Midpeninsula Regional
Open Space District

R-17-39
March 28, 2017

AGENDA ITEM 3

AGENDA ITEM

Schematic Design of the Alma College Parking Area and Bear Creek Road Trail Crossing at Bear Creek Redwoods Open Space Preserve

GENERAL MANAGER'S RECOMMENDATIONS

1. Review and confirm the recommended schematic design for the Alma College parking area and at-grade trail crossing.
2. Review trail undercrossing conceptual design alternatives, and confirm a phased approach to construction of the trail undercrossing.
3. Recommend to the full Board of Directors a contract amendment with Harris Design to complete design and engineering for a combined culvert-trail undercrossing.

SUMMARY

The Alma College parking area and Bear Creek Road trail crossing will provide essential parking capacity, a trail crossing at Bear Creek Road, and will facilitate the opening of Bear Creek Redwoods Open Space Preserve to the public. The project landscape architect, Harris Design, will present the completed schematic design of the parking area for Committee review and input. To meet the timeline for opening the Preserve in late 2018, the District will implement an at-grade crossing (crosswalk) over Bear Creek Road together with the new parking area as part of Phase I. An undercrossing is planned for after the grand opening as part of Phase II to separate trail users from Bear Creek Road for a safer path of travel. The General Manager recommends amending the Harris Design contract at this time to integrate the undercrossing into the design and engineering of the adjacent new parking area so as to avoid potential constructability issues and added costs once the parking area is constructed.

MEASURE AA

This project is part of Measure AA Expenditure Plan Portfolio #21, Bear Creek Redwoods Public Recreation and Interpretation Projects, which specifies, in part: *Open for hiking, equestrian activities. Provide parking areas, trails*, and is identified as MAA Project #21-5 Phase I Public Access Improvements.

DISCUSSION

In September 2015, the Planning and Natural Resources Committee (PNR) reviewed preliminary concept plans and phasing for the Bear Creek Redwoods public access facilities, and confirmed the General Manager's recommendation to proceed with design of a new parking area (maximizing capacity) and trail crossing near the former Alma College site (R-15-144). In May

2016, the Board of Directors awarded a contract to Harris Design, Inc., for design, engineering, permitting assistance, and construction administration services for the project. The initial project scope included a new parking area, an at-grade trail crossing of Bear Creek Road, a vault restroom, signage, and other site furnishings consistent with District standards. The design contract also included repair/replacement recommendations for the degraded Webb Creek culvert, which passes under Bear Creek Road and the majority of the project site. In January 2017, the Board approved the Bear Creek Redwoods Preserve Plan, including the proposed public access phasing, which sets the public opening of the west side of the Preserve for late 2018 (R-17-01). The Alma College Parking Area and Trail Crossing project is critical to reaching this goal. At the March 28, 2017 PNR meeting, Harris Design will review the project's schematic design to collect Committee feedback and input.

Schematic Design – Parking Area

The Alma College Parking Area is set in one of the few locations in the Preserve with sufficiently level topography to accommodate a parking area and adequate sight lines for the driveway and trail crossing (Attachment 1). The site forms the western boundary of the Alma College cultural landscape, and is therefore subject to federal and state standards and guidelines governing the treatment of historic resources. The 576 foot Webb Creek culvert underlies the proposed project footprint, and the main trace of the San Andreas Fault is estimated to run through or immediately adjacent to the site. The project area also provides regionally-uncommon breeding habitat for Western pond turtle, a California Species of Special Concern.

To respond effectively to topographic constraints, integrate into the cultural landscape, and minimize impacts to Western pond turtle, a design charrette was held with District staff and the consultant team. The preferred schematic design (Attachment 2) provides capacity for up to 51 cars, a visitor trailhead, vault restroom, signage, an accessible loop trail, avoidance and mitigation measures for western pond turtle, and other general amenities consistent with District standards. At this point in the design, the total construction cost estimate is $1,210,000.

The preferred schematic design maximizes the quantity of parking spaces, minimizes the conversion of western pond turtle breeding habitat, and retains the integrity of the cultural landscape at the former Alma College site. The design reduces impacts to pond turtle breeding habitat by an average of 30 percent from the original concept designs developed prior to the design charrette. Harris Design developed additional concept designs that were reviewed by Planning and Natural Resources staff and Consultants in order to balance all of the site constraints. The preferred schematic is the result of this iterative process.

Bear Creek Road Trail Crossing

In December 2014, Hexagon Traffic Consultants, Inc., was retained to analyze the feasibility of parking area driveways and crossing locations from a safety (line-of-sight) standpoint, and to perform traffic counts and an evaluation of typical traffic speeds. The study identified an appropriate driveway location and one safe pedestrian crossing location at the former Alma College site. Early consultation with the Santa Clara County Roads and Airports Department in 2016 indicated that these locations would be acceptable under County standards as long as traffic engineers confirmed the viability of the crossing for safe pedestrian access.

A concept design for the proposed at-grade crossing is presented as Attachment 3. In the District's consultation with the County, County Roads staff shared concerns with proposed

safety improvements (asphalt striping, flashing lights) at the at-grade crossing, which are not typically installed at mid-block crossings on County roads. County Roads staff indicated that an undercrossing is preferred at this location, but that an at-grade crossing, and associated safety improvements, would be acceptable as a first phase. County Roads staff understood that the Phase I at-grade crossing would likely be removed once the new trail undercrossing is built and operational.

Trail Undercrossing Options

A feasibility analysis was completed for two trail undercrossing options. Example photographs and illustrative drawings for each option are shown in Attachment 4 . Option A, Combined Culvert-Trail Undercrossing, would utilize existing channel topography within the banks of Webb Creek to install a trail within a new, prefabricated arch open-bottom culvert. This option would replace and greatly increase the capacity of the existing undersized and degraded Webb Creek culvert, improve wildlife passage, and provide a trail undercrossing with relatively minimal grading and infrastructure. However, Option A would require potentially complex and lengthy negotiations with the County to address cost sharing, maintenance, and liability considerations, and with regulatory agencies to obtain permits. In addition, the combined culvert and trail crossing may present problems for equestrians, and would need to be closed during major storm events due to flooding (potentially one to two days per year).

To address these constraints, Option B, Separate Trail Undercrossing, was developed wherein the trail would pass under Bear Creek Road at a location closer to the driveway. Option B would not require lengthy negotiations with the County (but would be subject to County building and encroachment permits), and would potentially be more conducive for horse use. However, engineering feasibility analysis showed that the separate trail undercrossing option would require extensive grading and substantial engineered walls, would still potentially require significant regulatory permitting review due to the close proximity of the creek, would potentially flood more frequently given the high water table, and would be significantly more costly than Option A. The feasibility and constraints of each undercrossing option are summarized in Table 1.

Based on this feasibility analysis, the General Manager recommends forwarding Option A, Combined Culvert-Trail Undercrossing, to the full Board for consideration.

Contract Amendment

In November 2015, the District completed a robust RFQP process for the design of the parking area. Five firms submitted proposals, and three firms were deemed qualified. The qualified firms were interviewed, and the consultant selection committee, comprised of Planning and Engineering & Construction staff, determined Harris Design to have superior expertise.

The parking area and trail crossing project has had to address numerous constraints early in the design given concerns related to special status species, potential impacts to cultural resources, the presence of a subsurface degraded culvert, and the adjacent Webb Creek drainage. These constraints required the collection and analysis of additional existing conditions data, resulting in a design that evolved in an iterative manner. As part of this work, the concept of combining the Webb Creek culvert and a trail undercrossing was identified. A separate undercrossing (not combined with the culvert) was also evaluated, but determined to be infeasible due to grade and subsurface water table constraints. This additional and unexpected work required the full expenditure of the design contract contingency as well as the shifting of contract funds from later phases of the project. Therefore, the General Manager is recommending PNR support to forward

a contract amendment to the full Board to replenish the project contingency and contract funds to proceed with design of the trail undercrossing.

Time is of the essence to complete this assessment and design to facilitate construction for the opening of the Preserve in 2018. Amending the Harris Design contract maintains continuity for completing the design and construction documents. The team developed schematic drawings for the combined Webb Creek culvert and trail undercrossing at the request of District, and has exercised an understanding of the opportunities and constraints associated with this type of structure.

Staff will need to bring a contract amendment with Harris Design to the full board for approval for other additional scope items that have been identified during design development. Design of the trail undercrossing could be incorporated in the contract amendment process. Construction of the parking area will be a phased approach, where Phase I would include construction of the parking area, an at-grade trail crossing, a vault toilet, and an accessible path and Phase II would include construction of the trail undercrossing and the associated trail approaches.

FISCAL IMPACT

The Planning Department's FY2016-17 Budget for the Bear Creek Redwoods Public Access Phase I Implementation (MAA21-005) includes $228,000 for schematic design, permitting, and construction documents. Funds for subsequent budget cycles will be included as part of the three-year Capital Improvement Program, which the Board will review and consider in May 2017.

	FY16-17	**FY17-18**	**FY18-19**	**FY19-20**
MAA 21-005 Planning Budget	**$228,000**			
Spent to Date (as of 03/14/17):	$73,096			
Encumbered:	$151,719			
Proposed Contract Amendment (Harris Design):	$0	$110,000	$60,000	$58,171
Budget Remaining (Proposed):	**$3,185**			

The following table outlines the Measure AA Portfolio budget, costs to date, and the fiscal impact related to MAA 21-005 Bear Creek Redwoods Public Access (Phase I Implementation.

MAA 21 Portfolio Allocation:	**$17,478,000**
Life-to-Date Spent (as of 3/14/17):	$593,183
Total Encumbrances:	$188,601
Award of Contract to HydroScience Engineers (MAA21-003):	$159,126
Award of Contract to Mesiti-Miller (MAA21-005):	$132,894
Award of Contract to John Northmore Roberts and Associates (MAA 21-004):	$922,190
Proposed Contract Amendment (Harris Design):	$228,171
Total BCR Projects Budget Balances*:	$1,116,295
Balance Remaining (Proposed):	**$14,137,540**

*FY2017 BCR Projects Budgets *less* the proposed contracts, current encumbrances, and year-to-to-date expenditures, reflecting current fiscal commitments to other BCR projects this fiscal year.

PUBLIC NOTICE

Public notice was provided as required by the Brown Act. Additional noticing was sent to the residents along Bear Creek Road.

CEQA COMPLIANCE

Construction of the Alma College Parking Area and Trail Crossing was included in the Bear Creek Redwoods Preserve Plan EIR, which was certified by the Board on January 25, 2017 (R-17-15).

NEXT STEPS

Pending PNR support, the General Manager would bring a contract amendment to the full Board in April. Remaining work will focus on the production of construction documents, and initial permitting. Construction is scheduled for Summer/Fall 2018. The timeline to meet the goal of providing public access to Bear Creek Redwoods Open Space Preserve by late 2018 appears in the table below.

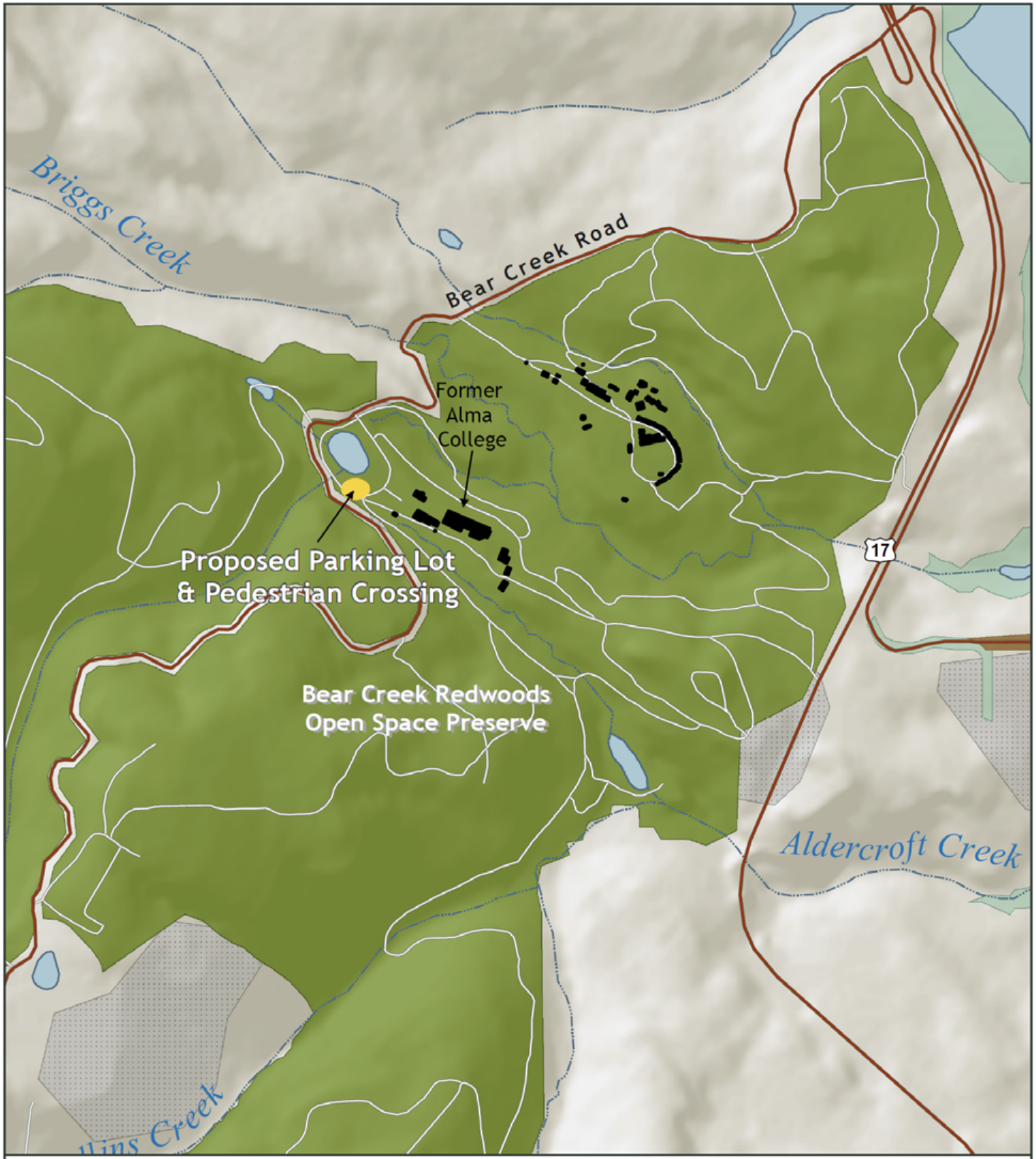
Milestone	Tentative Schedule
Present Schematic Design (30% Design) to PNR	March 2017
Design Development	Spring 2017
Construction Documents	Fall 2017
Bid & Award	Winter 2018
Construction (Phase I)	Summer/Fall 2018
Preserve Opening (Open western portion of the Preserve to public)	Late 2018
Trail Undercrossing (Phase II)	TBD

Attachments:

1. Project Location
2. Preferred Schematic Design
3. Conceptual Trail Crossing
4. Undercrossing Options
5. Opportunities and Constraints Table
6. Culvert Assessment Report

Responsible Department Head:
Jane Mark, AICP, Planning Manager

Prepared by:
Bryan Apple, Planner II
Lisa Bankosh, Planner III



Attachment 1 - Project Location

MROSD Preserves

Other Protected Open Space or Park Lands

Watershed Land

Urban Area

Midpeninsula Regional Open Space District
(MROSD)
October, 2015

0 0.25 0.5 Miles

While the District strives to use the best available digital data, this data does not represent a legal survey and is merely a graphic illustration of geographic features.

MIDPENINSULA REGIONAL OPEN SPACE

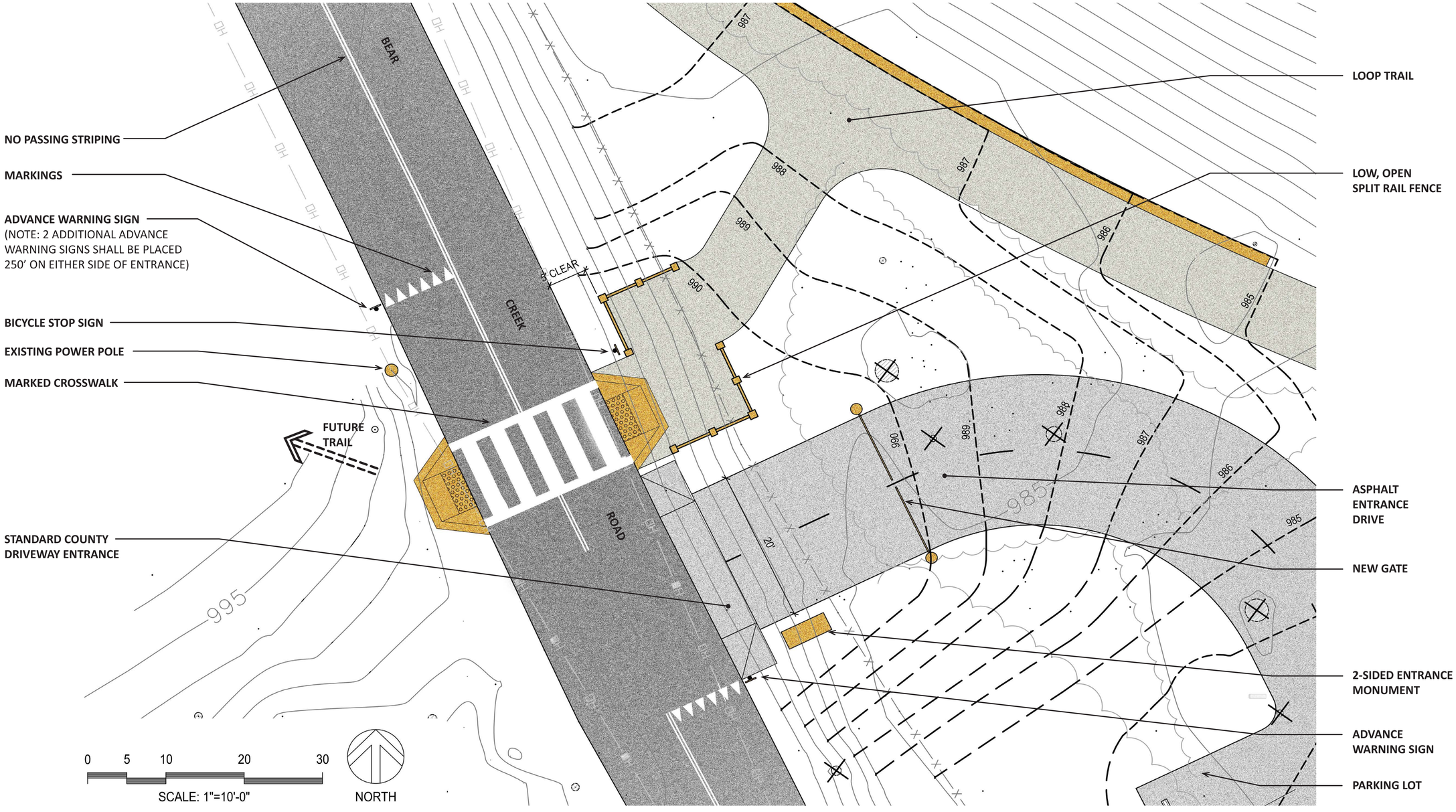
Jan 27, 2017

0 15 30 60 FT

Bear Creek Redwoods Open Space Preserve

Alma College Parking Area and Trailhead — Preferred Schematic Plan

HARRIS DESIGN

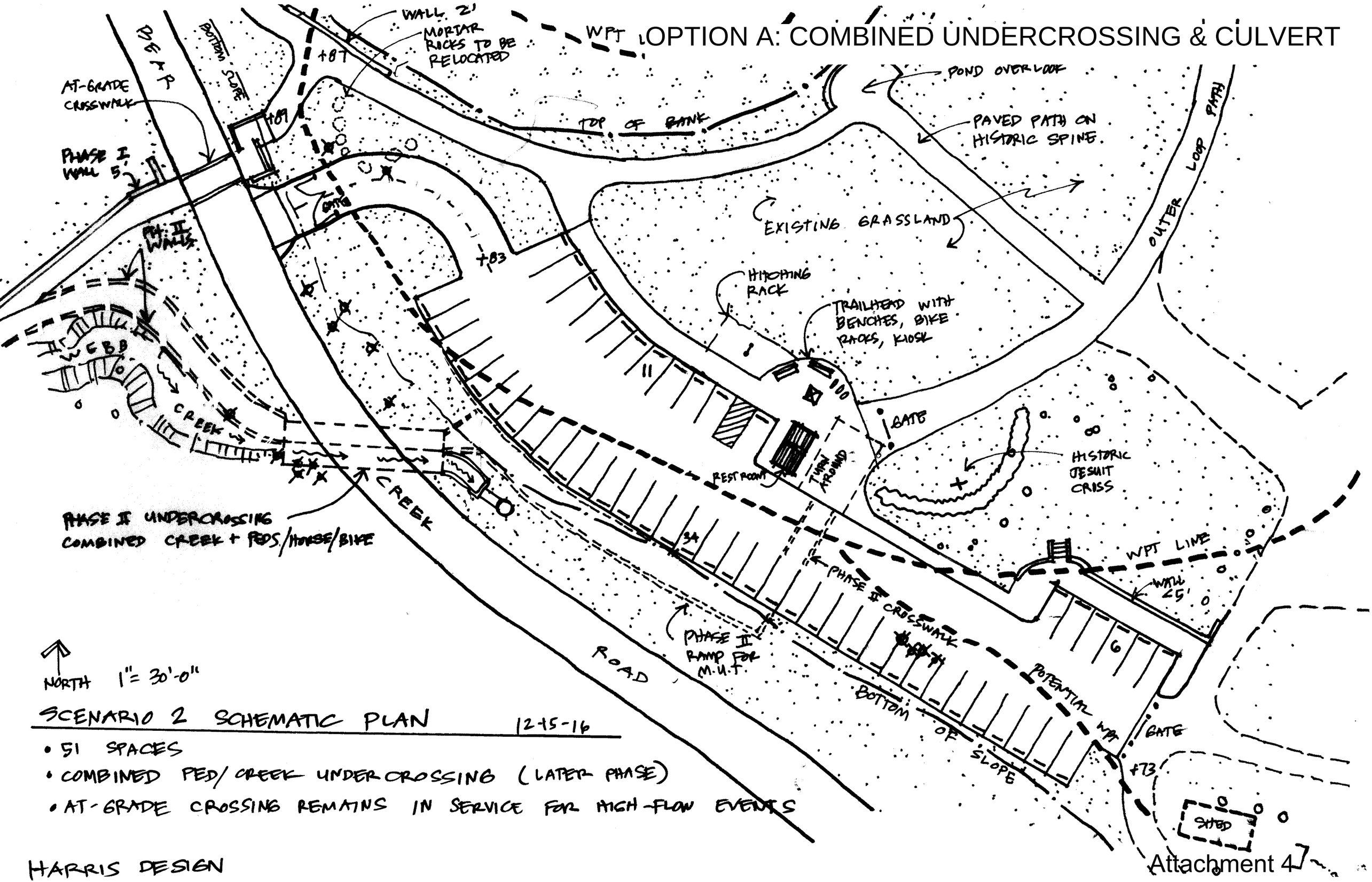

NO PASSING STRIPING
MARKINGS
ADVANCE WARNING SIGN
(NOTE: 2 ADDITIONAL ADVANCE WARNING SIGNS SHALL BE PLACED 250' ON EITHER SIDE OF ENTRANCE)
BICYCLE STOP SIGN
EXISTING POWER POLE
MARKED CROSSWALK
FUTURE TRAIL
STANDARD COUNTY DRIVEWAY ENTRANCE
LOOP TRAIL
LOW, OPEN SPLIT RAIL FENCE
ASPHALT ENTRANCE DRIVE
NEW GATE
2-SIDED ENTRANCE MONUMENT
ADVANCE WARNING SIGN
PARKING LOT
BEAR CREEK
ROAD
CLEAR
20'
OH
995
990
989
988
987
986
985
0 5 10 20 30
SCALE: 1"=10'-0"
NORTH

ATTACHMENT 4

EXAMPLE UNDERCROSSING

EXAMPLE UNDERCROSSING

OPTION A: COMBINED UNDERCROSSING & CULVERT

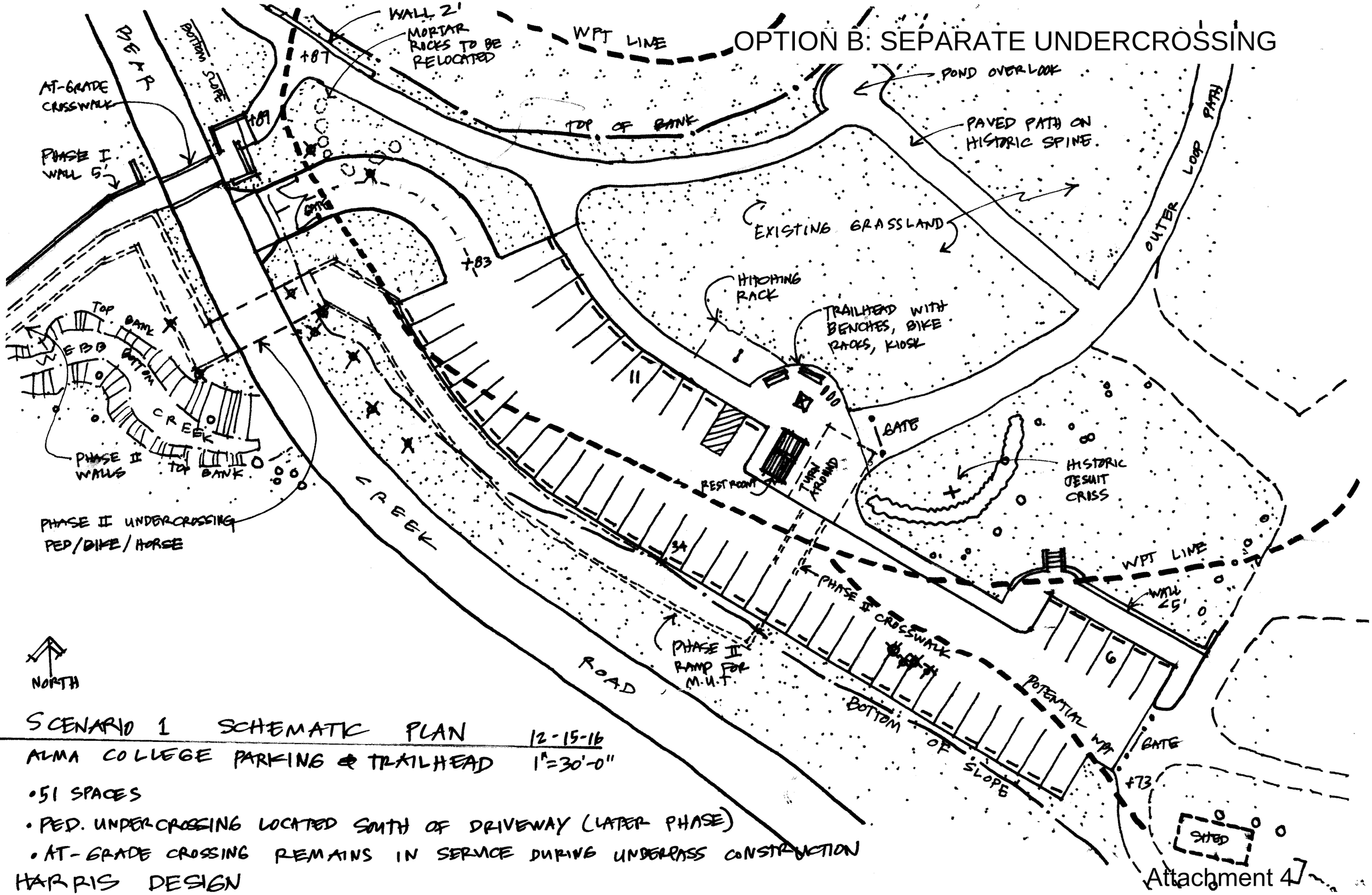


SCENARIO 2 SCHEMATIC PLAN 12-15-16

- 51 SPACES
- COMBINED PED/CREEK UNDERCROSSING (LATER PHASE)
- AT-GRADE CROSSING REMAINS IN SERVICE FOR HIGH-FLOW EVENTS

HARRIS DESIGN

OPTION B: SEPARATE UNDERCROSSING



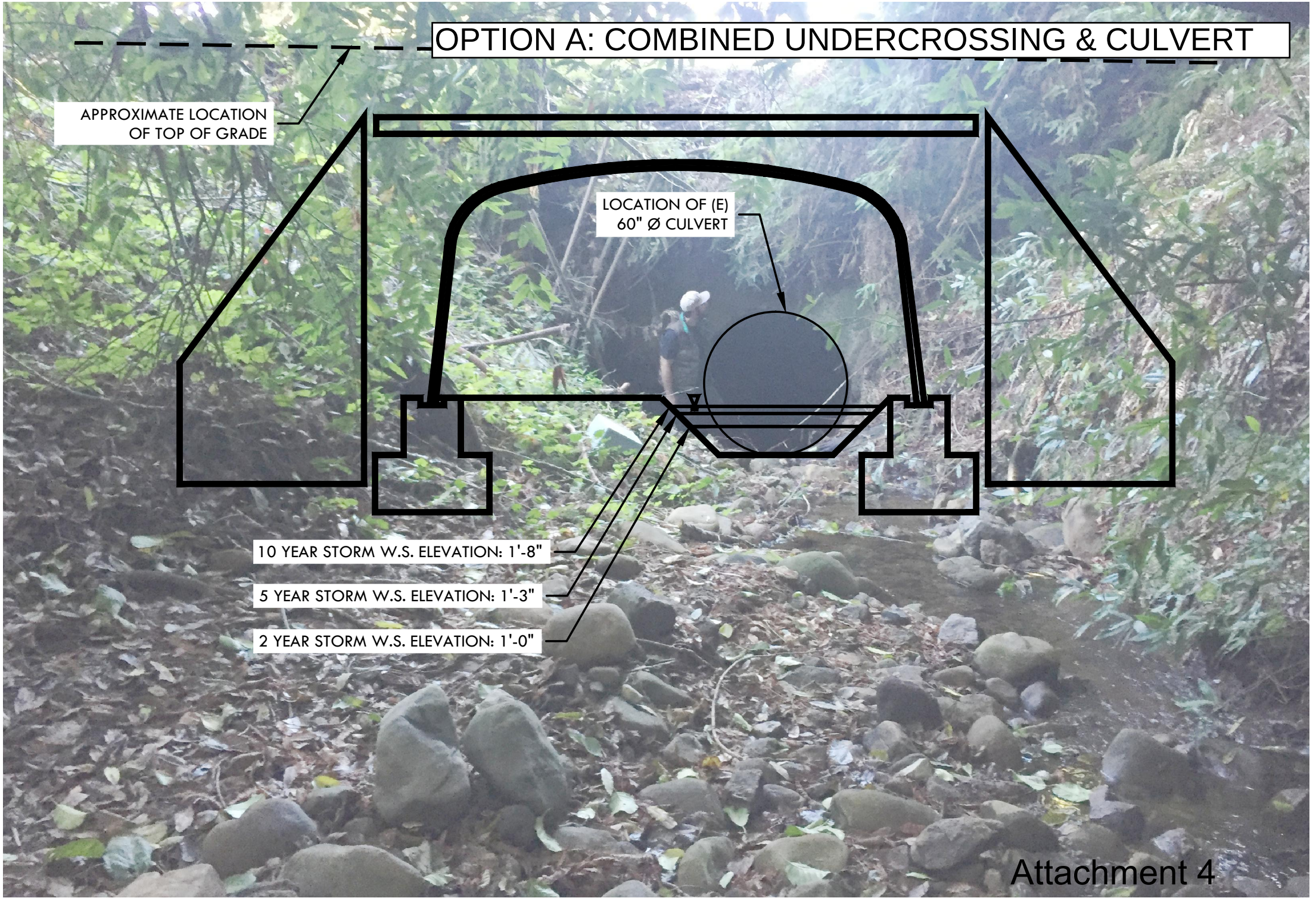
SCENARIO 1 SCHEMATIC PLAN 12-15-16

ALMA COLLEGE PARKING & TRAILHEAD 1"=30'-0"

- 51 SPACES
- PED. UNDERCROSSING LOCATED SOUTH OF DRIVEWAY (LATER PHASE)
- AT-GRADE CROSSING REMAINS IN SERVICE DURING UNDERPASS CONSTRUCTION

HARRIS DESIGN

Attachment 4



Attachment 4

	Permitting Feasibility	Constructability	Open Space Compatibility	Wildlife Passage	Long-term Maintenance	Partnership Opportunity	Ease of Trail Use
Option A Combined Culvert-Trail Undercrossing	○	◐	◐	●	◐	◐	◐
	CDFW, USACE permits required. SCCO encroachment permit required.	Natural channel topography and existing culvert would reduce grading, excavation, and engineered retaining walls. May need to temporarily close parking lot to construct.	Under-crossing would be an atypical open space structure (but already present at Alpine Road). Improves access to creek, minimizes infrastructure.	Provides an open crossing adjacent to the creek with daylight on either end. Removes a section of culvert and opens channel bottom.	Would require MOU with County for maintenance within right-of-way. District would be responsible at a minimum for trail surface maintenance.	Crossing would increase Webb Creek conveyance capacity and provide for easier maintenance of facility. County may be interested in executing partnership with the District.	Trail surface will be in close proximity to creek channel and will need to close during extreme high flows. May pose challenges for equestrians.
Option B Separate Trail Undercrossing	◐	○	○	◐	○	○	○
	CDFW, USACE permits ***may be*** required. SCCO encroachment permit required.	Construction challenges associated with amount of excavation, size of retaining walls, impacts to creek. May need to temporarily close parking lot to construct.	Creates a highly built structure. Impacts natural banks of Webb Creek with tall retaining walls. May also require armoring or slope protection.	Wildlife could use crossing, but requires navigation through trail approach with high walls (up to 11 feet).	District would be solely responsible for maintenance. May require sump pump to remove stormwater as tunnel floor will be below water table elevation.	No partnership available.	May need to close more frequently due to drainage issues. Lengthy tunnel created by high retaining walls may pose challenges for equestrians, and aesthetically unfavorable for all users.

●	**Strong alignment with policy/goal**
◐	**Medium alignment with policy/goal**
○	**Weak alignment with policy/goal**

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September 14, 2016

Lisa Bankosh
Midpeninsula Regional Open Space District
330 Distel Circle
Los Altos, CA 94022

Subject: **Draft Culvert Condition and Capacity Technical Letter**
Bear Creek Redwoods Open Space Preserve
Santa Clara County, California

Dear Ms. Bankosh:

Fall Creek Engineering, Inc., (FCE) is pleased to present to you this Draft Culvert Condition and Capacity (C&C) Analysis Technical Letter. The information in this report was compiled using the historic data that was provided to FCE by the Midpeninsula Regional Open Space District (District), an extensive in-person condition inspection of the culvert, and hydrologic and hydraulic calculations. In this letter report, FCE includes a project Introduction, Condition Analysis, Capacity Analysis, and Recommendations.

INTRODUCTION

The Bear Creek Redwoods Open Space Preserve (Preserve) is located in the Santa Cruz Mountain range approximately 1 mile west of the Bear Creek Road (BCR) exit off Highway 17. The Preserve encompasses 1,432 acres which contains historic Jesuit structures, several freshwater ponds, and expansive second growth redwood and fir forest. The District is preparing to open the facility for general public access in 2018.

The Preserve is divided by BCR which is a moderately traveled commuter road that serves the nearby communities in the Santa Cruz Mountains. There is a large culvert adjacent to BCR that collects and conveys the entirety of Webb Creek which has a drainage area of 0.7 square miles. The culvert inlet is located on the west side of BCR and the culvert passes underneath the road, and extends into the ravine alongside Alma College Road as shown in Figure 1 and Figure 3.

FCE has been retained to inspect the culvert and provide technical recommendations based on the condition and capacity of the drainage feature and the results of that analysis are presented below.

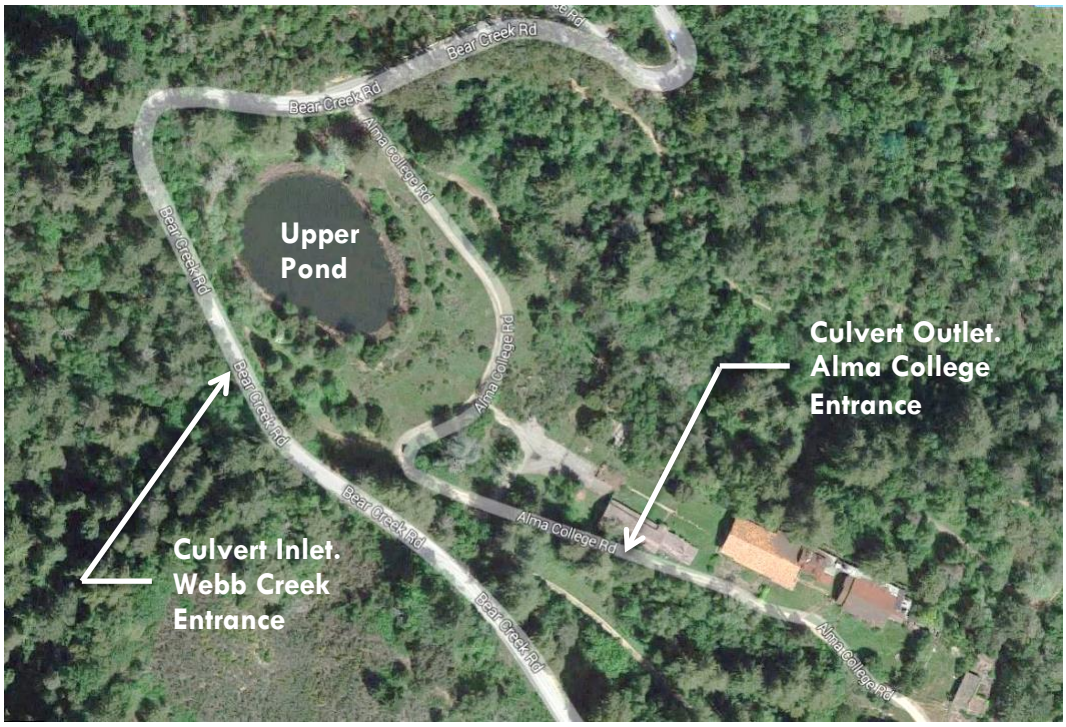

Figure 1. Approximate location of culvert inlet and outlet

The original concrete culvert was constructed in 1916 and was later lined with a corrugated metal pipe (CMP) in 1950. Since then, a number of improvements have been made, most notable, a concrete slurry lining on the culvert invert. The existing culvert is 60" in diameter, spans 587 feet and is constructed using a variety of materials including: highly corroded CMP, concrete slurry lined CMP and reinforced concrete. A comparison of the culvert materials is shown in Figure 2

Figure 2. Pipe culvert materials. Left to right: highly corroded CMP, concrete lined CMP, and concrete

CONDITION ANALYSIS

FCE conducted a confined space entry into the culvert on July 19, 2016 to visually inspect and record the condition of the culvert. In strict adherence to OSHA regulations there was a supervisor, an attendant and a confined space entrant. The entrant was the only person allowed in the culvert at any given time, and safety was a primary concern. The entrant inspected the culvert from both ends of the pipe: the entrance along Webb Creek (inlet) as well as the entrance along Alma College Road (outlet). The entrant was able to record the condition of the culvert with the use of video and still photos, and the results of those findings have been analyzed and presented in this report. The following provides the results of the condition analysis.

Culvert Condition from Upstream to Downstream

The culvert inlet at Webb Creek has a concrete collar that supports the CMP as it crosses underneath BCR. According to a traffic memorandum conducted by Hexagon Traffic Consultants Inc., BCR is a two lane county road that supports a modest amount of commuter traffic during weekdays, as well as recreational traffic on weekends (Black 2015). The road has an overall width of 28 feet and has a 4-5 foot vertical drop off the eastern side of the road where the culvert crosses into the Preserve. An approximate map of the culverts location is shown in Figure 3.

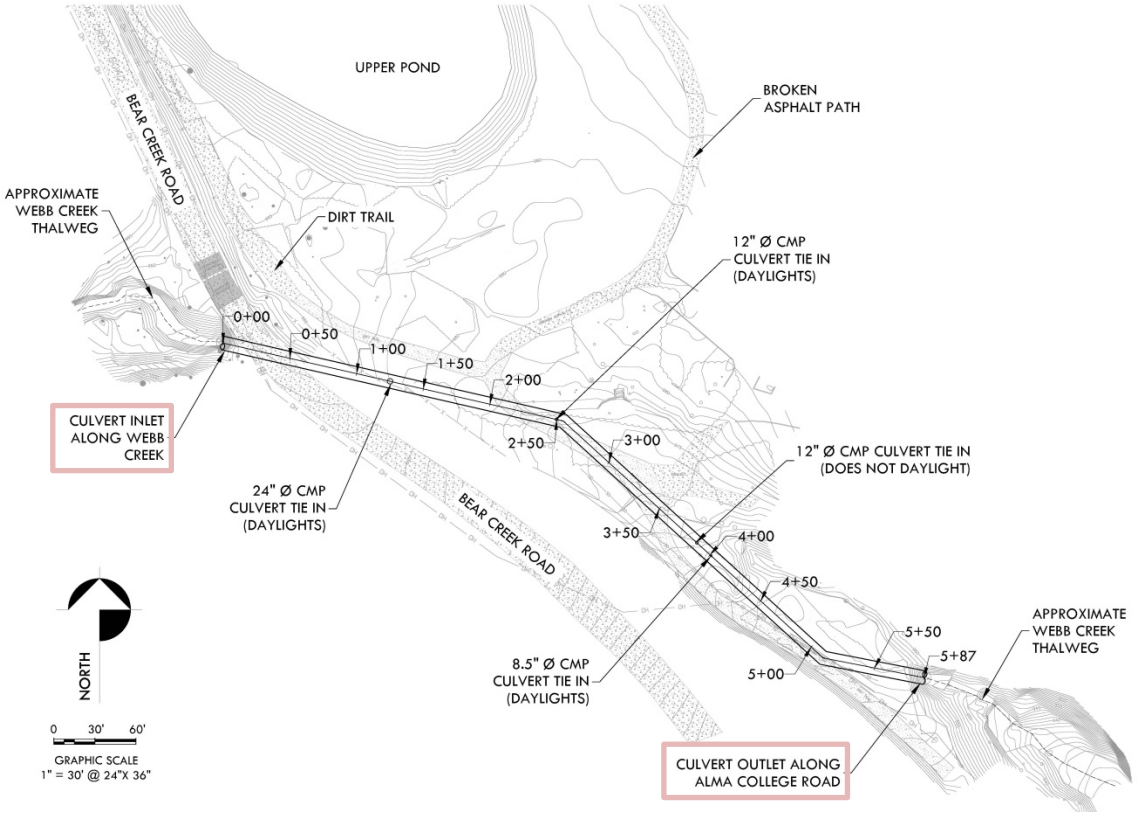

Figure 3. Approximate location of culvert with inlet and outlet highlighted in red. Note that minor pipe bends not shown and the true and accurate location of the culvert needs to be verified before any construction commences.

The condition of the culvert inlet on the along BCR is significantly damaged, and the damage can be visually noted from the outside of the culvert. Figure 4 shows the poor condition of the culvert; with up to 32" of the pipe invert completely corroded away, and up to 18" deep pools that expose the natural creek bed below the culvert.

Figure 4. Damaged culvert inlet on the southwestern side of BCR at Webb Creek

The condition of the first 66 feet of the CMP culvert is extremely impacted; especially in the segment that crosses underneath BCR. Major structural damage has occurred along that length of pipe, including; absence of pipe invert, complete pipe collapse, pipe buckling, pipe sagging and joint separation. This span of pipe is identified as the most probable source of hydraulic losses and possible pipe bed undercutting and overall destabilization. The depth of the creek channel that formed in the absence of the culvert measured up to 18-inches below the pipe's invert.

A significant separation of approximately 9 inches between pipe sections was noted 25.5 feet in from the culvert inlet and the damage can be seen in Figure 5.

Figure 5. Separation at CMP pipe joint (looking into culvert from Webb Creek Inlet)

Both sections of CMP culvert shown in Figure 5 were initially the same diameter, but over time, the corrosion along the pipe invert, combined with the soil pressure loading above, caused the pipe to

roll inwards and constrict the culvert's inner diameter. The constricted culvert extends from 25.5 feet from the inlet to 62 feet from the inlet (approximately 36.5 lineal feet). The culvert shows additional pipe sagging and overall roof distortion at 62 feet from the culvert entrance, and the damage is shown in Figure 6.

Figure 6. Roof collapse at 62 feet from entrance at Webb Creek (looking towards culvert outlet)

The distortions in the pipe are a clear indication that the structural integrity of the culvert has been severely compromised. Four feet past the pipe roof collapse, at 66 feet from the inlet, there is another pipe joint that has completely separated that can be seen in Figure 7.

Figure 7. Pipe joint separation at 66 feet from the culvert inlet (looking towards culvert inlet)

The invert of the CMP culvert is lined with concrete slurry from 64 feet to 106 feet (42 lineal feet) until the CMP culvert transitions to a concrete culvert. The concrete culvert extends from 106 feet to 171 feet (65 lineal feet) and then transitions back to concrete slurry lined CMP for the remainder of the culvert length (416 lineal feet).

The general condition of the concrete slurry lined CMP was similar for the segment of pipe after the concrete culvert (171 feet) until the outlet along Alma College Road (416 lineal feet). Figure 10 shows a typical section of slurry lined CMP and indicates how the culvert is reliably transporting water during the conditions when the culvert was investigated.

Figure 8. Typical section of concrete slurry lined CMP

The single structural abnormality that was encountered within this segment of pipe was a significant pipe collapse at 422 feet from the inlet. The distortion impacts approximately 17 lineal feet of pipe and encompasses an approximately 9-inch pipe joint separation. The damaged section of pipe is shown in Figure 11.

Figure 9. Left: Distorted CMP pipe 422 feet from inlet along BCR (looking towards inlet). **Right:** The 9-inch gap (looking towards outlet along Alma College Road).

The cause of the roof collapse is unknown, however, it is apparent that the constriction in the pipe diameter would cause impeded flow during high flow conditions.

Piped Inlets

FCE identified 4 piped inlets of various sizes that all connect to the main culvert. The piped inlets are all constructed of corrugated metal pipe (CMP) and have inside diameters of 24-inches, 12-inches, 12-inches, and 8.5-inches. A summary of the piped inlets is shown in Table 1 and images of the piped inlets are presented in Figure 8.

Table 1. Drainage features encountered in main culvert

Number	Station (ft)*	Description	Notes
1	125	24" I.D. CMP culvert	daylights
2	220	12" I.D. CMP culvert	does not daylight
3	387	12" I.D. CMP culvert	daylights
4	401	8.5" I.D. CMP culvert	daylights

* Station measured from inlet along Bear Creek Road

Figure 10. Four piped inlets. Starting top left: Clockwise: 24-inch., 12-inch, 12-inch, 8.5-inch

During the inspection, FCE was able to determine that three of the four piped inlets daylight as noted in Table 1. The fourth piped inlet had an old corroded steel pipe in the center that appeared to be approximately 4 inches in diameter and can be seen in Figure 9.

Figure 11. 12-inch piped inlet with steel pipe in center.

The inlet of the steel pipe is unknown; however it is clear that water has historically flowed in this inlet as indicated by the corrosion along the invert of the pipe.

It is unlikely that any of the piped inlets have an effect on the Upper Pond hydraulics due to their orientation to the Pond. All of the small piped inlets are likely serving as area drains for low points on the Preserve.

Additional Site Considerations

One of the added difficulties of the site is the presence of the San Andreas Fault line in relation to the culvert location. The fault line runs directly through the Preserve and can be seen in Figure 12.

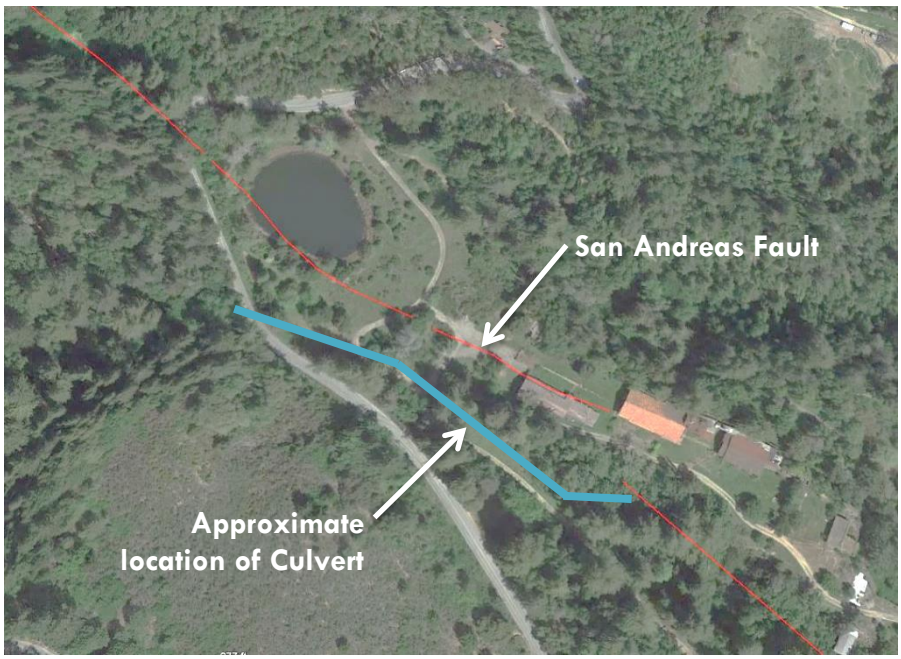

Figure 12. USGS generated map of San Andreas Fault crossing through site with approximate location of culvert shown. Actual location of culvert must be verified before any construction commences.

The presence of the fault line within such close proximity to the culvert may have been the cause of some of the pipe damage that was noted. The alignment of the culvert and the fault line parallel each other and slight subterranean shifts over the course of years may have impacted the culvert's integrity and caused some of the pipe joint separation that was noted in Figure 5, Figure 7, and Figure 11.

In addition to the condition analysis of the culvert, FCE was tasked with determining the hydraulic capacity of the existing culvert. FCE employed several methods to determine the peak design storm flow and determine whether or not the culvert is appropriately sized to handle the volume of water that will be generated in a design storm.

CULVERT CAPACITY ANALYSIS

Paired Watershed Analysis

Webb Creek is an ungaged creek and FCE approximated peak flood conditions by conducting a paired watershed analysis (PWA) using known data at a gaged site. FCE conducted a paired watershed analysis between nearby Saratoga Creek and Webb Creek. The correlation is based on known peak annual flow data obtained from United States Geological Survey (USGS) gaging station 11169500, located along Saratoga Creek and the relationship between the areas of each watershed. The gaging station is located approximately 5.3 miles from the inlet of the culvert on Webb Creek and both creeks share very similar climate, precipitation, and topographic features.

FCE utilized the USGS streamflow data for Saratoga Creek, in combination with the US Army Corp of Engineer's Hydrologic Engineering Center's Statistical Software Package (HEC-SSP), to analyze the flood flow frequency of Saratoga Creek. Peak discharge flows for Saratoga Creek were calculated for the 1, 2, 5, 10, 25 and 100-year return period design storm. The flow values that were generated for Saratoga Creek were then scaled by the ratio between the watershed areas of each creek to estimate the flow of Webb Creek. Saratoga Creek has a watershed area of 9.22 square miles and Webb Creek has a watershed area of 0.7 square miles which equates to a scaling factor of 13.2. The Peak discharge flows of Webb Creek are the result of dividing the Saratoga Creek peak discharge generated from HEC-SSP by the watershed scaling factor of 13.2. The results of the paired watershed analysis are shown in Table 2.

Table 2. Peak Discharge values for Saratoga Creek and Webb Creek using HEC-SSP.

Flood Frequency	Saratoga Creek Peak Discharge (cfs)	Webb Creek Peak Discharge (cfs)
2-yr	392	30
5-yr	920	70
10-yr	1,411	107
25-yr	1,991	151
50-yr	2,911	221
100-yr	3,735	284

USGS gaging station 11169500 on Saratoga Creek has 82 discreet peak flow measurements that were recorded between the years of 1934 and 2014. This large database covers years of extreme drought and years of extreme flooding, which statistically improves the accuracy of the predicted peak flow values for Webb Creek.

Regional Regression Equations

In addition to estimating the peak flow of Webb Creek using the PWA, FCE employed the USGS California regional flood frequency equations, or regional regression equations (RRE). The equations are based on regression analysis that has been applied to data collected from 705 individual gauging stations throughout California and empirically verified for each region within the state.

The annual peak discharge flows for the Central Coast region are estimated using the following equations:

2-yr	$(0.0061*A^{0.92})*(P^{2.54})*(H^{-1.10})$
5-yr	$(0.118*A^{0.91})*(P^{1.95})*(H^{-0.79})$
10-yr	$(0.583*A^{0.90})*(P^{1.61})*(H^{-0.64})$
25-yr	$(2.91*A^{0.89})*(P^{1.26})*(H^{-0.50})$
50-yr	$(8.20*A^{0.89})*(P^{1.09})*(H^{-0.41})$
100-yr	$(19.7*A^{0.88})*(P^{0.84})*(H^{-0.33})$

Where:
Q = peak discharge (cfs)
A = drainage area (square miles)
P = mean annual precipitation (in)
H = altitude index (thousands of feet)

The peak discharge for each storm frequency was determined using the following input data for Webb Creek: drainage area (A) was determined to be 0.7 square miles from an online GIS query using USGS StreamStats software (USGS 2016), mean annual precipitation (P) was estimated to be 43.3 inches from StreamStats and the altitude index (H) was determined from a Google Earth elevation query. Table 3 presents the results from the Webb Creek RRE analysis and Table 4 presents the results for both the RRE and PWA analysis.

Table 3. Webb Creek RRE results

Flood Frequency	Webb Creek Peak Discharge (cfs)
2-yr	41
5-yr	97
10-yr	142
25-yr	201
50-yr	247
100-yr	300

Table 4. Webb Creek results comparison between PWA and RRE analysis

Flood Frequency	PWA Peak Discharge (cfs)	RRE Peak Discharge (cfs)
2-yr	30	41
5-yr	70	97
10-yr	107	142
25-yr	151	201
50-yr	221	247
100-yr	283	300

The difference between the predicted peak discharge for the PWA as compared to that of the RRE was small especially for the 100-year return period design storm which had a percent difference of only 6%.

For each return period design storm event, the RRE generated a more conservative estimate for the expected peak discharge, so FCE applied the values generated from the RRE to the capacity analysis.

Capacity Analysis

FCE utilized the RRE flow values from the 25-year and 100-year storm events to conduct a capacity analysis of the existing 60" diameter culvert. The design storms were selected based on the criteria outlined in the Santa Clara County Drainage Manual (SCCDM) and the California Department of Transportation (CALTRANS) Highway Design Manual.

The SCCDM states in section 5.1.5.2 *Minimum Design Criteria for Culverts*, that "Culverts shall be sized to pass the 25-year design flow under free outfall conditions, without an inlet head in excess of the top of culvert, […][and] culvert sizing shall be checked under all inlet and outlet control conditions to safely pass the 100-year design flow." (SCCDM 2007)

Additionally, section 821.3 of the CALTRANS *Highway Design Manual* indicates that a 100-year design flood should be used to size the culvert "with-out headwaters rising above an elevation that would cause objectionable backwater depths or outlet velocities." (CALTRANS 2006)

FCE used the Hydraflow software program that is part of the Autodesk Civil 3D software package to evaluate the culvert's ability to convey the design storm. FCE analyzed both the 25-year design flow of 201 cfs and the 100-year design flow of 300 cfs. The results of the Hydraflow model can be seen in Figure 13 and Figure 14. The green line in the figure represents the embankment height, or in this instance the grade elevation of BCR, and the blue line represents the hydraulic grade line during the storm event. The black lines indicate the extent of the 60" circular CMP culvert.

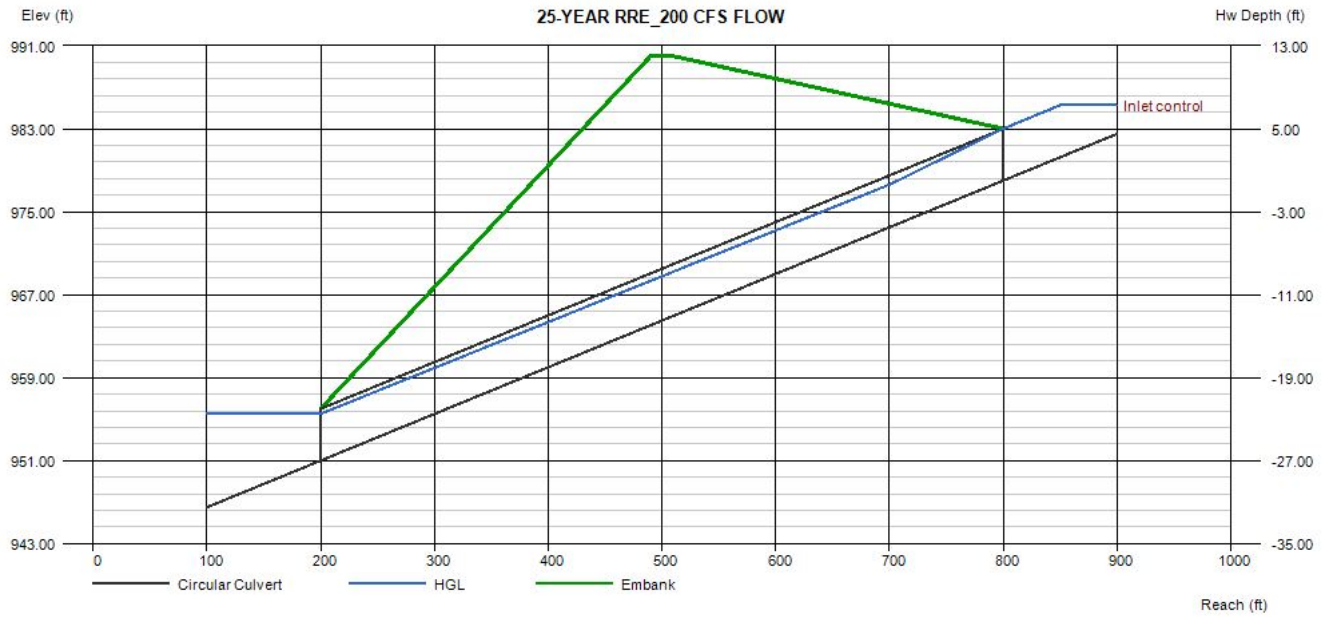

Figure 13. Hydraflow model for 25-year design storm

After running the Hydraflow model it was apparent that the 60" diameter culvert is adequately sized to convey the 25-year design storm flow. The water surface elevation at the inlet of the culvert along Bear Creek Road rises under these circumstances; however the culvert maintains several feet of freeboard from the top of the embankment. FCE also ran a 100-year storm flow value of 300 cfs using the Hydraflow model and the results can be seen in Figure 14.

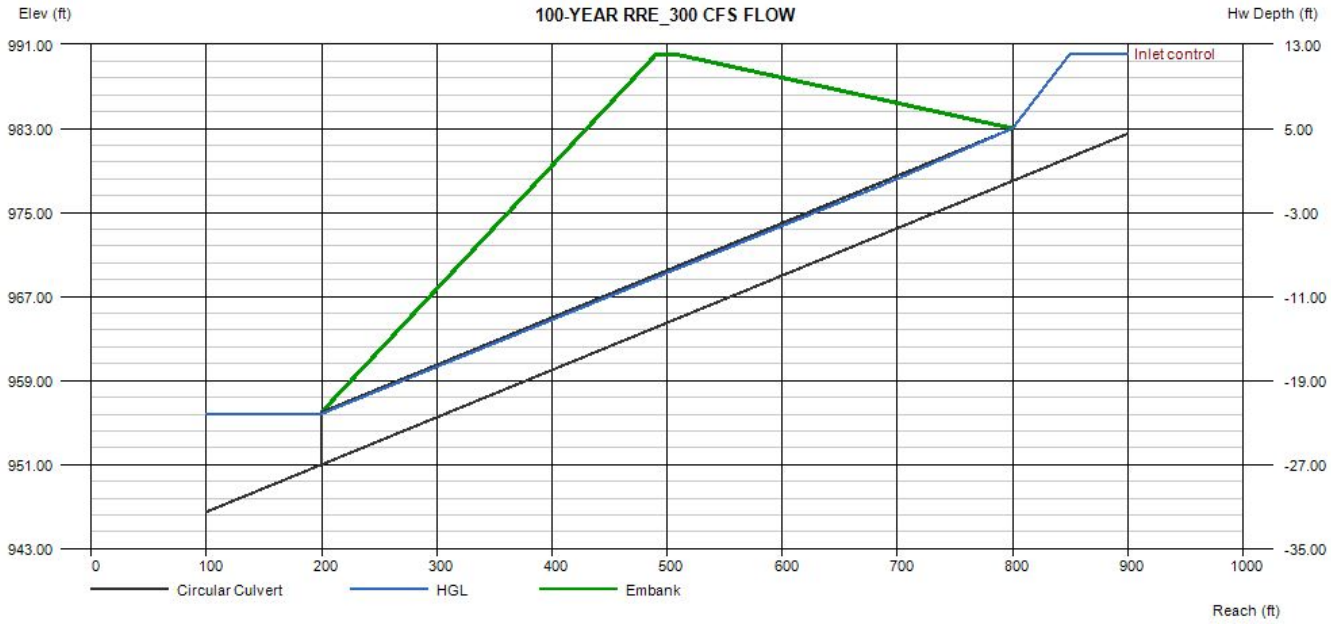

Figure 14. Hydraflow model for 100-year design storm

Based on the results of the Hydraflow analysis for the 100-year design storm, the existing culvert is inadequately sized to safely convey the design flow. The inlet of the culvert along Webb Creek is predicted to backwater and overtop the embankment, causing BCR to flood. The results of the

model suggest that the culvert needs to be replaced in order to satisfy the design requirements of the SCCDM and CALTRANS Highway Design Manual.

The Hydraflow model generates a "best-case-scenario" for the flow conditions and doesn't take into account other site conditions that may be associated with the 100-year design storm. Under the 100-year return period storm event, the culvert inlet would likely experience higher than normal volume of debris which could result in clogging of the inlet that would diminish the culvert's ability to convey the design flow, and increase the amount of overtopping and flooding of BCR. Similarly, the constricted diameter of the culvert where the CMP rolled inward (Figure 4), combined with the decreased diameter due to the concrete slurry along the invert, would all contribute to non-ideal conditions that are not accounted for in the model. Finally, during a large storm event, the structural integrity of the culvert could become damaged even further due to increased scouring, headwall bank erosion, pipe bed undercutting and overall culvert destabilization.

CONCLUSIONS AND RECOMMENDATIONS

FCE has determined that the structural condition of the 60" diameter culvert is compromised as indicated by the various forms of damage that were encountered during the condition analysis. The damage is most apparent within the first 66 feet from the culvert inlet along Webb Creek, and the structural implications of the damage are unknown. However, it is known that the options for repairing the culvert are limited due to the extent of damage as well as the constricted pipe diameter caused by inward pipe roll. The damaged culvert eliminates the possibility of slip-lining the culvert because the existing CMP is structurally jeopardized.

On top of the apparent structural damage, the results of the capacity analysis indicate that the existing culvert is undersized and incapable of reliably conveying the 100-year design storm flow according to both the SCCDM and CALTRANS Highway Design Manual. This result confirms that the culvert will need to be replaced with a larger diameter option that will safely pass the 100-year flow underneath Bear Creek Road, without overtopping and negatively impacting the road.

FCE recommends the following:

1. At minimum, replace the length of culvert that crosses underneath Bear Creek Road with a larger diameter culvert. In particular, the section that extends for the first 66 feet is the highest priority because it is the most structurally compromised.
2. As part of the continued culvert replacement design options, FCE recommends conducting additional analysis and assessment; including but not limited to: structural engineering, geotechnical engineering, biological surveys, hydrological modeling (HEC-RAS) and permitting requirement research.

Thank you for the opportunity to assist you with this project. Please contact me if you have any questions or require any additional information.

Sincerely,

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