Pleasant Creek Rock Vane Stabilization/Revegetation Project

Final Report: G/L Account #: 6140SC

May 28, 2021

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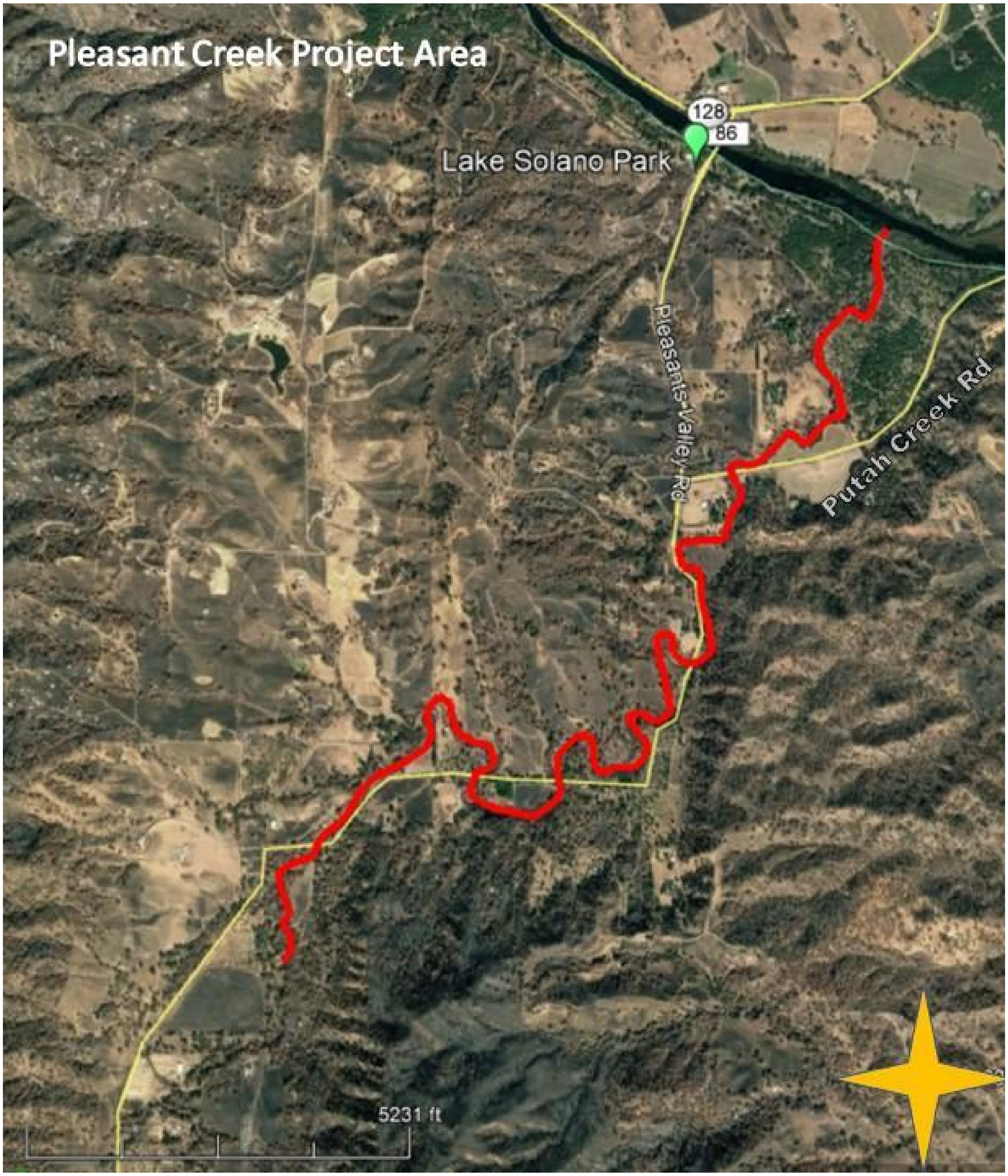


Figure 1 Pleasant Creek rock vane vegetation project area.

Executive Summary

During March through May 2021, a total of 1,200 native plants of 23 species (Table 1), in pots, rooted whips, rhizomes, and approximately 50 lbs of native seed were placed in around the rock vanes from April through May 15 2021.

Several techniques were used to enable the transport of the necessary plant materials and complete the project in a timely fashion. The techniques included root-rinsing, rooted whips, rhizome harvesting and seeding with a native mix.

All 86 rock vanes were reviewed to determine the preliminary survival rate from the planting effort. Of the 506 plants relocated during the evaluation there was an estimated 83% survival rate.

High survival rates are attributed to:

- Early season planting started while soils were still moist near the surface.
- The Pleasants Creek channel is the lowest point in the landscape.
- Planting was only done in sites with moist soil.
- Planting was only done in loose soils.
- Similar species were growing throughout the project area.

Fires influence many factors that can have immediate and lasting changes on the species and vegetational that can persist. This year, shrubs and ground cover species quickly resprouted throughout the drainage and the absence of canopy cover in some areas is creating a thick understory both in the channel and up the embankments. Understory and groundcover species will likely proliferate where the canopy was reduced.

Recommendations:

- Revegetation should be built into contracts associated with soil disturbance.
- Native grass and forb seed should be distributed immediately following completion of the disturbance to encourage native species and outcompete non-native invasives.
- Use of woodchips to promote plant health. Woodchips are a valuable resource on many levels: retaining soil moisture, reducing soil temperature, promoting biological activity, soil binder (fungal), and enhancing soil nutrition.
- Engage interested landowners beyond access permission by providing results of activities. It may also be worthwhile to reach out to some who may have valuable information about the history of the creek that could prove useful for future management. This promotes the LPCCC value of respecting local knowledge.

This project was funded by the Solano County Water Agency (SCWA). Opinions are those of the author, not necessarily SCWA.

Preamble

Rich Marovich, Streamkeeper

The LNU Complex Fire was the worst wildfire in the 62 year history of the Solano Project. It started from lightning strikes on August 17, 2020 and was fully contained on October 2, 2020 after burning over half of the Lower Putah Creek watershed downstream of Lake Berryessa including almost all of Pleasants Creek, already the most significant source of sediment to Lake Solano. Post fire assessments by CALFIRE and the US Geological Survey estimated that sediment loading would be up to twice the normal rate for any given amount of rainfall because fire destroyed nearly all vegetation in the affected areas.

Solano County Water Agency (SCWA) responded by constructing 86 rock vanes to trap excess sediment and rebuild the bed of the highly eroded channel. The project was constructed under emergency permits and focused only on the structures themselves, in the six month term of emergency permits that began in September 2020 starting just weeks after roads reopened following the fire. SCWA funded the rock vanes with emergency financial reserves that covered the cost of rock, rock hauling, installation and environmental monitoring.

The ensuing drought, one of the driest years on record, resulted in minimal silt and ash flows but also limited revegetation opportunities. The revegetation work was kept separate from rock vane construction and was funded by SCWA out of the Solano Project (non-emergency) budget.

The revegetation project tests the hypothesis that rock vanes will raise groundwater by trapping sediments and that it will increase the amount of substrate to grow native vegetation while adding stability as plants root among the rocks, binding them together and turning an engineering project into a bio-engineering project.

Even prior to the LNU Complex Fire, Pleasants Creek was a hostile place for most native vegetation. The channel is highly eroded and no longer floods the surrounding landscape that once contributed to groundwater recharge. Erosion has lowered the bed of the channel and water table along with it. The channel has increased in cross-sectional area nearly ten-fold in six decades due to water storage at Lake Berryessa. Pleasants Creek is no longer backwatered by the main channel of Putah Creek in peak on peak flows except when the Glory Hole is spilling. The rock vane project and this vegetation project have the potential to restore stability and sediment balance to Pleasants Creek along with groundwater and habitat benefits.

The first rock vanes on Pleasants Creek were installed in 2003 and were completely buried in sediment by the start of the 2020 rock vane project. New rock vanes were built over the top of existing vanes, using the existing vanes as a foundation. Vegetation planted in the vicinity of earlier rock vanes were thriving with additional depth of soil for moisture holding and rooting, with some completely overgrown by willows

Rock Vane Stabilization/Revegetation Final report

This report describes the process of using vegetation to stabilize a series of sediment control structures described as rock vanes that were placed within the Pleasants Creek Channel. A total of 86 rock vanes - one per foot of elevation drop - were systematically constructed over approximately 4.3 miles within the channel (Fig 1). The vane construction process required heavy equipment to place large and small boulders, rocks, gravel and sand into shaped groupings that can trap sediment and guide water flow patterns during flow events. While rock vanes are engineered to withstand high flows, optimal performance requires them to be sealed with gravel and vegetation. Encouraging vegetation to set roots within the relatively loose soils in and along these newly created features should provide some level of insurance against flows that could otherwise reconfigure the desired shape of the structure.

During March through May 2021, a total of 1,200 native plants of 23 species (Table 1), in pots, rooted whips, rhizomes, and approximately 50 lbs of native seed were placed in around the rock vanes from April through May 15 2021. Each vane was evaluated and planted or seeded according to the conditions that would best support the species. Ten rock vanes did not have adequate soil moisture to support rooted material and received only the native seed treatments in anticipation that future precipitation would germinate the seeds to establish rooted vegetation around the vanes.

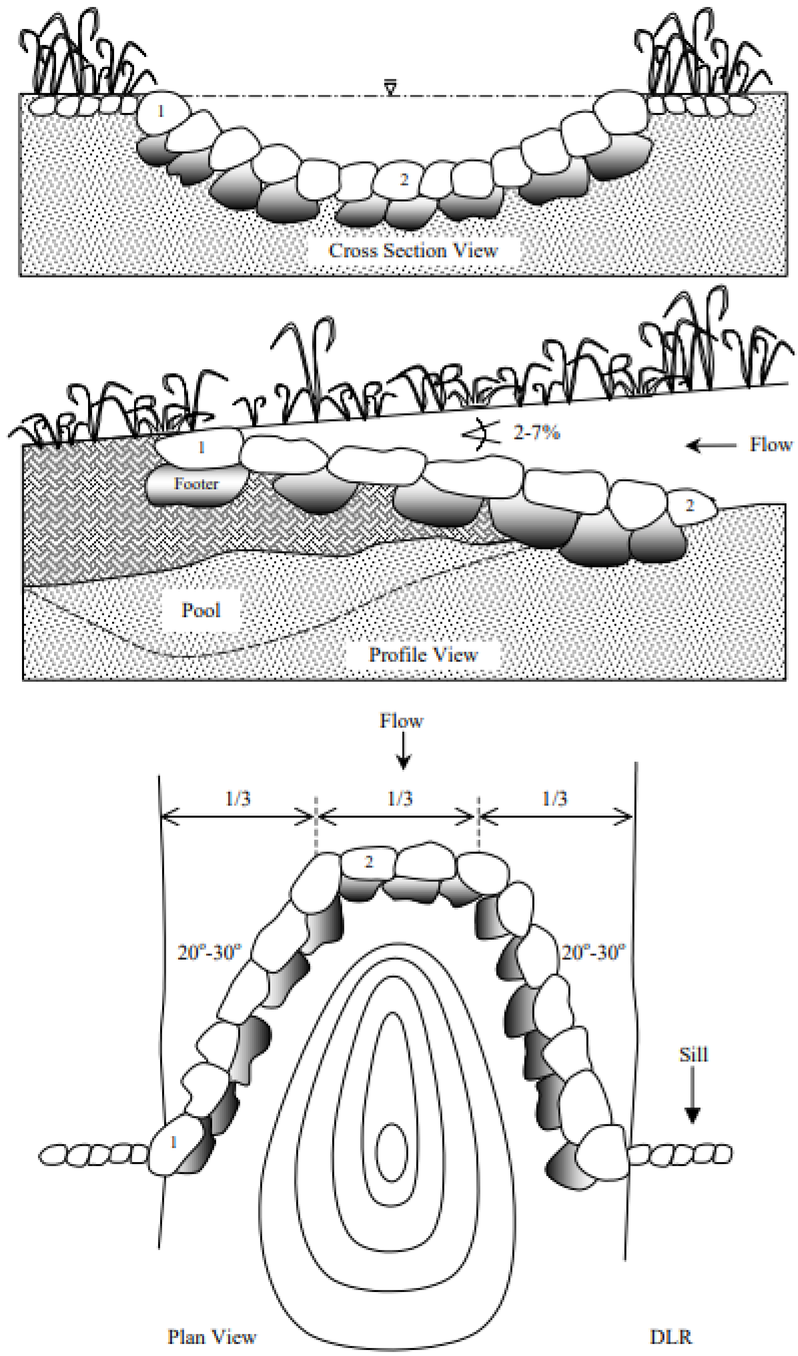
Rock Vanes

Rock vanes consist of rows of rock angled upstream at approximately 30 degrees off of the bank. They serve a number of functions including: establish grade control, reduce streambank erosion, facilitate sediment transport, enhance fish habitat, maintain width/depth ratio, maintain river stability, dissipate excess energy, withstand large floods, maintain channel capacity and be compatible with natural channel design (Rosgen 2001). There are two basic kinds of rock vanes, the ‘j-hook’ that curves in the center and the cross-vane that is essentially two vanes that merge in the center of the channel The cross vane looks like an upstream pointed ‘V’. A subtype of cross vane called a ‘w-weir’ is essentially two cross vanes side by side.

The vanes were created to interrupt and slow erosional processes within the creek channel to help reduce the sediment load that enters Lake Solano and all points downstream. Vane installation requires the use of heavy equipment within the channel which causes disturbance to the vegetation and soils. The purpose of the revegetation effort was to introduce native plants or seeds into and around the vanes to help stabilize the soils in advance of future flow events.

The vanes were constructed by placing rock, gravel and sand and when available large trunks of downed trees into shaped configurations to address erosional patterns occurring at the specific site within the creek channel. Most of the vanes span the entire channel where others extend part way across the channel.

The typical vane configuration has a V-shape where the point of the V points upstream causing sediment trapping upstream of the vane and convergent flows over the arms of the V, dissipating the energy of high flows in a plunge pool downstream of each vane (Fig 2). The vanes are located such that the lowest point of each vane is one foot of elevation lower than the vane immediately upstream, creating a system of rock vanes that work together to create a series of terraces when they eventually fill with sediment. In some locations, exposed bedrock served the same sediment trapping function as a rock vane. The point of the V is sometimes offset from the center to direct the flow in a desired direction to reduce erosional issues at that site. Partial vanes were often placed at locations where turns in the channel had caused severe erosional cuts resulting in high steep banks. Centrifugal force pushes the flow against the outside of the meander bend, undercutting the banks that then collapse due to gravity, causing not just surface erosion but mass wasting of the banks. The partial vanes were strategically placed to direct the water flow away from the embankment to interrupt and reduce erosive forces of the water.



Cross-section, profile and plan view of cross vane (Rosgen, 2001)

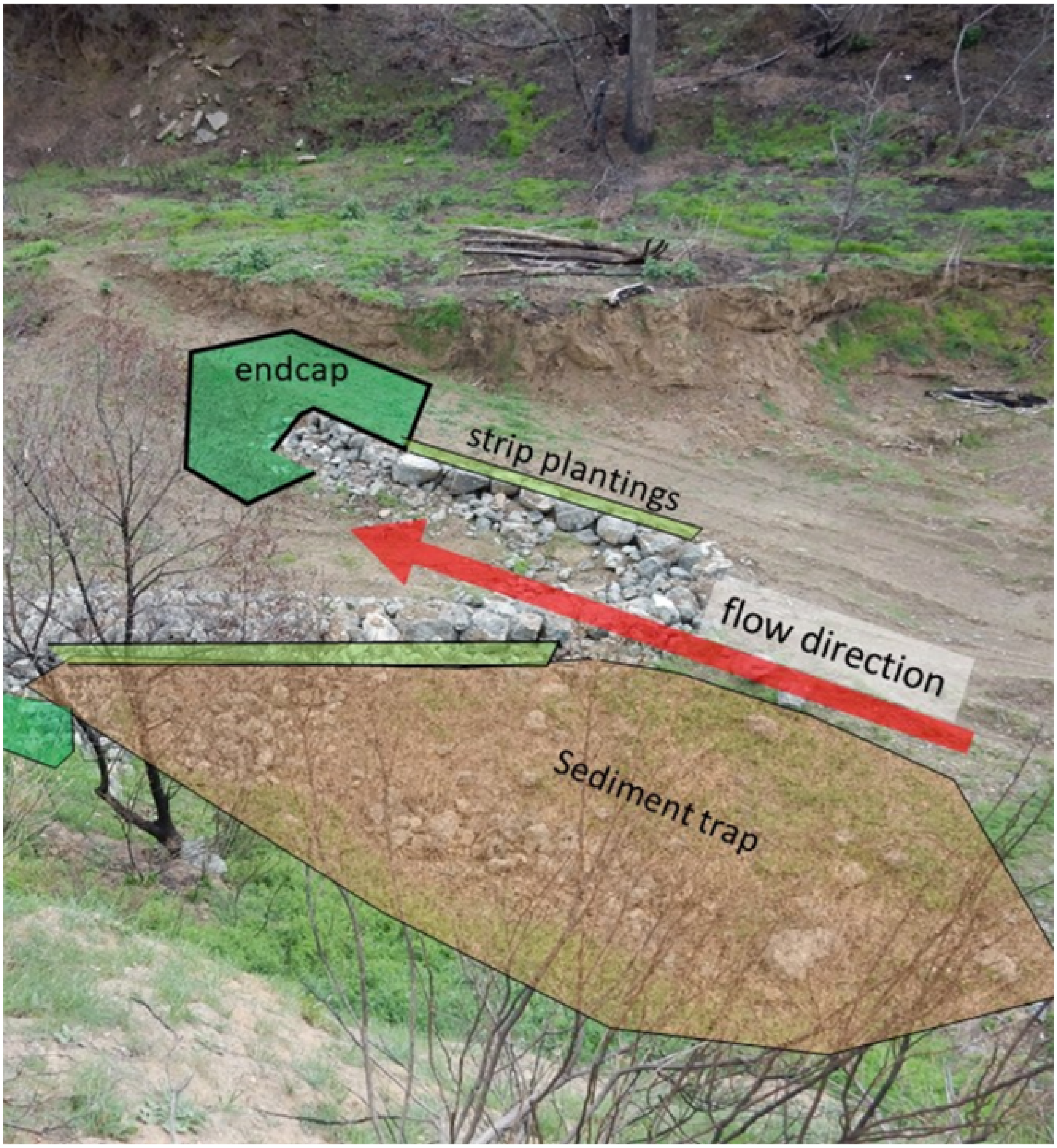


Figure 2. When a rock vane spans the entire channel it is shaped as an inverted "V" shaped to trap sediment upstream and center the flow downstream of each vane. Water crosses channel obstructions at 90 degrees, thus the rock vanes produce convergent flows over the arms of the rock vane into plunge pools that dissipate the energy of high flows.

Native Plant Introduction

The characteristics of each vane would dictate what kind of planting or seeding would best suit the conditions. Depending on the soil moisture, condition of the channel embankments, and vegetation present on the site, a series of plants were placed around each vane. A typical vane would receive 6 to 10 plants and approximately 0.5 lbs of a native grass seed mix. Since there is no ability to water the sites, it did not make sense to put plants into vanes that had no soil moisture. However, every vane received a dose of the seed mix.

There was very little precipitation during the winter and spring months through May of 2021 which undoubtedly affected how much moisture was in the creek channel. However, based on the presence of certain plant communities, there are several locations in the creek that appear to retain water for most of the year with good soil moisture available for plants. The initial installations of plants occurred in early April and continued through May 2021. At the beginning there were a few sites with flowing water in the channel and multiple locations with shallow pools, but by the end the surface water flows had ceased, and the majority of the pools had either dried completely or were drastically reduced in size.

Planting Techniques

The rock vanes are largely inaccessible by vehicle. Hiking on foot is required to access most of the vanes that are distributed along the creek channel filled with pools, logs, rock and sand. These conditions create a challenge for transporting materials such as heavy potted plants. Several techniques were used to enable the transport of the necessary plant materials and complete the project in a timely fashion (Fig 3). To reduce the weight associated with potted plants, the soil was removed by rinsing the roots (Fig 4). The newly cleansed roots were put into a bucket of water to keep them hydrated during transport while in the vehicle and then transferred to a bucket with no water during the hike into the vanes. Rhizomes and rooted whips were transported in a similar way.

Figure 3. Special techniques enabled planting of 295 plants into 8 vanes on the Lopez property in one afternoon.

Figure 4. Rinsing the soil from the roots substantially reduces the weight which improves planting efficiency and makes the root ball more malleable when planting among rocks.

There are many advantages to using the root-rinsing technique as it allows the ability to densely pack a bucket with an entire series of plants for efficiently transporting the day's materials needed for multiple vanes. Another benefit is that when the root ball is free of soil it is more malleable which made it easier to fit into the many irregular shaped holes that needed to fit between boulders. Removing the soil also helps to reduce introduction of unintended weed species that are sometimes growing in the pots. In the nursery, potting mixes are designed to be well drained but potting mix around the roots is somewhat of a liability in the field due to the sudden transition from potting mix to native soil. Bare root plants are immediately in contact with native soil with no soil-texture barriers to delay rooting. Virtually all forestry plantings are established with bare-root seedlings likely for all of these reasons.

Holes were dug for the potted plants between or adjacent to boulders in loose moist soils using a narrow trenching shovel. In many cases, several species were put into the same hole in an attempt to ensure something would survive. In general, trees and shrubs were not put into the intended flow zones but would target the ends of the vanes to follow the intention of the structure. A diverse list of species was used throughout the project area, choosing species that best matched the conditions at a particular location (see plant list).

Rooted whips were an ideal source of planting materials for this project. The whips were cut from the parent plant and put into buckets of water. By the end of April when planting began many of the whips had healthy roots. For rooted whips, we used 3 species of willows (*Salix lasiolepis, gooddingi, and leavigata*) and mulefat (*Baccharis salicifolia*).

A 4-foot pointed dowel with a handle on one end became the most efficient method to probe holes into moist soil among boulders or moist embankments. Rooted material or rhizomes can be inserted into the holes. The pointed dowel can also be used with plugs or the smaller potted plants.

Rooted whips were gently spiraled down into the hole to avoid damaging sensitive roots. A large number of rooted whips or rhizomes could be easily transported and quickly slipped into cracks and crevices in this way. Rooted whips were only used where the soils were moist, targeting pool edges or slipped into holes under boulders that were trapping moisture. The follow up evaluation later showed that a majority of these plantings were still alive up to a month later, which means the roots were growing and were likely getting a hold in the soils. Whips put into drier soils did not survive.

When possible, rhizomes from mugwort (*Artemisia douglasiana*) and ragweed *(Ambrosia psilostachya*) were used to augment plantings. If a good stand of mugwort or ragweed was nearby that was robust enough to serve as a borrow site with only temporary impact, rhizomes were dug up and transferred into moist soils to initiate a new stand among the boulders. The evaluations showed this to be a highly efficient way of promoting the establishment of a plant community to help stabilize the soils in and around the vanes.

Seeding was used at every site targeting any location soil had been disturbed that was directly associated with the vane. More seeding could have been used but the focus was at the vane.

Post-planting survival evaluations

All 86 rock vanes were reviewed to determine the preliminary post-planting survival rate from the planting effort. Of the 506 plants that were able to be relocated during the evaluation there was an estimated 83% survival rate. This number was calculated by dividing the total number of plants relocated by the ones that were dead. The number of plants relocated represent slightly less than half of those planted. There was difficulty finding the plants due to profuse plant growth that took place between the end of March and early May at many of the vanes. The invasive purple vetch (*Vicia benghalensis*) blanketed portions of the vanes and surrounding embankments making it challenging to relocate many of the plants which were in many cases nothing more than a small whip with a few budding leaves. The non-native vetch is an annual species that will die back and reseed itself by June. However, when plants were found under the blanket, they were often doing fine, so the proportion of plants that survived to this point may still be relatively accurate. If the many whips take root and build a canopy this year, they will help to suppress the proliferation of non-native species.

After the planting effort was completed in early May, the post-planting follow up evaluation was used to assess plant survival to determine the effectiveness of the plantings. It is a good sign if a plant survives the first few weeks after it is transferred from nursery care into the ground. It means that there was sufficient moisture to ensure it can begin the process of establishing its roots. Each live plant was marked with a short bamboo stake painted with non-toxic orange paint so that it may be possible to revisit the sites and assess survival at a later date (Fig 5).

Evaluation Criteria: Plants were counted as having survived if they were still green or had new leaves or buds. It is known that the number of plants surveyed were undercounted due to thick vegetation that sometimes made it difficult to locate the new plants. The evaluation was not intended to be a thorough inventory because it is not possible to find all of the plants again in areas where the vegetation had grown too thick to see them. Most of the thick vegetation is composed non-native invasive species like purple vetch (*Vicia benghalensis*) which is prolific throughout the region. It is hoped that the plants will emerge from thick vegetation as they grow. Plants that could be found nestled among thick vegetation appeared to be doing well, in fact in some cases the cover may have helped them survive by shielding them from desiccation.

Figure 5. These orange bamboo stakes were used to mark where plants are installed in the vanes. Post hole diggers are NOT recommended for planting in the channel.

The follow up evaluation showed that there was a high survival rate even for the plants that were not in close proximity to pooled water which is an indication that there is moisture retained in the creek channel even when it is superficially dry. Plantings were not used in vanes whose surrounding soils did not have obvious moisture. There were only 10 vanes that fell into this category and many of those were partial vanes. However, every vane received a dose of the native grass seed mix in anticipation that when moisture does occur germination can begin immediately with roots helping to retain soils surrounding the vanes.

The reasons why the survival rate is likely high is attributed to:

*Early season planting started while soils were still moist near the surface.

*The Pleasants Creek channel is the lowest point in the landscape which is where water gathers.

*Planting was only done in sites with moist soil.

*Planting was only done in loose soils.

*Similar species were growing throughout the project area.

Figure 6. An example of a dry rock vane on the Flaherty property that did not have enough moisture to support rooted plants, especially considering there is no ability to water the plants. 10 dry vanes received only native grass seed at this time of year.

2021 Rock Vane Revegetation Plan						
What was planned	**What was done**	**What was discovered**	**Results**	**What was learned**	**Successes**	**Challenges**
*Revegetate all rock vanes to introduce rooted native plants to stabilize soils and help compete with aggressive invasive species	*All vanes had some level of native plant material introduced *Rooted materials were used only at sites with moist soils	*Some vanes were difficult to plant due to rocks or dry soils *Potted plants are difficult to carry into remote areas	*Some vanes were too dry to use rooted plants	*Several techniques need to be developed to address challenges *Planned concepts needed in field adjustments	*Moist soils were present at most sites even though it was a dry year	*The Revegetation process could have started earlier. *Good quality field notes are time consuming and are sometimes difficult to decipher.
*Seeding of native species to enhance revegetation success	*Seeding was used at every vane	*~0.5 lbs of seed were used per vane	Some vanes received only seeding	*Initial seed quantities were grossly underestimated	*All vanes seeded because SCWA had extra seed	*Budget for appropriate amounts of seed.
*The post planting survival evaluation process was added once the plants had been installed to understand if it was working as planned	*Post planting survival estimates were conducted one month after completion	*It is difficult to do postplanting surveys because if the plants die they are just a dried up stick. *Planted material buried under profuse plant growth of invasive species (i.e. purple vetch (*Vicia benghalensis*))	*A full evaluation was completed adding markers where plants could be relocated. *Of the plants that could be relocated, survival rates were high (83%).	*Marking the plants with painted (nontoxic) bamboo stakes (not plastic flagging) was a good idea and extremely useful but it was an afterthought and should have been done at the beginning.	*Initial indications are that there is a high rate of success but the dry season may change that. *Moist soils were present during most of the planting effort.	*Plant marking using bamboo stakes during installation will help with more accurate inventory and then relocation to improve accuracy of the post-planting survival estimates. *A dry year will undoubtedly reduce survival.

		can be difficult to find.				
*Coordinate activities with landowners.	Landowners were informed of the activities.	*Very few landowner interactions occurred during the field effort.	*Vanes were visited with no interruptions	*Landowners have potentially useful information	*Landowner discussions were very positive and supportive of the project	*Some landowner friendly version of this report should be provided to interested landowners. *A landowner feedback concept should be incorporated into future contracts.

Discussion

Currently, it is unclear how future conditions in the creek will alter the vegetation that can survive there. In most regions of the central valley in California the highest diversity of plant species are associated with drainages. Periodic fires can dramatically alter the vegetational communities literally overnight. This last fire altered canopy cover in large patches throughout the drainage which will likely take 10 to 15 years to recover. The fires influence many factors that can have lasting changes on the vegetational communities and species that can persist. This year, shrubs and ground cover species quickly resprouted throughout the drainage and the absence of canopy cover in some areas is creating a thick understory both in the channel and up the embankments. Natural clusters of sapling cottonwoods and willows were observed to be fairly common in select areas along the creek channel this year.

One efficient way to address future unknowns associated with ecosystem stability along the creek is to ensure that the plant species diversity remains high. Putting plants into the creek channel like we did for this project is a good way to immediately improve the biodiversity and to ensure future seed loads find their way down the channel. Diverse plant communities help to enrich and stabilize ecosystem function at all trophic levels.

Figure 7. One major goal of using native species is to promote biodiversity. This caterpillar (Cerura vinula) was found feeding on one of the willows recently installed on the Garcia property.

The most efficient planting methods used for this project included using rooted whips and onsite harvested rhizomes in combination with a pointed jab-stick to check for moisture and quickly create a planting hole. Seeding with the native grass mix should be used whenever soil is disturbed in the creek channel to avoid providing spaces that can quickly become colonized by non-native invasive species. Although potted plants have the advantage of providing well-rooted plants, finding suitable locations among or near the vane boulders was at times a limiting factor and was no match for the efficiency behind transporting rooted whips or simply moving nearby rhizomes into the cracks and crevices among the boulders. The final evaluation revealed that there are good survival rates with all sources of planted materials throughout the project area. As

However, the true survival test will be determined by what makes it through the summer. At the last visit, the creek pools and soil moisture were quickly evaporating. Most of the locations selected for planting had good moisture at the time of planting and the evaluation showed that the survivors had rooted. The roots will chase the moisture as it recedes in the upcoming months. If there are any locations where plants could survive a summer without intense watering it will be in the channel which is the lowest place in the landscape. The mortality rate is expected to rise but it is hopeful that the new plants can take advantage of any residual channel moisture that remains throughout the summer. It will be especially interesting to learn if the naturally occurring clusters of cottonwoods and willows observed in the channel make it through the dry season.

Conclusion and Recommendations

If work that requires soil disturbance is planned within the creek channel, revegetation should be built into the contracts. At a minimum, native grass and forb seed should be distributed immediately following completion of the disturbance. Promoting the presence of native grasses and forbs will help to compete with non native species and will help to ensure a continuous supply of local native plant seeds. If replanting is deemed necessary, the ideal planting season is typically from October through April which would coincide with the winter months when soil moisture is typically higher. During years of average precipitation water may persist in the channel further into the summer months.

The use of woodchips has many benefits. Spreading chips during or after construction will help to reduce soil movement and can promote plant growth (Fig 8). Chips help to retain soil moisture, promote biological activity, reduce the soil temperature, and improve the soil as they break down through the years. Under certain conditions chips have the ability to reduce erosion by binding the chips and soil together by promoting fungal growth.

Figure 8. Woodchips promote plant growth. Oak seedlings found emerging from woodchips that were placed under an oak on what was a pulverized road surface.

As a side note, during the course of the project, some of the landowners shared stories about experiences of growing up along the creek that may provide useful information about how best to manage working along the creek while balancing landowner needs. It could be worthwhile to invest in compiling a collection of historical accounts of life along Pleasants Creek from some of the older landowners who are still around. This promotes the LPCCC value of respecting local knowledge.

Acknowledgements: A special thank you goes to Don Sanders for stepping in to voluntarily assist with important efforts at key moments. It is well-known that Don has become an invaluable asset to the Agency, where he generously and continuously volunteers his time and abilities to respond to multiple layers of the agency's needs. In addition, Herb Wimmer deserves to be recognized for allowing us to store and care for plants on his property on a daily basis. His property was in an ideal location enabling us to efficiently care for and move the plants during the effort. And he was a pleasure to engage in conversation when he would come around to share stories while on his daily walks along the creek. Rich Marovich provided guidance throughout the project ensuring the process flowed smoothly and helped to coordinate necessary stages of the project including report reviews/commentaries and a planting event with volunteers from the local Rotary chapter. Rich enabled a substantial number of plants to successfully make it into the ground in association with this project.

Table of plant species used for revegetation

Common name	***Scientific name***	**potted**	**rooted whips**	**rhizomes**	**seeds**
Red willow	*Salix laevigata*	x	x		
Arroyo willow	*Salix lasiolepis*	x	x		
Gooddings willow	*Salix gooddingii*	x	x		
Cottonwoods	*Populus fremontii*	x			
Sycamore	*Platanus racemosa*	x			
Alder	*Alnus rhombifolia*	x			
Valley Oak	*Quercus lobata*	x			
California buckeye	*Aesculus californica*	x			
Buttonwillow	*Cephalanthus occidentalis*	x			
California wild rose	*Rosa californica*	x			
Mugwort	*Artemisia douglasiana*	x	x	x	
Mulefat	*Baccharis salicifolia*	x	x		
Ragweed	*Ambrosia psilostachya*			x	
Perennials	**Apocynum cannabinum*	x			
Grass mix seeding					x
Blue rye	*Elymus glaucus*				x
CA brome grass	*Bromus carinatus*				x
Annual fescue	*Festuca microstachys*				x
Tomcat clover	*Trifolium willdenovii*				x
Wild rye	*Elumus triticum*				x

*Other single species were also substituted in proper conditions because they were appropriate and available.

Table of the 86 sites locations

Property	Vane#	X_Coordinate	Y_Coordiniate
Martin	1	6555690	1940111.375
Martin	2	6555216	1939242.125
Martin	3	6554880.5	1938876.125
Martin	4	6555149	1938247.75
Flaherty	5	6555270	1937884
Flaherty	6	6555270	1937818.5
Flaherty	7	6555214.5	1937798.625
Flaherty	8	6555069	1937806.625
Flaherty	9	6554897.5	1937608.625
Flaherty	10	6554823	1937516.125
Flaherty	11	6554763.5	1937503.875
Flaherty	12	6554648	1937605.875
Flaherty	13	6554290.5	1937400.25
Flaherty	14	6554177.5	1937270.25
Flaherty	15	6553955.5	1937190.75
Flaherty	16	6553759.5	1937222.75
Shurnas	17	6553703	1937012.875
Shurnas	18	6553823	1936827.875
Shurnas	19	6553139	1935790
Shurnas	20	6553206	1935787.375
Shurnas	21	6553272	1935755.125
Shurnas	22	6553291.5	1935682
Garcia	23	6552995.5	1934497
Garcia	24	6552943	1934538.75
Garcia	25	6552936	1934609.875
Garcia	26	6552810.5	1934884.375
Garcia	27	6552738.5	1934847.625
Garcia	28	6552697	1934819.875
Rose	29	6552366.5	1933088.375
Rose	30	6552300	1933118.875
Rose	31	6552215	1933148.375
Rose	32	6552108.5	1933081.875
Rose	33	6552023.5	1933044.625
Rose	34	6551902.5	1933067.5
Rose	35	6551834.5	1933231.25
Rose	36	6551827.5	1933274.125

Rose	37	6551818.5	1933377.125
Rose	38	6551806.5	1933435.25
Rose	39	6551793.5	1933516.25
Rose	40	6551731.5	1933540.5
Rose	41	6551648.5	1933503.875
Nichol's-Angies	42	6551343.5	1932683.75
Nichol's-Angies	43	6551226.5	1932574.75
Nichol's-Angies	44	6551135.5	1932484.5
Nichol's-Angies	45	6550838	1932491.5
Nichol's-Angies	46	6550604	1932493.125
Nichol's-Angies	47	6550462	1932535
Nichol's-Angies	48	6550414	1932579.125
Kowalski	49	6549657	1933976.25
Kowalski	50	6549618.5	1933894.875
Kowalski	51	6549632.5	1933637
Kowalski	52	6549640	1933483.625
Kowalski	53	6549609	1933408.75
Kowalski	54	6549556.5	1933362.625
Kowalski	55	6549438	1933298.25
Kowalski	56	6549242.5	1933124.875
Kowalski	57	6549178	1933089.5
Kowalski	58	6549086	1933056.375
Kowalski	59	6548876.5	1932989.125
Lopez	60	6548781.5	1932920.625
Lopez	61	6548749	1932864.625
Lopez	62	6548738.5	1932774.875
Lopez	63	6548709.5	1932663.25
Lopez	64	6548640	1932619.875
Lopez	65	6548547	1932506.75
Lopez	66	6548420	1932394.875
Lopez	67	6548325.5	1932335.375
Lopez	68	6548235.5	1932243
Lopez	69	6548186	1932186
Lopez	70	6548146.5	1932160.375
Hoskins	71	6547892	1931744.375
Hoskins	72	6547875.5	1931714.375
Hoskins	73	6547841	1931702.875
Hoskins	74	6547781.5	1931709
Hoskins	75	6547623	1931748.875
Hoskins	76	6547552.5	1931703.75

Hoskins	77	6547513	1931548.75
Hoskins	78	6547518.5	1931505.25
Hoskins	79	6547550.5	1931419.5
Hoskins	80	6547740.5	1931165.875
Hoskins	81	6547751.5	1931106.125
Hoskins	82	6547716.5	1931051.625
Hoskins	83	6547639	1930461
Hoskins	84	6547592	1930416
Hoskins	85	6547492	1930459
Hoskins	86	6547463.5	1930436.375

Aerial images of 86 sites distributed along Pleasant Creek covered by this report.

Figure 8 Martin

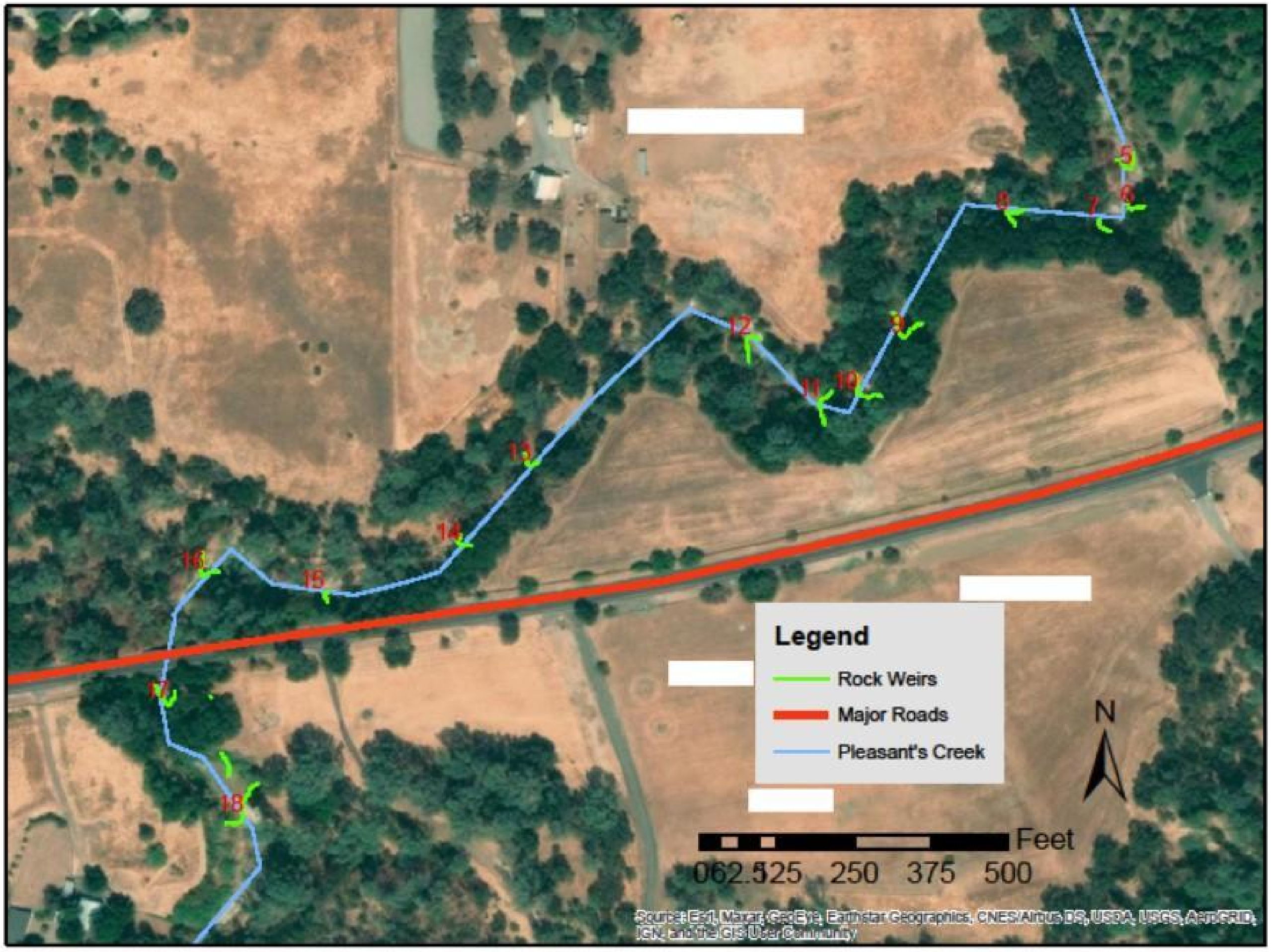


Figure 9 Flaherty

Figure 10 Shurnas

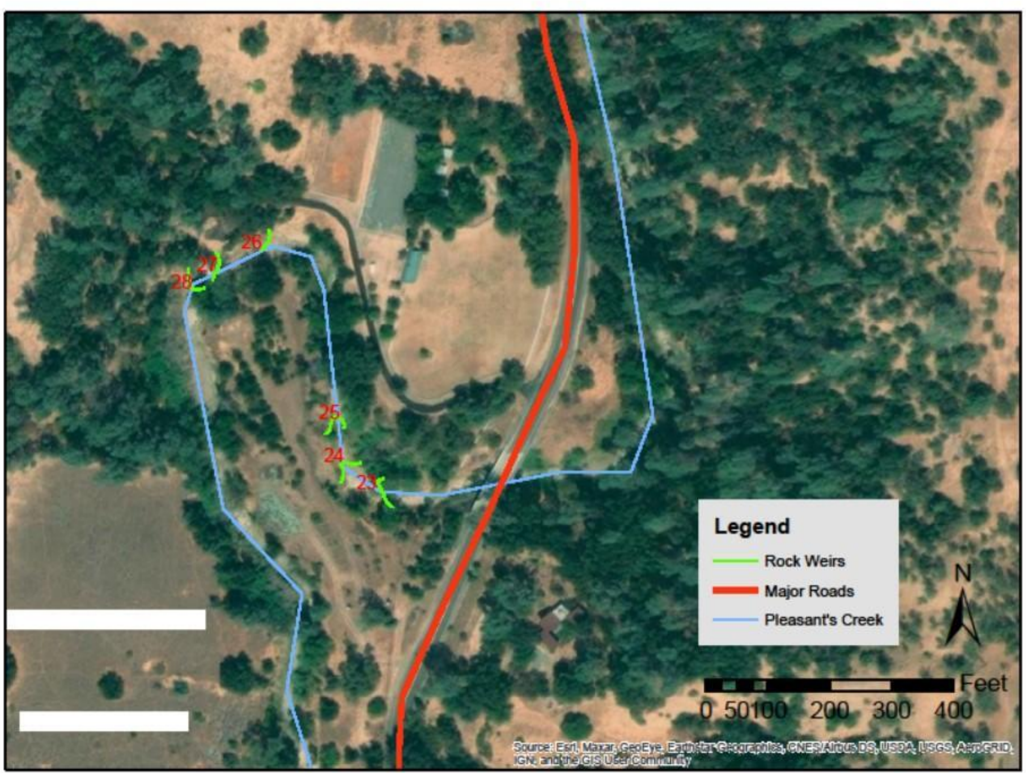


Figure 11 Garcia

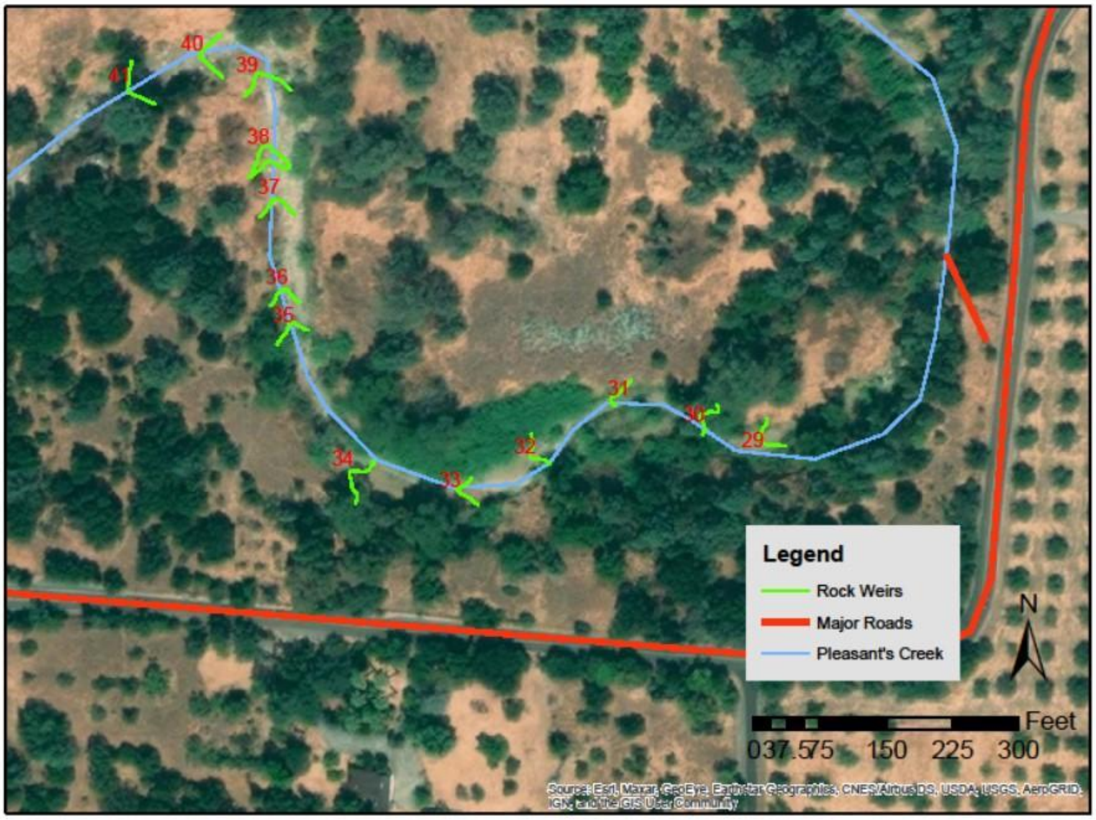


Figure 12 Rose

Figure 13 Nichols/Angies

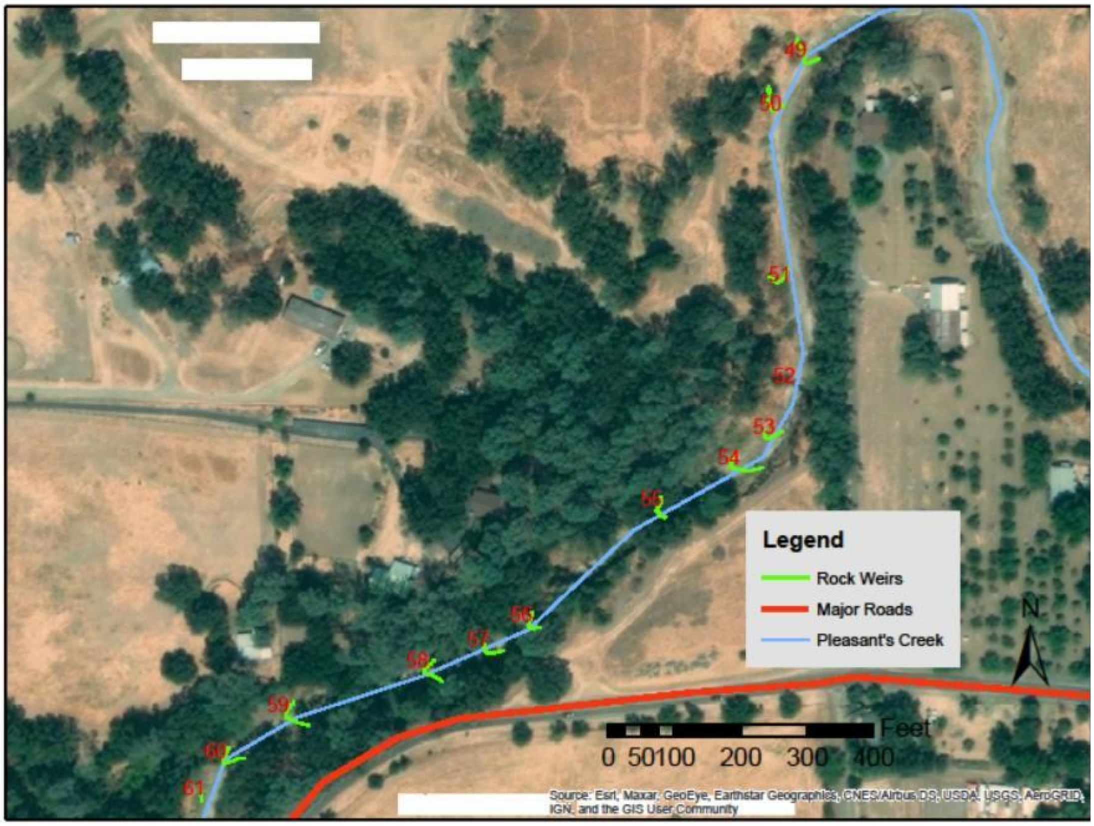


Figure 14 Kowalski

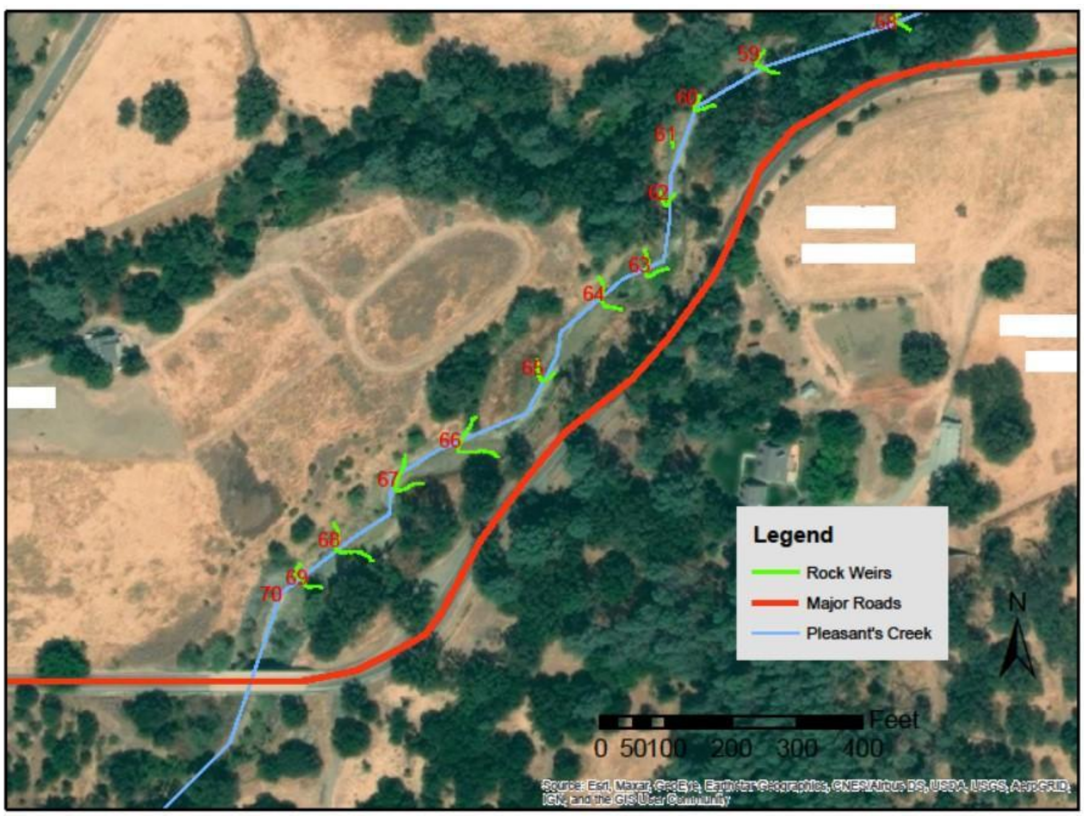


Figure 15 Lopez

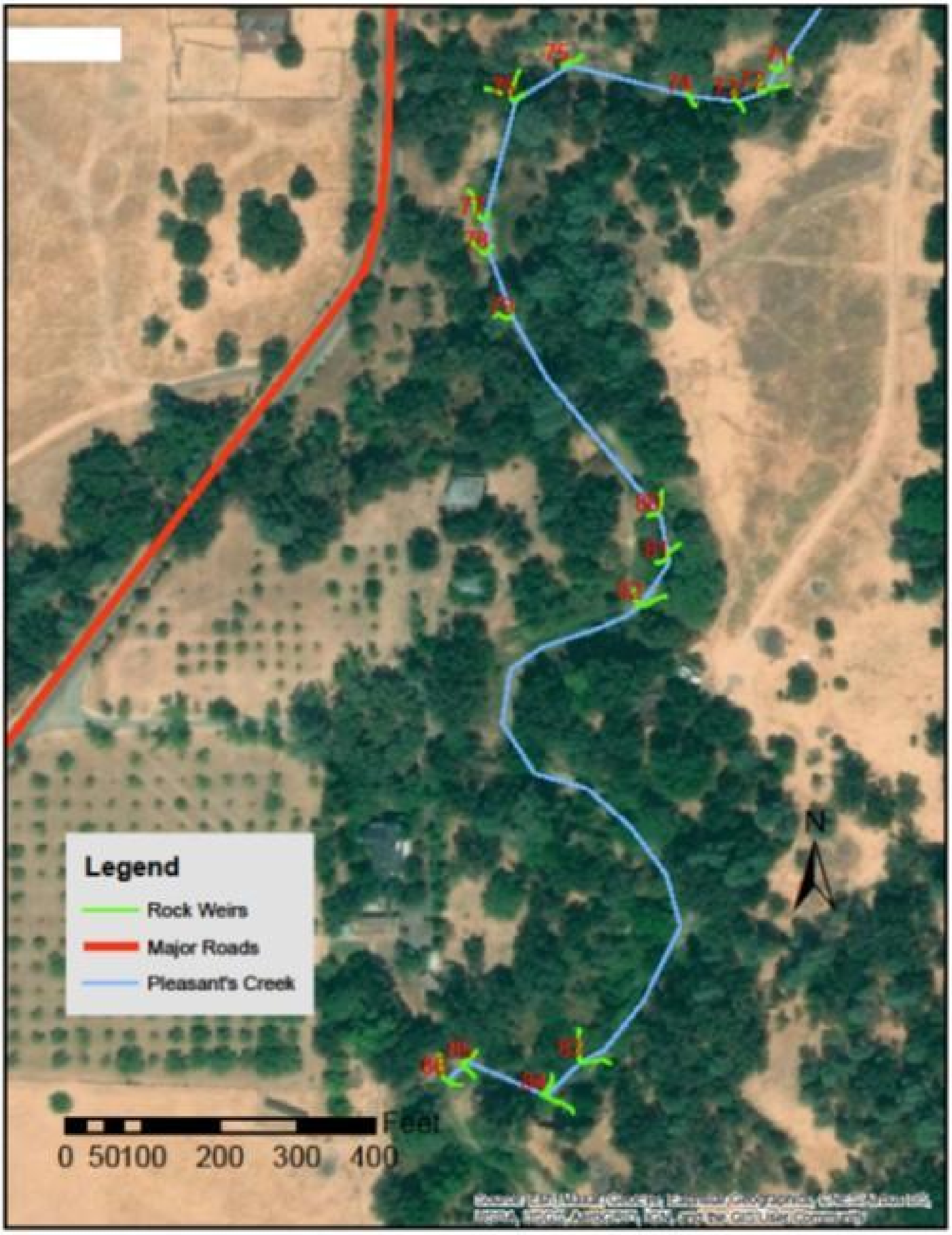


Figure 16 Hoskins

Useful documents:

Mulch

Brindle, Frances A. "Use of native vegetation and biostimulants for controlling soil erosion on steep terrain." *Transportation research record* 1819.1 (2003): 203-209.

Chalker-Scott, Linda. "Impact of mulches on landscape plants and the environment—a review." *Journal of Environmental Horticulture* 25.4 (2007): 239-249.

Claridge, Andrew W., James M. Trappe, and Karen Hansen. "Do fungi have a role as soil stabilizers and remediators after forest fire?." *Forest ecology and management* 257.3 (2009): 1063-1069.

Biodiversity

Goulson, Dave. "The insect apocalypse, and why it matters." *Current Biology* 29.19 (2019): R967-R971.

Hallmann, Caspar A., et al. "More than 75 percent decline over 27 years in total flying insect biomass in protected areas." *PloS one* 12.10 (2017): e0185809.

Rosenberg, Kenneth V., et al. "Decline of the North American avifauna." *Science* 366.6461 (2019): 120-124.

Rock Vanes

Rosgen, D.L., The Cross-Vane, W-Weir and J-Hook Vane Structures…Their Description, Design and Application for Stream Stabilization and River Restoration. September 2001. http://www.hydrology.bee.cornell.edu/BEE4730Handouts/Rosgen_Vanes.pdf