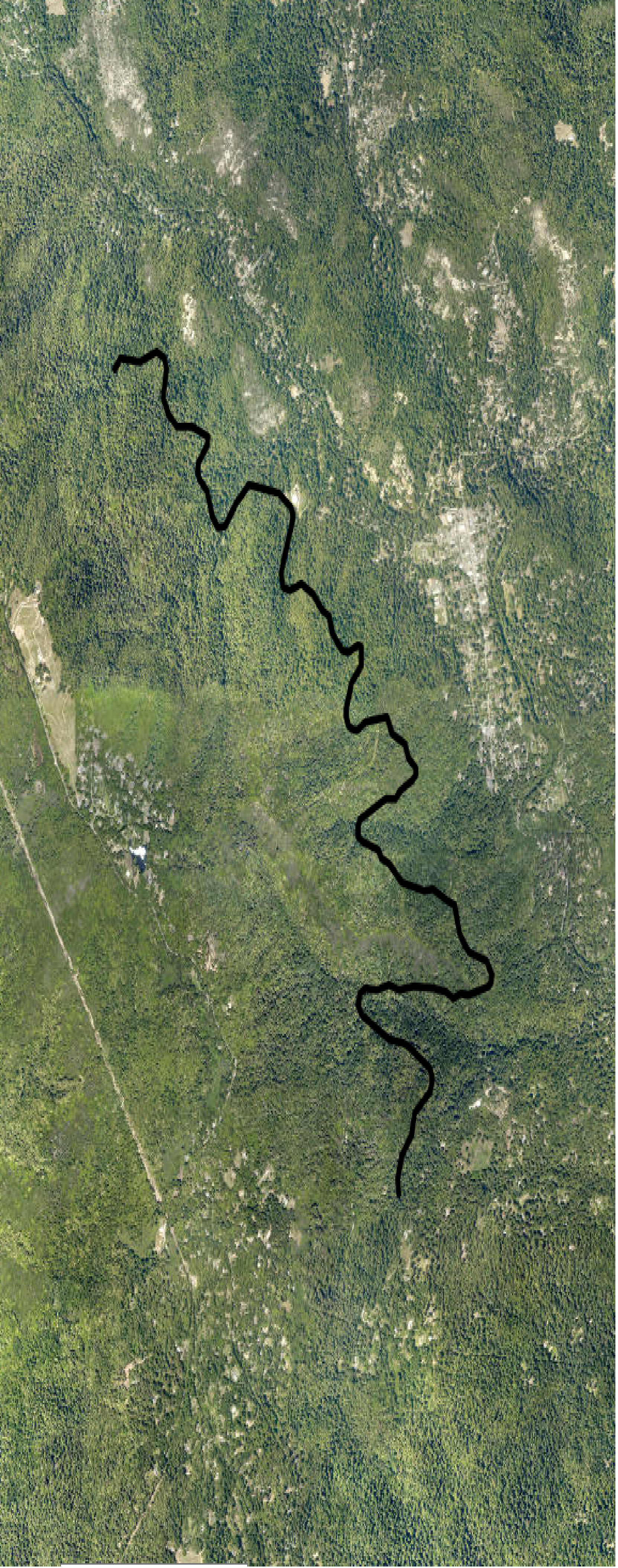

Cross Country Pipeline Constructability Study

Technical Memorandum
Alternative Analysis Report

March 2022

Prepared for:

San Lorenzo Valley Water District

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Abbreviations

AHE	Advanced Hydro Engineering
Alpine	Alpine Development
CalTrans	California Department of Transportation
CE&G	Cal Engineering & Geology, Inc.
CEQA	California Environmental Quality Act
DI	Ductile Iron
District	San Lorenzo Valley Water District
F&L	Freyer & Laureta, Inc.
gpm	Gallons Per Minute
HDD	Horizontal Directional Drilling
HDPE	High Density Polyethylene
kW	Kilowatts
lf	Linear Feet
LiDAR	Light Detection and Ranging
MSE	Mechanically Stabilized Earth
PRV	Pressure Recovery Valve
psi	Pounds Per Square Inch
PVC	Polyvinyl Chloride
SDS	Safety Data Sheet
SLVWD	San Lorenzo Valley Water District
Study	Cross Country Pipeline Constructability Study
VOC	Volatile Organic Compounds
WRA	WRA Environmental Consultants
WS	Welded Steel

1 Executive Summary

1.1 Background & Purpose

The CZU fire resulted in extensive damage to the San Lorenzo River watershed with significant impacts to the San Lorenzo Valley Water District's (District's) facilities including the Peavine and 5-Mile Pipeline, which were high density polyethylene (HDPE) pipe laid at grade along man made bench throughout the watershed. The Peavine and 5-Mile segments must be reconstructed to restore the critical surface water supply for the SLVWD system. The Cross Country Pipeline Constructability Study (Study) will focus on restoring the raw water conveyance system that serves the SLVWD system.

1.2 Existing Conditions

Freyer & Laureta, Inc. (F&L) along with it subconsultants and District staff performed a site reconnaissance of the existing Peavine and 5-Mile Segments in August 2021. The site reconnaissance provided the opportunity to observe the current conditions of the former pipeline system including site specific constraints that must be considered when completing the Study.

The following is a brief summary of the existing conditions observed during the site walk:

- The Peavine segment was found to have wider benches throughout a majority of the alignment.
- The 5-Mile segment was found to have the narrowest benches but there was wide variability in the width of the existing bench.
- Both segments were found to have areas of debris but the 5-Mile segment was found to have the largest accumulation of debris as well as upslope forest damage that may pose long-term risk of tree falls, debris flows, and landslides that could impact the restored pipeline.
- The existing slopes along large portions of the 5-Mile segment were found 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.
- Access to both segments is limited without temporary roads being constructed to facilitate future pipeline installation efforts.

Following the site reconnaissance, an environmental assessment was completed to identify potential constraints that may impact the overall permitting and constructability of the proposed Project improvements. The assessment 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;
- Nesting birds could limit the time of year for construction activities or result in unanticipated delays; and
- Forest and habitat removal to facilitate construction must be sequenced in a manner to reduce risk for construction delays.

A geotechnical assessment was performed to support the Study and provided the following observations and recommendations:

- The potential for seismically induced liquefaction and densification along the existing cross country pipelines alignment is low.
- Portions of the existing alignment may be subject to active landslide features that generally occur within the upper colluvium.
- Earth retaining structures to facilitate construction of the replacement pipeline will stabilize locally the bench for purposes of the protecting the new pipeline.
- Excavations are anticipated to only require conventional excavating equipment such as backhoes and excavators.

Additional geotechnical investigations are recommended to be completed during the final design phase for the preferred alternative.

1.3 Goal Based Risk Assessment Process

The F&L Team developed alternatives and established a goals based risk assessment process that involved establishing design criteria goals for a successful project developed in coordination with the District including long term water supply resiliency, effective pipeline operations and maintenance, construction and maintenance cost, and quickly restoring operational capacity.

The assessment approach followed by the team first established key areas that best describe the potential goals for the Project. Once the goals are established, the work group can identify potential success and risk factors that can be used to evaluate an alternative's ability to deliver a successful project while minimizing potential risks. The District and F&L Team identified the four key areas including Goal Statements:

- <u>Safety:</u> Implement a project that delivers the critical raw water supply system in a manner that establishes risk mitigation-based solutions for construction activities safety, long-term operations including maintenance and repairs, and hardening for changing environmental conditions.
- <u>Constructability:</u> Develop a project that considers current construction practices and technology while leveraging opportunities to comply with anticipated regulatory requirements in a cost-efficient manner.
- <u>Operations & Maintenance:</u> Build a project that optimizes the ease, accessibility for long-term operations and maintenance, while meeting established performance levels.
- <u>Stakeholder Impact:</u> Account for the project's potential benefits and impacts to the community and environment, and the influence of those stakeholders on project feasibility.

Individual working groups consisting of at least one District staff member and up to three F&L Team members utilized the key areas to develop goal statements, which provide guidance for development of potential alternatives.

The work groups developed metrics to facilitate evaluation and ranking of how each alternative can meet the success criteria. Each alternative will have different potential for meeting the established success metric. By establishing a range of success factors and metrics, the work groups are able to effectively evaluate each alternatives ability to meet the established goal statements.

The work groups also identified potential risk factors to allow for the team to evaluate the potential components of an alternative that may limit the alternatives ability to deliver a successful project. The risk factors identified separate metrics that would adversely impact an alternatives ability to meet the established goals.

1.4 Project Components

Before developing potential alternatives, the F&L Team reviewed key project components including:

- Pipeline Material
- Construction Methods
- Installation Methods
- Potential Alignments

The purpose of the individual project components review was to develop the preferred project components for consideration when developing potential alternatives. The key project components listed above presented a wide range of options for consideration and the F&L Team identified a preferred subset for each component that would provide the best opportunity to achieve the Goal Statements.

1.4.1 Pipeline Material

The CZU fire completely destroyed both the Peavine and 5-Mile segments resulting in an immediate loss of the critical raw water conveyance system. The construction and operational flexibility afforded to the District by HDPE must be balanced with the long-term risk of damage due to any number of natural disasters including fire, landslides, and seismic events.

The common pipeline materials used for raw water conveyance systems include:

- HPDE;
- Polyvinyl Chloride (PVC);
- Ductile Iron (DI), and;
- Welded Steel (WS).

When comparing each of the four pipe materials considered, key metrics to compare each material include:

- Fire resistivity including potential risk of loss due to a fire similar to the CZU event;
- Installation flexibility including equipment requirements;
- Operational reliability by minimizing potential for leaks or damage from tree, debris, and landslide within the alignment, and;
- Long-term maintenance requirements.

When comparing the pros and cons for each pipe material, only HDPE and WS were selected to be considered when developing potential alternatives. PVC did not provide any advantages over HDPE that warranted being advanced to the alternatives development phase. Similarly, DI was found to be less resilient to fire when compared to WS because of the potential for gaskets to melt based on experience with the CZU fire.

1.4.2 Construction Methods

Generally, pipeline construction regardless of whether standard open trench or trenchless methods are utilized result in short-term impacts within the work limits. The existing cross country pipeline alignments cross through largely natural watershed and include a number of stream crossings. In addition, the highly variable ground conditions combined with significant elevation change over the length of the two segments with limited access points require a comprehensive review of the most suitable potential construction methods.

The potential construction methods considered include:

- Standard methods including open trench and above ground; and
- Trenchless methods include including bore and jack, horizontal directional drilling (HDD), and mircortunneling.

Following the F&L Team's site visit, it was determined that large scale use of any one of the trenchless methods described above is likely not feasible for several reasons including:

- <u>Limited Access:</u> As noted in previous sections, the portions of the alignment within the watershed have limited access, which will impact a contractor's ability to mobilize the equipment needed for each trenchless method.
- <u>Potential Waste Stream Handling:</u> All methods generate spoils and/or mud as a result of the tunneling work requiring handling of the waste stream including potentially having to off haul and dispose of the spoils or mud outside of the project limits at an acceptable disposal facility.
- <u>Space Requirements:</u> All three methods, but in particular HDD, require large, relatively flat areas to facilitate casing and pipeline installation but the existing topography within the watershed would require significant site preparation work to construct, even on a temporary basis, the flat areas required to utilize any trenchless methods efficiently and effectively.

Based on the potential significant constraints described above, the F&L Team determined that the alternatives developed will consider using primarily open trench and above ground installation methods for purposes of the alternative evaluation and ranking. However, once the preferred alternative is selected and the design phase is initiated, the F&L Team will perform a second feasibility evaluation of potential limited use of trenchless methods for particularly sensitive locations such as creek crossings if there will be a potential benefit to reduce the overall temporary impacts anticipated as a result of the pipeline construction.

1.4.3 Installation Methods

The potential pipe installation includes both above-ground and buried conditions. By limiting pipe material choices to HDPE and WS, the potential installation methods for each pipe material can also be preliminary evaluated to determine if there is only a subset of techniques to consider as part of the alternative development process. The relative resilience to natural disasters including fire, landslides, debris flows, and seismic events influence the potential installation methods for both pipe materials.

Both HDPE and welded steel could be installed above grade. There are numerous challenges with above grade installation in particular with welded steel, which is heavy requiring larger equipment and the welding equipment needs will introduce additional construction and long-term maintenance challenges. For buried installation, only HDPE is considered because our observations of the existing pipeline system was that portions of the pipelines that were buried generally survived the CZU fire. Heat protection can be achieved through shallow cover and the additional fire hardening provided from welded steel in the above ground installation did not warrant considering burying welded steel.

In order to determine the minimum cover depth to provide additional fire hardening measures for the HDPE pipe, the properties of HDPE pipe were reviewed to identify the potential melting point.

The potential risk of heat penetration depth from a fire similar to the CZU event must be quantified both for the potential to melt HDPE pipe but also for elevating temperatures sufficiently that may result in creating off gassing of the pipe material thereby introducing VOCs and hydrocarbons into the conveyance system. The F&L Team performed a desktop study of available literature and the key points are summarized below:

- Most research suggests that heat temperature increase in soil from fires does not extend very deep into the soil due to the soil's poor thermal conductivity.
- Generally, maximum measured temperature in soil decreased exponentially with greater depth and, in fact, the increased temperature was limited at depths as shallow as 12-inches.
- Continuous burning of debris and other combustible material that may accumulate on the forest floor after the initial fire event can lead to continuous heat affect over time.
- The moisture content of the soil can significantly reduce the risk of heat increase due to fire.

The estimated temperature at varying depths as found in a study completed to model the potential heat penetration depth during a controlled burn (Massman, 2004) found the estimated soil temperature from a surface fire is predicated to drop below 400 degrees Fahrenheit at depths greater than 4 inches. In fact, soil temperatures are predicted to be below 200 degrees Fahrenheit at depths in excess of 12-inches. Based on available information on HDPE, 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 bury depth for HDPE pipe be 18-inches. 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.

The F&L Team also developed standard installation sections for crossing of existing creeks as well as locations where the steep topography requires additional engineered earth retaining structures. The earth retaining structures are anticipated to utilize pre-engineered systems such as Hilfiker Retaining Wall using welded wire or a mechanically stabilized earth (MSE) wall such as the TENSAR ARES Retaining Wall System. Sample produce information both for the Hilfiker and TENSAR systems are included in Appendix F.

1.4.4 Alignment

In order to increase resiliency of the District's raw water conveyance system, the F&L Team did consider potential alternative alignments to reduce the overall length of the cross country pipeline within the watershed. By considering alignments that vary from the current Peavine and 5-Mile segment alignments, the alternative alignments would result in requiring raw water pump stations or a second treatment plant to supplement the Lyon Surface Water Treatment Plant. In fact, the District reported that during the original construction of the HDPE cross country pipeline system that it had considered the feasibility of a second treatment plant instead of constructing the 5-Mile segment.

Based on review of the existing alignments and the potential additional facilities that may be required, the F&L Team and District agreed that the Peavine segment would not be a good candidate for considering alternative alignments. However, the 5-Mile segment should be evaluated to determine if reducing the overall length of the segment would be more beneficial even if a pump station or second water treatment facility were required in order to provide a more resilient and reliable system.

1.5 Alternative Descriptions

Seven alternatives were developed considering pipeline materials, construction methods, installation methods, and alignment. The seven alternatives including a brief description of key components is provided below:

- Alternative 1: Above-grade HDPE pipe including above grade creek crossings following the same Peavine and 5-Mile segments alignments.
- Alternative 2: Above-grade WS pipe including above grade creek crossings following the same Peavine and 5-Mile segments alignments.
- Alternative 3A: Shallow buried HDPE pipe with 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.
- Alternative 4A: Shallow buried HDPE pipe and below grade creek crossings with same Peavine alignment and independent Clear Creek and Sweetwater alignments to reduce the length of pipe including dedicated pump stations south of Boulder Creek discharging into a common transmission main to convey raw water to the Lyon Treatment Plant.
- Alternative 4B: Shallow buried HDPE pipe and below grade creek crossings with same Peavine alignment and single Clear Creek and Sweetwater alignment including dedicated pump station south of Boulder Creek discharging into a transmission main to convey raw water to the Lyon Treatment Plant.
- Alternative 5: Shallow buried HDPE pipe and below grade creek crossings with same Peavine alignment and single Clear Creek and Sweetwater alignment including a new surface water treatment plant south of Boulder Creek discharging into a transmission main to convey raw water to the Lyon Treatment Plant.

1.6 Alternatives Evaluation and Recommendations

Using the Risk and Success factors developed in coordination with the District, the individual work groups rank each alternative. The work groups performed independent review of each of the seven alternatives. For example, the Safety work group only evaluated each alternative's ability to meet the Goal Statement while minimizing potential risks. Once each of the four independent work groups completed the individual evaluations, the total success score and risk score for each alternative was calculated.

The alternative with the highest success score and the lowest risk score is likely to be the preferred alternative. The preferred alternative would also be required to provide enhanced resiliency from (1) wildfires, (2) seismic events, (3) landslides, and (4) debris flows.

The results for each alternative is included below:

- Alternative 1 was found to have a success score of 156, a risk score of 25.6, and only provided resiliency against seismic and landslide events.

- Alternative 2 was found to have a success score of 130, a risk score of 27.1, and only provided resiliency against wildfire events.
- Alternative 3A was found to have a success score of 156, a risk score of 21.8, and provided resiliency against wildfire, seismic, and landslides.
- Alternative 3B was found to have a success score of 162, a risk score of 20.1, and provided resiliency against all four anticipated natural disaster events.
- Alternative 4A was found to have a success score of 155, a risk score of 27.3, and provided resiliency against all four anticipated natural disaster events.
- Alternative 4B was found to have a success score of 153, a risk score of 25.3, and provided resiliency against all four anticipated natural disaster events.
- Alternative 5 was found to have a success score of 153, a risk score of 27.3, and provided resiliency against all four anticipated natural disaster events.

Based on the success and risk factor scoring as well as the ability to provide enhanced resiliency, Alternative 3B was identified as the preferred alternative.

1.7 Hydropower Opportunities

The existing 5-Mile Pipeline conveyance system operates under pressures above 200 pounds per square inch (psi) at the Lyon Surface Water Treatment Plant. The F&L Team performed a hydraulic feasibility evaluation to identify the potential for hydropower available from the head in the 5-Mile Pipeline. The potential use of a commercially available product that utilizes a pressure recovery valve (PRV) and referred to as “microhydropower” was reviewed. Other hydropower options may also be available.

The F&L Team contacted InPipe Energy, the manufacturer of the In-PRV to determine feasibility of energy recovery from the pipeline flow. The manufacturer identified an In-PRV system that can be installed in parallel with the existing pressure reducing valve to recover the energy previously lost at the pressure reducing valve during normal operations. The preliminary estimate of power generated may be 10 kilowatts (kW) to 20 kW, depending on actual flows in the system.

2 Introduction

2.1 Background

The San Lorenzo Valley Water District (District) is an urban water supplier established in 1941 and serves several communities within the 136 square-mile San Lorenzo River watershed. The District serves a population of approximately 21,920 through approximately 7,900 connections. The District owns, operates, and maintains two water systems that include the San Lorenzo Valley Water District (SLVWD) and the San Lorenzo Valley Water District – Felton (SLVWD-Felton). The Cross Country Pipeline Constructability Study (Study) will focus on restoring the raw water conveyance system that serves the SLVWD system.

The SLVWD system water supply consists of surface water diversions and cross country pipeline to convey water to the Lyon Surface Water Treatment Plant. During months of low-flow, the SLVWD surface water supply is supplemented by blending with three groundwater sources. Surface water is supplied from Peavine, Silver, Foreman, Clear, and Sweetwater Creeks from a total of seven diversion points. The raw water conveyance pipeline consists of two branches; Peavine (northern) and 5-Mile (southern). Both cross country pipelines consisted of 6-inch and 8-inch high density polyethylene (HDPE) pipe that was laid on an approximate 2-foot bench and, in some locations, free-standing wooden trestles. The original alignment of both branches, locations of the seven active diversion points, and the location of the Lyon Surface Water Treatment Plant is shown on Figure 1.

2.2 Study Purpose

The CZU fire resulted in extensive damage to the San Lorenzo River watershed with significant impacts to the District's facilities. In addition to the complete loss of the Peavine and 5-Mile segments, the HDPE pipe melted releasing smoke containing volatile organic compounds (VOCs) that were ultimately conveyed into the existing distribution system.

The Peavine and 5-Mile segments must be reconstructed to restore the critical surface water supply for the SLVWD system. The District is considering several strategies for replacement of the cross country pipeline including:

1. Replace in kind with new 8-inch diameter HDPE pipeline above grade along the same alignment;
2. Replace with new 8-inch pipeline with alternative pipeline materials above grade along the same alignment;
3. Replace with new 8-inch pipeline with HDPE or other suitable material below grade in a shallow trench; and
4. Replace with new 8-inch pipeline with HDPE or other suitable material along an alternative alignment.

The goal of the Study is not to just confirm the preferred approach to restore the cross country pipeline system but to learn from the CZU experiences, identify potential long-term environmental changes that may cause an increased risk of loss, and develop enhanced design criteria to improve the overall resiliency and reliability of the District's critical infrastructure. The potential reoccurrence of pipeline loss may also result in both short and long term impacts to multiple District facilities including storage and treatment components.

The Study focuses on key questions that will influence the evaluation by considering the potential risks and mitigation strategies through the alternative evaluation resulting a preferred solution. By identifying key questions, the engineering evaluation and study can be focused on critical risk items that will have the largest influence on the preferred alternative selection process.

Key questions identified during the Study development include:

- How significant was the CZU Fire Event and how can lessons learned improve the overall resiliency of the restored system?
- Should the Peavine and 5-Mile Segments be replaced in-kind?
- What are the environmental risks the District should be concerned with?

The alternative evaluation requires that the F&L Team determine the potential effects of numerous environmental factors in addition to pipe material selection and constructability challenges on the long term effectiveness and operations of the District's water system. A goals based risk assessment is utilized to compare each alternative in addressing the numerous environmental risk factors, constructability, safety, and operational considerations to determine the most effective project alternative.

The goals based risk assessment process involves establishing design criteria goals for a successful project developed in coordination with the District including long term water supply resiliency, effective pipeline operations and maintenance, construction and maintenance cost, and quickly restoring operational capacity. For each design criteria goal, potential risks are identified for use in evaluating each alternative identified including, but not limited to:

- Watershed protection measures required for different types of construction
- Geological considerations
- Debris flow and flood risk
- Biological resources and other environmental factors
- Risk of catastrophic natural events such as fire, mud flows, and seismic activity

For each alternative, the risk factors are reviewed and assigned numeric scores based on the risk presented by each factor and the consequence that each risk factor would have on achieving the goals. In this context, risk is defined as the potential that an event will occur within the lifetime of the project and consequence is defined as the potential effect that an event might have on the project goal (water supply resiliency, operations and maintenance, etc.). Multiplying the numerically defined values of risk and consequence provides a numeric value rating how well each alternative achieves each project goal. The numeric values can be weighted or unweighted based on the relative importance of each goal and can be used to develop a final numeric score to select the preferred project alternative. The work product provided by this task will be a brief memo with tabular results of the risk-based alternatives evaluation results.

2.3 Project Team

The project team includes multiple firms to provide a multidisciplinary team to support the District to complete the Study to select the preferred alignment. The project team includes:

- Freyer & Laureta, Inc. (F&L) serves as the lead team member providing civil engineering and pipeline engineering;
- WRA Environmental Consultants (WRA) provides environmental and permitting support.
- Cal Engineering & Geology, Inc. (CE&G) provides geotechnical support.

- Alpine Development (Alpine) provides pipeline constructability and cost estimating support.
- Advanced Hydro Engineering (AHE) provides hydraulics support.

The F&L Team collaborated with the District throughout the development of the Study including development of the goals and objectives, success criteria, risk factor, alternative development, and alternative ranking to select the preferred alternative.

2.4 Study Structure

The following tasks were conducted as part of this Study:

- Performed site reconnaissance of the existing Peavine and 5-Mile segments.
- Interviewed District staff to document historical operating conditions, desired operational modifications, actions taken immediately following the CZU fire, and key technical and non-technical constraints.
- Collaborated with the District staff to develop Goal Statements including identifying success and risk factors to support the risk based goals assessment.
- Evaluated potential pipeline materials and alignments.
- Performed a geological hazards analysis.
- Delineated potential environmental concerns.
- Reviewed constructability considerations.
- Developed potential alternatives.
- Performed risk based assessment to identify the preferred alternative.

A summary of each section is provided below:

- Section 1: Executive Summary
- Section 2: Introduction including key background information, Study purpose, identify the project team, and summarize the report structure.
- Section 3: Existing Conditions and Site Constraints to document observations from the site reconnaissance, present the Jurisdictional Assessment, and describe the geologic conditions.
- Section 4: Goals Based Risk Assessment describes the process followed by the F&L Team and District staff to establish Goal Statements, success factors, and risk factors including scoring metrics.
- Section 5: Project Components documents the technical evaluation performed to identify pipe materials, construction methods, installation methods including minimum cover depth, and alignment considerations to support the development of potential alternatives.
- Section 6: Alternative Descriptions presenting the seven alternatives developed to meet the overall District goals documented in the Goal Statements.
- Section 7: Alternatives Evaluation and Recommendation that documents the success factor scoring, risk factor scoring, and resulting recommended alternative to be

advanced for California Environmental Quality Act (CEQA) evaluation, permitting, design, and construction.

- Section 8: Hydropower Opportunities that documents the potential energy that could be produced by the restored Peavine and 5-Mile segments for the beneficial use of the District.
- Section 9: Opinion of Probable Project Cost that presents the estimated planning, permitting, design, and construction costs for the recommended alternative identified in Section 7.
- Section 10: Next Steps presents the F&L Team's suggested project sequence to advance the preferred alternative into the next project phase.
- Section 11: References presents key references used in the development of the Study.

3 Existing Conditions and Constraints

The Peavine and 5-Mile segments were routed through existing watershed over varying terrain. The original pipeline installation was completed in a manner to minimize site disturbance and the use of heavy construction equipment. Site visits and document studies were completed to evaluate the existing conditions and identify potential constraints to consider when developing potential alternatives to reconstruct the cross country pipeline system.

3.1 Site Conditions

Site walks were performed in August 2021 to document the existing condition of the cross country pipeline alignment. The goals of the site reconnaissance included:

- Document existing conditions such as existing slopes, bench widths, and potential construction access points;
- Identify potential alternative alignments to be further evaluated as part of the Study;
- Observe fire damage and debris field from the CZU fire including upslope areas that may contribute to future debris flows; and
- Map existing conditions to support jurisdictional and geotechnical assessments.

Appendix A includes select photos from the site walks. The following is a brief summary of the existing conditions observed during the site walk:

- The Peavine segment was found to have wider benches throughout a majority of the alignment.
- The 5-Mile segment was found to have the narrowest benches but there was wide variability in the width of the existing bench.
- Both segments were found to have areas of debris but the 5-Mile segment was found to have the largest accumulation of debris as well as upslope forest damage that may pose long-term risk of tree falls, debris flows, and landslides that could impact the restored pipeline.
- The existing slopes along large portions of the 5-Mile segment were found 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.
- Access to both segments is limited without temporary roads being constructed to facilitate future pipeline installation efforts.

The result of the site walk 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 alignments to potentially reduce the overall length of the pipeline following a similar pathway were not identified, although, significant rerouting of the 5-Mile pipeline may be feasible. The review of potential alignments is further described in Section 5.4.

3.2 Jurisdictional Assessment

Following the site walk, an environmental assessment was completed to identify potential constraints that may impact the overall permitting and constructability of the proposed Project improvements. A copy of the Jurisdictional Assessment is included in Appendix B and includes identification of habitats encountered and potential habitats that may support special status plant and wildlife species.

In summary, the assessment 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;
- Nesting birds could limit the time of year for construction activities or result in unanticipated delays; and
- Forest and habitat removal to facilitate construction must be sequenced in a manner to reduce risk for construction delays.

The Jurisdictional Assessment included in Appendix B includes a table summarizing the relevant regulatory agencies, anticipated permits, activities triggering the identified regulatory agency's permitting process, and jurisdictional limits. The goals based risk assessment further described in Section 4 will consider the potential environmental constraints when developing both success and risk criteria.

3.3 Geotechnical Assessment

A geotechnical assessment was performed to support the Study and a copy is included in Appendix C. The geotechnical assessment scope included:

- Review of published soil and geologic maps;
- Geologic site reconnaissance;
- Desktop geomorphic mapping along the pipeline alignment segments, using a detailed Light Detection and Ranging (LiDAR) derived topographic base map;
- Preliminary engineering evaluation; and
- Development of grading and erosion control mitigation measures.

The geotechnical study includes a detailed summary of the geotechnical conditions and requirements to be considered when developing the design including for both pipeline installation and retaining structures. Potential geological hazards such as landslides, liquefaction potential, and ground shaking are evaluated including recommended design criteria.

In summary, the geotechnical study includes the following observations and recommendations:

- The potential for seismically induced liquefaction and densification along the existing cross country pipelines alignment is low.
- Portions of the existing alignment may be subject to active landslide features that generally occur within the upper colluvium.
- Earth retaining structures to facilitate construction of the replacement pipeline will stabilize locally the bench for purposes of the protecting the new pipeline.
- Excavations are anticipated to only require conventional excavating equipment such as backhoes and excavators.

Additional geotechnical field investigations are recommended when proceeding with the design of the preferred alternative.

4 Goals Based Risk Assessment

The F&L Team and District followed a goals based risk assessment approach to:

- Establish up to four project goal categories including supporting statements that guide the development of alternatives to support the goal categories.
- Develop success and risk criteria for each project goal to allow ranking of each potential alternative's probability to achieve the stated goal as well as the potential risk factors that could adversely impact an alternative's ability to meet the project goal.
- Establish success and risk criteria scoring approach to facilitate evaluation and ranking of each alternatives.

A series of workshops attended by the F&L Team and District were held including individual work groups consisting of both technical team members and District staff. The value of the goals based risk assessment approach includes:

- Establishes the value and risks for an alternative;
- Documents decision making process; and
- Supports alternatives analysis for environmental processes

The following sections summarizes the results of the assessment process followed by the District and F&L Team.

4.1 Goal Statements

The assessment approach followed by the team first established key areas that best describe the potential goals for the Project. Once the goals are established, the work group can identify potential success and risk factors that can be used to evaluate an alternative's ability to deliver a successful project while minimizing potential risks. The District and F&L Team identified the four key areas that will result in a successful project including:

- Safety;
- Constructability;
- Operations & Maintenance, and;
- Stakeholder Impact.

Individual working groups consisting of at least one District staff member and up to three F&L Team members utilized the key areas to develop goal statements, which provide guidance for development of potential alternatives. The goal statements developed by the work groups are presented in Table 1.

Once the goal statements were established, the work groups proceeded with development of success and risk factors as further described in the following sections.

4.2 Success Factors

The work groups developed metrics to facilitate evaluation and ranking of how each alternative can meet the success criteria. Each alternative will have different potential for meeting the established success metric. For each of the metrics identified, the work groups developed metrics to allow for each alternative to be ranked on scale of one to 10 to identify each alternatives effectiveness to meet each metric. By establishing a range of success factors and metrics, the work groups are able to effectively evaluate each alternatives ability to meet the established goal statements.

Table 2 includes a summary of the success coarse criteria and metric developed for each goal to establish the methodology to be used when evaluating each alternative.

4.3 Risk Factors

The work groups also identified potential risk factors to allow for the team to evaluate the potential components of an alternative that may limit the alternatives ability to deliver a successful project. The risk factors identified separate metrics that would adversely impact an alternatives ability to meet the established goals.

For example, hardening of the pipeline system can lead to increased operation and maintenance costs. The risk is established by identifying the probability on a scale of 10% to 100% that a risk factor may occur. The probability is then multiplied by a weighted consequence factor on a scale of one to five where a one is minimal impact and five is a significant impact to establish a risk score.

Table 3 includes a summary of the risk coarse criteria and metric developed for each goal to establish the methodology to be used when evaluating each alternative.

5 Project Components

Before developing potential alternatives, the F&L Team reviewed key project components including:

- Pipeline Material
- Construction Methods
- Installation Methods
- Potential Alignments

The purpose of the individual project components review was to develop the preferred project components for consideration when developing potential alternatives. The key project components listed above presented a wide range of options for consideration and the F&L Team identified a preferred subset for each component that would provide the best opportunity to achieve the Goal Statements described in Section 4.1. By creating a focused menu of project components, the F&L Team has the most flexibility to develop potential alternatives that consider the varying considerations associated with each Goal Statement.

The following sections document the key project components including the initial evaluation that was performed to identify the preferred materials, methods, and alignment that was then used to develop the potential alternatives discussed in further detail in Section 6.

5.1 Pipeline Materials

As discussed in Section 2.1, the original cross country pipeline segments utilized HDPE laid on the ground surface of varying width benches that was constructed primarily by hand. The benefit of the HDPE material was that the inherent flexibility allowed installation within a variety of conditions including uneven terrain and large radii to install the pipeline along a consistent slope. Once constructed, the HDPE provided resiliency from tree falls and debris that would impact the pipeline. Based on discussions with District staff, the original pipeline was extremely reliable with minimal periods of significant flow disruption. In fact, raw water flows would typically only be reduced if a tree or other debris fell on the HDPE pipe that may cause partial compression until District staff removed the tree or other debris thereby allowing the pipeline to return to its original diameter and shape.

The largest risk to long-term, reliable operation of a HDPE pipeline installed at grade is fire. The CZU fire completely destroyed both the Peavine and 5-Mile segments resulting in an immediate loss of the critical raw water conveyance system. The construction and operational flexibility afforded to the District by HDPE must be balanced with the long-term risk of damage due to any number of natural disasters including fire, landslides, and seismic events.

The common pipeline materials used for raw water conveyance systems include:

- HPDE;
- Polyvinyl Chloride (PVC);
- Ductile Iron (DI), and;
- Welded Steel (WS).

The District typically utilizes DI pipe for most of its transmission and distribution system but does allow use of alternative pipeline materials for raw water conveyance system based on the proposed alignment and installation conditions. The F&L Team reviewed the potential use of both plastic and metal pipe materials although the metal pipe materials would be more fire resistance because long-term resiliency is only one consideration of many necessary to develop the preferred alternative. The preferred pipe material will also influence the selection of the remaining key project components to provide the largest number of options for developing several alternatives for further consideration and evaluation.

When comparing each of the four pipe materials considered, key metrics to compare each material include:

- Fire resistivity including potential risk of loss due to a fire similar to the CZU event;
- Installation flexibility including equipment requirements;
- Operational reliability by minimizing potential for leaks or damage from tree, debris, and landslide within the alignment, and;
- Long-term maintenance requirements.

Table 4 includes a summary of pros and cons for each of the four pipeline materials considered for use in reconstructing the Peavine and 5-Mile segments. When comparing the pros and cons for each pipe material, only HDPE and WS were selected to be considered when developing potential alternatives. PVC did not provide any advantages over HDPE that warranted being advanced to the alternatives development phase. Similarly, DI was found to be less resilient to fire when compared to WS because of the potential for gaskets to melt based on experience with the CZU fire.

5.2 Construction Methods

The Jurisdictional Assessment (see Section 3.2) identified several potential environmental constraints to consider when developing potential alternatives. Generally, pipeline construction regardless of whether standard open trench or trenchless methods are utilized result in short-term impacts within the work limits. The existing cross country pipeline alignments cross through largely natural watershed and include a number of stream crossings. In addition, the highly variable ground conditions combined with significant elevation change over the length of the two segments with limited access points require a comprehensive review of the most suitable potential construction methods.

The potential construction methods considered include:

- Standard methods include:
  - Open trench using conventional construction equipment such as backhoes and excavators, and
  - Above ground also using conventional equipment.
- Trenchless methods include:
  - Bore and jack that requires a launch and receiving pit to facilitate tunneling to install a casing for the pipe;
  - Horizontal directional drilling (HDD) also requires a launch and receiving pit to directly install the primary pipe but requires additional equipment to handle drilling mud and other waste from the drilling process, and;
  - Microtunneling is similar to bore and jack method but the horizontal and vertical alignment can be adjusted and the method is more commonly used for smaller

pipe diameters such as the pipe being considered for the cross country pipeline reconstruction.

Following the F&L Team's site visit (see Section 3.1), it was determined that large scale use of any one of the trenchless methods described above is likely not feasible for several reasons including:

- Limited Access: As noted in previous sections, the portions of the alignment within the watershed have limited access, which will impact a contractor's ability to mobilize the equipment needed for each trenchless method.
- Potential Waste Stream Handling: All methods generate spoils and/or mud as a result of the tunneling work requiring handling of the waste stream including potentially having to off haul and dispose of the spoils or mud outside of the project limits at an acceptable disposal facility.
- Space Requirements: All three methods, but in particular HDD, require large, relatively flat areas to facilitate casing and pipeline installation but the existing topography within the watershed would require significant site preparation work to construct, even on a temporary basis, the flat areas required to utilize any trenchless methods efficiently and effectively.

Based on the potential significant constraints described above, the F&L Team determined that the alternatives developed will consider using primarily open trench and above ground installation methods for purposes of the alternative evaluation and ranking. However, once the preferred alternative is selected and the design phase is initiated, the F&L Team will perform a second feasibility evaluation of potential limited use of trenchless methods for particularly sensitive locations such as creek crossings if there will be a potential benefit to reduce the overall temporary impacts anticipated as a result of the pipeline construction.

5.3 Installation Methods

The potential pipe installation includes both above-ground and buried conditions. By limiting pipe material choices to HDPE and WS, the potential installation methods for each pipe material can also be preliminary evaluated to determine if there is only a subset of techniques to consider as part of the alternative development process. The relative resilience to natural disasters including fire, landslides, debris flows, and seismic events influence the potential installation methods for both pipe materials. Generally, HDPE would be expected to perform better during and immediately following landslides, debris flows, and seismic events but the potential damage from a fire warrants additional hardening steps. In comparison, WS pipe is expected to be resilient to a fire but the fixed, welded joints and rigid pipe material could impact the overall reliability of pipeline following any other natural disaster that could displace or damage the WS pipe.

Both HDPE and welded steel could be installed above grade. There are numerous challenges with above grade installation in particular with welded steel, which is heavy requiring larger equipment and the welding equipment needs will introduce additional construction and long-term maintenance challenges. For buried installation, only HDPE is considered because our observations of the existing pipeline system was that portions of the pipelines that were buried generally survived the CZU fire. Heat protection can be achieved through shallow cover and the additional fire hardening provided from welded steel in the above ground installation did not warrant considering burying welded steel.

In order to determine the minimum cover depth to provide additional fire hardening measures for the HDPE pipe, the properties of HDPE pipe were reviewed to identify the potential melting point. A copy of the Safety Data Sheet (SDS) from Performance Pipe is included in Appendix D and provides the estimated melting point for HDPE is 482-degrees Fahrenheit. The SDS does not provide documentation when temperatures would be sufficiently elevated to cause the HDPE material to begin off gassing VOCs but information provided by the resin manufacturer indicates that smoke resulting in potential release of VOCs and hydrocarbons occurs at a temperature range between 400 degrees Fahrenheit and 450 degrees Fahrenheit[1].

The potential risk of heat penetration depth from a fire similar to the CZU event must be quantified both for potential to melt HDPE pipe but also for elevating temperatures sufficiently that may result in creating off gassing of the pipe material thereby introducing VOCs and hydrocarbons into the conveyance system. The F&L Team performed a desktop study of available literature evaluating the relative heat penetration depth that could be expected from a forest fire. A detailed summary of the desktop study is included in Appendix E and the key points are summarized below:

- Most research suggests that heat temperature increase in soil from fires does not extend very deep into the soil due to the soil's poor thermal conductivity.
- Generally, maximum measured temperature in soil decreased exponentially with greater depth and, in fact, the increased temperature was limited at depths as shallow as 12-inches.
- Continuous burning of debris and other combustible material that may accumulate on the forest floor after the initial fire event can lead to continuous heat affect over time.
- The moisture content of the soil can significantly reduce the risk of heat increase due to fire.

Table 5 presents the estimated temperature at varying depths as found in a study completed to model the potential heat penetration depth during a controlled burn (Massman, 2004). As noted, the estimated soil temperature from a surface fire is predicated to drop below 400 degrees Fahrenheit at depths greater than 4 inches. In fact, soil temperatures are predicted to be below 200 degrees Fahrenheit at depths in excess of 12-inches.

The F&L Team proposes that the minimum bury depth for HDPE pipe be 18-inches. Figure 2 plots the estimated temperature at varying depths presented in Table 5 and shows that the predicated temperature a depth of 18-inches is far below the temperature when polyethylene resin is predicated to begin smoking and off gassing. In fact, Table 5 lists 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.

The proposed installation methods for both below grade and above grade options including crossing of existing creeks is shown on Figure 3. The individual installation details shown on Figure 3 will be considered in the development of each of the potential alternatives further discussed in Section 6.

[1] Telephone conversation between Sean Chou of Freyer & Laureta, Inc. and a technical representative from Chevron Phillips Chemical Company, LP, who is listed as the manufacturer of the resin used by Performance Pipe for the provided SDS included in Appendix D.

The installation details also identify the potential need for earth retaining structures depending on the existing topography for the selected alignment. The earth retaining structures are anticipated to utilize either a soldier pile and wood lagging system or pre-engineered systems such as Hilfiker Retaining Wall using welded wire or a mechanically stabilized earth (MSE) wall such as the TENSAR ARES Retaining Wall System. The F&L team's intent is to utilized pre-engineered systems whenever feasible because the materials handling constraints would be minimized when compared to the soldier pile and wood lagging structures. The preliminary design effort will allow the design team to select the most appropriate earth retainage system based on site conditions.

Sample product information both for the Hilfiker and TENSAR systems are included in Appendix F. A California Department of Transportation (CalTrans) standard detail for a solider pile and wood lagging wall is also included in Appendix F.

5.4 Alignment

In order to increase resiliency of the District's raw water conveyance system, the F&L Team did consider potential alternative alignments to reduce the overall length of the cross country pipeline within the watershed. By considering alignments that vary from the current Peavine and 5-Mile segment alignments, the alternative alignments would result in requiring raw water pump stations or a second treatment plant to supplement the Lyon Surface Water Treatment Plant. In fact, the District reported that during the original construction of the HDPE cross country pipeline system that it had considered the feasibility of a second treatment plant instead of constructing the 5-Mile segment.

Based on review of the existing alignments and the potential additional facilities that may be required, the F&L Team and District agreed that the Peavine segment would not be a good candidate for considering alternative alignments. However, the 5-Mile segment should be evaluated to determine if reducing the overall length of the segment would be more beneficial even if a pump station or second water treatment facility were required in order to provide a more resilient and reliable system.

6 Alternative Descriptions

A total of seven potential alternatives were developed in order to balance the potential successes and risk for each alternative to deliver a project that is consistent the Goal Statements described in Section 4. The potential alternatives were identified by selecting from each of the key project component options discussed in Section 5. However, the alternatives development process did determine that there are key project features that will be consistent between all seven alternatives. The key features that are common to all alternatives are:

- All five creek diversions (intakes) along the cross country pipeline that were functional at the time of the CZU fire will be restored and are shown on Figure 1[2].
- The Peavine segment was found during the existing conditions assessment to already have reasonably wide benches and less debris than the 5-Mile segment. The Peavine segment can largely be restored along the existing alignment and therefore alternative alignments for the Peavine segment were not considered.
- Regardless of the alternative selected, tree removal and site preparation to facilitate pipeline construction will be completed as a separate first phase resulting in the most substantive potential environmental impacts that would be common to all alternatives although the relative impact from restoring within existing alignments as compared to new alignments is considered as part of the success and risk factors described in Section 4.

Each of the seven alternatives identified for evaluation are presented in the following sections.

6.1 Alternative 1

The first alternative was limited to restore the entirety of the cross country pipeline system within the same alignment only using above ground HDPE. The importance of evaluating the pre-CZU fire project is that it helps establish a baseline for comparing the remaining alternatives. Figure 4 provides an overview of Alternative 1 including key project information such as potential installation details, creek cross approach, and approximate pipeline length.

The key components of Alternative 1 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.

The total length of pipe to be installed is approximately 40,000 linear feet (lf).

6.2 Alternative 2

The second alternative is similar to Alternative 1 but uses WS pipe instead of HDPE. Figure 5 provides an overview of Alternative 2. The key components of Alternative 2 are :

[2] A total of seven creek diversions are shown on Figure 1 because the Foreman Intake is part of the complete raw water conveyance system that supplies the Lyon Water Treatment Plant. However, the Foreman Intake has been previously restored and is not considered part of the Cross Country Pipeline Constructability Study scope.

- The minimum bench width will be much wider than Alternative 1 because the equipment required to transport and install WS pipe is significantly larger than what is required for HDPE pipe.
- Welding required to join each pipe stick will increase the overall duration of construction as well as result in an elevated fire risk when compared to the butt-fusion process for joining sticks of HPDE.
- As a result of the wider benches, there is a high potential for extensive use of retaining structures in particular along the 5-Mile segment due to the existing steep terrain.
- More access points will likely be required to facilitate construction because the delivery equipment may be limited in the grade of access roads.
- All stream crossings will be above grade similar to Alternative 1.

The total length of pipe to be installed is approximately 40,000 lf.

6.3 Alternative 3A

The third alternative will follow the existing alignment similar to Alternative 1 and Alternative 2 but installs HDPE pipe in a shallow trench. Alternative 3A utilizes above grade creek crossings while Alternative 3B utilizes below grade creek crossings. Figure 6 provides an overview of Alternative 3A. The key components of Alternative 3A are :

- The minimum bench width will likely be between the widths for Alternative 1 and Alternative 2 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 above grade using WS pipe.
- The total number of access points will be similar to Alternative 1.

The total length of pipe to be installed is approximately 40,000 lf.

6.4 Alternative 3B

The fourth alternative will follow the existing alignment similar to Alternative 1 and Alternative 2 but installs HDPE pipe in a shallow trench and Alternative 3B utilizes below grade creek crossings. Figure 7 provides an overview of Alternative 3B. The key components of Alternative 3B are :

- The minimum bench width will likely be between the widths for Alternative 1 and Alternative 2 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 below grade creek using HDPE pipe and creek crossings may be constructed using trenchless methods.
- The total number of access points will be similar to Alternative 1.

The total length of pipe to be installed for is approximately 36,100 lf.

6.5 Alternative 4A

The fifth alternative will follow the existing alignment for the Peavine segment but alternative routing for the 5-Mile segment to reduce the overall length of pipe within the watershed. However, Alternative 4A results in addition of pump stations and construction of pipeline potentially with the California Department of Transportation (CalTrans) right of way. Figure 8 provides an overview of Alternative 4A. The key components of Alternative 4A are :

- The minimum bench width will be similar to Alternative 3A.
- 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 below grade creek using HDPE pipe and creek crossings may be constructed using trenchless methods.
- The Sweetwater Intake will have a dedicated pipeline and pump station.
- The four Clear Creek intakes will share a common, dedicated pipeline and pump station.
- The two pump stations will pump into a common transmission main to convey water to the Lyon Surface Water Treatment Plant.

The total length of pipe to be installed for is approximately 43,000 lf but reduces the total length of pipeline in the watershed from approximately 40,000 lf to approximately 20,000 lf.

6.6 Alternative 4B

The sixth alternative will follow the existing alignment for the Peavine segment and a large portion of the existing 5-Mile segment but does still reduce the overall length of pipe within the watershed. Similar to Alternative 4A, Alternative 4B does require a pump station and new pipe to be installed with CalTrans right of way. Figure 9 provides an overview of Alternative 4B. The key components of Alternative 4B are :

- The minimum bench width will be similar to Alternative 3A.
- 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 below grade creek using HDPE pipe and creek crossings may be constructed using trenchless methods.
- The Sweetwater Intake and four Clear Creek intakes will share a common, dedicated pipeline and pump station.
- The pump station will convey water to the Lyon Surface Water Treatment Plant.

The total length of pipe to be installed for is approximately 43,000 lf but reduces the total length of pipeline in the watershed from approximately 40,000 lf to approximately 22,000 lf.

6.7 Alternative 5

The seventh alternative will follow the existing alignment for the Peavine segment and the same new 5-Mile segment from Alternative 4B. Instead of a new pump station to convey raw water to the Lyon Surface Water Treatment Plant, a new package water treatment plant would be constructed adjacent to Highway 9 at a location to be determined if Alternative 5 is determined to be the preferred alternative. Similar to Alternative 4A and Alternative 4B, new pipe will be installed with CalTrans right of way in order to convey treated water into the existing distribution system. Figure 10 provides an overview of Alternative 5. The key components of Alternative 5 are :

- The minimum bench width will be similar to Alternative 3A.
- 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 below grade creek using HDPE pipe and creek crossings may be constructed using trenchless methods.
- The Sweetwater Intake and four Clear Creek intakes will share a common, dedicated pipeline and pump station.
- The new water treatment plant will be located south of Boulder Creek likely adjacent to the CalTrans right of way.
- Treated water will be pumped north from the treatment plant location to the existing distribution system at a point within Boulder Creek to allow for wider distribution of the treated water.

The total length of pipe to be installed for is approximately 41,000 lf but reduces the total length of pipeline in the watershed from approximately 40,000 lf to approximately 22,000 lf.

7 Alternatives Evaluation and Recommendation

As discussed in Section 4, the work groups developed both success factors and risk factors with metrics to facilitate evaluation of the proposed alternatives. The following sections provide an overview of the success factor and risk factor evaluation including identifying the recommended alternative.

7.1 Success and Risk Factors Ratings

The work groups performed independent review of each of the seven alternatives identified in Section 6. For example, the Safety work group only evaluated each alternative's ability to meet the Goal Statement while minimizing potential risks. Once each of the four independent work groups completed the individual evaluations, the total success score and risk score for each alternative was calculated.

The success criteria and risk criteria was performed as follows:

- Success Criteria Evaluation:
  - Metric communicates how the group developed the score and is scored on a scale relevant to the criteria.
  - Score is on a one to 10 scale with one being the alternative is least likely to meet the stated success metric and 10 being the alternative is most likely to meet the stated success metric.
- Risk Criteria Evaluation:
  - Probability is how likely that an event will occur or that the risk will be realized on a scale with 10% being the risk is improbable for the alternative and 100% is certain to occur.
  - Consequence is the effect to the project if the risk occurs on a one to five scale with one being no substantial impact and five being major system failure.
  - Risk score is calculated by multiplying the Probability by the Consequence.

Table 6 presents the results of the Success Factor Scoring and Table 7 presents the results of the Risk Factor Scoring. The two scoring tables include a brief summary of the determination made by the individual work groups to establish the scoring presented in Table 6 and Table 7.

7.2 Evaluation Summary and Recommended Alternative

The success and risk factor evaluation determined that Alternative 3B is the preferred alternative. Figure 11 presents that comparison of each alternatives relative success and risk score. Table 8 summarizes the total success and risk factor score for each of the alternatives and the individual alternatives ability to provide enhanced natural disaster resiliency.

Alternative 3B provides the greatest opportunity to deliver a project that meets the Goal Statements presented in Section 4.1 while improving the overall resiliency of the restored raw water conveyance system when compared to the original configuration represented by Alternative 1.

8 Hydropower Opportunities

The existing 5-Mile Pipeline conveyance system operates under pressures above 200 pounds per square inch (psi) at the Lyon Surface Water Treatment Plant. The F&L Team performed a hydraulic feasibility evaluation to identify the potential for hydropower available from the head in the 5-Mile Pipeline. Using previous hydraulic calculations for the 5-Mile Pipeline, a design head of 250 feet and a flow rate of 500 gallons per minute (gpm) was selected for the initial feasibility review. The potential use of a commercially available product that utilizes a pressure recovery valve (PRV) and referred to as “microhydropower” was reviewed. Other hydropower options may also be available.

The F&L Team contacted InPipe Energy, the manufacturer of the In-PRV to determine feasibility of energy recovery from the pipeline flow. The manufacturer identified an In-PRV system that can be installed in parallel with the existing pressure reducing valve to recover the energy previously lost at the pressure reducing valve during normal operations. The preliminary estimate of power generated may be 10 kilowatts (kW) to 20 kW, depending on actual flows in the system.

The manufacturer also noted that State grants are available for the proposed equipment that may cover or significantly reduce the cost of the installation. Alternatively, the equipment may be financed through a manufacturer program that would include installation of the equipment at no cost with the agreement by the District to purchase the generated power at a reduced rate for a defined period.

The next step is the preliminary design of the In-PRV system and identification of other potential hydropower system options for comparison. The Peavine segment should also be reviewed for a potential hydropower installation. For the preliminary design of the system, the historical range of monthly flows at each intake on the supply pipelines must be developed to better assess the estimated power generation capability throughout the year. The manufacturers will develop systems that are appropriate for the anticipated range of flows based on the historic intake flow rates. This will provide more specific values of energy production available from the District water supply systems and allow development of preliminary cost estimates.

9 Opinion of Probable Project Cost

As discussed in Section 7.2, the recommended Alternative 3B provides the greatest opportunity to deliver a project that meets the project goal statements. The following section provides an opinion of probable project cost for Alternative 3B. Total break down of the opinion of probable cost including a detailed narrative can be found in the Appendix H and a summary level presentation of the potential cost range is presented in Table 9.

The opinion of probable cost was calculated using HCSS HeavyBid Software. The F&L team was able to develop a resource loaded estimate that details all major cost components including materials, labor, equipment, subcontractors, and schedule. All estimations are in 2022 US Dollar. Major assumptions are outlined in Appendix H Class 4 – Opinion of Probable Construction Cost. As noted in Appendix H, it is assumed that the existing intake facilities have been cleaned and rehabbed. It is also 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. The intent is to install all creek crossings as below grade crossings.

The opinion of probable cost was calculated twice to insure a low and high range of cost. Each estimate was further divided into three main categories the Five Mile segment, the Peavine segment, and the hydropower cost.

The following is a summary of the estimation on the more conservative side:

- The Five Mile segment - $49,100,000
- The Peavine segment - $12,540,000
- The hydropower cost – $1,034,000

Alternatively, the following is the opinion of probable cost on the lower range:

- The Five Mile segment - $42,110,000
- The Peavine segment - $10,820,000
- The hydropower cost – $894,000

The numbers shown above and represented in Appendix H and Table 9 represent a Class 4 estimation. The next step in the project is the preliminary design phase in which the opinion of probable cost will be further refined.

10 Next Steps

Pending the District Board of Directors concurrence that Alternative 3B is the preferred alternative, the F&L Team suggests the following next steps:

- District and the F&L Team confirm the proposed implementation strategy to prioritize the reconstruction of the Peavine segment first followed by the 5-Mile segment.
- District to provide direction on the appropriate CEQA process and initiate the CEQA and permitting process.
- Initiate tree surveys beginning with the Peavine segment to develop the tree removal and clearing effort as the first phase of construction. The F&L Team has identified the approximate limits for the tree survey for the total project assuming a 200-foot wide area. The exact impacts will be quantified during the tree survey.
- Initiate final design for the cross country pipeline including provisions to complete the pipeline construction over multiple phases spanning up to three construction seasons.
- Consider potential alternative delivery methods for the cross country pipeline reconstruction effort.

11 References

Massman, 2004 *Effect of a controlled burn on the thermophysical properties of a dry soil using a new model of soil heat flow and a new high temperature heat flux sensor*, prepared by JM Frank and WJ Massman included the 2004 International Journal of Wildland Fire; 13, 427-442

TABLES

Table 1
Goal Statements
Cross Country Pipeline Constructability Analysis
San Lorenzo Valley Water District

Goal Category	Goal Statement
Safety	Implement a project that delivers the critical raw water supply system in a manner that establishes risk mitigation-based solutions for construction activities safety, long-term operations including maintenance and repairs, and hardening for changing environmental conditions.
Constructability	Develop a project that considers current construction practices and technology while leveraging opportunities to comply with anticipated regulatory requirements in a cost-efficient manner.
Operations & Maintenance	Build a project that optimizes the ease, accessibility for long-term operations and maintenance, while meeting established performance levels.
Stakeholder Impact	Account for the project's potential benefits and impacts to the community and environment, and the influence of those stakeholders on project feasibility.

Table 2
Success Factor Coarse Criteria and Metrics
Cross Country Pipeline Constructability Analysis
San Lorenzo Valley Water District

Success Category	Coarse Criteria	Metric Description
Safety	Emergency Medical Access	Construction site access and protocols to respond to emergencies.
		Ability to control public access to the alignment
		Operational access to the pipeline and intakes: ATV vs. Bike vs. Vehicle
	Natural Disaster Hardening	Level of protection provided against catastrophic fire
		Level of protection provided against disaster affecting discrete locations (tree falls, landslides, etc.)
		Level of redundancy to reduce risk of service outage in the event of another fire, catastrophic event, or major maintenance service.
Constructability	Buried vs. Above Ground Install	Relative level of difficulty to implement the pipeline resiliency strategy.
	Schedule - Construction Phasing	Ability to phase construction to avoid bird nesting season
	Reduce Construction Cost	Cost of materials and installation
		Cost of creating construction/operations access road
	Pipe Sections and Materials	Pipe material is conducive to construction given slope conditions
		Alternative allows for reducing the number of different Section Types
Operations & Maintenance	Accessibility	Long-term access to support ongoing O&M activities.
	O&M Cost	Labor/staffing, materials and training costs to operate new facilities.
	Schedule	Estimated construction time to full system operations
	Performance Levels	Pipe material ease of maintenance
		Gravity flow % of total linear footage vs. total linear footage of pressurized pipe (gravity is easier to maintain and operate)
	Hydroelectric Operations	Number & Location (less hydroelectric stations & making sure the location is easily accessible)
		Total potential energy generated

Success Factor Coarse Criteria and Metrics
Cross Country Pipeline Constructability Analysis
San Lorenzo Valley Water District

Success Category	Coarse Criteria	Metric Description
Stakeholder Impact	Public Acceptance	Level of disturbance to daily life during construction from truck trips, staging areas required, use of helicopters and similar equipment
		Construction impacts to forest (acres)
	Environmental	Estimated time to acquire regulatory permits
		Area of aquatic resources impacts
		Greenhouse Gas Emissions/Energy Use
		Potential to impact sensitive species
	Easements and Land Rights	Number of property owners involved in an alternative

Table 3
Risk Coarse Criteria
Cross Country Pipeline Constructability Analysis
San Lorenzo Valley Water District

Category	Coarse Criteria
Safety	Risk of long-term operational disruption due to catastrophic natural disaster (e.g., fire)
	Risk to O&M staff conducting condition assessment during an emergency.
	Risk of short term or partial operational disruption due to events such as landslide and tree falls
Constructability	Risk of major soil erosion or landslide event triggered by construction
	Risk of reduced or loss of FEMA funding
	Risk of long term pipe damage from slope or soil movement (non-disaster related)
	Risk of long term slope failure arising from construction induced changes to the landscape geotechnical conditions
	Risk of permitting requirements and potential utility conflicts impacting project cost.
Operations & Maintenance	Damage/Vandalism to the District owned facilities due to pathways allowing public accessibility
	Risk of pipe damage resulting from landslides, fire and other natural disasters
	Risk of rate escalation from increased O&M expenditures
Stakeholder Impact	Risk of red flags for board approval
	Risk of construction delays from cultural resources findings
	Potential opposition during CEQA
	Risk of habitat mitigation
	Risk of delays due to encroachment on property not owned by SLVWD

Table 4
Potential Pipeline Material Comparison
Cross Country Pipeline Constructability Analysis
San Lorenzo Valley Water District

	PVC	HDPE	Ductile Iron	Welded Steel
Pros	Lightweight	Flexible	Resistant to fire damage	Resistant to fire damage
	Push on joints and ability to use mechanical fittings	Lightweight	Strong compared to plastics	Strong compared to plastics
		Fused fittings		Welded joints
Cons	Rigid requiring multiple fittings	Susceptible to melting when above ground	Heavy equipment required for installation	Heavy equipment required for installation
	Susceptible to melting when above ground	Butt-fusion is weather dependent	Multiple fittings	Welding is weather dependent
	Gaskets susceptible to melting when above ground		Gaskets susceptible to melting when above ground	

Abbreviations
HDPE: High density polyethylene
PVC: Polyvinyl chloride

Table 5
Potential Maximum Soil Temperature at Varying Depth
Cross Country Pipeline Constructability Analysis
San Lorenzo Valley Water District

Soil Depth (inches)	Maximum Approximate Temperature (Degrees Fahrenheit)
0.8	752
2	653
3.9	437
11.8	176
19.7	131
53.5	68

Reference
Massman, WJ, Frank JM. 2004. “Effect of a controlled burn on the thermophysical properties of a dry soil using a new model of soil heat flow and a new high temperature heat flux sensor” International Journal of Wildland Fire; 2004, 13, 427-442. https://www.fs.fed.us/rm/pubs_other/rmrs_2004_massman_w001.pdf

Table 6
Success Factor Scoring (1)
Cross Country Pipeline Constructability Analysis
San Lorenzo Valley Water District

			Alternative 1:		Alternative 2:		Alternative 3A:		Alternative 3B:		Alternative 4A:		Alternative 4B:		Alternative 5:	
Category	**Coarse Criteria**	**Metric Description**	**Metric/ Rationale**	**Score (1-10; 1= bad; 10=good)**	**Metric/ Rationale**	**Score (1-10; 1= bad; 10=good)**	**Metric/ Rationale**	**Score (1-10; 1= bad; 10=good)**	**Metric/ Rationale**	**Score (1-10; 1= bad; 10=good)**	**Metric/ Rationale**	**Score (1-10; 1= bad; 10=good)**	**Metric/ Rationale**	**Score (1-10; 1= bad; 10=good)**	**Metric/ Rationale**	**Score (1-10; 1= bad; 10=good)**
Safety	Emergency Medical Access	Construction site access and protocols to respond to emergencies.	Emergency response time is longer due to fewer access points to construction site.	3	Emergency response time is longer due to fewer access points to construction site.	3	Emergency response time is longer due to fewer access points to construction site.	3	Emergency response time is longer due to fewer access points to construction site.	3	With the dedicated Sweetwater and Clear Creek pipelines, there are more access points.	8	The reduced pipeline length in the watershed provides additional access points for emergency vehicle access.	6	The reduced pipeline length in the watershed provides additional access points for emergency vehicle access.	6
		Ability to control public access to the alignment	The majority of the pipeline alignment is only accessible through controlled access points resulting in restricted public access.	7	The majority of the pipeline alignment is only accessible through controlled access points resulting in restricted public access.	7	The majority of the pipeline alignment is only accessible through controlled access points resulting in restricted public access.	7	The majority of the pipeline alignment is only accessible through controlled access points resulting in restricted public access.	7	The multiple pipeline alignments create more access points that must be controlled.	3	The multiple pipeline alignments create more access points that must be controlled.	4	The multiple pipeline alignments create more access points that must be controlled.	4
		Operational access to the pipeline and intakes: ATV vs. Bike vs. Vehicle	ATV Width	3	Vehicle Width	5	Vehicle Width	5	Vehicle Width	5	Vehicle Width, better access from developed areas	8	Vehicle Width, better access from developed areas	8	Vehicle Width, better access from developed areas	8
	Natural Disaster Hardening	Level of protection provided against catastrophic fire	Above ground, HDPE pipe provides minimal protection	1	Above ground welded steel pipe is resistant to fire.	8	Buried HDPE pipe is protected from fire but above grade pipe is at risk.	6	All below grade pipe is protected from fire.	8	All below grade pipe is protected from fire and the total pipe length within the watershed is reduced.	9	All below grade pipe is protected from fire and the total pipe length within the watershed is reduced.	9	All below grade pipe is protected from fire and the total pipe length within the watershed is reduced.	9
		Level of protection provided against disaster affecting discrete locations (tree falls, landslides, etc.)	Above ground HDPE pipe will be more flexible and reduce potential for pipe break.	7	Welded steel pipe is rigid and may catastrophically fail.	1	Buried HDPE pipe is protected from damage but above grade welded steel pipe still potentially could catastrophically fail.	6	Buried HDPE pipe protected from damage.	8	Buried HDPE pipe protected from damage and reduced pipe length within watershed..	9	Buried HDPE pipe protected from damage and reduced pipe length within watershed..	9	Buried HDPE pipe protected from damage and reduced pipe length within watershed..	9
		Level of redundancy to reduce risk of service outage in the event of another fire, catastrophic event, or major maintenance service.	Single alignment primarily within the watershed reduces the level of redundancy of the new system.	3	Single alignment primarily within the watershed reduces the level of redundancy of the new system.	3	Single alignment primarily within the watershed reduces the level of redundancy of the new system.	3	Single alignment primarily within the watershed reduces the level of redundancy of the new system.	3	Multiple, independent alignments within the watershed provide redundancy.	7	Multiple, independent alignments within the watershed provide redundancy.	7	Multiple, independent alignments within the watershed plus redundant treatment facility	10
			Subtotal	**24**	**Subtotal**	**27**	**Subtotal**	**30**	**Subtotal**	**34**	**Subtotal**	**44**	**Subtotal**	**43**	**Subtotal**	**46**

Table 6
Success Factor Scoring (1)
Cross Country Pipeline Constructability Analysis
San Lorenzo Valley Water District

Category	Coarse Criteria	Metric Description	Alternative 1:		Alternative 2:		Alternative 3A:		Alternative 3B:		Alternative 4A:		Alternative 4B:		Alternative 5:	
			Metric/ Rationale	Score (1-10; 1= bad; 10=good)	Metric/ Rationale	Score (1-10; 1= bad; 10=good)	Metric/ Rationale	Score (1-10; 1= bad; 10=good)	Metric/ Rationale	Score (1-10; 1= bad; 10=good)	Metric/ Rationale	Score (1-10; 1= bad; 10=good)	Metric/ Rationale	Score (1-10; 1= bad; 10=good)	Metric/ Rationale	Score (1-10; 1= bad; 10=good)
Constructability	Buried vs. Above ground install	Relative level of difficulty to implement the pipeline resiliency strategy.	Minimal bench widths will require more labor increasing construction complexity.	4	Welded steel pipe requires extensive access roads and benches.	2	Bench width wide enough for small equipment to install below grade HDPE.	6	Bench width wide enough for small equipment to install below grade HDPE.	7	Reduced pipe length in the watershed reduces construction complexity.	7	Reduced pipe length in the watershed reduces construction complexity.	7	Reduced pipe length in the watershed reduces construction complexity.	7
	Schedule - Construction phasing	Ability to phase construction to avoid bird nesting season	All work is within the watershed and therefore the amount of tree clearing is maximized.	6	All work is within the watershed and therefore the amount of tree clearing is maximized.	5	All work is within the watershed and therefore the amount of tree clearing is maximized.	5	All work is within the watershed and therefore the amount of tree clearing is maximized.	5	Reduced pipe length in the watershed reduces amount of tree clearing	8	Reduced pipe length in the watershed reduces amount of tree clearing	8	Reduced pipe length in the watershed reduces amount of tree clearing	9
	Reduce Construction Cost	Cost of materials and installation	Minimal excavation and HDPE pipe least costly.	9	Minimal excavation but welded steel pipe is more costly and labor increased.	4	Excavation is more extensive but HDPE pipe is least costly.	8	Excavation is more extensive but HDPE pipe is least costly.	8	Two pump stations are required	2	One pump station is required.	1	Treatment plant with pump station is required.	1
		Cost of creating construction/operations access road	Minimal work to create benches and access points.	7	Extensive earthwork to create benches and access points.	5	Excavation to bury pipe and install retaining structures.	6	Excavation to bury pipe and install retaining structures.	6	Excavation to bury pipe and install retaining structures.	6	Excavation to bury pipe and install retaining structures.	6	Excavation to bury pipe and install retaining structures.	6
	Pipe Sections and Materials	Pipe material is conducive to construction given slope conditions	HDPE requires least number of fittings.	8	Welded steel requires numerous fittings to accommodate existing topography.	3	HDPE requires least number of fittings.	8	HDPE requires least number of fittings.	8	HDPE requires least number of fittings.	8	HDPE requires least number of fittings.	8	HDPE requires least number of fittings.	8
		Alternative allows for reducing the number of different Section Types	Above grade installation with minimal width bench	7	Above grade installation but widest bench will require retaining structures.	5	Below grade HDPE will require widen bench for equipment and retaining structures.	5	Below grade HDPE will require widen bench for equipment and retaining structures.	6	Below grade HDPE will require widen bench for equipment and retaining structures plus construction of pump stations.	4	Below grade HDPE will require widen bench for equipment and retaining structures plus construction of pump station.	4	Below grade HDPE will require widen bench for equipment and retaining structures plus construction of treatment plant.	5
			Subtotal	**41**	**Subtotal**	**24**	**Subtotal**	**38**	**Subtotal**	**40**	**Subtotal**	**35**	**Subtotal**	**34**	**Subtotal**	**36**

Table 6
Success Factor Scoring (1)
Cross Country Pipeline Constructability Analysis
San Lorenzo Valley Water District

Category	Coarse Criteria	Metric Description	Alternative 1:		Alternative 2:		Alternative 3A:		Alternative 3B:		Alternative 4A:		Alternative 4B:		Alternative 5:	
			Metric/ Rationale	Score (1-10; 1= bad; 10=good)	Metric/ Rationale	Score (1-10; 1= bad; 10=good)	Metric/ Rationale	Score (1-10; 1= bad; 10=good)	Metric/ Rationale	Score (1-10; 1= bad; 10=good)	Metric/ Rationale	Score (1-10; 1= bad; 10=good)	Metric/ Rationale	Score (1-10; 1= bad; 10=good)	Metric/ Rationale	Score (1-10; 1= bad; 10=good)
O&M	Accessibility	Long-term access to support ongoing O&M activities.	Smaller width benches will likely limit access to walking, which will potential reduce inspection frequency	2	Wider benches will allow for vehicular access improving ease of inspection	7	Average width benches will allow for ATV access.	5	Average width benches will allow for ATV access.	5	Average width benches will allow for ATV access but more frequent maintenance for pump station.	3	Average width benches will allow for ATV access but more frequent maintenance for pump station.	3	Average width benches will allow for ATV access but more frequent maintenance for treatment plant.	3
	O&M Cost	Labor/staffing, materials and training costs to operate new facilities.	No new facility	10	No new facility	8	No new facility	10	No new facility	10	Two new pump stations	3	One new pump station	5	One new water treatment plant & pump to distribution	1
	Schedule	Estimated construction time to full system operations	28,966 ft, no additional pump stations or WTP, Above ground HDPE	6	28,966 ft, no additional pump stations or WTP, Above ground Welded Steel	4	28,966 ft, no additional pump stations or WTP, Below Ground HDPE	5	28,966 ft, no additional pump stations or WTP, Below Ground HDPE	5	34,460 ft (19,508 ft in street), two new pump stations, below ground HDPE	7	27,868 ft (13,965 ft in street) ,one new pump stations, below ground HDPE	8	15,745 ft, one new water treatment plant and pump station, below ground HDPE	5
	Performance Levels	Pipe material ease of maintenance	Above ground HDPE	7	Above Ground Welded Steel	4	Below Ground HDPE, small portion above ground welded steel	8	Below Ground HDPE	10	Below Ground HDPE	10	Below Ground HDPE	10	Below Ground HDPE	10
		Gravity flow % of total linear footage vs. total linear footage of pressurized pipe (gravity is easier to maintain and operate)	100% Gravity	10	100% Gravity	10	100% Gravity	10	100% Gravity	10	64% Gravity	5	67% Gravity	6	67% Gravity, accounting for pump station in wtp plus mechanical equipment for the WTP	7
	Hydroelectric Operations	Number & Location (less hydroelectric stations & making sure the location is easily accessible)	1 location	10	1 location	10	1 location	10	1 location	10	2 locations	5	2 locations	5	2 locations	5
		Total potential energy generated	345' + 22' + 453'= 820'	2	345' + 22' + 453'= 820'	2	345' + 22' + 453'= 820'	2	345' + 22' + 453'= 820'	2	345' + 22' + 886' + 858'=2,111'	10	345'+ 22' + 886' = 1,253	5	345'+ 22' + 886' = 1,253	5
			Subtotal	**47**	**Subtotal**	**45**	**Subtotal**	**50**	**Subtotal**	**52**	**Subtotal**	**43**	**Subtotal**	**42**	**Subtotal**	**36**

Table 6
Success Factor Scoring (1)
Cross Country Pipeline Constructability Analysis
San Lorenzo Valley Water District

Category	Coarse Criteria	Metric Description	Alternative 1:		Alternative 2:		Alternative 3A:		Alternative 3B:		Alternative 4A:		Alternative 4B:		Alternative 5:	
			Metric/ Rationale	**Score (1-10; 1= bad; 10=good)**	**Metric/ Rationale**	**Score (1-10; 1= bad; 10=good)**	**Metric/ Rationale**	**Score (1-10; 1= bad; 10=good)**	**Metric/ Rationale**	**Score (1-10; 1= bad; 10=good)**	**Metric/ Rationale**	**Score (1-10; 1= bad; 10=good)**	**Metric/ Rationale**	**Score (1-10; 1= bad; 10=good)**	**Metric/ Rationale**	**Score (1-10; 1= bad; 10=good)**
Stakeholder Impact	Construction Impacts	Level of disturbance to daily life during construction from truck trips, staging areas required, use of helicopters and similar equipment	no construction project completely avoids some effects; this one minimizes	8	some anticipated additional logistics resulting from steel pipe	5	similar public disturbance as Alt 1; small bit of additional logistics from handling of steel	7	same public disturbance as Alt 1	8	2 pump stations in populated areas, realignment through sparsely populated areas	1	slightly better than Alt 4A; only one pump station	1	Similar to Alt 4B in terms of public disturbance is a package treatment plant more disturbance than a pumps station?	1
		Construction impacts to forest (acres)	Minimal bench width but maximum pipe length within watershed.	4	Maximum bench width and maximum pipe length within watershed.	2	Average bench width and maximum pipe length in watershed.	3	Average bench width and maximum pipe length in watershed.	3	Average bench width and minimal pipe length in watershed	8	Average bench width and minimal pipe length in watershed	7	Average bench width and minimal pipe length in watershed	7
	Environmental	Estimated time to acquire regulatory permits	16 months	5	18 months	3	18 months	3	20 months	3	16 months	5	12 months	5	12 months	7
		Area of aquatic resources impacts	medium	5	med-high; wider benches	4	med-high; wider benches	4	high	2	low	6	med/low	7	med/low	7
		Greenhouse Gas Emissions/Energy Use	gravity flow, no new energy demands	9	gravity flow, no new energy demands	9	gravity flow, no new energy demands	9	gravity flow, no new energy demands	9	energy demands for two pump stations	3	energy demands for one pump station	4	energy demand for package treatment plant and related pump	3
		Potential to impact sensitive species	Minimal bench width but maximum pipe length within watershed.	5	Maximum bench width and maximum pipe length within watershed.	3	Average bench width and maximum pipe length in watershed.	4	Average bench width and maximum pipe length in watershed.	3	Average bench width and minimal pipe length in watershed	9	Average bench width and minimal pipe length in watershed	8	Average bench width and minimal pipe length in watershed	8
	Easements and Land Rights	Number of property owners involved in an alternative	Existing alignment	8	Existing alignment	8	Existing alignment	8	Existing alignment	8	New alignment; multiple paths out	1	New alignment	2	New alignment	2
			Subtotal	**44**	**Subtotal**	**34**	**Subtotal**	**38**	**Subtotal**	**36**	**Subtotal**	**33**	**Subtotal**	**34**	**Subtotal**	**35**
			Total	**156**	**Total**	**130**	**Total**	**156**	**Total**	**162**	**Total**	**155**	**Total**	**153**	**Total**	**153**

Notes
(1) Success score selected by individual work groups is best judgement based on professional opinion of the work group.

Table 7
Risk Rating Scoring
Cross Country Pipeline Constructability Analysis
San Lorenzo Valley Water District

		Alternative 1			Alternative 2			Alternative 3A			Alternative 3B			Alternative 4A			Alternative 4B			Alternative 5		
Category	**Risk Issue**	**Probability (0.1-1.0)**	**Consequence (1-5)**	**Score (1)**	**Probability (0.1-1.0)**	**Consequence (1-5)**	**Score (1)**	**Probability (0.1-1.0)**	**Consequence (1-5)**	**Score (1)**	**Probability (0.1-1.0)**	**Consequence (1-5)**	**Score (1)**	**Probability (0.1-1.0)**	**Consequence (1-5)**	**Score (1)**	**Probability (0.1-1.0)**	**Consequence (1-5)**	**Score (1)**	**Probability (0.1-1.0)**	**Consequence (1-5)**	**Score (1)**
Safety	Risk of long-term operational disruption due to catastrophic natural disaster (e.g., fire)	0.8	5	4	0.7	5	3.5	0.2	5	1	0.2	5	1	0.3	5	1.5	0.3	5	1.5	0.5	5	2.5
	Risk to O&M staff conducting condition assessment during an emergency.	0.5	2	1	0.5	4	2	0.1	2	0.2	0.1	2	0.2	0.1	4	0.4	0.1	4	0.4	0.1	4	0.4
	Risk of short term or partial operational disruption due to events such as landslide and tree falls	0.5	3	1.5	0.5	4	2	0.3	4	1.2	0.1	3	0.3	0.1	1	0.1	0.1	3	0.3	0.1	3	0.3
			Subtotal	**6.5**		**Subtotal**	**7.5**		**Subtotal**	**2.4**		**Subtotal**	**1.5**		**Subtotal**	**2**		**Subtotal**	**2.2**		**Subtotal**	**3.2**
Constructability	Risk of major soil erosion or landslide event triggered by construction	0.6	3	1.8	0.6	3	1.8	0.7	3	2.1	0.7	3	2.1	0.4	3	1.2	0.4	3	1.2	0.4	3	1.2
	Risk of reduced or loss of FEMA funding	0.2	4	0.8	0.3	4	1.2	0.3	4	1.2	0.2	4	0.8	0.4	4	1.6	0.4	4	1.6	0.4	4	1.6
	Risk of long term pipe damage from slope or soil movement (non-disaster related)	0.7	3	2.1	0.7	3	2.1	0.4	3	1.2	0.4	3	1.2	0.3	2	0.6	0.3	2	0.6	0.3	2	0.6
	Risk of long term slope failure arising from construction induced changes to the landscape geotechnical conditions	0.6	3	1.8	0.6	3	1.8	0.6	3	1.8	0.6	3	1.8	0.3	2	0.6	0.3	2	0.6	0.3	2	0.6
	Risk of permitting requirements and potential utility conflicts impacting project cost.	0.1	3	0.3	0.1	3	0.3	0.4	3	1.2	0.4	3	1.2	0.8	5	4	0.8	5	4	0.8	5	4
			Subtotal	**6.8**		**Subtotal**	**7.2**		**Subtotal**	**7.5**		**Subtotal**	**7.1**		**Subtotal**	**8**		**Subtotal**	**8**		**Subtotal**	**8**
Operations & Maintenance	Damage/Vandalism to the District owned facilities due to pathways allowing public accessibility	0.8	4	3.2	0.8	4	3.2	0.8	4	3.2	0.8	4	3.2	0.8	4	3.2	0.8	4	3.2	0.8	4	3.2
	Risk of pipe damage resulting from landslides, fire and other natural disasters	0.5	3	1.5	0.5	4	2	0.3	4	2.4	0.1	1	0.1	0.1	1	0.1	0.1	1	0.1	0.1	1	0.1
	Risk of rate escalation from increased O&M expenditures	0.1	1	0.1	0.1	1	0.1	0.1	1	0.1	0.1	1	0.1	1	4	4	1	3	3	1	5	5
			Subtotal	**4.8**		**Subtotal**	**5.3**		**Subtotal**	**5.7**		**Subtotal**	**3.4**		**Subtotal**	**7.3**		**Subtotal**	**6.3**		**Subtotal**	**8.3**
Stakeholder Impact	Risk of red flags for board approval	0.8	3	2.4	0.5	3	1.5	0.3	3	0.9	0.2	3	0.6	0.8	3	2.4	0.7	3	2.1	0.4	3	1.2
	Risk of construction delays from cultural resources findings	0.2	4	0.8	0.3	4	1.2	0.4	4	1.6	0.4	4	1.6	0.3	4	1.2	0.3	4	1.2	0.2	4	0.8
	Potential opposition during CEQA	0.9	3	2.7	0.7	3	2.1	0.7	3	2.1	0.7	3	2.1	0.9	2	1.8	0.9	2	1.8	0.7	2	1.4
	Risk of habitat mitigation	0.7	2	1.4	0.7	3	2.1	0.7	2	1.4	0.9	4	3.6	0.5	2	1	0.5	2	1	0.5	2	1
	Risk of delays due to encroachment on property not owned by SLVWD	0.2	1	0.2	0.2	1	0.2	0.2	1	0.2	0.2	1	0.2	0.9	4	3.6	0.9	3	2.7	0.7	2	1.4
			Subtotal	**7.5**		**Subtotal**	**7.1**		**Subtotal**	**6.2**		**Subtotal**	**8.1**		**Subtotal**	**10**		**Subtotal**	**8.8**		**Subtotal**	**5.8**
			Total	**25.6**		**Total**	**27.1**		**Total**	**21.8**		**Total**	**20.1**		**Total**	**27.3**		**Total**	**25.3**		**Total**	**25.3**

Notes
(1) Score is calculated by multiplying the probability by the consequence.

Table 8
Alternative Analysis Results

Cross Country Pipeline Constructability Analysis
San Lorenzo Valley Water District

Alternative	Success Score (1)	Risk Score (2)	Natural Disaster Resiliency: Wildfire Protection	Seismic Protection	Landslide Protection	Debris Flow Protection
1: Above Ground HDPE	156	25.6		X	X	
2: Above Ground Welded Steel	130	27.1	X			
3A: Below Grade HDPE with Above Grade Crossings	156	21.8	X	X	X	
3B: Below Grade HDPE (3)	162	20.1	X	X	X	X
4A: Clear Creek and Sweetwater Independent Pipelines with Pump Stations	155	27.3	X	X	X	X
4B: Clear Creek and Sweetwater Common Pipeline with Pump Station	153	25.3	X	X	X	X
5: Clear Creek and Sweetwater Common Pipeline with Treatment Facility	153	25.3	X	X	X	X

Notes

(1) See Table 6 for Success Score calcluation.
(2) See Table 7 for Risk Score calculation.
(3) Alternative 3B is the recommended alternative because it has the highest Success Score, lowest Risk Score, and provides resiliency for all identified potential natural disasters that could impact the proposed cross country pipeline system.

Table 9
Range of Opinion of Probable Project Cost (1)
Cross Country Pipeline Constructability Analysis
San Lorenzo Valley Water District

Low Range

	Peavine			5-Mile			HydroPower		
Project Phase	**Units**	**Unit Price**	**Cost (2)**	**Units**	**Unit Price**	**Cost (2)**	**Units**	**Unit Price**	**Cost (2)**
Construction	1	ls	$ 8,200,000	1	ls	$ 31,900,000	1	ls	$ 680,000
Planning/CEQA/Permitting	%	10%	$ 820,000	%	10%	$ 3,190,000	%	10%	$ 68,000
Design	%	10%	$ 820,000	%	10%	$ 3,190,000	%	10%	$ 68,000
CM/Inspection	%	10%	$ 820,000	%	10%	$ 3,190,000	%	10%	$ 68,000
District Administration	%	2%	$ 160,000	%	2%	$ 640,000	%	2%	$ 10,000
Total			**$ 10,820,000**			**$ 42,110,000**			**$ 894,000**

High Range

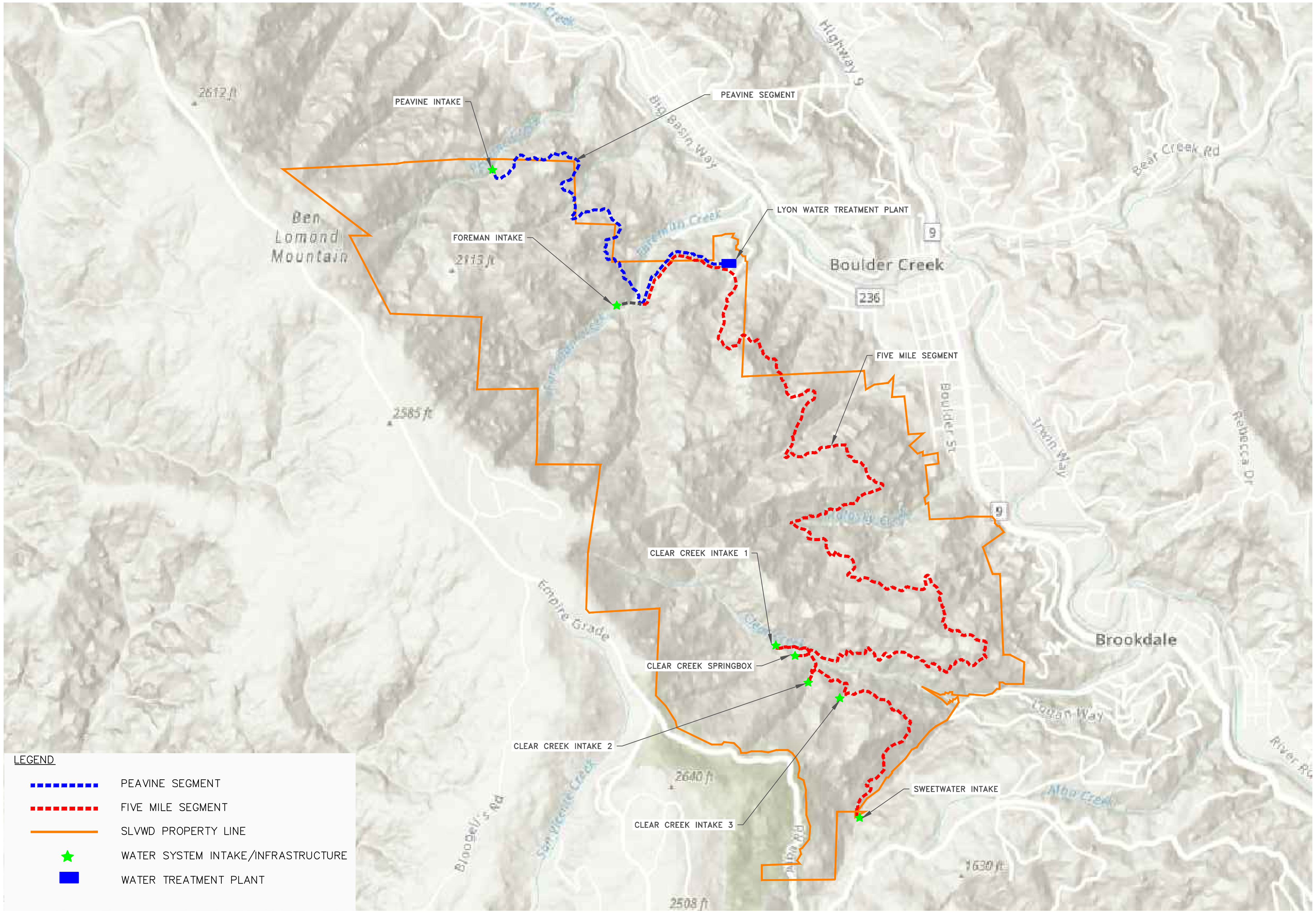
	Peavine			5-Mile			HydroPower		
Project Phase	**Units**	**Unit Price**	**Cost (2)**	**Units**	**Unit Price**	**Cost (2)**	**Units**	**Unit Price**	**Cost (2)**
Construction	1	ls	$ 9,500,000	1	ls	$ 37,200,000	1	ls	$ 780,000
Planning/CEQA/Permitting	%	10%	$ 950,000	%	10%	$ 3,720,000	%	10%	$ 78,000
Design	%	10%	$ 950,000	%	10%	$ 3,720,000	%	10%	$ 78,000
CM/Inspection	%	10%	$ 950,000	%	10%	$ 3,720,000	%	10%	$ 78,000
District Administration	%	2%	$ 190,000	%	2%	$ 740,000	%	2%	$ 20,000
Total			**$ 12,540,000**			**$ 49,100,000**			**$ 1,034,000**

Notes

(1) All costs are in 2022 dollars.

(2) Costs are rounded to the nearest $100,000 for costs over $1 million and nearest $10,000 for costs under $1 million

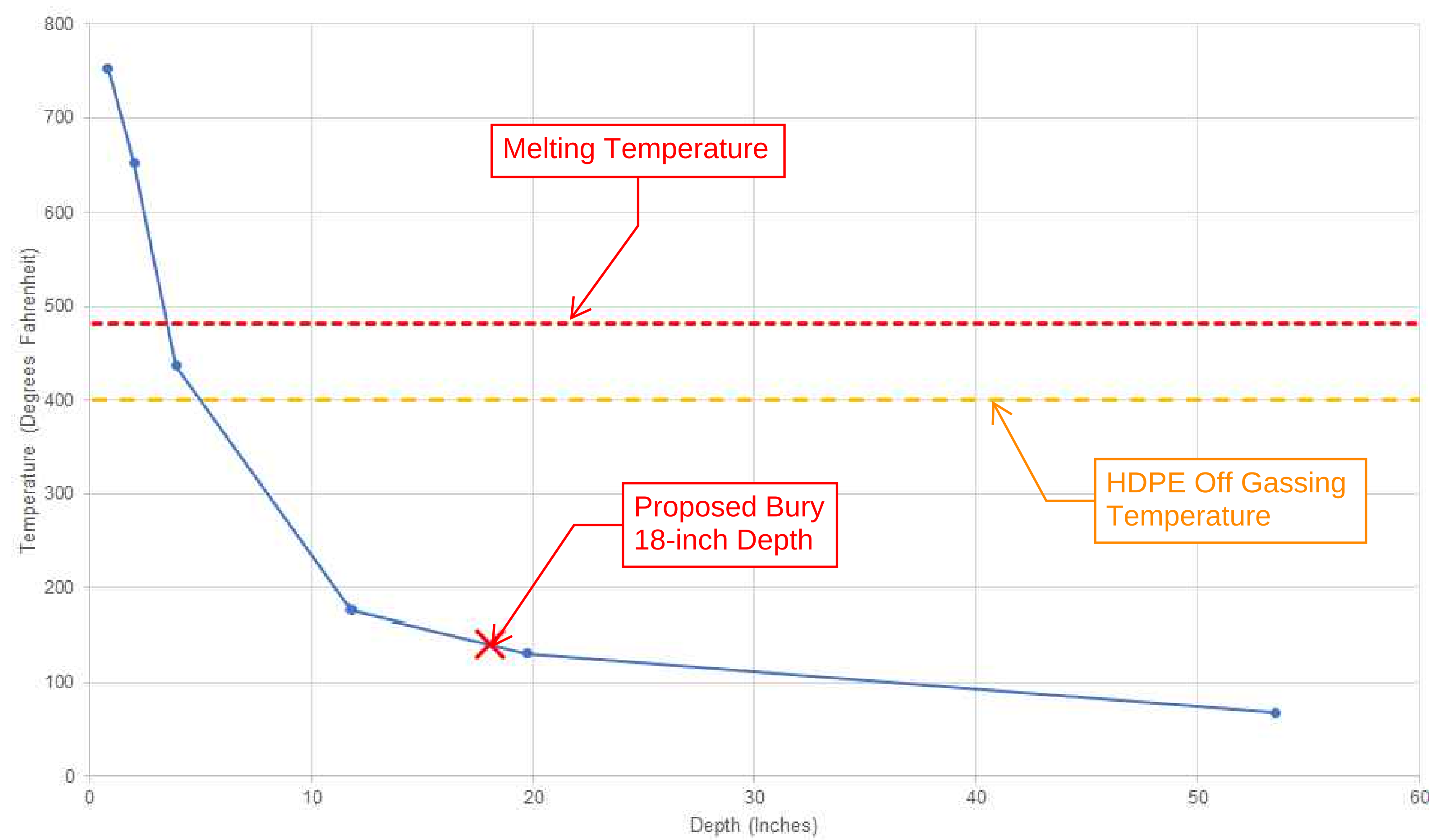
FIGURES



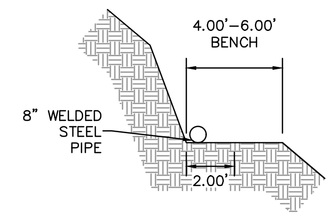
EXISTING CROSS COUNTY PIPELINE ALIGNMENT
FIGURE 1
SAN LORENZO VALLEY WATER DISTRICT

JOB NO.: 322002	DATE: 02/07/2022	FIGURE 1

Figure 2 - Estimated Soil Temperature at Varying Depths

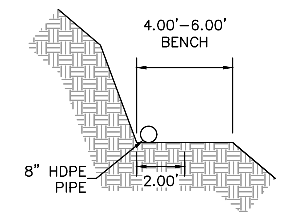


ALTERNATIVE CROSS COUNTY PIPELINE ESTIMATED SOIL TEMPERATURE AT VARYING DEPTHS FIGURE 2 SAN LORENZO VALLEY WATER DISTRICT		FIGURE 2
JOB NO.: 322002	DATE: 02/10/2022	



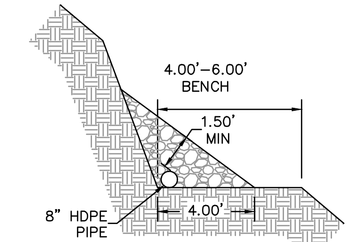
NOTES
1. ALL VEGETATION WITHIN THE BENCH MUST BE REMOVED.
2. NARROWED SHALLOW TRENCH MAY REQUIRE HAND DIGGING.

1 – NARROWED ABOVE GROUND
SCALE: NTS



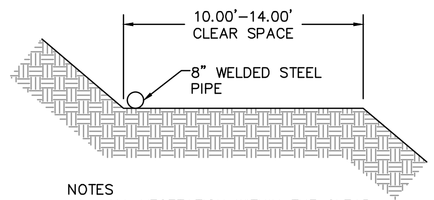
NOTES
1. ALL VEGETATION WITHIN THE BENCH MUST BE REMOVED.
2. NARROWED SHALLOW TRENCH MAY REQUIRE HAND DIGGING.

2 – NARROWED ABOVE GROUND
SCALE: NTS



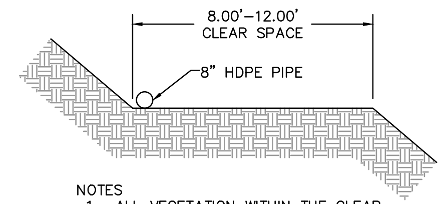
NOTES
1. ALL VEGETATION WITHIN THE BENCH MUST BE REMOVED.
2. MINIMUM COVER OVER THE PIPE IS 18 INCHES.
3. NARROWED SHALLOW TRENCH MAY REQUIRE HAND DIGGING.

3 – NARROWED SHALLOW TRENCH
SCALE: NTS



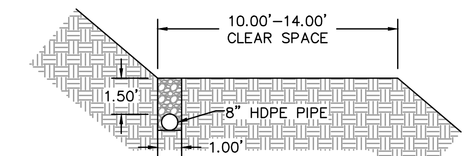
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.

4 – TYPICAL ABOVE GROUND WITH WIDENED BENCH
SCALE: NTS



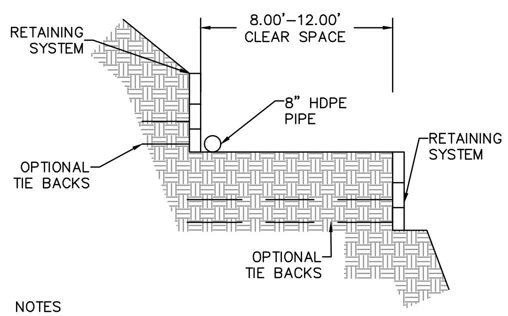
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.

5 – TYPICAL ABOVE GROUND WITH WIDENED BENCH
SCALE: NTS



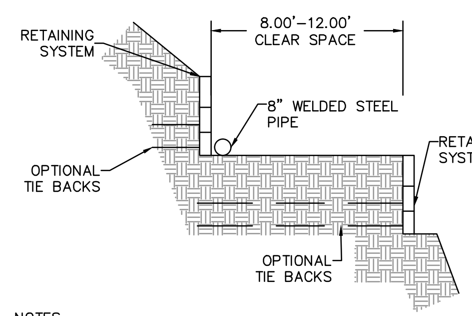
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.

6 – TYPICAL SHALLOW TRENCH WITH WIDENED BENCH
SCALE: NTS



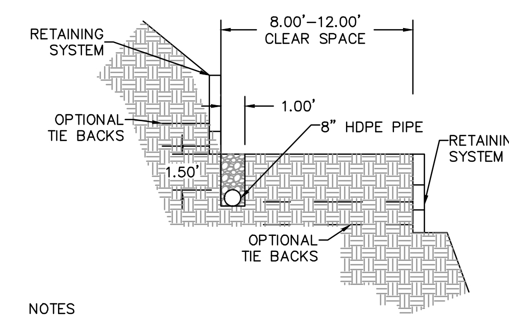
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.
2. RETAINING SYSTEM MAY BE UTILIZED ON BOTH UPHILL AND DOWN HILL SIDES OR ON EITHER SIDE SINGULARLY.

7 – STEEP SLOPE TRENCH WITH RETAINING SYSTEM
SCALE: NTS



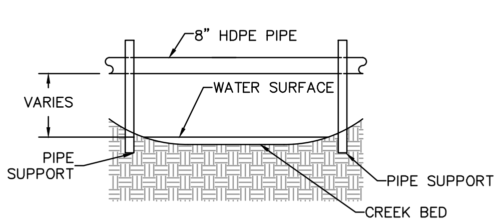
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.
2. RETAINING SYSTEM MAY BE UTILIZED ON BOTH UPHILL AND DOWN HILL SIDES OR ON EITHER SIDE SINGULARLY.

8 – STEEP SLOPE WITH RETAINING SYSTEM
SCALE: NTS

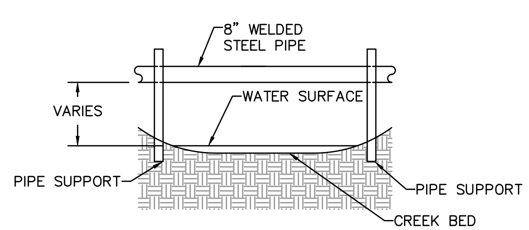


NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.
2. RETAINING SYSTEM MAY BE UTILIZED ON BOTH UPHILL AND DOWN HILL SIDES OR ON EITHER SIDE SINGULARLY.

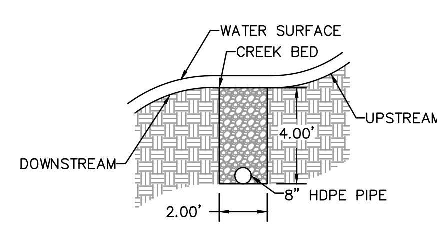
9 – STEEP SLOPE TRENCH WITH RETAINING SYSTEM
SCALE: NTS



10 – CREEK CROSSING ABOVE GROUND
SCALE: NTS

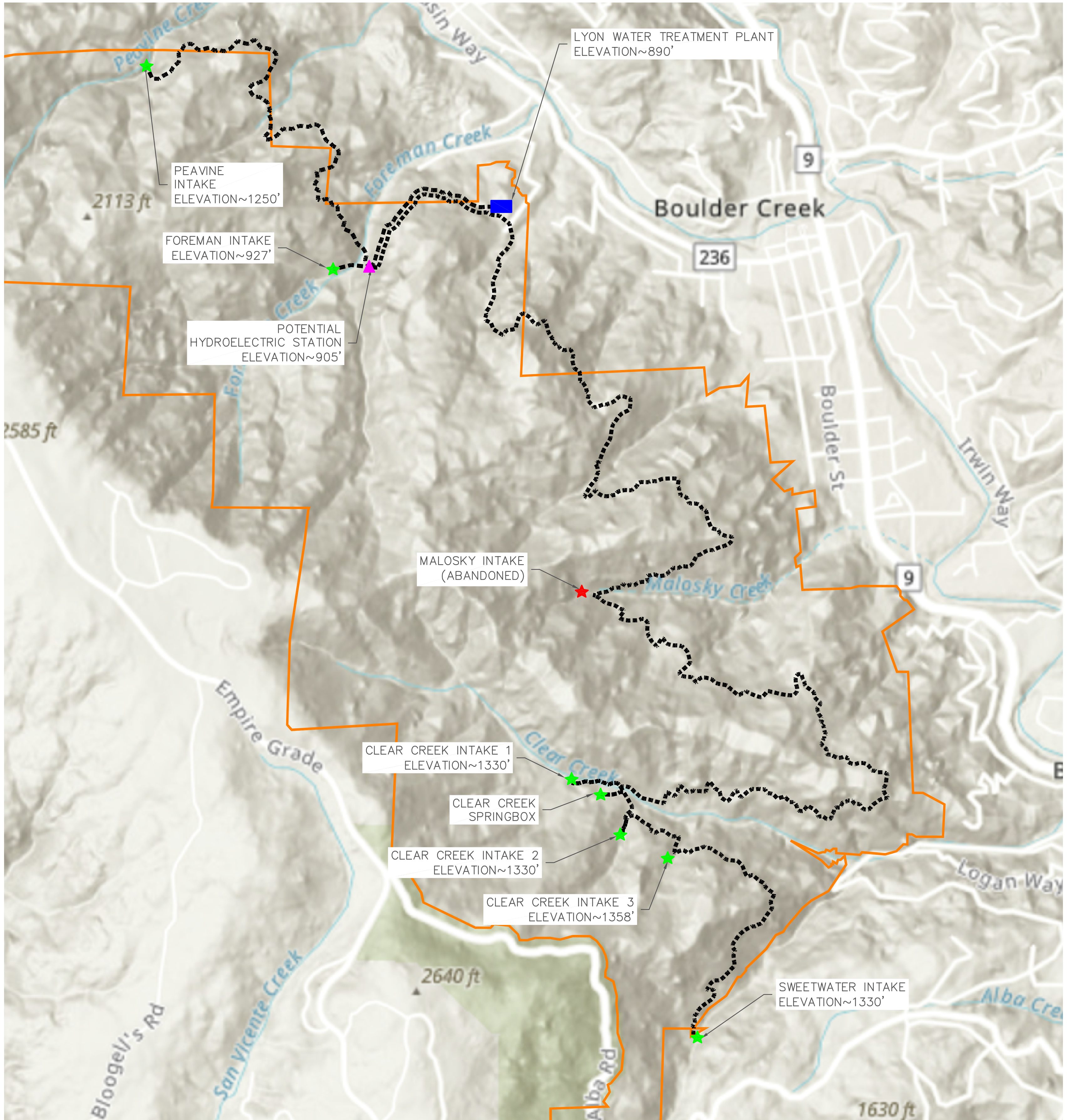


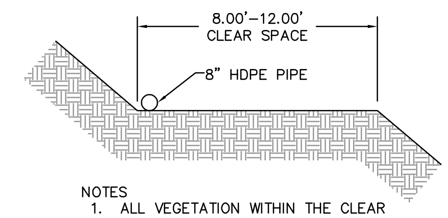
11 – CREEK CROSSING ABOVE GROUND
SCALE: NTS



12 – CREEK CROSSING BELOW GROUND
SCALE: NTS

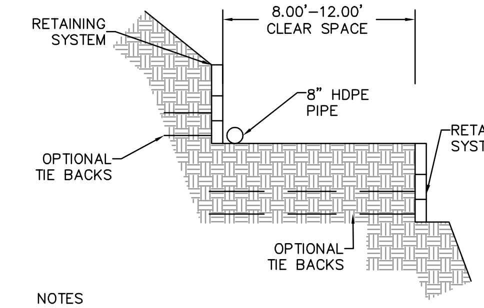
ALTERNATIVE CROSS COUNTY PIPELINE CROSS SECTIONS FIGURE 3 SAN LORENZO VALLEY WATER DISTRICT		FIGURE 3
JOB NO.: 322002	DATE: 11/24/2021	





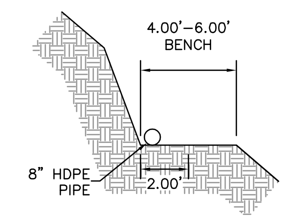
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.

1 TYPICAL ABOVE GROUND WITH WIDENED BENCH
SCALE: NTS



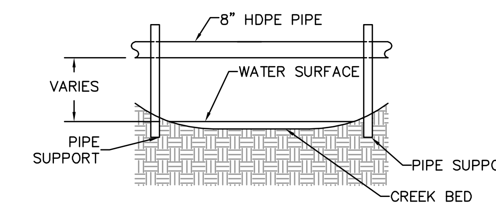
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.
2. RETAINING SYSTEM MAY BE UTILIZED ON BOTH UPHILL AND DOWN HILL SIDES OR ON EITHER SIDE SINGULARLY.

2 STEEP SLOPE TRENCH WITH RETAINING SYSTEM
SCALE: NTS



NOTES
1. ALL VEGETATION WITHIN THE BENCH MUST BE REMOVED.
2. NARROWED SHALLOW TRENCH MAY REQUIRE HAND DIGGING.

3 NARROWED ABOVE GROUND
SCALE: NTS



4 CREEK CROSSING ABOVE GROUND
SCALE: NTS

LEGEND

- EXISTING ALIGNMENT TO REMAIN
- SLVWD PROPERTY LINE
- WATER SYSTEM INTAKE/INFRASTRUCTURE
- ABANDONED WATER SYSTEM INTAKE/INFRASTRUCTURE
- WATER TREATMENT PLANT
- POTENTIAL HYDROELECTRIC STATION

TABLE 1: APPROXIMATE LENGTHS	
EXISTING PEAVINE ALIGNMENT	8,841 LF
EXISTING FIVE MILE ALIGNMENT	31,603 LF

ALTERNATIVE 1

PEAVINE PIPELINE
- RECONSTRUCT PEAVINE PIPELINE ALONG EXISTING ALIGNMENT
- MINIMIZE CONSTRUCTION ACCESS ROAD WIDTH
- ABOVE GROUND HDPE PIPE (DETAIL 1, DETAIL 2, DETAIL 3, DETAIL 4)

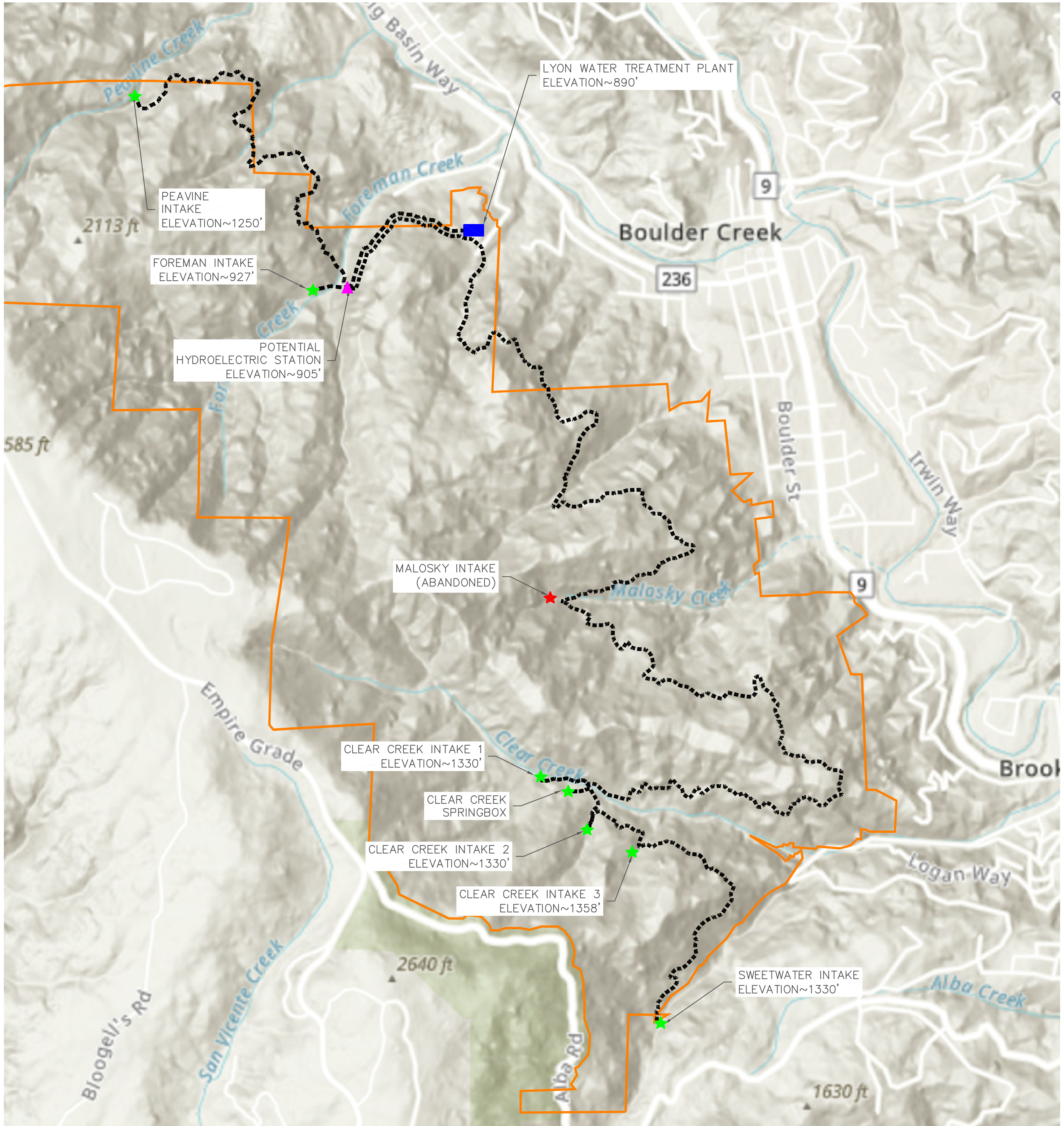
5-MILE PIPELINE
- RECONSTRUCT 5-MILE PIPELINE ALONG EXISTING ALIGNMENT
- MINIMIZE CONSTRUCTION ACCESS ROAD WIDTH
- ABOVE GROUND HDPE PIPE (DETAIL 1, DETAIL 2, DETAIL 3, DETAIL 4)

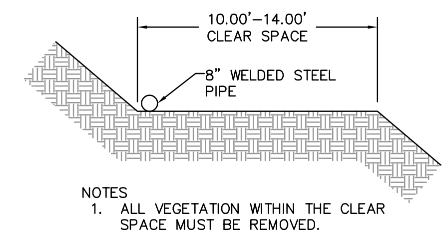
NORTH

ALTERNATIVE 1
EXISTING ALIGNMENT WITH HDPE PIPE
SAN LORENZO VALLEY WATER DISTRICT

JOB NO.: 322002
DATE: 02/07/2022

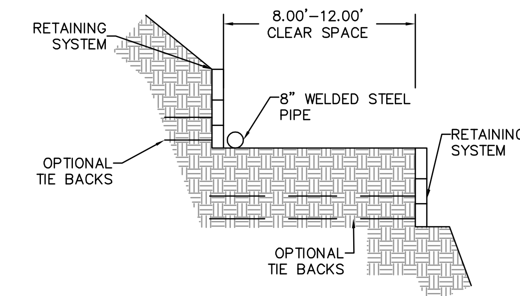
FIGURE 4





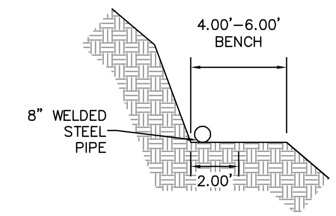
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.

TYPICAL ABOVE GROUND
WITH WIDENED BENCH
1 / –
SCALE: NTS



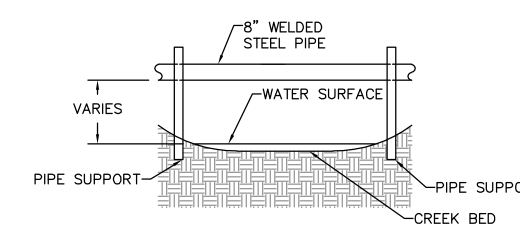
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.
2. RETAINING SYSTEM MAY BE UTILIZED ON BOTH UPHILL AND DOWN HILL SIDES OR ON EITHER SIDE SINGULARLY.

STEEP SLOPE
WITH RETAINING SYSTEM
2 / –
SCALE: NTS



NOTES
1. ALL VEGETATION WITHIN THE BENCH MUST BE REMOVED.
2. NARROWED SHALLOW TRENCH MAY REQUIRE HAND DIGGING.

NARROWED ABOVE GROUND
3 / –
SCALE: NTS



CREEK CROSSING
ABOVE GROUND
4 / –
SCALE: NTS

LEGEND

- EXISTING ALIGNMENT TO REMAIN
- SLVWD PROPERTY LINE
- WATER SYSTEM INTAKE/INFRASTRUCTURE
- ABANDONED WATER SYSTEM INTAKE/INFRASTRUCTURE
- WATER TREATMENT PLANT
- POTENTIAL HYDROELECTRIC STATION

TABLE 1: APPROXIMATE LENGTHS	
EXISTING PEAVINE ALIGNMENT	8,841 LF
EXISTING FIVE MILE ALIGNMENT	31,603 LF

ALTERNATIVE 2

PEAVINE PIPELINE
- RECONSTRUCT PEAVINE PIPELINE ALONG EXISTING ALIGNMENT
- CONSTRUCTION ACCESS ROAD MUST FACILITATE CRANE ACCESS
- ABOVE GROUND WELDED STEEL PIPE (DETAIL 1, DETAIL 2, DETAIL 3, DETAIL 4)

5-MILE PIPELINE
- RECONSTRUCT 5-MILE PIPELINE ALONG EXISTING ALIGNMENT
- CONSTRUCTION ACCESS ROAD MUST FACILITATE CRANE ACCESS

ABOVE GROUND WELDED STEEL PIPE (DETAIL 1, DETAIL 2, DETAIL 3, DETAIL 4)

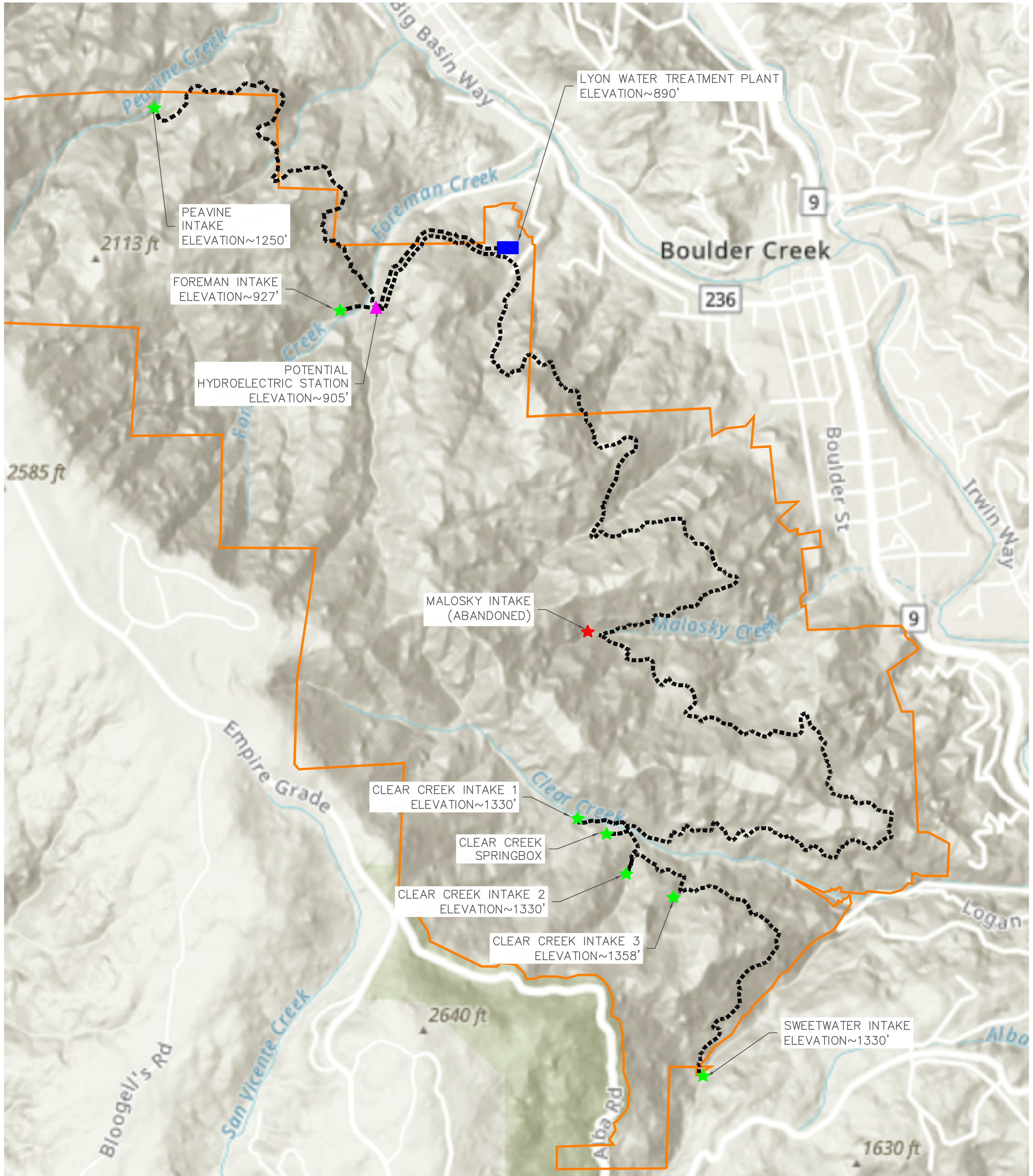
NORTH

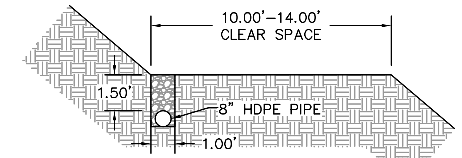
ALTERNATIVE 2
EXISTING ALIGNMENT WITH WELDED STEEL PIPE
SAN LORENZO VALLEY WATER DISTRICT

FIGURE
5

JOB NO.: 322002

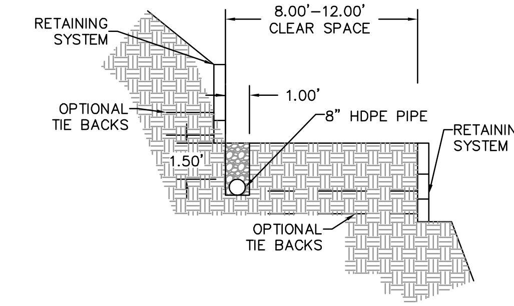
DATE: 02/07/2022





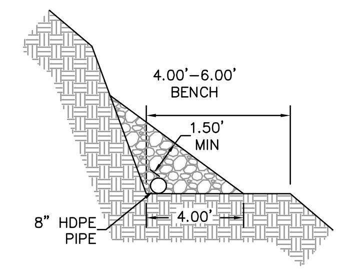
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.

1 – TYPICAL SHALLOW TRENCH WITH WIDENED BENCH
SCALE: NTS



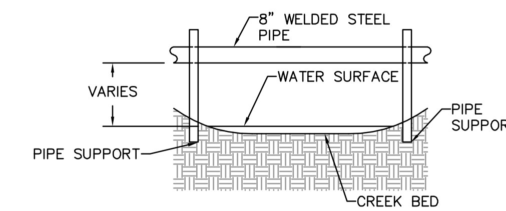
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.
2. RETAINING SYSTEM MAY BE UTILIZED ON BOTH UPHILL AND DOWN HILL SIDES OR ON EITHER SIDE SINGULARLY.

2 – STEEP SLOPE TRENCH WITH RETAINING SYSTEM
SCALE: NTS



NOTES
1. ALL VEGETATION WITHIN THE BENCH MUST BE REMOVED.
2. MINIMUM COVER OVER THE PIPE IS 18 INCHES.
3. NARROWED SHALLOW TRENCH MAY REQUIRE HAND DIGGING.

3 – NARROWED SHALLOW TRENCH
SCALE: NTS



4 – CREEK CROSSING ABOVE GROUND
SCALE: NTS

LEGEND

- EXISTING ALIGNMENT TO REMAIN
- SLVWD PROPERTY LINE
- WATER SYSTEM INTAKE/INFRASTRUCTURE
- ABANDONED WATER SYSTEM INTAKE/INFRASTRUCTURE
- WATER TREATMENT PLANT
- POTENTIAL HYDROELECTRIC STATION

TABLE 1: APPROXIMATE LENGTHS

EXISTING PEAVINE ALIGNMENT	8,841 LF
EXISTING FIVE MILE ALIGNMENT	31,603 LF

ALTERNATIVE 3A

PEAVINE PIPELINE
- RECONSTRUCT PEAVINE PIPELINE ALONG EXISTING ALIGNMENT
- BELOW GROUND, HDPE (DETAIL 1, DETAIL 2, DETAIL 3)
- SELECT AREAS ABOVE GROUND, WELDED STEEL (DETAIL 4)
- CONSTRUCTION ACCESS ROAD WIDTH CONSIDERS FINAL MAINTENANCE ROAD WIDTH REQUIREMENTS

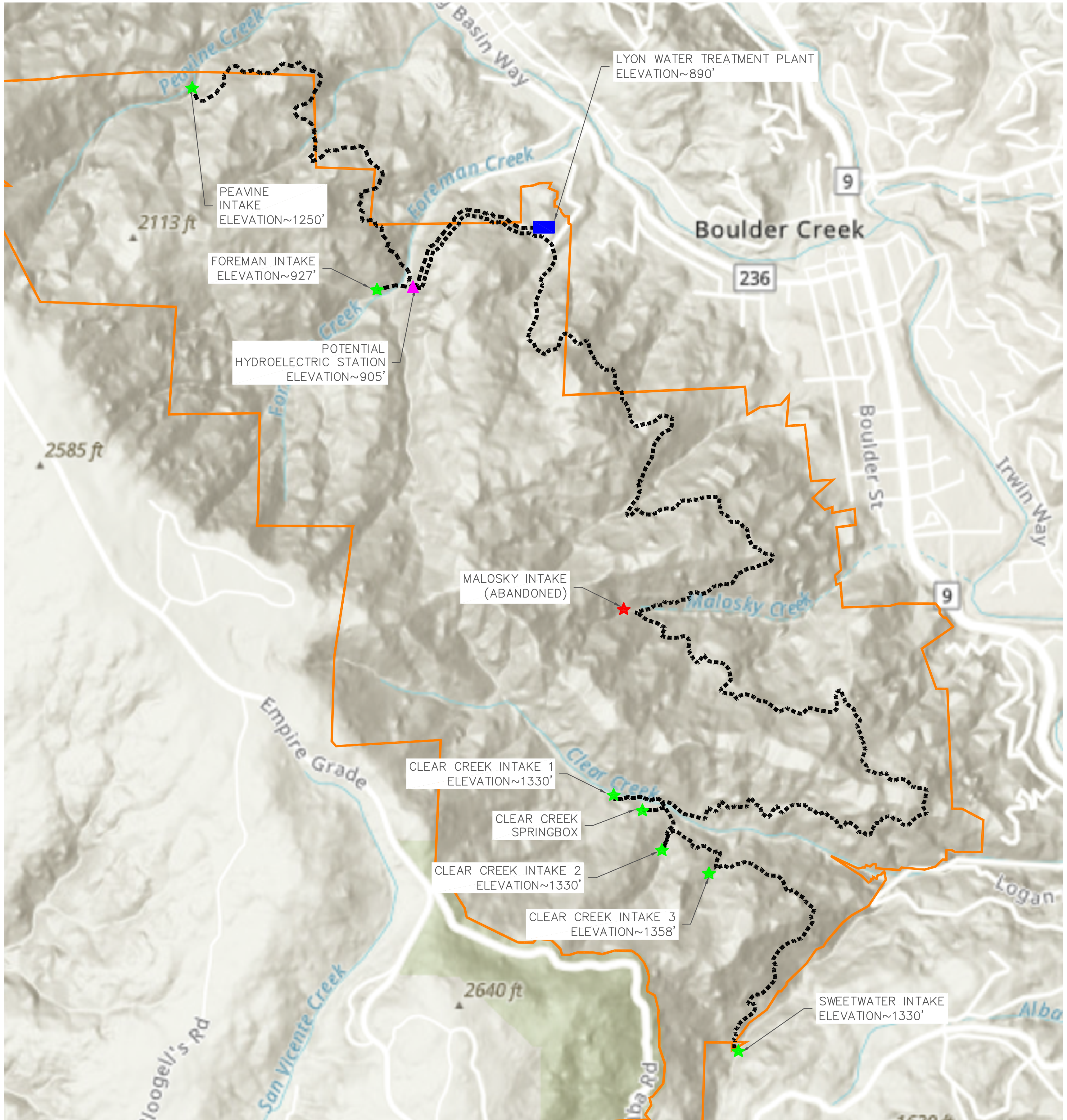
5-MILE PIPELINE
- RECONSTRUCT 5-MILE PIPELINE ALONG EXISTING ALIGNMENT
- BELOW GROUND, HDPE (DETAIL 1, DETAIL 2, DETAIL 3)
- SELECT AREAS ABOVE GROUND, WELDED STEEL (DETAIL 4)
- CONSTRUCTION ACCESS ROAD WIDTH CONSIDERS FINAL MAINTENANCE ROAD WIDTH REQUIREMENTS

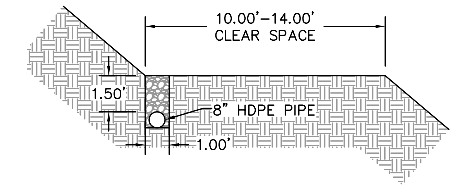
NORTH

ALTERNATIVE 3A
EXISTING ALIGNMENT, BURIED PIPE, AND ABOVE GROUND CREEK CROSSING
SAN LORENZO VALLEY WATER DISTRICT

JOB NO.: 322002
DATE: 11/24/2021

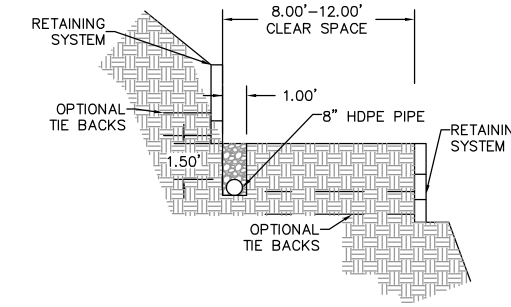
FIGURE 6





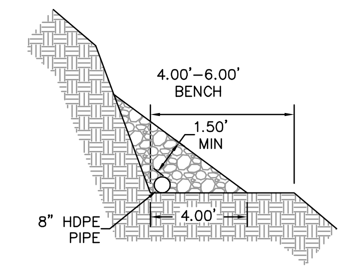
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.

1 – TYPICAL SHALLOW TRENCH WITH WIDENED BENCH
SCALE: NTS



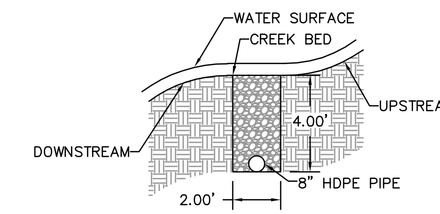
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.
2. RETAINING SYSTEM MAY BE UTILIZED ON BOTH UPHILL AND DOWN HILL SIDES OR ON EITHER SIDE SINGULARLY.

2 – STEEP SLOPE TRENCH WITH RETAINING SYSTEM
SCALE: NTS



NOTES
1. ALL VEGETATION WITHIN THE BENCH MUST BE REMOVED.
2. MINIMUM COVER OVER THE PIPE IS 18 INCHES.
3. NARROWED SHALLOW TRENCH MAY REQUIRE HAND DIGGING.

3 – NARROWED SHALLOW TRENCH
SCALE: NTS



4 – CREEK CROSSING BELOW GROUND
SCALE: NTS

LEGEND

- EXISTING ALIGNMENT TO REMAIN
- SLVWD PROPERTY LINE
- WATER SYSTEM INTAKE/INFRASTRUCTURE
- ABANDONED WATER SYSTEM INTAKE/INFRASTRUCTURE
- WATER TREATMENT PLANT
- POTENTIAL HYDROELECTRIC STATION

TABLE 1: APPROXIMATE LENGTHS	
EXISTING PEAVINE ALIGNMENT	8,841 LF
EXISTING FIVE MILE ALIGNMENT	31,603 LF

ALTERNATIVE 3B

PEAVINE PIPELINE
- RECONSTRUCT PEAVINE PIPELINE ALONG EXISTING ALIGNMENT
- BELOW GROUND, HDPE (DETAIL 1, DETAIL 2, DETAIL 3, DETAIL 4)
- CONSTRUCTION ACCESS ROAD WIDTH CONSIDERS FINAL MAINTENANCE ROAD WIDTH REQUIREMENTS

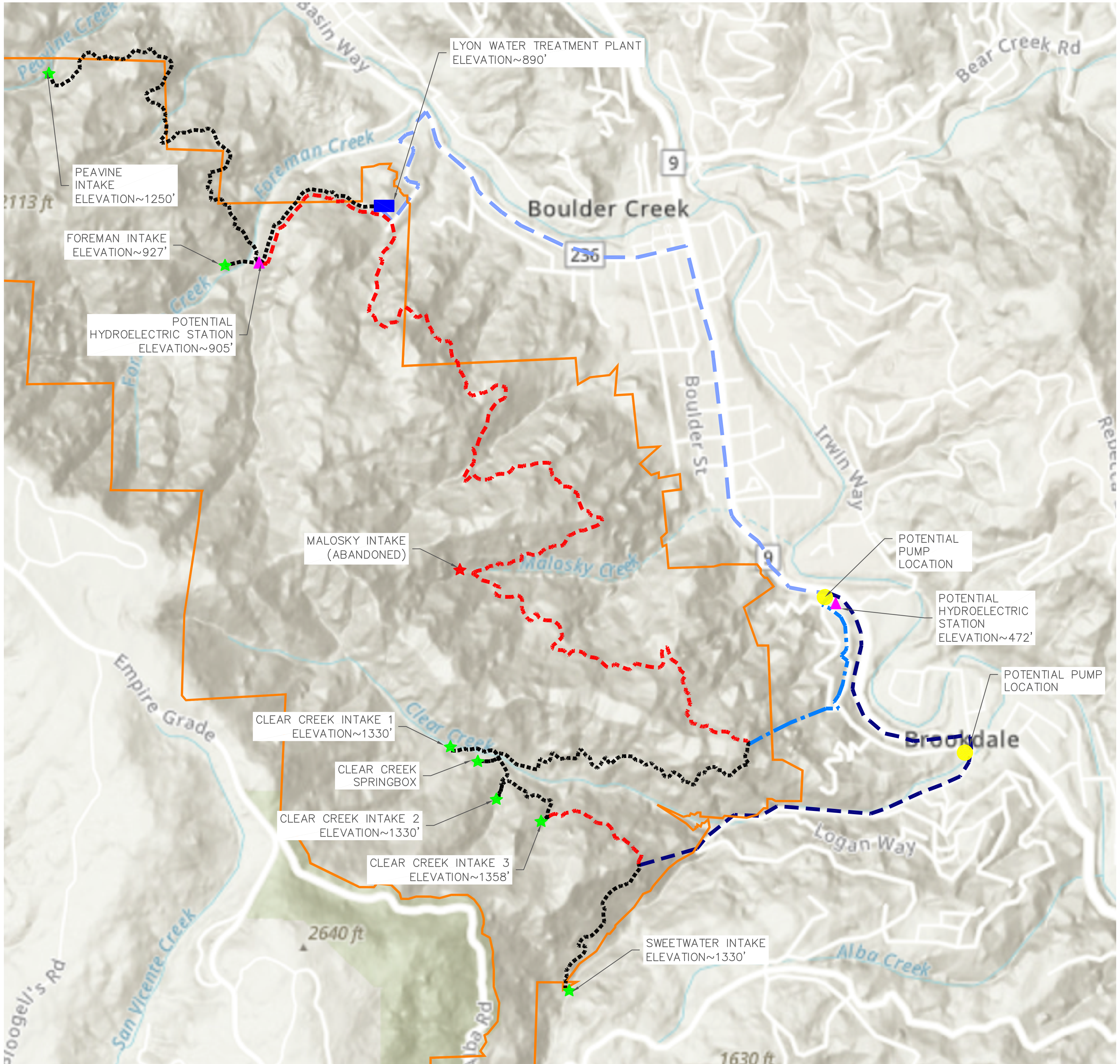
5-MILE PIPELINE
- RECONSTRUCT 5-MILE PIPELINE ALONG EXISTING ALIGNMENT
- BELOW GROUND, HDPE (DETAIL 1, DETAIL 2, DETAIL 3, DETAIL 4)
- CONSTRUCTION ACCESS ROAD WIDTH CONSIDERS FINAL MAINTENANCE ROAD WIDTH REQUIREMENTS

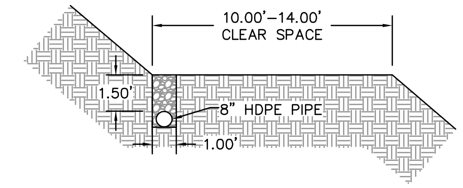
NORTH

ALTERNATIVE 3B
EXISTING ALIGNMENT AND BURIED PIPE
SAN LORENZO VALLEY WATER DISTRICT

JOB NO.: 322002
DATE: 11/24/2021

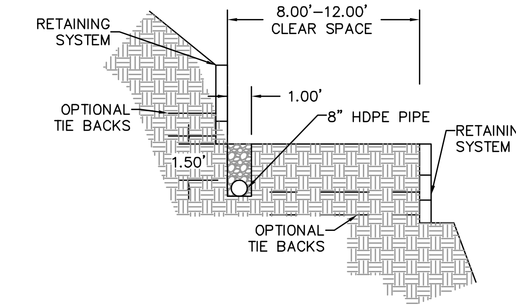
FIGURE 7





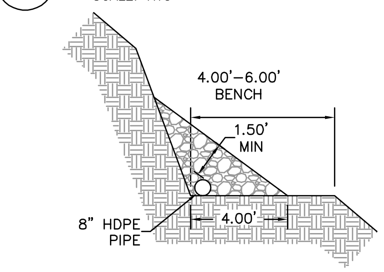
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.

1 TYPICAL SHALLOW TRENCH WITH WIDENED BENCH
SCALE: NTS



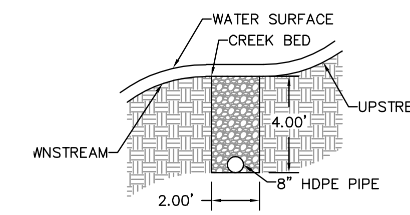
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.
2. RETAINING SYSTEM MAY BE UTILIZED ON BOTH UPHILL AND DOWN HILL SIDES OR ON EITHER SIDE SINGULARLY.

2 STEEP SLOPE TRENCH WITH RETAINING SYSTEM
SCALE: NTS



NOTES
1. ALL VEGETATION WITHIN THE BENCH MUST BE REMOVED.
2. MINIMUM COVER OVER THE PIPE IS 18 INCHES.
3. NARROWED SHALLOW TRENCH MAY REQUIRE HAND DIGGING.

3 NARROWED SHALLOW TRENCH
SCALE: NTS



4 CREEK CROSSING BELOW GROUND
SCALE: NTS

LEGEND

- EXISTING ALIGNMENT TO REMAIN
- SLVWD PROPERTY LINE
- NEW COMBINED ALIGNMENT
- NEW CLEAR CREEK ALIGNMENT
- NEW SWEETWATER ALIGNMENT
- EXISTING ALIGNMENT NO LONGER NEEDED
- POTENTIAL PUMP STATION LOCATION
- WATER SYSTEM INTAKE/INFRASTRUCTURE
- ABANDONED WATER SYSTEM INTAKE/INFRASTRUCTURE
- WATER TREATMENT PLANT
- POTENTIAL HYDROELECTRIC STATION

TABLE 1: APPROXIMATE LENGTHS	
EXISTING PEAVINE ALIGNMENT	8,841 LF
NEW COMBINED ALIGNMENT	11,879 LF
SWEETWATER PIPELINE	10,786 LF
CLEAR CREEK PIPELINE	11,795 LF

ALTERNATIVE 4A

PEAVINE PIPELINE
- RECONSTRUCT PEAVINE PIPELINE ALONG EXISTING ALIGNMENT
- BELOW GROUND, HDPE (DETAIL 1, DETAIL 2, DETAIL 3, DETAIL 4)
- CONSTRUCTION ACCESS ROAD WIDTH CONSIDERS FINAL MAINTENANCE ROAD WIDTH REQUIREMENTS

5-MILE PIPELINE
- RECONSTRUCT A SECTION OF 5-MILE PIPELINE ALONG EXISTING ALIGNMENT FROM SWEETWATER CREEK
- REALIGNMENT OF 5-MILE PIPELINE FROM SWEETWATER INTAKE TOWARDS HIGHWAY 9
- RECONSTRUCT A SECTION OF 5-MILE PIPELINE ALONG EXISTING ALIGNMENT FROM CLEAR CREEK INTAKES
- REALIGNMENT OF 5-MILE PIPELINE FROM CLEAR CREEK INTAKES TOWARDS HIGHWAY 9
- NEW ALIGNMENT WITHIN HIGHWAY 9 TO LYON WATER TREATMENT PLANT
- BELOW GROUND, HDPE (DETAIL 1, DETAIL 2, DETAIL 3, DETAIL 4)
- CONSTRUCTION ACCESS ROAD WIDTH CONSIDERS FINAL MAINTENANCE ROAD WIDTH REQUIREMENTS
- REQUIRES TWO NEW PUMP STATION
- NEW PUMP STATIONS REQUIRE NEW POWER CONNECTION
- REQUIRES INFRASTRUCTURE IN RIGHT OF WAY
- POTENTIAL EASEMENT ACQUISITION

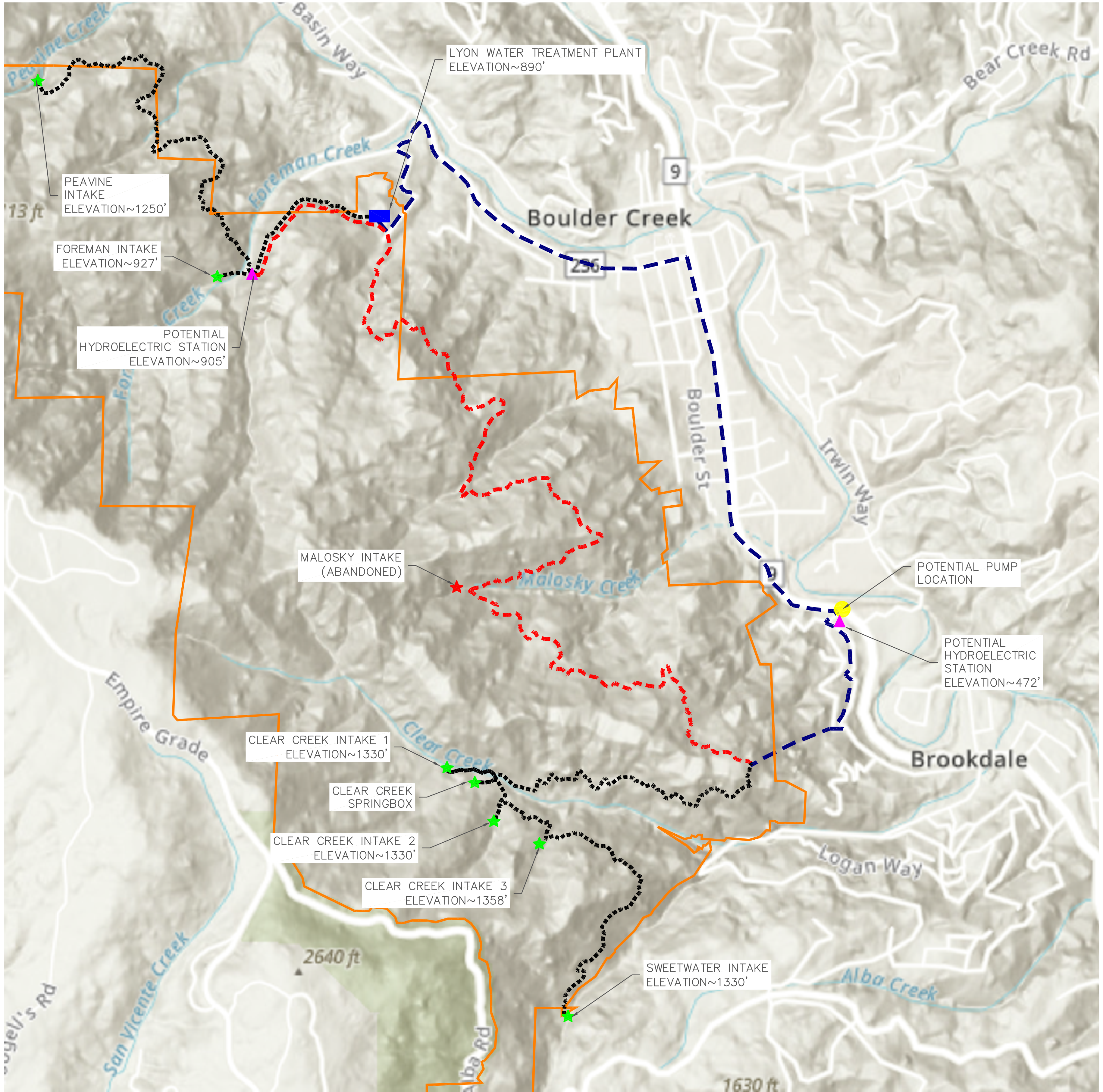
NORTH

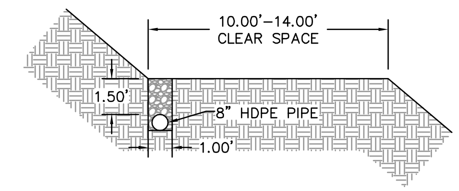
ALTERNATIVE 4A
NEW ALIGNMENT AND TWO PUMP STATIONS
SAN LORENZO VALLEY WATER DISTRICT

JOB NO.: 322002

DATE: 11/24/2021

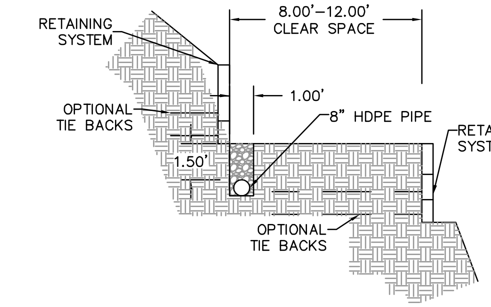
FIGURE 8





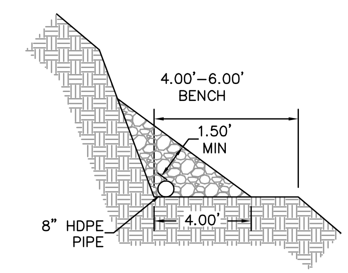
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.

1 – TYPICAL SHALLOW TRENCH WITH WIDENED BENCH
SCALE: NTS



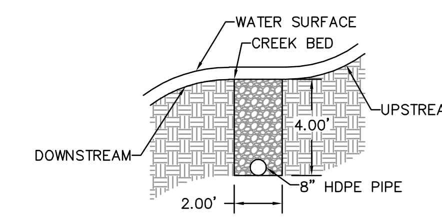
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.
2. RETAINING SYSTEM MAY BE UTILIZED ON BOTH UPHILL AND DOWN HILL SIDES OR ON EITHER SIDE

2 – STEEP SLOPE TRENCH WITH RETAINING SYSTEM
SCALE: NTS



NOTES
1. ALL VEGETATION WITHIN THE BENCH MUST BE REMOVED.
2. MINIMUM COVER OVER THE PIPE IS 18 INCHES.
3. NARROWED SHALLOW TRENCH MAY REQUIRE HAND DIGGING.

3 – NARROWED SHALLOW TRENCH
SCALE: NTS



4 – CREEK CROSSING BELOW GROUND
SCALE: NTS

LEGEND

- EXISTING ALIGNMENT TO REMAIN
- SLVWD PROPERTY LINE
- NEW FIVE MILE PIPELINE
- EXISTING ALIGNMENT NO LONGER NEEDED
- POTENTIAL PUMP STATION LOCATION
- WATER SYSTEM INTAKE/INFRASTRUCTURE
- ABANDONED WATER SYSTEM INTAKE/INFRASTRUCTURE
- WATER TREATMENT PLANT
- POTENTIAL HYDROELECTRIC STATION

TABLE 1: APPROXIMATE LENGTHS	
EXISTING PEAVINE ALIGNMENT	8,841 LF
NEW 5 MILE ALIGNMENT	27,686 LF
NEW 5 MILE ALIGNMENT WITHIN WATERSHED	12,924 LF

ALTERNATIVE 4B

PEAVINE PIPELINE
- RECONSTRUCT PEAVINE PIPELINE ALONG EXISTING ALIGNMENT
- BELOW GROUND, HDPE (DETAIL 1, DETAIL 2, DETAIL 3, DETAIL 4)
- CONSTRUCTION ACCESS ROAD WIDTH CONSIDERS FINAL MAINTENANCE ROAD WIDTH REQUIREMENTS

5–MILE PIPELINE
- RECONSTRUCT A SECTION OF 5–MILE PIPELINE ALONG EXISTING ALIGNMENT FROM SWEETWATER CREEK INTAKE TO CLEAR CREEK INTAKES
- REALIGNMENT OF 5–MILE PIPELINE FROM CLEAR CREEK INTAKES TOWARDS HIGHWAY 9
- NEW ALIGNMENT WITHIN HIGHWAY 9 TO LYON WATER TREATMENT PLANT
- BELOW GROUND, HDPE (DETAIL 1, DETAIL 2, DETAIL 3, DETAIL 4)
- CONSTRUCTION ACCESS ROAD WIDTH CONSIDERS FINAL MAINTENANCE ROAD WIDTH REQUIREMENTS
- REQUIRES NEW PUMP STATION
- NEW PUMP STATIONS REQUIRE NEW POWER CONNECTION
- REQUIRES INFRASTRUCTURE IN RIGHT OF WAY
- POTENTIAL EASEMENT ACQUISITION

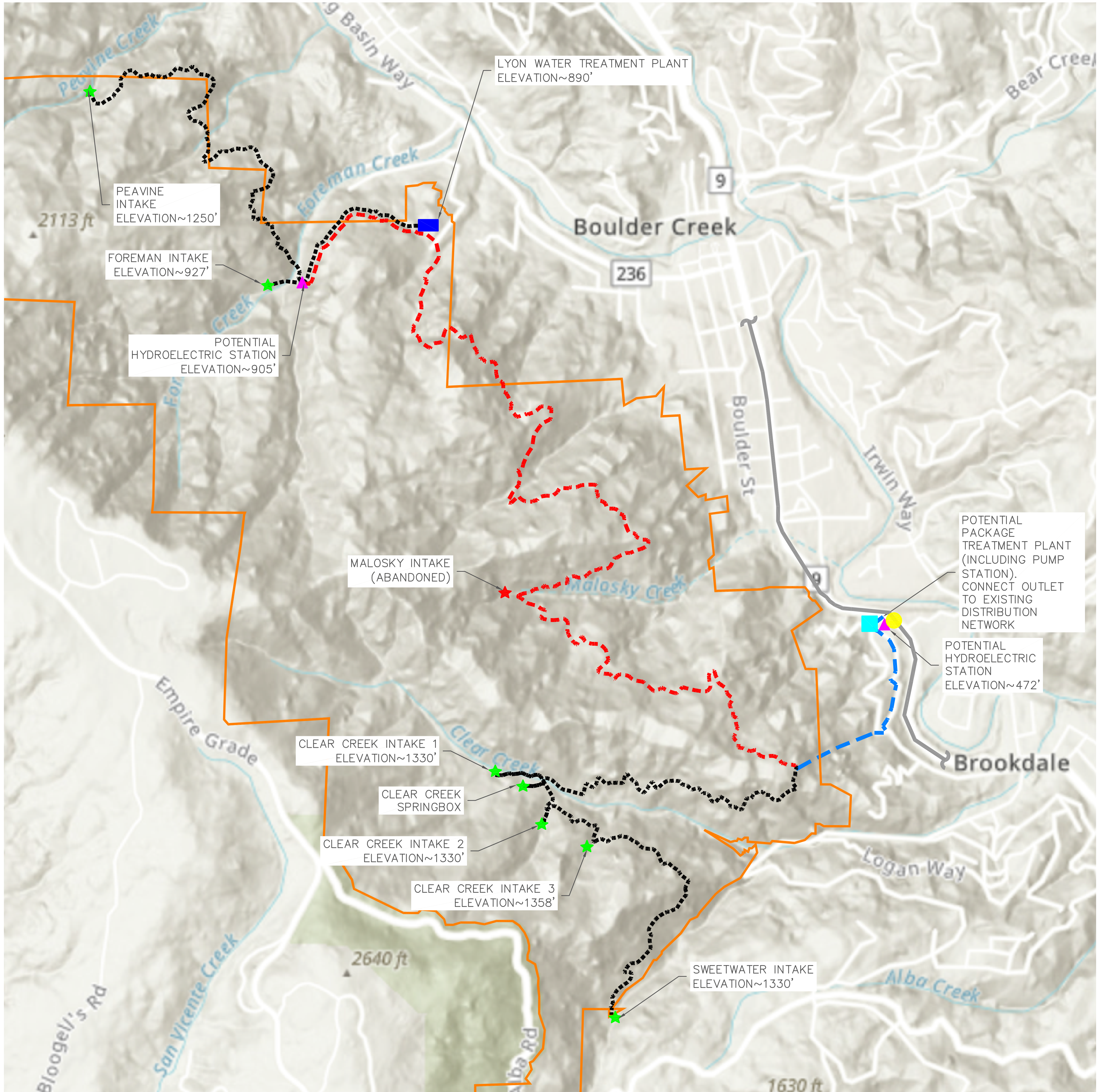
NORTH

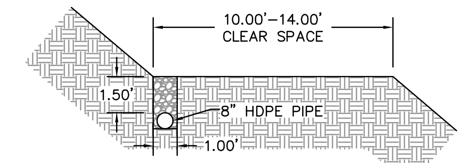
ALTERNATIVE 4B
NEW ALIGNMENT AND ONE PUMP STATION
SAN LORENZO VALLEY WATER DISTRICT

FIGURE 9

JOB NO.: 322002

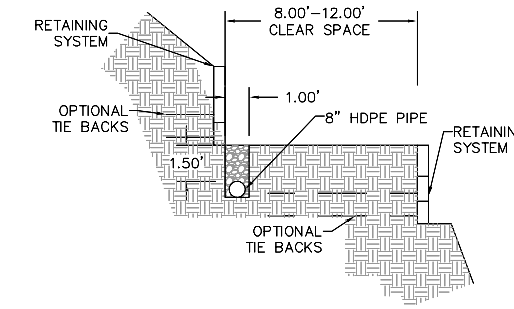
DATE: 11/24/2021





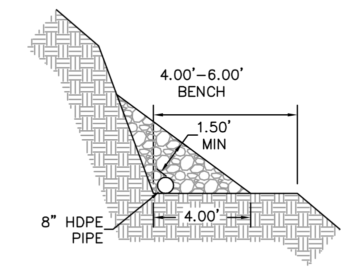
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.

1 – TYPICAL SHALLOW TRENCH WITH WIDENED BENCH
SCALE: NTS



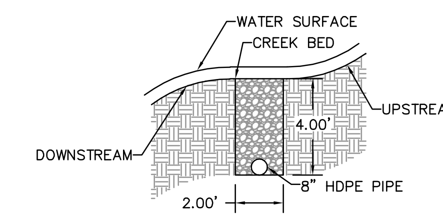
NOTES
1. ALL VEGETATION WITHIN THE CLEAR SPACE MUST BE REMOVED.
2. RETAINING SYSTEM MAY BE UTILIZED ON BOTH UPHILL AND DOWN HILL SIDES OR ON EITHER SIDE SINGULARLY.

2 – STEEP SLOPE TRENCH WITH RETAINING SYSTEM
SCALE: NTS



NOTES
1. ALL VEGETATION WITHIN THE BENCH MUST BE REMOVED.
2. MINIMUM COVER OVER THE PIPE IS 18 INCHES.
3. NARROWED SHALLOW TRENCH MAY REQUIRE HAND DIGGING.

3 – NARROWED SHALLOW TRENCH
SCALE: NTS



4 – CREEK CROSSING BELOW GROUND
SCALE: NTS

NORTH

LEGEND

- EXISTING ALIGNMENT TO REMAIN
- SLVWD PROPERTY LINE
- NEW COMBINED ALIGNMENT
- EXISTING ALIGNMENT NO LONGER NEEDED
- EXISTING DISTRIBUTION MAIN
- POTENTIAL PACKAGE TREATMENT PLANT
- WATER SYSTEM INTAKE/INFRASTRUCTURE
- ABANDONED WATER SYSTEM INTAKE/INFRASTRUCTURE
- WATER TREATMENT PLANT
- POTENTIAL HYDROELECTRIC STATION
- POTENTIAL PUMP STATION LOCATION

TABLE 1: APPROXIMATE LENGTHS

EXISTING PEAVINE ALIGNMENT	8,841 LF
NEW 5 MILE ALIGNMENT	15,745 LF

ALTERNATIVE 5

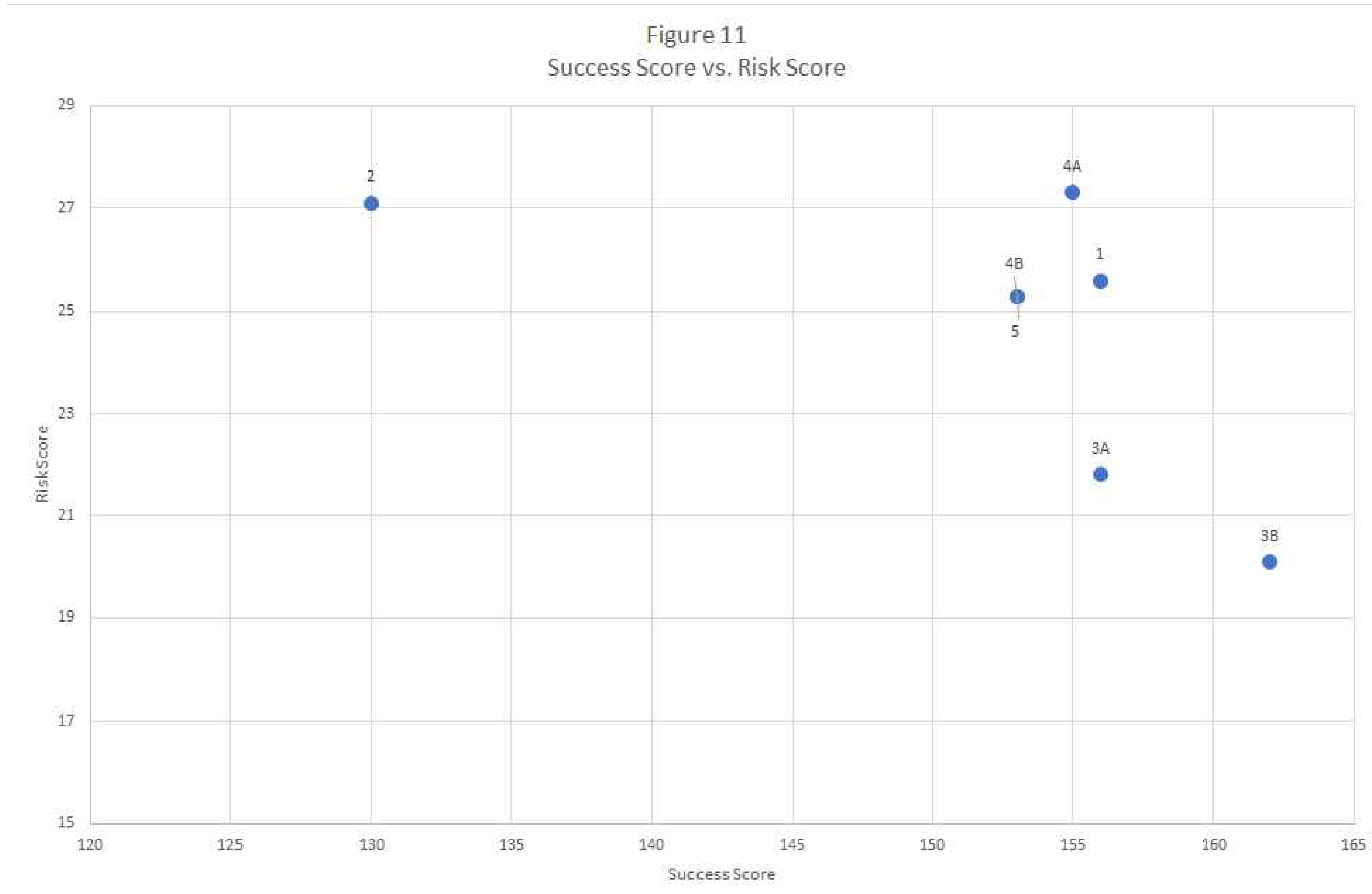
PEAVINE PIPELINE
- RECONSTRUCT PEAVINE PIPELINE ALONG EXISTING ALIGNMENT
- BELOW GROUND, HDPE (DETAIL 1, DETAIL 2, DETAIL 3, DETAIL 4)
- CONSTRUCTION ACCESS ROAD WIDTH CONSIDERS FINAL MAINTENANCE ROAD WIDTH REQUIREMENTS

5-MILE PIPELINE
- RECONSTRUCT A SECTION OF 5-MILE PIPELINE ALONG EXISTING ALIGNMENT FROM SWEETWATER CREEK INTAKE TO CLEAR CREEK INTAKES
- REALIGNMENT OF 5-MILE PIPELINE FROM CLEAR CREEK INTAKES TOWARDS HIGHWAY 9
- BELOW GROUND, HDPE (DETAIL 1, DETAIL 2, DETAIL 3, DETAIL 4)
- CONSTRUCTION ACCESS ROAD WIDTH CONSIDERS FINAL MAINTENANCE ROAD WIDTH REQUIREMENTS
- REQUIRES NEW PACKAGED WATER TREATMENT PLANT AND PUMP STATION
- NEW WATER TREATMENT PLANT REQUIRES NEW POWER CONNECTION
- REQUIRES INFRASTRUCTURE IN RIGHT OF WAY
- CONNECT TO EXISTING DISTRIBUTION SYSTEM
- POTENTIAL EASEMENT ACQUISITION

ALTERNATIVE 5
NEW ALIGNMENT AND PACKAGED WATER TREATMENT PLANT
SAN LORENZO VALLEY WATER DISTRICT

FIGURE 10

JOB NO.: 322002
DATE: 11/24/2021



ALTERNATIVE CROSS COUNTY PIPELINE
SUCCESS SCORE VS. RISK SCORE
FIGURE 11
SAN LORENZO VALLEY WATER DISTRICT

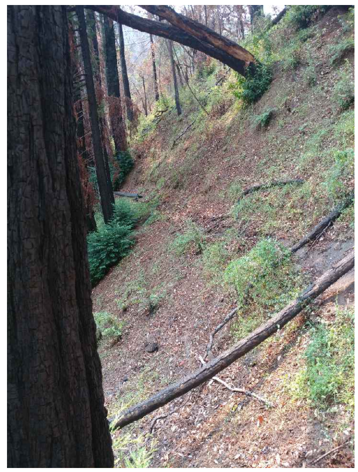
JOB NO.: 322002	DATE: 11/24/2021	FIGURE 11

APPENDIX A: Site Pictures

PICTURE #1
BURNT FOREST – 5 MILE

PICTURE #2
IRREPARABLE DAMAGED PIPE – 5 MILE

PICTURE #3
MELTED PIPE – 5 MILE



PICTURE #4
NARROW PIPE BENCH – 5 MILE

PICTURE #5
HILLSIDE SLOUGH – 5 MILE

PICTURE #6
STEEP HILLSIDE – 5 MILE

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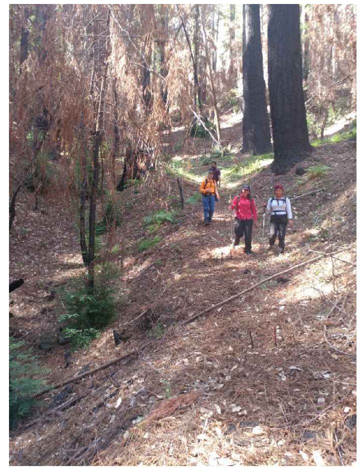
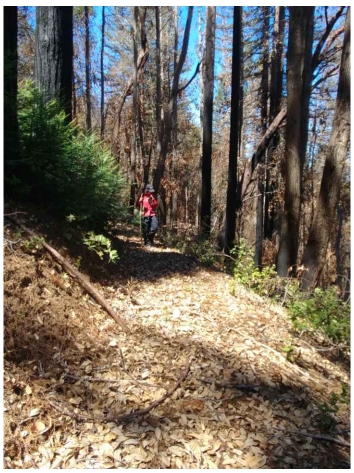
SITE VISIT PICTURES
AUGUST 18 AND AUGUST 26, 2021
SAN LORENZO VALLEY WATER DISTRICT
13060 CA–9,
BOULDER CREEK, CA 95006

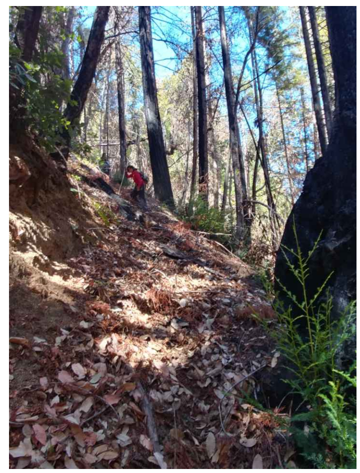
PICTURE #7
BURNT CANOPY – 5 MILE



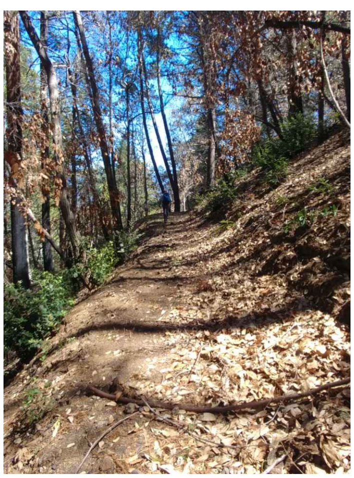
PICTURE #8
WIDER PIPE BENCH – PEAVINE



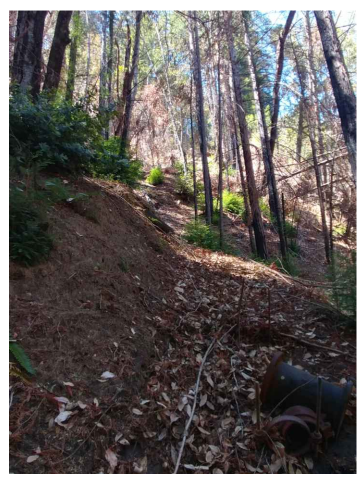
PICTURE #9
MILD DEBRIS ON BENCH – PEAVINE



PICTURE #10
STEEP GRADE – PEAVINE



PICTURE #11
MODERATE VEGETATION LOSS – PEAVINE



PICTURE #12
EXISTING STEEP SLOPE – PEAVINE

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SITE VISIT PICTURES
AUGUST 18 AND AUGUST 26, 2021
SAN LORENZO VALLEY WATER DISTRICT
13060 CA–9,
BOULDER CREEK, CA 95006

APPENDIX B: Jurisdictional Assessment

Jurisdictional Assessment for the San Lorenzo Valley Water District Cross County Pipeline Constructability Study

Prepared for:

Jeffrey Tarantino
Freyer & Lauretta, Inc.

Prepared by:

Scott Batiuk, BS
Brian Kearns, PhD
Justin Semion, MBA, PWS
Peter Kobylarz, GISP

February 7, 2022

1.0 Purpose and Scope

The table below provides information to assist project planning and environmental scoping for the San Lorenzo Valley Water District Cross County Pipeline Constructability Study. The constructability study is evaluating reconstruction of two existing alignments, the Peavine alignment and 5-mile pipeline alignment, after the existing water delivery pipelines were destroyed by the CZU fire in 2020. The information in this table will be used to help evaluate the construction feasibility of alternatives considered as part of the constructability study, and can serve as a guide for the District as to the potential environmental process for the eventual pipeline replacement projects along the Peavine and 5-mile alignments.

Data used to support this assessment was gathered in the field during site visits on August 18 and August 26, 2021. A wetland and vegetation ecology biologist and a wildlife biologist walked the existing Peavine and 5-mile pipeline alignments with District staff and others on the constructability team, noting habitats encountered and the potential for those habitats to support special status plant and wildlife species. Key biological constraints observed during the field visit were:

- Pipeline crossings of numerous streams, with potential retaining system impacts to up to 2 streams on the Peavine alignment and 16 streams on the 5-mile alignment
- Pipeline crossing of one seep wetland
- Potential habitat for threatened and endangered wildlife species marbled murrelet (*Brachyramphus marmoratus*) and foothill yellow-legged frog (*Rana boylii*)
- Potential habitat for "California rare" designated plant species Dudley's lousewort (*Pedicularis dudleyi*)
- Potential impacts to nesting birds during construction
- Potential impacts to redwood forest and non-listed special status species considered sensitive under the California Environmental Quality Act (CEQA)

Attachment 1 identifies the location and extent of regulated aquatic resources within 100 feet on either side of the existing Peavine and 5-mile alignments. Attachment 2 identifies the locations of streams that may be affected by slope retaining systems that may be required to maintain geotechnical stability during and after construction. The table below identifies regulatory agencies whose approvals are anticipated for various alternatives being considered as part of the Constructability Study.

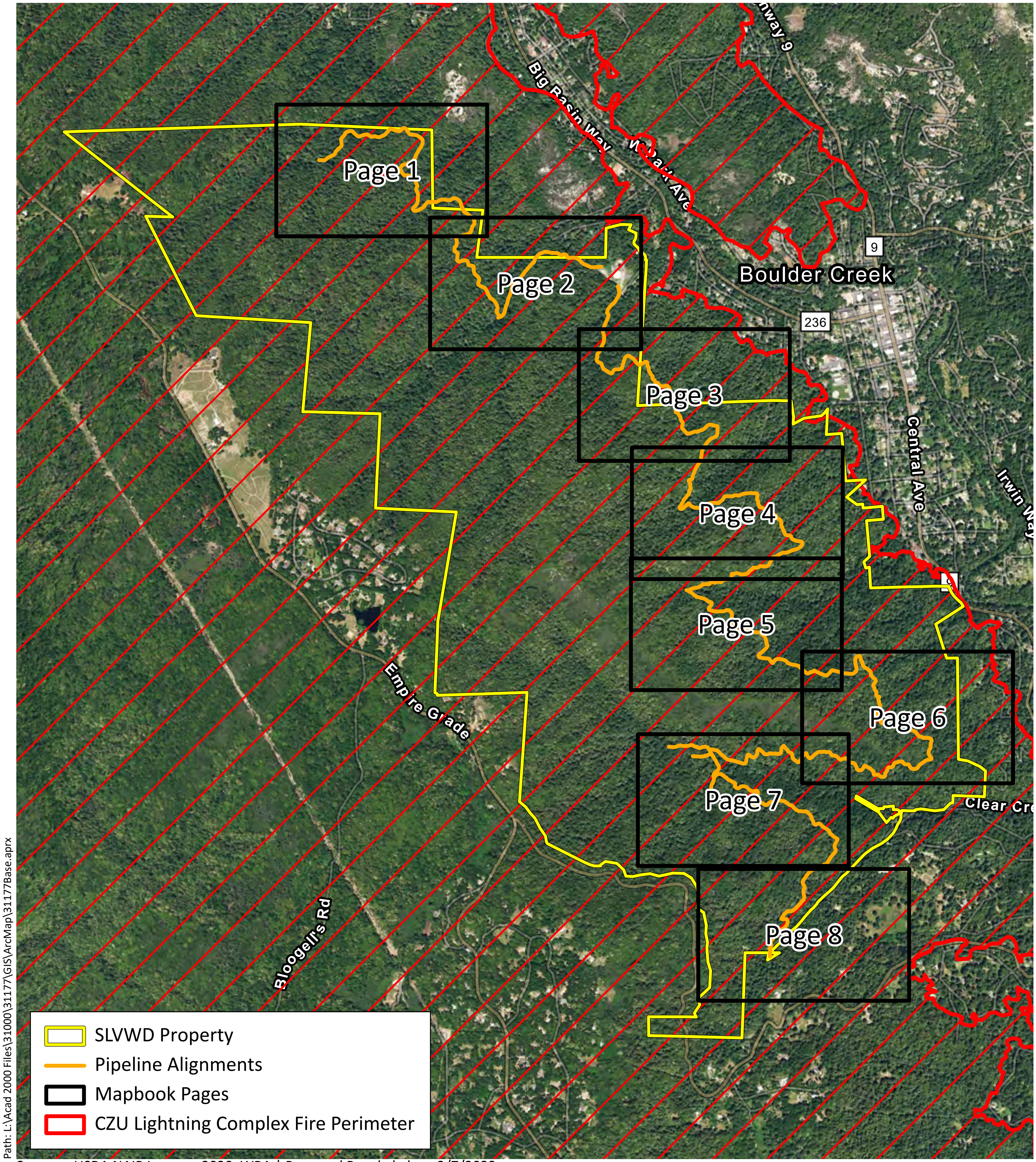
Table 1. Summary of Relevant Regulatory Agencies, Anticipated Permits, Triggering Activities, and Jurisdictional Limits					
Agency	**Governing Law(s)**	**Permit Mechanism(s) Anticipated**	**Permit Triggers**	**Potential Jurisdictional Limits within the Project Area**	**Potential Project Challenges and Recommendations**
U.S. Army Corps of Engineers, San Francisco District (USACE)	Clean Water Act, Section 404	Nationwide Permit 58	Fill or excavation within wetlands and/or the OHWM of streams	Wetlands and/or the OHWM of streams	• Emergency permitting pathway is available, however, project is unlikely to meet the Corps' high standard for qualification as an emergency project. • Some risk of more complex and lengthier Individual Permit process if the Corps views that as an easier pathway. • Avoid culverting streams to minimize potential mitigation requirements. • Avoid placing retaining systems across streams to the maximum extent practicable.
Central Coast Regional Water Quality Control Board (RWQCB)	Porter Cologne Water Quality Control Act Clean Water Act Section 401	401 Water Quality Certification and/or Waste Discharge Requirement Permit	Any work within wetlands or below OHWM of intermittent streams.	Wetlands and/or OHWM of streams	• Emergency permitting pathway is available, however, project is unlikely to meet the RWQCB's high standard for qualification as an emergency project. • Alternatives analysis will be required during permitting. Documentation from the constructability analysis will be helpful as background for the regulatory alternatives analysis. • Avoid culverting streams to minimize potential mitigation requirements. • RWQCB may require mitigation for other substantial rerouting or alteration of streams at stream crossings, not limited to culverting of segments. • Avoid placing retaining systems across streams to the maximum extent practicable.
U.S. Fish and Wildlife Service (USFWS)	Federal Endangered Species Act	Endangered Species Act Section 7 Consultation for marbled murrelet	Work within or adjacent to endangered species habitat; primarily redwood and Douglas fir stands within and surrounding old growth redwood	Forested areas where Douglas fir and redwoods are the dominant tree species. Critical Habitat is present at Henry Cowell Redwoods.	• Protocol surveys for marbled murrelet prior to permit application preparation may help provide information to support reduced survey and mitigation requirements during construction. • Substantial vegetation clearing could result in significant challenges managing nesting birds. • Removal of trees along each alignment outside of the nesting season is being pursued to avoid impacts to breeding birds. Tree removal to be completed between September 1 and January 31 to avoid the nesting season. • Depredation Permit may or may not be available mechanism to allow for take of nesting birds pending proposed regulatory changes.
	Migratory Bird Treaty Act	Possible Depredation Permit	Intentional removal or destruction of nesting birds, nests, or young (such as birds nesting in vegetation or on structures to be repaired/altered)	Nesting birds, particularly in vegetation that may need to be removed during construction.	
State Historic Preservation Office (SHPO)	National Historic Preservation Act (NHPA), Section 106	NHPA Section 106 Consultation	Projects affecting historic properties (including archaeological properties) and that require federal funding or permits	Properties listed and eligible for listing on the Register of Historic Places	• Historic properties are unlikely to be an issue for this project. Other cultural resources issues could arise for alternatives that involve trenching and excavation.

Table 1. Summary of Relevant Regulatory Agencies, Anticipated Permits, Triggering Activities, and Jurisdictional Limits					
Agency	**Governing Law(s)**	**Permit Mechanism(s) Anticipated**	**Permit Triggers**	**Potential Jurisdictional Limits within the Project Area**	**Potential Project Challenges and Recommendations**
California Department of Fish and Wildlife (CDFW)	Fish and Game Code and California Endangered Species Act	Section 2081 Incidental Take Permit (foothill yellow-legged frog; Dudley's lousewort); potential Section 2081 Incidental Take Permit and/or determination of concurrence with USFWS for marbled murrelet	Work with the potential to kill or injure foothill yellow-legged frog; work that may produce substantial visual/auditory disturbance near potential murrelet habitat (redwood stands)	Areas immediately surrounding perennial and intermittent streams; forested areas where old growth and established redwoods are dominant.	• Need for an Incidental Take Permit for foothill yellow legged frog can be avoided through preconstruction surveys and avoidance measures during construction. • Protocol surveys for marbled murrelet and Dudley's lousewort are recommended in advance of CEQA and permit applications to determine potential presence and potential need for an Incidental Take Permit for these species. • A 1602 Streambed Alteration Agreement could include conditions requiring minimum bypass flow. Any impact to streams or riparian vegetation would trigger a 1602 permit. Minimum bypass flow conditions are typical for CDFW 1602 permits involving stream related water supply infrastructure. • Removal of trees along each alignment outside of the nesting season is being pursued to avoid impacts to breeding birds. Tree removal to be completed between September 1 and January 31 to avoid the nesting season. • Emergency permitting pathway is available, but would not be a major project benefit if other agencies process permits as standard timelines.
	Fish and Game Code, Sections 1600-1616	Section 1602 Lake or Streambed Alteration Agreement	Work within or across streams	Streams, to top of bank	
	California Fish and Game Code – Nesting Bird Protections	No direct permit mechanism allowing incidental take is available	Removal or destruction of nesting birds, nests, or young (such as birds nesting in vegetation or on structures to be repaired/altered)	Nesting birds, particularly in vegetation that may need to be removed during construction.	
County of Santa Cruz	County of Santa Cruz Municipal Code Title 16: Environmental and Resource Protection • Chapter 16.20: Grading Regulations • Chapter 16.30: Riparian Corridor and Wetlands Protection • Chapter 16.32: Sensitive Habitat Protection • Chapter 16.40: Native American Cultural Sites • Chapter 16.52: Timber Harvesting Regulations	County Planning Approvals	Grading, excavation and other forms of County-defined "development" within sensitive habitats.	The majority of the alignment qualifies in some way as a sensitive habitat. Sensitive habitats along the alignment include: • Streams and riparian areas • Wetlands • Redwood forest	• Sensitive habitat avoidance and minimization will be accomplished via regulatory permitting and CEQA processes. • District is not required to apply for County permits due to California intergovernmental immunity.

Table 1. Summary of Relevant Regulatory Agencies, Anticipated Permits, Triggering Activities, and Jurisdictional Limits					
Agency	**Governing Law(s)**	**Permit Mechanism(s) Anticipated**	**Permit Triggers**	**Potential Jurisdictional Limits within the Project Area**	**Potential Project Challenges and Recommendations**
CAL FIRE	California Forest Practices Act	Public Utilities Exemption	Removal of "commercial species" trees within lands classified as "forestland" for the purposes of establishing and/or maintaining a utility ROWs	Forested areas	• 14 CCR 1104.1(c) exempts public and private utilities from the requirement to prepare a Timber Harvest Plan for construction and maintenance of rights of way (specifically including water utilities). • Exemption must be filed with CAL FIRE and forest clearing must be completed within one year of receipt of the exemption by CAL FIRE. • Utility exemptions are required to abide by Timber Harvest Plan regulations, including certain restrictions on work within sensitive habitat areas such as in areas surrounding streams. • Exemption requires name and license number for a "Licensed Timber Operator". Consultation with a Registered Professional Forester is recommended for further details.
California Environmental Quality Act (CEQA) District is its own Lead Agency.	California Environmental Quality Act	To be determined by SLVWD: Emergency Project Exemption (Statutory Exemption) Initial Study/Negative Declaration (IS/MND) Environmental Impact Report (EIR)	The Emergency Project Exemption could apply (Statutory Exemption). Project is both in response to (CEQA §15269(b)) and an action to prevent (CEQA §15269(c)) an emergency that relates to critical infrastructure necessary for the public health, safety and welfare. If District chooses not to apply Emergency Exemption, an Initial Study would be required to determine if the project requires an EIR or would qualify for a MND.	Applies to entire project and all alternatives.	• As the CEQA Lead Agency for the project, the District is the decision maker as to whether or not to apply the Statutory Exemption. The Exemption could be applied to the Peavine alignment individually, or to both the Peavine and 5-mile alignments. Projects have "independent utility", are anticipated to be bid as two separate projects, and could therefore be processed under two separate CEQA determinations. • Key issues anticipated if an IS/MND or EIR is prepared would be biological resources (sensitive habitats, nesting birds, and special-status species), geology and soils, hydrology and water quality, and wildfire. While unlikely, tribal cultural resources could be a concern pending more detailed cultural resources investigations. • CEQA must be completed prior to tree removal along either alignment. Achieving a project goal of construction for the Peavine alignment by summer of 2023 would require tree removal in the fall of 2022. • Construction on the Peavine alignment beginning in summer 2023 is possible with a Statutory Exemption. • To complete an IS/MND for the Peavine reach in time to enable construction in summer 2023, initial project design, including bench widths, retaining system design, and tree removal determinations would be needed by the end of April 2022. • Completing an EIR for the project would mean that tree removal is feasible in the fall of 2023, with start of construction on the Peavine alignment in the summer of 2024. • It is not required that the CEQA approach be the same for the Peavine and the 5-mile alignments. Each alignment can be viewed independently for CEQA analysis.

Table 1. Summary of Relevant Regulatory Agencies, Anticipated Permits, Triggering Activities, and Jurisdictional Limits					
Agency	**Governing Law(s)**	**Permit Mechanism(s) Anticipated**	**Permit Triggers**	**Potential Jurisdictional Limits within the Project Area**	**Potential Project Challenges and Recommendations**
National Environmental Policy Act (NEPA)	Federal Emergency Management Agency (FEMA)	To be determined by FEMA	Project anticipated to receive federal funding	Applies to all activities financed using federal funds.	• FEMA is responsible for completing NEPA for any project that it funds. • Studies completed by FEMA for NEPA compliance may be useful for project CEQA analysis. • Timing and schedule for CEQA and NEPA compliance should be discussed with FEMA to determine the scope and responsibility for completing studies performed for each process.

Attachment 1.
5-mile Pipeline Jurisdictional Assessment Aquatic Features



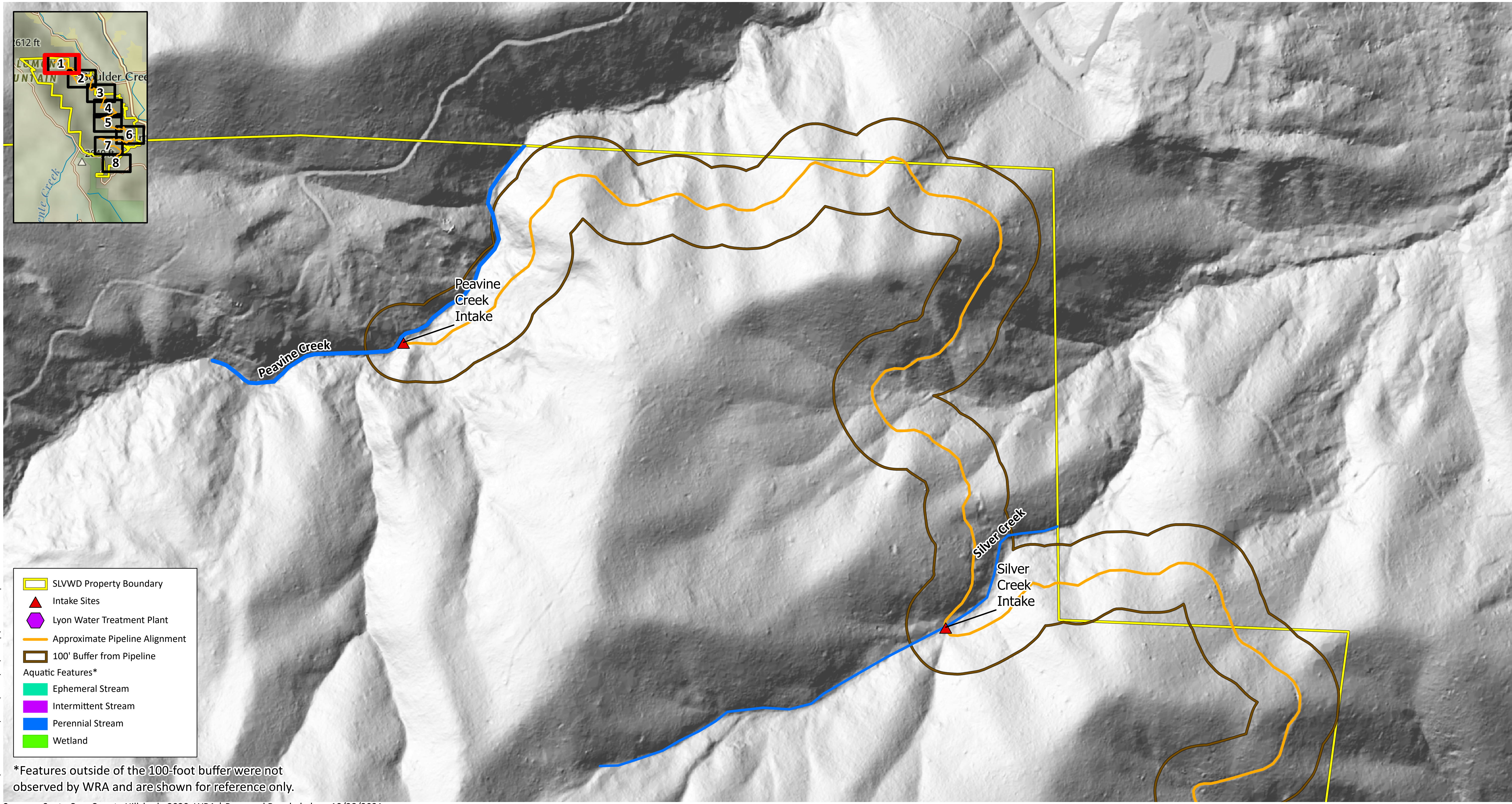
Sources: USDA NAIP Imagery 2020, WRA | Prepared By: pkobylarz, 2/7/2022

Study Area Overview

San Lorenzo Valley Water District
Cross Country Pipeline Constructability Analysis
Santa Cruz County, California

0 0.25 0.5 Miles
N

wra ENVIRONMENTAL CONSULTANTS



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Sources: Santa Cruz County Hillshade 2020, WRA | Prepared By: pkobylarz, 10/28/2021

Attachment 1. Peavine and 5-mile Pipelines Jurisdictional Assessment Aquatic Features
Page 1 of 8

San Lorenzo Valley Water District
Cross Country Pipeline Constructibility Analysis
Santa Cruz County, California

0 250 500 750 1,000 Feet

N

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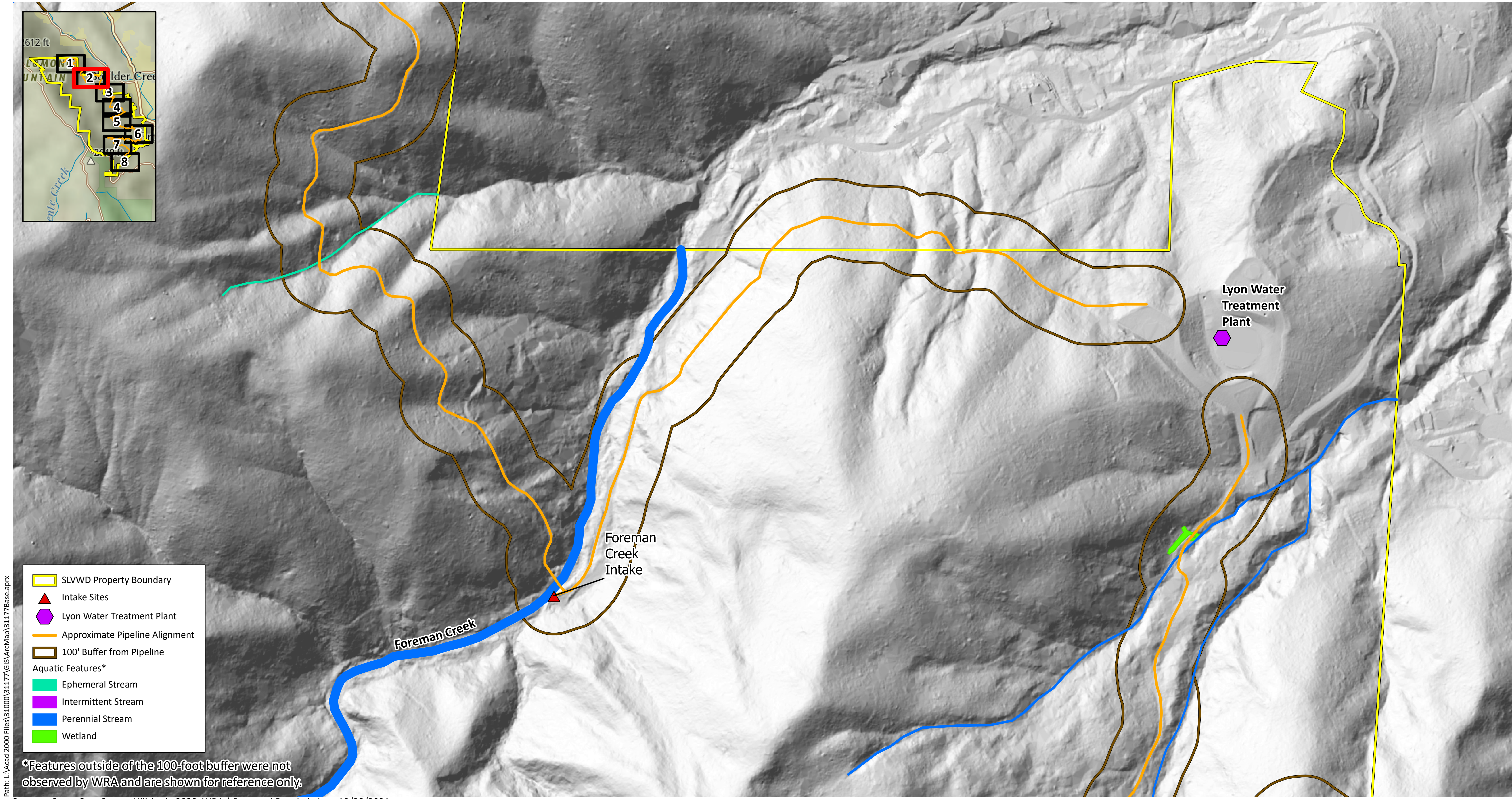


Sources: Santa Cruz County Hillshade 2020, WRA | Prepared By: pkobylarz, 10/28/2021

Attachment 1. Peavine and 5-mile Pipelines Jurisdictional Assessment Aquatic Features

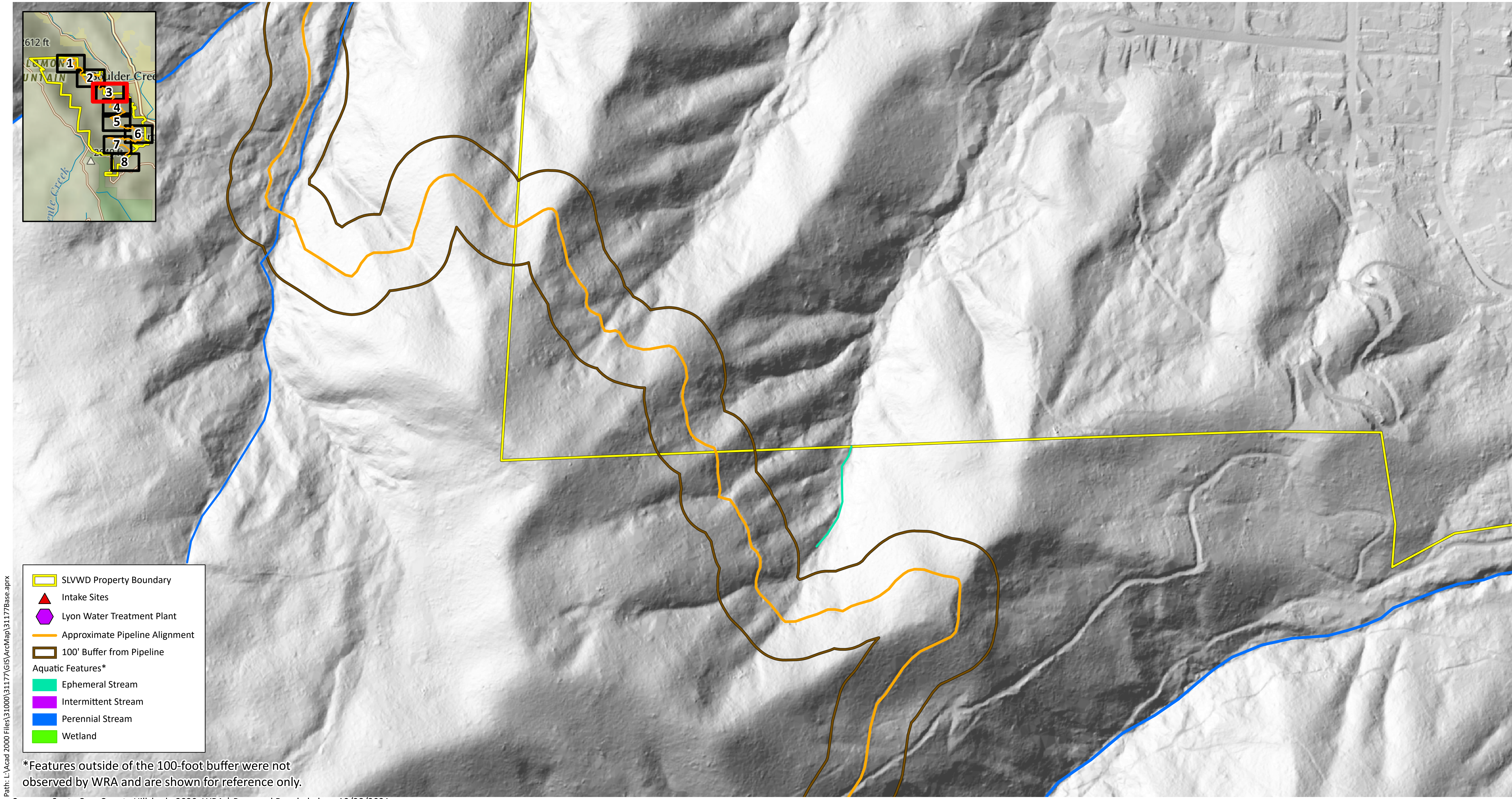
Page 2 of 8

San Lorenzo Valley Water District
Cross Country Pipeline Constructibility Analysis
Santa Cruz County, California

0 250 500 750 1,000 Feet

N

WRA ENVIRONMENTAL CONSULTANTS



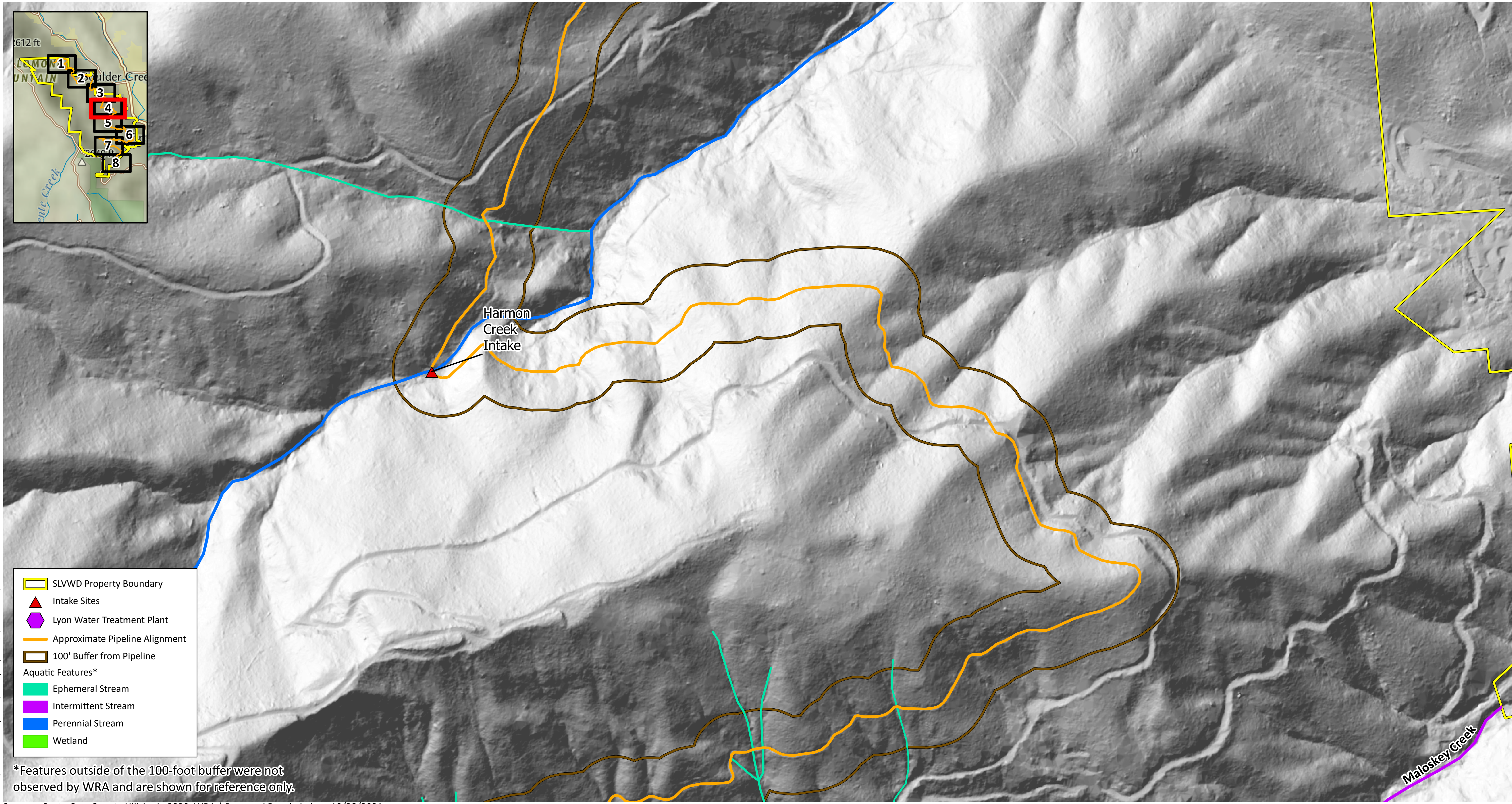
Sources: Santa Cruz County Hillshade 2020, WRA | Prepared By: pkobylarz, 10/28/2021

Attachment 1. Peavine and 5-mile Pipelines Jurisdictional Assessment Aquatic Features

Page 3 of 8

San Lorenzo Valley Water District
Cross Country Pipeline Constructibility Analysis
Santa Cruz County, California

wra ENVIRONMENTAL CONSULTANTS



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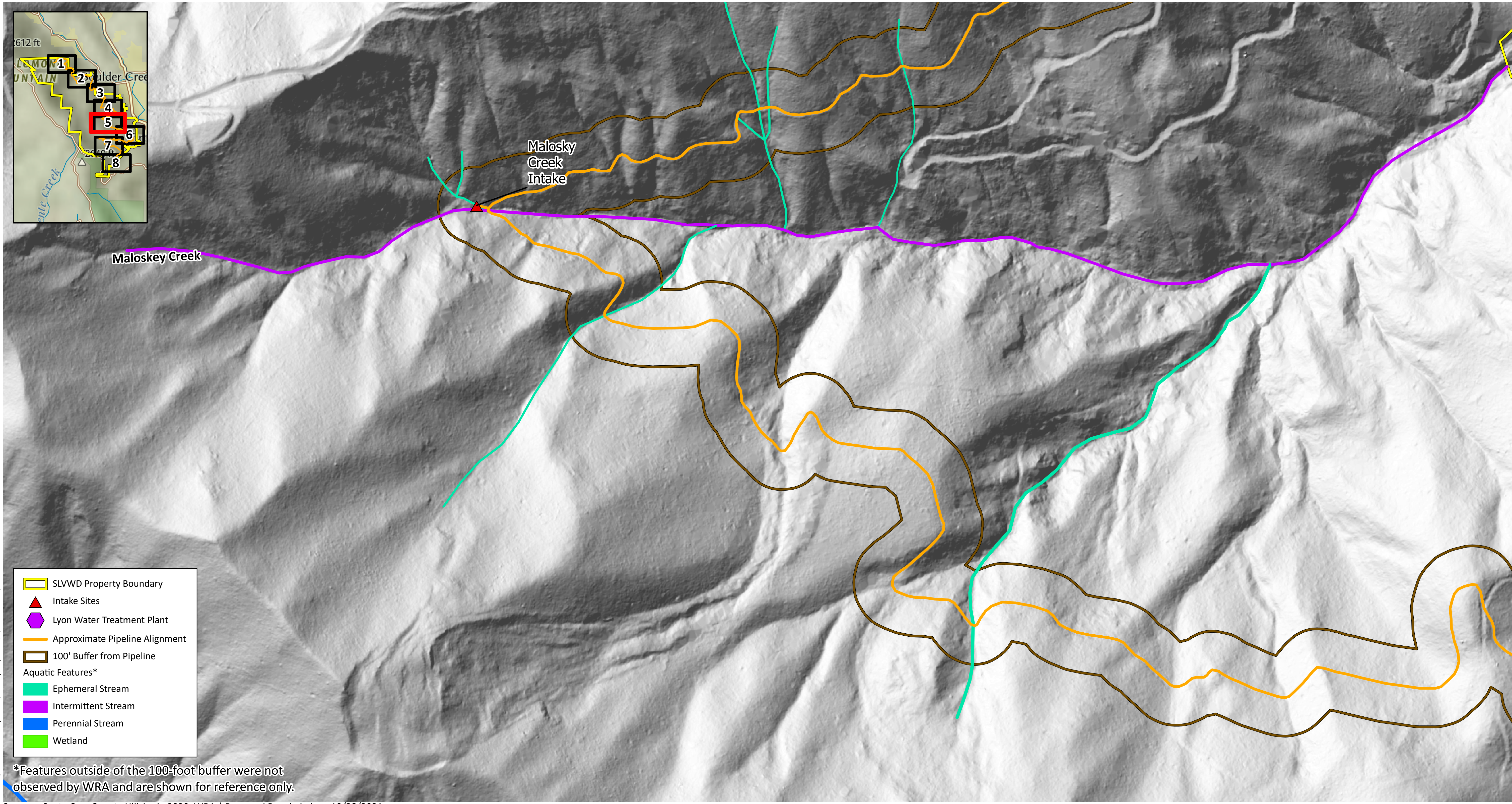
Sources: Santa Cruz County Hillshade 2020, WRA | Prepared By: pkobylarz, 10/28/2021

Attachment 1. Peavine and 5-mile Pipelines Jurisdictional Assessment Aquatic Features

Page 4 of 8

San Lorenzo Valley Water District
Cross Country Pipeline Constructability Analysis
Santa Cruz County, California

WRA ENVIRONMENTAL CONSULTANTS



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Sources: Santa Cruz County Hillshade 2020, WRA | Prepared By: pkobylarz, 10/28/2021

Attachment 1. Peavine and 5-mile Pipelines Jurisdictional Assessment Aquatic Features
Page 5 of 8

San Lorenzo Valley Water District
Cross Country Pipeline Constructibility Analysis
Santa Cruz County, California

0 250 500 750 1,000 Feet

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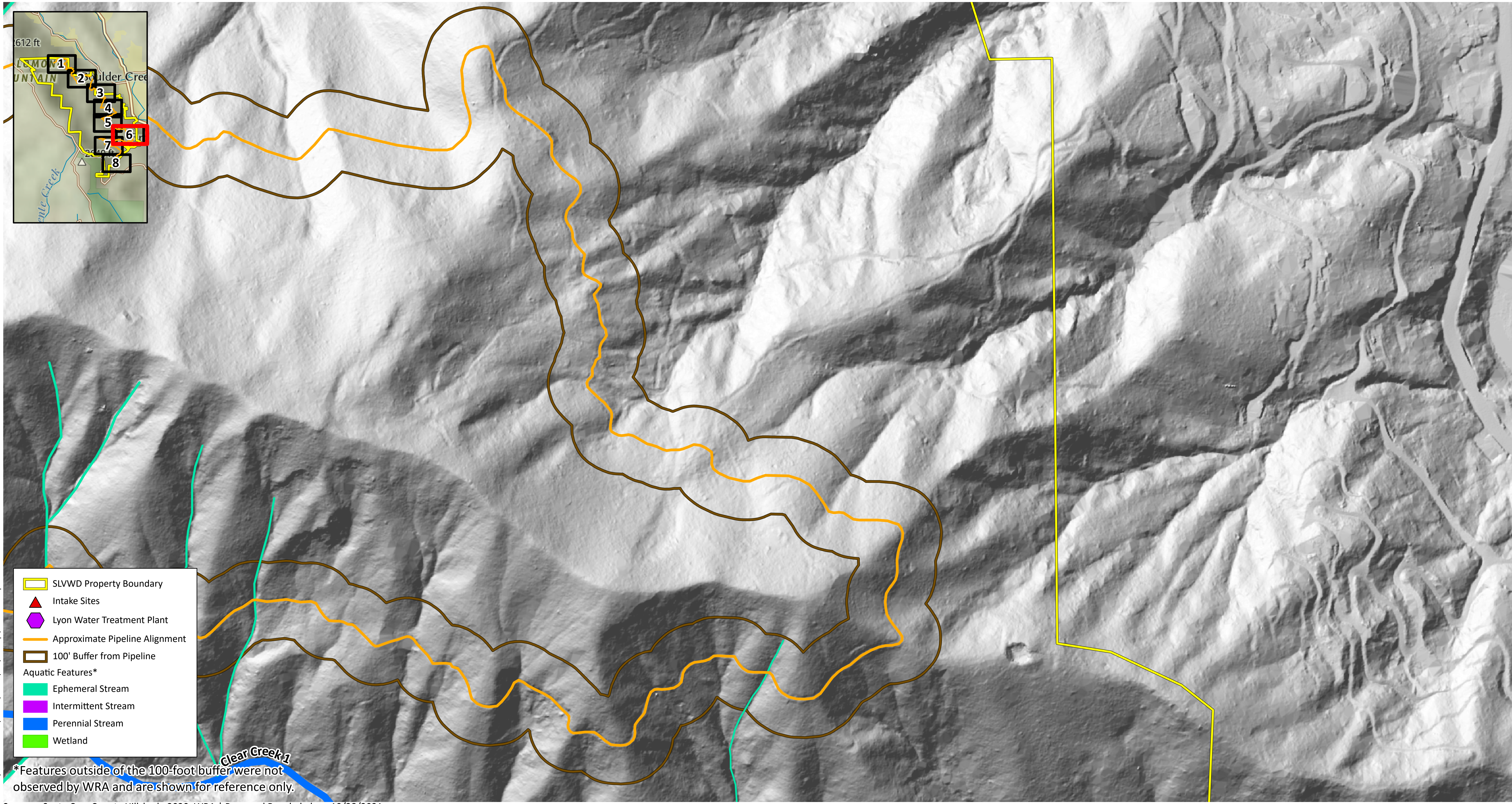
wra
ENVIRONMENTAL CONSULTANTS



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Sources: Santa Cruz County Hillshade 2020, WRA | Prepared By: pkobylarz, 10/28/2021

Attachment 1. Peavine and 5-mile Pipelines Jurisdictional Assessment Aquatic Features

Page 6 of 8

San Lorenzo Valley Water District
Cross Country Pipeline Constructibility Analysis
Santa Cruz County, California

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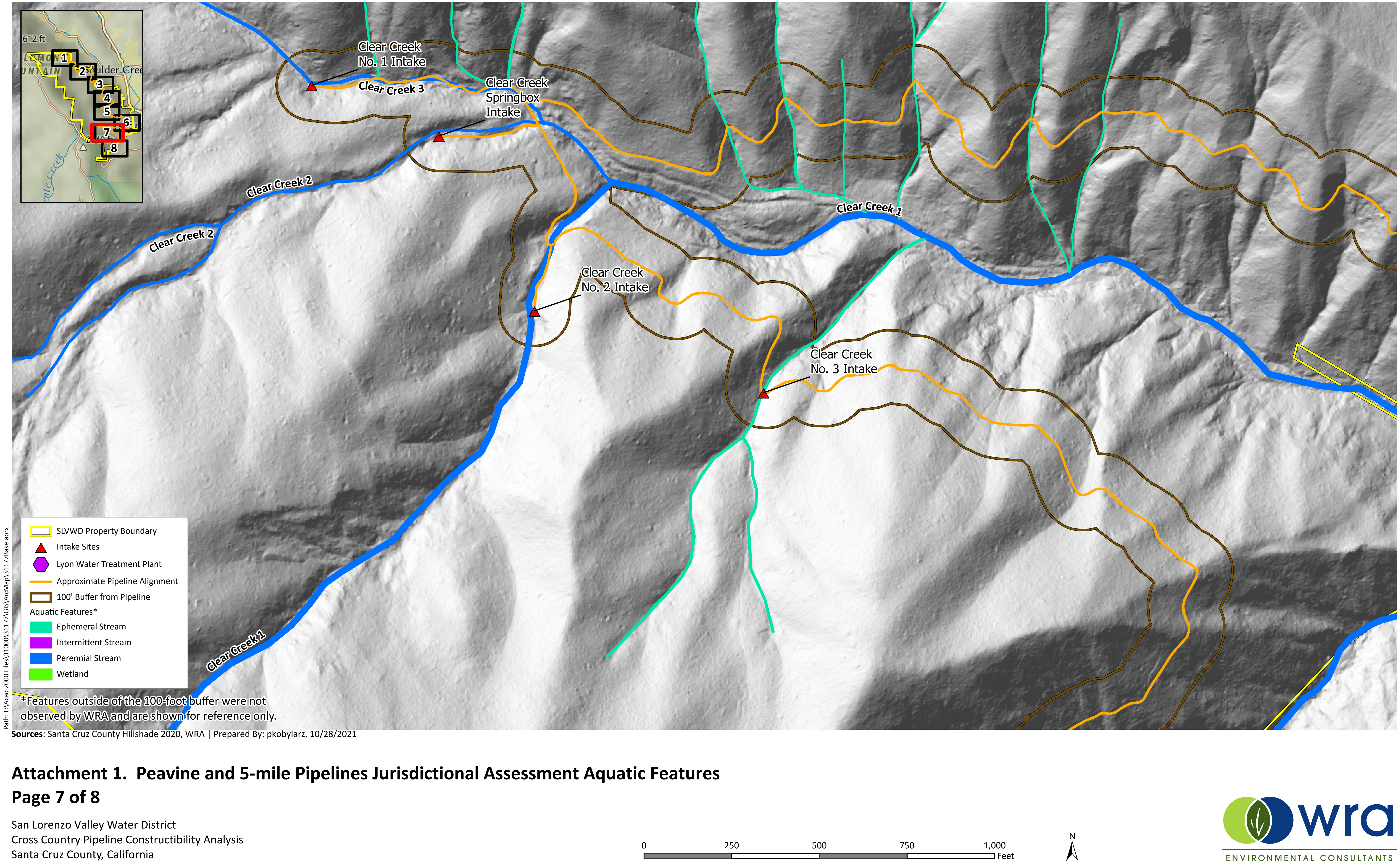

Sources: Santa Cruz County Hillshade 2020, WRA | Prepared By: pkobylarz, 10/28/2021

Attachment 1. Peavine and 5-mile Pipelines Jurisdictional Assessment Aquatic Features

Page 7 of 8

San Lorenzo Valley Water District
Cross Country Pipeline Constructibility Analysis
Santa Cruz County, California

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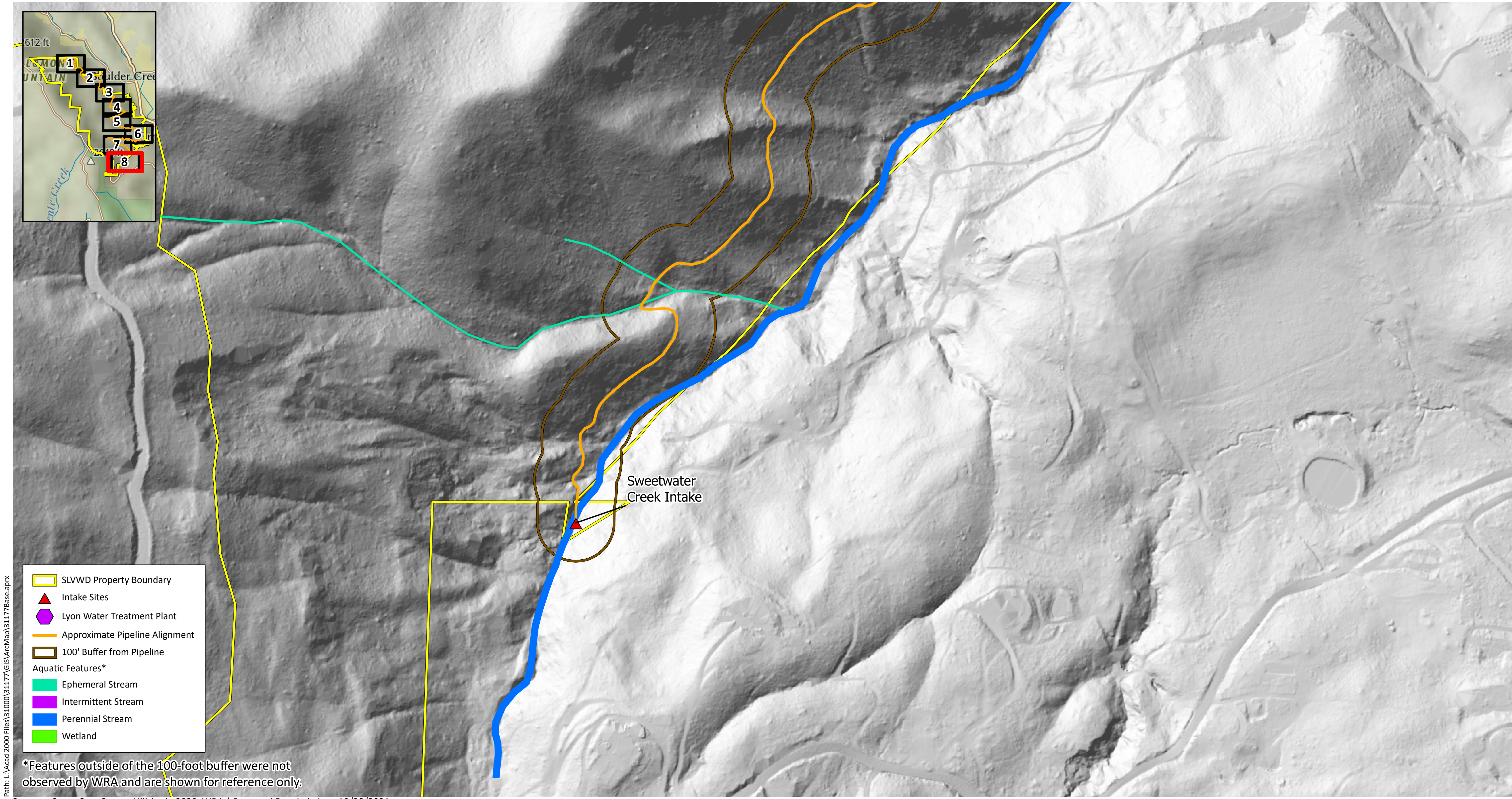

Sources: Santa Cruz County Hillshade 2020, WRA | Prepared By: pkobylarz, 10/28/2021

Attachment 1. Peavine and 5-mile Pipelines Jurisdictional Assessment Aquatic Features
Page 8 of 8

San Lorenzo Valley Water District
Cross Country Pipeline Constructibility Analysis
Santa Cruz County, California

0 250 500 750 1,000 Feet

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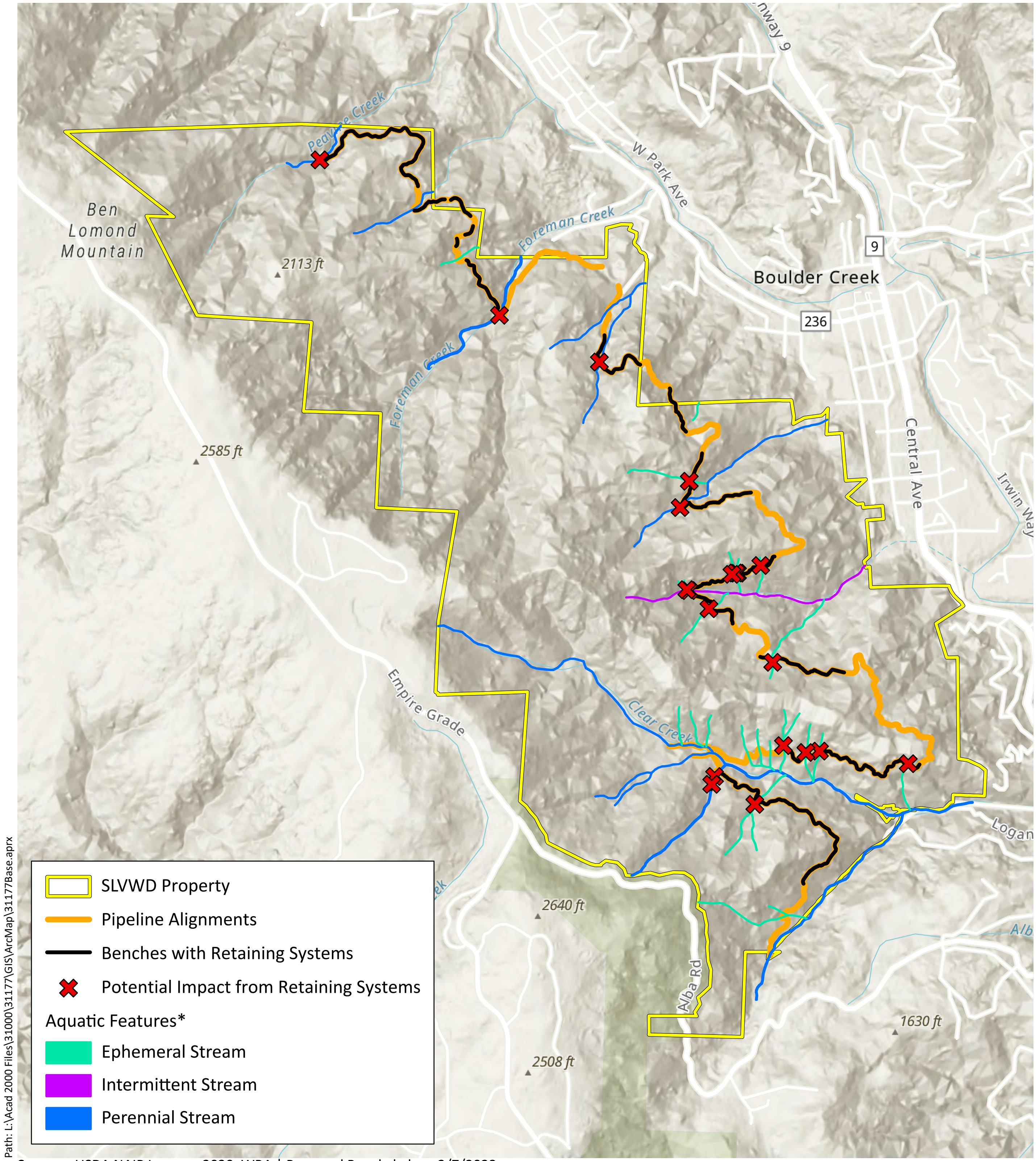
Attachment 2.
5-mile Pipeline Jurisdictional Assessment Aquatic Features



Sources: USDA NAIP Imagery 2020, WRA | Prepared By: pkobylarz, 2/7/2022

Potential Impacts from Retaining Systems

San Lorenzo Valley Water District
Cross Country Pipeline Constructibility
Analysis Santa Cruz County, California

0 0.25 0.5 Miles

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APPENDIX C: Geotechnical Summary

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GEOTECHNICAL DESIGN REPORT

SAN LORENZO VALLEY WATER DISTRICT
CROSS COUNTRY PIPELINE CONSTRUCTABILITY STUDY PROJECT

CE&G DOCUMENT NO.: 210460.001

27 JANUARY 2022

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1. INTRODUCTION

1.1. GENERAL

Cal Engineering & Geology (CE&G) is providing geotechnical engineering services to Freyer & Laureta for the San Lorenzo Valley Water District (District) Cross Country Pipeline Constructability Study. The project will replace the District's HDPE pipelines, which flow to the Lyon Water Treatment Plant (LWTP). These pipelines were destroyed by the 2020 CZU fire. As shown on Figure 1, the Peavine segment extends northwestward from the LWTP, and the Sweetwater segment (also referred to as the "5-Mile Pipeline") extends southeastward from the LWTP. Both of these raw water conveyance pipelines and the treatment plant are located in Boulder Creek, California. This draft geotechnical design report presents preliminary recommendations related to the preferred alternative which is described in Section 1.3. For this phase of work, no subsurface investigation work was completed. It should be noted that under a separate authorization some investigation work was completed along a segment of pipeline between the Foreman intake (the "Foreman Intake" segment is a a portion of the Sweetwater segment) and the LWTP. This work was related to the stabilization and erosion control of cuts and fills made to replace that segment.

1.2. PROJECT DESCRIPTION

The district is an urban water supplier established in 1941 and serves several communities within San Lorenzo River watershed. During the 2020 CZU fires, the Cross Country pipelines were destroyed and that the district has been working with FEMA and anticipates receiving FEMA funding to restore the raw water conveyance system. The destroyed pipelines comprise two branches that meet at the LWTP: the Peavine branch and Sweetwater (5-Mile) branch, both of which consisted of 6-inch and 8-inch high density polyethylene (HDPE) pipe that was laid on an approximate 2-foot-wide bench and, in some locations, free-standing wooden trestles. Isolated segments that had even limited soil cover had high survivability during the fire. The purpose of this report is to identify geologic conditions and provide preliminary recommendations for evaluation of the preferred alternatives for replacement of both branches of pipeline.

1.3. RECOMMENDED ALTERNATIVE

It is our understanding that this report will accompany a document describing the process used to identify and evaluate alternatives for replacement of the destroyed pipelines. The selected alternative is a minimally buried HDPE pipeline along the same general alignment as the damaged system. At creek crossings, the pipeline may be buried or transition to steel pipe above ground. Buried pipe will likely be used where feasible, and where allowed. The minimally buried pipeline will improve contractor efficiency by allowing materials and equipment to be transported over installed portions, and will also provide a reasonable level of protection against damage by fire.

1.4. SITE SURVEY

An accurate survey of the pipe alignment has not been developed for this phase of work. We have used LiDAR data (obtained through the County of Santa Cruz) as a basemap for geologic interpretation, which is discussed in the sections that follow.

1.5. PURPOSE AND SCOPE OF SERVICES

Our scope of work included, but was not limited to:

- review of published soil and geologic maps;
- geologic site reconnaissance;
- desktop geomorphic mapping along the pipeline alignment segments, using a detailed LiDAR-derived topographic base map;
- preliminary engineering evaluation;
- development of grading and erosion control mitigation measures;
- preparation of this draft geotechnical report.

CE&G's work has been specifically limited to evaluating the geologic and soil conditions in the vicinity of the Peavine and 5-Mile pipelines. Evaluation of the conditions in other areas was beyond the authorized scope of work. Evaluation or identification of the potential presence of hazardous materials at the site was not requested and is beyond the authorized scope of work. As noted in Section 1.1, subsurface investigation to date has been limited to the Foreman Intake segment.

2. GEOLOGIC CONDITIONS

2.1. REGIONAL SETTING

The project site lies within the Santa Cruz Mountains, within the Coast Ranges geomorphic province of California (Figure 1). This province is characterized by northwest-southeast trending mountain ranges and intervening valleys such as that occupied by San Francisco Bay and the Santa Clara Valley. The Santa Cruz Mountains are one such range, marking an area of regional uplift southwest of the San Andreas fault. The geologic setting is shown on our Regional Geologic Map (Figure 2).

2.2. SITE GEOLOGY

The general vicinity of the project site has been mapped several times, with geologic mapping having different emphases. For our report, the mapping completed by Graymer and others (2006); and Brabb and others (1997) is the most pertinent, and is used as the basis for Figure 2.

Brabb and others (1997) and Graymer and others (2006) maps are in agreement that the site is underlain by intrusive Cretaceous granitic rock. Brabb calls the geologic unit a gneiss granodiorite. Graymer refers to it as granite of the Salinian complex. Our mapping of the site is generally consistent with the regional data.

2.3. SURFICIAL SOILS

The surficial soils at the project site have been mapped by the USDA National Resource Conservation Service (NRCS) and USDA Soil Conservation Service. The majority of project area has been mapped as belonging to the Ben-Lomond-Catelli-Sur complex for 30 to 75 percent slopes (NRCS, 2021). Some locations appear to be mapped as Sur-Catelli complex, 50 to 75 percent slopes.

Soils of the Ben-Lomond-Catelli-Sur complex are described as well-drained residuum weathered from granite and/or sandstone and have a plasticity index ranging from non-plastic to 10 percent. The Sur-Catelli complex is similar with plasticity ranging from non-plastic to 5 percent and thinner soil profile.

2.4. LANDSLIDE GEOLOGY

Generalized regional landslide mapping (Cooper-Clark Associates, 1975; re-issued digitally as Roberts and others, 1998) shows a few “questionable landslide” deposits along or intersect with the 5-mile pipeline (see Figure 3). This mapping is regional in scale, and was performed largely on the basis of regional aerial photographic analysis, and generalized topographic base maps. It is generally taken as a "starting point" for landslide analysis in the Santa Cruz Mountains.

2.5. ACTIVE FAULTS AND SEISMICITY

The project site is located within the greater San Francisco Bay Area, which is recognized as one of the more seismically active regions of California. The right-lateral strike-slip San Andreas fault system controls the northwest-southeast structural grain of the Coast Ranges and the Bay Area. The fault system marks the major boundary between two of earth's major tectonic plates, the Pacific Plate to the west and the North American Plate to the east. The Pacific Plate is moving north relative to the North American plate at approximately 40 mm/yr in the Bay Area (WGCEP, 2014).

The transform boundary between these two plates has resulted in a broad zone of multiple, subparallel faults within the North American Plate, along which right-lateral strike-slip faulting predominates. In this broad transform boundary, the San Andreas Fault accommodates less than half of the average total relative plate motion. Much of the remainder in the greater South Bay Area is distributed across faults such as the San Gregorio-Hosgri, Monte Vista-Shannon, Sargent, Berrocal, Hayward (southern segment), Calaveras, Zayante-Vergeles, and Greenville fault zones.

Since the project site is located in seismically active California, it will likely experience strong ground shaking from a large (Moment Magnitude [Mw] 6.7) or greater earthquake along one or more of the nearby active faults during the design lifetime of the project (WGCEP, 2014). Table 3-1 shows the approximate distances between the project site and various major surface fault traces, and their estimated magnitude, within approximately 50 km of the site (Caltrans, 2018). Other active seismogenic faults (capable of generating significant earthquakes) and their distances near the site are included in Table 3-1.

Table 3-1. Distances to Selected Active Fault Traces[1]

Fault Name	Approximate Distance and Direction from Site to Surface Fault Traces	Estimated Mw
Zayante-Vergeles Upper	1 km northeast	7.0
Zayante-Vergeles Lower	4 km southwest	7.0
San Andreas	12 km northeast	8.0
San Gregorio fault (San Gregorio section)	15 km southwest	7.4
Sargent fault (southeastern section)	17 km east	7.0
Monte Vista-Shannon	20 km northeast	6.4
Monterey Bay-Tularcitos (Monterey Bay section)	23 km south	7.2
Cascade fault	24 km northeast	6.7
San Gregorio fault zone (Sur Region section)	28 km southwest	7.4
Silver Creek fault	34 km northeast	6.9
Hayward (Southern extension)	40 km northeast	6.7
Calaveras	43 km northeast	6.9

A large magnitude earthquake on any of these faults or other active fault systems in the greater Bay area has the potential to cause significant ground shaking at the site. The intensity of ground shaking that is likely to occur at the property is generally dependent upon the magnitude of the earthquake and the distance to the epicenter.

2.5.1. Liquefaction and Seismic Densification

Soil liquefaction is a phenomenon in which saturated, cohesionless soils (generally sands) lose their strength due to the build-up of excess pore water pressure during cyclic loading, such as that induced by earthquakes. Soils most susceptible to liquefaction are saturated clean, loose, fine-grained sands and silts. The primary factors affecting soil liquefaction include: 1) intensity and duration of seismic shaking; 2) soil type and relative density; 3) overburden pressure; and 4) depth to groundwater.

No California Geological Survey (CGS) Seismic Hazard Zone Map has yet been prepared for the 7.5-minute quadrangles (Davenport, Big Basin, and Felton 7.5' quadrangles) encompassing the site. These zones are established with the intent of triggering further

[1] The distances listed are to near the Lyon Water Treatment Plant. The distance to locations along the pipeline alignments will vary some from what is shown in Table 3-1.

evaluation (for certain projects) of the potential for seismically induced landsliding in hillside areas, and liquefaction potential in valley floor areas.

Dupre (1975) prepared an early liquefaction susceptibility map that includes the general site vicinity. At the scale mapped by Dupre, the site is shown as lying within a bedrock area lacking the materials and conditions needed for liquefaction.

The site is not mapped within a County of Santa Cruz Liquefaction Hazard Zone (County of Santa Cruz, gis.co.santa-cruz.ca.us/map_gallery, accessed September 2021).

Seismic densification is the densification of unsaturated, loose to medium dense granular soils due to strong vibrations resulting from earthquake shaking. We judge the potential for liquefaction and seismic densification of natural materials along the pipeline alignments to be low. Along the majority of the pipelines, which are located on the side of a hillside in steep terrain, there is no potential. There are a few creek crossing locations (likely representing less than 1% of the total pipeline length to be constructed) at which there may be isolated sand deposits which may be susceptible. At many other drainage locations, the terrain is very steep and the drainage axes are likely already eroded to bedrock.

3. DESKTOP AND FIELD INVESTIGATIONS

3.1. DESKTOP LANDSLIDE ANALYSIS

CE&G performed desktop landslide mapping using a detailed LiDAR-derived topographic dataset generated from 2018-2020 data available through the USGS and County of Santa Cruz. LiDAR (Light Detection and Ranging) uses airborne laser sources, sophisticated GPS, and computer processing to generate a highly detailed "bare earth" topographic model that permits mapping of landslide features otherwise typically obscured by vegetation. We performed further processing to highlight those features. Our landslide mapping on those base maps is presented as Figures 4A to 4H.

Our mapping classifies landslide features according to landslide type and inferred relative age. "Active" landslides (map unit Als) are features judged to have most recently moved within the last few years, based on sharpness of features, and scarp steepness. The mapped active landslides most commonly involve only colluvium, and possibly the uppermost, deeply weathered bedrock. "Dormant" landslides (map unit Dls) are features judged to have last moved within the past several to many decades, based on increasingly rounded, muted features due to soil creep, erosion and mass wasting (general downslope movement). They may be areas of primarily colluvial landslides, or more deep-seated landslides involving both colluvium and weathered bedrock. "Old" landslides (map unit Ols) are often incompletely preserved, with rounded, muted features, and may date from periods of wetter climate on the order of hundreds to thousands of years ago. The mapped Ols deposits all involve bedrock to some depth. "Undifferentiated" areas (primarily Dls) are areas of widespread landsliding where mapping of individual landslides is not feasible. Where scale and preserved detail permit, we have differented scarp (source) areas from the landslide masses themselves.

3.2. SITE WALK

CE&G joined District staff and other members of the Freyer and Laureta team to walk the existing pipeline alignment in August 2021. The walk was completed over two days by the team in order to understand the challenges of the project for the alternatives evaluation. The walk provided an understanding of the challenges of the project, which include but are not limited to: landslides, steep terrain, hard rock areas, creek crossings, and difficult access.

4. DISCUSSION AND CONCLUSIONS

As noted in Section 1.2, the entirety of the Peavine and 5-Mile (Sweetwater) pipeline branches were destroyed during the 2020 CZU fires. The goal of the project is reconstruction ofthe two branches in order to restore the critical surface water supply for the SLVWD system. Several replacement strategies have been considered by the district and those strategies will be discussed in the following sections.

4.1. PROJECT OBJECTIVES

The primary objective is to replace the damaged pipelines to restore the water supply. Based on our understanding of the project, this report will be included as an attachment to the alternatives study which resulted in the selection of a preferred alternative. The study considered numerous alternatives and weighted and scored success and risk factors to arrive at the preferred alternative.

CE&G's task was to address site geology and soil conditions as they pertain to the selected alternative.

4.1.1. Site Geology and Site Soil Conditions

The current pioneered trail follows slope contours, and repeatedly traverses across spur ridges with intervening colluvial/landslide ravines or swales. CE&G used existing geologic mapping of landslide features, geomorphic analysis of LiDAR-derived topography, and field observations to prepare a preliminary geomorphology map (Figure 4). The map shows areas of landsliding and debris flows that extend substantially beyond the limits of the pioneered trail and pipeline alignment.

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. Margins of landslide areas, regardless of age, can have more intensely sheared and weaker materials, and often are associated with wetter ground. It should be understood that stabilization of areas along the access trail that exhibit slope instability or pose an erosion hazard will not address stability of the entire hillside, which is beyond the scope of this current project.

4.2. CONCEPTUAL RECONSTRUCTION ALTERNATIVES

Seven conceptual reconstruction alternatives were considered by the design team with three of those including the preferred alternative (3B) using the existing pipeline alignment. A thorough discussion of the alternatives is contained within the Alternatives Study.

Alternative 1 – Existing Alignment with HDPE Pipe
Alternative 2 - Existing Alignment with Welded Steel Pipe
Alternative 3A - Existing Alignment, Buried Pipe, and Above Ground Creek Crossing
Alternative 3B - Existing Alignment and Buried Pipe
Alternative 4A – New Alignment and Two Pump Stations
Alternative 4B – New Alignment and One Pump Station
Alternative 5 – New Alignment and Packaged Water Treatment Plant

4.2.1. Geologic and Geotechnical Comparison of Existing Alignment Alternatives

It is our understanding that the previously installed HDPE pipeline was installed with hand labor by the California Conservation Corps over a 10-year period. The result is a very narrow bench that will need to be widened to construct any alternative. The proposed work will be completed by a contractor using mechanical equipment supplemented by minor hand labor.

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.

It is likely that the bench requirements for Alternatives 1, 3A and 3B are likely similar. It is also our opinion that the preferred alternative which buries the pipe (Alternatives 3A and 3B) will significantly ease project access while the project is being constructed, compared to having an exposed pipeline on the bench, which would impede movement of equipment and materials.

Alternative 2, which uses welded steel pipe, would require a wider bench (than Alternatives 1, 3A and 3B) and would therefore increase the complexity and cost associated with addressing geologic and geotechnical concerns.

Additionally, the geologic hazards associated with the proposed reconstruction are nearly identical to those faced by pipeline alignments that predated the fire. Based on our understanding, the previous performance related to (non fire-related) geologic hazards was acceptable to the District. Based on the observed effects of the CZU fire on the pipelines, even minimal soil cover provided generally adequate protection against direct fire damage. For this reason, the primary geotechnical/geohazard design concern is associated with design of earth retention improvements. In general, past active landslides (map unit Als) are representative of the most likely future landslides, and will involve primarily colluvium, not bedrock.

4.3. OTHER DESIGN CONSIDERATIONS

The site conditions (terrain, depth of soil, bedrock hardness) will vary along the pipeline alignments. It will be desirable to have several designed options to more easily adjust the construction to conditions encountered in the field.

5. DESIGN AND CONSTRUCTION RECOMMENDATIONS

The following design and construction recommendations assume Alternative 3B but are largely applicable to the other alternatives. Our evaluations and recommendations are based upon the previously discussed information collected for this investigation and our engineering analyses. The following recommendations may need to be modified if there are any changes in the proposed alignment that arise out of the design process.

5.1. DESIGN GROUNDWATER LEVEL

Groundwater was not encountered during the drilling of three borings at the Foreman Intake Pipeline Project located immediately north of the Lyon Water Treatment Plant. The borings were primarily located in areas of locally deeper soil based on visual observation and interpretation. The Peavine and 5-Mile pipelines are located north and south, respectively, of those borings, in similar terrain underlain by similar geologic materials as the Foreman Intake segment. Based on conditions encountered in those three borings, we anticipate that groundwater is generally deep along majority of the alignment of the cross country pipelines. If groundwater is encountered, it is most likely perched or semi-confined within a more permeable bedrock layer. Groundwater may fluctuate depending on the time of year and winter rainfall.

In general, groundwater is anticipated to be shallowest in areas near the axes of topographic swales, and deepest below spur ridge crests.

5.2. EARTHWORK

5.2.1. Clearing

Clearing should include the removal of all vegetation within the limits of work . Depending on the final alignment layout, some portion of the existing slope may require scaling of colluvium exposed and/or weak, disaggregating bedrock.

Site clearing should also include the removal of deleterious materials, debris, and obstructions that are designated for removal. Depressions, voids, and holes that extend below the proposed finish grades should be cleaned and backfilled with engineered fill compacted to the recommendations in this report.

5.2.2. Excavations

Excavations for the project will vary from minimal to more substantial where retaining walls are required. At location of retaining walls, excavation will need to extend into firm and unyielding weathered rock and/or soil as determined by Cal Engineering & Geology. In some cases, some over-excavation may be required where competent materials are encountered at greater depth.

Excavations should be constructed in accordance with the current CAL-OSHA safety standards and local jurisdiction. The stability and safety of excavations, braced or unbraced, are the responsibility of the contractor.

If areas of adversely oriented bedrock are exposed in excavations, supplemental recommendations may need to be developed to reduce the potential for localized instability.

5.2.3. Site Preparation

In general minimal preparation will be required for a large portion of the work. In areas where earth retention is required or soft materials are encountered, preparation will be dependent upon the method of earth retention selected, and on the terrain. For steep terrain with shallow bedrock, mechanically stabilized earth slopes or wire walls will be cost effective. At locations with deeper (thicker) soils, it may be desirable to consider a steel beam and lagging wall to reduce excavation requirements.

After site preparation and before placement of compacted fills, the excavation bottom should be observed and approved by the geotechnical engineer or their representative. After approval, the subgrade should be scarified, moisture conditioned to about 1 to 3 percent above optimum moisture content and compacted to 90 percent of the maximum dry unit weight as measured by ASTM D1557.

Prepared soil subgrades should be non-yielding under equipment. If the equipment is lightweight, smaller lifts may be required to provide a non-yielding surface for the placement of fill. Moisture conditioning of subgrade soils should consist of adding water if the soils are too dry and allowing the soils to dry if the soils are too wet. After the subgrades have been prepared, the areas may be raised to design grades by the placement of engineered fill.

If unstable, wet, or soft soil is encountered, the soil will require processing before compaction can be achieved. When the construction schedule does not allow for air-drying, other means such as lime or cement treatment, over-excavation and replacement, geotextile fabrics, etc. may be considered to help stabilize the subgrade. The method to be used should be determined at the time of construction based on the actual site conditions.

We recommend obtaining unit prices for subgrade stabilization during the construction bid process.

5.2.4. Material for Engineered Fill

In general, on-site soils with an organic content of less than 3 percent by weight, free of any hazardous or deleterious materials, and meeting the gradation requirements below may be used as general engineered fill to achieve project grades, except when special material (such as aggregate base or subbase material) is required.

In general, engineered fill material should not contain rocks or lumps larger than 3 inches in greatest dimension, should not contain more than 15 percent of the material larger than 1½ inches, and should contain at least 20 percent passing the No. 200 sieve.

5.2.5. Engineered Fill Placement and Compaction

Engineered fill should be placed on soil subgrades that are prepared as recommended in this report. Engineered fill should be placed in horizontal lifts each not exceeding 8 inches in thickness and mechanically compacted to the recommendations below at the recommended moisture content. Relative compaction or compaction is defined as the in-place dry density of the compacted soil divided by the laboratory maximum dry density as determined by ASTM Test Method D1557, latest edition, expressed as a percentage. Moisture conditioning of soils should consist of adding water to the soils if they are too dry and allowing the soils to dry if they are too wet.

Engineered fills consisting of on-site soils and imported soils should be compacted to a minimum of 87 percent relative compaction with moisture content about 1 to 3 percent above the laboratory optimum value. At locations where fills are thicker than 3 feet, soils should be compacted to a minimum relative compaction of 90 percent..

5.2.6. Trench Excavation and Backfill

Trenches are anticipated to be less than 4 feet in depth. Trenches less than 4 feet in depth in the near-surface soil materials should be able to stand near vertical in weathered bedrock. In areas where the bedrock has completely weathered to a sand, bracing may be needed to reduce raveling/caving of the granular soils. 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. During the site walk we observed that hard rock conditions exist at a relatively few locations. At these locations consideration may be given to reducing the excavation limits by placing fill to cover the pipe and/or using small segment(s) of exposed steel pipe.

Pipe zone backfill, extending from the bottom of the trench to about 1 foot above the top of the pipe, generally consists of free-draining sand (at least 90% passing a No. 4 sieve and less than 5% passing a No. 200 sieve) compacted to a minimum of 90 percent relative compaction unless concrete or cement slurry is specified. For this project with poor access and no traffic other than equipment for construction or future repair, it may be desirable to use onsite soil which is mapped as non-plastic, up to a low plasticity index (PI<10). If load on the pipe is a concern, consideration should be given to specifying track mounted equipment which will reduce the load to a level tolerated by the HDPE pipe.

Above the pipe zone, the trench can be backfilled with on-site soil free of deleterious and hazardous material. The trench backfill should be compacted to the requirements given in Section 5.2.5, "Engineered Fill Placement and Compaction." Trench backfill should be capped with at least the minimum cover specified on the plans. Compaction should be performed by mechanical means only. Water jetting or flooding to attain compaction of backfill should not be permitted.

5.2.7. Slopes

Along portions of the pipeline alignment where steep slopes aare present, a retaining system may be used on both uphill and downhill sides, or on either side singularly. The design parameters are discussed in Section 5.3.

5.2.8. Wet Weather Construction

If site grading and construction are to be performed during the rainy winter months, the owner and contractors should be fully aware of the potential impact of wet weather. Rainstorms can cause delays to construction and damage to previously completed work by saturating compacted pads or subgrades, or flooding excavations.

Earthwork during rainy months will require extra effort and caution by the contractors. The grading contractor should be responsible for protecting their work to avoid damage by rainwater. Standing pools of water should be pumped out immediately. Construction during wet weather conditions should be addressed in the project construction bid documents and/or specifications. We recommend the grading contractor submit a wet weather construction plan outlining procedures they will employ to protect their work and to minimize damage to their work by rainstorms.

5.3. REINFORCED SLOPES AND RETAINING WALLS

CE&G will need to provide final design parameters when the design is advanced. It is our understanding that a preliminary wall location plan is being developed based on the steepness of the terrain using the Lidar. CE&G is in concurrence with this approach for preliminary cost estimates.

CE&G recommends the following parameters for preliminary design of the earth retention structures:

- PGA=0.48 g (10 percent chance of exceedance in 50 years).
- Active equivalent fluid earth pressure of 34 pcf for level backfill and 48 pcf for 2:1 (horizontal:vertical) backfill based on a friction angle of 35 degrees for weathered bedrock-derived soils.
- Reinforced earth slopes founded on competent bedrock, designed with a friction angle of 35 degrees, can also be designed to use Hilfiker style welded wire forms to be near vertical.
- Walls taller than 6 feet will require a seismic increment. We recommend checking global stability for seismic conditions to address external stability along with adding 15 pcf to the recommended active pressure equivalent fluid pressures for the retaining wall design calculations.
- Soil resistance to lateral loads will be provided by passive pressures acting against twice the width of the CIDH piers. An allowable passive lateral bearing pressure equal to an equivalent fluid pressure of 200 psf/ft should be used for piers located on a descending slope.

For piers constructed within 10 horizontal feet of slopes, the active pressure should be extended to the lesser of the depth of bedrock or 5 feet. Passive pressure should begin below the depth of active pressure. Where loads are extended below ground and below a footing or lagging, the active pressure can be applied on one pile diameter.

Concrete should be placed only in excavations that are clean and free of loose soils or debris. Foundation excavations should be maintained in a moist condition before the placement of concrete. A member of our staff should observe foundation excavations to verify that adequate foundation-bearing soils have been reached.

5.4. SURFACE DRAINAGE

The proposed grading should be designed to promote sheet flow. Sheet flow will reduce the potential for concentrated flows resulting in damage to downslope improvements. Additionally, positive drainage should be maintained to provide for the rapid removal of surface water runoff. Ponding of water in the vicinity of the slope and bench should be avoided.

5.5. TECHNICAL REVIEW AND CONSTRUCTION OBSERVATION

During the design process, CE&G, the geotechnical engineer, should be kept informed of the design and design process to make suggestions to the design and/or add supplemental recommendations, if needed. At the completion of the design, CE&G should review the project plans and specifications for conformance with the intent of the recommendations presented in this report and any future addenda. The geotechnical engineer should be contacted a minimum of 48 hours in advance of excavation operations to observe the subsurface conditions.

6. LIMITATIONS

The conclusions and recommendations presented in this report are based on the information provided regarding the proposed project, and the results of the site reconnaissance and geologic mapping.

It is the Owner's/Client's responsibility to ensure that recommendations contained in this report are carried out during the construction phases of the project. This report was prepared based on preliminary design information provided which is subject to change during the design process.

The findings of this report should be considered valid for a period of three years unless the conditions of the site change. After a period of three years, CE&G should be contacted to review the site conditions and prepare a letter regarding the applicability of this report.

This report presents the results of a geotechnical and geologic investigation only and should not be construed as an environmental audit or study.

The conclusions and recommendations contained in this report are valid only for the project described in this report. We have employed accepted geotechnical engineering procedures, and our professional opinions and conclusions are made in accordance with generally accepted geotechnical engineering principles and practices. This standard is in lieu of all other warranties, either expressed or implied.

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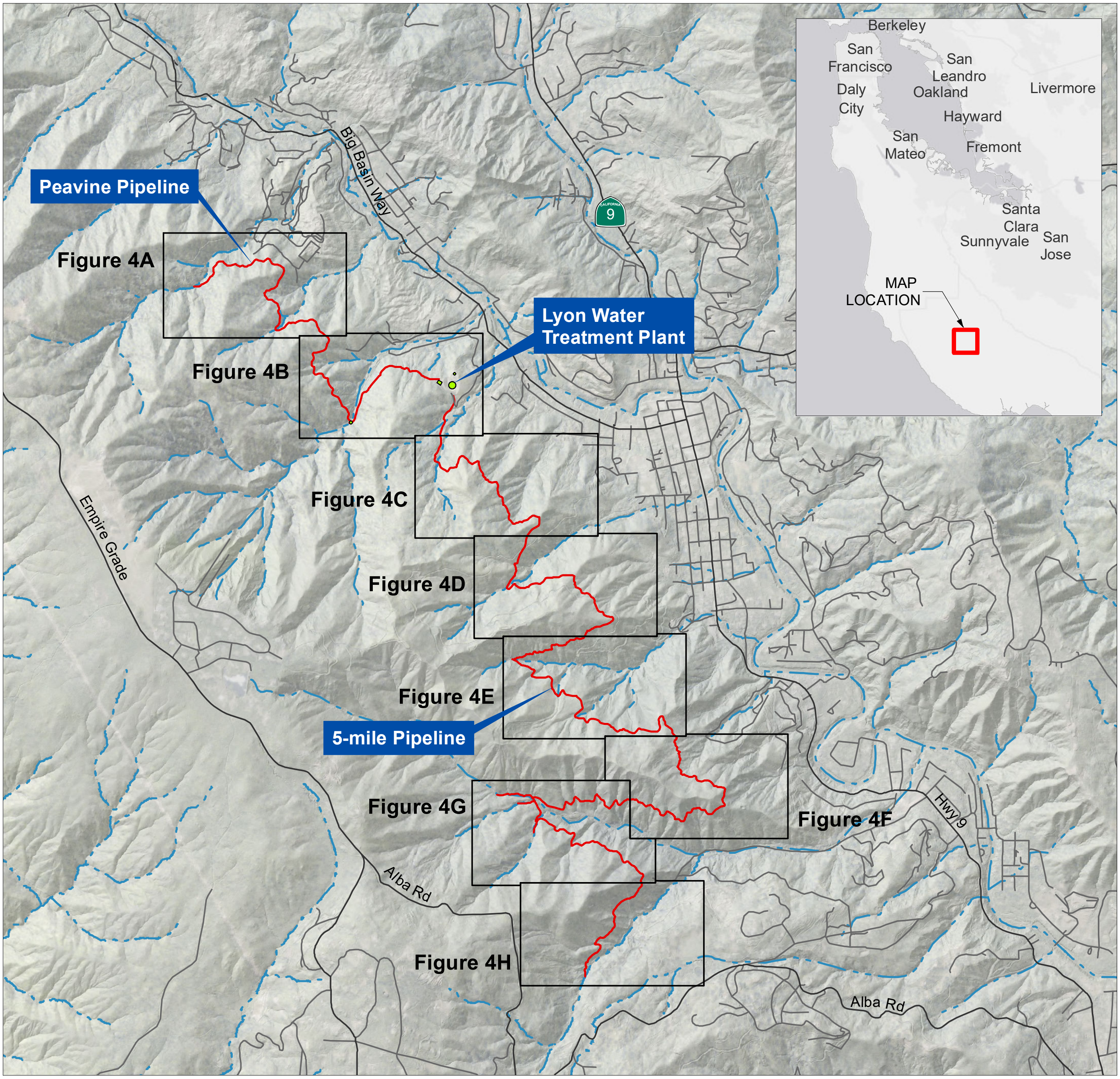
U.S. Geological Survey and California Geological Survey, Quaternary fault and fold database for the United States, accessed June 2020, at: https://www.usgs.gov/natural-hazards/earthquake-hazards/faults

Working Group on California Earthquake Probabilities (WGCEP), 2014, Published as Field, E.H., Biasi, G.P., Bird, P., Dawson, T.E., Felzer, K.R. Jackson, D.D., Johnson, K.M., Jordan, T.H., Madden, C. Michael, A.J., Milner, K.R., Page, M.T., Parsons, T., Powers, P.M., Shaw, B.E., Thatcher, W.R., Weldon, R.J. II, and Zeng, Y., 2015, Long-term, time-dependent probabilities for the third uniform California earthquake rupture forecast (UCERF3), Bulletin of the Seismological Society of America. —Authors: Edward H. Field and members of the 2014 WGCEP

Figures



BASEMAP REFERENCE

1. STREET CENTERLINES FROM CALTRANS CALIFORNIA ROAD SYSTEM, DOWNLOADED ON 18 FEB 2020.
2. ORTHOIMAGERY FROM ESRI (MAXAR), 2017.
3. HILLSHADE FROM SANTA CRUZ COUNTY, DERIVED FROM 2018-2020 DEM.

MAP UNIT DESCRIPTION

Approximate location of the 5-mile long Pipe Alignment, digitized by CE&G on 9/28/2021; digitized over slopeshade raster (2018-2020 Lidar)

M:\2021\210460-FreyerLaureta-SLVWDCrossCountryPipelineStudy\GIS\ArcGIS\210460-CrossCounty-Fig1-SiteLocation.mxd; 1/27/2022; kdrozynska

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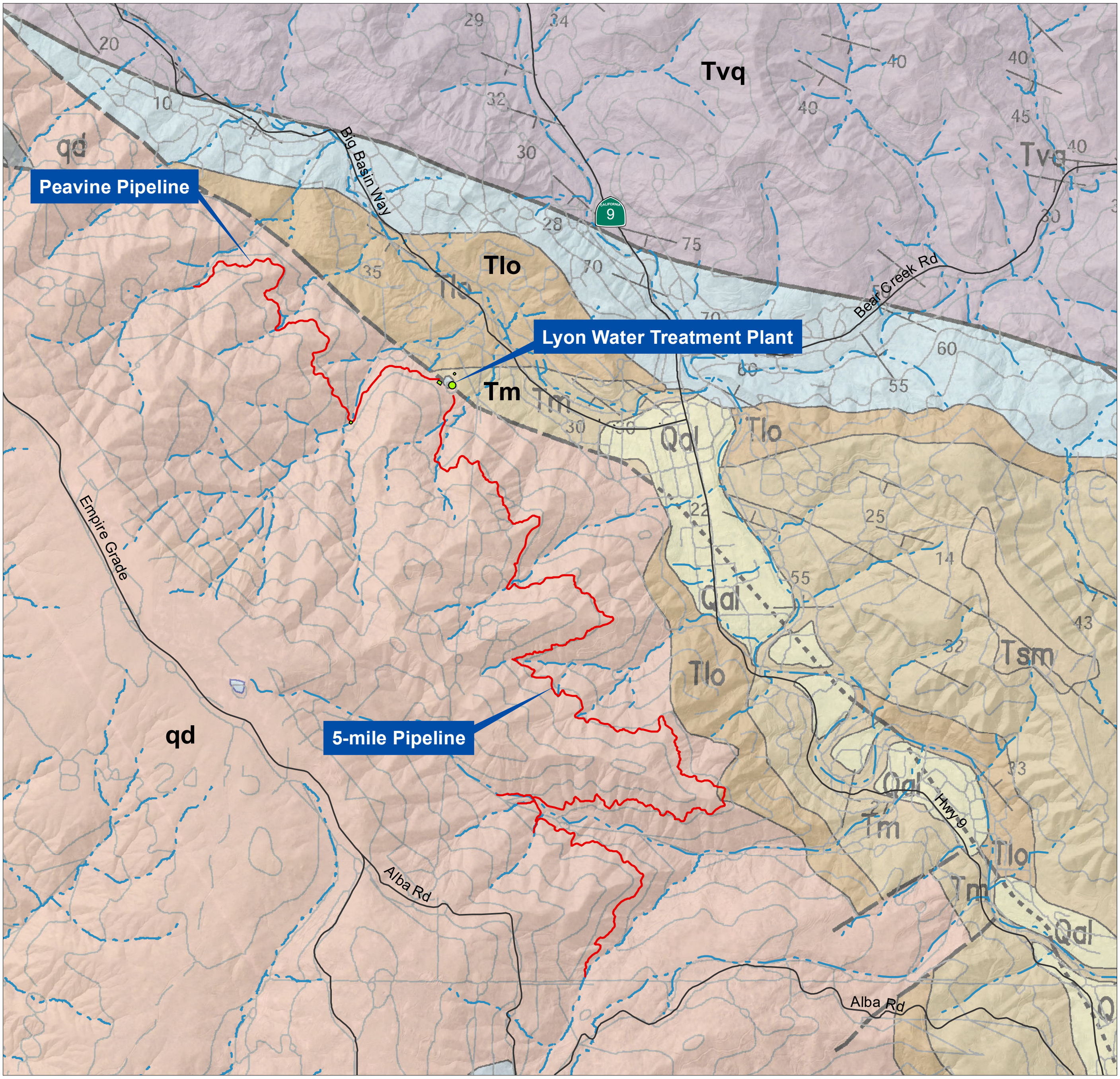
SAN LORENZO VALLEY WATER - CROSS COUNTY PIPELINE
SANTA CRUZ COUNTY
CALIFORNIA

SITE LOCATION MAP

210450	JANUARY 2022	FIGURE 1



BASEMAP REFERENCE

1. REGIONAL GEOLOGY FROM BRABB, 1997.

MAP UNIT DESCRIPTION

Qal	ALLUVIAL DEPOSITS, UNDIFFERENTIATED (HOLOCENE)
Tm	MONTEREY FORMATION (MIDDLE MIOCENE)
Tlo	LOMPICO SANDSTONE (MIDDLE MIOCENE)
Tvq	VAQUEROS SANDSTONE (LOWER MIOCENE AND OLIGOCENE)
Tbu	BUTANO SANDSTONE (EOCENE) UPPER SANDSTONE MEMBER
qd	QUARTZ DIORITE (CRETACEOUS)

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CALIFORNIA

REGIONAL GEOLOGY MAP

210450	JANUARY 2022	FIGURE 2

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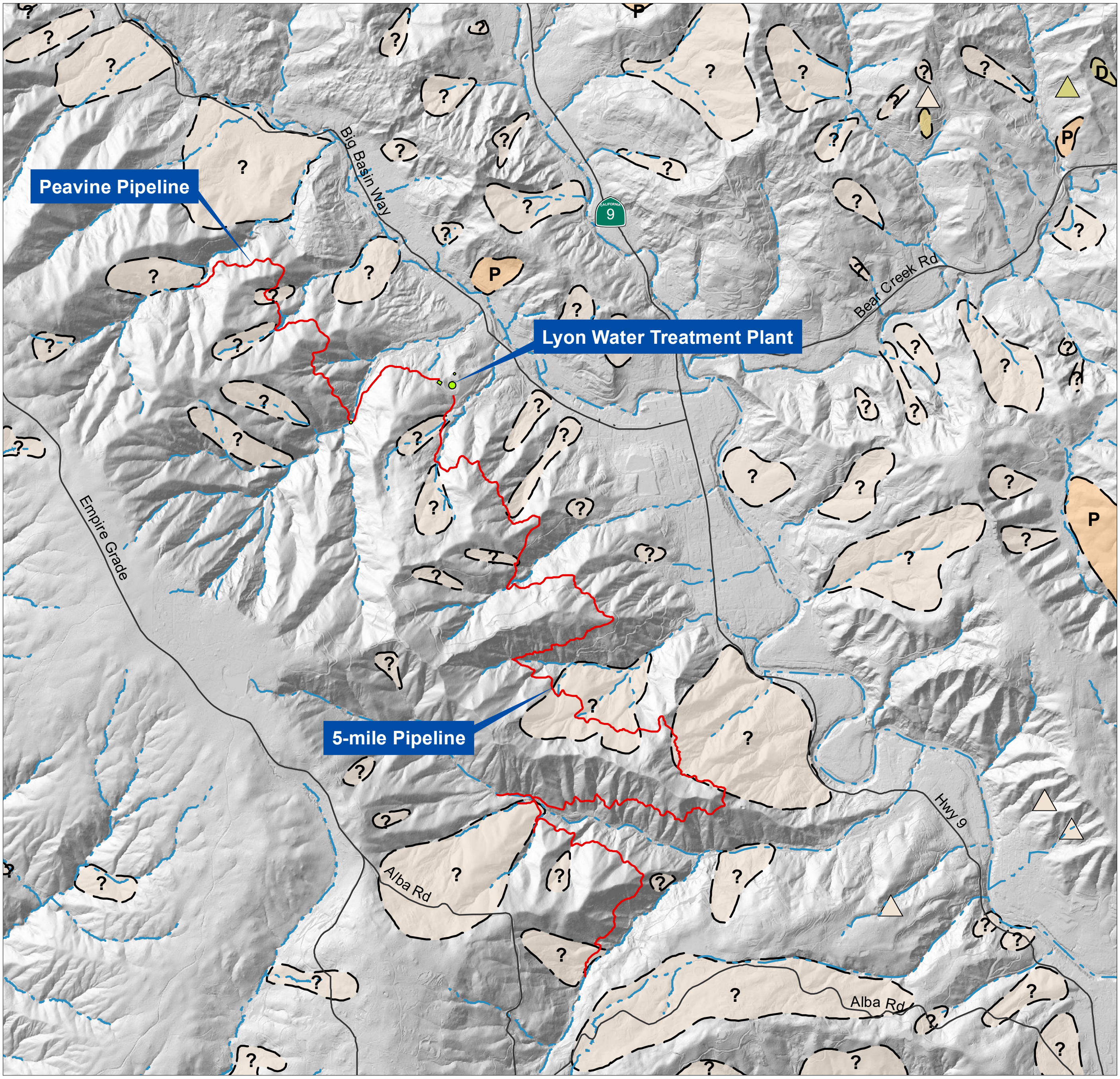

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0 0.25 0.5 1
MILES

BASEMAP REFERENCE

1. LANDSLIDE MAPPING FROM ROBERTS DIGITAL UPDATE OF THE COOPER CLARK & ASSOCIATES (1975) MAPPING.
2. HILLSHADE DEVELOPED FROM 2018-2020 COUNTY LIDAR DATA.

MAP UNIT DESCRIPTION

Large Landslides:

D Definite Landslide Deposit
DR Definite Rapid Landslide Deposit
P Probable Landslide Deposit
? Questionable Landslide Deposit
Unattributed Landslide Deposit

Small Landslides:

D - Definite Landslide Deposit
DR - Definite Rapid Landslide Deposit
? - Questionable Landslide Deposit

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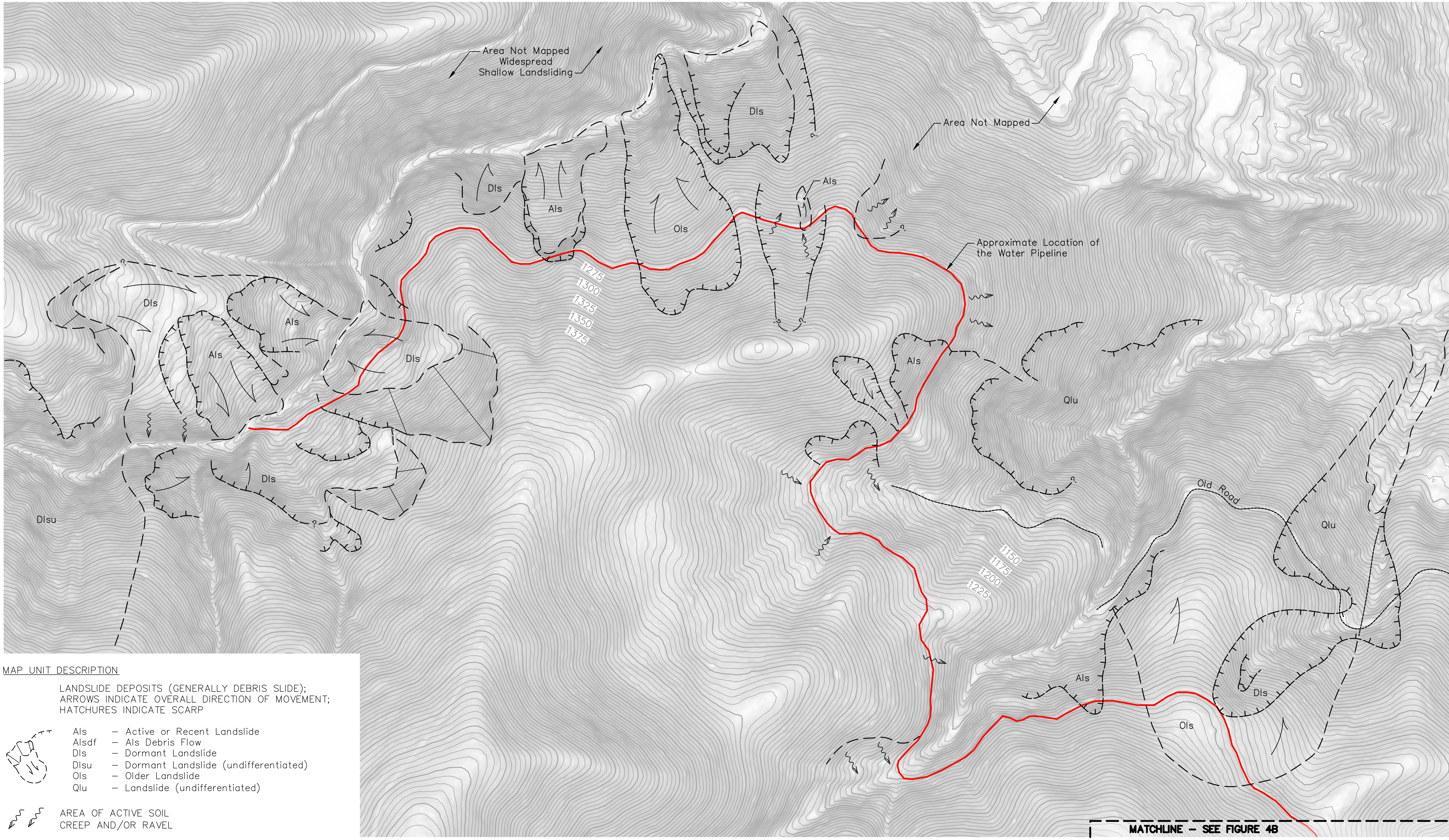
CALIFORNIA

PUBLISHED LANDSLIDE MAPPING

210450	JANUARY 2022	FIGURE 3



MAP UNIT DESCRIPTION

LANDSLIDE DEPOSITS (GENERALLY DEBRIS SLIDE);
ARROWS INDICATE OVERALL DIRECTION OF MOVEMENT;
HATCHURES INDICATE SCARP

- Als – Active or Recent Landslide
- Alsdf – Als Debris Flow
- Dls – Dormant Landslide
- Dlsu – Dormant Landslide (undifferentiated)
- Ols – Older Landslide
- Qlu – Landslide (undifferentiated)

AREA OF ACTIVE SOIL CREEP AND/OR RAVEL

REFERENCES

1. GEOLOGY MAPPING BY R. FISHER ON 01/14/2022.
2. 5-FT CONTOURS DERIVED FROM 2018-2020 COUNTY LIDAR DATA.
3. SLOPESHADE DERIVED FROM 2018-2020 COUNTY LIDAR DATA.

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SCALE FEET

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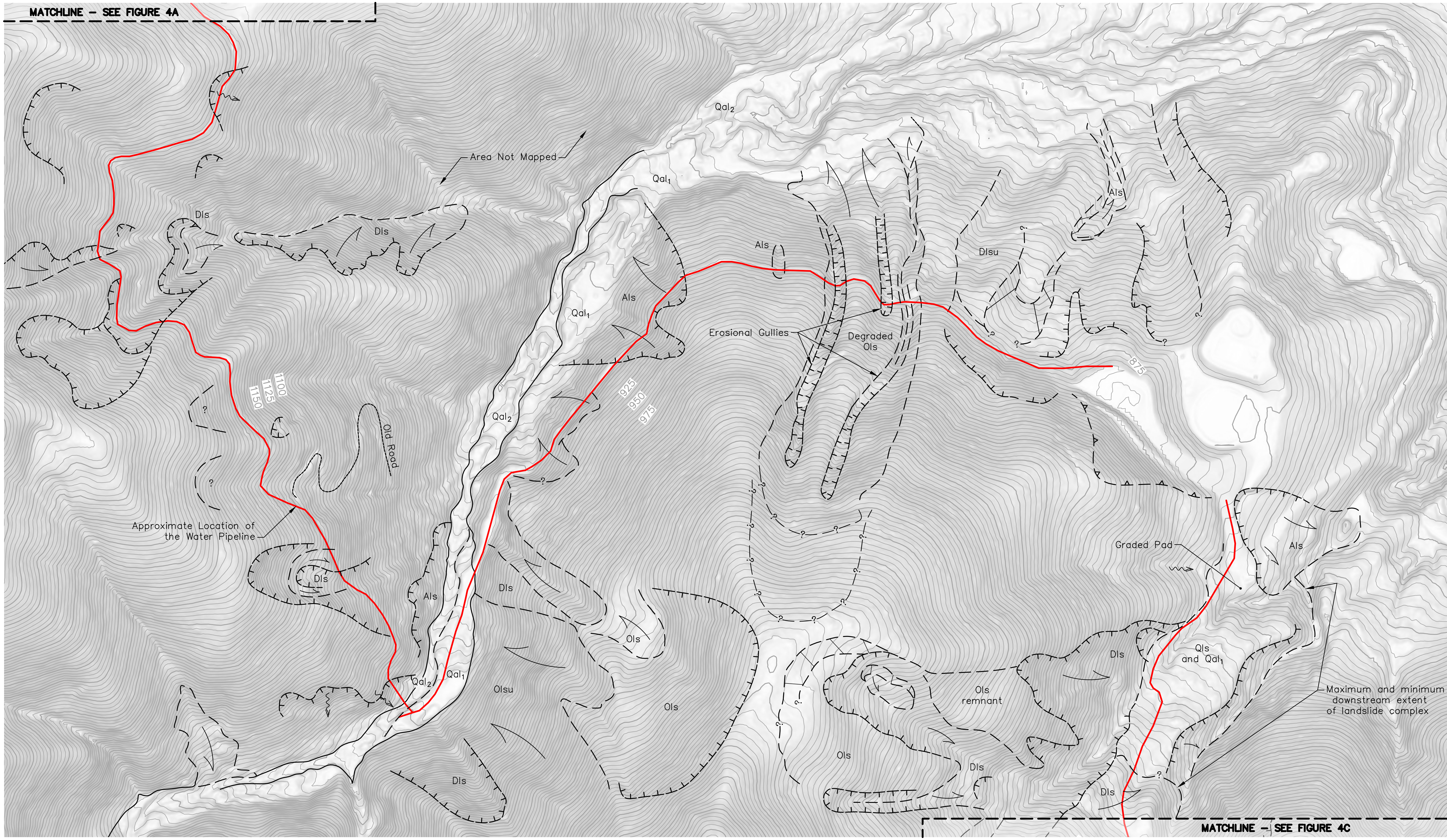
PRELIMINARY GEOMORPHOLOGY MAP

210460	JANUARY 2022	FIGURE 4A



NOTE

1. SEE FIGURE 4A FOR BASEMAP REFERENCES AND LEGEND.

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SCALE FEET

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SAN LORENZO VALLEY WATER - CROSS COUNTY PIPELINE
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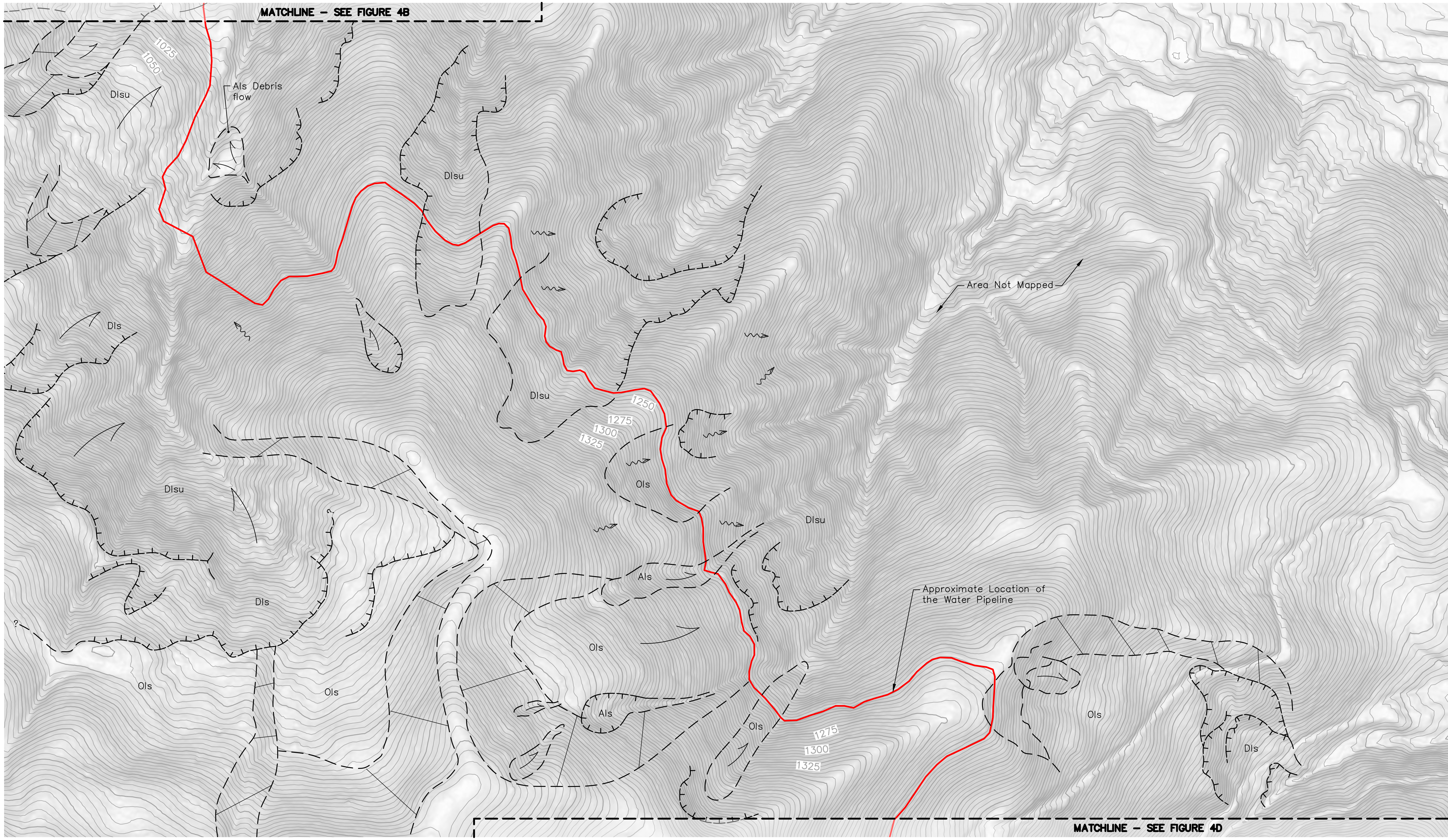
CALIFORNIA

PRELIMINARY GEOMORPHOLOGY MAP

210460	JANUARY 2022	FIGURE 4B



NOTE

1. SEE FIGURE 4A FOR BASEMAP REFERENCES AND LEGEND.

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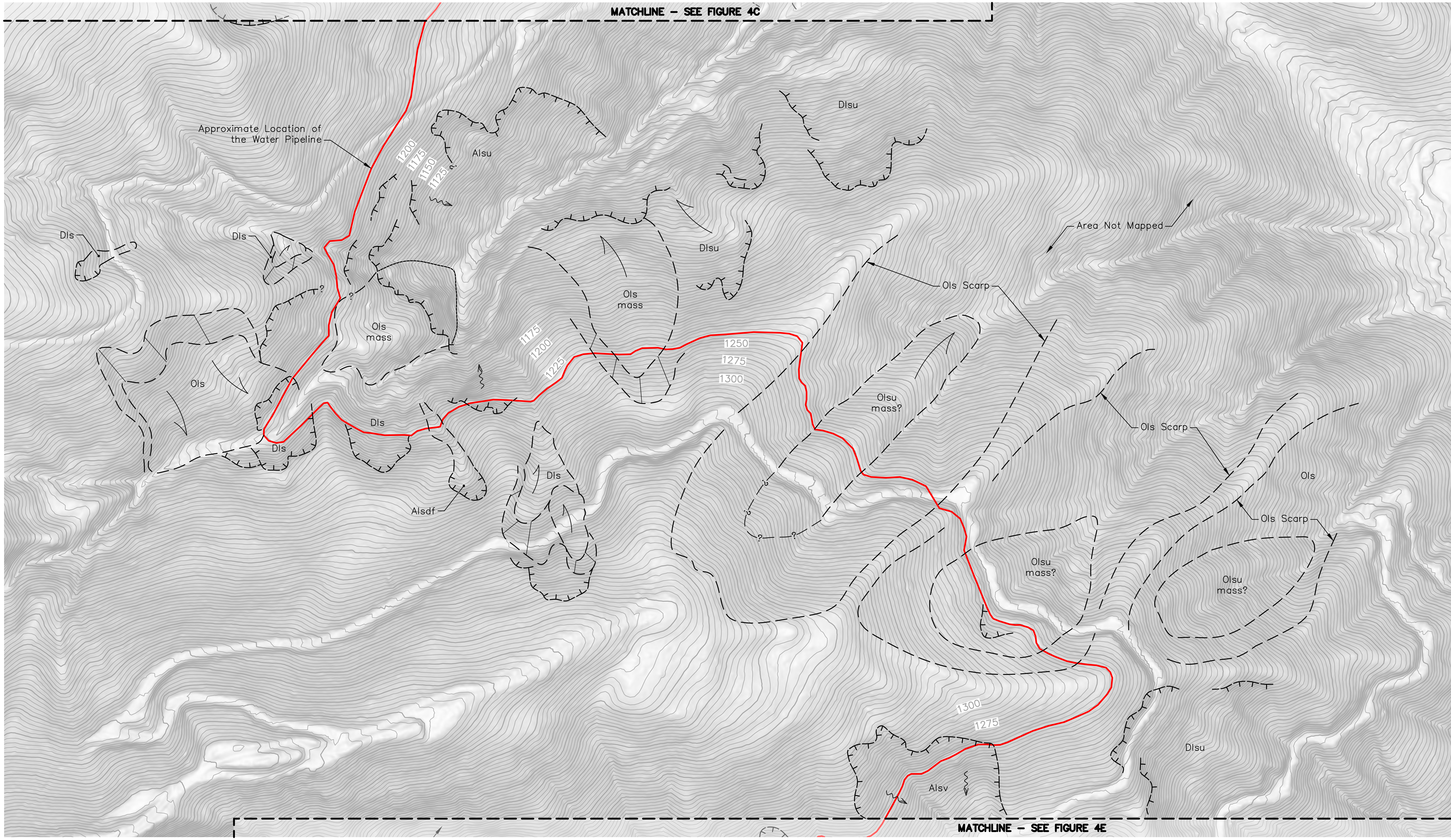
CALIFORNIA

PRELIMINARY GEOMORPHOLOGY MAP

210460	JANUARY 2022	FIGURE 4C



NOTE

1. SEE FIGURE 4A FOR BASEMAP REFERENCES AND LEGEND.

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SCALE FEET

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SAN LORENZO VALLEY WATER - CROSS COUNTY PIPELINE
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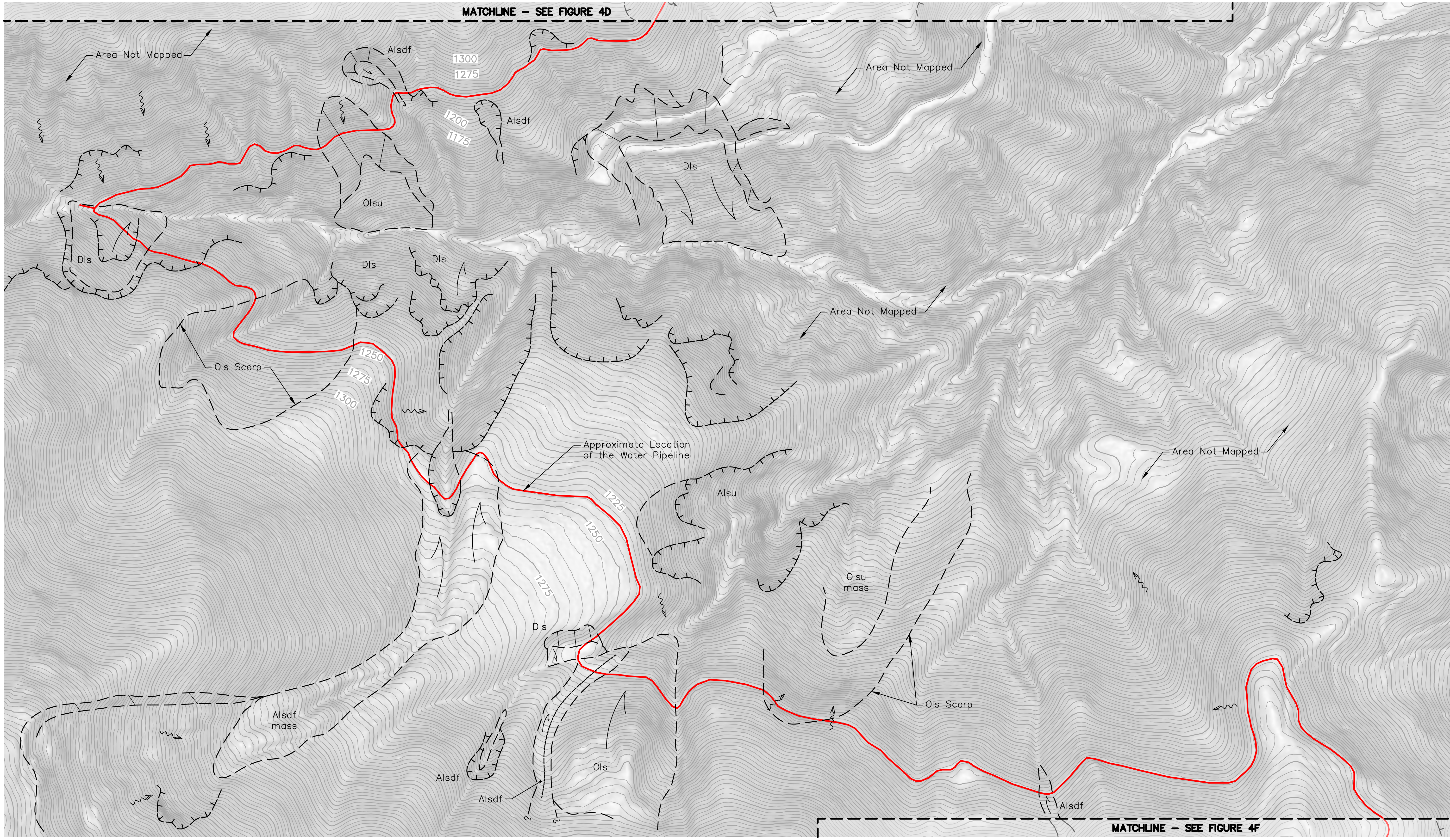
PRELIMINARY GEOMORPHOLOGY MAP

210460	JANUARY 2022	FIGURE 4D



NOTE

1. SEE FIGURE 4A FOR BASEMAP REFERENCES AND LEGEND.

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SCALE FEET

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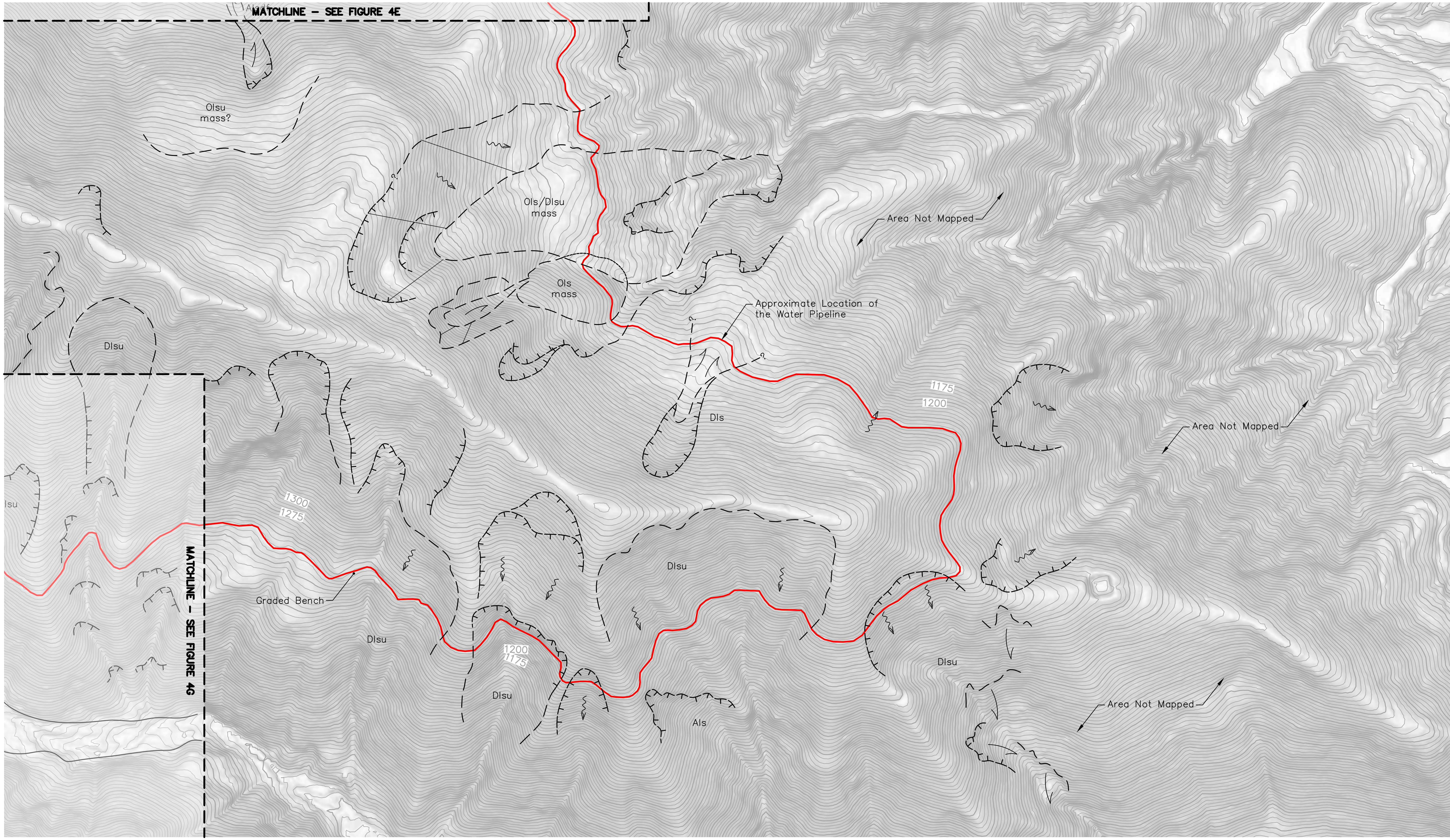
CALIFORNIA

PRELIMINARY GEOMORPHOLOGY MAP

210460	JANUARY 2022	FIGURE 4E



NOTE

1. SEE FIGURE 4A FOR BASEMAP REFERENCES AND LEGEND.

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SCALE FEET

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SAN LORENZO VALLEY WATER - CROSS COUNTY PIPELINE
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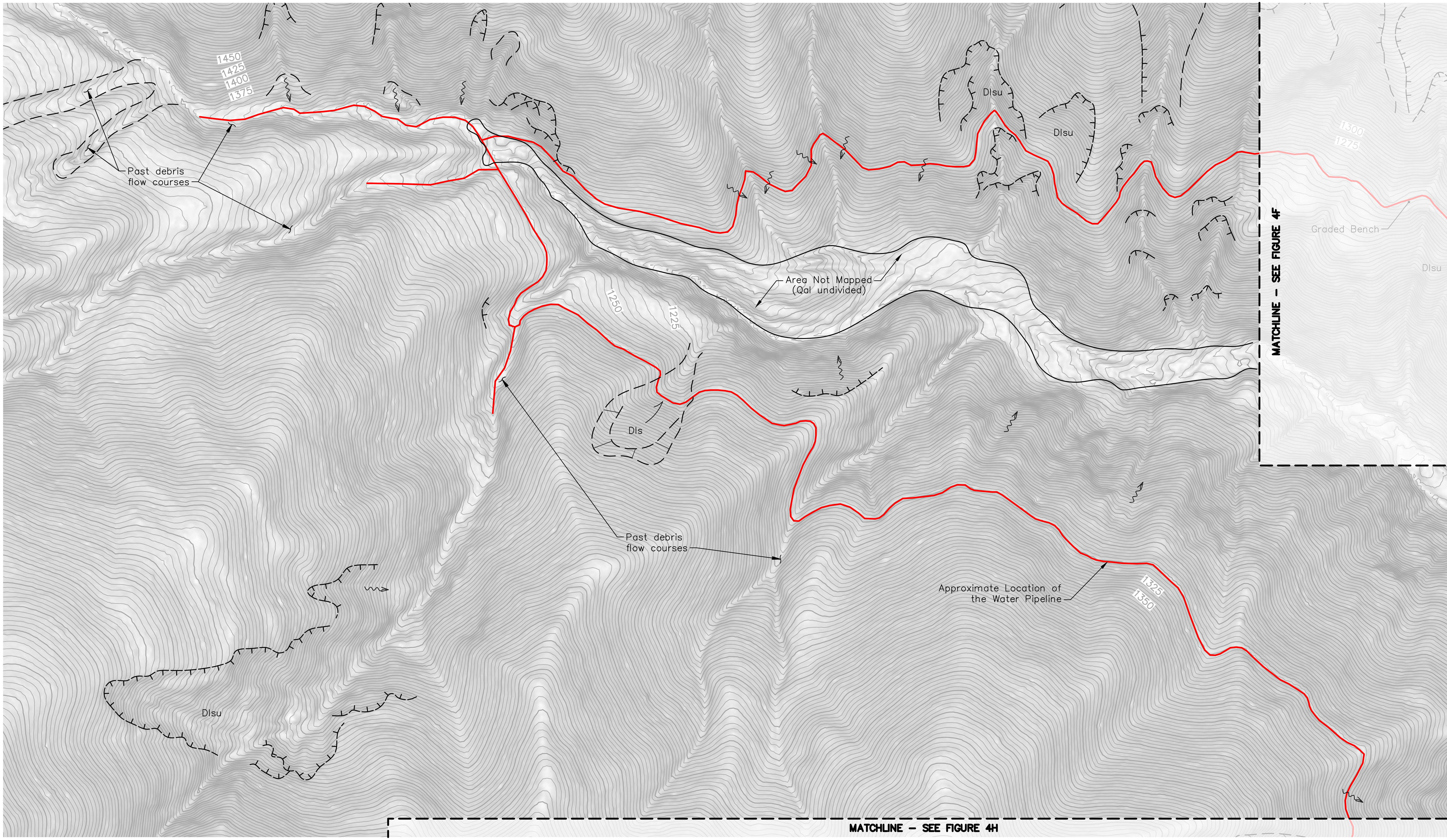
CALIFORNIA

PRELIMINARY GEOMORPHOLOGY MAP

210460	JANUARY 2022	FIGURE 4F



NOTE

1. SEE FIGURE 4A FOR BASEMAP REFERENCES AND LEGEND.

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SAN LORENZO VALLEY WATER - CROSS COUNTY PIPELINE
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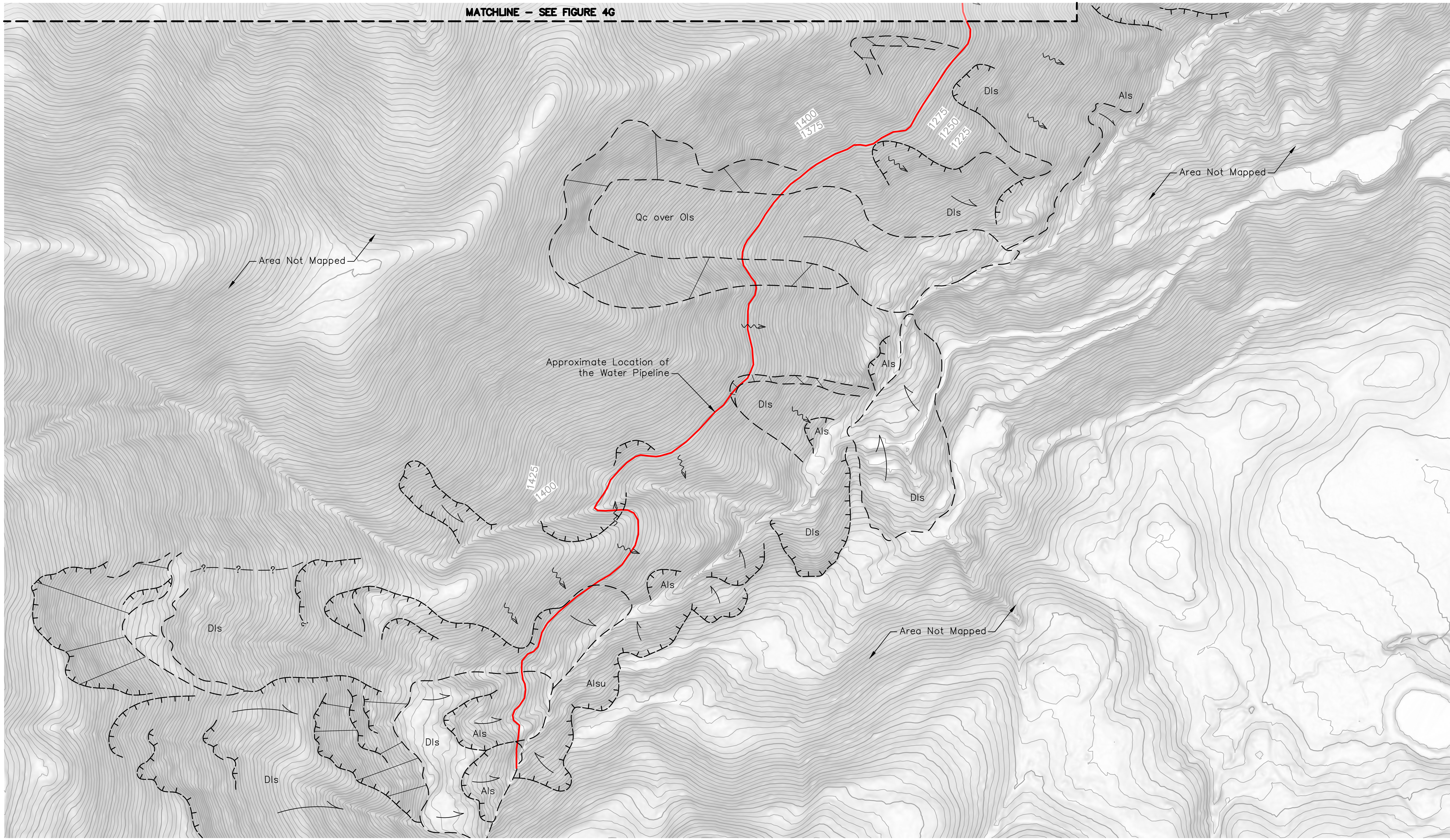
CALIFORNIA

PRELIMINARY GEOMORPHOLOGY MAP

210460	JANUARY 2022	FIGURE 4G



NOTE

1. SEE FIGURE 4A FOR BASEMAP REFERENCES AND LEGEND.

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SCALE FEET

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SAN LORENZO VALLEY WATER - CROSS COUNTY PIPELINE
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PRELIMINARY GEOMORPHOLOGY MAP

210460	JANUARY 2022	FIGURE 4H

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APPENDIX D: HDPE SDS

SECTION 1: Identification of the substance/mixture and of the company/undertaking

Product information

Product Name	:	Performance Pipe (PE Pipe and Fittings: Various Colors)
Material	:	1068064, 1096623, 1057036, 1103213, 1056889, 1056845, 1056798, 1061143, 1002382, 1008501, 1098385, 1002298, 1083165, 1002266, 1112056, 1002243, 1114924, 1097906, 1108020, 1108019, 1114925
Use	:	Conveyance of liquids, gases and other media.
Company	:	Performance Pipe, A Division of Chevron Phillips Chemical Company LP 10001 Six Pines Drive The Woodlands, TX 77380

Emergency telephone:

Health:
866.442.9628 (North America)
1.832.813.4984 (International)
Transport:
CHEMTREC 800.424.9300 or 703.527.3887(int'l)
Asia: CHEMWATCH (+612 9186 1132) China: 0532 8388 9090
EUROPE: BIG +32.14.584545 (phone) or +32.14583516 (telefax)
Mexico CHEMTREC 01-800-681-9531 (24 hours)
South America SOS-Cotec Inside Brazil: 0800.111.767 Outside Brazil: +55.19.3467.1600
Argentina: +(54)-1159839431

Responsible Department	:	Product Safety and Toxicology Group
E-mail address	:	SDS@CPChem.com
Website	:	www.CPChem.com

SECTION 2: Hazards identification

Classification of the substance or mixture
This product has been classified in accordance with the hazard communication standard 29 CFR 1910.1200; the SDS and labels contain all the information as required by the standard.

Classification :

Not a hazardous substance or mixture.

Labeling

Not a hazardous substance or mixture.

Potential Health Effects

Physical Hazards : Not a dangerous substance according to Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

Inhalation : Not a dangerous substance according to Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

Skin : Not a dangerous substance according to Globally Harmonized System of Classification and Labeling of Chemicals (GHS).
If this material is heated, thermal burns may result from contact. Thermal burns may include pain or feeling of heat, discolorations, swelling, and blistering.

Eyes : Not expected to cause prolonged or significant eye irritation. Thermal burns may result if heated material contacts eye.

Ingestion : Not a dangerous substance according to Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

Carcinogenicity:

IARC	Group 1: Carcinogenic to humans	
	Lead Chromate	1344-37-2
	Group 2A: Probably carcinogenic to humans	
	Group 2B: Possibly carcinogenic to humans	
	Carbon Black	1333-86-4
	Titanium Dioxide	13463-67-7
NTP	Reasonably anticipated to be a human carcinogen	
	Lead Chromate	1344-37-2

Components are encapsulated within the product matrix.

SECTION 3: Composition/information on ingredients

Synonyms : Polyethylene Plastic DriscoPlex® Pipe and Fittings

Molecular formula : Mixture

Component	CAS-No.	Weight %
Carbon Black	1333-86-4	0 - 5
Lead Chromate	1344-37-2	0 - 1
Titanium Dioxide	13463-67-7	0 - 1

SECTION 4: First aid measures

If inhaled : Move to fresh air in case of accidental inhalation of dust or fumes from overheating or combustion. If symptoms persist, call a physician.

In case of skin contact : If the molten material gets on skin, quickly cool in water. Seek immediate medical attention. Do not try to peel the solidified material from the skin or use solvents or thinners to dissolve it.

In case of eye contact	:	In the case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
If swallowed	:	Not a dangerous substance according to Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

SECTION 5: Firefighting measures

Flash point	:	Not applicable
Suitable extinguishing media	:	Water. Water mist. Dry chemical. Carbon dioxide (CO_2). Foam. If possible, water should be applied as a spray from a fogging nozzle since this is a surface burning material. The application of high velocity water will spread the burning surface layer. Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.
Specific hazards during fire fighting	:	Risks of ignition followed by flame propagation or secondary explosions can be caused by the accumulation of dust, e.g. on floors and ledges.
Special protective equipment for fire-fighters	:	Use personal protective equipment. Wear self-contained breathing apparatus for firefighting if necessary.
Further information	:	This material will burn although it is not easily ignited.
Fire and explosion protection	:	Treat as a solid that can burn.
Hazardous decomposition products	:	Normal combustion forms carbon dioxide, water vapor and may produce carbon monoxide, other hydrocarbons and hydrocarbon oxidation products (ketones, aldehydes, organic acids) depending on temperature and air availability. Incomplete combustion can also produce formaldehyde.

SECTION 6: Accidental release measures

Personal precautions	:	None
Environmental precautions	:	None

SECTION 7: Handling and storage

Handling

Advice on protection against fire and explosion	:	Treat as a solid that can burn.

Storage

Requirements for storage areas and containers : Keep in a dry place. Keep in a well-ventilated place.

Advice on common storage : Do not store together with oxidizing and self-igniting products.

Use : Conveyance of liquids, gases and other media.

SECTION 8: Exposure controls/personal protection

Ingredients with workplace control parameters

US

Components	Basis	Value	Control parameters	Note
Nuisance Dust	OSHA Z-3	TWA	15 mg/m3	Total dust
	OSHA Z-3	TWA	5 mg/m3	(respirable dust)

Control as Particulate Not Otherwise Classified (PNOC). The ACGIH Guideline* for respirable dust is 3.0 mg/m3 and 10.0 mg/m3 for total dust. The OSHA PEL for respirable dust is 5.0 mg/m3 and 15.0 mg/m3 for total dust.
* This value is for inhalable (total) particulate matter containing no asbestos and < 1.0% crystalline silica.

Personal protective equipment

Respiratory protection : No personal respiratory protective equipment normally required. Use a positive pressure, air-supplying respirator if there is potential for uncontrolled release, aerosolization, exposure levels are not known, or other circumstances where air-purifying respirators may not provide adequate protection.

Eye protection : No eye protection is ordinarily required under normal conditions of use. In accordance with good industrial hygiene practices, precautions should be taken to avoid eye contact.

Skin and body protection : At ambient temperatures use of clean and protective clothing is good industrial practice. If the material is heated or molten, wear thermally insulated, heat-resistant gloves that are able to withstand the temperature of the molten product. If this material is heated, wear insulated clothing to prevent skin contact if engineering controls or work practices are not adequate. Heavy duty work shoes.

SECTION 9: Physical and chemical properties

Information on basic physical and chemical properties

Appearance

Form : Plastic
Physical state : solid
Color : Various
Odor : Mild to no odor
Odor Threshold : No data available

Safety data

Flash point : Not applicable

Lower explosion limit : Not applicable

Upper explosion limit	:	Not applicable
Oxidizing properties	:	No
Thermal decomposition	:	Low molecular weight hydrocarbons, alcohols, aldehydes, acids and ketones can be formed during thermal processing.
Molecular formula	:	Mixture
pH	:	Not applicable
Melting point/range	:	250°C (482°F)
Boiling point/boiling range	:	Not applicable
Vapor pressure	:	Not applicable
Relative density	:	0.95
Density	:	0.95 g/cm3
Water solubility	:	Insoluble
Partition coefficient: n-octanol/water	:	No data available
Viscosity, kinematic	:	Not applicable

SECTION 10: Stability and reactivity

Reactivity : This material is considered non-reactive under normal ambient and anticipated storage and handling conditions of temperature and pressure.

Chemical stability : This material is considered stable under normal ambient and anticipated storage and handling conditions of temperature and pressure.

Possibility of hazardous reactions

Hazardous reactions : Hazardous reactions: Hazardous polymerization does not occur.

Conditions to avoid : Avoid prolonged storage at elevated temperature.

Materials to avoid : Avoid contact with strong oxidizing agents.

Thermal decomposition : Low molecular weight hydrocarbons, alcohols, aldehydes, acids and ketones can be formed during thermal processing.

Hazardous decomposition products : Normal combustion forms carbon dioxide, water vapor and may produce carbon monoxide, other hydrocarbons and hydrocarbon oxidation products (ketones, aldehydes, organic acids) depending on temperature and air availability. Incomplete combustion can also produce formaldehyde.

Other data : No decomposition if stored and applied as directed.

SECTION 11: Toxicological information

Performance Pipe (PE Pipe and Fittings: Various Colors)
Acute oral toxicity : Presumed Not Toxic

Performance Pipe (PE Pipe and Fittings: Various Colors)
Acute inhalation toxicity : Presumed Not Toxic

Performance Pipe (PE Pipe and Fittings: Various Colors)
Acute dermal toxicity : Presumed Not Toxic

Performance Pipe (PE Pipe and Fittings: Various Colors)
Skin irritation : No skin irritation

Performance Pipe (PE Pipe and Fittings: Various Colors)
Eye irritation : No eye irritation

Performance Pipe (PE Pipe and Fittings: Various Colors)
Sensitization : Did not cause sensitization on laboratory animals.

Performance Pipe (PE Pipe and Fittings: Various Colors)
Aspiration toxicity : No aspiration toxicity classification.

CMR effects

Carbon Black : Carcinogenicity: Limited evidence of carcinogenicity in animal studies

Lead Chromate
Carcinogenicity: Possible human carcinogen
Mutagenicity: In vivo tests did not show mutagenic effects
Reproductive toxicity: Positive evidence of adverse effects on sexual function, fertility and/or development from human epidemiological studies.

SECTION 12: Ecological information

Ecotoxicity effects

Biodegradability : This material is not expected to be readily biodegradable.

Elimination information (persistence and degradability)

Bioaccumulation : Does not bioaccumulate.

Mobility : The product is insoluble and floats on water.

Short-term (acute) aquatic hazard
Lead Chromate : Very toxic to aquatic life.

Long-term (chronic) aquatic hazard
Lead Chromate : Very toxic to aquatic life with long lasting effects.

SECTION 13: Disposal considerations

The information in this SDS pertains only to the product as shipped.

Use material for its intended purpose or recycle if possible. This material, if it must be discarded, may meet the criteria of a hazardous waste as defined by US EPA under RCRA (40 CFR 261) or other State and local regulations. Measurement of certain physical properties and analysis for regulated components may be necessary to make a correct determination. If this material is classified as a hazardous waste, federal law requires disposal at a licensed hazardous waste disposal facility.

SECTION 14: Transport information

The shipping descriptions shown here are for bulk shipments only, and may not apply to shipments in non-bulk packages (see regulatory definition).

Consult the appropriate domestic or international mode-specific and quantity-specific Dangerous Goods Regulations for additional shipping description requirements (e.g., technical name or names, etc.) Therefore, the information shown here, may not always agree with the bill of lading shipping description for the material. Flashpoints for the material may vary slightly between the SDS and the bill of lading.

US DOT (UNITED STATES DEPARTMENT OF TRANSPORTATION)
NOT REGULATED AS A HAZARDOUS MATERIAL OR DANGEROUS GOODS FOR TRANSPORTATION BY THIS AGENCY.

IMO / IMDG (INTERNATIONAL MARITIME DANGEROUS GOODS)
NOT REGULATED AS A HAZARDOUS MATERIAL OR DANGEROUS GOODS FOR TRANSPORTATION BY THIS AGENCY.

IATA (INTERNATIONAL AIR TRANSPORT ASSOCIATION)
NOT REGULATED AS A HAZARDOUS MATERIAL OR DANGEROUS GOODS FOR TRANSPORTATION BY THIS AGENCY.

ADR (AGREEMENT ON DANGEROUS GOODS BY ROAD (EUROPE))
NOT REGULATED AS A HAZARDOUS MATERIAL OR DANGEROUS GOODS FOR TRANSPORTATION BY THIS AGENCY.

RID (REGULATIONS CONCERNING THE INTERNATIONAL TRANSPORT OF DANGEROUS GOODS (EUROPE))

NOT REGULATED AS A HAZARDOUS MATERIAL OR DANGEROUS GOODS FOR TRANSPORTATION BY THIS AGENCY.

ADN (EUROPEAN AGREEMENT CONCERNING THE INTERNATIONAL CARRIAGE OF DANGEROUS GOODS BY INLAND WATERWAYS)

NOT REGULATED AS A HAZARDOUS MATERIAL OR DANGEROUS GOODS FOR TRANSPORTATION BY THIS AGENCY.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

SECTION 15: Regulatory information

National legislation

SARA 311/312 Hazards : No SARA Hazards

EPCRA - EMERGENCY PLANNING COMMUNITY RIGHT - TO – KNOW

CERCLA Reportable Quantity : This material does not contain any components with a CERCLA RQ.

SARA 302 Reportable Quantity : This material does not contain any components with a SARA 302 RQ.

SARA 302 Threshold Planning Quantity : No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 304 Reportable Quantity : This material does not contain any components with a section 304 EHS RQ.

SARA 313 Components : This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

Clean Air Act

Ozone-Depletion Potential : This product neither contains, nor was manufactured with a Class I or Class II ODS as defined by the U.S. Clean Air Act Section 602 (40 CFR 82, Subpt. A, App.A + B).

This product neither contains, nor was manufactured with a Class I or Class II ODS as defined by the U.S. Clean Air Act Section 602 (40 CFR 82, Subpt. A, App.A + B).

This product does not contain any hazardous air pollutants (HAP), as defined by the U.S. Clean Air Act Section 112 (40 CFR 61).

This product does not contain any chemicals listed under the U.S. Clean Air Act Section 112(r) for Accidental Release Prevention (40 CFR 68.130, Subpart F).

This product does not contain any chemicals listed under the U.S. Clean Air Act Section 111 SOCMI Intermediate or Final VOC's (40 CFR 60.489).

US State Regulations

Pennsylvania Right To Know

: Polyethylene - 9002-88-4
Polyethylene Butene Copolymer - 25087-34-7
Polyethylene Hexene Copolymer - 25213-02-9
Carbon Black - 1333-86-4
Dioxotitanium -
Lead(2+) dioxido(dioxo)chromium -

California Prop. 65 Components : WARNING: This product can expose you to chemicals including [listed below], which is [are] known to the State of California to cause cancer. For more information go to www.P65Warnings.ca.gov/food.

Carbon Black	1333-86-4
Titanium Dioxide	13463-67-7
Lead Chromate	1344-37-2

WARNING: This product can expose you to chemicals including [listed below], which is [are] known to the State of California to cause birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov.

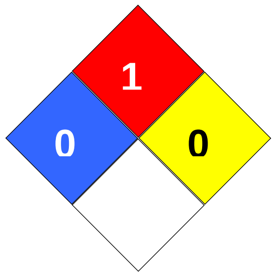
Lead Chromate	1344-37-2

Notification status

Europe REACH	:	Exemptions from the obligation to register
United States of America (USA) TSCA	:	Exemptions from the obligation to register
Canada DSL	:	Exemptions from the obligation to register
Other AIIC	:	Exemptions from the obligation to register
New Zealand NZIoC	:	Exemptions from the obligation to register
Japan ENCS	:	Exemptions from the obligation to register
Korea KECI	:	Exemptions from the obligation to register
Philippines PICCS	:	Exemptions from the obligation to register
Taiwan TCSI	:	Exemptions from the obligation to register
China IECSC	:	Exemptions from the obligation to register

SECTION 16: Other information

NFPA Classification : Health Hazard: 0
Fire Hazard: 1
Reactivity Hazard: 0



Further information

Legacy SDS Number : 6371

Significant changes since the last version are highlighted in the margin. This version replaces all previous versions.

The information in this SDS pertains only to the product as shipped.

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

Key or legend to abbreviations and acronyms used in the safety data sheet			
ACGIH	American Conference of Government Industrial Hygienists	LD50	Lethal Dose 50%
AICS	Australia, Inventory of Chemical Substances	LOAEL	Lowest Observed Adverse Effect Level
DSL	Canada, Domestic Substances List	NFPA	National Fire Protection Agency
NDSL	Canada, Non-Domestic Substances List	NIOSH	National Institute for Occupational Safety & Health
CNS	Central Nervous System	NTP	National Toxicology Program
CAS	Chemical Abstract Service	NZIoC	New Zealand Inventory of Chemicals
EC50	Effective Concentration	NOAEL	No Observable Adverse Effect Level
EC50	Effective Concentration 50%	NOEC	No Observed Effect Concentration
EGEST	EOSCA Generic Exposure	OSHA	Occupational Safety & Health

	Scenario Tool		Administration
EOSCA	European Oilfield Specialty Chemicals Association	PEL	Permissible Exposure Limit
EINECS	European Inventory of Existing Chemical Substances	PICCS	Philippines Inventory of Commercial Chemical Substances
MAK	Germany Maximum Concentration Values	PRNT	Presumed Not Toxic
GHS	Globally Harmonized System	RCRA	Resource Conservation Recovery Act
>=	Greater Than or Equal To	STEL	Short-term Exposure Limit
IC50	Inhibition Concentration 50%	SARA	Superfund Amendments and Reauthorization Act.
IARC	International Agency for Research on Cancer	TLV	Threshold Limit Value
IECSC	Inventory of Existing Chemical Substances in China	TWA	Time Weighted Average
ENCS	Japan, Inventory of Existing and New Chemical Substances	TSCA	Toxic Substance Control Act
KECI	Korea, Existing Chemical Inventory	UVCB	Unknown or Variable Composition, Complex Reaction Products, and Biological Materials
<=	Less Than or Equal To	WHMIS	Workplace Hazardous Materials Information System
LC50	Lethal Concentration 50%		

APPENDIX E: Fire Intensity

MEMORANDUM

To:	Jeff Tarantino, Freyer & Laureta	**From:**	Cailin Notch Justin Semion
cc:			
Date:	January 14, 2022		
Subject:	Research Review: Fire Heat Soil Penetration for San Lorenzo Valley Water District 5-mile Pipeline		

The purpose of this memorandum is to summarize existing scientific literature related to soil temperature at different depths under various fire scenarios to support depth of soil cover above a proposed buried raw water pipeline for the San Lorenzo Valley Water District. Based on an initial literature review of fire's effect on soil temperatures at various depths, most research suggests that heat temperature increase from fires does not extend very deep into the soil, due to its poor thermal conductivity. The specific depth for risk to a buried pipeline would depend on the heat tolerance of the pipeline material. While information in the literature addressing the specific needs of the project is relatively sparse, several useful articles were found which can be used as a basis for establishing a safe depth of burial for the new pipeline to withstand most fire conditions. A summary of specific soil heat depths found in the literature review is provided in **Table 1** below. Additional detail for each study is provided in the discussion below.

Table 1. Literature review summary.

Study	Vegetation Community	Soil Characteristics	Soil Heat Penetration
Badia et al. 2017	Aleppo pine forest (*Pinus halepensis*) with understory of kermes evergreen oak (*Quercus coccifera*) and Mediterranean false brome (*Brachypodium retusum*).	Topsoil in and dry wet and conditions.	See **Table 3.** Range of 589°C (1092°F) at surface to 131°C (268°F) at 3 cm (1.2 in) in dry soils, and 324°C (615°F) at surface to 47°C (117°F) at 3 cm (1.2 in) in wet soils.
Busse et al. 2005	Ponderosa pine (*Pinus ponderosa*) with dense understory of whiteleaf manzanita (*Arctostaphylos viscidal*), poison oak (*Rhus diversiloba*), mahala mat (*Ceanothus prostrates*), and black oak (*Quercus kelloggii*).	Clay loamy soil in moist and dry conditions.	60°C (140 °F) throughout the 10 cm (3.9 in) soil profile.

Massman and Frank. 2004	Grassy controlled burn site of senescent bunchgrasses within ponderosa pine (*Pinus ponderosa)* forest.	Semi-arid environment with usually dry soils.	See **Table 2**. Range of 400°C (752 °F) at 0.02 m (0.8 in) to 20°C (68 °F) at 136 cm (53.5 in).
Steward et al. 1990	N/A	Mineral soils from New Bruswick gravel pits.	40°C (104°F) reached at various depths ranging from 2.7 cm (1.1 in) to 7.1 cm (2.8 in) across various soil types.
Valette et al. 1994	Surface fuel composed of needles and twigs of maritime pine *(Pinus pinaster).*	Intact soil blocks with duff layer at moisture conditions between 7 and 19% percent dry rate.	Absence of duff layers reduced maximum temperatures from 350 °C (662°F) at the surface to 7 °C (44.6 °F) at 3.5 cm (1.4 in).
Zavala et al. 2014	Mediterranean ecosystems.	Mediterranean forest soils.	Limited to the first few inches in depth in most cases.

The most relevant article found for the project is a 2004 study by Massman and Frank titled "Effect of a controlled burn on the thermophysical properties of a dry soil using a new model of soil heat flow and a new high temperature heat flux sensor" measures soil temperatures and heat fluxes at several soil depths before, during, and after controlled burns in southern Colorado. This study evaluates fire's effect on soil's thermophysical properties including thermal conductivity and heat capacity. **Figure 1** below is a graph from this study and shows the maximum soil temperature at the site of a controlled burn measured over several days in January 2002. The burn took place on January 11 at 12:00 p.m. The graph includes measurements taken at six soil depths ranging from 2 cm (0.8 in) to 136 cm (53.5 in).

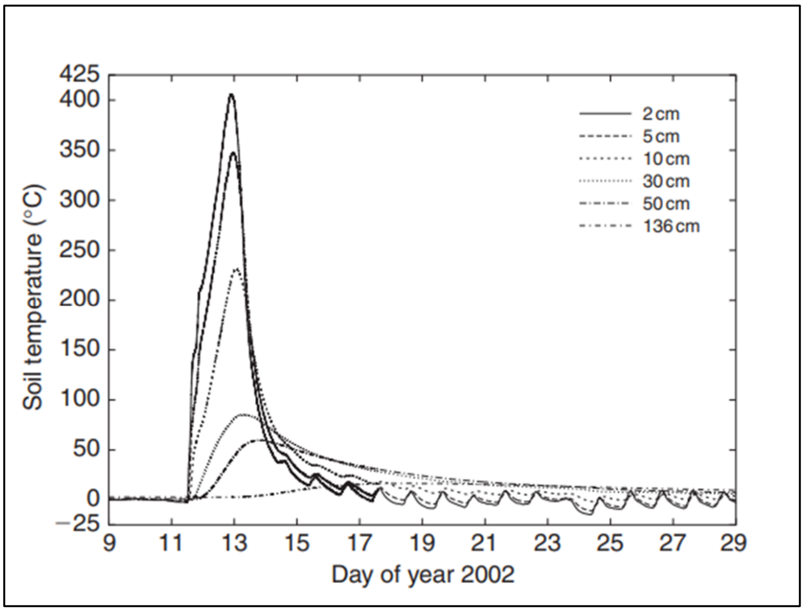


Figure 1. Measured Soil Temperature for 9-28 January 2002 at Manitou Experimental Forest Controlled Burn Site

As shown in Figure 1, the **soil heats to over 400°C (752 °F) at 0.02 m (0.8 in), and approaches 100°C (212°F) at 0.30 m (11.8 in). At the lowest soil depth taken at 136 cm (53.3 in), peak soil temperature reached 20°C or 68°F. Table 2** below lists the full range of approximate maximum temperatures and corresponding soil depths shown in **Figure 1.**

Table 2. Approximate maximum temperature at various soil depths during the controlled burn evaluated in Massman and Frank (2004) study.

Soil Depth	Maximum Temperature (approx.)
2 cm (0.8 in)	400°C (752 °F)
5 cm (2 in)	345°C (653 °F)
10 cm (3.9 in)	225°C (437 °F)
30 cm (11.8 in)	80°C (176 °F)
50 cm (19.7 in)	50°C (131 °F)
136 cm (53.5 in)	20°C (68 °F)

As seen in **Figure 1,** the study finds **relatively high temperatures persisting for several hours to days at all soil depths.** Additionally, **Figure 1 shows a correlation between time elapsed to reach maximum temperature and soil depth, with the shallowest depths reaching peak temperature most immediately.** For example, the lowest soil depth (136 cm or 53.5 in) reached peak temperature approximately one week after the controlled burn occurred. **The article explains further that heat from the fire does not penetrate the soil directly below the burn until the pile collapses and combusting material comes into physical contact with the soil surface.** This happened several hours after ignition.

A 2017 study by Badia et al. titled "Burn effects on soil properties associated to heat transfer under contrasting moisture content" explores moisture content's effect on changes of soil temperatures in depths ranging from 1-4 cm (0.4-1.2 in). In this study, topsoil was sampled from a long-unburned, wooded, mountainous environment in northeast Spain and burned in a laboratory under different moisture conditions. The article states that **because soil is a poor conductor of heat, a strong gradient of temperatures with soil depth exists during wildfire and prescribed fire.**

The article finds that heat transmission into soil can be modified under high moisture conditions**,** with **maximum temperatures lower as well as soil heating slower and cooling faster in wet soils compared to dry soils. Table 3** summarizes maximum temperatures reached in wet and dry conditions at the surface to 3 cm (0.4-1.2 in). Temperatures were measured at 0-1 cm (0-0.4 in), 1-2 cm (0.4-0.8 in), 2-3 cm (0.8-1.2 in), and 3-4 cm (1.2-1.6 in).

Table 3. Maximum Temperature at Soil Depth in Dry vs. Wet Moisture Conditions in Badia et al. 2017 Study.

Moisture Condition	Maximum Temperature at Soil Depth			
	Surface	1 cm (0.4 in)	2 cm (0.8 in)	3 cm (1.2 in)
Dry	589°C (1092°F)	427°C (801°F)	235°C (455°F)	131°C (268°F)
Wet	324°C (615°F)	123°C (253°F)	60°C (140°F)	47°C (117°F)

A study from the U.S. Department of Agriculture (USDA) Forest Service titled "Lethal soil temperatures during burning of masticated forest residues" (Busse et al., 2005) explores if the remaining mulch from the mastication of woody shrubs leads to extreme soil heating at four depths measured at 0, 2.5, 7.5 and 12 cm (0, 1, 3 and 4.7 in). It also evaluates soil moisture content, finding that moist soils lead to lower maximum surface temperatures. For example, maximum temperatures reached 600°C (1112°F) on the surface of dry soils and were 100-200°C (212-392°F) lower for moist soils. Results show that **heating is extensive in dry soil for the two deepest mulch depths and exceeds the lethal threshold for plants (60°C or 140 °F) for a minimum of 7 hours throughout the 10-cm (3.9 in) soil profile.**

An article titled "Heat transfer in the soil during very-low intensity fires" (Valette et al., 1994) studies low-intensity prescribed burns' effects on soils, particularly looking at the role of duff thickness in insulating soils from fire's effect. The study finds that **duff thickness's role is secondary, and that increasing moisture content reinforced its insulating effect.** The study states:

> *Because of low soil thermal conductivity, temperature attenuation with increasing depth was noticed.* ***For low intensity fires, the absence of a duff layer maximum temperatures reduced from 350 C 662°F at the surface to 7 C at 3.5 cm. The temperature rise in soil decreased with depth according to a negative exponential relation****. The rate constant of this relation was greater when the initial surface temperature and the soil moisture content were higher. For the soil studied, and under the moisture conditions encountered (between 7 and 19% of dry weight), the rate constant could be predicted with acceptable precision (r squared = 0.67), if the surface soil temperature rise and the soil moisture content were known.*

An article by Steward et al. from 1990 titled "A method for predicting the depth of lethal heat penetration into mineral soils exposed to fires at various intensities" presents a model to predict the depth of lethal heat penetration into mineral soils using information about the total amount of heat transferred, time, physical soil properties, and the cooling coefficient at the soil surface. The model predicts the depth at which soils reach the lethal temperature for plants. The article notes that exposure of any living part of a plant to a temperature of 60°C (140°F), even for a short duration, is lethal.

A series of 24 experimental fires in a laboratory were conducted to test the model. From these experiments, **the temperature of 40°C (104°F) was reached at various depths ranging from 2.7 cm (1.1 in) to 7.1 cm (2.8 in) across various soil types**. The test fires measured other variables including fuel loading density, diameter of fuel, voidage of fuel bed, rate of fire spread, fire intensity, time of heating, and total heat to soil. The types of soil evaluated are described as "mineral," and were acquired from various New Brunswick Department of Highways gravel pits.

A trend from study indicates that **as fuel loading density of the fuel bed increases, the time of heating increases and the total amount of heat transferred to the soil increases, together increasing the depth of lethal heat penetration.** Additionally, identical test fires resulted in various lethal heat penetration depths.

An article from titled "How wildfires affect soil properties. A brief review" (Zavala et al. 2014) summarizes the effect of fire on biological, chemical, and physical properties on Mediterranean forest soils. It asserts **"the effect of fire is usually very limited in depth because of poor thermal conductivity, being negligible from the first few inches in most cases."** Citing a previous study from 1971, it continues that when fire affects soils directly, **only a small portion of thermal energy is transmitted to the ground.** The article also states that fire intensity is not a good measure of energy transmitted to soil, as high severity fires may have little or no impact on soil surface, (i.e. high severity crown fires that don't reach soil). Therefore, some authors prefer to use fire severity, which is "an indirect measure of the magnitude of changes in the soil or ecosystem as a result of fire. Additionally, the review states that **low intensity fires where high temperatures are not reached and don't affect vegetation cover do not cause major impacts and, in most cases, only affect the first few millimeters of soil depth.**

Relatedly, a *Cornell Chronicle* from 2013 titled: "Hot fires don't always scorch soil, study finds" summarizes the findings of an experiment at a 22-acre watershed in Portugal. In this experiment, the research team set the test area ablaze and found that **areas with the hottest soil temperatures were in direct sunlight and had sparse, dry vegetation.** Cathelijne Stoof, a soil and water scientist at Cornell University explains this is because **"it's already dried out, it doesn't have the moisture shield that more densely vegetated areas have to preserve the soil."**

Moreover, the experiment found that the hotter the fire and the denser the vegetation, the less the underlying soil heated. Conversely, **soil temperature was most affected by the fire's speed, the direction of heat travel and the landscape's initial moisture content**. Stoof attributes this to the fact that "fires moving fast will quickly burn up all the vegetation and also have little effect on the soil, but slow-moving fires will have much more time to heat up the soil and burn up its organic matter and seeds."

References

1. Badía D, López-García S, Martí C, Ortíz-Perpiñá O, Girona-García A, Casanova-Gascón J. Burn effects on soil properties associated to heat transfer under contrasting moisture content. Sci Total Environ. 2017 Dec 1;601-602:1119-1128. doi: 10.1016/j.scitotenv.2017.05.254. Epub 2017 Jun 9. PMID: 28599368.
https://pubmed.ncbi.nlm.nih.gov/28599368/

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3. "Hot fires don't always scorch soils, study finds," Cornell Chronicle, April 29, 2013
https://news.cornell.edu/stories/2013/04/hot-fires-dont-always-scorch-soil-study-finds

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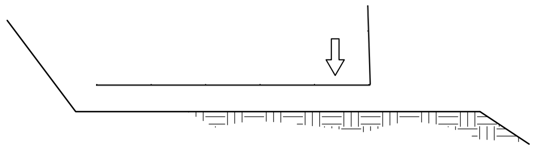
7. Zavala, L, De Celis R, Jordan A. 2014. How wildfires affect soil properties. A brief review Cuadernos de Investigacion Geografica 40(2):311.
https://www.researchgate.net/publication/277945337_How_wildfires_affect_soil_properties_A_brief_review

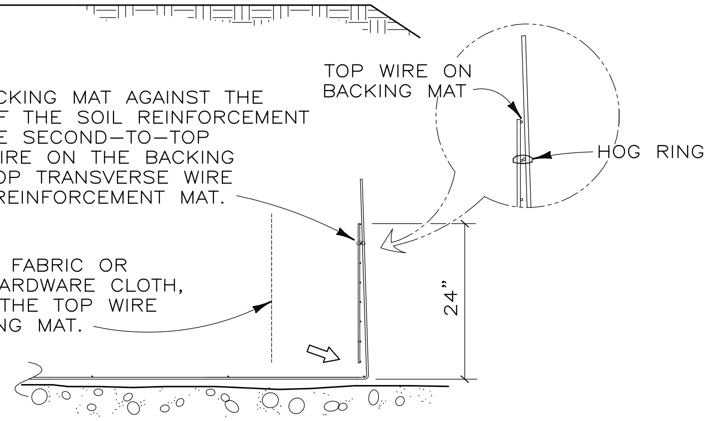
APPENDIX F: Retaining Systems

STEP 1
PLACE THE FIRST COURSE OF SOIL REINFORCEMENT MATS ON PREPARED FOUNDATION



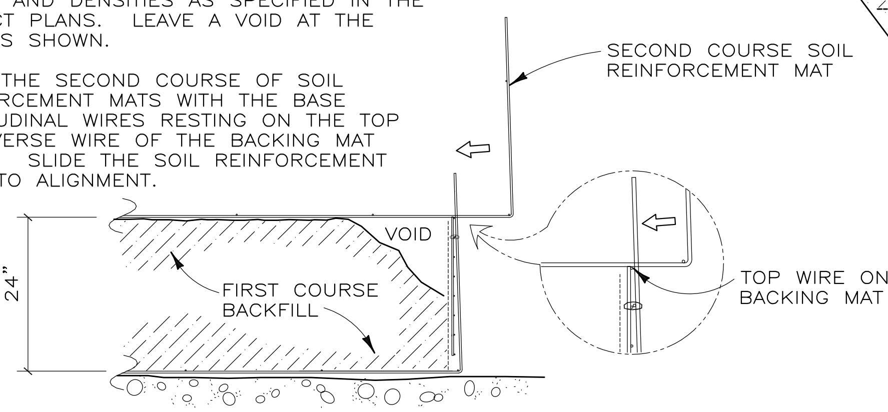
STEP 2
PLACE THE BACKING MAT AGAINST THE INSIDE FACE OF THE SOIL REINFORCEMENT MAT. CLIP THE SECOND–TO–TOP TRANSVERSE WIRE ON THE BACKING MAT TO THE TOP TRANSVERSE WIRE ON THE SOIL REINFORCEMENT MAT.

INSTALL FILTER FABRIC OR CONTINUOUS HARDWARE CLOTH, HOG–RING TO THE TOP WIRE ON THE BACKING MAT.

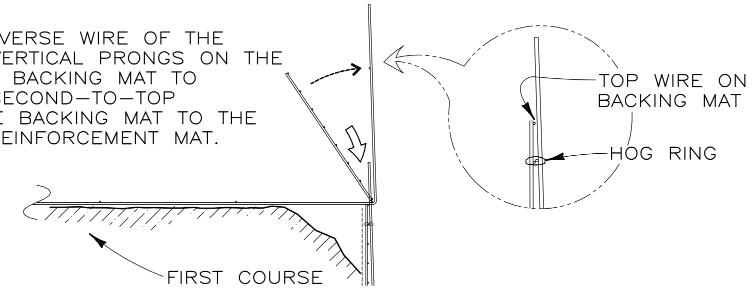


STEP 3
PLACE AND COMPACT THE BACKFILL IN LAYERS AND DENSITIES AS SPECIFIED IN THE PROJECT PLANS. LEAVE A VOID AT THE FACE AS SHOWN.

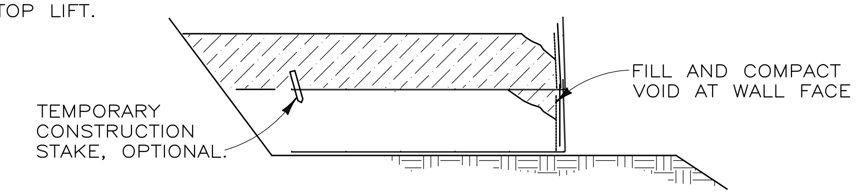
PLACE THE SECOND COURSE OF SOIL REINFORCEMENT MATS WITH THE BASE LONGITUDINAL WIRES RESTING ON THE TOP TRANSVERSE WIRE OF THE BACKING MAT BELOW. SLIDE THE SOIL REINFORCEMENT MAT INTO ALIGNMENT.

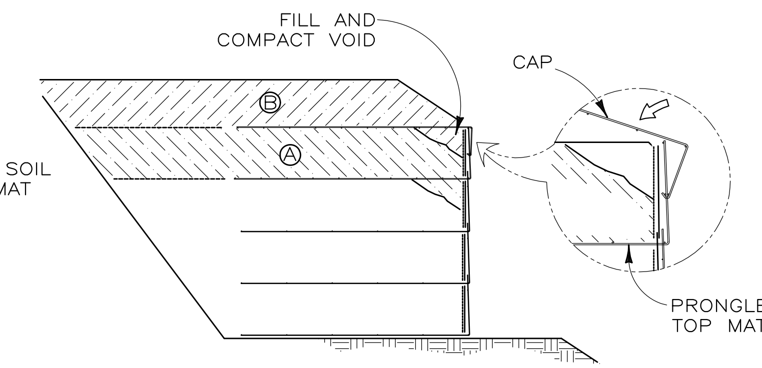


STEP 4
HOOK THE BOTTOM TRANSVERSE WIRE OF THE BACKING MAT OVER THE VERTICAL PRONGS ON THE LOWER MAT. ROTATE THE BACKING MAT TO VERTICAL AND CLIP THE SECOND–TO–TOP TRANSVERSE WIRE ON THE BACKING MAT TO THE TOP WIRE ON THE SOIL REINFORCEMENT MAT.



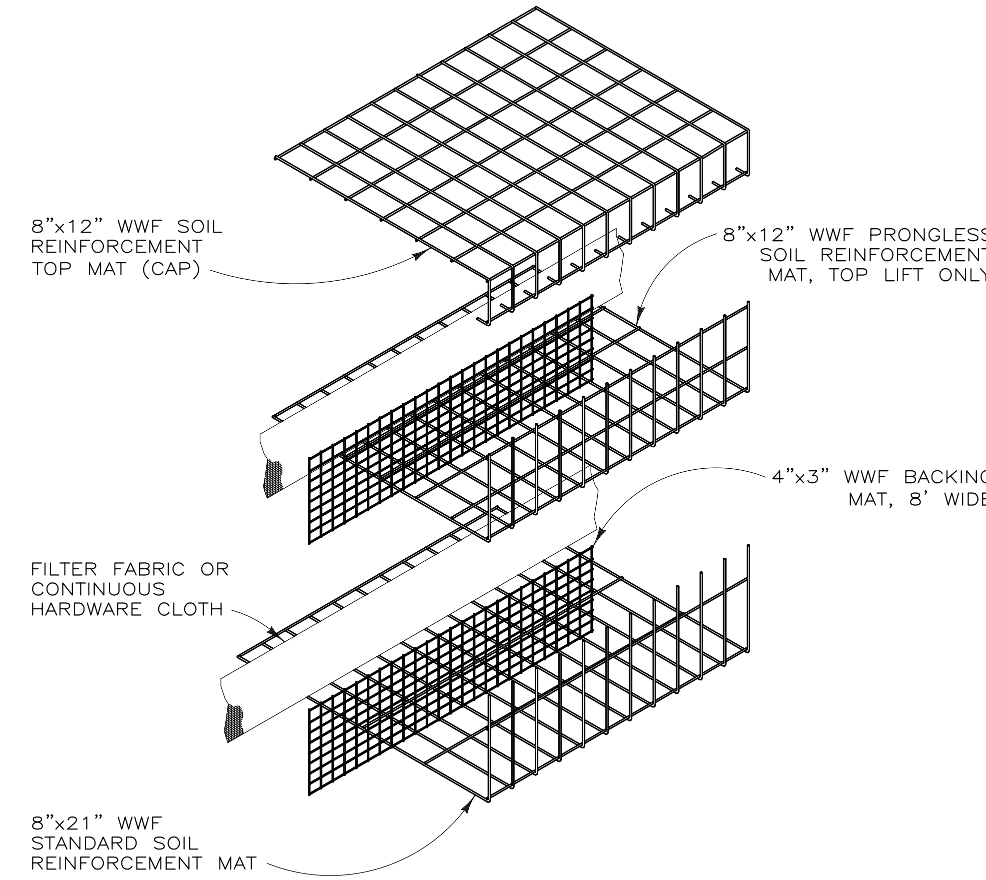
STEP 5
INSTALL THE FILTER FABRIC OR CONTINUOUS HARDWARE CLOTH. PLACE AND COMPACT THE BACKFILL TO THE BASE ELEVATION OF THE NEXT MAT. REPEAT STEPS 3 THROUGH 5 TO THE TOP LIFT.





STEP 6: TOP LIFT
PLACE THE TOP LIFT (PRONGLESS MAT), BACKING MAT AND FILTER FABRIC OR CONTINUOUS HARDWARE CLOTH. PLACE AND COMPACT BACKFILL IN AREA "A". HOOK THE CAP OVER THE MIDDLE TRANSVERSE WIRE ON THE PRONGLESS MAT, AND ROTATE INTO PLACE. BACKFILL "B" TO 1'–6" MIN. COVER OVER THE CAP.

CONSTRUCTION SEQUENCE
NOT TO SCALE



WALL COMPONENTS
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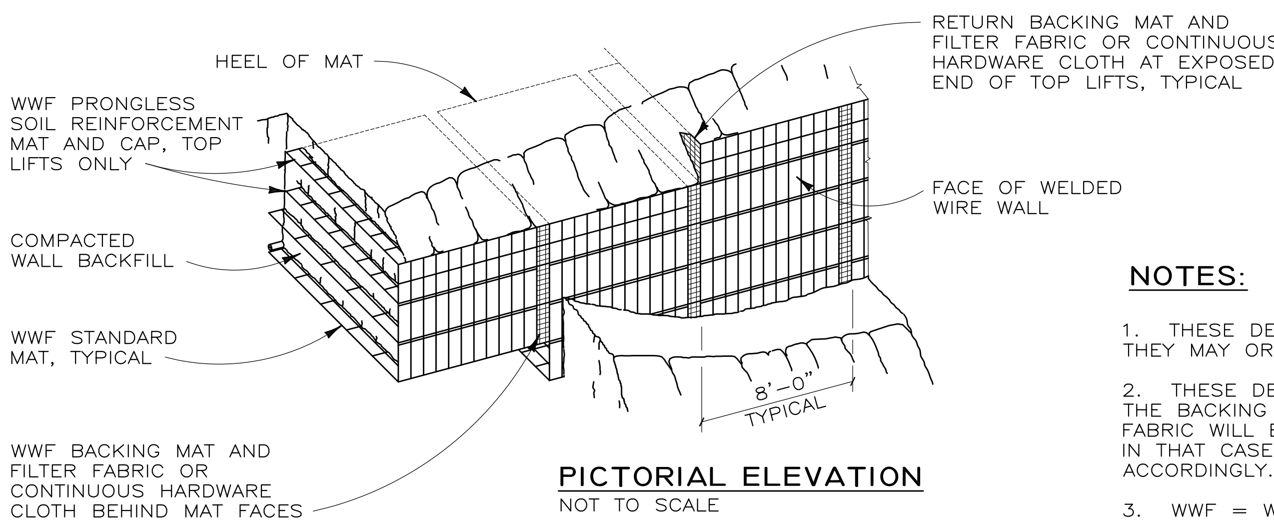


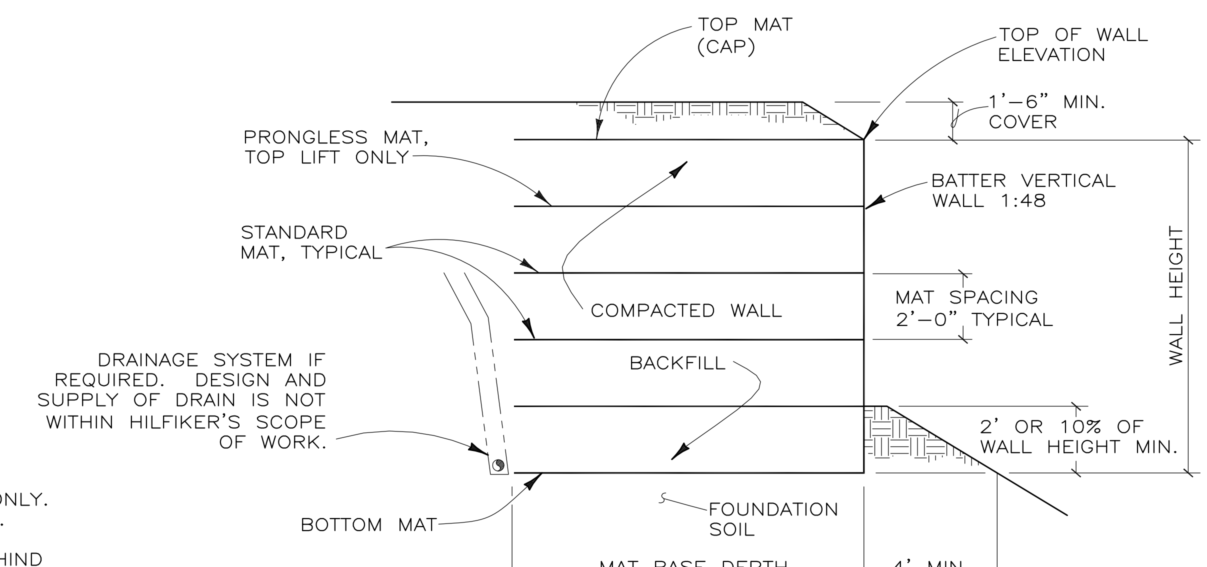
PICTORIAL ELEVATION
NOT TO SCALE

NOTES:

1. THESE DETAILS ARE INTENDED FOR INFORMATION ONLY. THEY MAY OR MAY NOT APPLY TO SPECIFIC PROJECTS.

2. THESE DETAILS SHOW HARDWARE CLOTH USED BEHIND THE BACKING MATS. IN SOME APPLICATIONS, FILTER FABRIC WILL BE REQUIRED INSTEAD OF HARDWARE CLOTH. IN THAT CASE, THESE DETAILS SHOULD BE REVISED ACCORDINGLY.

3. WWF = WELDED WIRE FABRIC



TYPICAL SECTION
NOT TO SCALE

WELDED WIRE WALL STANDARD DETAILS

REV.NO.	DATE	BY	DESCRIPTION
1	6 JAN 03	DR	MINOR REVISIONS
2	25 SEP 06	AMJ	MINOR REVISIONS
3	12 SEP 07	AMJ	MINOR REVISIONS, UPDATED BORDER
4	17 SEP 07	JTE	CHANGED LOGO, FIXED LEADERS

GRAPHIC SCALE
LINE IS 20 UNITS LONG ON ORIGINAL DRAWING
0 10 20

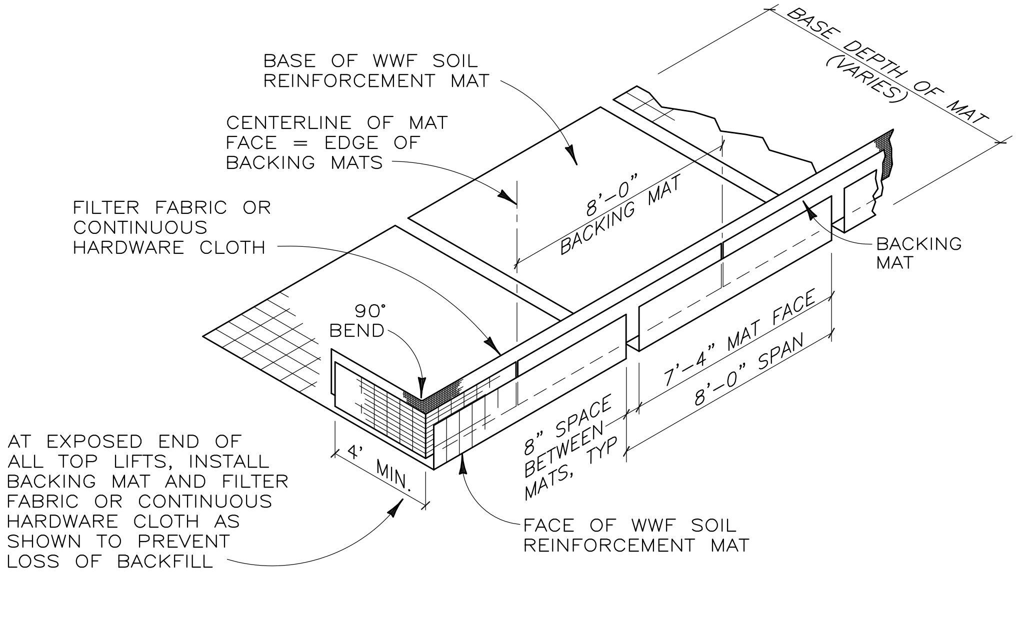
PROJ.MGR.
ENGINEER
CADD BY: HRW

HILFIKER RETAINING WALLS
1902 Hilfiker Lane
Eureka, CA 95503-5711
TOLL-FREE 800.762.8962
PH 707.443.5093 FAX 707.443.2891
WEB SITE www.hilfiker.com E-MAIL info@hilfiker.com
SINCE 1902 QUALITY PRODUCTS

DWG DATE: NOV 98
REVISION DATE: 17 SEP 07
SCALE: NOTED

STANDARD DRAWING
WELDED WIRE RETAINING WALL
24" LIFTS
STANDARD DETAILS

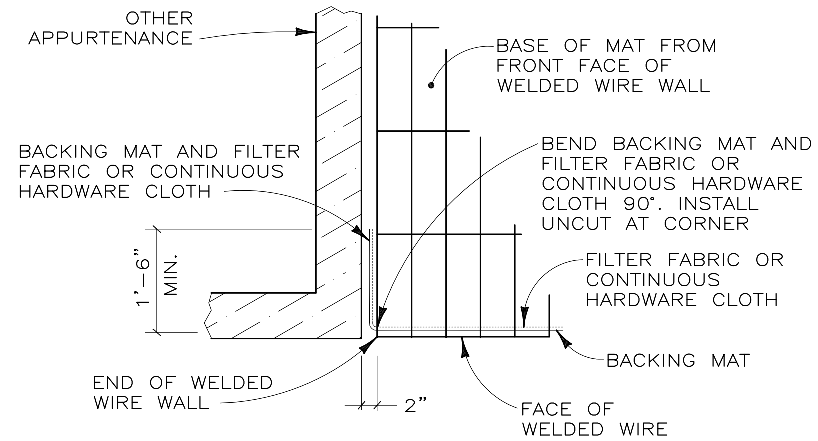
PROJECT NO.
SHEET 1 OF 3



ISOMETRIC VIEW

WELDED WIRE WALL COMPONENTS WITH RETURN MAT

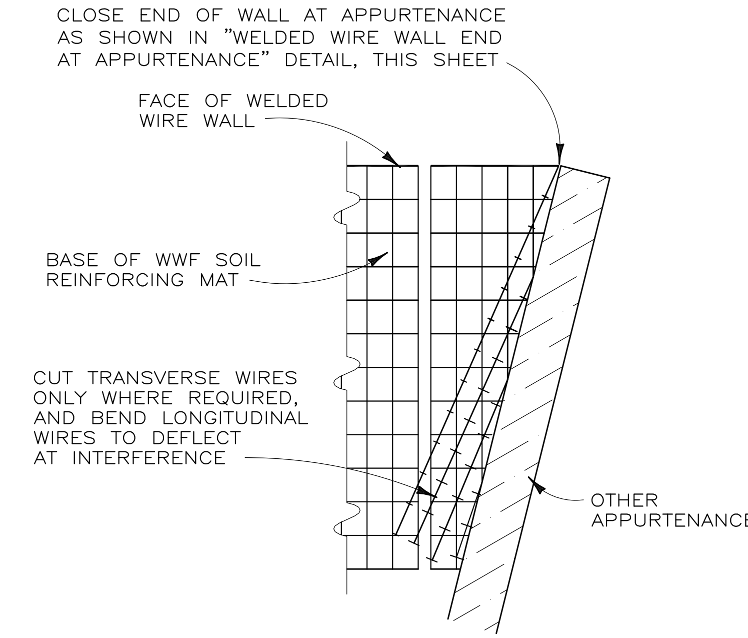
NOT TO SCALE



PLAN VIEW

WELDED WIRE WALL END AT OTHER APPURTENANCE

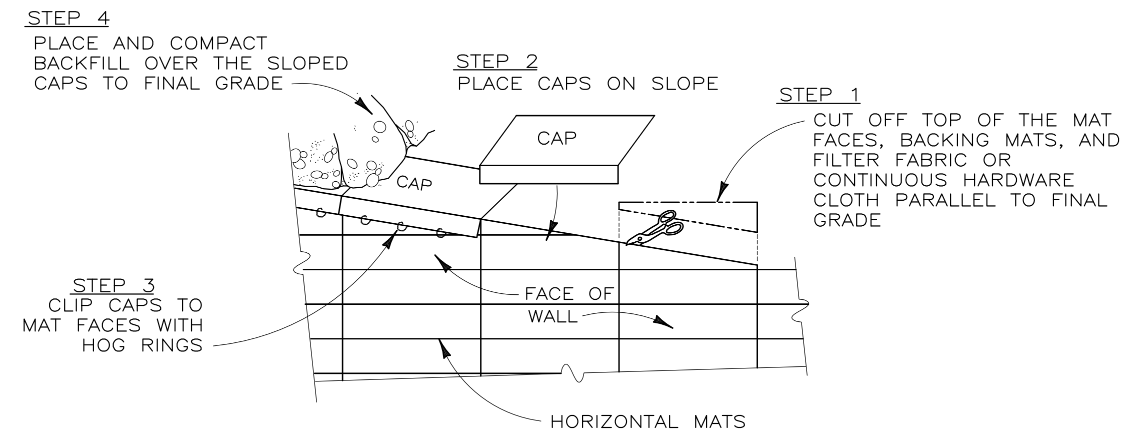
NOT TO SCALE



PLAN VIEW

DEFLECTED LONGITUDINAL WIRES

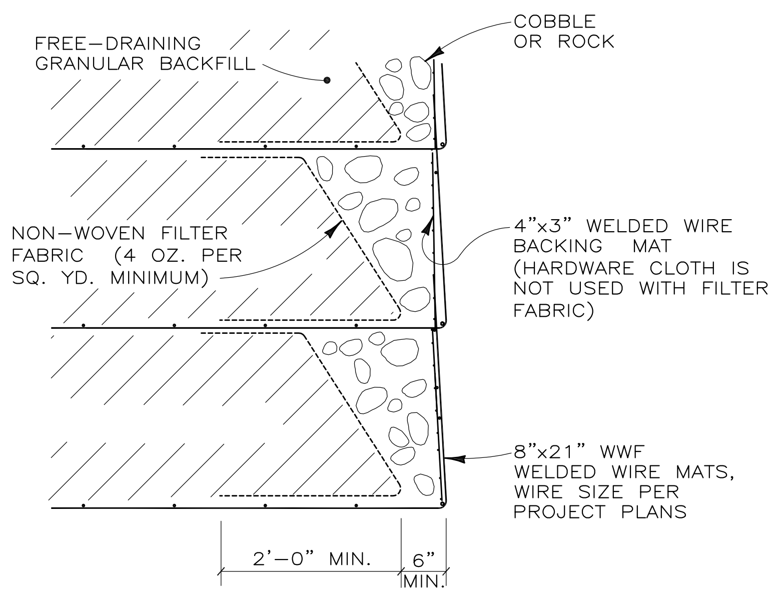
NOT TO SCALE



PICTORIAL ELEVATION

SLOPED CAP MAT DETAIL

NOT TO SCALE



SECTION

ROCK FACING DETAIL

NOT TO SCALE

LEGEND
(THIS DETAIL ONLY)

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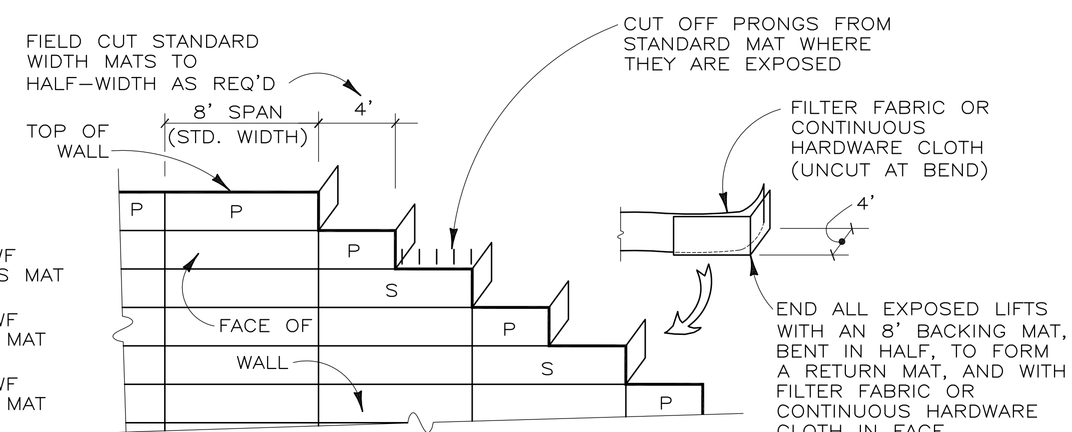
- S — 8"X21" WWF STANDARD MAT
- (blank) — 8"X21" WWF STANDARD MAT



RETURN MATS AND TOP OF WALL DETAIL

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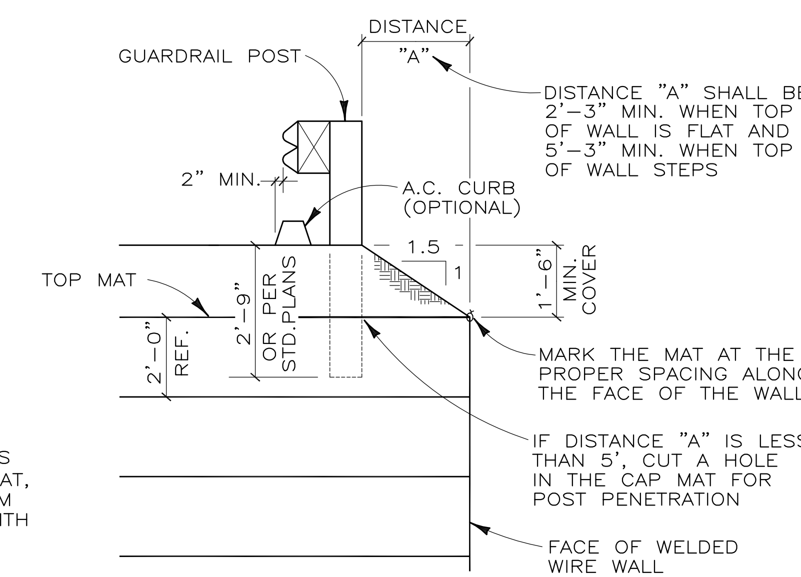

SECTION

GUARDRAIL DETAIL

NOT TO SCALE
(FENCE DETAIL SIMILAR)

WELDED WIRE WALL STANDARD DETAILS

REV.NO.	DATE	BY	DESCRIPTION
1	6 JAN 03	DR	MINOR REVISIONS
2	25 SEP 06	AMJ	MINOR REVISIONS
3	12 SEP 07	AMJ	MINOR REVISIONS, UPDATED BORDER
4	1 NOV 07	JTE	CHANGED LOGO, FIXED LEADERS

GRAPHIC SCALE
LINE IS 20 UNITS LONG ON ORIGINAL DRAWING
0 10 20

PROJ.MGR.
ENGINEER
CADD BY: HRW

HILFIKER RETAINING WALLS
1902 Hilfiker Lane
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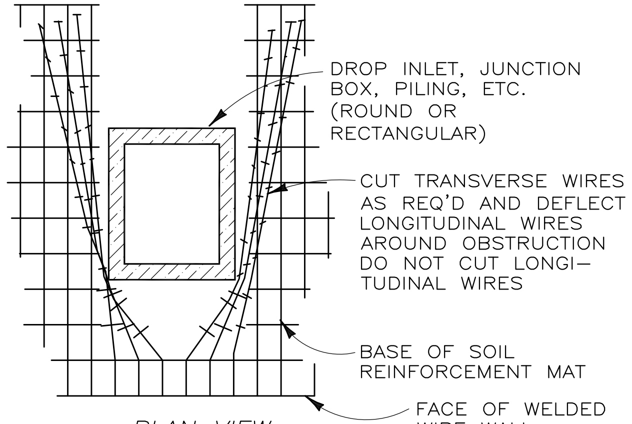
WEB SITE www.hilfiker.com E-MAIL info@hilfiker.com
SINCE 1902 QUALITY PRODUCTS

DWG DATE: NOV 98
REVISION DATE: 17 SEP 07
SCALE: NOTED

STANDARD DRAWING
WELDED WIRE RETAINING WALL
24" LIFTS
STANDARD DETAILS

PROJECT NO.
SHEET 2 OF 3



PLAN VIEW

MAT PENETRATION DETAIL

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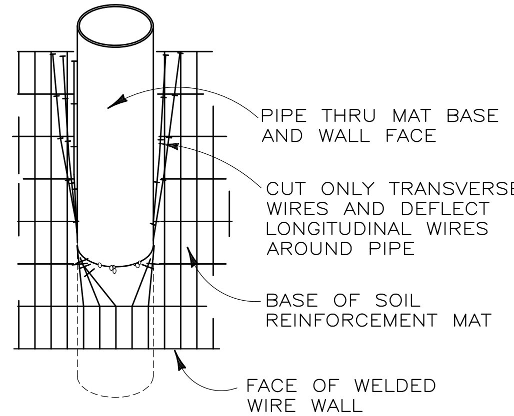
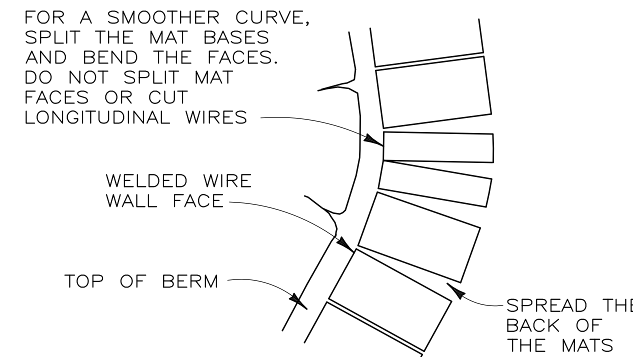


PLAN VIEW

ANGLED PIPE PENETRATION

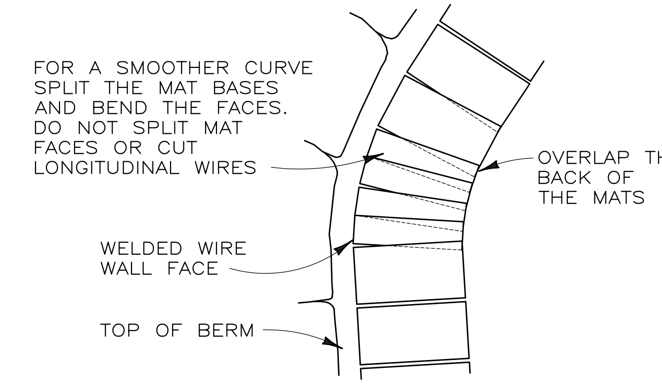
NOT TO SCALE



PLAN VIEW

CONCAVE CURVE

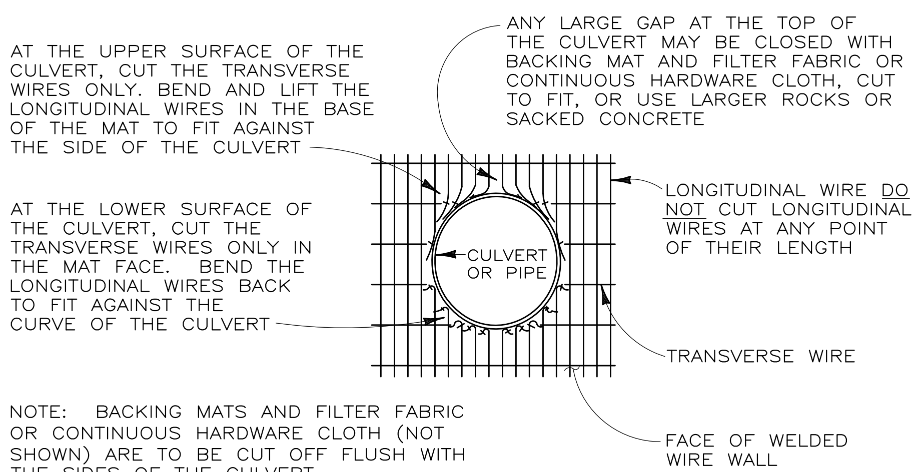
NOT TO SCALE



PLAN VIEW

CONVEX CURVE

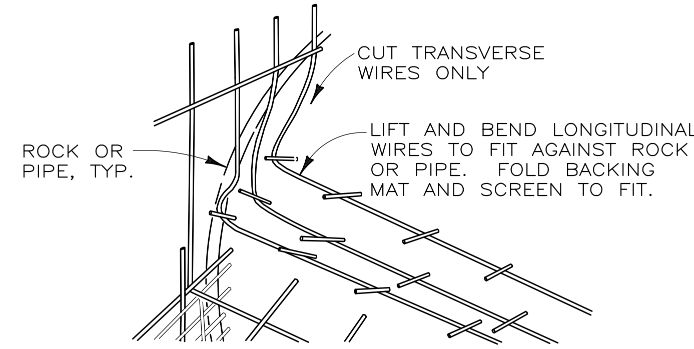
NOT TO SCALE



ELEVATION

CULVERT THRU WALL FACE

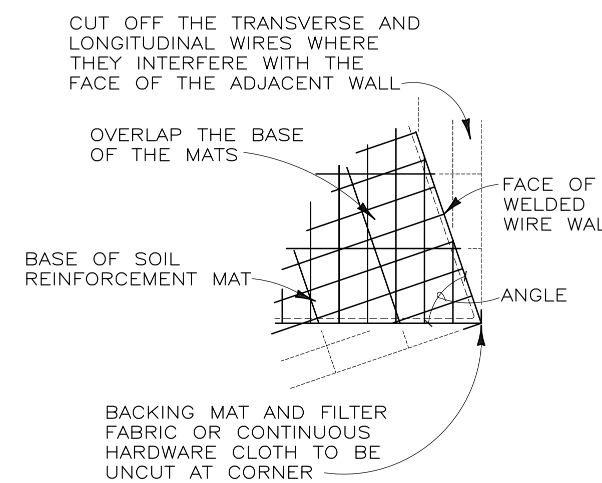
NOT TO SCALE



PICTORIAL

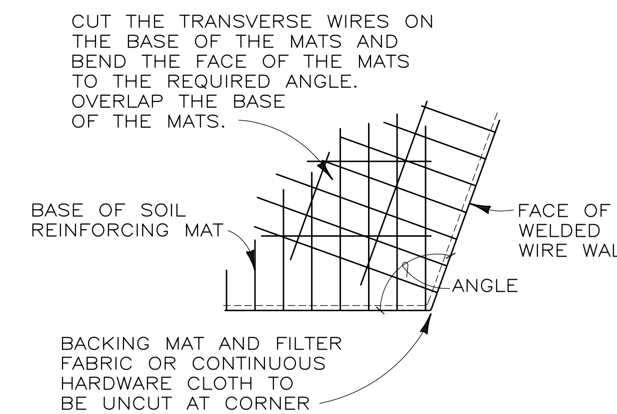
FITTING MATS TO OBSTRUCTION

NOT TO SCALE



ACUTE CONVEX ANGLE

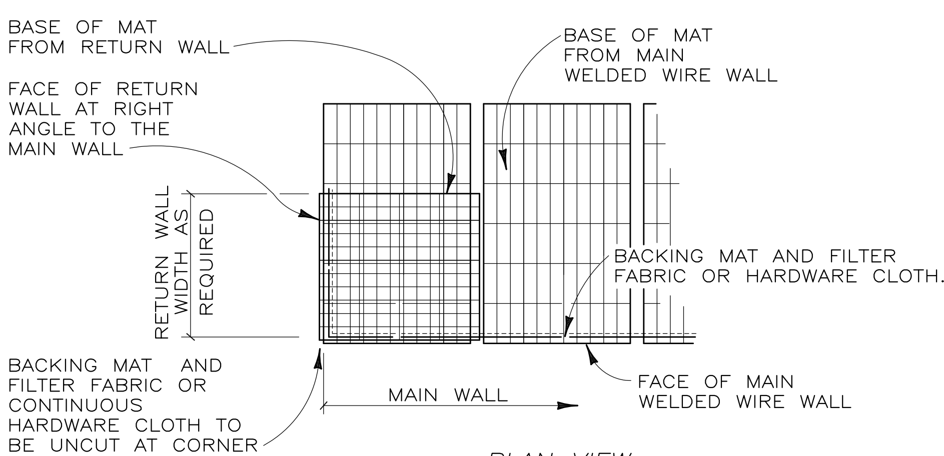
NOT TO SCALE



PLAN VIEW

OBTUSE CONVEX ANGLE

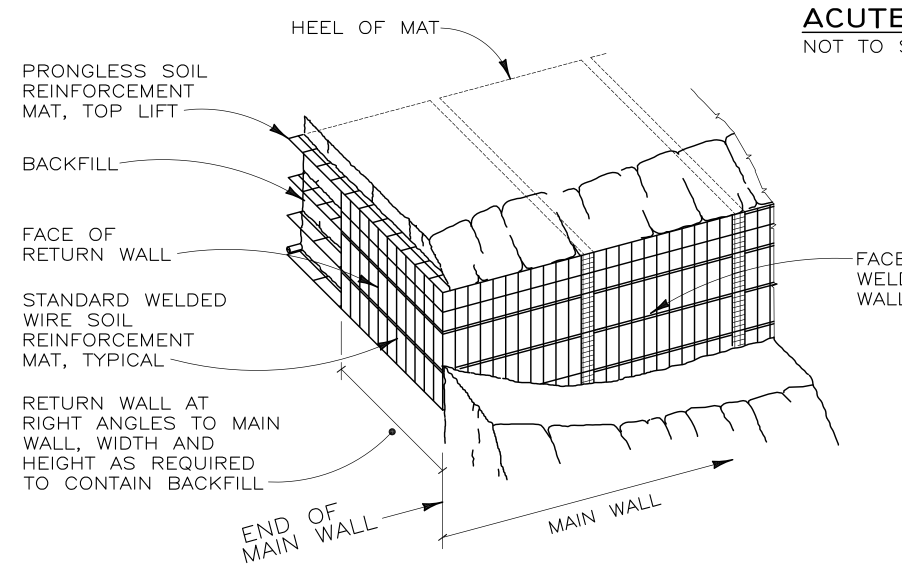
NOT TO SCALE



PLAN VIEW

RETURN WALL DETAIL

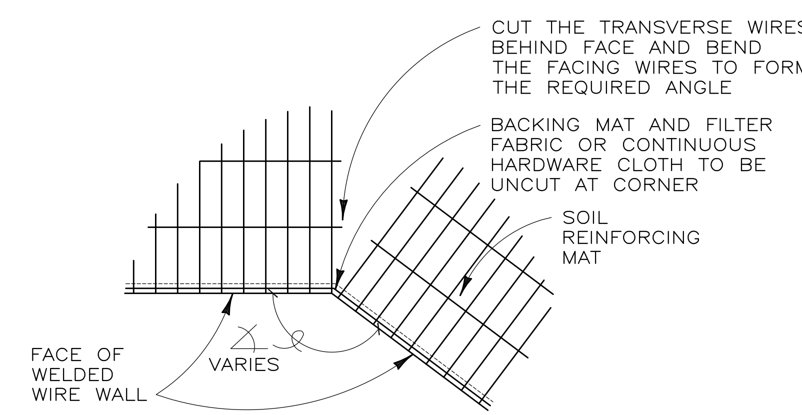
NOT TO SCALE



PICTORIAL

RETURN WALL DETAIL

NOT TO SCALE



PLAN VIEW

CONCAVE ANGLE DETAIL

NOT TO SCALE

REV.NO.	DATE	BY	DESCRIPTION

GRAPHIC SCALE

LINE IS 20 UNITS LONG ON ORIGINAL DRAWING

0 10 20

PROJ.MGR.

ENGINEER

CADD BY: HRW

HILFIKER RETAINING WALLS

1902 Hilfiker Lane
Eureka, CA 95503-5711
TOLL-FREE 800.762.8962
PH 707.443.5093 FAX 707.443.2891
WEB SITE www.hilfiker.com E-MAIL info@hilfiker.com

SINCE 1902 QUALITY PRODUCTS

DWG DATE: NOV 98

REVISION DATE: 17 SEP 07

SCALE: NOTED

STANDARD DRAWING

WELDED WIRE RETAINING WALL

24" LIFTS

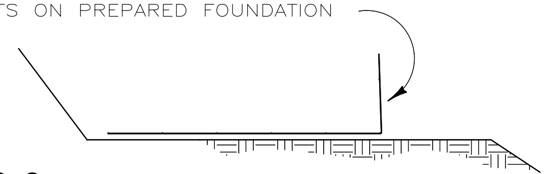
STANDARD DETAILS

PROJECT NO.

SHEET 3 OF 3

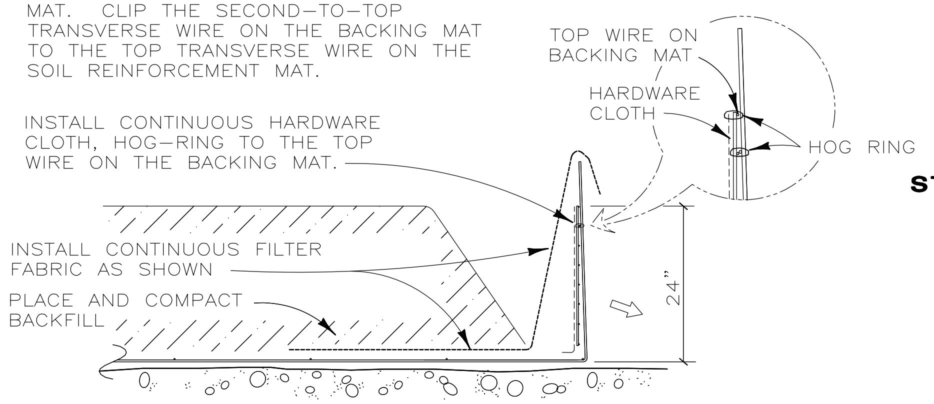
STEP 1

PLACE THE FIRST COURSE OF SOIL REINFORCEMENT MATS ON PREPARED FOUNDATION



STEP 2

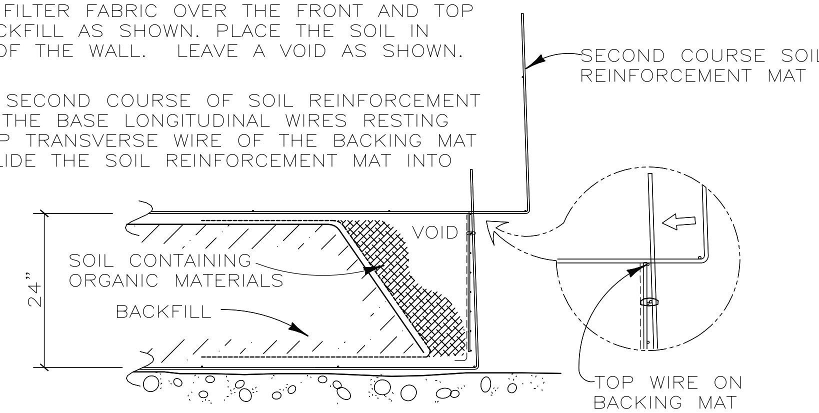
PLACE THE BACKING MAT AGAINST THE INSIDE FACE OF THE SOIL REINFORCEMENT MAT. CLIP THE SECOND–TO–TOP TRANSVERSE WIRE ON THE BACKING MAT TO THE TOP TRANSVERSE WIRE ON THE SOIL REINFORCEMENT MAT.



STEP 3

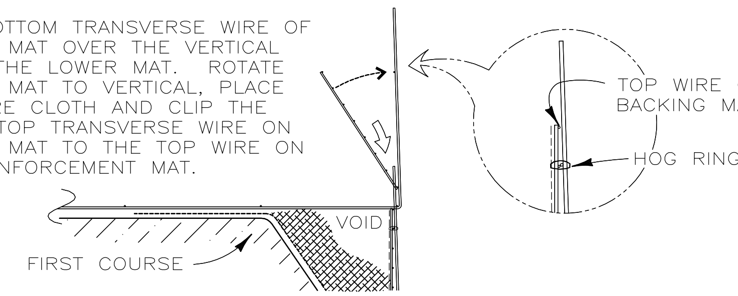
BRING THE FILTER FABRIC OVER THE FRONT AND TOP OF THE BACKFILL AS SHOWN. PLACE THE SOIL IN THE FACE OF THE WALL. LEAVE A VOID AS SHOWN.

PLACE THE SECOND COURSE OF SOIL REINFORCEMENT MATS WITH THE BASE LONGITUDINAL WIRES RESTING ON THE TOP TRANSVERSE WIRE OF THE BACKING MAT BELOW. SLIDE THE SOIL REINFORCEMENT MAT INTO ALIGNMENT.



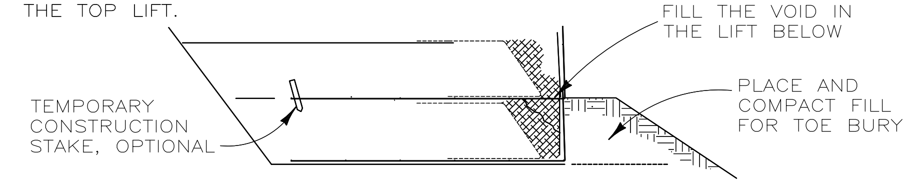
STEP 4

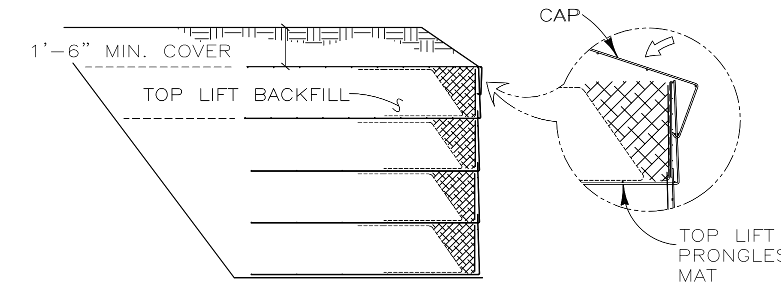
HOOK THE BOTTOM TRANSVERSE WIRE OF THE BACKING MAT OVER THE VERTICAL PRONGS ON THE LOWER MAT. ROTATE THE BACKING MAT TO VERTICAL, PLACE THE HARDWARE CLOTH AND CLIP THE SECOND–TO–TOP TRANSVERSE WIRE ON THE BACKING MAT TO THE TOP WIRE ON THE SOIL REINFORCEMENT MAT.



STEP 5

INSTALL THE FILTER FABRIC AS IN STEPS 2 AND 3. PLACE AND COMPACT THE BACKFILL AND ROCK TO THE BASE ELEVATION OF THE NEXT MAT. REPEAT STEPS 2 THROUGH 5 TO THE TOP LIFT.



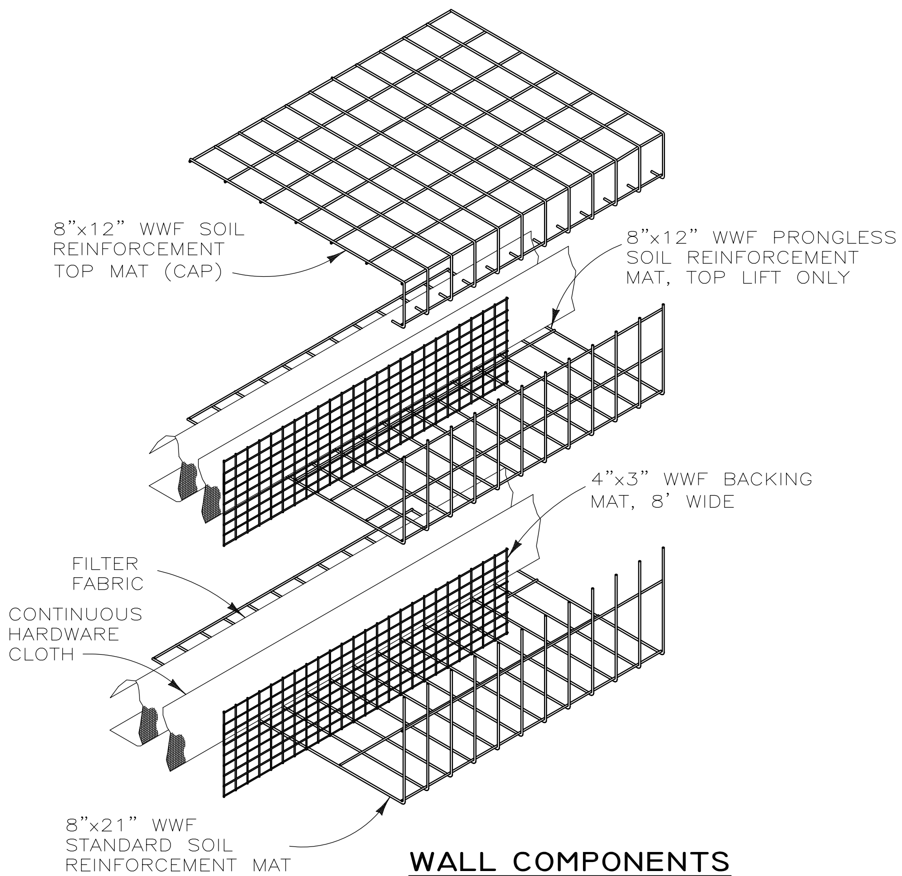


STEP 6: TOP LIFT

PLACE THE TOP LIFT PRONGLESS MAT, BACKING MAT AND FILTER FABRIC. PLACE AND COMPACT BACKFILL AND ROCK IN THE TOP LIFT. HOOK THE CAP OVER THE MIDDLE TRANSVERSE WIRE ON THE PRONGLESS MAT, AND ROTATE INTO PLACE. PLACE AND COMPACT COVER OVER TOP MAT TO 1'–6" MINIMUM DEPTH.

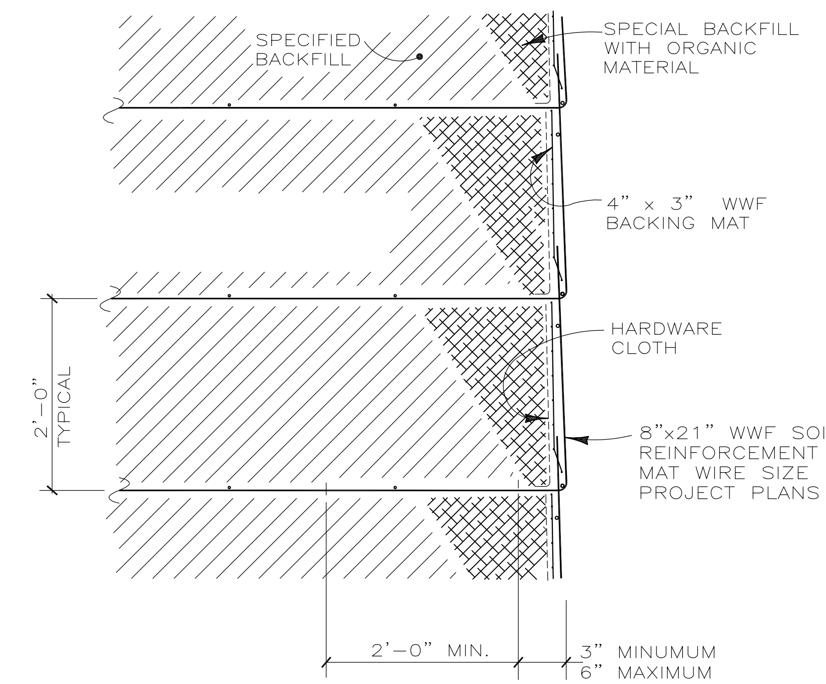
CONSTRUCTION SEQUENCE

NOT TO SCALE



WALL COMPONENTS

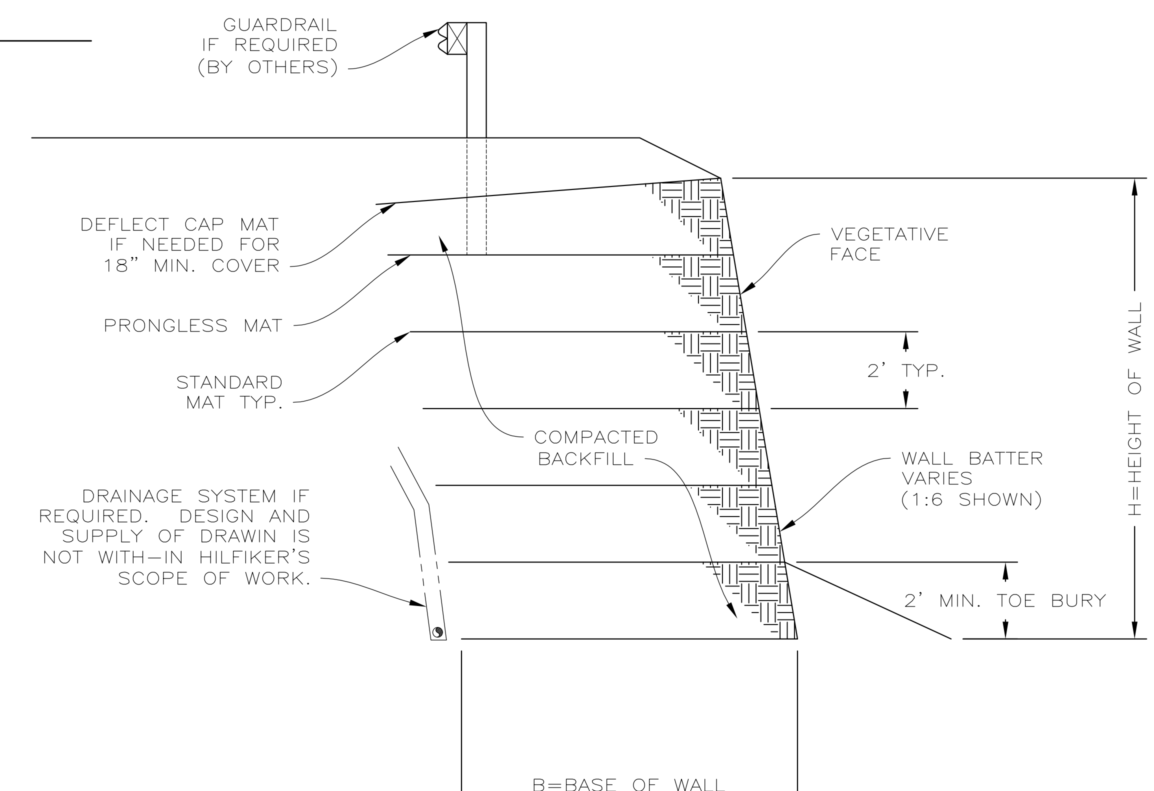
NOT TO SCALE



SECTION

VEGETATIVE WALL FACE DETAIL

NOT TO SCALE



TYPICAL SECTION 1:6 BATTER

SCALE: 1" = 5'

WWF BATTERED VEGETATIVE FACE

REV.NO.	DATE	BY	DESCRIPTION
1	11 AUG 08	AMJ	ADDED 1:3 BATTER SECTION

GRAPHIC SCALE

LINE IS 20 UNITS LONG ON ORIGINAL DRAWING

0 10 20

PROJ.MGR.	
ENGINEER	
CADD BY	HRW

HILFIKER RETAINING WALLS

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TOLL-FREE 800.762.8962
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WEB SITE www.hilfiker.com E-MAIL info@hilfiker.com

DWG DATE	26 OCT 07
REVISION DATE	11 AUG 08
SCALE	NOTED

STANDARD DRAWING

WELDED WIRE RETAINING WALL, 24" LIFTS

VEGETATIVE FACE

SECTION, DETAILS AND NOTES

PROJECT NO.

SHEET 1 OF 1

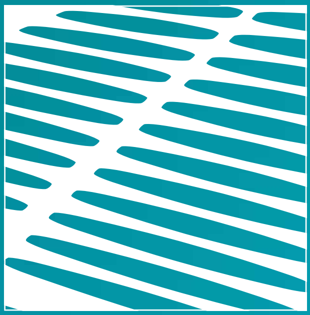
ARES®
RETAINING WALL SYSTEMS

ARES®
RETAINING WALL SYSTEMS

INSTALLATION GUIDE AND CONSTRUCTION MANUAL

Tensar®

When long-term performance and speed of construction are important, ARES® Retaining Wall Systems offer unmatched advantages.



Tensar® Geogrids

The ARES Retaining Wall Systems owe their long-term performance and durability to high strength **Tensar® Uniaxial (UX) Geogrids**. Due to their stiff interlocking capabilities, these geogrids stand the test of time, outperforming other commercially available geosynthetics. For more information, visit **www.tensarcorp.com**.

ARES® Retaining Wall Systems

DOTs, Contractors and Engineers have long appreciated the many advantages of panel walls. Their wide range of appearances and finishes, combined with the simplicity and speed of construction, make them attractive when compared to other types of wall systems. Unfortunately, limitations imposed by the behavior of reinforcing materials and a very narrow and expensive range of acceptable backfill materials have restricted their use until the introduction of Geogrids manufactured by Tensar International Corporation (Tensar).
By mechanically connecting Tensar Geogrids with the advantages of panels, the fully integrated ARES® Retaining Wall Systems now offer a high-performance, cost-effective and aesthetically pleasing solution.

NO METAL – NO CORROSION

With soil reinforcement that is 100% polymeric, ARES Retaining Wall Systems are proven concrete panel wall solutions that eliminate corrosion concerns of soil reinforcement. ARES Systems offer cost advantages over conventional panel walls while eliminating the risks associated with the long term exposure to chlorides, sulfates, low-resistivity soils or stray electric current potential. This makes the system the logical choice for “hot” backfill soils, transformer platform areas and electrified rail systems.

As testimony to the durability of the ARES Systems, one of the first Tensar-reinforced panel walls was built as a seawall on the Gaspe Peninsula in Canada. After 30 years of North Atlantic storms and constant exposure to salt water, there are no signs of deterioration of the soil reinforcement. In fact, some of the first ARES installations were instrumented and carefully observed to verify the effectiveness and long-term performance of the systems. As part of an FHWA study at the Tanque Verde project in Arizona, the Tensar Geogrid behind sections of one such ARES wall was excavated to validate its durability. Thirty years after the original installation, the walls continue to perform as designed with no maintenance issues.

PURPOSE OF THIS DOCUMENT

This document is intended to provide the Owner, Engineer, Contractor and the Inspector with the guidelines and criteria required to facilitate construction and quality control of the ARES Precast Panel Retaining Wall System.

ARES® Systems’ Components

COMPONENT	FUNCTION
Tensar Geogrids	High-density polyethylene (HDPE) structural geogrids internally reinforce the fill materials. Inert to chemical degradation, they can be used with different backfill materials, even crushed concrete.
Precast Panel Facing	Available in standard 5 ft x 5 ft (1.5 m x 1.5 m), 5 ft x 9 ft (1.5 m x 2.75 m), 5 ft x 10 ft (1.5 m x 3.0 m) or can be customized for full height construction.
Bodkin Connector	HDPE Connector for high connection efficiency without the concern for corrosion.
Full Engineering and Construction Services	Detailing, design, site assistance and stamped drawings for each ARES project upon request.

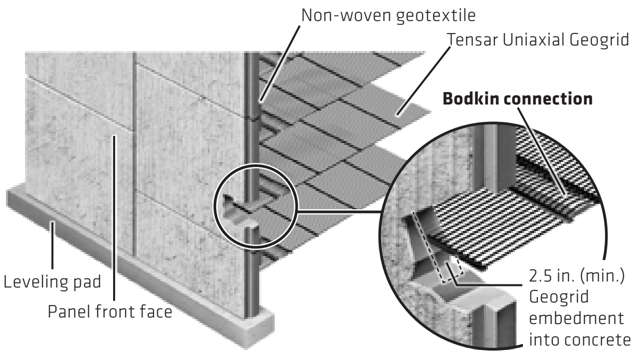


FIGURE 1: *ARES® Retaining Wall System – incremental 5 ft x 5 ft panel*

Wall Component Definitions

The following are standard terms that will be used for the ARES® Retaining Wall Systems. Refer to Figures 1 and 2 for a typical cross-section and the associated terms.

- **Bearing Pads** – Wall panel spacers are typically ribbed elastomeric or polymeric pads. They are inserted at the horizontal joint between panels to help provide the proper spacing. Proper spacing keeps the panels from having point contact and spalling the concrete.
- **Bodkin Connection** – This is where the connection is made between the wall facing panel and the soil reinforcement.
- **Concrete Leveling Pad** – The leveling pad is unreinforced cast-in-place concrete for precast panel facing to sit on a level foundation.
- **Coping** – The coping is used to tie in the top of the wall panels and to provide a pleasing finish to the wall top. It is cast-in-place or precast.
- **Filter Fabric** – Typically a non-woven geotextile fabric is used to cover the joint between panels. It is placed on the backside of the panel joints. This keeps the soil from piping through the joints and allows excess water to flow out.
- **Random Backfill (retained)** – Random backfill is the backfill that is retained.
- **Select Backfill** – Select granular backfill within the reinforced mass that meets the gradation, unit weight, internal friction angle and any other requirements.
- **Temporary Wooden Wedges** – Are used to help hold the panels at the correct batter during the backfilling operation.
- **Tensar Structural Geogrid** – Soil reinforcement that holds the wall facing panels in position and provides reinforcement for the soil.
- **Wall Facing Panel** – Wall facing panels are used to hold the soil in position at the face of the wall. The panels are made of precast concrete.

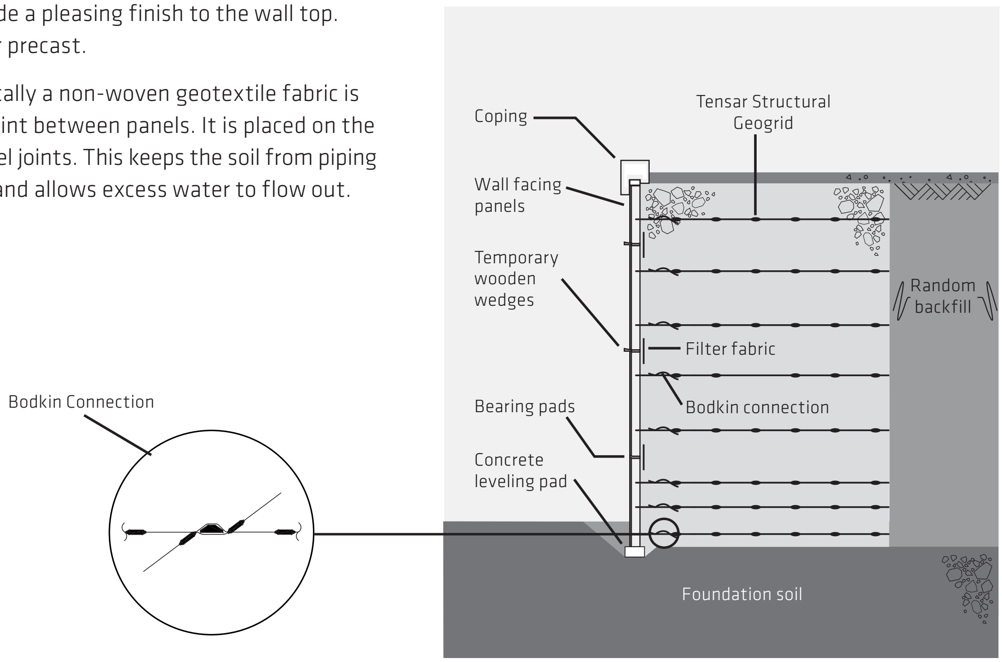


FIGURE 2: *Typical Cross Section*

MSE Wall Construction Best Practices

- Confirm receipt of the Tensar approved construction drawings.
- Confirm backfill material has been tested and approved before it is brought to the job site.
- Review the approved construction drawings.
- Ensure the Contractor's field supervisor has a copy of the approved construction drawings as well as Tensar Installation Guide and is familiar with them.
- Confirm the foundation soils are in accordance with project specifications.
- Confirm the leveling pad elevations, alignment and step locations prior to pouring the concrete.
- Notify the Tensar project manager of the expected start date for panel installation.
- Ensure panels, geogrid and accessories are properly stored to prevent damage.
- Inspect geogrid, accessories and panels for damage. Notify Tensar of any materials that are not in compliance with the plans and specifications.
- Install panels in accordance with the plans and specifications.
- Use corner panels at all corners. If corner panels are not indicated on the Tensar approved construction drawings, Tensar should be notified.
- Ensure wedges are installed on each course of panels. Use hardwood wedges.
- Check the batter of the panels daily (at a minimum) and adjust the initial batter accordingly. The vertical alignment of the panels below the panels being installed may be affected by the compaction of the soil behind those panels.
- When installing the filter fabric to the panel apply the adhesive to the panel and then apply the fabric.
- Place and compact fill in accordance with the plans and specifications. If fill lift thickness is not included in the plans and specifications, do not exceed fill lifts thicker than 10 in. (250 mm) loose. Thick lifts may cause the panels to move out of alignment.
- Ensure the geogrid reinforcement can be installed around all obstructions without skewing the geogrid more than 15 degrees from normal. Notify Tensar of any obstructions not shown on the Tensar approved construction drawings.

›ARES® modular panels provide significant face area while the Tensar® Geogrid reinforcement is lightweight and easy to field connect.

Responsibilities for Construction Compliance

- The Contractor is responsible to provide construction in accordance with the contract documents and to coordinate the wall construction with related work.
- The Contractor is responsible for using the most recent set of approved construction drawings to perform the work and for verifying line, grade and offset needed to establish wall location according to the contract documents.
- The Contractor is responsible for monitoring material supply and ensuring that adequate lead time is provided with each request for delivery and that ordered quantities are available to prevent construction delays.
- The Contractor is responsible for unloading and inspecting materials upon delivery to the job site, and to provide proper storage and protection of materials.
- The Engineer is responsible for enforcing the requirements of the contract documents and the approved construction drawings.
- The Tensar technical advisor will be available at the start of the project to advise the Contractor's project team of the recommended construction procedures within the scope of this manual. The Tensar technical advisor is not a member of the inspection or quality control staff on the project.

Work provided by the Contractor includes:

- All wall site preparation and survey layout
- Forming and pouring the leveling pad
- Wall construction in its entirety according to approved construction drawings
- Installation of the top-of-wall treatment where required

If requested, services provided by Tensar include:

- Wall construction drawings
- On-site technical assistance at the start of construction

Materials

TYPICAL MATERIALS SUPPLIED BY TENSAR

- Precast concrete facing panels
- HDPE Tensar® Uniaxial (UX) Geogrid
- Filter fabric
- Bearing pads
- Bodkin bars

Materials supplied by Tensar are typically delivered in full truck load quantities. Off-loading is scheduled by the Contractor.

Any damage to the materials or discrepancies in quantities must be noted by the Contractor on the delivery ticket at the time of delivery and reported promptly to Tensar. The materials must be properly stored in such a manner and location to avoid damage or theft.

HDPE Tensar Uniaxial (UX) Geogrids can be color-coded to differentiate roll types.

ARES® panels typically arrive at the job site on flatbed trucks.

Palletized component materials upon arrival at site.

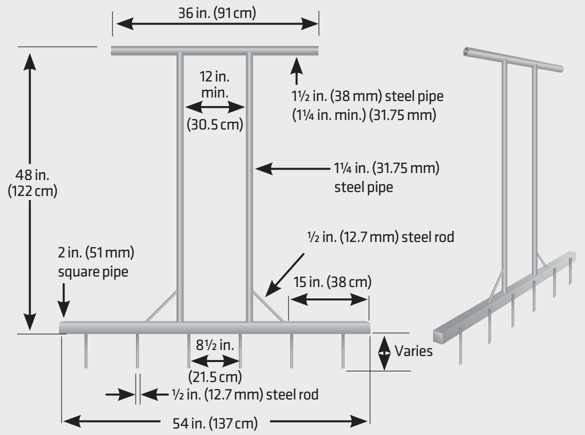


FIGURE 3: *Sample configuration of steel rake for tensioning geogrid.*

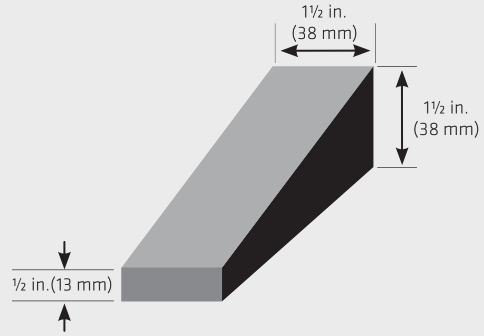


FIGURE 4: *Temporary Wooden Wedge, two per horizontal joint required on 5 x 5 and four per horizontal joint required on 5 x 9 and 5 x 10.*

Materials (continued)

MATERIALS AND TOOLS PROVIDED BY THE CONTRACTOR:

- Nylon slings for unloading panels
- Equal length cables with shackles to connect the lifting devices
- Devices for lifting panels by the embedded lifting inserts
- Rake for tensioning geogrid (Figure 3)
- Lumbers for bracing, staking, and fabrication of clamps, as well as threaded rod, washers and nuts
- Hardwood wedges (Figure 4)
- Standard and Header Clamps (Figures 5 and 6)
- ¾ in. (19 mm) plywood spacer to set panel vertical joints gap
- Spray paint for marking geogrid and panels
- Standard grade construction adhesive such as Liquid Nail or 3M 77 to attach the filter fabric to the panels at the joints
- Crowbars, 4 ft (1.2 m) long
- Wrenches for clamp bolts
- Sledge and Claw hammers
- Broom for sweeping the leveling pad
- Sharp blade or scissors to cut the filter fabric
- 4 ft (1.2 m) level
- Chalk line
- Plumb bob
- Concrete, steel, and forming materials for leveling pad and top of the wall treatment as required
- Backfill materials

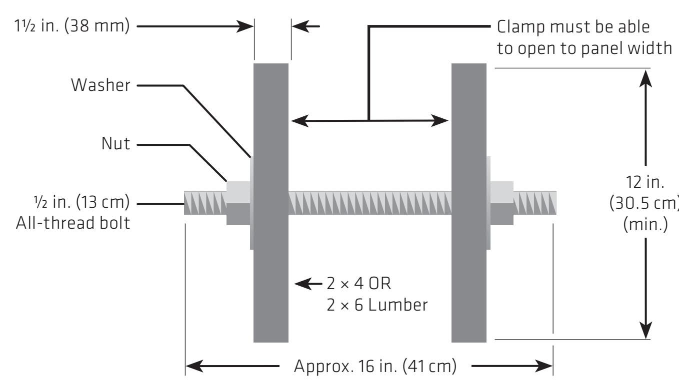


FIGURE 5:
Standard Clamp: *One per vertical joint*

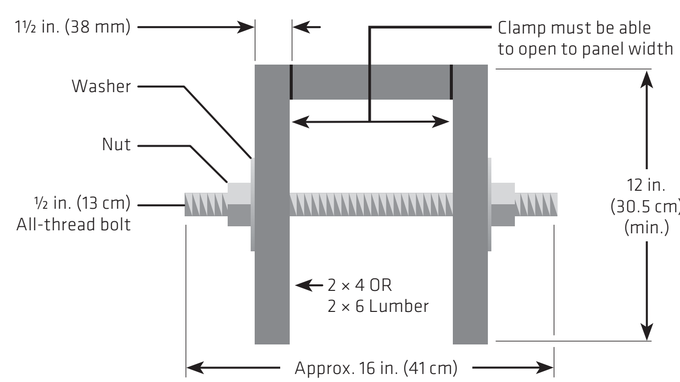


FIGURE 6:
Bracing Header Clamp: *For initial course only*

Materials (continued)

EQUIPMENT PROVIDED BY CONTRACTOR

- Panel handling and setting equipment – excavator, loader or similar equipment capable of properly lifting and placing the precast concrete facing panels.

  NOTE: *Typical weight of largest standard panel type is approximately 3,000 lbs (1,360 kg) for projects using nominal 5 ft (1.5 m) wide, 5.5 in. (140 mm) thick panels, approximately 5,500 lbs (2,495 kg) for projects using nominal 9 ft (2.75 m) wide, 5.5 in. (140 mm) thick panels, and approximately 6,000 lbs (2,720 kg) for 10 ft (3 m) wide, 5.5 in. (140 mm) thick panels.*

- Equipment to transport the select fill to the wall site.
- Equipment, such as a rubber-tired loader and small track dozer, preferably with angle blade, for placing and spreading the select fill.
- Large, smooth-drum roller for mass compaction
- Small, hand-operated, vibratory plate tamper or roller for compaction within 3 ft (0.9 m) of the back face of wall panel.

  NOTE: *Use of Jumping Jack is not recommended.*

IMAGE A:
ARES® panels should be stacked on a level, stable surface provided by the Contractor. Dunnage shall be carefully selected to allow panel separation and placed to avoid panel cracking.

Handling Materials Supplied by Tensar

All materials supplied by Tensar shall be properly stored in a secure location to prevent damage or theft.

PRECAST CONCRETE FACING PANELS

- It is the responsibility of the Contractor to schedule delivery of the panels in accordance with the installation schedule. Proper coordination will help avoid delays by having the precasting performed in harmony with the wall construction schedule.
- ARES® panels are usually delivered on flatbed trailers. The Contractor must provide a level, stable area to unload and stage panels. The acceptability of this access is at the discretion of the driver or his employer. The Contractor is allowed one hour to unload each truck, unless specifically agreed otherwise in writing with Tensar.
- The Contractor must take care to protect the panels from staining due to rain splash or damage due to improper placement of the dunnage. The number of panels in a stack shall not exceed five 5 x 5 panels, four 5 x 9 panels or four 5 x 10 panels as shown in Image A.
- The dunnage shall be properly spaced to avoid uneven loading in the panel stacks. (See Figure 7.) **All dunnages are the property of Tensar or its precaster and should be stacked by the Contractor for loading on a subsequent panel delivery truck.**
- Delivery tickets are included with each shipment and indicate the panel types furnished in that load. It is the responsibility of the Contractor to confirm the accuracy of the tickets and to note any damage that is visible prior to accepting delivery. Tensar or its precaster must be notified immediately if any panels have been damaged.

BEARING PADS FOR HORIZONTAL JOINTS BETWEEN PANELS

- Bearing pads will be delivered in cardboard cartons.
- The quantity of these cartons shall be noted on the delivery ticket and confirmed by the Contractor.

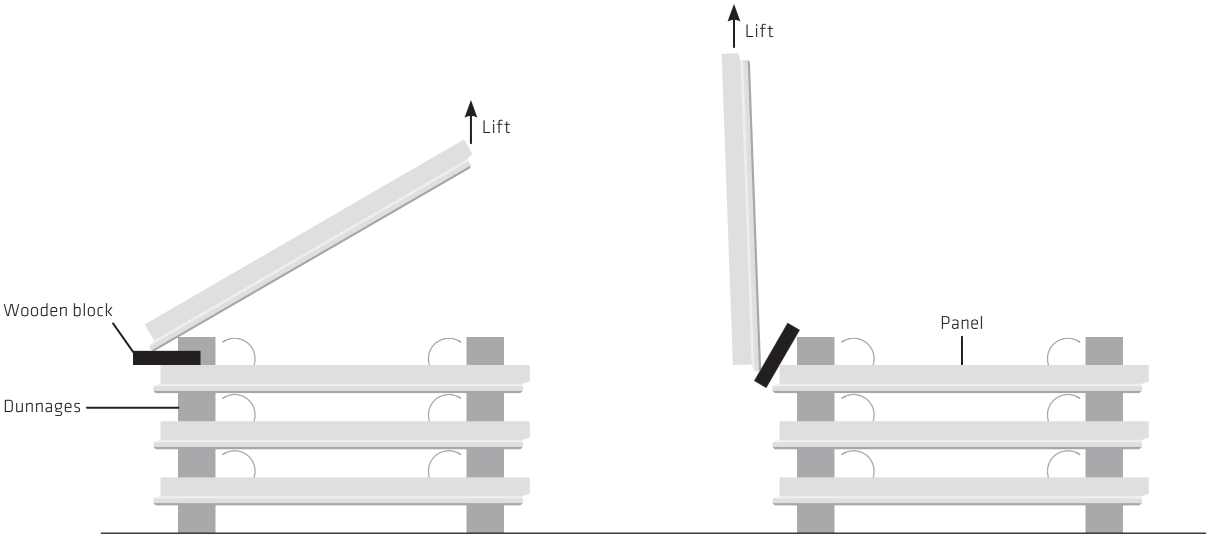


FIGURE 7: *Suggested stacking and lifting procedures for ARES segmental panels.*

Color-code the geogrid tabs on each panel to correspond with the geogrid rolls.

GEOGRID REINFORCEMENT

- Geogrid reinforcement shall be delivered in rolls and shall be labeled by type. These labels must be protected until the geogrid has been color-coded at the job site. The Contractor should retain any certifications included with the packing slip for the Engineer.
- The Contractor should immediately color code each of the geogrid types using spray paint on the edges and ends of the rolls (Images B and C). The Contractor may choose to highlight geogrid types on the approved construction drawings using corresponding colors.
- The Contractor is responsible for cutting the geogrid to length in the field. Precut geogrid should then be tagged for length and type. The first transverse bar (at the connection) on each section of geogrid should be trimmed neatly to expedite making the connection of the geogrid to the wall facing. Do not cut into the transverse bar of the geogrid (Figure 8 and Image D).

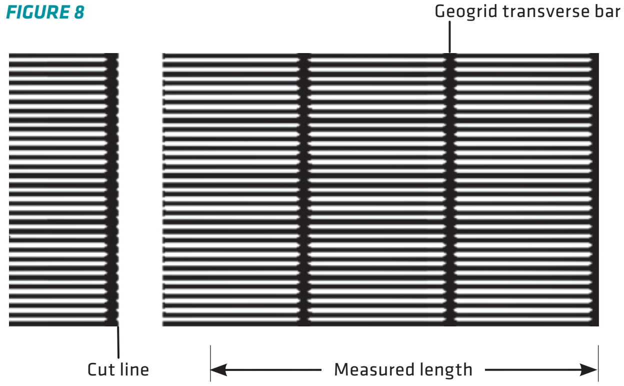
IMAGE B: *Uniaxial geogrid rolls should be color-coded prior to removing roll labels.*

IMAGE C: *Color coding of geogrid panels allows for quick, accurate identification even after labels are removed.*

FILTER FABRIC

- The filter fabric will be delivered in rolls and must be covered to protect it from direct sunlight.

FIGURE 8



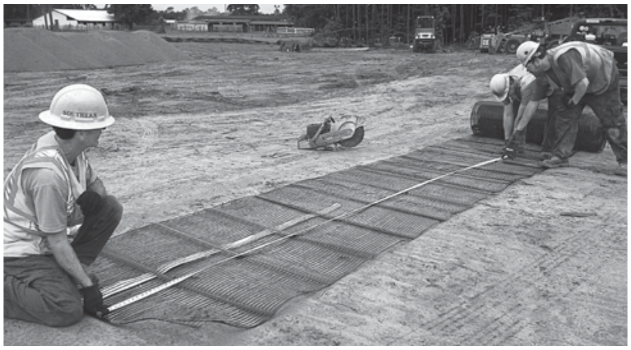
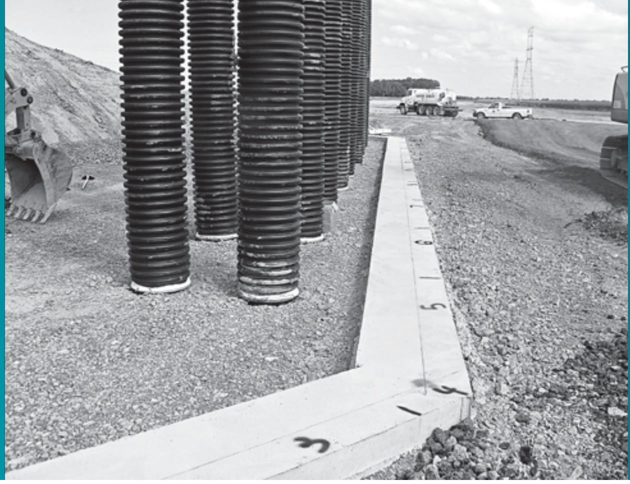


IMAGE D: *Safe cutting of geogrid may be accomplished with a variety of cutting tools. Care should be taken to avoid cutting the transverse bar.*

As with any wall system, the foundation is crucial to the wall's performance.



Construction Procedures for ARES® Retaining Wall Systems

EXCAVATION, FOUNDATION AND DRAINAGE

- Excavation will be performed to the lines and grade required for the installation of the entire wall system.
- The Contractor will be responsible for supporting the wall excavation. All work to support the excavation or to fill the void behind the wall will be the responsibility of the Contractor.
- Evaluation and approval of foundation suitability is the responsibility of the Engineer. Any foundation soils found to be unsuitable by the Engineer shall be removed and replaced with material suitable to the Engineer. The material shall be compacted to the density necessary to obtain the bearing pressure required by the Contract Documents, including the Project Plans and Specifications.
- Foundation shall be prepared according to contract documents and project specifications. The foundation is crucial to the performance of any panel wall system.
- The wall drainage system shall be installed as required in the Contract Documents.

CAST-IN-PLACE LEVELING PAD

- Once the foundation is prepared and approved by the Engineer, an unreinforced concrete pad is constructed. The purpose of this pad is to serve as a guide for the wall panel construction. This leveling pad is not intended for 'significant' structural foundation support in the final configuration of the wall. There is significant construction panel loading on the leveling pad, and it must be properly constructed and on a firm foundation in order to minimize potential wall movement during the construction of the wall.
- The leveling pad is important to the overall construction of the wall and the horizontal and vertical alignment of the wall. It must be in the correct horizontal position, level and at the correct grade.
- Unless otherwise shown in the contract documents or approved in writing by the Engineer, the leveling pad shall consist of 6 in. (150 mm) thick by 12 in. (300 mm) wide unreinforced concrete which shall be formed and poured in place. The concrete strength shall be in accordance with the contract documents or a minimum of 2,500 psi (17MPa), whichever is greater. The leveling pad must cure a minimum of 12 hours prior to the placement of the panels.

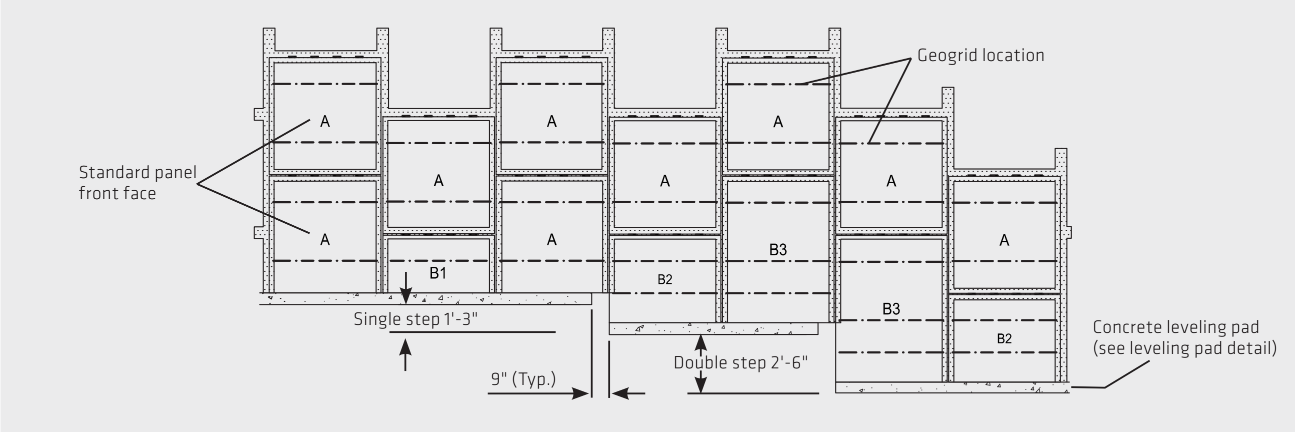


FIGURE 9: *Example of leveling pad and typical panels configuration.*

IMAGE E: *Panel placement commonly begins at corner locations. Placement and bracing of concrete panels.*

- The leveling pad shall have formed sides and a smooth, level surface set to the grades as shown on the approved construction drawings and shall be finished such that the elevation variance is less than +1/8 in. (3 mm) or -1/4 in. (6 mm). A leveling pad that is not placed accurately will create problems with wall alignment and joint spacing during the construction process.
- Where steps in the leveling pad are shown on the approved construction drawings, the actual location of each step should be located and the bulkhead for the upper leveling pad step set back 9 in. (225 mm), nominal. (See Figure 9 and Image G.)
- After the concrete has cured and the forms are removed, lay out the front face of the wall and establish the location on the leveling pad by striking a chalk line at the front face of the bottom course of panels. (See Image F.) For panels with an architectural finish, the location and chalk line should be based on the face of the structural, non-architectural portion of the panel, i.e. immediately behind the architectural relief.
- Do not allow any overhanging of the panels off the leveling pad. If this happens, stop the construction and investigate the problem.

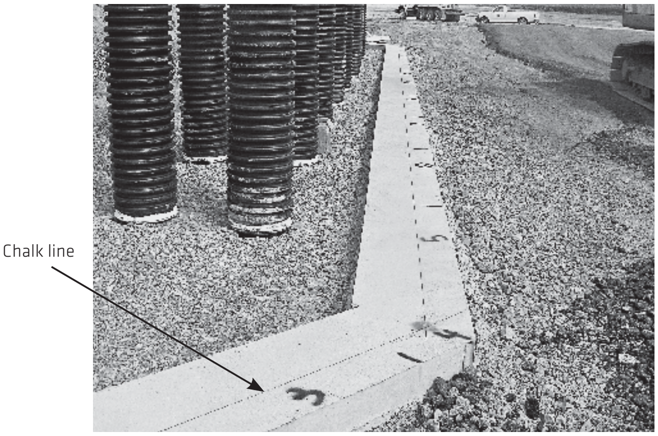


IMAGE F: *Recommended location of chalk line on leveling pad.*

PANEL PLACEMENT – BOTTOM COURSE

- At this point, the foundation has been constructed, drainage has been added, the materials have been checked and the leveling pad has been constructed. Shop drawings must be checked to ensure that the correct panels are being used in the correct location along the wall.
- It is generally preferable to start a wall at the lowest leveling pad elevation and at the location of any fixed point such as a corner and/or existing structure. (See Image E.)
- The bottom course is made up of alternating tall panels (A or B3) and half panels (B1 or B2), with the tall A panels above the half panels as shown in Figure 9.
- The alignment of the first course of panels will determine to a large degree the resulting appearance of the wall. Considerable attention must be paid to the setting and positioning of these panels.
- Remove the panels from the stack using proper lifting devices. Wood blocking must be placed under the bottom of the panel prior to lifting. (See Figure 7.) This protects the face of the panel being lifted from being scarred by the lower panel.
- Prior to setting any panel, sweep off the top of the leveling pad or lower panel, and the bottom of the panel being set, to assure that no foreign material will potentially be trapped under the panel, which could affect horizontal level. Bearing pads are not required between the leveling pad and the panels of the bottom course.

IMAGE G: *Upper leveling pad offset 9 in.*

IMAGE H: *Bracing of ARES® panels.*

IMAGE I: *Establishing batter of ARES® panels.*

Below is the suggested sequence for placing panels on the bottom course: It is important to note that the panel should NOT be released prior to the step specifically calling for that action in the following sequence:

- Lower the panel into position on the pad, using one person on each end of the panel. (See Image H.)
- Using crowbars, position the base of the panel so that it matches the chalk line.
- Use a temporary spacer to assure that the ¾ in. (19 mm) space across the vertical joint is consistently provided between panels. (See Image J.) Without the correct joint spacing, panel corners may crack and spall.
- Check the panel for horizontal level; shim if required. (See Figure 11.) If it is not level, shims are placed under the panel in order to make the panel level. Galvanized metal washers or rubber shims are allowed. A maximum ⅜ in. (9.5 mm) in total shim height at any location is allowed. If more shims are required then the leveling pad is not level.
- Set the batter on the panel. (See "An Important Note on Batter" on pg. 15.)

NOTE: *Shims shall consist of permanent material that will not deteriorate.*

- Using the 4 ft (1.2 m) level with a predetermined blocking attached to one end, push the top of the panel back until the level reads plumb. (See Image I.)
- On the taller panels, install a header clamp and brace and tighten the clamp securely. Drive a stake in front of the wall at the midpoint of the panel for adequate bracing. (See Figure 10.) Nail the bottom of the brace into the stake. Check the batter and then nail the brace to the header clamp.
- On the half-panels, the header clamp and staking are not necessary; the half-panels should be held in place by clamping to the adjacent taller panels. At every vertical joint, position a standard clamp at the top of the half-panel (such that it will result in one clamp on either end of the half-panel) and loosely fasten it. (See Figure 10.)
- The panel may be released at this point.
- Tighten the clamps, pulling the half-panel to the same batter as the taller panel, and recheck the panels for alignment, batter and level.
- Drive wedges at the quarter points of the bottom front of the panel to maintain the batter.
- Nail 2 x 4 wooden blocks at the joint of the panel to prevent sliding during backfill of the first course. (See Figure 10.)

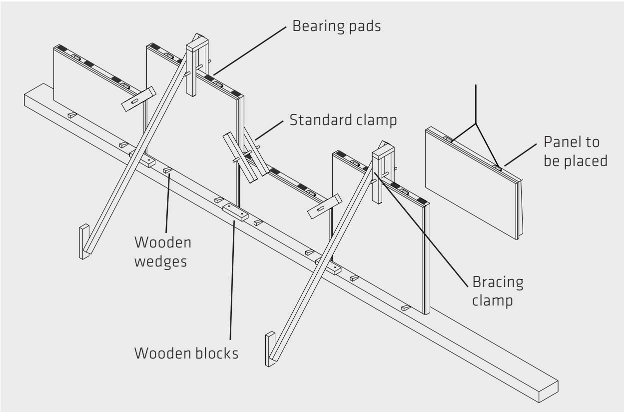


FIGURE 10: *Layout of bearing pads, wedges and clamps.*

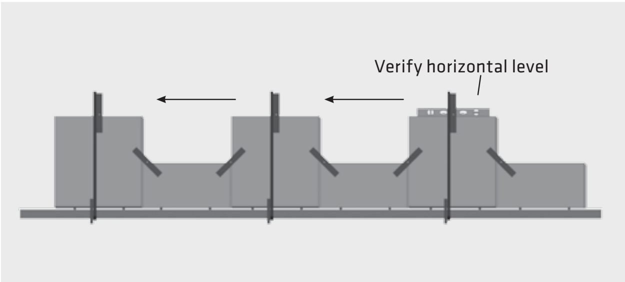


FIGURE 11: *Verifying horizontal level.*

IMAGE J: *Placement of 5 x 5 panels.*

Subsequent Course: *Panels placed, positioned, aligned, clamped, battered and wedged: all but the top course have been backfilled.*

Below is the suggested sequence for placing panels on all subsequent courses: It is important to note that the panel should NOT be released prior to the step specifically calling for that action in the following sequence:

- Subsequent panel rows are placed between panels that were previously placed. The ability to properly space and align these rows relies on the proper placement of the lower rows. All of the error produced by the lower rows is propagated upward and is difficult to correct. The same leveling, joint spacing, vertical and horizontal alignment applies to all of these rows as well.
- Prior to placing a panel on a subsequent course, the panel below should be backfilled to the point that the uppermost layer of geogrid attached to it is covered with at least one lift of compacted fill.
- Check the batter of the panel below the panel being set. Constant attention to the amount of rotation that is occurring in the adjacent panels and compensating in the following panels will yield the best results.
- Place bearing pads on lower panel. (See Images J and M.)
- Lower the panel into position on the bearing pads on the lower panel, using one person on each end of the panel.
- Using crowbars, position the panel and visually align it with the adjacent panels. (See Figure 12.)
- Check that the ¾ in. (19 mm) space across the vertical joint is consistently provided between panels. (See Image J.)
- Check the panel for horizontal level and shim if required. This is particularly important for taller walls to prevent alternate opening and closing of the vertical joints.
- Wedges may be temporarily placed in the vertical joints to maintain alignment until another panel is placed on top.
- Position and loosely fasten a standard clamp on each side of the new panel.
- The panel may be released at this point.
- Set the batter on the panel. (See "An Important Note on Batter" on pg. 15.)
- Tighten both side clamps and recheck the panel for alignment, batter and level.
- Drive the hardwood wedges at the quarter points between the top of the lower panel and the bottom of the new panel to assist in maintaining batter. These wedges should be checked during compaction and re-driven if they become loose.

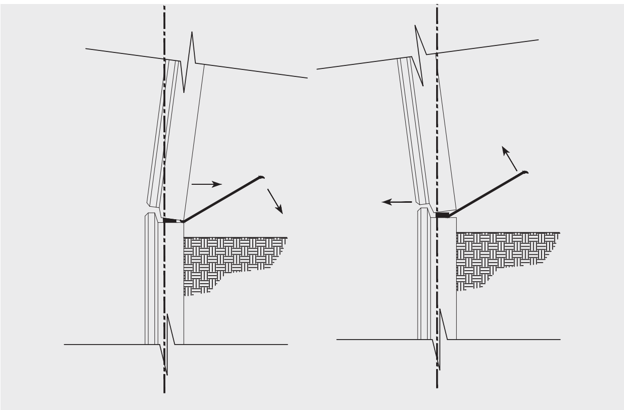


FIGURE 12: *Use of crowbars to align ARES® panels.*

IMAGE K: *Preslit fabric at geogrid elevations.*

IMAGE L: *Placement of filter fabric at ARES® vertical joint.*

Construction Procedures for ARES® Retaining Wall Systems (continued)

AN IMPORTANT NOTE ON BATTER

The amount of batter to which the panel is set is a function of the type, gradation and moisture content of the select fill. It is recommended that the batter in sands be initially set at 1 in. (25 mm) in 4 ft (1.2 m), and for coarser material be set at ¾ in. (19 mm) in 4 ft (1.2 m). The batter on subsequent rows of panels should be adjusted based on the results of the previous courses of panels when they have been backfilled to the top. Note also, particularly in sand backfill, that the required batter tends to be less on panels with more than two layers of geogrid and spaced vertically less than 30 in. (750 mm) apart. Guidance for determining and adjusting the batter is available from the Tensar technical advisor.

NOTE: *Failure to properly use wedges and clamps may result in excessive rotation of the panel.*

The lowest wedges in the column should be removed from the panels after three levels of wedges are in place above. Failure to remove wedges at this time can make subsequent removal difficult and may cause spalling of the concrete.

The vertical alignment of the overall wall should be checked daily using a plumb bob. These checks should be used to adjust the batter to which the panel is set. For example, if a batter of ¾ in. (19 mm) was used initially and after backfilling the batter measured with a plumb bob is ¼ in. then the next course should be set with ½ in. (13 mm) batter. If the panel gets a negative batter of ¼ in. (6 mm) after backfill is placed, the next course should be set with an additional ¼ in. batter. If for any reason the backfill source changes this process should be repeated. Monitoring and adjusting the batter of the panels will help maintain the vertical wall tolerances as required by the contract documents.

PLACING THE JOINT MATERIALS

- The Contractor should place the required bearing pads equally spaced along each horizontal joint between panels.
- Filter fabric is placed across the joints so that the backfill does not pipe through the joints to the outside of the wall. The minimum lap on each side of the joint is 6 in. and 1 ft along any cut piece of fabric along the joint. These requirements apply to horizontal and vertical joints. (See Image N.)
- The filter fabric is typically provided in a 12 in. (300 mm) wide strip and should be centered over all panel-to-panel joints and at special locations as shown in the contract documents where the wall abuts to other structures. The fabric should be slit around the embedded geogrid tabs.

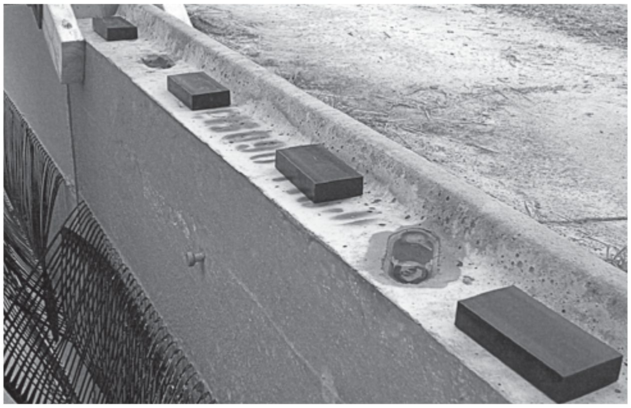


IMAGE M: *Common location of bearing pads.*

IMAGE N: *Filter fabric at vertical joint of ARES panels.*

IMAGE O: *Uniaxial geogrid shall be tensioned prior to fill placement.*

IMAGE P: *Placement of fill on tensioned geogrid.*

The following procedures are recommended for filter fabric preparation and installation:

- Once the filter fabric is cut, lay the filter fabric down and mark the location of the geogrid tab on the fabric.
- Pre-slit the fabric at the marked location to fit around the geogrid tabs. ***NOTE:*** *Use a sharp blade.*
- Use construction adhesive to hold the filter fabric in place prior to select fill placement. Adhesive to be applied surrounding the fabric about 2 in. from the edges including the area where the filter fabric is slit. The filter fabric needs to fully engage the back of the ARES® panels at all locations to ensure that the backfill does not leak through the joints.

GEOGRID IDENTIFICATION

- The Contractor is recommended to highlight the geogrid types on the construction drawings and spray paint the geogrid tab cast-in the back of the panels before fill placement using colors corresponding to colors of geogrid roll edges. (See pg. 10.)
- It is also recommended to label the geogrid embedment length for the particular section of the panel on the back of the panel face to ease installation prior to fill placement. (See pg. 10.)

PLACEMENT OF THE GEOGRID

- Install the UX Geogrid called for on the approved construction drawings, using the type, width and length of geogrid shown for each location within the wall. Installation of the geogrid must be coordinated with the panel and fill placement. The geogrid must be connected to the panels using the Bodkin connection as shown on the approved construction drawings.
- At the Contractor's discretion, prior to fill placement, the geogrid may be connected to the panels and then the geogrid may be temporarily flipped over the front face of the wall. The select fill shall be brought up to the level of the geogrid connection after compaction and shall be compacted and level for the entire geogrid embedment length prior to placing the geogrid.
- The Contractor should take care to ensure the level of the compacted fill is flush to the back face of the panel and up to the level of the geogrid connection.
- The geogrid shall not be placed on the grade until the necessary testing and acceptance of the in-place fill material has been obtained from the Engineer.
- The geogrid shall be positioned near perpendicular to the face of the panel and such that the tension is relatively uniform across the width of the connection and such that the geogrid lays flat on the grade for the entire embedment length.
- A tensioning rake is then inserted in front of one of the transverse bars to provide adequate tensioning from the panel and pushed down into the select fill (See Image O). The geogrid is then pulled with sufficient force to remove all slack. Proper technique is important to apply and maintain proper tension.
- While maintaining tension on the geogrid, select fill should be placed on the geogrid between the rake and the back of the panels (preferably immediately beyond the 3 ft (0.9 m) zone behind the panels). (See Image P.)
- The rake may be withdrawn immediately after initial placement of about one cubic yard (.76 m^3) loose, nominal or more of select fill on the section of geogrid.

***IMAGE Q:** Geogrid tensioning and fill placement process.*

***IMAGE R:** Use only lightweight equipment to compact fill within 3 ft of ARES® panel.*

FOR 5 FT X 9 FT PANELS AND 5 FT X 10 FT PANELS

- Unless otherwise noted on the approved construction drawings, two full widths of the proper type and length of geogrid shall be attached to each standard-width panel at each elevation requiring geogrid.

REINFORCEMENT FILL PLACEMENT

- Fill placement shall be performed in a manner that prevents the development of slack in the UX Geogrid. The select fill should be spread in a direction away from or parallel to the face of the wall. In this way, any slack that does develop will tend to be shoved toward the free (back) end of the geogrid. Further care should be taken during fill placement to avoid shoving the geogrid panels and causing them to shift sideways.
- Place and compact the select fill in accordance with the approved construction drawings and the contract documents. The select fill shall be compacted to a minimum of 95% of the maximum dry density as determined in accordance with AASHTO T-99 or as required by the contract documents, whichever is more stringent. Unless otherwise directed by the Engineer, the select fill lift thickness shall not exceed 10 in. (250 mm) loose. The lift thickness allowed is at the discretion of the Engineer, provided the Contractor can meet compaction requirements and maintain proper alignment.
- Static rolling is typically adequate for achieving the required compaction; heavy vibratory equipment may cause movement of wall components and potential misalignment of the wall facing, particularly in sand fill. The actual procedure used should be determined based on field trial results.
- Only hand-operated lightweight compaction equipment shall be used within 3 ft (0.9 m) of the back face of the panel. (See Image R.) Lightweight vibratory equipment and/or lightweight roller may be used for this purpose. The use of a Jumping Jack is not recommended.
- Tracked construction equipment shall not be operated directly on the geogrid. A minimum of 6 in. (150 mm) of fill is required between the tracks and the geogrid. Rubber-tired equipment may be operated directly on the geogrid, provided the subgrade is not pumping or rutting. Turning of all equipment shall be minimized to prevent dislocation or damage to the geogrid. The equipment must travel slowly and with sufficient care to avoid dislocating the geogrid.

***IMAGE S:** Bodkin connection used to connect geogrid panels to geogrid tab.*

***IMAGE T:** Compacted select fill brought up to the level of the geogrid.*

- At the end of each day, the Contractor must ensure that the reinforced fill zone is compacted and graded to drain away from the face of the wall and that berms or ditches are in place and functioning to prevent the entrance of runoff into the wall construction site.
- **Proper installation and tensioning of the geogrid and select fill is critical to the alignment, appearance and performance of the ARES® Retaining Wall Systems. Care should be taken to ensure that the geogrid is properly tensioned and select fill is properly placed.**

WALL TOLERANCES

Unless otherwise noted on the approved construction drawings or in the contract documents, ensure the following:

- Deviation in vertical and horizontal alignment does not exceed ¾ in. (19 mm) when measured with a 10 ft (3 m) straightedge. Offsets (measured perpendicular to wall face) at the joints between panels do not exceed ¾ in. (19 mm).
- Gaps at horizontal and vertical joints between adjacent panels are not less than ½ in. (12 mm) and not more than 1¼ in. (32 mm).
- Deviation in the final overall verticality of the completed wall (plumbness from top to bottom) does not exceed ½ in. per 10 ft (4 mm per m) of wall height.

THE ARES® SYSTEMS ADVANTAGE

For more than 30 years industry professionals have been using Tensar® Geogrids to build economical, long-lasting structures. With clear advantages in performance, design and installation, ARES® Systems offer a proven technology for addressing the most challenging projects.

For more information on ARES Systems, call **800-TENSAR-1**, visit **www.tensarcorp.com** or send an e-mail to **info@tensarcorp.com**. We are happy to supply you with additional information, system specifications, design details, conceptual designs, preliminary cost estimates, and much more.

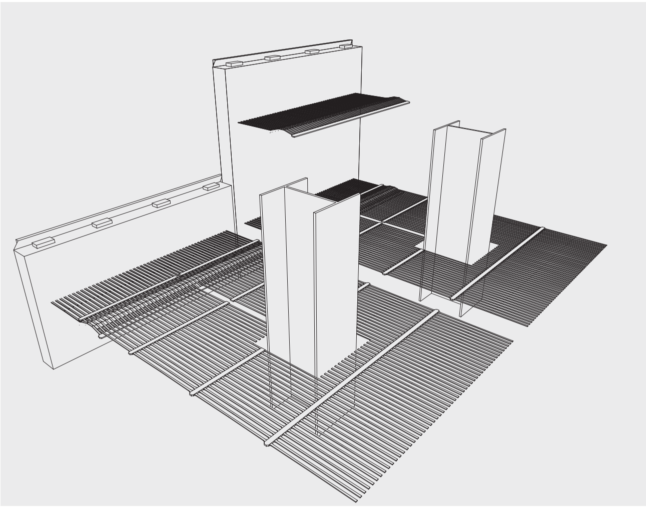
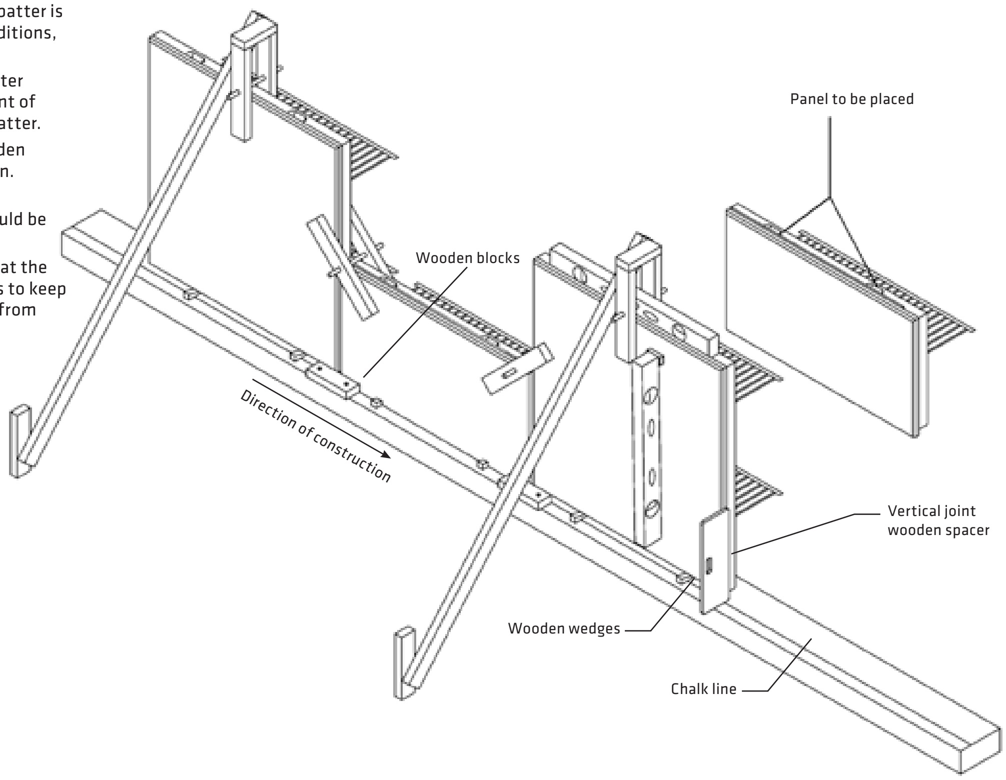


IMAGE U: *Placement of geogrid panels around and adjacent to vertical penetrations.*

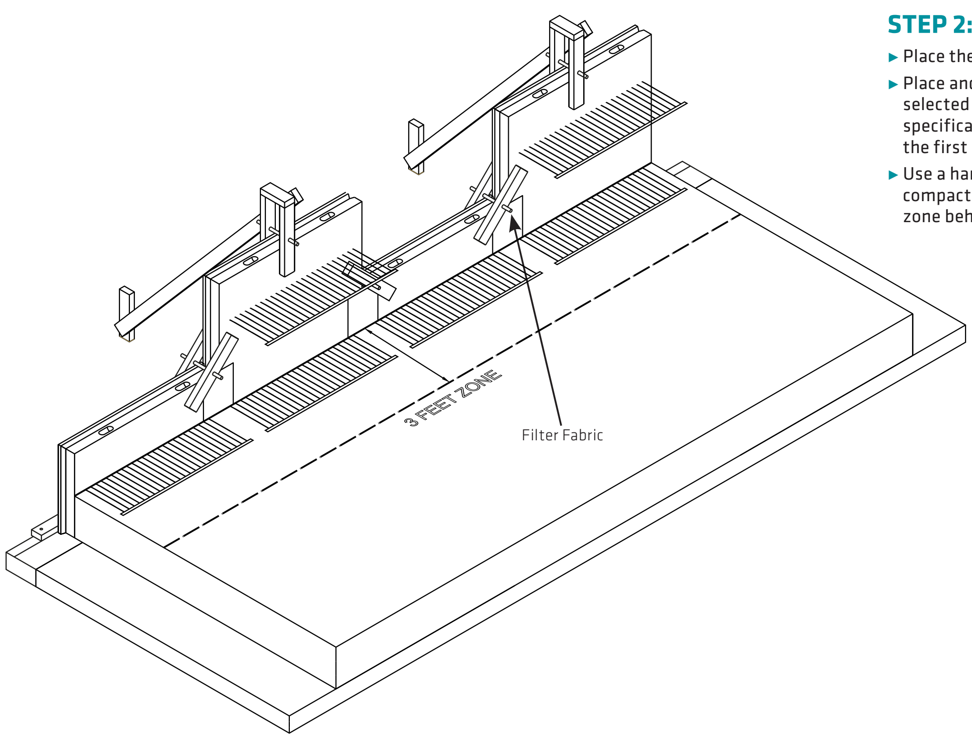
STEP 1:

- The first row of panels are placed on the leveling pad and braced.
- The panels should be set with a backward batter according to the panel batter recommendation on page 15. Important: The batter is adjusted for the site conditions, e.g. backfill properties.
- Drive wedges at the quarter points of the bottom front of the panels to maintain batter.
- Use a ¾ in. (19 mm) wooden spacer to achieve the ¾ in. (19 mm) vertical joints.
- Adjacent half panels should be clamped together.
- Nail 2 x 4 wooden blocks at the joint of the panels; this is to keep the bottom of the panel from "kicking out."



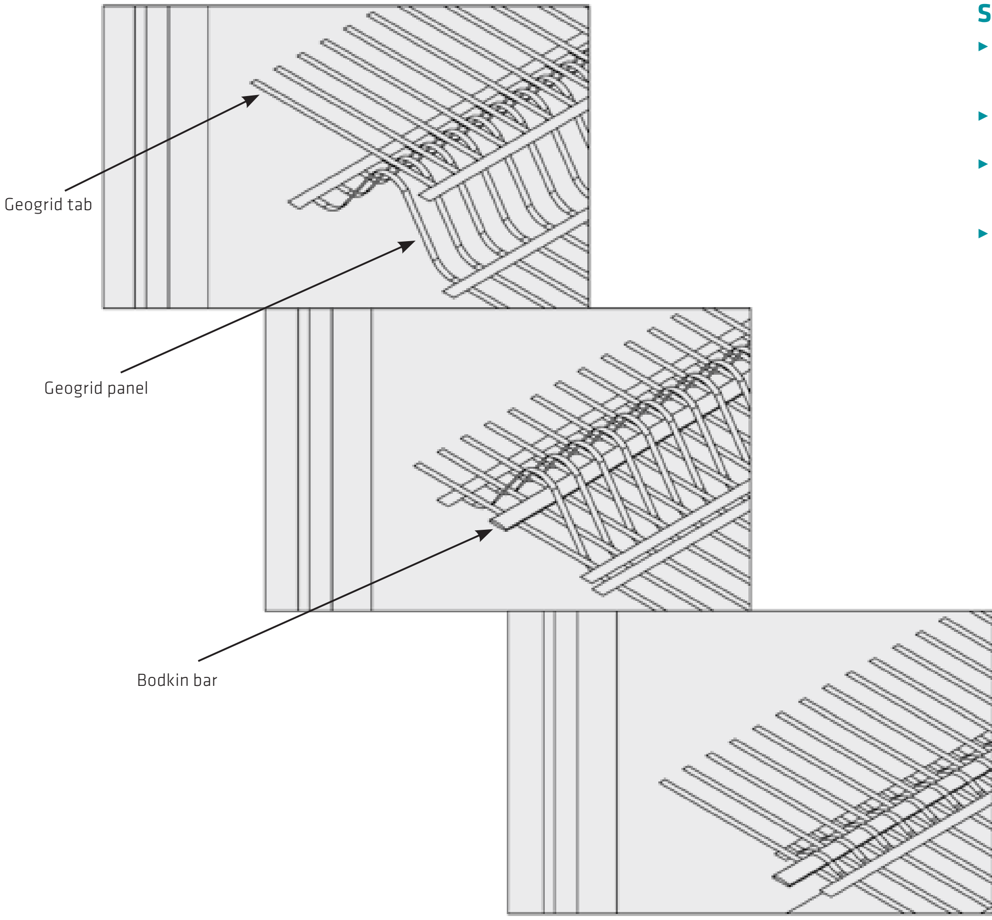
STEP 2:

- Place the filter fabric over vertical joints.
- Place and compact initial lifts of selected granular backfill, per project specifications, up to the bottom of the first geogrid tab.
- Use a hand-operated vibratory compactor in the 3 ft (900 mm) zone behind the panels.



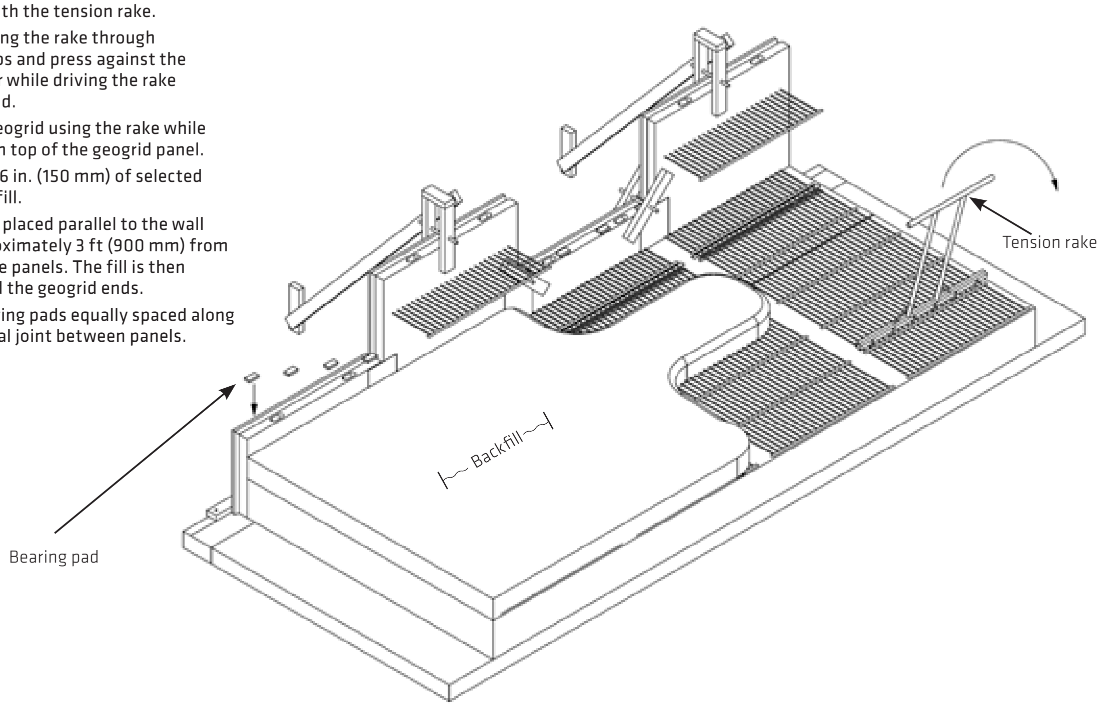
STEP 3:

- Connect each geogrid panel to the geogrid tab embedded in the panel with the Bodkin bar.
- Start by bending the geogrid through the tab to create a tunnel.
- Slide the Bodkin bar through the tunnel that was formed by the geogrid panel and the georid tab.
- Pull the geogrid snug by hand.



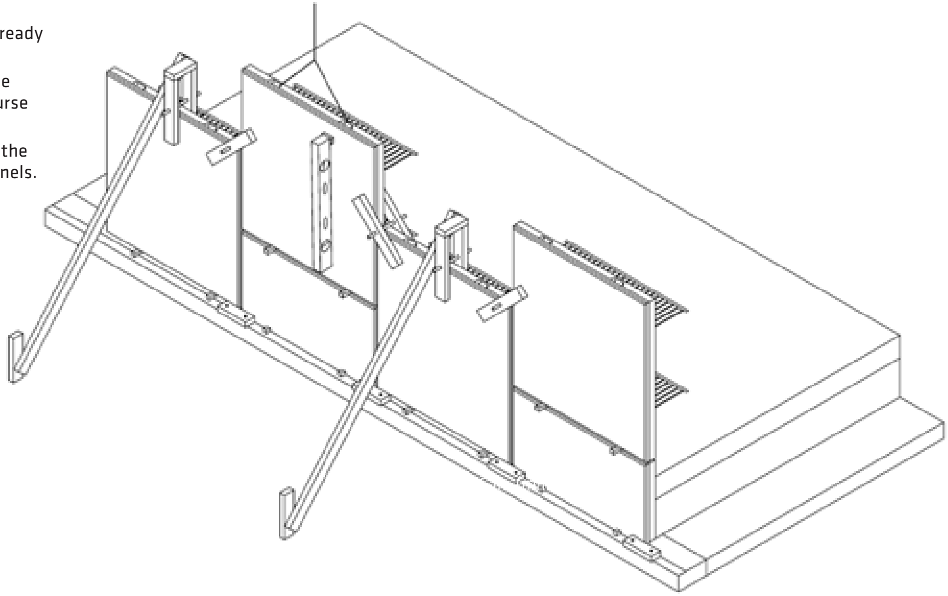
STEP 4:

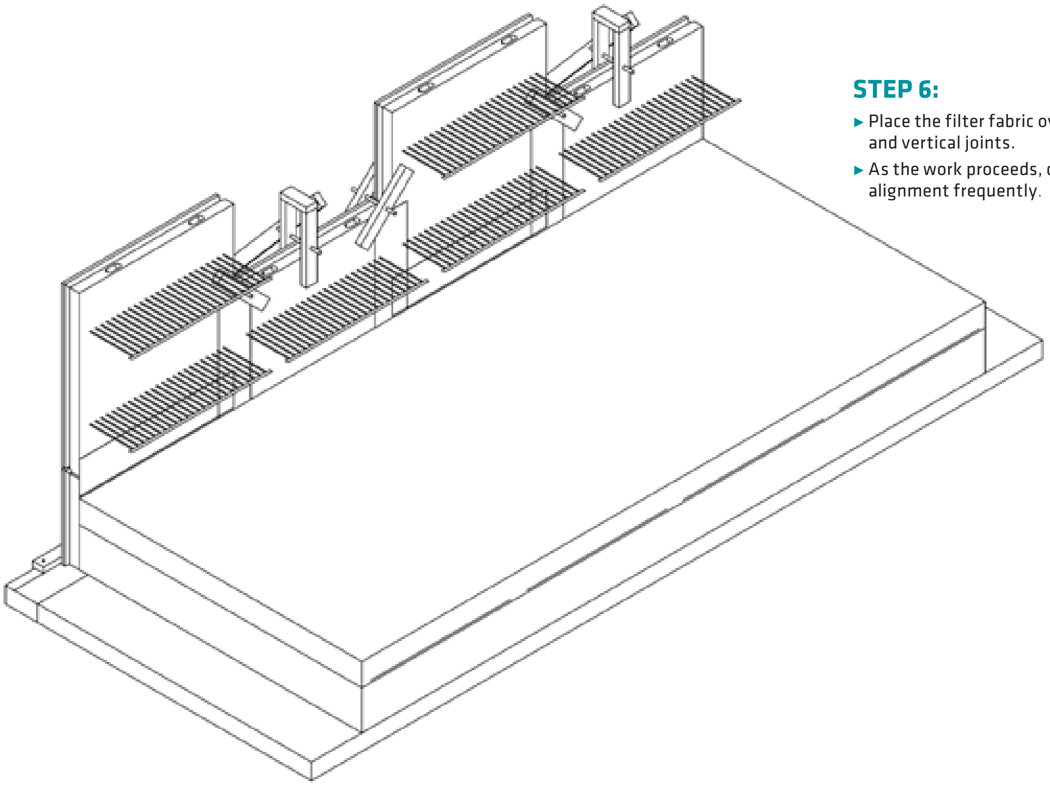
- When the fill is ready to be placed, tension the geogrid with the tension rake.
- Start by pushing the rake through the geogrid ribs and press against the transverse bar while driving the rake into the ground.
- Tension the geogrid using the rake while fill is placed on top of the geogrid panel.
- Place at least 6 in. (150 mm) of selected granular backfill.
- The backfill is placed parallel to the wall starting approximately 3 ft (900 mm) from the back of the panels. The fill is then spread toward the geogrid ends.
- Place the bearing pads equally spaced along each horizontal joint between panels.



STEP 5:

- Place the second row of panels only after backfill has reached 6 in. below the half panels.
- When the next row of panels are ready to be set, remove the clamps.
- Place the next row of panels in the "window" created by the first course of panels.
- Check the batter and then install the wedges and clamp to adjacent panels.



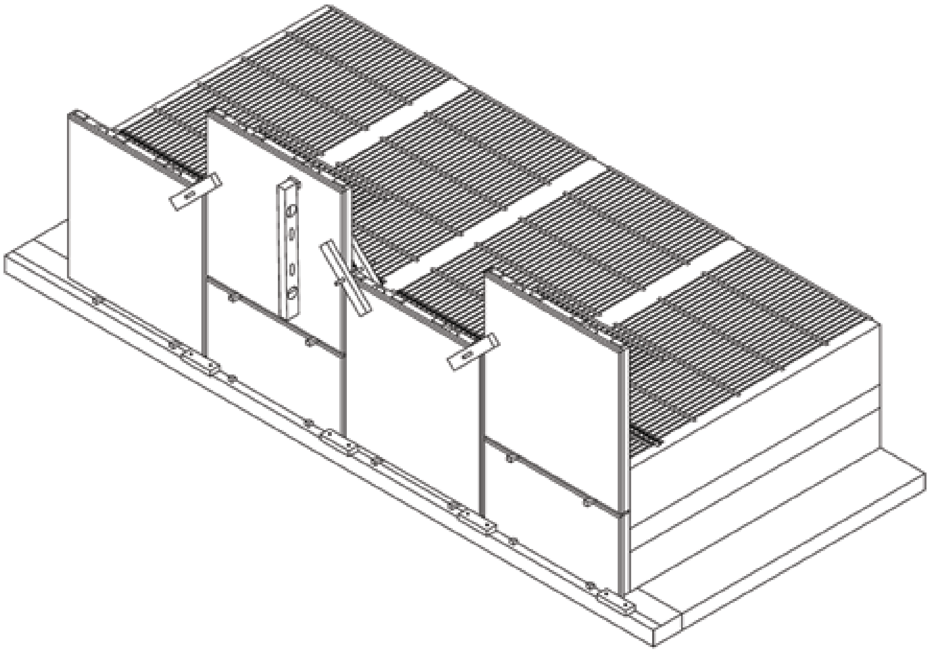


STEP 6:

- Place the filter fabric over the horizontal and vertical joints.
- As the work proceeds, check the panel's alignment frequently.

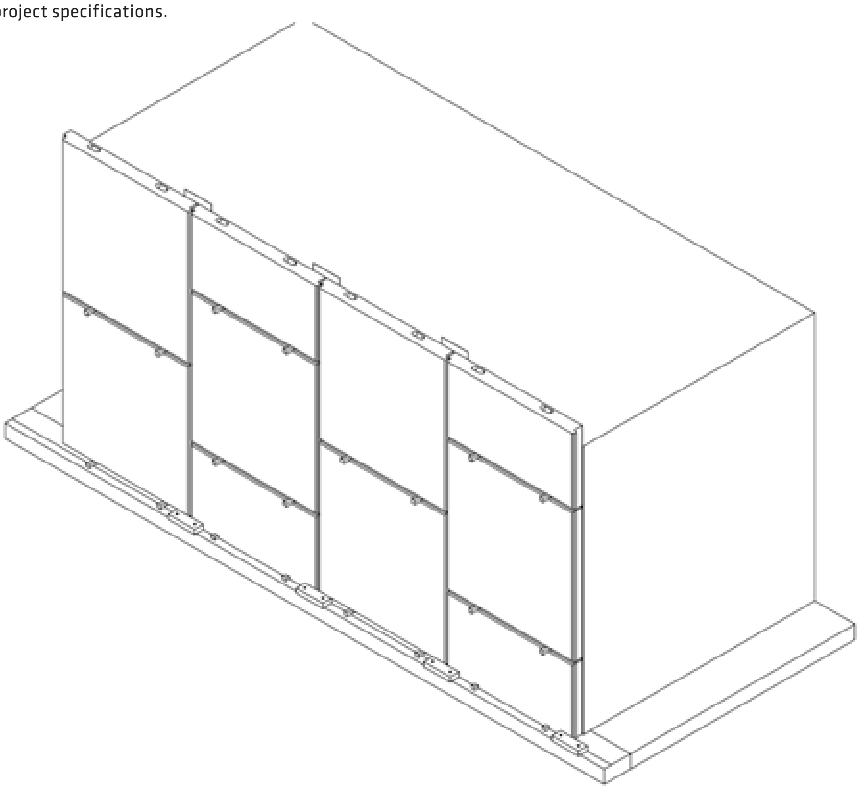
STEP 7:

- Place selected granular backfill in lifts per project specifications.
- After backfilling, recheck the batter and alignment of the panels.



STEP 8:

- Connect and install geogrid panels as described on step 3.
- Repeat the process from steps 4 to 7.
- As soon as practical, the front of the wall should be backfilled.
- The top wall treatment is then placed per project specifications.



General Terms

Approved Construction Drawings
The final wall drawings provided by Tensar to the Contractor for submittal to the Owner/Owner's Engineer and subsequently approved by the Owner/Owner's Engineer for construction.

Contract Documents
The agreement between the Owner and the Contractor including the plans and specifications, the conditions and provisions of the agreement, including any addenda and other modifications issued prior to or after the bid and the execution of the original contract.

Contractor
The individual, firm or corporation acting directly through its agents or employees to undertake the execution of the work under terms of the contract.

Engineer
The Owner's representative with authoritative charge over the inspection and acceptance of the wall construction in accordance with the contract documents.

Inspector
An authorized representative of the Owner assigned to see that the workmanship and materials are in accordance with the terms of the contract.

Owner
The Owner of the project with whom a contract has been made for payment for the work performed under the terms of the contract.

Plans
The part of the contract documents consisting of the plans, profiles, typical cross-sections, working drawings and supplemental drawings, or exact reproductions thereof, which show the location, character, dimensions and details of the work to be performed.

Precaster
Every precast panel manufacturer under contract with Tensar.

Specifications
The part of the contract documents consisting of a description of the quality and quantity of the materials and workmanship that will be required of the Contractor in the execution of the work under the contract between the Owner and the Contractor.

Tensar Technical Advisor
An authorized representative of Tensar that is available on site at the start of the project to advise the Contractor recommended construction procedures within the scope of this document. This person is not an inspector or member of the quality control staff on the project.

Work
All work items to be performed by the Contractor under the terms and conditions of the contract that are necessary to fulfill the obligations of said contract.

Tensar International Corporation
2500 Northwinds Parkway, Suite 500
Alpharetta, Georgia 30009

800-TENSAR-1
tensarcorp.com

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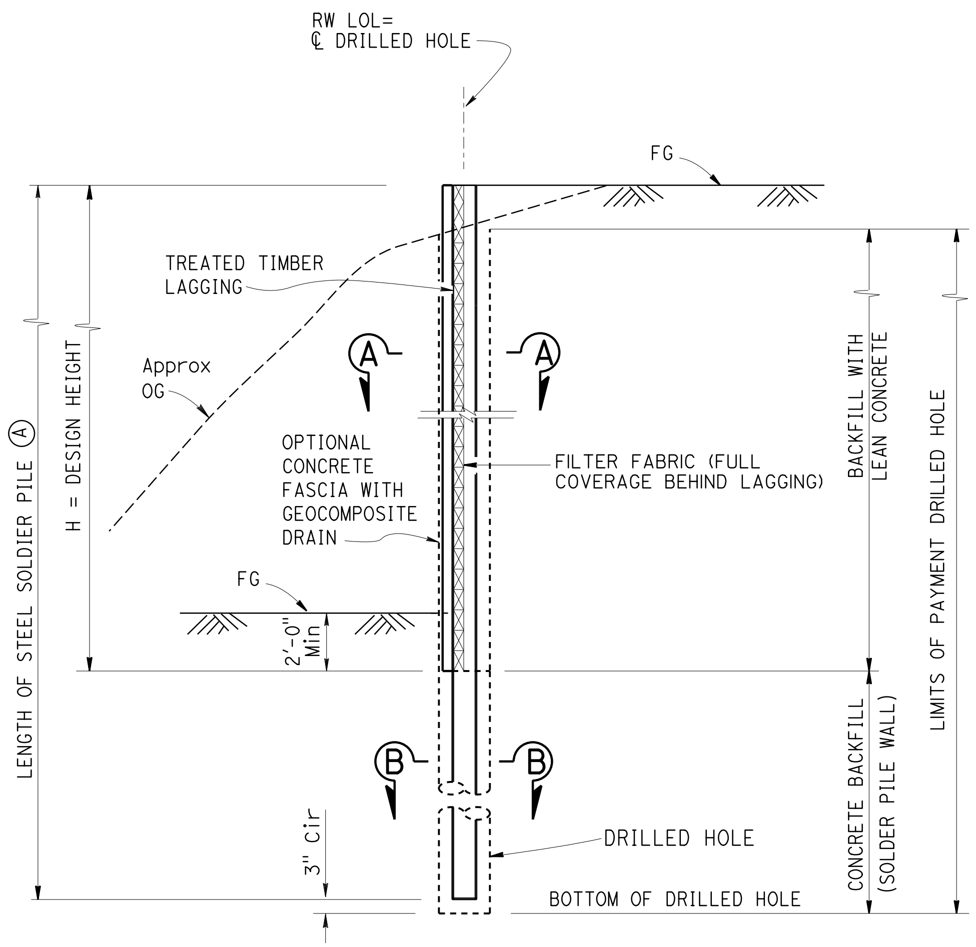


FOR DETAILS NOT SHOWN, SEE "PROJECT PLANS"

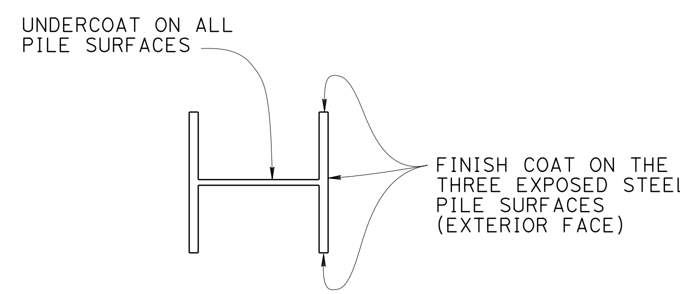
TYPICAL SECTION

NO SCALE

NOTE:

Ⓐ Clean and paint Steel Soldier Pile from top of pile to 5 feet, Min below bottom of lagging.

For lagging details see "SOLDIER PILE WALL LAGGING DETAILS".



LIMITS OF CLEAN & PAINT STEEL SOLDIER PILE

NO SCALE

GENERAL NOTES:

DESIGN: AASHTO LRFD Bridge Design Specifications, 4th Edition with California Amendments.

LIVE LOAD: 240 psf equivalent to 2 feet soil weight.

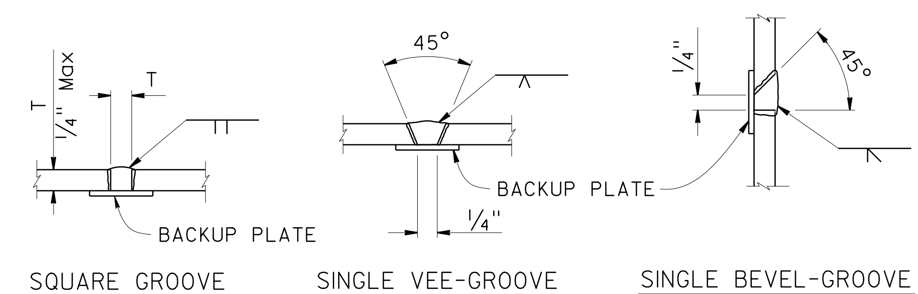
SOIL PARAMETERS: (For determination of Design Lateral Earth Pressures)
- Backfill soil weight = _____ lb/ft^3
- Friction Angle = _____ °
- Active Pressure coefficent, Ka = _____
- Bedrock Unit Weight = _____ lb/ft^3

SEISMIC PARAMETERS: k_h = _____

STEEL SOLDIER PILES: ASTM A572/A, ASTM 572M Grade 50 Min, or ASTM A36/A36M

REINFORCED CONCRETE (FASCIA): f'c = 4000 psi, fy = 60 ksi

STRUCTURAL TIMBER: Treated Douglas Fir, Grade No. 1 or better. Timber to be full sawn.

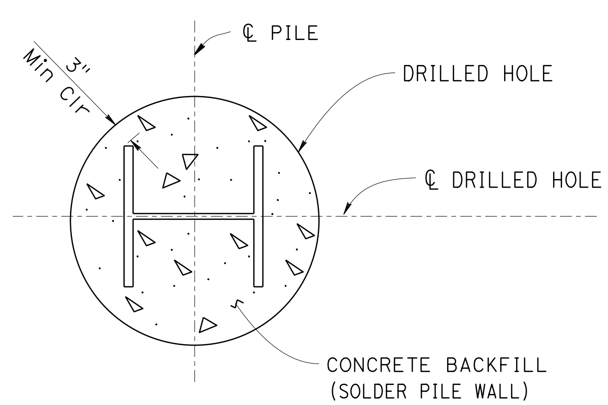


PILE WELDING DETAIL-BUTT JOINTS

NO SCALE

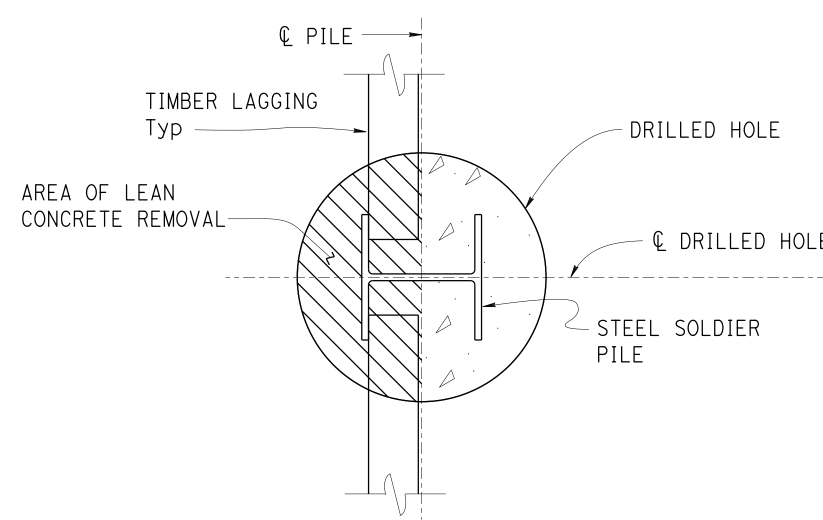
NOTES:

1. Single vee-groove and square groove permitted for all positions.
2. Single bevel-groove permitted for horizonal joints only.



SECTION B-B

NO SCALE



SECTION A-A

NO SCALE

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS

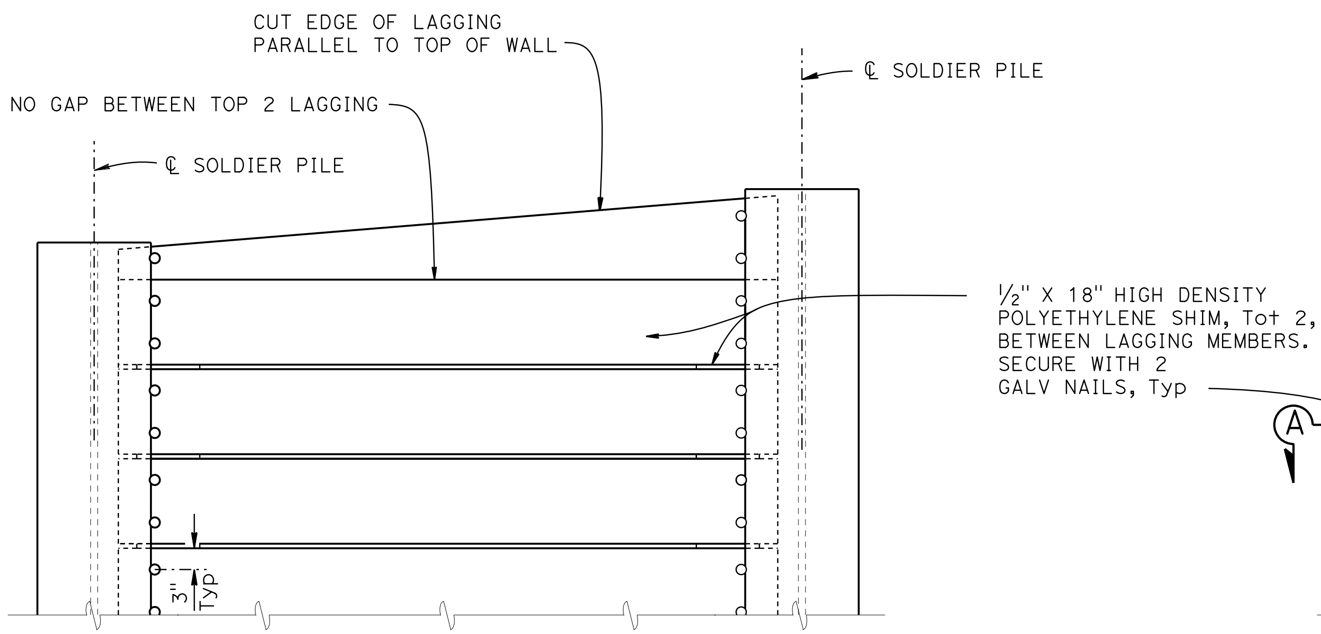
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of scanned copies of this plan sheet.

REGISTERED PROFESSIONAL ENGINEER No. Exp. CIVIL STATE OF CALIFORNIA

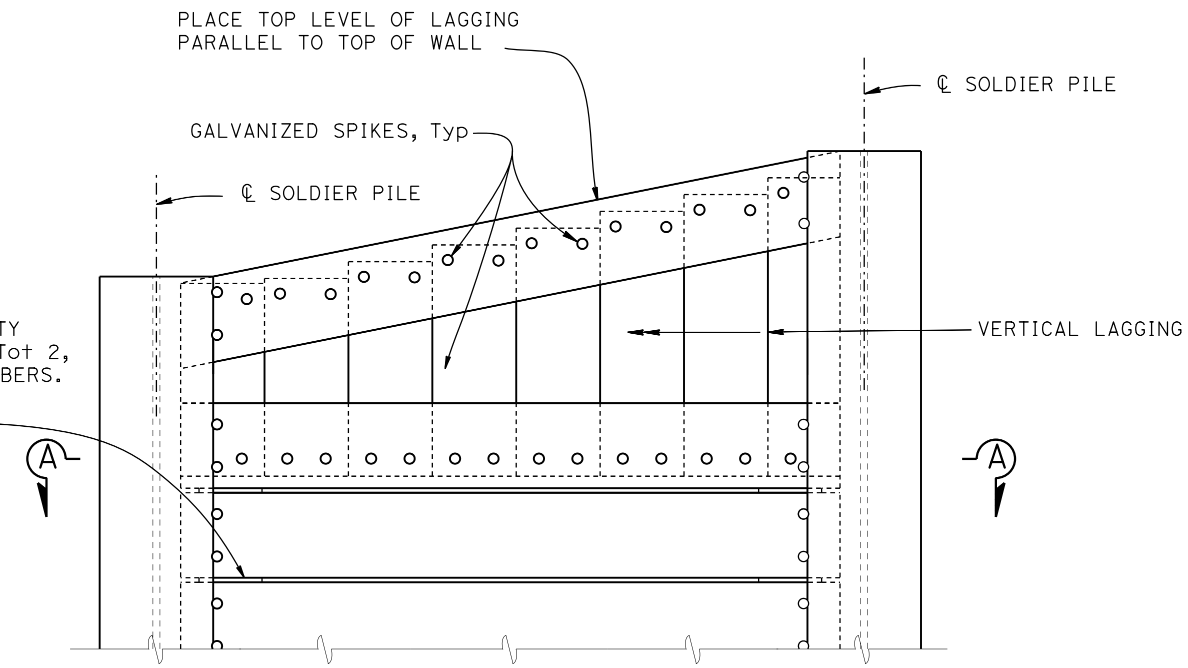
The Registered Civil Engineer for the project is responsible for the selection and proper application of the component design and any modifications shown.



PART ELEVATION

LAGGING DETAILS (ALTERNATIVE 1)

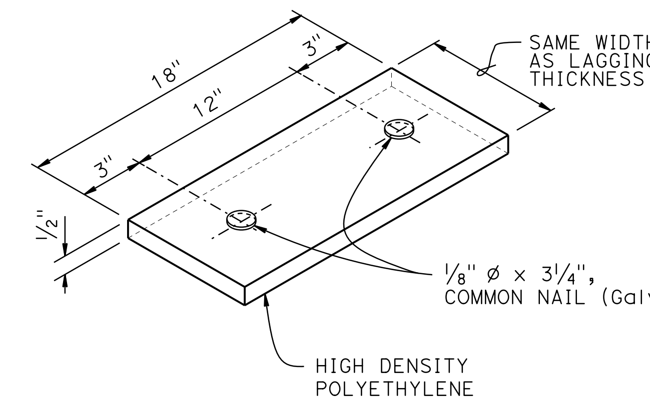
NO SCALE



PART ELEVATION

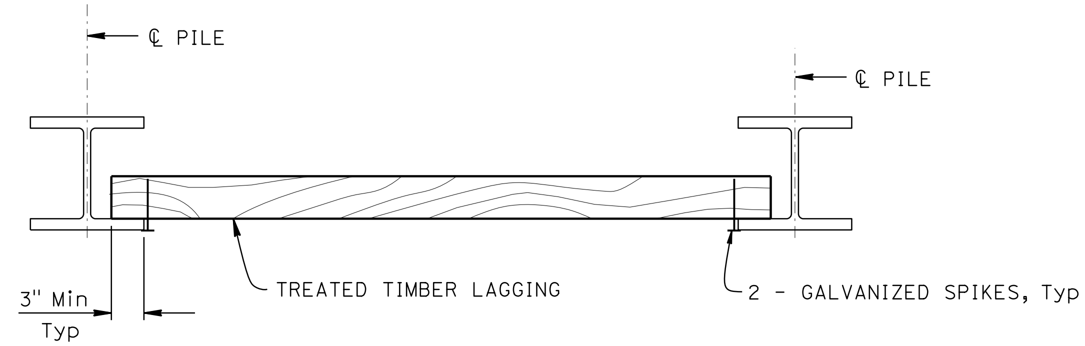
LAGGING DETAILS (ALTERNATIVE 2)

NO SCALE



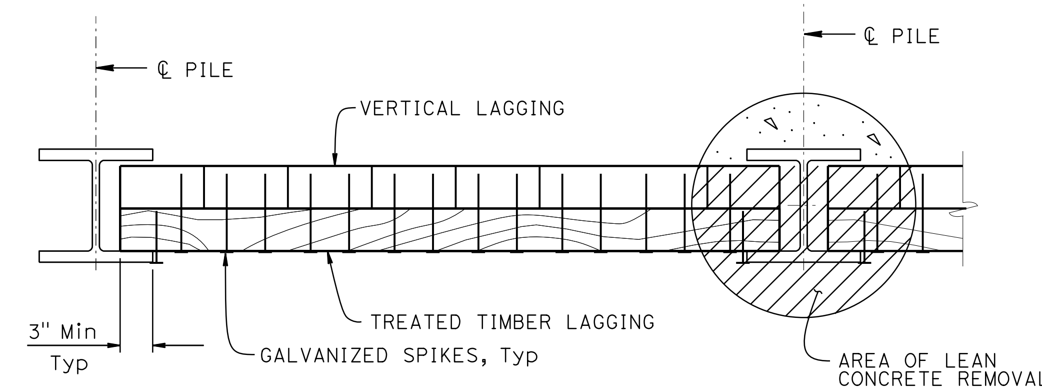
SHIM DETAIL

NO SCALE



PART PLAN

NO SCALE



SECTION A-A

NO SCALE

NOTES:

1. No clipping of timber lagging corners allowed
2. Use 16d Galv wire spikes for 4 x 12 lagging, and 40d Galv wire spikes for 6 x 12 lagging
3. Spikes shall not be bent

BRIDGE STANDARD DETAILS

xs12-080 FILE NO. | July 2014 APPROVAL DATE

The components of the Bridge Standard Details have been prepared under the responsible charge of the Technical Owner, a registered civil engineer in the State of California

Refer to: http://www.dot.ca.gov/hq/esc/techpubs/manual/bridgemanuals/bridge-standard-detail-sheets/index.html

FILE => xs12-080.dgn USERNAME => s136236 TIME PLOTTED => 16:02 DATE PLOTTED => 14-JUL-2016

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

DIVISION OF ENGINEERING SERVICES

BRIDGE NO.

POST MILE

SOLDIER PILE WALL LAGGING DETAILS

UNIT:

PROJECT NUMBER & PHASE: CONTRACT NO.:

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES 6-24-14 7-12-16 SHEET OF

APPENDIX G: Hydropower

SAN LORENZO VALLEY WATER DISTRICT

CROSS COUNTRY PIPELINE CONSTRUCTABILITY REVIEW

DATE: February 11, 2022

TO: Jeffrey Tarantino, P.E., F&L

FROM: Dr. Jeff Lewandowski, P.E., C 52503

SUBJECT: Microhydropower Feasibility Review

REGISTERED PROFESSIONAL ENGINEER
JEFF A. LEWANDOWSKI
C52503
CIVIL
STATE OF CALIFORNIA

Summary and Key Findings

Microhydropower systems are typically defined as those that generate less than 100 kilowatts (kW) of electricity. Potential microhydropower equipment options for the 5-Mile Pipeline have been identified by vendors based on preliminary estimates of pipeline flow rate and available head. Power generation of about 20 kW is expected based on preliminary estimates. The costs for these systems is expected to be between $50K and $100K for equipment only. Capital costs for equipment and installation costs may be offset by State grants and manufacturer financing.

The next step would be the preliminary design of the potential microhydropower facilities to confirm power generation conditions, to compare installation requirements and equipment types and to determine facility capital costs. The Peavine pipeline should also be reviewed for a potential microhydropower installation.

Background

The existing 5-Mile Pipeline conveyance system operates at pressures above 200 pounds per square inch (psi) at the Lyon Water Treatment Facility. AHE performed a hydraulic feasibility evaluation to identify the potential for microhydropower available from the head and flow in the 5-Mile Pipeline. Using previous hydraulic calculations from the San Lorenzo Valley Water District (District) for the 5-Mile Pipeline and flow estimates obtained from Freyer & Laureta (F&L), a design head of 250 feet and a flow rate of 500 gallons per minute (gpm) was selected for the initial feasibility review.

Two types of microhydropower systems were reviewed. The first was the use of a commercially available product called an In-PRV (pressure recovery valve). This product is installed parallel to an existing pressure reducing valve. Diversion of water through the In-PRV will activate a turbine that utilizes the available head to generate power during reduction of pressure. The second type of microhydropower system was an in-line impulse turbine using a Pelton Wheel.

AHE contacted InPipe Energy, the manufacturer of the In-PRV (pressure recovery valve) to determine feasibility of energy recovery from the pipeline flow. A schematic configuration of the In-PRV system is shown on Figure 1. The manufacturer confirmed that an In-PRV system can be installed in parallel with the existing pressure reducing valve to recover the energy previously lost at the pressure reducing valve during normal operations. The preliminary estimate of power generated may be 10 kW to 20 kW, depending on actual flows in the system. An estimated cost for the system could not be developed by the manufacturer due to the limited preliminary information regarding flow and available head. A minimum facility cost would be at least $50K.

FIGURE 1 - INPIPE ENERGY IN-PRV (PRESSURE RECOVERY VALVE) OPERATION SCHEMATIC

The In-PRV manufacturer also noted that State grants are available for the proposed equipment that may cover or significantly reduce the cost of the installation. Alternatively, the equipment may be financed through a manufacturer program that would include installation of the equipment at no cost with the agreement by the District to purchase the generated power at a reduced rate for a defined period.

AHE also contacted Canyon Hydro, a vendor that builds hydroelectric systems for public and independent power producers. Canyon Hydro identified a microhydropower option using a Pelton turbine for this application. The expected system energy production is 21 kW using a Canyon Hydro Pelton turbine based equipment package. Since flow will vary, a PLC based actuation of the turbine needle nozzles was suggested. The estimated equipment package cost is $80K to $85K to include the Canyon Pelton turbine, induction generator, low voltage switchgear to parallel the generator with the electrical utility, PLC based controls, direct drive coupling set, turbine inlet valve and structural steel equipment mounting frame. A photo of a Pelton generator and controls is shown on Figure 2. The availability of State grants to offset costs for this system is not known and requires further research.

The next step would be the preliminary design of the potential microhydropower facilities to confirm power generation conditions, to compare installation requirements and equipment types and to determine facility capital costs. The Peavine pipeline should also be reviewed for a potential microhydropower installation. For the preliminary design of the system, the historical range of monthly flows at each intake on the supply pipelines must be developed to better assess the estimated power generation capability throughout the year. The manufacturers will develop systems that are appropriate for the anticipated range of flows based on the historic intake flow rates. This will provide more specific values of energy production available from the District water supply systems and allow development of preliminary capital cost estimates.

FIGURE 2 – PHOTO OF PELTON GENERATOR AND CONTROLS

APPENDIX H: Opinion of Probable Cost

Alpine Summit Development, LLC

5-Mile Raw Water Pipeline
Pre-Design Phase

CLASS 4 - OPINION OF PROBABLE CONSTRUCTION COST

February 23, 2022

CLIENT PREPARED FOR:
Freyer & Laureta, Inc.
144 San Mateo DR.
San Mateo, CA 94401

PREPARED BY:
Alpine Summit Development, LLC
Aaron J. Smud
1852 W. 11TH Street, Suite 266
Tracy, CA 95376
(925) 605-6762

Alpine Summit Development, LLC

PROJECT: **5-Mile Raw Water Pipeline**
LOCATION: **Boulder Creek, CA**
ESTIMATOR: **AARON SMUD**
ESTIMATE DATE: **2/23/2022**

ESTIMATE INFORMATION

1.0 ESTIMATE TYPE:

PRE-DESIGN OPINION OF PROBABLE CONSTRUCTION COST
AACE ESTIMATE CLASSIFICATION: CLASS 4
Expected Accuracy - Low Range of -20% to -50% and High Range of +30% to +100%

2.0 ESTIMATE BACKGROUND:

This estimate of cost is prepared from a survey of the quantities on scope items. Utilizing HCSS HeavyBid Software we are able to develop a resource loaded estimate that details all major cost components including materials, labor, equipment, subcontractors, and schedule. Cost information provided by subcontractors and suppliers, plus judgmental evaluation by the Estimator are incorporated. Allowances as appropriate will be included for items of work which are not indicated on the design documents provided that the Estimator has identified. We cannot, however, be responsible for items or work of an unusual nature of which we have not been informed.

3.0 PROJECT DESCRIPTION:

The Peavine and 5-Mile Pipeline consists of approximately 36,100 LF of 8" HDPE raw waterline.
The pipeline alignment will mostly follow heavily wooded and steep cross country ROW.
The proposed existing alignment will cross a total of approximately 37 creek crossings locations.
General pipeline appurtenances such as mainline valves, air release valves, BO valves and sample stations are included. Improvements to the existing raw water intake facilities will also be required with the new pipeline.
Tree removal, access grading, retaining walls, erosion control, and restoration are other key areas of work.

4.0 ESTIMATE DOCUMENTS:

This estimate was developed using the following drawings, specifications, and other supplied documents

Drawings: Alignment Maps and Trench Detail Sections

Specification: None Provided

Cost Provided: Pace Supply - Pipe, Fitting, and Valves
Zefero Drilling - Beam and Lag Retaining Wall
Tree Removal - Mike Powers Forestry

Alpine Summit Development, LLC

PROJECT: **5-Mile Raw Water Pipeline**

LOCATION: **Boulder Creek, CA**

ESTIMATOR: **AARON SMUD**

ESTIMATE DATE: **2/23/2022**

ESTIMATE INFORMATION

5.0 MARKET CONDITIONS:

In the current market conditions for construction, our experience shows the following results on competitive bids:

Number of Bids	Percentage Differential
1	+25 to 100%
2 - 3	+10 to 25%
4 - 5	0 to +10%
6 - 7	0 to -10%
8 or more	-10 to -20%

Accordingly, it is extremely important to ensure that a minimum of 4 to 5 valid bids are received. Since we have no control over the bid process, there is no guarantee that proposals, bids or construction cost will not vary from our opinions or our estimates.

6.0 COMPETITIVE BIDDING:

The prices in this Estimate are based on Competitive Bidding. Competitive Bidding is receiving responsive bids from at least Four (4) or more General Contractors and three (3) or more responsive bids from Major Subcontractors or Trades. Major Subcontractors are Clearing and Tree Removal, Retaining walls, and Electrical Subcontractors for the project.

7.0 PROJECT ASSUMPTIONS:

Given the preliminary concept level design for the project a number of assumptions have been made. Until a tree survey, ROW survey and other field investigation is conducted its undetermined what footages could be constructed utilizing a more typical sized working bench compared to what areas would be restricted to the level that would require a retaining wall system and a narrow access bench. The estimate has assumed a 50% split between the Typical Trench Details 1 and 3 and 50% requiring Trench Detail 2 as shown on the Pipeline Alternate Option Exhibits. Tree removal assumptions and estimated costs were provided by Mike Powers Forestry. Preliminary environmental survey's have identified approximately 37 potential creek crossing locations. It has been assumed that half of these crossings could be direct bury crossings and half would require above ground steel pipe crossings. Mainline valves have been included every 1,000 LF of pipeline. Air release valves and blow-off valves have been included as a percentage of total pipeline footage. Existing intake facilities have been cleaned and rehabbed, but not reconstructed. Allowances have been included for erosion control measures, possible rock excavation, geo-hazard mitigation and final restoration.

Alpine Summit Development, LLC

PROJECT: **5-Mile Raw Water Pipeline**
LOCATION: **Boulder Creek, CA**
ESTIMATOR: **AARON SMUD**
ESTIMATE DATE: **2/23/2022**

ESTIMATE INFORMATION

8.0 ESCALATION:

Given the Class 4 Estimate, Escalation have been considered part of project contingency

9.0 LABOR WAGE RATES:

Prevailing Wage Rates - January 2022

10.0 EQUIPMENT RATES:

Equipment rates used in the estimate are based on local DOT standard rates, or trade contractor rates

11.0 CONTINGENCY:

Please refer to summary table for Construction Contingency in this estimate

12.0 PHASING:

Given current project schedule no phasing allowance or cost is included within the estimate

13.0 BONDS:

We have included approximately 0.91% Bid Bond for the estimate
There is no bond included for any subcontractors or suppliers

14.0 OVERHEAD AND PROFIT

15% General Contractor overhead and profit is included within the estimate

Alpine Summit Development, LLC

PROJECT: **5-Mile Raw Water Pipeline**
LOCATION: **Boulder Creek, CA**
ESTIMATOR: **AARON SMUD**
ESTIMATE DATE: **2/23/2022**

ESTIMATE SUMMARY

CLASS 4 - OPINION OF PROBABLE CONSTRUCTION COST

DESCRIPTION	QUANTITY	UNIT	BASE BID COST	20% CONTINGENCY	40% CONTINGENCY
Peavine Pipeline Segment	6,820.00	LF	$ 6,776,390.00	$ 8,131,668.00	$ 9,486,946.00
5-Mile Pipeline Segment	29,280.00	LF	$ 26,530,594.00	$ 31,836,712.80	$ 37,142,831.60
Peavine Hydropower Facility	1	LS	$ 229,993.00	$ 275,991.60	$ 321,990.20
5-Mile Hydropower Facility	1	LS	$ 287,491.00	$ 344,989.20	$ 402,487.40
Bid Total	**36,100.00**	**LF**	**$ 33,824,468.00**	**$ 40,589,361.60**	**$ 47,354,255.20**

GENERAL NOTES:

A. All Indirect cost, insurance, bond and profit have been spread throughout the base bid items
B. Estimated allowance are included for rock excavation and trench stabilization
C. Estimated Allowance are included for potential Geo-Hazard Mitigation work

GENERAL EXCLUSIONS:

1. Permits, fees, engineering, and inspection cost
2. Remediation, treatment or disposal of contaminations.
3. Cost related to delays from weather, permits, or work schedule restrictions