

D Transportation/Traffic

Harbor Coastal Trail Traffic Analysis



Prepared for the
County of Sonoma



Submitted by

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Introduction

Introduction

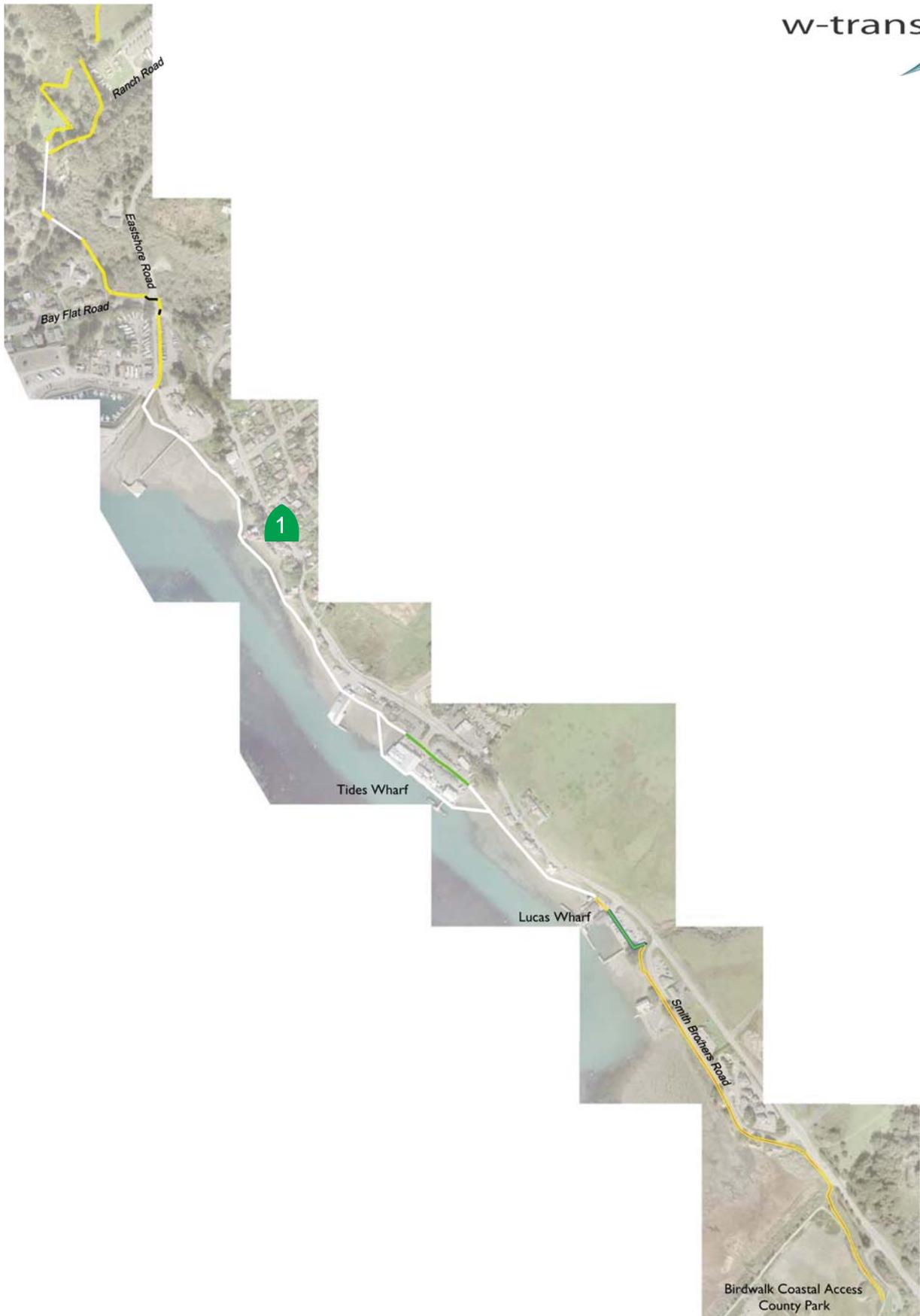
This report presents a traffic analysis of the proposed primary and alternative routes for a Class I Bikeway/Shared Use Path which would be part of the Harbor Coastal Trail project in the community of Bodega Bay in the County of Sonoma. The focus of this analysis was on the safety of bikeway street crossings, parking area crossings, roadway intersections and street frontages, together with the identification of essential traffic control devices. The traffic study was completed in accordance with the criteria established by the County of Sonoma, and is consistent with standard traffic engineering techniques.

Project Description and Study Locations

The Harbor Coastal Trail project is intended to create approximately two miles of Class I shared use trail along the town of Bodega Bay's east harbor shoreline, extending north of Bodega Bay from State of California parklands near State Route 1 (SR 1) and Ranch Road, to the south of town near Bird Walk Coastal Access County Park, which is south of Smith Brothers Road, as shown in Figure 1.

Several proposed and alternative routes are identified in the Harbor Coastal Trail Aerial Topographic Site Map/Exhibit A, Proposed Pathway and Alternative Alignments. The following locations were evaluated for this study:

- Eastshore Road/Bay Flat Road intersection
- Eastshore Road from Bay Flat Road to roadway terminus 450 feet south
- SR 1 between Bay Flat Road and Smith Brothers Road
- Tides Wharf parking lot
- Lucas Wharf parking lot
- Smith Brothers Road
- SR 1 between Smith Brothers Road South and Bird Walk Coastal Access County Park



Evaluation Criteria

Design Standards

The study locations include private parking lots, local streets and intersections, and a street owned and maintained by the State of California Department of Transportation (Caltrans). The distinction between state and local facilities is important because Caltrans may wish to apply California *Highway Design Manual* design criteria while the County of Sonoma typically applies American Association of State Highway and Transportation Officials (AASHTO) criteria. These criteria differ for shared use path design elements such as design speed and the minimum separation between multi-use paths and streets, as well as others. Of the study street segments, SR 1 is within state jurisdiction and Eastshore Road and Smith Brothers Road are local streets.

State of California Bicycle Facility Standards

Consideration was given to the possibility that Class I facilities might not be feasible everywhere within the project limits, especially where modifications such as eliminating numerous parking spaces or extensive removal of landscaping along SR 1 would be untenable. Therefore, Class II Bikeways (bike lanes) and Shared Lane Markings (SLM) were also considered. All three types of bicycle facilities are defined in the *California Manual on Uniform Traffic Control Devices (CA-MUTCD)* dated January 21, 2010, with specific design parameters provided in the *California Highway Design Manual, 6th Edition (HDM)*. Additionally, the *American Association of State Highway and Transportation Officials Guide for the Development of Bicycle Facilities (AASHTO Guide)* provides detailed guidance on the design of bicycle facilities, with extensive details provided for the design of shared use paths.

Class I Bikeways/Shared Use Paths

Class I Bikeways/Share Use Paths are intended to be shared by bicyclists and pedestrians, constructed of all-weather surfaces, typically a minimum of eight feet in width (though ten feet is preferred), and separated from adjacent streets by an open space at least five feet in width or equipped with a barrier. The AASHTO Guide and the HDM include more specific recommendations on the design of this separation area, including a two-foot minimum graded area in order to provide clearance from obstructions such as signposts, delineators, and drainage inlets. The remaining separation area is intended to prevent path users from unintentionally entering the street travel way and to reinforce the concept that the path is an independent facility. If a barrier is used, AASHTO recommends a minimum height of 42 inches, while the HDM lists 54 inches as the minimum path barrier height. A summary of some of these dimensions is included in the AASHTO Guide figure shown in Plate 1.

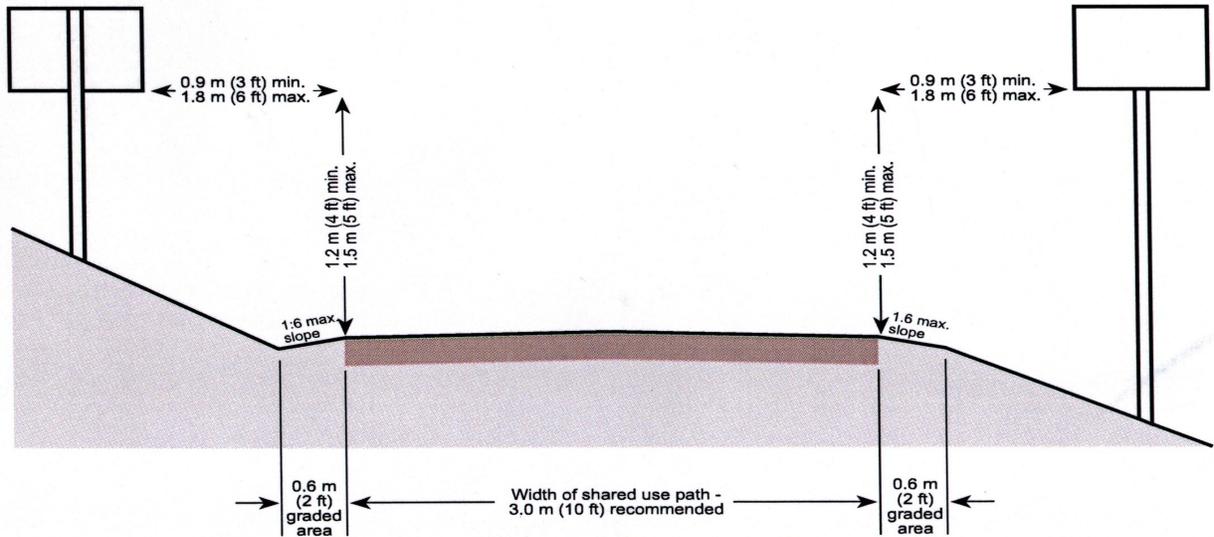


Plate I Cross Section of Two-Way Shared Use Path on Separated Right-of-Way

A design speed of 20 miles per hour (mph) for bicycle travel is recommended. For example, the AASHTO Guide indicates that a 20-mph design speed should be used “even though bicyclists can travel faster than this to do so would be inappropriate in a mixed-use setting.” The HDM provides additional design parameters and recommendations. For example a maximum path gradient of five percent is recommended. Two other design recommendations address path curve radii and sight distance, as follows: assuming a 20-mph design speed, a minimum curve radius should be slightly less than 90 feet; and stopping sight distance on a five percent descending grade path should be nearly 120 feet. Furthermore, the vertical clearance to obstructions across the clear width of the path should be a minimum of eight feet, though ten feet is desirable. It should be noted that the HDM also includes recommendations for design speeds as low as 15 mph on bike paths, with additional signing, striping or widening improvements recommended where right-of-way or topography constraints limit the feasibility of using higher design speeds.

Class II Bikeways

Class II bikeways (bike lanes) are for the exclusive use of bicyclists, are constructed within a roadway travel way, and are usually located between the closest vehicular travel lane and the parking lane on both sides of the street. The standard width of a bike lane is five feet where adjacent to curbs and four feet where no curb exists, though wider bike lanes are preferred, especially on high-speed or high-volume roadways.

The deployment of bike lanes was considered for Smith Brothers Road due to the possibility of topography constraints along the west side of the street combined with a low volume, low speed roadway.

Additional Bikeway Design Standards

Intersection Treatments

In accordance with HDM and AASHTO Guide recommendations, bicycle path intersections and approaches should be on relatively flat grades and adequate warning given to permit bicyclists to stop before reaching the intersection, especially on downgrades. When crossing a street the crossing should occur either at the pedestrian crossing, where motorists can be expected to stop, or at a location

completely out of the influence of any intersection to permit adequate opportunity for bicyclists to see turning vehicles.

Lighting

Fixed-source lighting reduces conflicts along paths and at intersections. In addition, lighting allows the bicyclist to see the bicycle path direction, surface conditions, and obstacles. Lighting for bicycle paths is important where riding at night is expected, at street intersections, through underpasses or tunnels, and when nighttime security could be a problem.

Existing Conditions

Traffic Volumes

Traffic volumes for the study roadway segments were researched or developed for use in evaluating traffic patterns and collision rates. Counts for SR 1 were obtained from the Caltrans website, with data from Year 2009 available at the time of the analysis. Counts for the remaining study roadway segments were unavailable from a search of County records, so volumes were estimated based upon engineering judgment and comparison to adjacent SR 1 traffic volumes. The following average daily traffic volumes (ADT) were used:

- SR 1 – 6,100 vehicles per day (vpd)
- Eastshore Road – 1,500 vpd
- Smith Brothers Road – 1,500 vpd

Collision History

The collision history for the study area was reviewed to determine any trends or patterns that may indicate a safety issue. Collision rates were calculated based on records obtained from the California Highway Patrol and published in their *Statewide Integrated Traffic Records System (SWITRS)* reports. The most recent three-year period for which records are available includes 2007 through 2009.

There were no collisions reported at the study intersection of Bay Flat Road/Eastshore Road, nor were there any on Smith Brothers Road or Eastshore Road within the study segments, though there were 20 reported collisions along SR 1 between Bay Flat Road and Smith Brothers Road (south). The calculated collision rate for this study roadway segment is 2.85 collisions per million vehicle miles traveled (c/mvm) which is more than twice the statewide average collision rate for a similar facility, or 1.21 c/mvm.

Since this is a significant difference further review was performed. Of the 20 crashes reported, 15 occurred during daylight hours, only four were attributable to unsafe driving speed, and none involved pedestrians or bicyclists. However, approximately half of the collisions involved a vehicle either turning onto or off the road at driveways and intersections, or a vehicle stopped prior to such a turn. This could be attributable to the higher-than-average number of unfamiliar drivers such as tourists who may be concentrating on finding a destination adjacent to the roadway and be distracted from driving. Such a pattern is considered unsafe for all road users but especially bicyclists or pedestrians who are unprotected. It would be best to separate these users to the maximum extent practicable in these circumstances.

Evaluation

The following seven locations were identified for inclusion in this evaluation. In addition to these specific locations, a general evaluation of the Harbor Coastal Trail use is also provided.

Locations

General

Project Proposal

It is assumed that the proposed trail is to consist of a shared use path wherever feasible. Given its proximity to the California coast and the urbanized community of Bodega Bay, it is anticipated that the shared use path would be used by pedestrians, joggers, skaters, strollers, and cyclists. All ages and ranges of these users would be expected, including children, adults, seniors and disabled path users. In addition, large maintenance vehicles would be expected to access the trail given its location in a saltwater climate. Furthermore, it is understood that a continuous path is an important project objective and meeting this objective will require that some segments be constructed at steep grades, or grades greater than five percent.

Recommendations

The variety of path uses and users is expected to cause path congestion, to the extent that pedestrians may congregate along the tidelands segments, taking photographs or standing to admire a view. Such activities will block the paths of pedestrians and cyclists, traveling in both directions, creating a potential conflict. If not adequately addressed in the path design, some cyclists would be expected to elect not to use the path, resulting in a decreased use of the path, while others would use the path but not as carefully as necessary under such constrained conditions. The following recommendations would ensure a safe two-way travel facility as intended:

- The path should provide a ten-foot travel width wherever possible together with turnouts or bays for pedestrians to stop at the 'vista' segments, such as those to be located within tidelands areas. The wider path and pedestrian bays will allow northbound and southbound users in motion to maintain reasonably unimpeded flows.
- The path should be equipped with various guide signs and warning signs. For example, an SG 60 post office guide sign should be installed near the Bodega Bay Post Office to alert tourists to the presence of the post office on Smith Brothers Road. Other SG series tourist-oriented guide signs may be appropriate, including near the wharfs, at the south end of the project near the Bird Walk Coastal Access County Park, and further north near the state park lands in the vicinity of Ranch Road. Similarly, various warning signs, including *W7-5 Hill*, *W11-2 Pedestrian Crossing*, and *W2-1 Intersection Ahead*, should be installed on the path as needed to warn cyclists and pedestrians of steep grades, each other, or of nearby motor vehicle crossings.
- Two-way travel is not always understood by shared use path users which can lead to conflicts as faster moving cyclists attempt to pass slower moving cyclists or pedestrians. A dashed centerline stripe is recommended to impart this concept of two-way travel to all path users.

Intersection of Eastshore Road/Bay Flat Road

Existing Conditions

The intersection of Eastshore Road/Bay Flat Road is a two-way stop-controlled intersection, with the

north- and southbound legs stopped. The eastbound approach is uncontrolled and there is no westbound approach as the fourth leg is a one-way outbound travel lane for Bay Flat Road. There is an existing street light on the northwest corner and bike lanes striped on southbound Eastshore Road and on both sides of Bay Flat Road west of the intersection, though the bike lane markings are faded. The Eastshore Road southbound approach has a descending grade which likely contributes to a higher approach speed than the other two intersection approaches.

Project Proposal

The proposed shared use path alignment provides two crossings at this intersection including a crossing of Eastshore Road on the north side of the intersection and a crossing of Bay Flat Road on the east side of the intersection, as shown in Figure 2.

Recommendations

North side approach and crossing

The path on the northerly approach extends from higher elevation state park lands near Ranch Road to the intersection within the northwest quadrant, essentially creating a fifth approach to the intersection. The southbound path approach is estimated to be a minimum five percent grade along its 150-foot parallel alignment on the north side of Bay Flat Road, though it appears to be steeper further north. Several improvements are necessary to ensure southbound bicyclists can approach and cross the two public streets safely, which are shown in Figure 2 and described as follows:

- A *W1-1 Turn Warning* sign should be installed for southbound cyclists on the path north of Bay Flat Road in advance of the 90-degree turn. A *W7-5 Hill Warning* sign should also be installed for southbound trail users north of Bay Flat Road where the path appears to be steeper than a five-percent grade. These signs would caution fast-moving cyclists to reduce speeds as they approach this intersection.
- The path should be separated from the adjacent parallel bike lane on westbound Bay Flat Road to meet state standards by adding a fence, landscaped barrier, or five-foot wide open space. If only open space or landscaping is provided some wall or fence should be installed in the 90-degree path turn to prevent southbound bicyclists from entering the roadway.
- Existing landscaping along both roads in the northwest quadrant of the intersection should be removed to ensure adequate corner sight distance for both southbound road users and eastbound path users.
- Stop signs, stop legends and a limit line should be installed on the path at its approach to the intersection. The approach should be as close to perpendicular to southbound Eastshore Road as possible, and the crosswalk should be located as close to the intersection as possible to ensure all intersection users are aware of the presence of entering traffic.
- Both crosswalks should be enhanced with continental markings to elevate the crossing visibility. In addition, *W11-1 Bicycle Warning* and *W11-2 Pedestrian Crossing* signs should be placed on southbound Eastshore Road and eastbound Bay Flat Road to alert drivers to the shared path crossings in the intersection.
- Street lighting should be provided to illuminate the crosswalks, with one streetlight placed to illuminate the crossing of Bay Flat Road and two streetlights placed to illuminate the crossing of Eastshore Road, including one on either side of the street.



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Eastshore Road & Bay Flat Road Proposed Improvements
 Figure 2

East side approach and crossing

The proposed path alignment extends from the harbor along northbound Eastshore Road to the intersection of Eastshore Road/Bay Flat Road, crossing in a new crosswalk on the east side of the intersection, continuing into the northeast quadrant of the intersection and aligning with the northerly crosswalk discussed above. There are two path segments on this approach, including the approach to the Bay Flat Road crosswalk in the southeast quadrant and the approach to the Eastshore Road crosswalk in the northeast quadrant. Both segments appear to be located in fairly flat terrain and in close proximity to the approaching drivers' views. Several improvements are recommended to ensure northbound bicyclists can safely approach and cross both streets at this intersection, which are shown in Figure 2 and described as follows:

- The geometry of this intersection appears to limit sight distance between northbound cyclists and eastbound motorists. Since these motorists are not required to stop, it may be necessary to add stop controls on the eastbound approach. It may be possible to increase sight distance by trimming existing landscaping on the southwest corner, eliminating the need to change the intersection controls.
- There are two street crossings for northbound bicyclists, including the crossing of Bay Flat Road and the crossing of Eastshore Road. Stop signs, stop legends and a limit line should be installed on the northbound paths at both of these approaches.

Eastshore Road from Bay Flat Road to its terminus 450 feet south

Existing Conditions

Eastshore Road is a narrow two-way roadway south of Bay Flat Road, with approximately 16 to 20 feet of pavement and an additional 12 to 18 feet of unimproved flat terrain on the east side of the street. The road functions as a cul-de-sac and terminates in an area with four 'driveways' though it is unclear where the public road right-of-way ends. It provides access to commercial and residential land uses, including a parking lot on the east, a vacant restaurant on the southeast, and the Porto Bodega Marina on the southwest and west. This segment of Eastshore Road functions as a low-volume, low speed local street.

Project Proposal

The proposed path alignment extends along the east side of Eastshore Road in the unimproved flat area, from its intersection at Bay Flat Road to its terminus 450 feet south, as shown in Figure 2. The road appears to have sufficient right-of-way to accommodate a ten-foot wide path and five-foot buffer area. It is understood that the proposed alignment south of this segment includes crossing a one-lane bridge and continuing along on a newly constructed path above the shoreline or tidelands.

Pedestrians can walk two or more abreast and would be expected to do so routinely in a setting such as the Harbor Coastal Trail where being outdoors and enjoying the harbor views will be popular. However, the path is also expected to function as a travel way for cyclists, including fast-moving commuters.

Recommendations

This project segment is to be constructed parallel to an existing road with good sight distance, low travel speeds, no street crossings and few driveway crossings, making it a good location for alternative

modes of travel. The following traffic improvements shown in Figure 2 are recommended to provide guidance:

- If not already existing, street name guide signs reading “Bay Flat Road” and “Eastshore Road” should be installed at the intersection of Bay Flat Road/Eastshore Road for path user location guidance.
- Install R9-7 *Shared Use Path Restriction* signs facing both travel directions, with one approximately 100 to 200 feet south of the Bay Flat Road/Eastshore Road intersection for southbound path users and one approximately the same distance north of the bridge crossing for northbound path users. Such signs permit pedestrians to walk side-by-side but also inform them of their responsibility to stay to the right when other path users are present.

SR 1 from Bay Flat Road to Smith Brothers Road

Existing Conditions

State Route 1 consists of two 12-foot travel lanes and narrow shoulders within this segment, and the review of the collision history of SR 1 indicated a much higher than average collision rate for a similar facility.

Project Proposal

There are several alternative pathway alignments being considered for this vicinity, including a westerly alignment along the tidelands, a combination of tidelands/parking lot alignments, or some combination of these and a pathway or bike lanes adjacent to SR 1 near the Lucas Wharf property.

Recommendations

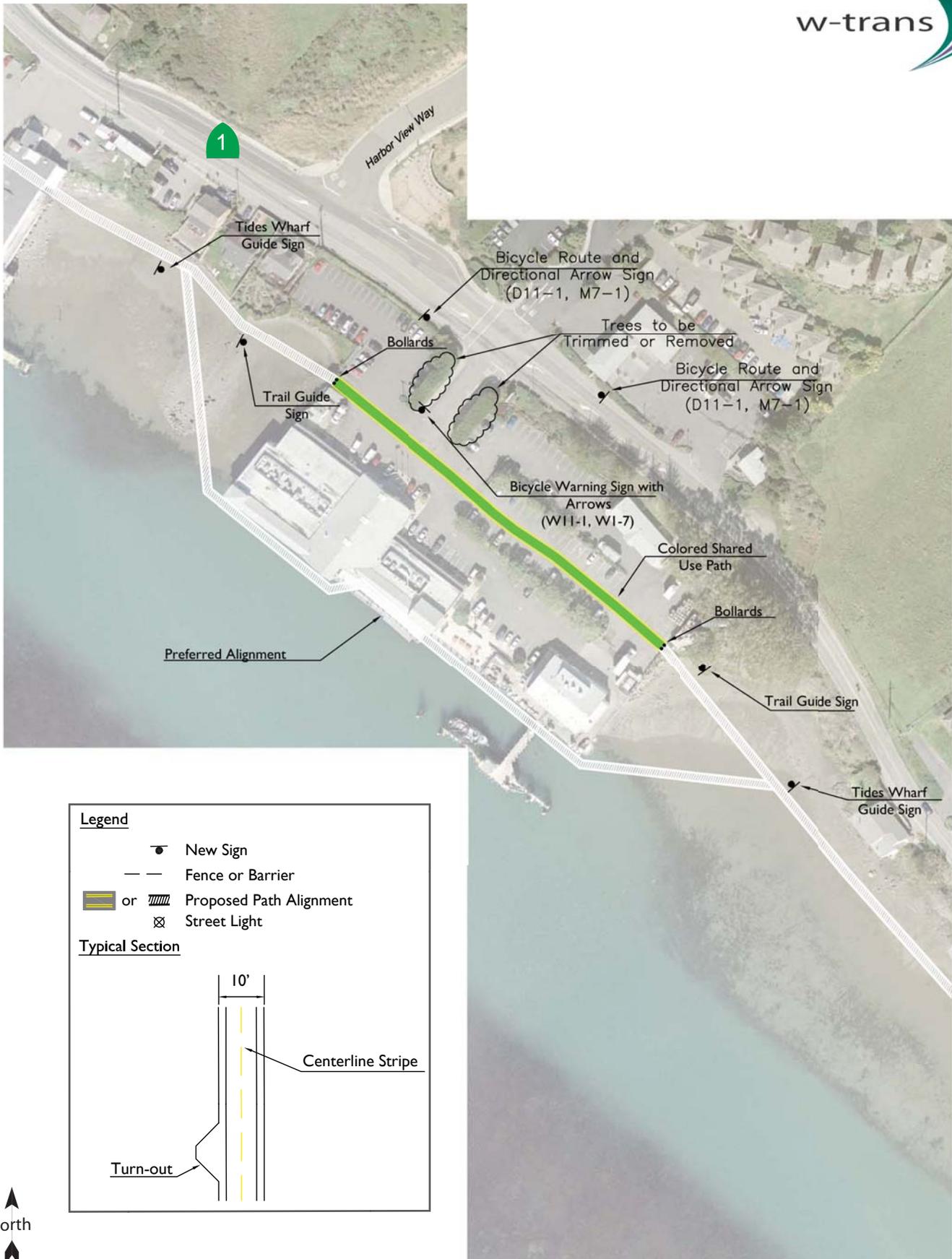
Following are recommendations which are also shown in Figure 3:

- Due to the high rate of collisions on SR 1 within the study segment bike lanes or a shared use path are not recommended in this location. The collision pattern could be attributable to distracted drivers and maintaining a maximum degree of separation between motorists and path users along the state highway is recommended.
- Bicyclists would be expected to continue to use SR 1 to travel through Bodega Bay and it is recommended that they be provided on-roadway bicycle guide signs in both travel directions to alert them to the project trail, including a *D11-1 Bike Route* sign and *M7-1 Directional Arrow* sign. For southbound cyclists, these signs should be placed north of the SR 1/Eastshore Road intersection, the Tides Wharf site, the Lucas Wharf site, and both SR 1/Smith Brothers Road intersections. For northbound bicyclists similar signing should be placed just south of these intersections and sites. Such signing will provide guidance to conveniently and safely access the shared use path.

Tides Wharf

Existing Conditions

The Tides Wharf is a popular tourist destination and local commercial business center, generating numerous vehicle trips by familiar and unfamiliar drivers. Access to this wharf is via a single driveway on SR 1, with an estimated grade between five- and ten- percent. It is bounded by trees and shrubs which obstruct sight distance across the parking lot and also of traffic entering and exiting the driveway. The driveway is approximately 95 feet in length and 36 feet in width and consists of three 12-foot lanes,



including a single inbound lane and two outbound lanes, which provides for a dedicated right-turn lane and a shared left-turn/through lane.

The Tides Wharf parking lot is the largest parking lot along the east side of the harbor, providing an estimated 150 to 200 parking spaces. At the height of tourist activities parking demand likely exceeds the parking lot supply, resulting in a queue of vehicles circling through the parking lot looking for available spaces and/or stopped in the parking lot drive aisles.

Pedestrian activity is also expected to be high in the parking lot as motorists make their way to and from their vehicles for a view of the harbor or to access the stores. Parking is prohibited near the main building entrance which helps to improve visibility of pedestrians congregating near the building entrance. Overall, the interaction of pedestrians and motorists in this parking lot would be expected to be somewhat chaotic, with slow travel essential to maintain safe pedestrian passage.

Project Proposal

There are two alternative pathway alignments being considered for this vicinity, including a westerly alignment along the tidelands or a pathway through the parking lot.

Recommendations

As shown in Figure 3, recommendations for the alignment and traffic controls are described as follows:

- The tidelands alignment is recommended rather than the parking lot alignment. If the path were aligned along the tidelands there would be minimal interaction necessary between path users and parking lot users. Separating these users would be safest for bicyclists and pedestrians, and also the most convenient for the motorists who would be expected to be anxious if delayed by a bicyclist/pedestrian when trying to obtain a parking space during a peak parking demand period.
- If the tidelands alignment is constructed, the path should be designed and equipped with the recommended improvements listed in the 'General' section above.

If the tidelands alignment is infeasible, then the following improvements are recommended to ensure bicyclists can safely approach and cross the Tides Wharf parking lot:

- The shared use path through the parking lot should be marked with a colored or textured surface treatment. This will provide strong guidance to the path users that the path actually continues through the parking lot (as opposed to discontinuing or terminating). Since signs would obstruct the path of motorists traveling throughout the parking lot, the pavement markings must provide all the necessary guidance. These markings could be blue or green colored pavement with white painted edge lines, or a textural treatment such as a stamped asphalt concrete brick pattern, or actual pavers or bricks. It is essential that the treatment contrast with the other parking lot surfaces, including the marked parking spaces, drive aisles and disabled parking areas. It is also important that the path width be maintained, for continuity.
- At the two approaches to the parking lot the path should be equipped with custom guide signs that indicate that the path continues through the parking area and continues beyond. A symbol sign is preferred over word signs.
- Stop signs and limit lines should be installed on the path as close to the parking lot intersections as possible. Adequate stopping sight distance should be provided for the path users to allow bicyclists to stop before reaching the parking lot. A relatively flat grade, two percent or less, should be provided on these approaches.

- Bike lanes should *not* be installed in the parking lot drive aisles because these imply exclusive cyclist use which is inconsistent with the parking lot operations.
- Bollards should be installed across the shared use path/parking lot intersections to prevent motorized traffic from using the path beyond the limits of the parking lot.
- A combination of warning signs should be installed along the Tides Wharf driveway to alert inbound motorists to the shared use path crossing, including the *W11-1 Bicycle Warning* sign and the *W1-7 Two-Way Arrow Warning* sign.
- Lower tree branches should be removed and tall shrubs trimmed to improve sight distance along the driveway. No landscaping should be taller than 12 inches or lower than three feet in these planting areas.

Lucas Wharf

Existing Conditions

Lucas Wharf is similar in land use to the Tides Wharf business but on a smaller scale. It is a popular tourist destination and local commercial business center, with access via a single steep driveway on SR 1. The driveway has low landscaping which is helpful in allowing good sight distance to the parking lot upon entering, though the Lucas Wharf sign and sign posts partially obstruct sight distance to the south. The driveway is approximately 50 feet in length and 40 feet in width and consists of one inbound and one outbound lane.

The Lucas Wharf parking lot provides an estimated 70 parking spaces. At the height of tourist activities parking demand would be expected to exceed the parking lot supply, likely resulting in a queue of vehicles circling through the parking lot looking for available spaces and/or stopped in the parking lot drive aisles.

Pedestrian activity is also expected to be high in the parking lot as motorists make their way to and from their vehicles for a view of the harbor or to access the stores. Parking is prohibited near the main building entrance which helps to improve visibility of pedestrians congregating near the building entrance. Overall, the interaction of pedestrians and motorists in this parking lot would be expected to be somewhat chaotic, with slow travel essential to safe pedestrian passage.

The path is proposed to continue south of Lucas Wharf within or along Smith Brothers Road westerly right-of-way.

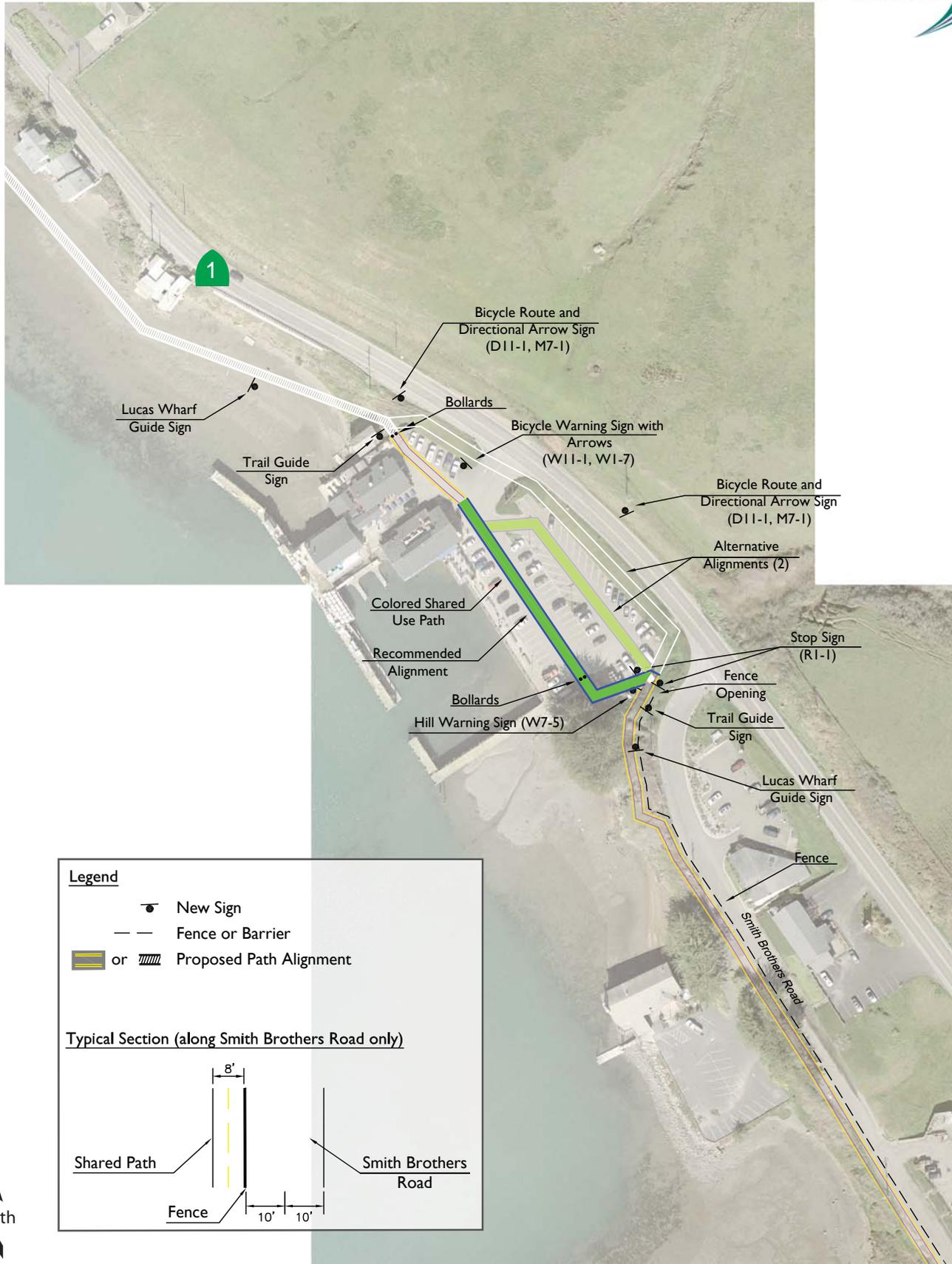
Proposed Improvements

There are two alternative pathway alignments being considered for this vicinity, including a central alignment through the parking lot and an easterly pathway adjacent to SR 1.

Recommendations

As shown in Figure 4, recommendations for which alternative to choose and also what improvements should be made for each alignment choice include:

- The parking lot alignment is recommended rather than the alignment adjacent to SR 1. If the shared use path were aligned through the parking lot there would be greater separation between path users and highway traffic, and maintaining a maximum degree of separation between the motorists and path users along the state highway is recommended.



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State Route I, Lucas Wharf & Northerly Smith Brothers Road

Proposed Improvements

Figure 4

The following improvements are recommended to ensure that bicyclists can safely approach and cross the Lucas Wharf parking lot:

- The seven recommendations made for the Tides Wharf location should be implemented at the Lucas Wharf location.
- The parking lot path alignment should be shifted west, eliminating the two turns just south of the driveway, with the path located in the drive aisle closer to the harbor. This shift is safer for path users because it moves them further from the Lucas Wharf sign/sight obstruction.
- The grade separation between the parking lot and Smith Brothers Road to the south appears to exceed ADA requirements and a switchback alignment is proposed in order to provide some connection to Smith Brothers Road, which is recommended.

Smith Brothers Road

Existing Conditions

Smith Brothers Road has two travel lanes, with curb and gutter improvements on a portion of the east side and no improvements on the west side; no sidewalk is present. The street is fairly flat and has good sight distance. It is a loop street with two intersections on SR 1. The northerly intersection is adjacent to the Lucas Wharf site, and the southerly intersection is approximately 300 feet north of the County of Sonoma Birdwalk Coastal Access. The road provides access to the Bodega Bay Post Office and several commercial enterprises in a small shopping center, as well as several residences. Smith Brothers Road is a low-volume, low speed local street.

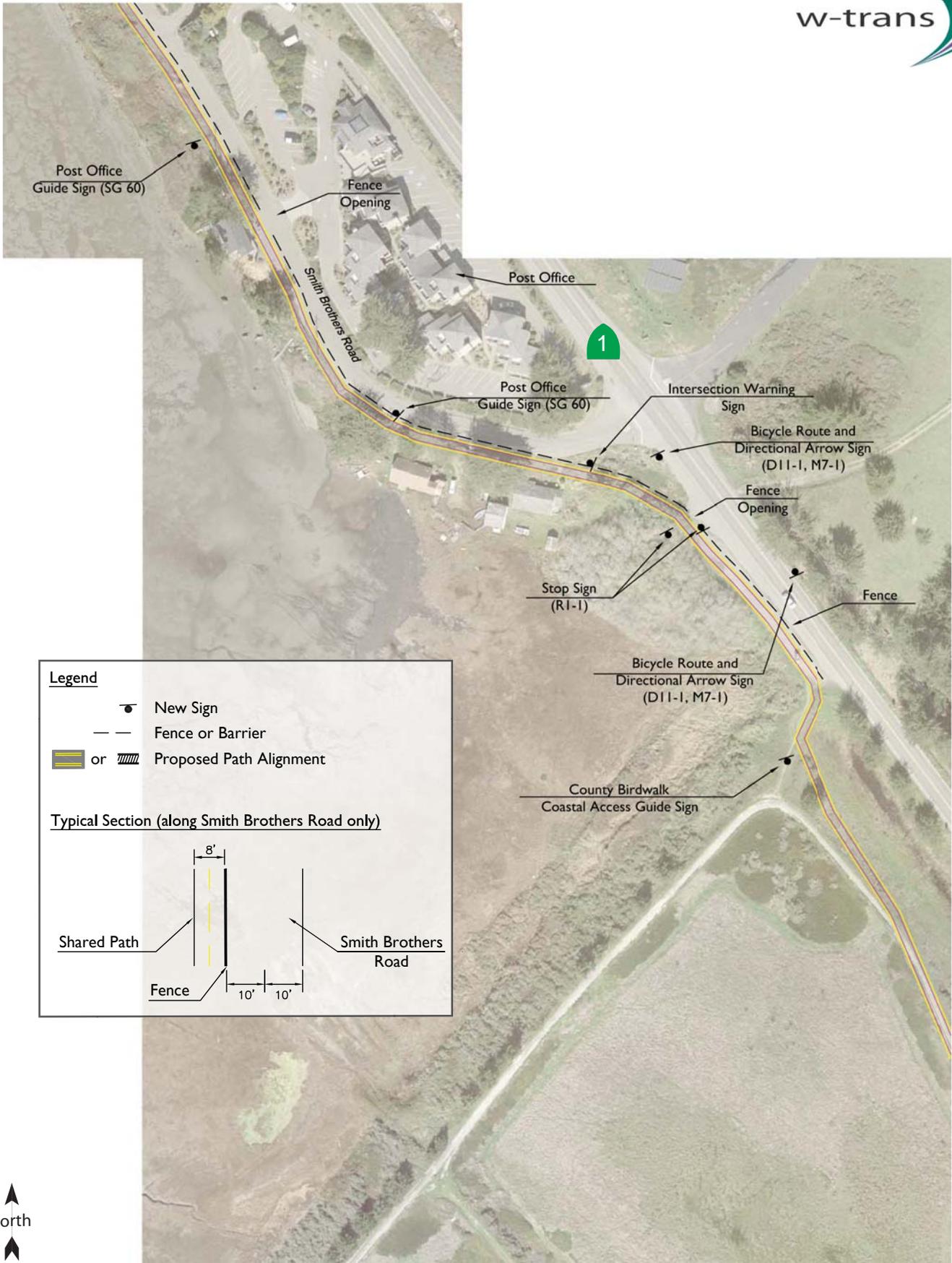
Project Proposal

The proposed shared use path alignment extends along the west side of Smith Brothers Road adjacent to the road for the most part though the westerly topography is steep and it appears that there is insufficient right-of-way to accommodate a ten-foot wide path and five-foot buffer area. As a cost saving measure the path could be narrowed to eight feet with no graded shoulder or other separation from Smith Brothers Road.

Recommendations

Proposed improvements along Smith Brothers Road at the north end are shown in Figure 4 and at the south end are shown in Figure 5, together described as follows:

- A ten-foot wide path is recommended along Smith Brothers Road, though an eight-foot wide path may be necessary due to right-of-way or cost constraints. The path should be equipped with a 42-inch high fence to separate the path from the road. Access points through the fence should be provided near the Bodega Coast Inn driveway, the Post Office and where the path adjoins the Lucas Wharf parking lot segment.
- Alternatively, bike lanes are recommended on both sides of the street only if the shared use path cannot be accommodated.
- Stop signs and limit lines should be installed on the path at the intersection of Smith Brothers Road (south)/SR 1.



- Two-way travel is not always understood by multi-use path users which can lead to conflicts as faster moving cyclists attempt to pass slower moving cyclists or pedestrians. A dashed centerline stripe is recommended to impart this concept of two-way travel to all path users.
- The *R9-7 Shared Use Path Restriction* sign should be installed facing both travel directions, with one approximately 100 feet south of the Lucas Wharf segment for southbound path users and one approximately the same distance north of southerly intersection of SR 1/Smith Brothers Road for northbound path users.

SR 1 from Smith Brothers Road South to Bird Walk Coastal Access County Park

Existing Conditions

SR 1 is a two-lane State highway that carries approximately 6,100 vehicles per day in this segment. South of Smith Brothers Road it has fewer reported collisions than on the segment noted in Location 3 above. This is likely due to fewer turning movements and also because the adjacent land uses back onto the highway rather than face it, creating fewer distractions.

The west side of the roadway is adjacent to a gravel area that functions as an informal parking area/trail head for the County of Sonoma Birdwalk Coastal Access. Sight distance along this roadway segment is estimated to significantly exceed the 300 feet of stopping sight distance needed for the 40 mph posted speed limit.

Proposed Improvements

The proposed path alignment extends along the west side of SR 1 for approximately 300 feet along the vacant/unimproved area, from its intersection at Smith Brothers Road (south) to the County of Sonoma Birdwalk Coastal Access informal trailhead. The road right-of-way appears to include the informal parking lot/trailhead area, and also appears to accommodate a ten-foot wide path and five-foot buffer area.

Recommendations

As shown in Figure 5, the following are recommended improvements to the path in this location:

- The path should provide a minimum ten-foot travel width and five-foot separation because there seems to be sufficient room to accommodate this standard path design. If a wider separation area were possible it should be provided. The path will allow northbound and southbound users to maintain reasonably unimpeded flows.
- A barrier/fence is recommended in order to channelize cyclists to enter and exit the path safely at either end, at the intersection of SR 1/Smith Brothers Road (south) and at the existing bollards that mark an access location to the County bird viewing area.
- Bicyclists would be expected to continue to use SR 1 to travel through Bodega Bay and it is recommended that they be provided on-roadway bicycle guide signs in both travel directions to alert them to the project trail, including a *D11-1 Bike Route* sign and *M7-1 Directional Arrow* sign. For southbound cyclists, these signs should be placed north of the SR 1/Smith Brothers Road intersection and near the existing bird walk trailhead bollards. For northbound bicyclists similar signing should be placed just south of these two locations. Such signing will provide guidance to conveniently and safely access the shared use path.

- A dashed centerline stripe is recommended to impart the concept of two-way travel to all path users.

The recommendations include numerous traffic signs, which are included in the CA-MUTCD and also shown in Figure 6.



Stop Sign
(R1-1)



Curve Warning
(W1-1)



Bicycle Warning
(W11-1)



Shared Use
(R9-7)



Hill Warning
(W7-5)



Post Office Guide
(SG60)



Bicycle Route with
Directional Arrow
(D11-1, M7-1)



Bicycle Warning with
Directional Arrow
(W11-1, W1-7)



Summary of Recommendations

- The path should provide a minimum ten-foot travel width wherever possible, together with turn-outs or bays for pedestrians to stop along the ‘tidelands’ segments.
- A dashed centerline stripe is recommended to remind all path users to stay to the right so that faster-moving travelers can pass on the left and to keep the path unobstructed for oncoming traffic.
- The path should be equipped with various guide signs: an SG 60 post office guide sign should be installed near the Bodega Bay Post Office to alert tourists to the presence of the post office on Smith Brothers Road; other SG series tourist-oriented guide signs could be installed near the two wharfs, at the south end of the project where connection to the County Birdwalk Coastal Access path is located, and further north near the state park lands.
- *W7-5 Bicycle-Hill Symbol* signs, *W11-2 Pedestrian Crossing* signs, and *W2-1 Intersection Warning* signs, should be installed on the path to warn cyclists and pedestrians of steep grades, each other, or of nearby motor vehicle crossings. The grade warning signs should be installed where the path grade exceeds five percent, including north of Bay Flat Road, between Smith Brothers Road and Lucas Wharf. The intersection warning signs should be placed in advance of approaches to Bay Flat Road at the north end and Smith Brothers Road and SR 1 at the south end of the project.
- A *W1-1 Turn Warning* sign should be installed for southbound cyclists on the path north of Bay Flat Road in advance of the 90-degree turn.
- The path should be separated from the adjacent parallel bike lane on westbound Bay Flat Road by a fence, landscaped barrier, or five-foot wide buffer area.
- Existing landscaping along both roads in the northwest quadrant of the intersection of Bay Flat Road/ Eastshore Road should be removed to ensure that adequate corner sight distance is provided for both southbound road users and eastbound path users.
- Stop signs, stop legends and a limit line should be installed on the shared use path at all approaches to the Bay Flat Road/Eastshore Road intersection. These approaches should be as close as possible to perpendicular to the respective street crossing, and the crosswalks should be located as close to the intersection as possible to ensure all intersection users are aware of entering traffic.
- The two crosswalks at the intersection of Bay Flat Road/Eastshore Road should be enhanced with continental markings to elevate the crossing visibility. In addition, *W11-1 Bicycle Warning* and *W11-2 Pedestrian Crossing* signs should be placed on southbound Eastshore Road and eastbound Bay Flat Road to alert drivers to the shared path crossings in the intersection.
- Street lighting should be provided to illuminate the two intersection crosswalks, with one streetlight placed to illuminate the crossing of Bay Flat Road and two streets placed to illuminate the crossing of Eastshore Road, including one on either side of the street.
- The geometry of the intersection of Bay Flat Road/Eastshore Road appears to limit the sight distance for northbound cyclists to see eastbound motorists. Since these motorists are not required to stop it may be necessary to add stop controls for the eastbound approach to the intersection. Alternately, it may be possible to increase sight distance by trimming existing landscaping on the southwest corner, eliminating the need to change the intersection controls.

- The *R9-7 Shared Use Path Restriction* sign should be installed facing both travel directions, with one approximately 100 to 200 feet south of the Bay Flat Road/Eastshore Road intersection for southbound path users and one approximately the same distance north of the bridge crossing for northbound path users.
- Street name guide signs “Bay Flat Road” and “Eastshore Road” should be installed at the intersection of Bay Flat Road/Eastshore Road for path user guidance if they do not already exist.
- Bike lanes or a shared use path are not recommended along SR 1 from Bay Flat Road to Smith Brothers Road due to high collision rates.
- At the Tides Wharf study location the tidelands alignment is recommended rather than the parking lot alignment. If the tidelands alignment is infeasible the following improvements are recommended:
 - The parking lot path should be marked with a colored or textured surface treatment. These markings could be blue or green colored pavement with white painted edge lines, or a textured treatment such as a stamped asphalt concrete brick pattern or actual pavers or bricks. It is essential that the treatment contrast with the other parking lot surfaces, including the marked parking spaces, drive aisles and disabled parking areas. It is also important that the ten-foot width of the path be maintained.
 - At the two approaches to the parking lot the path should be equipped with custom guide signs that indicate that the path continues through the parking area and continues beyond. A symbol sign is preferred over word signs.
 - Stop signs and limit lines should be installed on the path as close to the parking lot intersections as possible. Adequate stopping sight distance should be provided for the path users to allow bicyclists to stop before reaching the parking lot. A relatively flat grade, two percent or less, should be provided on these approaches.
 - Bollards should be installed across the shared use path/parking lot intersections to prevent motorized traffic from using the path beyond the limits of the parking lot.
 - A combination of warning signs should be installed along the Tides Wharf driveway to alert inbound motorists to the shared use path crossing, including the *W11-1 Bicycle Warning* sign and the *W1-7 Two-Way Arrow Warning* sign.
 - Lower tree branches should be removed and tall shrubs trimmed to improve sight distance along the driveway. No landscaping should be taller than 12 inches or lower than three feet in these planting areas.
 - Bike lanes should *not* be installed in the parking lot drive aisles because these imply exclusive cyclist use which is inconsistent with the parking lot operations.
- At the Lucas Wharf study location the parking lot alignment is recommended rather than the alignment adjacent to SR 1 to maximize separation between road and path travelers.
- The seven recommendations made for the Tides Wharf location should be implemented at the Lucas Wharf location.
- The parking lot path alignment should be shifted west, eliminating the two turns just south of the driveway, with the path located in the drive aisle closer to the harbor. This shift is safer for path users because it moves them further from the Lucas Wharf sign/sight obstruction.

- The switchback alignment proposed in the south parking lot area appears to provide an ADA compliant connection to Smith Brothers Road and is recommended for the safety of all users and for the continuity of the path.
- The path along Smith Brothers Road may be eight feet in width and should be equipped with a 42-inch fence along the west side of the street to separate the path from the road. Access points through the fence should be provided across from the Bodega Coast Inn driveway, the Post Office and near where the path meets the Lucas Wharf segment.
- Bike lanes are recommended on both sides of the street only if the eight-foot wide shared use path cannot be accommodated.
- Stop signs and limit lines should be installed on the path at both Smith Brothers Road/SR 1 intersections.
- The path along SR 1 from Smith Brothers Road South to County of Sonoma Birdwalk Coastal Access should have a minimum ten-foot travel width and five-foot separation from the roadway. A barrier/fence is recommended in order to channelize cyclists to enter and exit the path safely at either end, at the intersection of SR 1/Smith Brothers Road (south) and at the existing bollards that mark an access location to the County bird viewing area.
- Bicyclists would be expected to continue to use SR 1 to travel through Bodega Bay and it is recommended that they be provided on-roadway bicycle guide signs in both travel directions to alert them to the project trail, including a *D11-1 Bike Route* sign and *M7-1 Directional Arrow* sign. For southbound cyclists, these signs should be placed north of the SR 1/Smith Brothers Road intersection and near the existing bird walk trailhead bollards. For northbound bicyclists similar signing should be placed just south of these two locations. Such signing will provide guidance to conveniently and safely access the shared use path.

Study Participants and References

Study Participants

Principal in Charge:	Steve Weinberger, PE, PTOE
Traffic Engineer:	Mary Jo Yung, PE, PTOE
Transportation Planner:	Josh Abrams
Assistant Engineer:	Tony Henderson, EIT
Technician/Graphics:	Deborah J. Mizell
Editing/Formatting:	Angela McCoy
Report Review:	Dalene J. Whitlock, PE, PTOE

References

California Manual on Uniform Traffic Control Devices for Streets and Highways, California Department of Transportation, 2010

Guide for the Development of Bicycle Facilities, American Association of State Highway and Transportation Officials, 1999

Highway Design Manual, 6th Edition, California Department of Transportation, 2006

Statewide Integrated Traffic Records System (SWITRS), California Highway Patrol, 2004-2009

SOX913-2





Memorandum

Date: November 12, 2019

Project: SOX931-1

To: Mr. Ken Tam
Regional Parks
County of Sonoma

From: Steve Weinberger
sweinberger@w-trans.com
Allison Jaromin
ajaromin@w-trans.com

Subject: Bodega Bay Trail – Coastal North Harbor Trail Segment Response to Comments

As requested, W-Trans has reviewed comments from Mitch Simson, County of Sonoma, dated April 16, 2019, related to the Bodega Bay Trail Project – Coastal North Harbor Segment Review. The purpose of this memo is to address three of the traffic related questions.

County Comment A - *At least one stop sign and multiple stop bars are removed or relocated. Provide an exhibit that shows there is adequate sight distance provided at the stop bars.*

Sight Distance was reviewed in the field, as shown in Plate 1, from the new proposed stop bar location on the west leg, a vehicle stopped on the northbound approach of Eastshore Road at the new stop bar location would be visible, as shown by the cone representing a stopped vehicle.



Plate 1: Sight Distance from Eastbound Bay Flat Road looking towards Northbound Eastshore Rd

Sight distance was also reviewed for the northbound Eastshore Road towards the eastbound approach (west leg) of Bay Flat Road. As shown in Plate 2, there is sufficient sight distance to see a vehicle stopped at the new stop bar location.



Plate 2: Sight Distance from Northbound Eastshore Rd looking toward Eastbound Bay Flat Rd

County Comment B - Bay Flat Road (south leg) is being narrowed significantly with the addition of delineators. Is there still enough space here for two-way traffic? (Note: Eastshore Road, the south leg, which would be narrowed to 22 feet was evaluated).

The roadway will be 22' at the narrowest point. This is adequate for two-way traffic, as the minimum width allowed by *A Policy on Geometric Design of Streets and Highways*, AASHTO, 2018 is 20 feet for a 25 mile per hour (mph) roadway with 400 to 2,000 vehicles per day which applies to Eastside Road.

County Comment C - Has the reduction in turning radius been analyzed at the northwesterly corner of the intersection? There is commercial truck traffic and trailered boats that enter and exit Bay Flat Road/Westshore Road from Eastshore Road (north leg).

It is expected that larger vehicles, such as motorhomes or trucks with trailers will be able to maneuver the right and left-turn movements between the north leg, west leg and south legs of the intersection. Semi-trucks are also expected to be able to maneuver the turns, however they will need to cross into the opposing lanes for some of the movements which is currently the case for the intersection. Attached is the AutoTURN exhibits for three vehicles, a motorhome, a 40-foot long semitruck, and a 62-foot long semitruck which shows each vehicle successfully maneuvering the turns.

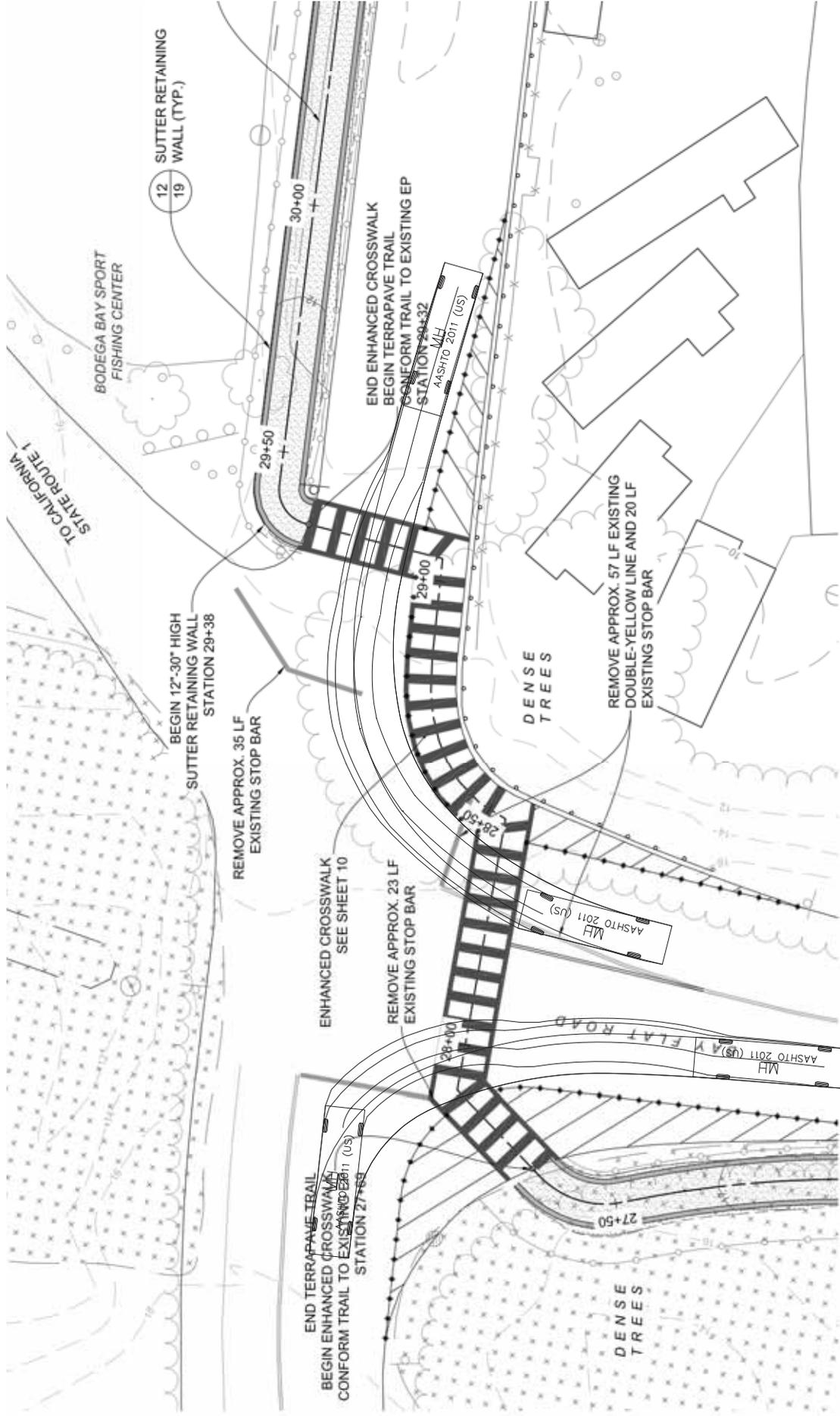
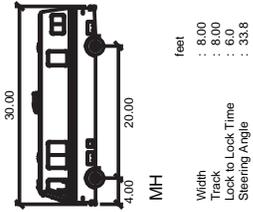
Conclusions and Recommendations

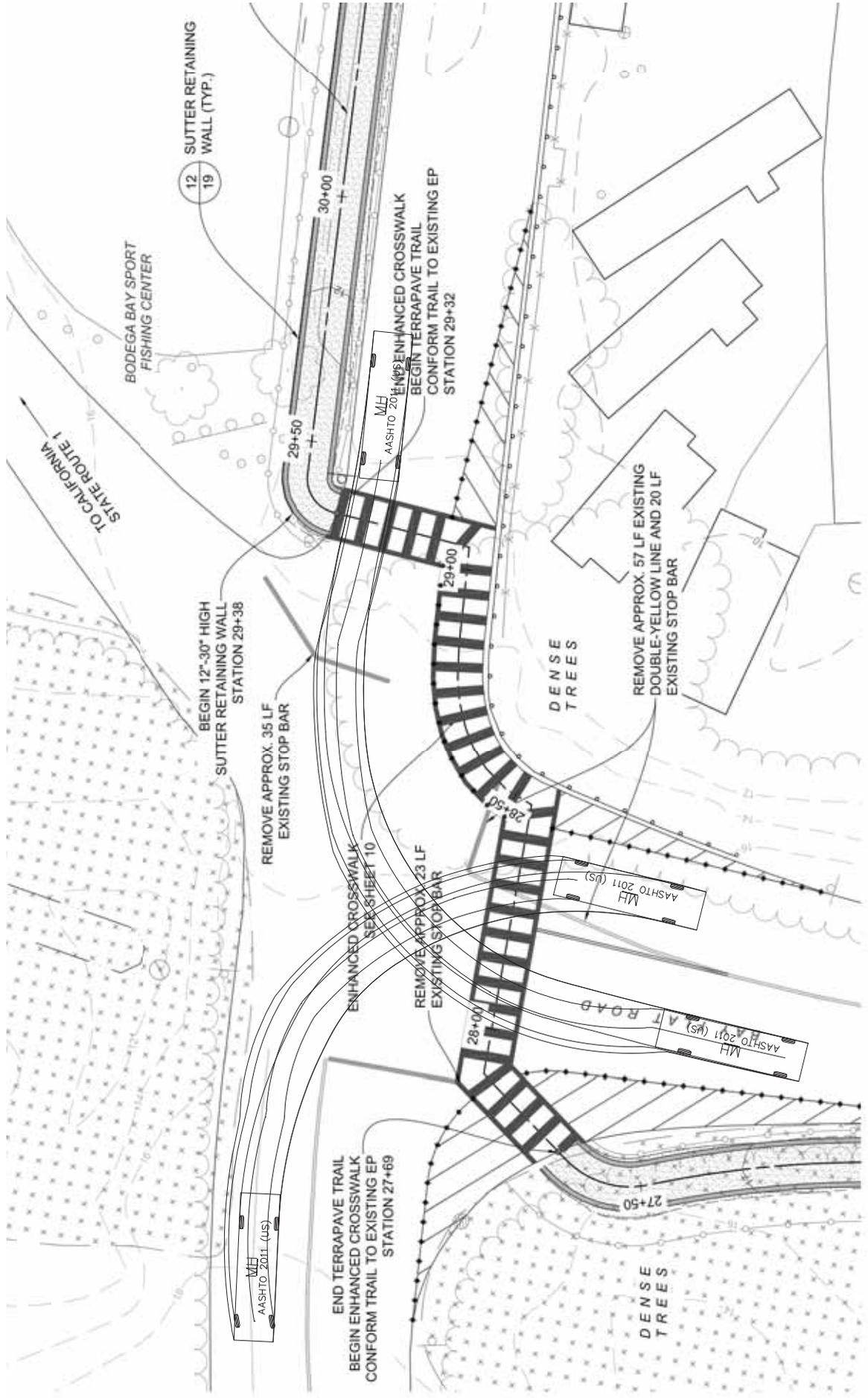
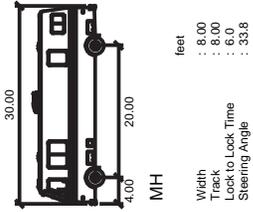
- There are adequate sight lines at the stop bars which are being relocated.
- There is enough width on the reconfigured south leg, for two-way traffic.
- Commercial trucks are expected to be able to complete turns between the north Eastshore Road leg, the western Bay Flat Road leg and the southern Eastshore Road leg with the proposed changes.

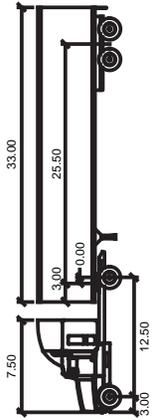
Thank you for giving W-Trans the opportunity to provide these services. Please call if you have any questions.

SJW/acj/SOX931-1.M1

Attachments: AutoTURN Exhibits

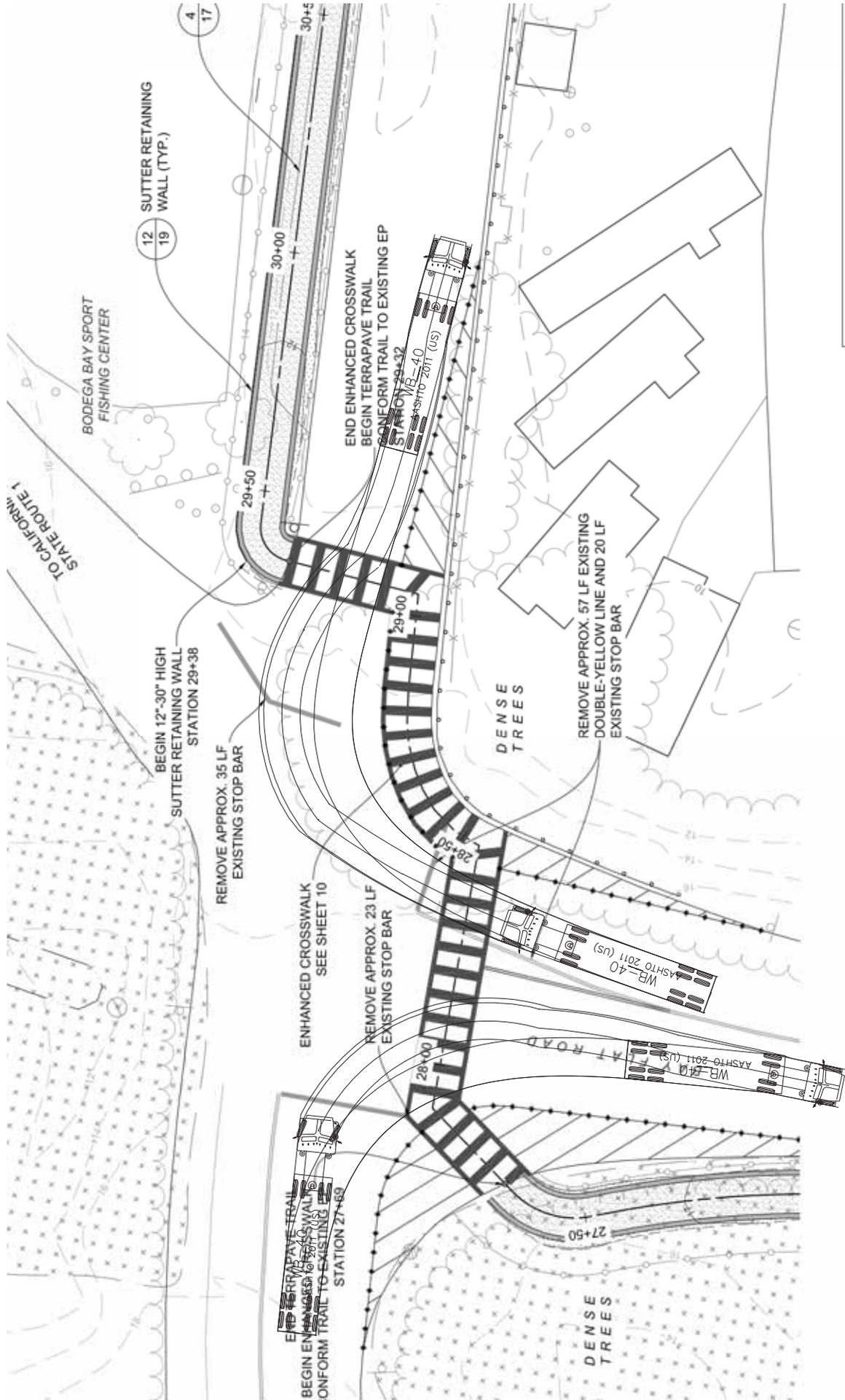


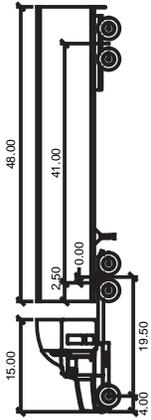




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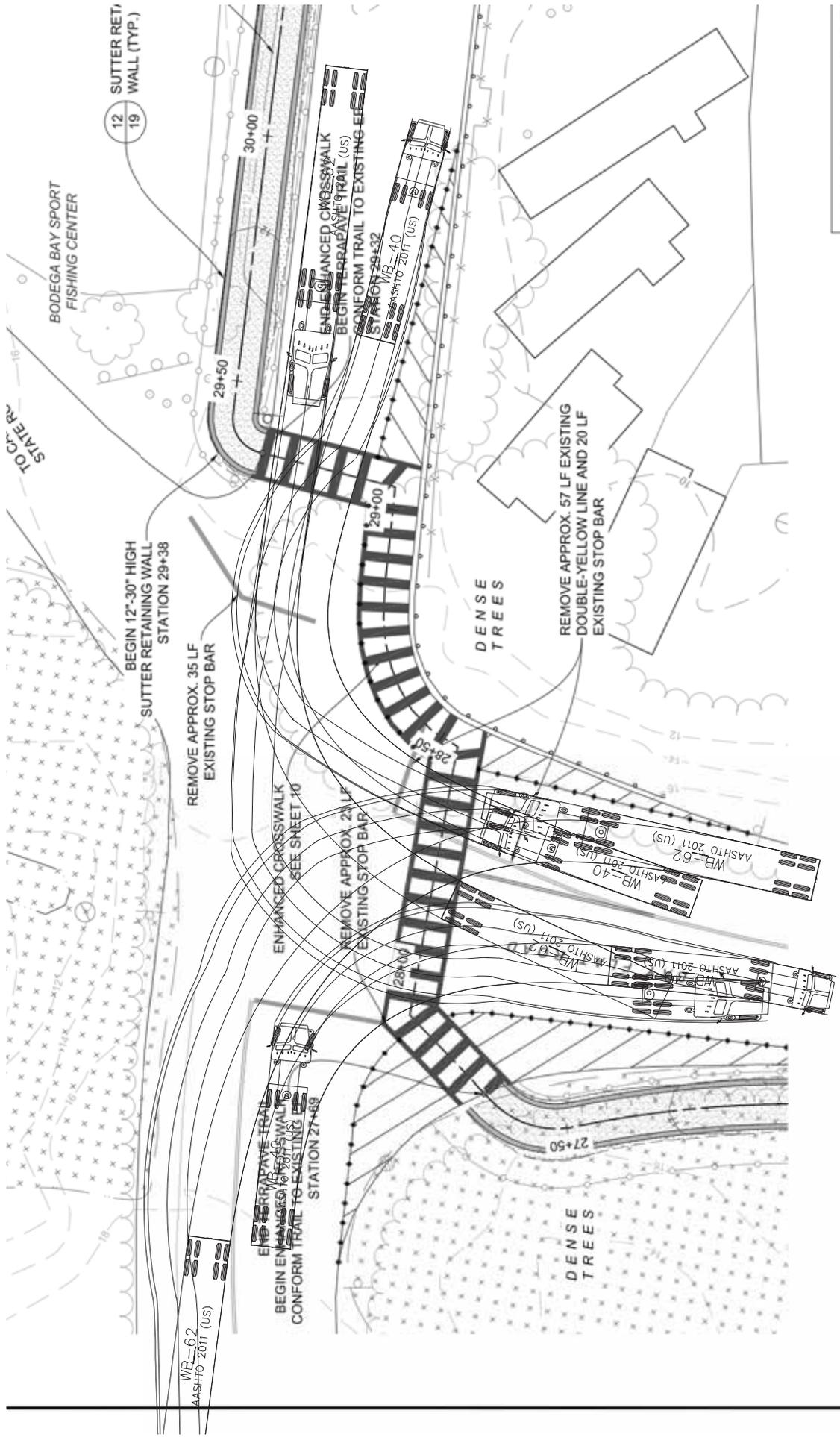
feet	
Tractor Width	: 6.0
Trailer Width	: 8.00
Tractor Track	: 20.3
Trailer Track	: 8.00
Lock to Lock Time	: 70.0
Steering Angle	: 20.3
Articulating Angle	: 8.00





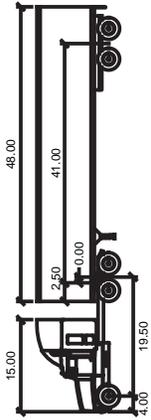
WB-62

feet	
Tractor Width	: 6.0
Tractor Length	: 28.4
Tractor Track	: 8.00
Trailer Track	: 8.50
Lock to Lock Time	: 6.0
Steering Lock	: 28.4
Articulating Angle	: 70.0



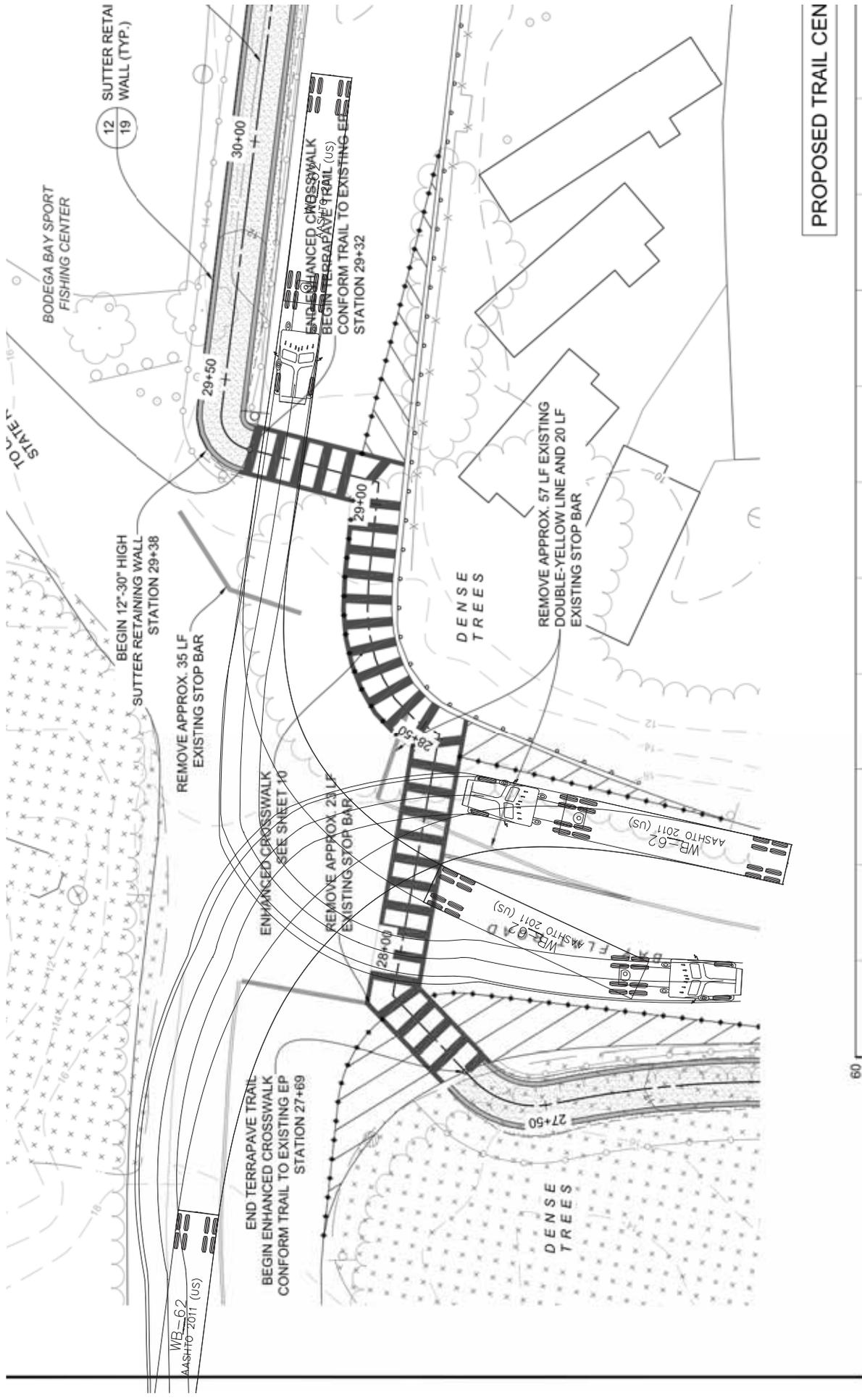
PROPOSED TRAIL CEI

60'



WB-62

feet	
Tractor Width	: 6.0
Tractor Length	: 28.4
Tractor Track	: 8.00
Trailer Track	: 8.50
Lock to Lock Time	: 6.0
Stroke Length	: 28.4
Articulating Angle	: 70.0



E Monarch Butterfly Management Guidelines (Xerces Society)

Protecting California's Butterfly Groves

Management Guidelines for
Monarch Butterfly Overwintering Habitat



Protecting California's Butterfly Groves

Management Guidelines for
Monarch Butterfly Overwintering Habitat





The Xerces Society for Invertebrate Conservation is a nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat. Established in 1971, the Society is a trusted source for science-based information and advice. Our conservation team draws together experts from the fields of habitat restoration, entomology, botany, farming, and conservation biology with a single focus: protecting the life that sustains us.

Portland, Oregon
www.xerces.org



Creekside Center for Earth Observation was founded in 2006 by Drs. Stuart B. Weiss and Paul M. Rich to apply the latest science and technology to address challenging conservation problems. We specialize in experimental design, field measurement, and quantitative analysis. We subscribe to the worldview of Aldo Leopold, who expounded a "land ethic" in which the basic ethical considerations given to human beings are expanded to include the natural world around us. As such, while our work is founded in science, it is also rooted in a deep philosophical commitment to achieve and maintain ecosystem health, preserve vital ecosystem functions, protect rare and endangered species, and expand consciousness about conservation through education and outreach.

Menlo Park, California
www.creeksidescience.org

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Acknowledgments

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Front Cover Photograph

Overwintering monarchs clustering in a Monterey pine at a site in California. Photo: The Xerces Society / Carly Voight.



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Executive Summary

Every year, hundreds of thousands of monarch butterflies spend the winter in groves of trees along coastal California. However, their numbers have declined by over 95% since the 1980s and the migratory population is at a high risk of extinction. In the 1980s, about 10 million monarchs overwintered in coastal California, while in 2016 fewer than 300,000 were counted. While researchers are still evaluating what may have caused the long term population trend of monarchs in California, the declines that have been observed may be attributable to:

- ⇒ Loss of milkweed and nectar plants due to herbicide use, urban and agricultural development, and long-term drought (which may be linked to climate change),
- ⇒ Loss and degradation of overwintering groves due to development and grove senescence, and
- ⇒ Other stressors such as disease, insecticides, and impacts of climate change.

Monarchs are especially vulnerable during the overwintering stage because so many animals are concentrated in a few locations. They have very specific overwintering habitat requirements and will only utilize tree groves that provide suitable environmental conditions, which include high humidity, dappled sunlight, a nearby water source, and protection from high winds, storms, and fluctuating temperatures. These butterfly groves are part of a dynamic ecosystem, and active management of groves is often required to maintain the environmental conditions that monarchs require to survive over the long term. Loss of trees and branches due to aging, storms, pests, and disease; tree and branch removal; and human visitors can all contribute to changes in the microclimate of overwintering groves, potentially resulting in unsuitable monarch habitat.

This document is intended to serve as a guide for land managers and landowners who wish to implement management actions to protect, improve, and restore monarch overwintering habitat. As all overwintering sites are unique, detailed site-specific guidelines should be developed for each overwintering site following the recommendations in this document, and if possible, in consultation with a monarch habitat specialist and a certified arborist.

The following five steps will guide you in developing a site-specific management plan.

1. Become Familiar with Monarch Overwintering Habitat Requirements and Characteristics

Monarchs are thought to select sites based on:

- ⇒ protection from high wind and storms;
- ⇒ absence of freezing temperatures;
- ⇒ presence of spatially variable light including a mix of full sun, shade and dappled sunlight;
- ⇒ presence of high humidity; and
- ⇒ availability of water.

2. Create an Initial Monarch Overwintering Habitat Boundary Map

Use aerial imagery to produce a base map of the overwintering site. Monarch habitat includes cluster trees and the features that provide important windbreaks, encompassing trees well outside the main

grove. Use observations and consult with Xerces Society staff or a local monarch expert to determine where monarchs have overwintered at your site in the past to refine the habitat boundary and focus survey efforts.

3. Conduct a Habitat Site Assessment and Monitor During the Overwintering Season

Habitat site assessment should include identification and mapping of:

- ☞ property lines and locations of cluster trees and surrounding trees,
- ☞ very important trees and saplings, and
- ☞ hazard trees.

Monitoring for microclimate and monarchs should include:

- ☞ evaluation of wind exposure of cluster trees,
- ☞ assessment of solar radiation patterns and dappled sunlight availability, and
- ☞ counts of monarch abundance at regular intervals throughout the overwintering season (October to March).

4. Revise the Monarch Overwintering Habitat Boundary Map

Revise the habitat boundary map after each season of monitoring based on the habitat site assessment and monitoring data.

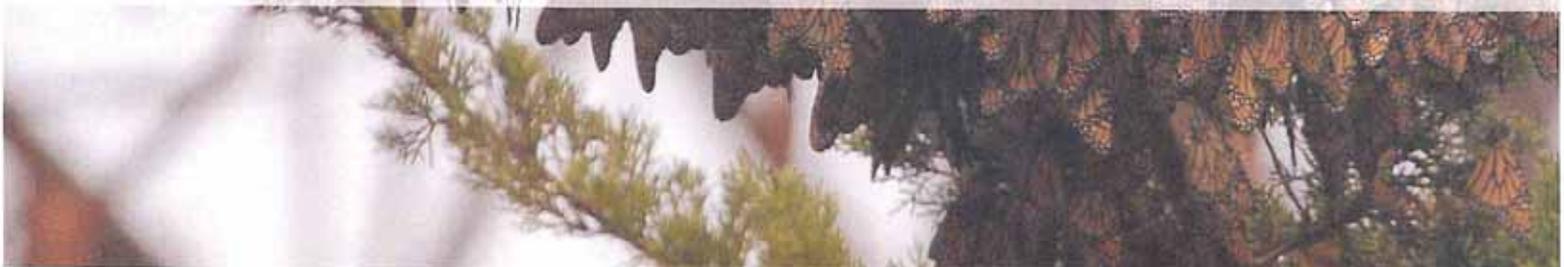
5. Develop an Adaptive Management Plan

A site specific management plan that includes the principles of adaptive management may include:

- ☞ recommendations for trimming or removing select trees or branches for hazard reduction and increasing sun exposure,
- ☞ developing and implementing a long-term tree planting strategy,
- ☞ planting fall- and winter-blooming nectar flowers,
- ☞ reducing or altering pesticide use,
- ☞ implementing erosion control measures,
- ☞ minimizing the negative impacts of public access by planning trail locations, installing signage, and/or providing staff or docents, and
- ☞ involving stakeholders and adjacent landowners in the decision making process.



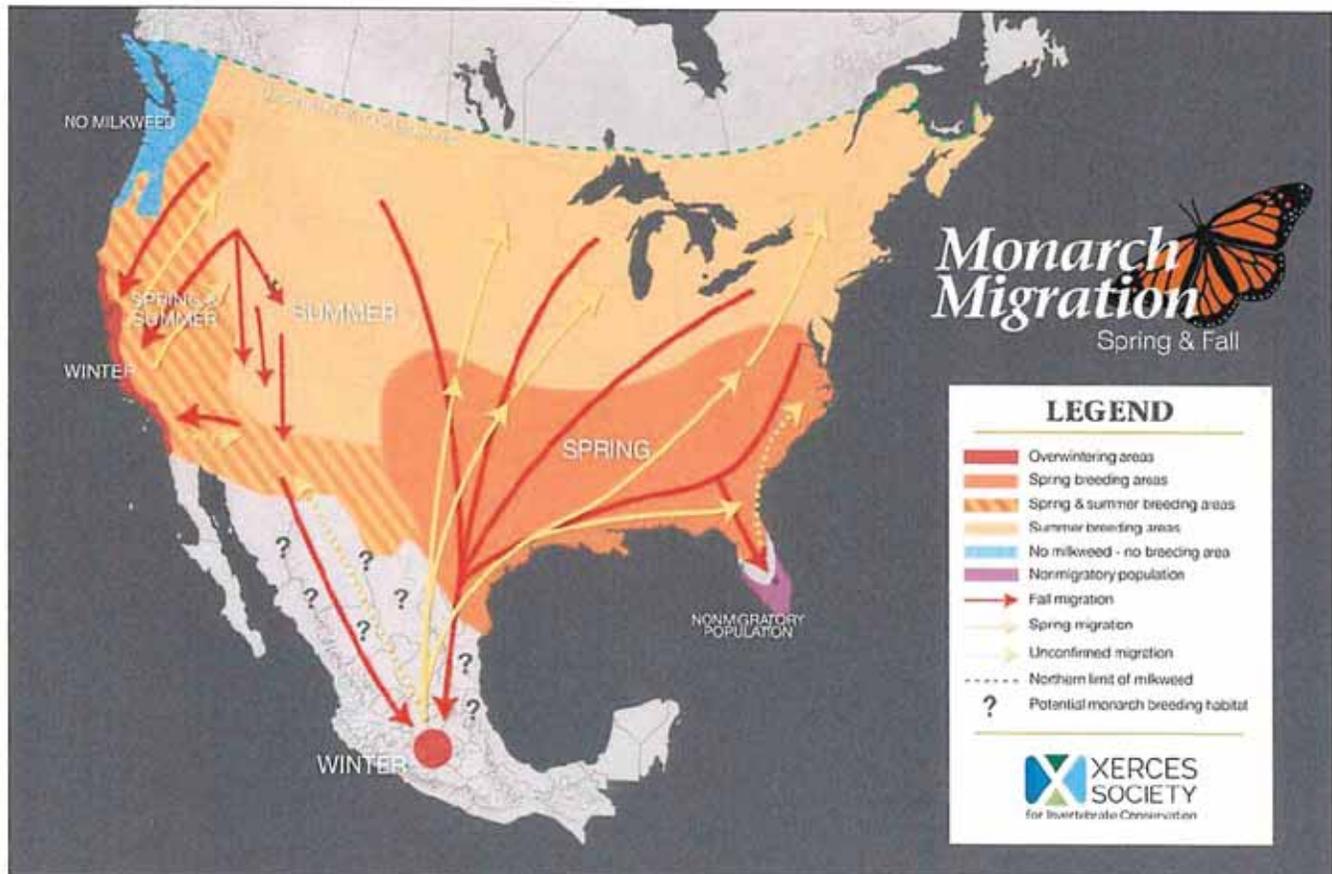
Monarchs shelter on the underside of a Monterey cypress branch. (Photograph: The Xerces Society / Carly Voight.)



Introduction

Every fall, hundreds of thousands of monarchs arrive at forested groves along the California coast and aggregate en masse. This seemingly impressive number is just a small fraction of the more than 10 million butterflies that have congregated in the past. A long-term citizen monitoring effort, the Xerces Society Western Monarch Thanksgiving Count (Monroe et al. 2017), has provided annual estimates of the number of monarchs overwintering at 300 coastal California sites since 1997. Data from the Thanksgiving Count and historical data show a population decline of over 95% since the 1980s and the migratory population is at a high risk of extinction. In the 1980s, about 10 million monarchs overwintered in coastal California, while in 2016 fewer than 300,000 were counted (Schultz et al. 2017). While climatic factors such as rainfall and drought may explain much of the interannual variation in monarch numbers (Stevens and Frey 2010; Espeset et al. 2016), loss or degradation of habitat including breeding and overwintering habitat are persistent factors that likely are also contributing to long-term declines in the species' ability to survive and reproduce (Pelton et al. 2016). In California, active management of monarch overwintering sites is an important component of monarch conservation.

Figure 1. Migration routes, breeding areas, and overwintering areas of monarchs in North America.



Biology and Conservation of Western Monarchs

Biology and Life History of Monarchs in Western North America

The monarch butterfly (*Danaus plexippus plexippus*) is renowned for its long-distance seasonal migration and its spectacular winter gatherings in central Mexico's oyamel fir forests and along the California coast. In western North America, monarch overwintering sites are distributed along the California coast from Mendocino County to the Mexican border, and south into Baja California, Mexico (Xerces Society Western Monarch Overwintering Site Database 2017). Each spring, monarchs depart these sites and spread out across the Californian interior and the western U.S., sometimes reaching as far north as British Columbia.

After mating, female monarchs lay their eggs on milkweed plants (*Asclepias* spp.). Several generations of adult butterflies are produced throughout the spring, summer, and fall. Each autumn, the last generation of monarch butterflies migrates to overwintering habitat. It was formerly thought that monarchs west of the Rocky Mountains would only migrate to California overwintering sites, and those east of the Rocky Mountains would only migrate to sites in Mexico. Tagging studies (Morris et al. 2015) by citizen scientists, however, have shown that monarchs in western North America migrate to both Mexico and California, and genetic research (Lyons et al. 2012) confirms that eastern and western monarchs comprise a single population (Brower and Pyle 2004).

Monarchs generally begin to arrive at the California coast in mid-October (Hill et al. 1976) but may arrive as early as September (Leong 1990a). They form dense groups on the branches, leaves, and occasionally, trunks of trees. Trees that support these large groups of monarchs are called cluster trees. While a few monarchs will attempt to mate during the winter, most overwintering monarchs are in a state of reproductive dormancy called reproductive diapause (Herman 1981), and remain in this state until February or March. In the spring, monarchs leave overwintering sites and return to their spring and summer breeding grounds.

Overwintering monarchs have very specific microclimatic requirements, such as protection from wind and storms, absence of freezing temperatures, exposure to dappled sunlight, presence of high humidity, and availability of water (Chaplin and Wells 1982; Calvert and Cohen 1983; Masters et al. 1988; Anderson and Brower 1996; Leong 1999). Monarchs use nectar for energy, storing the calories obtained as lipids. The presence of fall- or winter-blooming flowers at overwintering sites may be important to maintain lipid reserves required for the spring migration (Tuskes and Brower 1978).

Conservation and Management of Monarch Overwintering Habitat

The historical composition of vegetation on the California coast differed from the contemporary composition, and groves of native trees presumably hosted dense monarch aggregations (Lane 1984, 1993). Today, monarch overwintering habitat in California is directly threatened by urban and suburban development, and to a lesser extent, agricultural development. Habitat alterations such as tree trimming

or tree removal as well as natural factors such as fire, severe storms, and disease or senescence of trees, can alter the structure and microclimate of an overwintering site and reduce its suitability for monarchs (Sakai and Calvert 1991; Commission for Environmental Cooperation 2008).

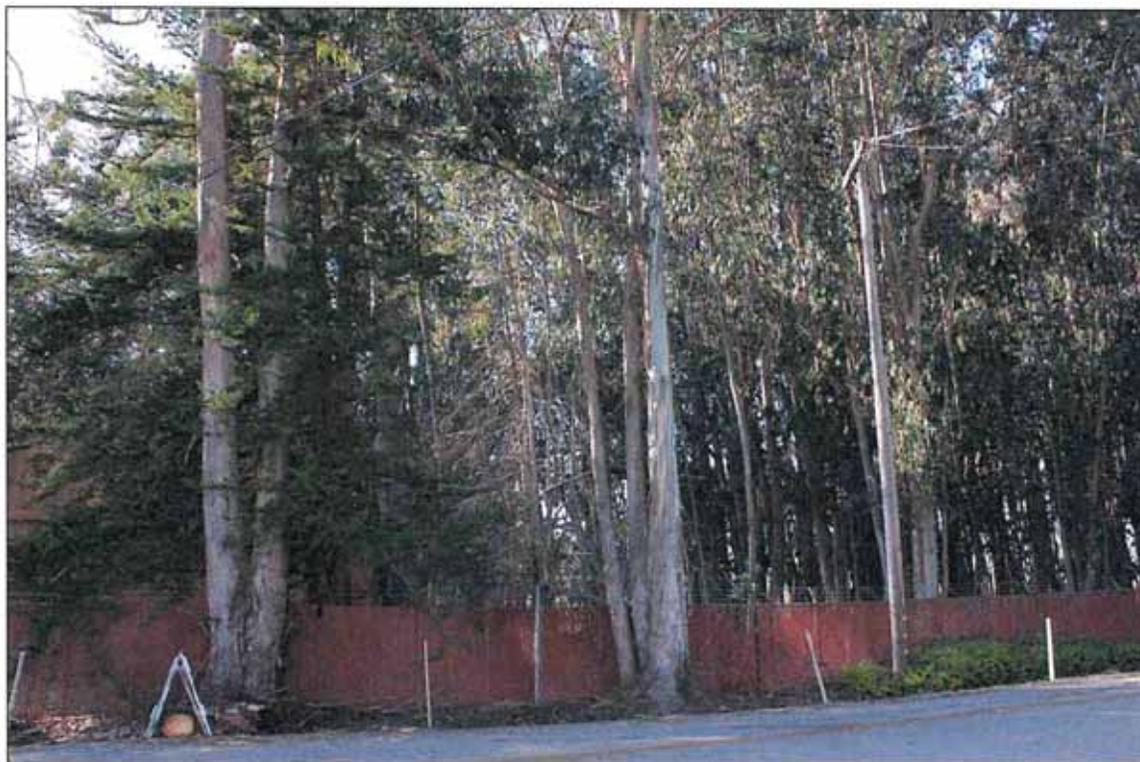
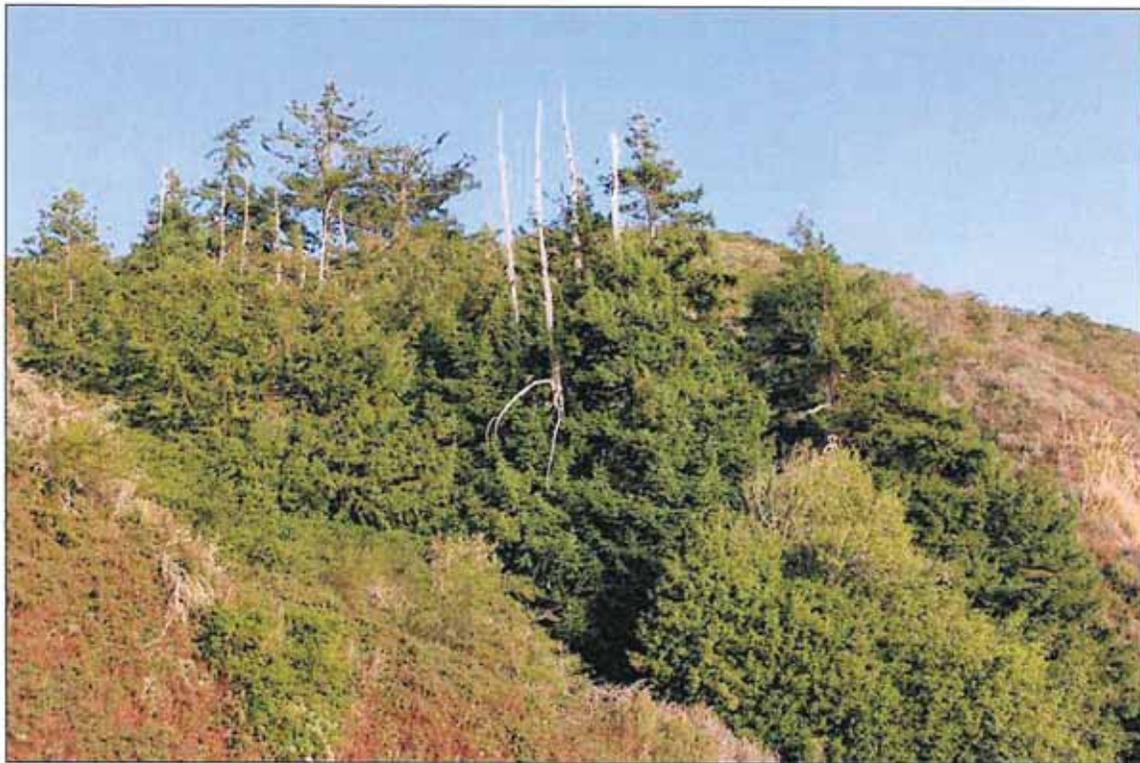
Housing development is a major cause of overwintering site loss. A statewide report published in 1991 documented 38 overwintering sites that had been lost or destroyed; 16 of these were lost to housing developments (Sakai and Calvert 1991). In the 1990s, an additional 11 overwintering sites were lost to development (Meade 1999), and there are seven more that have been destroyed due to development since the late 1990s, including one in 2016 (Xerces Society Western Monarch Overwintering Sites Database 2017). In recent years, advocates seeking to protect overwintering sites have contacted the Xerces Society to report that additional sites are slated for development (SJ, personal observation). Anecdotal reports suggest that overwintering sites have also been lost due to tree cutting or trimming (Sakai and Calvert 1991), or that the monarch population has declined after tree trimming, although this assertion can be difficult to demonstrate (see discussion in Villablanca 2010).

At present, the dominant trees on most overwintering sites are nonnative blue gum (*Eucalyptus globulus*) or red river gum eucalyptus (*E. camaldulensis*), although many sites also contain Monterey pine (*Pinus radiata*), Monterey cypress (*Cupressus macrocarpa*), western sycamore (*Platanus racemosa*), and other native trees (Xerces Society Western Monarch Overwintering Site Database 2017). Eucalyptus are exotic invasive species and have been shown to reduce biodiversity (Bossard et al. 2000). Removal of eucalyptus is often a restoration goal in natural areas, and conflicts can emerge between monarch habitat conservation and eucalyptus removal. Recent studies suggest that monarchs do not prefer eucalyptus trees to native tree species (Griffiths and Villablanca 2015), so restoration of overwintering sites with native tree species should be the long-term aim. This work, however, can take decades because many of California's native conifers are relatively slow-growing. Consequently, removing eucalyptus at overwintering sites should be done in phases while native trees are planted so that viable monarch habitat will be continually present (Lane 1993).

Many monarch overwintering sites also contain aging or diseased trees. For example, Monterey pine is affected by pitch canker (*Fusarium circinatum*), a fungus that causes swollen lesions that girdle branches, trunks, and exposed roots. The disease was first observed in California in Santa Cruz County in 1986 and has since spread to many coastal counties (Winkler et al. 2003). As aging or diseased trees lose limbs or die, sites can become less suitable for monarchs and pose a public safety hazard. To reduce safety hazards, land managers prune aging or diseased trees which may result in microclimatic changes that make a site unsuitable for overwintering monarchs.

The planning and implementation of long-term management of monarch groves is critical to maintaining sufficient, viable overwintering monarch habitat in coastal California.

(Opposite) California's butterfly groves are diverse in location and varied in character. Despite their differences, they have one thing in common: they each provide just the right conditions to sustain clusters of monarch butterflies through the winter months. Their care and management is essential to maintain the phenomenon of migrating butterflies. (Photographs: The Xerces Society / Carly Voight.)



Developing a Site-Specific Management Plan

The most vulnerable element of the monarch annual cycle may be the overwintering stage (Pyle and Monroe 2004). Protection and active, careful management of overwintering habitat are critical to supporting the migratory phenomenon and conserving the species. In this section, guidance is provided as five steps to consider in developing a site specific management plan for California overwintering groves:

- 1) Become familiar with monarch overwintering habitat requirements and characteristics.
- 2) Create an initial monarch overwintering habitat boundary map.
- 3) Conduct a habitat site assessment and monitor during the overwintering season.
- 4) Revise the monarch overwintering habitat boundary map.
- 5) Develop an adaptive management plan and continue to monitor and refine over time.

Step 1

Become Familiar with Monarch Overwintering Habitat Requirements and Characteristics

The mild conditions at forested groves along the California coast provide the microclimate that monarchs require to survive the winter in western North America. The majority of these sites are within 1.5 miles (about 2.4 km) from the Pacific Ocean or San Francisco Bay (Leong et al. 2004), and these water bodies moderate temperature fluctuations (Chaplin and Wells 1982). The suitability of habitat for overwintering monarchs is likely also influenced by landscape- and site-level characteristics that create very specific environmental conditions. These conditions include: protection from winds and storms, absence of freezing temperatures, exposure to dappled sunlight, high humidity, and access to nectar and water. Monarch habitat encompasses the cluster trees that monarchs roost on, as well as surrounding trees that influence the microclimate of the grove (Leong 1989; Leong et al. 1991).

Monarch behavior is influenced by conditions within the region and individual sites. The distribution of butterflies among overwintering sites in California changes from year to year and from month to month (Leong 1989, 1990b; Leong et al. 1991). Migrating monarchs that reach the coast in October roost in groves that offer a wide range of conditions. As the rainy season brings strong winds and cooler temperatures, monarchs frequently leave sites that do not provide enough shelter, and remain at sites that do. Monarchs are likely attracted to the presence of other monarchs as an indicator of site quality, so that occupied sites attract wandering monarchs that have left unsuitable sites. Monarchs may use a given site only in the fall, but in years with mild weather, they may occupy the site throughout the fall and winter. Monarchs may also use certain sites in northern California in the fall temporarily on their way to central or southern California sites for the winter.

Knowledge of the habitat conditions that monarch butterflies require and the forest characteristics that determine these conditions is essential for managing or restoring overwintering habitat. Details of



The suitability of a grove for overwintering monarchs is influenced by many factors, including shelter from wind and storms and the right amount of sunlight for the butterflies to maintain body temperature. Even seemingly small things such as a tree branch at the correct height and angle can be significant. (Photograph: The Xerces Society / Carly Voight.)

monarch habitat requirements are provided below to aid in the development of management plans at overwintering sites.

Landscape Topography

Local landscape topography contributes to the microclimatic characteristics of overwintering habitat. Most sites occur at low elevations (below 300 feet [90 m]) and sometimes can be found in shallow canyons or gullies (Lane 1993). Many groves occur on slopes that are oriented to the south, southwest, or west, which likely offer the most favorable solar radiation exposure and wind shelter (Leong et al. 2004).

Shelter from Storms and Prevailing Winds

Strong winds or rain dislodge monarch clusters, and batter individuals, and can be lethal to the butterflies (Calvert and Cohen 1983). Monarchs that have been blown off trees can die of exposure and become susceptible to ground predators, such as wasps and ants. Forest groves that provide the best wind protection for monarchs have areas that are free from strong, sustaining winds of 4.5 mph (2 m/s) or greater, in at least a portion of the site (Leong 1990a; Leong et al. 1991). Winter storms along the California coast can produce southerly winds of >56 mph (25 m/s) and pose the greatest risk to successful overwintering.

Wind may drive much of the short-term movement of monarchs within a site. For example, if a cluster site is exposed to storm winds from the southeast, it may drive monarchs to seek cluster trees



away from the winds in more sheltered areas. When the prevailing northwest winds return after the passage of the storm, monarchs may return to the original cluster sites (Leong 1990a). Strong winds may drive monarchs completely from some sites; after a December 1995 storm with hurricane force winds, the Monarch Grove Sanctuary in Pacific Grove was abandoned, perhaps due to the storm (Weiss 1998). Trees, especially when growing in high density, act as a shelter and slow near-surface winds. Isolated trees provide less of a shelter effect because the wind wraps around them (Weiss and Luth 2002).

Temperature and Humidity

The survival and behavior of monarchs are influenced by both temperature and humidity. Freezing temperatures can be lethal to monarchs (Calvert and Cohen 1983). Generally, monarchs can only crawl when the temperature is between 39° and 55° F (4° and 12.7° C) (Anderson and Brower 1996) and they are only able to fly when temperatures reach 54.9° F (12.7° C) or greater (Chaplin and Wells 1982; Masters et al. 1988). However, monarchs require mild daytime temperatures to conserve their fat reserves throughout the overwintering season (Chaplin and Wells 1982). Monarchs also require high humidity; low humidity can cause desiccation and lead to death (Chaplin and Wells 1982; Masters et al. 1988).

Monarchs appear to adjust their distribution within an overwintering site as temperature conditions vary throughout the winter months (Leong et al. 1991). The butterflies will only cluster in deeply shaded areas if the area is warmer than approximately 55° F (Leong 1999). Near the ground, temperatures are cooler at night and warmer in the day. Monarchs cluster closer to the ground at warmer, more southerly sites, and higher in the canopy at cooler, more northerly sites. The height at which monarchs cluster may be a function of the level to which cold air reaches at night (Tuskes and Brower 1978). Thus, the presence of branches at different heights that can be used for clustering is an important structural component of overwintering habitat.

Features that make a good monarch grove include shelter from storms and winds, a choice of roosting branches, dappled sunlight, a water source, and nectar plants that bloom in fall and winter. (Photographs: top and middle, The Xerces Society / Carly Voight; bottom, Matthew Shepherd.)

Solar Radiation

Solar radiation entering the grove is an important component of monarch overwintering habitat. Full sunlight allows for rapid warming to increase activity levels and flight temperatures, even under cool air temperatures (<50° F [10° C]) (Chaplin and Wells 1982; Masters 1993). Dappled sunlight provides options for flight or rest, and shade provides the coolest conditions for maintaining fat reserves. Monarchs generally cluster in areas that receive dappled sunlight in the late morning and early afternoon (Leong et al. 1991). The sunlight warms the butterflies, enabling them to fly to nectar sources to refuel their energy and lipid reserves. If a cluster area remains shady throughout the day, the monarchs' internal temperature may remain too low for them to fly. Conversely, if a cluster area is in direct sunlight, monarchs may overheat, which increases fat depletion (Chaplin and Wells 1982).

There may be predictable seasonal patterns in the distribution of clusters within a site, as sun angles and the needs of the monarchs change through the season. In mid-winter, when there is less need for activity, sites that remain sheltered, shaded, and cool may be preferred. However, once mating begins in February, there may be a preference for sites with early morning sun exposure.

The amount of solar radiation reaching the monarchs through the day and through the overwintering season is determined by canopy density. Larger canopy gaps provide longer periods of solar radiation, whereas a single layer of branches and foliage can produce dappled or filtered light. Solar radiation is greatly influenced by fine-scale gap patterns in the canopy and can, therefore, be highly variable from point to point within a grove. A single branch can make a large local difference, and small differences in height or horizontal position can create high variability in solar radiation.

Suitable overwintering habitat will have small canopy gaps that allow dappled sunlight and contain areas with larger gaps that allow for sunning and nectaring. The overwintering habitat as a whole must be dense enough to provide protection from strong winds and winter storms, yet also contain canopy gaps (Leong 1990a; Leong et al. 1991; Weiss et al. 1991).

Water

Water is another basic habitat requirement of monarchs. Most overwintering sites in California exist adjacent to natural water courses (Lane 1993; Xerces Society Western Monarch Overwintering Sites Database 2017). Water can be obtained from dew in open areas, local mud puddles, and sluggish streams, as well as from flowering plants in the form of nectar (Leong 1989; Leong et al. 1991; Weiss et al. 1991). While monarchs are generally inactive on rainy, windy, and cold days, they will fly from the clusters on sunny, warm days to obtain water necessary to sustain them throughout the winter (Frey et al. 1992; Leong 2003). Water sources close to cluster trees allow monarchs to conserve their fat reserves because they fly shorter distances to reach this essential resource (Masters et al. 1988; Wells et al. 1990). Also, water sources should be in direct or dappled sunlight as monarchs will not readily fly into shaded areas except under relatively warm air temperatures (Leong 2003).

Fall- and Winter-Blooming Nectar Plants

Monarchs in California use up approximately half of their lipid reserves during the overwintering period, and their ability to migrate in the spring may depend upon the amount of nectar that they consume during the winter (Tuskes and Brower 1978). It has also been suggested that abundant nectar sources contribute to the formation of temporary autumnal monarch aggregations, and that reduced nectar availability may cause the dispersion of these aggregations (Lane 1993).

Sunny areas with abundant nectar plants that bloom in the late fall, winter, and early spring form an important component of monarch overwintering habitat. In particular, blue gum eucalyptus blooms in early winter and provides copious nectar. Ensuring that a variety of nectar plants grow near the grove

provides choices for the monarchs through the overwintering season. A list of recommended monarch nectar plants native to California and commercially available can be found in Appendix A (page 28).

Forest Structure

The forest canopy of a monarch overwintering habitat serves as both “a thermal blanket and a rain umbrella” (Anderson and Brower 1996) because it provides protection from temperature extremes, high winds, and heavy rains during storms. By filtering wind, light, heat, and moisture, the canopy creates conditions within the overwintering groves that are calmer, darker, more humid, cooler in the day, and warmer at night as compared to those on the outside (Geiger 1965). Overhead branches are particularly important for protecting monarchs from heavy rainstorms, although wind-driven rain can come from many angles. Most high-quality monarch sites fall within a relatively narrow range (15–25%) of overall canopy openness (Weiss et al. 1991).

Monarch habitat includes the trees that provide important windbreaks, sometimes encompassing trees (and on occasion, structures) well outside the main grove. Wind exposure is determined by canopy density and canopy height. Denser canopies block the wind more effectively, whereas large tree gaps can funnel winds into groves.

Understory Structure

Monarchs overwintering sites often have a moderate level of ground vegetation and detritus, such as branches or shed tree bark. These elements provide a substrate upon which monarchs can crawl on if they are dislodged by the wind from cluster trees on cold or cloudy days. If a site lacks sufficient ground vegetation, monarchs may die from freezing ground temperatures or by being eaten by predators. Conversely, excessive ground vegetation may impede a monarch’s ability to freely fly in the forest understory.

Step 2

Create an Initial Monarch Overwintering Habitat Boundary Map

Develop a Base Map

Begin with an aerial image of your grove and the vicinity using available photographs (e.g., GIS or Google Earth) to create a base map. Monarch overwintering habitat encompasses not only the trees upon which monarchs cluster, but also surrounding trees and grove features that create the habitat characteristics described in Step 1. An overwintering site may include cluster trees, trees that provide windbreaks and dappled light, buildings or objects that provide windbreaks, flowering nectar plants, ground vegetation, and water sources (Leong 2003; Weiss 1998, 2011). Trees or structures that provide windbreaks can be located more than 110 yards (100 m) from what may appear to be the habitat boundary (Weiss 1998). You will need to use your best judgment in determining which trees and features may provide windbreaks until you have completed at least one season of monitoring.

Consult with the Xerces Society or a Local Monarch Expert

If you are conducting an assessment for the first time, past records of monarch presence or behavior will be valuable to focus monitoring efforts. Individuals involved in the Xerces Society’s Western Monarch Thanksgiving Count and organizations such as Monarch Alert have been monitoring monarchs at scores of sites and may have records of monarchs at your site or other site-specific information. Contact the Xerces Society at monarchs@xerces.org for more information about long-term monitoring of specific overwintering sites.

Step 3

Conduct a Habitat Site Assessment and Monitor During the Overwintering Season

Information gathered during a habitat site assessment and by monitoring through the overwintering season will provide the necessary data to inform management decisions. Evaluating a site should consist of both a habitat site assessment to help you identify important trees, hazards, and other areas used by overwintering monarchs, monitoring of microclimate variables that contribute to habitat suitability, and conducting a monarch count. Ideally, monitoring should be conducted at least twice a month during the overwintering season (October to March), as monarchs often move within the grove in response to changing conditions.

Habitat Site Assessment

Begin with aerial imagery of the grove. A map of property lines and tree locations is essential. This map can be made using GIS, triangulation with measuring tapes (50–100m long), or more sophisticated surveying equipment. Note that most GPS units, even high end models, may perform poorly in dense forests; in this case, a static map is extremely useful.

Identify Cluster Trees

Observe the use of trees by clustering monarchs and note the height and aspect (cardinal direction) of the branches being used. Record the location and species of these trees and note if monarch clusters are shifting vertically or between trees over the season.

Identify “Very Important Trees” (VITs)

While all trees may play some role in creating suitable habitat, there may be a limited number of trees that play key roles, such as cluster sites or trees that provide storm wind protection. The loss of such trees will seriously compromise the integrity of the overwintering habitat. Identifying these trees or groups of trees will help to prioritize tree management objectives. Initially, this will include all cluster trees and surrounding trees that provide appropriate shade or protection from the predominant wind directions. (Storm winds typically come from the southeast, south, or southwest. During non-storm periods, the winds are predominantly from the west and northwest.)

Identify “Very Important Saplings” (VISs)

These are smaller trees that are in key locations and which may grow to replace larger VITs. Note the tree species to predict how the tree’s anticipated height and branching structure will affect the microhabitat characteristics nearby. If useful, you can classify the saplings’ current heights to track changes over time. Suggested height classes are 3–10 ft., 10–30 ft., 30–100 ft., and >100ft. (1–3 m, 3–10m 10–30m, >30 m). Also note if there are no saplings present which are poised to replace a VIT and thus planting in the near future may be necessary.



Aerial photography is easily available (for example, from Google Earth) and will make a good foundation for mapping the boundary of a site as well as the location of significant trees and other habitat components.



The site assessment should identify and map all features of significance for the butterflies and site management. Significant trees can be those that provide shelter or roosting branches, but also those that create hazards or need replacing. (Photograph: The Xerces Society / Carly Voight.)

Identify Hazard Trees

A certified arborist should evaluate the health of trees at the overwintering site to determine which trees are in danger of losing limbs or falling. Obvious hazard trees should be identified, as well as trees that are infected by pests or pathogens and may become hazards in the near future. The location of all hazard trees should be mapped. Hazard trees should also be evaluated for “targets” (e.g., paths, other trees, structures) should they shed branches or fall. VITs that are also hazard trees should be replaced.

Tracking Important Trees

After mapping the location and species of the important trees (cluster trees, VITs, VISs, and hazard trees), marking key trees with tags or a unique identifier on a map is useful for tracking the trees into the future. Proper identification also helps ensure that cluster trees, VITs, or VISs are not misidentified and accidentally trimmed or removed. If there are many small trees or clustered re-sprouts, then groups of trees rather than individuals can be defined by a single identifier. Physically marking trees or identifying them clearly on a static map may be very important for finding them again in the grove as GPS units may perform poorly under a tree canopy.

Identify Nectaring, Sunning, and Water Areas

Walk through the habitat and take note of any areas that monarchs use for nectaring, water consumption, or sunning. Record any species of flowering plants that are in bloom during the overwintering period, in particular, any that are used by monarchs for nectaring. Mark all documented and potential foraging, water, and sunning locations on your map.

in bloom during the overwintering period, in particular, any that are used by monarchs for nectaring. Mark all documented and potential foraging, water, and sunning locations on your map.

Record Microclimate Variables

By using simple tools such as a compass, pocket weather meter, and standard digital camera, coupled with basic mapping, you can document differences in variables such as wind and light exposure that determine site suitability and areas which may require management to improve conditions for monarchs.

Wind Exposure

Classify the wind profile of the site by measuring the wind direction and speed with a pocket weather meter (several brands are readily available) and the compass at many points throughout the grove. Wind measurements should be done during periods of sustained winds. Baseline measurements in open areas outside the grove, coupled with interior grove measurements, allow an estimate of wind attenuation. Hourly wind data from a local weather station, if available, can supplement your measurements. Wind measurements should be taken in multiple areas in the grove close to cluster trees and in nearby areas

which do not host monarchs, as well as outside the grove. Comparing these measurements will allow you to better understand where wind protection may be insufficient outside of the cluster area. If a recent event (e.g., storm, tree removal) has made the area with clustering monarchs susceptible to high winds or storm winds, planting fast-growing trees and shrubs—or even transplanting mature trees—may be imperative to close the gap. Creating a wind profile also helps identify which lines of trees are contributing the most to wind protection of the grove and should be labeled as VITs and/or which areas may require additional plantings to increase redundancy in wind protection.

Solar Radiation

Examine the pattern of light through the day and identify those trees that are providing shade to cluster trees. This can be achieved using photographs of the canopy and ground and/or by using a light meter. Also, evaluate the amount of dappled sunlight that clusters on trees receive throughout the course of the day, and especially early morning and late afternoon. Observations in early November and in late December will be sufficient to represent the majority of the overwintering season (since the sun tracks in early November are the same as in late February). Take note if areas of the grove are allowing or blocking too much sunlight (consideration of the differences between ground level measurements and cluster heights are essential). These may be areas which would benefit from select limb thinning or additional tree planting.

Temperature and Relative Humidity

Record the temperature and humidity of the interior of the grove, near the cluster tree(s). These data can be collected with a pocket weather meter or a continuous microclimate recorder. Compare these measurements to other areas of the grove unoccupied by monarchs and outside of the grove. Colder and drier areas of the grove may benefit from management to make the microclimate conditions more suitable for clusters, such as additional tree planting.

Developing a basic wind and solar radiation profile of a monarch overwintering site can be achieved using the methods described above, and for many overwintering sites, these methods may be sufficient to plan beneficial management action. Site managers with the resources to undertake more advanced monitoring of site conditions should consider consulting with a monarch habitat expert to assess their site's conditions and needs in greater detail. Contact monarchs@xerces.org for recommendations of individuals and organizations in your area.

Two approaches to assess monarch habitat suitability in greater detail are profiled below:

- ☞ **Develop a detailed microclimate profile:** Utilize systematic wind, temperature, and humidity monitoring over the course of the overwintering season to map the microclimate profile of the site over time (see Leong et al. 1991). Combining this map with your knowledge of monarch habitat requirements and monarch movement will reveal when and where site conditions are unsuitable for clustering within the grove.
- ☞ **Utilize hemispherical photography and detailed tree mapping:** Together, these methods allow an assessment of canopy structure, and its effects on wind, solar radiation, and monarch habitat in a high degree of detail (Weiss et al. 1991, 2012; Weiss 1998, 2011). For example, data from this approach can identify areas of the grove which may receive excessive indirect and direct solar radiation throughout the season and may benefit from additional tree planting.

Conduct a Monarch Count

Observations of monarch distribution and abundance in a grove are critical to understanding site suitability—the vulnerabilities of a site are expressed by the movements of monarchs themselves. Monitoring should be done as frequently as possible during the overwintering season to capture changing distributions through the season and in response to storm events. Monitors should record the number of monarchs present and, to get an accurate estimate, counts should be done in the morning (before monarchs become active) or late afternoon/evening (after they have settled for the night). During the middle of the day, observations of monarchs sunning and nectaring can be made to identify habitats that are utilized for these activities. The monarchs' duration of occupancy (e.g., October to March) should be noted.

The Xerces Society, Monarch Alert, and others provide training on counting clustering monarchs. Land managers can contact these organizations for guidance in establishing a local monitoring program. They may be able to provide training to land management staff or initiate contacts between landowners and trained volunteer citizen scientists to monitor the site. Additional information on monitoring monarch clusters and data sheets are available online from the Western Monarch Count Resource Center, www.westernmonarchcount.org.

Step 4

Revise the Monarch Overwintering Habitat Boundary Map

Once you have completed at least one season of monitoring, revise your initial monarch overwintering habitat boundary map. Three seasons of monitoring are ideal, although often not realistic (Leong 2003). Incorporate information from the habitat site assessment, including the trees you mapped and water or nectar sources that may not have been apparent early in the season. Use data from your wind exposure evaluations to determine if additional features in the landscape act as wind buffers. If so, redraw your boundary to include these features. If the monarchs used different cluster trees throughout the season, make sure to also note this on your map.

Based on the temperature, humidity, wind, and solar radiation data you collected, highlight areas of the grove on the map which are currently unsuitable or marginally suitable for monarchs. These are areas which may benefit from active management such as tree thinning to open up the canopy or tree planting to provide additional wind/storm protection or to replace/expand the current cluster trees as the grove ages.

Figure 2 offers an example of an overwintering habitat boundary map including specific cluster trees, windbreaks, and areas targeted for active management.

Step 5

Develop an Adaptive Management Plan

A site-specific management plan should be developed using an adaptive management model (Figure 3). Adaptive management is a process that involves the continuous refinement and improvement of future management practices by learning from the outcomes of previous actions. Under this model, management regimes are designed and implemented in order to achieve stated objectives. Results are assessed through monitoring, and information gained is used to assess and adjust the management plan.



Figure 2. Aerial image of the Plaskett Creek Campground, Los Padres National Forest, showing key features of the monarch butterfly overwintering habitat, including overall boundary, clustering trees, and areas for future tree planting.

The following key elements should be included in an adaptive management plan:

- ✦ Assess the habitat to determine the existing environmental conditions at an overwintering site (See Step 3, above).
- ✦ Identify goals and objectives, and specific management actions to meet them, and set a timeline for accomplishing these actions.
- ✦ Implement management actions and grove modifications.
- ✦ Routinely monitor monarch abundance, roosting location, and microclimatic variables (See Step 3, above).
- ✦ Evaluate the information obtained from monitoring to determine the effectiveness of the management actions.
- ✦ Adjust and improve the management plan and specific actions based upon the evaluation of implemented grove modifications.

Many sites are on publicly owned or managed land. For those, a predictable annual cycle of meetings allowing for appropriate stakeholder and public input to proposed management actions is highly recommended. For all sites, both public and private, good record keeping is valuable for building institutional memory, because the adaptive management process can take decades and personnel may come and go during that time or site ownership may change.

As you develop your adaptive management plan, keep in mind that monarch abundance at a site is likely influenced by a variety of different factors (including region-wide milkweed availability and quality in breeding areas, overwintering habitat availability and quality, and climate), and monitoring yearly monarch abundance will not necessarily tell you if you have been successful at managing or restoring monarch habitat. Keeping track of the overall monarch numbers in California, and within your region, via the Xerces Society Western Monarch Thanksgiving Count and the New Year's Count (www.westernmonarchcount.org), provides a context for local fluctuations. Routine monitoring of micro-climatic variables, such as temperature, wind speed and direction, solar radiation, and nectar plant availability, both before and after implementing management actions, will allow you to evaluate the effectiveness of your activities in creating an overwintering habitat that is suitable for monarchs. In addition, trees that have been identified as providing an important function to the overwintering site (e.g., contributing to a windbreak) should be periodically assessed for pests and diseases. The earlier that hazard trees are identified, the earlier they can be replaced.

Patience is critical in the adaptive management process. As discussed in chapter 4, newly planted trees can take a decade or more to reach heights where they provide wind shelter and affect the light environment. Short-term impacts of hazard branch and tree removal may be ameliorated in subsequent years by growth responses of remaining trees, especially eucalyptus that can develop new branches to take advantage of increased light availability.

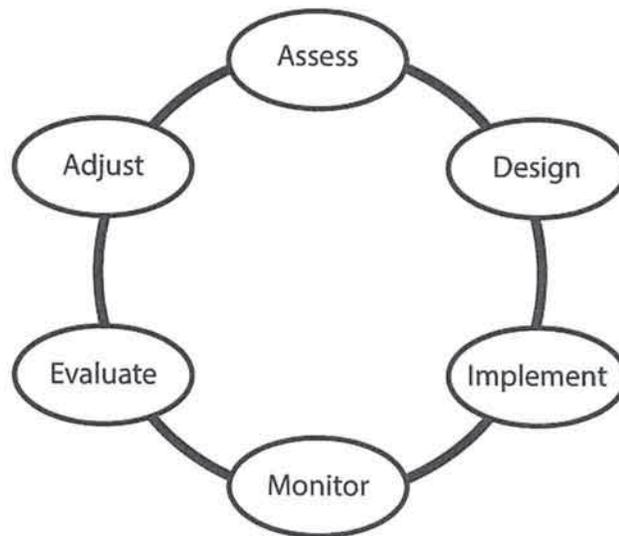


Figure 3. The adaptive management cycle (adapted from Elzinga et al. 1998).

Considerations to Include in a Management Plan

Since every overwintering habitat is unique, different management strategies and actions will be necessary for each site. Any management modifications should be based on at least one seasonal assessment of the microclimatic conditions and biological characteristics of the habitat. For example, if the habitat assessment indicates that the grove is aging and no longer provides sufficient wind shelter, additional trees should be planted at precise locations to provide a windbreak.

The following recommendations are general management modifications or actions that land managers can implement to manage and restore their monarch overwintering habitat.

Tree Management

Remove or Trim Hazard Trees When Necessary

If hazard trees are identified during the habitat site assessment, consider removing or trimming them. Hazard has two components: the likelihood of structural failure, such as a limb falling or an entire tree collapsing, and the “target” should failure occur. Targets include viewing areas, paths, structures, and other trees. Consult with a monarch habitat specialist and certified arborist before cutting or trimming any trees within the overwintering habitat; contact monarchs@xerces.org for recommendations of individuals and organizations in your area. Unless there is an immediate danger, these activities should only occur when monarchs are not present (usually between April and August). A tree planting strategy should be developed to replace any function such as wind protection that is lost or significantly diminished when trees or branches are removed (see “Plant Native Trees” below).

Old trees within monarch groves that are open to the public may need to be periodically trimmed or cut for safety reasons. These trees can shed branches, become diseased, or deteriorate with old age, and falling trees and branches can injure and kill people. Obvious hazards include standing dead trees and dead branches that could fall onto trails or observation areas. Completely dead trees and branches generally do not contribute to monarch habitat and are a major potential liability. Felled debris from diseased and infected trees should be removed from the habitat to eliminate host material.

If the habitat site assessment indicates that trees are affected by pests or pathogens, integrated pest management can be utilized to control pests without harming monarchs or other wildlife. The use of systemic insecticides at overwintering sites is strongly discouraged because they are toxic to butterflies and persistent in the environment.

Remove or Trim Select Trees to Create Appropriate Solar Radiation Pattern

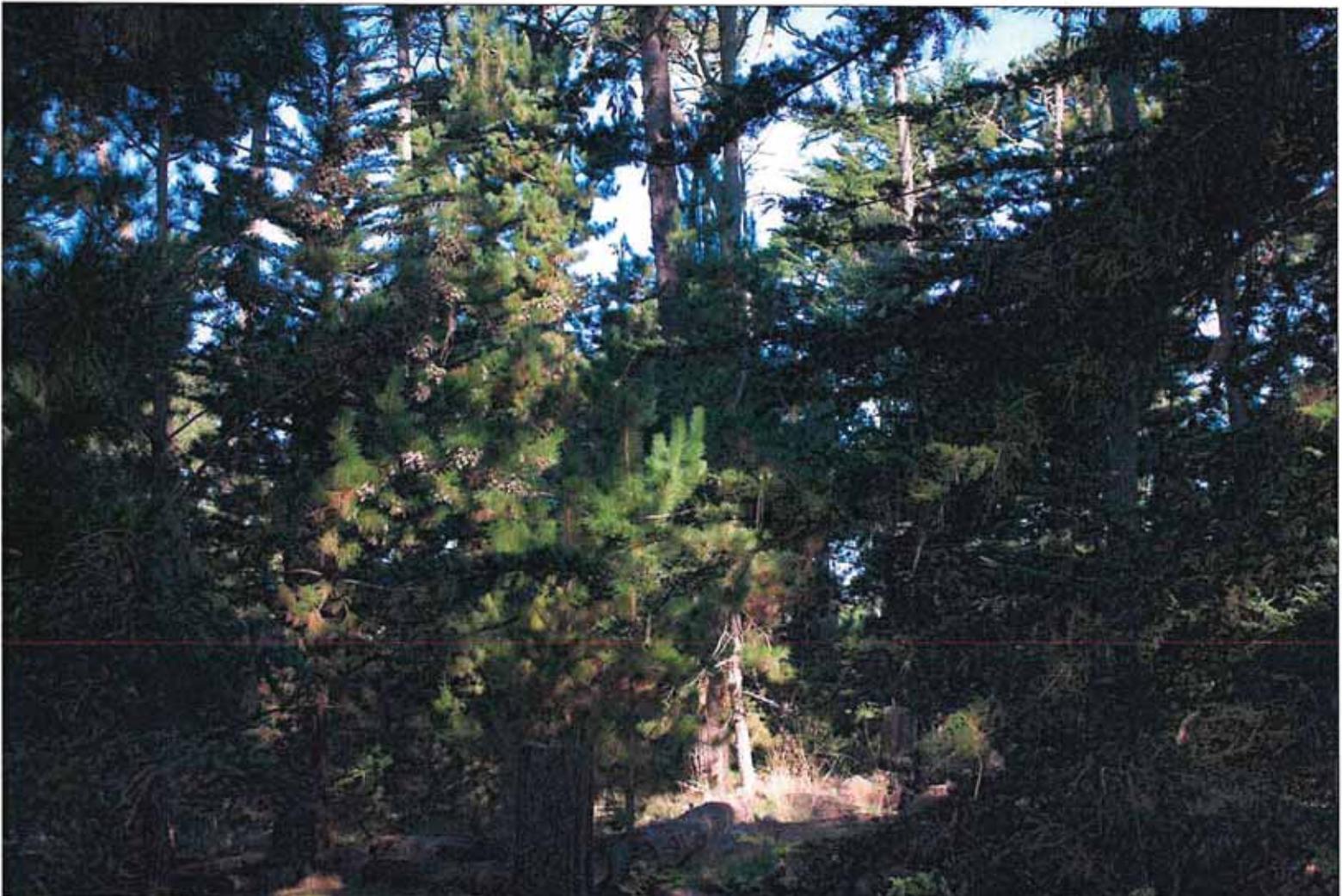
Branches or trees can be selectively removed if the habitat site assessment indicates that the monarch site does not provide adequate dappled sunlight (Weiss et al. 2012). The removal should only occur if suitable wind protection can still be maintained at the site. Additionally, some areas of shade should be retained to create a heterogeneous habitat that provides access to areas with full sun, dappled sunlight, and shade. Trees or branches should only be removed after careful thought and planning to address the potential positive and negative impacts of tree removal (Weiss 1998, 2011).

Develop a Long-Term Tree Planting Strategy

New trees could be planted to replace removed, old, or lost trees and also to provide additional wind protection. The appropriate action will be guided by conclusions from the habitat site assessment. Because it takes decades for new trees to grow and replace the function of lost trees, a plan should be developed to plant replacement trees long before old trees die or lose their ability to provide suitable microclimatic conditions. It is critically important to anticipate forest dynamics over several decades (Weiss 1998, 2011; Leong 1999). In areas where no saplings exist, new trees should be planted (Weiss and Luth 2002). Anticipate that these new plantings will take 15–30+ years to reach functional heights. Stands of the same age should be avoided and therefore plantings should be planned at appropriate intervals over time (Weiss 1998). In cases where there is an immediate need to fill a gap in an overwintering site, managers may consider excavating and relocating already established young conifers from other areas to the desired location. However, this option may be much more costly than planting saplings. If removal of nonnative trees is a goal, planting native trees many years before eucalyptus removal is necessary. Include overstory species (conifers) and mid-story trees (oaks, or delayed plantings of conifers) that can fill gaps when the lower branches of overstory conifers senesce. Tree planting and removal strategies should be designed to maintain or increase the size of the habitat and to ensure a balanced ratio of saplings to mature trees and sufficient density of the upper and lower forest layers (Janecki et al. 2004).

Take care to plant trees where they will provide the wind protection necessary for monarchs but not where they will cast shade over areas of dappled sunlight. If the monarch cluster is located far from the

Hundreds of monarchs cluster on the smaller trees in a sunlit opening. Ensuring suitable conditions are retained within this grove necessitates a long-term tree management plan that addresses trimming of branches or entire trees to remove hazards or provide adequate levels of sunlight, maintaining a windbreak against winter storms, and replacement of nonnative species. (Photograph: The Xerces Society / Carly Voight.)



newly planted trees, light infiltration may not be a concern and it may be best for the windbreak to be composed of tall trees that create a dense mid-story and understory.

Ideally, trees should be planted in the fall, after the first heavy rains (Weiss 1998). Two new trees should be planted for each removed tree, since not all saplings survive to maturity and trees can be thinned as needed. Eventual spacing of trees should be on the order of 10–20 ft. (3–6 m) so that they will not be overcrowded. To provide suitable wind protection, multiple rows of trees can be planted and trees can be offset by +/- 3 ft. (1 m) within the rows to avoid straight lines of trees (Weiss and Luth 2002). Irrigation of new plantings may be needed during the first two years to ensure survival of plantings and avoid stressing trees, but irrigation beyond should not be necessary beyond that period, except perhaps, during extreme drought. If the area is frequented by deer, deer-edible tree species should be protected (Weiss 1998).

Plant Native Trees

The Xerces Society recommends planting trees that are native to your geographic region. Recent studies suggest that monarchs do not have a preference for eucalyptus trees (Griffiths and Villablanca 2015), and that they may shift to native trees during adverse weather conditions. Ideally, restoration plantings at overwintering sites would consist of only native tree species. If this is not possible, ensure native trees are included in any planting plan.

Below are descriptions of a variety of tree species that monarchs utilize at overwintering sites, the advantages and disadvantages of using these species in restoration projects, and some insight into their management. The best option may be to plant a diversity of tree species at an overwintering site to create the variety of microhabitats that monarchs require and, potentially, to deter pests and pathogens (Weiss and Rich 2008).

Native Tree Species

Monterey Cypress (*Cupressus macrocarpa*)

Monterey cypress is one of the most desirable trees to plant at monarch groves. It is native only to the Monterey Peninsula and produces thick foliage on sturdy limbs that are able to buffer gusty winds and storms (Leong 2003). At groves which contain both cypress and eucalyptus, such as Lighthouse Field State Beach in Santa Cruz, monarchs apparently prefer Monterey cypress to nonnative eucalyptus during windy and stormy conditions (J. Dayton, unpublished data). This is perhaps because Monterey cypress has less flexible limbs and smaller scale-like leaves than eucalyptus, which may provide clustering monarchs with increased stability during strong wind events (J. Dayton, personal communication) as well as more shelter.

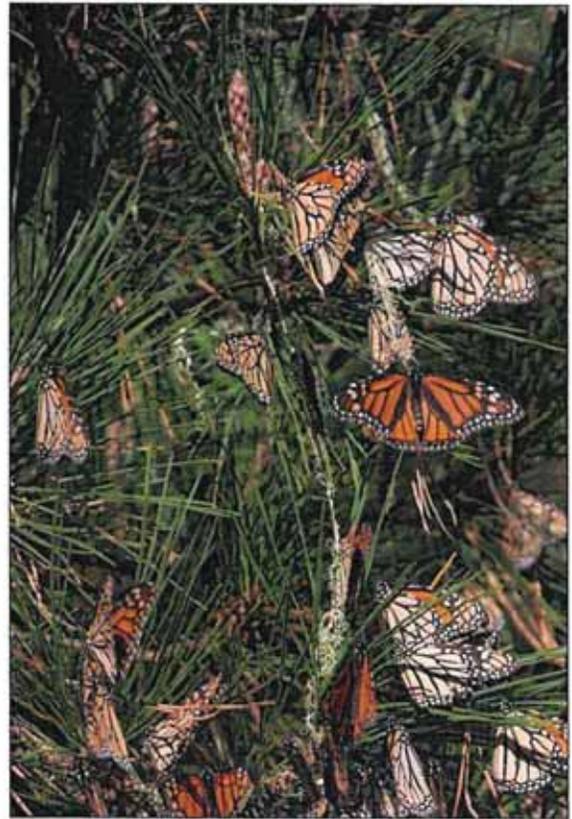
Careful placement of this tree is important. Its dense growth can obstruct light and prevent monarchs from receiving sufficient dappled sunlight if placed in inappropriate areas.

One disadvantage of Monterey cypress is that it is slow growing. It should be planted either well before hazard or aging trees are removed or in conjunction with a fast growing tree (Weiss 1998), such as Monterey pine or eucalyptus. As with most monarch grove trees, hazard management is required for old Monterey cypress since trees become frail with age. It also does not quickly regenerate new growth if trimmed (Leong 2003). Lower branches are lost with age and do not regenerate, leaving large open areas under the upper tree crown, so establishment of a mid-story of younger conifers or perhaps oaks is necessary.

Monterey Pine (*Pinus radiata*)

Monterey pine is also native to the Monterey Peninsula and was among the trees used by monarchs when butterfly groves were first recorded in that area in the 1800s (Lane 1993; Brower 1995). Additionally, it is a fast growing tree and can live up to 100 years. As with Monterey cypress, monarchs apparently prefer Monterey pine to eucalyptus during windy conditions at sites that contain both species (J. Dayton, personal communication). Monterey pine produces excellent wind shelter foliage at many heights well into the middle years (ca. 50 years old) of its lifespan. Like Monterey cypress, Monterey pine loses foliage and branches in the middlestory and understory as it matures (Weiss 1998, 2011). They do not produce new branches quickly when cut and frequently die when the top of the tree is cut (Leong 2003).

The major disadvantage to planting Monterey pine is that it can develop pitch canker fungus (Weiss 1998). Monterey pine found at many overwintering sites have developed this disease (Xerces Society Western Monarch Overwintering Site Database 2017) and mortality rates can be quite high. Generally, Monterey pine develops pitch canker during its mature years, but younger trees can also exhibit symptoms. Recent research indicates that approximately 10% of Monterey pines are at least somewhat resistant to pitch canker and will not sustain serious damage from this disease, although resistant varieties are not yet commercially available (Camilli et al. 2013). When available, resistant Monterey pines could be planted for revegetation efforts.



Fast-growing Monterey pine provides monarchs with excellent wind shelter. Unfortunately, it is prone to pitch canker fungus. (Photograph: The Xerces Society / Carly Voight.)

Coast Redwood (*Sequoia sempervirens*)

Coast redwood is native to the northern and central California coast, from Del Norte to Monterey counties. Since it produces dense foliage and grows rapidly, coast redwood provides excellent wind shelter at monarch sites. Similar to Monterey cypress and Monterey pine, monarchs apparently prefer coast redwood to eucalyptus during windy conditions at sites that contain both trees (Monarch Alert, unpublished data). Redwoods may not be appropriate for sites very close to the Pacific coast as they cannot tolerate direct exposure to ocean winds (Weiss 1998).

Coast Live Oak (*Quercus agrifolia*)

Coast live oak is native to western California, from Mendocino County to the southern border. Although coast live oaks are generally not used as cluster trees, they can be an important component of monarch groves. Their dense understory growth primarily serves as low- and mid-level windbreak, especially as other tree species lose understory branches. For this reason, the coast live oak may be a suitable tree species to plant at aging overwintering habitats. Usually they are unable to offer adequate

shelter from upper winds since they are not tall enough (Weiss 1998; Weiss and Luth 2002). These shorter trees can be planted in a matrix among taller trees to provide heterogeneity of wind shelter and ample solar radiation (Weiss and Rich 2008). They are fire resistant and can lessen the hazard of a potential fire, especially at sites containing eucalyptus (Weiss 1998). One disadvantage to using this tree in restoration efforts is that they are relatively slow growing (Weiss and Rich 2008).

Douglas-Fir (*Pseudotsuga menziesii*)

Another tree species that provides an effective windbreak at overwintering habitats is Douglas-fir. This tree is broadly distributed in western North America, and is native to the northern California coast, as well as isolated areas of the central and southern California coast. Douglas-fir is relatively fast growing, making it a good choice for restoration efforts. Although it can develop pitch canker, it is less susceptible to this disease than Monterey pine.

Other Natives

Monarchs have also been documented using western sycamore (*Platanus racemosa*) and bishop pine (*Pinus muricata*). These both may be options for improving tree diversity in groves.

Nonnative Tree Species

Blue Gum (*Eucalyptus globulus*), Red River Gum (*Eucalyptus camaldulensis*), and Other Eucalyptus Species

Blue gum, red river gum, and other eucalyptus species produce durable limbs and dense foliage that are readily used by monarchs. They grow quickly and regenerate rapidly after trimming. They also produce winter flowers, which provide a nectar source for monarchs (Weiss 1998; Weiss and Rich 2008; Leong 2003). Many species of eucalyptus of varying stature will grow in coastal California and a list of some potential species is provided by Weiss and Rich (2008).

The majority of California monarch overwintering sites are dominated by eucalyptus. This is likely due to its high relative abundance on the California coast, rather than preference by monarchs. Recent research by Griffiths and Villablanca (2015) indicates that monarchs do not prefer eucalyptus over native tree species. Despite its use for overwintering, eucalyptus is an invasive exotic species that was introduced to California in 1853 from Australia (Butterfield 1935). It can rapidly spread and encroach on native plant species, reducing biodiversity (Bossard et al. 2000).

Decomposers native to California are typically unable to process fallen eucalyptus leaves and shed bark strips, creating a thick layer on the forest floor—up to four feet deep in extreme cases—that native plants can seldom infiltrate (del Moral and Muller 1970). In addition, this leaf and bark litter leaches allelopathic compounds into the soil, preventing the establishment of native plant species in the forest understory and reducing plant species diversity (Bossard et al. 2000; del Moral and Muller 1970). The presence of eucalyptus groves also affect bird species diversity, with negative impacts on cavity nesters, warblers, and vireos (Sax 2002; Suddjian 2004).

Eucalyptus species are prone to acquire pests such as eucalyptus leaf beetle (*Chrysophtharta* sp.), eucalyptus lerp psyllids (*Glycaspis brimblecombei* and *Blastopsylla occidentalis*), or eucalyptus longhorn borer (*Phorocantha semipunctata*) (Weiss 1998; Leong 2003; Janecki et al. 2004). Many overwintering sites that contain eucalyptus have been critically affected by these pests (Xerces Society Western Monarch Overwintering Site Database 2017). Pest pressure, combined with stressors such as drought, make eucalyptus prone to developing unstable limbs that can fall and injure people. This abundance of downed branches, foliage, and shed bark strips can pose a major fire hazard (Weiss 1998; Leong 2003).



The presence of eucalyptus trees in groves presents managers with something of a conundrum. Nonnative eucalyptus species support fewer native birds and insects than native tree species, and the leaf litter and shed bark suppresses plant growth below the trees. Many of California's butterfly groves are dominated by eucalyptus, however, and the trees are used by monarchs. (Photographs: The Xerces Society / Carly Voight.)

The continued existence of the monarch overwintering phenomenon in California in the short term, however, may depend on maintaining certain groves of eucalyptus with the appropriate physical structure and microclimate. Although it is preferable to plant only native trees at monarch sites, it may not be possible. For example, if the site is composed exclusively of eucalyptus, a complete conversion to native tree species within a short time period is not feasible without negatively affecting the grove's microclimatic conditions. Also, since eucalyptus are fast-growing species, it may be necessary to plant them to provide an immediate replacement for trees unexpectedly lost from a fire, windthrow, or unplanned hazard tree removal. In these instances, it is recommended that a mixture of eucalyptus and natives be planted. A long-term plan should be developed to restore the grove with native trees as eucalyptus trees age and senesce.

The concept of managing a nonnative species for the benefit of a desirable native species has been difficult for many to grasp, and polarization of views has made management decisions contentious in many cases. A compromise is necessary to make decisions that benefit both the monarchs and the surrounding native habitats. The following guidelines for eucalyptus management are offered:

- ☞ If the site is dominated by one species of eucalyptus—this is typically blue gum (*E. globulus*)—consideration should be given to diversifying the stand with other species, such as Monterey pine and Monterey cypress, and even other eucalyptus species. Single species stands are vulnerable to pests and diseases.
- ☞ The least desirable variety of blue gum is *E. globulus* variety 'compacta.' This variety does not provide appropriate branch structure for clustering monarchs, nor does it allow for sufficient dappled sunlight (Weiss 1998). It is highly recommended that this is not planted.
- ☞ Delineate a distinct footprint for eucalyptus and establish a clear boundary beyond which all

spreading eucalyptus will be controlled. Every 3 to 5 years, find and pull seedlings and/or saplings to prevent invasion of adjacent habitats.

- ↪ Standing dead trees generally do not contribute to monarch habitat and are a hazard to people and other trees. These can be removed when monarchs are not present (April to August). All tree removal work should be done carefully and under supervision to avoid impacts on adjacent live trees. As described above, identification of hazards by a professional arborist is essential and human safety should always come first.
- ↪ Eucalyptus forests can build up large amounts of fuel and pose fire hazards. Fuel management at and beyond the edges of groves is critical and is the first option to be pursued as opposed to working the interior of the groves. All activities regarding fuel management should be conducted in conjunction with local fire agencies. The role of “ladder fuels” in fire behavior creates potential conflicts with wind protection; disrupting multi-storied forest structures that provide wind shelter should be avoided within the core footprint of a monarch site. As with hazard branches and trees, these decisions need to be made on a case-by-case basis and alternatives to large-scale removal and trimming should be considered.
- ↪ In the interior of groves, and especially near the cluster sites themselves, small downed branches, low-growing vegetation, and shed bark provides substrates for monarchs to climb off the ground and recover from being dislodged from clusters. Full removal of ground litter to bare earth is not recommended in and near cluster sites.
- ↪ Some management of eucalyptus duff and debris can encourage establishment of an understory. Native shrubs such as toyon, as well as nonnative annual grasses and some forbs, can establish and thrive.

Shrub and Forb Management

Plant Native Fall- and Winter-Blooming Flowers to Provide Nectar

Fall- and winter-blooming flowers should be maintained or planted at overwintering sites to provide nectar sources. Monarchs use nectar for energy, and store the calories obtained as lipids, which may contribute to their ability to fly great distances as spring migrants (Tuskes and Brower 1978). Nectar species should be planted in open areas that have ample sunlight between the hours of 9:00 a.m. and 2:00 p.m., as the butterflies will not readily nectar in shaded areas. Furthermore, the closer the nectar plants are to the cluster trees, the better. Monarchs that forage for nectar far from the cluster trees expend more of their energy and fat reserves and are more vulnerable to predators (Leong 2003). Nectar plants should be located within the habitat or within a quarter-mile of the cluster trees.

Appendix A (page 28) provides a list of native plants that bloom in the fall, winter, or early spring and that grow along the California coastline between Mendocino and San Diego counties. These flowers are known to be visited by monarchs. Xerces Society recommends planting only native species and selecting from nurseries plants which have not been treated with systemic insecticides.

Do Not Plant Milkweed at Overwintering Sites

The majority of monarchs spend the winter in reproductive diapause (Herman 1981) until February or March when breeding resumes. Monarchs require milkweed for egg laying and larval development, but historic records suggest that milkweed was largely absent from most coastal areas of California (Xerces

Society Western Milkweed and Monarch Occurrence Database 2017). There is some evidence of milkweed historically growing along parts of southern California's coast and in the East Bay of San Francisco, but not in central and northern coastal California. Planting milkweed outside of its historic range and close to overwintering sites may encourage monarchs to continue breeding and laying eggs during the winter. Until additional research results are available, the Xerces Society recommends a precautionary approach: Do not plant milkweed near overwintering sites (generally within 5–10 miles) in those parts of coastal California where it did not historically occur.

Xerces Society opposes the planting of non-native tropical milkweed (*Asclepias curassavica*) because its evergreen nature is associated with higher infection loads of the monarch parasite OE (*Ophryocystis elektroscirrha*), both in California and the Gulf Coast (Altizer et al. 2015; Satterfield et al. 2015, 2016).

Minimize or Eliminate Pesticide Use

Refrain from using insecticides and herbicides at overwintering sites because they may negatively impact butterflies or nectar plants. Of particular concern are systemic insecticides because of their lethal and sublethal effects on monarch caterpillars (Pecenka and Lundgren 2015; Krischik et al. 2015) and their persistence in the environment (Hopwood et al. 2016). If pesticides are used, it is best to apply the chemicals when monarchs are not present in the habitat (from April to August) and the lowest amount and least toxic chemicals should be employed.



Milkweed, such as woollypod milkweed (*Asclepias eriocarpa*) shown here, is necessary for monarch caterpillars. It should not be planted within 5–10 miles of a known overwintering grove (Photograph: The Xerces Society / Scott Hoffman Black.)

Visitor Management

Publicly accessible sites that host overwintering monarchs can provide important educational and scientific research opportunities, but such sites may be vulnerable to impacts from even the most well-intentioned visitors. Site management should balance public access with protection of overwintering monarchs and their habitat. The following recommendations will help to minimize the negative impacts.

Plan Trails to Avoid Interfering with Monarch Habitat

Designated trails help prevent trampling of grounded monarchs and vegetation and help prevent soil compaction and erosion. A trail system should be limited, such as an in-and-out trail to a viewing area or a loop trail to allow access to the butterfly area with minimal damage to the habitat. Using trail markers such as posts or cones or moveable fencing may be sufficient and allow the markers to be easily moved as the monarchs move during and between overwintering seasons. In some groves, boardwalks

may be useful to cater to high visitor numbers, although there is the risk that monarchs will move out of view from permanent facilities as microclimate conditions within the grove change over time. Trails should not be paved as this may increase the temperature in the delicate microclimate; wood chips or similar materials have fewer impacts. Motor vehicles should not be allowed in monarch habitat when monarchs are present.

Protect Public Access Overwintering Sites with a Staff or Docent Presence

A staff or docent presence at public overwintering habitats can help protect monarchs and their habitat from disturbance as well as educating visitors about monarchs and their conservation. Staff and docents can remind tourists to only walk on the designated trails and discourage inappropriate collecting or dislodging of monarchs. If a public site is unable to hire staff or enlist help from docents, appropriate interpretative signs can help educate visitors about the needs of the overwintering monarchs. Railings and signs placed along trails can prevent erosion and keep tourists at a distance from monarchs.

Erosion Prevention and Control Measures

Erosion, which can lead to runoff and pollution, is a serious problem at several monarch overwintering sites. Erosion can be caused by soil compaction from foot or bicycle traffic. Trail planning (see above) can prevent this problem. In some cases, run off of toxic oils and other materials and erosion can be caused by increases in paved roads, parking lots, and other impervious surfaces nearby. One option for minimizing this issue is to divert stormwater runoff by surface grading to impede the pooling of water within the grove. If the monarch site is located in a residential area, street water runoff may also be re-routed to storm drains although this can cause issues if the storm drains discharge into nearby creeks. Sedges (*Carex* spp.) and rushes (*Juncus* spp.) can be planted to control erosion, as can grasses such as fescue (*Festuca* spp.) (Janecki et al. 2004).

Involve Adjacent Landowners and Stakeholders

The successful conservation or restoration of overwintering habitat is contingent upon the involvement of land managers as well as adjacent landowners. If possible, tree cover should be maintained in areas surrounding the overwintering site and the area should be managed as one unit. As previously mentioned, windbreak trees can be located a considerable distance from the monarch habitat. Adjacent landowners should be aware of monarch habitat requirements and encouraged to implement management which benefits the site such as the proper removal of hazard trees and planting new trees to replace removed trees. This requires the coordination and cooperation of all surrounding landowners in management plans. Ideally, all stakeholders are included in management planning, implementation, and monitoring. In addition, funding may be more available for management and monitoring projects that are implemented with a collaborative or community approach (Weiss and Luth 2002; Janecki et al. 2004).

Additional Guidance

Information about the legal status of monarch butterflies and their habitat is available through the International Environmental Law Project and the Xerces Society (IELP 2012). Additional guidance focused on managing monarch overwintering habitat in California can be found in Bell et al. (1993) and Leong (2016).

Appendix A: Recommended Nectar Plants for Monarchs

Note: All species in this list are native to California, commercially available, and monarch butterflies have been documented visiting the flowers.

Form	Bloom Period	Common name	Species name	Flower Color
	Sp = spring, Su = summer, Fa = fall, Wi = winter			
Herb	Sp–Fa	Coastal sand verbena	<i>Abronia latifolia</i>	Yellow
Herb	Su–Fa	California goldenrod	<i>Solidago velutina</i> ssp. <i>californica</i>	Yellow
Herb	Su–Fa	Common sandaster	<i>Corethrogyne filaginifolia</i>	Yellow/purple
Herb	Su–Fa	Dunn’s lobelia	<i>Lobelia dunnii</i> var. <i>serrata</i>	Purple
Herb	Su–Fa	Roughleaf aster	<i>Eurybia radulina</i>	Purple
Herb	Su–Fa	Sweetscent	<i>Pluchea odorata</i>	Pink/purple
Herb	Su–Fa	Western goldentop	<i>Euthamia occidentalis</i>	Yellow
Herb	Wi–Sp	Bluedicks	<i>Dichelostemma capitatum</i>	Purple
Herb	Wi–Su	Seaside fleabane	<i>Erigeron glaucus</i>	Purple
Shrub	Sp–Su	Black sage	<i>Salvia mellifera</i>	Blue/purple
Shrub	Sp–Su	Blueblossom	<i>Ceanothus thyrsiflorus</i>	Blue
Shrub	Sp–Fa	Dune ragwort	<i>Senecio blochmaniae</i>	Yellow
Shrub	Su–Fa	California broomsage	<i>Lepidospartum squamatum</i>	Yellow
Shrub	Su–Fa	Saltmarsh baccharis	<i>Baccharis douglasii</i>	White
Shrub	Fa	California goldenbush	<i>Ericameria ericoides</i>	Yellow
Shrub	Fa–Wi	Coyotebrush	<i>Baccharis pilularis</i>	Yellow/white
Shrub	Fa–Su	Bladderpod spiderflower	<i>Cleome isomeris</i>	Yellow
Shrub	Wi	Desertbroom	<i>Baccharis sarothroides</i>	Pink/white
Tree	Wi–Sp	Arroyo willow	<i>Salix lasiolepis</i>	Yellow/white
Tree	Wi–Sp	Hollyleaf cherry	<i>Prunus ilicifolia</i>	Yellow/white
Shrub	Wi–Sp	Morro manzanita	<i>Arctostaphylos morroensis</i>	Pink/white
Shrub	Wi–Sp	Refugio manzanita	<i>Arctostaphylos refugioensis</i>	White
Shrub	Wi–Sp	Sugar sumac	<i>Rhus integrifolia</i>	Pink
Shrub	Wi–Su	California brittlebush	<i>Encelia californica</i>	Yellow

Height	Water Needs	Notes
Maximum, in feet.	Low, Medium, or High	All species are perennials. Monarchs are typically present in coastal California from September through March, but can be found year-round in some parts of the region.
1	L/M	Tolerates salt spray and prefers sandy soils; can bloom year-round.
3	L	Important late-season forage for bees, butterflies, wasps, beetles, and more.
3	L/M	Host plant for Gabb's checkerspot (<i>Chlosyne gabbii</i>)
2	H	Excellent butterfly plant.
2	M	High drought tolerance once established.
3	L	Mostly coastal, brackish plant. Can tolerate saline sites.
6	M/H	Wetland-riparian.
3	L	Attracts other bees, butterflies, and hummingbirds. An early spring bloomer.
2	L/M	A great butterfly plant.
6	L	Important butterfly and hummingbird plant. Quail eat the seeds.
15	L	Amazing pollinator plant. Host plant to many butterfly species. Birds will eat the seeds.
3	L/M	Limited distribution.
6	L/M	Can be used in restoration and stream stabilization projects.
3	M/H	Important nectar source for many species of wasps, butterflies, and flies.
3	L/M	Great late season nectar source for bees and butterflies.
8	L	Easy to grow and extremely drought-tolerant. Attractive to many insects.
4	L	Tolerates salt spray. Also attracts bees.
10	L	Can be used for streambank stabilization.
20	H	Tolerates sand and seasonal flooding; good for erosion control. Important wild-life plant.
14	L	Fruits eaten by many birds and small mammals.
20	L	Limited distribution. On CA rare/threatened/endangered list.
7	L	Limited distribution. On CA rare/threatened/endangered list.
8	L/M	Good for erosion control on coastal bluffs. Fruits are eaten by birds and other wildlife.
4	L/M	Tolerates salt spray. Can be used to stabilize slopes. Good bee and butterfly plant.

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Protecting the Life That Sustains Us

The Xerces Society for Invertebrate Conservation is a nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat. Established in 1971, the Society is a trusted source for science-based information and advice. Our conservation team draws together experts from the fields of habitat restoration, entomology, botany, farming, and conservation biology with a single focus: protecting the life that sustains us.

628 NE Broadway, Suite 200, Portland, OR 97232
(855) 232-6639 www.xerces.org

Regional offices across the United States.

BODEGA BAY TRAIL PROJECT

ITEMS TO BE PROVIDED BY COUNTY:

1. ENCROACHMENT PERMIT FROM SONOMA COUNTY TRANSPORTATION & PUBLIC WORKS
2. SOILS REPORT BY QUESTA
3. SIGNS
4. COASTAL DEVELOPMENT PERMIT (CPH09-0007)
5. WATER QUALITY CERTIFICATION (W010-1B12018WH56)
6. ARMY CORPS OF ENGINEERS PERMIT (2009-00266-H)
7. CA. DEPARTMENT OF FISH & WILDLIFE PERMIT (1600-2012-011-R3)
8. TIP ID SON 070008

SCOPE OF WORK:

BASE BID: PERFORM CLEARING, GRUBBING, BOARDWALKS, STABILIZED PATHS, DRAINAGE IMPROVEMENTS, CONCRETE LANDING, CONCRETE PADS, GRAVEL PARKING AREAS, PREPARE & IMPLEMENT STORMWATER POLLUTION PREVENTION PROGRAM, PARKING LOT STRIPING, INSTALL SIGN POSTS (SIGNS TO BE PROVIDED BY COUNTY), AND ASSORTED AMENITIES.

PHASE --

BODEGA BAY, SONOMA COUNTY, CALIFORNIA CONSTRUCTION PLANS

GENERAL NOTES

1. ALL MATERIALS, WORKMANSHIP, AND CONSTRUCTION SHALL CONFORM TO THE STATE OF CALIFORNIA STANDARD SPECIFICATIONS AND STANDARD PLANS (LATEST REVISION), UNLESS OTHERWISE NOTED.
2. ALL UTILITIES CONFLICTING WITH THE PROPOSED CONSTRUCTION SHALL BE LOCATED PRIOR TO START OF CONSTRUCTION.
3. THE SUBGRADE, CLASS II AGGREGATE BASE, ASPHALTIC CONCRETE SHALL BE 50% (MIN.) VIRGIN MATERIALS AND SHALL HAVE A RELATIVE COMPACTION OF 95%, SHALL BE FREE OF LOOSE OR EXTRANEANEOUS MATERIAL, AND BE A TIGHT, NON-YIELDING SURFACE WITH NO VISIBLE DISPLACEMENT.
4. UNDERGROUND SERVICE ALERT (USA) - CALL TOLL FREE 800-642-2444 AT LEAST 48 HOURS PRIOR TO EXCAVATION.
5. ALL UNUSABLE EXCESS SOIL MATERIAL, STUMPS AND BOULDERS SHALL BE REMOVED FROM THE SITE AND DISPOSED OF IN A LEGAL MANNER AND BECOME PROPERTY OF THE CONTRACTOR.

GRADING NOTES

1. PERFORM GRADING IN ACCORDANCE WITH THE LATEST EDITION OF APPENDIX CHAPTER 33 OF THE CALIFORNIA BUILDING CODE, APPLICABLE SONOMA COUNTY REGULATIONS AND TO THE RECOMMENDATIONS OF THE GEOTECHNICAL ENGINEERING REPORT TITLED "GEOTECHNICAL INVESTIGATION REPORT FOR BODEGA BAY COASTAL PRAIRIE TRAIL, BODEGA BAY, CALIFORNIA" PREPARED BY QUESTA ENGINEERING CORPORATION, DATED FEBRUARY 25, 2009.
2. EXISTING DRAINAGE COURSES RECEIVING WATERS FROM THIS SITE AND LOCATED THROUGHOUT THIS SITE SHALL REMAIN OPEN AND CLEAR OF DEBRIS TO PROPERLY CONVEY STORM WATER. IF EXISTING DRAINAGE COURSES RECEIVING WATERS FROM THIS SITE ARE LOCATED IN THE COUNTY RIGHT-OF-WAY AND NEED MAINTENANCE, CONTACT THE DEPARTMENT OF TRANSPORTATION AND PUBLIC WORKS AT (707) 565-2231 AND THE DEPARTMENT OF PARKS AND RECREATION AT (707) 865-2391 FOR FURTHER ASSISTANCE. IN ANY EVENT, THE OWNER AND/OR CONTRACTOR SHALL BE HELD LIABLE FOR ANY DAMAGE DUE TO OBSTRUCTING NATURAL DRAINAGE PATTERNS.
3. THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE DESIGN ENGINEER UPON DISCOVERING SIGNIFICANT DISCREPANCIES, ERRORS OR OMISSIONS IN THE PLANS. PRIOR TO PROCEEDING, THE OWNER SHALL HAVE THE PLANS REVISED TO CLARIFY IDENTIFIED DISCREPANCIES, ERRORS OR OMISSIONS. THE REVISED PLANS SHALL BE SUBJECT TO REVIEW BY THE CHIEF BUILDING OFFICIAL.
4. THE CONTRACTOR SHALL BE RESPONSIBLE FOR NOTIFYING UNDERGROUND SERVICE ALERT (USA), TOLL FREE AT 1-800-642-2444, AT LEAST TWO WORKING DAYS PRIOR TO EXCAVATION. THE CONTRACTOR SHALL UNCOVER RELEVANT UTILITIES TO VERIFY THEIR LOCATION AND ELEVATION. IF UNEXPECTED OR CONFLICTING UTILITIES ARE ENCOUNTERED DURING EXCAVATION, NOTIFY USA, THE UTILITY OWNER AND/OR THE PROJECT ENGINEER IMMEDIATELY. UTILITIES INCLUDE BUT ARE NOT LIMITED TO WATER, SEWER, ELECTRICAL, GAS, TELEPHONE AND CABLE/TV.
5. IN THE EVENT CULTURAL RESOURCES (I.E., HISTORICAL, ARCHAEOLOGICAL, AND PALEONTOLOGICAL RESOURCES, AND HUMAN REMAINS) ARE DISCOVERED DURING GRADING OR OTHER CONSTRUCTION ACTIVITIES, WORK SHALL BE HALTED WITHIN A 100 FOOT RADIUS OF THE FIND. THE NORTHWEST INFORMATION CENTER SHALL BE NOTIFIED AT (707) 664-0880. A QUALIFIED ARCHEOLOGIST SHALL BE CONSULTED FOR AN ON-SITE EVALUATION. ADDITIONAL MITIGATION MAY BE REQUIRED BY THE COUNTY PER THE ARCHEOLOGISTS RECOMMENDATIONS. IF HUMAN BURIALS OR HUMAN REMAINS ARE ENCOUNTERED, THE CONTRACTOR SHALL ALSO NOTIFY THE COUNTY CORONER AT (707) 565-5070.
6. SHOULD GRADING OPERATIONS ENCOUNTER HAZARDOUS MATERIALS, OR WHAT APPEAR TO BE HAZARDOUS MATERIALS, STOP WORK IN THE AFFECTED AREA IMMEDIATELY AND CONTACT 911 OR THE APPROPRIATE AGENCY FOR FURTHER INSTRUCTION.

EARTHWORK NOTES

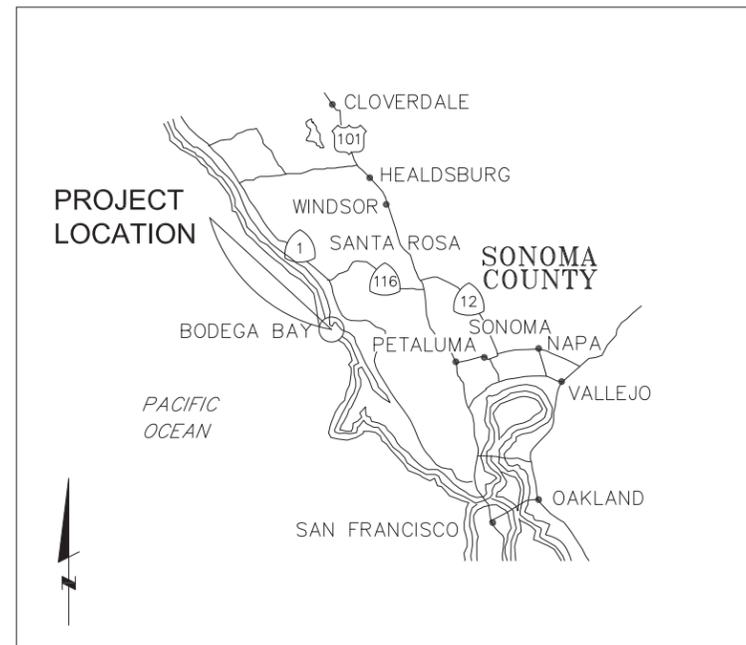
1. ALL QUANTITIES SHOWN ON THIS PLAN ARE APPROXIMATE. CALCULATED EXCESS AND SHORTAGE ARE TO FINISHED ROUGH GRADE AND EXISTING GROUND. THE ACTUAL AMOUNT OF EARTH MOVED WILL VARY, DEPENDENT ON COMPACTION, CONSOLIDATION, STRIPPING REQUIREMENTS, AND THE CONTRACTOR'S METHOD OF OPERATION.
2. DUE TO THE INEXACT NATURE OF EARTHWORK ESTIMATING, THERE IS NO GUARANTEE OF THESE QUANTITIES. CONTRACTOR SHALL MAKE HIS OWN ESTIMATE FOR BID AND CONSTRUCTION PURPOSES.

DISTURBED AREA

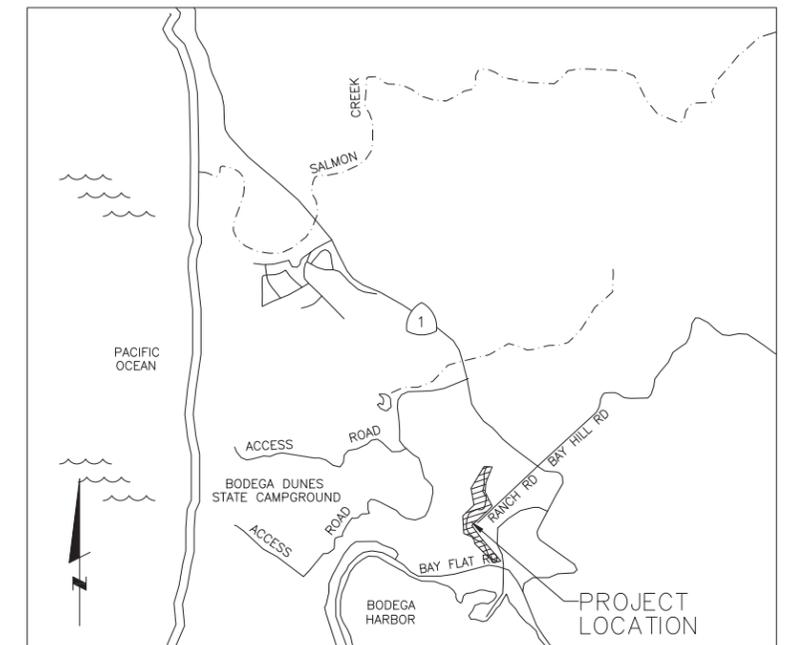
TOTAL AREA = 0.70 ACRES

ABBREVIATIONS

AB	AGGREGATE BASE
AC	ASPHALT CONCRETE
AFG	ABOVE FINISH GRADE
AGGR	AGGREGATE
&	AND
APPROX	APPROXIMATE
@	AT
BFG	BELOW FINISH GRADE
BVCE	BEGIN VERTICAL CURVE ELEVATION
BVCS	BEGIN VERTICAL CURVE STATION
CL	CLASS
CONC	CONCRETE
CLR	CLEARANCE
CP	CONTROL POINT
DIA, Ø	DIAMETER
EA	EACH
EL, ELEV	ELEVATION
EP	EDGE OF PAVEMENT
EVCE	END VERTICAL CURVE ELEVATION
EVCS	END VERTICAL CURVE STATION
EX., EXIST	EXISTING
(E)	EXISTING
FG	FINISHED GRADE
FL	FLOW LINE
FT	FEET
GALV	GALVANIZED
GB	GRADE BREAK
H, HORIZ	HORIZONTAL
INV	INVERT
JP	JOINT POLE
LF	LINEAR FEET
LT	LEFT
LT	MAXIMUM
MIN	MINIMUM
MISC	MISCELLANEOUS
MH	MANHOLE
MON	MONUMENT
N	NORTH
NO. #	NUMBER
NTS	NOT TO SCALE
O.C.	ON CENTER
OH	OVER HEAD
PCC	POINT COMPOUND CURVE
PRC	POINT OF REVERSE CURVATURE
PI	POINT OF INTERSECTION
PP	POWER POLE
PROP	PROPERTY
PT	POINT
PRVCE	POINT OF REVERSE VERTICAL CURVE ELEVATION
PRVCS	POINT OF REVERSE VERTICAL CURVE STATION
PVI	POINT OF VERTICAL INTERSECTION
R	RADIUS
RBP	RESIN BASED PAVEMENT
RC	RELATIVE COMPACTION
RCP	REINFORCED CONCRETE PIPE
R/W	RIGHT OF WAY
S	SLOPE OR SOUTH
SD	STORM DRAIN
SDMH	STORM DRAIN MANHOLE
SHT	SHEET
SS	SANITARY SEWER
STA	STATION
STD	STANDARD
ST	STREET
STL	STEEL
TC	TOP OF CURB
TYP	TYPICAL
VC	VERTICAL CURVE
W/	WITH
W/O	WITHOUT



VICINITY MAP
NOT TO SCALE



LOCATION MAP
NOT TO SCALE

SHEET INDEX	
SHEET NUMBER	SHEET TITLE
1	COVER SHEET
2	TRAIL OVERVIEW
3	ENV, PROTECTION AND TREE AND VEG. REMOVAL
4	STATION 0+00 TO 5+70
5	STATION 5+70 TO 11+40
6	STATION 11+40 TO 17+10
7	STATION 17+10 TO 22+80
8	STATION 22+80 TO 28+40
9	STATION 28+40 TO 32+70
10	ROAD AND CROSSWALK STRIPING
11	SECTIONS 1+00 TO 10+50
12	SECTIONS 11+00 TO 16+50
13	SECTIONS 17+00 TO 22+50
14	SECTIONS 23+00 TO 30+00
15	SECTIONS 30+50 TO 31+50
16	PLANTING AND HABITAT ENHANCEMENT
17	TRAIL DETAILS
18	BOARDWALK DETAILS
19	BOARDWALK DETAILS

BODEGA BAY TRAIL PROJECT
SONOMA COUNTY, CALIFORNIA
SONOMA COUNTY REGIONAL PARKS

QUESTA
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Civil Environmental & Water Resources
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questa@questaec.com
P.O. Box 70356 1220 Bitckyard Cove Road Point Richmond, CA 94807

90% PROFESSIONALS
REGISTERED PROFESSIONAL ENGINEER
No. 87949
Exp. 06-30-18
C.S. 11
STATE OF CALIFORNIA
CONSULTATION

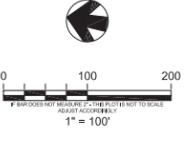
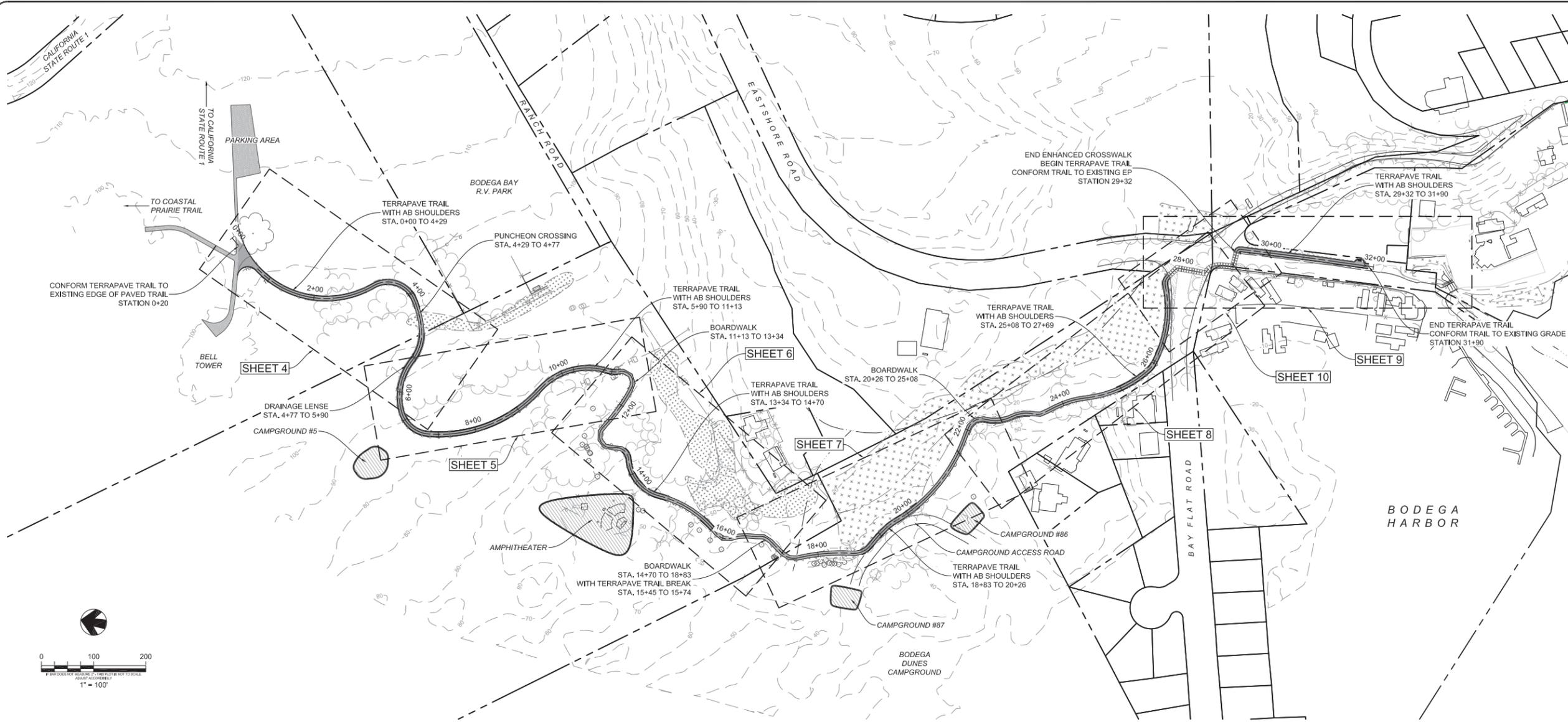
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COASTAL NORTH HARBOR SEGMENT
COVER SHEET
BODEGA BAY
SONOMA COUNTY, CALIFORNIA

Size	Project
D	1400152
Scale:	AS NOTED
Date:	07/30/18
FIGURE:	1 OF 19

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LEGEND			
	EXISTING MAJOR CONTOUR		NEW MAJOR CONTOUR
	EXISTING MINOR CONTOUR		NEW MINOR CONTOUR
	EXISTING STRUCTURE		PROPOSED TRAIL CENTERLINE
	EXISTING EDGE OF AC PAVEMENT		NEW EDGE OF TRAVELWAY
	EXISTING ROAD STRIPE		NEW LIMIT OF GRADING
	EXISTING EDGE OF CONCRETE		NEW TERRAPAVE TRAIL/BOARDWALK TRAVELWAY
	EXISTING DRIVEWAY		NEW TRAIL SHOULDER
	EXISTING EDGE OF TREE DRIPLINE		SEEDED FINISH GRADE
	EXISTING EDGE OF BRUSH		NEW CROSSWALK STRIPING
	EXISTING DRAINAGE FLOWLINE		ESA FENCE/LIMIT OF WORK
	EXISTING CHAINLINK FENCE		EXISTING SIGN
	EXISTING TRAFFIC GUARDRAIL		EXISTING SIGN
	EXISTING OVERHEAD LINE		EXISTING PIPE BOLLARD
	EXISTING WETLAND AREA		EXISTING CATCH BASIN
	EXISTING RIPARIAN AREA		EXISTING MANHOLE
	EXISTING TREE		EXISTING WATER VALVE
	EXISTING JOINT UTILITY POLE		EXISTING FIRE HYDRANT
	EXISTING SECONDARY UTILITY POLE		EXISTING LAMPPOST

BODEGA BAY TRAIL PROJECT
 SONOMA COUNTY, CALIFORNIA
 SONOMA COUNTY REGIONAL PARKS



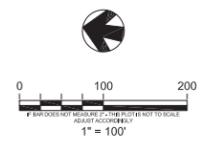
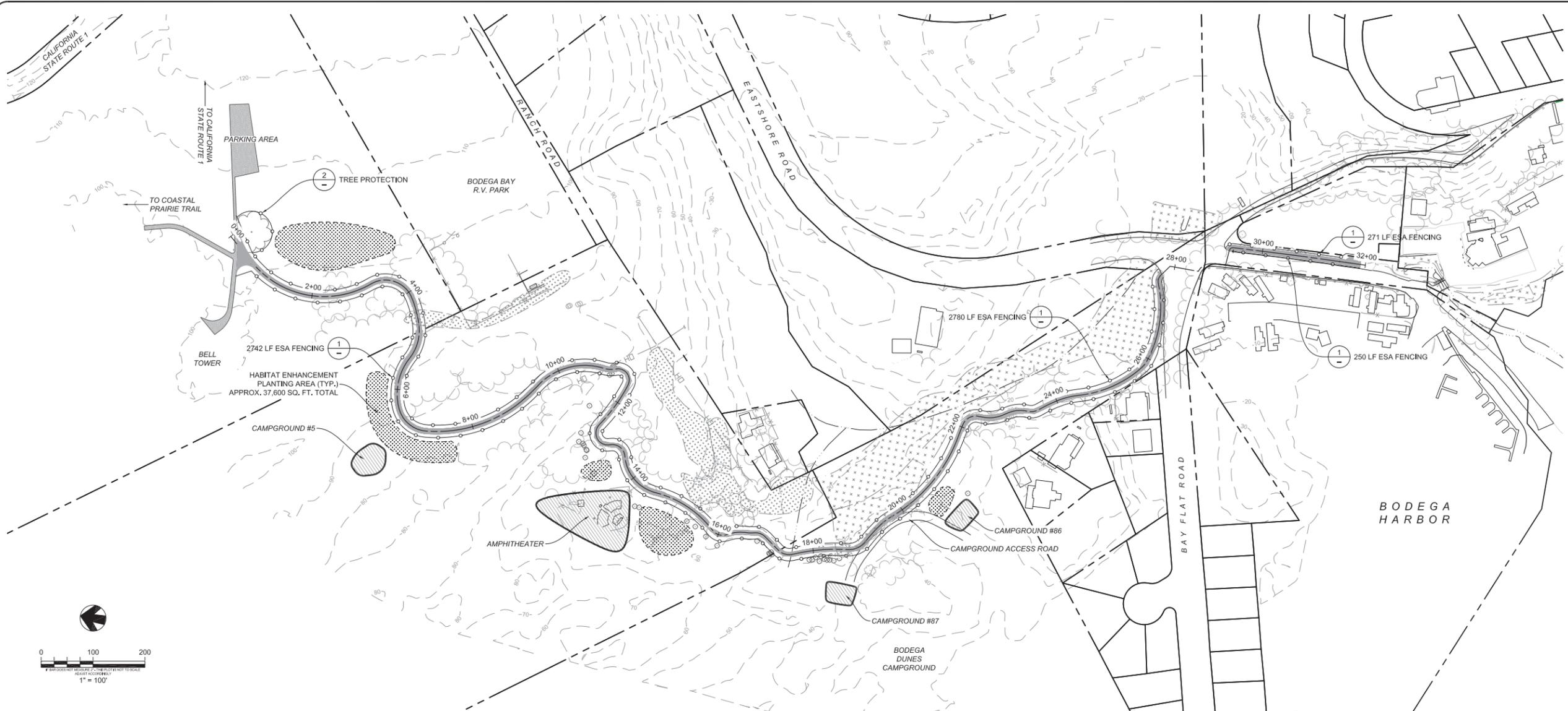
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COASTAL NORTH HARBOR SEGMENT
 TRAIL OVERVIEW
 BODEGA BAY
 SONOMA COUNTY, CALIFORNIA

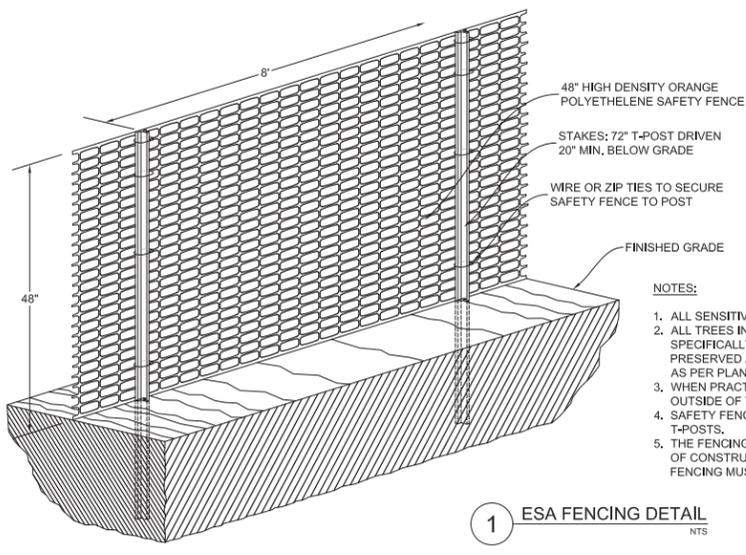
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FIGURE:	2 OF 19

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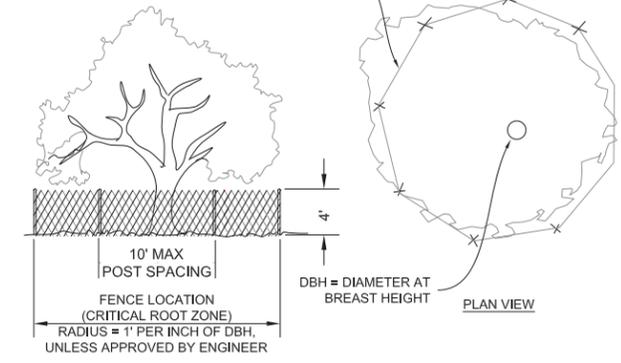
LEGEND

	EXISTING MAJOR CONTOUR		NEW MAJOR CONTOUR
	EXISTING MINOR CONTOUR		NEW MINOR CONTOUR
	EXISTING STRUCTURE		PROPOSED TRAIL CENTERLINE
	EXISTING EDGE OF AC PAVEMENT		NEW EDGE OF TRAVELWAY
	EXISTING ROAD STRIPE		NEW LIMIT OF GRADING
	EXISTING EDGE OF CONCRETE		NEW TERRAPAVE TRAIL/BOARDWALK TRAVELWAY
	EXISTING DRIVEWAY		NEW TRAIL SHOULDER
	EXISTING EDGE OF TREE DRIPLINE		SEEDED FINISH GRADE
	EXISTING EDGE OF BRUSH		NEW CROSSWALK STRIPING
	EXISTING DRAINAGE FLOWLINE		ESA FENCE/LIMIT OF WORK
	EXISTING CHAINLINK FENCE		EXISTING SIGN
	EXISTING TRAFFIC GUARDRAIL		EXISTING PIPE BOLLARD
	EXISTING OVERHEAD LINE		EXISTING CATCH BASIN
	EXISTING WETLAND AREA		EXISTING MANHOLE
	EXISTING RIPARIAN AREA		EXISTING WATER VALVE
	EXISTING TREE		EXISTING FIRE HYDRANT
	EXISTING JOINT UTILITY POLE		EXISTING LAMPPOST
	EXISTING SECONDARY UTILITY POLE		



- NOTES:**
1. ALL SENSITIVE AREAS SHALL BE PROTECTED AS PER PLAN.
 2. ALL TREES IN THE CONSTRUCTION AREA NOT SPECIFICALLY DESIGNATED FOR REMOVAL SHALL BE PRESERVED AND PROTECTED WITH HIGH VISIBILITY FENCE AS PER PLAN.
 3. WHEN PRACTICABLE, INSTALL HIGH VISIBILITY 3 FEET OUTSIDE OF THE DRIP LINE OF THE TREE.
 4. SAFETY FENCE SHOULD BE FASTENED SECURELY TO THE T-POSTS.
 5. THE FENCING MUST REMAIN IN PLACE DURING ALL PHASES OF CONSTRUCTION; ANY CHANGE OF THE PROTECTIVE FENCING MUST BE APPROVED.

4' HIGH TREE PROTECTION FENCE PROVIDE 1' RADIUS FOR EACH INCH OF DBH UNLESS APPROVED BY ENGINEER



BODEGA BAY TRAIL PROJECT
SONOMA COUNTY, CALIFORNIA
SONOMA COUNTY REGIONAL PARKS

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questa@questaec.com



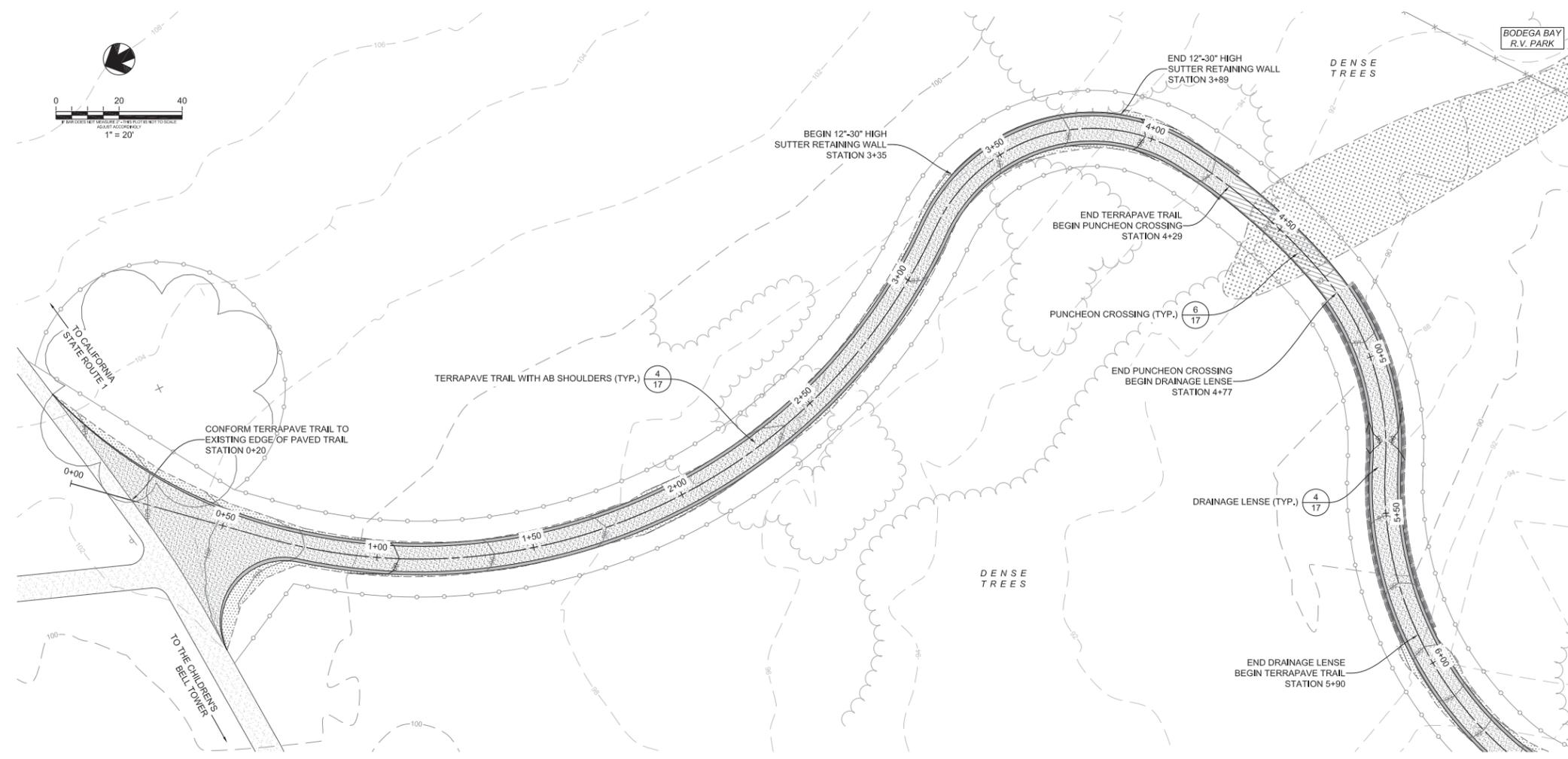
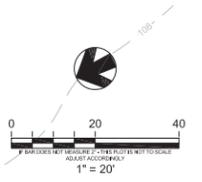
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COASTAL NORTH HARBOR SEGMENT
ENV. PROTECTION AND TREE AND VEG. REMOVAL
BODEGA BAY
SONOMA COUNTY, CALIFORNIA

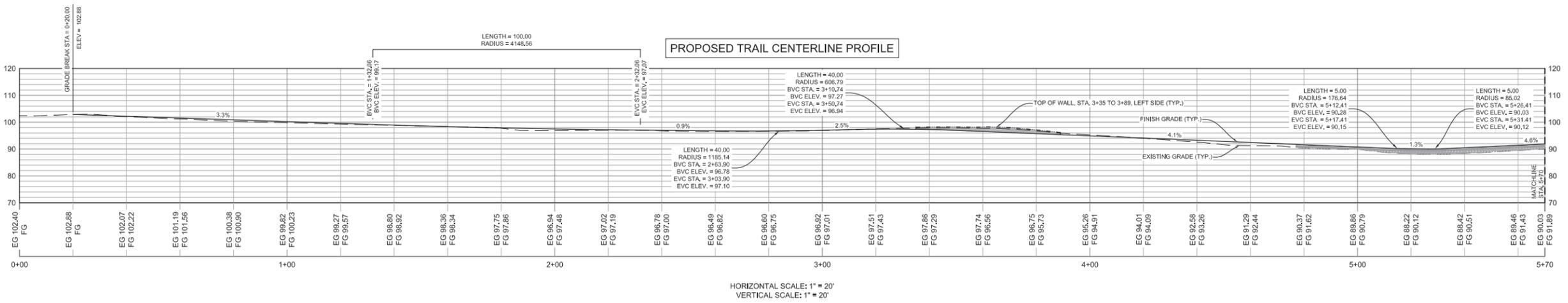
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FIGURE:	3 OF 19

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LEGEND

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	EXISTING MINOR CONTOUR		NEW MINOR CONTOUR
	EXISTING STRUCTURE		PROPOSED TRAIL CENTERLINE
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	EXISTING JOINT UTILITY POLE		EXISTING WATER VALVE
	EXISTING SECONDARY UTILITY POLE		EXISTING FIRE HYDRANT
			EXISTING LAMPPOST



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 SONOMA COUNTY REGIONAL PARKS

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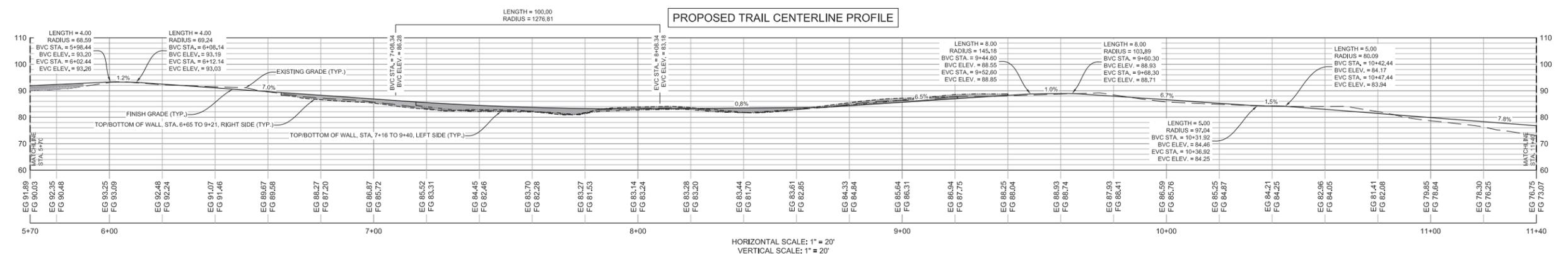
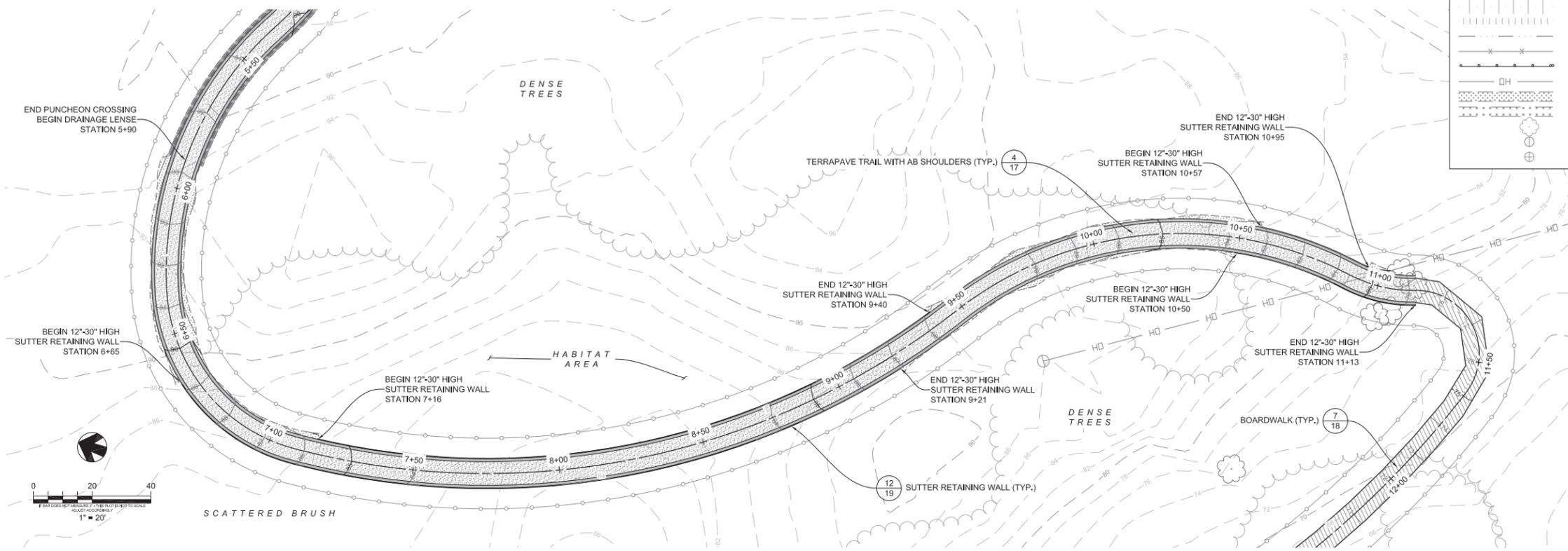
COASTAL NORTH HARBOR SEGMENT
 STATION 0+00 TO 5+70
 BODEGA BAY
 SONOMA COUNTY, CALIFORNIA

Size D	Project 1400152
Scale: AS NOTED	
Date: 07/30/18	
FIGURE: 4 OF 19	

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 IF BAR DOES NOT MEASURE, 1" DRAWING IS NOT TO SCALE - ADJUST ACCORDINGLY

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 IF BAR DOES NOT MEASURE, 1" DRAWING IS NOT TO SCALE - ADJUST ACCORDINGLY

LEGEND			
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	EXISTING MINOR CONTOUR		NEW MINOR CONTOUR
	EXISTING STRUCTURE		PROPOSED TRAIL CENTERLINE
	EXISTING EDGE OF AC PAVEMENT		NEW EDGE OF TRAVELWAY
	EXISTING ROAD STRIPE		NEW LIMIT OF GRADING
	EXISTING EDGE OF CONCRETE		NEW TERRAPAVE TRAIL/BOARDWALK TRAVELWAY
	EXISTING DRIVEWAY		NEW TRAIL SHOULDER
	EXISTING EDGE OF TREE DRIP LINE		SEEDED FINISH GRADE
	EXISTING EDGE OF BRUSH		NEW CROSSWALK STRIPING
	EXISTING DRAINAGE FLOWLINE		ESA FENCE/LIMIT OF WORK
	EXISTING CHAINLINK FENCE		EXISTING SIGN
	EXISTING TRAFFIC GUARDRAIL		EXISTING SIGN
	EXISTING OVERHEAD LINE		EXISTING PIPE BOLLARD
	EXISTING WETLAND AREA		EXISTING CATCH BASIN
	EXISTING RIPARIAN AREA		EXISTING MANHOLE
	EXISTING TREE		EXISTING WATER VALVE
	EXISTING JOINT UTILITY POLE		EXISTING FIRE HYDRANT
	EXISTING SECONDARY UTILITY POLE		EXISTING LAMPPOST



BODEGA BAY TRAIL PROJECT
 SONOMA COUNTY, CALIFORNIA
 SONOMA COUNTY REGIONAL PARKS

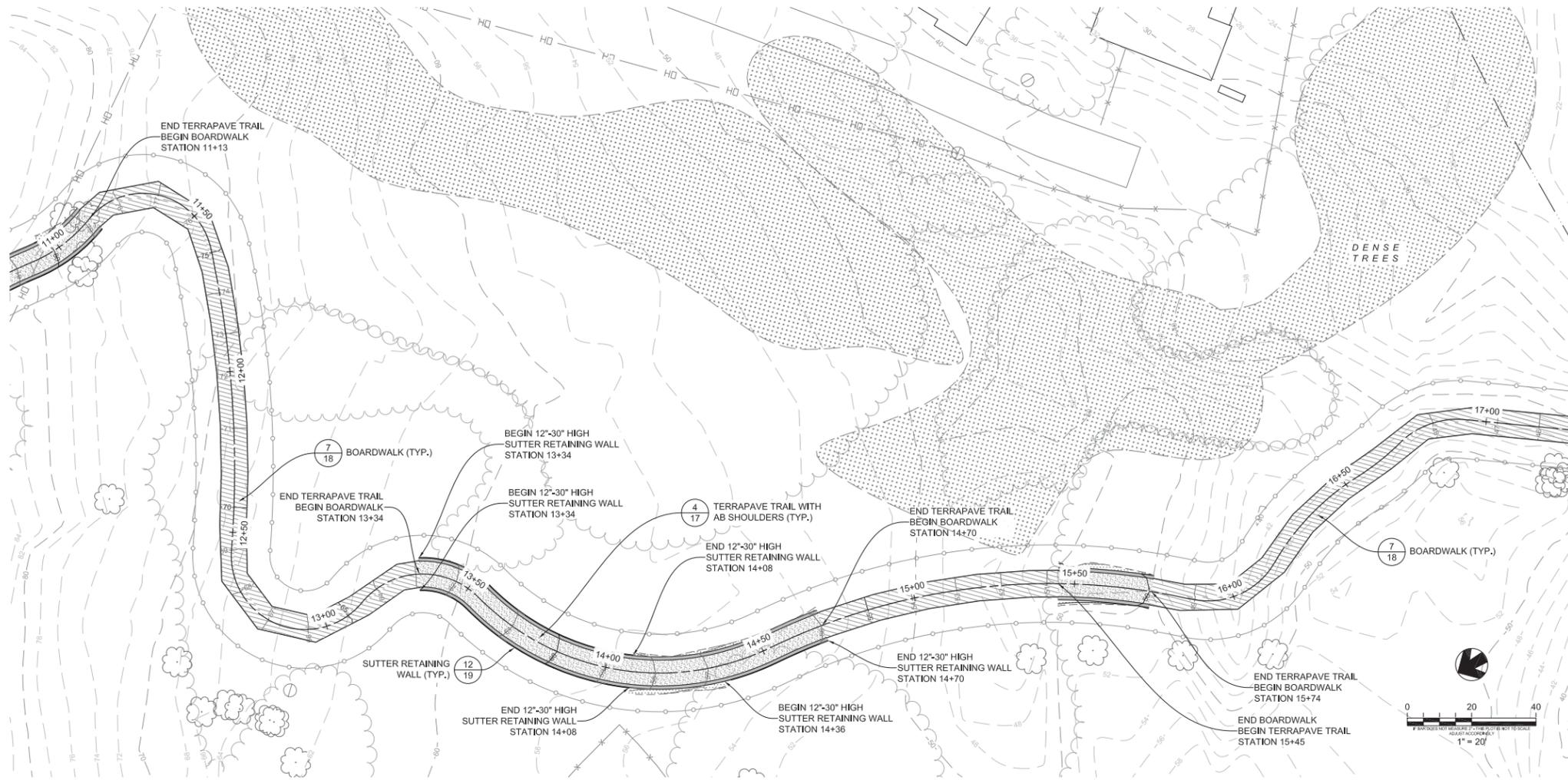
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 P.O. Box 70356 1220 Bidyard Cove Road Point Richmond, CA 94807



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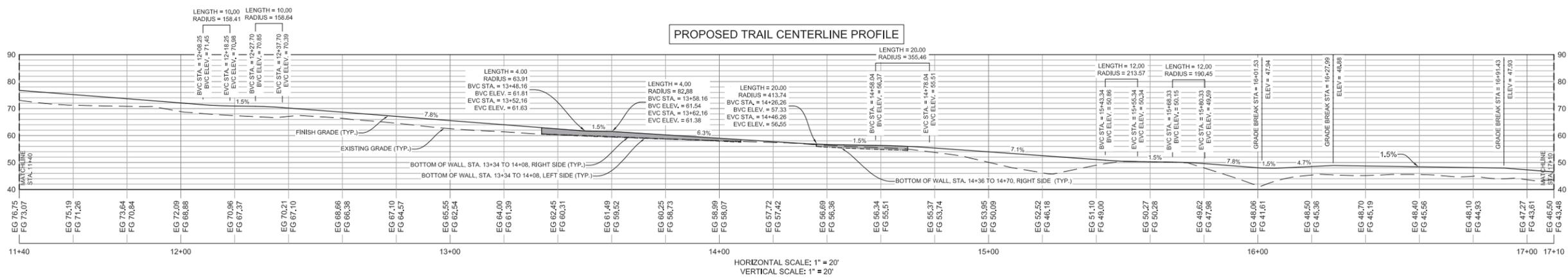
COASTAL NORTH HARBOR SEGMENT
 STATION 5+70 TO 11+40
 BODEGA BAY
 SONOMA COUNTY, CALIFORNIA

Size	Project
D	1400152
Scale:	AS NOTED
Date:	07/30/18
FIGURE:	5 OF 19



LEGEND

	EXISTING MAJOR CONTOUR		NEW MAJOR CONTOUR
	EXISTING MINOR CONTOUR		NEW MINOR CONTOUR
	EXISTING STRUCTURE		PROPOSED TRAIL CENTERLINE
	EXISTING EDGE OF AC PAVEMENT		NEW EDGE OF TRAVELWAY
	EXISTING ROAD STRIPE		NEW LIMIT OF GRADING
	EXISTING EDGE OF CONCRETE		NEW TERRAPAVE TRAIL/BOARDWALK TRAVELWAY
	EXISTING DRIVEWAY		NEW TRAIL SHOULDER
	EXISTING EDGE OF TREE DRIPLINE		SEEDED FINISH GRADE
	EXISTING EDGE OF BRUSH		NEW CROSSWALK STRIPING
	EXISTING DRAINAGE FLOWLINE		ESA FENCE/LIMIT OF WORK
	EXISTING CHAINLINK FENCE		EXISTING SIGN
	EXISTING TRAFFIC GUARDRAIL		EXISTING SIGN
	EXISTING OVERHEAD LINE		EXISTING PIPE BOLLARD
	EXISTING WETLAND AREA		EXISTING CATCH BASIN
	EXISTING RIPARIAN AREA		EXISTING MANHOLE
	EXISTING TREE		EXISTING WATER VALVE
	EXISTING JOINT UTILITY POLE		EXISTING FIRE HYDRANT
	EXISTING SECONDARY UTILITY POLE		EXISTING LAMPPOST



BODEGA BAY TRAIL PROJECT
 SONOMA COUNTY, CALIFORNIA
 SONOMA COUNTY REGIONAL PARKS

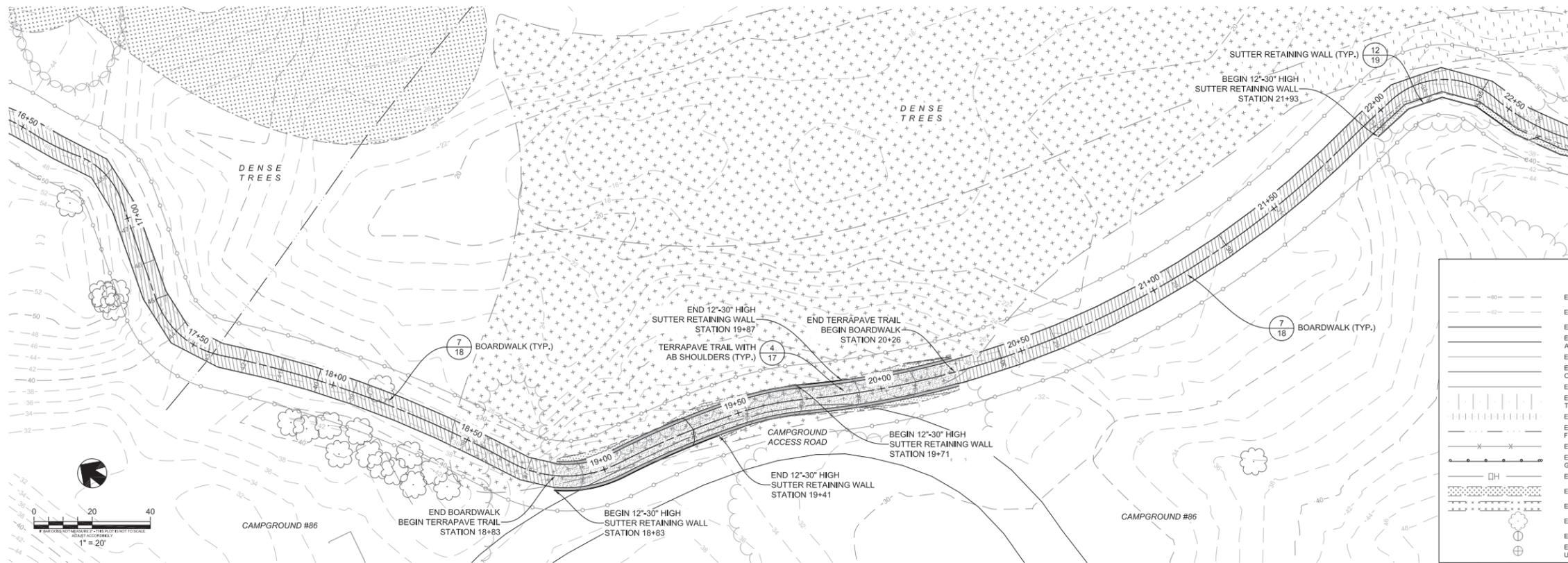


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COASTAL NORTH HARBOR SEGMENT
 STATION 11+40 TO 17+10
 BODEGA BAY
 SONOMA COUNTY, CALIFORNIA

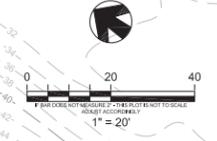
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Date: 07/30/18	
FIGURE: 6 OF 19	

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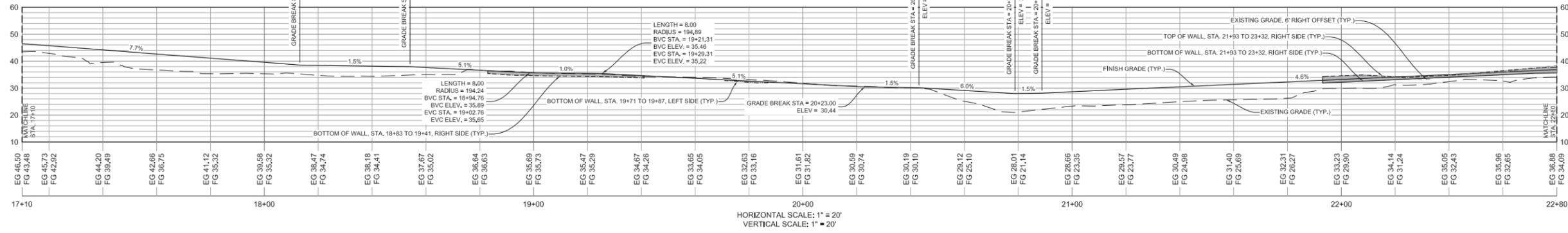


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---	EXISTING MINOR CONTOUR	---	NEW MINOR CONTOUR
---	EXISTING STRUCTURE	---	PROPOSED TRAIL CENTERLINE
---	EXISTING EDGE OF AC PAVEMENT	---	NEW EDGE OF TRAVELWAY
---	EXISTING ROAD STRIPE	---	NEW LIMIT OF GRADING
---	EXISTING EDGE OF CONCRETE	---	NEW TERRAPAVE TRAIL/BOARDWALK TRAVELWAY
---	EXISTING DRIVEWAY	---	NEW TRAIL SHOULDER
---	EXISTING EDGE OF TREE DRIFLINE	---	SEEDED FINISH GRADE
---	EXISTING EDGE OF BRUSH	---	NEW CROSSWALK STRIPING
---	EXISTING DRAINAGE FLOWLINE	---	ESA FENCE/LIMIT OF WORK
---	EXISTING CHAINLINK FENCE	---	EXISTING SIGN
---	EXISTING TRAFFIC GUARDRAIL	---	EXISTING SIGN
---	EXISTING OVERHEAD LINE	---	EXISTING PIPE BOLLARD
---	EXISTING WETLAND AREA	---	EXISTING CATCH BASIN
---	EXISTING RIPARIAN AREA	---	EXISTING MANHOLE
---	EXISTING TREE	---	EXISTING WATER VALVE
---	EXISTING JOINT UTILITY POLE	---	EXISTING FIRE HYDRANT
---	EXISTING SECONDARY UTILITY POLE	---	EXISTING LAMPPOST



PROPOSED TRAIL CENTERLINE PROFILE



HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 20'

BODEGA BAY TRAIL PROJECT
SONOMA COUNTY, CALIFORNIA
SONOMA COUNTY REGIONAL PARKS



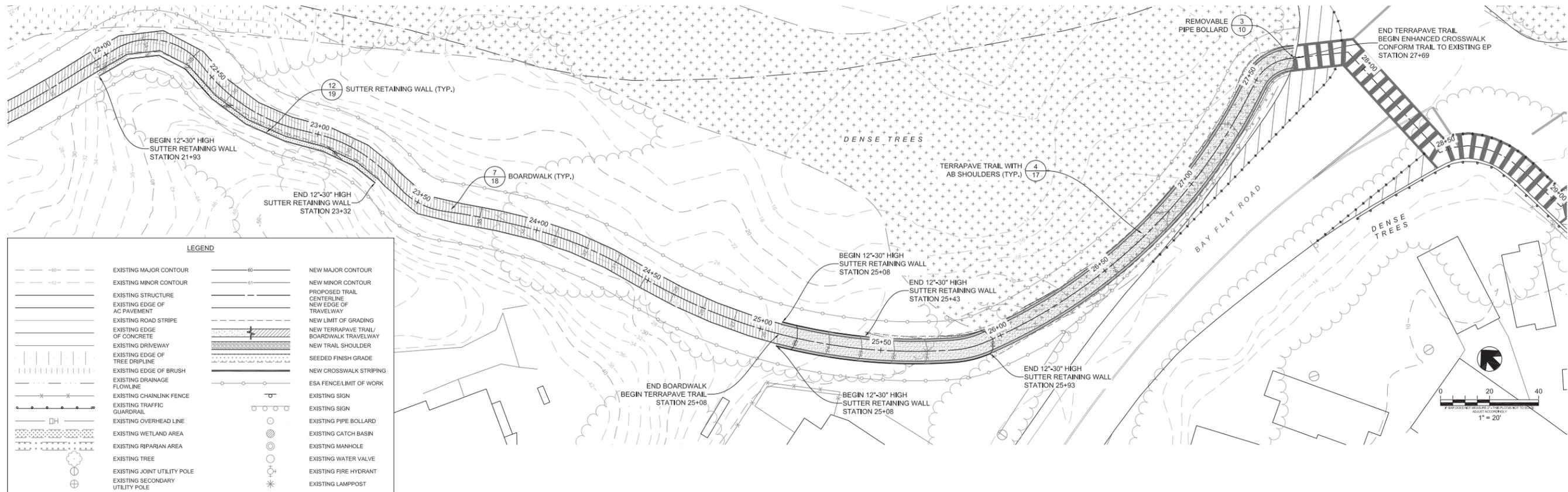
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COASTAL NORTH HARBOR SEGMENT
STATION 17+10 TO 22+80
BODEGA BAY
SONOMA COUNTY, CALIFORNIA

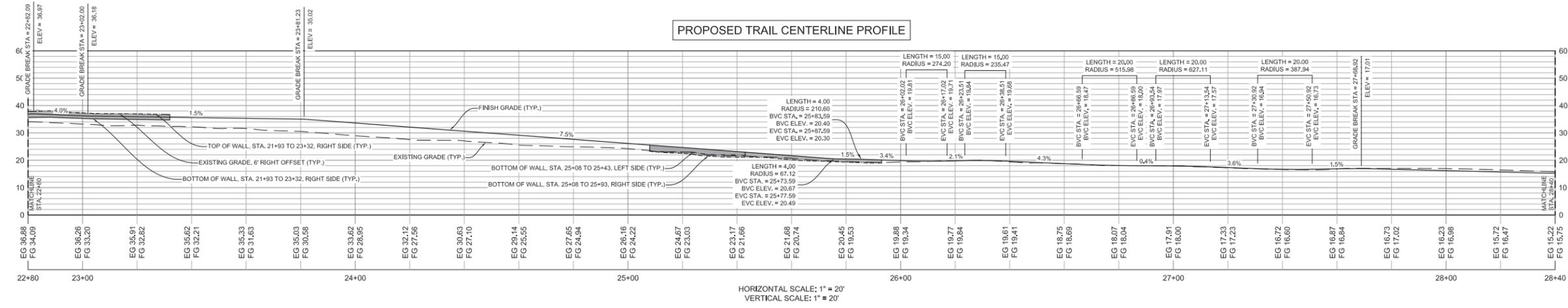
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D	1400152
Scale:	AS NOTED
Date:	07/30/18
FIGURE:	7 OF 19

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LEGEND

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	EXISTING MINOR CONTOUR		PROPOSED TRAIL CENTERLINE
	EXISTING STRUCTURE		NEW EDGE OF TRAVELWAY
	EXISTING EDGE OF AC PAVEMENT		NEW LIMIT OF GRADING
	EXISTING ROAD STRIPE		NEW TERRAPAVE TRAIL/BOARDWALK TRAVELWAY
	EXISTING EDGE OF CONCRETE		NEW TRAIL SHOULDER
	EXISTING DRIVEWAY		SEEDED FINISH GRADE
	EXISTING EDGE OF TREE DRIPLINE		NEW CROSSWALK STRIPING
	EXISTING EDGE OF BRUSH		ESA FENCE/LIMIT OF WORK
	EXISTING DRAINAGE FLOWLINE		EXISTING SIGN
	EXISTING CHAINLINK FENCE		EXISTING SIGN
	EXISTING TRAFFIC GUARDRAIL		EXISTING PIPE BOLLARD
	EXISTING OVERHEAD LINE		EXISTING WETLAND AREA
	EXISTING WETLAND AREA		EXISTING CATCH BASIN
	EXISTING RIPARIAN AREA		EXISTING MANHOLE
	EXISTING TREE		EXISTING WATER VALVE
	EXISTING JOINT UTILITY POLE		EXISTING FIRE HYDRANT
	EXISTING SECONDARY UTILITY POLE		EXISTING LAMPPOST



BODEGA BAY TRAIL PROJECT
 SONOMA COUNTY, CALIFORNIA
 SONOMA COUNTY REGIONAL PARKS

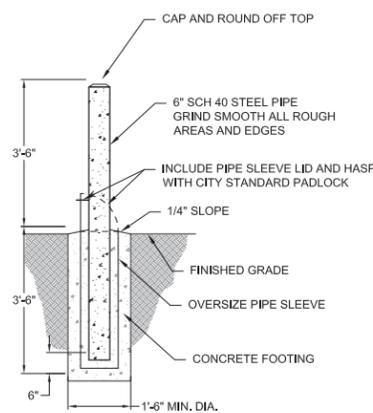
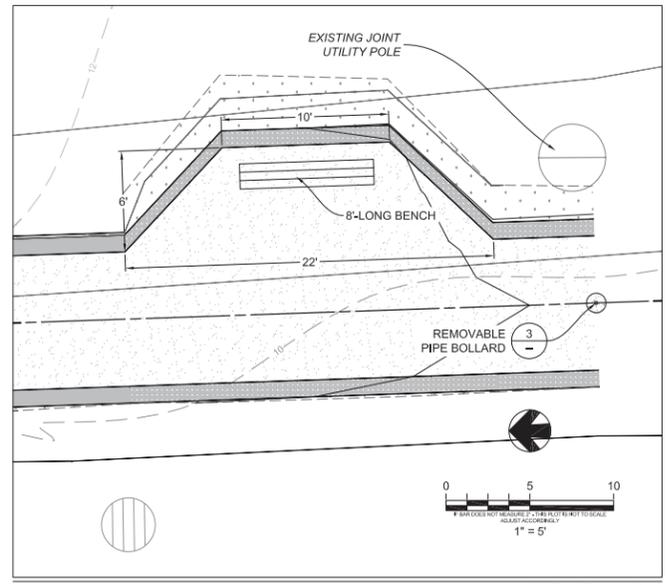
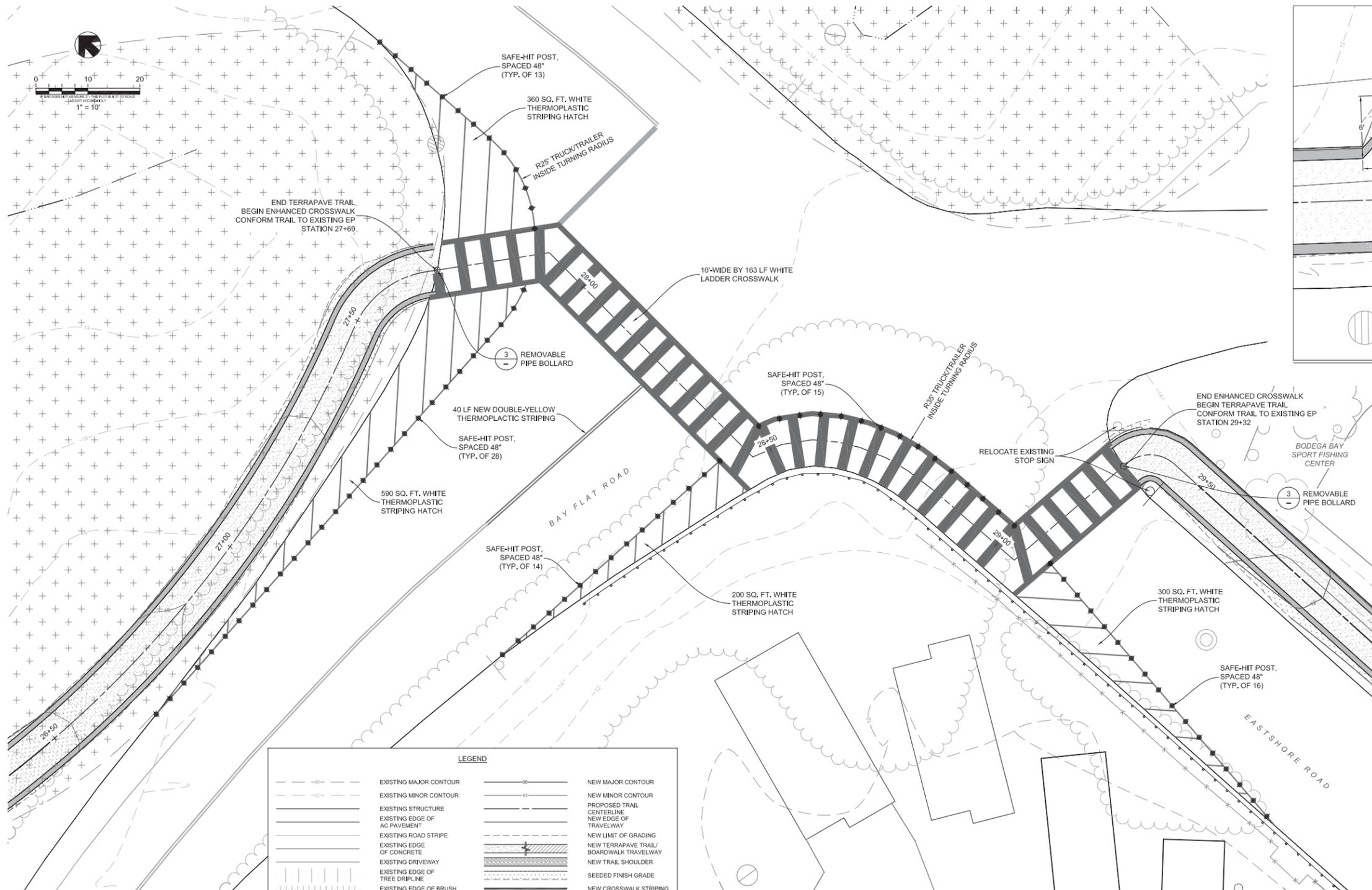
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COASTAL NORTH HARBOR SEGMENT
 STATION 22+80 TO 28+40
 BODEGA BAY
 SONOMA COUNTY, CALIFORNIA

Size	Project
D	1400152
Scale:	AS NOTED
Date:	07/30/18
FIGURE:	8 OF 19



LEGEND

	EXISTING MAJOR CONTOUR		NEW MAJOR CONTOUR
	EXISTING MINOR CONTOUR		NEW MINOR CONTOUR
	EXISTING STRUCTURE		PROPOSED TRAIL CENTERLINE
	EXISTING EDGE OF AC PAVEMENT		NEW EDGE OF TRAVELWAY
	EXISTING ROAD STRIPE		NEW LIMIT OF GRADING
	EXISTING EDGE OF CONCRETE		NEW TERRAPAVE TRAIL/ BOARDWALK TRAVELWAY
	EXISTING DRIVEWAY		NEW TRAIL SHOULDER
	EXISTING EDGE OF TREE DRIPLINE		SEEDED FINISH GRADE
	EXISTING EDGE OF BRUSH		NEW CROSSWALK STRIPING
	EXISTING DRAINAGE FLOWLINE		ESA FENCE/LIMIT OF WORK
	EXISTING CHAINLINK FENCE		EXISTING SIGN
	EXISTING TRAFFIC GUARDRAIL		EXISTING SIGN
	EXISTING OVERHEAD LINE		EXISTING PIPE BOLLARD
	EXISTING WETLAND AREA		EXISTING CATCH BASIN
	EXISTING RIPARIAN AREA		EXISTING MANHOLE
	EXISTING TREE		EXISTING WATER VALVE
	EXISTING JOINT UTILITY POLE		EXISTING FIRE HYDRANT
	EXISTING SECONDARY UTILITY POLE		EXISTING LAMPOST

3 REMOVABLE PIPE BOLLARD

BODEGA BAY TRAIL PROJECT
SONOMA COUNTY, CALIFORNIA
SONOMA COUNTY REGIONAL PARKS

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questa@questaec.com



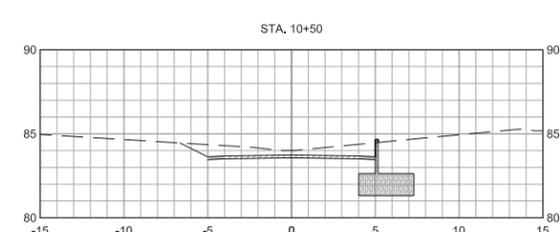
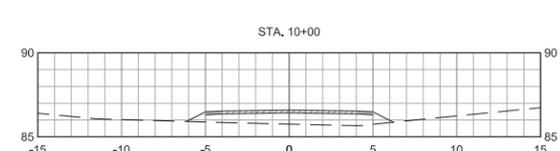
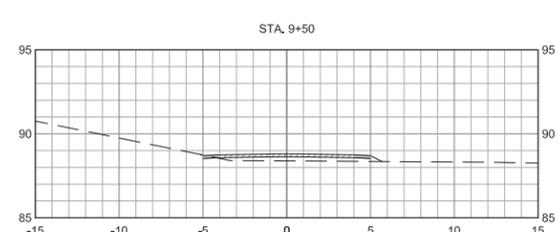
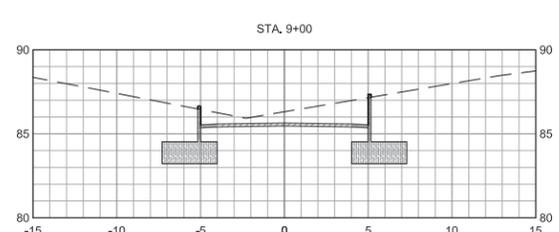
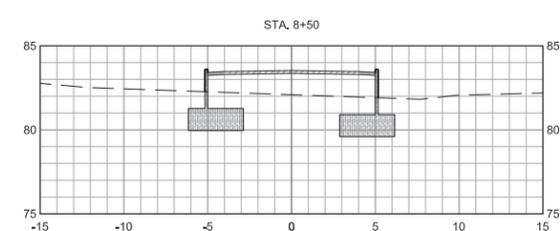
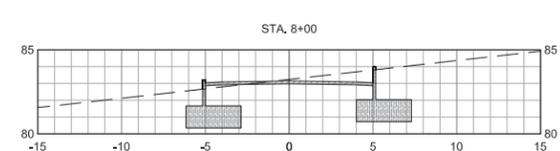
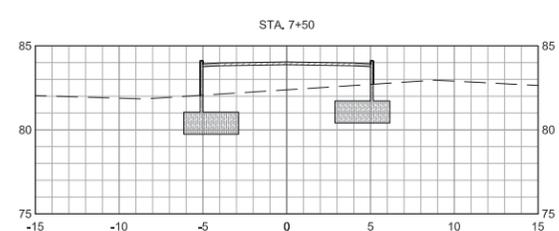
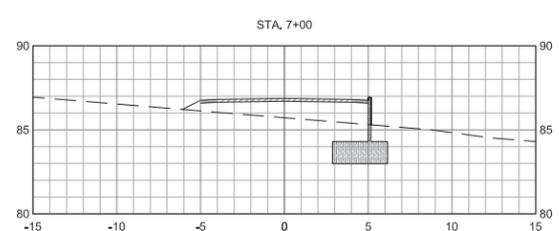
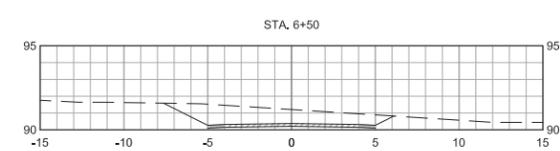
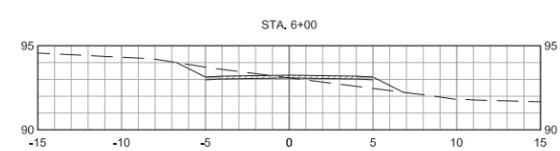
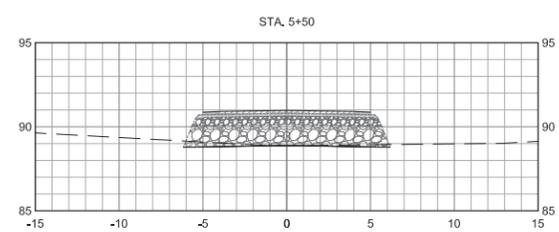
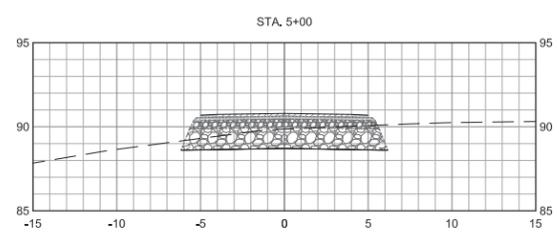
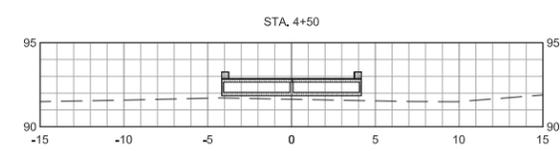
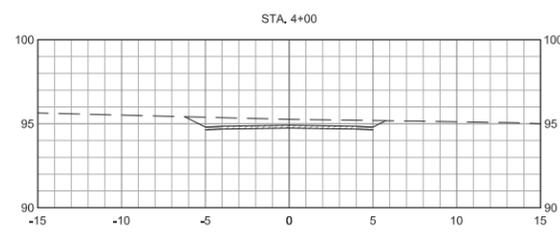
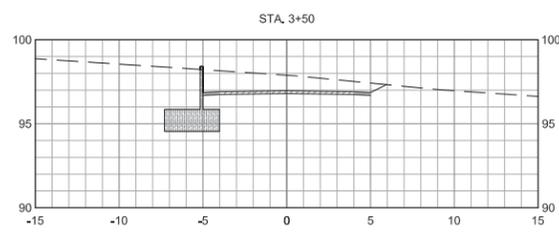
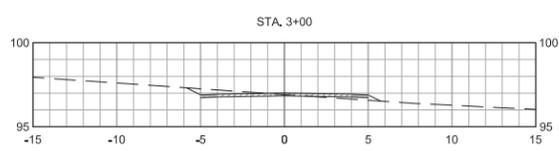
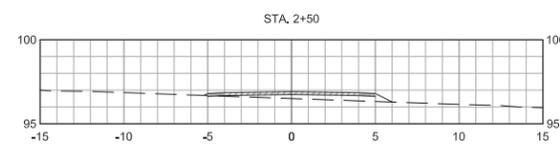
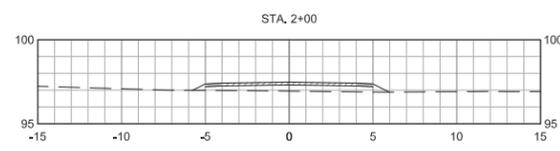
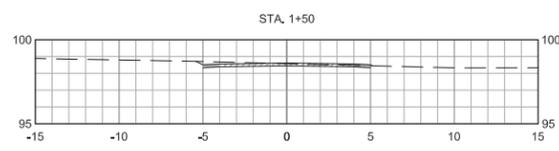
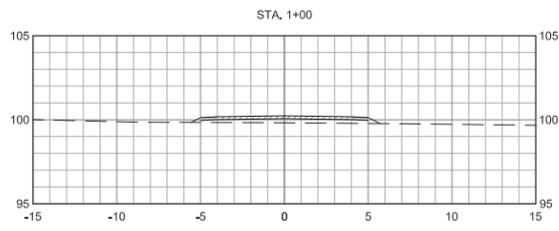
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Checked:	JP
App'd:	JP

COASTAL NORTH HARBOR SEGMENT
ROAD AND CROSSWALK STRIPING
BODEGA BAY
SONOMA COUNTY, CALIFORNIA

Project	1400152
Scale:	1" = 10'
Date:	07/30/18
FIGURE:	10 OF 19

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BODEGA BAY TRAIL PROJECT
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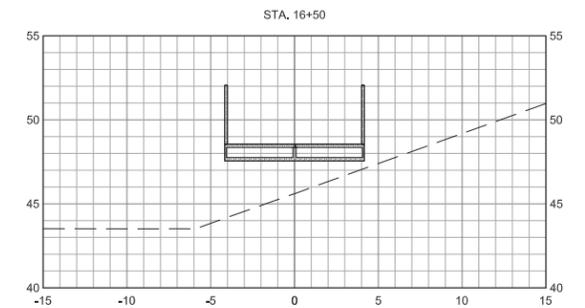
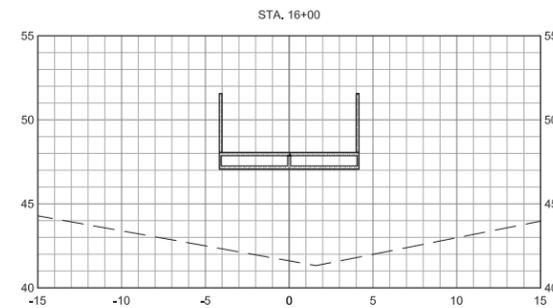
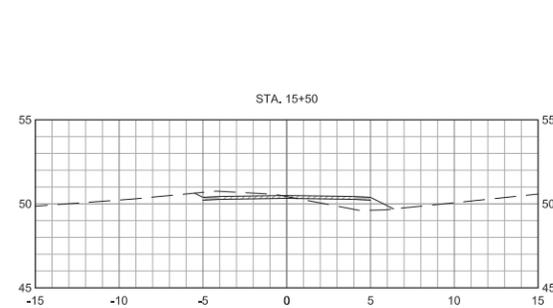
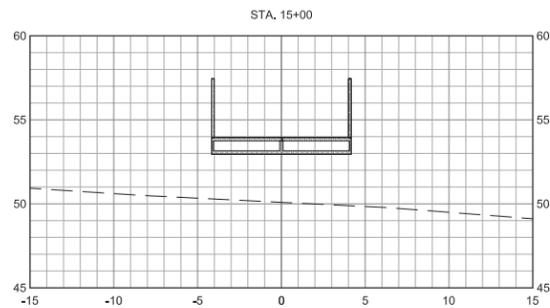
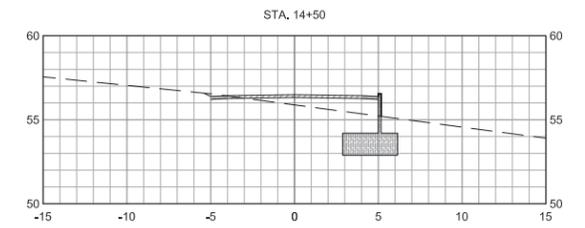
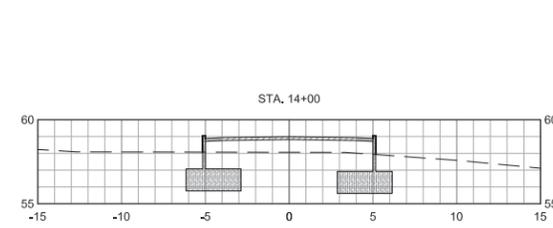
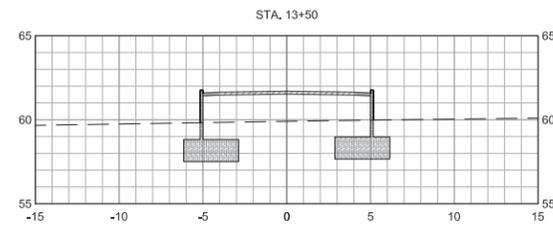
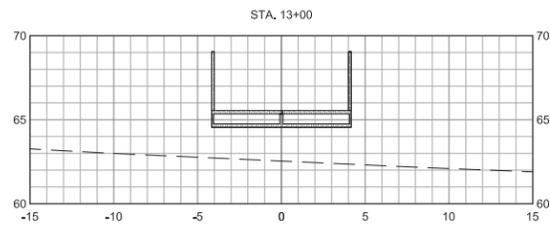
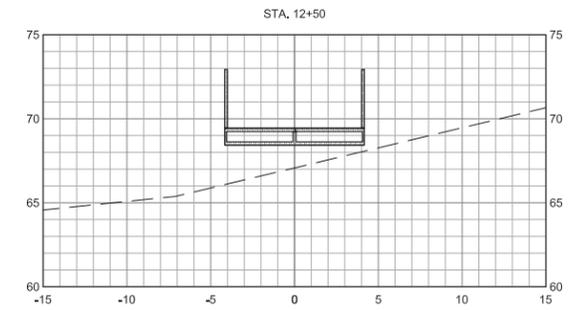
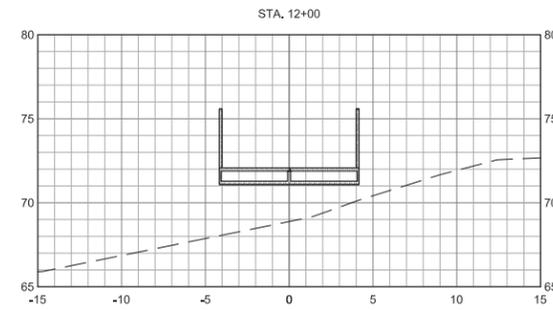
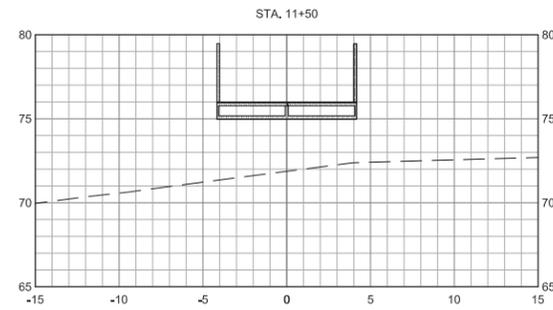
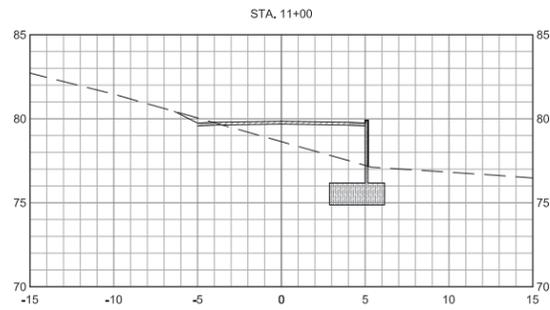
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Drawn: AM
Checked: JP
Appr'd: JP

COASTAL NORTH HARBOR SEGMENT
SECTIONS 1+00 TO 10+50
BODEGA BAY
SONOMA COUNTY, CALIFORNIA

Size D	Project 1400152
Scale: 1" = 5'	
Date: 07/30/18	
FIGURE: 11	OF 19

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BODEGA BAY TRAIL PROJECT
 SONOMA COUNTY, CALIFORNIA
 SONOMA COUNTY REGIONAL PARKS

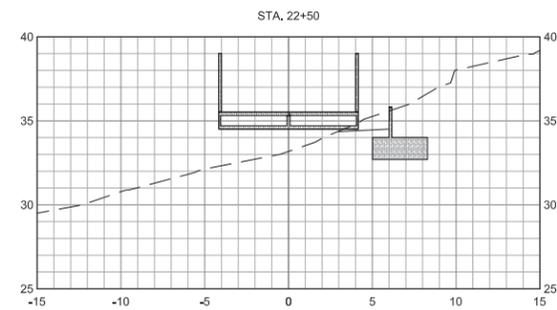
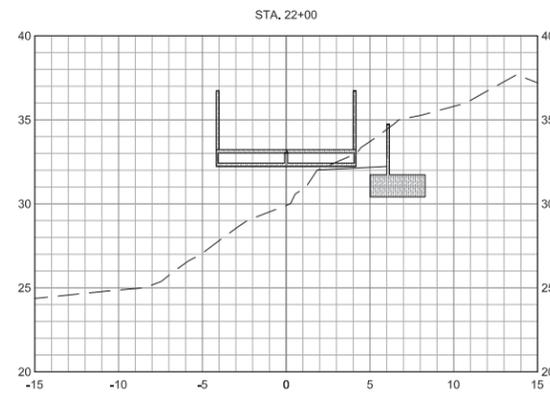
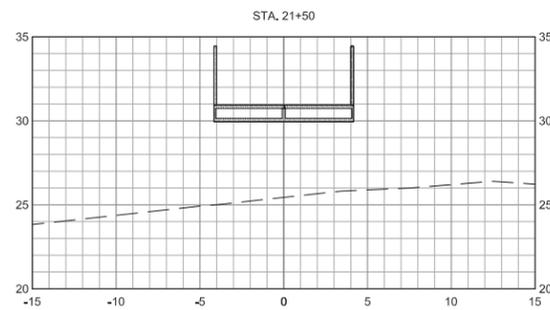
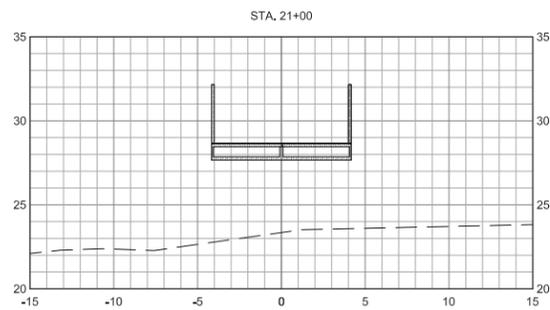
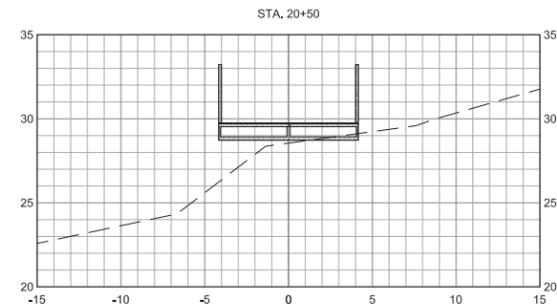
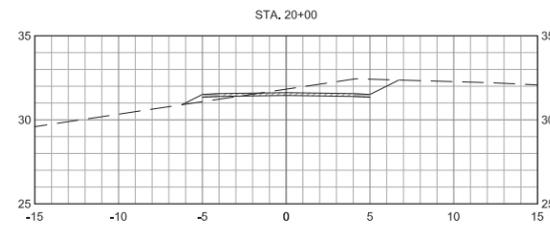
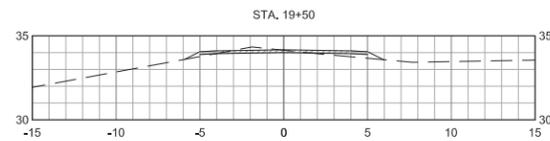
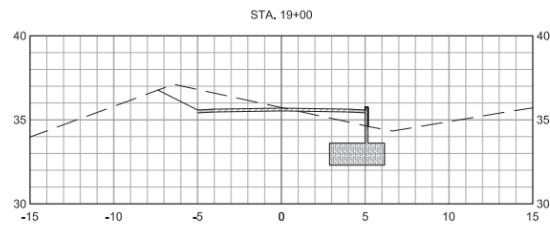
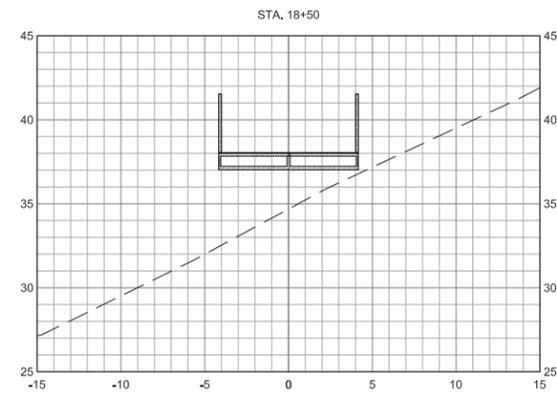
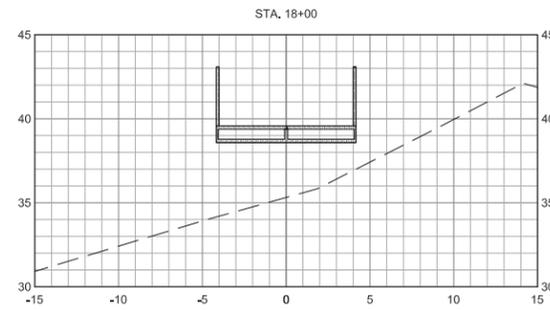
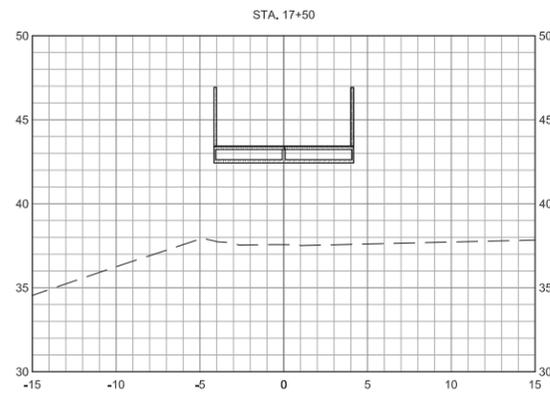
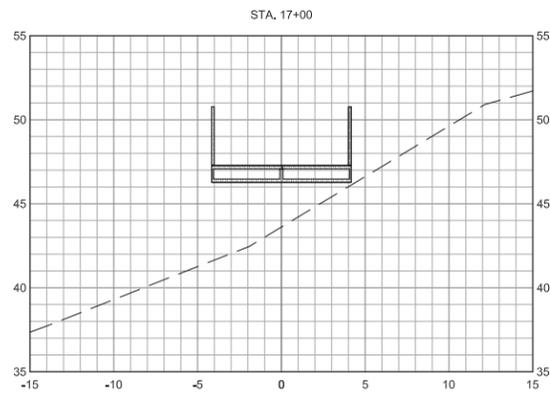


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Checked:	JP
Appr'd:	JP

COASTAL NORTH HARBOR SEGMENT
 SECTIONS 11+00 TO 16+50
 BODEGA BAY
 SONOMA COUNTY, CALIFORNIA

Size D	Project 1400152
Scale:	1" = 5'
Date:	07/30/18
FIGURE:	12 OF 19



BODEGA BAY TRAIL PROJECT
SONOMA COUNTY, CALIFORNIA
SONOMA COUNTY REGIONAL PARKS

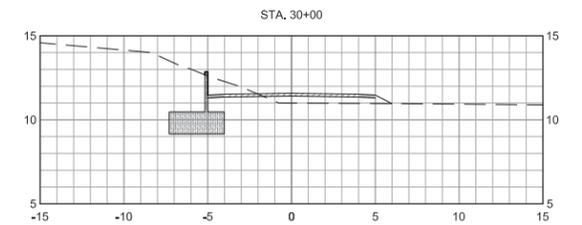
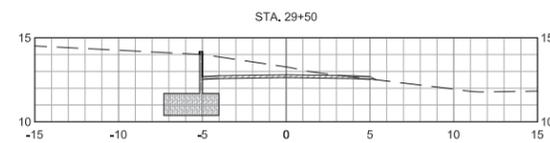
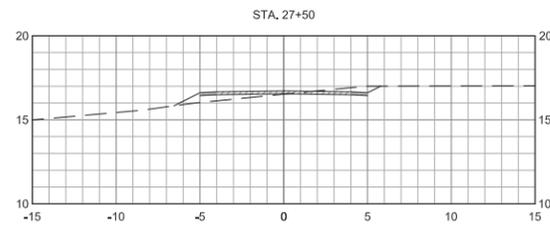
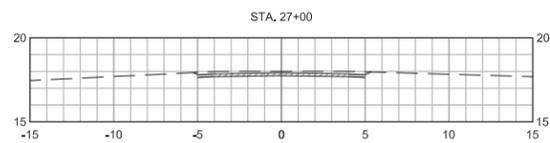
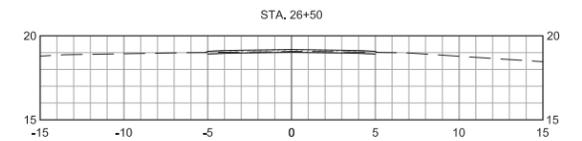
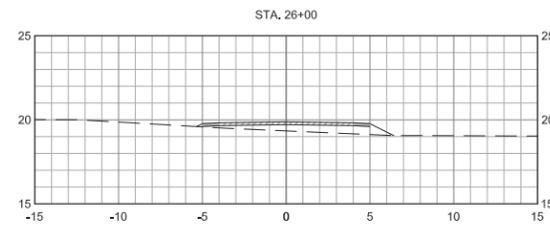
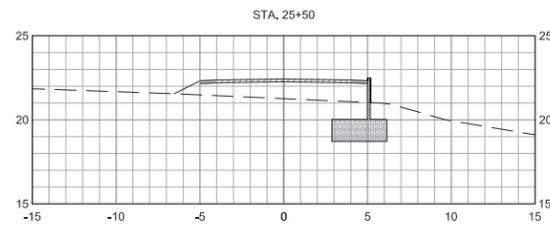
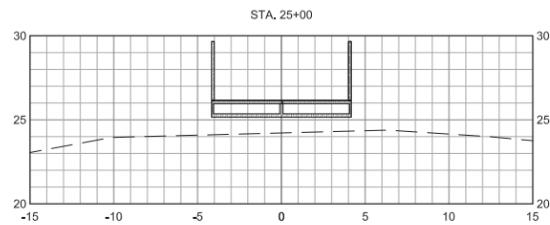
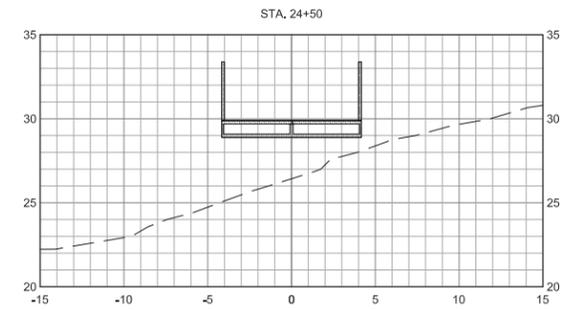
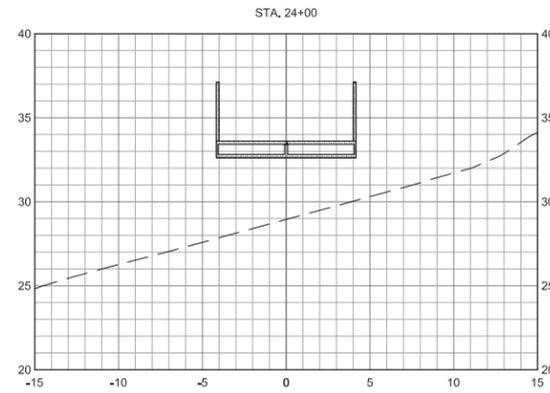
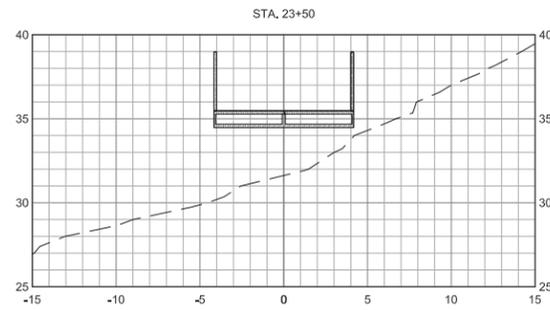
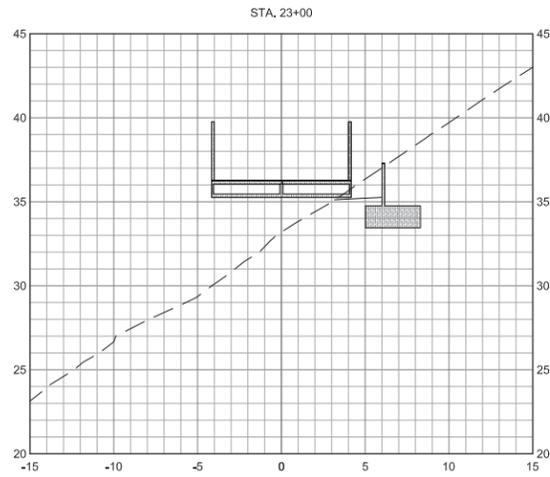


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COASTAL NORTH HARBOR SEGMENT
SECTIONS 17+00 TO 22+50
BODEGA BAY
SONOMA COUNTY, CALIFORNIA

Size	Project
D	1400152
Scale:	1" = 5'
Date:	07/30/18
FIGURE:	13 OF 19



BODEGA BAY TRAIL PROJECT
SONOMA COUNTY, CALIFORNIA
SONOMA COUNTY REGIONAL PARKS



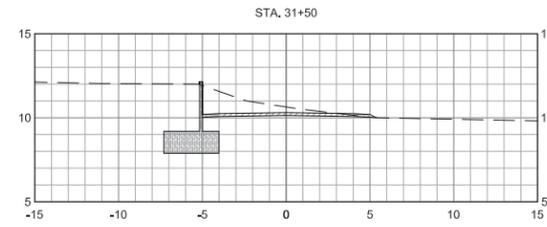
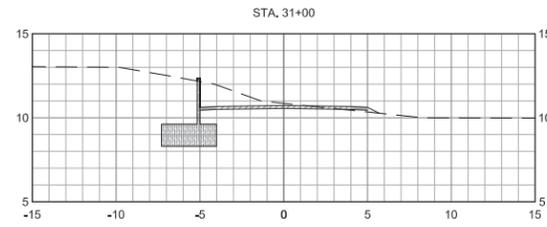
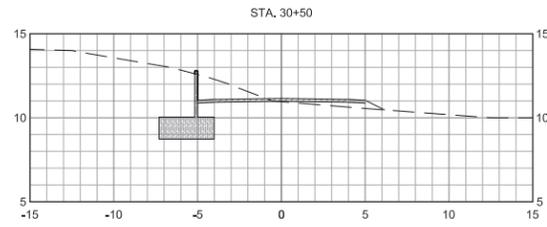
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COASTAL NORTH HARBOR SEGMENT
SECTIONS 23+00 TO 30+00
BODEGA BAY
SONOMA COUNTY, CALIFORNIA

Size	Project
D	1400152
Scale:	1" = 5'
Date:	07/30/18
FIGURE:	14 OF 19

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BODEGA BAY TRAIL PROJECT
SONOMA COUNTY, CALIFORNIA
SONOMA COUNTY REGIONAL PARKS

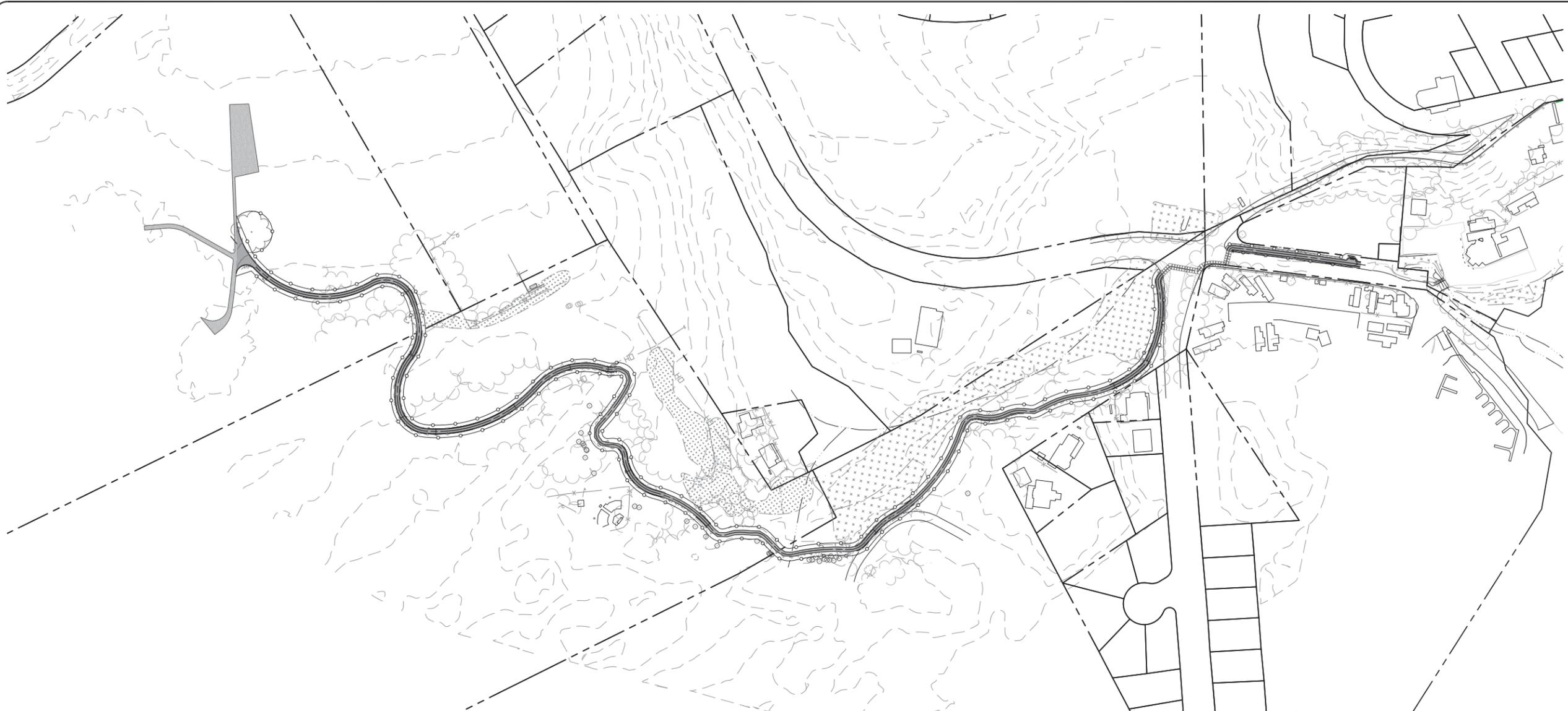


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COASTAL NORTH HARBOR SEGMENT
SECTIONS 30+50 TO 31+50
BODEGA BAY
SONOMA COUNTY, CALIFORNIA

Size	Project
D	1400152
Scale:	1" = 10'
Date:	07/30/18
FIGURE:	15 OF 19



LEGEND

	EXISTING MAJOR CONTOUR		NEW MAJOR CONTOUR
	EXISTING MINOR CONTOUR		NEW MINOR CONTOUR
	EXISTING STRUCTURE		PROPOSED TRAIL CENTERLINE
	EXISTING EDGE OF AC PAVEMENT		NEW EDGE OF TRAVELWAY
	EXISTING ROAD STRIPE		NEW LIMIT OF GRADING
	EXISTING EDGE OF CONCRETE		NEW TERRAPAVE TRAIL/BOARDWALK TRAVELWAY
	EXISTING DRIVEWAY		NEW TRAIL SHOULDER
	EXISTING EDGE OF TREE DRIPLINE		SEEDED FINISH GRADE
	EXISTING EDGE OF BRUSH		NEW CROSSWALK STRIPING
	EXISTING DRAINAGE FLOWLINE		ESA FENCE/LIMIT OF WORK
	EXISTING CHAINLINK FENCE		EXISTING SIGN
	EXISTING TRAFFIC GUARDRAIL		EXISTING SIGN
	EXISTING OVERHEAD LINE		EXISTING PIPE BOLLARD
	EXISTING WETLAND AREA		EXISTING CATCH BASIN
	EXISTING RIPARIAN AREA		EXISTING MANHOLE
	EXISTING TREE		EXISTING WATER VALVE
	EXISTING JOINT UTILITY POLE		EXISTING FIRE HYDRANT
	EXISTING SECONDARY UTILITY POLE		EXISTING LAMPPPOST

BODEGA BAY TRAIL PROJECT
 SONOMA COUNTY, CALIFORNIA
 SONOMA COUNTY REGIONAL PARKS



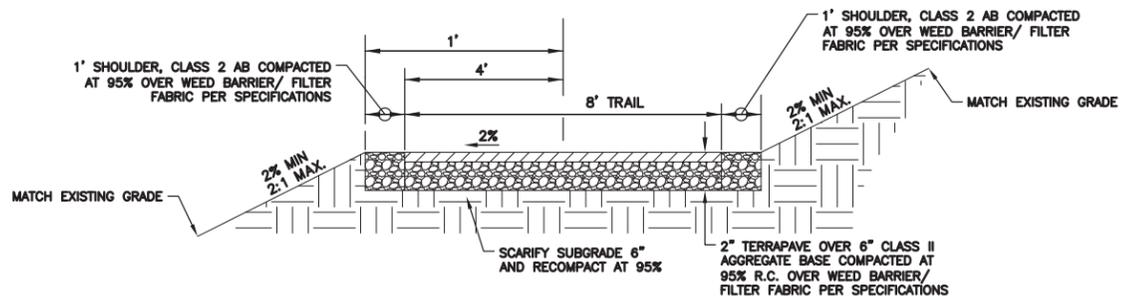
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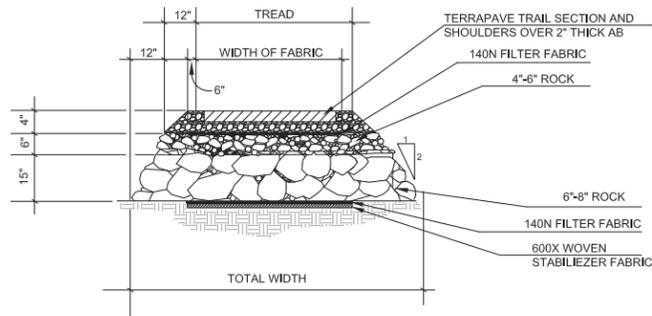
COASTAL NORTH HARBOR SEGMENT
 PLANTING AND HABITAT ENHANCEMENT
 BODEGA BAY
 SONOMA COUNTY, CALIFORNIA

Size	Project
D	1400152
Scale:	1" = 5'
Date:	07/30/18
FIGURE:	16 OF 19

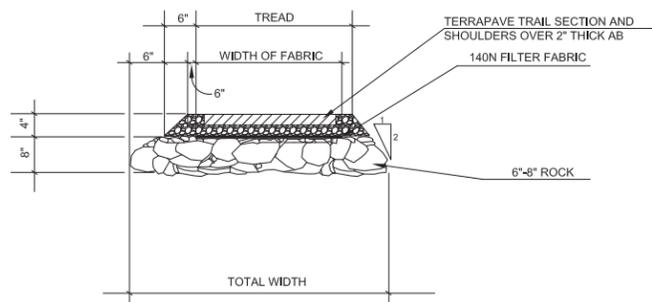
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 IF BAR DOES NOT MEASURE 1" DRAWING IS NOT TO SCALE - ADJUST ACCORDINGLY



4 TERRAPAVE TRAIL

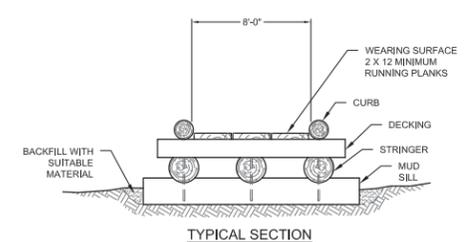
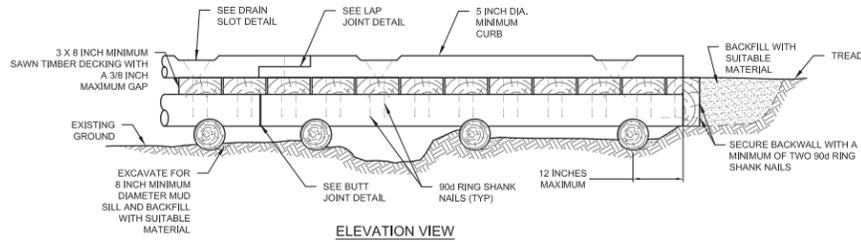


MAJOR DRAINAGE LENSES

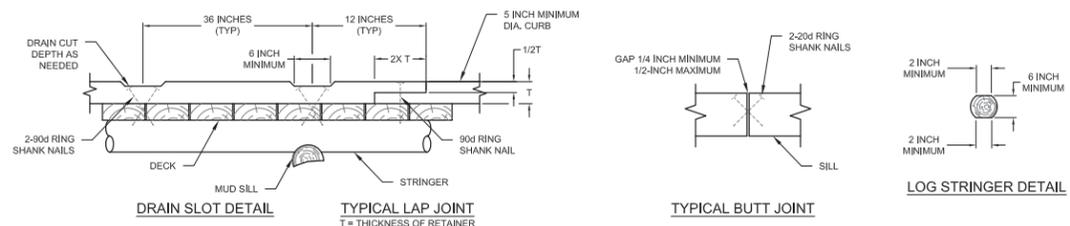
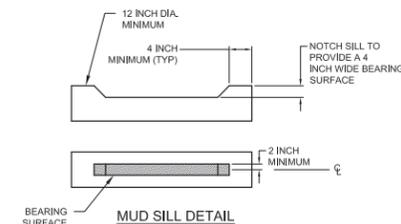
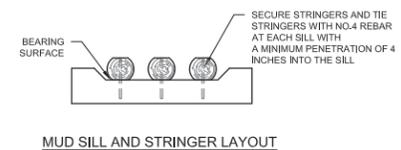
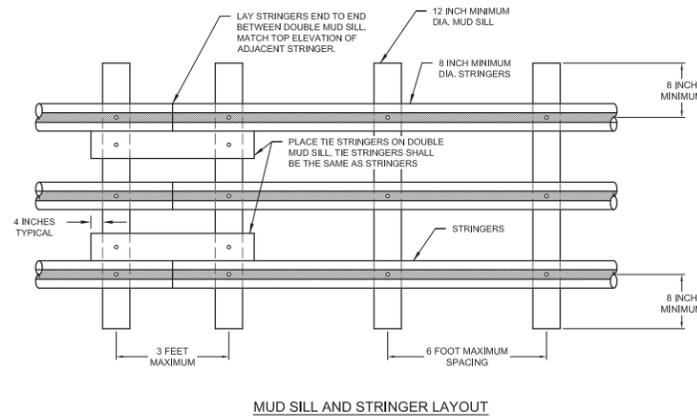
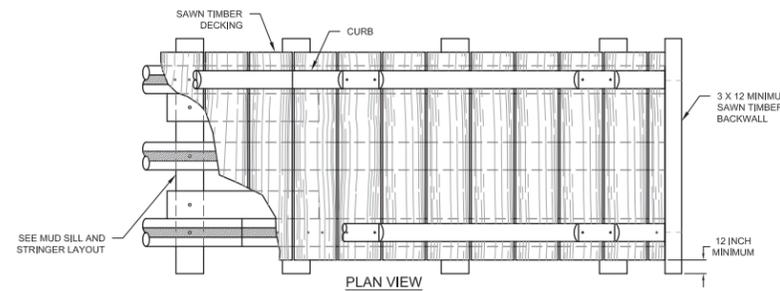


MINOR DRAINAGE LENSES

5 DRAINAGE LENSE



- NOTES
1. PRE-DRILL HOLES FOR FASTENERS TO PREVENT SPLITTING OF LOGS OR SAWN TIMBERS.
 2. RECESS END OF REBAR 1/2 INCH BELOW TOP OF STRINGERS.
 3. COMPACT BACKFILL IN 6 INCH LIFTS UNTIL NO VISUAL DISPLACEMENT.
 4. ALL FIELD DRILLED HOLES AND CUTS SHALL BE FIELD TREATED.
 5. FINAL DECK ELEVATION FOR RUNNING PLANKS OR DECKING SHALL BE NO MORE THAN 1/2 INCH DIFFERENCE IN ELEVATION.



6 TYPICAL PUNCHEON CROSSING

BODEGA BAY TRAIL PROJECT
SONOMA COUNTY, CALIFORNIA
SONOMA COUNTY REGIONAL PARKS

QUESTA
ENGINEERING CORP.
Civil Environmental & Water Resources
(510) 236-6114
FAX (510) 236-2423
questa@questaec.com
P.O. Box 70356 1220 Bitckyard Cove Road Point Richmond, CA 94807

90% COMPLETE
CONSULTATION

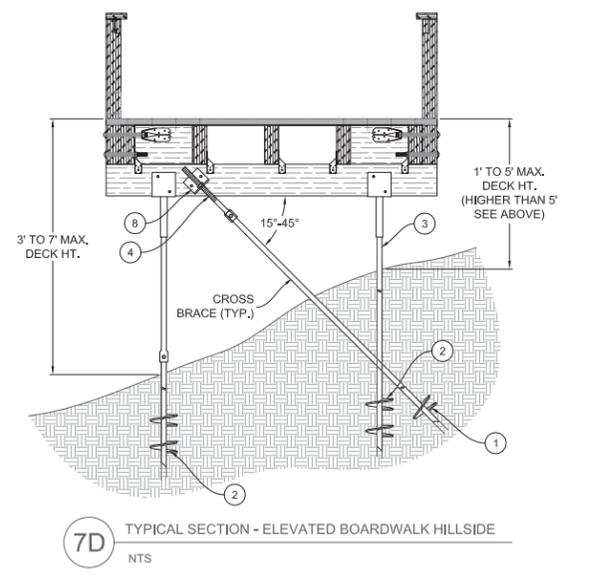
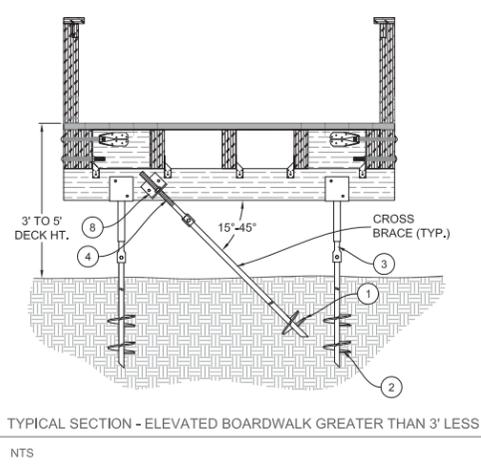
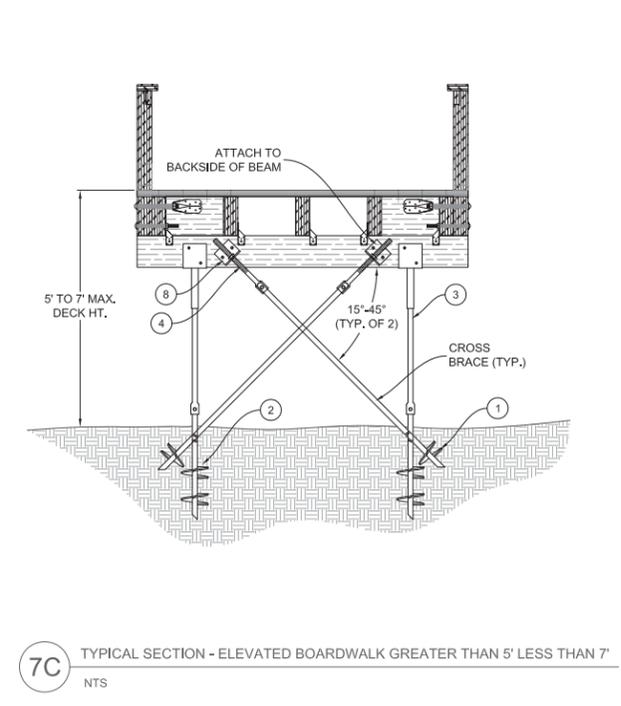
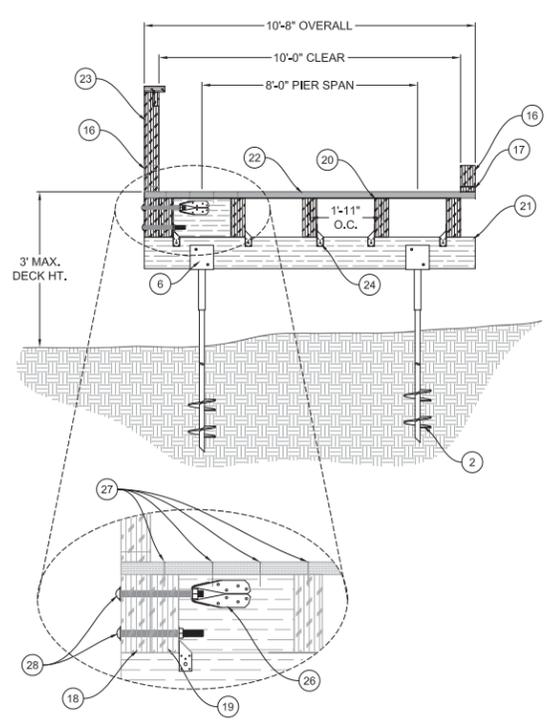
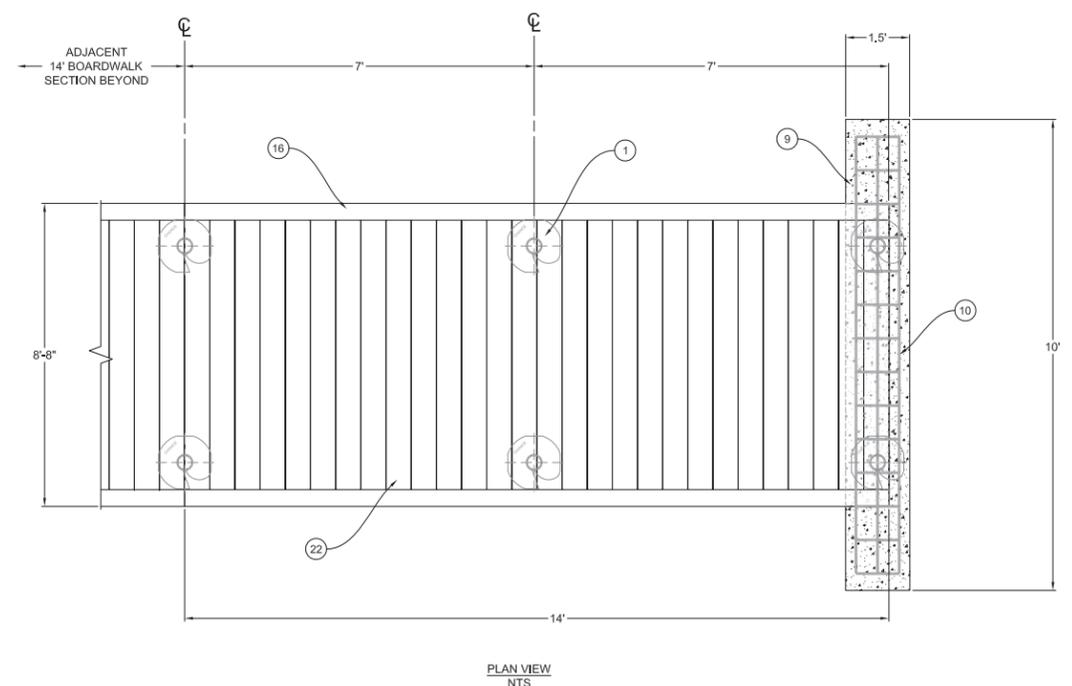
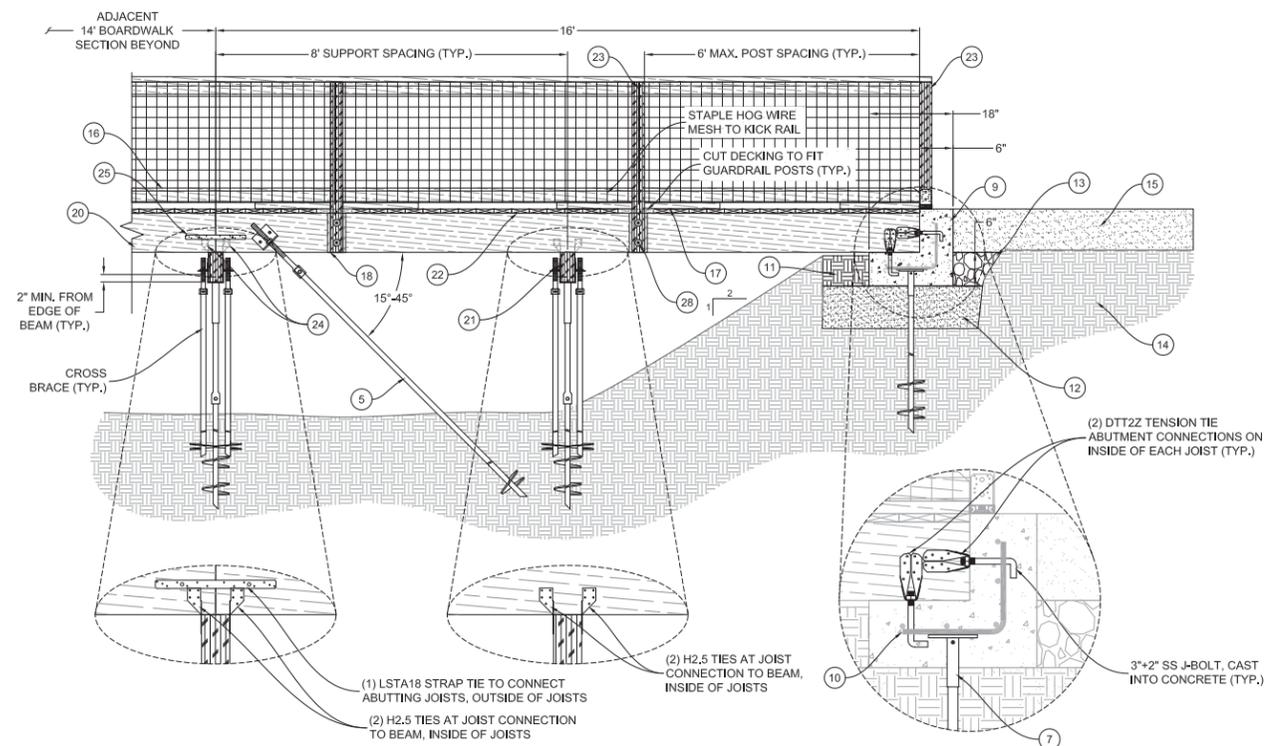
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Checked: JP
Appr'd: JP

COASTAL NORTH HARBOR SEGMENT
TRAIL DETAILS
BODEGA BAY
SONOMA COUNTY, CALIFORNIA

Project 1400152
Scale: AS NOTED
Date: 07/30/18
FIGURE: 17 OF 19

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1. SINGLE HELIX LEAD SECTION, HELIX DRIVEN 4' MIN. INTO COMPETENT MATERIAL, SEE DETAIL 8, SHEET 19
2. TWIN HELIX LEAD SECTION, LOWER HELIX DRIVEN 4' MIN. INTO COMPETENT MATERIAL, SEE DETAIL 8, SHEET 19
3. PLAN EXTENSION AS NEEDED, SEE DETAIL 9, SHEET 19
4. THREADED STUD ADAPTER, SEE DETAIL 9, SHEET 19
5. LONGITUDINAL BRACING REQUIRED EVERY OTHER SPAN WHEN GREATER THAN 4' AND LESS THAN 5' OR EVERY SPAN GREATER THAN 5' AND LESS THAN 7'.
6. BEAM SEAT BRACKET, SEE DETAIL 10, SHEET 19
7. PIER CAP, SEE DETAIL 11, SHEET 19
8. STEEL ANGLE WITH 1-3/8" DIAMETER HOLES BOLTED TO BEAM
9. CAST IN PLACE CONCRETE ABUTMENT
10. #4 REBAR, 6" O.C. EACH WAY
11. COMPACT EXISTING SUBGRADE TO 95%
12. 6" DEEP X 18" WIDE 3/8" MINUS CRUSHED ROCK BASE
13. 5/8" DRAIN ROCK BEHIND ABUTMENT
14. UNDISTURBED NATIVE SOILS
15. TRAIL SURFACE PER PLAN
16. 2X4 KICK RAIL (BOTH SIDES)
17. 2X4 LIFT SPACERS @ 6" O.C. MAX.
18. 10" LONG 4X6 P.T. GUARDRAIL SPACER
19. 2X10 P.T. BLOCKING
20. 4X10 P.T. JOISTS @ 14" O.C.
21. 4X8 P.T. BEAMS
22. RANDOM PLACEMENT 2X6, 2X8, 2X10, 2X12 ROUGH SAWN REDWOOD
23. 4X4 P.T. GUARDRAIL POST WHERE INDICATED PER PLAN WHERE GUARDRAIL TERMINATES AT BOARDWALK ABUTMENT, ANCHOR TERMINAL POSTS IN CONCRETE ABUTMENT WITH SIMPSON ABU44 POST BASE
24. SIMPSON H2.5 HURRICANE/SEISMIC TIE, OR APPROVED EQUAL
25. SIMPSON LSTA18 STRAP, OR APPROVED EQUAL
26. SIMPSON DTT2Z TENSION TIE, OR APPROVED EQUAL
27. SIMPSON DSVT4 WOOD SCREW, OR APPROVED EQUAL
28. 1/2"x16" THROUGH-BOLTS

BODEGA BAY TRAIL PROJECT
SONOMA COUNTY, CALIFORNIA
SONOMA COUNTY REGIONAL PARKS

QUESTA
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Civil Environmental & Water Resources

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90% PROFESSIONALS

REGISTERED PROFESSIONAL ENGINEER

NO. 87949

EX. 06-30-18

CONSTRUCTION

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COASTAL NORTH HARBOR SEGMENT
BOARDWALK DETAILS
BODEGA BAY
SONOMA COUNTY, CALIFORNIA

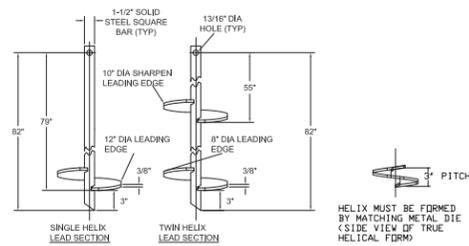
Project 1400152

Scale: 1" = 10'

Date: 07/30/18

FIGURE: 18 OF 19

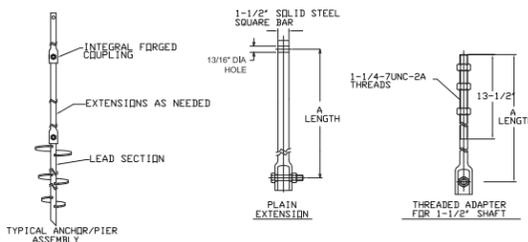
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NOTES

- HOT DIP GALVANIZED PER ASTM A153-(LATEST REV.)
- LEAD AND EXTENSION SECTION AND PILE POINT LENGTHS ARE NOMINAL
- SHAFT MATERIAL-HOT ROLLED ROUND-CORNERED-SQUARE (RCS) SOLID STEEL BARS PER ASTM A29, MINIMUM YIELD STRENGTH=70 KSI.
- HELIX MATERIAL-HOT ROLLED LOW CARBON STEEL SHEET, STRIP, OR PLATE PER ASTM A56, OR A101B GRADE 80, MINIMUM YIELD STRENGTH=80 KSI.
- COUPLING BOLTS: 3/4" DIAMETER X 3" LONG HEX HEAD PER ASTM A320 GRADE L7.
- NOMINAL SPACING BETWEEN HELICAL PLATES IS THREE TIMES THE DIAMETER OF THE LOWER HELIX.
- MANUFACTURER TO HAVE IN EFFECT INDUSTRY RECOGNIZED WRITTEN QUALITY CONTROL FOR ALL MATERIALS AND MANUFACTURING PROCESSES.
- ALL WELDING TO BE DONE BY WELDERS CERTIFIED UNDER SECTION 5 OF THE AWS CODE D1.1.

8 LEAD SECTION DETAILS
NTS

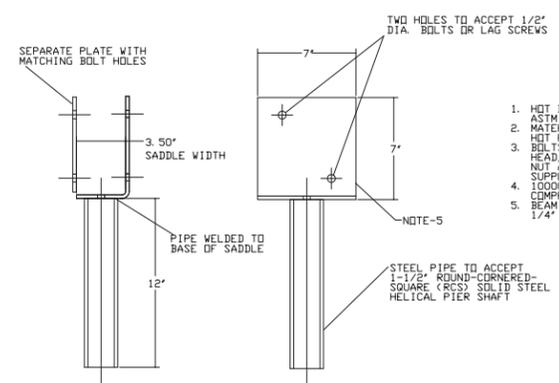


NOTES

- HOT DIP GALVANIZED PER ASTM A153-(LATEST REVISION)
- LEAD AND EXTENSION SECTION LENGTHS AND HELIX SPACINGS ARE NOMINAL
- SHAFT MATERIAL-HOT ROLLED ROUND-CORNERED-SQUARE (RCS) SOLID STEEL BARS PER ASTM A29, MINIMUM YIELD STRENGTH=70 KSI.
- COUPLING BOLTS: 3/4" DIAMETER X 3" LONG HEX HEAD PER ASTM A320 GRADE L7.
- MANUFACTURER TO HAVE IN EFFECT INDUSTRY RECOGNIZED WRITTEN QUALITY CONTROL FOR ALL MATERIALS AND MANUFACTURING PROCESSES.
- ALL WELDING TO BE DONE BY WELDERS CERTIFIED UNDER SECTION 5 OF THE AWS CODE D1.1.
- SEE ICC EVALUATION SERVICE INC., EVALUATION REPORT NO. ER-5110 FOR ALLOWABLE VALUES AND/OR CONDITIONS OF USE CONCERNING MATERIAL PRESENTED IN THIS DOCUMENT.

EXTENSION SECTION CAT. NO.	A
C150-0144	38"
C150-0145	59"
C150-0146	81"
C150-0175	124"
C150-0036	20"
C114-0009	11"

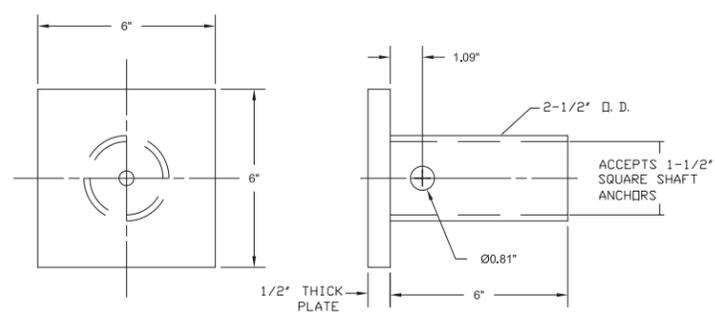
9 EXTENSION AND ADAPTER DETAILS
NTS



NOTES

- HOT DIPPED GALVANIZED PER ASTM A-153
- MATERIAL FOR SADDLE HOT ROLLED STEEL
- BOLTS: 1/2" DIA. HEX HEAD, 4-1/2" LONG WITH NUT AND LOCKWASHER, SUPPLIED BY OTHERS
- 1000 LB MAX. LOAD COMPRESSION ONLY
- BEAM SADDLE FORMED FROM 1/4" THICK STEEL PLATE.

10 BEAM SEAT BRACKET
NTS

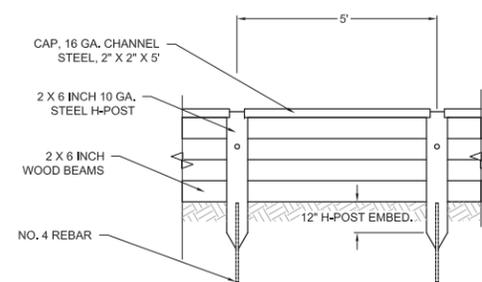


COUPLING BOLT AND NUT			
BOLT DIA.	BOLT LENGTH (MIN.)	BOLT GRADE	NUT
3/4"	4.25"	ASTM A325 TYPE 1	3/4", MATCHING HEX NUT

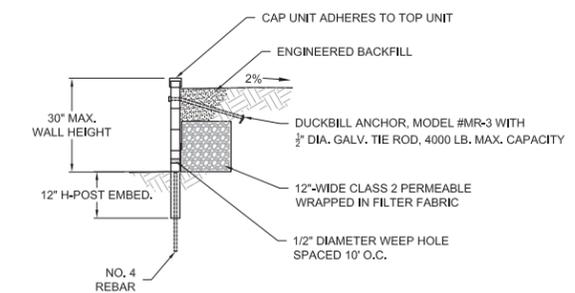
NOTES

- FINISH: HOT DIP GALVANIZED PER ASTM-A153 (LATEST REVISION)
- MATERIAL SPECIFICATIONS: PIPE: BLACK UNCOATED ROUND STEEL TUBE PER ASTM A513 TYPE 5, GRADE 1026. PLATE: PER ASTM A572 GRADE 50.
- TENSION RATING VALID ONLY IF USING COUPLING BOLT AND NUT SPECIFIED IN CHART BELOW OR THEIR MECHANICAL EQUIVALENT.
- THESE ABOVE RATINGS ARE VALID ONLY IF THE PIER CAP DETAIL HAS BEEN DESIGNED TO ENSURE ADEQUATE LOAD TRANSFER FROM REINFORCED CONCRETE FOUNDATION TO SCREW PIER, AND IN ACCORDANCE WITH EXISTING LOCAL CODE REQUIREMENTS AND /OR ESTABLISHED LOCAL PRACTICES.

11 PIER CAP
NTS



FRONT VIEW



SIDE VIEW

12 SUTTER RETAINING WALL DETAIL
NTS

BODEGA BAY TRAIL PROJECT
SONOMA COUNTY, CALIFORNIA
SONOMA COUNTY REGIONAL PARKS



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COASTAL NORTH HARBOR SEGMENT
BOARDWALK DETAILS
BODEGA BAY
SONOMA COUNTY, CALIFORNIA

Project	1400152
Scale:	1" = 10'
Date:	07/30/18
FIGURE:	19 OF 19

P:\2018\1400152_BODEGA_BAY_TRAIL_2015\CAD\MODEL\1400152_BODEGA_BAY_TRAIL_COVER_NOTES_DETAILS.DWG LAST SAVED: 3/21/2019 PLOT DATE: 7/17/2019 PLOT STYLE: CAL_1050-GREYSCALE.CTB IF BAR DOES NOT MEASURE 1" DRAWING IS NOT TO SCALE - ADJUST ACCORDINGLY