwater elevation contours suggest that groundwater will likely flow towards the west to southwest away from the project site.

References

California Department of Water Resources (DWR, 2003). Sacramento Valley Groundwater Basin, Vina Subbasin. Bulletin 118. 2004.

DWR SGMA Data Viewer for groundwater level and land subsidence data (DWR, 2023), accessed August 2023 https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#currentconditions.

Helley, E.J., and D.S Harwood (Helley and Harwood 1985). Geologic Map of the Late Cenozoic Deposits of the Sacramento Valley and Northern Sierran Foothills, 1985

Vina Groundwater Subbasin Groundwater Sustainability Plan (VGS GSP 2021) Vina and Rock Creek Reclamation District Groundwater Sustainability Agencies, December 2021

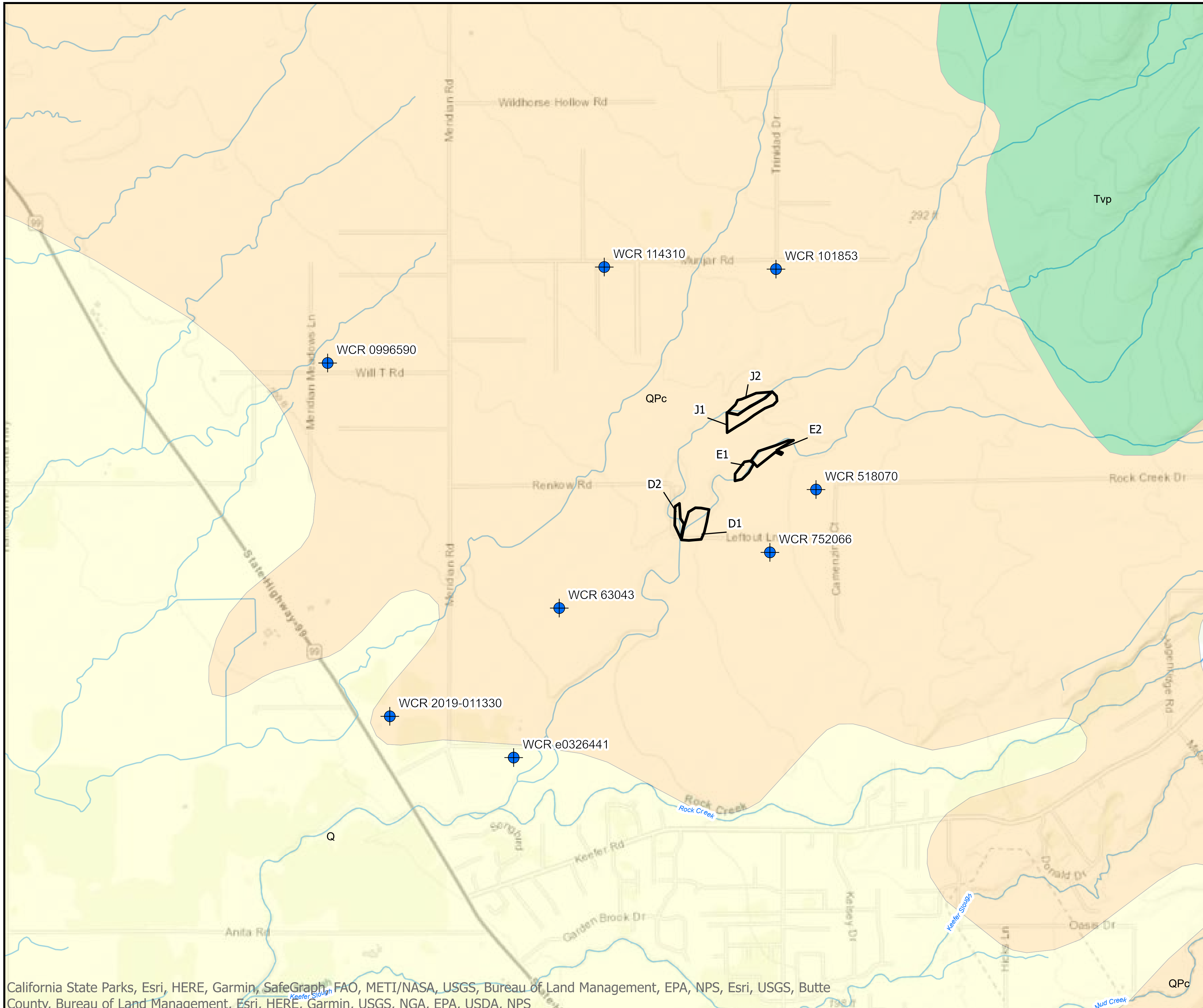
FIGURE 1

ROCK CREEK RECLAMATION DISTRICT

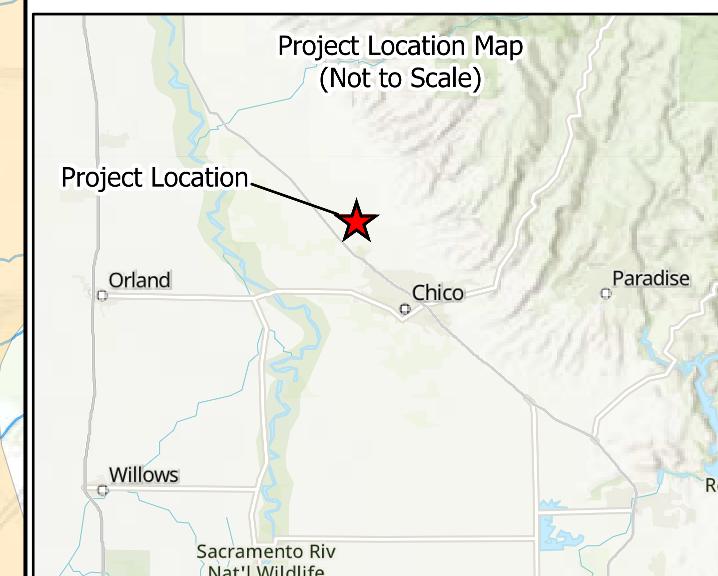
ROCK AND SAND CREEK FLOOD MITIGATION PROJECT

BUTTE COUNTY, CA

SEPTEMBER 2023



- Nearby Well Locations with Lithology Data
- Potential Recharge Basin Location
- Q — Pleistocene-Holocene - Marine and nonmarine (continental) sedimentary rocks
- QPc — Pliocene-Pliestocene - Nonmarine (continental) sedimentary rocks
- Tvp — Tertiary - Volcanic flow deposits



Notes:
Wells are labeled by their Well Completion Report (WCR) number.

0 1,500 3,000
Feet

NORTH

WOOD RODGERS

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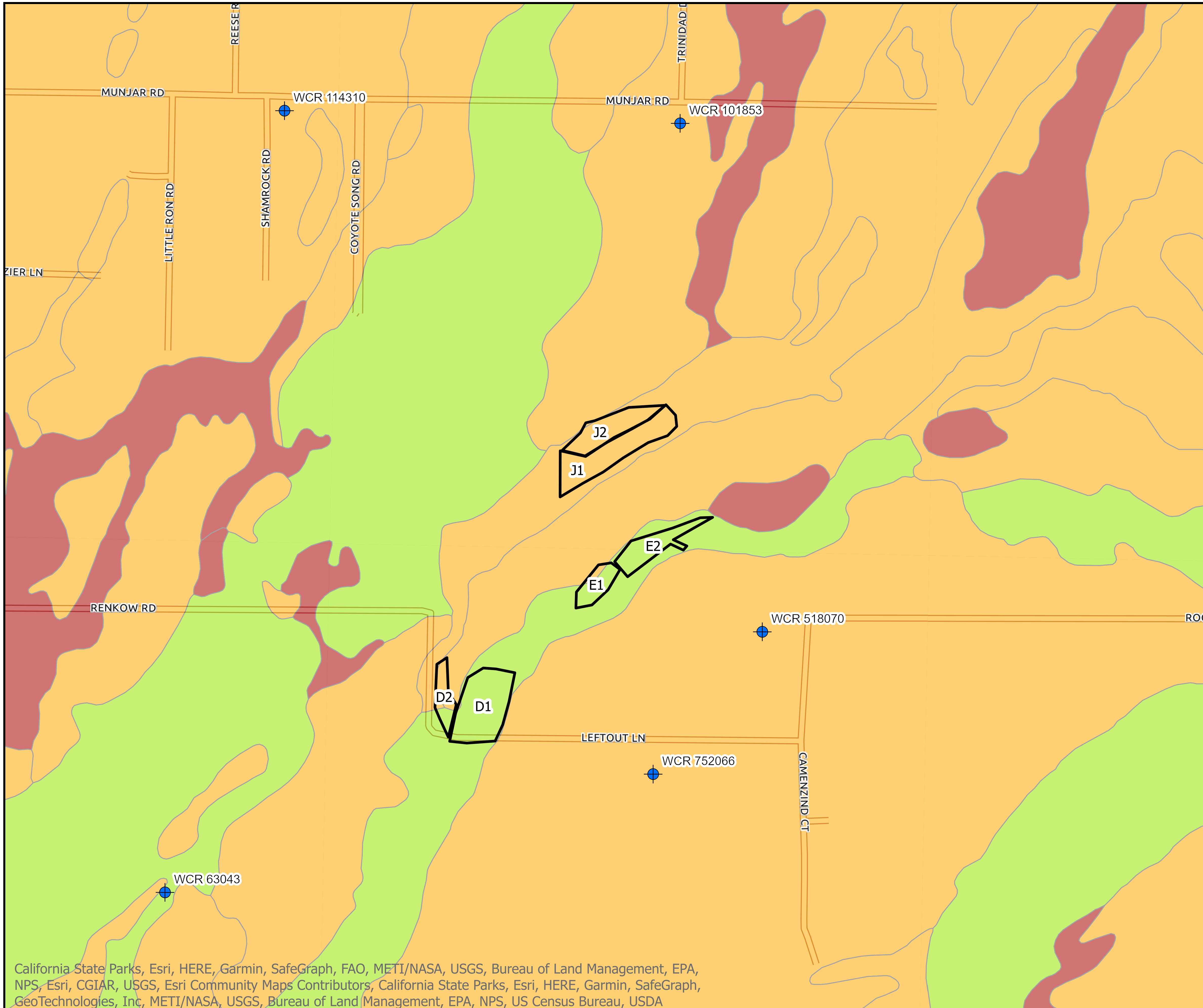


FIGURE 2

ROCK CREEK RECLAMATION DISTRICT

ROCK AND SAND CREEK FLOOD MITIGATION PROJECT

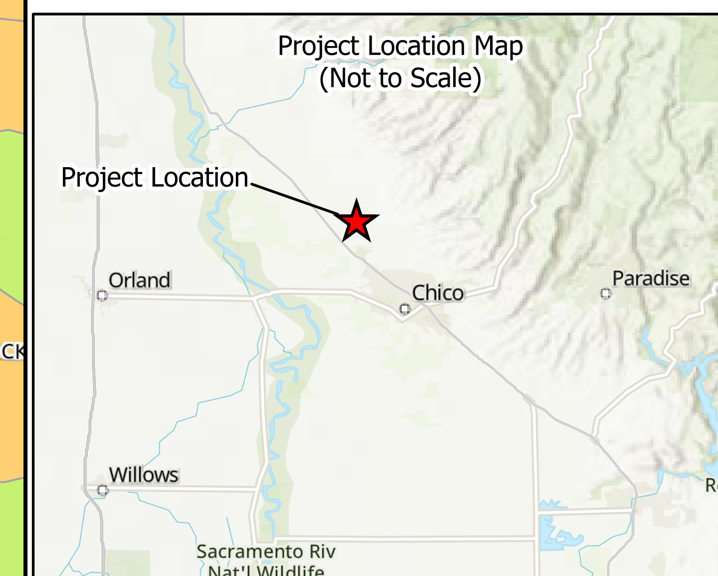
BUTTE COUNTY, CA

SEPTEMBER 2023

- Nearby Well Locations with Lithology Data
- Potential Recharge Basin Location

Soil Agriculture Groundwater Banking Index Rating

- Excellent
- Good
- Moderately Good
- Moderately Poor
- Poor
- Very Poor
- No Data



Notes:
Wells are labeled by their Well Completion Report (WCR) number.
Data sourced from the California Soil Research Lab at UC Davis and UC-ANR.

0 500 1,000
Feet

NORTH

WOOD RODGERS

J:\Jobs\8874_RCRD\8874001_RockSand\GIS\ArcGISPro\Recharge_Study\Recharge_Study.aprx 9/5/2023 11:13 AM akieta

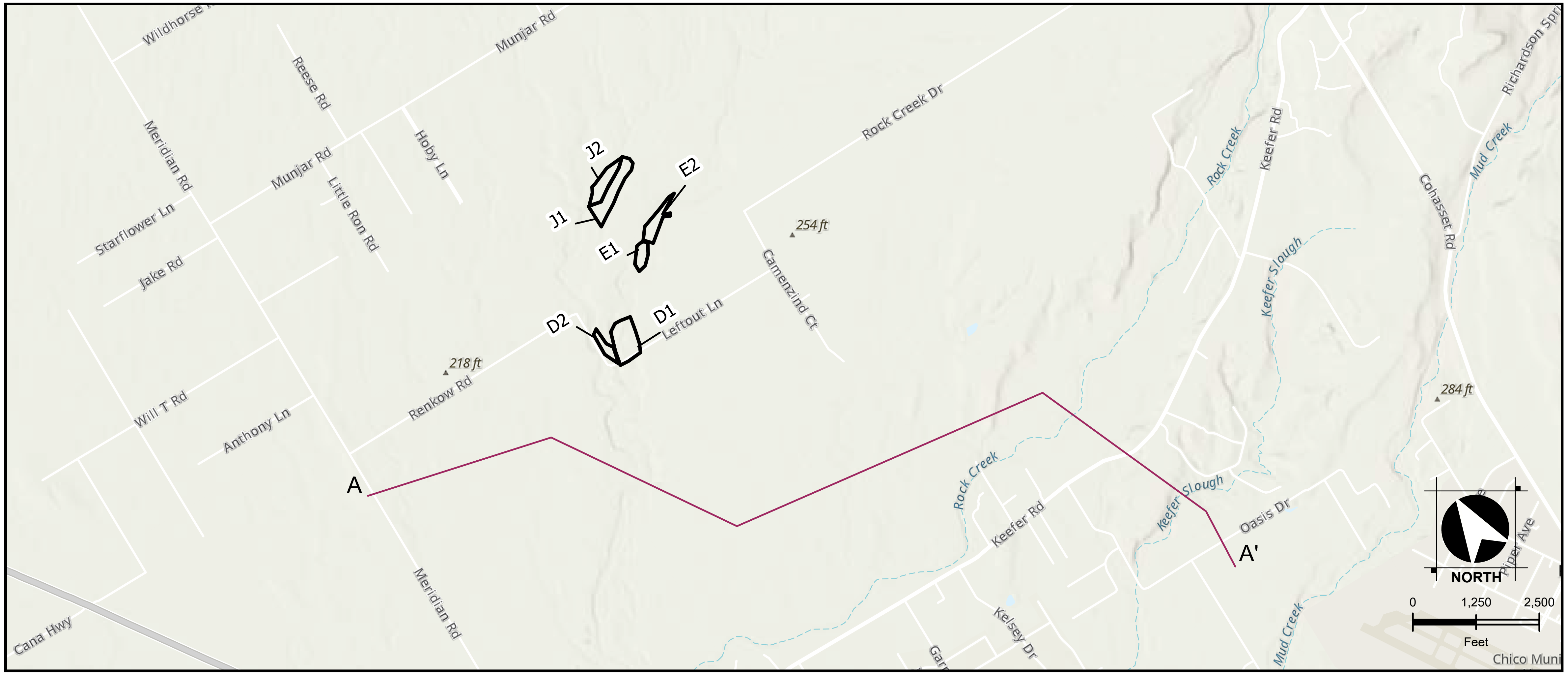
FIGURE 3

ROCK CREEK RECLAMATION DISTRICT

ROCK AND SAND CREEK FLOOD MITIGATION PROJECT

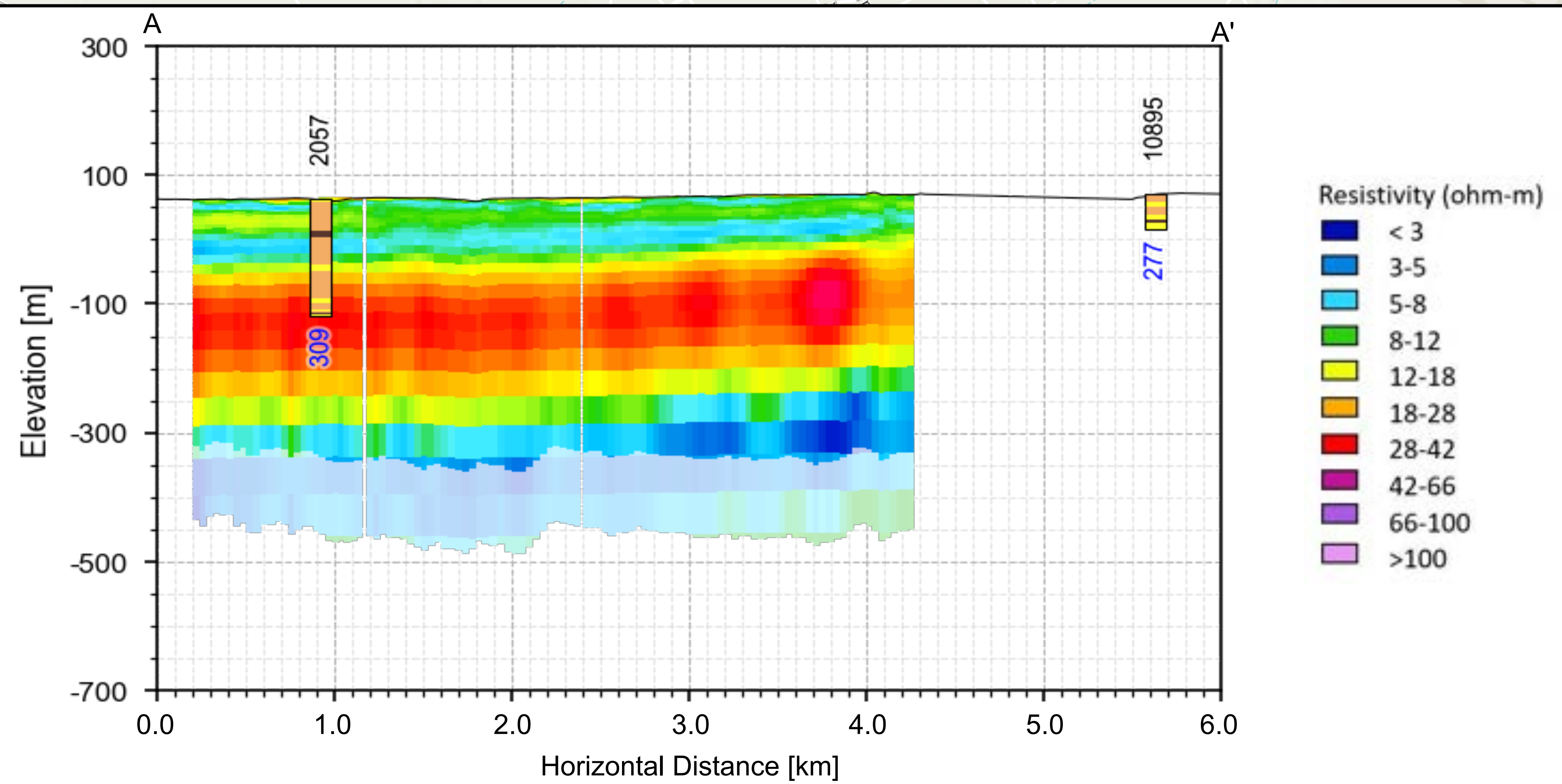
BUTTE COUNTY, CA

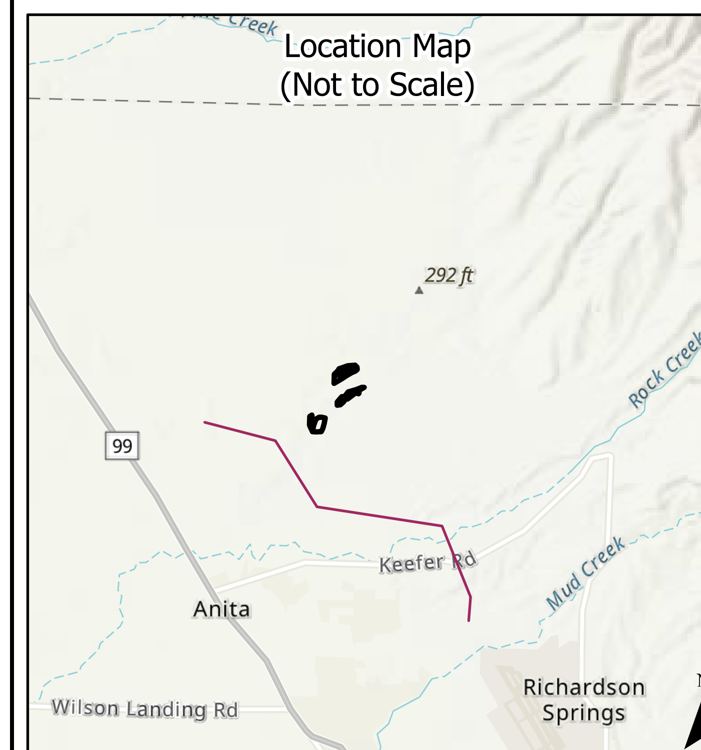
SEPTEMBER 2023



Department of Water Resources Airborne Electromagnetic Survey Line - Panel Section No. 413606

Potential Recharge Basin Location





Note: 1 km = ~3,281 ft

WOOD RODGERS

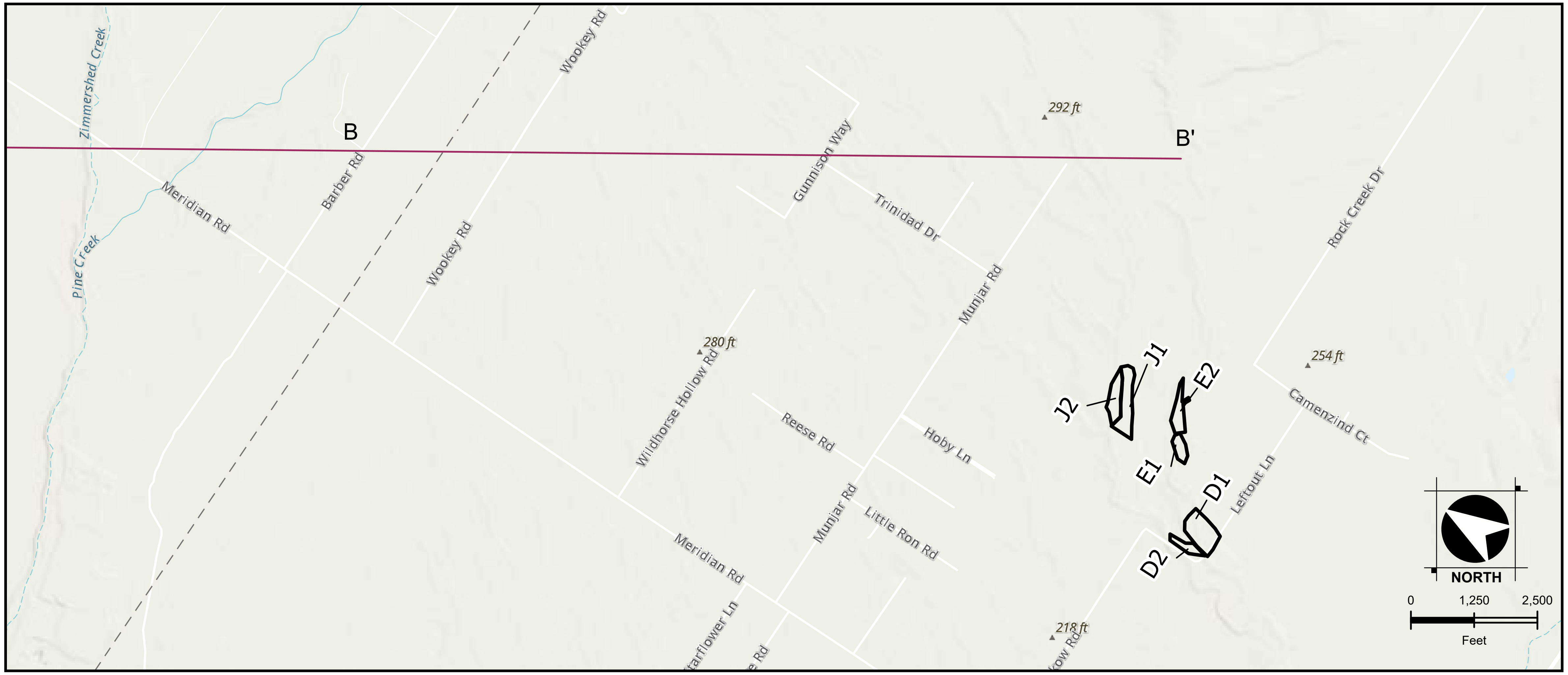
FIGURE 4

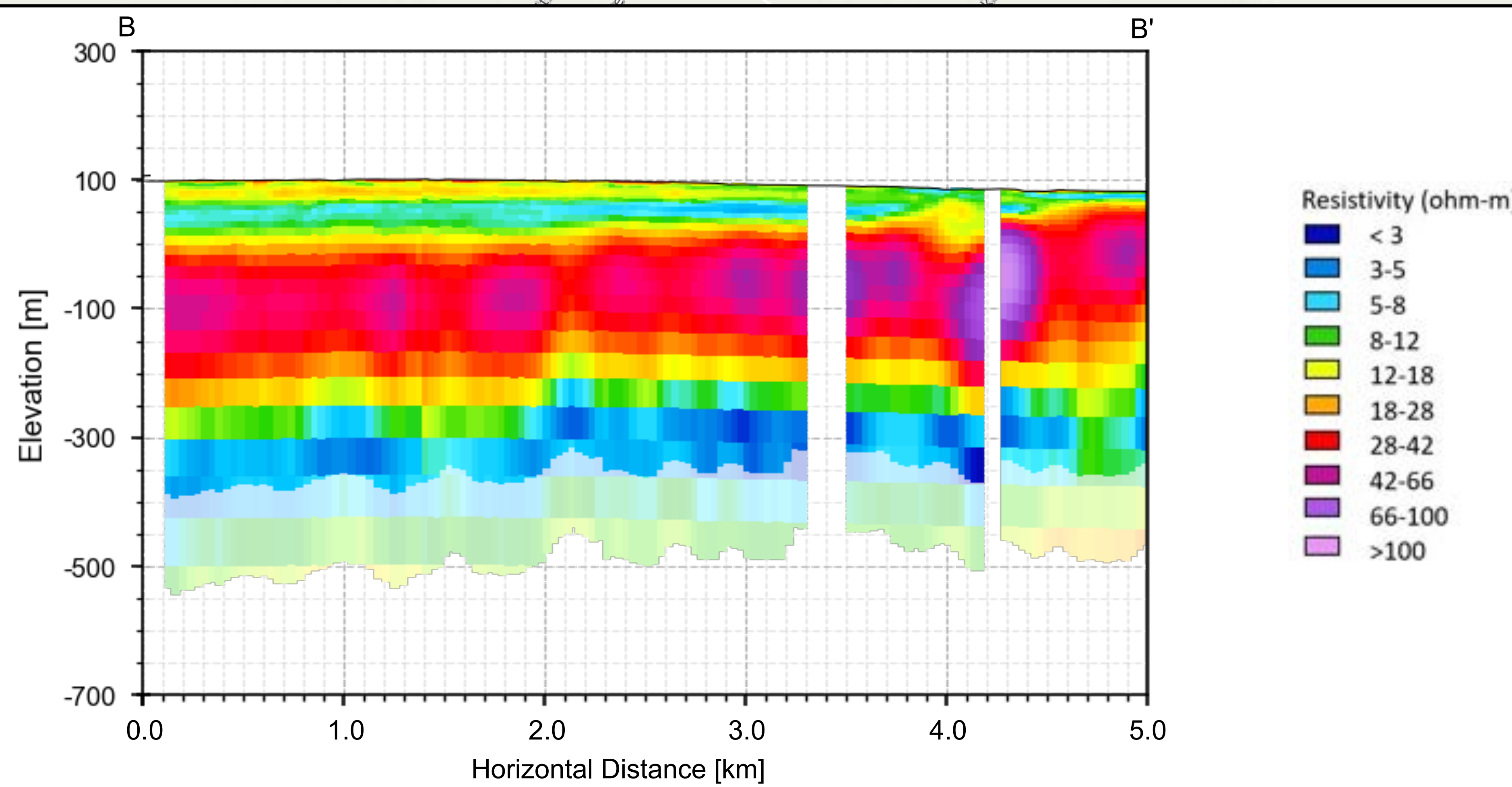
ROCK CREEK RECLAMATION DISTRICT

ROCK AND SAND CREEK FLOOD MITIGATION PROJECT

BUTTE COUNTY, CA

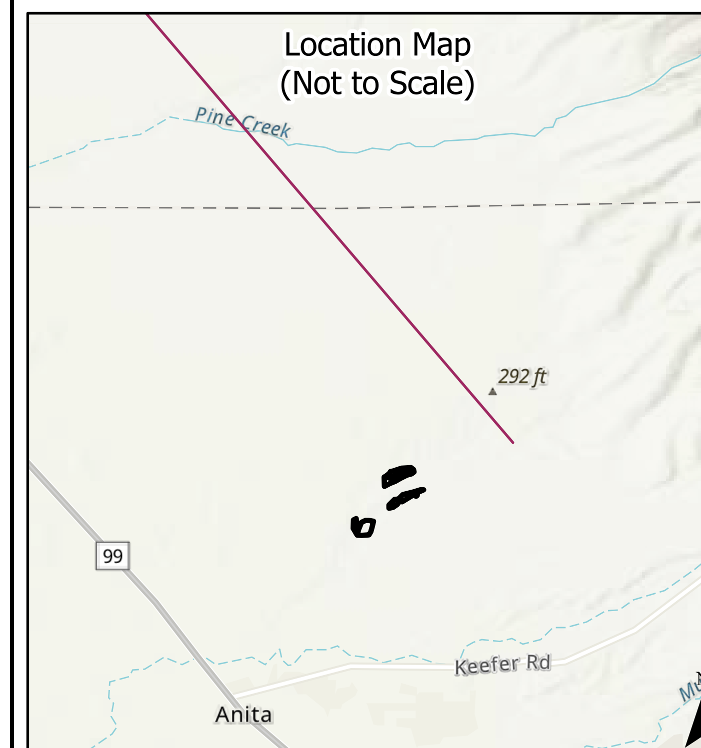
SEPTEMBER 2023





Department of Water Resources Airborne Electromagnetic Survey Line - Panel Section No. 413704

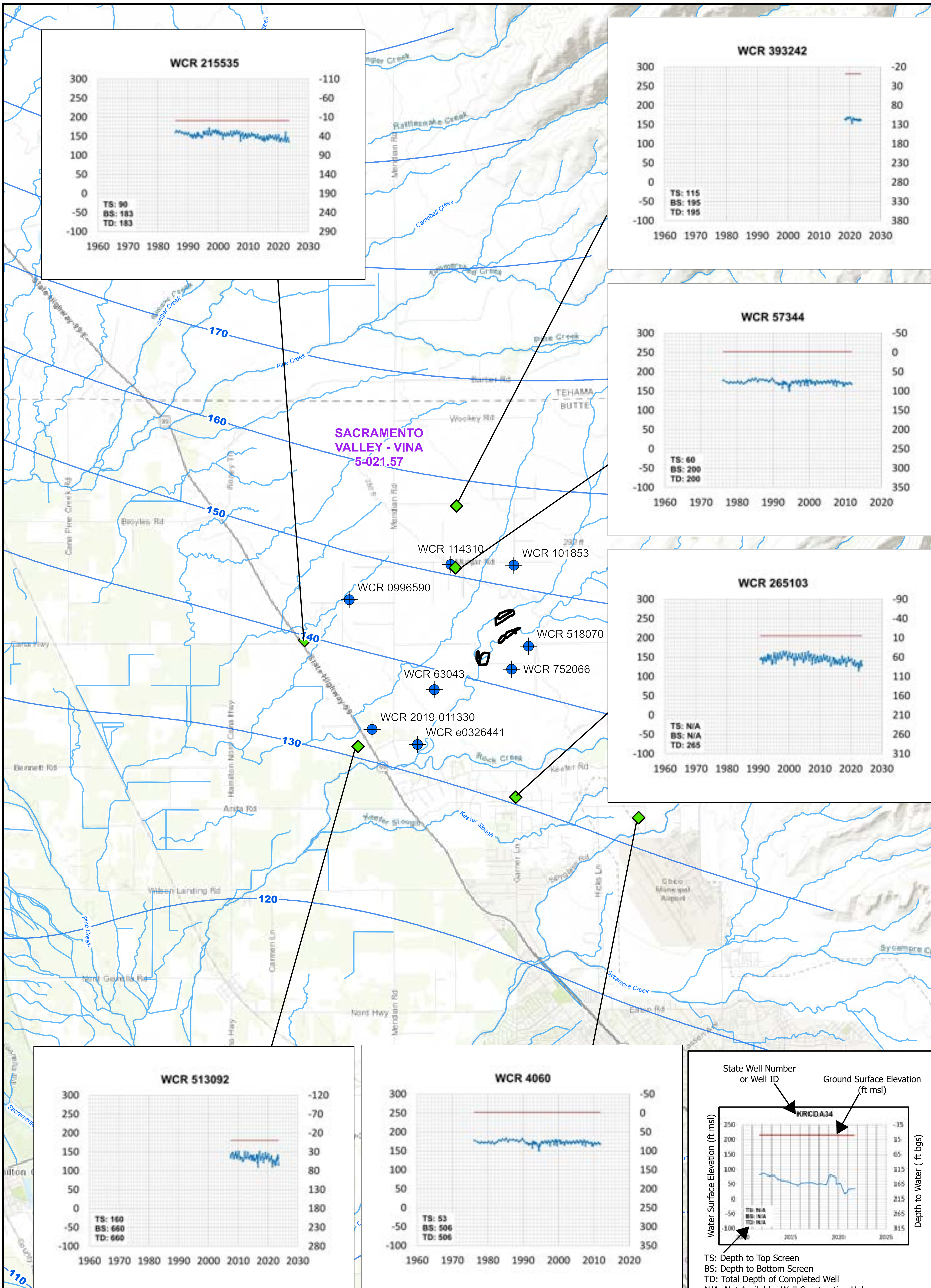
Potential Recharge Basin Location



Note: 1 km = ~3,281 ft

WOOD RODGERS

J:\Jobs\8874_RCRD\8874001_RockSand\GIS\ArcGISPro\Recharge_Study\Recharge_Study.aprx 9/5/2023 11:20 AM akieta



Notes: Wells are labeled by their Well Completion Report (WCR) number. Source: DWR SGMA Data Viewer, 2023

FIGURE 5

ROCK CREEK RECLAMATION DISTRICT

ROCK AND SAND CREEK FLOOD MITIGATION PROJECT

BUTTE COUNTY, CA

SEPTEMBER 2023

- DWR Groundwater MWs
- Nearby Well Locations with Lithology Data
- Potential Recharge Basin Location
- Fall 2022 Groundwater Elevation Contour (ft msl)
- Streams and Rivers

0 1 2 Miles

NORTH

WOOD RODGERS

J:\Jobs\8874_RCRD\8874001_RockSand\GIS\ArcGISPro\Groundwater\Groundwater.aprx 9/5/2023 10:59 AM akieta

ATTACHMENT A

Department of Water Resources Well Completion Reports within a 2-Mile Radius of the Project Site

23N/11E-17

ORIGINAL

File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
WATER WELL DRILLERS REPORT

Do not fill in

No. 101853

State Well No. CONFIDENTIAL LOG
Other Well No. Water Code Sec. 13752

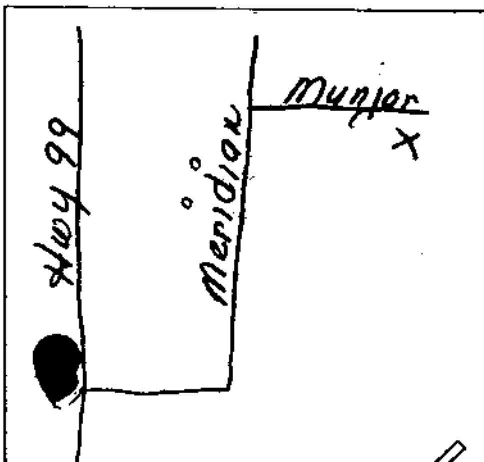
Not[redacted] Intent No.______
Local Permit No. or Date______

(1) (

Address

City

(2) LOCATION OF WELL (See instructions):
County Butte Owner's Well Number______
Well address if different from above______
Township 23 N Range 1E Section 17
Distance from cities, roads, railroads, fences, etc. Munjor Rd. - 8 mi. No. Chico Airport



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☒
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☐
Other ☐

(5) EQUIPMENT:
Rotary ☐ Reverse ☐
Cable ☒ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☐ No ☒ Size______
Diameter of bore______
Packed from______ to______ ft.

(7) CASING INSTALLED:
Steel ☒ Plastic ☐ Concrete ☐

From ft.	To ft.	Dia. in.	Gage or Wall
0	57	6	.125

(8) PERFORATIONS:
Type of perforation or size of screen______

From ft.	To ft.	Slot size

(9) WELL SEAL: Sanitized
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth______ ft.
Were strata sealed against pollution? Yes ☐ No ☐ Interval______ ft.
Method of sealing Clay

(10) WATER LEVELS:
Depth of first water, if known 90 ft.
Standing level after well completion 85 ft.

(11) WELL TESTS:
Was well test made? Yes ☐ No ☒ If yes, by whom?______
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test______ ft. At end of test______ ft
Di[redacted]e______ gal/min after______ hours Water temperature______
Chemical analysis made? Yes ☐ No ☒ If yes, by whom?______
Was electric log made? Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 230 ft. Depth of completed well 230 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	10	Dirt
10	18	Rock
18	70	Brown Clay
70	85	Hard Red Clay
85	102	Brown Clay
102	117	Layer
117	163	Red Clay
163	165	Gravel
165	187	Brown Clay
187	189	Gravel
189	229	Red Clay
229	230	Gravel

Work started 3/14 1981 Completed 3/15 1981

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

SIGNED (signature)

NAME CHICO WELL DRILLING AND PUMP SERVICE (Person, firm, or corporation) (Typed or printed)
Address CAL. LIC. No. 363175
City RT. 1, BOX 477 CHICO, CA 95927 Zip
License No.______ Date of this report______

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

ORIGINAL
File Original, Duplicate and Triplicate with the REGIONAL WATER POLLUTION CONTROL BOARD No.____
(Insert appropriate number)

WATER WELL DRILLERS REPORT

(Sections 7076, 7077, 7078, Water Code)

STATE OF CALIFORNIA

LOCATION NOT CHECKED

Do Not Fill In

Nº 63043

State Well No. ____
Other Well No. 23N/1E-30 19

(1) OWNER:

(2) LOCATION OF WELL:

County Butte   Owner's number, if any—

R. F. D. or Street No.

T.23 N. R.1E Sec ~~30~~ 19

(3) TYPE OF WORK (check):

New well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐

If abandonment, describe material and procedure in Item 11.

(4) PROPOSED USE (check):

Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☒ Test Well ☐ Other ☐

(5) EQUIPMENT:

Rotary ☐
Cable ☒
Dug Well ☐

(6) CASING INSTALLED:

SINGLE ☒ DOUBLE ☐

From	to	Diam.	Gage or Wall
0 ft.	100 ft.	14	10

If gravel packed

Diameter of Bore	from ft.	to ft.

Type and size of shoe or well ring 1-14" Shoe

Size of gravel:

Describe joint

(7) PERFORATIONS:

Type of perforator used none

Size of perforations ____ in., length, by ____ in.

From ____ ft. to ____ ft. Perf. per row ____ Rows per ft.

(8) CONSTRUCTION:

Was a surface sanitary seal provided? ☐ Yes ☒ No To what depth ____ ft.

Were any strata sealed against pollution? ☐ Yes ☒ No If yes, note depth of strata

From ____ ft. to ____ ft.

Method of Sealing

(9) WATER LEVELS:

Depth at which water was first found 32 ft.

Standing level before perforating ____ ft.

Standing level after perforating ____ ft.

(10) WELL TESTS:

Was a pump test made? ☐ Yes ☐ No If yes, by whom?

Yield: 1420 gal./min. with 231 ft. draw down after ____ hrs.

Temperature of water ____ Was a chemical analysis made? ☐ Yes ☒ No

Was electric log made of well? ☐ Yes ☒ No

(11) WELL LOG:

Total depth 568 ft. Depth of completed well ____ ft.

Formation: Describe by color, character, size of material, and structure.

CONFIDENTIAL LOG Water Code Sec. 13752

From (ft.)	To (ft.)	Formation
0	3	Soil
3	12	Hard Pan
12	30	Gravel
30	47	Clay
47	58	Gravel
58	74	Clay
74	80	Gravel
80	90	Clay
90	95	Gravel
95	155	Clay
155	169	Lava
167	290	Clay
290	310	Lava
310	325	Clay
325	332	Lava
332	345	Hard Pan
345	360	Lava
360	390	Clay
390	410	Hard Pan
410	435	Gravel Cement
435	475	Lava
475	484	Gravel Cement
484	495	Sand stone
495	540	Hard pan
540	560	Gravel
560	568	Sand & Gravel

CONFIDENTIAL
Section 7076.1, Water Code

Work started Mar21,1959 19 . Completed Apr.16,1959 19

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Lassen Pump & Motor Works
(Person, firm, or corporation) (Typed or printed)

Address P. O. Box 964
Chico, California

[Signed] (signature)
Well Driller

License No. 59221 / 457   Dated June15,1959, 19__

DWR 188 (REV. 9-54)

DUPLICATE
~~Driller's Copy~~ DWR
Page ___ of ___

Owner's Well No. 1   JUL 0 1999

Date Work Began 6-27-99, Ended 6-28-99

Local Permit Agency Butte

Permit No. 269614   Permit Date 6-1-99

RECEIVED

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 518070

DWR USE ONLY — DO NOT FILL IN

23N/01E-20M

STATE WELL NO./STATION NO.

LATITUDE / LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ✓ VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER 80 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft. to Ft.		DESCRIPTION Describe material, grain size, color, etc.
0	2	Soil
2	4	Hard Pan - Cemented
4	20	Hard Pan
20	30	Gravel
30	80	Cobble + Clay
80	85	Gravel
85	160	Red Clay + Cobble
160	180	Sand + Gravel

TOTAL DEPTH OF BORING 180 (Feet)

TOTAL DEPTH OF COMPLETED WELL 180 (Feet)

WELL OWNER

WELL LOCATION

Address Comenzind Ct.

City Chico

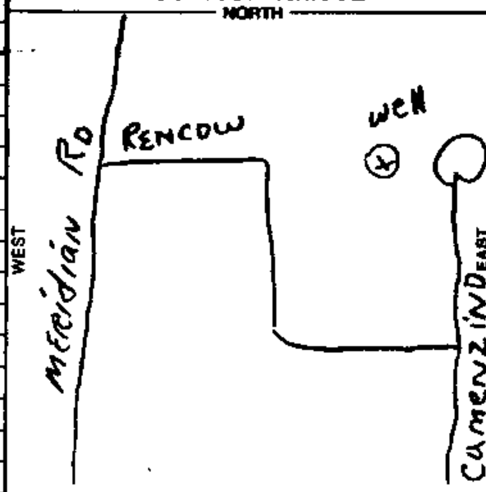
County Butte

APN Book 047 Page 220 Parcel 096

Township 23N Range 01E Section 20

Latitude ___ NORTH (DEG. MIN. SEC.) Longitude ___ WEST (DEG. MIN. SEC.)

LOCATION SKETCH



Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

✓ NEW WELL

MODIFICATION/REPAIR

___ Deepen

___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

___ MONITORING

WATER SUPPLY

✓ Domestic

___ Public

___ Irrigation

___ Industrial

___ "TEST WELL"

___ CATHODIC PROTECTION

___ OTHER (Specify)

DRILLING METHOD Rotary   FLUID Air

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 75 (Ft.) & DATE MEASURED 6-28-99

ESTIMATED YIELD* 50 (GPM) & TEST TYPE Air Lift

TEST LENGTH 2 (Hrs.) TOTAL DRAWDOWN ___ (Ft.)

* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft. to Ft.		BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	100	9.00	✓				PVC	5.00	CL 200	
100	180	9.00		✓			PVC	5.00	CL 200	.032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft. to Ft.		CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	45	✓			
45	180				3/8 Gravel

JUL 14 1999

ATTACHMENTS (✓)

___ Geologic Log

___ Well Construction Diagram

___ Geophysical Log(s)

___ Soil/Water Chemical Analyses

___ Other ___

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Earl Watson Well Drilling
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

8015 Cohasset Rd. Chico Ca 95973
ADDRESS CITY STATE ZIP

Signed Earl Watson   7-1-99   409780
WELL DRILLER/AUTHORIZED REPRESENTATIVE   DATE SIGNED   C-57 LICENSE NUMBER

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

ORIGINAL
File with DWR

JAN 02 2004

Page 1 of 1

Owner's Well No. 67

Date Work Began 11-24-03, Ended 11-26-03

Local Permit Agency BUTTE CO. HEALTH DEPT.

Permit No. 384252 Permit Date 07-29-03

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 752066

DWR USE ONLY — DO NOT FILL IN

23N/01E - 20M

STATE WELL NO./STATION NO.

LATITUDE | LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ✓ VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD MUD ROTARY FLUID BENTONITE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	15	COBBLES
15	150	LAVA, CLAY AND GRAVEL
150	165	LAVA
165	250	LAVA AND CLAY

TOTAL DEPTH OF BORING 250 (Feet)

TOTAL DEPTH OF COMPLETED WELL 250 (Feet)

WELL OWNER

N

M

CIT | STATE | ZIP

WELL LOCATION

Address 14577 CHAMENZIND

City CHICO

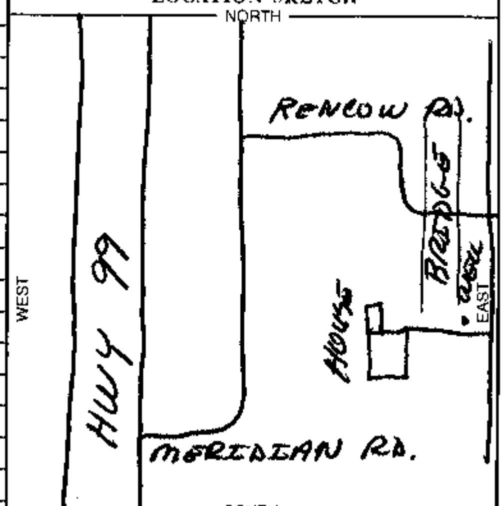
County BUTTE

APN Book 047 Page 220 Parcel 100

Township 23N Range 01E Section 20

Latitude ___ DEG. MIN. SEC. NORTH Longitude ___ DEG. MIN. SEC. WEST

LOCATION SKETCH



Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. **PLEASE BE ACCURATE & COMPLETE.**

ACTIVITY (✓)

✓ NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

PLANNED USES (✓)

WATER SUPPLY
✓ Domestic ___ Public
___ Irrigation ___ Industrial

MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 80 (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 80 (Ft.) & DATE MEASURED 11-26-03

ESTIMATED YIELD * 150 (GPM) & TEST TYPE AIR LIFT

TEST LENGTH 1 (Hrs.) TOTAL DRAWDOWN N/A (Ft.)

* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	150	12"	✓				P.V.C.	6"	CL.200	N/A
150	250	12"		✓			P.V.C.	6"	CL.200	.032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	40	✓			7SACK
40	250				3/8" PEA GRAVEL

JAN 23

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME NORTH STATE DRILLING
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

#6 FREIGHT LN. CHICO CA. 95973
ADDRESS | CITY | STATE | ZIP

Signed Tim Watson
WELL DRILLER/AUTHORIZED REPRESENTATIVE

12-12-03 DATE SIGNED

812678 C-57 LICENSE NUMBER

DWR 188 REV. 11-97

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

ORIGINAL
File with DWR

Page 1 of 1 JUL 25 2017

Owner's Well No.

Date Work Began 11-10-16 , Ended 11-11-16

Local Permit Agency Butte County Health Dept

Permit No. EHWS16-0100 Permit Date 8-5-16

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 0996590

DWR USE ONLY — DO NOT FILL IN

23N/01W+13

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD Air Rotary FLUID O-Foam

DEPTH FROM SURFACE Ft. to Ft.		DESCRIPTION Describe material, grain size, color, etc.
0	8	Clay & Rock
8	45	Clay
45	53	Gravel & Rock
53	200	Sandstone with Seams of Cemented Gravel

TOTAL DEPTH OF BORING ______ (Feet)

TOTAL DEPTH OF COMPLETED WELL 200 (Feet)

WELL OWNER

WELL LOCATION

Address Will 'T' Road

City Chico

County Butte

APN Book 047 Page 100 Parcel 085 202

Township ___ Range ___ Section ___

Lat ___ N DEG. MIN. SEC. Long ___ W DEG. MIN. SEC.

LOCATION SKETCH

NORTH / SOUTH / WEST / EAST

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

XX NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

USES (✓)

WATER SUPPLY
XX Domestic ___ Public
___ Irrigation ___ Industrial

MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER ______ (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 58 (Ft.) & DATE MEASURED 11-11-16

ESTIMATED YIELD * 100+ (GPM) & TEST TYPE Air Lift

TEST LENGTH ______ (Hrs.) TOTAL DRAWDOWN ______ (Ft.)

* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	160	6-5/8					Steel	6	.188	
160	200						PVC	4	Liner	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	24		XX		

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ______

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME W. S. Heitman Drilling
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

P. O. Box 1010, Red Bluff, CA 96080
ADDRESS CITY STATE ZIP

Signed W S Heitman Lo
C-57 LICENSED WATER WELL CONTRACTOR

11-15-16 DATE SIGNED

386577 C-57 LICENSE NUMBER

DWR 188 REV. 05-03

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

OSP 03 78836

State of California

Well Completion Report

Form DWR 188 Auto-Completed 10/14/2019

WCR2019-011330

Owner's Well Number ______ Date Work Began 07/17/2019 Date Work Ended 08/13/2019

Local Permit Agency Butte County Public Health

Secondary Permit Agency ______ Permit Number EHWL 19-0009 Permit Date 08/01/2019

Well Owner (must remain confidential pursuant to Water Code 13752)

Name XXXXXXXXXXXXXXXXXXXX

Mailing Address XXXXXXXXXXXXXXXXXXXX

XXXXXXXXXXXXXXXXXXXX

City XXXXXXXXXXXXXXXXXXXX State XX Zip XXXXX

Planned Use and Activity

Activity New Well

Planned Use Water Supply Irrigation - Agriculture

Well Location

Address ______

City ______ Zip ______ County Butte

Latitude 39 Deg. 49 Min. 32.5199 Sec. N

Longitude -121 Deg. 55 Min. 27.12 Sec. W

Dec. Lat. 39.8257 Dec. Long. -121.9242

Vertical Datum ______ Horizontal Datum WGS84

Location Accuracy ______ Location Determination Method ______

APN 047.100.200

Township 23 N

Range 01 W

Section 25

Baseline Meridian Mount Diablo

Ground Surface Elevation ______

Elevation Accuracy ______

Elevation Determination Method ______

Borehole Information

Orientation Vertical Specify ______

Drilling Method Other - Reverse Rotary Drilling Fluid Bentonite

Total Depth of Boring 770 Feet

Total Depth of Completed Well 770 Feet

Water Level and Yield of Completed Well

Depth to first water ______ (Feet below surface)

Depth to Static Water Level 55 (Feet) Date Measured 08/13/2019

Estimated Yield* ______ (GPM) Test Type ______

Test Length ______ (Hours) Total Drawdown ______ (feet)

*May not be representative of a well's long term yield.

Geologic Log - Free Form

Depth from Surface Feet to Feet		**Description**
0	12	clay
12	45	volcanics with gavel
45	55	clay
55	60	gravel
60	97	clay
97	138	volcanic gravel
138	155	clay
155	177	gravel
177	440	clay
440	465	gravel
465	508	clay
508	600	gravel
600	770	volcanics

Casings

Casing #	Depth from Surface Feet to Feet		Casing Type	Material	Casings Specificatons	Wall Thickness (inches)	Outside Diameter (inches)	Screen Type	Slot Size if any (inches)	Description
1	0	420	Blank	PVC	OD: 17.400 in. | SDR: 17 | Thickness: 1.024 in.	1.024	17.4			
1	420	480	Screen	PVC	OD: 17.400 in. | SDR: 17 | Thickness: 1.024 in.	1.024	17.4	Milled Slots	0.05	
1	480	500	Blank	PVC	OD: 17.400 in. | SDR: 17 | Thickness: 1.024 in.	1.024	17.4			
1	500	770	Screen	PVC	OD: 17.400 in. | SDR: 17 | Thickness: 1.024 in.	1.024	17.4	Milled Slots	0.05	

Annular Material

Depth from Surface Feet to Feet		Fill	Fill Type Details	Filter Pack Size	Description
0	50	Cement	10.3 Sack Mix		
50	770	Filter Pack	6 x 16	6 x 16 and 6 x 12 mix	

Other Observations:

Borehole Specifications

Depth from Surface Feet to Feet		Borehole Diameter (inches)
0	770	28

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name: SULLIVAN DRILLING INC
Person, Firm or Corporation

P O BOX 1227 (Address) | ORLAND (City) | CA (State) | 95963 (Zip)

Signed: *electronic signature received* (C-57 Licensed Water Well Contractor) | 08/13/2019 (Date Signed) | 656504 (C-57 License Number)

DWR Use Only

CSG #	State Well Number	Site Code	Local Well Number

			N

Latitude Deg/Min/Sec

			W

Longitude Deg/Min/Sec

TRS:

APN:

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. e0326441

Page 1 of 1 FEB 27 2017

Owner's Well Number ______

Date Work Began 10/05/2016 Date Work Ended 10/13/2016

Local Permit Agency Butte County Public Health

Permit Number EHWL 16-0012 Permit Date 6/20/16

DWR Use Only – Do Not Fill In

23N/01W-30

State Well Number/Site Number

Latitude N Longitude W

APN/TRS/Other

Geologic Log

Orientation ⦿ Vertical ○ Horizontal ○ Angle Specify ______

Drilling Method Direct Rotary Drilling Fluid Bentonite mud

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	3	clay
3	18	rock
18	38	clay
38	42	gravel
42	176	clay
176	185	gravel
185	187	clay and fractured clay
187	196	gravel 192 Hard
196	240	clay and fractured clay
240	246	gravel
246	330	clay
330	335	gravel
335	555	clay
555	650	black gravel
650	692	clay
692	740	black gravel

Total Depth of Boring 740 Feet

Total Depth of Completed Well 270 Feet

Well Owner

Well Location

Address 4684 Kilkare Lane

City Chico County Butte

Latitude ___ Deg. ___ Min. ___ Sec. N Longitude ___ Deg. ___ Min. ___ Sec. W

Datum ___ Dec. Lat. ___ Dec. Long. ___

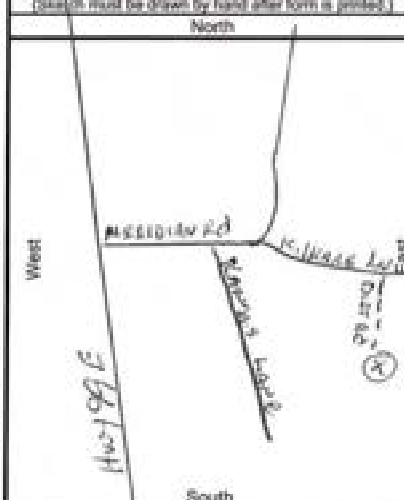
APN Book 047 Page 330 Parcel 010

Township ___ Range ___ Section ___

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North



West East South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

⦿ New Well
○ Modification/Repair
○ Deepen
○ Other ______
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

⦿ Water Supply
☐ Domestic ☐ Public
☑ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
○ Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other ______

Water Level and Yield of Completed Well

Depth to first water ______ (Feet below surface)

Depth to Static Water Level 50 (Feet) Date Measured 10/13/2016

Estimated Yield * ______ (GPM) Test Type ______

Test Length ______ (Hours) Total Drawdown ______ (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	160	20	Blank	PVC	SDR-21	10		
160	200	20	Screen	PVC	SDR-21	10	Milled Slots	0.050
200	240	20	Blank	PVC	SDR-21	10		
240	270	20	Fill pipe	PVC	SDR-21	10	Milled Slots	0.050

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	20	Bentonite	3/8" chips
20	270	Filter Pack	6 x 16 sand

Attachments

☐ Geologic Log
☐ Well Construction Diagram
☐ Geophysical Log(s)
☐ Soil/Water Chemical Analyses
☐ Other ______

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name Sullivan Drilling, Inc.
Person, Firm or Corporation

6458 County Rd 25 (Address) Orland (City) CA (State) 95963 (Zip)

Signed Charlie Sullivan (C-57 Licensed Water Well Contractor) 10/19/2016 (Date Signed) 656504 (C-57 License Number)

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

23N/1E-17

Do Not Fill In

Nº 114310

State Well No.

Other CONFIDENTIAL LOG Water Code Sec. 13752

ORIGINAL
File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

(1) OWNER:

(2) LOCATION OF WELL:

County: Butte — Owner's number, if any:

Township, Range, and Section: T22N R1E Sec 17

Distance from cities, roads, railroads, etc.: 575 Feet South [illegible] 200 Feet E [illegible]

(3) TYPE OF WORK (check):

New Well ☒ Deepening ☐ Reconditioning ☐ Destroying ☐

If destruction, describe material and procedure in Item 11.

(4) PROPOSED USE (check):

Domestic ☒ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(5) EQUIPMENT:

Rotary ☐
Cable ☒
Other ☐

(6) CASING INSTALLED:

STEEL: OTHER: SINGLE ☒ DOUBLE ☐

From ft.	To ft.	Diam.	Gage or Wall	If gravel packed: Diameter of Bore	From ft.	To ft.
0	70	8"	12Ga.			

Size of shoe or well ring: 8x6x1/2 — Size of gravel:

Describe joint: Elect Butt Weld 8x24x1/4 B.U.

(7) PERFORATIONS OR SCREEN:

Type of perforation or name of screen:

From ft.	To ft.	Perf. per row	Rows per ft.	Size in. x in.

(8) CONSTRUCTION:

Was a surface sanitary seal provided? Yes ☒ No ☐ To what depth 50 ft.

Were any strata sealed against pollution? Yes ☐ No ☐ If yes, note depth of strata

From ft. to ft.

From ft. to ft.

Method of sealing: Puddled Clay

(9) WATER LEVELS:

Depth at which water was first found, if known: 91 ft.

Standing level before perforating, if known: ft.

Standing level after perforating and developing: 70 ft.

(10) WELL TESTS:

Was pump test made? Yes ☒ No ☐ If yes, by whom? Bailer

Yield: 30 gal./min. with 0 ft. drawdown after hrs.

Temperature of water — Was a chemical analysis made? Yes ☐ No ☐

Was electric log made of well? Yes ☐ No ☐ If yes, attach copy

(11) WELL LOG:

Total depth 165 ft. Depth of completed well 165 ft.

Formation: Describe by color, character, size of material, and structure — ft. to ft.

0--2 Light Rocky Soil
2--21 Hard Pan & Large Rocks
21--34 Yellow Clay
34--63 Coarse Sand & Gravel
63--91 Hard sticky brown clay
91--113 Sandstone
113--127 Coarse sand
127--164 Coarse sand & brown clay
164--165 Coarse sand & gravel

CONFIDENTIAL LOG
Water Code Sec. 13752

Work started 3/15 19 , Completed 3/23/76

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME: J. C. Plummer & Co
(Person, firm, or corporation) *(Typed or printed)*

Address: 541 West 11 th St.
Chico, Calif

[SIGNED]
(Well Driller)

License No. 279572 Dated 3/31/76, 19

SKETCH LOCATION OF WELL ON REVERSE SIDE