



SONOMA ECOLOGY CENTER

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A Vision for Water Resource Management and Climate Resilience within the Open Spaces of the Sonoma Developmental Center (SDC)



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Introduction

In 2018 Sonoma Ecology Center (SEC) secured funding from the California State Coastal Conservancy (SCC) to do studies, restoration work and planning focused on Sonoma Creek and its associated riparian areas as it runs through the shuttering Sonoma Developmental Center (SDC) and the adjacent open spaces of the Sonoma Valley Wildlife Corridor. The Sonoma Creek watershed likely supported the second largest steelhead run among Bay Area streams historically, yet decades of hydrological modifications across the watershed, including groundwater extractions and direct pumping of surface waters have resulted in declining dry season streamflow and increased stresses on steelhead and other sensitive aquatic species. Through our previous work, SEC has determined that declining streamflow during the summer rearing season is the primary factor limiting the recovery of steelhead in Sonoma Creek. Groundwater declines have led to the establishment of the Sonoma Valley Groundwater Sustainability Agency who recently released a groundwater recovery plan for the valley (see: https://sonomavalleygroundwater.org/wp-content/uploads/Sonoma_Valley_GSP.pdf). Given these concerns, one task built into the aforementioned SCC grant was to identify one or more favorable locations on the SDC property to plan for and implement stormwater retention and groundwater infiltration projects to combat declining groundwater levels and improve dry season streamflows in Sonoma Creek and its tributaries. Since this study was initiated, even greater public emphasis has been placed on addressing groundwater declines including a recent change in California law which treats aquifers as ‘natural infrastructure’ and considers groundwater recharge a strategic defense against climate change. This law lends strong support to the diversion and retention of flood waters for groundwater recharge and is expected to result in significant increases in public funding for such projects on public and private lands.

The staff of SEC has a deep, collective knowledge of the open space areas of SDC. The organization has been doing projects to steward these land resources for nearly three decades including the original conceptualization, naming and promoting of the Sonoma Valley Wildlife Corridor (SVWC) which encompasses these lands. Steven Lee, SEC Senior Scientist, Research Program Manager and Project Manager on the SCC project has particular knowledge of the fields, forests and creeks of SDC. They are his backyard, as he grew up and still lives on a small farm property bordering the SDC open space land in the heart of the wildlife corridor.

Given our extensive knowledge of the property and our organizational mission to promote climate resiliency in Sonoma Valley, and enabled by additional funding from the Sonoma Valley Catalyst Fund to promote natural resource protections on SDC lands, we elected to expand the mission of this project task beyond just one or two project sites. Instead, we set out here to develop a more comprehensive and “living” water resources planning and visioning document which outlines *multiple* locations for retention and infiltration opportunities of various scales to take maximum advantage of the unique landscape context of this large section of publicly owned land and its potential to foster tangible improvements in local water and watershed management. At the same time, we elected to include in this document a discussion of chronic erosion sites on the SDC land which, if addressed appropriately, could pay significant dividends with respect to the Sonoma Creek Sediment Total Maximum Daily Load (TMDL). Here we present that document.

Orientation to the SDC Open Space Lands

Outside the redevelopment footprint (see SDC specific Plan: <https://www.sdcspecificplan.com/>), and for the purposes of this document, the open space lands of SDC can be divided into the lands west of Sonoma Creek and those to the east of Sonoma Creek (Figure 1 and see Appendix 1 for additional resource maps of SDC).

Western Open Space Lands

West of Sonoma Creek (see Figure 2) the SDC open space extends from Asbury Creek at its northern boundary to Hill Creek which aligns with most of its southern boundary. A middling section of Hill Creek (also referred to as Mill Creek) extends onto private properties to the south of SDC before returning to SDC property just above the redevelopment footprint. Fern Lake currently defines the approximate uphill boundary of the western SDC open space area, although the Jack London State Park property above that used to be part of SDC before being transferred to the park in the 1990s. Five notable subwatershed areas drain portions of the west side. These are: 1) Corridor Creek North which drains much of the lower wildlife corridor areas and enters Sonoma Creek near the middle of the creek bend between the two Arnold Drive bridges; 2) Corridor Creek South which drains the more southerly portion of the corridor. This otherwise seasonal drainage has a long history of being fed sporadically during the dry season by overflow water from SDC’s water treatment plant. These two creeks have been referred to by SEC as comprising the “SDC” subwatershed; 3) Cemetery Creek which drains to Hill Creek during the wet

season and encompasses the SDC cemetery and associated draws with erosive, fine sediments delivering high turbidity flow to Hill and Sonoma Creeks; 4) Sluice Creek is more of a wet season draw, but drains the large meadow below Fern Lake to Asbury Creek via a steep and highly erosive sluice canyon that appears to be a byproduct a historic landslide event; and 5) Roulette Creek which also drains to Asbury Creek and is fed by the notable Roulette Springs which is a high-volume, year round spring responsible in large part for the original siting of SDC at this location. Historically, flow from Roulette Springs was diverted as completely as possible year-round for use at the facility. In recent decades, flow in Asbury Creek (a former steelhead bearing stream) has gone dry by early summer. Since the facility was shuttered and the treatment plant was taken offline, flow from Roulette Springs has been allowed to feed Asbury Creek throughout the dry season creating a de facto streamflow restoration project. Another drainage feature in this western area is an artificial channel running from the Fern Lake overflow spillway to the Roulette Creek tributary of Asbury Creek. This channel cuts through a portion of the aforementioned meadow, is steep-sided and has been headcutting in recent years, including impacts to a critical fire service road. Fire service roads run throughout much of this western area including a primary road running from Arnold Drive to Fern Lake, and another primary road running from the paved Orchard/Camp Via road to the Asbury Creek diversion.

Eastern Open Space Areas

East of Sonoma Creek (see Figure 3) the open space areas run from Sonoma Valley Regional Park at the north end to a fenced boundary with the privately held Old Hill Ranch at the south. Highway 12 marks the eastern edge of these lands with much open space and agricultural land beyond that. The southern half of the area abuts the redevelopment area, but the northern half is largely undeveloped and represents the critical portion of the Sonoma Valley Wildlife Corridor. Within the pinch point of the wildlife corridor, Sonoma Creek makes a significant bend west of Arnold Drive between the two Sonoma Creek bridge crossings and in this area between Arnold Drive and Sonoma Creek significant (and watershed-atypical) floodplain habitat exists. Through our SCC grant we have documented extensive wildlife crossing activity through this area. East of Arnold Drive the land begins to slope up toward Lake Suttonfield and more steeply to the hills of the Regional Park north of there. A small wet season tributary enters Sonoma Creek a bit downstream from the southern bridge crossing. The drainage area of this tributary was mostly modified to form Lake Suttonfield, but what remains still drains the periphery of the lake dam area including the overflow spillway. East from there, much of the open space land is part of other subwatersheds and is comprised of the old and largely burned out (2017 fires) SDC farm

area. A small impoundment (frog pond) occurs at the northern end of this area below the Regional Park boundary, and from there to the southern property line much low and fallow grazing land occurs on what used to be historic seasonal wetland habitat. Near the southern end of this area the drainage system coalesces into a defined channel (John Mesa Creek), crosses onto the Old Hill Ranch and joins Sonoma Creek downstream of SDC. Another subwatershed tributary (Butler Creek, part of the Hooker Creek subwatershed) bisects the far southeast corner of the SDC open space area. This creek drains the agricultural and conservation easement lands of the Oak Hill Ranch, crosses under Highway 12 onto SDC and then departs the property to the south over a quarter mile downstream. This section of creek is very low gradient.

SDC Water System

SDC has a unique and substantial water system that must be considered as part of any water resources planning exercise. The system consists of Fern Lake near the upper, western boundary of the open space and Lake Suttonfield within the eastern portion of the open space. Roulette Springs is a high volume spring complex north of Fern Lake and was the original water source for the developing facility. Water collected from Roulette Springs is routed toward campus in meandering fashion through the center of the western open space area. Fern Lake was constructed in the early 1900s by impounding a small drainage tributary to Hill Creek and later expanded by raising the initial dam and by adding a second impoundment on the opposite side (north end) of the lake. In addition to direct rainfall, creek water is delivered to Fern lake via streamflow diversions on both Hill and Asbury Creeks and associated earthen/pipe conveyance systems. These diversions have been improved throughout the years to raise the inlets to favor high flow diversion and allow lower flows to continue down the creek channel. The diversion inlet at Asbury Creek, reconstructed around 2012, is particularly high off the streambed and only draws water during more elevated storm flows. Water from Fern Lake is delivered to a water treatment plant located at a suitable elevation between Fern Lake and the developed campus. Water from Roulette Springs is also routed to this treatment plant. Water delivery infrastructure from the treatment plant runs through additional open space between the plant and the main campus with additional routing along Orchard Road. In the 1920's, as the facility continued to grow, the water system expanded through the addition of Lake Suttonfield. The two lakes are connected through a large diameter pipeline that runs through the open space north of campus proper and then crosses under Sonoma Creek upstream of the Harney Street bridge. Creek water filling Fern Lake during the winter is transferred through this pipe to Lake Suttonfield. During the dry season, Lake Suttonfield water is pumped back

uphill to Fern Lake through that same pipeline via a pumping station located adjacent to the Sonoma Creek undercrossing. Also located proximate to that crossing and pumping station, a bank-side collecting well allows a substantial volumes of Sonoma Creek subsurface water to be pumped into Lake Suttonfield during the wet season. This diversion is operated, as needed, to supplement water collected off the western creeks. Treated water passing through the facility is also routed to a pair of large storage tanks situated on a hill above Lake Suttonfield. Once filled, overflow water from these tanks flows back into Lake Suttonfield via a constructed, high gradient drainage course. Large storage tanks also occur adjacent to the water treatment plant. Overflow from these tanks, and also water releases during maintenance episodes, flow first into a small pond and from there run down the otherwise seasonal drainage referred to previously as Corridor Creek South. This water system was engineered when the facility was operating at full capacity. As the institution contracted over the past several decades, water overflows from these tank locations became regular and almost perennial features on the landscape. When the institution shuttered in 2018 the water treatment plant shut down and the water source for the campus switched to municipal water via an interconnected service line along Arnold Drive. Since that time water has continued flowing into Fern Lake passively through the Asbury Creek and Hill Creek diversions, hence to Lake Suttonfield. Draws of Roulette Springs water have ceased however, and for the first time in over 130 years, that water was allowed to flow down its drainage course naturally allowing Asbury Creek to once again be perennial.

Water Resource Management Opportunities at SDC

As was stated earlier, the primary objective for the planning portion of our SCC grant was to identify one or two favorable water detention/retention sites in the SDC open space near Sonoma Creek where modest modifications to the land could allow storm water to be held back during rain events. Retained water could either be discharged slowly to the Creek after the storm peak passed or be encouraged to percolate to recharge ground water and, hence, improve dry season streamflow in Sonoma Creek. Given our collective knowledge of the area and following early reconnaissance visits into the field with this topic in mind, a single, greatest bang-for-buck project concept emerged pretty quickly (see water resource management Opportunity #1 below). However, our understanding of the urgency for which we need to be addressing climate resilience, combined with our understanding of how important this large piece of publicly owned land is within the landscape context of our local Sonoma Creek Watershed, combined in turn with uncertainties regarding the eventual disposition and future management priorities of these open space lands (due to be transferred

to State Parks or potentially, in part, to County Parks) prompted us to take a more comprehensive approach to pointing out as many opportunities for water resource management strategies on these lands as possible. This set of project opportunities is provided below. As stated earlier, given that identifying and remediating sites contributing fine sediments to Sonoma Creek was another important objective of this SCC grant, several chronic erosion sites in the SDC open space are also highlighted here. A map displaying all these sites is provided in Figure 4.

Opportunity #1: Highest priority water retention site on SDC Lands

On the outside bend of Sonoma Creek between the two bridges, west side of the creek on the right bank near the Wagner building (see Figure 5) lies a deep section of riparian area perched atop a historical floodplain area that is no longer inundated, even during the largest storms. The reason it is no longer flooded by the creek is because the entire creek system has been degrading (downcutting and lowering) through the years. Remnant floodplain areas like this occur throughout upper Sonoma Creek, though none quite as expansive as this one. As development of the facility progressed in its early years the lower portion of an unnamed tributary draining the hillside above the cafeteria building was modified through earth moving and the creek was channelized in one section and redirected through an underground culvert at its lower extent before daylighting onto this relic floodplain. Rather than allowing the water to spread out upon that floodplain, a drainage ditch was constructed across the floodplain bringing those storm flows (a combination of natural drainage water and street/roof runoff) directly to the active channel of Sonoma Creek (Figure 6). As can be found on soil survey maps of Sonoma Valley (see Figure 7), while much of the SDC open space areas consist of poorly draining adobe soils, this alluvial, relic floodplain is well draining and highly favorable for groundwater infiltration. What is proposed here is to eliminate the drainage channel between the storm drain terminus and the active creek channel, and recontour this relic floodplain area to encourage retention and infiltration of storm flows. A bit further northwest, another drainage system, (Corridor Creek South), empties onto this same relic floodplain terrace. A channel also cuts across the flood plain at this location similarly delivering storm flows, and water treatment system overflows, directly to Sonoma Creek with little opportunity for infiltration. Terrace recontouring would extend to this area to enable retention and infiltration for both of these flow inputs. Additionally, there is a separate and somewhat higher floodplain terrace in between this aforementioned terrace the developed campus where two smaller storm drains terminate. Recontouring on this terrace would provide a separate infiltration zone with any overflow water cascading the lower retention terrace. Based on our calculations of drainage area and average rainfall, we

estimate that well over 100 acre feet of water drains to these terrace areas annually. A significant amount of that volume could be retained at this site and allowed to feed more slowly to Sonoma Creek through the subsurface alluvium. Allowing for such retention and infiltration at this site would also lessen sediment inputs to Sonoma Creek from these flow pathways. Contouring would be done around the larger, high value trees to maintain proper riparian habitat functions. This area is part of the critical, pinch point portion of the wildlife corridor and so such a project would create short term impacts to wildlife. But there has been a long history of human activities throughout all of these SDC open spaces, including within this section of riparian habitat, and yet we are today placing high value on these lands for their habitat functions. The long term benefits of water infrastructure projects like what is proposed here by far outweighs the short term impacts of doing such recontouring work. This water retention and infiltration opportunity was conceived while SEC was in the middle of a visioning process to explore and promote fisheries restoration opportunities in upper Sonoma Creek (see <https://sonomaecologycenter.org/restoration-vision/>). As part of that process some initial restoration concepts and cross sections were drafted for the selected restoration sites. Appendix 2 displays schematics for this opportunity area excerpted from our Upper Sonoma Creek Restoration Vision document. These drawings do not depict the upper terrace area mentioned above as that component was conceived at a later stage. This project, and others like it, should be included as part of the SDC redevelopment process.

Opportunity #2: Cessation of Dry Season Diversion at Roulette Springs

Throughout the entire history of SDC, up to the closure of the facility in 2018 and the subsequent shutdown of the water treatment plant, as much water has been being diverted from the high volume Roulette Springs as practicable, including throughout the dry seasons. It has been well documented in the historical record that Asbury Creek used to be a steelhead bearing stream. But at least for the past 2-3 decades, Asbury Creek has been drying up completely by June or July, May even in drought years. But beginning in the Summer of 2019, after the treatment plant shut down and Roulette Springs water was no longer being diverted, Asbury Creek has again become a perennial stream from Roulette Springs all the way down to Sonoma Creek. SEC temperature monitoring has identified dry season temperatures in Asbury Creek as being especially favorable for rearing steelhead, and so this development amounts to the most significant opportunity for steelhead recovery in Sonoma Creek SEC has seen over the past 30 years. Roulette Springs water should be allowed to flow freely to Sonoma Creek during the dry season from this point forward! However, the

redevelopment of SDC has been predicated on the criterion that all previous water sources remain available to the new development. The tradeoff to make this possible is to lower the diversion inlets on Asbury and Hill Creeks and allow more water to be diverted from those creeks, and also from Sonoma Creek, during the wet season in exchange for the abandonment of this Roulette Springs flow during the dry season. Because flows diverted from creeks during the wet season are turbid, Fern Lake and Lake Suttonfield have been silting in over the years resulting in a lessening of their capacities and increased encroachment of aquatic vegetation to the shallowing margins of the lakes. These water reservoirs should be dredged back to their original design capacity to allow for greater overall water storage. It may be that the combination of these two actions (increased wet season diversions and greater lake capacity) can result in water stores exceeding the demands of a redeveloped campus. Should that be the case, excess flows could be released in regulated fashion to both Asbury and Hill Creeks during the dry season to create additional restoration potential in each of these former steelhead creeks.

Opportunity #3: Sluice Canyon Impoundment at Great Meadow

Just below Fern Lake a great meadow exists in an area that, through major earth moving, could likely have supported another lake of the same size (see Figure 8). This meadow area has very high habitat values and of course we aren't suggesting anything like that. But by taking some modest steps, significant wet season precipitation and drainage water could be retained at this site in a way that would reduce peak storm flows in Asbury and Sonoma Creeks, lessen sediment inputs, and add significant seasonal wetland habitat values to this portion of the open space. Some groundwater replenishment could occur as well as the soil maps (Figure 7) show the area to have marginal, but not poor, drainage capacity. Much of this moderately sloped meadow area drains to a low bowl like area (Figure 9) and from there it transitions abruptly into a very narrow, steeply sided and high gradient sluice canyon (Figure 10) which seems to be the byproduct of historic landslide activity. Based on our calculations of drainage area and average rainfall, approximately 48 acre feet of winter precipitation drains directly to this area. As it stands, much of this water flows down this sluice during storm events eroding the fine sediments of the sluice banks along the way and delivering those sediments to Asbury and Sonoma Creeks. At the far end of the sluice canyon (Figure 11) that drainage continually causes washouts on a fire service road it crosses and also further erosion from there as it drops down a steep slope towards Asbury Creek (Figure 12). With very little impoundment work at this meadow/canyon transition point a significant volume of water could be retained in the lower, bowl portion of this meadow.

Such an impoundment could be installed with a small outlet at the base to allow flow to slowly drain to the creek following the storm peak. Or it could be designed to encourage longer duration retention and infiltration. Further, an artificial channel (Figure 13) running from the Fern Lake overflow, which cuts through and is causing headcutting issues (Figure 14) at the north end of this meadow, could very easily be rerouted to instead drain to this same water retention area at the sluice canyon. Rather than running a new flow channel all the way through the meadow, the rerouted channel could be made to follow grade south toward the retention site for as short a distance possible before fanning out and continuing as sheet flow the rest of the way down slope. Whether designed for peak flow avoidance or groundwater infiltration, such a site would certainly foster wetland development within and at the margins of the retention zone. Following study and engineering, reasonably little construction effort would be required to implement such a project, and once in place it would represent a net benefit to the habitat values of this great meadow site.

Opportunity #4: Impoundment at Corridor Creek North Bowl Area

Closer to Sonoma Creek within the SDC subwatershed, two branches of the Corridor Creek North tributary come together right at the spot (Figure 15) where they begin to descend to Sonoma Creek down a steep and highly eroded channel cutting through the low spot between two hilltops (Figure 16). Upstream from that steep channel the subwatershed forms a bowl at the junction of the two drainages. Over the past decade or more a headcut emerging from that steep channel has been migrating upstream along both branches of the tributary. During the 2022-2023 rainy season the advancing headcut on the northern of the two branches finally made its way across a fire service road which traverses this bowl area (Figure 17). That road is currently impassable by emergency vehicles. Based on our calculations over 200 acre feet of precipitation drain to this area annually. This bowl area is more steeply sloped and is a less favorable retention and infiltration site than the aforementioned site in the great meadow. But if there was motivation to do so, proper placement of an impoundment of some size could detain a significant amount of water and at the same time could help address the chronic erosion and channel downcutting occurring there. Because this bowl is squarely in the middle of the SVWC narrowing point, there is motivation among SEC and other local natural resource advocates to deemphasize human use in this area and instead route public access pathways and trails around the periphery of this area. Once infrastructure was in place, water retention in this area would be fully consistent with wildlife corridor functioning and would, in fact, enhance wildlife benefits due to the additional aquatic resources which would develop there.

Opportunity #5: Floodplain Water Retention Inside the Sonoma Creek Bend

East of Sonoma Creek and west of Arnold Drive between the two bridges, lies the most significant floodplain zone in the entirety of Sonoma Creek (Figure 18). In appearance, this area is like a scaled down version of Sonoma Water's Mirabel infiltration site on the Russian River where water is diverted from the river during higher flows and conveyed into a series of infiltration basins. During high flow events Sonoma Creek already spreads out onto the lower floodplain on the inside of the river bend allowing for some retention and infiltration into the water table, but it does not have access, even at the highest flow events, to the higher, relic alluvial areas further inside the bend (Figure 19). A set of infiltration basins similar to Mirabel could be constructed in this area, not for subsequent, domestic water supply extraction, but to promote increased baseflow in Sonoma Creek during the dry season. These days the SDC reach of Sonoma Creek represents the transition zone between the upper watershed, where flows remain cool enough for summertime rearing of steelhead and other anadromous fishes, and the middle watershed where flow remains mostly perennial, but the water temperatures are starting to get too warm for salmonid rearing. Within the SDC reach you start to see increased numbers of introduced species like sunfish, large mouth bass and bullfrogs in the creek. It would take a lot before we saw dry season rearing of steelhead throughout all of Sonoma Creek like there used to be. But anything we can do to foster improved summertime base flow and inputs of cool groundwater into this part of the creek will allow this transition zone to shift back downstream toward Madrone Road or even into the Springs area. This region on the creek bend between the two bridges IS the narrowest and most critical pinch point of the Sonoma Valley Wildlife corridor. Until recently there were two active and full-time family homes, plus other SDC facilities activities occurring in this area...and yet it remained highly valuable as a wildlife crossing zone. We at SEC would like to see no redevelopment and no nighttime lighting in this area. We feel that fences should be removed and that the entrance to the Sonoma Valley Regional park should be relocated to another area within the SDC redevelopment area. Rather than just have the one safe road crossing underneath the Jim Berkeland bridge, we should explore other opportunities for providing safe passage across/under Arnold Drive in this area. But we also believe that short-term impacts of constructing water resources/infiltration infrastructure within this critical area is manageable and that it is possible to have the project completed and passively operated in a way that does not hinder the wildlife habitat and crossing values we care about so much for this area.

Opportunity #6: BDA's and other Water Retention Strategies in Butler Creek

East of Sonoma Creek and east of the SDC redevelopment footprint exists a section of Butler Creek (a tributary in the Hooker Creek subwatershed) which bisects the far southeast corner of the SDC open space (Figure 20). This is a very flat reach of stream corridor with rises to either side (Figure 21) and with two branches extending from a confluence point to separate culvert crossings under Hwy 12. Blackberry brambles surround much of the stream channels in this area. Based on our calculations nearly 1800 acre feet of precipitation falls upon this catchment area annually. And groundwater recharge potential on this portion of the SDC open space appears favorable (Figure 7). Previous efforts to detain water in this area are evident (Figure 22) which is testament to the favorability of this area for water retention. As we have come to understand the severity of declining streamflows and groundwater levels, we have begun to invoke the lessons of beavers, who are natural ecosystem engineers, as a means of promoting water retention in the landscape. Beavers have returned to the watershed and are beginning to exert their restorative influence in portions of Sonoma Creek causing areas which had gone dry during the summer months to remain wet and ponded all year long (Figure 23). In watershed areas where beavers have yet to return, humans can simulate their actions through the installation and maintenance of Beaver Dam Analogs (BDAs): vegetation based structures that partially impound stream channels, retain water and enhance aquatic habitat just like beaver dams do (Figure 24). Such structures don't work everywhere; their installation and efficacy require a relatively flat channel gradient and sloping terrain to help contain retained water. This reach of Butler Creek has that perfect combination of characteristics. It also represents an important linkage point at its upstream end for the Sonoma Valley Wildlife Corridor, so improving habitat functions in this relatively out-of-way portion of the SDC open space will pay additional dividends for migrating wildlife. We propose studying the area and installing a network of BDAs all through this entire reach to create several step pools of flooded habitat from the southern SDC property line to the eastern line along Hwy 12. Several stretches of eroding banks within this reach can also be addressed simultaneously. Pursuing and implementing such an approach would not be inconsistent with the improvement of a SDC to Hwy 12 connector road. Such a road is being proposed as part of the redevelopment plan, which would likely follow the progression of an existing fire service road crossing through this area near the downstream end of the reach.

Opportunity #7: Wetland Restoration at the SDC Farm Area

Also east of Sonoma Creek and the SDC redevelopment footprint lies the former institutional farm area (Figure 25) within which, due to the successful lobbying efforts of SEC and other associated entities, extensive wetland restoration is already being envisioned as part of the redevelopment process. Several opportunities for cascading water retention and wetland restoration features exist in this area beginning at an old farm impoundment (frog pond) which occurs at the north end of the drainage valley (Figure 26). With an estimated 400 acre feet of rainfall reaching this drainage area annually, huge bang-for-buck water retention and groundwater replenishment benefits are possible in this key watershed location (see recharge potential map in Figure 7). We suggest aiming as high as possible in this regard. This would begin at a re-engineered and enlarged impoundment at the north end, and continue with multiple detention or retention zones between there and the property line to the south (see Figures 27, 28 and 29). Such a plan could include opportunities for additional water inputs to this area beyond direct rainfall. There has been discussion that as part of the SDC redevelopment process, and notably consistent with the goals of a climate adaptation center envisioned for the site, a secondary wastewater treatment facility should be developed at the site, perhaps at the location of the old SDC Junior Farm. This would be a positive development for the Valley since the current sanitary system is already suffering from capacity issues and its location at the lower end of the valley is less suitable for reuse of recycled water. Should a secondary facility be installed onsite, dry season feeding of recycled water into the restored wetland complex would be favorable for both wetland function, ground water replenishment and post-wetland streamflow inputs to Sonoma Creek. Second, relocating the overflow spillway of Lake Suttonfield to the eastern side of the lake would allow another wet season input of water into this restored wetland complex and would also eliminate the channel downcutting and sediment inputs to Sonoma Creek which are occurring along its current drainage course (but see Opportunity #8). Third, Sonoma Water has been looking for opportunities for groundwater injection or infiltration as part of the Sonoma Valley Groundwater Sustainability Plan. The large storage tanks for the Sonoma Valley aqueduct occur on a hilltop just above the north end of this drainage area, so the opportunity for aqueduct inputs into this zone for groundwater injection or infiltration are present. This sort of water resource planning for the former agricultural part of the SDC land is wholly consistent with concepts for sustainable agriculture also being envisioned for this portion of the property. Wetland restoration and other water resource development would occur on the lower portions of this valley area while sustainable agriculture could occur at higher ground around the perimeter and

elsewhere. Agricultural sectors would have to be carefully sited in order to maintain adequate corridor connectivity toward Audubon Canyon Ranch to the north (where better crossing development over or under Hwy 12 is warranted) and the Butler Creek corridor to the south where existing culvert undercrossings should be widened.

Opportunity #8: Water Retention Berms Below Lake Suttonfield Dam

In the area east of Arnold Drive, between there and the dam for Lake Suttonfield (Figure 30), exist two relic railroad berms which interrupt the drainage pathways within this gently sloping area (see Figures 31 and 32). Currently, culvert undercrossings through these berm areas allow rainwater to concentrate and rush to Sonoma Creek during storm events. Erosion and sediment inputs to Sonoma Creek are occurring here because of these erosive channels combined with a chronic erosion site on the adjoining hillside (see Chronic Erosion Site #8 below in document) and improper drainage along the lake access road which has been spilling out onto Arnold drive until a recent, SEC -initiated repair job addressed the issue temporarily. The overflow spillway for Lake Suttonfield also occurs uphill from this site but its drainage channel bends around to the south where it joins its historical tributary flow pathway along the north edge of the developed campus. This is another favorable area for stormwater retention and groundwater infiltration. Through modifications to the berm culvert undercrossing points combined with moderate regrading of these meadow areas to create slight retention “bowls,” and by redirecting Lake Suttonfield overflow water into this area (should the related aspect of Opportunity #7 be deemed undesirable), significant water retention could occur in this area. Post-construction, such retention zones would exist without any fundamental, negative aspects to wildlife habitat values including the corridor functions. In fact, having more diverse habitat within these areas which are nearly 100% grassland presently, would improve said habitat values. An even better scenario would be to improve wildlife connectivity either under or over Arnold Drive at this location. While the undercrossing at the downstream bridge (Berkland Bridge) is heavily used by wildlife, crossings over this section of Arnold Drive are very common as well. As this is the most critical pinch point of the wildlife corridor, and because the presence of this corridor was the primary justification for protecting these open space areas, development of a safe crossing point for animals at this location would seem worthy of consideration. Such projects would change some of the access pathways for visitors to the Sonoma Valley Regional Park who currently park there on the Arnold Drive road shoulder. But because this is the most critical section of the wildlife corridor, this parking and access

point should be discouraged anyway in favor of a formal parking and access point within the redeveloped campus at the end of the old railroad pathway.

Opportunity #9: Large Wood Aquatards Structures in Asbury and Hill Creeks

Up in the Mattole and other watersheds, innovative water retention approaches are being taken to replenish groundwater levels and improve dry season flows in salmonid rearing streams. One such approach is to construct moderately sized retention basins in strategic locations proximate to stream corridors and allow retained water to slowly leak to the stream into the dry season. Another is to apply stage zero approaches such as inserting large wood elements bank-to-bank in narrow, v-shaped stream courses where the gradient is less than 2-2.5% slope. By setting such tree sections at existing grade, embedding them into the banks and then backfilling with a mixture of fine streambed materials and bentonite, an aquatard is produced which allows for bed aggradation, slow-release water retention and resulting rising of the water table (Figure 33). Natural features just like this are elements found frequently in healthy creeks. Trees employed in this way are sized according to the characteristics of the channel such that they don't become potential barriers to spawning fish. Generally, a scour pool develops just downstream of these structures which creates resting habitat during upstream migration during the wet season as well as rearing habitat during the dry season. SEC has done an analysis of both Asbury and Hill Creeks and has identified a suite of locations (yellow segments in Figure 34) of appropriate gradient for this approach. Further study would be required to fully vet these sites, but we already know several of these locations to be particularly suitable (e.g., the section of Asbury Creek upstream of the Roulette Creek confluence).

Opportunity #10: BDAs in Open Space Draws

Throughout the SDC open space, small draws and gullies occur (see example sites in Figure 35) where actions could be taken to slow down the transference of gathering storm flows to the creek during storm peaks, reduce some of the entrainment of sediments which takes place in these areas, and allow some of that retained water to percolate into the ground, while improving habitat values at the same time. One of the draws depicted here has been headcutting in recent years. Process based restoration actions such as BDA installations, large wood check dams and packing of smaller gullies and draws with forest thinning slash can all serve to retain water and help to rehydrate the landscape (see: <https://oaec.org/forest->

thinning-and-gully-repair/). Figures 36 and 37 show different views of one such draw we are particularly familiar with which has a favorable gradient and configuration for such strategies to be appropriate. We highly recommend pursuing strategies like this throughout the property, and especially doing so in association with fire fuels management work which generates lots of slash to be made available for gully packing.

Chronic Erosion Sites on SDC Lands

As was mentioned in the preceding sections, issues surrounding the Sonoma Creek sediment TMDL and restoration work to address and remediate several sites contributing fine sediments to the creek system were important elements of the SCC project (project which primarily funded this water resource visioning document). And as is evident for many of the project opportunities outlined above, efforts to improve water retention also commonly help address issues of soil erosion and sediment inputs to nearby creeks. Much of the open space land on the hills west of Sonoma Creek is comprised of Adobe soils. These clay soils are actually quite resistant to water borne erosion, but once destabilized, through rutting, headcuts or other bank failures, adobe soils contribute the worst kinds of fine sediments to creek systems. Through our studies of water quality in this area we found the adobe laden drainages of Asbury Creek, Corridor Creek North within the SDC subwatershed and the Cemetery Creek tributary to Hill Creek to have particularly high turbidity during storm events. This indicates these areas are making significant contributions to fine sediment loading to Sonoma Creek, likely as a result of streambank erosion and other soil destabilization. Given this, and given our general knowledge of these SDC lands, we felt it important to identify several sites in these areas, and elsewhere on the property where chronic erosion sites exist and need remediation to various degrees. Here we present information about 8 such chronic erosion sites (see Figure 4).

Chronic Erosion Site #1: Culvert-Related Gully Erosion at Corridor Creek South

Early in the SCC project a map of SDC's stormwater system was studied, and then reconnaissance occurred along the entire ~1 mile reach of Sonoma Creek to physically locate and assess every drainage culvert daylighting within the creek's riparian zone. Opportunistically, the reconnaissance work was done in the midst of a significant, February 2019 storm event when outflows were near their 10-year peaks. This allowed us to

understand, without hydrological analysis, the erosive potential of these outflows, and hence prioritize which culverts at SDC were in the greatest need and best suited for remediation and restoration using our SCC project funds. Since our project work plan mandated habitat-related regulatory permitting and implementation involving hand tools (as compared to heavy equipment), several culvert sites had issues which were well beyond the scope of what we could address. One such site is a culvert-related erosion gully which exists just north of the developed campus at the downstream end of Corridor Creek South (see Chronic Erosion Site Ero #1 in Figure 4). At this location a primary fire service road crosses this drainage and just below the road crossing culvert (Figure 38) the drainage drops down through at least two worsening head cuts (Figure 39) into a deep, vertically sided arroyo-type erosion zone (Figure 40). Crossing this zone is the large diameter conveyance pipeline connecting Fern Lake and Lake Suttonfield via the pumping station. The buttress for the pipeline is losing its soil support and the pipeline is bowing downhill and showing signs of stress including a leak at a connection joint. Not only is this site contributing eroded sediment to Sonoma Creek, but this critical conveyance pipeline seems about to breach. Should that occur, even more sediment will find its way to the creek. The issues at this site were beyond the scope of what SEC's restoration team could address as part of this project. However, after seeking approval from the SCC grant manager, we did use project planning funds to hire an engineering consultancy and have them study the site and develop a conceptual design plan for how that site should be remediated. That design plan is included here in Appendix 3.

Chronic Erosion Site #2: Massive Bank Failure along Sonoma Creek

At the downstream end of the SDC reach of Sonoma Creek, adjacent to Redwood Drive near the Emparan building exists a massive bank failure that began on SDC property but has migrated downstream and is threatening a home on Burbank Drive in the adjacent community. Many years ago the main channel of Sonoma Creek was well to the east closer to the opposite bank of the creek. But in recent years the channel has migrated to the west eliminating an old relic floodplain that occurred there, and subsequently caused incision on the right bank to the point where it became nearly vertical. Two SDC culverts daylight in this area. Initially they emerged onto the relic floodplain as they do elsewhere at the facility, but as the bank retreated, sections of those pipes have fallen away with continuing stormflow cascading down the steepening banks, thus contributing to further erosion. Stormflow energy reflecting off this eroding bank has been deflecting to the opposite bank just downstream of SDC where it has caused a vertical incision problem of similar scale there. The situation in this area constitutes a massive chronic erosion site that will require

significant engineering efforts to address. As part of the SDC specific plan, setbacks of 100 feet are called for along the margins of Sonoma Creek. But in this portion of the redevelopment footprint, such setback considerations should not be based on the current margin of the creek corridor. Any redevelopment should remain well outside the needed restoration envelope for this site. SEC's Upper Sonoma Creek Restoration Vision (see <https://sonomaecologycenter.org/restoration-vision/>) should be consulted before any future creek setback decisions are solidified.

Chronic Erosion Site #3: Road Washout Induced Landslide at Roulette Confluence

Land slides, historic and contemporary, are a common feature within the SDC open space, and Glen Ellen generally. The existence of Roulette Springs is the result of a historic landslide at the foot of which the spring is located. Further downhill, where Roulette Creek makes its confluence with Asbury Creek, a significant, contemporary slide exists which has been delivering quarry-scale amounts of fine sediments to Asbury Creek over the past decade or two. A fire service road used to dip down and cross Roulette Creek at this site, but the culvert under this road was washed out some time ago (probably the result of a debris jam), and the toe of the bank became destabilized leading ultimately to the situation seen in Figures 42 and 43. There are actually two individual slide escarpments in this area separated by a narrow ridge of apparently firmer material. Due in part to the presence of spring water outflows, but also because of the dense vegetative cover and afternoon sun angle, Asbury Creek, which used to be a steelhead bearing stream, has cool water temperatures throughout the dry season and is a viable candidate for fisheries restoration. However, much of the creek's streambed is laden with fine sediments due to this slide and other erosion issues described in this document. Young steelhead could successfully rear in Asbury Creek with these sediment accumulations present, but spawning is currently favorable only upstream of the Roulette Creek confluence. Finding a way to stabilize this slide area and prevent continued sloughing of fine sediments to Asbury Creek would be an important, if challenging, management goal for this property.

Chronic Erosion Site #4: Headcutting Along Fern Lake Overflow Channel

In the meadow below (east of) Fern Lake, a man made overflow channel (Figure 13) connecting the lake spillway to the Roulette Creek tributary of Asbury Creek has been headcutting in recent years. In the last rainy season (2022/2023) this headcut advanced across an important fire service road making that road impassible (Figure 14). As was discussed above in water retention and infiltration Opportunity #3, we feel it would be best to redirect that lake overflow via sheetflow into a water retention zone to the southwest. In so doing, this section of the manmade channel (including the headcutting zone) would be restored back to meadow habitat, thereby addressing this chronic erosion site.

Chronic Erosion Site #5: Sluice Canyon Outlet

The sluice canyon mentioned above in water retention and infiltration Opportunity #3 is a major source of fine sediments to Asbury and Sonoma Creeks (Figure 44). While a fire service road crosses this drainage course below the outlet of the sluice canyon and is subject to repeated washouts (Figure 45), the erosion issue itself is natural and not the result of improper land management practices in the past. Still, this sluice canyon is a major chronic erosion site and the above suggestion of developing a water retention site at the upstream end of the sluice canyon would reduce the erosive flows moving through this area and help reduce fine sediment inputs to Asbury and Sonoma Creeks.

Chronic Erosion Site #6: Fire Service Roads Near Lower Asbury

Many of the roads and trails traversing the SDC open space areas were constructed in the early days before we started thinking so much about erosion and watershed health. Several of these roads remain important with respect to emergency response and fire suppression, but their lack of adequate management over the past few decades has allowed for the development of road downcutting and gully formation. There had been a collection of horse enthusiasts riding frequently on these fire roads until the 2017 fires eliminated their boarding facilities in the SDC farm area. These horse riders, and also the mountain bike riders who have been increasingly using these in the time since, have the tendency to ride down the same beaten path each time. On steep sections of fire road, this leads to rill formation and, if not addressed, gully formation. As these lands transition to other land management agencies (e.g., State Parks) the assumption is that most of these fire roads will continue to exist as public trails. Within the western open space, one such fire service road which runs along a section of lower Asbury Creek (see Ero #6 in Figure 4) is really too steep throughout most of its

progression for continued use as a pedestrian and riding trail. Due to horse traffic in the past the road is already v-shaped with a recurring rivulet running down the central pathway during and after rain events (Figure 46). This section of road is a chronic erosion site, creating turbid runoff which makes its way to Asbury Creek, including through one particular headcutting zone (Figure 47). At the top of this steep road, a branching section of road drops steeply down with additional rutting and erosion to the road washout area shown in Figure 12. This location is also critical to wildlife as the adjacent section of the Asbury Creek canyon represents an important north-south and east-west movement corridor for animals. It would be nice if this service road could be regraded and kept in place for emergency fire access, but without being developed and included in any future, codified trail network. An adjacent road on this same sloping hill has also seen increased rilling and gully formation in recent years (Figure 48), especially given the combination of seep drainage and adobe soils occurring there. However, this road is a primary fire service route and it has become a popular recreational artery (referred to as the Carolyn Day Trail) as the institution stopped policing its no-access policy. Thus, it is less practical to close this road off completely to public access. That said, the progression of this road through the most critical pinch point of the wildlife corridor along with the lack of parking development opportunities at its intersection with Arnold Drive mean that this route should not become a primary public access point in the future.

Chronic Erosion Site #7: SDC Employee Trail

Throughout the history of SDC, fire service roads were all that was found within the managed lands we now think of as wildlife corridors and open space. The public was not allowed onto these lands and even facility employees were not allowed to roam there without specific permissions. Hence, single track walking paths did not exist. Things became much more *laissez faire* over the past 20 years or so as the institution retracted and moved further toward closure. Employees began exploring the open space lands more and more, especially as health and fitness became more of a cultural goal at the institution. Several single track walking paths developed over this time including one extending from the Paxton Goddard area of campus up to the main fire service road below Fern Lake (see Ero #7 in Figure 4). This trail is very steep in places, especially in its upper section. Over time, as it was discovered by new users, including horse and mountain bike riders, its adobe soils have eroded turning this path in to a trench which concentrates overland flows during rain events (Figure 49). This path/trench represents a chronic erosion site which adds additional turbidity to the Corridor Creek (north and south) drainages of the SDC subwatershed where we found such high, recurring turbidity. This poorly routed trail needs to be reconsidered and rerouted, especially at its steep upper reach. Instead, it should be routed through the meadow to the north along existing service roads. At its lower reach, this same path crosses through the Corridor Creek south channel two times (one crossing is

shown in Figure 50). There is favorable grade in this area to reroute this trail without the need for these channel crossings. Doing so would also allow the primary public ingress/egress route to remain on the periphery of the most critical portion of the wildlife corridor. Currently, that primary route ascends and descends a very steep hilltop on its way into the bowl area mentioned in water retention Opportunity 4. That fire service road should remain in place for emergency use, but future public movements should be routed away from this area.

Chronic Erosion Site #8: Fire Access Road Near Lake Suttonfield

On the east side of Sonoma Creek between the Lake Suttonfield dam and the entrance to the Sonoma Valley Regional Park, exists an almost impossibly steep fire access road which ascends in a nearly straight line up to the summit of the adjacent hilltop (see Ero#8 in Figure 4). This hillside and most of the surrounding hilltops remain SDC property, but have popularly become known as part of the Regional Park due to its contiguity and interconnectedness. During the dry season, and with proper grading, this road section is passable by 4 wheel drive emergency vehicles, but over the past 20 years of waning management, this section has deeply rutted and become a chronic erosion site (Figure 51). It is also quite a hazard since hikers and mountain bikers approaching from the uphill side often realize too late how steep and slippery this steep section is. Due to its steepness, and because other routes toward this hilltop are available for emergency access, this section of fire service road should be eliminated and restored.

Conclusion

Within California, millions of dollars are spent annually trying to protect and restore groundwater resources, and additional millions are spent trying to improve dry season streamflows for the purposes of fisheries restoration. Beyond this, vast resources are expended annually, even in Sonoma County, trying to keep fine sediments out of watershed systems. More often than not, these projects are just chipping away at the problem in ways that are not very measurable or profound. In contrast, within the extensive, publicly owned lands of the former Sonoma Developmental Center exists some of the best and biggest bang-for-buck opportunities within the Sonoma Creek Watershed for projects which address these critical issues and promote climate resiliency. And with adequate motivation and support among natural resource managers to take such important steps, most of the projects outlined herein could be carried out with relatively moderate funding and with

minimal long term impacts to the treasured habitat and other uses driving the passionate support for the preservation of this land. The working lands of SDC are not wilderness. They have been impacted and managed by people for the past 18 decades and beyond. And yet the area remains some of the most important and reasonably natural land remaining in the Sonoma Valley. We encourage all State, Federal, local and regulatory agencies responsible for the management of this land moving forward to appreciate how critical this property is within the context of watershed function, to heed the new policy positions taking form statewide with respect to climate resilience, and to support the planning and implementation of the sorts of projects outlined in this document. This set of project concepts (see Figure 4) is not even complete or fully comprehensive. Lots of other opportunities exist beyond the ones we have focused on here, including an entirely different suite of projects which should be pursued within the redevelopment footprint (e.g., rainwater capture). We would also encourage agencies to pursue similar approaches on the other large sections of publicly owned lands within Jack London and Sugarloaf State Parks. Given the “headwaters” nature of those park lands, even greater watershed-scale efficacy could be achieved with respect to wet season water retention, groundwater recharge and dry season streamflow augmentation.

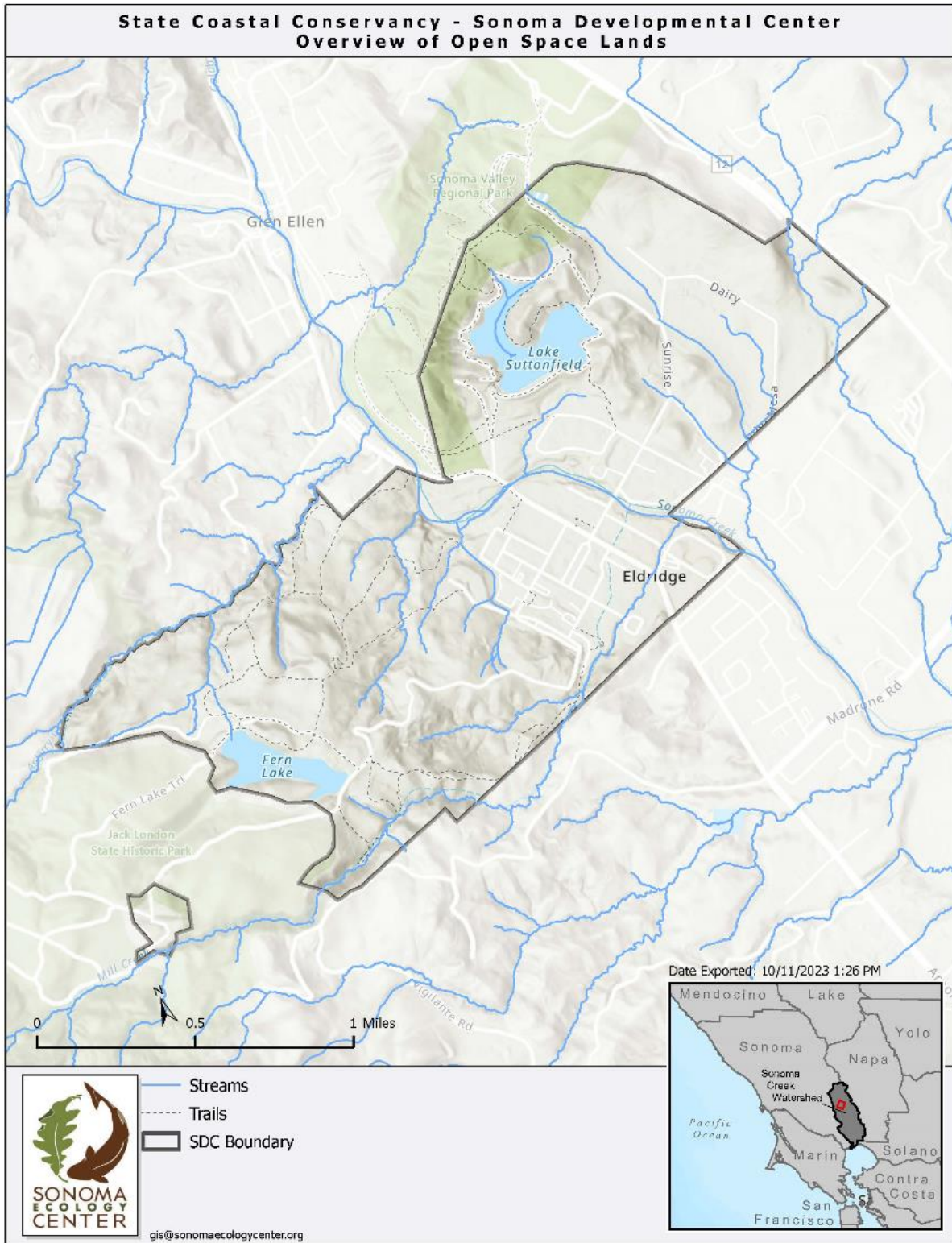


Figure 1. SDC Overview Map.

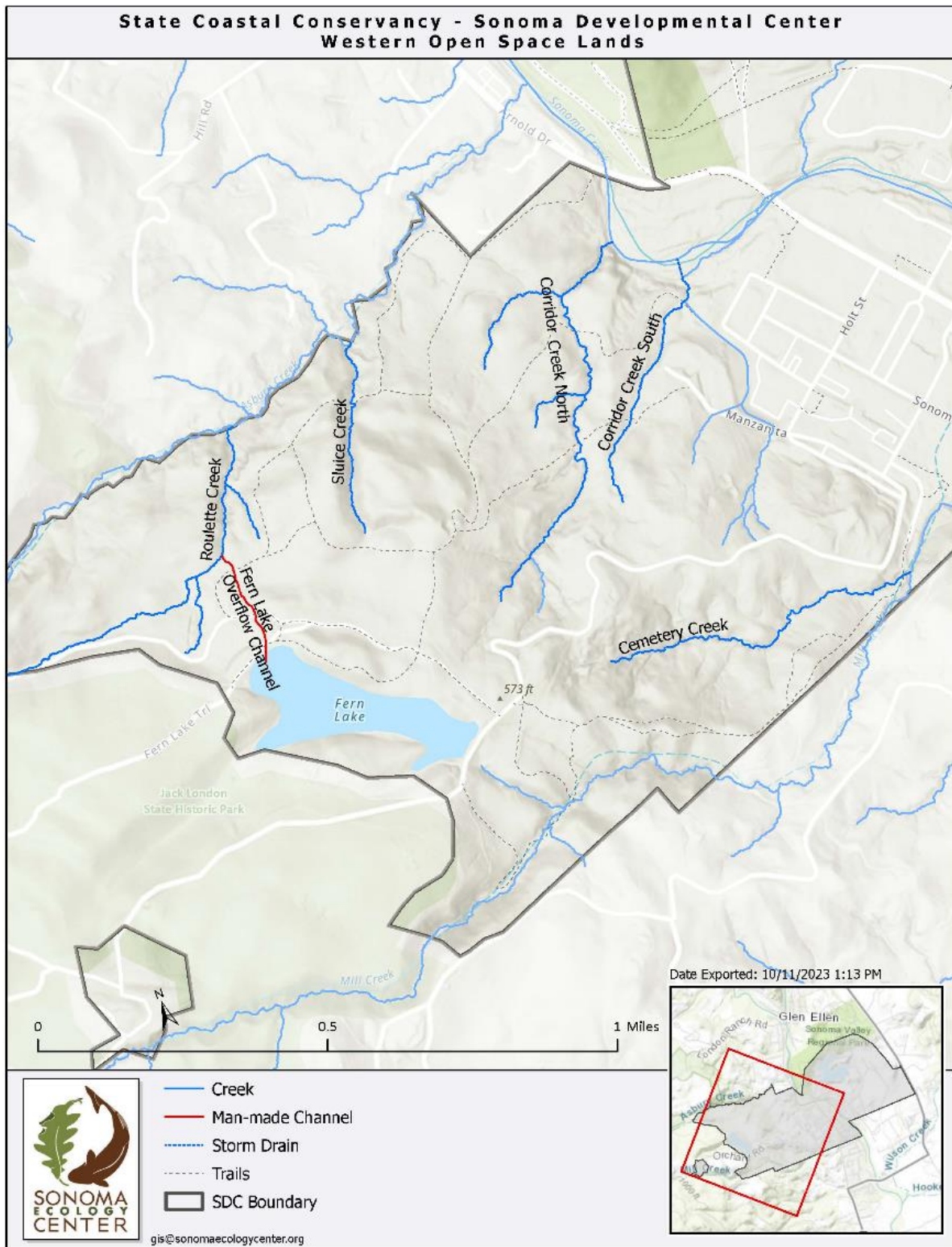


Figure 2. Map of SDC open space area west of Sonoma Creek.

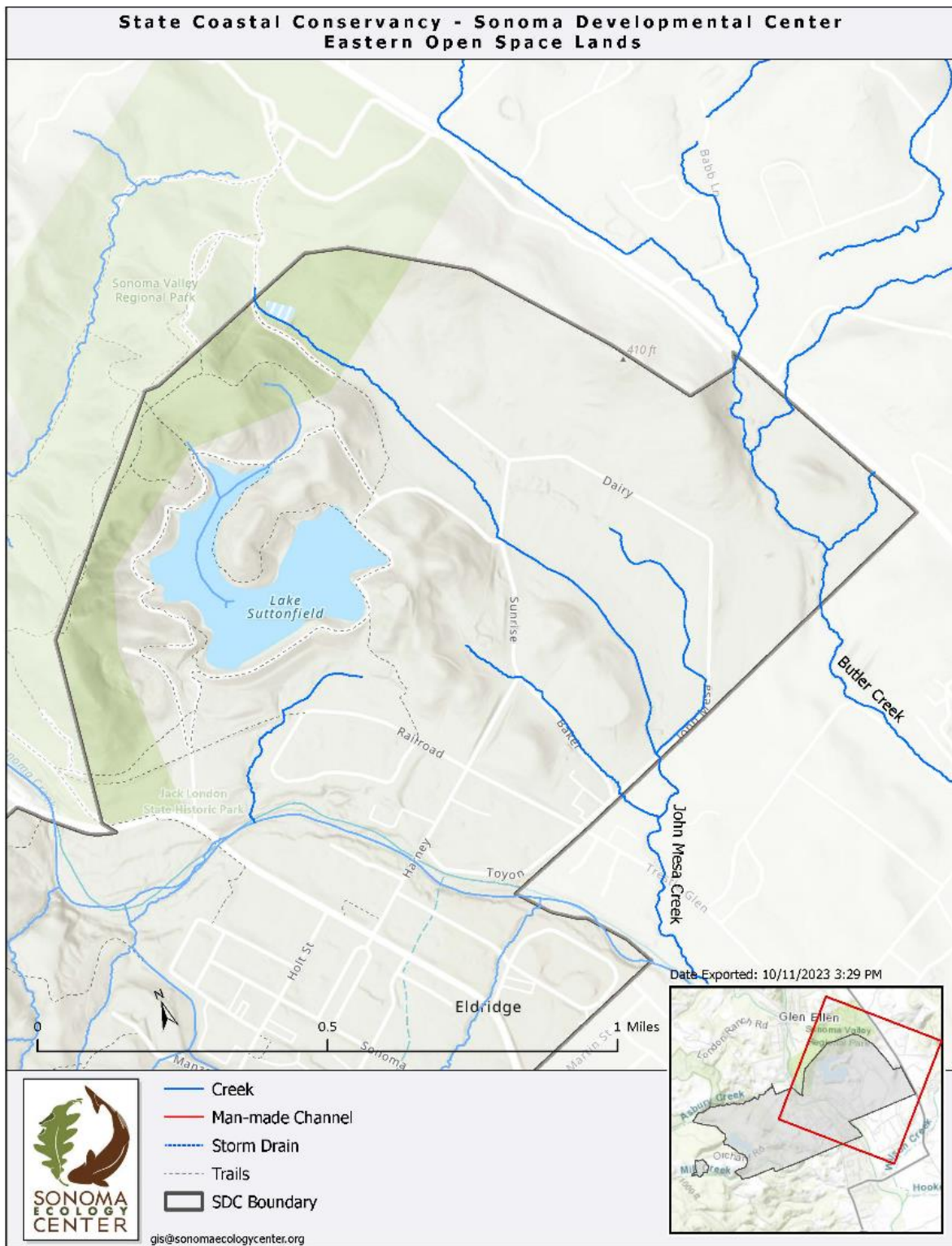


Figure 3. Map of SDC open space area east of Sonoma Creek.

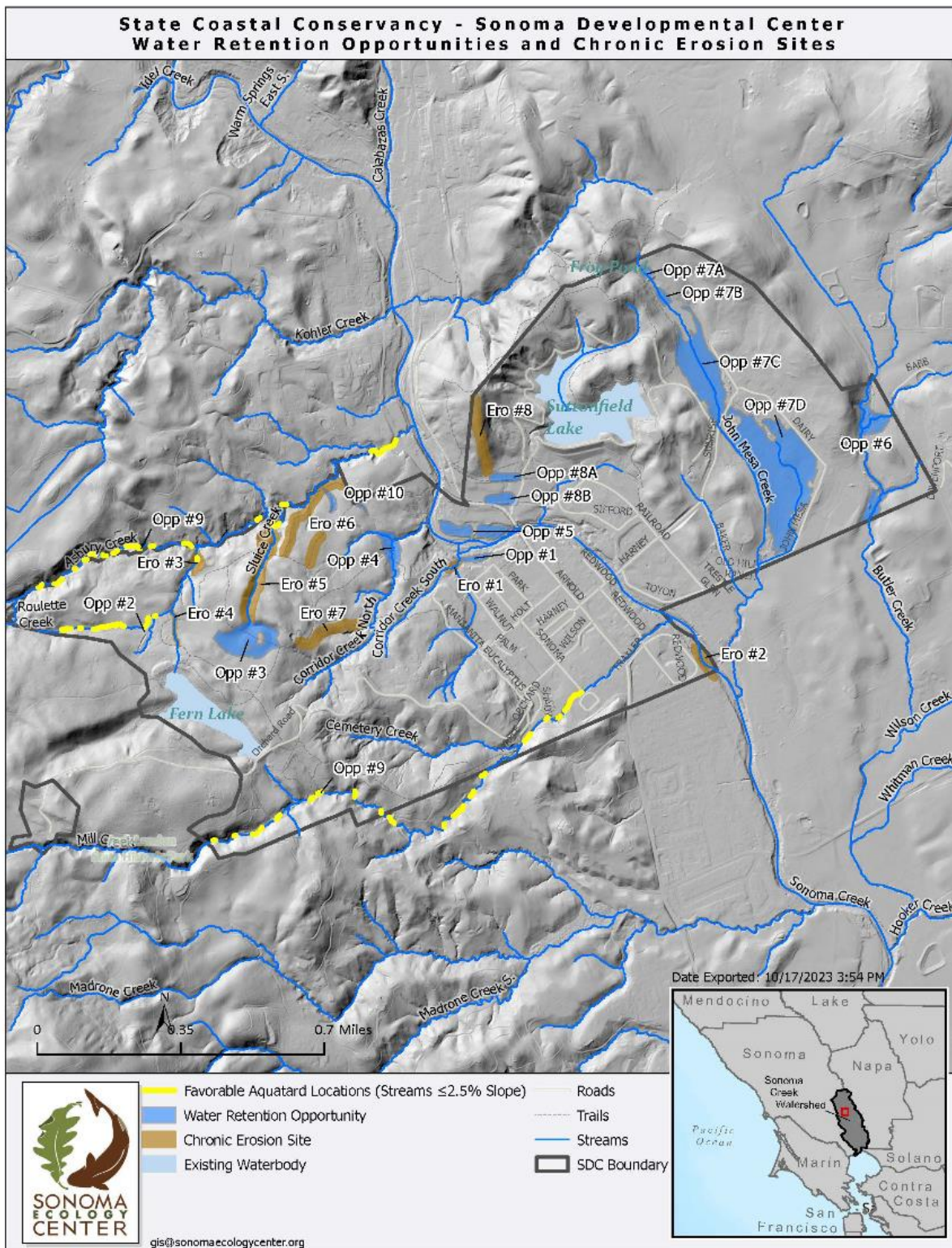


Figure 4: Map showing all proposed project concept sites on SDC open space lands. Water retention opportunities are identified by “Opp” and chronic erosion sites are identified by “Ero.”



Figure 5. Water Retention Opportunity #1 location outside of bend in creek and just north of developed campus. Satellite view is facing south.



Figure 6. Water Retention Opportunity #1 Site showing stormwater outflow running straight to creek across relic floodplain without opportunity to percolate to groundwater.

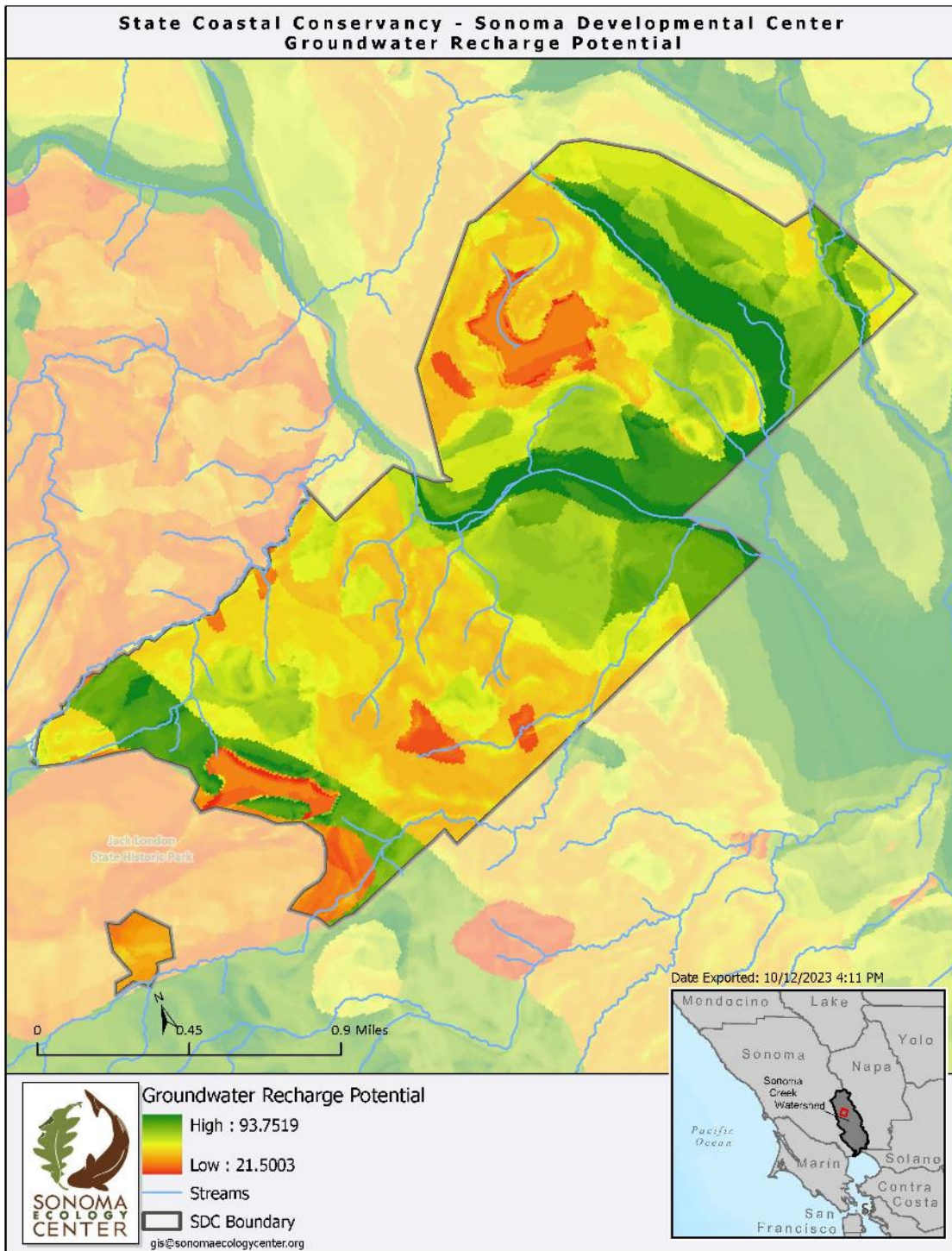


Figure 7. Groundwater recharge potential map for SDC and surrounding areas.



Figure 8. Great meadow below Fern Lake.



Figure 9. Water Retention Opportunity #3 Sluice canyon impoundment at low point of great meadow below Fern Lake..



Figure 10. Retention Opportunity #3, sluce canyon entrance.



Figure 11. Retention Opportunity #3, sluice canyon exit with headcut visible.



Figure 12. Water Retention Opportunity #3, road and drainage erosion below sluice canyon.



Figure 13: Constructed channel leading from Fern Lake overflow spillway to Roulette Creek via Great Meadow. Shown here is the place where the channel crosses the primary service road leading to the diversion point on Asbury Creek.



Figure 14: Chronic Erosion Site #4, Headcut on constructed Fern Lake overflow channel impacting fire service road. Road is currently impassable by emergency vehicles.

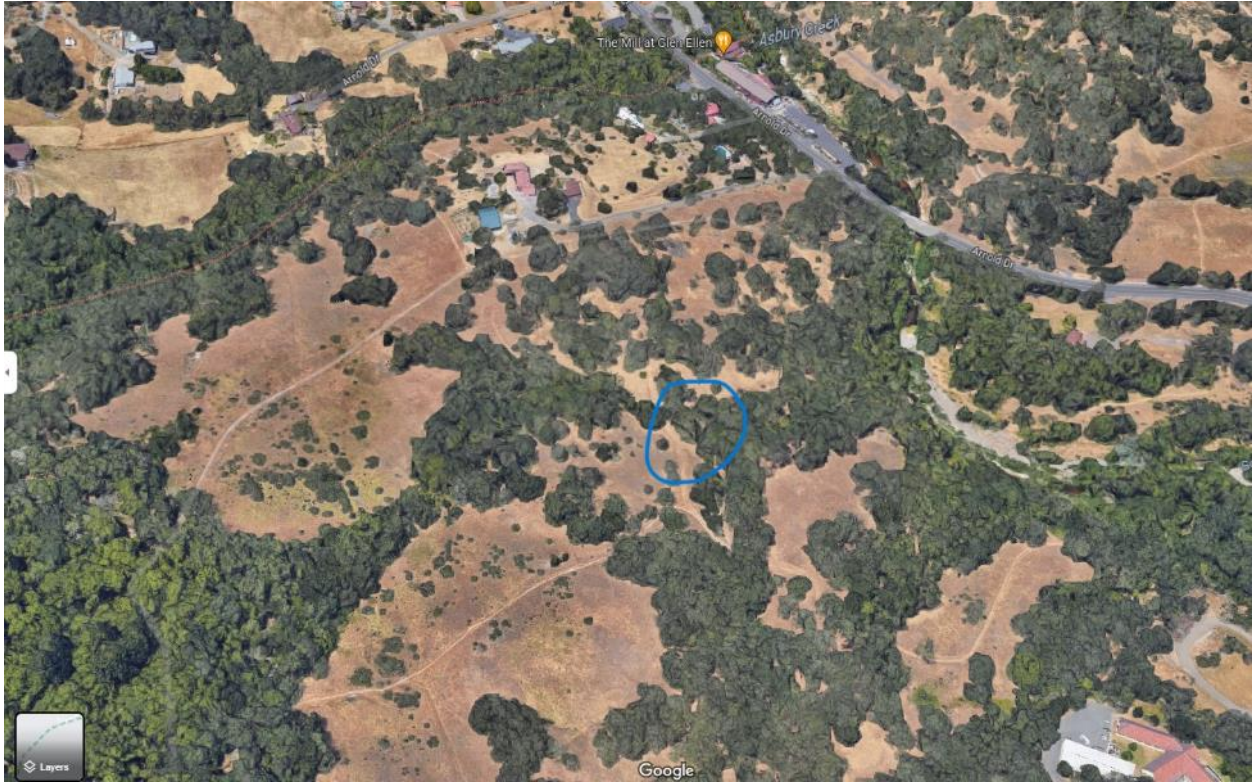


Figure 15. Water Retention Opportunity #4 Impoundment and channel aggradation at Corridor Creek North branching zone.



Figure 16. Water Retention Opportunity #4 Below the bowl of the Corridor Creek North branch point where steep hill slopes occur to either side of a high gradient, eroding creek section.



Figure 17. Water Retention Opportunity #4 Headcutting section of Corridor Creek North just upstream of the tributary branch point. A fire service road has become impassable at this location.



Figure 18. Water Retention Opportunity #5 Floodplain retention on the inside bend of Sonoma Creek between two bridges.



Figure 19. Water Retention Opportunity #5 Floodplain retention on the inside bend of Sonoma Creek between two bridges. High alluvial terrace area shown. An even higher terrace area exist to the left of this photo where an old residential building is located.



Figure 20. Water Retention Opportunity #6 BDAs and other water retention opportunities in Butler Creek at the far southeast corner of the SDC open space lands.



Figure 21: Water Retention Opportunity #6 BDAs and other water retention strategies could retain and recharge significant volumes of water in this low gradient section of Butler Creek.



Figure 22. Section of Butler Creek in SDC showing a relic section of water detention berm.



Figure 23. Beaver dam and perennially wet habitat in Fryer Creek.



Figure 24: Example of Beaver Dam Analog (BDA) allowing for water retention in a low slope drainage area..



Figure 25: Water Retention Opportunity #7 Wetland restoration at the SDC farm area. View is facing northwest with Lake Suttonfield visible to the west of the old SDC farm area. Frog pond impoundment is visible at north end.



Figure 26: Water Retention Opportunity #7 Wetland restoration at the SDC farm area. View of the frog pond impoundment area, facing south.



Figure 27: Water Retention Opportunity #7 Wetland restoration at the SDC farm area. Shown here is the view facing south from below the frog pond impoundment.



Figure 28. Water Retention Opportunity #7 Wetland restoration at the SDC farm area. Shown here is the view facing north from below (south) of the old Junior Farm site.



Figure 29. Water Retention Opportunity #7 Wetland restoration at the SDC farm area. Shown here is the view facing south from the old Junior Farm area.



Figure 30: Water Retention Opportunity #8 Water retention berms between Arnold Drive and Lake Suttonfield dam.



Figure 31: Water Retention Opportunity #8 Potential water retention zone above Arnold Drive and the old North West Pacific Railroad Berm.



Figure 32: Water Retention Opportunity #8, Potential water retention zone further upslope above old Southern Pacific Railroad berm.



Figure 33: Water Retention Opportunity #9, Example of “Stage Zero” creek restoration involving large wood “aquatard” structures embedded into the stream banks.

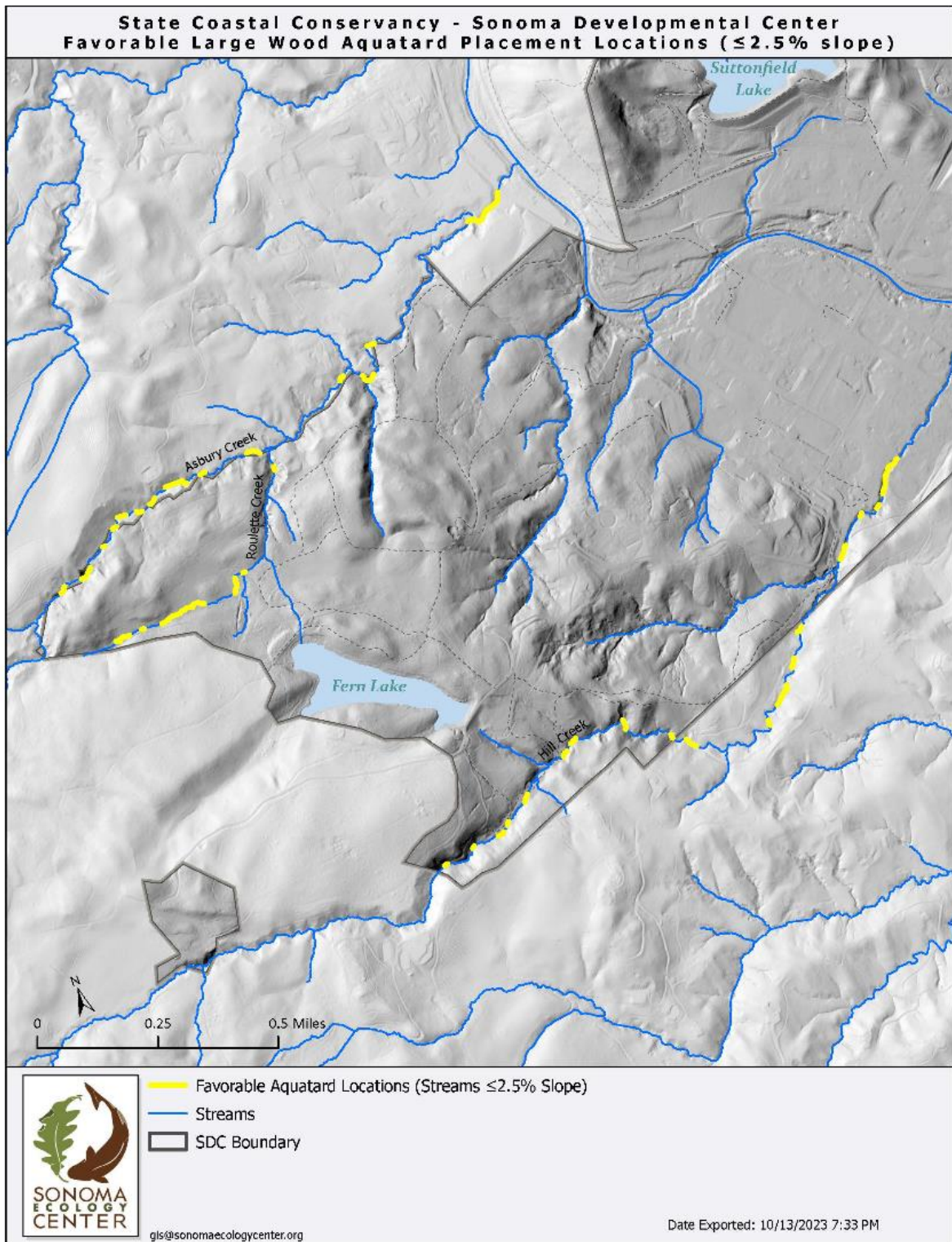


Figure 34. Water Retention Opportunity #9 Potential large wood “aquatard” locations in Asbury and Hill Creeks. Shaded in yellow are creek sections of favorable gradient (less than 2.5%) which could be studied further to determine their appropriateness for implementation of such an approach.



Figure 35. Water Retention Opportunity #10, Example gently sloped draws on SDC western open space where BDA and/or gully packing approaches could be implemented.



Figure 36. Water Retention Opportunity #10, Example of a gently sloped draw on SDC western open space where BDA approach could be implemented.



Figure 37. Water Retention Opportunity #10, Example of a gently sloped draw on SDC western open space where BDA and/or gully packing approaches could be implemented.



Figure 38: Chronic Erosion Site #1, Culvert-related gully erosion just north of developed campus at bottom of Corridor Creek South.



Figure 39: Chronic Erosion Site #1, Headcut and beginning of severe gully formation at lower Corridor Creek South.



Figure 40: Chronic Erosion Site #1 Extensive culvert-related gully formation at lower Corridor Creek South. A large diameter conveyance pipeline connecting Fern Lake and Lake Suttonfield is threatened with breach at this location.



Figure 41: Chronic Erosion Site #2, Bank failure on Sonoma Creek at downstream end of SDC reach. Nearby house is threatened.



Figure 42: Chronic Erosion Site #3 at confluence of Roulette and Asbury Creeks. Quarry scale amounts of fine sediment have been eroding to Asbury and Sonoma Creeks from this location for the past two decades.



Figure 43: Chronic Erosion Site #3 at confluence of Roulette and Asbury Creeks. Quarry scale amounts of fine sediment have been eroding to Asbury and Sonoma Creeks from this location for the past two decades.



Figure 44: Chronic Erosion Site #5, Headcut at Sluice canyon outlet. Erosion occurs all throughout this canyon, at this outlet and further down between there and Asbury Creek.



Figure 45: Chronic Erosion Site #5, Wash across fire service road shown along with additional erosive area further below that.

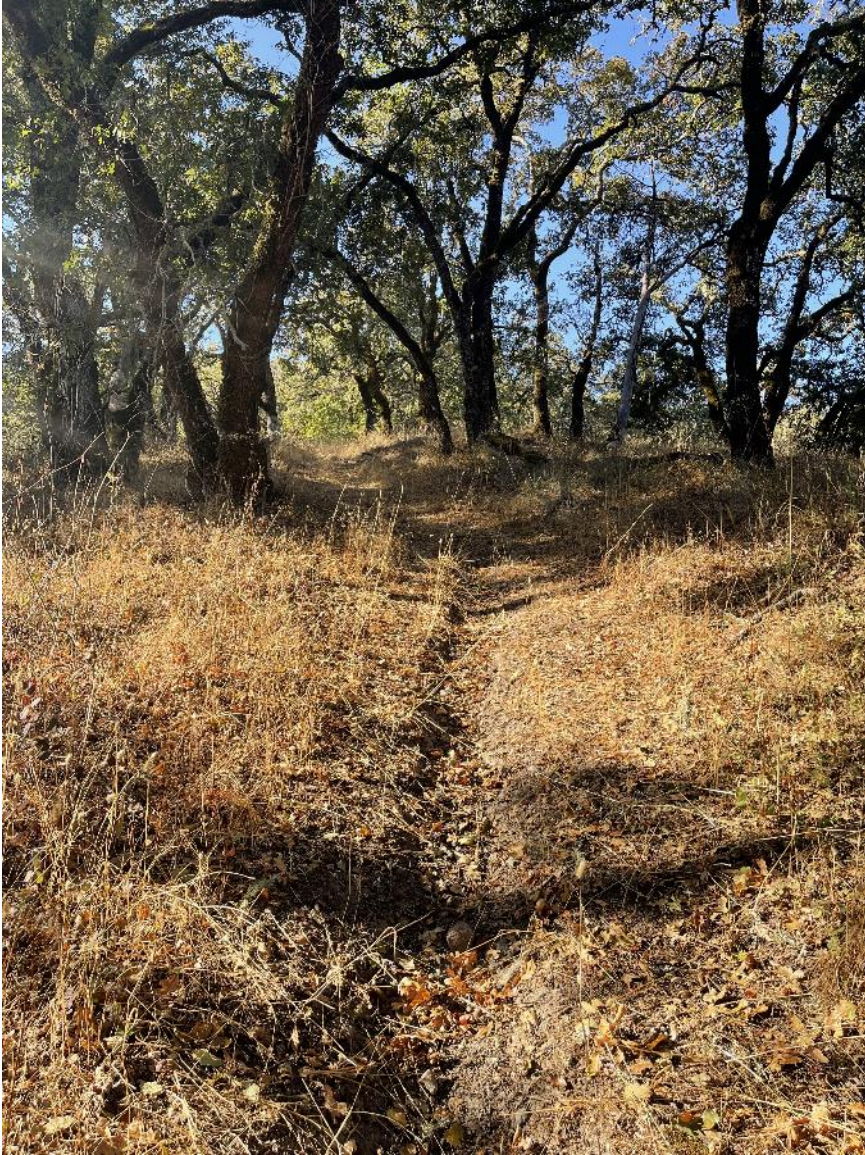


Figure 46: Chronic Erosion Site #6, Steep fire service road along lower Asbury showing deep v erosion caused by horse and mountain bike riders following the same path each time and then rivulets deepening that pathway during rain events.



Figure 47: Chronic Erosion Site #6, Headcutting across fire service road as a result of concentrated flow running down middle of road from steeper sections uphill.



Figure 48: Chronic Erosion Site #6, Rill and gully erosion on a steep section of a primary fire service road running through the western SDC open space within the Sonoma Valley Wildlife Corridor. A seep occurs at the top of the steep section and hikers, bikers and horseback riders using this adobe laden route during the wet season continually promote rill and gully erosion here.

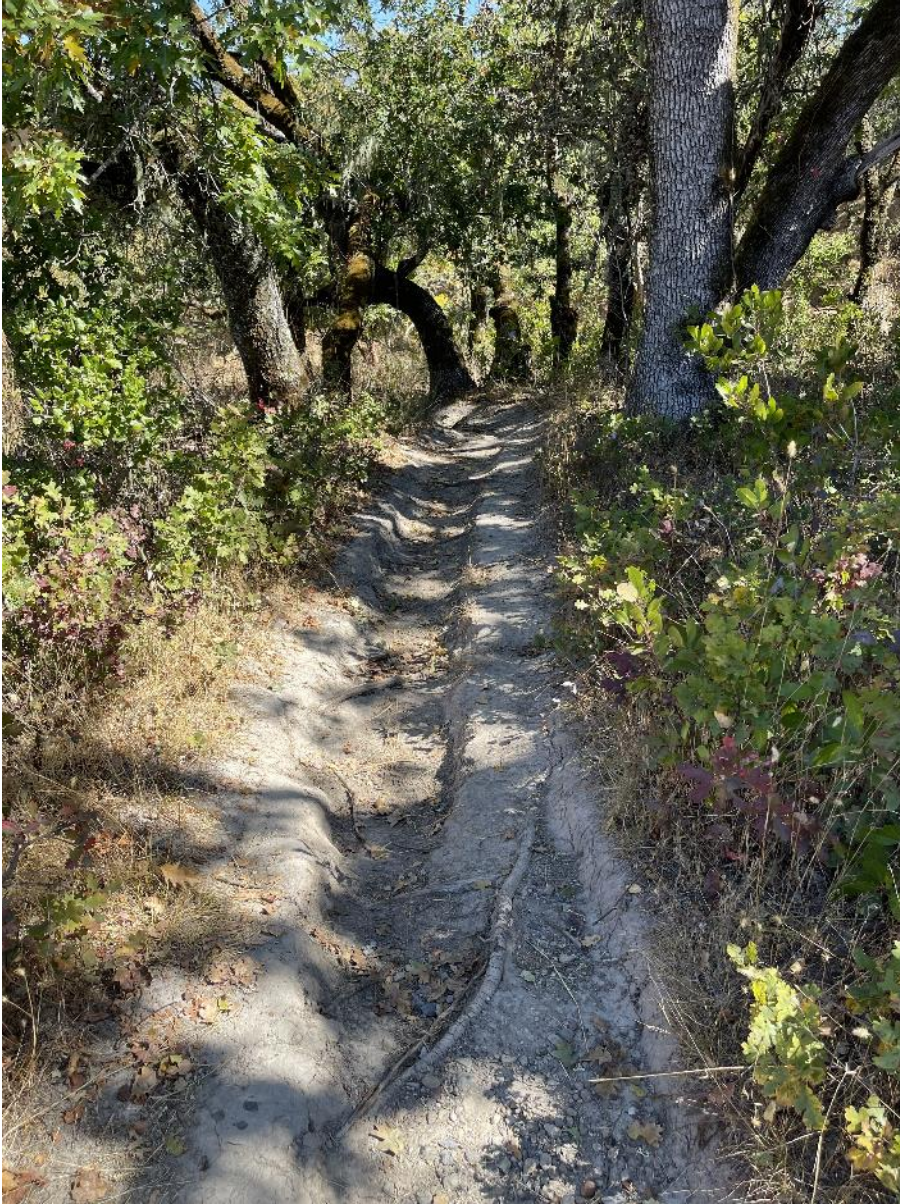


Figure 49: Chronic Erosion Site #7, heavy erosion along steep and ill-sited employee use trail just north of water treatment plant. This single track trail has become popular among mountain bike riders including during the wet season when such uses of adobe soil trails should be discouraged.



Figure 50: Chronic Erosion Site #7, One of two stream channel crossing points on single track employee use trail which has become popular among mountain bike riders including during the wet season when such uses of adobe soil trails should be discouraged.



Figure 51: Chronic Erosion Site #8, Impossibly steep, former fire service road northwest of the Lake Suttonfield dam with rutting evident. This trail is still being used by hikers and mountain bikers transiting south from the Sonoma Valley Regional Park trails with moderate safety risk of doing so.