Memo

To: Beth Christman, Truckee River Watershed Council

From: David Shaw

Date: November 20, 2019

Subject: Design Basis Memorandum: Sardine Meadow Restoration Project, Sierra County, California

Introduction

The Truckee River Watershed Council (TRWC) has contracted with Balance Hydrologics (Balance) to conduct field investigations, analysis, and provide design services for restoration of Sardine Valley Meadow in Sierra County, California. The purpose of this memo is to describe findings of our site investigation and background research, present Intermediate (65%) Design Drawings, and document the basis for the design.

Earlier work at the project site was completed by the U.S. Forest Service Tahoe National Forest (TNF), Plumas Corporation, and California State University Sacramento (CSUS) and summarized by Stantec (2017). Earlier work concluded that significant morphological change has occurred in Sardine Valley, with significant impacts on the system's ecological value. During this design phase, Balance has carried out reconnaissance-level field activities, geomorphic mapping, as well as analysis of high-resolution topographic data and recent and historical aerial photography. Our work supports previous findings, which indicate that extensive historical disturbance resulted from road and railroad construction (Stantec, 2017; Copren, 2014), as well as from more recent ranching activity and road maintenance. As a result of historical land use, channels are degraded and they continue to incise and widen.

Based on this earlier work, the TRWC and U.S. Forest Service Tahoe National Forest (TNF) elected to implement a restoration approach to introduce more frequent annual flooding to the meadow surface by filling portions of the incised channel. TRWC contracted Balance to assist in developing restoration design plans for this selected restoration approach. The remainder of this memo provides a contextual overview of the site and watershed setting, outlines the design elements, and describes additional analyses that may be carried out to support and refine the proposed design concept. The Intermediate 65% Restoration Design Plans are attached to this memo and include alternative design options for a portion of the project area.

This memo should always accompany the restoration design documents.

Location

The Project is located at Sardine Valley in Sierra County, California, Township 19 N, Range 17 E, Sections 7 and 8, also identified as 39° 30’ 47” N, 120° 7’ 16” W (NAD27), as shown in Figure 1. Davies Creek flows through Sardine Meadow and via Stampede Reservoir, is tributary to the Little Truckee River and the Truckee River, a terminal river which flows to Nevada and ultimately Pyramid Lake.

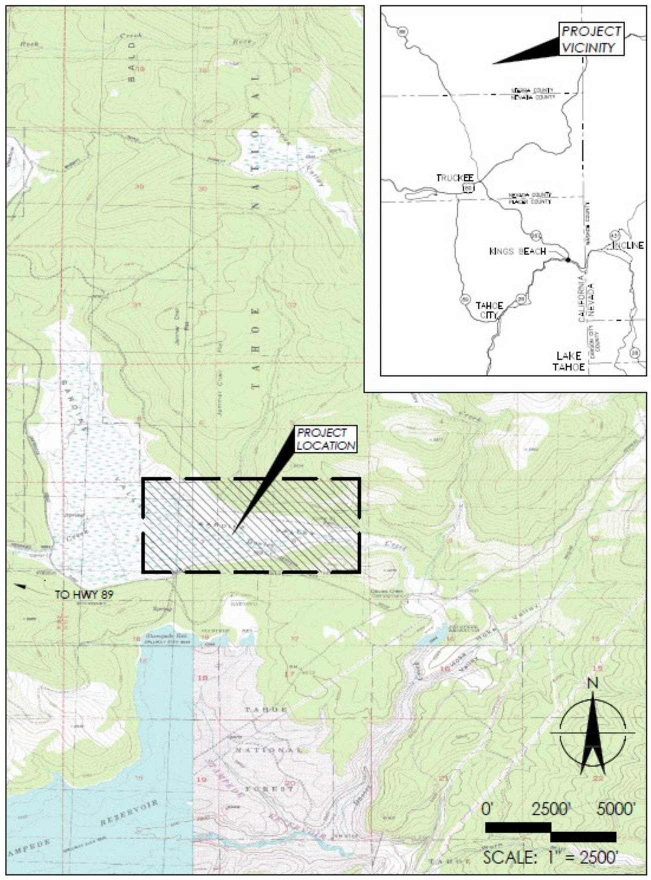


Figure 1. Sardine Meadow Restoration Project Location

The Project would address approximately 25,000 feet of degraded channels and swales associated with the Davies Creek alluvial fan, tributaries, distributary and secondary channels, and swales within Sardine Valley on lands owned by the Trust for Public Land (TPL) and a private landowner. Figure 2 shows the project area and extent of proposed work, including channel and ditch fill and railroad grade removal.

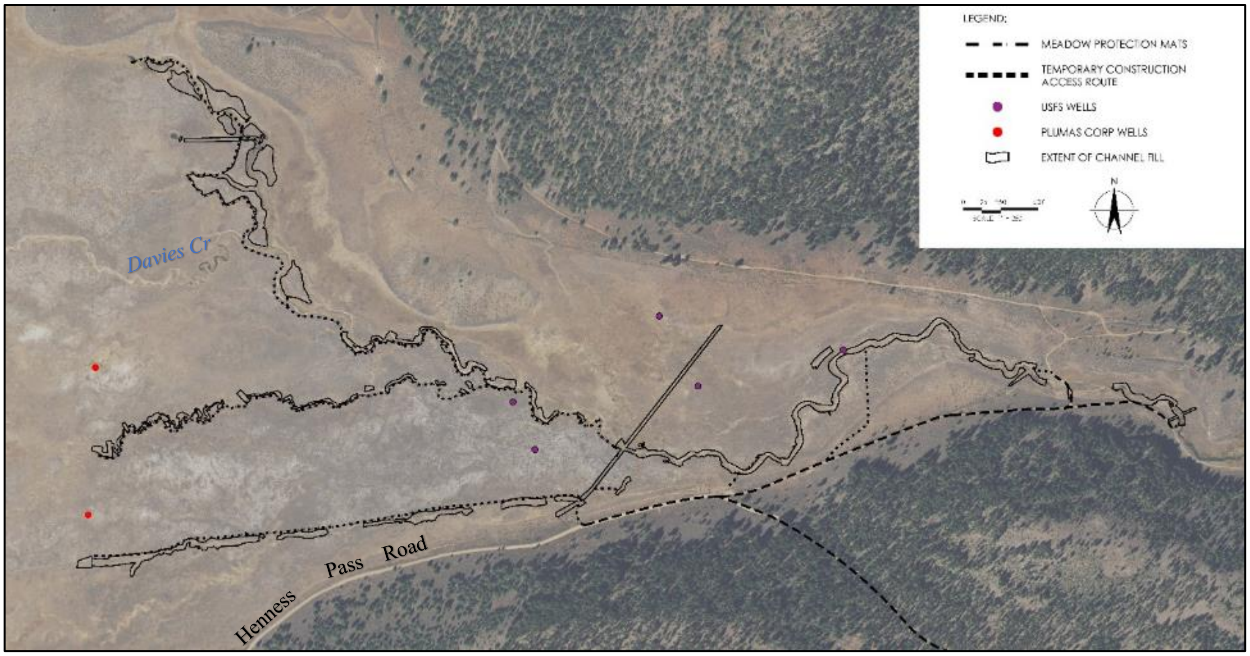


Figure 2. Sardine Meadow Restoration Project Area and Maximum Extent of Proposed Work

Setting

Upper Davies Creek runs along Henness Pass Road and drains southern flanks of Sardine Peak, east of the Sierra Nevada Crest, with a maximum watershed elevation of 8,134 at Sardine Peak. Davies Creek exits its canyon and enters the west side of Sardine Valley near an historical mill site and corral, where it has formed a broad and low-angle alluvial fan. After crossing Sardine Valley, the creek exits the project site at an elevation of approximately 6,035 feet.

The Davies Creek watershed is approximately 19.5 square miles as measured at the downstream end of Sardine Valley. Davies Creek flows into the Little Truckee River via Stampede Reservoir, which ultimately flows to the Truckee River. Portions of Davies Creek upstream and downstream of Sardine Valley underwent "plug and pond" enhancements in the past 15 years, as did a tributary to the creek in the northern arm of Sardine Valley, upstream of the project area.

Geology

The Project area is located in the transition between the Sierra Nevada and Basin and Range Geomorphic Provinces. This transition includes active Holocene faulting oriented in the north and northwest directions, which influences the locations of drainages and drainage patterns, springs, and other geomorphic expression (Melody, 2009; Stantec, 2017). The valley itself is located within a down-dropped graben, bound by both extensional and transverse faults associated with the Dog Valley and Polaris Fault Zones. The valley floor is dominated by alluvial sediments near the mouths of canyons, especially along the mouth of Davies Canyon where the broad alluvial fan has formed, but most of the valley floor consists of lake deposits (Saucedo and Wagner, 1992). The surrounding watershed is dominantly underlain by Tertiary volcanic rocks that are found in much of the Central Sierra Nevada- predominately andesitic breccias and associated mudflows (Saucedo and Wagner, 1992).

A generalized geologic map of the study area and surrounding watershed is included in **Figure 3**, which shows the distribution of geologic formations. Site-specific geomorphic and Anthropocene features were mapped as part of our analysis of the site and are described in more detail below.

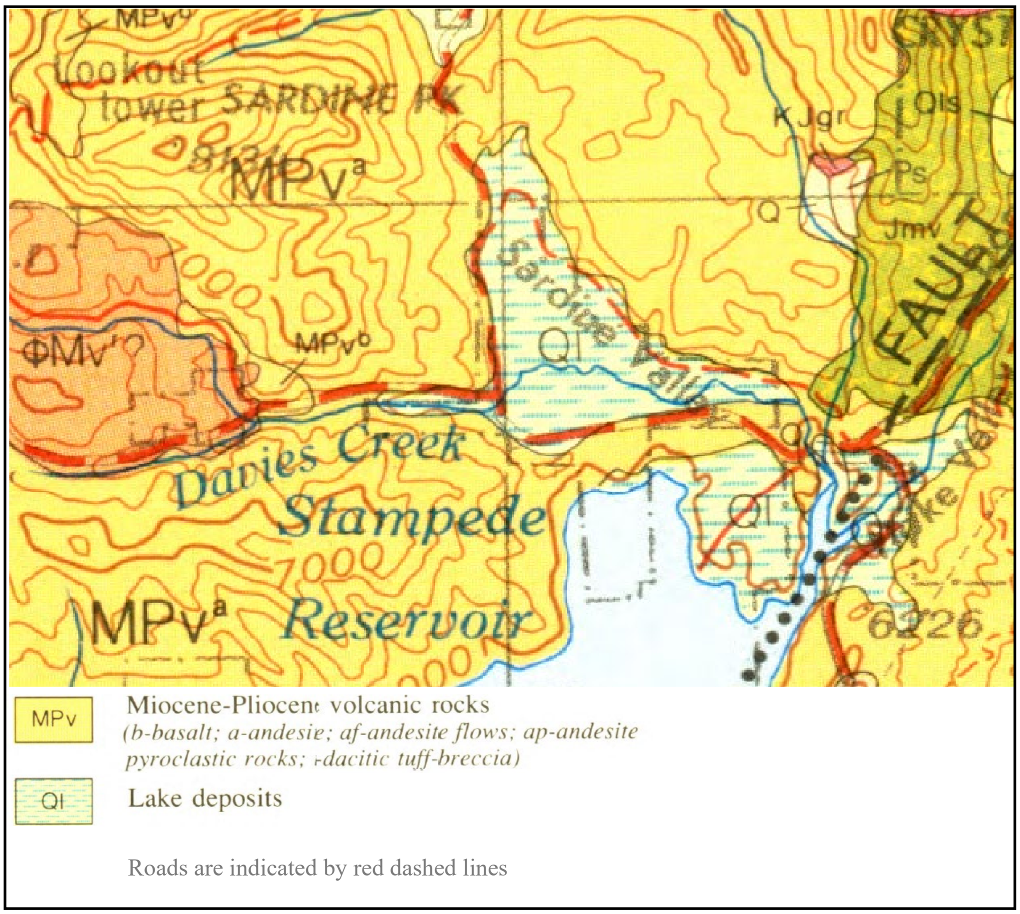


Figure 3. Generalized Geologic Map of the Study Area (Saucedo and Wagner, 1992)

Soils

Sardine Meadow soils are mapped entirely as Aquolls and Borolls, 0 to 5 percent slopes. Aquolls and Borolls are wetland soils found along stream corridors and at distal toes of alluvial fans. They are poorly drained (Hydrologic Soil Group D) soils and are noted as having a high water table during much of the year. These soils also support wetland vegetation such as willow, rush, and sedge. Reconnaissance-level soils evaluations reveal predominately clay and silty clay exposed in streambanks throughout much of the valley, and boring information at a single location in the center of the valley indicate sandy clay and gravelly clay to a depth of approximately 5.5 feet (Rust and others, 2017).

Historical Land Use

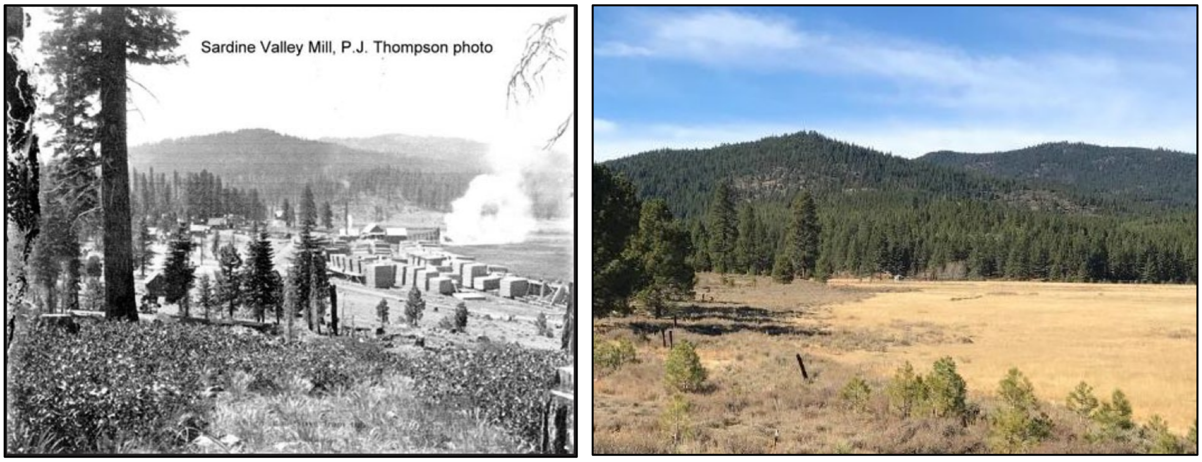
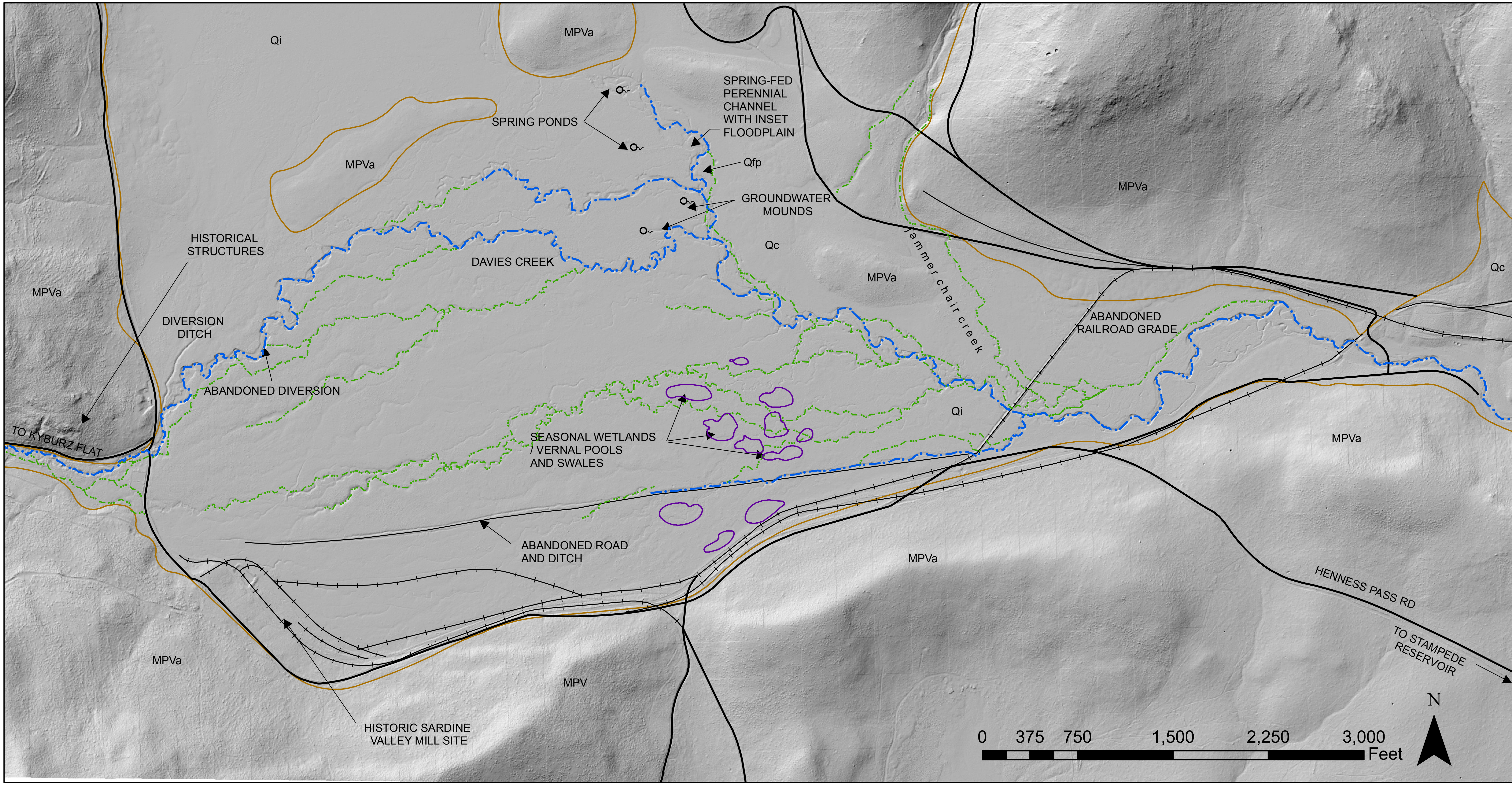


Figure 4. Sardine Valley Mill c. 1900 (reprinted from Copren, 2014) and existing conditions in Fall 2019

A number of events and land-use themes in the watershed and at the site appear to play an important role in the current status of meadow health and integrity and are well-summarized by Copren (2014). Early settlers first opened the Henness Pass Trail through the south side of Sardine Valley in 1853, which great numbers of immigrants used for travel to and from California through the 1850s. A flurry of mining activity occurred during the 1860s, during which time numerous stage stops and station houses were established in the area. Livestock and dairying operations were extensive in Sardine Valley beginning in the 1870s. Regional infrastructure for logging activities was first established in the1880s and began a period of several decades during which roads, railroad grades, and mills were built throughout Sardine Valley and in the surrounding contributing watershed. Figure 5 highlights numerous remnant roads and railroad grades that are discernable in the field and through analysis of high-resolution topographic data collected by the USFS (2013).

Channel and Wetland Form

Channel and wetland morphology appear to be controlled by regional geologic structure. Widespread seasonal ponding and wetland formation in the nearly closed valley is thought to have occurred during the Pleistocene epoch. With a valley floor slope on the order of 0.3 percent and localized depressions of up to 1-foot, seasonal ponding can still occur across the valley and in isolated closed depressions, or vernal pools, with hydrologic support from localized runoff and direct precipitation or snowmelt. Ditch construction and channel incision at roads and railroad grades, however, now serve to drain or cut off runoff to many of the closed depressions and swales, and it appears that much of Sardine Meadow has been converted from a discontinuous and seasonally-inundated system of shallow and broad swales and vernal pools to a system of distinct channels, with 2 to 3 primary incised channels now conveying much of the flow through the valley. Where railroad crossings and roads captured flow or forced flow paths into a single, straightened location, channels have formed and incised (see Figure 6). Where diversions and irrigation ditches were constructed, adjacent wetland areas appear to have been



Legend

- Main Channel
- Relict Channels
- Seeps/springs
- Existing Roads
- Abandoned Road, Railroad or Skid Trail
- Seasonal Wetland / Vernal Pools
- Geologic Contact

Qc Colluvium
Qf.p. Floodplain deposits
Ql Lake Deposits
MPV Volcanic Bedrock

Balance Hydrologics, Inc.

Figure 5 . Geomorphic Features and Historical Disturbance, Sardine Meadow, Sierra County, California
Source: Hillshade Source USFS 2013

converted to upland (Figure 7). At the north end of the project site, a series of springs is present, at least two of which appear to have been excavated into ponds with constructed outflow channels (Figure 8).

Figure 6. Railroad crossings have forced flows into a single location, causing erosion and incision, Davies Creek, looking southeast.

Figure 7. Road construction has captured flow and limited transmission of sheet flow across the meadow, Sardine Meadow, looking east.

Groundwater

The TNF established a groundwater monitoring program in the middle and downstream end of the of the project site beginning in 2017, and Plumas Corporation and CSUS researchers expanded the monitoring network, collecting and reporting groundwater level data from May 2017 through November 2018 (Rust and others, 2018). Groundwater data indicate groundwater levels to consistently have been within 1 foot of the ground surface in the spring before falling to 3 to 5 feet below the ground surface by August or September. This pattern was observed in both 2017 and 2018, years with above-average and near-average snowpack, respectively (Rust and others, 2018).

Surface Hydrology

Streamflow in Davies Creek has been measured by others downstream of the project site and a daily flow hydrograph was reported for period between May and July 2018 (Rust and others, 2018), after both the peak annual flow and peak annual snowmelt runoff.[1] Based on the information presented, it appears that the maximum daily average streamflow value for the period of record was on the order of 20 to 30 cfs[2]; The channel was reported to have become dry at the gaging location in early July 2018. Peak flow information was not presented, but our field observations of high-water marks suggest that the bankfull flow conditions were achieved in 2019, such that inset floodplains were inundated at times, but most of the valley floor was not subjected to overbank flooding.

Gotvald and others (2012) developed regional regression equations using watershed size, location, and elevation in portions of California to predict peak flow statistics. Application of these regression equations using the USGS StreamStats online tool (StreamStats, 2019) provides a rough estimate of flow magnitudes and frequencies on Davies Creek downstream of Sardine Valley, with varying degrees of accuracy, as reflected in the standard error of prediction. As shown in Table 1, the regression indicates that the 2-year flow is approximately 216 cfs, and the estimated 100-year flow is on the order of 1,570 cfs.

Table 1. Estimated Flood Frequencies, based on Regional Regression developed by Gotvald and others (2012), Davies Creek below Sardine Valley, Sierra County, California

Probability of Exceedence (percent)	Recurrence Interval (years)	Streamflow (cfs)	Standard Error of Prediction (cfs)
50	2	216	97.5
20	5	434	82.7
10	10	644	77.7
4	25	939	76.1
2	50	1,270	75.7
1	100	1,570	77.2

[1] Peak snowmelt timing is based on the instantaneous record for Sagehen Creek near Truckee California (USGS 10343500), roughly 8 miles southwest of the project area.
[2] A manual streamflow measurement of approximately 26 cfs is indicated in Rust and others (2018) Figure 46, though the accompanying text indicates that the maximum daily average streamflow value was approximately 29 cfs, the accompanying daily flow hydrograph shows a maximum peak daily flow of approximately 19 cfs. Continued streamflow gaging is warranted to better understand the nature of streamflow into and out of the project site as well as to document pre-project baseline hydrologic conditions.

Summary of the Proposed Restoration Design Elements

Restoration Objectives

TRWC proposes to re-establish a multi-threaded seasonal wetland and swale system in Sardine Meadow by raising the bed of the main channel, thereby blocking drainage paths, raising seasonal water surface elevations, and forcing more frequent inundation of abandoned swales and seasonal wetlands. As presented in the project Initial Study / Mitigated Negative Declaration prepared by Stantec (2017), the objectives of the overall Sardine Meadows Restoration Project are as follows:

- Restore approximately 350 acres of meadow by removing flow impediments to historical drainage patterns and filling portions of the existing degraded channel;
- Attract native willow flycatchers to the meadow;
- Increase groundwater levels to within plant rooting zones during the growing season;
- Improve late season streamflow;
- Improve grazing forage;

The restoration approach selected by the TRWC and USFS is intended to redistribute seasonal flows to spread across a greater area than the existing channel corridor and into the abandoned and discontinuous secondary relict channels, valley-floor depressions, and degraded seasonal wetlands. Partial filling of portions of the channel and eroded historical features will offset the effects of channelization, flow capture, and incision. Balance has reviewed the proposed restoration approach and developed design drawings to support the selected restoration approach. The following design elements are shown in the attached Intermediate (65%) Restoration Design Plans (Appendix A). Appendix A includes two alternatives for the upstream (northern) end of the project site, as represented on Sheets 3.05A/3.05B, 3.13A/3.13B, and 3.14A/3.14B and shown in Figure 8 and described below.

- **Channel Treatments.** Three primary channel treatment approaches will be employed where shown in Plans:

    A. **Preserve Functional Habitat**. Portions of the existing channel are serving as functional aquatic habitat and will be preserved. Functional habitat preservation areas tend to occur:

        - In moderately incised and widened channel reaches that have become dominated by well-vegetated inset floodplain surfaces, and
        - Where perennial spring discharge supports aquatic habitat and wetland vegetation.

    B. **Channel Fill.** Where the existing channel does not intersect secondary channels or seasonal wetland depressions, fill material will be placed to aggrade the channel to an elevation approximately 0.5- to 1-foot higher than the adjacent meadow surface. Prior to filling, the channel will be over-excavated to clear the bed and banks of vegetation, which will be salvaged and stored for transplanting or incorporation into a surface planting layer. The excavated surface will be scarified, and channel fill will be placed in lifts and compacted.

C. **Channel Fill at Relict Channel or Swale Crossing.** Where the existing channel crosses a smaller relict channel or swale, or where a broader inset floodplain has developed with functional wetland habitat, fill material will be placed to aggrade the channel to an elevation matching the relict channel or adjacent inset floodplain elevation, and to maintain flow along the swale. Prior to fill placement, the sub-grade will be prepared as described in (B), above.

- **Two Riffle Grade Control Structures.** Each grade control riffle is intended to prevent the lower meadow fill treatments from unraveling (i.e. reach-scale erosion) by allowing streamflow to transition from the meadow surface to the downstream channel bed over a short distance along Davies Creek. It is critical that the grade control riffle be a persistent feature for the long-term stability of the restored meadow, and the gradation of the riffle mixture be designed to be immobile in more than a 100-year event and also contain enough fine-grained material to seal the structure and avoid subsurface piping.

  One structure is proposed in the vicinity of an historical railroad crossing, and the other is proposed at the downstream end of the project, where the stream transitions into the upper end of plug and pond restoration project that was completed about 10 to 15 years ago. Both structures are sited at relatively narrow valley constrictions, where soils are interpreted to be coarser and therefore more stable. Additional investigations in this area are warranted to better understand the nature of the surrounding soils and degree to which keying of the structure will be required.

- **Debris Dams.** Where Channel Fill placement is anticipated to direct a significant flow volume to secondary channels or abandoned diversion ditches, Debris Dams are designed to slow water velocities and limit erosive forces on the receiving channels. Debris dams will be constructed of placed vegetation (i.e., sage and bitterbrush), branches, and shrubs, sourced locally, and held in place by driven stakes or posts.

- **Upper Meadow Alternatives A and B: Channel plugs and Inset Floodplain Excavation.**

  A. Alternative A is mostly consistent with the design initially put forth by the TNF but limits the originally envisioned extent of channel fill to only include strategically placed earthen plugs. The plugs would backwater upstream areas to increase the extent and depth of ponded water. The total area of disturbance and required fill volume would be less than originally anticipated with this approach but would still force more frequent inundation of secondary channels. This would likely cause a conversion of existing functional wetland floodplain habitat from perennial wet meadow to shallow ponded areas.

B. Alternative B, on the other hand, would consist of excavating converted upland areas to bring the grade down, closer to the current water surface, in order to expand the perennial floodplain and wetland habitat that is present. This work would also generate fill for use in other areas of the project and would be advantageous in that the generated fill material would be fine-grained and consistent with existing soils at the site. Both alternatives address modifications to spring-fed ponds and ditches that have been constructed for cattle-grazing operations. Additional subsurface investigations in this area are warranted to better understand the degree to which excavated sub soils can be successfully planted with wetland vegetation.

Figure 8. Upper Meadow at the northern end of project, looking upstream (west) at a spring-supported perennial swale system. Alternative A includes several earthen plugs to increase the depth, extent, and duration of ponded water in the channel and inset floodplain. Alternative B includes excavation of inset floodplains from adjacent upland areas to expand the extent of spring-fed perennial wet meadow across a greater area.

Construction Considerations

The attached plans also show the proposed location of access routes and haul routes. We understand that 20,000 cubic yards of fill material are available from the U.S. Bureau of Reclamation's Boca Dam Improvement Project, approximately 11 miles south of the site. Additional off-site borrow sites have not yet been identified, though approximately 10,000 cubic yards of material could potentially be generated as part of implementing Alternative B as described above and shown in the plans.

The project is anticipated to be constructed during dry conditions with limited or no flow present in the channel. If wet conditions occur during construction, flow rates are anticipated to be low enough to be pumped to a sprinkler system or discharged directly to the meadow surface. Revegetation plans are not included in the current design but are anticipated to be provided by TRWC staff or others.

Haul Road Considerations

Within the meadow, the channel itself or a 30-foot buffer at the top of the bank will serve as the primary haul route, allowing for moderate compaction of the channel fill material and minimal disturbance of meadow soils. Where haul roads must cross the meadow, meadow mats are proposed. Localized decompaction and rehabilitation of meadow soils may be needed where the mats were not 100-percent effective.

Limitations

This report was prepared in general accordance with the accepted standard of practice existing in Northern California at the time the investigation was performed. No other warranties, expressed or implied, are made. It should be recognized that interpretation and evaluation of geomorphic and ecologic conditions is a difficult and inexact art. Judgment leading to conclusions and recommendations presented above were based on observations of conditions during September through November 2019, existing information, personal communications and limited site reconnaissance, which in total represent an incomplete picture of the site. Natural seasonal, annual, and decadal variability in climate will cause different conditions than those observed during this period of study; more extensive observations over a longer time period would lead to a more robust understanding of variability in this system.

Balance Hydrologics has prepared this report for the Truckee River Watershed Council's exclusive use on this project. Analyses and information included in this report are intended for use at Sardine Meadow in Sierra County, California for the purposes of planning for meadow restoration only. Information and interpretations presented in this report should not be applied elsewhere without the expressed written permission of the authors, nor should they be used beyond the area to which we have applied them.

More extensive studies can reduce some of the uncertainties associated with this study. The following work would help form a more comprehensive basis for design of the project:

- Detailed topographic field surveys of the channel and relict channels;
- Vegetation mapping or surveys;
- Evaluation of subsurface conditions in the vicinity of each grade control structure and areas of inset floodplain grading (Alternative B);
- Streamflow gaging at a level of detail to confirm anticipated peak flow rates and baseflow conditions;
- 0.5-foot contour mapping and detailed grading plans for areas of cut and fill;

- Geotechnical evaluation of available fill material;
- Preparation of a watershed hydrologic model and reach-scale hydraulic model for evaluation of potential project effectiveness;
- Modeling of tractive forces associated with predicted peak flows for sizing of material to be used in grade control riffles.

References

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