Draft Preferred Trail Design

Table of Contents

Draft Preferred Trail Design 2
Northern On-Street Connection 4
Northern Steep Slope Connection 8
Central Waterline Road and Southern Steep Slope Connections 18
Southern On-Street Connection 22
Revegetation and Habitat Restoration 24
Data and Steps Needed for Detailed Trail Design 26

Table of Figures

Figure 1: Pedro Point Coastal Trail Connection Segment Map Layout 3
Figure 2: Northern On-Street Connection Trail Plan 5
Figure 3: Cross Section A-A - Before and After of Northern On-Street Connection 6
Figure 4: Cross Section B-B at ACE Hardware with Viaduct Design 7
Figure 5: Cross Section B-B at ACE Hardware with Retaining Wall Design 7
Figure 6: Northern Steep Slope Connection Trail Plan 9
Figure 7: Typical 8 Foot Trail Cross Section with Base Rock Surface 10
Figure 8: Typical 6 Foot Trail Cross Section with Base Rock Surface 10
Figure 9: Lime-Treated Base Rock Surface 12
Figure 10: Lime-Treated Base Rock Surface after Use and Weathering 12
Figure 11: Turn Cross Section and Plan with 8 Foot Trail and 12 Foot Radius 14
Figure 12: Turn Cross Section and Plan with 6 Foot Trail and 10 Foot Radius 15
Figure 13: Central Waterline Road Connection Trail Plan 19
Figure 14: Cross Section C-C - Existing Waterline Road Cross-Section with New Base Rock Trail Surface 20
Figure 15: Southern Steep Slope Connection Trail Plan 21
Figure 16: Southern On-Street Connection Trail Plan 23

Draft Preferred Trail Design

This report describes the proposed trail design based on feedback from the community, the Project Advisory Team and careful consideration by the consultant team.

The *Existing Conditions and Alternatives Analysis Report* section 7 presents layouts and design concepts for the trail segments, moving from north to south. The following report sections clarify or confirm the details of these concepts, focusing on the most challenging segment – the Northern Steep Slope Connection.

Figure 1 shows the trail connection segment map layout:

1. Northern On-Street Connection
2. Northern Steep Slope Connection
3. Central waterline Road Connection
4. Southern Steep Slope Connection
5. Southern On-Street Connection

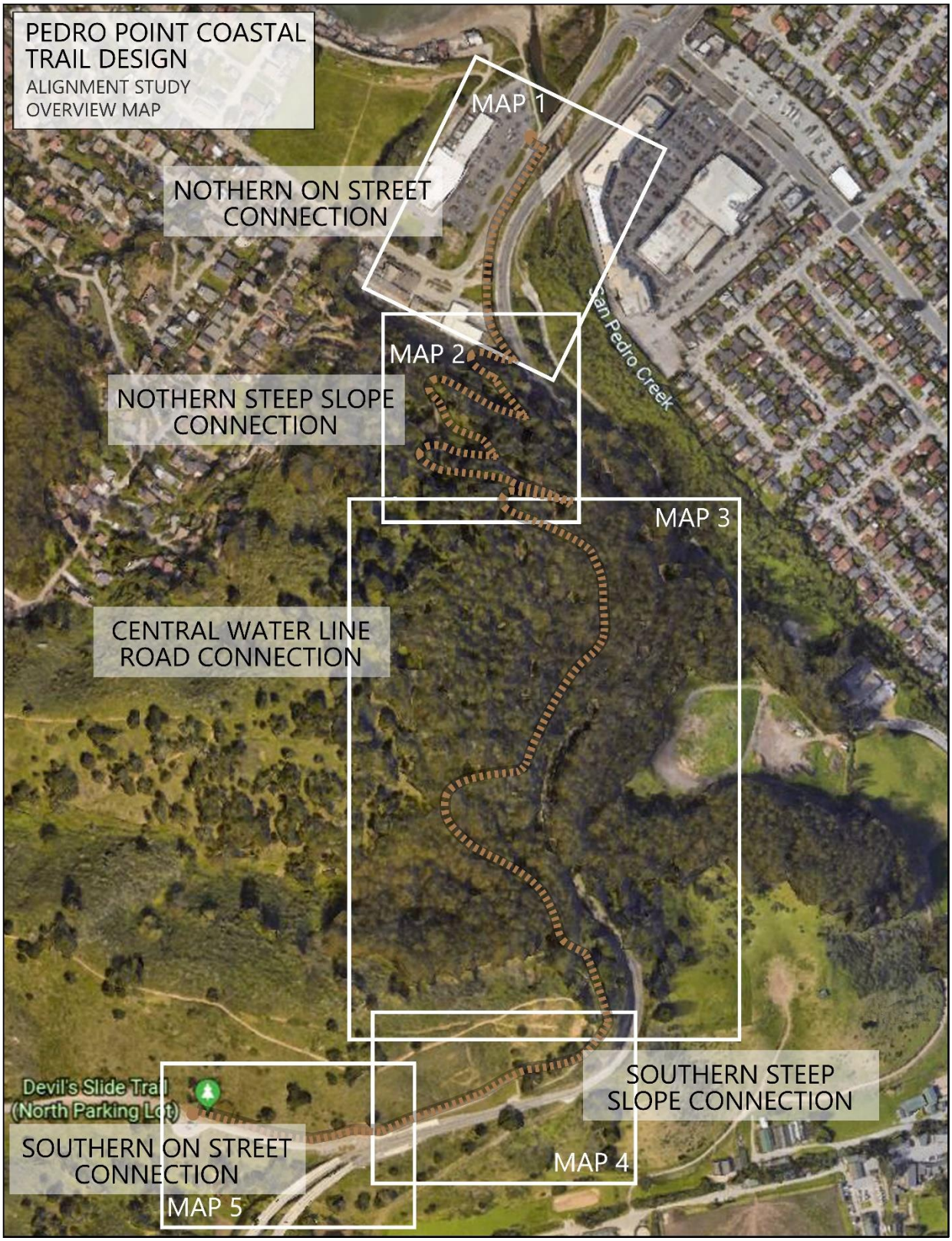

Figure 1: Pedro Point Coastal Trail Connection Segment Map Layout

Northern On-Street Connection

The Northern On-Street Connection (see Figure 2) will be a Class I paved ADA-compliant trail 10 feet wide with a maximum gradient of 5%, or 8.33% with 5 foot wide level landings provided every 30 feet, to meet Caltrans standards and urban Coastal Trail objectives.

The first portion of the trail is proposed to be built on the existing ground ("on grade") as shown in Figure 3.

The challenges of construction on the steep highway embankment will need to be resolved based on detailed survey, geotechnical investigations and analysis, and coordination with Caltrans. Retaining walls and related construction elements will be reinforced concrete, as Caltrans generally does not allow wood retaining walls and structures. There are two potential options currently envisioned. The section adjacent to ACE Hardware may be a viaduct design as illustrated in Figure 4, or a retaining wall as illustrated in Figure 5. The viaduct design is shown 7 feet wide and aligned with the approximate 3 foot wide concrete shoulder to create a 10 foot wide trail. This arrangement may be not be feasible due to the requirement for 5 foot square landings at regular intervals, unless the transition from the landings to the even grade of the concrete shoulder can be accommodated in the 2 foot space in between. The retaining wall design is shown as separate, which would simplify the design of the landings.

Caltrans is likely to require a fence between the highway proper and the trail. The design would be resolved in conjunction with detailed design and the encroachment permit process.

Some trail staging/parking area concepts near ACE Hardware are included in section 7 of the *Existing Conditions and Alternatives Analysis Report*. These are preliminary and weren't fully assessed. Further planning efforts through the City, including public and stakeholder input and parking and traffic studies will need to be conducted to resolve the parking design and related amenities.

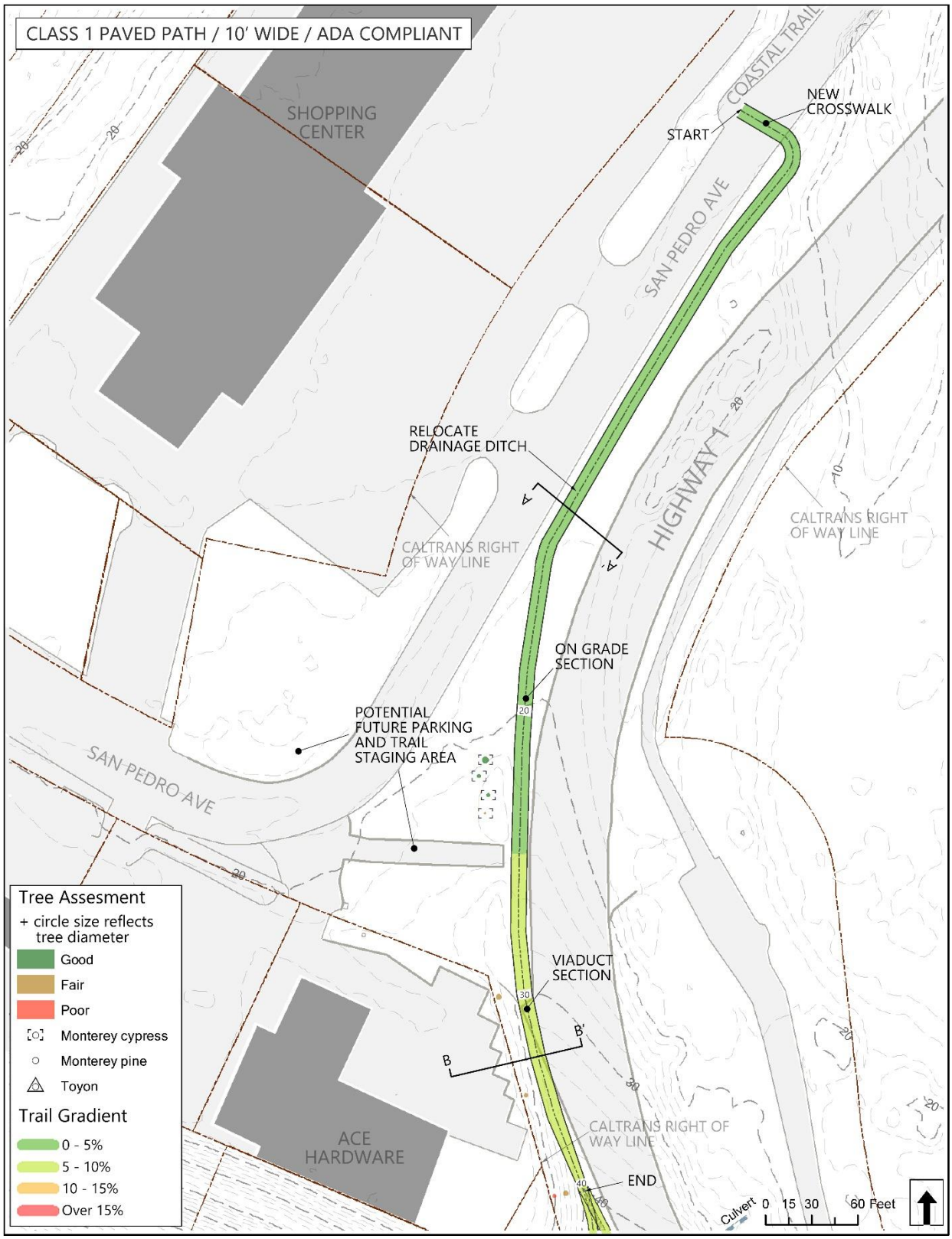

Figure 2: Northern On-Street Connection Trail Plan

Figure 3: Cross Section A-A - Before and After of Northern On-Street Connection

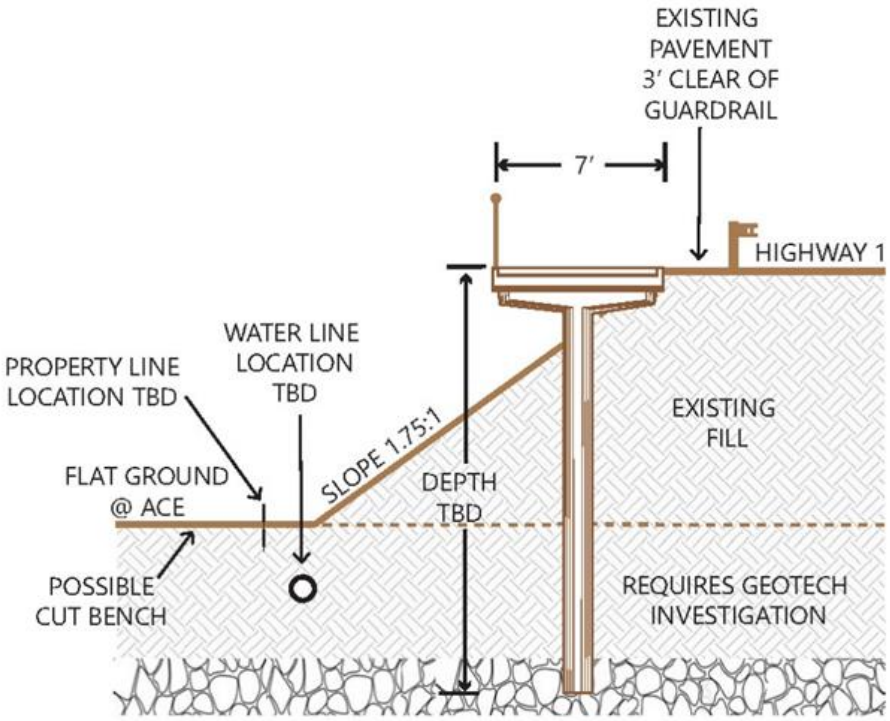

Figure 4: Cross Section B-B at ACE Hardware with Viaduct Design

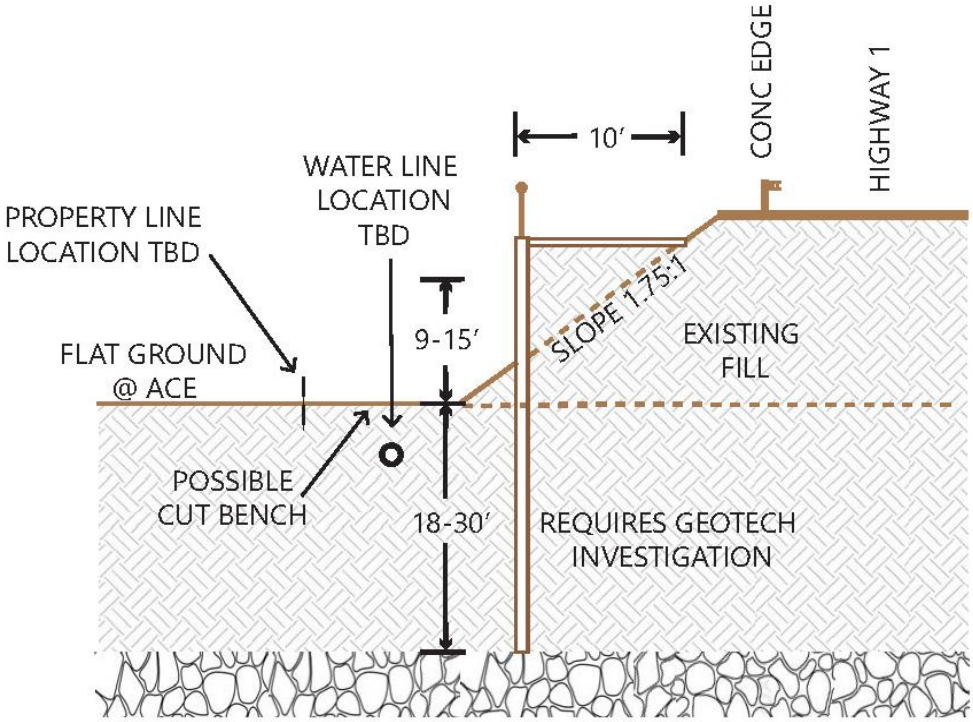

Figure 5: Cross Section B-B at ACE Hardware with Retaining Wall Design

Northern Steep Slope Connection

The Northern Steep Slope Connection is the most challenging portion of the trail, and the focus of the input and technical analysis. It is clear from community input that the preferred trail design falls close to Alternative 2 from the survey on the spectrum of alternatives. But the proposed specific design parameters in each category are influenced by the spectrum of input in each survey category (width, steepness, surface, etc.) The trail design seeks the best performance under each of the evaluation criteria and design features while recognizing the need for overall compromise (see the *Existing Conditions, Opportunities and Constraints Analysis Report* for more illustrations and descriptions of these features and their respective trade-offs).

Preliminary Plan. Figure 6 presents a refined version of the Northern Steep Slope Connection layout from the *Existing Conditions, Opportunities and Constraints Analysis Report*, with associated cross-sections and details that illustrate the proposed features. The plan shows alternative alignments, such as going into the cut slope above ACE Hardware (Alternative 1-1 on Figure 6) vs. extending into the Caltrans right of way (Alternative 1-2 or the southern turn on Figure 6). The latter is preferred because the cut slope above ACE Hardware is steeper than current grading ordinances allow, and the wall and any associated cuts and fills will need to be carefully engineered to ensure that their failure does not threaten the structure below. Construction above the highway must also be carefully designed, but the slopes on this alternative are much less steep.

Alternative 2-1 on Figure 6 shows an upper alignment that avoids stream crossings, while Alternative 2-2 includes two more crossings. The choice would be resolved based on more detailed topographic and geotechnical data. The trail alignment shown on Figure 6 makes use of the existing culverts where the waterline road crosses the central stream. Figure 6 also calls out a "control point" along the drainage where there is a berm intended to prevent drainage from running down onto the ACE Hardware property in the event the adjacent culvert was plugged. The trail must climb over this control point.

The precise preferred alternatives and alignment cannot be determined until the detailed data is obtained and the detailed design stage is undertaken.

Width – 6 feet wide minimum; 8 feet goal. The trail should be wide enough to accommodate multi-use by bicycles, hikers, equestrians, and people with dogs on leash. There is not an absolute standard for a multi-use recreational trail – it varies by agency and situation. For example, the Midpeninsula Regional Open Space District tends to build trails 5 feet wide, and a clear passing space width of 5 feet is the minimum standard per the federal recreational trail ADA access guidelines. Because of the dense trees and very steep slopes, trail width has a very significant impact on cost and habitat disturbance. Cost relates strongly to the extent of retaining walls which is directly related to the width of the trail as illustrated in the trail cross sections in Figures 7 and 8.

This trail connection is expected to be very popular and heavily used by many user types. The 6 to 8 foot constructed width would tend to have a 4 to 6 foot usable trail area, and is seen as a reasonable compromise for a multi-use trail in this constrained setting.

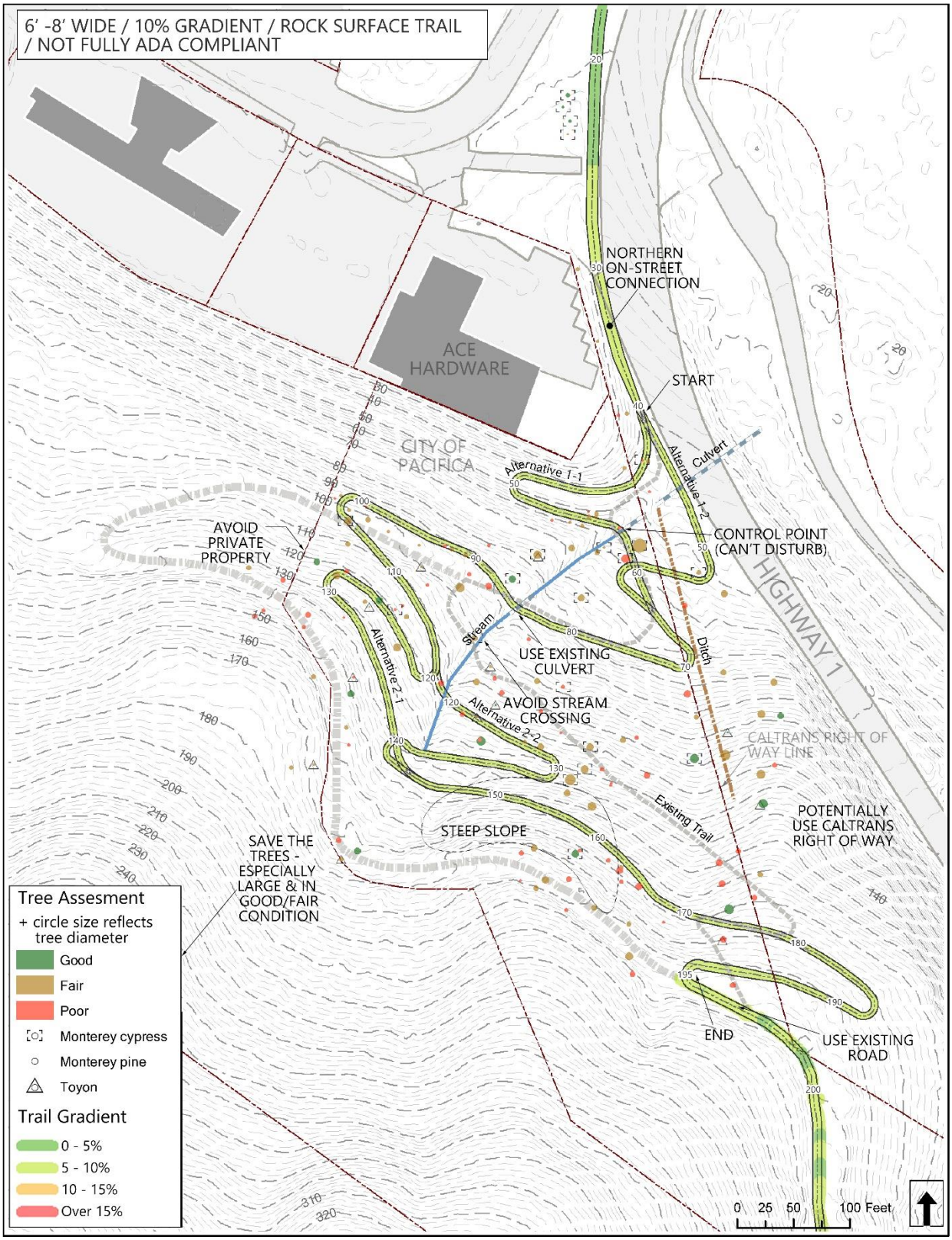

Figure 6: Northern Steep Slope Connection Trail Plan

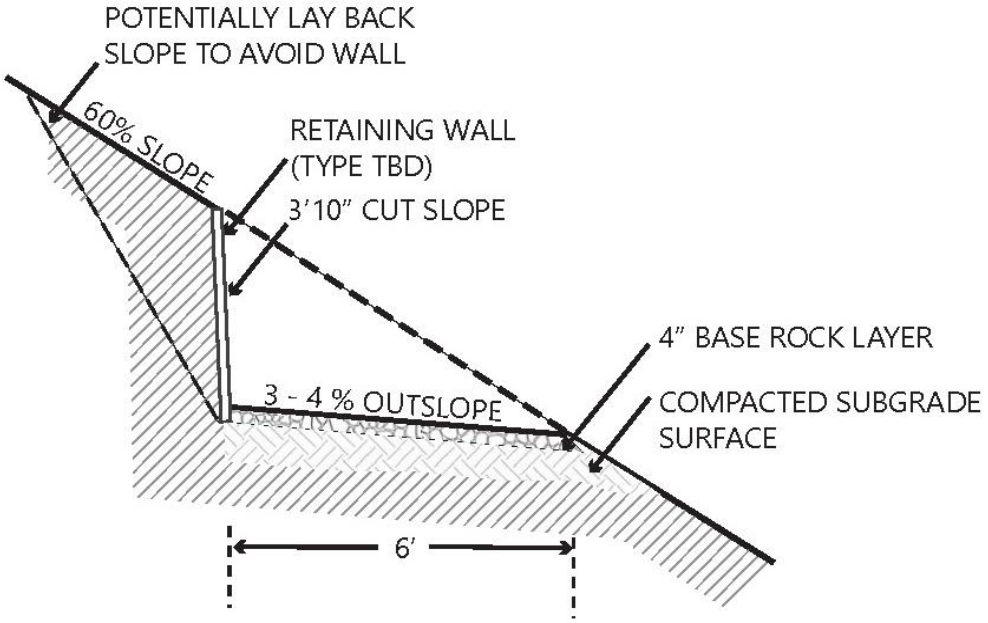

Figure 8: Typical 6 Foot Trail Cross Section with Base Rock Surface

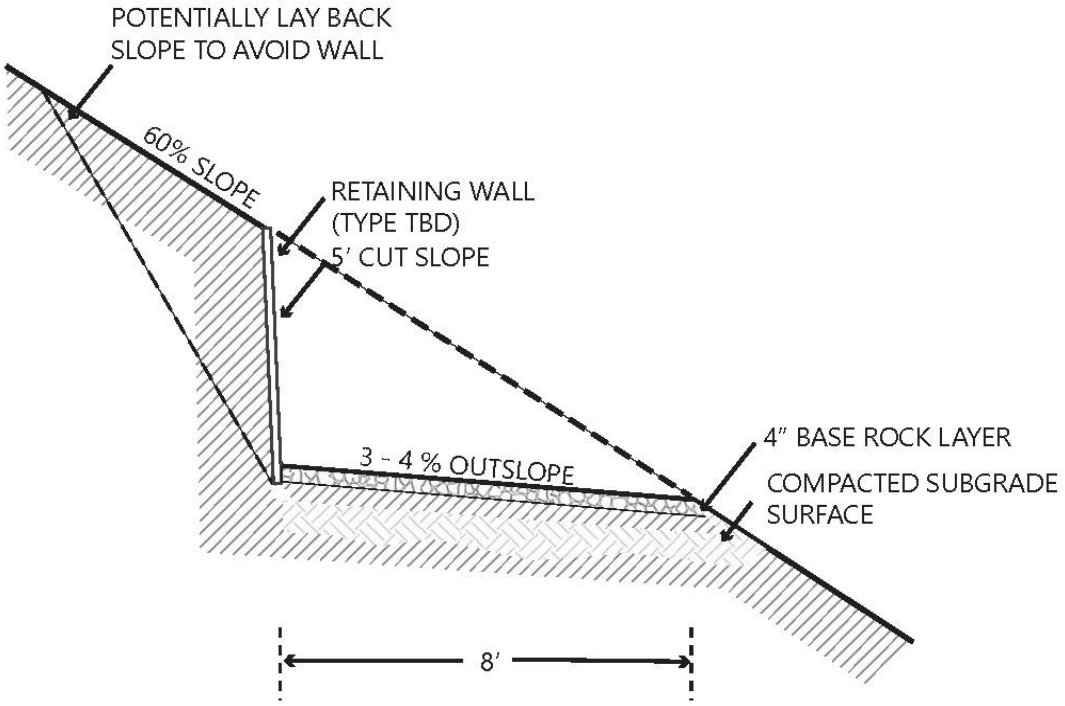

Figure 7: Typical 8 Foot Trail Cross Section with Base Rock Surface

Gradient – 10% design goal. For a recreational trail a 10% gradient design objective is a good rule of thumb, recognizing that some portions of the trail will be steeper than that as it follows local hillside contours and sub-drainages per trail design guidelines. Even if the trail gradient complied with the California Building Code ramp standard of 8.33% with 5 foot wide level landings every 30 feet, or the federal ADA standard of landings every 40 feet, people with physical disabilities (such as people using wheelchairs or walkers) are not likely to use the trail due to its significant overall length, long climb and remoteness. This gradient is a reasonable compromise between reducing the length, cost and impact of the trail, and accommodating a wide range of users.

Surface – compacted lime treated base rock. While many people would like a paved trail, most respondents preferred "natural." The cost difference and benefit reductions for paving in this case are discussed in the *Comparative Analysis* report. An improved surface that is compacted and relatively firm is a good compromise because it keeps the trail from getting muddy and accommodates a wider range of bicycles and other wheeled conveyances such as strollers, walkers and wheelchairs. "Hybrid" bicycles with wider tires could use it, and even road bikes with skinny tires if the surface is firm enough and they exercise caution. Some road bicyclists have stated that they would rather walk their bike up or down this segment rather than use the adjacent winding portion of Highway 1 that has no shoulders. Such a surface also blends in more in a natural setting than asphalt or concrete.

Midpeninsula Regional Open Space District has had good success on their access roads using a special base rock mixture, with smaller sized rock than the standard road base mixture, and treated with lime to help it bind and compact (see Figure 9). This could be installed with much less subgrade preparation than pavement. It would be much less expensive at the outset (on the order of a fourth to a third the cost of asphalt pavement) but it would require more annual maintenance. Figure 10 shows an Open Space District road after a few years of wear, including use by cattle (similar to horse impacts). This surface would not be as smooth and stable as asphalt and would be more challenging/uncomfortable for some users (i.e. people using strollers or wheeled walkers) but given the inevitable long steep climb on the Northern Steep Slope Connection the benefits of paving for access are reduced. This lime-treated base rock mixture is a reasonable compromise given the significant cost savings compared to asphalt.

Figure 9: Lime-Treated Base Rock Surface

Figure 10: Lime-Treated Base Rock Surface after Use and Weathering

Drainage Design. The design of drainage for the trail must respond to the type of surfacing. A base rock surface is more irregular than paving and will become rougher as it wears and weathers. This requires more significant drainage features – "drain dips" built into the trail at regular intervals. These will create short sections of trail steeper than the 10% average

Alignment – use all available property to minimize turns/switchbacks and avoid multiple stream crossings. Participants recognized the significance of constructing trails, and especially turns, on steep slopes, and the undesirability of repeated crossings of the central natural drainage. Both of these issues could be minimized by using the maximum space available to route the trail, potentially including the cut slope above ACE Hardware and/or parts of the Caltrans right of way, though utilizing these areas requires verification of feasibility and design requirements though geotechnical testing and permission from Caltrans to use their right of way (which is required in any case for the Northern On-Street portion and the Southern Steep Slope portion).

Avoid stream crossings. From an environmental impact standpoint, stream crossings should be avoided. Ultimately the trail layout must be resolved based on more detailed surveying and more complete geotechnical information so there may be other factors that warrant stream crossings.

Take advantage of the existing water line road as much as possible. Most of the water line road is below 10% gradient except the northwest portion, which goes onto private property and gets steeper than 15%. The goal is to use the maximum amount of the public portion that is below 10% and minimize building a parallel trail to connect to it.

Climbing turns rather than switchbacks – limit width and radius to reduce wall height. Climbing turns are desirable rather than sharp switchbacks to allow bicycles to negotiate the turn. Figures 11 and 12 illustrate the impact of turn radius and trail width on the height of walls. A centerline radius of 12 feet is considered desirable to accommodate bicycles, but if the trail was 8' wide the overall outside dimension of the turn would be 32 feet, plus width of retaining walls. On slopes as steep as 60% gradient this would mean cuts and fills/retaining walls 7.75 feet high (about 8 feet with some margin) on a 60% slope – and some of the slopes in the corridor are even steeper – i.e. 67% or 20 feet of elevation in 30 feet horizontal. Taller walls would be exponentially more expensive and more intrusive in the natural environment.

For every 2 feet the radius and/or trail width was reduced it would save approximately a foot in retaining wall height – for example as illustrated in Figure 12 a 10 foot radius turn with 6 foot wide trail would require a 6.25 foot retaining wall, plus margin. The final decision should occur in conjunction with more detailed design, based on geotechnical testing and more specific site survey and analysis.

While it is desirable to minimize turns to reduce disturbance and cost, a benefit from frequent turns is that they help to control bike speed. The drain dips that are required for the base rock surface tend to function as "speed bumps" in the trail to help constrain bike speed, but speed limits and trail courtesy signage are important to help manage bike speed and yielding on a shared use trail.

Minimize "stacked" trail segments. When the trail doubles back on itself it creates more visual disturbance of the setting, is likely to take out more trees, and tends to incline some users to cut the corners. It isn't possible to completely avoid stacking, but it should be minimized.

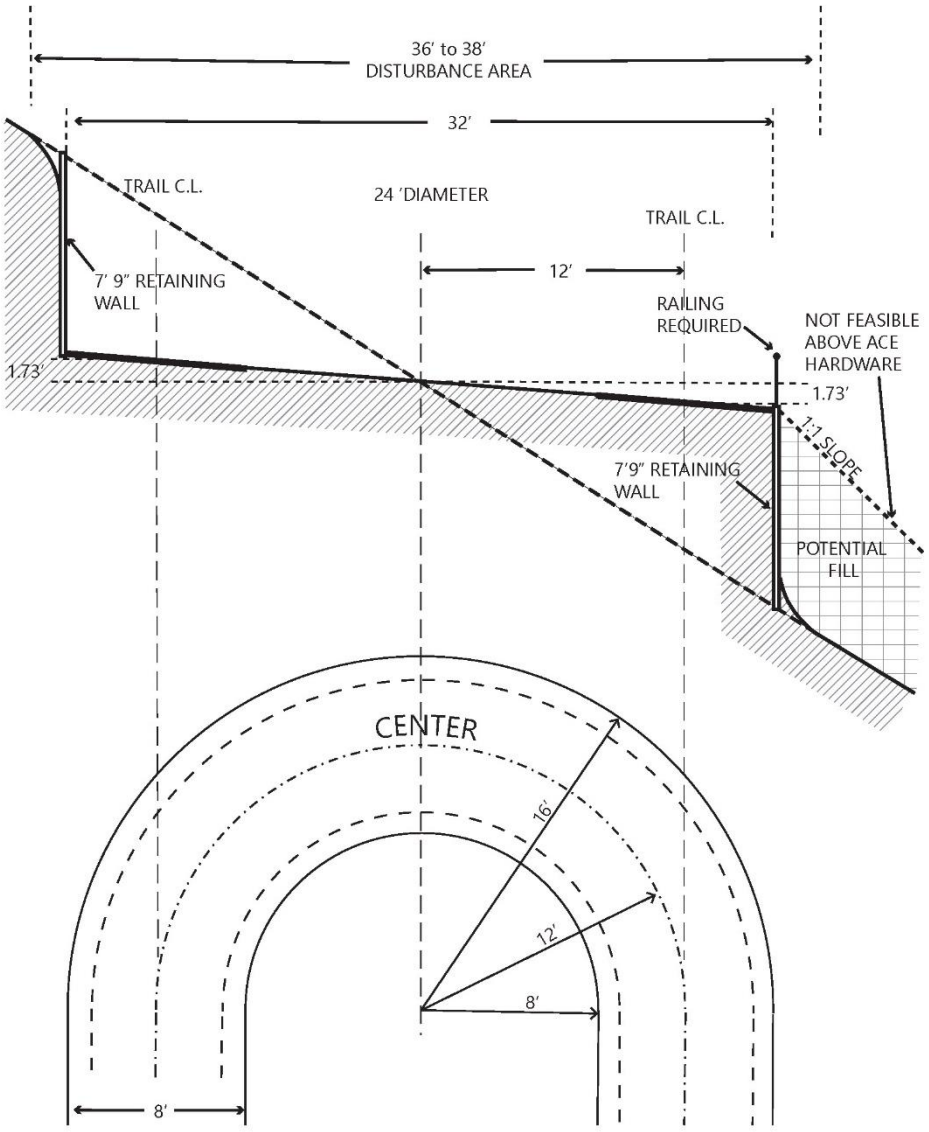

Figure 11: Turn Cross Section and Plan with 8 Foot Trail and 12 Foot Radius

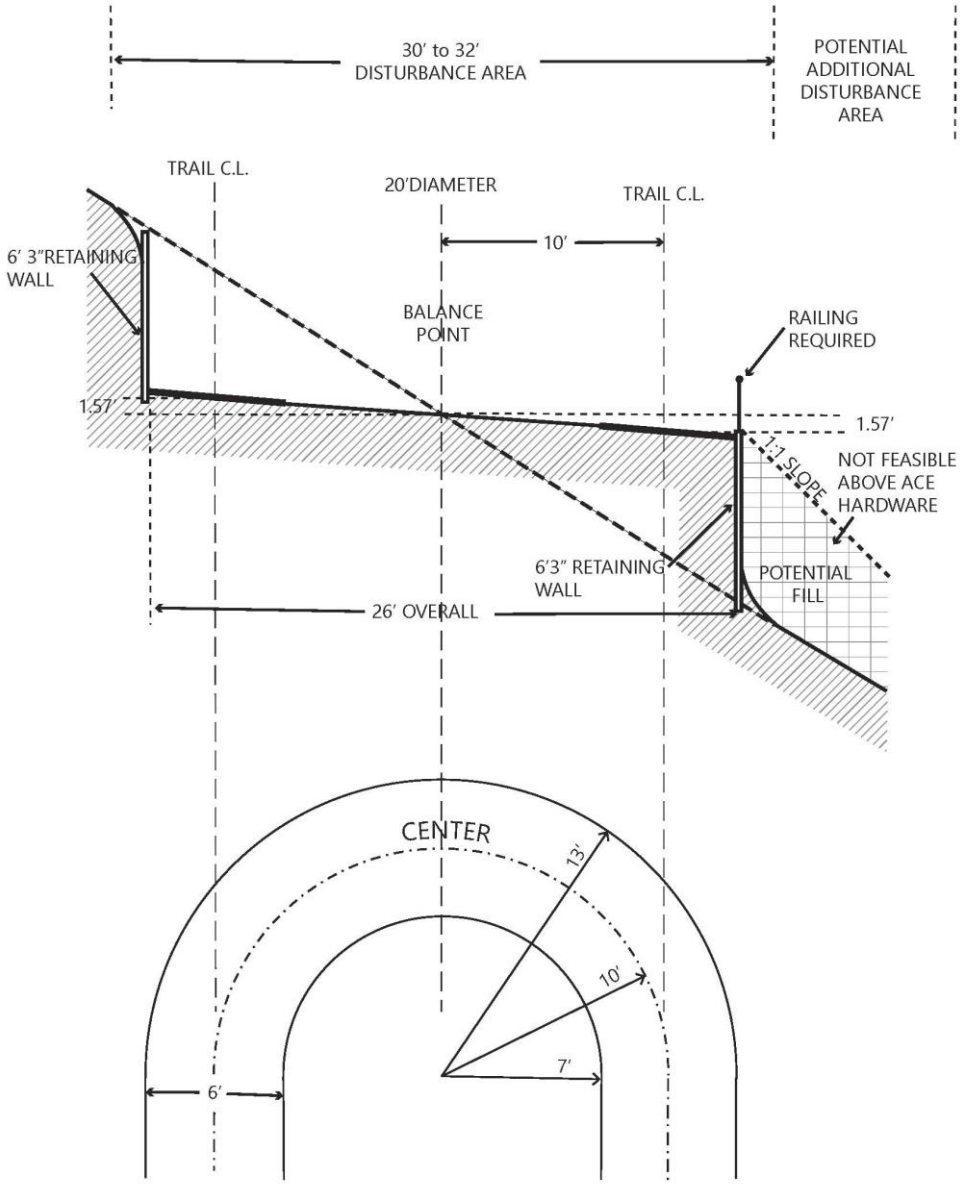

Figure 12: Turn Cross Section and Plan with 6 Foot Trail and 10 Foot Radius

Drainage and ditch crossings – small trail bridges or embedded culverts. Trail bridges are preferred on natural drainages because they involve less disturbance, but they require more maintenance. Embedded oversized culverts (usually double-walled ABS plastic) are placed below the stream or ditch bottom and then partially filled so there is a continuous natural drainage surface. These usually have rock headwalls and are filled over to create space for the trail. The specific design can't be pinned down until the detailed design and permitting stage. Crossings of the natural drainage are intended to be minimized but doing this plus minimizing turns and avoiding steep slopes by using the maximum available property means more crossings of existing ditches.

Save as many trees as possible. Some trees would inevitably have to be removed for the trail. The smaller and poorer condition trees identified by the consulting arborist would be removed in preference to the larger healthier trees (though the trees are not native to the site, people still love them). In conjunction with the tree removal there will also be removal of the native understory plants. The overall objective is to find a balance between a trail that accommodates the most user types and preserving the experience of a natural forested setting. Generally, arborists recommend staying out of the drip line of trees to avoid impacting them, but this won't be feasible with so many trees. The more practical guideline may be to stay some multiple of the trunk diameter (i.e. 4x) away from the base of the tree. The specific recommended multiple should be resolved during more detailed design.

Retaining walls – use timber or rock walls to blend into the natural setting. Public survey and outreach responses supported a more natural trail appearance. A significant extent of retaining walls will be needed for the Northern Steep Slope Connection, and timber or rock walls would blend better into the forest setting than concrete and are likely to be less expensive. Types of timber and rock walls are discussed below, along with considerations for wall design, potential opportunities to avoid the expense of walls and factors that may require or justify concrete walls in some areas.

Timber wall types. Stacked timber walls, supported by vertical steel beams, are frequently used on "backcountry" trails because the components can be brought in on the trail as it is constructed and because they tend to blend in more to the natural setting than concrete or concrete masonry unit (CMU) walls. The actual wall design would be resolved at the more detailed design stage.

> Sutter walls. These timber walls are designed with "tie-backs" driven horizontally into the cut slope to support the steel beams. The beams have relatively shallow embedment below the trail surface. These are known as "Sutter Walls" after a contractor who popularized them. But the thin soils and dense bedrock observed on the site may not be suitable for driving in such tie-backs.
>
> Soldier Pile Walls. The alternative would be a similar "soldier pile" wall that has the steel beams embedded in concrete deep enough in the subgrade to retain the wall without tie-backs, using heavier drilling rigs.

Stacked rock walls (less than 3 feet high). Rock may be practical for walls up to 3 feet high, such as transitions to taller walls and separation between the trail legs at turns. They are by their nature un-engineered.

Engineered (4 feet or higher) vs. un-engineered (less than 4 feet) walls. Where walls are 4 feet or higher they typically are required to be engineered – formally designed to support the slope based on geotechnical data. This increases the cost of design and construction, because the wall tends to be more robustly designed. "Un-engineered" walls under 4 feet high can be much less expensive. Retaining walls on a trail are often designed with less assurance against failure, because there is less risk presented by their failure, and the cost of rebuilding them may be much less than the added cost of designing them to be assured that they won't fail.

Special wall requirements in proximity to highway or structures. In some locations timber or rock walls may not be practical or permitted. For trail segments on the slope above ACE Hardware or in the Caltrans right of way retaining walls and associated cuts and fills must be carefully engineered to ensure against failure, potentially requiring a different wall design, such as concrete. The specifics would be determined in later design stages.

Concrete masonry unit (CMU) walls (for lower part of turns). These stacked masonry unit walls have geotextile retaining mats layered into the backfill behind them. CMU walls are practical on the downslope side of climbing turns where they can be buried provided the slope isn't too steep. Placement of such fill would not be feasible on the steep cut slope behind ACE hardware, for example. This fill slope would increase the initial disturbed area and potentially cause tree removal, though it would be replanted with native plants and trees.

Cut slopes with no walls (where cut slopes are low and/or stable). Depending on site-specific geotechnical data and the willingness of the project sponsors to accept the risk, the less high trail cut slopes could be laid back at a 1:1 angle or even a 1:2 angle with no retaining wall. This is often practiced on "back country" trails, and the near vertical cut slopes on the waterline road have held up well, so it may be a viable option. This would increase the disturbed area width, removing more vegetation and potentially trees.

Central Waterline Road and Southern Steep Slope Connections

The preferred 8 foot wide base rock surface for the Northern Steep Slope portion of the route would continue on the existing Central Waterline Road portion (see Figure 13). The existing road section does not have the challenges of very steep cross slopes, climbing turns or requirement for retaining walls.

The road averages about 14 feet wide. The 8 foot wide improved base rock surface should be located toward the cut side of the road, as illustrated in Figure 14, because the fill side is less stable and more likely to crack or subside. This does increase the risk that if the cut bank fails it will impact the trail, but these cut banks have generally held up well over the years. The installation of this surface will require earthwork across the road so that the added surface does not create a ridge that blocks cross-drainage. Some cross-drainage improvements would be required.

Formalizing this segment as a public trail will also would require permission to cross a corner of private property near the north end of the segment. This segment would provide connection to existing trails in the Pedro Point Headlands Preserve, including the Arroyo Trail and the South Ridge Trail, and would pass near to the Pacifica Land Trust restoration work staging area.

The Southern Steep Slope Connection (see Figure 15) does cross steep side slopes, but the proposed trail from the existing waterline road to the end of the existing paved road-width trail (built in conjunction with the Devils Slide tunnel improvements) would be almost level, and would be similar to the cross section shown in Figure 7.

These segments are/will be less steep than the Northern Steep Slope Segment, so travel from the south will be more accessible than access from the north for users who are challenged by long steep slopes.

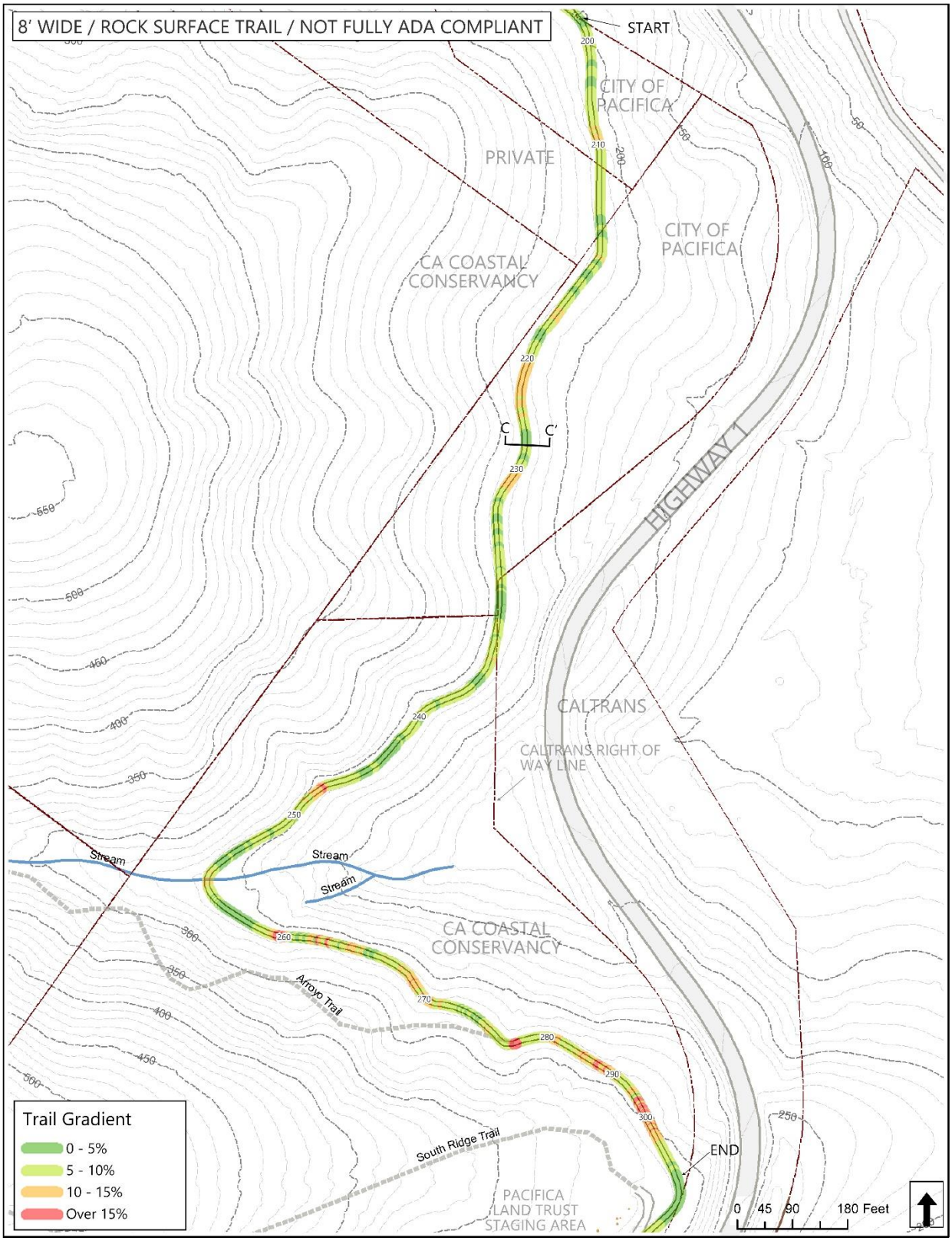

Figure 13: Central Waterline Road Connection Trail Plan

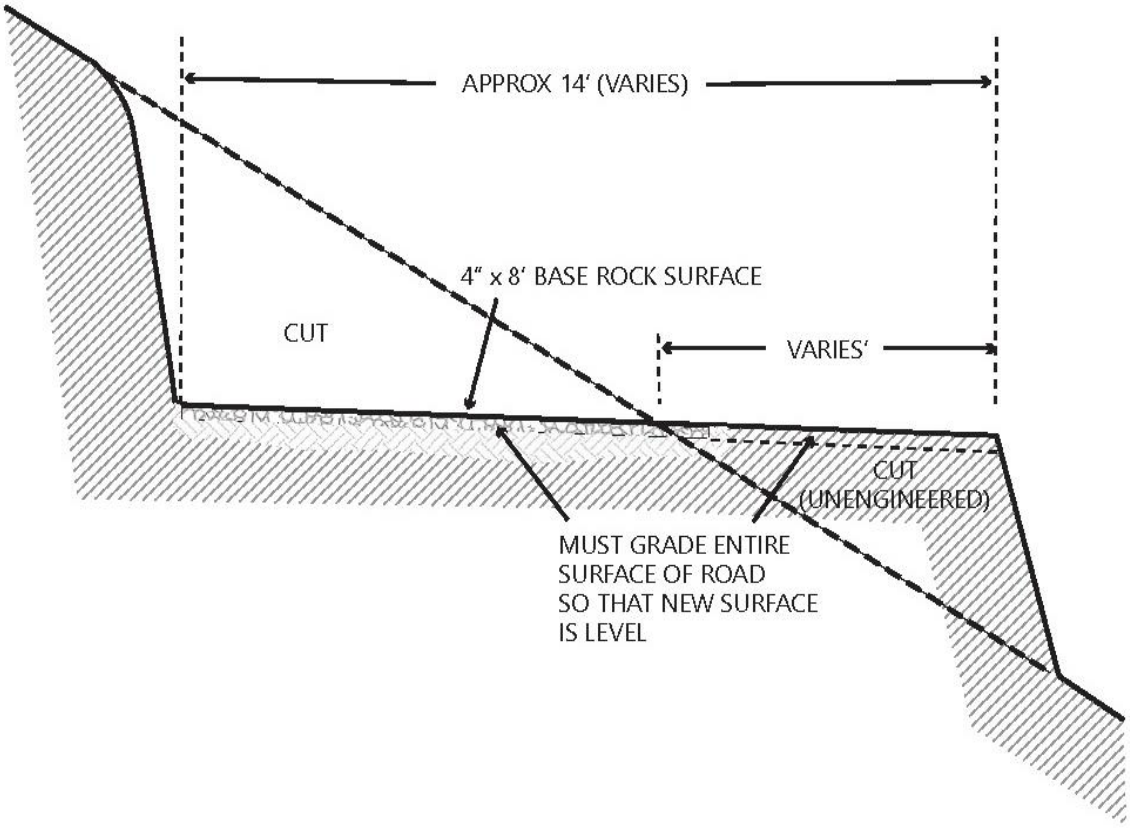

Figure 14: Cross Section C-C - Existing Waterline Road Cross-Section with New Base Rock Trail Surface

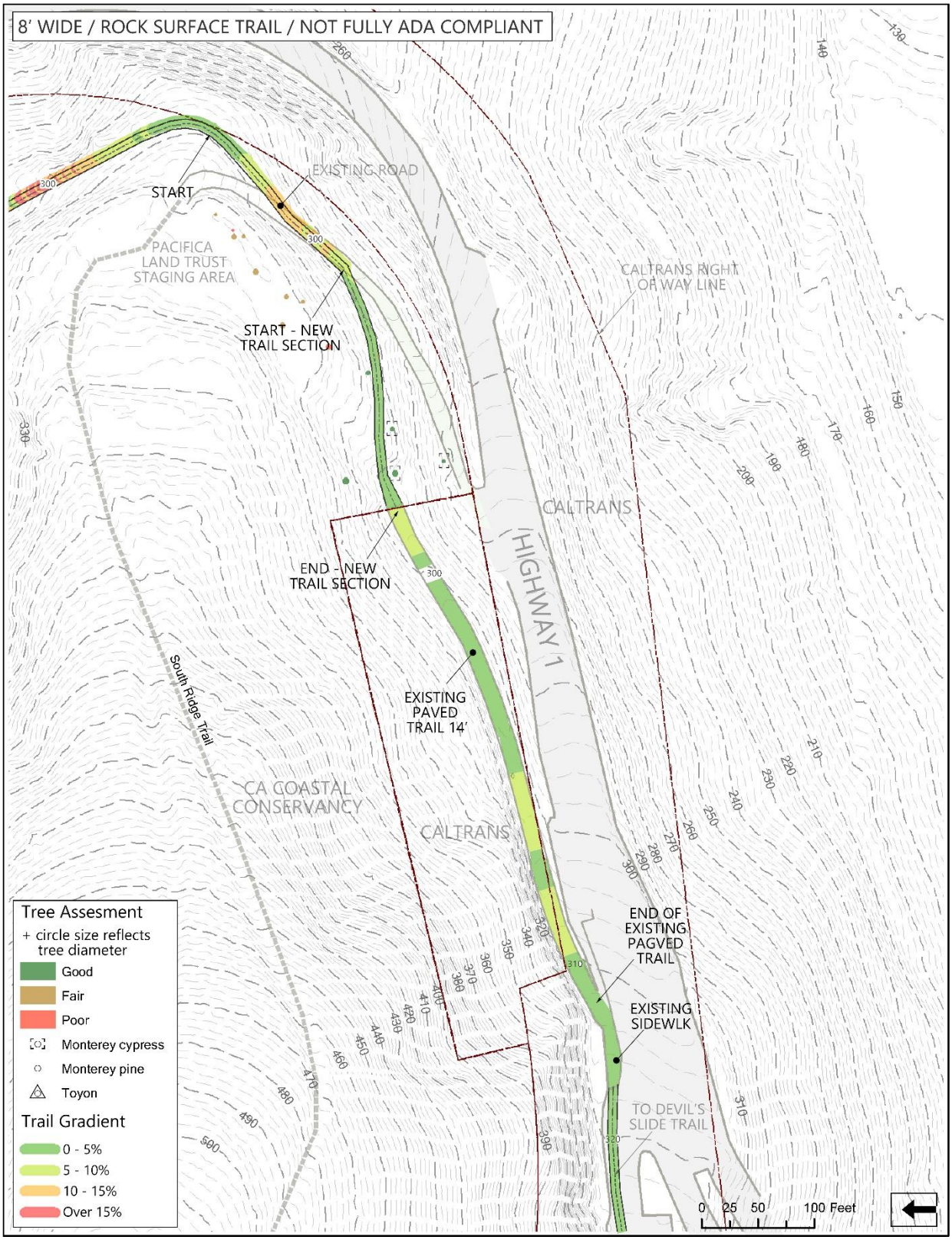

Figure 15: Southern Steep Slope Connection Trail Plan

Southern On-Street Connection

The southern on-street connection will be potential improvements to existing sidewalks, crosswalks and pavement striping improvements to bike and pedestrian routes along the access road to Devils Slide Trail parking, as shown in Figure 16 and discussed in the *Existing Conditions and Alternatives Analysis Report*. These improvements depend on acceptability to Caltrans and San Mateo County Parks and probably can't be resolved in detail until later stages of design.

Figure 16: Southern On-Street Connection Trail Plan

Revegetation and Habitat Restoration

One of the objectives of the project and the overall Headlands Management Plan is to restore habitat disturbed by construction and generally improve native habitat quality. The project biologists recommend the following measures, reflecting experience with habitat restoration including the Pillar Point Bluffs, the Cowell-Purisima Coastal Trail and the Cloverdale Ranch:

Erosion Control Seeding. Areas disturbed by trail construction should be seeded with a native seed mix for erosion control and to aid in natural restoration of the cut/fill slopes. A non-invasive non-native grass, such as cereal barley or wheatgrass hybrid could be added to the seed mix to aid in plant cover during the first year. The suggested seed mix in listed in Table 1. If the seed is hydroseed on the disturbed areas, wood mulch, binder and fertilizer should be applied. This can also apply to other areas of disturbance, and areas where native plantings are sought to replace non-native habitat.

In addition to the seed application, it is recommended that duff from the adjacent forested areas be collected and spread onto the hydroseeded areas. The forest duff can hold native seeds and nutrients that can aid in forest recovery.

Table 1. Erosion Control/ Forest Recovery Seed Mixture

Common Name and Botanical Name		Application
California Brome	*Bromus carinatus*	10 lbs./acre
Blue Wild Rye	*Elymus glaucus*	25 lbs./acre
Western Fescue	*Festuca occidentalis*	4 lbs./acre
Blue Bunch Fescue	*Festuca idahoensis*	4 lbs./acre
Deerweed	*Acmispon glaber*	11 lbs./acre.
Common Yarrow	*Achillea millefolium*	2 lbs./acre
Tomcat Clover	*Trifolium wildenovii*	4 lbs./acre
Sterile Barley or Sterile Wheat	*Hordeum vulgare Triticum X Elymus "Regreen"*	50 lbs./acre.
Forest Duff		Minimum 1-inch thickness

Container Stock Planting. Areas disturbed by trail construction, other areas of disturbance, and areas where native plantings are sought to replace non-native habitat can also be planted with container stock trees, shrubs and subshrubs. Container stock planting presents some challenges as the plantings will require supplemental irrigation in Years 1-3. A water tank could be installed at the top of the hill and plants irrigated with a gravity-fed drip system or the plantings could be hand-watered. The plantings would also need to be protected from animal browse (deer) with above-ground wire cages. Plantings will need to be installed in areas that will not pose visibility issues at switchbacks. If trees are installed at trail switchbacks, tree limbs may need to be

limbed-up over time to provide visibility around the switchback. Table 2 presents a plant palette that would be compatible with the pine/cypress forest.

Table 2. Plant Species Suitable for Revegetation of Disturbed Areas

Common Name and Botanical Name	
TREES	
Coast Live Oak	*Quercus agrifolia*
Red Elderberry	*Sambucus racemosa*
Hazelnut	*Corylus cornuta*
SHRUBS AND SUBSHRUBS	
Wood Rose/ CA Rose	*Rosa gymnocarpa/ Rosa californica*
Thimbleberry	*Rubus parviflorus*
California Blackberry	*Rubus ursinus*
HERBACEOUS PLANTS	
Sword Fern	*Polystichum munitum*
Spreading Rush	*Juncus patens*
CA Bee Plant	*Scrophularia californica*
CA Aster	*Symphyotrichum chilense*
Mugwort	*Artemisia douglasiana*

Data and Steps Needed for Detailed Trail Design

The Draft Preferred Trail Design is as well resolved as is feasible based on the preliminary data available for this study. The following data and design steps are necessary to confirm and finalize the design.

Topographic and boundary surveying. The base data used for these preliminary plans includes survey data from the 2009 Kennedy Jenks plan that covered a limited area within the forested northern steep slope segment. That survey located the trees and indicated their size and species, but the consulting arborist HortScience warned that such surveys often have errors regarding the trees. The arborists carefully identified the tree species, size and condition, and used Geographic Positioning Systems (GPS) to locate them, but these locations are not necessarily highly accurate.

The rest of the study area, including the surrounding portion of the northern steep slope, used lidar-generated topography with 2 foot contour intervals. Airborne LIDAR (Light Detection And Ranging) is an optical remote-sensing technique that uses laser light to densely sample the surface of the earth, producing highly accurate x,y,z measurements. But with significant tree and vegetation cover the LIDAR topography can be inaccurate – some of it lined up with the 2009 survey contours, but some contours were off as much as 10 feet.

In addition to obtaining accurate topography and tree locations the property boundaries need to be accurately located within the trail corridor. There are also buried and above ground utilities in the trail corridor (particularly a buried water line that extends to the Devils Slide Tunnel) that need to be accurately located as a basis for detailed design.

Design in AutoCAD Civil 3D. With the accurate boundary, topographic, tree and utility information the project can be designed in AutoCAD, which is necessary for efficient generation of alignments, disturbance and grading areas and quantities, profiles and cross-sections.

Geotechnical testing. Geotechnical testing of the soils and underlying geology is necessary to determine the design requirements and acceptable risk of constructing the trail, especially in proximity to the highway and Ace Hardware structures.

Confirmation of trail in Caltrans right of way. The trail connection at the north end including the segment past Ace Hardware must occupy the Highway 1 right of way, so an encroachment permit from Caltrans will be necessary to build the trail. These sections can and will be designed to be Class I paved trails that are ADA compliant, which Caltrans requires. But the proposed northern steep slope connection cannot meet these standards. It will need to be determined if, and how much, Caltrans will allow this recreational trail design to extend into their right of way.