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Inundation Mapping for Wallace Lake Dam

Dam #CA01314

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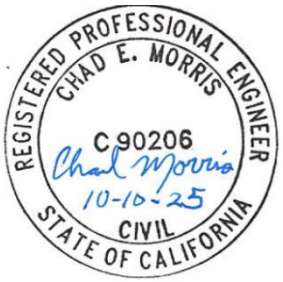

Verdantas Project No: 37670

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Flow Labs

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1. Executive Summary

Verdantas was tasked with delivering inundation mapping and an Emergency Action Plan (EAP) for Wallace Lake Dam No. 499 (CA01314) in Calaveras County, California, in compliance with California's Division of Safety of Dams (DSOD) and Office of Emergency Services (OES) regulations. The project addresses the dam's **Significant Hazard** classification, ensuring the safety of downstream communities and infrastructure through technical studies and regulatory submissions.

The project scope includes:

- Preparation of dam breach modeling and inundation maps using state-of-the-art hydraulic analysis tools, with results showing flood extents, depths, arrival times, and affected critical facilities.
- Development of a comprehensive technical report detailing methods, data, and findings.
- Creation of an EAP, integrating inundation maps and outlining emergency response procedures to meet all DSOD and OES requirements.
- Coordination with regulatory agencies and stakeholders throughout the project.

The results presented in this flood study report are derived from dam breach modeling conducted to generate the required inundation maps. This report fulfills Task 2 as outlined in the scope of work. Development of the EAP will proceed once the inundation mapping included herein has been reviewed and approved by both the client and DSOD.

2. Introduction

The California Department of Water Resources (DWR) has adopted emergency regulations under Title 23 of the California Code of Regulations (CCR), requiring development of inundation mapping and an EAP for all dams under the jurisdiction of DSOD that pose a significant risk to people and/or property in the event of failure.

Wallace Lake Dam (No. 499), owned and operated by the Wallace Lake Community Services District, has been classified by DSOD as a **Significant Hazard** dam and is therefore subject to Title 23 regulations. Dams with this classification are typically located in rural areas where a failure would result in economic losses, such as structural or agricultural damage, but where loss of life is considered unlikely.

This report, along with the attached inundation mapping, is intended to satisfy DSOD's regulatory requirements for Wallace Lake Dam. It outlines methodology followed in accordance with DSOD guidelines. All elevations in this report are based on the North American Vertical Datum of 1988 (NAVD88).

2.1.1 Background

Wallace Lake Dam is located in Calaveras County, just east of the town of Wallace, as shown in Figure 2-1. Project Site Location (Google Earth, 2025).. According to design drawings, the dam was completed in 1982 adjacent to Bear Creek to support water supply and irrigation needs. Nestled in the foothills of the Sierra Nevada, Wallace Lake has a contributing drainage area of about 1.1 square miles and is impounded by a 700-foot long earthen dam crest, with a peak storage capacity of approximately 400 acre-feet (ac-ft) and a dam crest elevation of 257.89 feet. The emergency spillway is set at an invert elevation of 252.69 feet, which was used as the maximum pool elevation in the breach modeling analysis. Table 2-1 provides a summary of the dam and reservoir characteristics.

Figure 2-1. Project Site Location (Google Earth, 2025).

Table 2-1: Dam and Reservoir Data.

Dam	
Name:	Wallace
DSOD Dam Number:	499[1]
National ID Number:	CA01314[1]
Location:	Lat: 38˚11'39" Long: 120˚58'19"
Name and Location of Affected Areas:	Wallace, CA; Bear Creek; Route 12
Type of Construction:	Earthen
Elevation of Dam Crest (ft):	257.89
Elevation of Upstream Dam Toe (ft):	229.69
Elevation of Downstream Dam Toe (ft):	226
Height (above upstream toe):	28.2[2]
Total Freeboard (ft):	5.2
Reservoir	
Current Maximum Storage at 252.69 ft (ac-ft):	400[3]
Reservoir Area (ac):	33[4]

[1] From National Inventory of Dams, accessed 2025.
[2] Based on height calculation from Figure 2-2 profile. National Inventory of Dams reports dam height of 29 feet.
[3] Based on the spillway crest elevation and composite rating curve (National Inventory of Dams reports a storage volume of 410 ac-ft)
[4] Based on area calculation within GIS software.

Figure 2-2 illustrates the dam profile with station 0+00 located on the reservoir side at approximately elevation 230 feet, and the downstream toe of the dam positioned at station 5+00 near elevation 226 feet. These elevation profiles, combined with design drawings, were used to populate the characteristics summarized in Table 2-1.

The storage-elevation curve for Wallace Lake Reservoir was created by merging 2017 bathymetric survey data conducted by The Mapping Network with a digitized design curve from client documents. Since the design elevations predated NAVD88, they were converted from NGVD29 using a +2.69-foot adjustment based on NOAA's Vertical Datum Transformation tool. The adjusted data produced the curve shown in Figure 2-3.

Figure 2-3 demonstrates a strong correlation between the original design storage curve and the 2017 bathymetric survey data up to approximately 200 ac-ft, which represents the upper limit of the survey. The storage curve used in the breach model, shown as a dashed line, incorporates the full extent of the 2017 survey and is extended beyond the survey limit using the remaining portion of the original design curve to represent storage up to the dam crest.

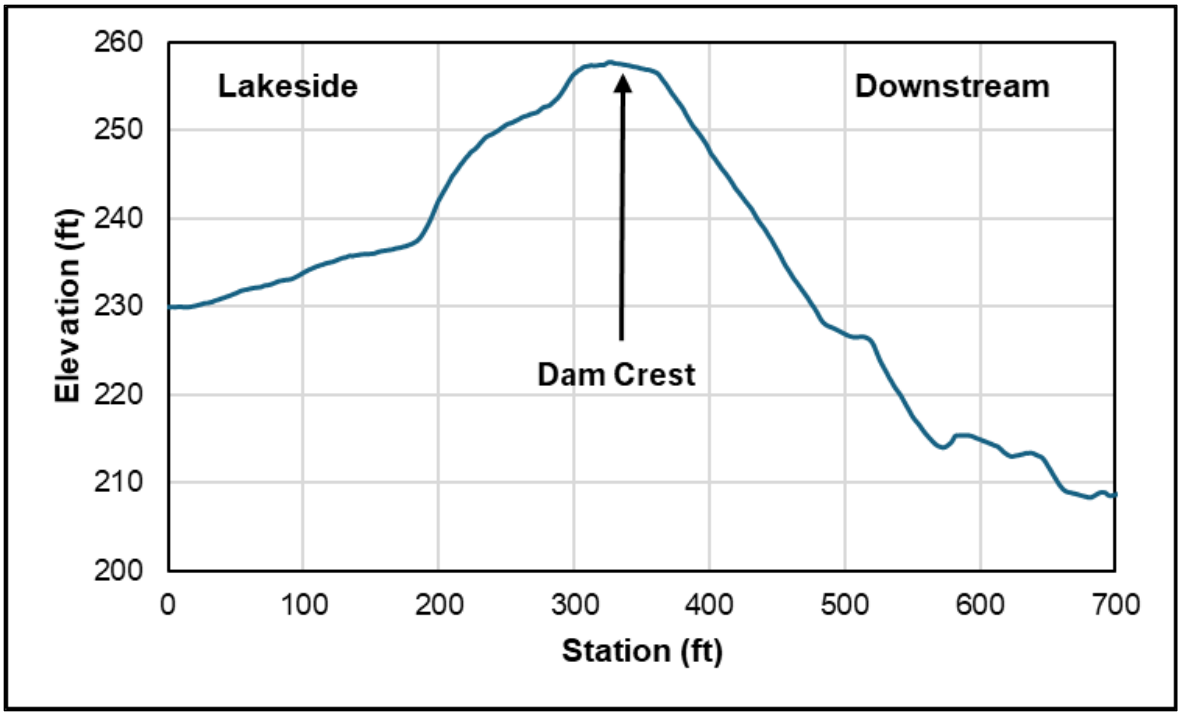

Figure 2-2: Dam Profile View (2021 LiDAR survey).

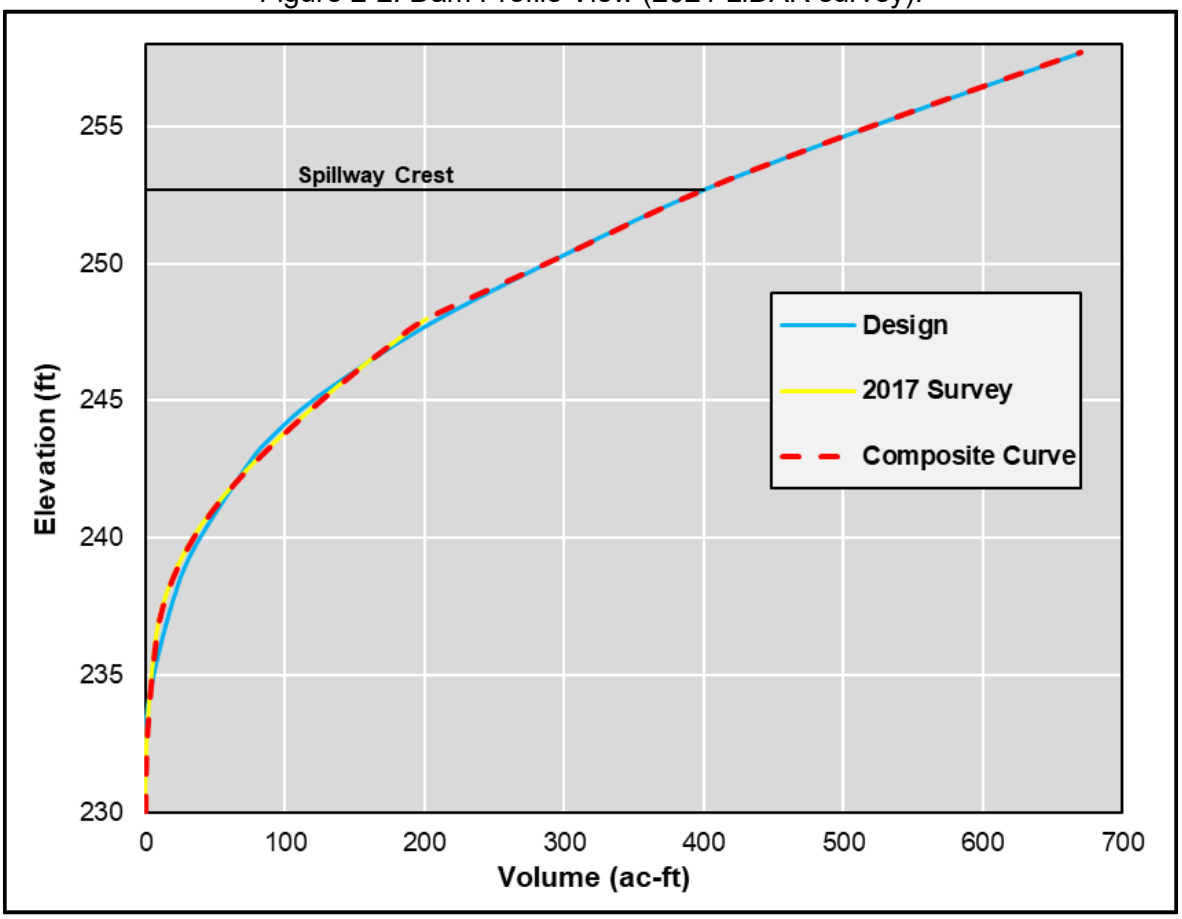

Figure 2-3: Wallace Lake Storage-Elevation Curves.

3. Model Development

A two-dimensional (2D) hydraulic model was developed to evaluate potential inundation resulting from a dam breach scenario at Wallace Lake. Verdantas utilized HEC-RAS version 6.6, developed by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers (2024). The model incorporates a 2D flow mesh extending from Wallace Lake downstream approximately 12 miles along Bear Creek. HEC-RAS 2D was selected because it is publicly available, industry standard, improved stability over one dimensional models, and the two-dimensional model handles complicated flow patterns in overbanks often experienced during dam breach events.

To balance accuracy and computational efficiency, a uniform mesh resolution of approximately 100 feet by 100 feet was selected, with approximately 10-feet by 10-feet refinement regions applied in areas requiring greater detail. Wallace Lake was modeled as a storage area with a full pool volume of 400 ac-ft, as defined by the spillway crest elevation shown in Figure 2-3.

The dam itself was represented as a 2D hydraulic connection using crest elevation data provided in the original design drawings. A uniform crest width of 60 feet was applied to the connection.

3.1 Topography

The horizontal datum used for this study is the North American Datum of 1983 (NAD83) State Plane California Zone III (feet), incorporating the 2011 adjustment. The vertical datum is NAVD88 (feet). For details on vertical datum adjustments, refer to Section 2.1.1.

Ground topography for the hydraulic model was developed using a composite surface derived from three high-resolution light detection and ranging (LiDAR) datasets to ensure the entire model domain was adequately represented:

- A 2017 dataset of the East Sacramento foothills, compiled by the U.S. Geological Survey (USGS) in partnership with the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), with a cell spacing of 2.3 feet.
- A 2021 dataset of the Sierra Nevada region, compiled by USGS in collaboration with the University of California San Diego (UCSD), with a cell spacing of 1.6 feet.
- A 2023 dataset of California levees, compiled by USGS in partnership with the Federal Emergency Management Agency (FEMA), also with a 1.6-foot cell spacing.

All datasets were downloaded as digital elevation models (DEMs) from NOAA's Digital Coast Data Access Viewer. Figure 3-1 shows the location of each of the three datasets used to build the unified digital terrain model. These DEMs were imported into HEC-RAS and merged to create a unified digital terrain surface for the study area shown in Figure 3-2.

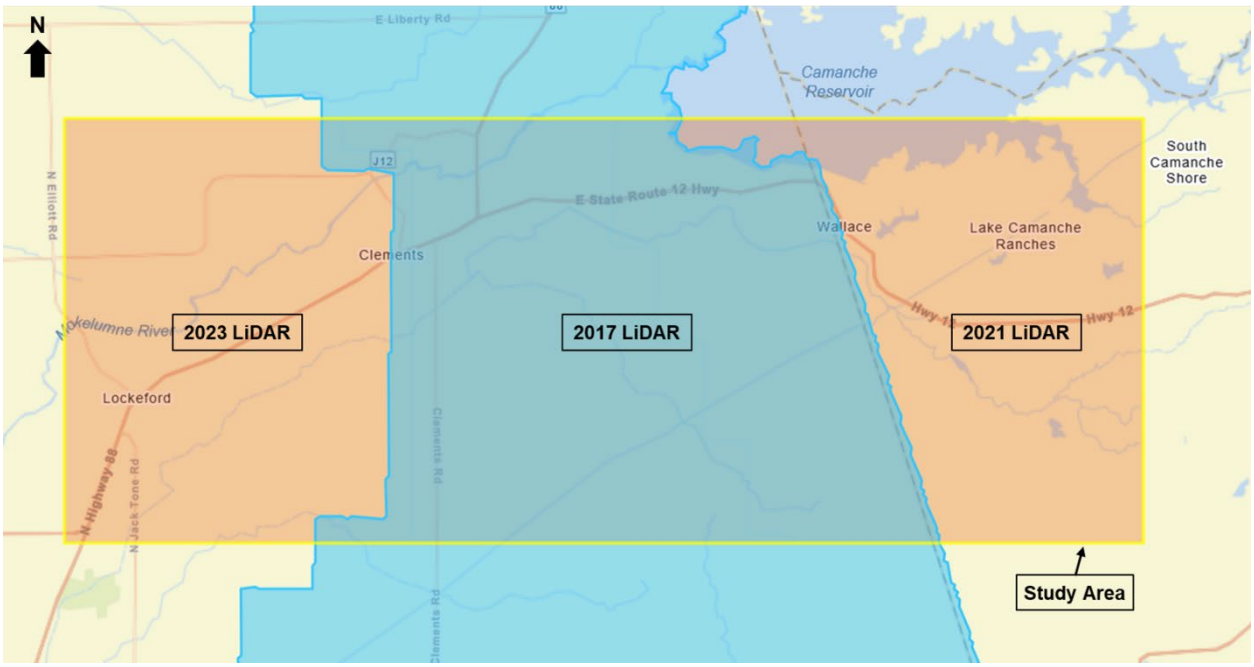

Figure 3-1. Spatial orientation of the three datasets used to generate the model terrain.

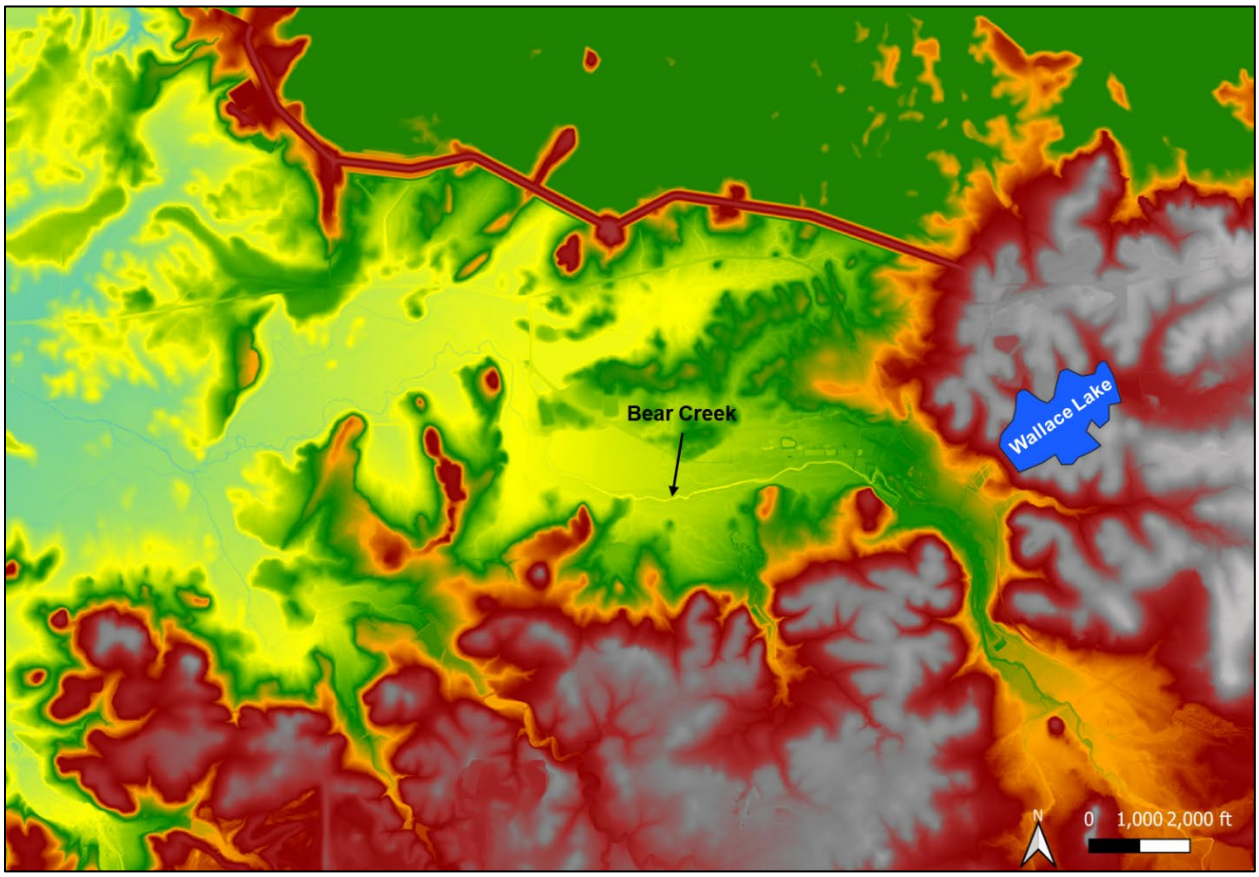

Figure 3-2: Composite topography (terrain) mapping with Wallace Lake shown filled in blue.

3.2 Manning's n Values

Manning's n roughness values[1] for the hydraulic model were derived using land cover data from the National Land Cover Database (NLCD). NLCD provides an online portal that allows users to upload a shapefile of their study area and retrieve land cover classifications organized by year. For this study, the Wallace Lake project area, shown in Figure 3-2, was uploaded to extract land cover values from the 2024 dataset, which was the most recent available.

Due to the relatively coarse resolution of the land cover data. Figure 3-3 displays the distribution of land cover classifications and the delineated refinement region along Bear Creek to better distinguish between overland and streamflow roughness. This ensures accurate roughness in hydraulically sensitive areas. Table 3-1 summarizes the land classifications and corresponding n values used in the model.

Table 3-1. Summary of NLCD and Corresponding Manning's n Values

Classification	N Value
Open Water	0.035
Developed, Open Space	0.035
Developed, Low Intensity	0.08
Developed, Medium Intensity	0.12
Developed, High Intensity	0.15
Barren Land Rock-Sand-Clay	0.03
Deciduous Forest	0.1
Evergreen Forest	0.15
Shrub-Scrub	0.07
Grassland-Herbaceous	0.04
Pasture-Hay	0.045
Cultivated Crops	0.05
Woody Wetlands	0.07
Emergent Herbaceous Wetlands	0.05

[1] Manning's n values are roughness coefficients used to calculate flow characteristics in open channels.

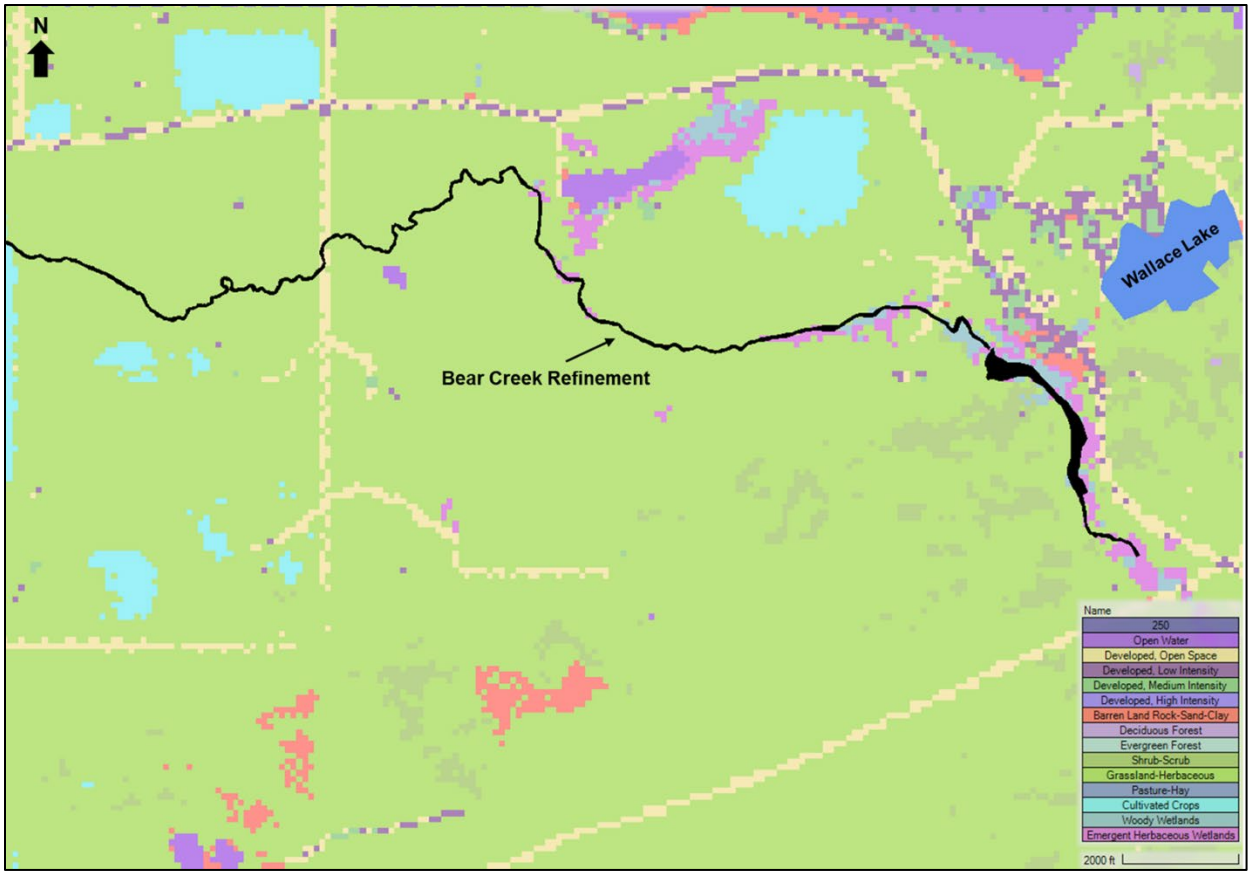

Figure 3-3: 2024 NLCD Layer showing land classification variability through different colors. Notice the winding black region denoting the Bear Creek Refinement Region.

3.3 Dam Breach Scenario

DSOD requires dam breach modeling for both the primary dam structure and any major appurtenant structures. In the case of Wallace Lake, no critical appurtenant structures are present.

Per California Code of Regulations Title 23, Section 335.6, a “Sunny Day” failure is required to meet inundation mapping requirements. A Sunny Day scenario was simulated for the earthen dam, representing a breach occurring under normal conditions with the reservoir at full capacity. For this study, the full pool elevation was set at 252.69 feet, corresponding to the emergency spillway invert elevation.

The HEC-RAS model was initialized with Wallace Lake reservoir containing a water surface elevation of 252.69 feet, equating to a total volume of 400 ac-ft. The dam was then modeled as a complete breach down to the reservoir bottom, elevation 230 feet, using a piping failure mechanism, allowing the entire reservoir volume to discharge downstream. The simulation extended approximately 12 miles downstream and ran for 32 hours, which was more than sufficient for the flood wave to attenuate. The advanced time step control was selected to allow the model to adjust the computational time step in order to maintain courant conditions between 0.49 and 1. The time step was allowed to adjust between 0.25 seconds and 8.0 seconds.

A sensitivity analysis was conducted during the model calibration phase to identify the most appropriate dam breach parameter configuration. HEC-RAS offers five empirical methods for

estimating breach parameters, all applicable to Wallace Lake due to its earthen dam classification. To conservatively represent a worst-case “Sunny Day” failure scenario, the method that produced the highest peak discharge was selected. As shown in Figure 3-4, the Von Thun & Gillette method resulted in the greatest peak outflow and was therefore used in the final breach simulation and breach parameters for the breach are summarized in Table 3-2.

Table 3-2. Summary of Breach Parameters for Von Thun & Gillette.

Breach Parameter	Value
Final Bottom Width (ft)	63
Final Bottom Elevation (ft, NAVD88)	230
Side Slopes	0.5
Breach Weir Coefficient	2.6
Breach Formation Time (hrs)	0.39
Failure Mode	piping
Piping coefficient	0.5
Initial Piping Elevation (ft, NAVD88)	247

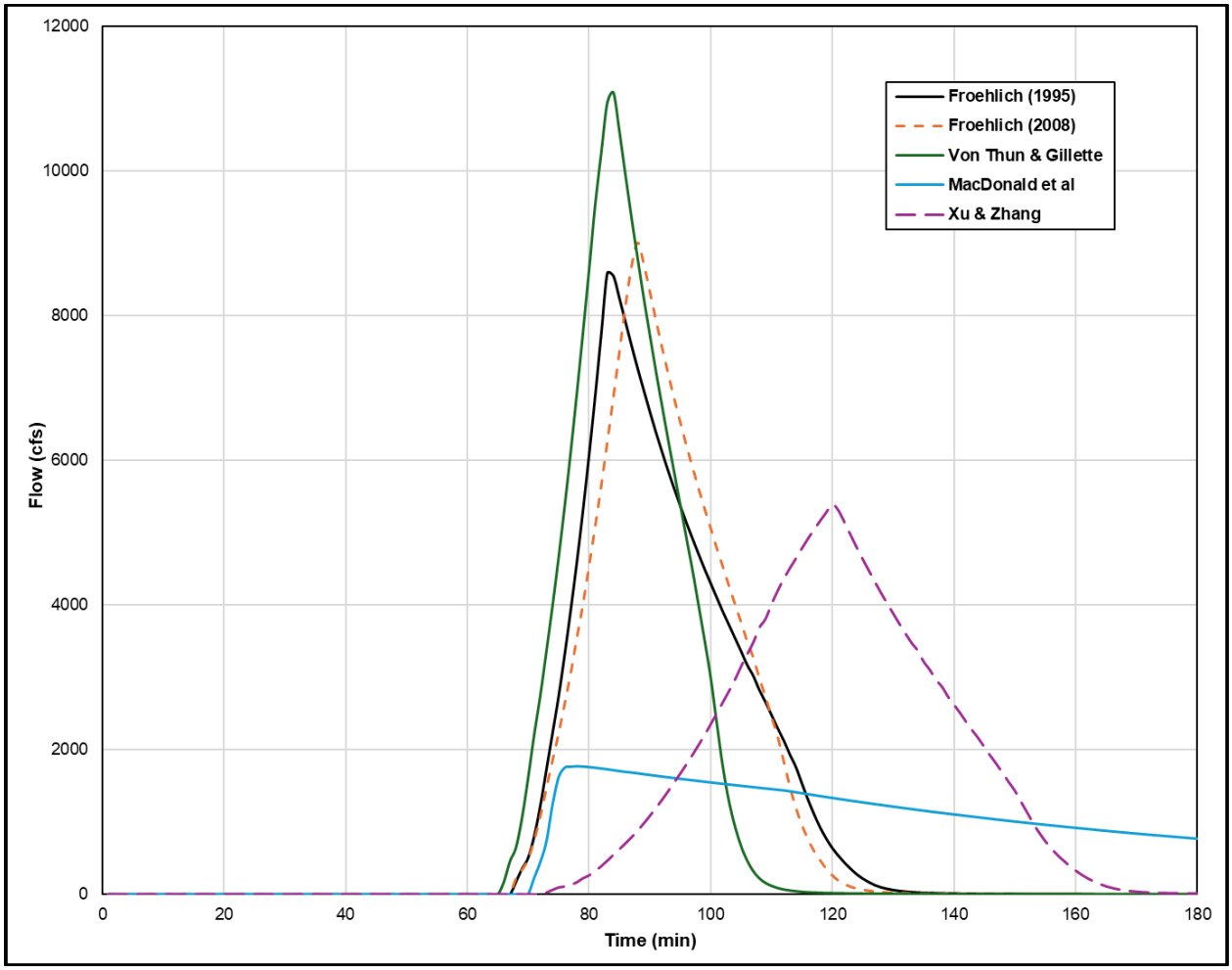

Figure 3-4: Peak Outflow for 5 Different Dam Breach Parameter Methods.

4. Results

The resultant inundation maps from the study are provided in Attachment A and were created to show the maximum extents of this failure scenario.

The peak flow of the dam breach is approximately 14,300 cubic feet per second (cfs) at the dam, which attenuates as it travels downstream along Bear Creek. The total breach volume in the model was verified as 400.24 ac-ft, consistent with the 400 ac-ft specified in the model input. From the time of the breach, the leading edge of the flood wave takes approximately 12 minutes to reach Bear Creek, traveling an average of about 8 ft/s. The flood wave continues approximately 12 miles downstream along Bear Creek, where the peak flow attenuates to about 490 cfs. This occurs about 11 hours after the breach, and the results show the flood wave is contained within the channel at a flood depth of about 8.5 feet. Table 4-1 summarizes the information conveyed by callouts on the inundation mapping.

Table 4-1: Summary of Inundation Results (see also Appendix A).

Callout ID (Stationing in feet downstream of dam)	Peak Discharge (cfs)	Peak Velocity (ft/s)	Max Depth (ft)	Arrival Time
Station 0+00	14,300	20	10.4	0 min
Highway 12	Overtopped			
Station 50+00	7,500	10	9	43.2 min
Station 100+00	4,500	7.1	9.6	1.3 hrs
Station 150+00	2,880	5.1	8.9	1.7 hrs
Cord Road	Overtopped			
Station 200+00	2,190	5.9	8.4	2.9 hrs
Station 250+00	1,760	4.3	8.3	3.3 hrs
Johnson Road	Overtopped			
Station 300+00	1,450	5.4	5.3	4.4 hrs
Station 350+00	1,250	1.9	6.3	5.3 hrs
Station 400+00	1,080	1.7	6.8	6.3 hrs
Clements Road	Overtopped			
Station 450+00	850	4.0	5.6	7.8 hrs
Station 500+00	700	3.8	6.0	8.7 hrs
Atkins Road	Overtopped			
Station 550+00	660	3.7	7.5	9.2 hrs
Station 600+00	530	1.9	6.1	10.2 hrs
Station 650+00	490	3.9	8.5	10.9 hrs

5. References

Hydrologic Engineering Center. *HEC-RAS: River Analysis System, Version 6.6*. United States Army Corps of Engineers, 30 Sept. 2024. https://www.hec.usace.army.mil/software/hec-ras/

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Wallace Lake Dam Site Plan and Detail (Original Design Documents). 1981. PDF.

Attachment A

Wallace Lake Dam Inundation Mapping

Sunny Day Failure