SAN LORENZO VALLEY WATER DISTRICT
CROSS COUNTRY PIPELINE CONSTRUCTABILITY
PEER REVIEW OF FREYER & LAURETA STUDY AND MEMO

Peer Review of March 2022 Study and
Draft Supplemental Evaluation Dated April 6, 2022

24 NOVEMBER 2022
PROJECT NO. 12196

To:
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EXECUTIVE SUMMARY

At the request of the District, Haro Kasunich and Associates Inc. (HKA) have conducted a peer review of the geological and geotechnical aspects of the F&L STUDY and MEMO to evaluate and comment on their accuracy and completeness, and to provide preliminary recommendations to a possible middle-ground option for pipeline replacement, slope stability methodologies, and erosion control.

We find the F&L study does not yet adequately incorporate consideration of the actual field conditions and the difficulty of construction and equipment access which are necessary to determine the best alternative for waterline replacement, constraints for installation, or costs. Moreover, our review finds that large portions of the waterline are likely not accessible by equipment (large or small) without very significant new road/trail construction which will likely be cost prohibitive and/or unwarranted in light of alternative installation methods. Because of the steep slopes and limited access, we believe it will be difficult and expensive to reconstruct the entire waterline in a manner to fully protect it from future wildfires while at the same time mitigating risks to downslope water quality and public safety.

Our review found there are multiple physical constraints that impact the constructability and ultimately the feasibility for waterline reconstruction, including:

- **Very steep slopes (>100%)**
  We find about 87% of the alignment (5.7 miles) traverses slopes steeper than 2:1 slope (50% gradient) with nearly 13% (4,600 feet) steeper than 100% gradient
- **Steep streamside slopes adjacent to watercourses**
  The project site is located within the San Lorenzo River watershed, which is listed as impaired by sediment under Section 303(d) of the Clean Water Act and is regulated by the May 16, 2003 California State RWQCB Resolution No. R3 2002 0063, thus increased sediment loads to watercourses are of significant concern and may not be permitted.
- **Unstable areas (including existing waterline related failures)**
  Much of the project area is subject to shallow debris slide and debris flow landsliding, and debris from such failures can extend long distances down the native slopes and may enter watercourse areas and/or flow offsite and damage neighboring development.
- **Localized areas of hard bedrock**
  Some of the steep streamside and inner gorge conditions at watercourse crossings locally expose hard granitic bedrock forming very steep slopes that may be difficult to excavate through with small equipment.
- **Large trees containing large root-wads in the pipeline alignment**
  The existence of large stumps essentially blocking the existing waterline bench to be a significant constraint that requires further review. Gaining access with equipment that is large enough to remove or route the waterline around the root wads to allow for both the installation of a buried pipeline and equipment to continue and work further along the alignment will be difficult and quite possibly infeasible due mainly to the steep slopes such equipment will need to traverse.
- **Watercourse crossings**
  We found that most of the existing smaller watercourse crossings were crossed at grade on a narrow bench and likely can again be crossed on rock fords or similar crossings. The larger crossings will be much more difficult to construct and may be best crossed with elevated pipeline crossing structures.

Further evaluation of these constraints and their associated limitation on construction and access is essential prior to deciding on the design bench width, selection of the best alternative, and associated budget for construction.

We observed numerous “Choke Points” which are locations where equipment access may not be feasible within the economic and regulatory restrictions of the project. Reconstructing the waterline requires getting equipment and material to the site, which is constrained by both access to the waterline and choke points along the waterline. If equipment cannot reasonably traverse past a choke point for whatever reason, then the segment of waterline beyond may not be able to be constructed with that equipment, regardless of how favorable the conditions are past this point. Identifying choke points and their associated limitation on construction and access is essential prior to deciding on the design bench width, selection of the best alternative, and associated budget for construction. Additional review, analysis, and discussions with contractors are necessary to assess equipment access and constructability.

In our opinion, the presented F&L work does not yet adequately incorporate consideration of the actual field conditions and the difficulty of construction and equipment access. Our review finds that large portions of the waterline alignment are likely not accessible by equipment (large or small) without very significant new road/trail construction which will likely be cost prohibitive, environmentally unfeasible, and/or unwarranted in light of alternative installation methods. Thus, it is premature to make definitive conclusions on the best alternative for waterline reinstallation. Ultimately, selection of the best waterline replacement alternative, and determination of the associated costs will come down to constructability and the ability to feasibly use heavy equipment, small equipment and/or hand labor. The steep slopes that dominate the waterline alignment present a significant constraint and were one of the reasons why the original waterline was installed by hand.

Because of the steep slopes and limited access, we believe it will be difficult and expensive to reconstruct the entire waterline in a manner to fully protect it from future wildfires while at the same time mitigating risks to downslope water quality and public safety.

Where equipment access is possible, it is our opinion that the waterline replacement is best suited to small (trail size) equipment with tread widths less than 5 feet to minimize the size of cuts and fills and associated impacts on erosion and hillslope stability. It has been our experience that small equipment can generally traverse across slopes up to 80% to 90% gradient, though retaining walls may be required. Though we have used equipment on steeper sideslopes, it becomes much more difficult, can be unsafe, and by no means is certain. A problem with using small equipment is lower production rates and increased difficulty getting past large stumps or rock embankments.

In our opinion:

- Regulatory agencies will likely require this project to be constructed utilizing a less environmentally damaging alternative than 3A or 3B presented in the F&L report, unless those alternatives are re-defined to significantly limit the temporary construction bench widths, associated grading volumes, and risks to water quality and public safety.
- A combination of Alternative 2 (Above Grade Welded Steel pipe) and Alternative 3 (below grade HDPE pipe) using a narrow bench width where feasible is likely the best option if a fireproof waterline is required. If a fireproof waterline is not required, then Alternative 1 is best. The District should decide if fireproof waterline is mandatory, and if so, if it is required for the entire alignment.

A narrow width bench (5 foot width) is superior to a standard road width bench (12 feet), and may be required due to instability and access constraints.

- Where the waterline is accessible by small equipment and where slopes are less than about 90%, we believe that majority of the waterline could be buried below grade per Alternative 3.
- Where the waterline is not accessible by small equipment, hand construction will be required. In these areas a combination of Alternatives 2 (above ground welded steel pipe) and Alternative 3 (below grade HDPE pipe) are still likely viable. Hand constructed narrow benches and benches retained by small retaining walls, particularly if designed to bury the pipeline a minimum of 12 inches using the minimum bench width, are considered feasible.

RECOMMENDED NEXT PHASE

Ultimately the feasibility of the project is a function of constructability and equipment access. To that end we believe the following next steps are needed prior to selecting the preferred alternative.

1. Further review and analysis to identify, map, and characterize access locations and choke points. A preliminary access and constraint map is shown in Figure 4A, B C of our report, but that map is not comprehensive. A complete understanding of physical constraints and their associated limitation on construction and access is essential prior to deciding on the design bench width, selection of the best alternative, and associated budget for construction.
2. Review of site by a Geotechnical Engineer, Engineering Geologist, and Contractor (equipment operator) with considerable experience working with small equipment in steep terrain to confirm access and constructability. This will include developing preliminary construction alternatives for each access location and choke point.
3. Utilize narrow width trail to limit environmental impacts wherever possible or practical.
4. Evaluate possible access locations to the waterline for material, equipment and fuel delivery. This should include:
    a. Existing roads or tractor trails that cross the alignment, but which traverse across neighboring properties.
    b. Potential new tractor access routes down ridge lines.
    c. Use of helicopter support.
    d. Use of highline systems for material and equipment delivery to bypass choke point
5. Evaluate if the entire waterline needs to be fireproof or if the more difficult areas to construct and access can be constructed using exposed HDPE pipe. Give further consideration to replacing the existing (burned) pipe in a similar manner to how it was constructed in the 1980's. This would expose it to some level of fire risk in the future. Depending on the recurrence interval of damaging fire (historically it may be 50 to 100 years or so) in the pipeline zone, it could be deemed an acceptable risk. Mechanisms and protocols to isolate areas of the pipeline and shut down the district’s water treatment plant might help minimize future risks associated with fire damage to the water system.
6. Further evaluate the feasibility of getting steel pipe and above grade crossing structure materials into the stream crossing areas.
7. Refine cost estimates to include hand installation of above and below grade waterline alternatives. Include cost estimates for above grade steel pipe placement at watercourse crossings, fall line segments and work arounds at choke points.

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INTRODUCTION

The team of Haro Kasunich and Associates Inc. (HKA) in conjunction with Timothy C. Best (TCB) (hereinafter HKA) have conducted a peer review of the geological and geotechnical aspects of the March 2022 Cross Country Pipeline Constructability Study (STUDY) and DRAFT Supplemental Evaluation Memorandum dated April 6, 2022 (MEMO) prepared by the Freyer and Laureta, Inc. team (hereinafter F&L) including their team members Cal Engineering and Geology, WRA Environmental Consultants, and Alpine Summit Development.

SCOPE OF SERVICES

The HKA Scope of Services contracted by the San Lorenzo Valley Water District , who requested a peer review of the geologic and geotechnical aspects of the F&L work, consisting of the following evaluation:

1. Overall accuracy and completeness of the geotechnical work in the STUDY;
2. Recommended slope stabilization methodologies;
3. Constructability and long-term impacts of temporary construction bench;
4. Long term erosion control measures; and
    a. Recommendations related to a possible middle-ground option for pipeline replacement, described as follows:
    b. Construction of a four- to five-foot-wide bench, built to the standards of POST hiking trails and specifically leveraging Tim Best's experience and expertise in design and construction of wildland hiking trails and built similarly to such trails;
    c. Trenching into the surface of the new bench where feasible with lightweight equipment able to safely access the narrow bench;
    d. Placement of HDPE pipe in the trench or, where trenching is not feasible, at grade on the bench as close to the inboard edge (cut slope) of the bench as is practicable;
    e. Backfill of the trench or placement of the grading spoil over the at-grade pipe, either case including compaction to a minimum of 80% relative Proctor, up to 90% relative Proctor where feasible;
    f. Seeding or other restoration of the disturbed area; and
    g. Placement of permanent erosion controls measures where required. Such permanent erosion controls would be designed and installed in conformance with current United States Forest Service standards, details, and methodologies for work in steeply sloped and heavily forested areas.

BACKGROUND and PROJECT UNDERSTANDING

The waterline extends for approximately 6.6 miles along the west side of the San Lorenzo Valley above Ben Lomond and Boulder Creek along the midslope of the eastern flank of Ben Lomond Mountain. It consists of two separate waterlines: 5-Mile, extending south of the Lyon Water Tank to Sweetwater Creek, and Peavine, extending north of Peavine Creek.

The site is characterized by moderate to very steep slopes underlain by granitic bedrock. Overlying bedrock is a thin to thick mantle of colluvial soils consisting mainly of low cohesion sand, silt and gravel. The steep hillsides are indented by multiple narrow and steep gradient watercourses and swales, many of which are prone to shallow debris slide and debris flow landsliding. The hillside is underlain by multiple shallow and deep-seated landslides. The hillside is vegetated with advanced second growth redwood and Douglas-fir, oak woodland, and brush. Residential homes and public roads are located downslope along the valley bottom of San Lorenzo River and the lower portions of its larger tributaries.

The current waterlines were constructed over a several year period between 1982 and 1988. It consisted of an above grade HDPE pipe installed along a narrow 2 to 5 foot wide hand excavated bench cut into the locally steep hillside with portions of the waterline spanning the larger watercourses.

The waterline was destroyed in the 2020 CZU Lighting Complex Fires necessitating its replacement to restore the critical surface water supply for the SLVWD system.

In 2021 SLVWD contracted with the F&L team to prepare the Cross-Country Pipeline Constructability Study (hereinafter STUDY) to focus on restoring the raw water conveyance system that serves the SLVWD water system. F&L prepared a DRAFT Supplemental Evaluation Memorandum dated April 6, 2022 (hereinafter MEMO) was focused on the construction cost differential between Alternatives 1 and 3B presented in the original STUDY.

In 2022 HKA was retained by SLVWD to provide a peer review of the F&L STUDY and a subsequent MEMO that addresses the items in their Scope of Services that is defined above.

WATERLINE REPLACEMENT GOALS

From our discussions with SLVWD staff, the goal of the waterline replacement project is to:

- Install a new replacement fireproof water line to the extent practicable:
  - Below grade - plastic with sufficient earth material coverage on all sides to protect it from future fires
  - Above grade – welded steel
  - Combination

- Minimize construction and waterline related landsliding and erosion that could result in adverse offsite impacts including:
  - Impacts to downslope properties and structures
  - Increased sediment discharge to watercourses
- Minimize pipe replacement and maintenance costs
- Maintain access (by foot) to valves, water intakes, etc.

PHYSICAL CONSTRAINTS

To comment on the completeness of the F&L report and more importantly to provide recommendations related to a possible middle-ground option for pipeline replacement, we believe it is important to first understand the various physical and logistical constraints that affect replacement of the waterline. There are multiple constraints that affect the project that include, but not limited to:

- **Topography and Landsliding**
  - Locally very steep (>100%) slopes that will be difficult to traverse without potentially expensive retaining structures
  - Steep streamside slopes where it will be very difficult to control spoils from entering a watercourse
  - Existing slope failures, including cutbank failures with unstable fill material retained on the old trail tread
  - Locally hard bedrock

- **Watercourse Crossings**
  - Deeply incised watercourse crossings with steep streamside slopes

- **Large Trees and Root Wads**
  - Large isolated or clumps of trees containing large root-wads in the pipeline alignment

- **Constructability and Access**
  - Limited equipment access points
  - “Choke Points” that can prevent large and small equipment access to areas beyond that segment. In HKA's opinion, identification of those "choke points" and understanding equipment accessibility is necessary prior to deciding on the design bench width, selection of the best alternative, and associated budget for construction.

- **Offsite impacts**
  - Water Quality – San Lorenzo River Watershed listed under 303(d) of the Clean Water Act as impaired by sediment
  - Public Safety – downslope structures are locally at risk from upslope landsliding

The following is a brief discussion of these constraints. It includes the findings of F&L in italics and subsequent HKA findings and comments for several topics.

TOPOGRAPHY and LANDSLIDING

The project site is located on moderate to very steep slopes on the west side of the San Lorenzo Valley. The hillside is indented by multiple narrow and steep gradient watercourses and swales, many of which host infrequent debris slide and debris flow landslides. HKA believes that the steep and potentially unstable topography presents the most significant physical constraint to the construction and maintenance of a stable and sustainable waterline.

F&L TOPOGRAPHY and LANDSLIDING FINDINGS

Topography

The F&L STUDY reported *"The existing slopes along large portions of the 5-Mile segment to be modest to steep slopes both above and below the existing bench in particular when the existing bench width was found to be less than four-feet wide". The* F&L MEMO further reported *"We have conservatively estimated using publicly available LiDAR data that approximately 50% of the alignment is adjacent to slopes steeper than 2:1 …. "*

Site Stability and Landsliding

A Geotechnical Design Report was prepared by Cal Engineering & Geology, Inc. (CEG) and was included in Appendix C of the F&L STUDY. CEG presented a series of maps that show areas of landsliding and debris flows along and beyond the limits of the pipeline alignment. The CEG report stated: *"That for purposes of this pipeline reconstruction project, in general it is the shallowest, most active landslide features (Als) that are of greatest concern, since they have the greatest potential to reactivate or enlarge in the project lifetime. Dormant landslides (Dls) have a somewhat lesser likelihood of reactivation or enlargement, and older landslides (Ols) still lower potential."* The CEG study does not discuss debris flow hazards in detail. Mitigation of debris flow hazards may influence selection of the best alternative and future project design. In addition, the CEG study does not discuss smaller landslides along the alignment that, as to be discussed later, will have significant impacts on waterline constructability.

HKA TOPOGRAPHY and LANDSLIDING FINDINGS AND COMMENTS

Topography

HKA believes that significantly more than 50% of the alignment is adjacent to undisturbed slopes located immediately uphill and downhill from the pipeline that are steeper than 2:1 slope (50%) and includes nearly 4,600 feet of waterline that traverses slopes steeper than 100%. In our opinion, the steep slopes that the waterline traverses present a significant logistical and environmental constraint to the installation of a new waterline and from our understanding was one of the principal reasons the past waterline was originally installed by hand crews.

To further evaluate topographic conditions along the alignment, the HKA team generated a slope map of the project area based on a GIS analysis of the 2020 Santa Cruz County, CA LiDAR-derived bare earth digital elevation model (DEM)(NOAA, 2020) coupled with field observations. LiDAR (Light Detecting And Ranging) is a technology that uses lasers to determine the distance to surfaces or objects and can be used to generate relatively accurate measurements of ground elevation. The results were filtered to removal small areas less than 1,000 square feet that were either steeper or gentler than the surrounding ground and which, in our opinion, is generally not representative of the larger average site conditions. The slope map generated for the project area is depicted in Figure 1.

Native slope gradients along the waterline bench were then calculated based on a GIS comparison of the slope map to the waterline location and locally field verified. Adjustments were made to eliminate the influence of the flatter waterline bench, and steeper cuts and fills to more accurately depict native slope conditions, which, as will be discussed later, is necessary when evaluating grading and retaining wall requirements for bench widening to install the new waterline. The volume of resultant grading, the extent of required retaining walls and the ability to obtain access for construction equipment to accomplish the project are all a function of the sideslope gradients. The results of our analysis are depicted in Table 1 which summarizes approximate length of waterline by LiDAR derived slope gradient class.

TABLE 1: APPROXIMATE LENGTH OF WATERLINE BENCH BY LIDAR DERIVED SLOPE CLASS

SLOPE CLASS	APPROXIMATE LENGTH OF ALIGNMENT		% OF ALIGNMENT	PERCENT GENTLER THAN CLASSIFICATION	PERCENT EQUAL TO OR STEEPER THAN CLASSIFICATION
	(Feet)	(Miles)			
0 - 10%	150	0.03	0%	0%	100%
10 - 20%	300	0.06	1%	0%	100%
20 - 30%	700	0.13	2%	1%	99%
30 - 40%	1400	0.27	4%	3%	97%
40 - 50%	2150	0.41	6%	7%	93%
50 - 60%	**3050**	**0.58**	**9%**	**13%**	**87%**
60 - 70%	4100	0.78	12%	22%	78%
70 - 80%	6500	1.23	19%	34%	66%
80 - 90%	**6850**	**1.30**	**19%**	**53%**	**47%**
90 - 100%	5150	0.98	15%	72%	28%
100 - 110%	3350	0.63	10%	87%	13%
110 - 120%	800	0.15	2%	97%	3%
>120%	500	0.09	1%	99%	1%
	35,000	**6.63**	**100%**		

Based on the foregoing, we find that approximately 87% of the waterline bench transverses slopes steeper than 50% with nearly 48% on slopes steeper than 80% gradient, which is significantly greater than the estimate presented by F&L. These steep slopes present a significant constraint for construction and access. Current accepted engineering practices generally limit placement of unretained fill on slopes steeper than 50% gradient. On recreational trails, un-retrained thin fill is often allowed on steeper sideslopes, if placed at a thin depth (<12" to 18"). On slopes greater than 90% gradient, it has been our experience that fill is often retained, depending on local site conditions, width of trail, and underlying geologic conditions.

HKA believes that as a rule of thumb, small (4 to 5 foot wide) excavators can work on sideslopes less than 80%. On 90% slopes that can be tricky and by 100%+ many equipment operators will not do it because it is unsafe. Many areas on the waterline where slopes are less than 80% may not be accessible by equipment due to access constraints ("choke points") along the alignment to either side of the "good ground".

During our field reconnaissance we also identified multiple locations where the alignment traverses very steep slopes greater than 110% gradient where it may be impracticable to construct a wide bench for equipment to cross for access further along the pipeline alignment. An example of this is found at the north side of the Clear Creek #1 stream crossing where there is a roughly 50 to 100+ foot long segment of the very steep channel bank (Photograph 1), which based on our experience, will not be feasible to cross with equipment without very significant retaining structures which could be cost prohibitive and may not be permittable.

We recognize that many existing roads in the San Lorenzo Valley have historically (since 1900) been built with bulldozers and excavators crossing sideslopes greater than 80%; however, these were built without concern for the disposal of sidecast fill and whether it might become unstable and/or enter watercourses below the road being constructed. The regulatory environment is presently different and the required environmental and public safety controls on projects are more stringent, with harsh penalties and legal liabilities for violations. Thus, careful design, detailed construction management planning and best management practices now must be adhered to.

Photograph 1: Example of Extremely Steep Slopes Along Existing Waterline Bench at North side of Clear Creek #1 crossing

Overall, the actual length of waterline across steep slopes and existence of “choke points” that may prevent equipment access will alter the conclusions on the cost and feasibility of pipeline replacement, and will be a primary factor in selection of the best alternative. Not surprisingly, the steeper the ground the more difficult it is to install the waterline. This is due to greater amount of required grading (cuts and fills), greater risk of instability without retaining structures, greater risk for increased sediment discharge into watercourses, and the overall physical and regulatory feasibility and safety of the work.

Site Stability and Landsliding

Desktop Landslide Mapping

HKA concurs with the general desktop landslide mapping of the waterline prepared by CEG but finds that many smaller failures such as debris slides and debris flows, including those associated with the waterline, have not yet been mapped or discussed.

Fill Placement and Spoil Disposal

In our LiDAR review and field reconnaissance we found Portions of the existing trail (bench) have failed or washed out, mostly on steep side slopes where there is thin colluvial cover over harder bedrock. Many of these are associated with the failure of the fill embankment from the hand construction of the narrow bench, because the predominantly very steep slope areas along the pipeline alignment are not conducive to placement of compacted fill.

We also observed significant cracking of the fill embankment and underlying colluvial soils along the 10 foot wide bench constructed along the Peavine Waterline north of the Lyon water tanks where the road was built with fill partially retained by crib logs. We find the cracking fill to be at risk for instability and, in our experience, it will be required to be removed or stabilized by regulatory agencies. We understand that F&L and CEG have prepared construction documents to repair this section of waterline. We have not reviewed those plans in detail

Debris from fillslope failures may generate debris flows that extend long distances down the native slopes, and may entering watercourse areas and/or flow offsite and damage neighboring development. More study is appropriate to evaluate and prevent this from occurring.

Photograph 2: Example of Extremely Steep Slopes Along Existing Waterline Bench with Black HDPE Pipeline Visible

Going forward, much of the spoils generated from the construction of the new waterline will need to be end-hauled to suitable fill disposal areas or retained. Thick un-compacted fills that are placed on steep sideslopes which are not structurally retained are unlikely to have enough bearing capacity to support conventional heavy equipment loads during construction. Bearing capacity failures in fills along the outer edge of the bench pose the safety risk of such heavy equipment overturning.

Cutslope Instability

Cutslope instability is where the excavated cut made to create the bench has failed due to the slope being undercut by grading. The cutslopes associated with pipeline bench construction in 1980's have deteriorated from instability and erosion in many areas, resulting in the bench being buried by a wedge of talus derived from the cutslope deterioration. In most areas, this is less of a concern than fillslope and downslope instability but large cutbank failures have occurred along the waterline with slide debris overtopping the bench and extending downslope to watercourses. More study is appropriate to evaluate the potential hazard and risk from cutbank instability

Photograph 3: Area of Extremely Steep Slopes where Cutbank Landsliding Impacted Existing Waterline Bench

Debris Flow Hazards

Debris slide and debris flows are typically shallow rapid landslides. Debris flows have the potential to travel down steep swales and drainages potentially resulting in offsite impacts (public safety and water quality).

Ellen and Others (1997) prepared a map identifying the principal areas in the San Francisco Bay region that are likely to produce debris flow landslides. This map also shows the location of debris flow landslides mapped after the catastrophic January 1982 storm. The map shows nearly the entire alignment to be located on “principal predicted debris-flow source areas” and identified multiple historical 1982 debris flow landslides along the hillside in the general vicinity of the waterline. The CEG report does not discuss these past failures.

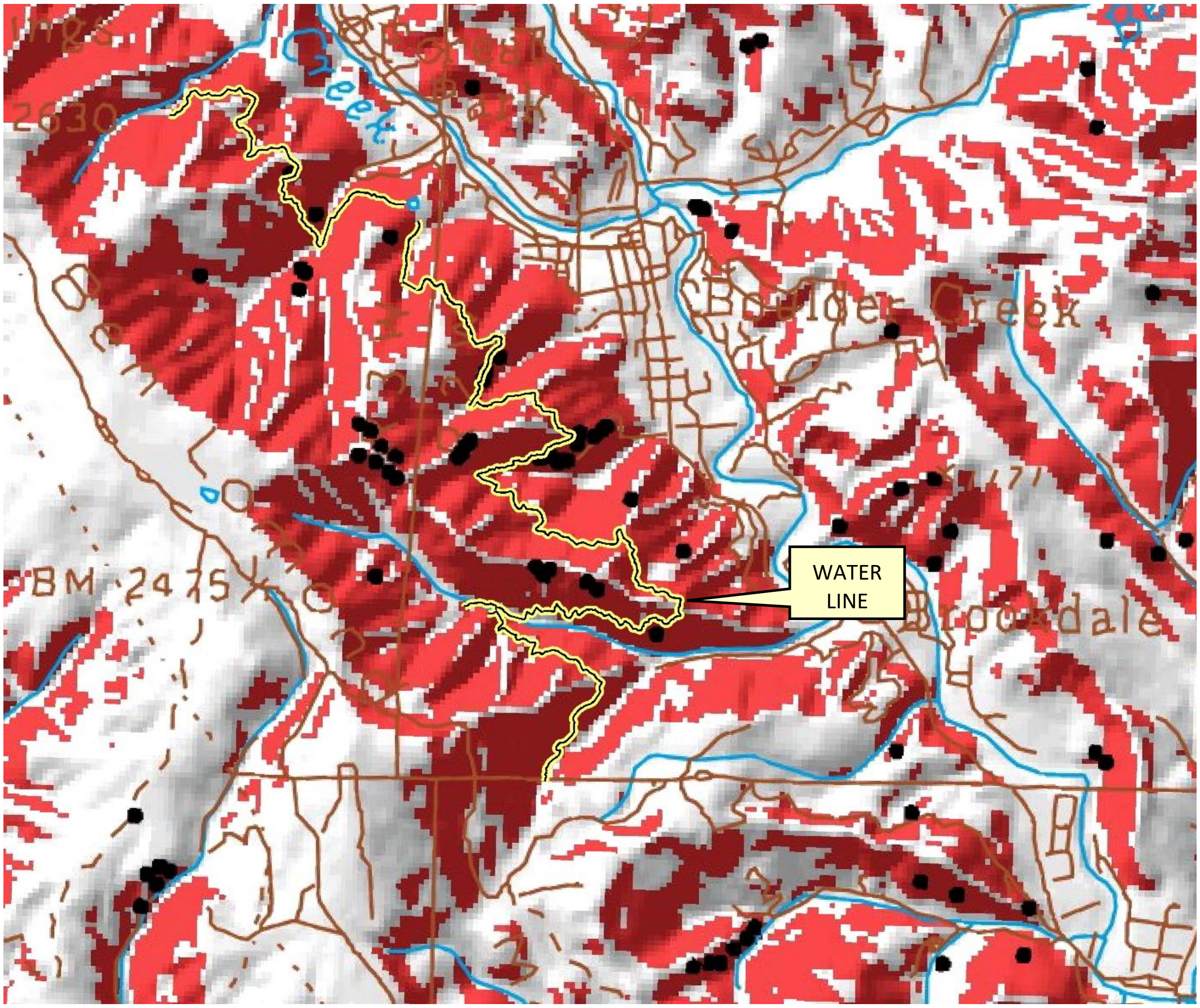

FIGURE 2: DEBRIS FLOW SOURCE AREAS
(From USGS Open-File Report 97-745 E; Santa Cruz County Map of Debris-Flow Source Areas In The San Francisco Bay Region, California, by Ellen and Others, 1997)

Our review finds that slopes in the project area greater than about 65% gradient can, in general, be classified as debris slide slopes having formed over time by repeated shallow debris slide type surficial landsliding, which is consistent with the findings of Ellen and Others (1997). These slopes, in general, are inherently prone to shallow debris slide/flow landsliding with the risk being greatest in colluvial slopes, headwall swales, steep streamside slopes, areas with perched ground water, surface runoff, low cohesion soils, etc.

Areas downslope of the pipeline alignment are subject to debris flow runout originating upslope landslides and multiple debris flow landslides occurred in the 1982 storms resulting in significant damage to homes and infrastructure, including in areas downslope of the waterline. Following the 2020 CZU fire, debris flow runout paths downslope of the waterline have been mapped by

CGS (2020) and Atkins, a member of the SNC Lavalin Group (September 2021). These studies and maps found at:

- https://www.co.santa-cruz.ca.us/Portals/0/County/OR3/DebrisResultsMemo2021_v06.pdf
- https://www.co.santa-cruz.ca.us/Portals/0/County/OR3/Workmaps_SantaCruz_Optimized.pdf
- https://sccgis.maps.arcgis.com/apps/webappviewer/index.html?id=c19f04a3035c43e79ad06f8fdd1a1297
- CZU_OES_Mission_Task_2020-SOC-42611_Boulder_Creek_Post_WERT_Study_CGS_Final_20201102.pdf (santacruzcounty.us)

A copy of a portion of the Atkins/Lavalin Group map that shows primary debris flow paths, inundation areas (water, mud, and/or debris) and uncertain debris flow paths all as predicted by their modeling is shown below in Figure 3.

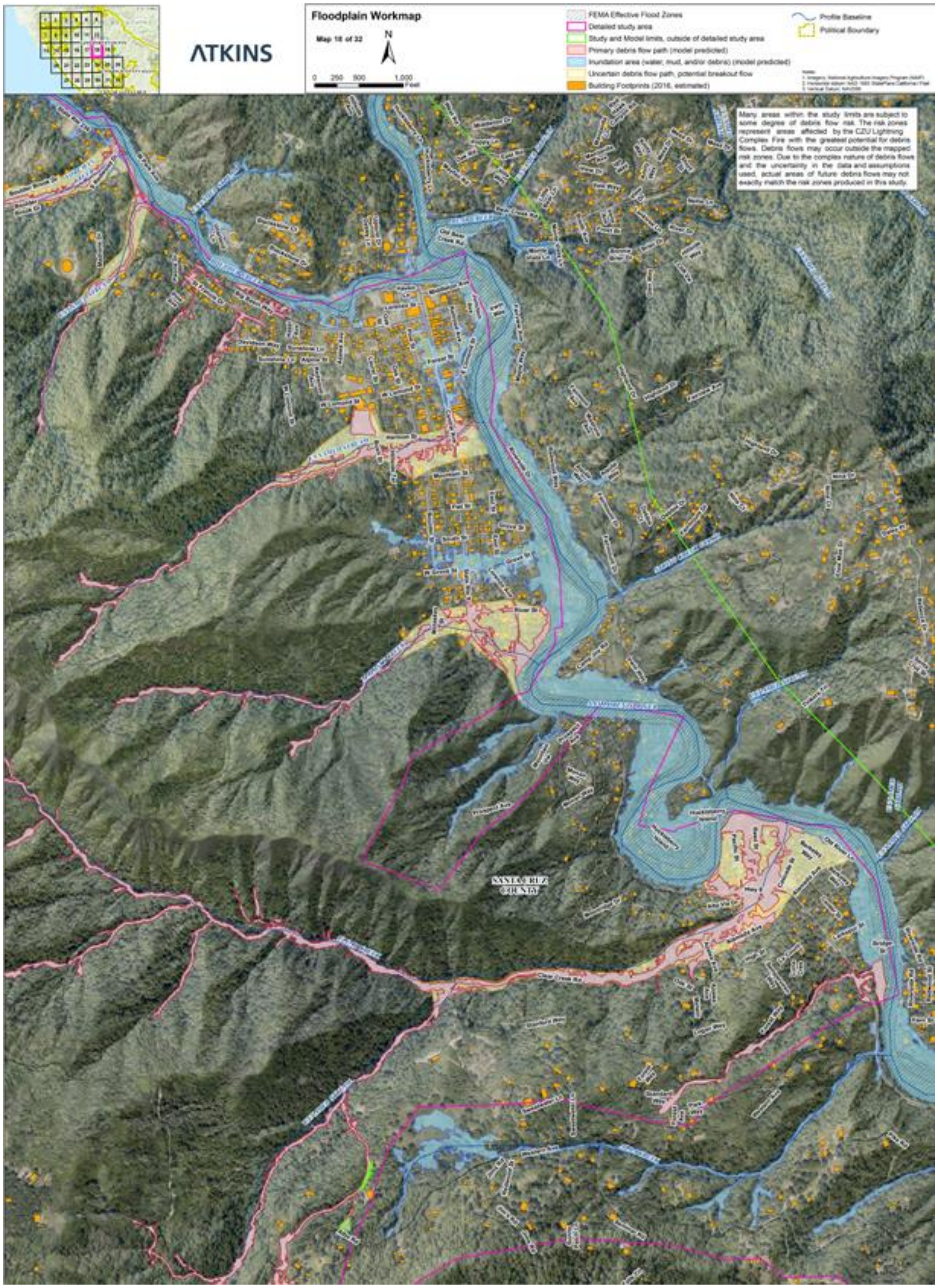

***FIGURE 3:* DEBRIS FLOW INUNDATION AREAS**
A Portion of Debris Flow Floodplain Workmap # 18 for the CZU Fire Zone
(from Atkins/Lavalin, September 2021)

It must be understood that future landslides will occur along the steep slopes that the waterline crosses. The construction and expansion of the waterline bench can increase the risk of slope instability thru the placement of fill, undercutting of the hillside, and concentration of runoff. This risk increases with slope gradient and width of bench because of the larger associated cuts and fills. Mitigating this risk becomes more difficult, again with increased slope gradient and width of bench. In our opinion, it is very likely that permitting agencies will require a comprehensive geotechnical investigation and report to demonstrate at a minimum that the proposed improvement will not significantly increase the risk for instability. Mitigating the risk of natural landslides may not be feasible due to the size and depth of many of the slides.

As previously discussed, we found that the existing 3 to 4 foot wide waterline bench has already experienced multiple failures associated with historical cuts and fills, undercutting of the hillside, watercourse erosion, and natural slope instability. The potential for waterline related failures to generate a debris flow landslide that could travel offsite and impact water quality and downslope public safety cannot be ruled out. This risk is greatest along steep streamside slopes that descend to watercourses without benching, and within colluvial filled swales which are locations where surface and groundwaters are concentrated and which generally have a much higher incidence of failure. These areas will be difficult areas for bench widening and pipeline construction due to the potential for delivering sediment to watercourses which drain to the San Lorenzo River, which is listed as impaired by sediment under Section 303(d) of the Clean Water Act and is regulated by the May 16, 2003 California State RWQCB Resolution No. R3 2002 0063.

WATERCOURSE AND SWALE CROSSINGS

The existing waterline traverses steep slopes drained by multiple ephemeral to perennial watercourses that are tributaries to the San Lorenzo River.

F&L WATERCOURSE AND SWALE CROSSINGS FINDINGS

An environmental assessment was completed by WRA Environmental Consultants and included as an Appendix to the F&L STUDY found that key environmental constraints that could result in constraints during construction of the Peavine segment and 5 Mile segment include stream crossings where fill or excavation may occur within the limits of the stream will require permits from multiple agencies.

Maps prepared by WRA appear to show 37 ephemeral to perennial stream crossings and water intakes along waterline. This is consistent with Alpine Summit Development who utilized 37 stream crossings in their opinion of construction cost. WRA further report *"Pipeline crossings of numerous streams, with potential retaining system impacts up to 2 streams on the Peavine alignment and 16 streams on the 5 mile alignment".* This implies that that the remaining 19 crossings do not require potential retaining systems.

HKA WATERCOURSE AND SWALE CROSSINGS FINDINGS AND COMMENTS

We did not attempt to identify or classify watercourses as that work is outside our scope of services. However, from our experience working on multiple timber harvest plans in the Santa Cruz Mountains, there may be more small ephemeral watercourse crossings (identified as Class III per forest practice rules) than are mapped by WRA.

Steep Streamside Slopes:

Nearly all of the watercourses along the waterline are deeply incised with steep streamside and inner gorge slopes. For the purpose of our review, we define these areas as slopes steeper than 75%, and often greater than 100%, that extend roughly 50 to 150+ feet from the stream channel without intervening benches. They are often characterized by coalescing scars from shallow landsliding and stream erosion.

We also found that some of the steep streamside and inner gorge conditions at the watercourse crossings locally expose hard bedrock forming very steep slopes that may be difficult to excavate through with small equipment and may require creation of large benches to provide suitable access for large equipment that can rip hard granitic bedrock if it is to be able to pass these locations and perform work further along the pipeline alignment. The existence of this rock may result in choke points that limit or prevent small equipment access.

An example of this is found where the waterline crosses what is referred to as Clear Creek 1 (Photo 1). At the north side of this crossing there is a roughly 50 to 100 foot long segment of the very steep channel bank with slope gradients exceeding 150%. Based on our experience, it will not be feasible to cross this area with equipment without very significant retaining structures which may be cost prohibitive and may not be permittable (due to the regulatory requirements that give preference toward selection of the least environmentally damaging design alternative). As will be discussed later, issues like this present significant constraints for equipment access with some areas likely being inaccessible within the economic constraints of the project.

Watercourse crossings:

Most of the smaller watercourse crossings were crossed at grade on a narrow bench. Some of these benches are intact, others have washed out with little of the original bench remaining. The larger watercourse crossing appear to have been spanned with the pipe elevated and anchored to fallen logs or wood timbers. Moving forward, we believe that most of the smaller watercourses can be crossed on rock fords or similar crossings, provided such is approved by CDFW and RWQCB.

Photograph 4: Clear Creek #1 Crossing with Remains of Above Grade Crossing Structure

Photograph 5: Looking Downstream where the Prior Waterline Spanned the Creek on Top of the Visible Log

The larger crossings will be much more difficult to construct and may be best crossed with elevated pipeline crossing structures. We do not believe that trenchless crossing (boring below the stream channel) as proposed by F&L will be feasible due to the nature of the hard rock and likely inability to feasibly get boring equipment to the site.

Photograph 6: Example of Steep Streamside Slopes and Hard Bedrock Along Existing Streamside Waterline Bench above Sweetwater Creek

Water Quality:

Potential sediment discharge into watercourses is a significant issue. The entire project is in the San Lorenzo River watershed, which is listed as impaired by sediment under Section 303(d) of the Clean Water Act and is regulated by the May 16, 2003 California State RWQCB Resolution No. R3 2002 0063. The 37 streams that cross the pipeline alignment have the potential to deliver sediment to the River from any erosion or landsliding triggered (even if it occurs years or decades later than initial construction due to long recurrence interval extreme storm events) by this project. Our experience has found that controlling sediment from construction across steep slopes at or adjacent to watercourses can be very challenging and we have found that regulatory agencies have required that the least damaging alternative be implemented, which may not be the widening of the waterline bench in those areas.

VEGETATION and LARGE ROOT WADS

Prior to the CZU fire the project area was vegetated with healthy advanced second growth redwood and Douglas fir of varying degrees of stocking, hardwood, and brush. The fire left most trees standing, however there was substantial mortality and damage to the trees that remain alive. During our field review we identified multiple large trees and stumps with root wads blocking the pipeline alignment. The larger of these are redwood (which typically are associated with trees that are still alive) and Douglas fir (with associated trees that are often dead), though there are considerable hardwoods as well. Many trees are in the range 3 to 4 feet in diameter DBH with larger root balls. Some of the redwoods often clumped with interconnected root wad systems that are much larger in diameter. The existing pipeline extended through tightly spaced tree clumps or veered around them where it was restrained by steel stakes that are driven into the ground along the downslope edge of the alignment.

F&L VEGETATION FINDINGS

While WRA study discusses the potential biologic impacts associated with vegetation and tree removal, the potential impact of large stumps in constructability is not addressed.

HKA VEGETATION FINDINGS AND COMMENTS

The large stumps and root wads on and adjacent to the existing waterline bench present a significant constraint (choke point) with respect to the grading of a new bench with equipment. They pose a future fire risk wherever they may be located in close proximity to HDPE pipeline, particularly if they are dead and are composed of dry wood.

HKA believes that gaining access with equipment that is large enough to remove or route the waterline around the root wads to allow for the installation of a buried pipeline and/or small equipment access will likely be difficult and quite possibly infeasible within the economic, logistical and environmental constraints of the project. The existence of large stumps essentially blocking the existing waterline bench to be a significant constraint that requires further review. The photographs below illustrate this.

Photograph 7: Example of Extremely Steep Slopes, Unstable Conditions and Large Root Wad Along Existing Waterline Bench

Photograph 8: Example of Extremely Steep Slopes, Unstable Conditions and Closely Spaced Trees along Existing Waterline Bench

ACCESS AND CONSTRUCTABILITY

Access to and along the waterline is required for both construction and long-term maintenance. Access to the waterline is restricted to discrete locations where the waterline crosses or extends to existing roads, as identified in Figures 4A, B and C. Moreover, access along the waterline is, as previously discussed, constrained by steep slopes, landslides, large trees, etc. which present “choke points", that severely limits the ability to construct the waterline. Any alternative to install the waterline, including width of construction benches, must consider access and the feasibility of construction.

We understand the existing waterline was originally constructed and accessed by hand crews from the California Conservation Corps primarily with hand equipment. (shovels, pickaxes, rakes, sledgehammers, wheelbarrows, etc.). In most areas the existing pipeline is located along a hand built two to four foot wide trail (bench) that was built across the steep hillside terrain which was built by side-casting spoils. In some areas where slopes are exceeding steep (i.e. > 100%) or with shallow bedrock, the water line was placed on the ground surface without a bench. Much of the existing trail is currently not suitable for equipment access unless widened.

It appears that all of the alternatives outlined in the F&L STUDY proposed installation of the waterline by a contractor using conventional excavating equipment (excavator, backhoe, etc.). The subsequent F&L MEMO indicates that the temporary construction bench will be narrower than the STUDY suggests and thus more of the bench may be constructed using narrower equipment.

F&L CONSTRUCTABILITY AND ACCESS FINDINGS

The F&L STUDY states that "*Access to both segments is limited without temporary roads being constructed to facilitate future pipeline installation efforts."* It also states that *"… portions of the alignment within the watershed have limited access, which will impact a contractor's ability to mobilize the equipment"*.

The F&L STUDY comments *"Based on the emergency grading at Foreman Intake Project, we estimate that excavations should be achievable with conventional excavating equipment such as backhoes and excavators."* However the report also notes that *"Access to both segments is limited without temporary roads being constructed to facilitate future pipeline installation efforts."*

The subsequent F&L MEMO indicates that the temporary construction bench will be narrower than the STUDY. The MEMO states *"The relative width of the temporary construction bench will vary between 4-feet and 14-feet with the wider bench used in limited, strategic locations in areas with slopes of 2.5:1 or shallower."*

The CEG Geotechnical Design Report states that *"From a geologic and geotechnical standpoint, the required bench width is the most important factor. A wider bench will increase the need for (and height of) retaining walls, will increase the amount of cut and fill grading, and will involve more extensive slope stability concerns."*, and *"It is likely that the bench requirements for Alternatives 1, 3A and 3B are likely similar."* The report did not provide geotechnical design criteria for acceptable bench width, fill depth, or cutslope height.

The F&L STUDY identifies the "Goal Category of Constructability" to be "*Develop a project that considers current construction practices and technology while leveraging opportunities to comply with anticipated regulatory requirements in a cost-efficient manner.*" However, a detailed discussion of access points, choke points, physical equipment limitations, etc. is not included in the STUDY and MEMO. In our opinion, these constraints will have a very significant impact on the means and method of pipe replacement. Without in depth review of where the physical constraints are present, the feasibility of each alternative can only be estimated. In our opinion, to make an informed decision on which alternative is the best, requires a more detailed assessment of equipment access.

HKA CONSTRUCTABILITY AND ACCESS FINDINGS AND COMMENTS

HKA believes that equipment access poses a major limitation to reinstallation of the waterline and that some segments of waterline may not be accessible by equipment (large or small) due to:

- Very steep slopes (>100%),
- Unstable areas (including existing waterline related failures),
- Large trees,
- Washed out stream crossings
- Local hard bedrock
- Pipe orientation
- Other logistical and environmental constraints

These constraints can result in what we refer to as "Choke Points" where access past this point may not be feasible within the economic and regulatory restrictions of the project. The significance of choke points will be different depending upon the design bench width and the contractor's chosen means and methods to construct the replacement pipeline.

It does not appear that the F&L team has yet documented or fully evaluated the implications of the various physical constraints (choke points) on constructability, varying levels and quantities of grading, retaining wall face footage and extent, and the comparative magnitude of potential impacts from a narrower temporary construction bench (5 foot) and wider bench (12 foot) for this project.

Access Locations

F&L report "*Access to both segments is limited without temporary roads being constructed to facilitate future pipeline installation efforts*". It is unknown from the STUDY where these temporary roads are to be constructed or if these costs are included.

HKA finds that good access to the waterline is restricted to about 7 locations where existing roads cross the waterline (See Figure 4 in Appendix A). Three of these locations are at old logging road and tractor road crossings that appear to cross private property. It is unknown if the District has an easement to use these roads. In addition, one of the three access points is an old overgrown tractor road, of which the condition and suitability of the entire length has not been assessed and where certainty of equipment access is unknown. There may be the potential to access the waterline from above by constructing new access along ridgelines, though again, additional review will be required to evaluate this. Outside of these locations, the waterline cannot be reasonably accessed without new road or trail construction across steep sideslopes. Access by helicopter may be possible in some areas.

It is our opinion that additional work is required to determine feasible equipment access points to the waterline.

Choke Points

For the purpose of our review “choke points” are defined as specific locations or reaches where access by small or large heavy equipment may be infeasible for the reasons discussed earlier (steep slopes, landslides, large trees, etc.). These choke points will have a very significant impact on how the waterline is reinstalled since they could preclude equipment access past that point. If equipment cannot reasonably traverse past a choke point for whatever reason, then the segment of waterline beyond may not be able to be constructed with the desired equipment, regardless of how favorable the conditions are past this point.

In HKA’s opinion, portions of the alignment may not be accessible by equipment (large or small) due to existence of multiple choke points. Therefore, identifying choke points and their associated limitation on construction and access is essential for evaluating the feasibility of waterline replacement and which alternative is the best.

For example, about 0.95 of the Peavine waterline is not currently accessible past Foreman Creek due to the lack of access. At this location the waterline extends nearly straight up the hillside at 50% to 70% grade on an intermittent narrow bench. Because of the steep slopes, steep alignment, and unstable ground along Foreman Creek, constructing a new road or trail for equipment may not be feasible or practicable.

As part of our field reconnaissance, we made a preliminary identification of the more significant choke points where we believe access past these points may be significantly constrained and where additional study will be required to determine the method and means of pipeline replacement. Selected examples of “Choke points” identified in our review are mapped on Figures 4A, B and C, and a discussion of several of these are presented below. It must be understood, that the choke points mapped and discussed here are preliminary and that a more in depth field review of the entire alignment is required.

Choke Point Types:

- **Steep Slopes and Slope Failures**
  As discussed earlier, the steep slopes and existing slope failures that the waterline traverses present the most significant logistical and environmental constraint to the installation of a new waterline, and from our understanding this was one of the principal reasons the past waterline was originally installed by hand crews. Our preliminary GIS analysis of LiDAR derived topography finds over 4,600 feet of the alignment traverse slopes steeper than 100% gradient. The steepness of the slopes is extensive and inclusive in many areas, and it will be impossible to construct a stable access bench without

excavating large cut slopes into the underlying bedrock. Outboard fill wedges cannot be maintained on the side of these steep slopes. The access trail would have to be constructed entirely on cut with excavated spoils hauled away and/or the outer edge of the fill prism fully retained. The major effort required to build this section of the access trail and the erosion problems created by necessity, prohibit construction of the access trail along these portions of the pipeline route. Additional studies and discussions with a qualified contractor to determine equipment access will be required to further identify these choke points.

Photograph 8: Example of Steep Failing Slopes along Existing Waterline Bench

Photograph 9: Example of Extremely Steep Slope, Hard Bedrock, and Outboard Slope Failure along Existing Waterline Bench

Photograph 10: Example of Extremely Steep Slope and Outboard Slope Failure along Existing Waterline Bench

- **Steep Streamside Slopes**
  The major watercourses draining the project area (Sweetwater Creek, Clear Creek, Makosky Creek, Harmon Creek, Foreman Creek, and Peavine Creek) are deeply incised with steep streamside and inner gorge slopes. For the purpose of our review, steep streamside and inner gorge slopes are defined as slopes greater than 75% gradient, and often greater than 100%, located within 50 to 150 feet of a stream and which descend directly to the valley bottom without intervening topographic benches. These slopes are generally characterized by coalescing scars from shallow landsliding and stream erosion. Because of the steep slopes and close proximity to active stream channels. Excavating a bench for equipment access across these slopes without inadvertent spoils entering the adjacent watercourse will be challenging and quite possibly infeasible within the economic constraints of the project. Select examples of Steep Streamside Slopes where bench widening will be challenging include but not limited to:

  Clearwater Creek Intake: Just past the Clearwater Creek intake at the southern end of the waterline the waterline bench traverses steep 80% to 100+% slopes a short distance upslope of Clearwater Creek (See photo 6). Access past these slopes is uncertain.

  Clear Creek #1 crossing: The north side of Clear Creek #1 crossing is characterized by essentially a 50 to 100 foot long cliff exposing bedrock (See Photo 1). Access past this point with equipment is unlikely.

Photograph 11: Example of a Steep Streamside Slope

- **Cutbank Failures:** During our field review we observed multiple cutbank failures on very steep sideslopes that deposited debris onto the trail. Most of these are minor but we did observe at least one large failure on the 5 Mile segment that overtopped the existing waterline bench and debris extended downslope (See Photo 3). The concern is whether or not widening the road into the hillside will further destabilize this location or other locations with similar topography and geology.

- **Large Trees:** As previously discussed there are multiple large trees and root wads along the alignment (See Photographs 3 and 4 above). The existing waterline had been installed on the ground surface by winding the pipe around the trees/root wads. To bury the waterline will require constructing a bench through the trees/root wads for both equipment access and to excavate a trench for the pipe. Because of the large size of some of the root wads, excavating through these with a mini excavator is, in our experience, impractical. In some areas it may be possible to route the bench around stumps, however that is likely to affect pipeline invert gradient and cause "bellies" in the pipeline which could accumulate sediment over time. In other areas it may not be possible to excavate around the rootwads due to steep slopes, other trees, etc.

- **Fall Line Pipe Alignments:** There are two locations where the pipe is routed directly up the hillside at 50% to 70% grade, which is too steep for equipment access. Because of the steep slopes, steep alignment, and, at Foreman Creek, unstable ground, constructing a new road or trail for equipment access at these locations may not be feasible or practicable. Examples of these locations are mentioned below:

Unnamed tributary south of Lyon Tank (5-Mile): At this location the pipe extends about 350 feet straight up ~70% gradient slopes before reaching the bench on which the waterline continues along contour. Granitic bedrock appears to be at a shallow depth with bedrock locally exposed. The alignment is too steep for equipment, though a walking (spider) excavator (Menzi Muck) might be able to be winched up it. Regardless, the bench at the top of this reach can be accessed from the other direction.

Photograph 12: Looking Up Steep 70% Fall Line Waterline Alignment Above Unnamed Tributary south of Lyon Tank

- **Foreman Creek (Peavine):** At this location the pipe angles steeply up the hillside for 350+ feet before reaching a bench in the topography where the waterline then contours across the hillside. The hillside that the waterline climbs is steep at 70% to 90% gradient. Shallow instability was observed along the steep streamside slopes of Foreman Creek. There is an intermittent narrow bench at 50% grade, which is generally too steep for small equipment to safely climb. The problem with this site is that the entire Peavine Waterline extending north past this site is inaccessible by equipment unless equipment can climb this slope, which is unlikely without significant engineering and construction effort to build new access roads that equipment can safely traverse.

Photograph 13: Looking Down Steep 70% to 90% Fall Line Waterline Alignment above Foreman Creek. Foreman Creek and Adjacent Access Road are Visible towards the Center Left of the Photo.

Construction Equipment Limitations

The F&L MEMO focused on the construction cost differential between Alternatives 1 and 3B. HKA believes it does a good job describing why a temporary construction bench is required. The MEMO states that:

> "*The maximum construction access road width will be minimized but some site conditions may warrant the use of a bench up to 14-feet wide including providing access to staging areas*.", as well as:"*F&L anticipates that both the above grade and open trench installation methods can be accomplished without widespread use of a standard excavator, which will allow for maximum bench widths to be less than 14-feet wide. The use of a standard excavator will likely only be required for areas where either limited use of welded steel pipe may be required for an above ground installation or for construction of larger staging areas that may require localized additional clearing and site preparation activities. The wider construction benches will be used selectively in areas with slopes of 2.5:1* [40%] *or shallower to minimize the overall excavation effort and reduce the potential impacts to the watershed. Because the temporary construction bench widths would be similar for both above ground and open trench methods, the relative construction cost differential will be primarily related to the additional labor and equipment costs for digging a trench and backfilling the pipe once it is properly placed in the trench*."

As previously discussed, in HKA's observation, the pipeline alignment predominantly crosses very steep to extremely steep sideslopes, and contains significant "choke points" that severely constrains the ability to permit and cost effectively construct a temporary bench that excavating equipment can utilize for access.

Some areas may be accessed by a small excavator that gains access by being delivered with a helicopter or by track walking equipment down the ridgelines from upslope if legal access can be arranged but this needs more review. Some areas may require specialty construction equipment such as a Menzi Muck.

A conventional 8 foot or 8.5 foot wide excavating equipment typically requires a 10 to 12 foot wide road for travel in order for the equipment tracks to have minimum clearance from the edges of the bench and to be able to execute the turns required to repeatedly travel along the sinuous alignment of the bench. A mini-excavator with a 4 to 5 foot width typically requires a 5 foot or wider bench for safe access, though small excavators can use somewhat narrower benches.

The problem with a larger excavator is a significantly greater volume of material needs to be graded and associated larger retaining walls will be required. This is illustrated in Figure 5 that show grading volumes are much greater for the 12 foot wide (road width) bench compared to a 5 foot (trail width) bench. The problem with a smaller excavator in this environment is they tend to be more tippy and do not have the weight or power to excavate through harder soils or large tree roots in an effective manner.

In our opinion, most of the alignment is not suitable for road width construction due to steep and unstable slopes without significant engineering, which will not be cost effective or warranted.

In areas where equipment access in not feasible or is cost prohibitive, the waterline will need to be either 1) welded steel, 2) plastic but buried with a wedge of soil over the pipe, possibly with hand built retaining walls that stabilize the pipe coverage earth materials, or consist of 3) exposed plastic HDPE which may burn again in the future.

DISCUSSION OF F&L ALTERNATIVES

The F&L STUDY evaluated 7 alternatives considering pipeline materials, construction methods, installation methods, and alignment. Alternative 1 and 3B were the top two Alternatives identified in the STUDY:

- **Alternative 1:** Above-grade HDPE pipe including above grade creek crossings following the same Peavine and 5-Mile segments alignments.

- **Alternative 3B:** Shallow buried HDPE pipe with below grade creek crossings following the same Peavine and 5-Mile segments alignments.

The STUDY found that if the pipeline is reconstructed within the similar alignment that the existing benches, regardless of width, will likely be the best option for installing the replacement pipeline most efficiently. Alternative 3B will likely require conventional equipment (e. g. excavators, dump trucks, log skidders, chippers, loaders, directional drilling equipment that are not classified as oversize or overweight) access continuously along the alignment. The description of Alternative 1 (above grade) is not explicit about equipment access, but it is implied that more hand construction techniques may be used in many areas.

F&L COMPARISON OF ALTERNATIVES

F&L Alternative 1 included restoring the entirety of the cross-country pipeline system within the same alignment only using above ground HDPE. The key components of Alternative 1 as described in the STUDY are:

- *Minimizes the total width of benches needed to install the above ground pipe;*
- *All creek crossings will be above ground on pipe support system;*
- *Because of the relative light weight of the HDPE pipe, the total number of access points required to facilitate construction can be minimized because more material can be brought in with each delivery.*
- *Use of retaining structures may be minimized because of the smaller bench requirements.*

F&L Alternatives 3B will follow the existing alignment similar to Alternative 1 but installs HDPE pipe in a shallow trench utilizing below grade creek crossings. The key components of Alternative 3B described in the STUDY are:

- *The minimum bench width will be much wider than Alternative 1 because the excavation will require additional space as compared to Alternative 1 to manage trench spoils.*
- *It is anticipated that most of the backfill will utilize native materials generated during the excavation operation to minimize the volume of spoils that may have to be transported and disposed of off-site.*
- *All creek crossings will be below creek grade using HDPE pipe and creek crossings may be constructed using trenchless methods.* [We note that Alpine Summit Development reported that 50% of the crossings will be trenchless].
- *The total number of access points will be similar to Alternative 1*

HKA COMMENTS ON F&L ALTERNATIVES

HKA concurs with F&L that the existing benches and alignment will likely be the best option for installing the replacement pipeline most efficiently. However, we also believe for reasons discussed in the Physical Constraints section of this report that the information presented in the F&L STUDY does not yet adequately incorporate consideration of the actual field conditions and the difficulty of construction and equipment access. Thus, in our opinion, it is premature to make a definitive conclusion on the best alternative for reinstallation, with respect to Alternatives 1 and 3B:

Alternative 1 is simple replacement of the existing waterline above ground, presumably in a similar manner in which it was originally constructed. Therefore, it is reasonable to assume that similar effort by hand crews with helicopter support could be used to install the waterline. Much of the existing bench is in place and only limited clearing would be required. Moreover, we observed many locations where the waterline was installed directly on the ground surface without a bench, therefore widening the existing bench may not be necessary. Above grade crossings would be used at watercourse crossing. Of course, the downfall of this alternative is it would be vulnerable to fire as discussed in the F&L report and in places could be more susceptible to instability if not properly anchored. As we will discuss later, it is likely feasible to hand bury at least portions of the waterline.

Alternative 3B is a new buried waterline with below grade stream crossings. HKA believes that the description of Alternative 3B in the F&L report over-simplifies the construction difficulty and the physical and regulatory constraints associated with accomplishing it, particularly in a cost effective manner. As previously mentioned, there are multiple locations where equipment access is not feasible or at least uncertain without more review (i.e. choke points).

The volume of spoils that will be generated in order to construct continuous segments of bench that extend to viable access points for the required equipment will be very large, especially if conventional full size equipment is used (or if oversize or overweight equipment is required). End-hauling those spoils to suitable stable disposal points or retaining them on site will be a very large, costly and time-consuming effort, which will be exacerbated by seasonal construction constraints posed by biological and meteorological conditions. Less volume of material would need to be excavated and any retaining structures would be of shorter length and smaller height if smaller equipment can be used, however, as discussed earlier, such equipment will have significant difficulty excavating past the large root wads within the existing bench.

Trenchless methods to cross the 37 streams will exacerbate this difficulty, because of the extreme difficulty of gaining access for the necessary equipment to penetrate hard granite bedrock, and disposing of the drill spoils. We believe that boring below the crossings will require access for larger equipment, which as discussed earlier may not be feasible or practical. In our opinion, Alternative 3A, which proposes that all creek crossings will be above grade using Welded Steel pipe is more feasible; however, this may require significant amounts of material to be delivered by helicopter. More study is required to confirm this.

COST CONSIDERATIONS

The opinion of probable project cost for Alternative 3B provided in the STUDY indicates costs of $53 to $62 million; excluding the cost of the proposed hydropower elements. It indicates that it is assumed that half of the creek crossings are direct bury and half of the creek crossings are above ground steel. The creek crossing construction is split to account for situations, permitting or other conditions that would prevent below grade crossings. It goes on to say "The intent is to install all creek crossings as below grade crossings." It is not clear to HKA if that cost was estimated. Moreover, it may not have taken into consideration the great difficulty in getting equipment to several of the crossing sites due to choke points. HKA concurs that permitting or other conditions (including equipment access, debris flow hazards, CEQA requirements) may influence whether above grade or below grade crossings are feasible.

In our opinion, regulatory agencies will likely require this project to be constructed utilizing a less environmentally damaging alternative than 3A or 3B, unless those alternatives are re-defined to significantly limit the temporary construction bench widths and associated grading volumes.. In our opinion Alternative 1 will be less environmentally damaging than Alternatives 3A and 3B, particularly if Alternative 1 is designed to bury the pipeline a minimum of 12 inches using the minimum bench width that is feasible and crossing substantial streams above grade with either HDPE or Welded Steel pipe material; crossing of Class 3 watercourses may utilize pipeline burial, with the pipeline sufficiently below the ground surface to protect it from being exposed by erosion and damaged by future wildland fires.

Retaining Wall Factors

The F&L MEMO states: "*A significant construction cost component is the use of retaining structures to construct the temporary construction benches when the existing slopes adjacent to the existing benches exceed 2:1. The additional unit price to construct retaining structures is approximately $700 per linear foot (lf). We have conservatively estimated using publicly available LiDAR data that approximately 50% of the alignment is adjacent to slopes steeper than 2:1 and may require retaining structures to construct the necessary temporary construction benches.*" HKA understands that Alpine Summit Development used a total of 18,000 linear feet of 5 foot high retaining structure in their cost estimate. This could be characterized as one-quarter of the pipeline length requiring retaining structures on both the cut (inboard) and fill (outboard). As previously stated, HKA believes that significantly more than 50% of the alignment is adjacent to undisturbed slopes located immediately uphill and downhill from the pipeline that are steeper than 2:1 slope.

Our LiDAR analysis (See Figure 1A, B and C in Appendix A and Table 1 on Page 20) and the field reconnaissance suggests that about 87% of the alignment is adjacent to slopes steeper than 50% = 2:1(H:V). This difference corresponds to approximately 13,000 feet (lf) of additional alignment that may require retaining structures. Using the F&L unit price cost estimate of $700/lf, an additional 37%

of the alignment requiring retaining structures would represent an additional **large** cost, even IF only the outboard side of the temporary construction bench is retained and IF retained heights of only 5 feet are required. We understand the F&L unit price cost estimate of $700/lf represents 5 face feet per lineal foot, but cannot comment on the accuracy of that unit price without consulting with an experienced contractor that specializes in limited access construction. Significantly higher costs will likely be incurred at choke points.

In order to select the best Alternative design, equipment access, equipment width, and extent of required retaining structures is to be a key question. This will be directly related to the natural slope gradients above and below the pipeline alignment and will be strongly affected by the equipment that can feasibly obtain access to each retaining structure area. This will in turn strongly influence project cost, grading volumes, equipment access requirements, environmental review, etc.

With regard to retaining walls, we believe that:

1. Earth retaining structures are needed in many areas, particularly if the existing benches are to be widened. The length and height of benches will be governed, in part, by the width of the bench required.

2. If wide benches are utilized that allow construction to be done and materials to be delivered with either A) only conventional equipment (e. g. excavators, dump trucks, log skidders, chippers, loaders, directional drilling equipment that are not classified as oversize or overweight), or using B) some oversize and/or overweight equipment that require transportation permits, then hard granite bedrock will likely be encountered in some areas during excavation, which will slow down construction, and increase the need for hauling excavated spoils to stable locations for disposal, or constructing significant retaining structures to stabilize the spoils in close proximity to where they are excavated. In general, the wider and deeper the continuous excavation that will be required along the alignment, the more likely that significant amounts of hard bedrock may be encountered that cannot be excavated without the use of large excavators capable of hydraulic rock breaking that cannot readily gain access along the entire construction alignment. Many San Lorenzo Valley roads are unsuitable for transportation of such large equipment by low-boy trailer.

3. We believe that short (2 to 3 foot) height Hilfiker type retaining wall systems or a system using closely (2' O. C.?) driven pipes and non-flammable lagging (corrugated metal sheeting or closely spaced galvanized mesh) maybe most suitable for use along the outboard edge of the temporary construction bench (assuming use of small equipment), since their components are lighter weight and do not rely on HDPE geogrid elements that may be susceptible to future fire damage (Figures 6B, 6C and 7B). Such walls are routinely

constructed on multi use recreational trails across steep slopes. Alternately soldier pile and concrete lagging could be used, however this will likely complicate construction, especially if small equipment is used.

4. A detailed inventory of the alignment may reveal areas where the cutslopes expose bedrock of sufficient strength that it does not require retaining structures; although the colluvium exposed in cuts above the bedrock may require retaining.

5. For a narrow trail, significantly fewer retaining walls will be required, and the retaining walls that are required can be of lesser height (See Figures 5, 6A, 6B and 6C in Appendix A). In fact, it may be possible to limit the amount of retaining walls by temporary building the bench out on fill, then pulling the fill back to cover the trench and pipe. This, of course, could only be done if equipment could get to the site, which as we have discussed earlier is questionable in many areas.

Depth of burial

The depth of pipeline burial that is required will influence the length and height of retaining walls that are required. The F&L Study indicates the estimated melting point for HDPE is 482-degrees Fahrenheit and HDPE was found to begin smoking at temperatures between 400 degrees Fahrenheit and 450 degrees Fahrenheit. The F&L Team proposes that the minimum burial depth for any replacement HDPE pipe be 18-inches. The STUDY indicated the estimated soil temperature at a depth of 19.7-inches to be 131 degrees Fahrenheit which provides a safety factor of three from the lowest predicated temperature where HDPE may begin off gassing. Based on Table 5 in the STUDY, HKA notes that 18” of cover results in a Factor of Safety (FS) of 3, 12” of cover results in a Factor of Safety (FS) of 2.25, and 8” of cover results in a Factor of Safety (FS) of 1.33.

IMPLICATIONS FROM REVIEW OF DESIGN SECTIONS

HKA examined Figure 3 in the F&L March 2022 STUDY. The cross sections presented are not to scale and thus could be misleading. We have redrawn Sections 1, 3, 4, 6, 7 and 9 to scale on 50%, 70% and 100% slopes and those are presented in Figure 5. As Table 1 shows, it is likely that 87% of the pipeline alignment crosses slopes over 50%, and 48% of the pipeline alignment crosses slopes that exceed 80%.

The cross sections in the HKA Figure 5 above illustrate the comparative difficulty of construction of 5 foot and 12 foot wide temporary construction benches to support a replacement pipeline. The utilize balanced cut and fill volumes, 0.5:1 (H:V) unretained cutslope concepts, either full retaining structures or thin sliver fills.

What Figure 5 indicates is that 4 to 6 times as much cut is required for a 12 foot wide bench compared to a 5 foot wide bench. Taking into account both the linear footage of alignment across each slope class as presented in Table 1 and the associated retaining wall heights shown in Figure 5 indicates approximately 6 times as much retaining wall face footage is required for a 12 foot wide bench compared to a 5 foot wide bench. On average, average retaining wall heights on a 12 foot wide bench is over twice that required for a narrower 5 foot wide bench. What this means is very significant grading and engineered retaining walls will be required if a 12 foot wide bench is pursued. We note that retaining wall cost estimates are often not linear with retaining wall height ratios; taller walls have greater costs per square foot of wall face.

In our opinion, the increased costs and increased environmental impacts of a 12 foot wide bench are not warranted in comparison to a narrower bench with lesser costs and impacts. Additional geotechnical work and detailed design would be required to make accurate estimates for a given concept.

TOPOGRAPHIC SURVEY REQUIREMENT

The F&L MEMO states that "*During the first step of the design phase, a comprehensive topographic survey to allow for a more detailed study of the slopes along the alignments, which may result in a reduction in the total estimated linear footage of retaining structures that could be required. Furthermore, the preliminary design phase will include geotechnical studies along the alignment to compliment the topographic survey to evaluate the relative risk associated with portions of the alignment that, although relatively steep, may have sufficient soil strength to allow excavation within some portions without the use of retaining structures.*

HKA generally concurs with this statement, however has observed that a topographic field survey may be very difficult to cost-effectively prepare due to the conditions found at the site, and topographic surveys are not generally prepared for recreational trail development and Timber Harvest Plan road construction. It may be appropriate to prepare 100 foot long topographic profiles and at selected intervals (perhaps at 100 foot spacing) along the proposed pipeline alignment that illustrate the conditions at each profile, so that appropriate geologic and geotechnical field work can be done in order to illustrate and account for the estimated required grading and retaining wall construction needed along the alignment for various areas to be identified and tabulated. This would allow a more meaningful selection of the preferred alternative, since the critical problem areas and the appropriate solutions there could be identified and discussed with an experienced qualified contractor.

EXPERIENCED CONTRACTOR FEEDBACK

We recommend that experienced contractors that specialize in steep terrain construction tour the site to comment on the feasibility of the alternatives prior to selection of the design alternative to give ball-park construction costs and comment on the construction constraints, choke points, and the means and methods they observe to be most feasible and cost effective.

CONCLUSIONS

In our opinion, the presented F&L work does not yet adequately incorporate consideration of the actual field conditions and the difficulty of construction and equipment access. Our review finds that large portions of the waterline alignment are likely not accessible by equipment (large or small) without very significant new road/trail construction which will likely be cost prohibitive, environmentally unfeasible, and/or unwarranted it light of alternative installation methods. Thus, it is premature to make definitive conclusions on the best alternative for waterline reinstallation. Ultimately, selection of the best waterline replacement alternative, and determination of the associated costs will come down to constructability and the ability to feasibly use heavy equipment, small equipment and/or hand labor.

HKA finds about 87% of the alignment (5.7 miles) appears to traverse slopes steeper than 2:1 (50%) with nearly 13% (4,650 feet) steeper than 100% (See Figures 1A, B and C in Appendix A, and Table 1 on Page 20). The steep slopes that dominate the waterline alignment present a significant constraint and were one of the reasons why the original waterline was installed by hand.

Access to the waterline is restricted to about 7 locations where existing roads or trails cross the waterline. Moreover, our review found there are multiple physical constraints that impact the constructability and ultimately the feasibility for waterline reconstruction, including:

- Very steep slopes (>100%)
- Steep streamside slopes adjacent to watercourses
- Unstable areas (including existing waterline related failures),
- Localized areas of hard bedrock
- Large trees containing large root-wads in the pipeline alignment
- Watercourse crossings

Because of choke points coupled with limited access points to the waterline, we find that potentially up to 50% of the existing waterline may not be accessible by standard equipment (large or small) within a cost-effective manner and therefore these sections may need to be hand constructed, require the use of specialty equipment, and or require development of alternative access routes or helicopter support (See Figures 4A, B and C in Appendix A).

Because of the steep slopes and limited access, we believe it will be difficult and expensive to reconstruct the entire waterline in a manner to fully protect it from future wildfires while at the same time mitigating risks to downslope water quality and public safety.

Where equipment access is possible, it is our opinion that the waterline replacement is best suited to small (trail size) equipment with tread widths less than 5 feet to minimize the size of cuts and fills and associated impacts on erosion and hillslope stability (See Figures 6A, 6B, 6C and 7A in Appendix A). It has been our experience that small equipment can generally traverse across slopes up to 80% to 90% gradient, though retaining walls may be required. Though we have used equipment on steeper sideslopes, it becomes much more difficult, can be unsafe, and by no means is certain. A problem with using small equipment is lower production rates and increased difficulty getting past large stumps or rock embankments.

We do not believe using large equipment on wide benches (10 to 14 foot width) is viable along the majority of alignment that crosses slopes steeper than 50% due to 1) the significant increase in grading volumes resulting in larger cuts and fills and associated impacts to site stability, 2) the need for more and larger and more robust retaining structures to mitigate the increase hazard associated with larger cuts and fills, 3) the greater likelihood to encounter hard granitic bedrock that will slow construction, 4) the greater width of ground disturbance and associated erosion risk in the construction corridor along the alignment, and 5) because it is unwarranted in light of a narrower bench option that appears feasible in many areas (See Figures 4A, B and C in Appendix A). Regardless, the complexity of delivering fuel for large should be reviewed.

The depth of pipeline burial that is required will influence the amount of grading to directly burry the pipe in a trench, and the length and height of retaining walls that may be used to contain the overlying protective fill cover. The F&L Study recommends a minimum burial depth of 18 inches; 12 inches may be sufficient (See Figures 6A, B and C in Appendix A). A thinner depth of fill cover, especially along portions of the waterline that cross steep slopes or where hand-built construction is selected will simplify construction in those critical areas.

Where the waterline is accessible by small equipment, we believe that majority of the waterline could be buried below grade either within a trench, or on steeper side slopes, behind retaining walls that support the fill burying the pipe.

For a narrow 5-foot bench, we find that approximately one sixth retaining wall face footage will be required compared to a wider 12 foot bench, and the retaining walls that are needed will need to be less than half the height (See Figure 5 in Appendix A). In some areas, depending on geology, topography, and distance from a watercourse, it may be possible to limit the amount of retaining walls by building the bench out on temporary fill (possibly retained behind logs), then pulling back the oversteepened fill to cover the trench and pipe. This, of course, could only be done if equipment can get to these portions of the alignment, which as we have discussed earlier is questionable in many areas. Moreover, it has been our experience on small trail projects that the precise requirements for retaining walls cannot be predicted with certainty in advance and such walls are often “field fitted” based on actual conditions encountered and are dependent on the skill of the equipment operators.

As mentioned earlier, up to 50% of the waterline may not be readily accessible due to combination of limited access points to the waterline and choke points. Finding alternative access routes to the inaccessible portions of the waterline by building new temporary trails down ridge lines, helicoptering in materials and equipment, or using specialty equipment such as a Menzi-Muk may provide the necessary access. Further evaluation of choke points and equipment access is needed to refine the areas where the waterline can be reinstalled with equipment.

Segments of waterline that cannot be feasible accessed by equipment (large or small) will need to be hand constructed, which we believe is a viable alternative. On moderately steep slopes it is likely feasible to either place an HDPE pipe within a hand dug trench and/or on the ground surface and backfilling over the pipe with earth. On steeper slopes where the pipe cannot be reasonably buried in a trench, a low retaining wall could be hand built to retain fill to sufficiently cover the pipe.

There are two locations on the waterline where the pipe extends directly downslope on very steep slopes (fall line segments). Within these segments standard equipment access does not appear to be feasible.

Earth retaining structures are needed in many areas, particularly if the existing benches are to be widened. The length and height of benches will be governed, by slope steepness, geology, width of the bench required, require fill coverage.

We believe that short (2 to 3 foot) height Hilfiker type retaining wall systems or a system using closely (2' O. C.?) driven pipes and non-flammable lagging (corrugated metal sheeting or closely spaced galvanized mesh) (See Figures 6B, 6C, and 7B in Appendix A) may be most suitable for use along the outboard edge of the temporary narrow construction bench, since their components are lighter weight and do not rely on HDPE geogrid elements that may be susceptible to future fire damage. Alternately soldier pile and concrete lagging could be used, however this will likely complicate construction, especially if small equipment is used.

The F&L study identify 17 large and small watercourse crossings. Trenchless watercourse crossings will likely be infeasible or at least very difficult to construct due to access constraints and the existence of hard rock.

The smaller watercourse crossings pipe can generally be installed in a trench through the crossing if the area of the excavated channel is restored with a rock ford to act as a grade check. Because of the potential for watercourse incision, we believe it would be prudent to have steel pipe at the crossing.

The larger crossings will likely require longer steel pipes placed above grade. We recognize that transporting steel pipe can be difficult, especially in areas that are not accessible by equipment, but still may be more cost effective. Where access to the watercourse is not possible due to choke points it may be possible to deliver the pipe materials by helicopter, though this will require site specific review by the helicopter company to confirm feasibility Alternatively, the pipe could be spliced using short sections 2 to 3 feet long to reduce the section weight to a level where sections can be hand carried in. Highline delivery of material may also be feasible in some inaccessible areas.

Permanent erosion control should be incorporated in the final construction documents by design, mainly limit the amount of grading, depth and height of cuts, and the footprint of the project. This is achieved if small equipment is used, where accessible, and inaccessible areas are constructed by hand. The depth of unretained fill should be minimized. The acceptable depth of unretained fill is variable and is dependent on slope gradient, earth materials, site morphology, distance to a watercourse, and other factors. Drainage dips should be installed along the bench at roughly 100 to 150 foot spacings to prevent the concentration of runoff, though storm runoff flowing along the alignment of the bench does not appear to have been a significant problem in the past. Long term surface erosion should not be a significant issue or constraint along most of the project if unretained fills are minimized and short-term erosion control is utilized.

For construction stormwater control and short term erosion control we expect both NPDES and SWPPP permits and plans will need to be developed. Some areas may require seeding and mulch but generally the area does not have much vegetation outside of the trees. Use of slash and native mulch should be adequate in most areas, depending on the downslope length of exposed soils.

In our opinion, regulatory agencies will likely require this project to be constructed utilizing a less environmentally damaging alternative than 3A or 3B presented in the F&L report, unless those alternatives are re-defined to significantly limit the temporary construction bench widths, associated grading volumes, and risks to water quality and public safety.

In our opinion, a combination of Alternative 2 (Above Grade Welded Steel pipe) and Alternative 3 (below grade HDPE pipe) using a narrow bench width where feasible is likely the best option if a fireproof waterline is required. If a fireproof waterline is not required, then Alternative 1 is best. The District should decide if fireproof waterline is mandatory, and if so, if it is required for the entire alignment.

In our opinion, a narrow width bench (5 foot width) is superior to a standard road width bench (12 feet), and may be required due to instability and access constraints.

Where the waterline is accessible by small equipment and where slopes are less than about 90%, we believe that majority of the waterline could be buried below grade per Alternative 3.

Where the waterline is not accessible by small equipment, hand construction will be required. In these areas a combination of Alternatives 2 (above ground welded steel pipe) and Alternative 3 (below grade HDPE pipe) are still likely viable. Hand constructed narrow benches and benches retained by small retaining walls, particularly if designed to bury the pipeline a minimum of 12 inches using the minimum bench width, are considered feasible.

Retaining walls will be required on both machine and hand-built sections to support any fill required to cover the pipe and protect it from fire damage.

Steel pipe may be required at the two fall-line segments, where the waterline crosses very steep sideslopes and cannot be reasonably buried, at watercourse crossings, and to get past large stumps that block the trail. It may be possible to route equipment up and around large stumps in the existing bench and thread steel pipe through the trees. Each of these sites will need to be identified and evaluated.

Scheduling and sequencing equipment access, equipment fuel delivery, delivery of pipeline materials, trench excavation, pipe placement and welding, fill placement, etc. could get complicated due to narrow bench widths and limited passing areas. The viability of construction access needs to be confirmed by the F&L team, in consultation with contractors that are experienced completing projects with small equipment at remote worksites, with limited access constraints that affect logistics, construction techniques and labor force availability. Ultimately, the feasibility of the waterline project will come down to the capabilities of the selected contractor.

Finding alternative access routes to the inaccessible portions of the waterline by building new temporary trails down ridge lines, helicoptering in materials and equipment, or using specialty equipment such as a Menzi-Muck may provide the necessary access, although additional field review will be required to confirm this.

RECOMMENDED NEXT PHASE

Ultimately feasibility of the project is a function of constructability and equipment access. To that end we believe the following next steps are needed prior to selecting the preferred alternative.

1. Further review and analysis to identify, map, and characterize access locations and choke points. A preliminary access and constraint map is shown in Figure 4A, B C in this report, but that map is not comprehensive. A complete understanding of physical constraints and their associated limitation on construction and access is essential prior to deciding on the design bench width, selection of the best alternative, and associated budget for construction.

2. Review of site by a Geotechnical Engineer, Engineering Geologist, and Contractor (equipment operator) with considerable experience working with small equipment in steep terrain to confirm access and constructability. This will include developing preliminary construction alternatives for each access location and choke point.

3. Utilize narrow width trail to limit environmental impacts wherever possible or practical.

4. Evaluate possible access locations to the waterline for material, equipment and fuel delivery. This should include:
    a. Existing roads or tractor trails that cross the alignment, but which traverse across neighboring properties.
    b. Potential new tractor access routes down ridge lines.
    c. Use of helicopter support.
    d. Use of highline systems for material and equipment delivery to bypass choke points.

5. Evaluate if the entire waterline needs to be fireproof or if the more difficult areas to construct and access can be constructed using exposed HDPE pipe. Give further consideration to replacing the existing (burned) pipe in a similar manner to how it was constructed in the 1980's. This would expose it to some level of fire risk in the future. Depending on the recurrence interval of damaging fire (historically it may be 50 to 100 years or so) in the pipeline zone it could be deemed an acceptable risk. Mechanisms and protocols to isolate areas of the pipeline and shut down the district's water treatment plan might help minimize future risks associated with fire damage to the water system.

6. Further evaluate the feasibility of getting steel pipe and above grade crossing structure materials into the stream crossing areas.

7. Refine cost estimates to include hand installation of above and below grade waterline alternatives. Include cost estimates for above grade steel pipe placement at watercourse crossings, fall line segments and work arounds at choke points.

This concludes our report. Please call us if you have any questions.

Sincerely,

HARO, KASUNICH & ASSOCIATES, INC.

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CEG # 1493
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Copies: 1 to Addressee
1 to File

APPENDIX A: SELECTED FIGURES

SOUTH SEGMENT: 5-MILE WATERLINE

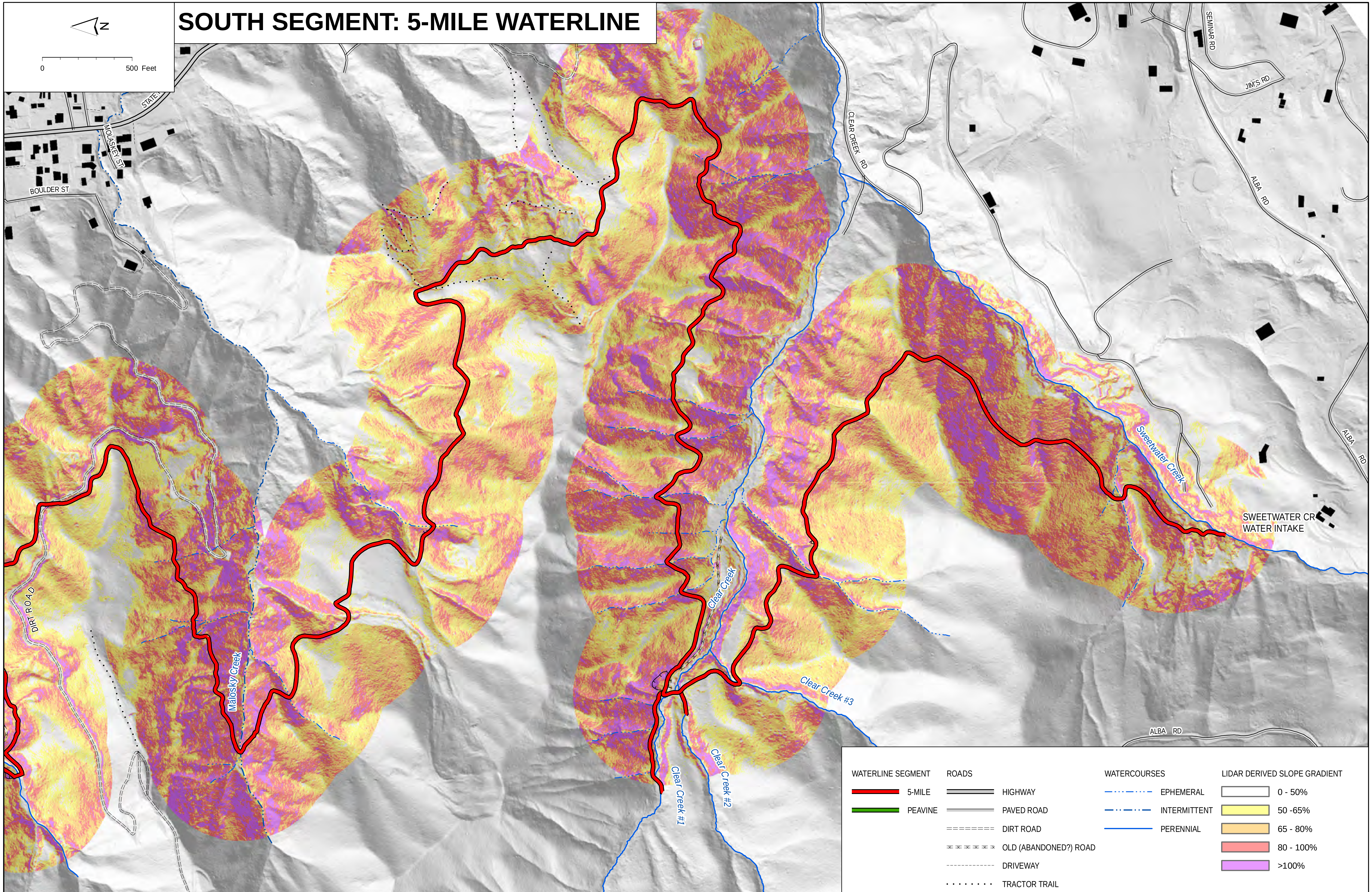


FIGURE 1A
PROJECT: 12196
Date: 10/24/2022

SLOPE MAP
5-MILE AND PEAVINE WATER LINES
San Lorenzo Valley Water District

116 East Lake Ave
Watsonville, CA 95076
(831) 722-4175

NORTH SEGMENT: 5-MILE WATERLINE

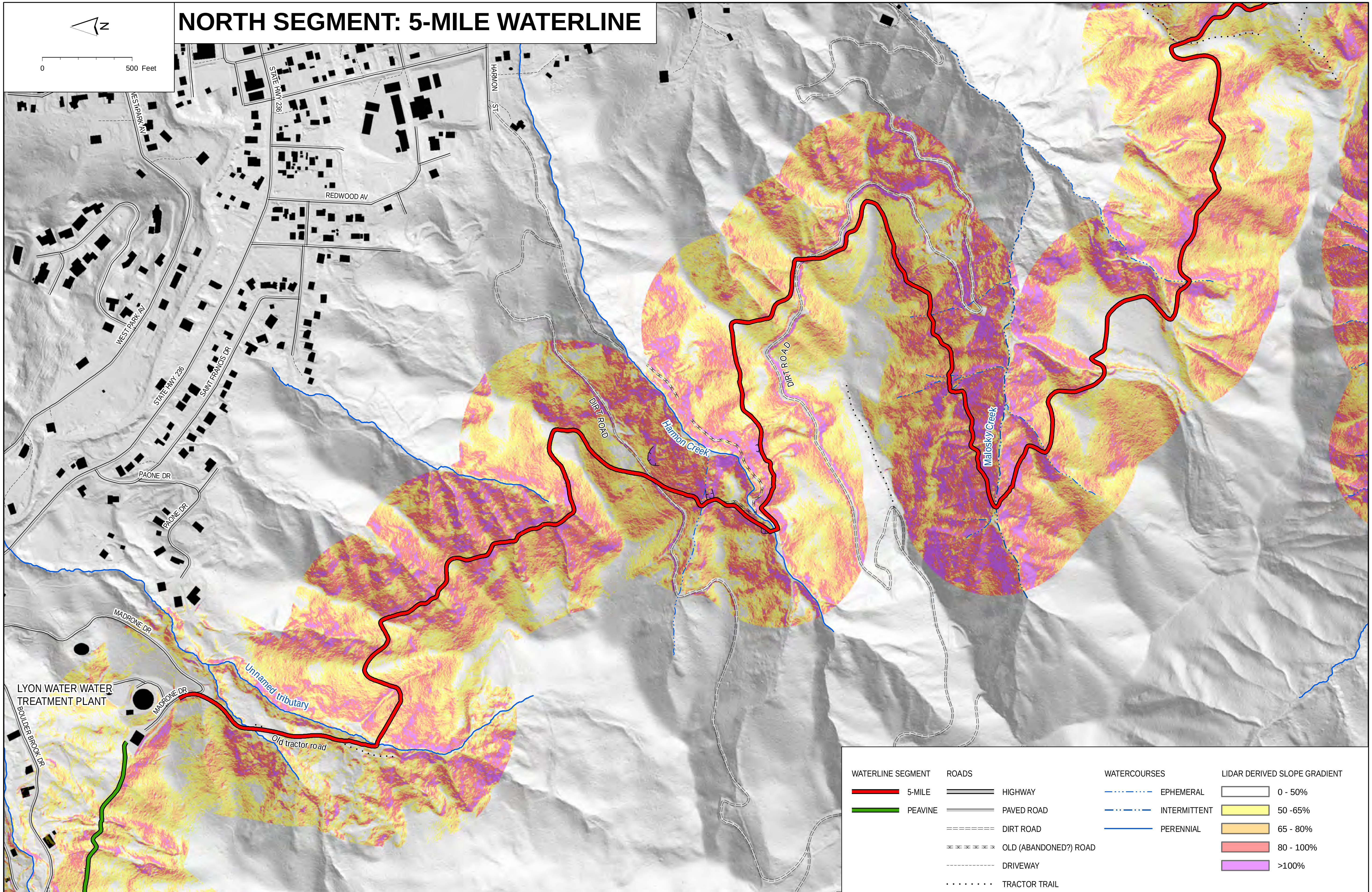


FIGURE 1B
PROJECT: 12196
Date: 10/24/2022

SLOPE MAP
5-MILE AND PEAVINE WATER LINES
San Lorenzo Valley Water District

116 East Lake Ave
Watsonville, CA 95076
(831) 722-4175

PEAVINE WATERLINE

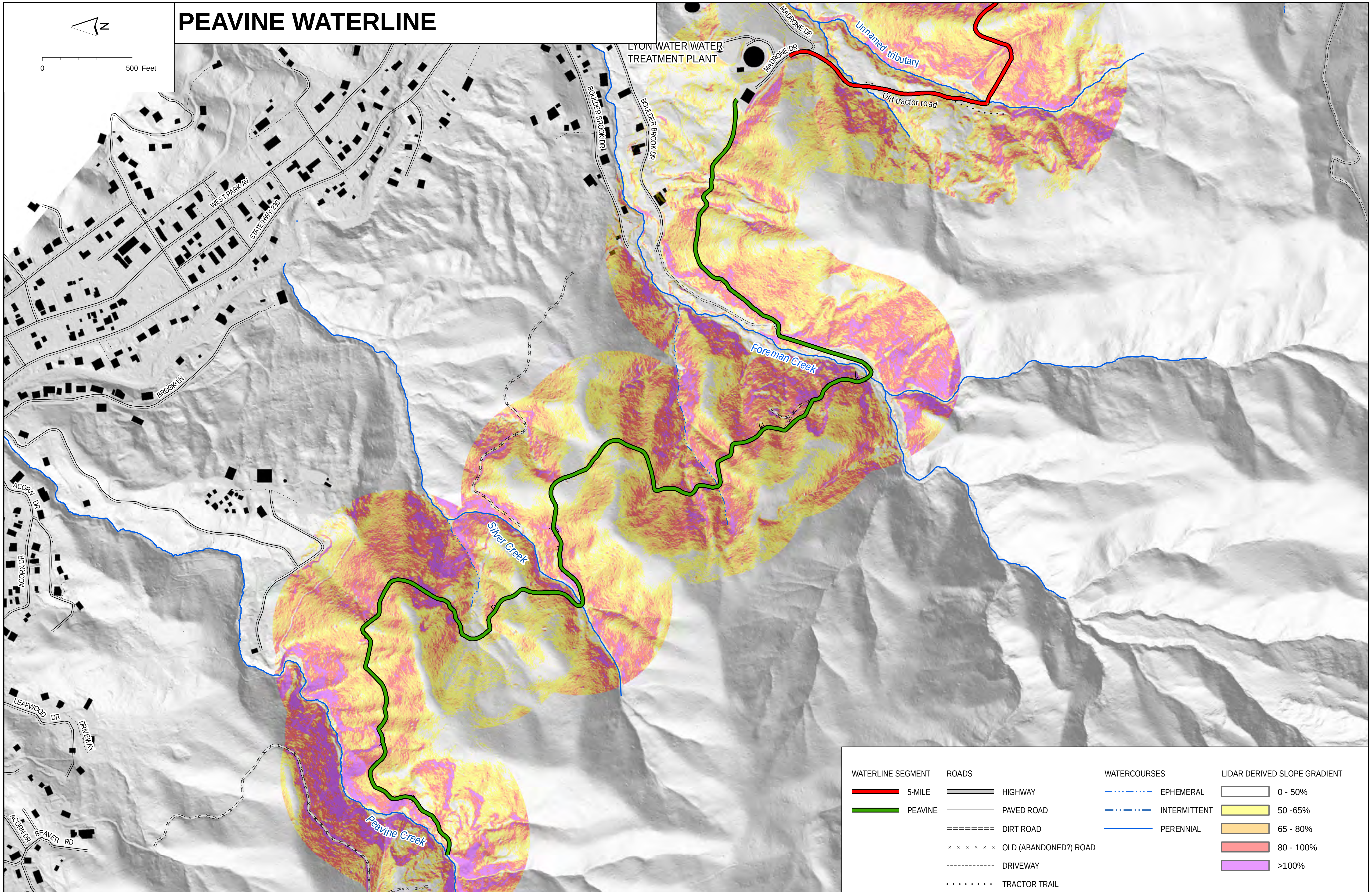


FIGURE 1C
PROJECT: 12196
Date: 10/24/2022

SLOPE MAP
5-MILE AND PEAVINE WATER LINES
San Lorenzo Valley Water District

116 East Lake Ave
Watsonville, CA 95076
(831) 722-4175
Haro, Kasunich and Associates, Inc.

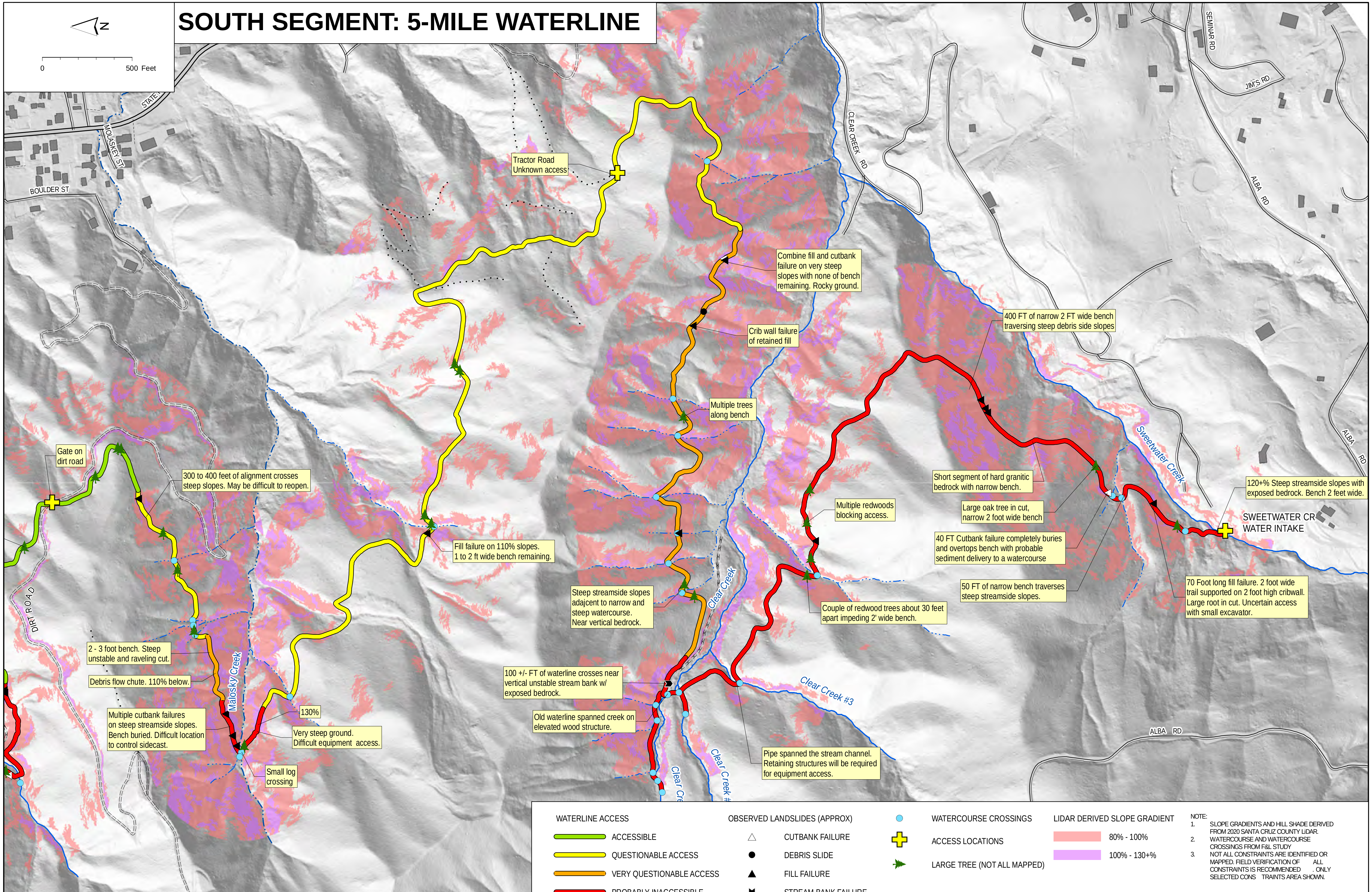


FIGURE 4A
PROJECT: 12196
Date: 10/24/2022

PRELIMINARY ACCESS AND CONSTRAINT MAP
5-MILE AND PEAVINE WATER LINES
San Lorenzo Valley Water District

116 East Lake Ave
Watsonville, CA 95076
(831) 722-4175
Haro, Kasunich and Associates, Inc.

NORTH SEGMENT: 5-MILE WATERLINE

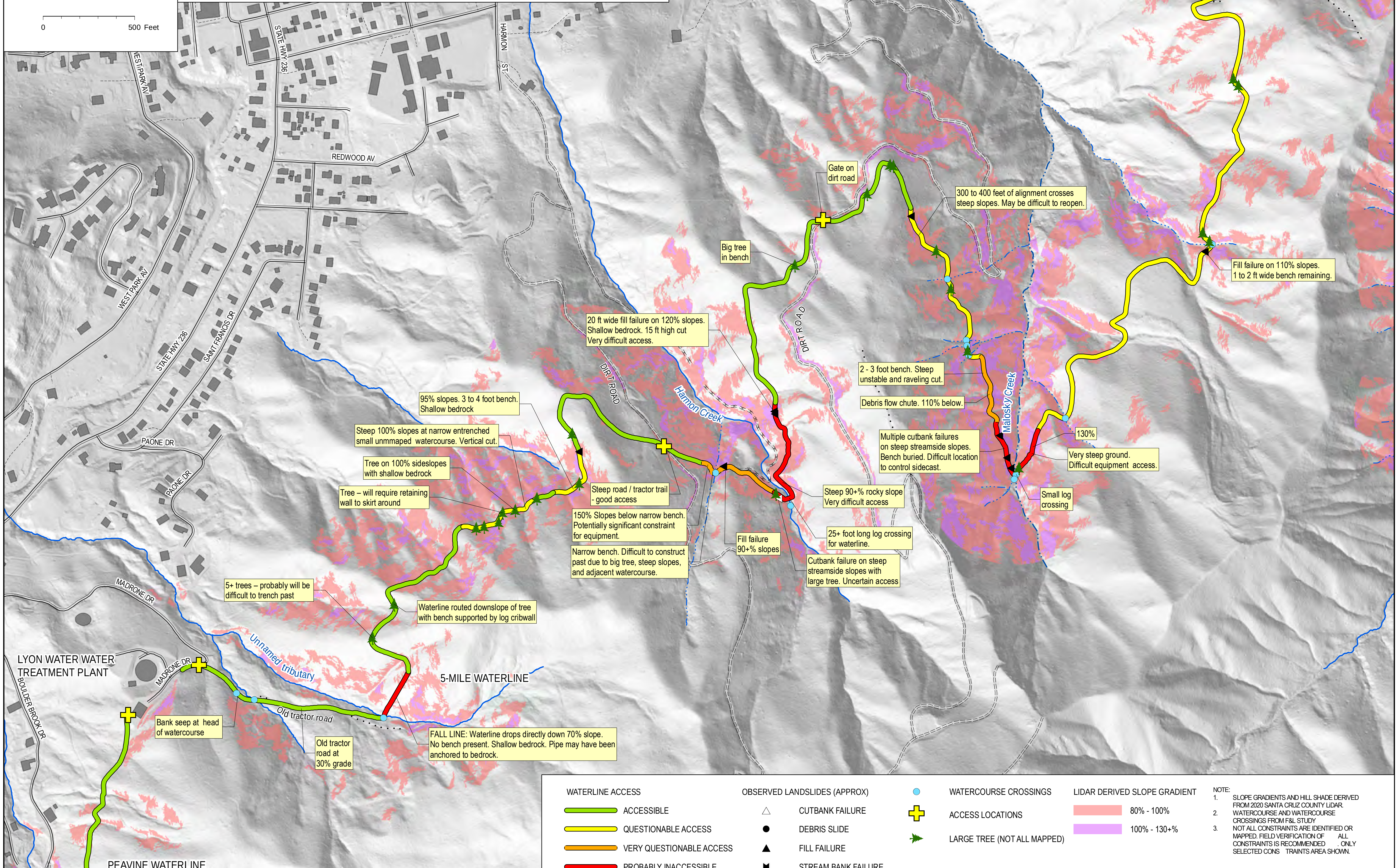


FIGURE 4B
PROJECT: 12196
Date: 10/24/2022

PRELIMINARY ACCESS AND CONSTRAINT MAP
5-MILE AND PEAVINE WATER LINES
San Lorenzo Valley Water District

116 East Lake Ave
Watsonville, CA 95076
(831) 722-4175

Haro, Kasunich and Associates, Inc.

PEAVINE WATERLINE

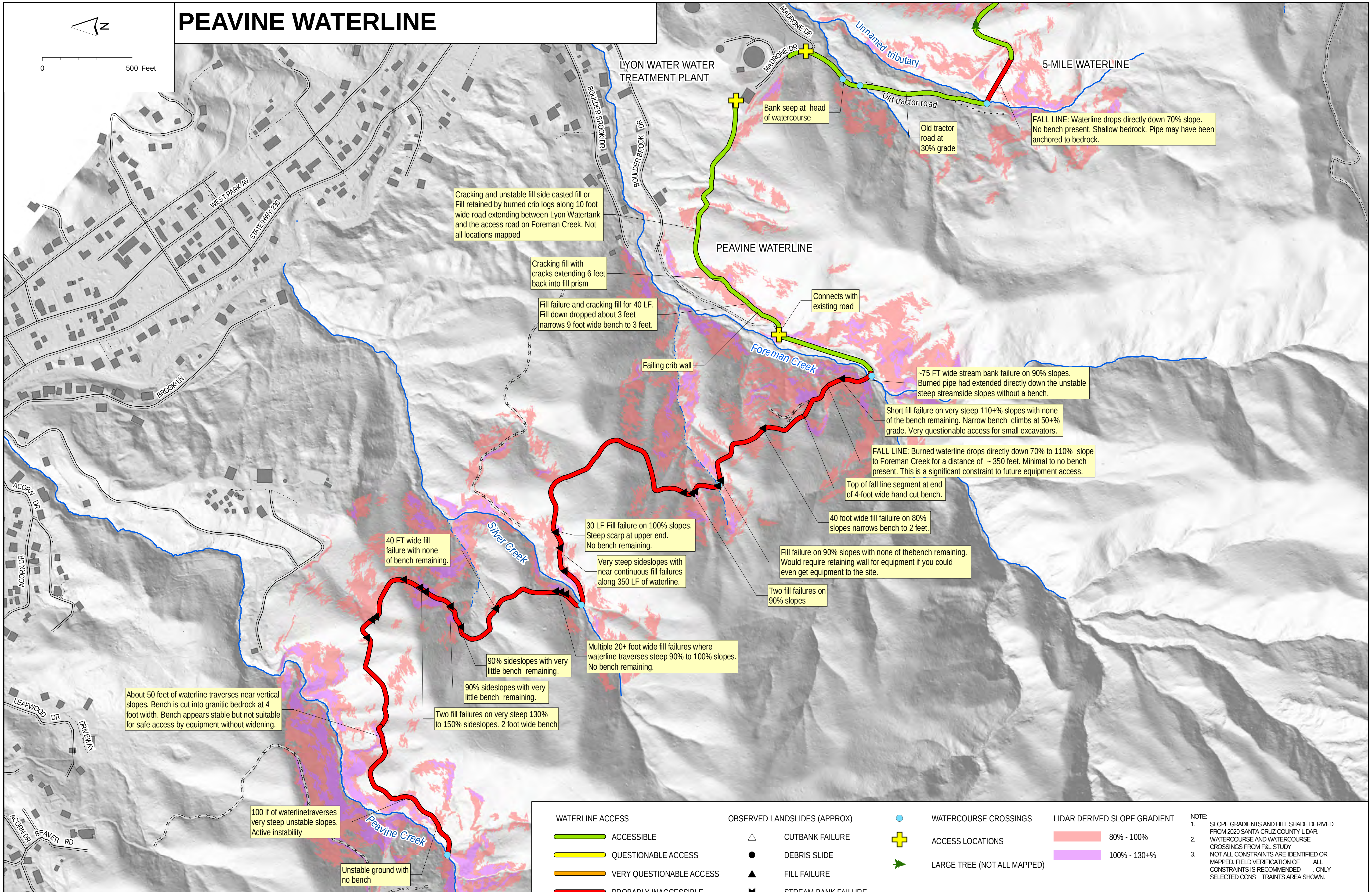
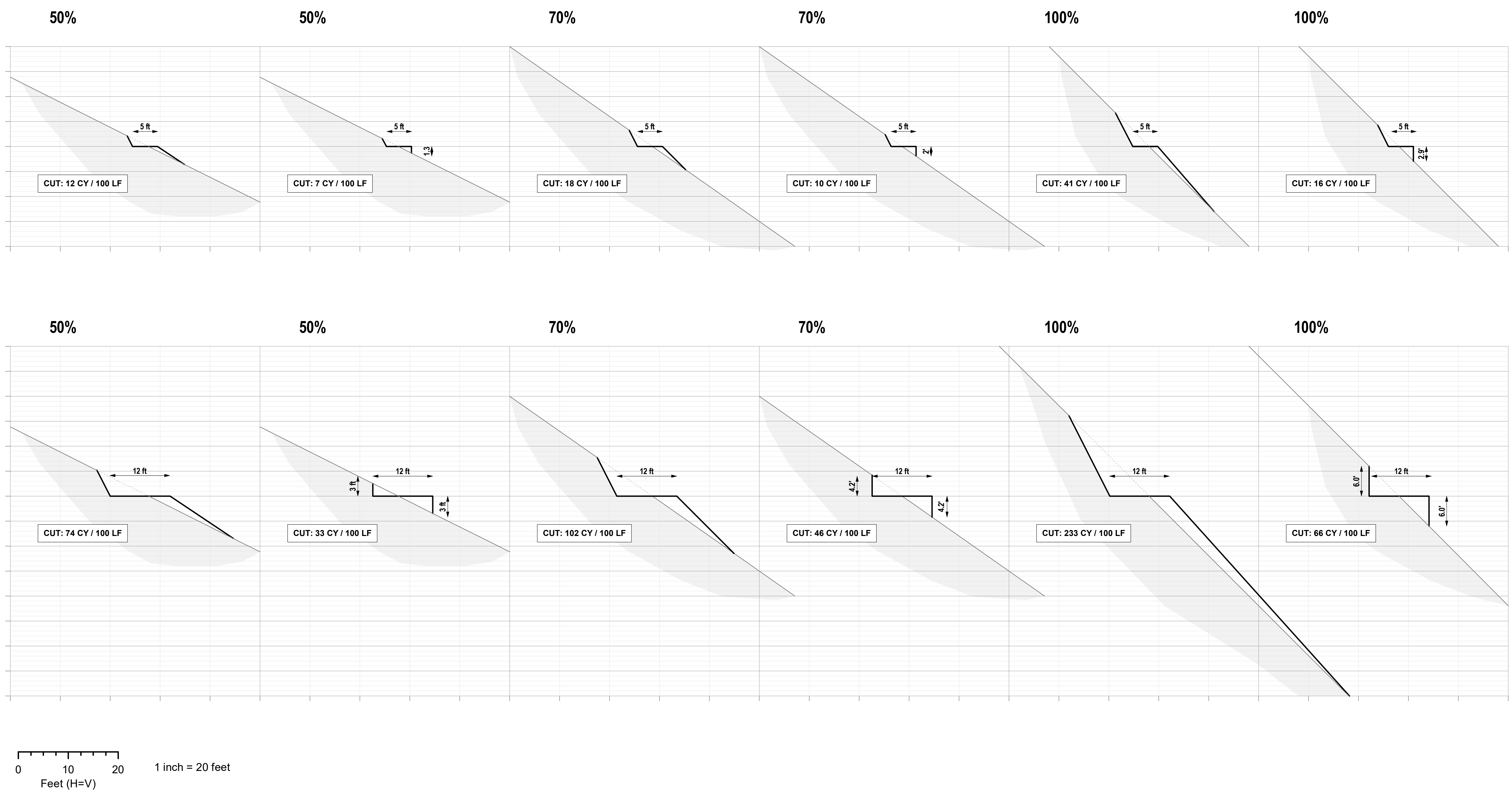


FIGURE 4C
PROJECT: 12196
Date: 10/24/2022

PRELIMINARY ACCESS AND CONSTRAINT MAP
5-MILE AND PEAVINE WATER LINES
San Lorenzo Valley Water District

116 East Lake Ave
Watsonville, CA 95076
(831) 722-4175
Haro, Kasunich and Associates, Inc.



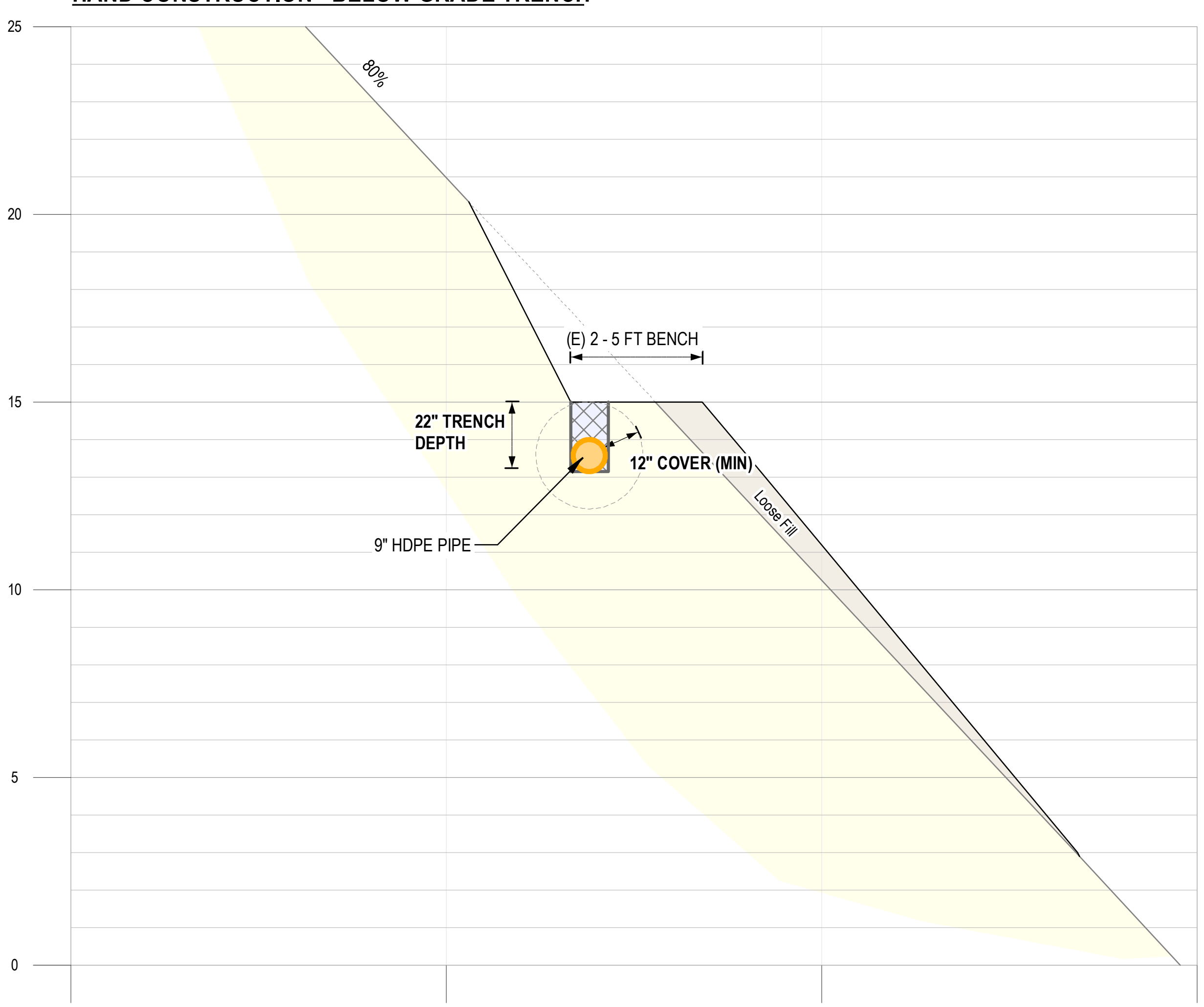
Haro, Kasunich and Associates, Inc.
Consulting Geotechnical & Coastal Engineers
116 East Lake Ave
Watsonville, CA 95076
(831) 722-4175

TYPICAL CROSS-SECTIONS FOR NARROW AND WIDE BENCH PER SLOPE CLASS

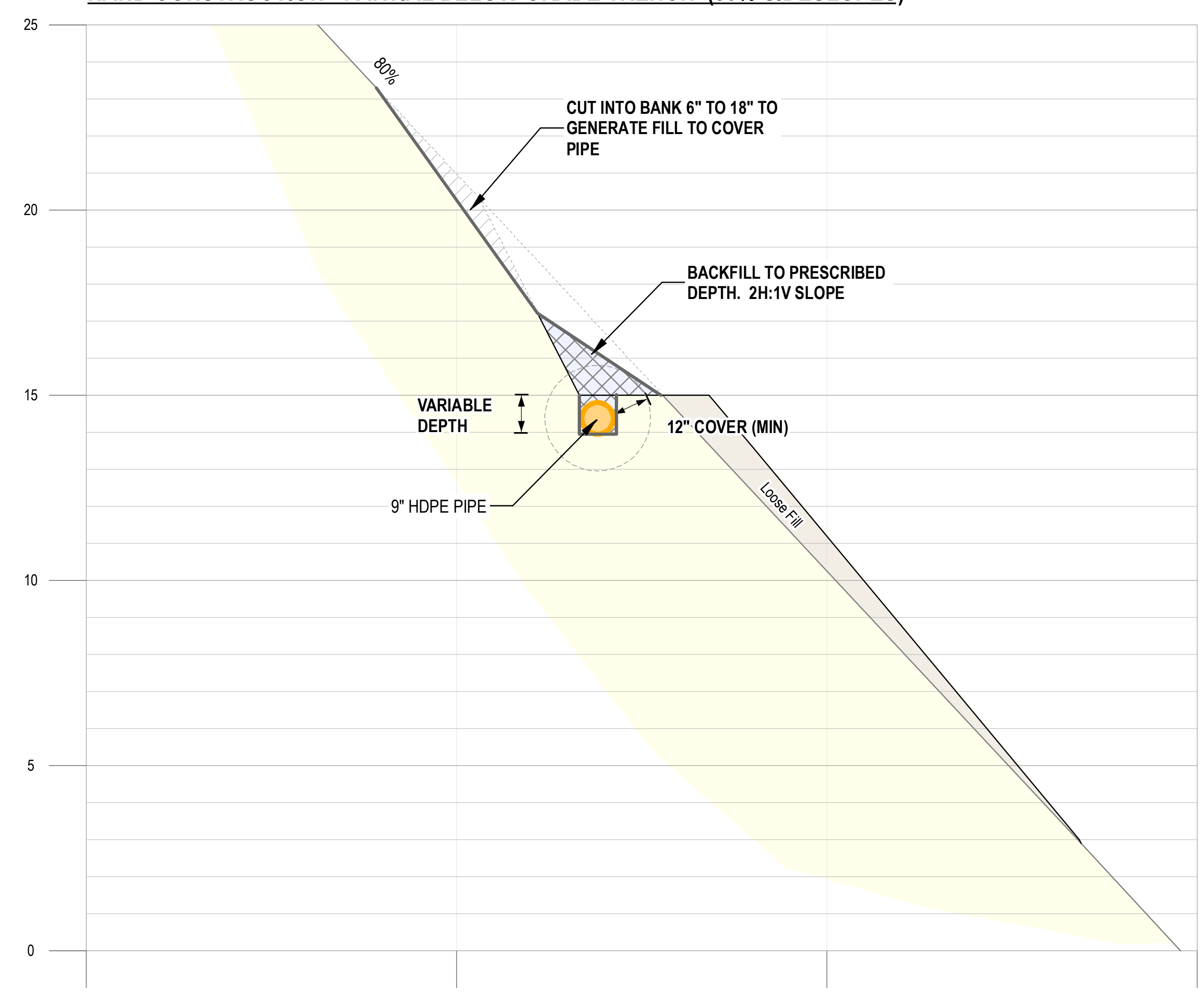
5-MILE AND PEAVINE WATER LINES

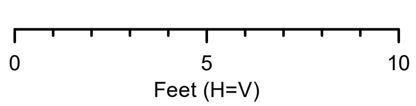
FIGURE 5
PROJECT: 12196
Date: 10/24/2022

HAND CONSTRUCTION - BELOW GRADE TRENCH



HAND CONSTRUCTION - PARTIAL BELOW GRADE TRENCH (80% SIDESLOPES)





1 inch = 5 feet

NOT FOR CONSTRUCTION
WITHOUT ENGINEER OF RECORD AND GEOLOGIST OF RECORD APPROVAL

NOTE

FIGURE 6A
PROJECT: 12196
Date: 10/24/2022

CONCEPTUAL NARROW BENCH DETAILS FOR WATERLINE REPLACEMENT
5-MILE AND PEAVINE WATER LINES

116 East Lake Ave
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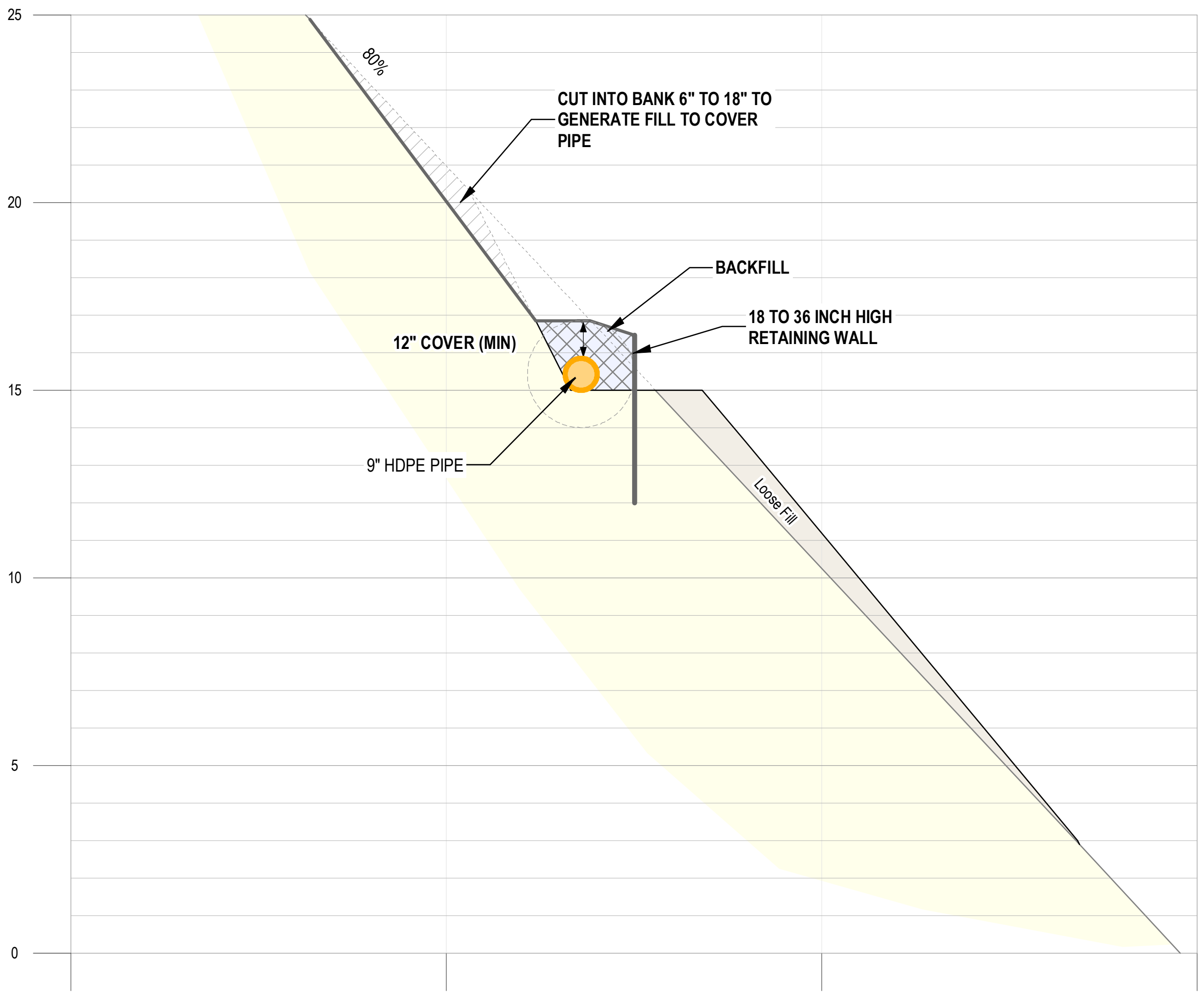
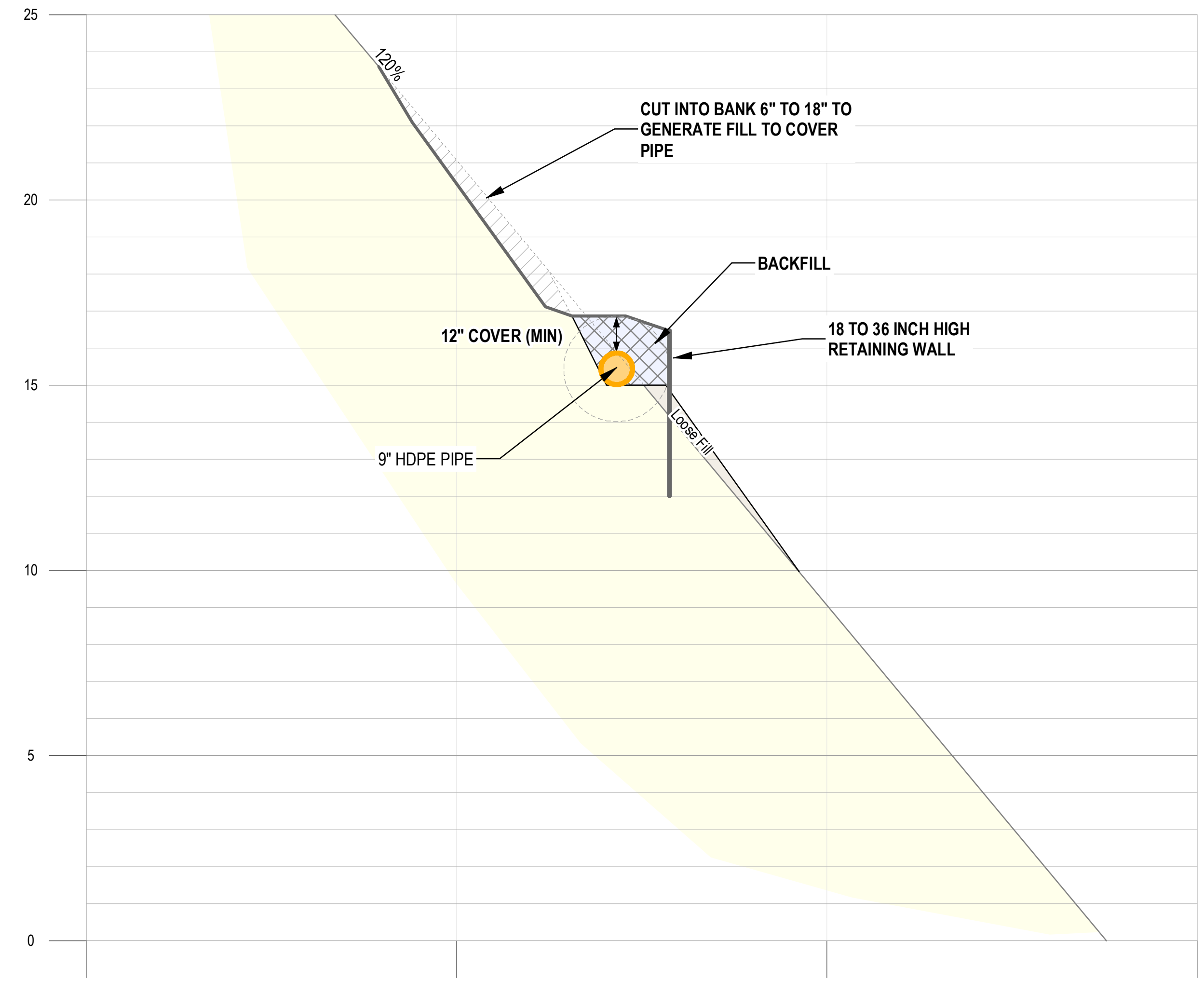
HAND CONSTRUCTION - RETAINED FILL COVER (80% SIDESLOPES)



HAND CONSTRUCTION - RETAINED FILL COVER (NARROW 0 - 3 FOOT BENCH, 120% SIDESLOPES)



0 5 10

Feet (H=V)

1 inch = 5 feet

NOT FOR CONSTRUCTION
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NOTE

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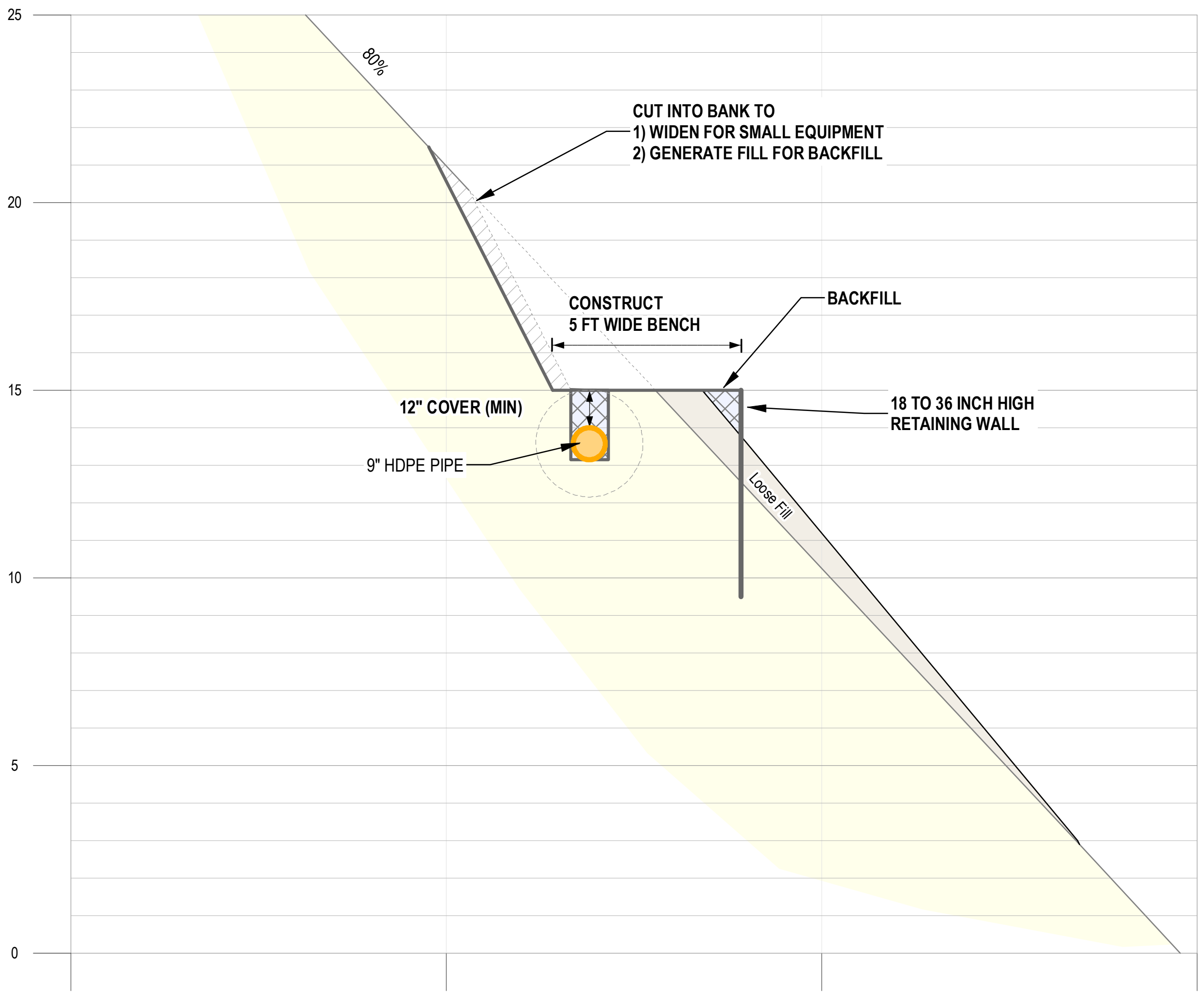
FIGURE 6B
PROJECT: 12196
Date: 10/24/2022

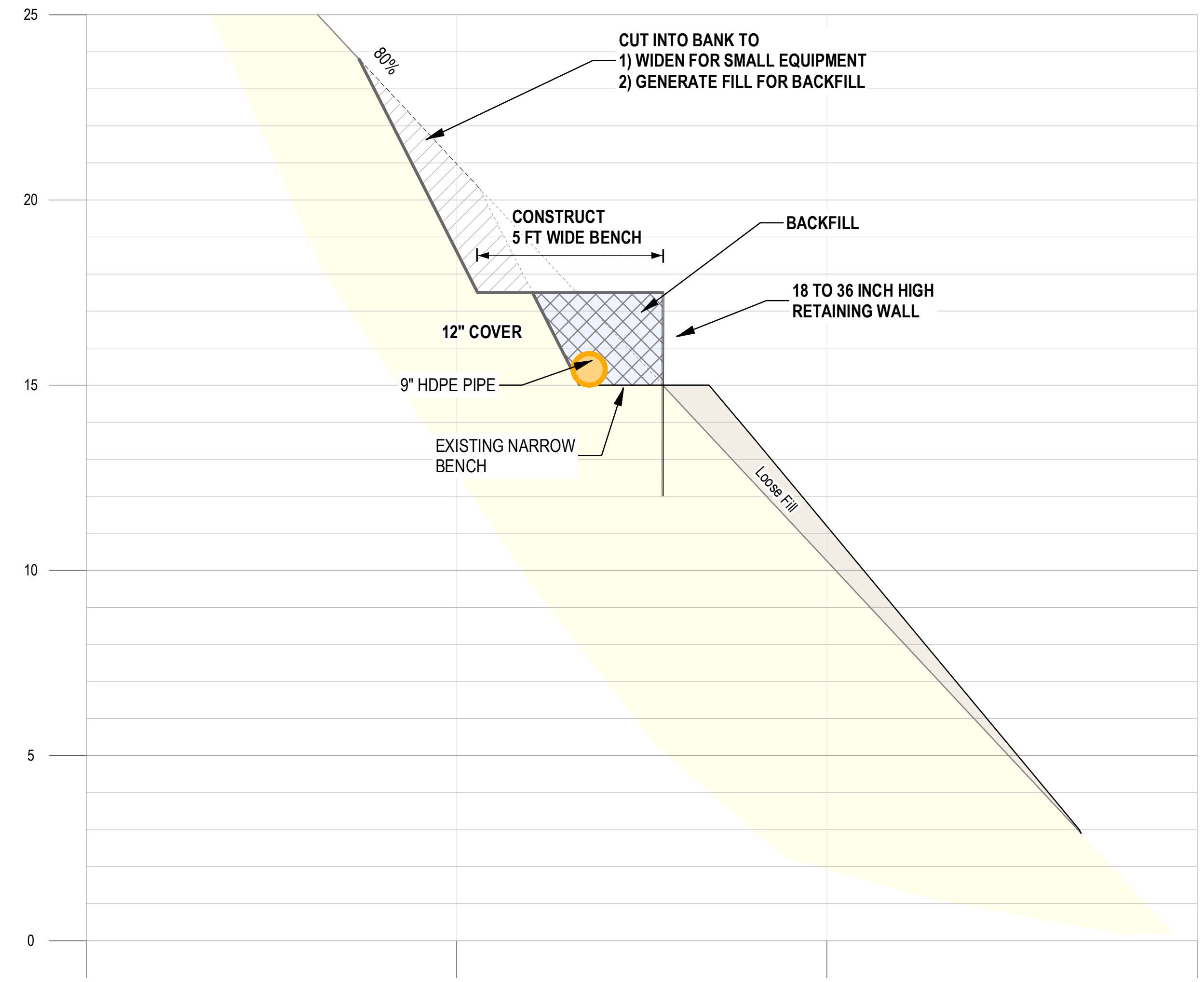
CONCEPTUAL NARROW BENCH DETAILS FOR WATERLINE REPLACEMENT
5-MILE AND PEAVINE WATER LINES

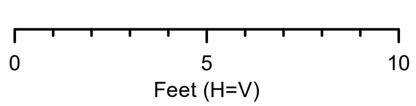
116 East Lake Ave
Watsonville, CA 95076
(831) 722-4175

SMALL MACHINE CONSTRUCTION - 5-FOOT WIDE BENCH, BELOW GRADE TRENCH (80% SIDESLOPES)



SMALL MACHINE CONSTRUCTION - 5-FOOT WIDE BENCH, RETAINED FILL COVER (80% SIDESLOPES)





1 inch = 5 feet

NOT FOR CONSTRUCTION
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FIGURE 6C
PROJECT: 12196
Date: 10/24/2022

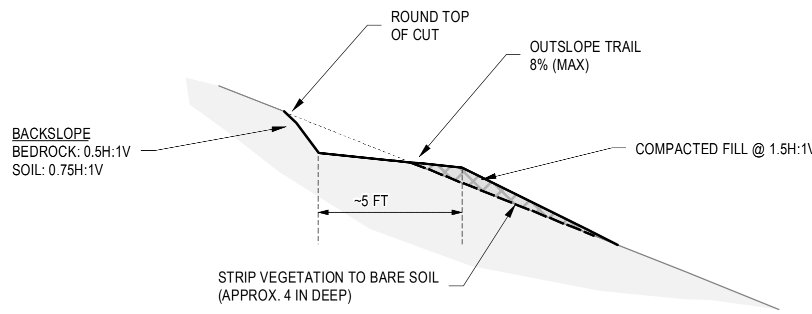
CONCEPTUAL NARROW BENCH DETAILS FOR WATERLINE REPLACEMENT
5-MILE AND PEAVINE WATER LINES

116 East Lake Ave
Watsonville, CA 95076
(831) 722-4175

HARO, KASUNICH AND ASSOCIATES, INC.

1/7A TRAIL CONSTRUCTION: <50% SLOPES

TYPICAL SCALE: NTS



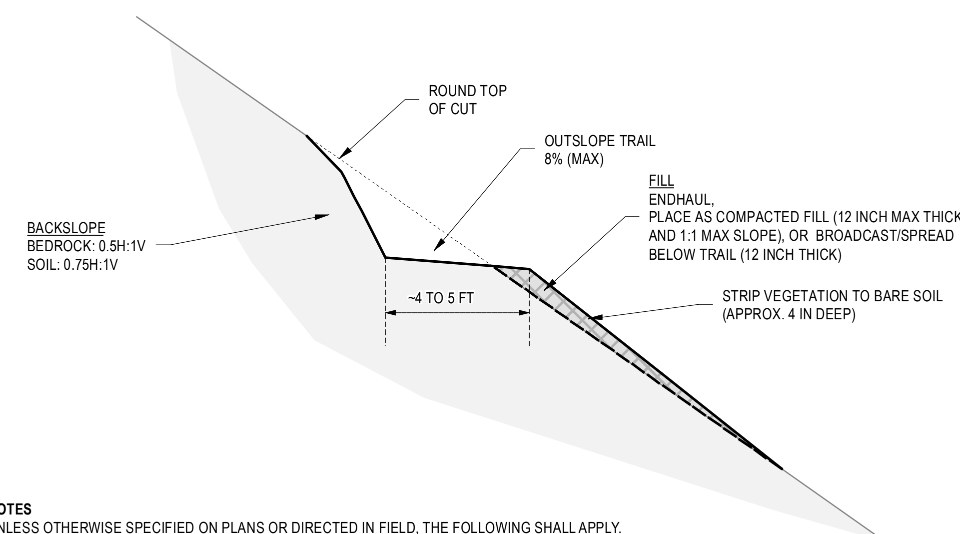
NOTES

UNLESS OTHERWISE SPECIFIED ON PLANS OR DIRECTED IN FIELD, THE FOLLOWING SHALL APPLY.

1. TRAIL SHALL BE CONSTRUCTED AT 5 FOOT MAXIMUM WIDTH ON BALANCED CUT AND FILL.
2. AREAS TO RECEIVE FILL SHALL BE STRIPPED OF VEGETATION AND HIGHLY ORGANIC SOIL (~ 4" DEPTH).
3. ONSITE SOILS MAY BE REUSED AS COMPACTED FILL OR SPREAD ONSITE BELOW THE TRAIL AS APPROVED BY THE ENGINEER.
   A. COMPACTED FILL: FILL SHALL BE COMPACTED TO A LEVEL EQUAL OR GREATER THAN THE SURROUNDING NATIVE MATERIALS (APPROXIMATELY 85 PERCENT RELATIVE COMPACTION PER ASTM D 1557). DURING PLACEMENT AND COMPACTION OF FILL, THE MOISTURE CONTENT OF THE MATERIALS BEING PLACED SHALL BE MAINTAINED AS NECESSARY. FILL SHALL BE A MAXIMUM OF 24 INCHES THICK UNLESS OTHERWISE SPECIFIED. FILL EMBANKMENT SHALL BE INCLINED NO STEEPER THAN 1.5:1 (UNLESS OTHERWISE SPECIFIED).
   B. ONSITE SPREAD: BROADCAST/SPREAD FILL MAXIMUM 12 INCHES THICK.
5. CUTBANK BACKSLOPE SHALL BE INCLINED AT 0.75H:1V SLOPE IN SOIL AND 0.5H:1 IN SOUND BEDROCK. WHERE CUTS ARE STEEPER THAN 4 FEET OR WHERE SEEPAGE OF WATER OR UNSUITABLE EARTH MATERIALS ARE ENCOUNTERED, THE BACKSLOPE SHALL BE SELECTED BY THE ENGINEER.
6. ALL DISTURBED AREAS SHALL BE TREATED TO CONTROL EROSION PER SPECIFICATIONS.
7. DRAINAGE DIPS (REVERSE GRADE DIPS, KNICKS, ETC) SHALL BE INSTALLED AS SPECIFIED ON PLANS.
8. SPECIFICATIONS ARE INTENDED ONLY AS GUIDELINES. MODIFICATIONS MAY BE MADE IN THE FIELD BY ENGINEER OR DESIGNEE.

2/7A TRAIL CONSTRUCTION: >50% SLOPES

TYPICAL SCALE: NTS



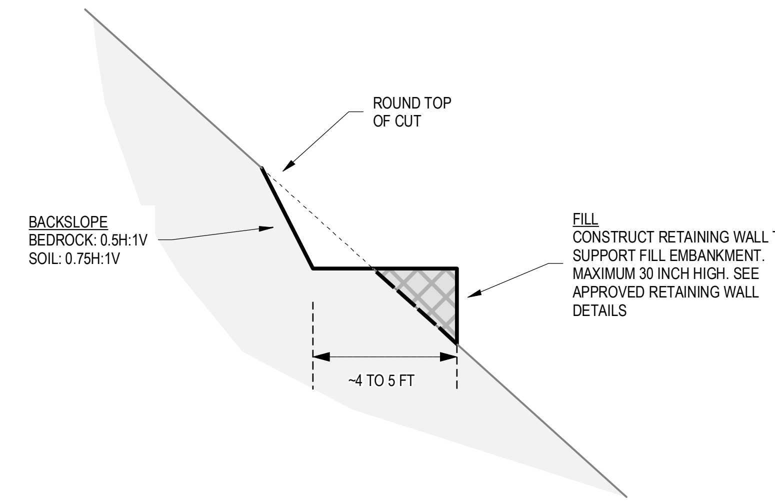
NOTES

UNLESS OTHERWISE SPECIFIED ON PLANS OR DIRECTED IN FIELD, THE FOLLOWING SHALL APPLY.

1. TRAIL SHALL BE CONSTRUCTED AT 4 TO 5 FOOT MAXIMUM WIDTH ON BALANCED CUT AND FILL.
2. AREAS TO RECEIVE FILL SHALL BE STRIPPED OF VEGETATION AND HIGHLY ORGANIC SOIL (~ 4" DEPTH).
3. ONSITE SOILS MAY BE REUSED AS COMPACTED FILL OR SPREAD ONSITE BELOW THE TRAIL AS APPROVED BY THE ENGINEER.
   A. COMPACTED FILL: FILL SHALL BE COMPACTED TO A LEVEL EQUAL OR GREATER THAN THE SURROUNDING NATIVE MATERIALS (APPROXIMATELY 85 PERCENT RELATIVE COMPACTION PER ASTM D 1557). DURING PLACEMENT AND COMPACTION OF FILL, THE MOISTURE CONTENT OF THE MATERIALS BEING PLACED SHALL BE MAINTAINED AS NECESSARY. FILL SHALL BE A MAXIMUM OF 12 INCHES THICK UNLESS OTHERWISE SPECIFIED. FILL EMBANKMENT SHALL BE INCLINED NO STEEPER THAN 1:1 (UNLESS OTHERWISE SPECIFIED).
   B. ONSITE SPREAD: BROADCAST/SPREAD FILL MAXIMUM 12 INCHES THICK.
   C. ENDHAUL TO AN APPROVED LOCATION
5. CUTBANK BACKSLOPE SHALL BE INCLINED AT 0.75H:1V SLOPE IN SOIL AND 0.5H:1 IN SOUND BEDROCK. WHERE CUTS ARE STEEPER THAN 4 FEET OR WHERE SEEPAGE OF WATER OR UNSUITABLE EARTH MATERIALS ARE ENCOUNTERED, THE BACKSLOPE SHALL BE SELECTED BY THE ENGINEER.
6. ALL DISTURBED AREAS SHALL BE TREATED TO CONTROL EROSION PER SPECIFICATIONS.
7. DRAINAGE DIPS (REVERSE GRADE DIPS, KNICKS, ETC) SHALL BE INSTALLED AS SPECIFIED ON PLANS.
8. SPECIFICATIONS ARE INTENDED ONLY AS GUIDELINES. MODIFICATIONS MAY BE MADE IN THE FIELD BY ENGINEER OR DESIGNEE.

3/7A TRAIL CONSTRUCTION - RETAINED FILL: >80% SLOPES

TYPICAL SCALE: NTS



NOTES

UNLESS OTHERWISE SPECIFIED ON PLANS OR DIRECTED IN FIELD, THE FOLLOWING SHALL APPLY.

1. TRAIL SHALL BE CONSTRUCTED AT 4 TO 5 FOOT MAXIMUM WIDTH ON BALANCED CUT AND FILL.
2. SUPPORT OUTER EDGE OF FILL ON APPROVED RETAINING WALL (MAXIMUM 30 INCH HIGH)
3. CUTBANK BACKSLOPE SHALL BE INCLINED AT 0.75H:1V SLOPE IN SOIL AND 0.5H:1 IN SOUND BEDROCK. WHERE CUTS ARE STEEPER THAN 4 FEET OR WHERE SEEPAGE OF WATER OR UNSUITABLE EARTH MATERIALS ARE ENCOUNTERED, THE BACKSLOPE SHALL BE SELECTED BY THE ENGINEER.
4. ALL DISTURBED AREAS SHALL BE TREATED TO CONTROL EROSION PER SPECIFICATIONS.
5. DRAINAGE DIPS (REVERSE GRADE DIPS, KNICKS, ETC) SHALL BE INSTALLED AS SPECIFIED ON PLANS.
6. SPECIFICATIONS ARE INTENDED ONLY AS GUIDELINES. MODIFICATIONS MAY BE MADE IN THE FIELD BY ENGINEER OR DESIGNEE.

NOT FOR CONSTRUCTION
WITHOUT ENGINEER OF RECORD AND GEOLOGIST OF RECORD APPROVAL

NOTE

TYPICAL TRAIL SPECIFICATIONS ARE TYPICAL AND PRESENTED FOR ILLUSTRATIVE PURPOSES ONLY. SUITABILITY FOR WATERLINE REPLACEMENT WILL NEED TO BE CONFIRMED AND ADJUSTED ACCORDINGLY

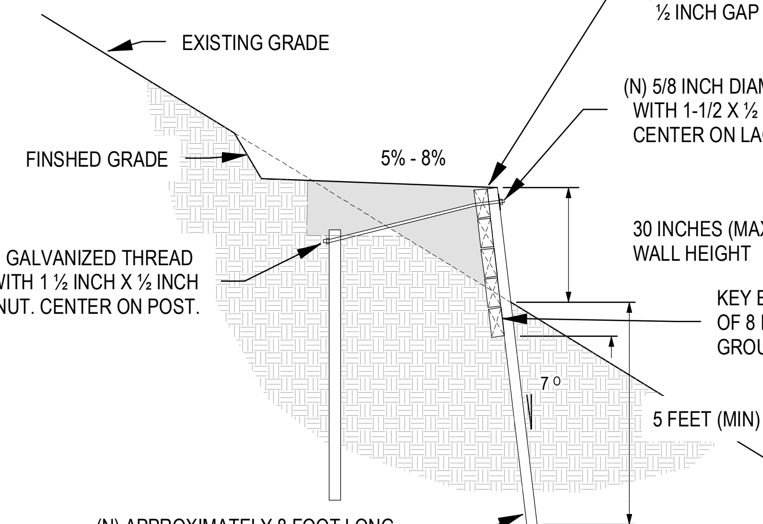
FIGURE 7A
PROJECT: 12196
Date: 10/24/2022

TYPICAL RECREATIONAL TRAIL DETAILS
5-MILE AND PEAVINE WATER LINES

116 East Lake Ave
Watsonville, CA 95076
(831) 722-4175

5/7B WOOD LAG WALL (TYPICAL)

SCALE: NTS

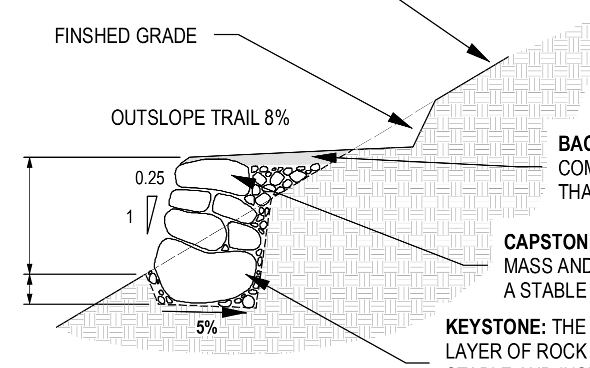


NOTES:
- FOR WALLS OVER 18 INCHES IN HEIGHT, INCLUDE TIEBACK AND ANCHOR POST AS SHOWN.
- WALL POSTS SHALL BE 8 FOOT X 2.0 LBS/FT GALVANIZED U-CHANNEL CONFORMING TO ASTM A4999, GRADE 60.
- FINAL DEPTH OF POST AND LAGGING EMBEDMENT TO BE DETERMINED IN FIELD BY ENGINEER BASED ON SOIL CONDITIONS.
- ANCHOR LAGGING TO U-CHANNEL USING 3-INCH GALVANIZED DECK SCREWS.
- INSTALL PER SATISFACTION OF ENGINEER.

NOTE: MODIFICATION S TO WOOD LAG RETAINING WALL WILL BE REQUIRED FOR FIRE PRO OFING

4/7B STACKED ROCK WALL (TYPICAL)

SCALE: NTS



NOTES:
- EXCAVATE A KEYWAY FOR THE FOOTING INTO FIRM, NATIVE MATERIAL. DEPTH OF KEYWAY TO BE DETERMINED IN FIELD BY ENGINEER. BACKSLOPE THE FOOTING INTO THE HILLSIDE AS SHOWN. EMBED BASE ROCK ONE FULL DIAMETER OR 12 INCHES, WHICHEVER IS GREATER UNLESS OTHERWISE SPECIFIED OR DIRECTED BY THE ENGINEER.
- ROCK SHALL BE SOUND AND DURABLE OF SUBROUNDED TO ANGULAR SHAPE AND BE APPROVED BY THE ENGINEER. ROUNDED STONE WILL NOT BE ACCEPTABLE. A MINIMUM OF 50% OF THE ROCK SHALL BE LARGER THAN 18 INCHES (130 LB MIN). ALL STRUCTURAL PIECES SHALL BE GREATER THAN 10 INCHES. SMALLER STONES MAY BE USED TO CHINK VOIDS.
- ROCKS IN EACH SUCCESSIVE TIER SHOULD BE SET SO THEY HAVE AT LEAST THREE POINTS OF GOOD CONTACT WITH THE ROCKS BELOW. GOOD CONTACT IS DEFINED AS NO WOBBLE OR SHIFTING UNDER A LOAD, WITHOUT RELYING ON SHIMS (OR CHINKING) TO ELIMINATE MOVEMENT. SHIMS ARE PRONE TO SHIFTING AND SHOULD NOT BE USED TO ESTABLISH CONTACT, ESPECIALLY ON THE FACE OF THE BUTTRESS, WHERE THEY CAN FALLOUT. ADD BACKFILL AND TAMP CRUSHED ROCKS INTO THE CRACKS AS YOU BUILD.
- FOR EACH TIER, OVERLAP THE GAPS BETWEEN ROCKS IN THE NEXT LOWER TIER. EACH TIER SHOULD BE PROGRESSIVELY SET INTO THE HILL TO CREATE THE DESIRED AMOUNT OF BATTER.
- INSTALL PER SATISFACTION OF ENGINEER.
- SPECIFICATIONS MODIFIED FROM U.S. FOREST SERVICE TRAIL CONSTRUCTION AND MAINTENANCE NOTEBOOK, 2007 EDITION (HESSELBARTH ET AL., 2007).

NOT FOR CONSTRUCTION
WITHOUT ENGINEER OF RECORD AND GEOLOGIST OF RECORD APPROVAL

NOTE
TYPICAL TRAIL SPECIFICATIONS ARE TYPICAL AND PRESENTED FOR ILLUSTRATIVE PURPOSES ONLY. SUITABILITY FOR WATERLINE REPLACEMENT WILL NEED TO BE CONFIRMED AND ADJUSTED ACCORDINGLY

FIGURE 7B
PROJECT: 12196
Date: 10/24/2022

TYPICAL RECREATIONAL TRAIL DETAILS
5-MILE AND PEAVINE WATER LINES

116 East Lake Ave
Watsonville, CA 95076
(831) 722-4175