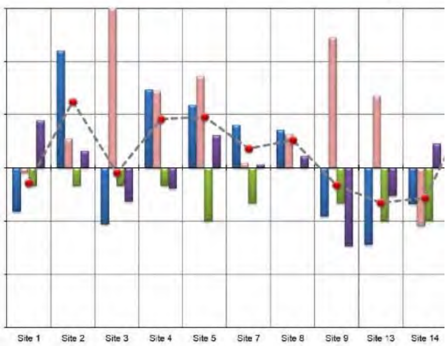

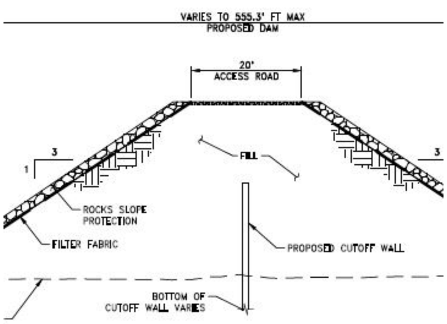

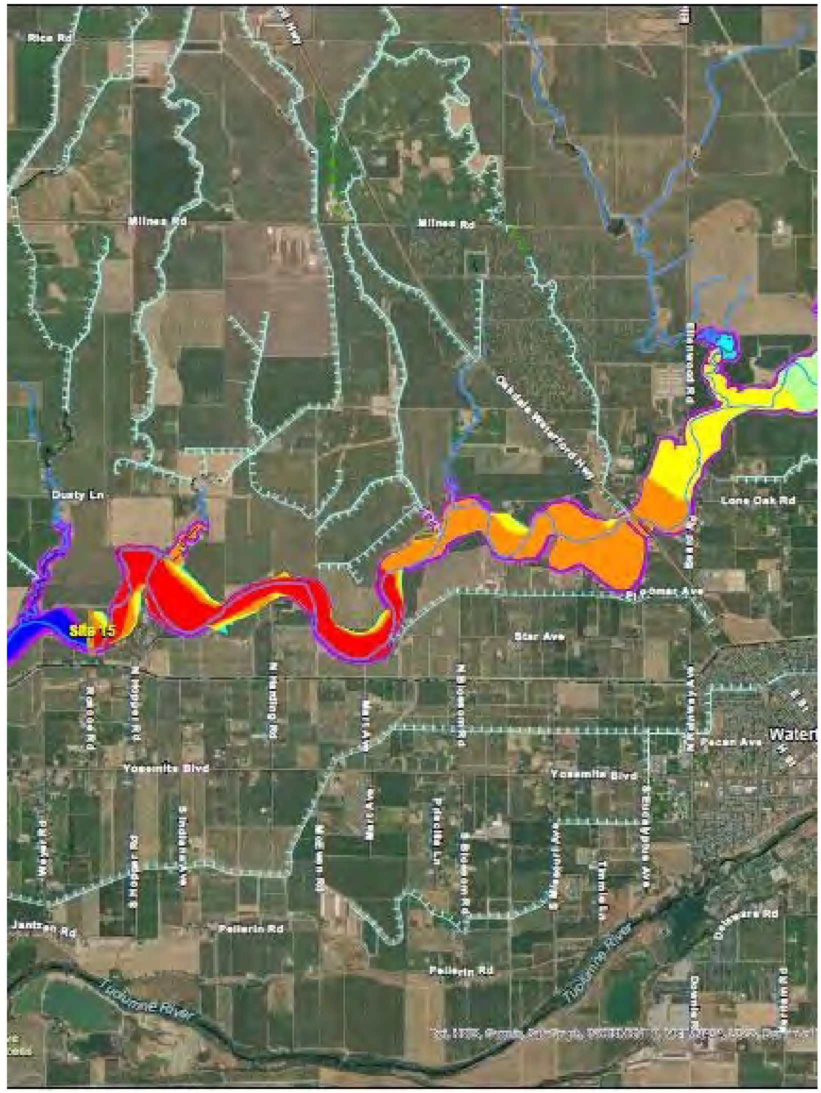

Prepared for: Stanislaus County

Phase II – Evaluation of Stormwater Management and Groundwater Recharge in the Dry Creek Watershed of Stanislaus County FINAL Summary Report

June 30, 2022

GeoSystems Analysis, Inc. Innovations in Hydrology

WOOD RODGERS

E PUR Safe Water for All

DOCUMENT CONTROL SUMMARY

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LIST OF ATTACHMENTS

EXECUTIVE SUMMARY

This report summarizes the results of the Phase II evaluation of potential stormwater management and groundwater recharge project locations within the Dry Creek watershed above the City of Modesto in Stanislaus County. The focus of the Phase II study was to evaluate a preliminary list of potential projects which could reduce flood risk within the Dry Creek watershed and the downstream Tuolumne River and which could also support groundwater recharge within the Modesto Groundwater Subbasin in addition to other multi-benefit opportunities. Fifteen potential flood control sites were identified in Phase I of this study and, after further analysis, 11 potential sites were evaluated as described below. The results of the Phase II evaluation were presented to and discussed with community stakeholders in January 2022. Follow-up meetings were conducted with landowners adjoining the potential flood control detention sites in April 2022 and with the primary water rights holders on the Tuolumne River in March 2022 to discuss opportunities for cooperation and support of regional flood mitigation and water resource management.

The Phase II evaluation consisted of surface water modeling and a Multiple Account Analysis (MAA) to evaluate the 11 potential flood control sites. Surface water modeling was used to predict the flood depths, inundation areas, inundation times, and water surface elevations (WSE) under existing conditions (no flood control) and with the proposed flood control detention at each potential site. The MAA framework was used to evaluate relative advantages and disadvantages of the different potential stormwater control sites by applying various technical, economic, environmental, and social/cultural factors. The purpose of the MAA was to use the criteria in a methodical fashion to rank the overall attributes of each potential site. It should be noted that this study was primarily focused on the technical aspects on flood control and groundwater recharge, under the assumption that sites that are potentially technically feasible would be thoroughly evaluated for environmental and social/cultural factors in a later phase.

Potential sites 2, 4, 5, 8, and 15 are predicted to have the greatest reduction in water surface elevations at the El Vista Bridge and hence the greatest potential to reduce flooding at and below the confluence of the Tuolumne River and Dry Creek. A comparison of the predicted change in inundation area along Dry Creek, both above and below each potential site, also shows significantly greater reduction in flooding downstream than the predicted increase in inundation in upstream areas. Four potential sites (Sites 2, 15, 5, and 4) had the highest MAA scores.

Community stakeholders identified a variety of environmental and social/cultural concerns. Issues identified by the stake holders included potential inundation of agricultural crops at the different potential sites, potential effects on flora (i.e. Blue Oaks), and cultural impacts below Tim Bell Road. In addition, the large water right holders within the watershed are considering other

stormwater control and recharge projects that could change the flood control issues and conditions within Dry Creek. Together, the Turlock Irrigation District and the Modesto Irrigation District have filed an appropriative water right covering Dry Creek and therefore are likely to be the lead agency(ies) of any future studies or work within the Dry Creek Watershed should they acquire that water right.

Consequently, we recommend that Phase III of the DCW study expand the evaluation of flood control alternatives to add potential regional flood control and water supply projects to be considered by the irrigation districts and other major water right holders.

Specific recommendations are that Stanislaus County Public Works:

a. Inform the Stanislaus County Board of Supervisors and Executive of the Phase II study results and conjunctive efforts of the Tuolumne River water rights holders;
b. Further engage with the Tuolumne River water rights holders on cooperative approaches to developing projects that can provide flood mitigation and groundwater recharge relative to the Tuolumne River and its tributary Dry Creek;
c. Engage with and obtain support from the Stanislaus & Tuolumne Rivers Groundwater Basin Association groundwater sustainability agency to pursue a variety of available funding opportunities eligible under the California Sustainable Groundwater Management Act (SGMA).

1.0 Introduction

Stanislaus County contracted with GeoSystems Analysis Inc. (GeoSystems), Wood Rogers Inc. (WRI) and E-PUR, LLC to conduct a Phase II evaluation of potential stormwater management and groundwater recharge project locations within the Dry Creek Watershed (DCW) above the City of Modesto in Stanislaus County. This study is the second phase of a multi-phase stormwater management and groundwater recharge program designed to identify and implement multi-benefit flood control projects that will protect downstream Disadvantaged Communities (DAC) and provide water resources benefits:

- Phase I - identify potential flood control projects within the Dry Creek watershed that can reduce the risk of downstream flooding to DACs and enhance local water resources
- Phase II - identify and evaluate potential highest-benefit projects in the Dry Creek watershed (Priority Projects) and initiate stakeholder engagement
- Phase III - bring one or more project alternatives to the implementation-grant-ready stage with site-specific investigations and design engineering to provide documentation for preparation of necessary environmental permits and water rights documents.
- Phase IV - project implementation.

While the major irrigation districts and the City of San Francisco were identified as stakeholders for engagement in Phase I and Phase II, the scope of Phase II was expanded somewhat by the January 26, 2022 filing for new floodwater rights on the Tuolumne River by Turlock Irrigation District (TID) and Modesto Irrigation District (MID). These additional efforts are discussed in Section 2.4

1.1 Project Background

The history of flooding in the DCW at its confluence with the Tuolumne River in the City of Modesto (i.e. in 1997 and 2017) and the need for the local groundwater sustainability agency, the Stanislaus and Tuolumne Rivers Groundwater Basin Association Groundwater Sustainability Agency, to reduce groundwater overdraft in the eastern portion of the Modesto Groundwater Subbasin motivate this Study and its overall goal of identifying multi-benefit projects that can mitigate both issues.

In Phase I of the Dry Creek study GeoSystems developed a surface water model to determine estimated flow rates and flow volumes during design storm-events of different frequency and conducted a hydrogeologic suitability analysis for groundwater recharge (GeoSystems, 2020a, 2020b). The DCW is approximately 215 square miles (or 137,000 acres) in size and is located north/north-east above the City of Modesto. The surface water evaluation indicated that surface water flows in Dry Creek above approximately the 5-year return interval cause downstream flooding at and downstream of the confluence of the Tuolumne River and Dry Creek if these storms are coincident with required releases from the Don Pedro Reservoir for its floodwater management and dam safety control. Options for mitigating this flood risk from the Dry Creek stormwater flows are needed and are a key part of this Study's objectives.

With limited exception, the entire non-irrigation-district eastern portion of the Modesto Groundwater Subbasin is solely reliant on groundwater and the recently completed Groundwater Sustainability Plan (GSP) estimates the annual groundwater overdraft to be 43,000 acre-feet/year (Todd, 2022). Currently, developed agriculture in the non-district east areas of the Subbasin is estimated to be approximately 36,000 acres, of which approximately 30,000 acres is deciduous fruits and nuts (permanent crops). Enhancing groundwater recharge may be an economically advantageous way to address the overdraft as compared to taking land out of production.

Most of the soils in the DCW have low estimated relative permeability or are underlain by restrictive soil units. The estimated soil permeabilities are highest in the western portion of the DCW (GeoSystems, 2020a). Because of potential permeability restrictions from near-surface restrictive units or fine-grained layers at depth, potential groundwater recharge may require the use of recharge enhancement features (i.e. drywells or infiltration galleries) at different locations. Almond orchards and grape vineyards predominate in the DCW. Both of these agricultural crop types have been shown to be suitable for Flood Managed Aquifer Recharge if properly managed.

Fifteen (15) potential flood control and stormwater capture sites within Dry Creek were identified in Phase I based on the contributing sub-watershed area, potential access to the site, distance from nearby infrastructure, and proximity to irrigation canal networks. In this Phase II study, further evaluations were conducted on 11 sites to include conceptual flood control structure designs and additional surface water modeling to predict the influence of stormwater detention on peak flood flows and stormwater volumes detained. The relative advantages and disadvantages of the 11 potential stormwater flood control sites were evaluated by applying various technical, economic, environmental, and social/cultural factors in a Multiple Account Analysis (MAA) framework (Attachment 2). The MAA used various criteria in a methodical fashion to rank the overall attributes of each potential site.

Section 2.0 provides a summary of the Phase II study methods and results. A detailed discussion of the methods used and results of the surface water modeling are presented in Attachment 1; methods used and results of the MAA are presented in Attachment 2.

2.0 SUMMARY OF PHASE II RESULTS

Surface water modeling analyses and the MAA were performed on the potential site locations shown in Figure 1. The following sub-sections discuss the results of the Phase II analyses.

2.1 HEC-RAS Model Development

WRI developed a two-dimensional (2D) HEC-RAS hydraulic model (HEC-RAS) for use in evaluating the feasibility of potential stormwater control sites in the DCW. HEC-RAS is a US Army Corp of Engineers hydraulic model designed to aid engineers in channel flow analysis and floodplain determination (see https://www.hec.usace.army.mil/software/hec-ras/). The 2D HEC-RAS model was used to compare predicted flood depths, water velocities, inundation areas, inundation times, and water surface elevations (WSEs) with existing conditions (no flood control) and proposed flood control detention at each potential site. Figure 1 presents the location of the 11 potential evaluation sites. Attachment 1 describes the methodology and results of the HEC-RAS modeling.

Reductions in WSE were evaluated at the El Vista Bridge because this location is sufficiently upstream such that backwater flows from the Tuolumne River into Dry Creek do not influence WSEs at this location. The HEC-RAS model was used to estimate peak flow reduction and change in WSE for design storm events and volumes captured and reduced flood risk to landowners and disadvantaged communities (DAC). Potential sites 2, 4, 5, 8, and 15 are predicted to have the greatest reduction in WSEs at the El Vista Bridge and hence the greatest potential to reduce flooding at and below the confluence of the Tuolumne and Dry Creek (See Attachment 1).

Table 1 shows the predicted change in inundation area to occur within Dry Creek both above and below each potential site compared to existing (no flood control) conditions. Most of the potential detention structure sites show a predicted reduction in flooding downstream twice or more than the predicted increase in inundation in upstream areas.

Table 1. Change in predicted inundation within Dry Creek resulting from potential flood control detention

Potential Site	Existing Conditions		Proposed Flood Control Structure		Increase in Upstream Inundation (acres)	Decrease in Downstream Inundation (acres)
	Area Inundated Upstream (acres)	Area Inundated Downstream (acres)	Area Inundated Upstream (acres)	Area Inundated Downstream (acres)		
2	917	1785	1178	1160	260	-624
4	513	2189	748	1743	235	-446
5	501	2202	746	1650	245	-551
8	299	2403	602	1894	303	-509
15	1979	723	2076	582	97	-140

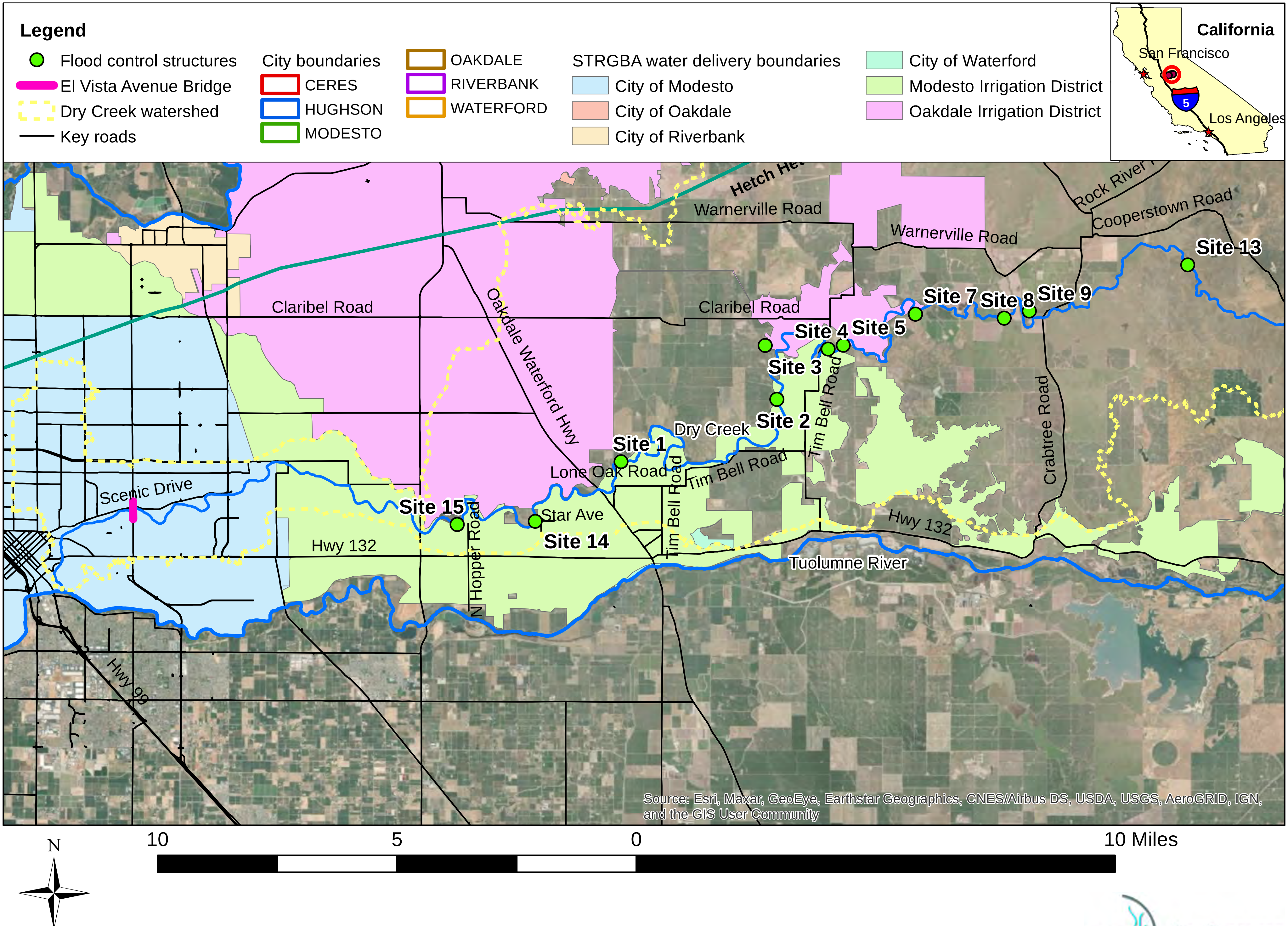

Figure 1. Potential flood control structure locations and El Vista Avenue Bridge

2.2 Multiple Accounts Analysis Results

To evaluate the relative advantages and disadvantages of the different potential stormwater control sites, assessment of technical, economic, environmental, and social/cultural factors for each site were applied into an MAA evaluation matrix. Technical criteria were supported by the 2D HEC-RAS model-predicted inundation area, capture volume, and water surface elevations at each site for a range of return frequency storms ranging from a 5-year to a 100-year event. The purpose of the MAA was to use the various criteria in a methodical fashion to rank the overall attributes of each potential site. A detailed description of the MAA methodology and results is presented in Attachment 2. Four potential sites ranked highest in the MAA: Site 2 had the highest score, followed by Site 15, Site 5, and Site 4.

2.3 Public Outreach

Following completion of the MAA on December 13, 2021, it was posted on the Stanislaus County website at https://www.stancounty.com/publicworks/pdf/dry-creek.pdf. Stanislaus County Public Works then organized a public meeting to report the findings for preliminary sites and the concepts for floodwater detention project locations that scored highest on multi-benefit characteristics and other MAA ranking criteria. The public meeting was held at 6 pm on the evening of January 18, 2022 at Harvest Hall in greater Modesto and was the opening date of a 30-day public comment period. Landowners in the Dry Creek watershed within a few miles of the watercourse itself were notified directly by U.S. Mail prior to the meeting, and notice of the meeting was posted on the Stanislaus County Public Works stormwater site, https://www.stancounty.com/publicworks/storm/. The meeting was also published in the local newspaper. The meeting was well attended with roughly 100 people in attendance (a sign-in sheet was used but not all attendees signed the sheet). Public Comment cards and pencils were made available for all and comments were invited to be submitted at that meeting or mailed to project personnel at Stanislaus County Public Works. The public meeting was recorded and transcribed by a stenographer. The transcript is available on the County stormwater website at https://www.stancounty.com/publicworks/pdf/dry-creek-project-open-house-01-18-22.pdf. Many comments were received and are posted to the Stanislaus County Public Works website at https://www.stancounty.com/publicworks/pdf/dry-creek-project-open-house-01-18-22-comments-received.pdf

At the request of the Stanislaus County Board of Supervisors, additional meetings were held on April 6 and April 7, 2022 with landowners adjacent to the prospective floodwater detention areas. These meetings were conducted by Stanislaus County Public Works staff to provide a forum for discussion of some of the concerns being expressed by local landowners.

2.4 Tuolumne River Water Right Holders Engagement

Stanislaus County has identified the principal surface water rights holders with facilities in the Dry Creek watershed. Those entities are:

- Turlock Irrigation District (TID),
- Modesto Irrigation District (MID),
- Oakdale Irrigation District (OID), and
- City of San Francisco via their Public Utilities Commission (SFPUC)

During Phase I, data and documents were exchanged with MID and TID to utilize existing data collected by them and to report out preliminary findings. TID. as the operator of flow controls at Don Pedro Dam. also provided feedback in May 2020 on their concerns (see Attachment 3). The Phase II Technical Memorandum describing the project team's development of a dynamic stormflow model (Attachment 1) was shared with TID, as the Tuolumne River primary operator, in late November 2021. Subsequently, the project team held a virtual meeting on January 12, 2022 to discuss the Dry Creek project status and timing and to coordinate further.

2.4.1 TID/MID Water Rights Filing for Unappropriated Water in the Tuolumne River

TID and MID filed for new water rights of flood control water in the Tuolumne River on January 2, 2022 (Water Rights Application A033277). In that filing the irrigation districts identified 16 categories of projects for flood control; some of these projects could mitigate much of the flood risk at the confluence of Dry Creek with the Tuolumne and downstream. Within the 16 project types are 5 or more projects that also consider groundwater recharge enhancement in the Dry Creek project area. Those project types provide a basis for further engagement between TID/MID and Stanislaus County.

2.4.2 Tuolumne River and Stanislaus River Water Rights Holder Engagement

After preliminary document exchanges and virtual meetings, Stanislaus County Public Works met with the water right holders on March 2, 2022 to discuss the DCW stormwater control and groundwater recharge evaluation. The meeting was attended by each of the four water-rights holders identified in Phase 1: TID, MID, OID, and SFPUC. These preliminary discussions identified that the objectives of the DCW study are compatible with the TID/MID application for flood control water rights, and the need for all of the water right holders to improve their water supply resiliency, reduce flood control risks, and produce groundwater recharge benefits.

Engagement around project types that can improve flood risk management at and below the confluence of the Tuolumne River and Dry Creek, and increase groundwater recharge in the Modesto Subbasin are expected to continue between Stanislaus County and these entities to identify additional projects to evaluate in Phase III of this study.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The Phase II Evaluation of Stormwater Management and Groundwater Recharge in the Dry Creek Watershed evaluated 11 potential stormwater detention structures within the DCW. Surface water modeling and an MAA analysis were conducted to identify potential sites with the greatest overall potential benefits for flood control and groundwater recharge. Potential sites 2, 4, 5, 8, and 15 are predicted to have the greatest reduction in water surface elevations at the El Vista Bridge and hence the greatest potential to reduce flooding at and below the confluence of the Tuolumne and Dry Creek (See Attachment 1). A comparison of the predicted change in inundation area along Dry Creek, both above and below each potential site, also shows a significantly greater reduction in flooding downstream than the predicted increase in upstream inundation. Four potential sites (Sites 2, 15, 5, and 4) had the highest MAA.

Community stakeholders identified a variety of environmental and social/cultural concerns. Issues identified by the stake holders included potential inundation of agricultural crops at the different potential sites, potential effects on flora (i.e. Blue Oaks), and cultural impacts below Tim Bell Road. In addition, the large water right holders within the watershed are considering other stormwater control and recharge projects that could change the flood control issues and conditions within Dry Creek. TID/MID has filed an appropriative water right covering Dry Creek and therefore are likely to be the lead agency(ies) of any future studies or work within the Dry Creek Watershed should they acquire that water right.

Consequently, we recommend that Phase III of the DCW study expand the evaluation of flood control alternatives to add potential regional flood control and water supply projects to be considered by the irrigation districts and other major water right holders.

Specific recommendations are that Stanislaus County Public Works:

a. Inform the Stanislaus County Board of Supervisors and Executive of the Phase II study results and conjunctive efforts of the Tuolumne River water rights holders;

b. Further engage with the Tuolumne River water rights holders on cooperative approaches to developing projects that can provide flood mitigation and groundwater recharge relative to the Tuolumne River and its tributary Dry Creek;

c. Engage with and obtain support from the Stanislaus & Tuolumne Rivers Groundwater Basin Association groundwater sustainability agency to pursue a variety of available funding opportunities eligible under the California Sustainable Groundwater Management Act (SGMA).

4.0 REFERENCES

GeoSystems Analysis, Inc., 2020a. Evaluation of Stormwater Management and Groundwater Recharge Projects in the Dry Creek Watershed of Stanislaus County. Prepared by GeoSystems Analysis with E-PUR LLC, and Wood Rodgers Inc. for Stanislaus County Public Works, March 12, 2020.

GeoSystems Analysis, Inc., 2020b. Technical Memorandum 2 – Dry Creek Watershed Stormwater Management and Groundwater Recharge Multiple Account Analysis. Prepared by GeoSystems Analysis Inc. for Stanislaus County Public Works, April 23, 2020.

GeoSystems Analysis, Inc., 2021. Technical Memorandum 1 – Phase II Dry Creek Watershed Stormwater Management and Groundwater Recharge Multiple Account Analysis (MAA) Results. Prepared by GeoSystems Analysis with E-PUR LLC and Wood Rodgers for Stanislaus County Public Works, December 13, 2021.

Todd, 2022. "Modesto Subbasin Groundwater Sustainability Plan" Prepared by Todd Groundwater and Woodard & Curran. Prepared for the Stanislaus and Tuolumne Rivers Groundwater Basin Association, January 31.

Wood Rodgers, 2020. Technical Memorandum #1: HEC-HMS Model Development and Surface Water Analysis of Phase I Evaluation of Stormwater Management and Groundwater Recharge Projects in the Dry Creek Watershed, Prepared for GeoSystems Analysis Inc., February 2020.

Wood Rodgers, 2021. Technical Memorandum #2: HEC-RAS Model Development, Phase II Evaluation of Stormwater Management and Groundwater Recharge Projects in the Dry Creek Watershed, Prepared for GeoSystems Analysis Inc., November 16, 2021.

Woodard & Curran, 2019, "Stanislaus Multi-Agency Regional Storm Water Resources Plan, Public Draft" April 2019.

ATTACHMENT 1

Technical Memo 2: HEC-RAS Model Development, Phase II Evaluation of Stormwater Management and Groundwater Recharge Projects in the Dry Creek Watershed

TECHNICAL MEMORANDUM

TO: Michael Milczarek, Program Director, GSA

FROM: David Mueller, Wood Rodgers Inc.

DATE: November 17, 2021

SUBJECT: Technical Memo #2: HEC-RAS Model Development, Phase II Evaluation of Stormwater Management and Groundwater Recharge Projects in The Dry Creek Watershed

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INTRODUCTION

Wood Rodgers, Inc. (WRI) has developed a two-dimensional (2d) HEC-RAS hydraulic model (HEC-RAS Model) for use in evaluating the feasibility of proposed projects for the Phase II Evaluation of Stormwater Management and Groundwater Recharge (SMGR) Projects in The Dry Creek Watershed (Project). The 2d model was developed to determine a comparison of hydraulic characteristics such as depths, velocities, inundation areas, inundation times, and water surface elevations (WSE) with the existing condition for each potential site throughout the entire reach. The purpose of this memo is to describe model development and summarize the results of the model.

Fifteen (15) potential flood control and stormwater capture sites within the Dry Creek Watershed (DCW) were identified in the Phase I study, which were later reduced to eleven potential sites based on additional information and engineering judgement. The locations of the eleven potential flood control structures are shown in **Figure 1**. To evaluate the relative advantages and disadvantages of the different potential stormwater control sites, technical, economic, environmental, and social/cultural factors for each site was applied into a Multiple Account Analysis (MAA) evaluation matrix (Mendoza and Martins, 2006). The purpose of the MAA was to use the various criteria in a methodical fashion to rank the overall attributes of each potential site. WRI utilized the HEC-RAS model to populate the MAA indicators for volumes captured, flood protection, reduced flood risk to landowners, and reduced flood risk to disadvantaged communities (DAC). The three highest ranked sites will be further evaluated using the HEC-RAS model in the Alternatives Analysis, also performed in Phase II.

MODEL DEVELOPMENT

A 2d HEC-RAS model was developed for the reach of Dry Creek encompassing each of the potential sites. WRI developed the HEC-RAS model using available topographic data obtained in Phase I, input hydrographs from the HEC-RAS model developed in Phase I, and conceptual designs for 11 of the 15 sites.

<u>Model Geometry</u>

WRI utilized the 3-foot DEM developed with Phase 1 to develop the 2d mesh within the model geometry. A Manning's 'n' value of 0.045 was used to represent the Dry Creek channel from bank to bank, and a Manning's 'n' value of 0.060 was used for over bank areas. The existing condition model geometry domain includes Dry Creek from the confluence with the Tuolumne River to just upstream of Site 13.

Each of the 11 potential projects was represented in the hydraulic model as a hydraulic structure within the 2d model domain. Therefore, 11 proposed condition models were run independently from the existing condition. Each structure consisted of a dam with a culvert. Exhibits presenting preliminary designs for the 11 sites are attached to this memo.

The downstream boundary condition of the model is assumed to be a constant stage of 53.9 feet, which corresponds with the maximum stage during the 2017 storm event at stream gauge MOD in Tuolumne River when releases from the Don Pedro Reservoir occurred. As described in Phase I, review of documentation from the Regional Flood Management Plan for the Mid-San Joaquin River Region (California Department of Water Resources, 2014) indicated flooding occurs in Dry Creek when flows above 5,000 – 6,000 cfs in Dry Creek occur concurrently with releases from Don Pedro Dam of 9,000 cfs.

<u>Input Hydrology</u>

In Phase 1, a design storm based on the January 2017 storm event was developed, and design storm hydrographs ranging from a 2-year to a 50-year frequency were constructed using a HEC-HMS model calibrated to the historic flood records at the DCM gauge on Dry Creek. The 2d HEC-RAS model utilizes the existing condition flow hydrographs constructed with the HEC-HMS model to determine the existing and proposed condition hydraulic characteristics for the entire reach for the existing condition and for the 11 proposed conditions models.

MODEL RESULTS

The existing conditions 2d model established baseline maximum depths and water surface elevations throughout the reach. **Figure 1** presents the location of the 11 potential evaluation sites and the Existing Condition maximum flood depths in the 25-year storm event.

For the purposes of comparison, the reduction in WSE is reported at the El Vista Bridge because this location is sufficiently upstream of the confluence with the Tuolumne River so that backwater flows from the Tuolumne River do not influence WSEs at this location. **Table 1** presents a comparison of WSE reduction at the El Vista Bridge. Sites 2, 4, 5, 8, and 15 result in the greatest reduction in water surface elevations at the El Vista Bridge.

Table 1, WSE Reduction at El Vista Bridge

Site	WSE Reduction El Vista				
	Q10	Q25	Q50	Q100	Sum Q10-Q100
Site01	0.52	0.47	0.53	0.57	2.1
Site02	4.18	4.46	4.49	4.54	17.7
Site03	0.3	0.21	0.19	0.16	0.9
Site04	2.57	2.55	2.44	2.67	10.2
Site05	2.81	2.75	2.59	1.58	9.7
Site07	1.9	1.85	1.97	2.29	8.0
Site08	2.58	2.55	2.39	1.88	9.4
Site09	1.01	0.65	0.68	0.7	3.0
Site13	0.97	0.74	0.85	0.95	3.5
Site14	2.05	0.35	0.13	-0.05	2.5
Site15	3.78	4.12	4.26	4.43	16.6

ENCLOSURES

Figure 1: Evaluation Sites, Existing Condition Maximum Flood Depth, 25-year Storm Event

Conceptual Design Exhibits for 11 Sites

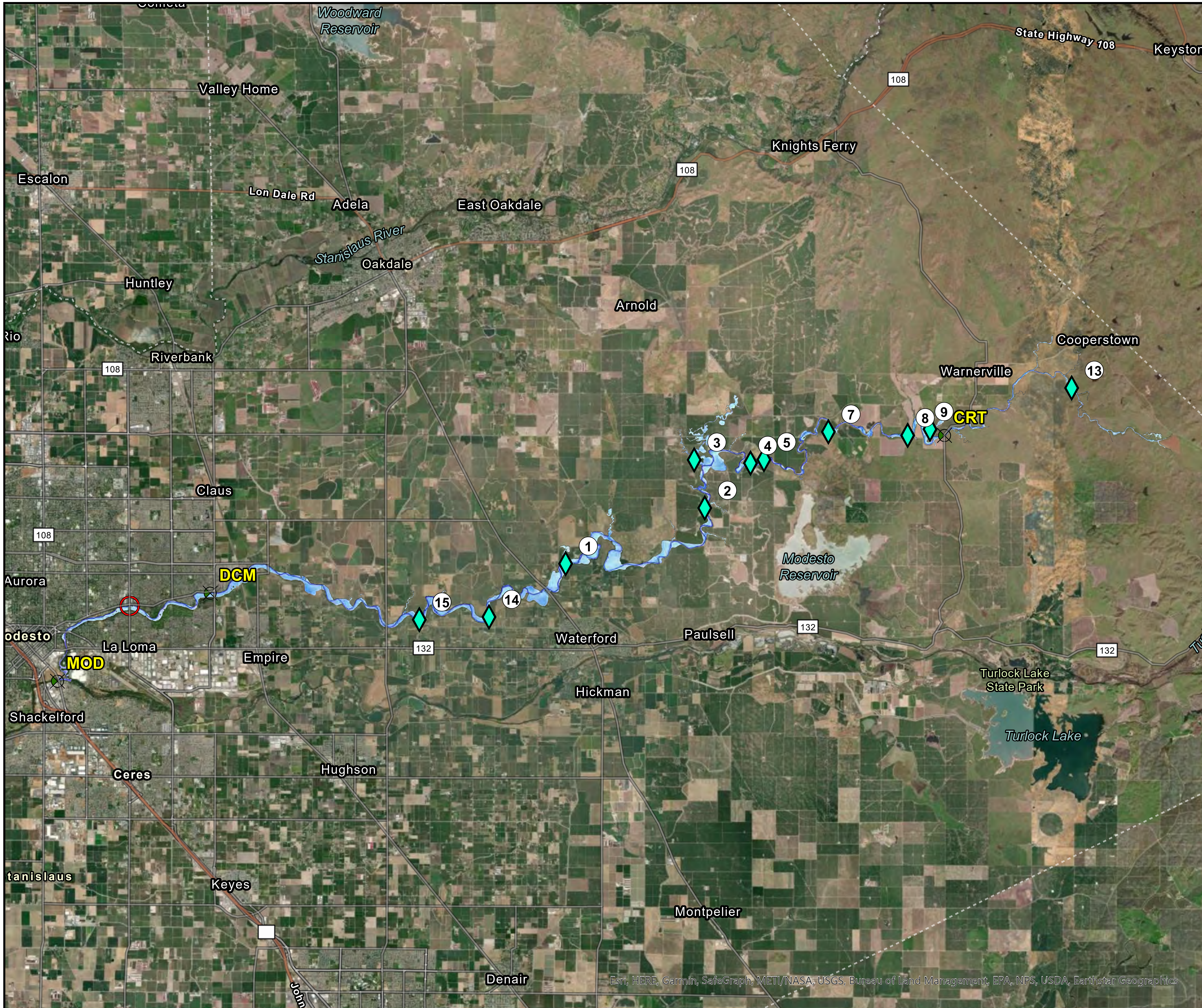

FIGURE 1

EVALUATION SITES
EXISTING CONDITION
MAXIMUM FLOOD DEPTH
25-YEAR STORM EVENT

PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECTS IN THE DRY CREEK WATERSHED

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2021

Legend

- Stream Gauges
- El Vista Bridge (WSE Comparison Point)
- Eval_Sites

NoProject_Q25_Depth__Max

Max Depth, Feet

High : 28.0675

Low : 0.000999451

0 6,000 12,000 24,000
Feet

NORTH

WOOD RODGERS

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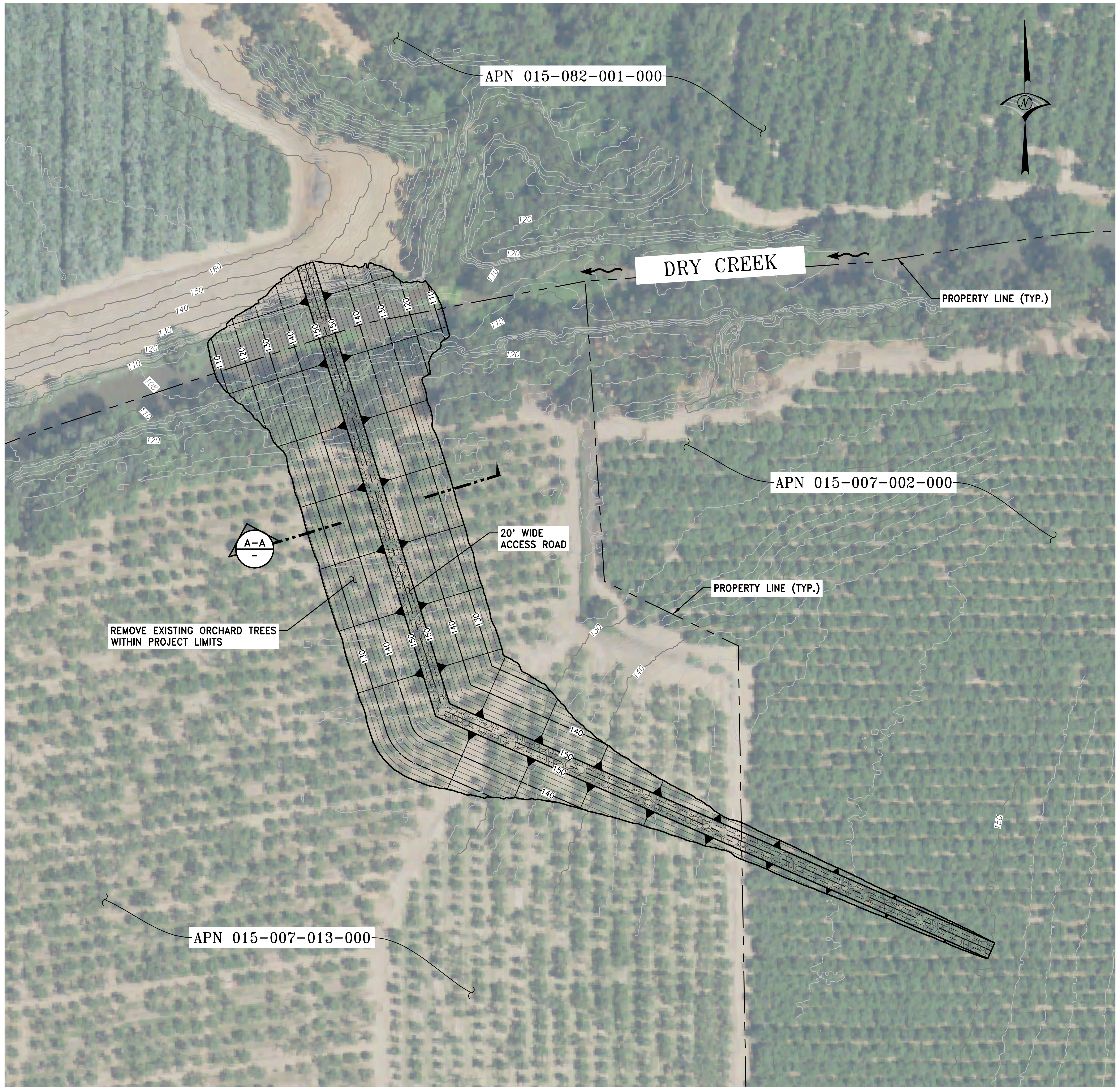

SITE 1 - PLAN VIEW

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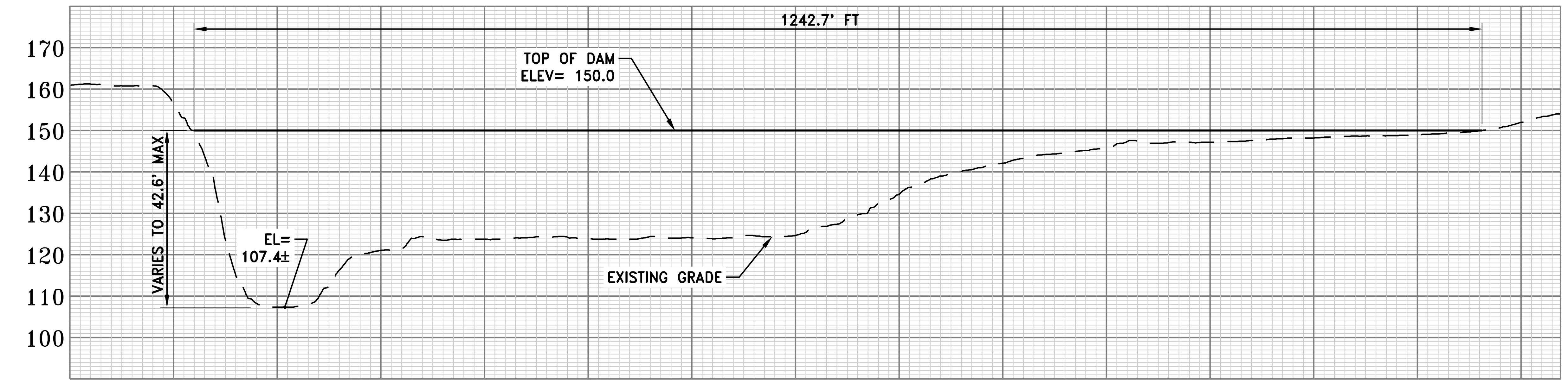

SITE 1 - PROFILE VIEW

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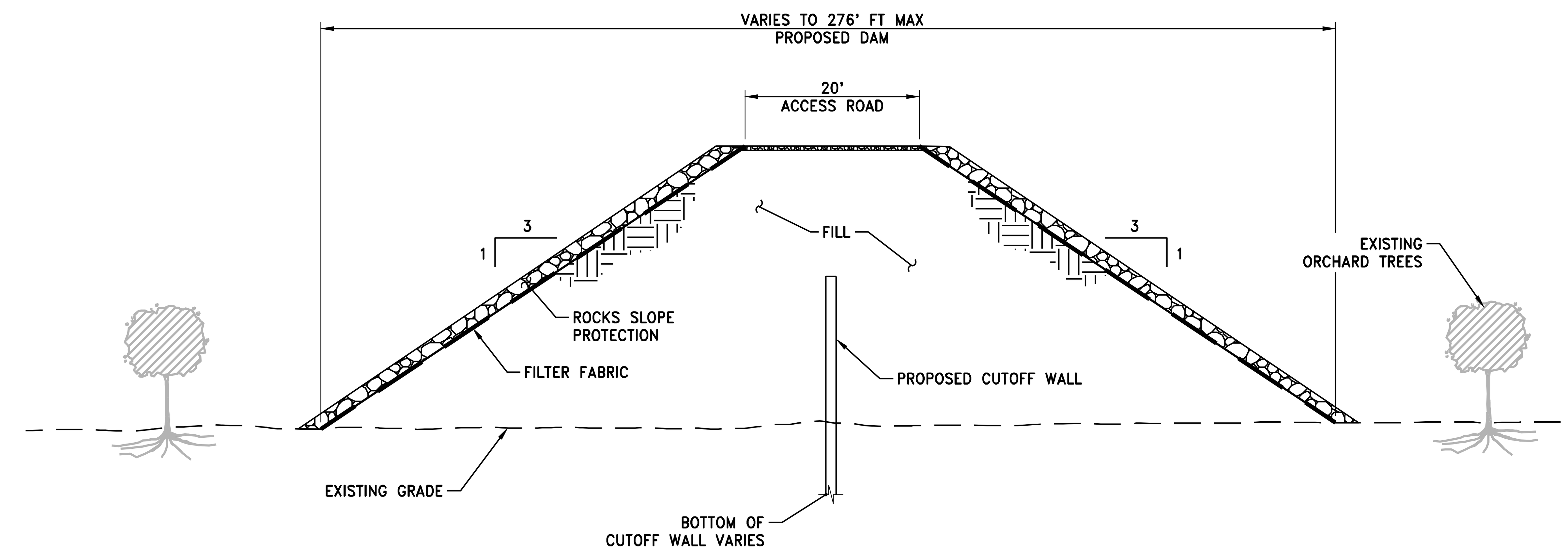
VERT-1"=25'



A-A **SITE 1 -TYPICAL SECTION**

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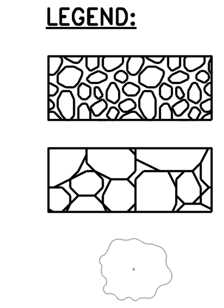
LEGEND:



PROPOSED ACCESS ROAD

PROPOSED ROCK SLOPE PROTECTION

EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY:
DRAWN BY:
CHECKED BY:
IN CHARGE:
DATE: 8/31/2021

PRELIMINARY

WOOD RODGERS
DEVELOPING • INNOVATIVE • DESIGN • SOLUTIONS
3301 C STREET, BLDG. 100-B, SACRAMENTO, CA 95816
PHONE: (916) 341-7760 FAX: (916) 341-7767

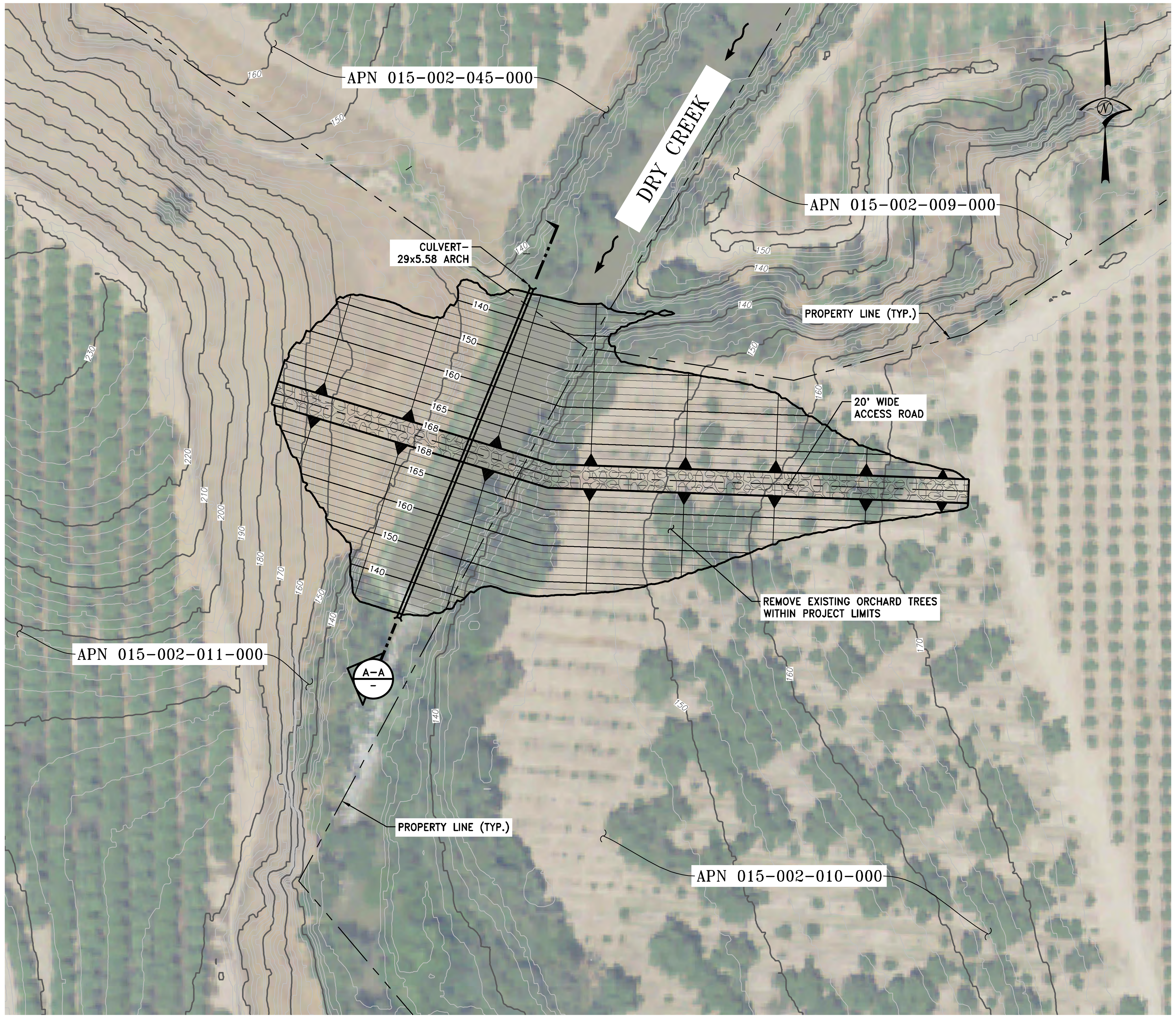
SUBMITTED
APPROVED

GEOSYSTEMS ANALYSIS, INC

DRY CREEK STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECT

SITE 1 DAM

DRAWING NO. | SHEET



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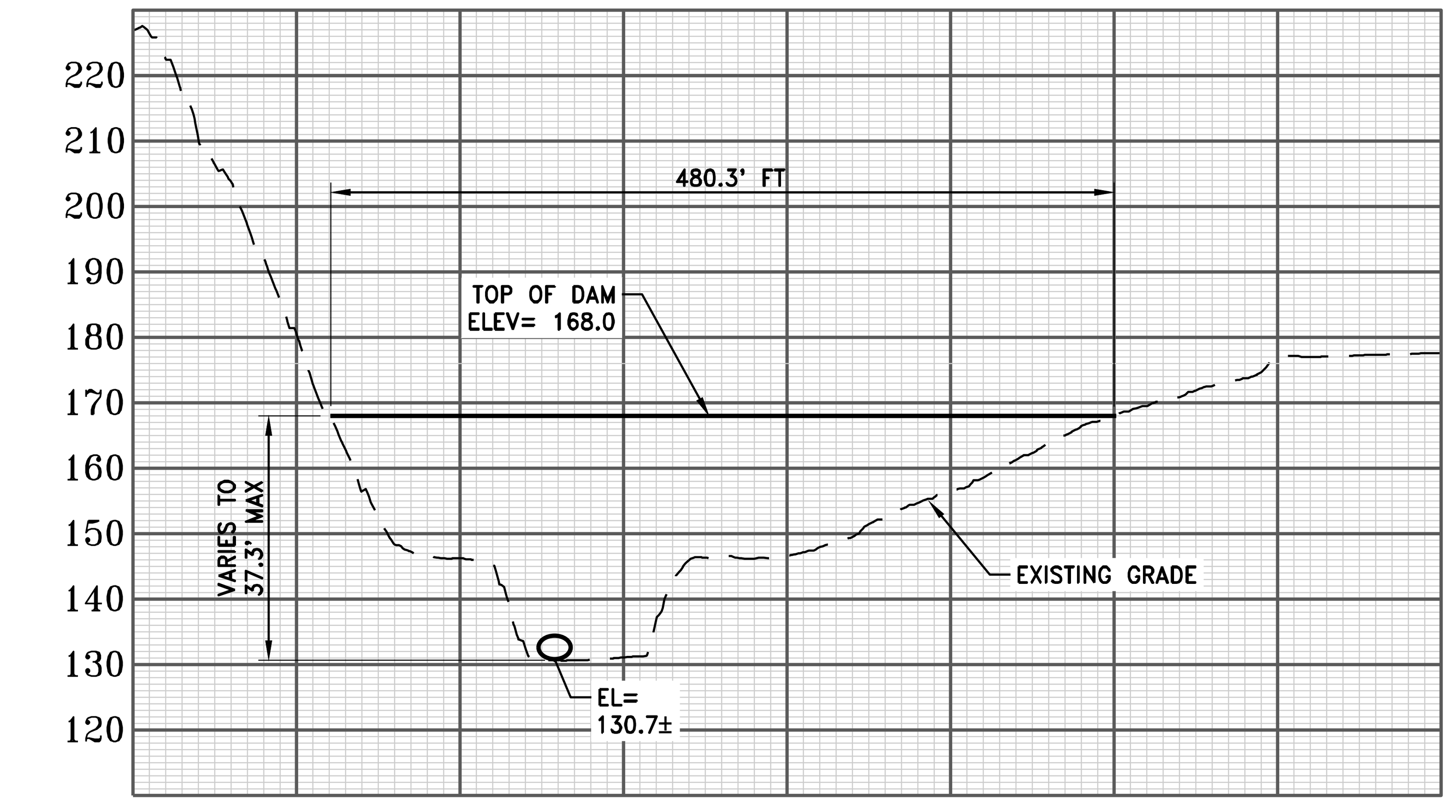

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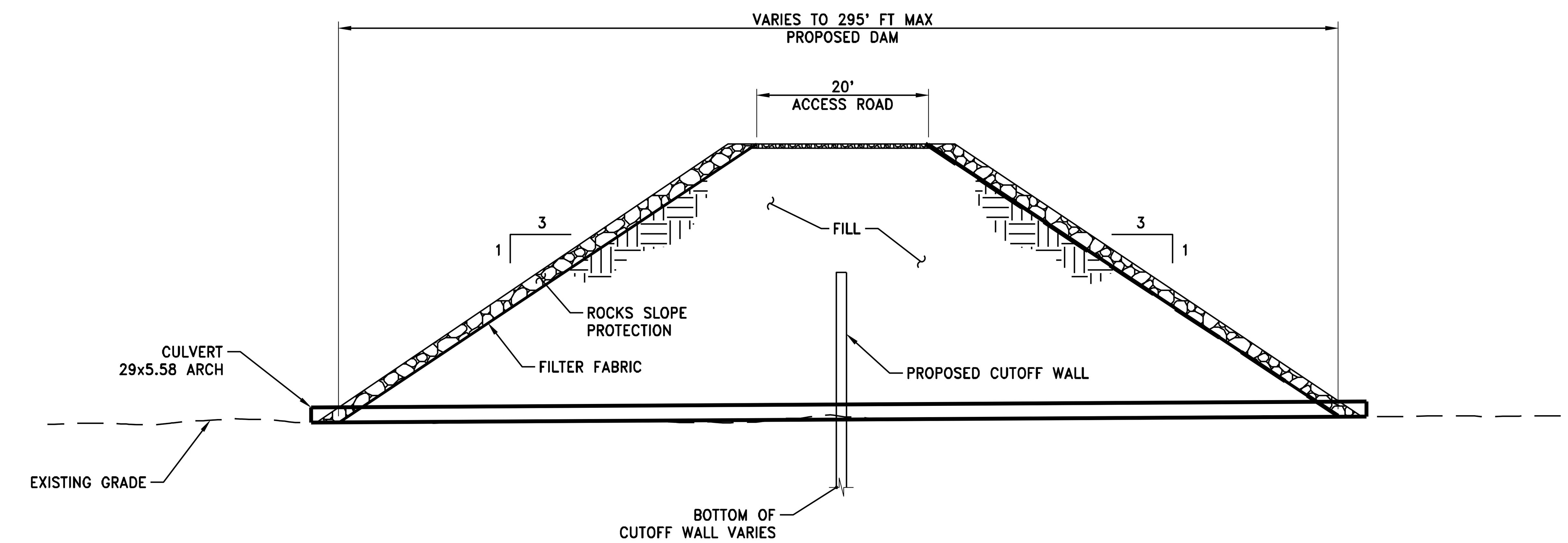

A-A SITE 2 -TYPICAL SECTION

SCALE: NOT TO SCALE

LEGEND:

	PROPOSED ACCESS ROAD
	PROPOSED ROCK SLOPE PROTECTION
	EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

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SITE 2 DAM

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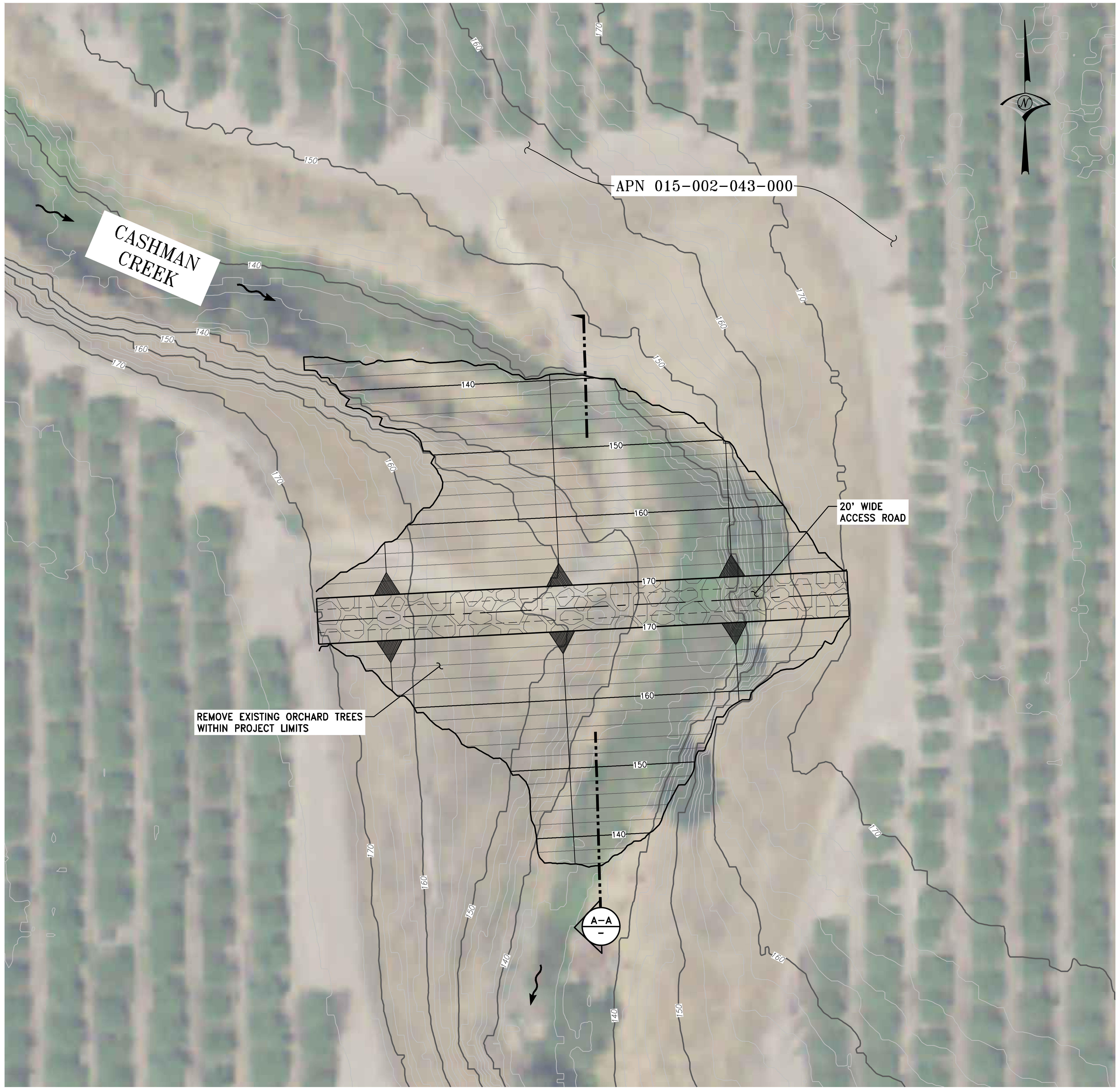
SHEET



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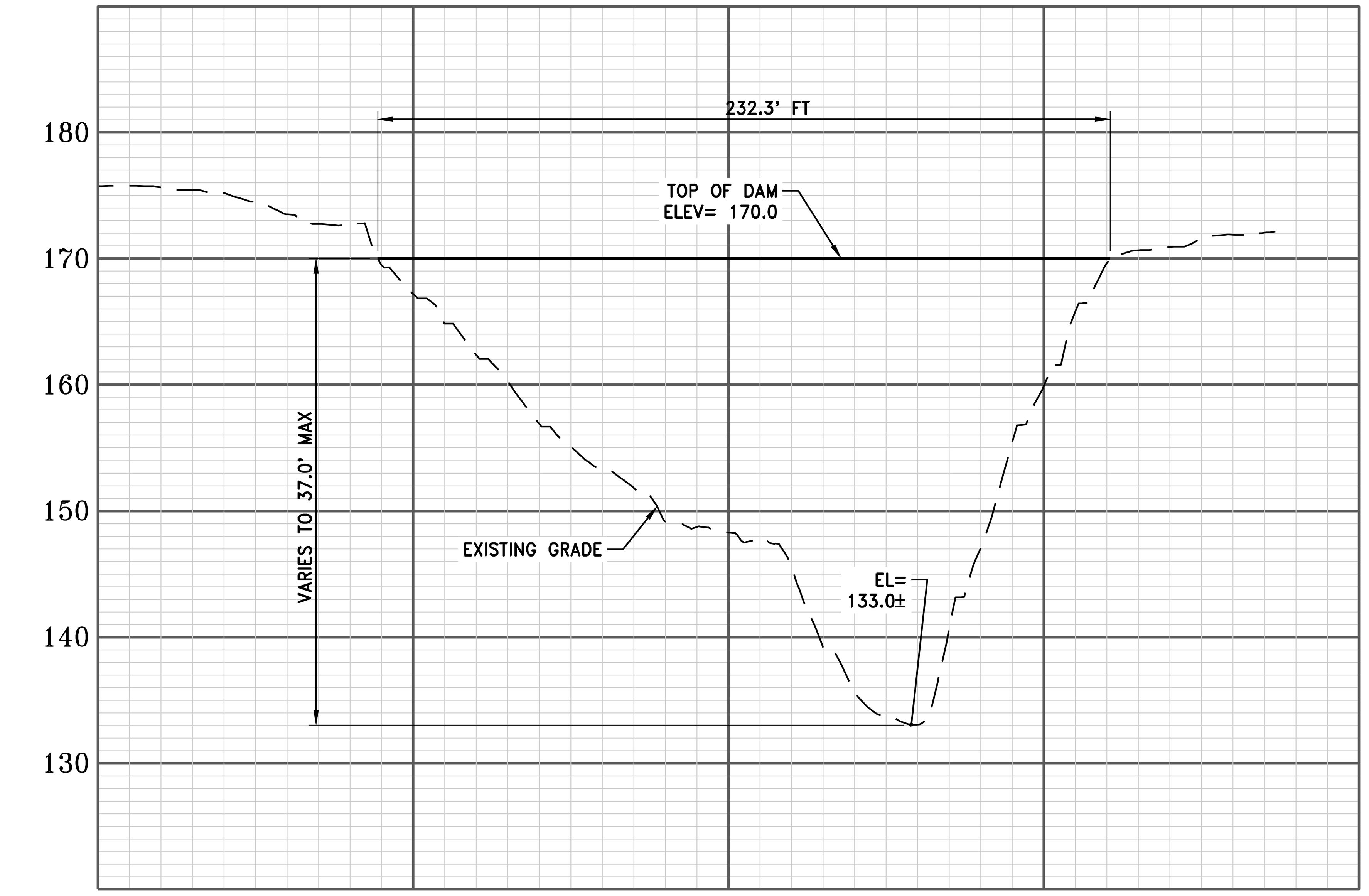

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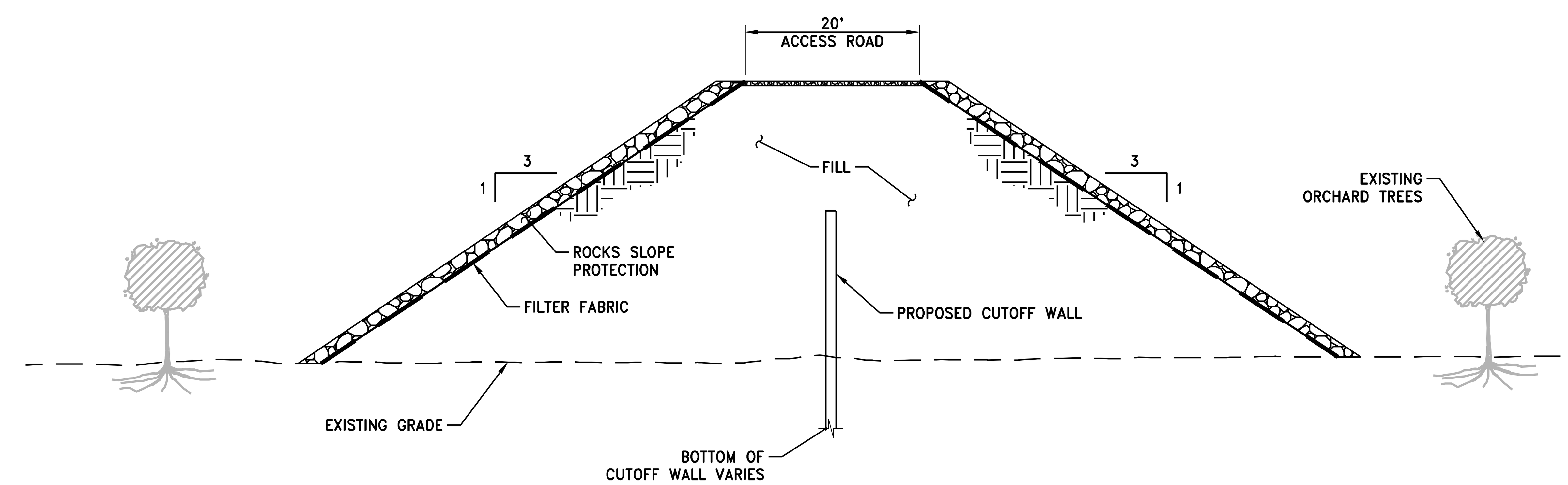

A-A SITE 3 -TYPICAL SECTION
SCALE: NOT TO SCALE

LEGEND:

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	PROPOSED ROCK SLOPE PROTECTION
	EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

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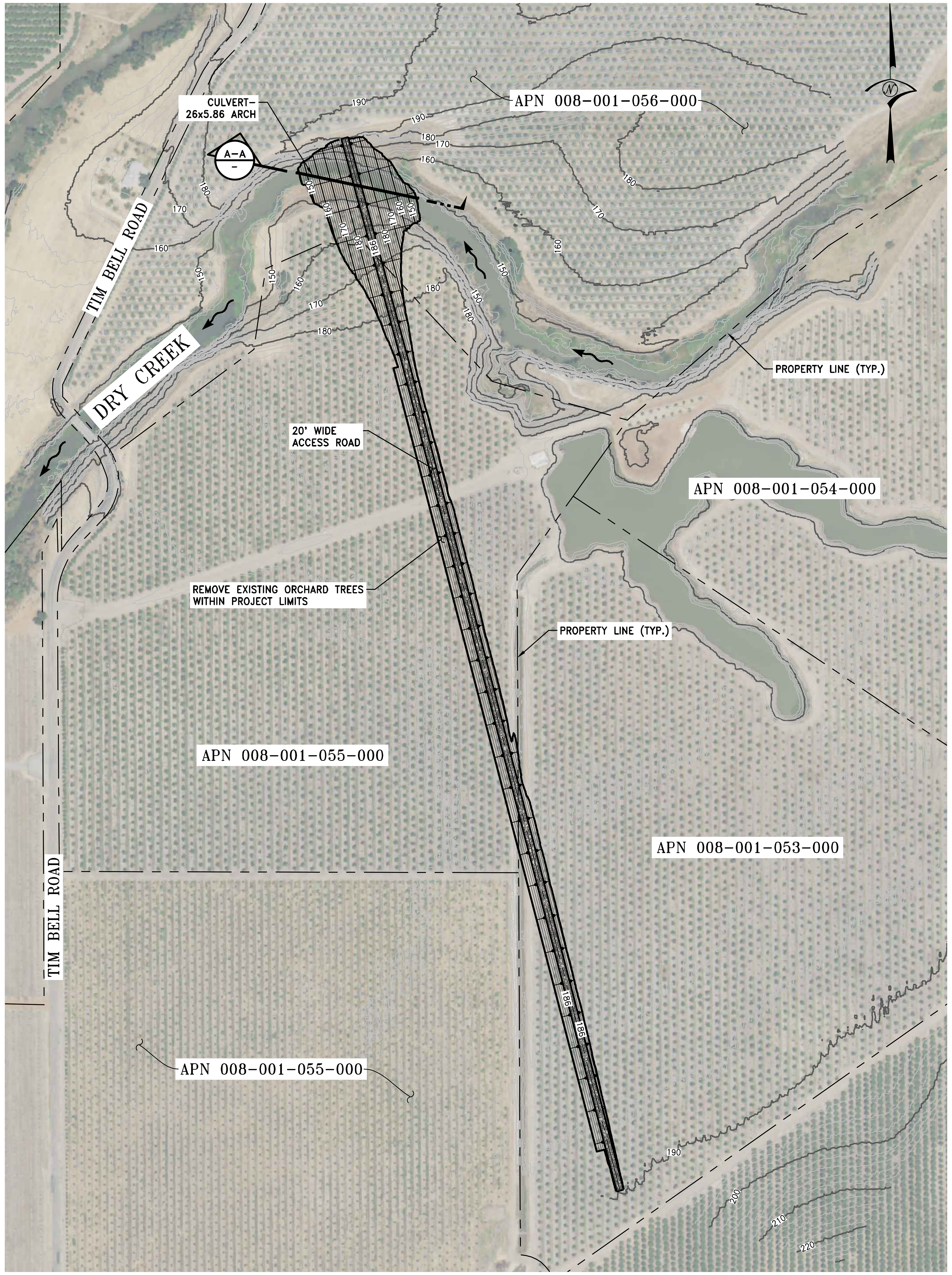

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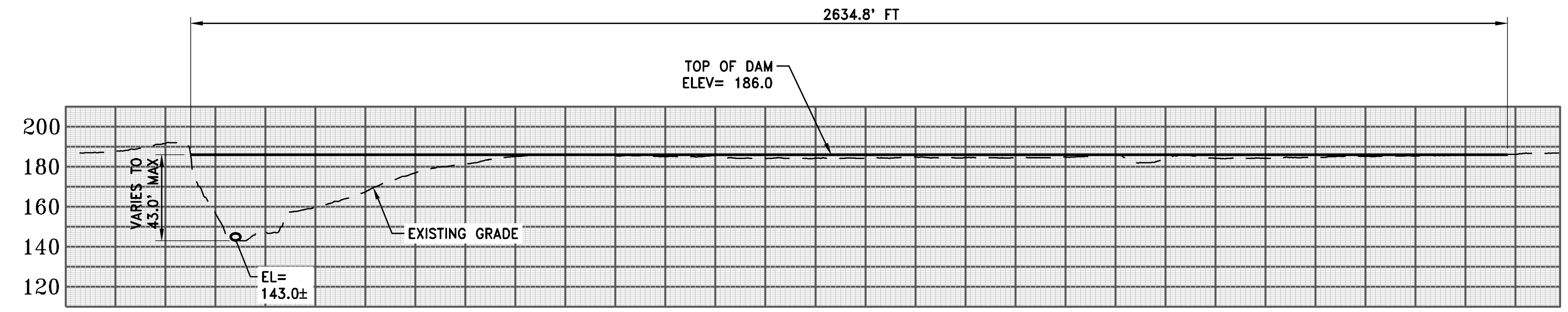
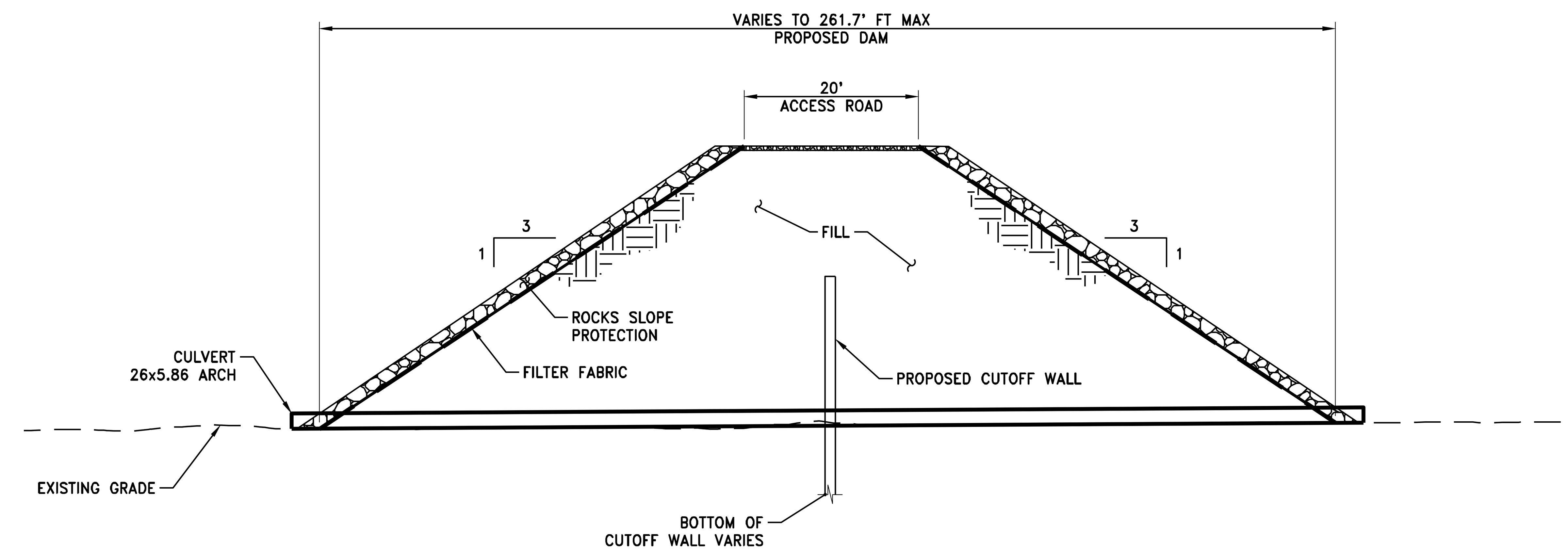


SITE 4 - PROFILE VIEW

SCALE: HORZ-1"=200'
VERT-1"=50'



A-A SITE 4 -TYPICAL SECTION

SCALE: NOT TO SCALE

LEGEND:

PROPOSED ACCESS ROAD

PROPOSED ROCK SLOPE PROTECTION

EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

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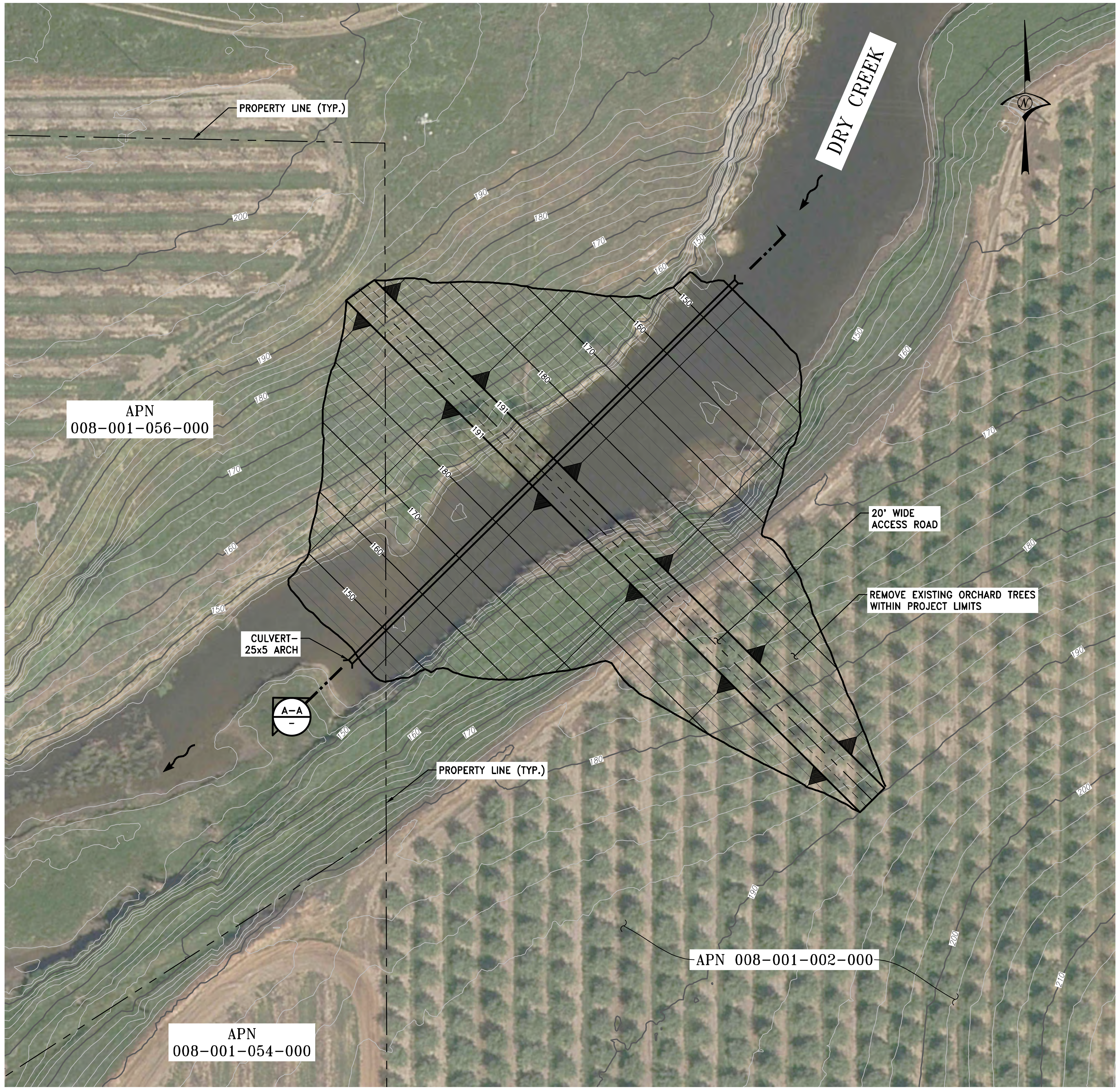

SITE 5 - PLAN VIEW

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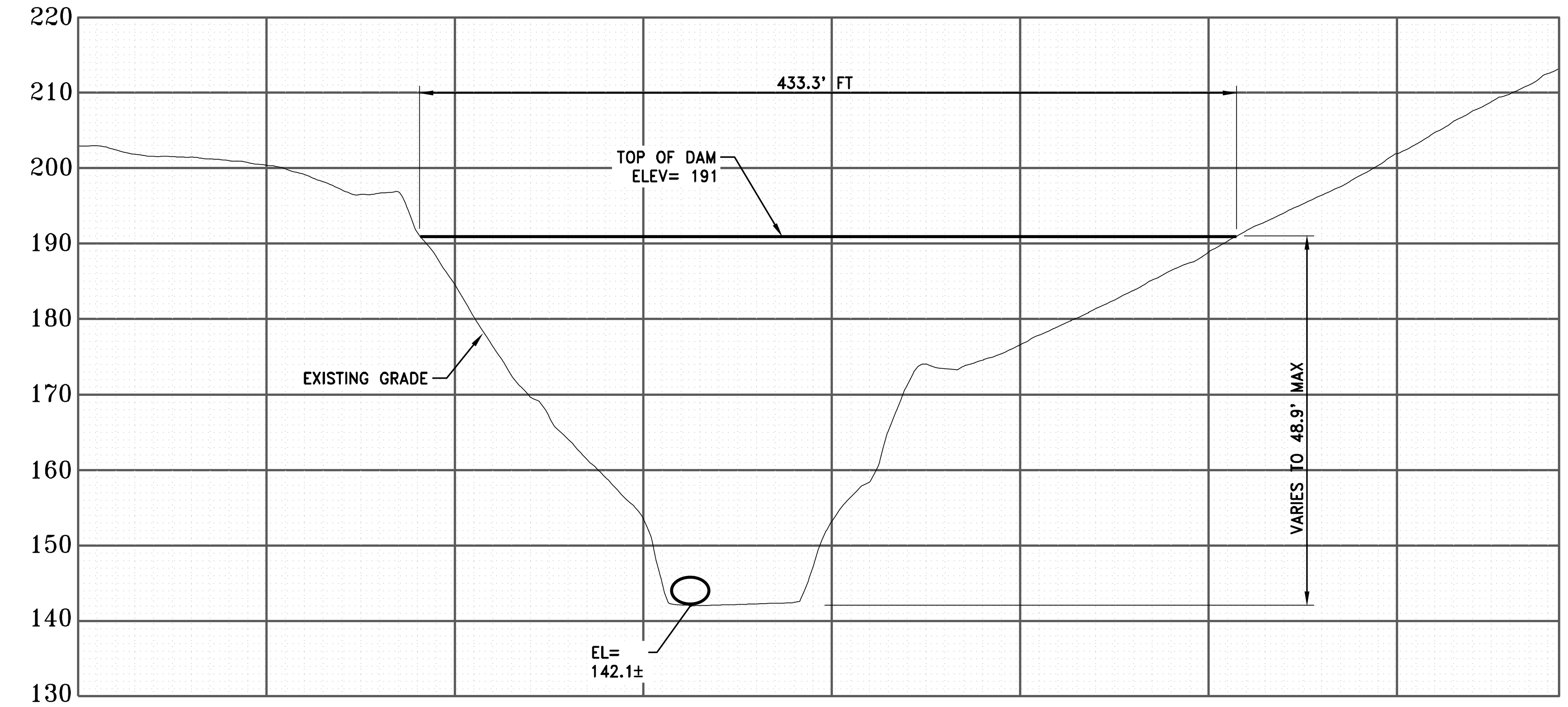

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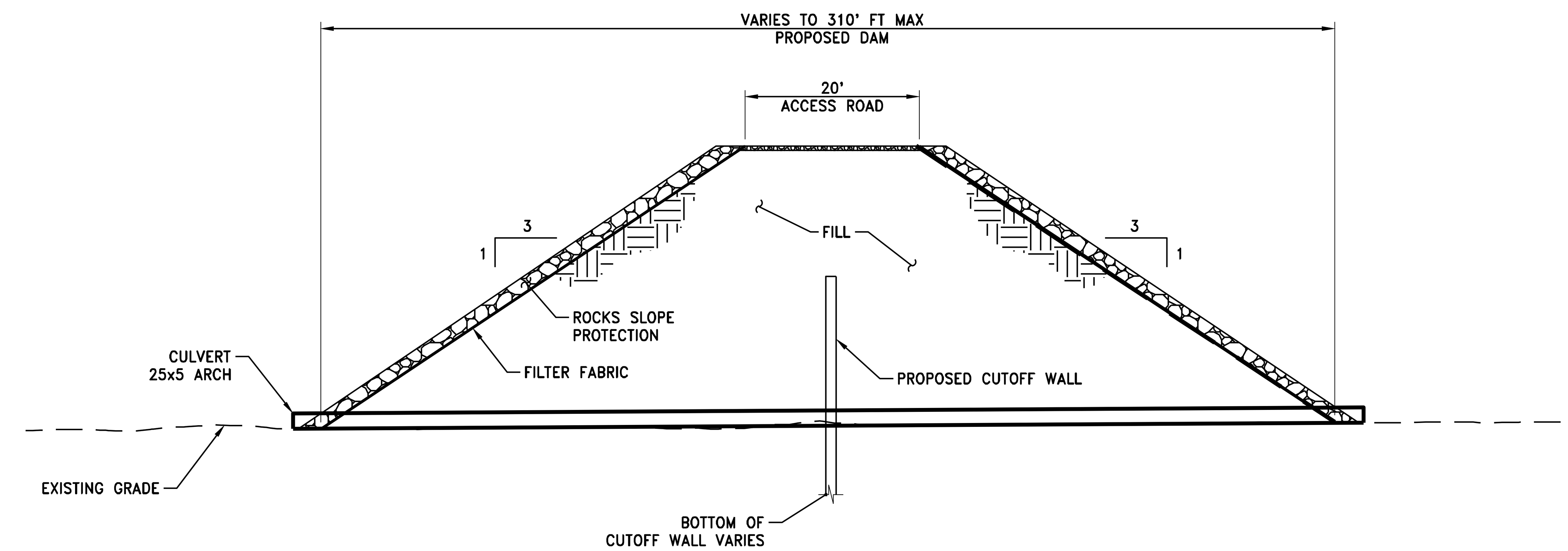

A-A SITE 5 -TYPICAL SECTION

SCALE: NOT TO SCALE

LEGEND:

- PROPOSED ACCESS ROAD
- PROPOSED ROCK SLOPE PROTECTION
- EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

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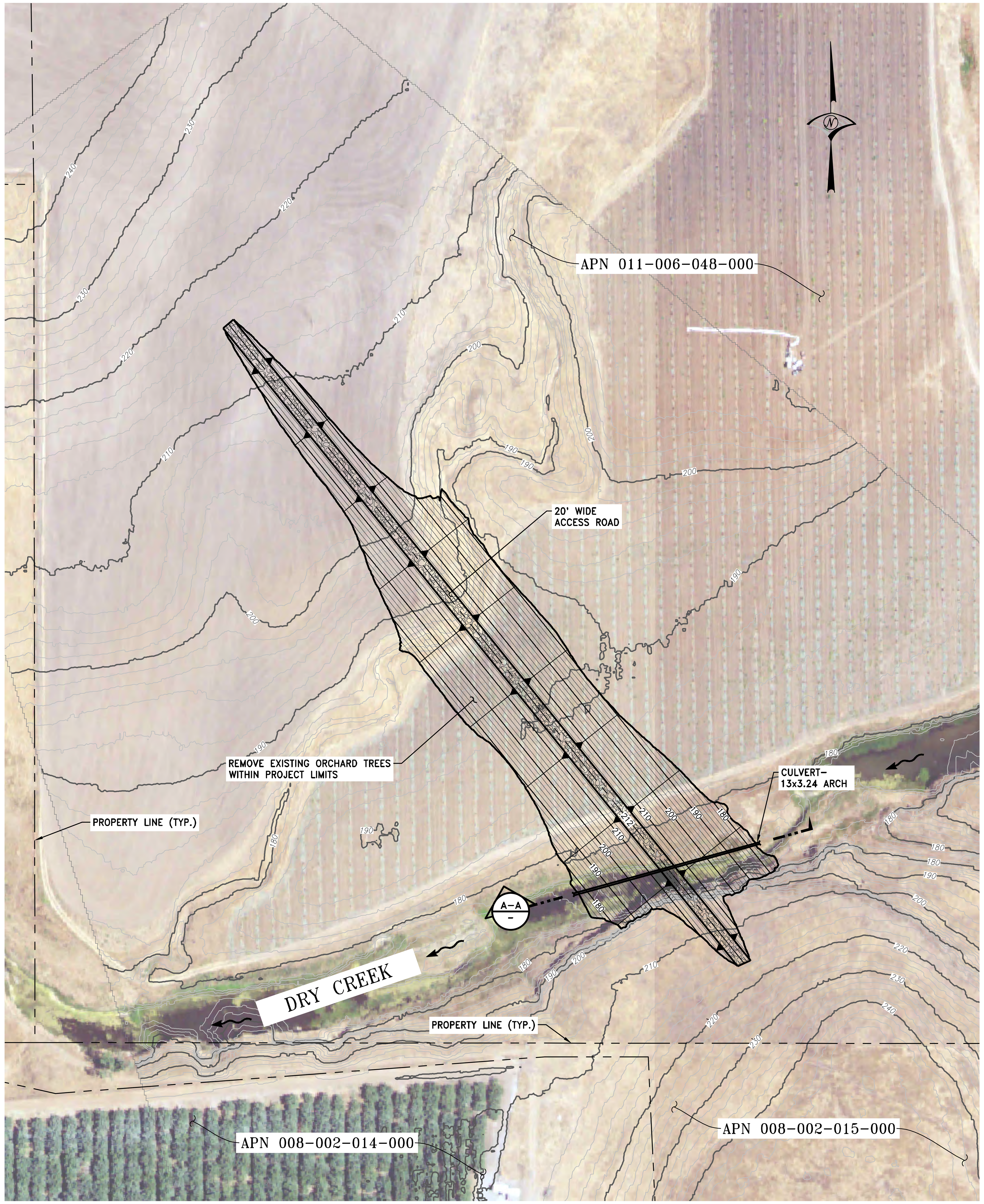
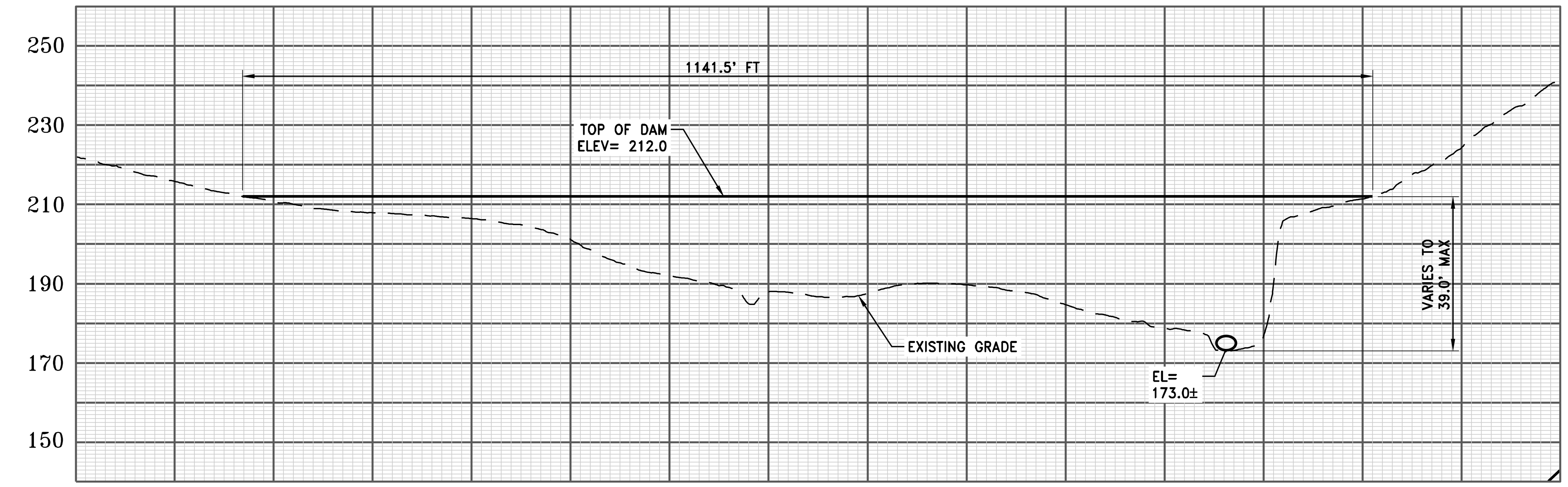


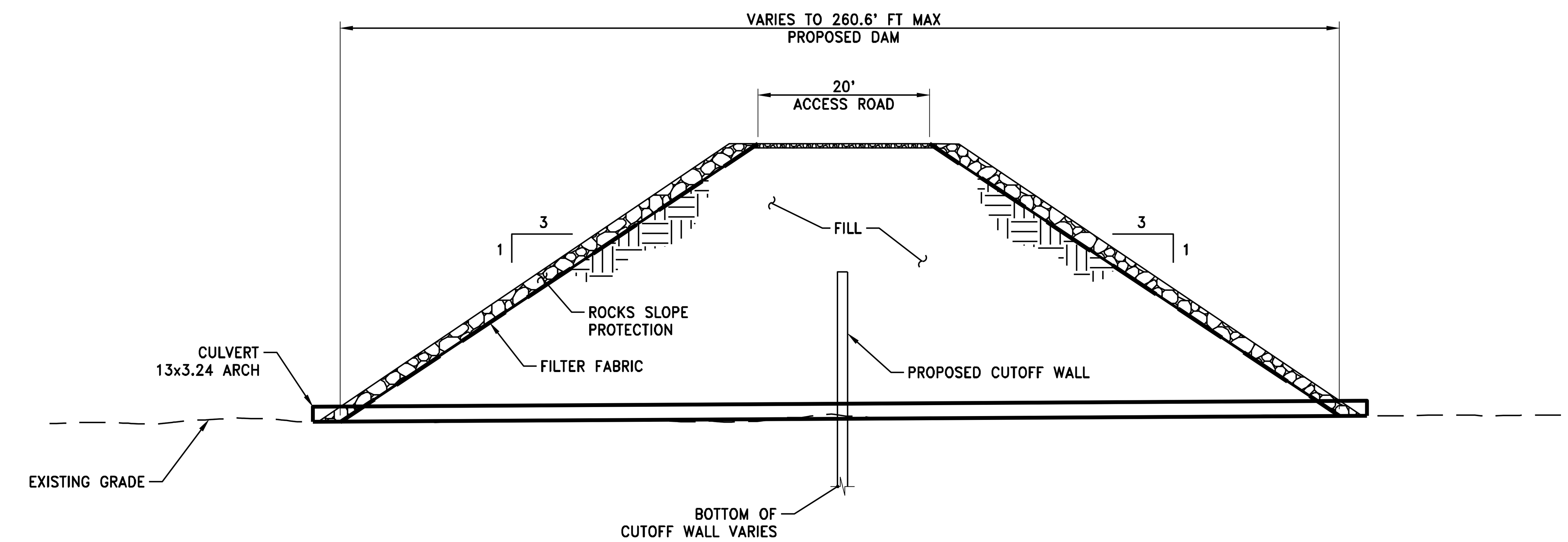
SITE 8 - PLAN VIEW

SCALE: 1"=100'



SITE 8 - PROFILE VIEW

SCALE: HORZ-1"=100'
VERT-1"=25'



A–A SITE 8 -TYPICAL SECTION

SCALE: NOT TO SCALE

LEGEND:

PROPOSED ACCESS ROAD

PROPOSED ROCK SLOPE PROTECTION

EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

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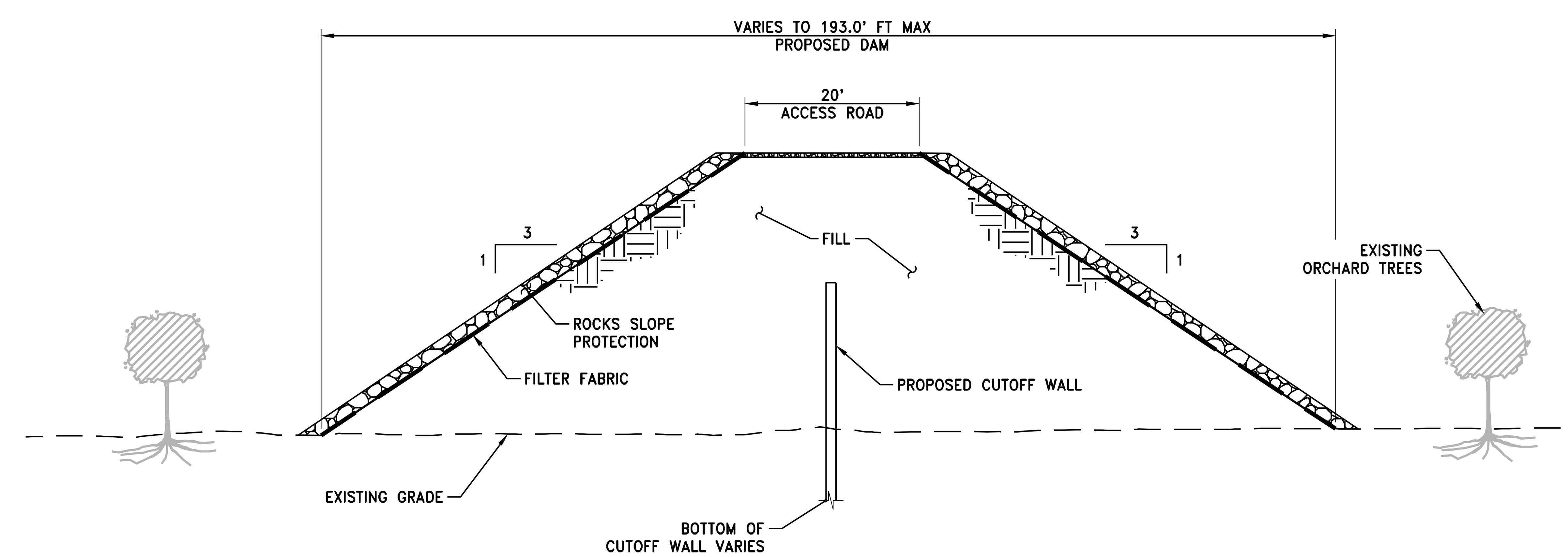
SITE 9 - PLAN VIEW

SCALE: 1"=120'

SITE 9 - PROFILE VIEW

SCALE: HORZ-1"=120'
VERT-1"=30'



LEGEND:

- PROPOSED ACCESS ROAD
- PROPOSED ROCK SLOPE PROTECTION
- EXISTING ORCHARD TREE

A-A **SITE 9 -TYPICAL SECTION**

SCALE: NOT TO SCALE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

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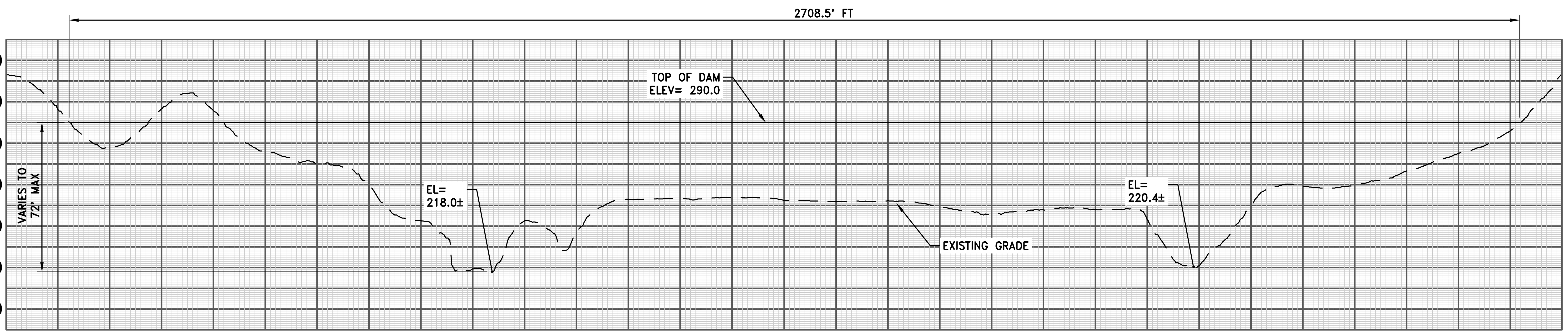
SITE 13 - PLAN VIEW

SCALE: 1"=100'

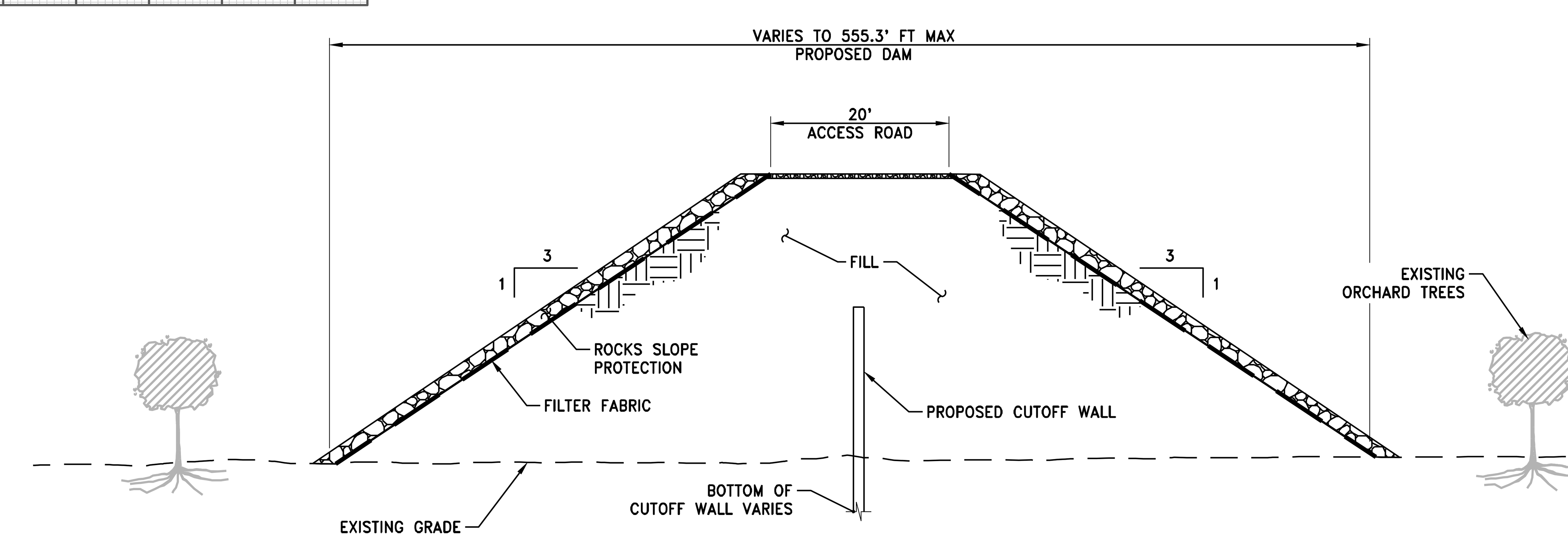


SITE 13 - PROFILE VIEW

SCALE: HORZ-1"=150'
VERT-1"=50'

LEGEND:

- PROPOSED ACCESS ROAD
- PROPOSED ROCK SLOPE PROTECTION
- EXISTING ORCHARD TREE



A-A SITE 13 -TYPICAL SECTION

SCALE: NOT TO SCALE

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AND GROUNDWATER RECHARGE PROJECT

SITE 13 DAM

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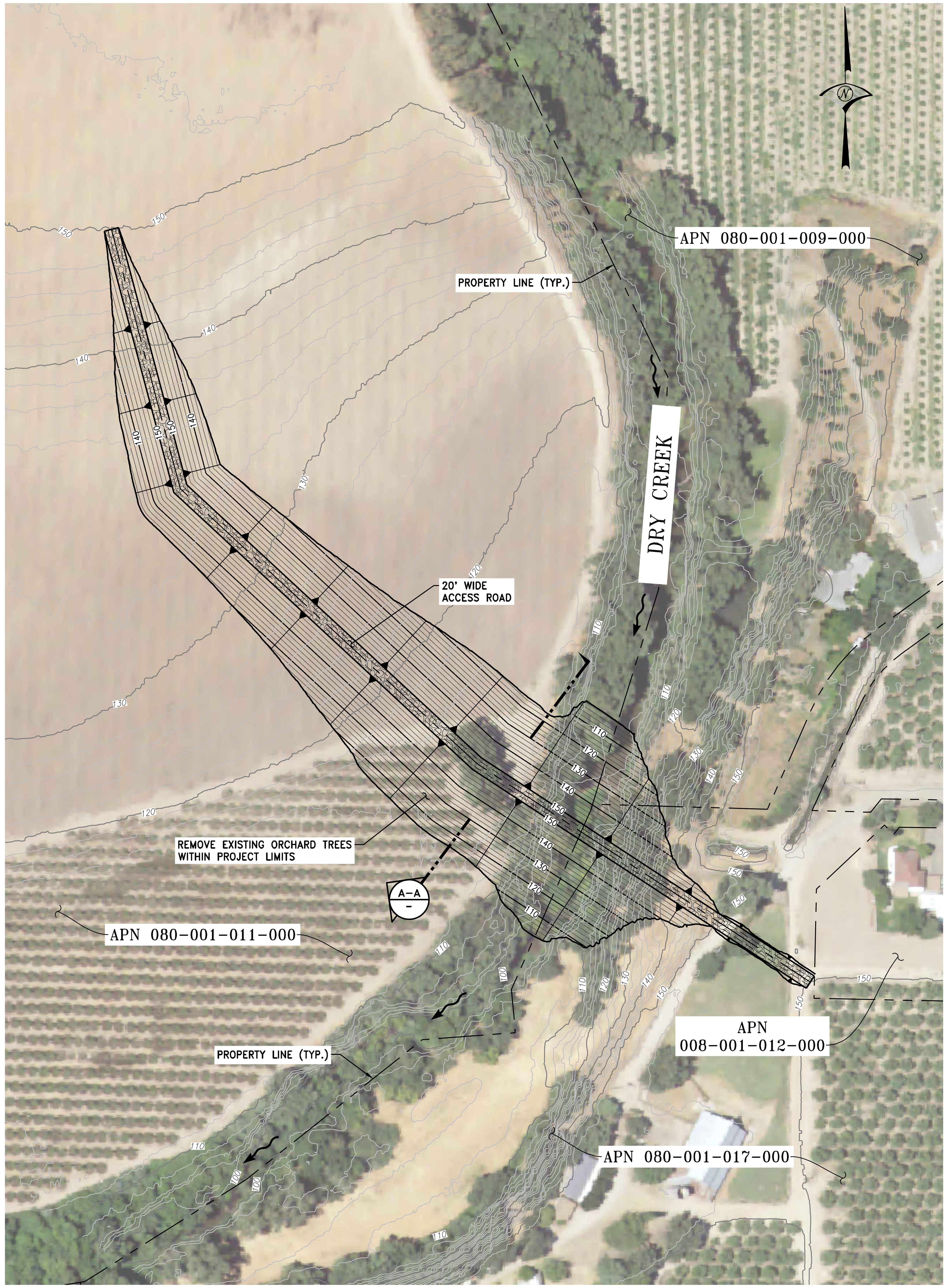
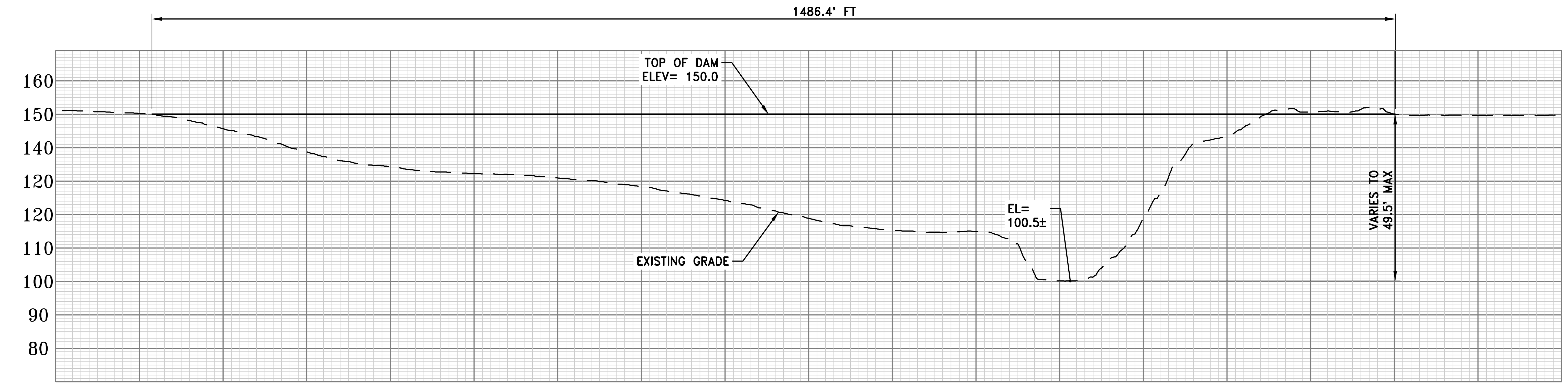


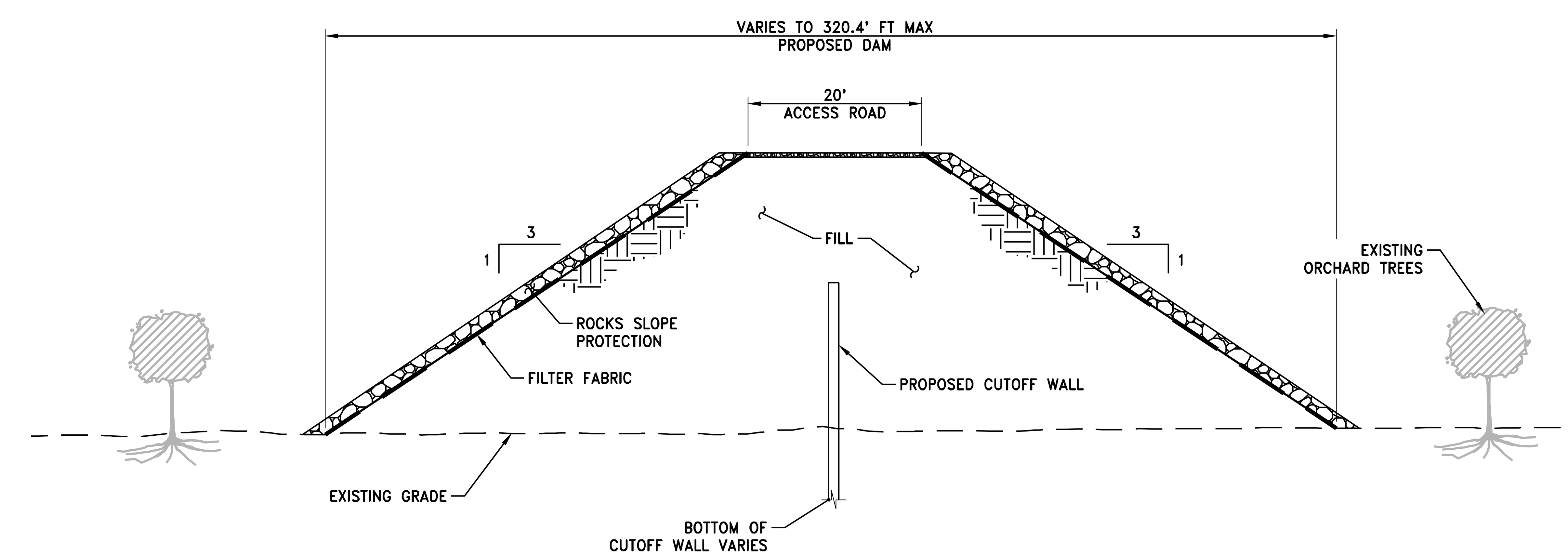
SITE 14 - PLAN VIEW

SCALE: 1"=100'



SITE 14 - PROFILE VIEW

SCALE: HORZ-1"=100'
VERT-1"=25'



A-A SITE 14 -TYPICAL SECTION

SCALE: NOT TO SCALE

LEGEND:

PROPOSED ACCESS ROAD

PROPOSED ROCK SLOPE PROTECTION

EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

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SITE 14 DAM

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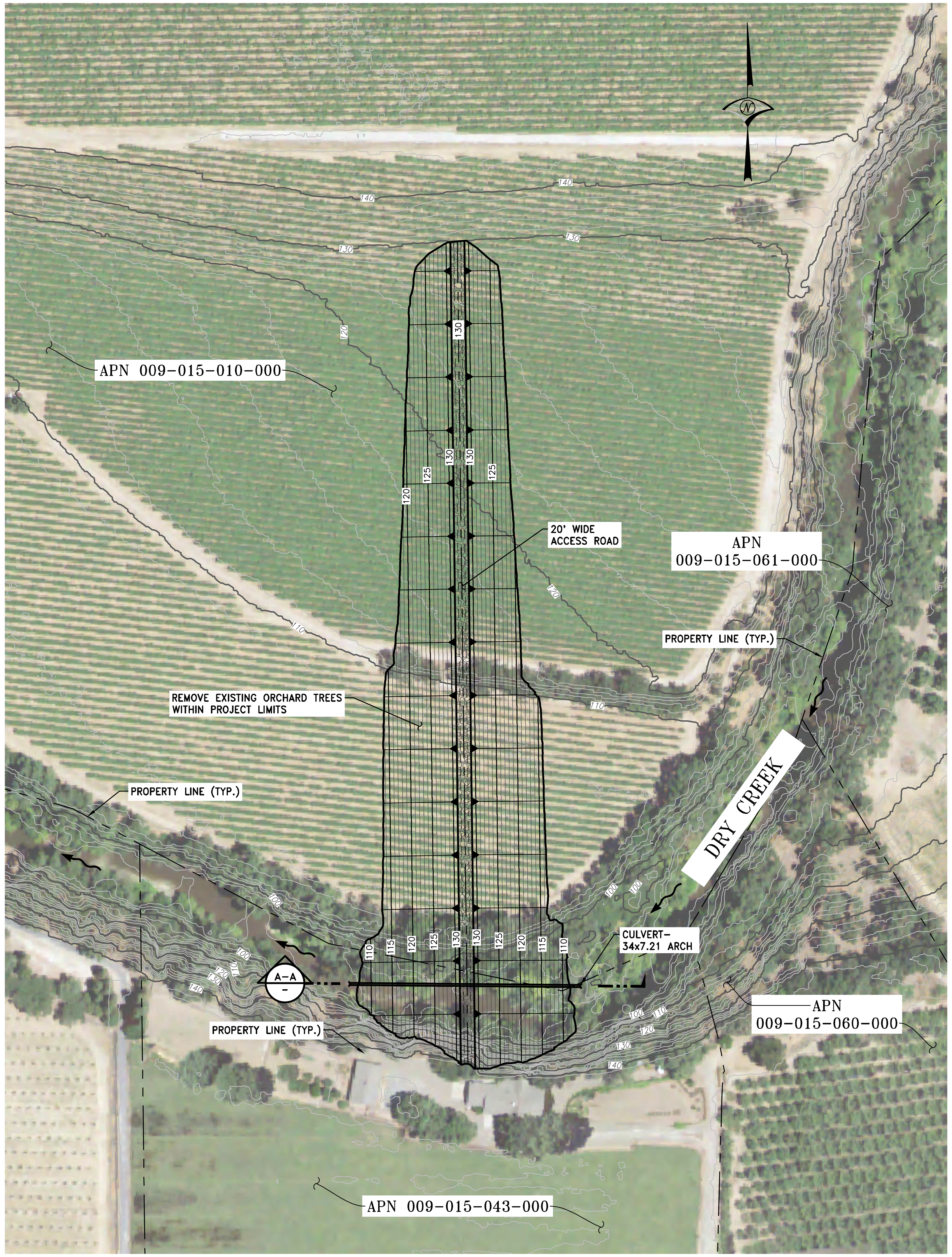
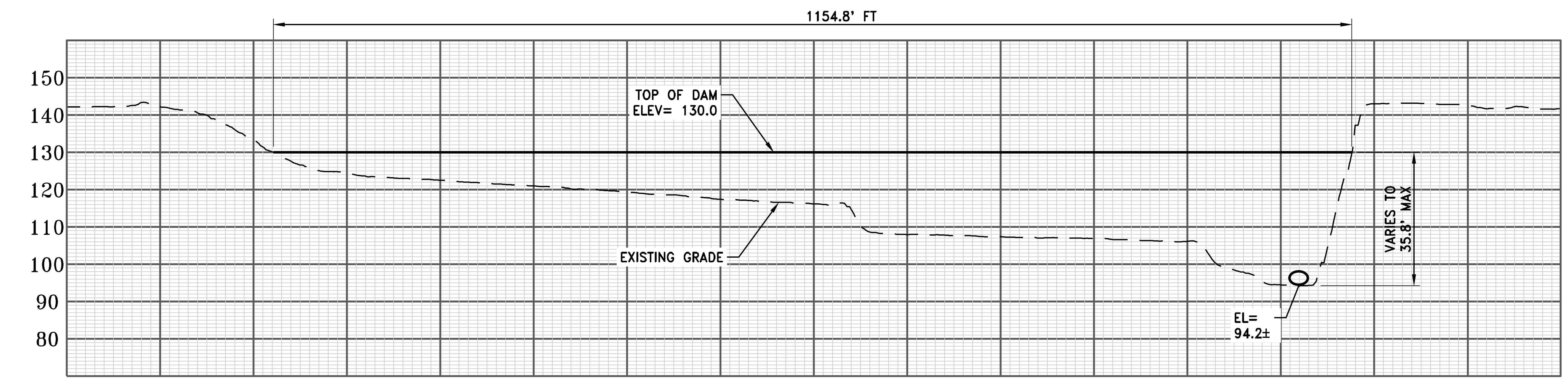
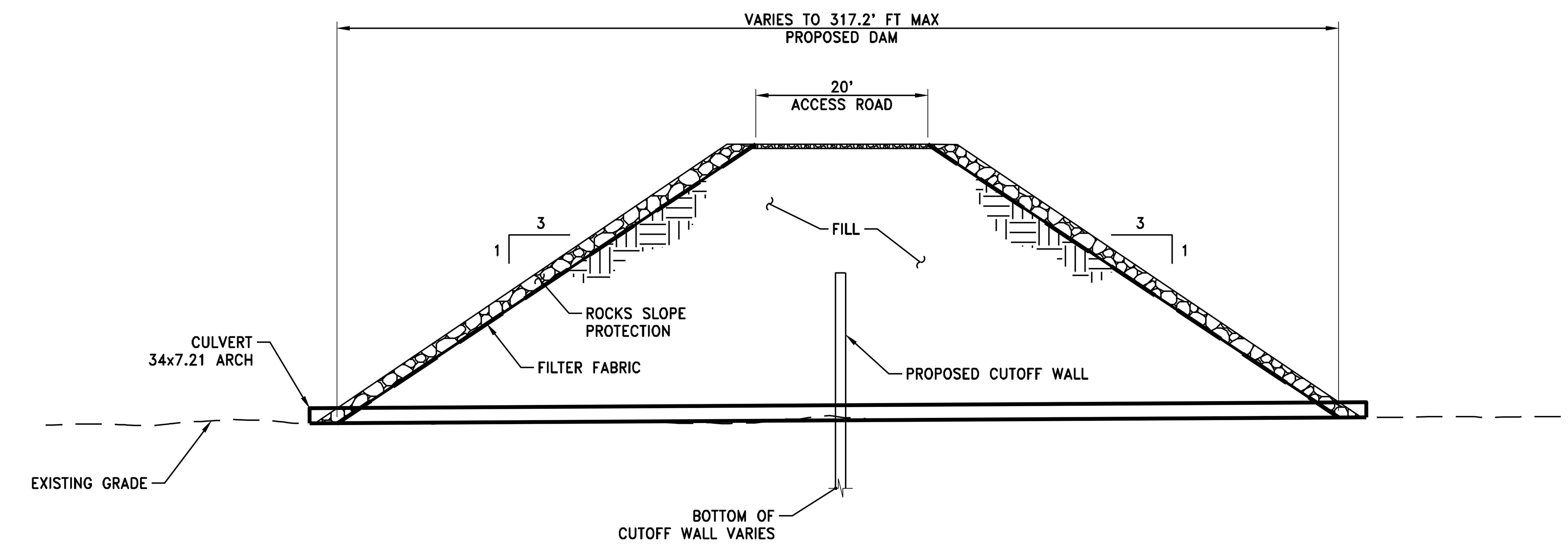


SITE 15 - PLAN VIEW
SCALE: 1"=100'



SITE 15 - PROFILE VIEW
SCALE: HORZ-1"=100'
VERT-1"=25'



A-A
SITE 15 -TYPICAL SECTION
SCALE: NOT TO SCALE

LEGEND:

	PROPOSED ACCESS ROAD
	PROPOSED ROCK SLOPE PROTECTION
	EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

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SITE 15 DAM

DRAWING NO.
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ATTACHMENT 2

Technical Memorandum 1 – Phase II Dry Creek Watershed Stormwater Management and Groundwater Recharge Multiple Account Analysis Results

DEFINITIONS

DCW – Dry Creek watershed

DEM – Digital elevation model.

GSA – GeoSystems Analysis, Inc.

Geodatabase – A collection of geographic data, including maps, created, viewed, and processed in a geographic information system (GIS).

Harmonic mean – An average calculated as the reciprocal of the arithmetic mean of the reciprocals of the values being averaged.

HEC-HMS – U.S. Army Corps of Engineers Hydrologic Engineering Center’s Hydrologic Modeling System. Software used to simulate precipitation and runoff in watersheds.

HEC-RAS – U.S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis System. Software used to model water flow, sediment bed and transport, temperature, and water quality in watersheds.

Hydrograph – A plot showing water flow rate over time in a stream or other channel.

Inundation area – An area of land subject to flooding

LiDAR - Light Detection and Ranging. A remote sensing method using laser light to measure distances to the Earth.

MAA – Multiple Accounts Analysis. A tool for assessing the impacts from a list of alternatives by describing and measuring those impacts.

Managed aquifer recharge – Intentional recharge of water into aquifers.

Reservoir routing – A mathematical method for determining the peak flow of a hydrograph as water enters a reservoir.

Saturated hydraulic conductivity – A measure of the speed or ease at which water moves through the pores between soil particles when that soil is holding its maximum amount of water.

USGS – U.S. Geological Survey

Vadose zone – The portion of ground between the earth surface and the groundwater table.

Watershed delineation – Identification of a watershed’s boundaries.

WRI – Wood Rodgers, Inc.

WSE – water stage elevation. The water surface elevation in a stream above the elevation of the streambed.

MEMORANDUM

December 13, 2021

TO: Michael Brinton, Stanislaus County Public Works (SPCW)
Dhyan Gilton, SCPW

FROM: Jason Keller, GSA

CC: Frederic Clark, SCPW
Mike Milczarek, GSA
John Lambie, E-PUR, LLC
David Mueller, Wood Rogers, Inc.
Jonathan Kors, Wood Roger, Inc.

RE: Technical Memorandum 1 – Phase II Dry Creek Watershed Stormwater Management and Groundwater Recharge Multiple Account Analysis Results

1.0 INTRODUCTION

In conjunction with Stanislaus County, the GeoSystems Analysis, Inc. (GSA) Team developed key criteria for evaluating and comparing potential stormwater management sites identified in the Phase I Evaluation of Stormwater Management and Groundwater Recharge Projects in the Dry Creek Watershed (GSA, 2020a, 2020b). Fifteen (15) potential flood control and stormwater capture sites within the Dry Creek Watershed (DCW) were identified in the Phase I study, which were later reduced to eleven potential sites based on additional information. The locations of the eleven potential flood control structures are shown in Figure 1. To evaluate the relative advantages and disadvantages of the different potential stormwater control sites, technical, economic, environmental, and social/cultural factors for each site was applied into a Multiple Account Analysis (MAA) evaluation matrix (Mendoza and Martins, 2006). The purpose of the MAA was to use the various criteria in a methodical fashion to rank the overall attributes of each potential site. This memo presents MAA key criteria, weighting factor values, and MAA evaluation results for the DCW potential flood control and stormwater capture sites.

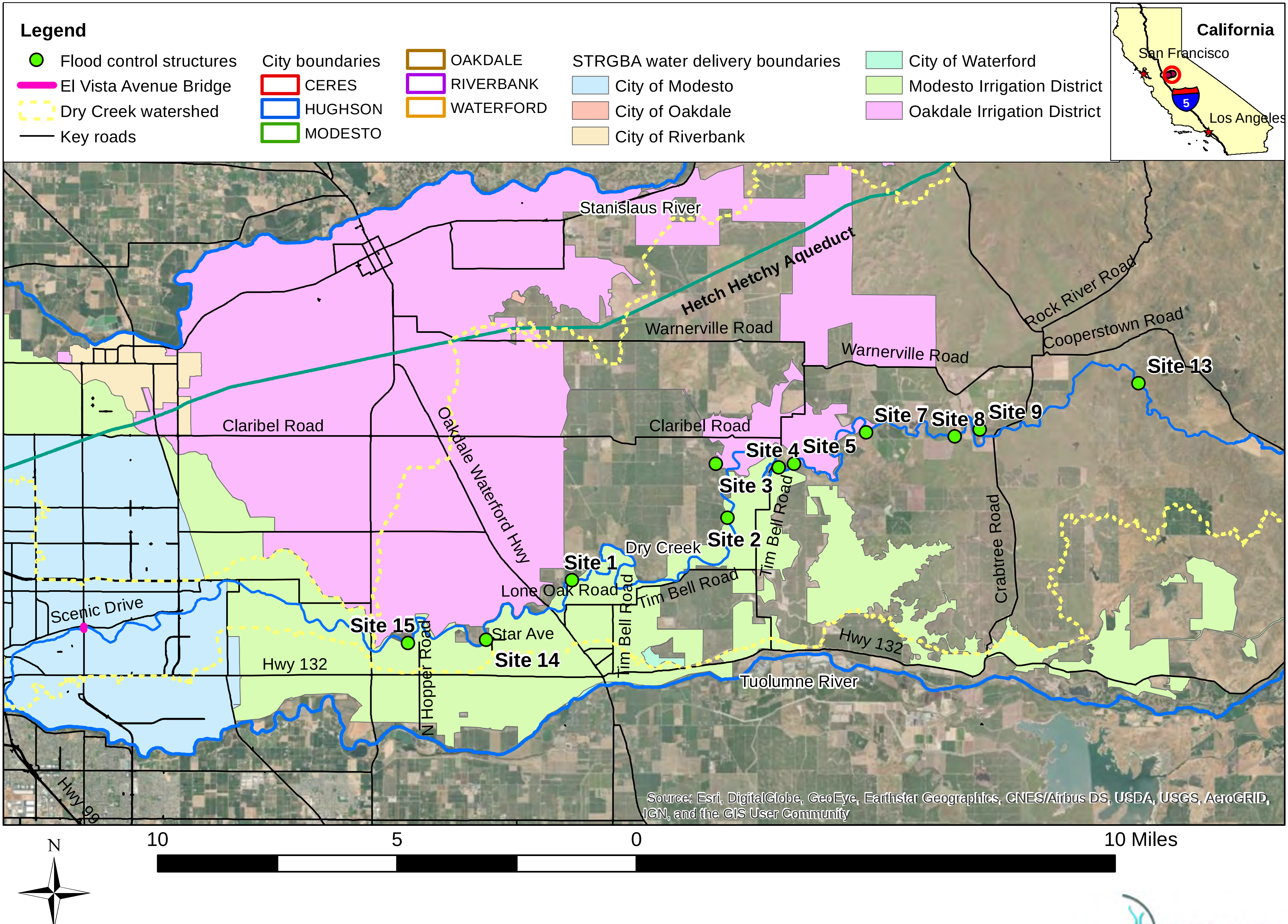


Figure 1. Flood control structure locations and El Vista Avenue Bridge

GSA GeoSystems Analysis, Inc. Innovative Solutions

2.0 MULTIPLE ACCOUNT ANALYSIS MATRIX

The MAA methodology considers a series of principal criteria (accounts) with a weighting value. Each account has different influence factors or sub-criteria (sub-accounts), which also have their own weighting value. Finally, for each sub-account, there are different indicator criteria with their own weighting values. The MAA process is subjective given that the weighting values and accounts are provided based on the experience and professional criteria of the GSA team.

The comprehensive MAA evaluation matrix, incorporating technical, economic, environmental, social and cultural criteria is presented in Table 1. The description of each criterion and its scoring is provided in Section 4.0. Each site was analyzed, and a score value from -3 to +3 was assigned to each indicator criterion (Table 2). The values assigned for the indicators, sub-accounts, and accounts were then multiplied to obtain a total weighting value per account, and the account values were then added to obtain the total value per site alternative. The site alternative with the highest value can then be considered the best option. Additional information on the MAA methodology can be found in GSA (2020b) and Mendoza and Martins (2006).

Table 1. Evaluation criteria matrix

Account	Account Weight	Sub-Account	Sub-Account Weight	Indicator	Indicator Weight
Technical	**0.5**	Managed Aquifer Recharge Suitability	0.5	Soil permeability	2
				Offsite opportunities	2
				Vadose zone permeability	5
				Depth to groundwater	4
				Volumes captured	4
		Flood Control Suitability	0.5	Flood protection	4
Economic	**0.2**	Cost	1	Capital cost	3
				Constructability/Feasibility	5
				Operation costs	3
Environmental	**0.1**	Wildlife/Habitat	0.33	Habitat improvement/maintenance	4
		Water Quality	0.33	Dilution contaminants	4
		Regulatory	0.33	Permitting/regulated	4
Social and Cultural	**0.2**	Social	0.7	Reduced flood risk to DACs	4
				Increased water availability	4
				Potential impact to landowners	5
		Cultural	0.3	Impacts to cultural resources	4
				Visual impacts	3

DAC – Disadvantaged Communities

Table 2. Indicator score values

Score Value	Description
3	Good
2	Moderately Good
1	Slightly Good
0	Neutral
-1	Slightly Poor
-2	Moderately Poor
-3	Poor

3.0 SURFACE WATER ANALYSES

Wood Rodgers, Inc. (WRI) developed a HEC-HMS hydrologic model in January 2020 to serve as the basis for comparing potential stormwater control/ground water recharge sites within the DCW. This effort was documented in GSA (2020a). To support the model development WRI collected existing data within the DCW and developed a project geodatabase containing site topography, soils data, land use data, precipitation data, and canals and storm drain linework. In addition, WRI obtained topographic digital elevation models (DEM) from the United States Geological Survey (USGS), National Elevation Data, and DEMs generated from LiDAR data from the California Department of Water Resources Central Valley Floodplain Evaluation and Delineation Program (CVFED) to create a hydrologically accurate DEM for the purposes of watershed delineation.

In Phase 1 of the project the HEC-HMS model was calibrated against a January 2017 storm event, and design storm hydrographs ranging from a 2-year to a 50-year frequency were constructed using the HEC-HMS model (GSA, 2020a). Additionally, the HEC-HMS model was used to determine preliminary reductions in peak flow values (and corresponding maximum storage) at each of the sites using one-dimensional reservoir routing (GSA, 2020a).

For the MAA, WRI used the same HEC-HMS model framework and built a two-dimensional (2D) HEC-RAS model. The 2D HEC-RAS model used the existing condition flow hydrographs from the HEC-HMS model to estimate the existing and proposed condition hydraulic characteristics for the entire DCW reach, allowing for a much more robust comparison of hydraulic characteristics from existing and proposed conditions for each potential site. The 2D HEC-RAS model was used with a focus on the flow, stage (head), and inundation area to assess the potential flood control project sites against the criteria in the MAA. Detailed topographic data were used at each potential project site to conceptualize earthen dams that could provide flood protection. The available height/elevation of those practical structures was used at each site individually to model the flow and stage effects on a range of return frequency storm ranging from 5-year to 100-year with 96-hour duration. For the purposes of the MAA evaluation, the results from the 25 year, 96-hour storm event were used unless otherwise described.

Examples of the 2D HEC-RAS model predicted 25-year storm event inundation area and maximum flood depth with and without the potential flood control structure is presented in Appendix B for Sites 2, 4, 5, and 15. Each project provides reduced flood risk downstream and temporarily increases the maximum flood depth and inundation area upstream from the control structure.

4.0 MULTIPLE ACCOUNTS ANALYSIS

4.1 Technical Criteria

Technical criteria account for 50% of the total weight of the MAA; 25% for Managed Aquifer Recharge Suitability and 25% for Flood Control Suitability.

4.1.1 Managed Aquifer Recharge Suitability

Five indicator criteria that affect the feasibility of Managed Aquifer Recharge projects were evaluated for each site as discussed below.

Soil

The soil indicator represents the permeability of near surface soils (0 to 6.5 ft below ground surface) for infiltration of project retained stormwater. The soil indicator ranking was determined from the weighted harmonic mean saturated hydraulic conductivity (K_{sat}) for soils within the 2D HEC-RAS model predicted 25-year storm event inundation area for each site. U.S. Natural Resources Conservation Service estimated K_{sat} values for each soil unit (GSA, 2020a) were applied in the analysis. Multiple soil units exist in the 25-year storm event inundation area, therefore the harmonic mean K_{sat} weighting was based on the area and depth of each soil unit within the inundation area. Table 3 presents the mean K_{sat} values for each site and the indicator score.

Table 3. 25-year storm event inundation area weighted harmonic mean saturated hydraulic conductivity and site score

Site	Weighted Harmonic Mean Saturated Hydraulic Conductivity (ft/day)	Indicator Score[1]
1	0.281	3
2	0.120	0
3	0.109	0
4	0.116	0
5	0.120	0
7	0.153	1
8	0.127	0
9	0.068	-1
13	0.113	0
14	0.175	1
15	0.186	1

[1]3=> 0.25 ft/day; 2=0.20-0.25 ft/day; 1=0.15-0.20 ft/day; 0=0.10-0.15 ft/day; -1=0.05-0.10 ft/day; -2=0.01-0.05 ft/day; -3=<0.01 ft/day

Offsite Opportunities

The offsite opportunities indicator represents the potential for retained stormwater to be recharged at locations outside of the DCW channel/flood inundation area. The offsite opportunity indicator was determined from the proximity of the predicted 25-year storm event inundation area to existing water conveyance infrastructure or existing off-channel water storage infrastructure. These existing facilities may be accessible from the project site and increase potential recharge opportunities. This assessment was qualitative, using visual inspection of canal networks relative to the predicted 25-year storm event inundation area. Table 4 presents the offsite indicator score applied in the MAA for each site. Note that LF Brichetto Farming, LLC has an existing off-site recharge facility and riparian water rights that should be considered in further design evaluations.

Table 4. Offsite opportunities site score

Site	Indicator Score
1	3
2	2
3	2
4	1
5	2
7	0
8	-2
9	-2
13	-2
14	3
15	3

Vadose zone permeability

The vadose zone permeability indicator represents the permeability of vadose zone sediments for percolating infiltrated detained stormwater. The vadose zone permeability indicator was determined from the surficial geologic unit weighted harmonic mean vertical saturated hydraulic conductivity ($K_{sat\text{-}v}$) for geologic units within the 2D HEC-RAS model predicted 25-year storm event inundation area. The distribution of surficial geologic units and geologic unit estimated $K_{sat\text{-}v}$ values were acquired from GSA (2000a). Multiple geologic units exist in the 25-year inundation storm event inundation area; therefore, the harmonic mean $K_{sat\text{-}v}$ weighting was based on the area of each geologic unit within the inundation area. Table 5 presents the mean $K_{sat\text{-}v}$ for each site and the indicator score.

Table 5. 25-year storm event inundation area weighted harmonic mean vertical saturated hydraulic conductivity and site score

Site	Weighted Harmonic Mean Vertical Saturated Hydraulic Conductivity (ft/day)	Indicator Score[1]
1	0.71	-2
2	1.03	0
3	1.83	3
4	1.73	2
5	1.99	3
7	1.02	0
8	0.83	-1
9	1.36	1
13	0.31	-3
14	0.78	-1
15	0.98	-1

[1]3=> 1.75 ft/day; 2=1.50-1.75 ft/day; 1=1.25-1.50 ft/day; 0=1.00-1.50 ft/day; -1=0.75-1.00 ft/day; -2=0.50-0.75 ft/day; -3=<0.50 ft/day

Depth to Groundwater

The depth to groundwater indicator represents available vadose zone thickness for storage of detained and infiltrated stormwater. The mean depth to groundwater within the 2D HEC-RAS model predicted 25-year storm event inundation area was calculated from the 2015 groundwater depths provided in GSA (2020a). Table 6 presents the mean groundwater depth for each site and the resulting indicator score.

Table 6. 25-year event inundation area mean depth to groundwater and project scoring

Site	Mean Groundwater Depth (ft below ground surface)	Indicator Score[1]
1	74.5	1
2	81.6	2
3	89.7	2
4	69.5	0
5	66.9	0
7	90.0	3
8	90.0	3
9	90.0	3
13	90.0	3
14	67.3	0
15	62.8	0

[1]3=>90 ft; 2=80-90 ft; 1=70-80 ft; 0=60-70 ft; -1=50-60 ft; -2=40-50 ft; -3<40 ft

Volumes Captured

The volumes captured indicator represents the estimated flood control structure maximum volume of water from the 2D HEC-RAS model predicted detention depths and areas during the 25-year storm event. Table 7 presents the predicted 25-year storm event water detained at each site and the indicator score.

Table 7. 25-year storm event water captured and project scoring

Site	25 Year Storm Event Water Captured (acre-ft)	Indicator Score[1]
1	5,905	0
2	10,845	3
3	1,133	-3
4	6,433	1
5	7,264	1
7	3,472	-1
8	6,794	1
9	2,657	-2
13	2,385	-2
14	8,287	2
15	11,310	3

[1]3=>9000 acre-ft; 2=7500-9000 acre-ft; 1=6000-7500 acre-ft; 0=4500-6000 acre-ft; -1=3000-4500 acre-ft; -2=1500-3000 acre-ft; -3<1500 acre-ft

4.1.2 Flood Control Suitability

Flood Protection

The flood protection indicator was based on the 2D HEC-RAS model predicted reduction in water stage elevation (WSE) at the El Vista Avenue bridge with and without each proposed flood control structure for the 10-, 25-, 50-, and 100-year storm events. The sum of the WSE decrease with the flood control structure for all four storm events was applied in the MAA scoring analysis. Table 8 presents the 10-, 25-, 50-, and 100-year storm event model predicted WSE reduction with the flood control structure, total WSE reduction for all four storm events and the indicator score.

Table 8. Dry Creek flood control structure model predicted water surface elevation reduction at El Vista Avenue bridge for 10-, 25-, 50-, and 100-year storm event and project scoring

Site	Water Surface Elevation Reduction at El Vista Bridge (ft)					Indicator Score[1]
	10 Year Storm Event	25 Year Storm Event	50 Year Storm Event	100 Year Storm Event	Sum	
1	0.5	0.5	0.5	0.6	2.1	-2
2	4.2	4.5	4.5	4.5	17.7	3
3	0.3	0.2	0.2	0.2	0.9	-3
4	2.6	2.6	2.4	2.7	10.2	2
5	2.8	2.8	2.6	1.6	9.7	1
7	1.9	1.8	2.0	2.3	8.0	1
8	2.6	2.6	2.4	1.9	9.4	1
9	1.0	0.6	0.7	0.7	3.0	-2
13	1.0	0.7	0.8	1.0	3.5	-2
14	2.1	0.3	0.1	0.0	2.5	-2
15	3.8	4.1	4.3	4.4	16.6	3

[1]3=>12 ft; 2=10-12 ft; 1=8-10 ft; 0=6-8 ft; -1=4-6 ft; -2=2-4 ft; -3<2 ft

4.2 Economic Criteria

Economic criteria account for 20% of the total MAA to include weights for capital costs, constructability/feasibility and operations cost as discussed below.

4.2.1 Capital Costs

Capital costs for construction of the project were estimated by WRI based on the following components. Preliminary detention structure designs are provided in Appendix A.

- Land acquisition costs: Assumed to be land acquisition within the 2D HEC-RAS model predicted 25-year storm event inundation area and detention structure footprint assuming a unit price of $25,000/acre and a 25% contingency.

- Environmental mitigation costs: Assumed to be 7% of construction costs with a 50% contingency.
- Construction costs: Includes costs for mobilization and demobilization, stormwater pollution prevention plan preparation and implementation, fill and material import quantities, and structure cutoff wall length. Construction costs assumed a 50% contingency.
- Design costs: Assumed to be 8% of land acquisition, environmental, and construction costs with a 50% contingency.
- Construction management costs: Assumed to be 6% of land acquisition, environmental, and constructions costs with a 50% contingency.

Table 9 presents the estimated capital costs for each site and indicator score.

Table 9. Estimated project capitol cost and project scoring

Site	Capital Cost	Indicator Score[1]
1	$28,646,800.00	1
2	$31,212,200.00	0
3	$7,624,800.00	3
4	$20,912,500.00	1
5	$18,002,300.00	2
7	$40,586,200.00	-1
8	$36,311,300.00	0
9	$14,519,900.00	2
13	$29,730,900.00	1
14	$39,089,600.00	0
15	$47,920,200.00	-1

[1]3=<$10M; 2=$10M-$20M; 1=$20M-$30M; 0=$30M-$40M; -1=$40M-$50M; -2=$50M-$60M; -3>$60M

4.2.2 Operations Costs

Project operation costs were estimated by WRI to be 1% of the construction costs amortized over 30 years. Table 10 presents the estimated operation costs for each site and indicator score.

Table 10. Estimated project operations and maintenance cost and project scoring

Site	Operation Cost	Indicator Score[1]
1	$1,192,000.00	2
2	$968,500.00	2
3	$246,200.00	3
4	$1,343,000.00	1
5	$1,343,000.00	1
7	$4,708,200.00	-2
8	$3,507,500.00	-1
9	$740,200.00	2
13	$3,433,100.00	-1
14	$1,842,100.00	1
15	$2,311,300.00	0

[1]3=<0.25M; 2=0.25M-1.25M; 1=1.25M-2.25M; 0=2.25M-3.25M; -1=3.25M-4.25M; -2=4.25M-5.25M; -3>5.25M

4.2.3 Constructability/Feasibility

The constructability/feasibility indicator represents potential fatal flaw impediments to construction based on number of impacted landowners. The land parcels and landowners within the 2D HEC-RAS model predicted 25-year storm event inundation area was provided by Stanislaus County and the total number of unique landowners was tallied and applied in the scoring. Table 11 presents the number of landowners within the 25-year storm event inundation area for each site and the indicator score applied in the MAA.

Table 11. Number of landowners within the 25-year event inundation area and project scoring

Site	Number of Landowners	Indicator Score[1]
1	33	-2
2	22	0
3	7	3
4	13	2
5	12	2
7	13	2
8	14	2
9	7	3
13	4	3
14	48	-3
15	61	-3

[1]3=<10; 2=10-15; 1=15-20; 0=20-25; -1=25-30; -2=30-35; -3>35

4.3 Environmental Criteria

Environmental criteria account for 10% of the total MAA to include weights for wildlife habitat, water quality and regulatory impediments as discussed below.

4.3.1 Wildlife/Habitat

Improvement of habitat for native wildlife (e.g., aquatic species, birds) and/or habitat maintenance (e.g., control of non-native vegetation species) was not considered in this phase of the analysis; however, thus sub-account remained in the MAA for potential future consideration. All sites were given an indicator score of 0.

4.3.2 Water Quality

The water quality indicator represents the potential dilution of nitrate within the groundwater from recharge of detained stormwater. Mean groundwater nitrate concentrations from wells within 0.5 miles of the 2D HEC-RAS model predicted 25-year storm event inundation area were acquired from the California State Water Resources Control Board's Groundwater Ambient Monitoring and Assessment Program Groundwater Information System (GSA, 2020a). Inundation areas with greater mean nitrate concentration received a higher score due to the potential for infiltrated surface water to reduce the elevated nitrate concentrations. Table 12 presents the 2019 through 2021 mean groundwater nitrate concentration from groundwater samples within 0.5 miles of the 25-year storm event inundation area for each site and the indicator score applied in the MAA.

Table 12. Mean groundwater nitrate concentration of 2019 through 2021 samples within 0.5 miles of the 25-year event inundation area and score

Site	Groundwater Mean Nitrate Concentration (mg/l)	Indicator Score[1]
1	2.1	0
2	1.8	0
3	1.7	0
4	2.2	0
5	2.2	0
7	3.0	1
8	3.0	1
9	3.0	1
13	1.7	0
14	2.5	0
15	2.8	0

[1]3=>10 mg/l; 2=5.0-10.0 mg/l; 1=3.0-5.0 mg/l; 0=1.0-3.0 mg/l; -1=<1.0 mg/l

4.3.3 Regulatory

The regulatory indicator was evaluated against three recognized permitting issues related to construction of a flood control structure: 1) Jurisdictional dam permit approval from the California Division of Safety of Dams (DOSD), 2) Section 404 of the Clean Water Act permit for in-water work from the U.S. Army Corps of Engineers (USACE), and 3) California Environmental Quality Act (CEQA) thresholds for compliance and level of effort. Each issue or criterion was evaluated independently. A project received a +1 score for each regulatory permit condition deemed to be statutorily excluded and each required permit was given a -1 scoring to arrive at the weighting on Subaccount.

Each type of project site under consideration will require an individual permit approval from DOSD given their height (i.e., greater than 6 feet) and their volumetric hold. Each project site was evaluated for 404-permit requirements based upon whether it fits within a standing Nationwide Permit (NWP) 43 the USACE for stormwater management. NWP 43 exists to enable stormwater management projects that result in less than a 1/2 acre loss of streambed. Thus, the in-water footprint size of each project site was evaluated by measurement of the bank-to-bank ordinary high-water mark multiplied by the linear width of the preliminary embankment design (Appendix A) placed in the streambed. Sites with embankments less than 1/2 acre received a +1 score and sites with an embankment greater than 1/2 acre received a -1 score because the larger embankments would have to file for an individual project 404 permit. It is anticipated that each project would need file for a 404-permit approval but at sites with footprints less than 1/2 acre that conform to NWP 43 would greatly reduce the time, effort, and cost to obtain construction approval from USACE.

Each project site was evaluated for CEQA regulatory approval requirements. At a minimum it was judged that barring a Categorical Exemption, that each project would need to prepare information and submit for a CEQA Mitigated Negative Declaration. A Negative Declaration means that the identified environmental disruptions such as a flow alteration to the natural hydrograph could be mitigated in project construction and operation. However, there is a Categorical Exemption in CEQA potentially available for Emergency Projects that prevent or mitigate an emergency condition such as flood control potential (Section 15269.(c)). It is uncertain as to what constitutes an “emergency condition”, but for the purposes of the MAA, it was assumed that if a project could reduce the large flood risk of a 25-year event to below that of a 5-year event then a Categorical Exemption might apply, and the project could proceed more rapidly to approval and construction. The actual threshold conditions for CEQA Categorical Exemptions may be found to be different by Stanislaus County Planning or other oversight entities on CEQA compliance. Table 13 presents the resulting indicator score applied in the MAA.

Table 13. In-channel embankment area, embankment height, flood risk reduction, and regulatory score

Site	In-Channel Embankment Area (acres)	Embankment Height (ft)	Reduce Flood Risk for 25 Year Storm Event to Below 5 Year Storm Event (ft)	Indicator Score
1	0.43	33	No	-1
2	0.53	45	Yes	-1
3	0.33	31	No	-1
4	0.47	47	No	-1
5	1.05	48	No	-3
7	2.33	46	No	-3
8	0.39	42	No	-1
9	0.70	24	No	-3
13	0.89	52	No	-3
14	0.85	28	No	-3
15	0.44	41	Yes	1

4.4 Social and Cultural Criteria

Social and cultural criteria account for 20% of the total MAA to include weights for reduced flood risk to DACs, increased water availability, potential impacts to landowners, impacts to cultural resources and visual impacts as discussed below.

4.4.1 Reduced Flood Risk to Disadvantaged Communities

The reduced flood risk to disadvantaged communities indicator represents the reduction in flood risk to below a 5-year storm event with the presence of a flood control project. Regional flood control studies indicate that localized flooding in disadvantaged community areas occurs when the Tuolumne River flows exceed 9,000 cfs and the DCW receives a 5-year or greater storm event (GSA, 2020a). This criterion was assessed using the 2D HEC-RAS model predicted difference in maximum WSE at the El Vista Avenue bridge crossing for a 5-year storm event without the control structure present (current conditions) versus a 25-year storm event with the control structure present. Table 14 presents the model predicted WSE at El Vista Avenue bridge, difference in WSE, and the indicator score applied in the MAA.

Table 14. Model predicted water surface elevation at El Vista Avenue bridge for a 5- and 25-year storm event with and without a control structure and project scoring

Site	Water Surface Elevation at El Vista Bridge for 5 Year Storm Event and No Project (ft)	Water Surface Elevation at El Vista Bridge for 25 Year Storm Event with Project (ft)	Difference in Water Surface Elevation (ft)	Indicator Score[1]
1	73.6	76.6	-3.0	-2
2	73.6	72.6	1.0	3
3	73.6	76.8	-3.3	-3
4	73.6	74.5	-0.9	2
5	73.6	74.3	-0.7	2
7	73.6	75.2	-1.6	0
8	73.6	74.5	-0.9	2
9	73.6	76.4	-2.8	-2
13	73.6	76.3	-2.7	-2
14	73.6	76.7	-3.1	-3
15	73.6	72.9	0.6	3

[1]3=>-0.5 ft; 2=-0.5 to -1.0 ft; 1=-1.0 to -1.5 ft; 0=-1.5 to -2.0 ft; -1=-2.0 to -2.5 ft; -2=-2.5 to -3.0 ft; -3<-3.0 ft

4.4.2 Increased Water Availability

The increased water availability indicator represents increased groundwater storage that may be available to water users. This indicator was evaluated from the estimated detained water that could infiltrate for a 25-year storm event. The infiltration volume estimate was calculated by summing the product of the 2D HEC-RAS model predicted inundation area and the inundation area harmonic mean soil K_{sat} for each day that inundation was predicted to occur. Table 15 presents the predicted potential infiltration volume for a 25-year storm event and the indicator score applied in the MAA.

Table 15. Predicted infiltration of detained stormwater for the 25-year storm event

Site	Potential Recharge (acre-ft)	Indicator Score[1]
1	732	3
2	423	1
3	76	-3
4	178	-2
5	201	-1
7	227	-1
8	218	-1
9	98	-3
13	74	-3
14	589	2
15	746	3

[1]3=>600 acre-ft; 2=500-600 acre-ft; 1=400-500 acre-ft; 0=300-400 acre-ft; -1=200-300 acre-ft; -2=100-200 acre-ft; -3<100 acre-ft

4.4.3 Potential Impacts to Landowners

This indicator represents potential impacted cropped land due to inundation of the land during the 25-year storm event with a control structure present. This was assessed using the 2D HEC-RAS model predicted difference in inundation area for a 25-year storm event without the control structure present (current conditions) versus with the control structure present. The cropped land areas compiled by GSA (2020a) and residing within the model predicted increased inundation area were applied in the MAA score. Table 16 presents the increased inundated crop area and the indicator score applied in the MAA.

The model predicted 25-year storm event inundation area and maximum flood depth with and without the potential flood control structure for Sites 2, 4, 5, and 15 (Appendix B, Table 16) indicate a moderate increase of inundation area upstream from the control structure for Sites 4, 5, and 15. A large increase in inundation area for Site 2 is predicted (Appendix B, Table 16), predominately occurring adjacent to Cashman Creek, a tributary of Dry Creek.

Table 16. Increased inundated crop area within the 25-year storm event inundation area with project versus without project and project scoring

Site	Increased Inundated Crop Area for 25 Year Storm Event with Project Versus without Project (acres)	Indicator Score[1]
1	19	2
2	232	-3
3	53	1
4	86	0
5	93	0
7	46	1
8	100	0
9	111	0
13	0	3
14	34	2
15	74	1

[1]3=0 acres; 2=0-40 acres; 1=40-80 acres; 0=80-120 acres; -1=120-160 acres; -2=160-200 acres; -3>200 acres

4.4.4 Impacts to Cultural Resources

Impacts to cultural resources were not evaluated in this phase of the analysis; however, the sub-account remained in the MAA for potential future consideration. All sites were given an indicator score of 0.

4.4.5 Visual Impacts

The visual impacts indicator represents changes to the scenic attributes of the landscape due to the construction of the flood control structure. This indicator was evaluated based on the length of the constructed flood control structure (Appendix A), assuming a longer structure may result in greater visual impacts. Table 17 presents the flood control structure length and the indicator score applied in the MAA.

Table 17. Flood control structure length and project scoring

Site	Structure Length (ft)	Indicator Score[1]
1	1,250	1
2	590	2
3	235	3
4	3,070	-3
5	415	3
7	1,670	0
8	1,540	0
9	3,300	-3
13	2,800	-2
14	1,490	1
15	1,400	1

[1]3=<500 ft; 2=500-1,000 ft; 1=1,000-1,500 ft; 0=1,500-2,000 ft; -1=2,000-2,500 ft; -2=2,500-3,000 ft; -3>3,000 ft

4.5 Total Matrix Score

The MAA account and total matrix score for each alternative analyzed are presented in Table 18 and Figure 2. The total matrix score is greatest for Site 2 (1.24), which also had the greatest Technical score (2.21) and a moderately low Economic score (0.55). Site 15 had the second largest total score (1.09), due in part to a high Technical score (2.09) and a low Economic score (-1.64). Site 5 and Site 4 had the third (0.95) and fourth (0.92) largest scores, respectively. All other site alternatives had a Matrix score of 0.52 or less.

Table 18. Account and total matrix score

Account	Score										
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 7	Site 8	Site 9	Site 13	Site 14	Site 15
Technical	-0.82	2.21	-1.06	1.47	1.18	0.79	0.71	-0.91	-1.44	-0.68	2.09
Economic	-0.09	0.55	3.00	1.45	1.73	0.09	0.64	2.45	1.36	-1.09	-1.64
Environmental	-0.33	-0.33	-0.33	-0.33	-1.00	-0.67	0.00	-0.67	-1.00	-1.00	0.33
Social/Cultural	0.88	0.31	-0.64	-0.39	0.60	0.05	0.22	-1.46	-0.53	0.45	1.69
Total[1]	**-0.29**	**1.24**	**-0.09**	**0.92**	**0.95**	**0.36**	**0.52**	**-0.32**	**-0.65**	**-0.57**	**1.09**

1 – Total Matrix Score = (Technical Score × 0.5) + (Economic Score × 0.2) + (Environmental Score × 0.1) + (Social and Cultural Score × 0.2)

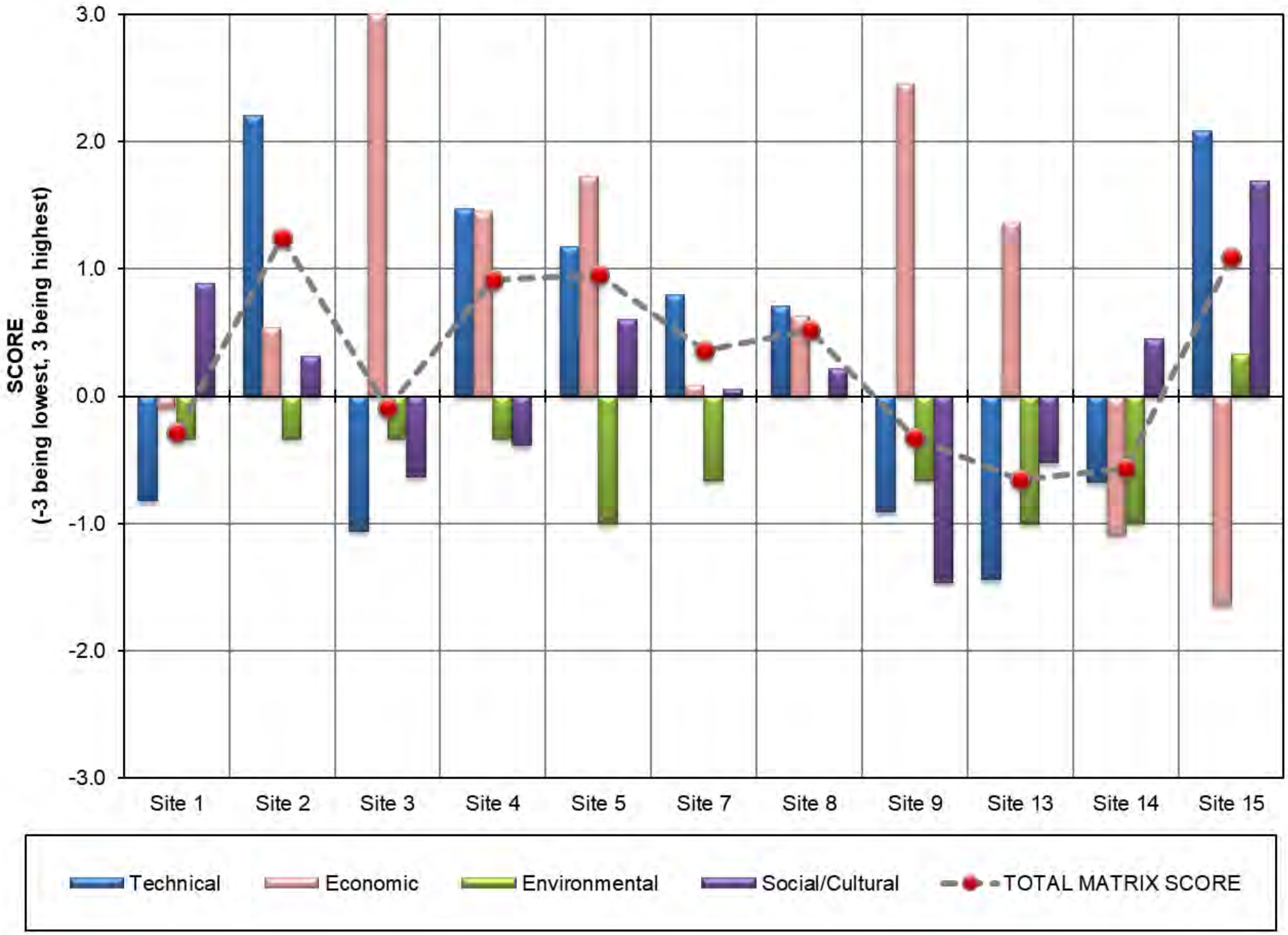


Figure 2. Multiple Accounts Analysis results

5.0 CONCLUSIONS

A comprehensive MAA evaluation was completed for eleven potential flood control structures on Dry Creek. The evaluation incorporated technical, economic, environmental, and social and cultural criteria and was supported by 2D HEC-RAS model predicted inundation area, capture volume and water surface elevations at each site for a range of return frequency storm ranging from 5-year to 100-year. The total matrix score was greatest for Site 2 (1.24), followed by Site 15 (1.09), Site 5 (0.95), and Site 4 (0.92). All other site alternatives had a Matrix score of 0.52 or less.

The MAA results indicate that Sites 2, 15, and 5 should be further evaluated to optimize the designs. Additionally, Site 4 may also be included in the additional evaluation due to the small difference between the Site 5 and Site 4 scores (0.95 versus 0.92).

6.0 REFERENCES

GSA – See GeoSystems Analysis, Inc.

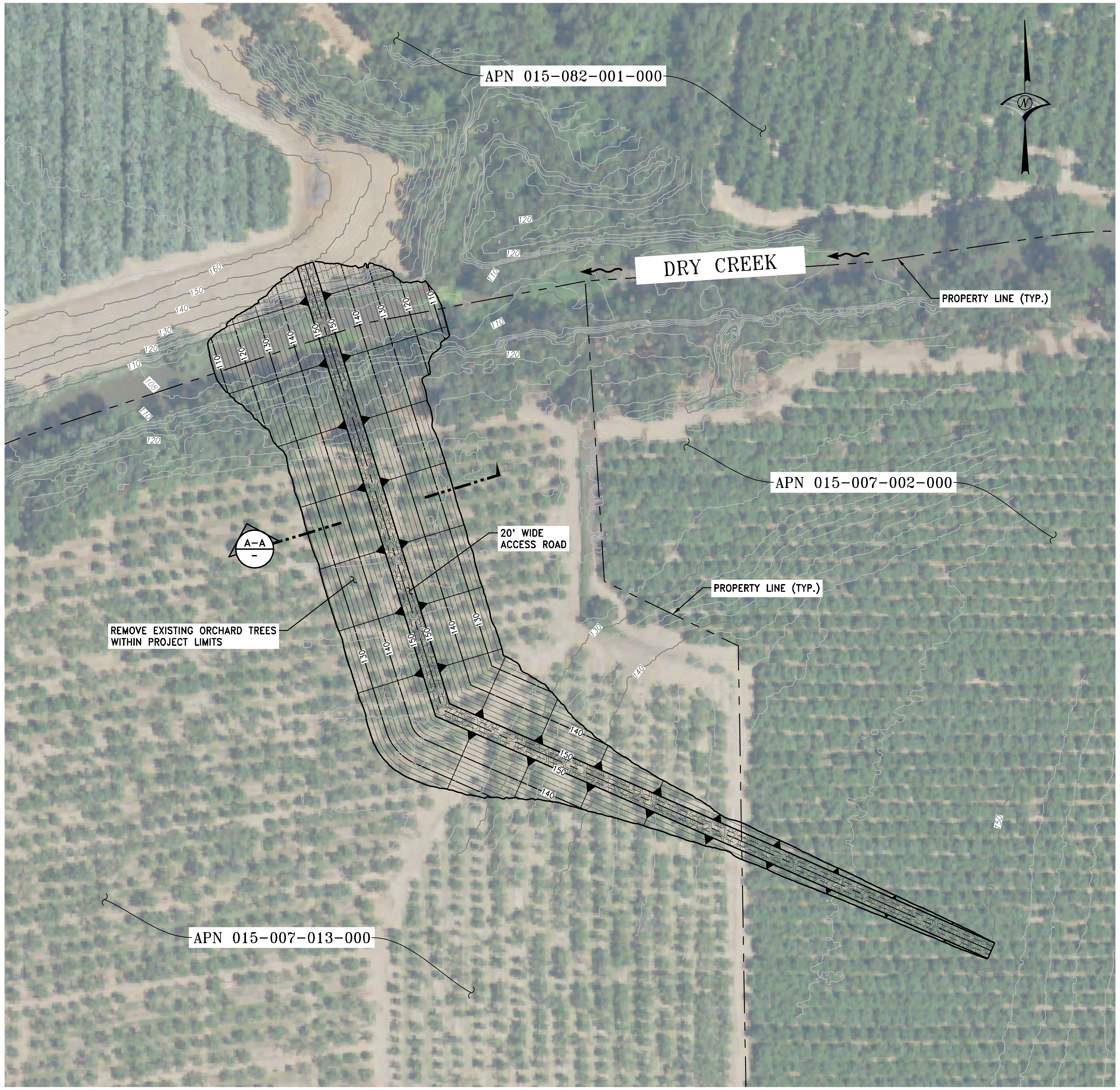
GeoSystems Analysis, Inc. 2020a. Evaluation of Stormwater Management and Groundwater Recharge Projects in the Dry Creek Watershed of Stanislaus County. Prepared for Stanislaus County Public Works, March 12, 2020.

GeoSystems Analysis, Inc. 2020b. Technical Memorandum 2 – Dry Creek Watershed Stormwater Management and Groundwater Recharge Multiple Account Analysis. Prepared for Stanislaus County Public Works, April 23, 2020.

Mendoza, G.A. and H. Martins, 2006. Multi-criteria decision analysis in natural resource management: A critical review of methods and new modelling paradigms. Forest Ecology and Management. 230 (2006), pg. 1-22.

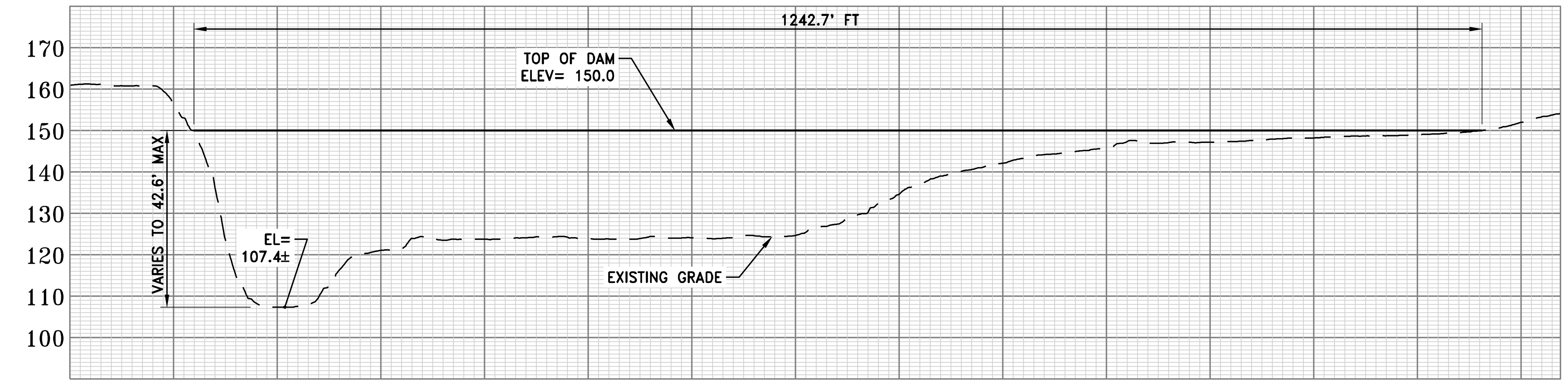
Appendix A

Flood Control Structure Preliminary Design



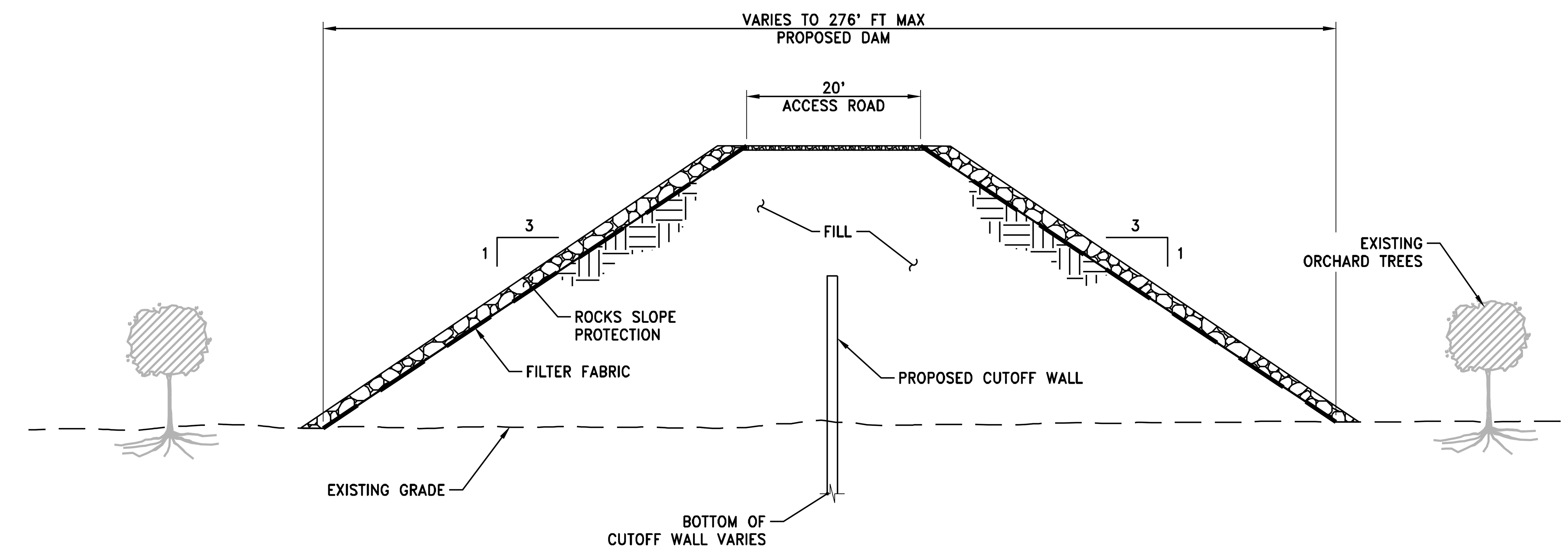
SITE 1 - PLAN VIEW

SCALE: 1"=80'



SITE 1 - PROFILE VIEW

SCALE: HORZ-1"=100'
VERT-1"=25'



A-A SITE 1 -TYPICAL SECTION

SCALE: NOT TO SCALE

LEGEND:

- PROPOSED ACCESS ROAD
- PROPOSED ROCK SLOPE PROTECTION
- EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

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DRAWN BY:
CHECKED BY:
IN CHARGE:
DATE: 8/31/2021

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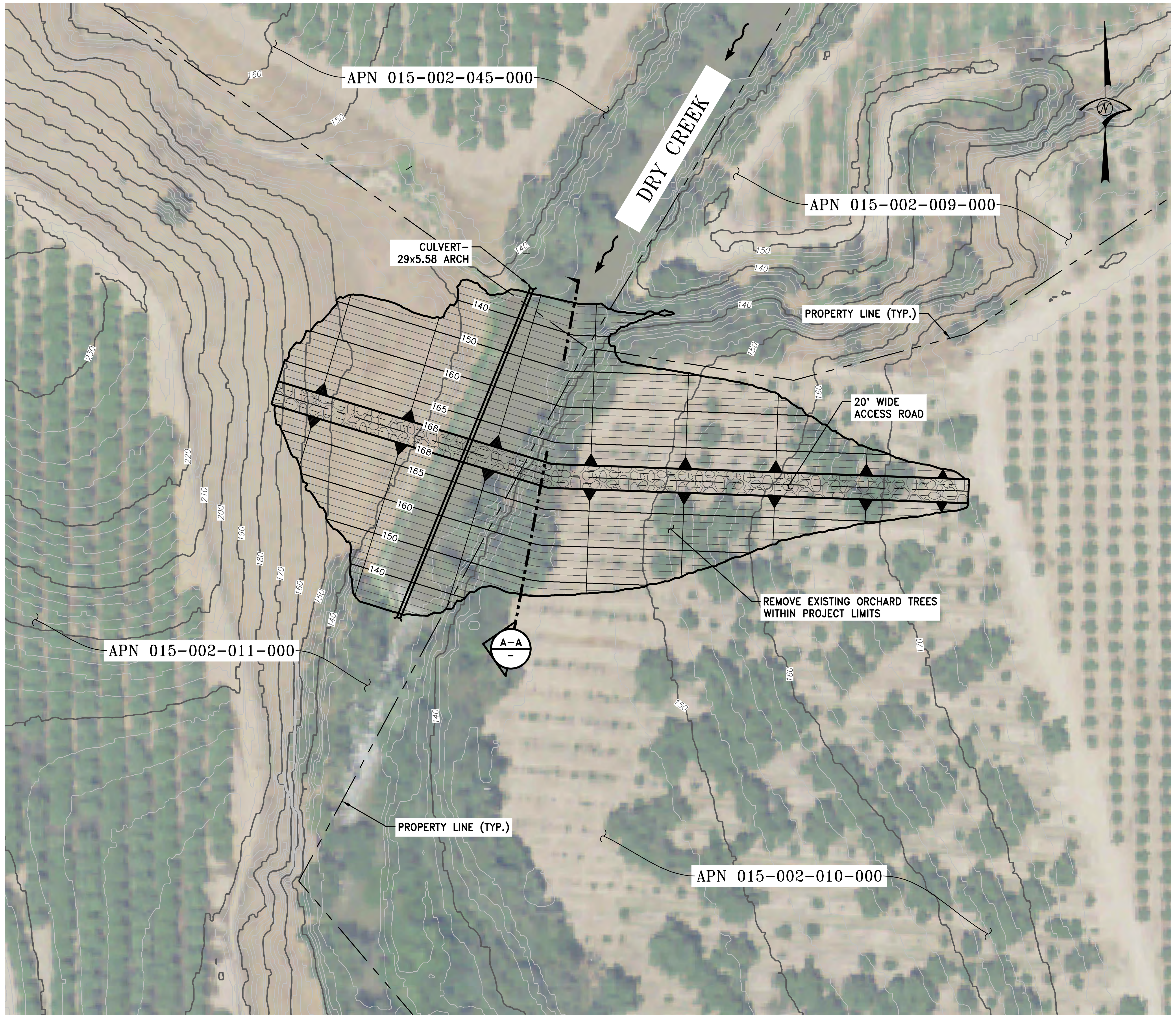
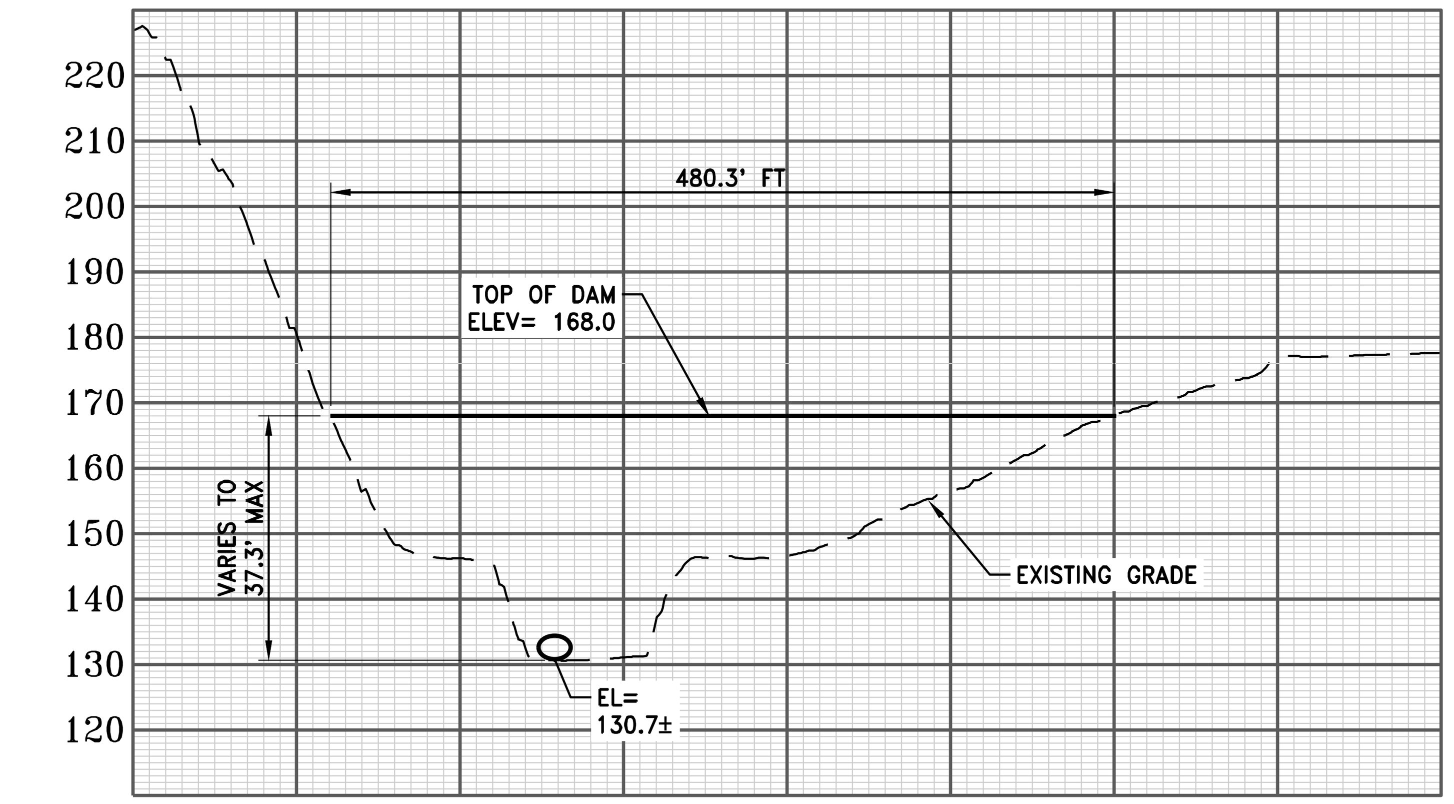
SITE 1 DAM

DRAWING NO.
SHEET



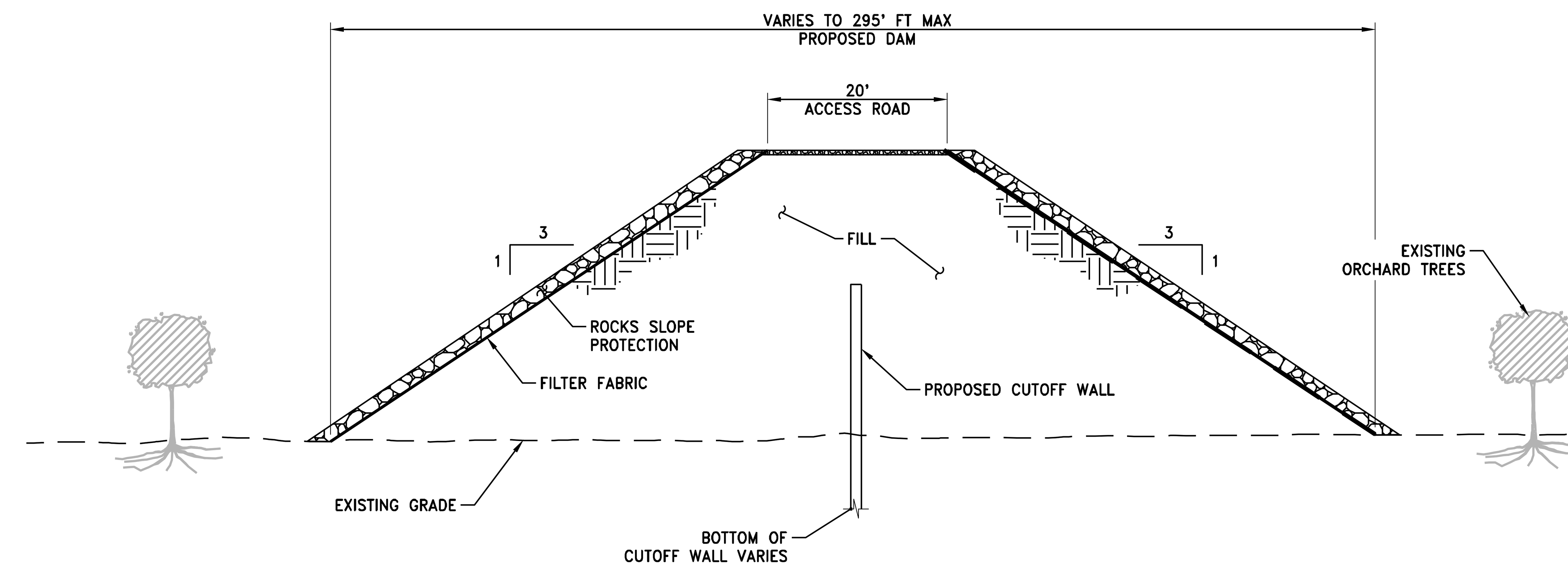
SITE 2 - PLAN VIEW

SCALE: 1"=60'



SITE 2 - PROFILE VIEW

SCALE: HORZ-1"=100'
VERT-1"=25'



A-A SITE 2 -TYPICAL SECTION

SCALE: NOT TO SCALE

LEGEND:

	PROPOSED ACCESS ROAD
	PROPOSED ROCK SLOPE PROTECTION
	EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

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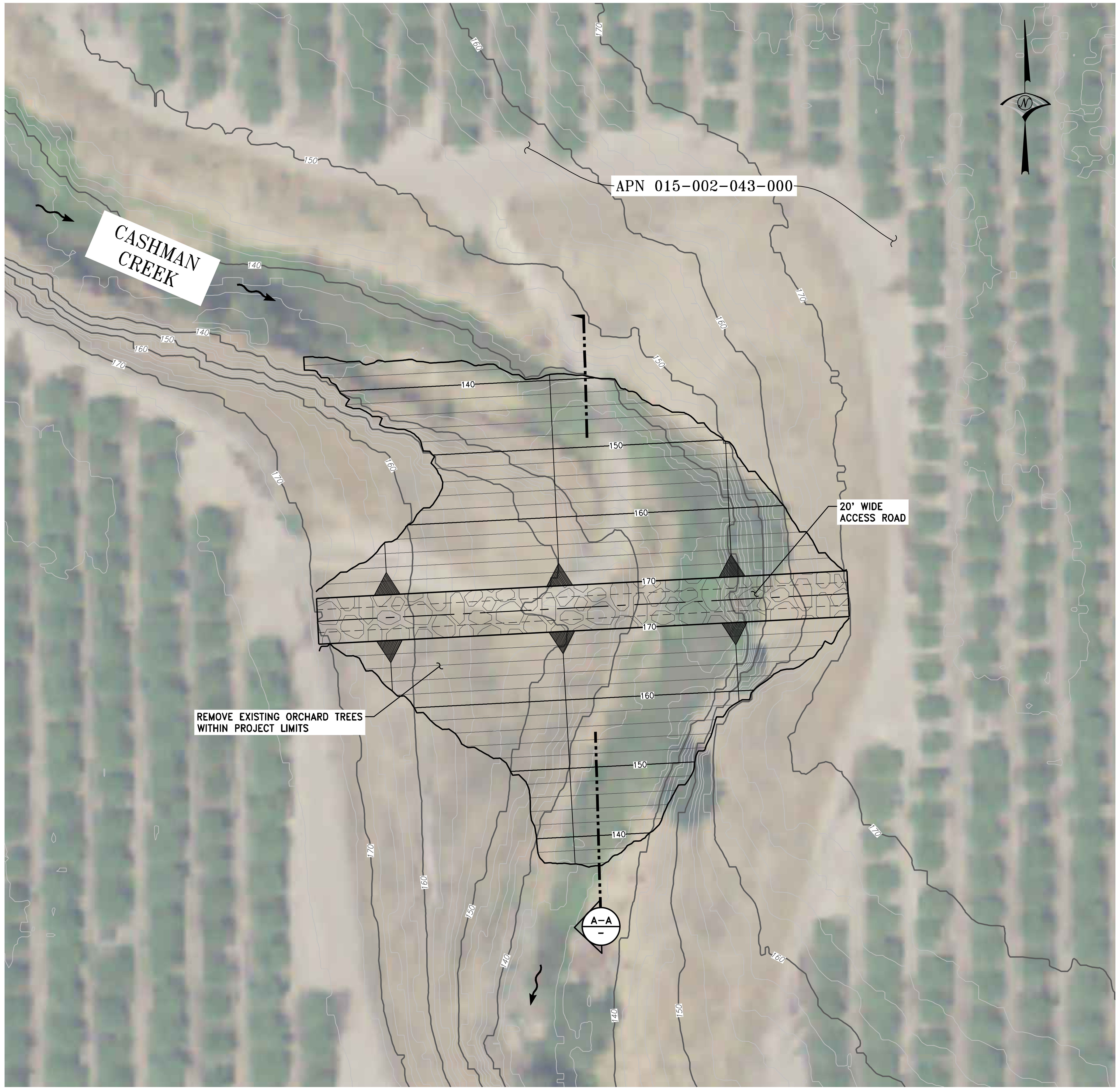
AND GROUNDWATER RECHARGE PROJECT

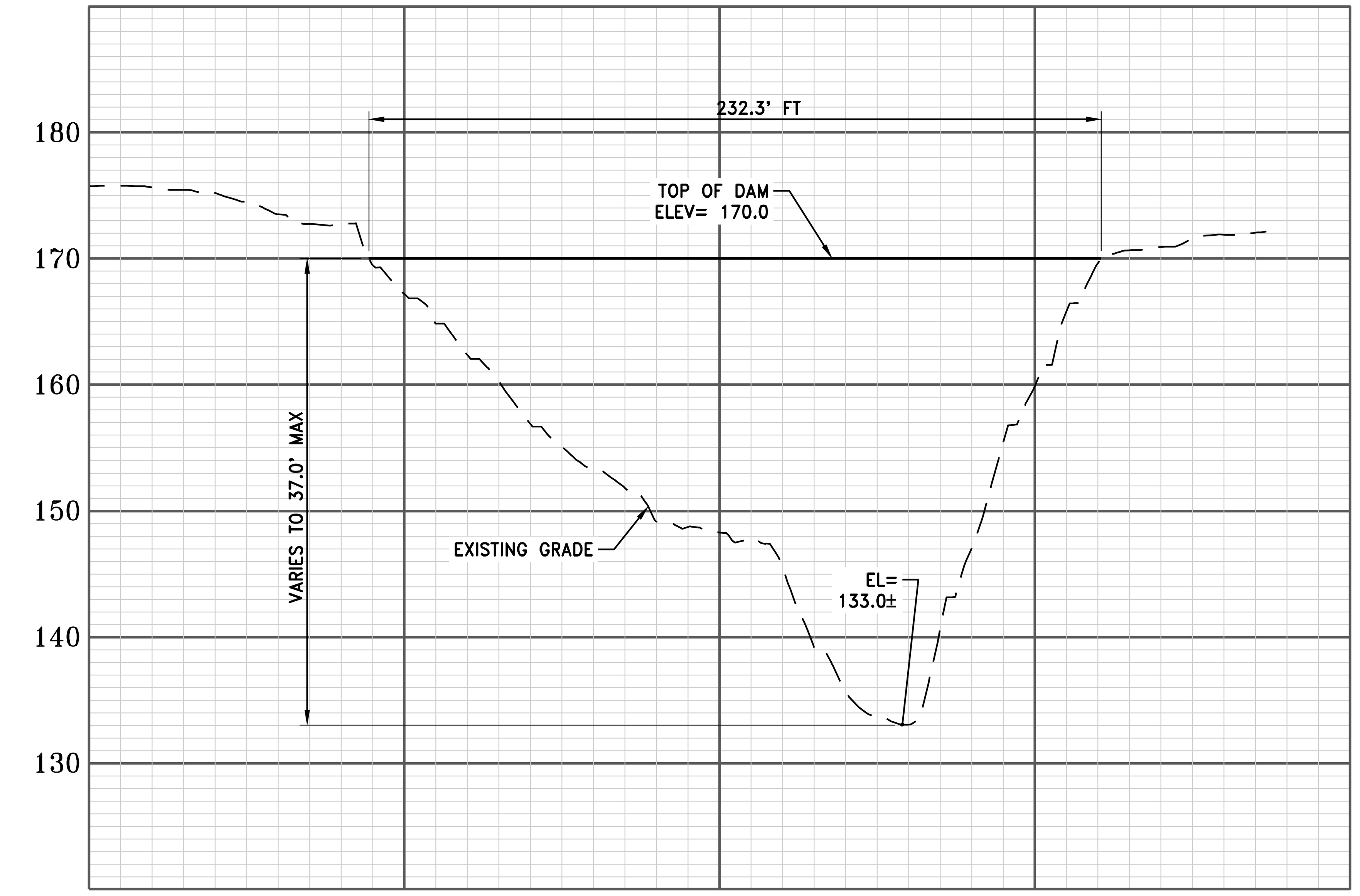
SITE 2 DAM

DRAWING NO.
SHEET



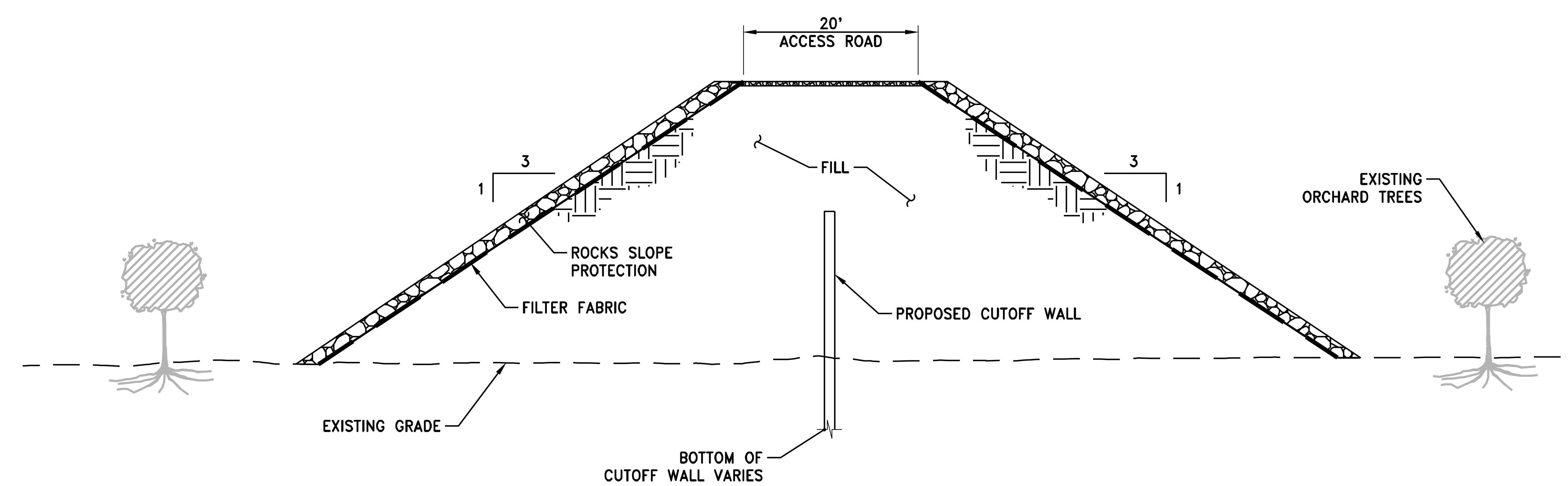
SITE 3 - PLAN VIEW

SCALE: 1"=30'



SITE 3 - PROFILE VIEW

SCALE: HORZ-1"=40'
VERT-1"=10'



A-A SITE 3 -TYPICAL SECTION

SCALE: NOT TO SCALE

LEGEND:

PROPOSED ACCESS ROAD

PROPOSED ROCK SLOPE PROTECTION

EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY:

DRAWN BY:

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IN CHARGE:

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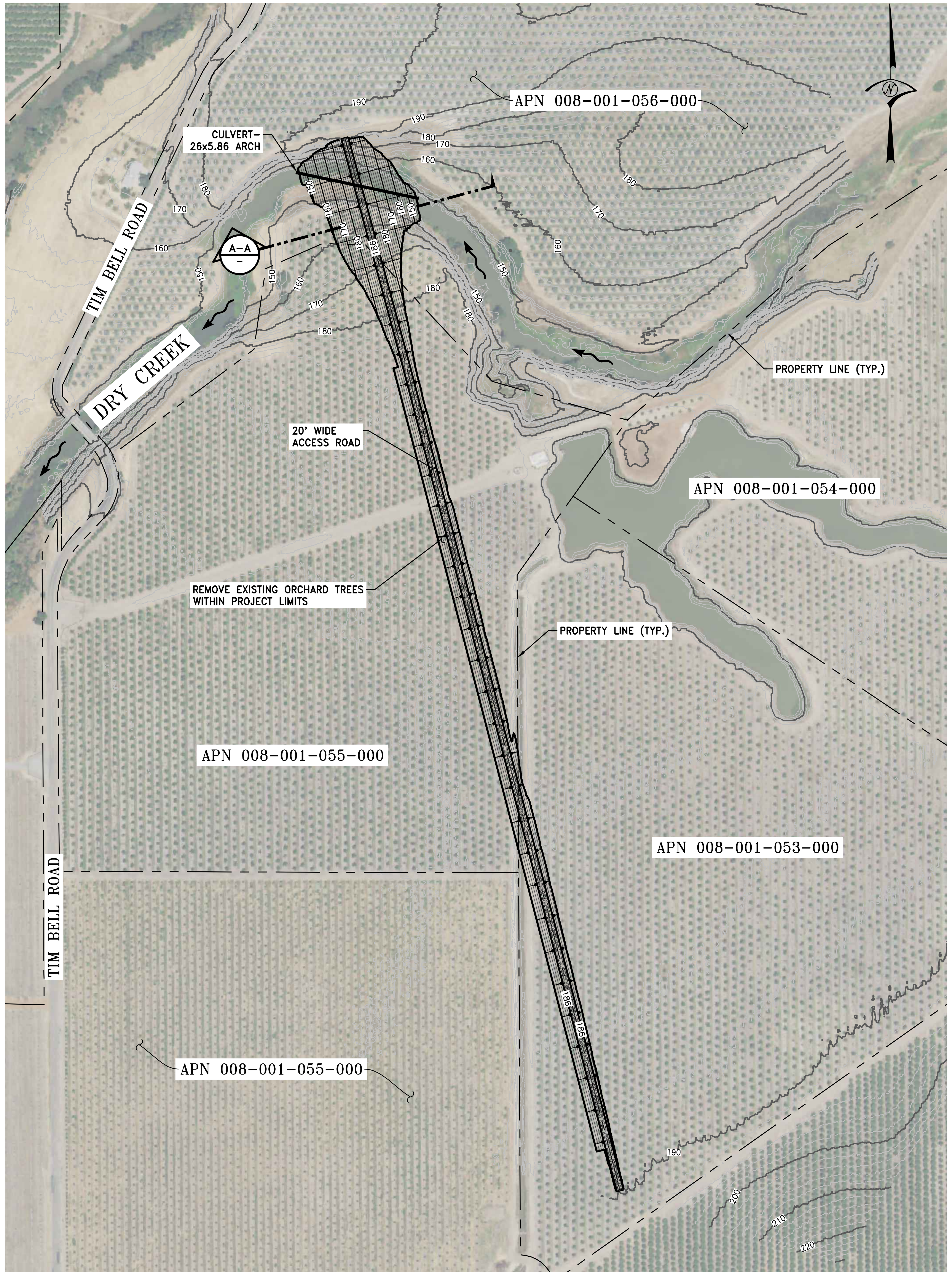
SITE 3 DAM

DRAWING NO.

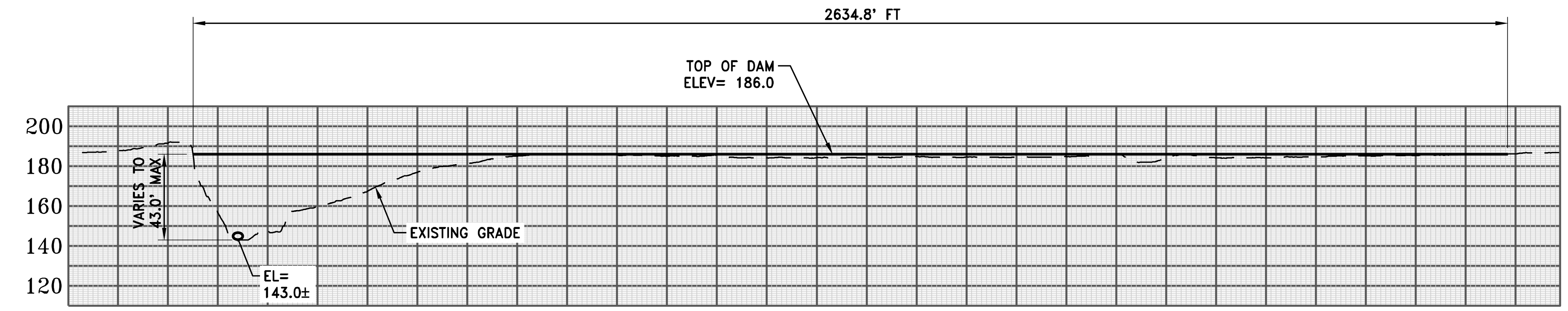
SHEET

z:\3000-s\3772_GSA\377200_Stanislaus_SM_GR_Projects\Civil\Exhibits\Dam_Structures_Cost_Estimates\EXH-03_SITE-03_DC-SMG.dwg 3/22/2022 6:23 PM Jenny Priest



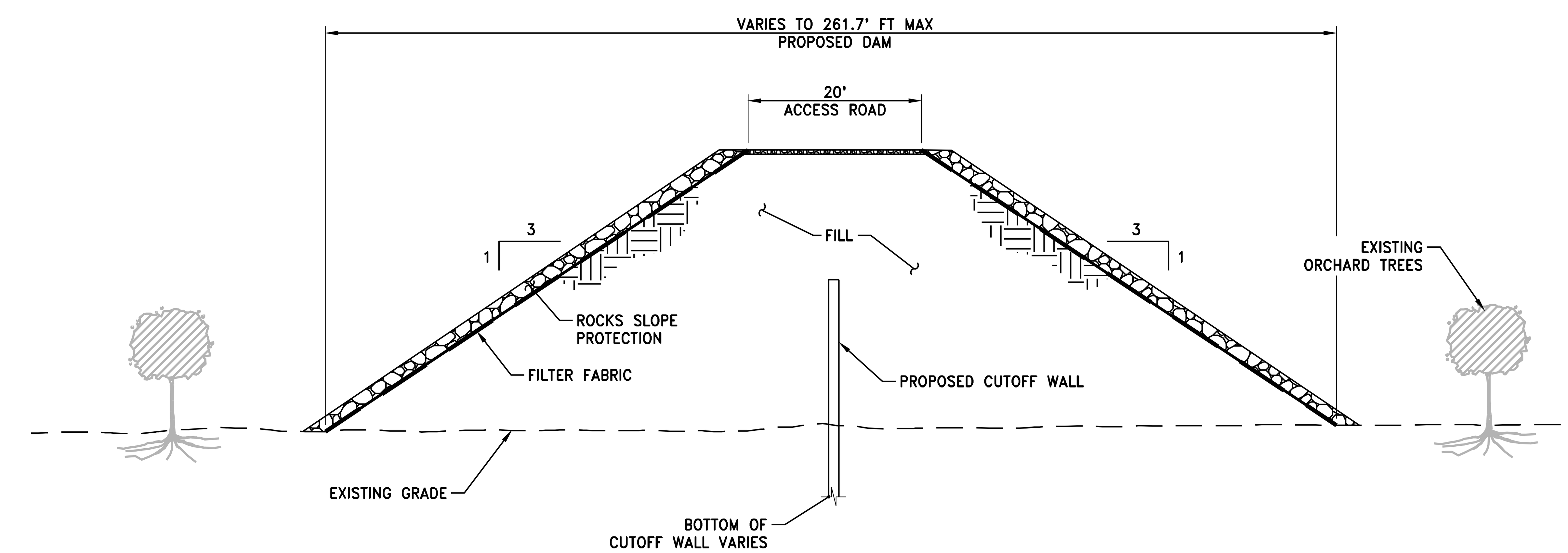
SITE 4 - PLAN VIEW

SCALE: 1"=200'



SITE 4 - PROFILE VIEW

SCALE: HORZ-1"=200'
VERT-1"=50'



A-A

SITE 4 -TYPICAL SECTION

SCALE: NOT TO SCALE

LEGEND:

- PROPOSED ACCESS ROAD
- PROPOSED ROCK SLOPE PROTECTION
- EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY:
DRAWN BY:
CHECKED BY:
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DATE: 8/31/2021

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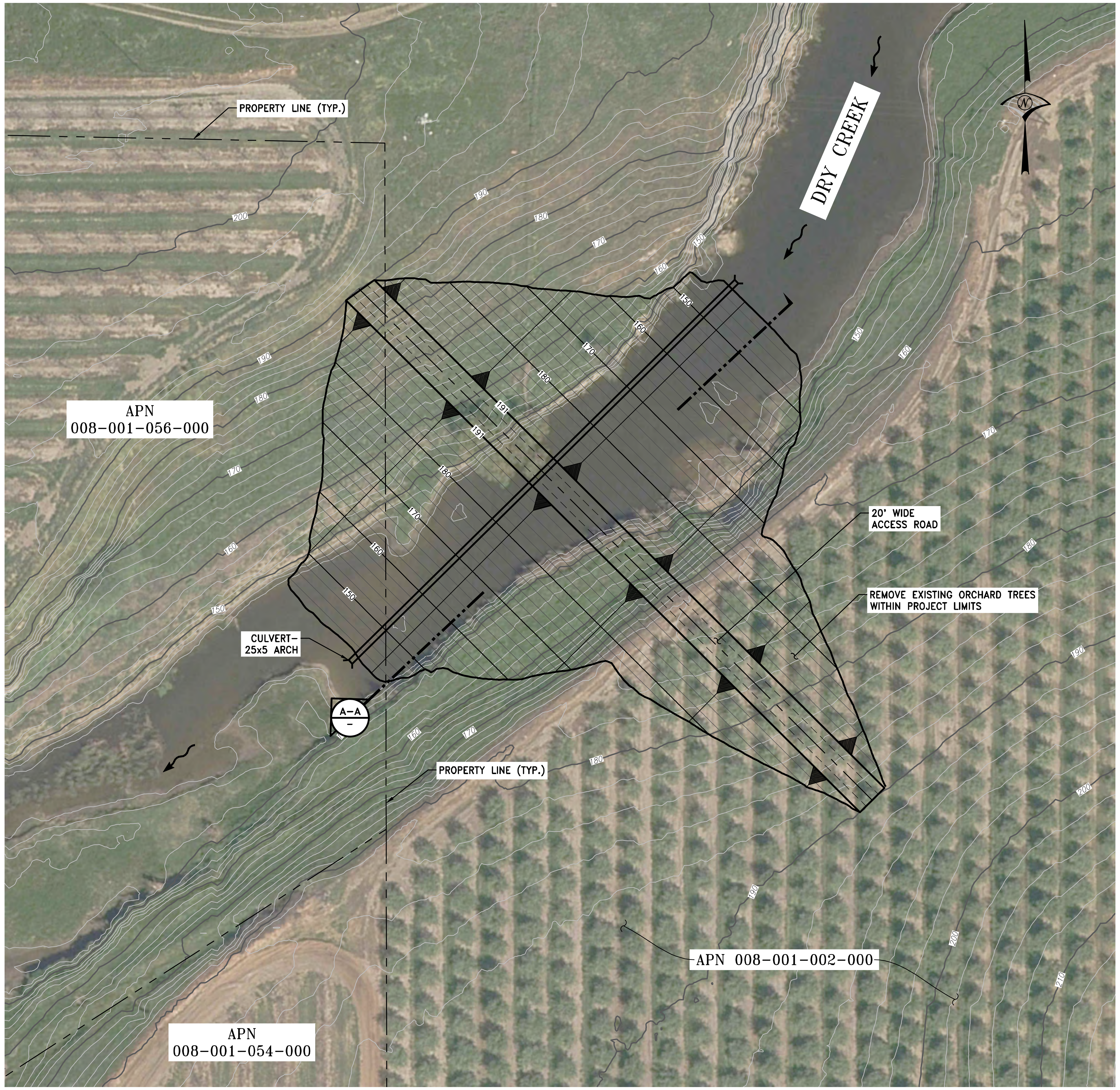
SITE 4 DAM

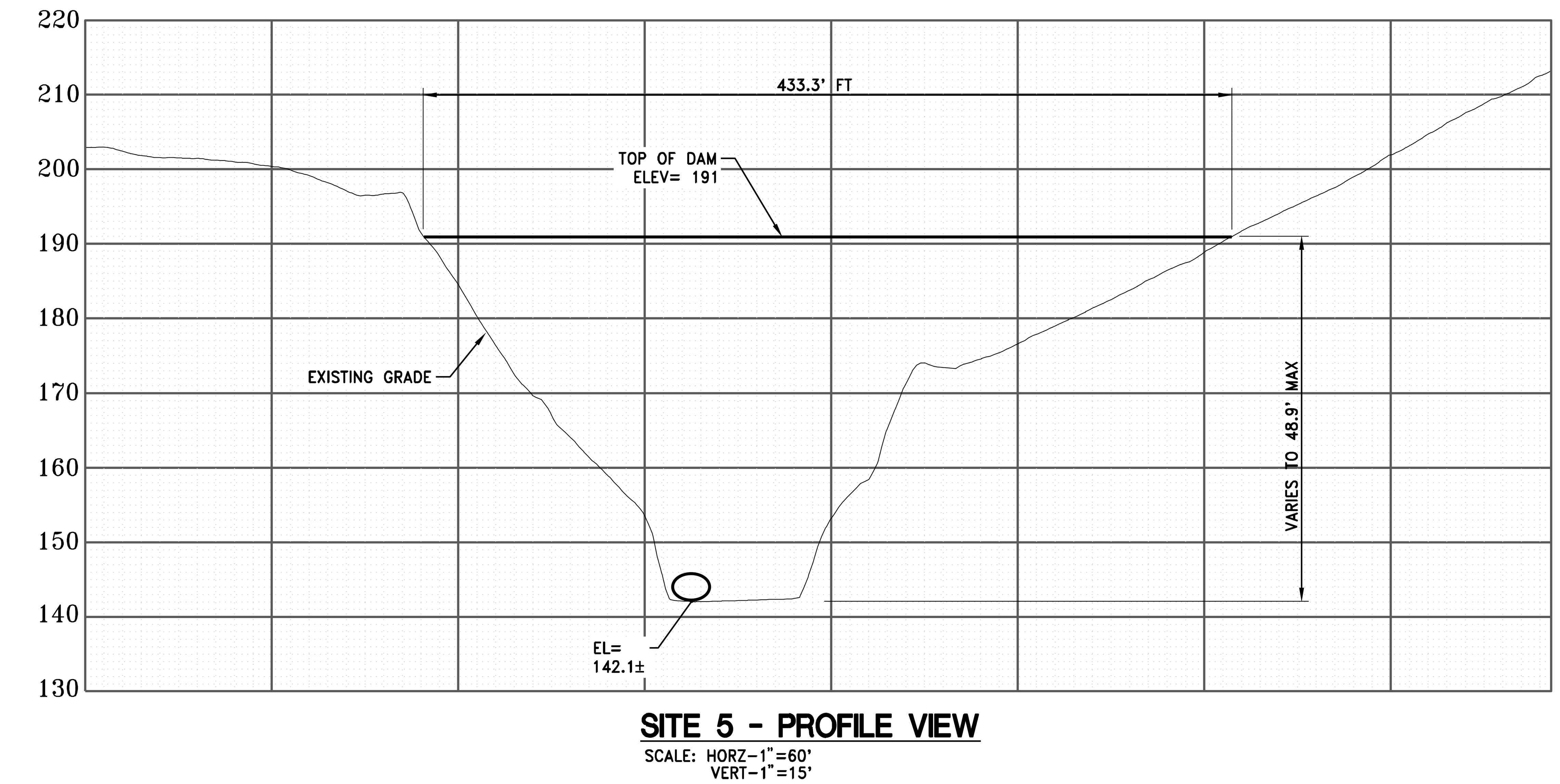
DRAWING NO. | SHEET

z:\3000-s\3772_GSA\377201_Stanislaus_SM_GR_Projects\Civil\Exhibits\Dam_Structures_Cost_Estimates\EXH-04_SITE-04_DC-SMG.dwg 3/23/2022 9:38 AM Jenny Priest



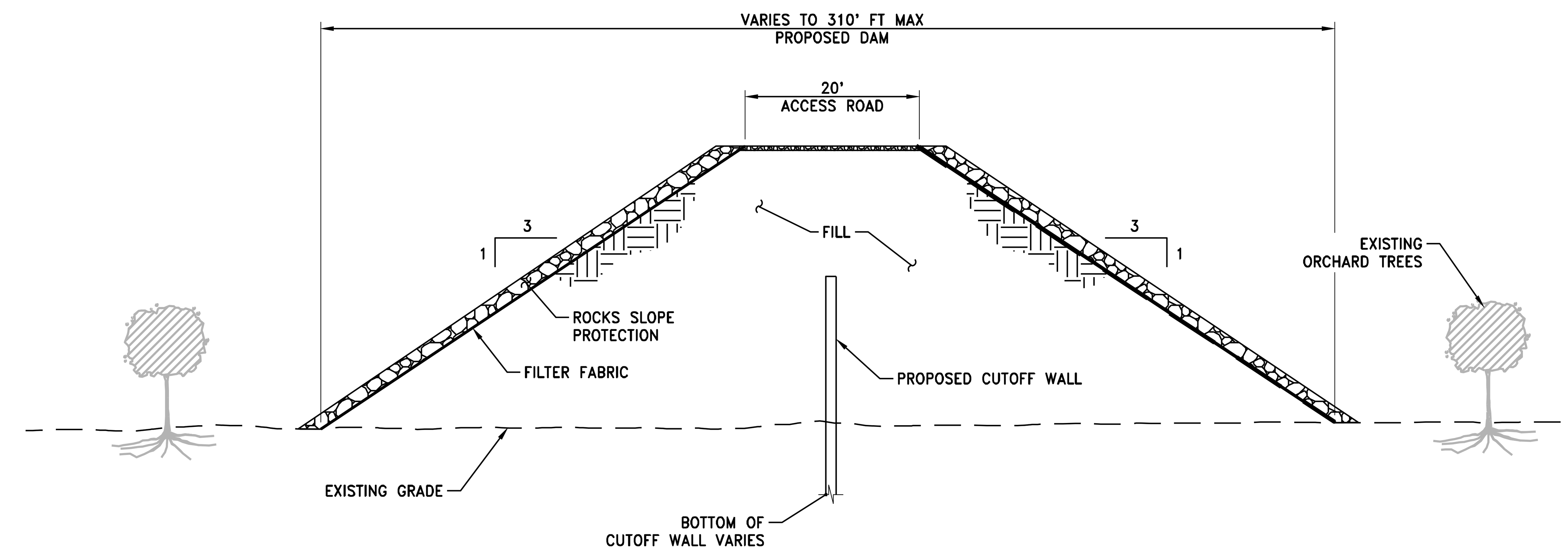
SITE 5 - PLAN VIEW

SCALE: 1"=40'



SITE 5 - PROFILE VIEW

SCALE: HORZ-1"=60'
VERT-1"=15'



A-A SITE 5 -TYPICAL SECTION

SCALE: NOT TO SCALE

LEGEND:

- PROPOSED ACCESS ROAD
- PROPOSED ROCK SLOPE PROTECTION
- EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY:
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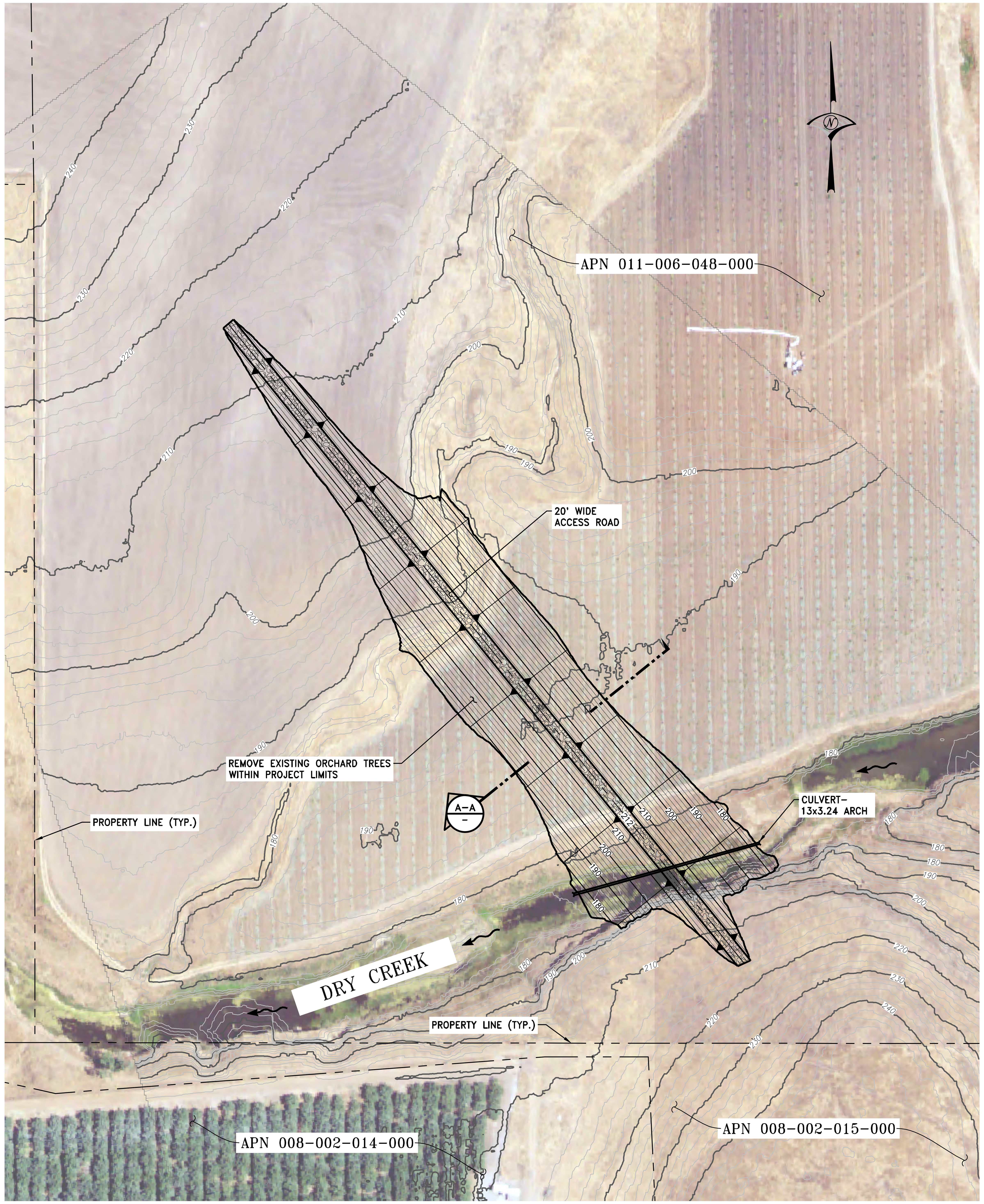
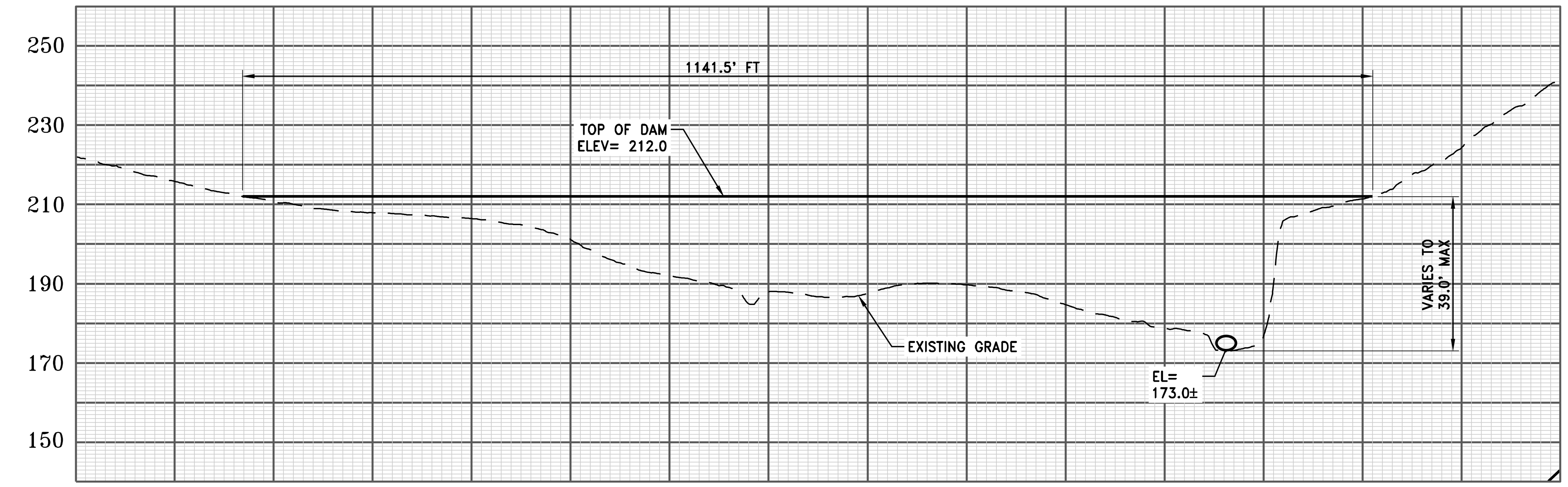
SITE 5 DAM

DRAWING NO. | SHEET



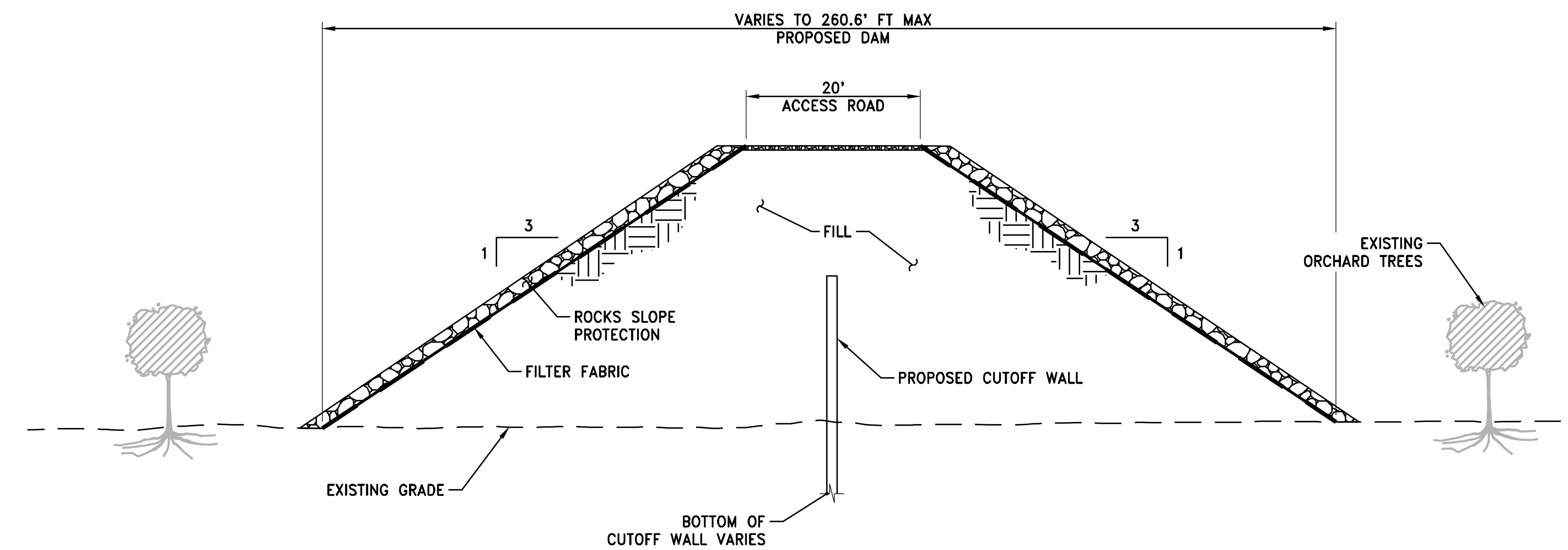
SITE 8 - PLAN VIEW

SCALE: 1"=100'



SITE 8 - PROFILE VIEW

SCALE: HORZ-1"=100'
VERT-1"=25'



A-A SITE 8 -TYPICAL SECTION

SCALE: NOT TO SCALE

LEGEND:

PROPOSED ACCESS ROAD

PROPOSED ROCK SLOPE PROTECTION

EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY:
DRAWN BY:
CHECKED BY:
IN CHARGE:
DATE: 8/31/2021

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SITE 8 DAM

DRAWING NO. | SHEET

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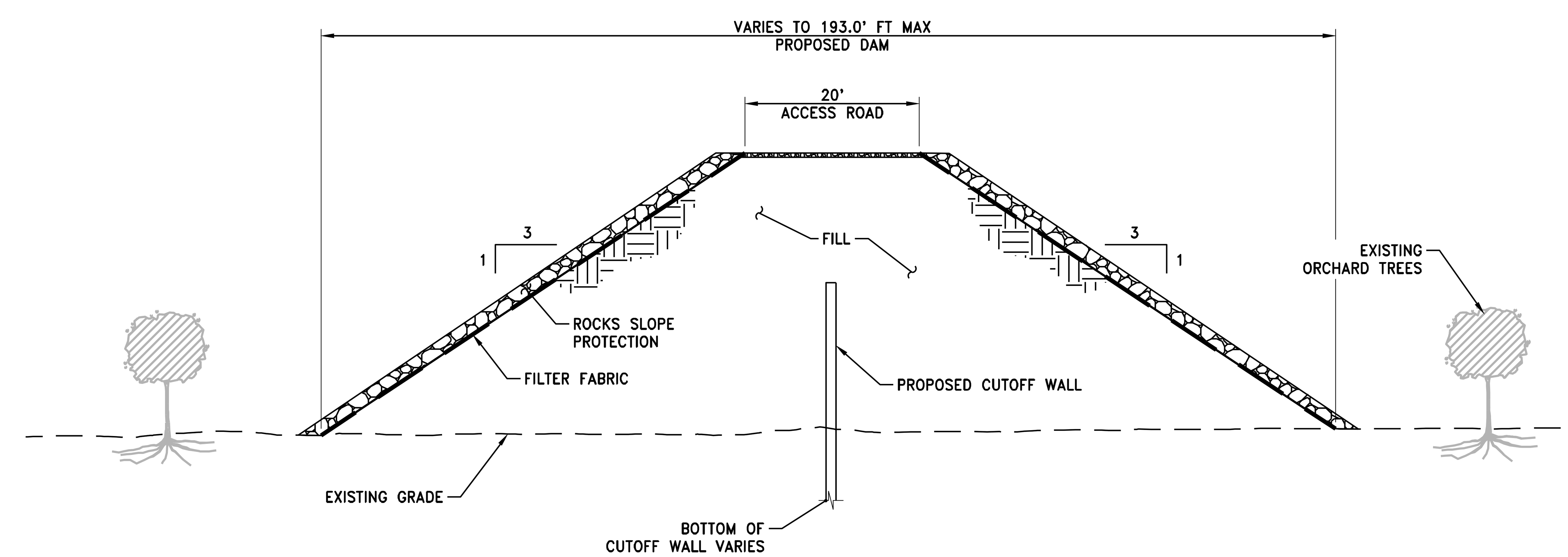
SITE 9 - PLAN VIEW

SCALE: 1"=120'

SITE 9 - PROFILE VIEW

SCALE: HORZ-1"=120'
VERT-1"=30'



A-A — **SITE 9 -TYPICAL SECTION**

SCALE: NOT TO SCALE

LEGEND:

- PROPOSED ACCESS ROAD
- PROPOSED ROCK SLOPE PROTECTION
- EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY:
DRAWN BY:
CHECKED BY:
IN CHARGE:
DATE: 8/31/2021

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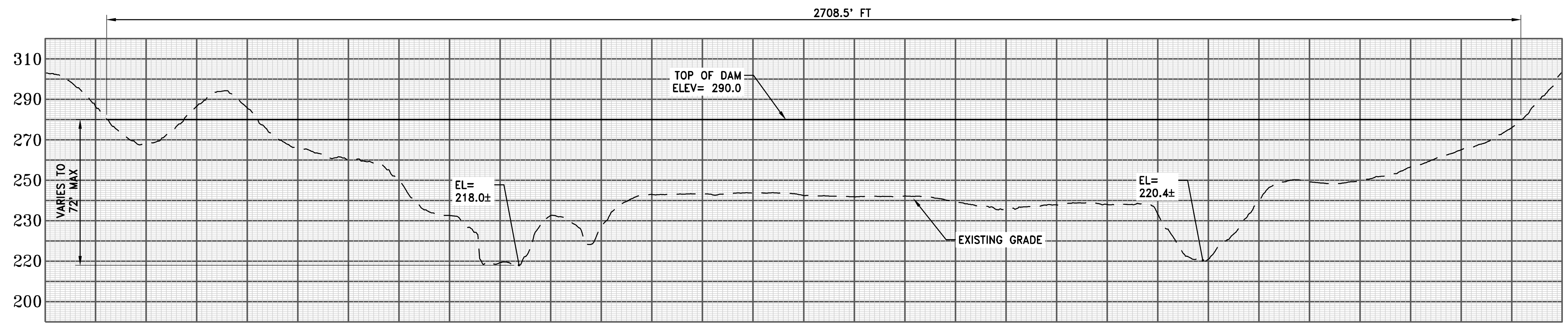
SITE 9 DAM

DRAWING NO. | SHEET

SITE 13 - PLAN VIEW

SCALE: 1"=100'

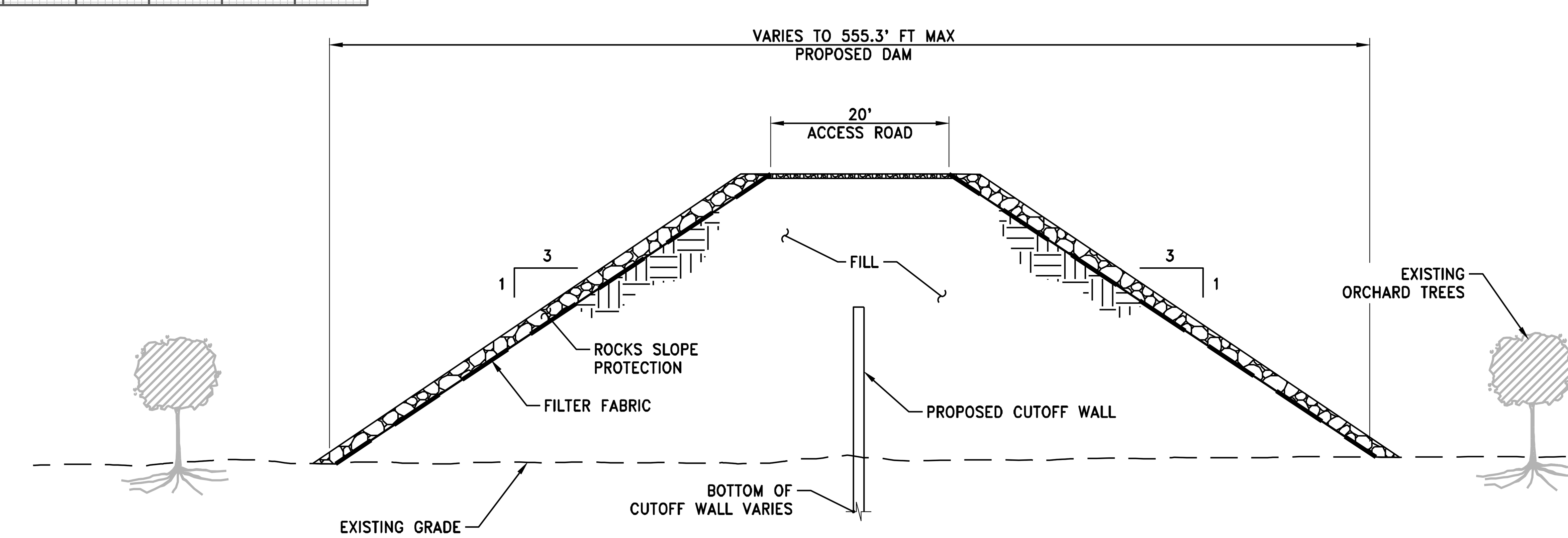


SITE 13 - PROFILE VIEW

SCALE: HORZ-1"=150'
VERT-1"=50'

LEGEND:

- PROPOSED ACCESS ROAD
- PROPOSED ROCK SLOPE PROTECTION
- EXISTING ORCHARD TREE



A-A SITE 13 -TYPICAL SECTION

SCALE: NOT TO SCALE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY:
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SITE 13 DAM

DRAWING NO.
SHEET

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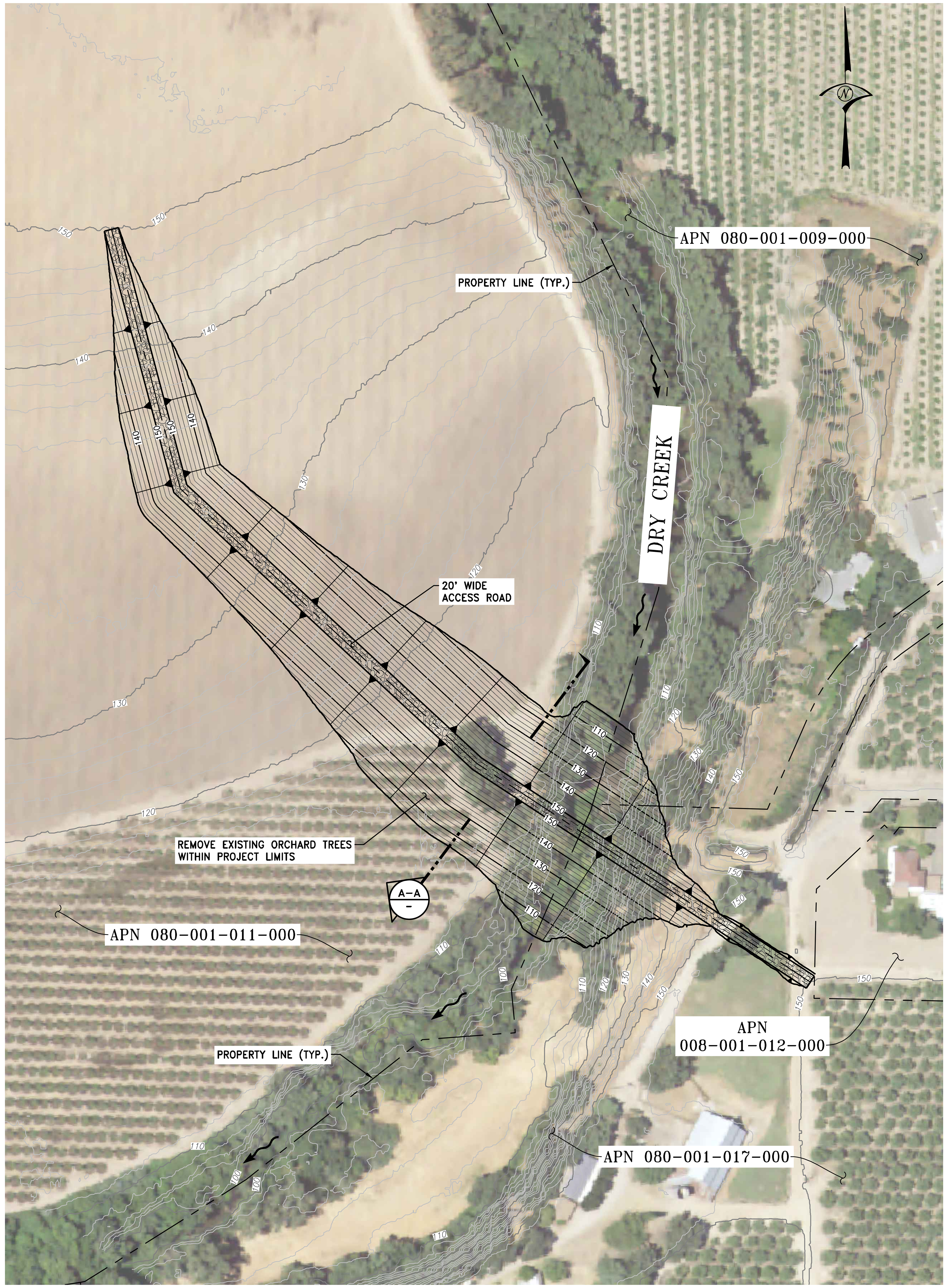
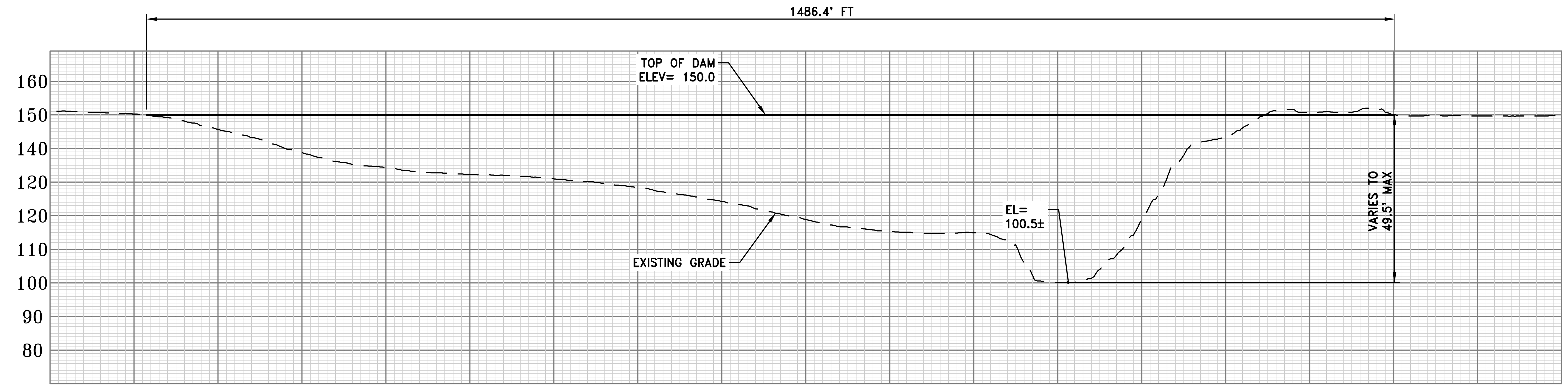


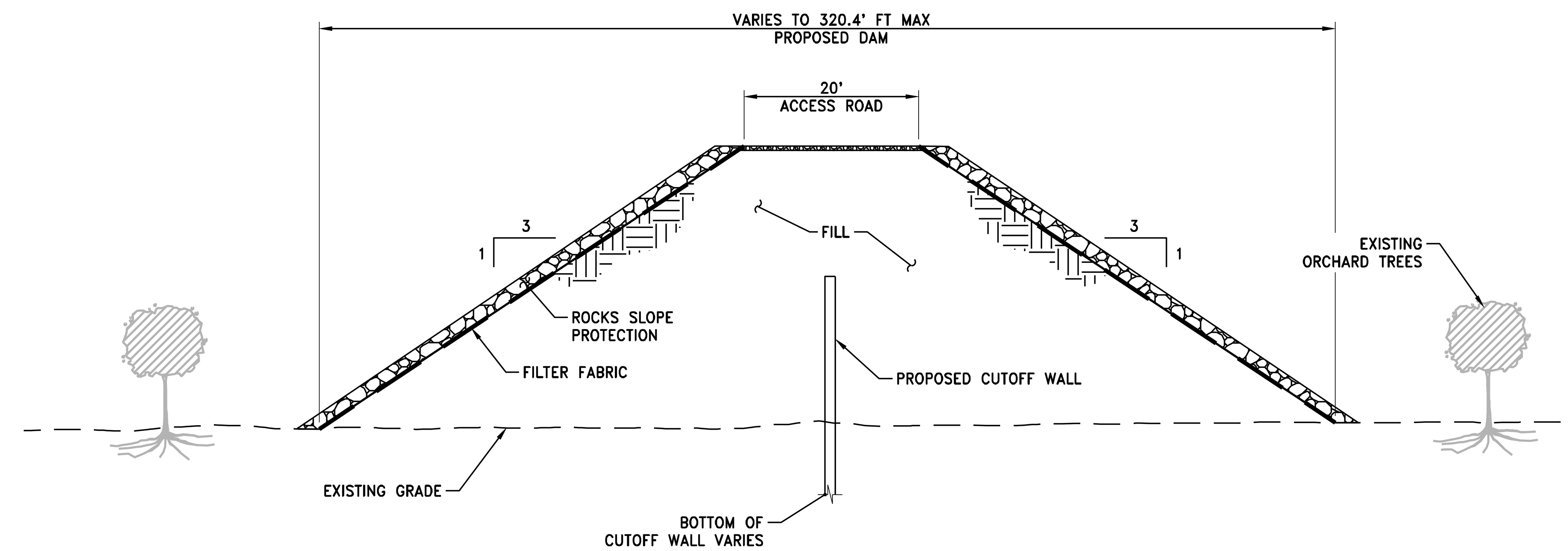
SITE 14 - PLAN VIEW

SCALE: 1"=100'



SITE 14 - PROFILE VIEW

SCALE: HORZ-1"=100'
VERT-1"=25'



A-A SITE 14 -TYPICAL SECTION

SCALE: NOT TO SCALE

LEGEND:

PROPOSED ACCESS ROAD

PROPOSED ROCK SLOPE PROTECTION

EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY:
DRAWN BY:
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SITE 14 DAM

DRAWING NO. | SHEET

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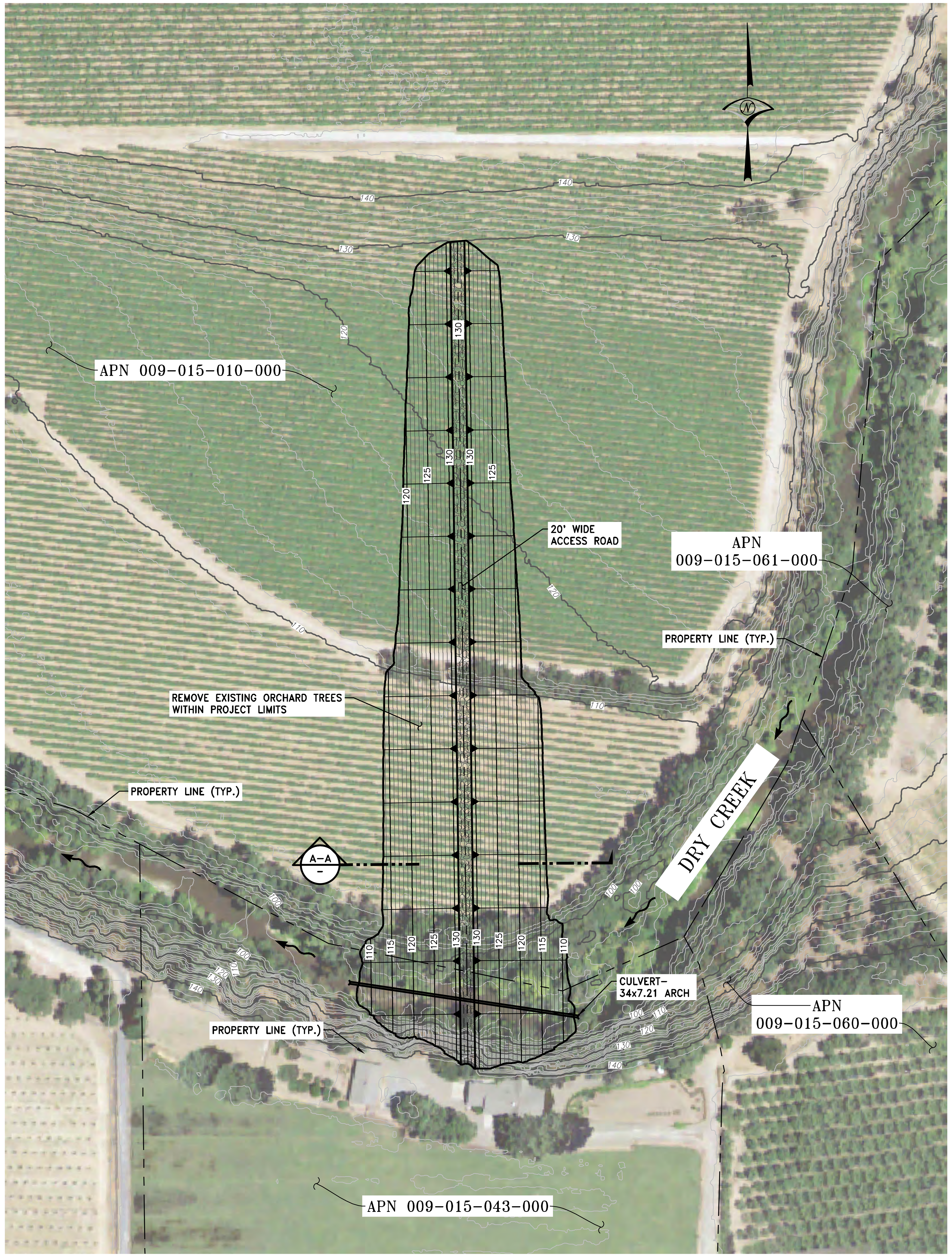
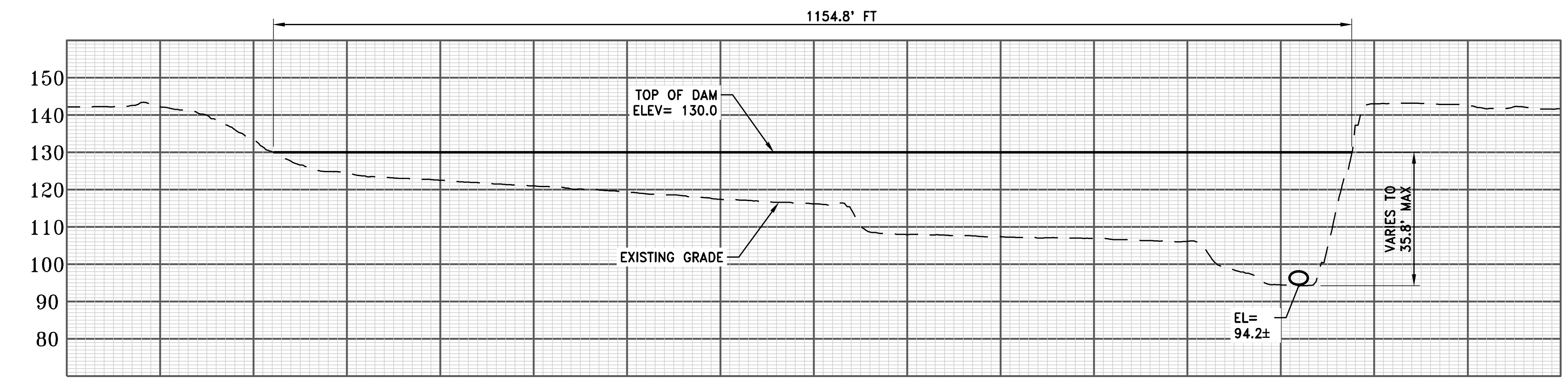
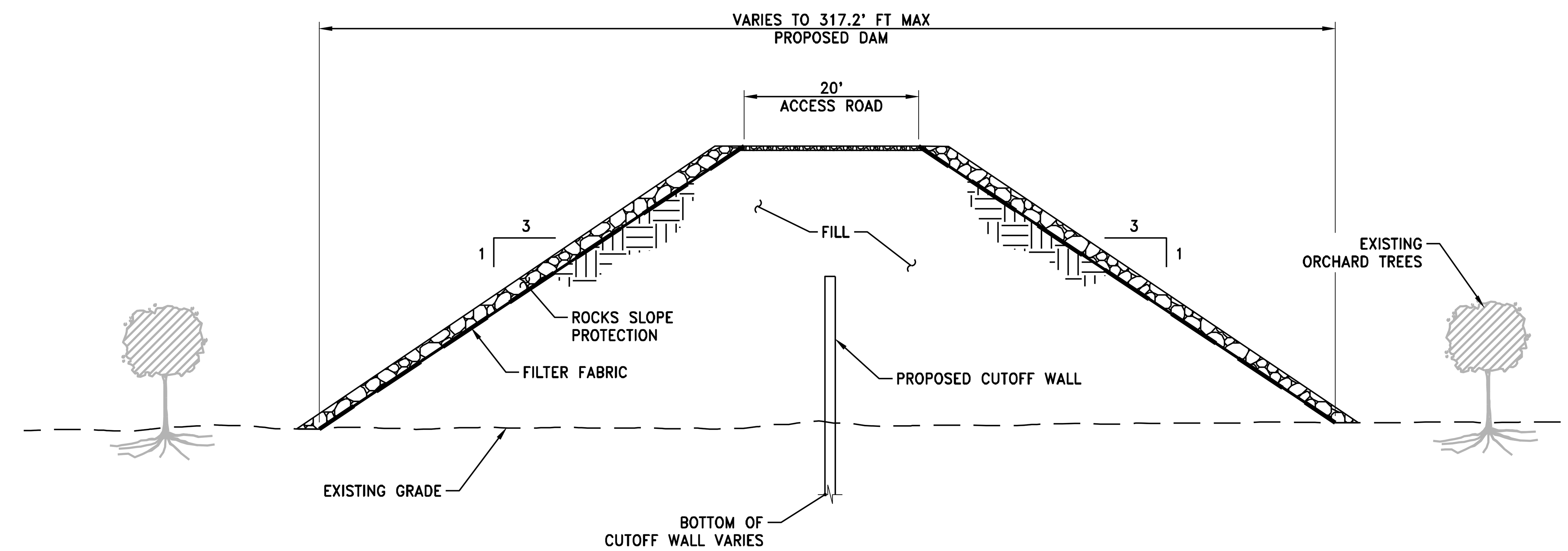


SITE 15 - PLAN VIEW
SCALE: 1"=100'

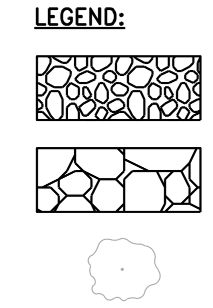


SITE 15 - PROFILE VIEW
SCALE: HORZ-1"=100'
VERT-1"=25'



A-A
SITE 15 -TYPICAL SECTION
SCALE: NOT TO SCALE

LEGEND:



PROPOSED ACCESS ROAD

PROPOSED ROCK SLOPE PROTECTION

EXISTING ORCHARD TREE

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION	REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY:
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SITE 15 DAM

DRAWING NO.
SHEET

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Appendix B

HEC-RAS Model Predicted 25-year Storm Event Inundation Area and Maximum Flood Depth With and Without Flood Control Structure (Sites 2, 4, 5, and 15)

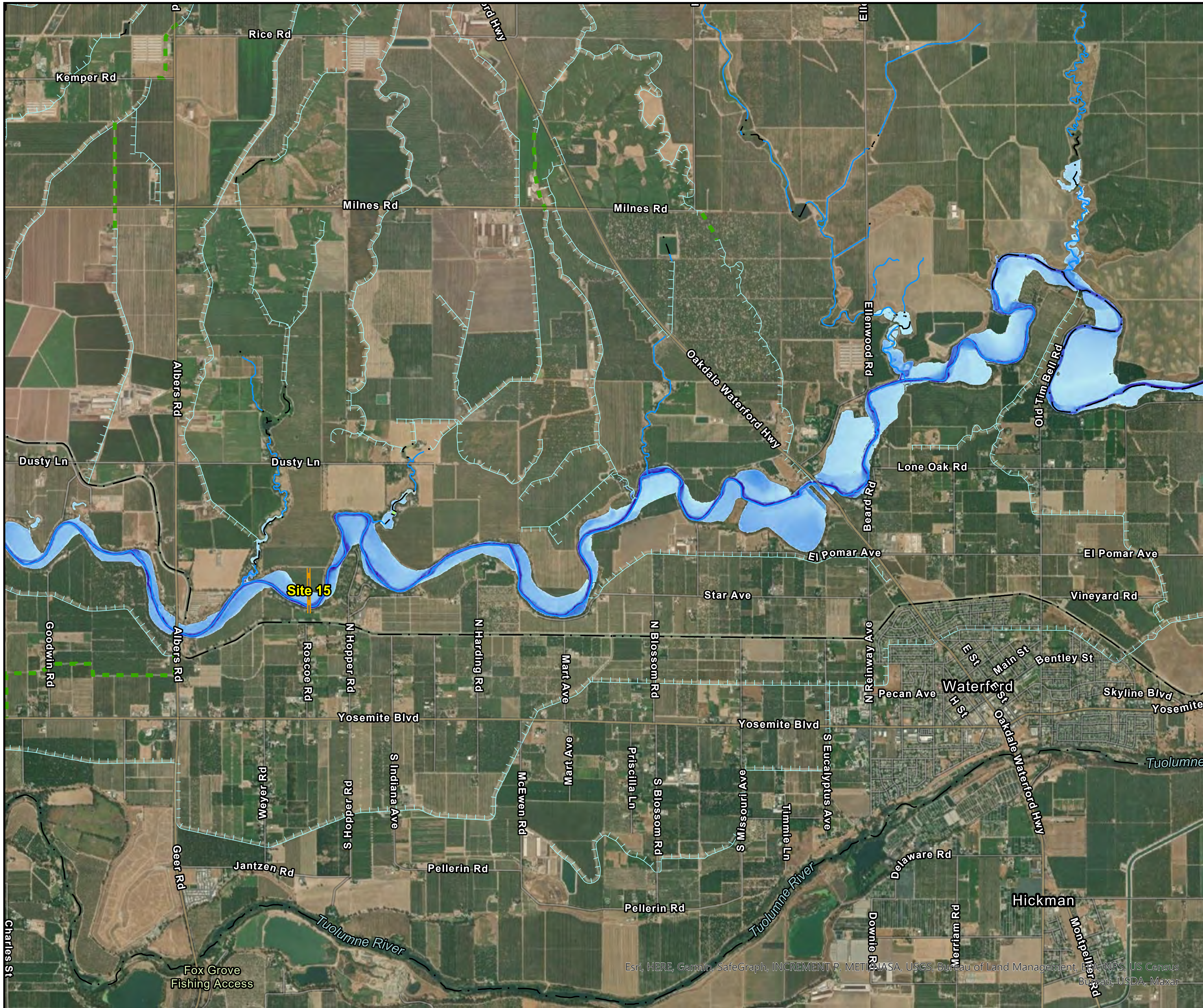

FIGURE 1

SITE 15
EXISTING CONDITION
MAXIMUM FLOOD DEPTH
25-YEAR STORM EVENT

PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECTS IN THE DRY CREEK WATERSHED

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2021

Legend

Site15CL

NHD_Agree

ArtificialPath

CanalDitch

Connector

Pipeline

StreamRiver

Underground Conduit

NoProject_Q25_Depth__Max

Max Depth, Feet

High : 28.0675

Low : 0.000999451

0 1,500 3,000 6,000

Feet

NORTH

WOOD RODGERS

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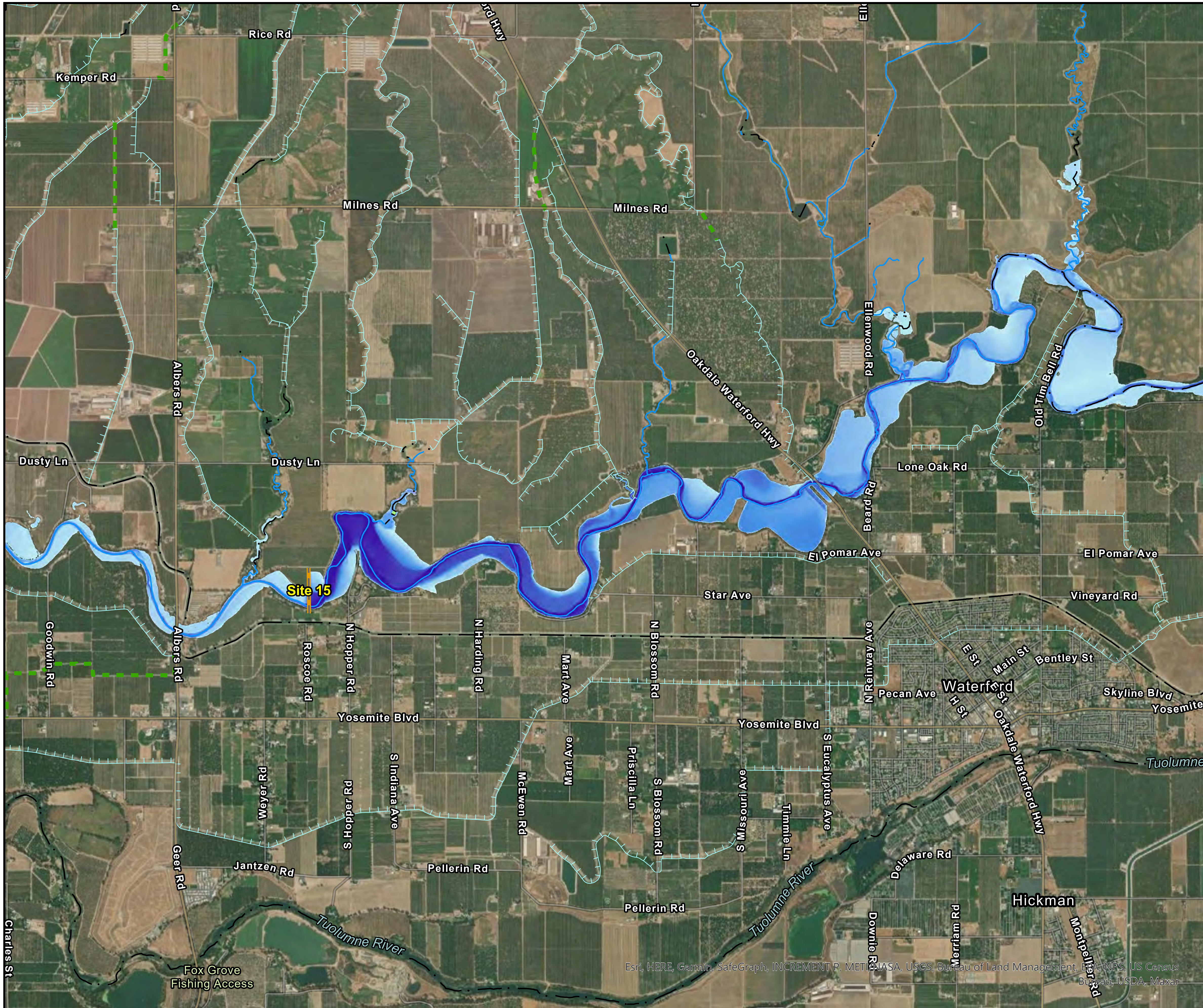
FIGURE 2

SITE 15
PROPOSED CONDITION
MAXIMUM FLOOD DEPTH
25-YEAR STORM EVENT

PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECTS IN THE DRY CREEK WATERSHED

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2021



Legend

- Site15CL

NHD_Agree

- ArtificialPath
- CanalDitch
- Connector
- Pipeline
- StreamRiver
- Underground Conduit

Site15Q25Depth__Max

Value

High : 36.2267

Low : 0.000999451

0 1,500 3,000 6,000

Feet

NORTH

WOOD RODGERS

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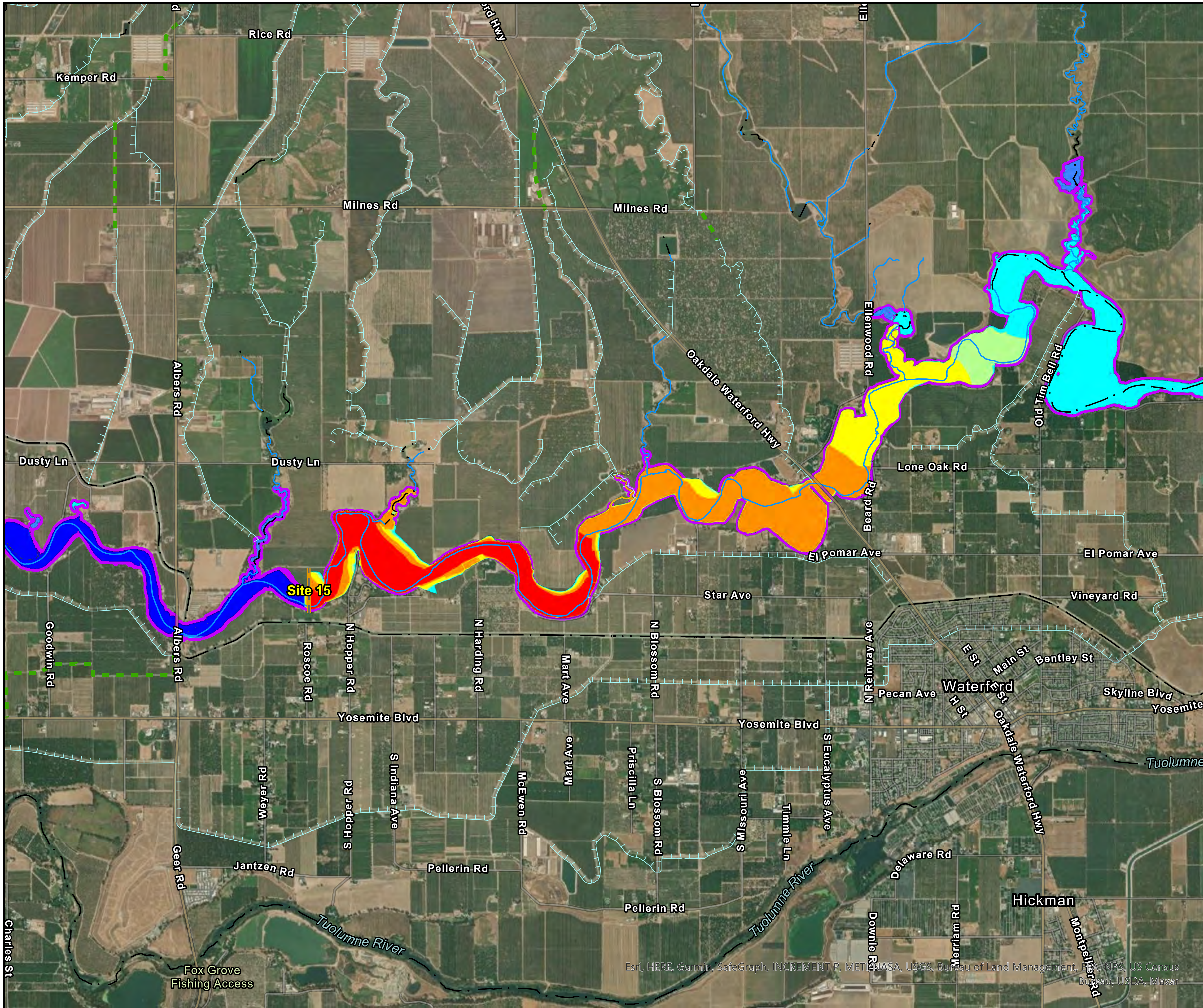
FIGURE 3

SITE 15
MAXIMUM FLOOD DEPTH INCREASE
25-YEAR STORM EVENT
PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECTS IN THE DRY CREEK WATERSHED
STANISLAUS COUNTY, CALIFORNIA
NOVEMBER 2021



Legend

- Site15CL

NHD_Agree

- ArtificialPath
- CanalDitch
- Connector
- Pipeline
- StreamRiver
- Underground Conduit

Site15_MinNoProject

Feet

- -5.8 - -1.4
- -1.4 - 0
- 0 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 17.1

NoProjectQ25_Inundation

- NoProjectQ25_Inundation

0 1,500 3,000 6,000
Feet

NORTH

WOOD RODGERS

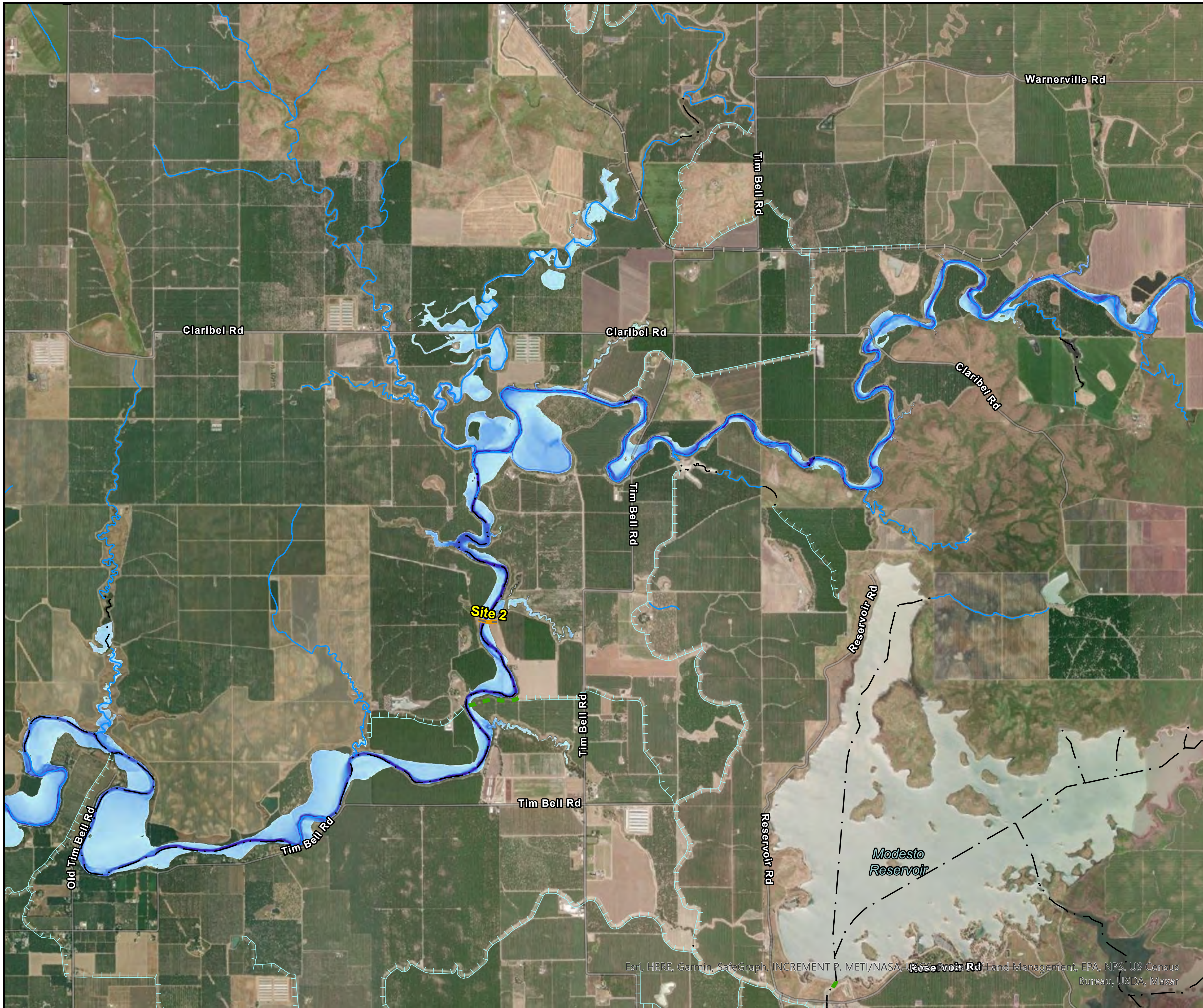


FIGURE 4

SITE 2
EXISTING CONDITION
MAXIMUM FLOOD DEPTH
25-YEAR STORM EVENT

PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECTS IN THE DRY CREEK WATERSHED

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2021

Legend

Site2CL

NHD_Agree

FType

ArtificialPath

CanalDitch

Connector

Pipeline

StreamRiver

Underground Conduit

NoProject_Q25_Depth__Max

Max Depth, Feet

High : 28.0675

Low : 0.000999451

0 1,500 3,000 6,000

Feet

NORTH

WOOD RODGERS

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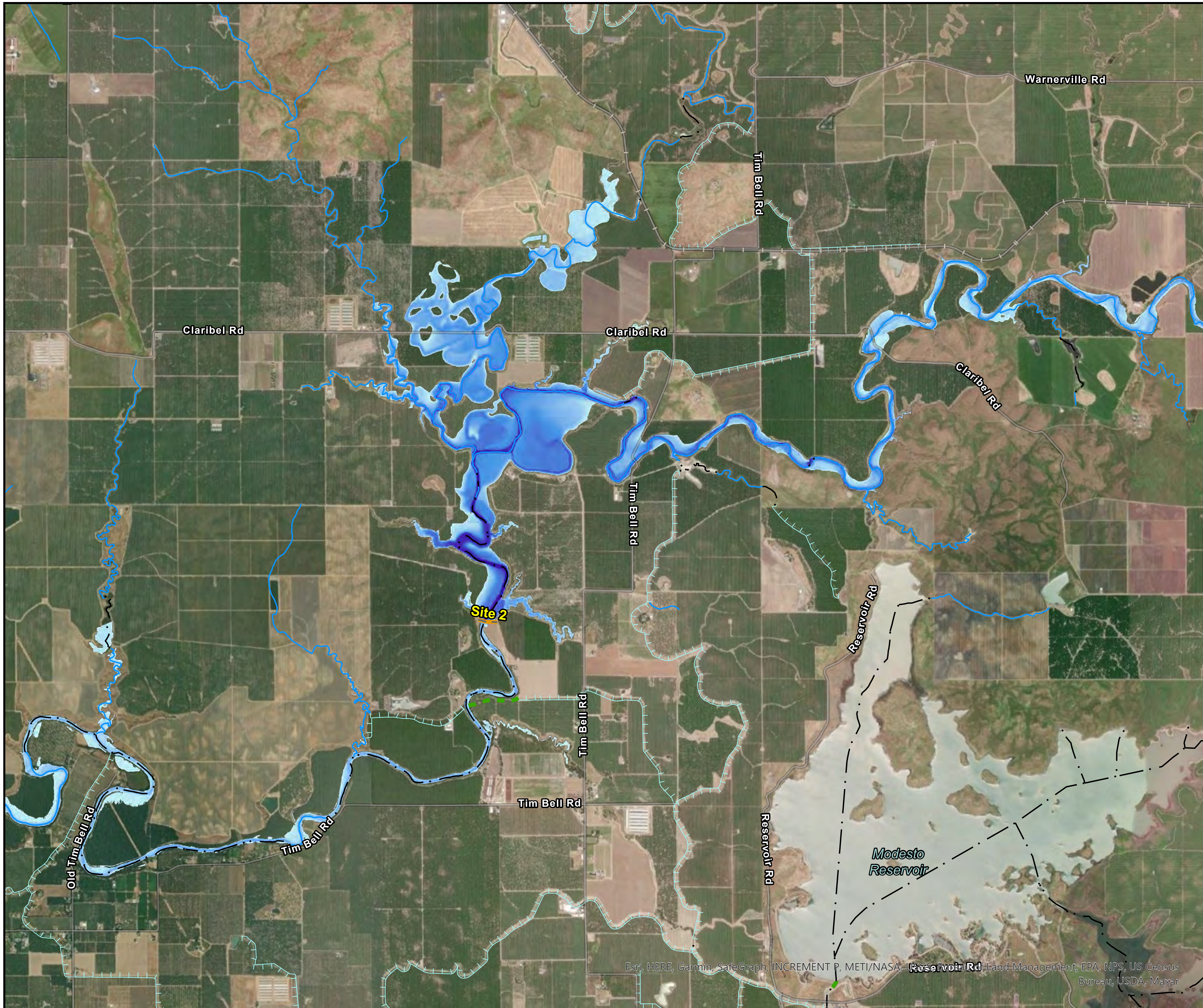

FIGURE 5

SITE 2
PROPOSED CONDITION
MAXIMUM FLOOD DEPTH
25-YEAR STORM EVENT

PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECTS IN THE DRY CREEK WATERSHED

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2021

Legend

- Site2CL

NHD_Agree

- ArtificialPath
- CanalDitch
- Connector
- Pipeline
- StreamRiver
- Underground Conduit

Site2_Q25Depth__Max

Max Depth, Feet

High : 37.0793

Low : 0.000999451

0 1,500 3,000 6,000

Feet

NORTH

WOOD RODGERS

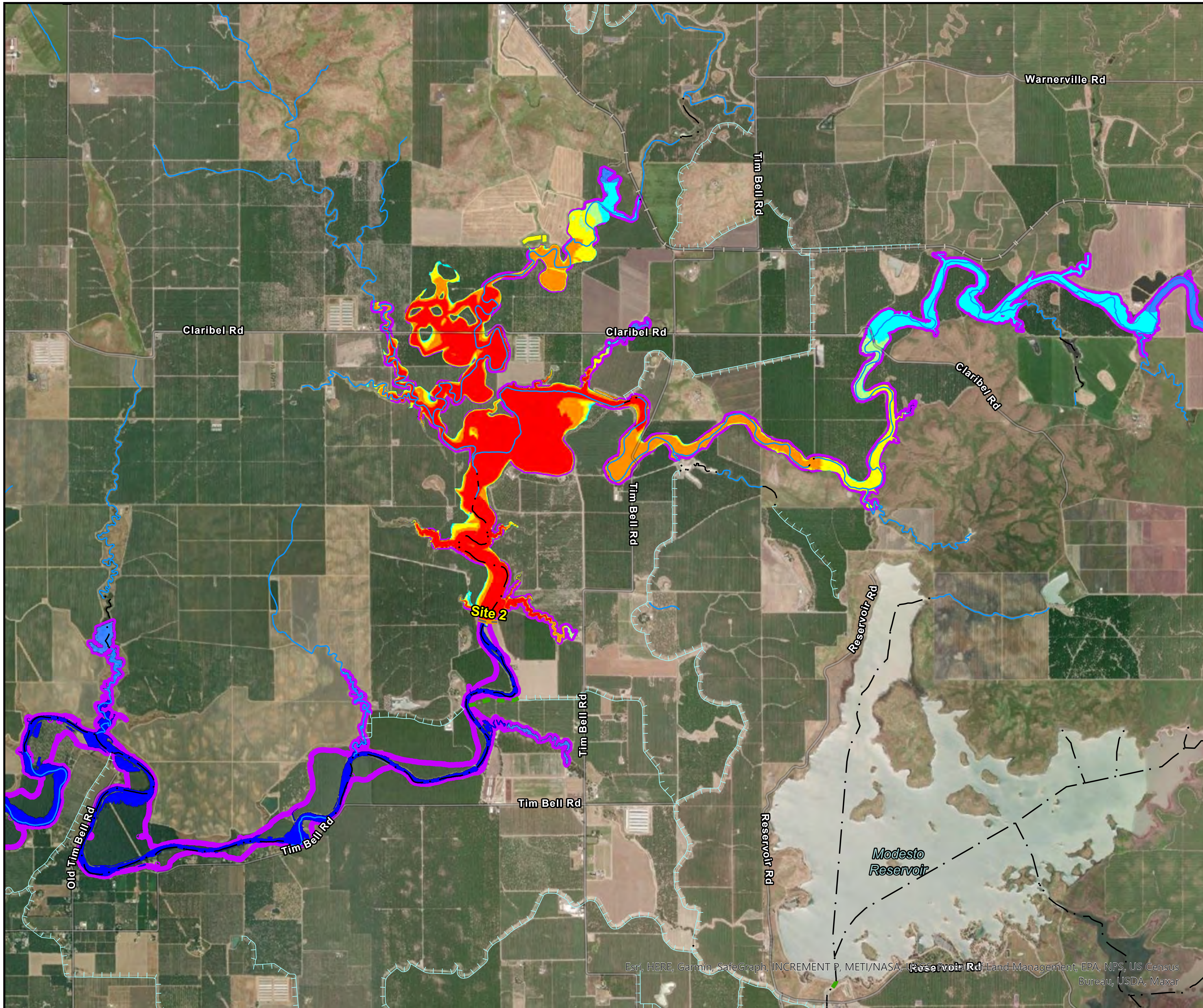

FIGURE 6

SITE 2
MAXIMUM DEPTH INCREASE
25-YEAR STORM EVENT

PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECTS IN THE DRY CREEK WATERSHED

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2021

Legend

Site2CL

NHD_Agree

ArtificialPath

CanalDitch

Connector

Pipeline

StreamRiver

Underground Conduit

Site2MinNoProject

Feet

-6.2 - -1.8

-1.8 - 0

0 - 1

1 - 2

2 - 5

5 - 10

10 - 18.1

NoProjectQ25_Inundation

NoProjectQ25_Inundation

0 1,500 3,000 6,000

Feet

NORTH

WOOD RODGERS

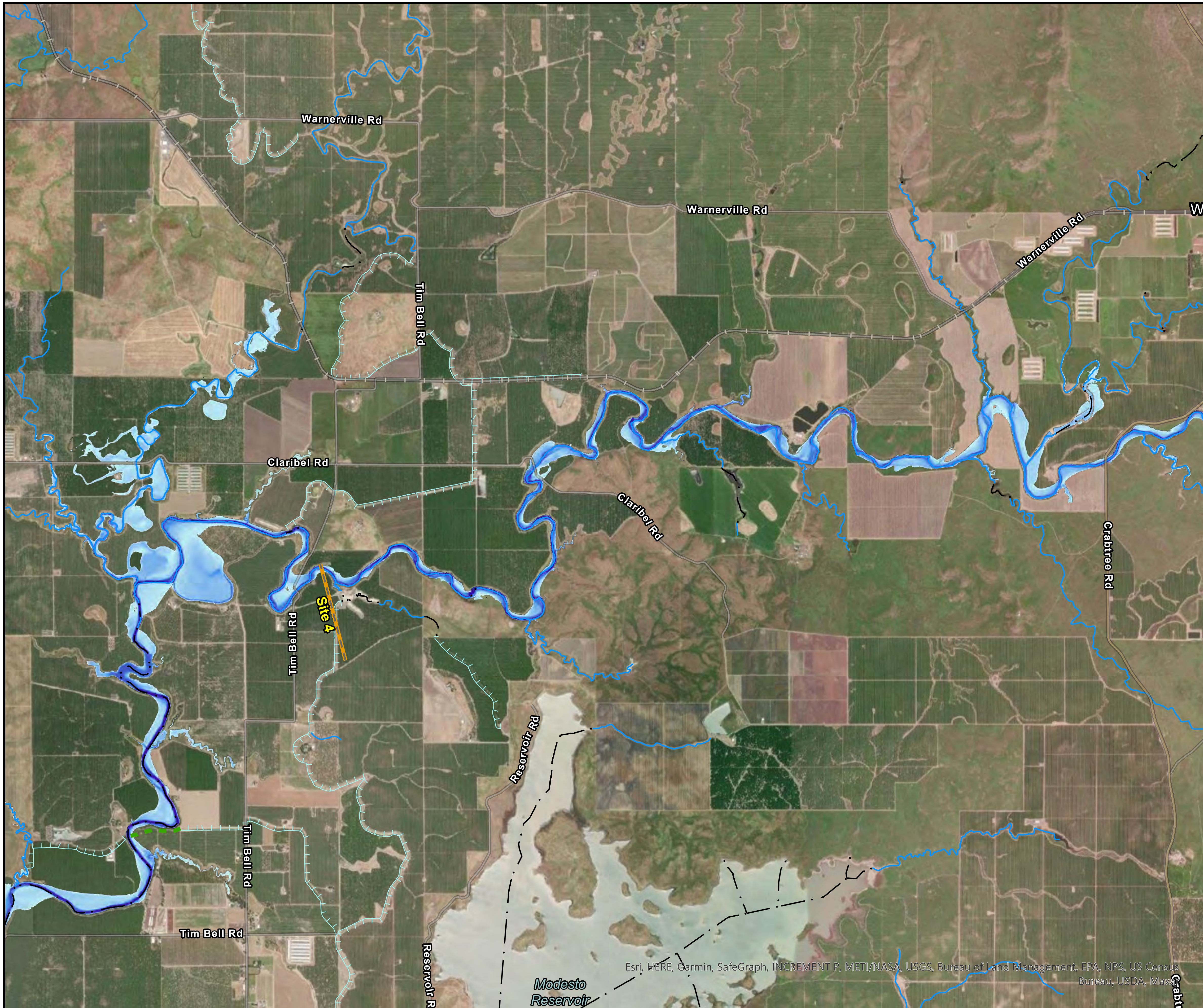

FIGURE 7

SITE 4
EXISTING CONDITION
MAXIMUM FLOOD DEPTH
25-YEAR STORM EVENT

PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECTS IN THE DRY CREEK WATERSHED

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2021

Legend

- Site4CL

NHD_Agree

- ArtificialPath
- CanalDitch
- Connector
- Pipeline
- StreamRiver
- Underground Conduit

NoProject_Q25_Depth__Max

Max Depth, Feet

High : 28.0675

Low : 0.000999451

0 1,500 3,000 6,000
Feet

NORTH

WOOD RODGERS

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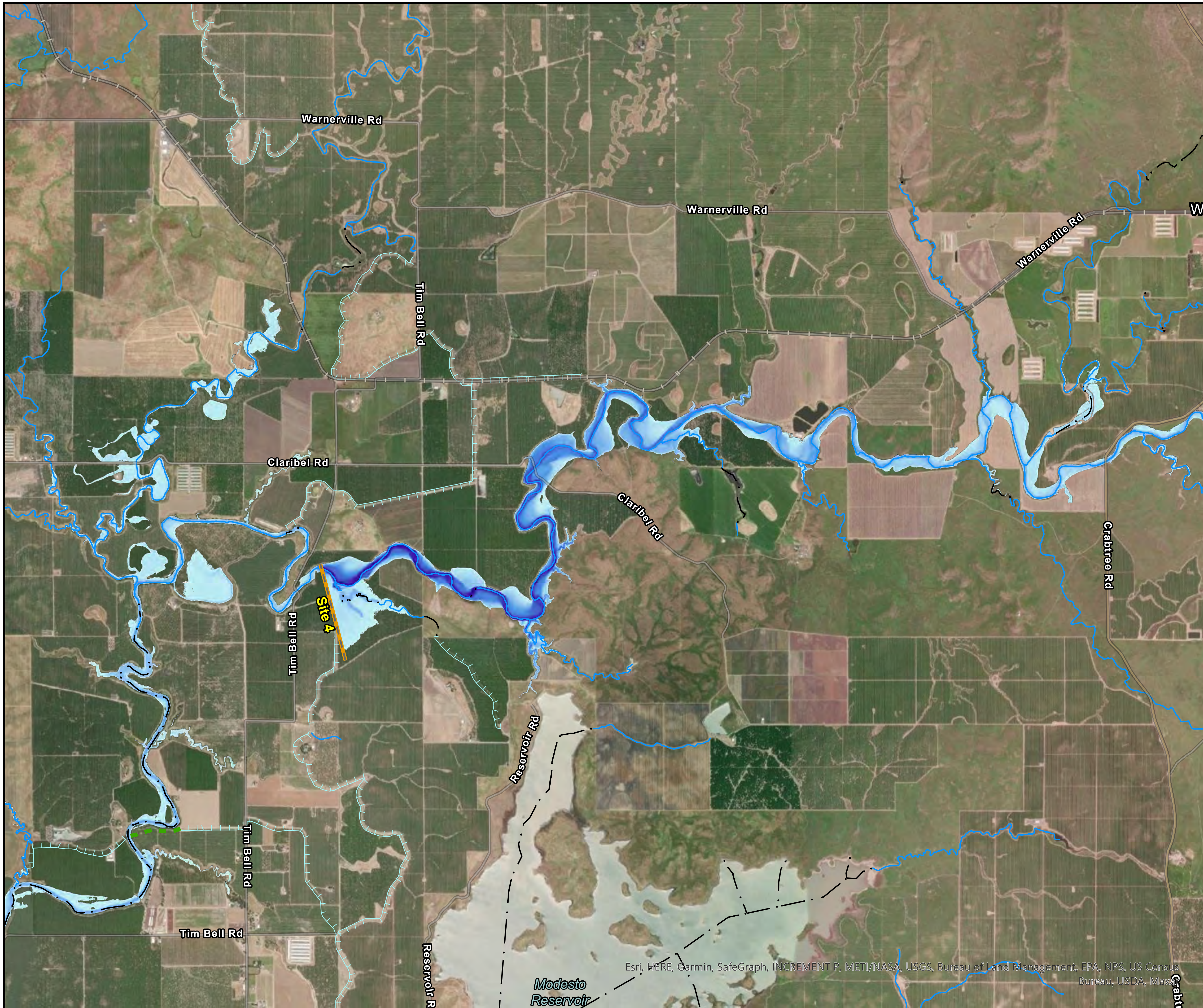

FIGURE 8

SITE 4
PROPOSED CONDITION
MAXIMUM FLOOD DEPTH
25-YEAR STORM EVENT

PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECTS IN THE DRY CREEK WATERSHED

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2021

Legend

Site4CL

NHD_Agree

ArtificialPath

CanalDitch

Connector

Pipeline

StreamRiver

Underground Conduit

Site4Q25MaxDepth

Max Depth, Feet

High : 52.261

Low : 0.000999451

0 1,500 3,000 6,000

Feet

NORTH

WOOD RODGERS

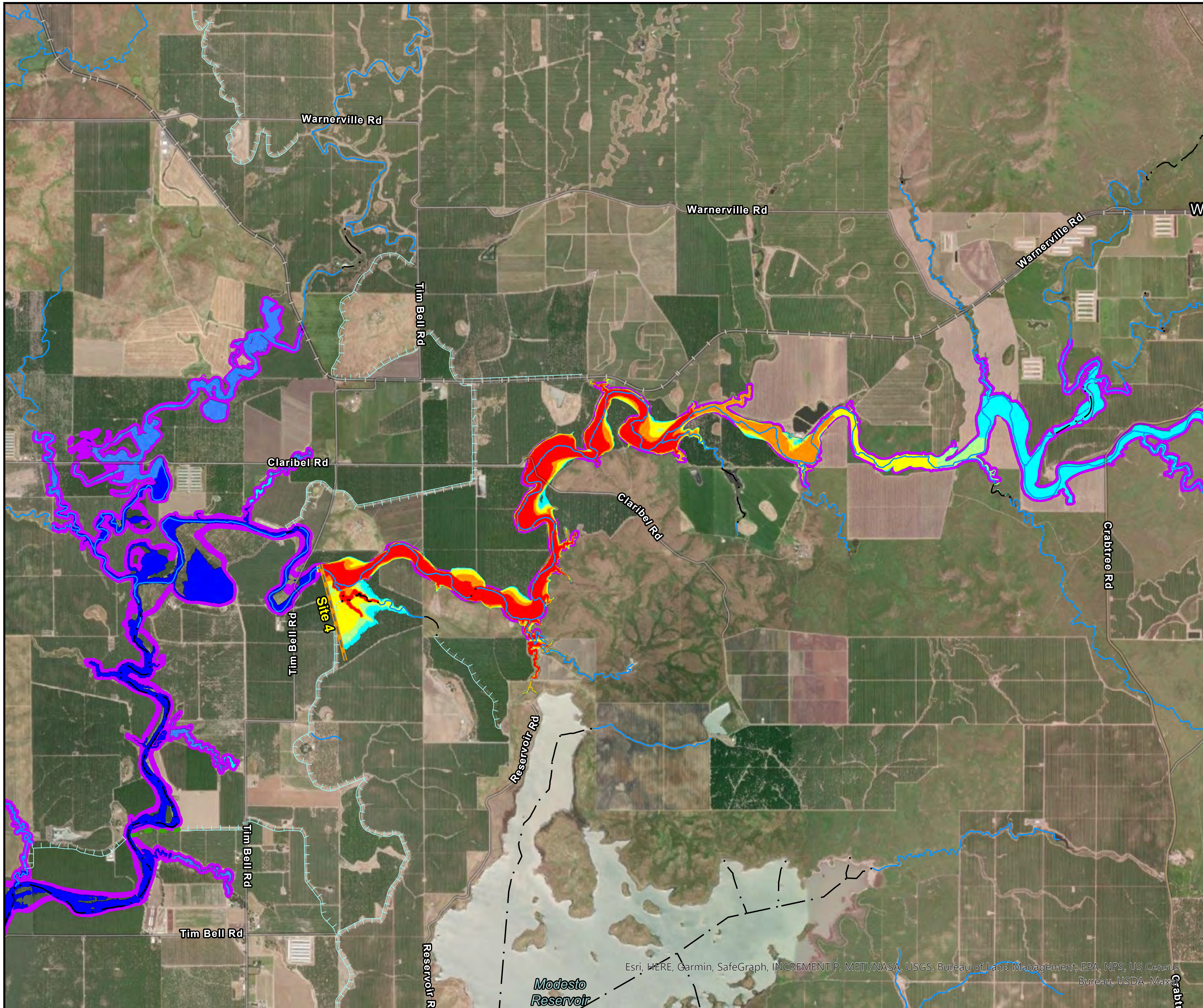

FIGURE 9

SITE 4
MAXIMUM DEPTH INCREASE
FROM NO PROJECT
25-YEAR STORM EVENT

PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECTS IN THE DRY CREEK WATERSHED

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2021

Legend

Site4CL

NHD_Agree

- ArtificialPath
- CanalDitch
- Connector
- Pipeline
- StreamRiver
- Underground Conduit

Site4MinNoProject

Feet

- -5.3 - -1.1
- -1.1 - 0
- 0 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 34.1

NoProjectQ25_Inundation

- NoProjectQ25_Inundation

0 1,500 3,000 6,000

Feet

NORTH

WOOD RODGERS

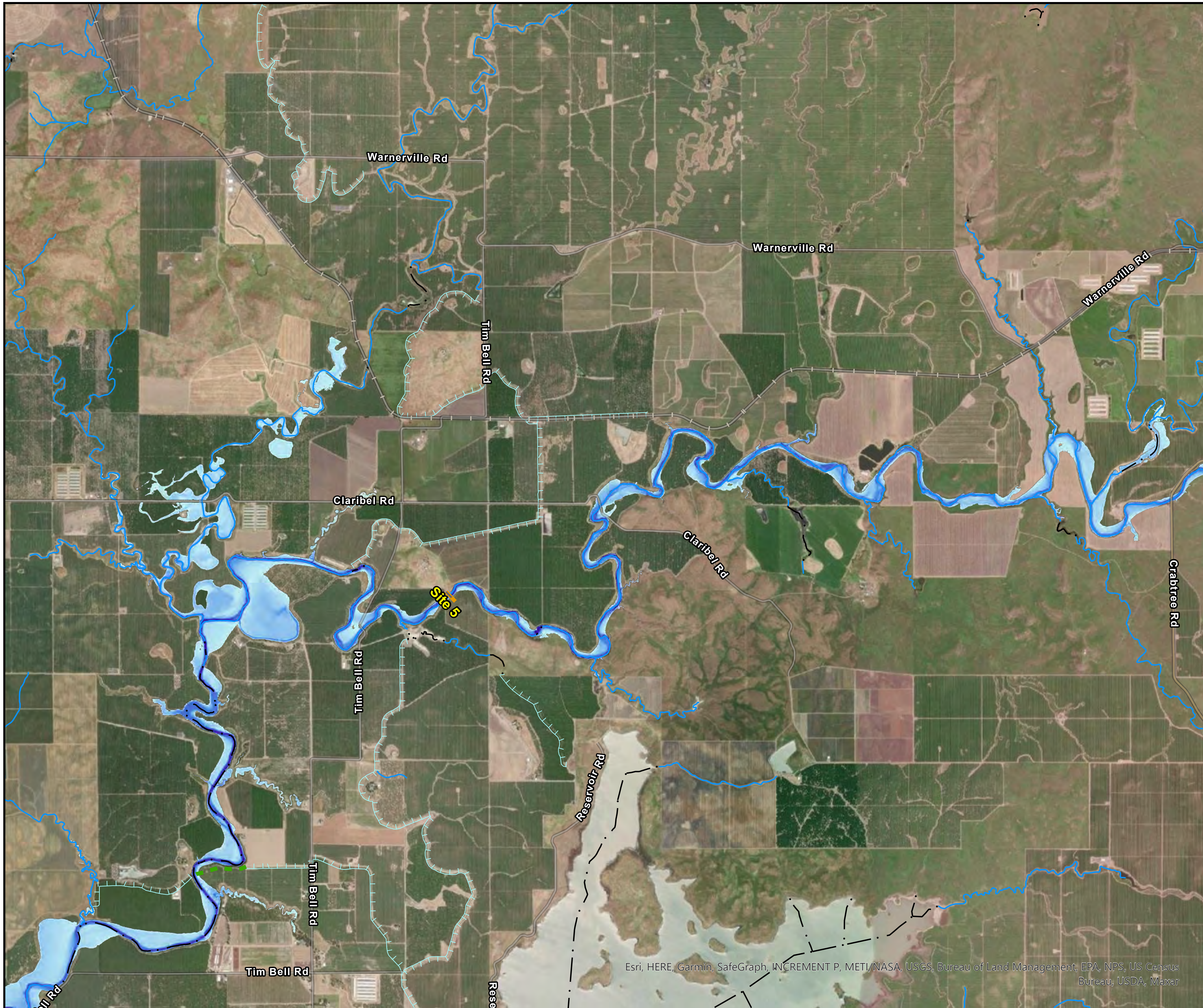

FIGURE 10

SITE 5
EXISTING CONDITION
MAXIMUM FLOOD DEPTH
25-YEAR STORM EVENT

PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECTS IN THE DRY CREEK WATERSHED

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2021

Legend

Site5CL

NHD_Agree

ArtificialPath
CanalDitch
Connector
Pipeline
StreamRiver
Underground Conduit

Value

High : 28.0675

Low : 0.000999451

0 1,500 3,000 6,000
Feet

NORTH

WOOD RODGERS

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FIGURE 11

SITE 5
PROPOSED CONDITION
MAXIMUM FLOOD DEPTH
25-YEAR STORM EVENT
PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECTS IN THE DRY CREEK WATERSHED
STANISLAUS COUNTY, CALIFORNIA
NOVEMBER 2021

WOOD RODGERS

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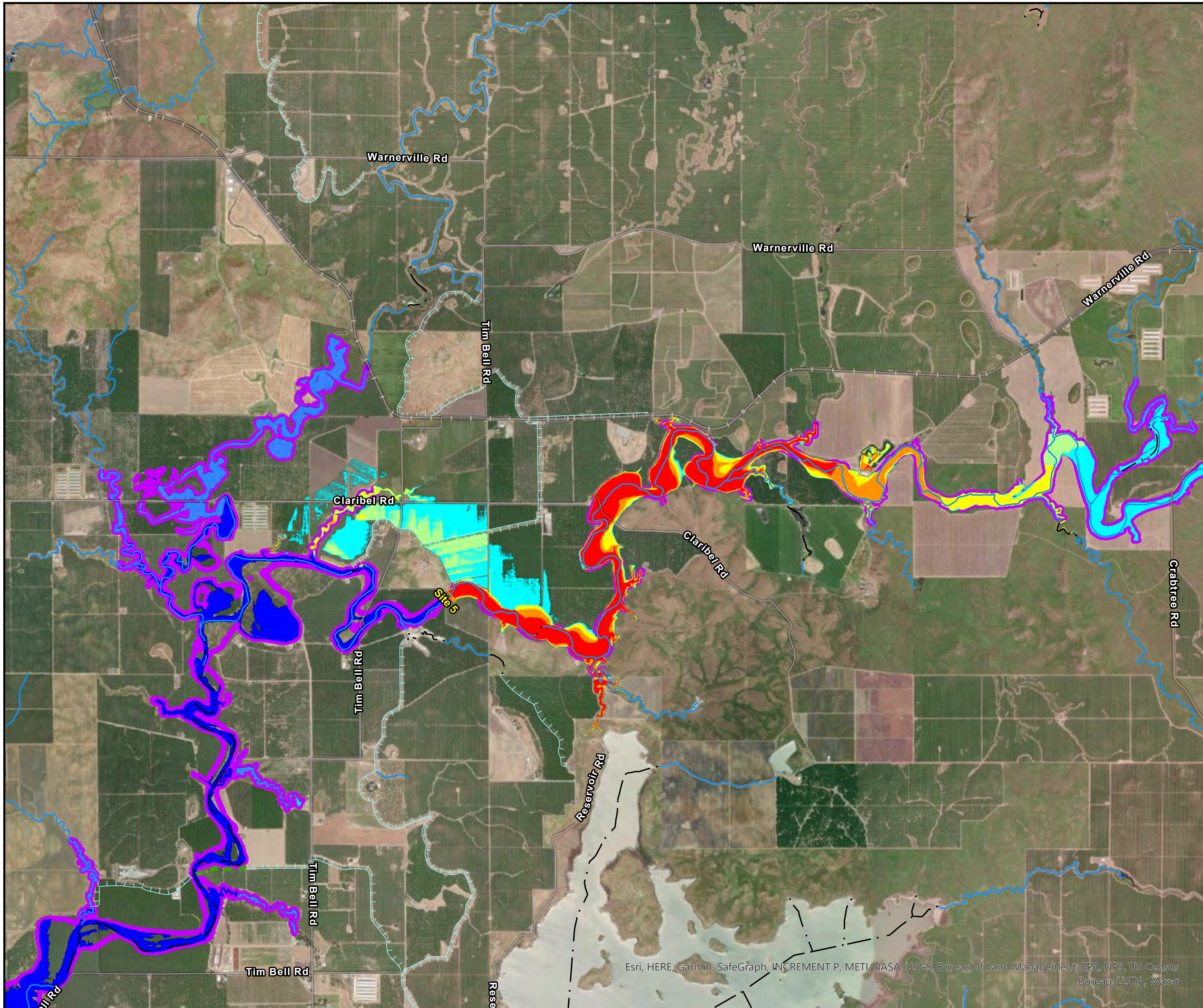

FIGURE 12

SITE 5
MAXIMUM DEPTH INCREASE
25-YEAR STORM EVENT
PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE
PROJECTS IN THE DRY CREEK WATERSHED
STANISLAUS COUNTY, CALIFORNIA
NOVEMBER 2021

Legend

Site5CL

NHD_Agree

FType

ArtificialPath
CanalDitch
Connector
Pipeline
StreamRiver
Underground Conduit

Site5MinNoProject

Feet

-4.8 - -1.1
-1.1 - 0
0 - 1
1 - 2
2 - 5
5 - 10
10 - 28.9

NoProjectQ25_Inundation

NoProjectQ25_Inundation

0 1,500 3,000 6,000
Feet

NORTH

WOOD RODGERS

D:\DryCreekFiguresV2\DryCreekFiguresV2.aprx 11/22/2021 11:00 AM dmueller

FIGURE 11

SITE 5
PROPOSED CONDITION
MAXIMUM FLOOD DEPTH
25-YEAR STORM EVENT

PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECTS IN THE DRY CREEK WATERSHED

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2021

Legend

Site5CL

NHD_Agree

FType

ArtificialPath

CanalDitch

Connector

Pipeline

StreamRiver

Underground Conduit

Site5Q25Depth__Max

Max Depth, Feet

High : 54.4151

Low : 0.000999451

0 1,500 3,000 6,000

Feet

NORTH

WOOD RODGERS

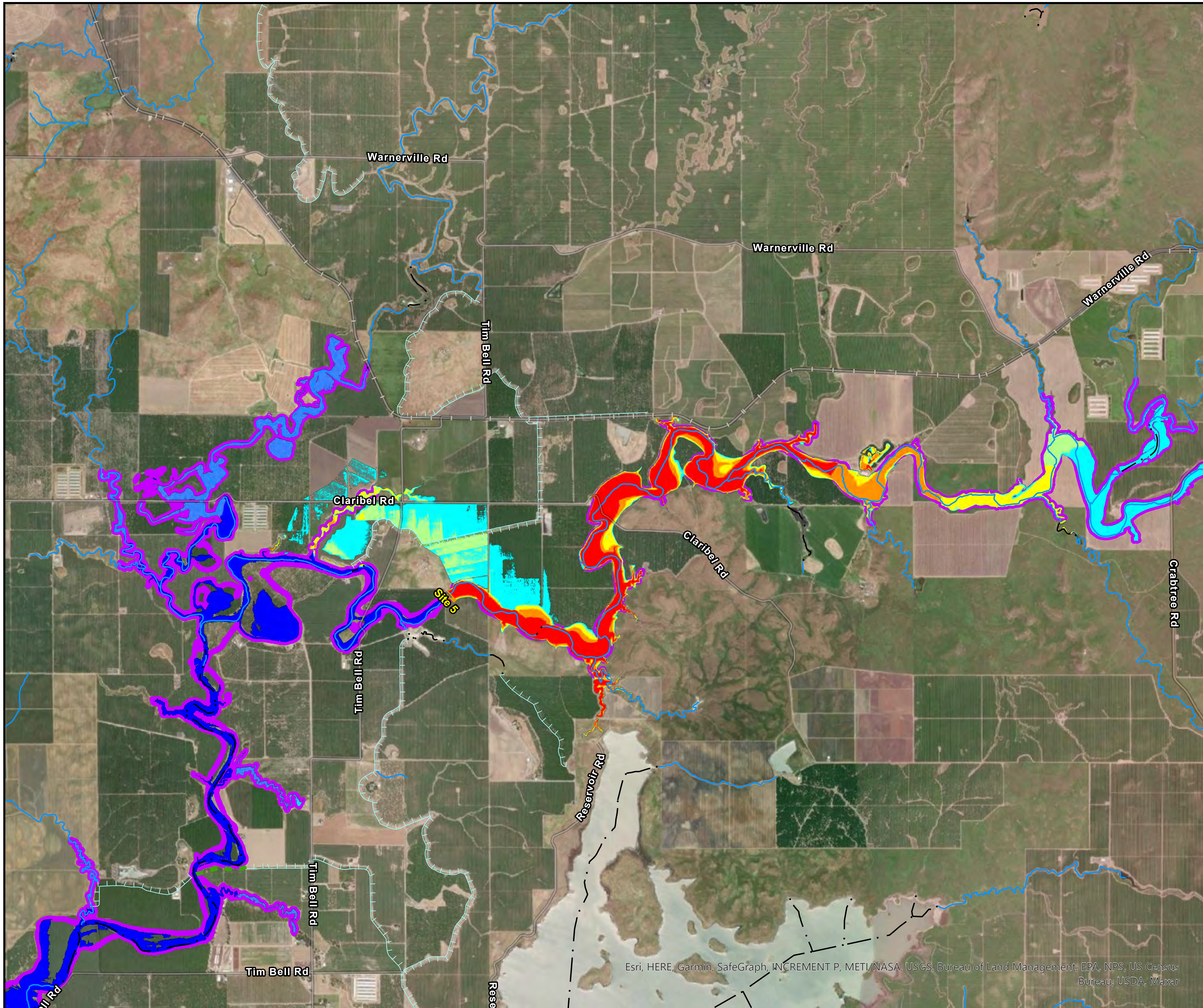

FIGURE 12

SITE 5
MAXIMUM DEPTH INCREASE
25-YEAR STORM EVENT

PHASE II EVALUATION OF STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE PROJECTS IN THE DRY CREEK WATERSHED

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2021

Legend

Site5CL

NHD_Agree

FType

ArtificialPath

CanalDitch

Connector

Pipeline

StreamRiver

Underground Conduit

Site5MinNoProject

Feet

-4.8 - -1.1

-1.1 - 0

0 - 1

1 - 2

2 - 5

5 - 10

10 - 28.9

NoProjectQ25_Inundation

NoProjectQ25_Inundation

0 1,500 3,000 6,000

Feet

NORTH

WOOD RODGERS

ATTACHMENT 3

Turlock Irrigation District

Comment Letter on Phase 1

May 20, 2022

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Michael F. Brinton, P.E.
Public Works Engineer
Roadside Drainage & Stormwater Program
1010 10th Street, Suite 4204
Modesto, CA 95354

Delivered via Electronic Mail

May 20, 2020

Technical Memorandum 2—Dry Creek Watershed Stormwater Management and Groundwater Recharge Multiple Account Analysis

Dear Mr. Brinton:

Thank you for the opportunity to review the Technical Memorandum 2 (TM-2) for the Dry Creek Watershed Stormwater Management and Groundwater Recharge Multiple Account Analysis. At this time, our comments are as follows:

In the Multiple Account Analysis matrix described in TM-2 at Table 3, two of the indicators with the highest score of 5 are flood protection and reduced flood risk to disadvantaged communities. Current flood control operations at Don Pedro Reservoir include use of flows in Dry Creek as observed at Crabtree Road in the calculation of releases from Don Pedro Reservoir. To the extent that a stormwater management reservoir on Dry Creek may interfere with the validity or usefulness of observations at Crabtree Road, said reservoir may actually *decrease* flood protection and *increase* flood risk to disadvantaged communities downstream. Any project for stormwater management on Dry Creek needs to consider current flood control methodology and mitigate or remedy any such interference to maintain or improve the levels of flood protection and risk to disadvantaged communities.

We appreciate the opportunity to comment, and, as the flood control operators for Don Pedro Reservoir, we look forward to working with you throughout this process to ensure your project produces the greatest efficacy possible with respect to flood control in the greater Tuolumne River Watershed.

Sincerely,

Wes Monier

Wes Monier
Chief Hydrologist
Turlock Irrigation District

Cc: Tou B. Her
Phil Govea
Debbie Liebersbach
Jason A. Carkeet