FINAL TECHNICAL MEMORANDUM

785 Grand Ave, Suite 202, Carlsbad, California 92008
TEL: (760) 730-0701 FAX: (415) 457-1638 e-mail: jeffs@stetsonengineers.com

TO:	Irvine Ranch Water District	DATE:	December 4, 2018
FROM:	Stetson Engineers Inc.	JOB NO:	2478-005-FF
RE:	Inundation Modeling for Syphon Canyon Dam Enlargement		

The Irvine Ranch Water District (IWRD) is planning to upgrade and enlarge Syphon Canyon Dam and Syphon Reservoir to provide additional storage capacity for recycled water. Syphon Reservoir, one of four recycled water earthen embankment reservoirs owned and operated by IRWD, currently provides seasonal storage of about 500 acre-feet (ac-ft) of recycled water. IRWD intends to enlarge the dam and increase the storage capacity of the reservoir up to about 5,000 ac-ft.

Syphon Canyon Dam is a state-regulated dam under the jurisdiction of the Department of Water Resources (DWR) and its Division of Safety of Dams (DSOD). Senate Bill 92 added Sections 6160 and 6161 to the California Water Code that became effective on June 27, 2017, requiring owners of State-regulated dams to prepare inundation maps and emergency action plans (EAPs). An inundation map was recently prepared for Syphon Canyon Dam to meet the requirements of the new regulations. The inundation extents and timing were developed using an unsteady, two-dimensional flood inundation model. As part of its planning process for expanding Syphon Reservoir, IRWD requested additional inundation modeling and mapping for the enlarged dam and reservoir.

This memorandum describes the modeling and mapping of inundation from Syphon Reservoir associated with a potential failure of an enlarged Syphon Canyon Dam. The first section of the memorandum provides background information on the reservoir and dam, and describes the scenarios which were evaluated in the model. The second section of the memorandum describes the model setup and configuration. Finally, the third section provides the model output and resulting inundation maps.

1.0 SYPHON RESERVOIR DESCRIPTION

Syphon Canyon Dam and Syphon Reservoir are located in Orange County, California, on unincorporated land, just northeast of the City of Irvine. The reservoir is located to the east of

Portola Parkway. The California state dam number is 1029.004 and the national dam number is CA00749. Figure 1 shows the location of the dam and reservoir.

Syphon Canyon Dam is located within the San Diego Creek watershed. Flood waters from a failure at Syphon Canyon Dam would drain through the City of Irvine, City of Tustin, and into Peters Canyon Wash. Peters Canyon Wash is tributary to San Diego Creek, which discharges into Newport Bay.

Syphon Canyon Dam was constructed in 1949 by The Irvine Company (TIC). IRWD purchased the reservoir from TIC in 2010. The dam is a compacted earth fill embankment with a height of 59 ft and a crest length of 843 ft. The capacity of the reservoir is 578 ac-ft[1] at the spillway crest elevation of 380.4 feet (ft) in the North American Vertical Datum of 1988 (NAVD88) (TIC, 1949).

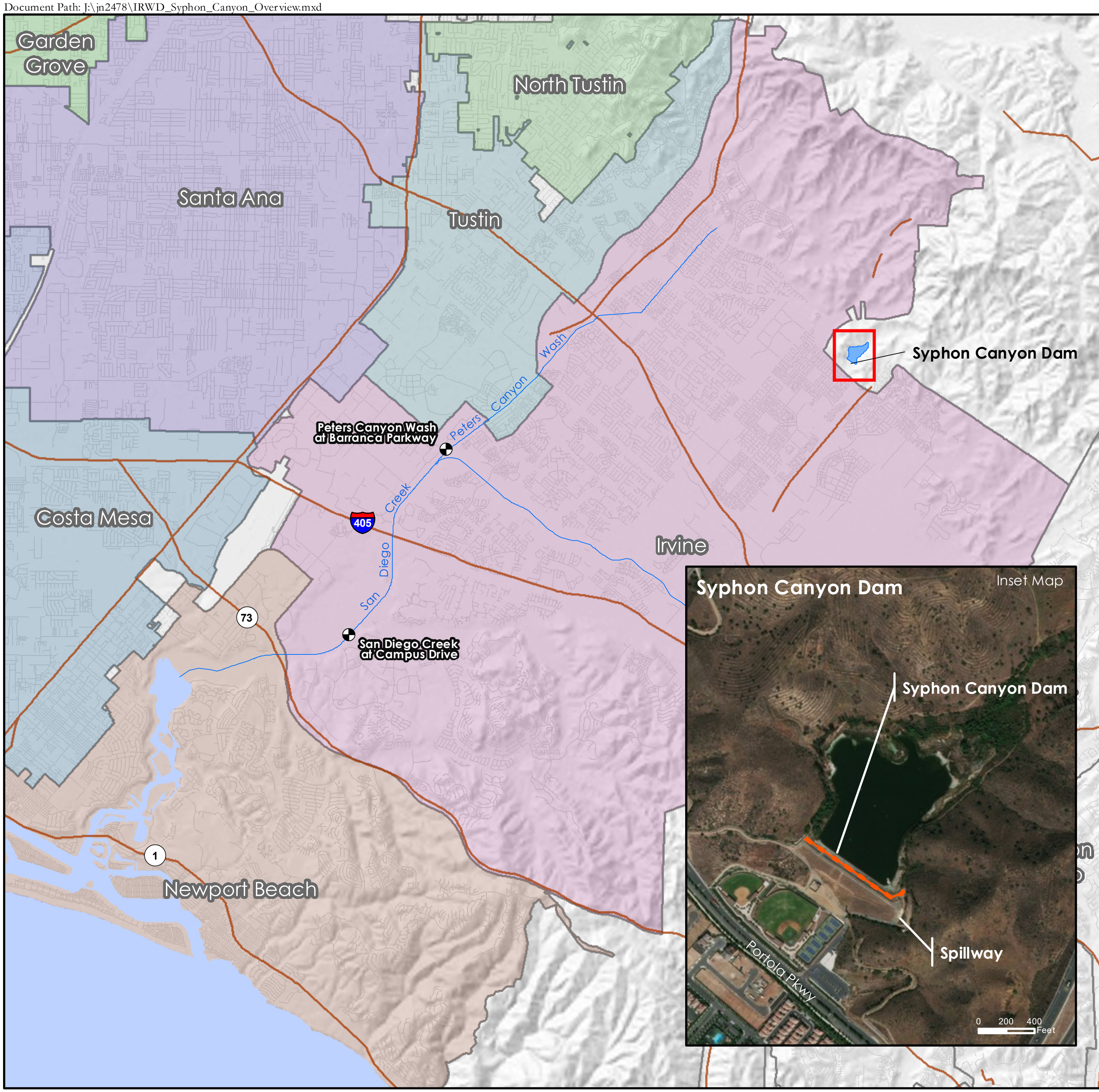
The drainage area upstream of Syphon Canyon Dam is 0.3 square miles (~200 acres). The reservoir collects natural runoff during the rainy season from this area. The original use of Syphon Reservoir was for irrigation water storage. Now, the reservoir is connected to IRWD's recycled water system, providing seasonal storage for recycled water treated at IRWD's Michelson Water Recycling Plant (MWRP). Recycled water is conveyed from the MWRP to Rattlesnake Reservoir, and then delivered to Syphon Reservoir through the Highline Canal. Syphon Reservoir has a 15-inch outlet pipe, which conveys water to a chlorination station and then into IRWD's recycled water distribution system. The dam has a concrete spillway which discharges into a concrete- and gunite-lined channel of approximately 85 ft and then transitions to overland flow down a dirt and gravel access road.

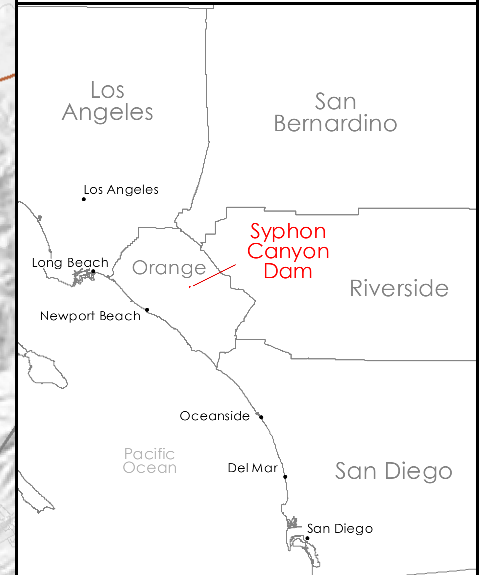
Syphon Canyon Dam is proposed to be raised about 80 ft for a new height of 136 ft (GEI, 2012). IRWD conducted an engineering feasibility study for enlarging the dam, and the conceptual design calls for enlarging the existing earthfill embankment to the new dam crest height of 466 ft NAVD88. The crest length of the enlarged dam would be about 1,300 ft. A new spillway would be constructed with a crest at 456 ft NAVD88. The enlarged dam would create reservoir capacity of approximately 5,000 ac-ft. For this technical memorandum, IRWD requested that two operating water surface elevations (WSEs) be evaluated for the enlarged dam: WSE at 440 ft NAVD88 and WSE at 455 ft NAVD88[2].

[1] 578 ac-ft is the storage capacity of the reservoir per the as-built drawings. Since construction, the capacity of the reservoir has been reduced due to sedimentation. DSOD regulations [DWR, 2018a; §335.12(c)(1)] require that jurisdictional inundation maps be based upon the maximum historical storage volume, regardless of sedimentation.
[2] Throughout this document, all ground and water surface elevations are given in the NAVD88 datum.

Document Path: J:\jn2478\IRWD_Syphon_Canyon_Overview.mxd

SYPHON CANYON DAM LOCATION
ORANGE COUNTY CALIFORNIA





Legend

- Stream Gage (Orange County Public Works)
- Creek / River
- Street
- Highway

STETSON ENGINEERS INC.

N

0 1 2 Miles

FIGURE 1

Figure 2 shows the elevation-storage curves for the existing and enlarged dams. The existing capacity curve is from the as-built drawings (TIC, 1949), with elevations shifted to NAVD88 (Stetson, 2018d). The proposed curve was developed in the dam feasibility study (GEI, 2012). The historical capacity of the reservoir is 578 ac-ft. The two proposed operating WSEs of 440 ft and 455 ft have projected storage volumes of 3,990 ac-ft and 4,870 ac-ft, respectively. The three storage volumes identified on Figure 2 – 578 ac-ft, 3,690 ac-ft, and 4,870 ac-ft – are associated with the three inundation scenarios described in this memorandum.

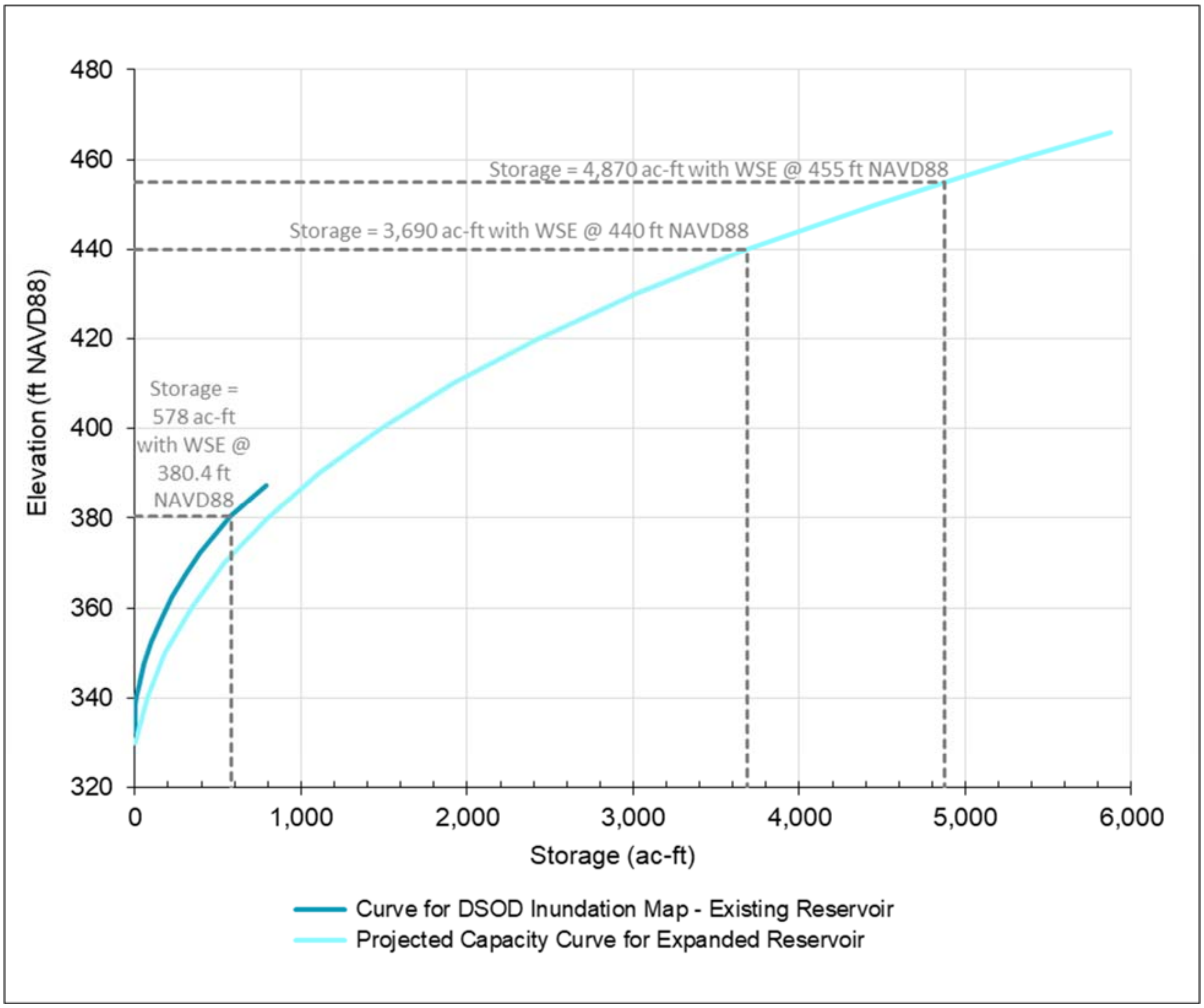


FIGURE 2 ELEVATION-STORAGE CURVE FOR EXISTING AND EXPANDED RESERVOIRS

Parameters for the existing dam failure scenario were developed to conform to current DWR/DSOD regulations. The regulatory process under sections 6160 and 6161 of the California Water Code is ongoing: several sets of emergency regulations have been adopted, most recently in July 2018 (DWR, 2018a). At the time of this writing, draft regulations had been proposed but not adopted (DWR, 2018b). Breach parameters for the existing dam scenario are documented in the technical study submitted to DSOD (Stetson, 2018d). Parameters for the existing Syphon Canyon Dam were selected in a conservative and appropriate manner, consistent with other technical studies developed for IRWD-owned dams (Stetson, 2018a; 2018b; 2018c). The existing dam breach uses a short formation time (6 minutes) and a large width (5 times the dam height).

Parameters for the enlarged dam scenarios were provided by IRWD. Breach formation time is 30 minutes and the breach width factor is 1.5 times the dam height. These factors fall within the range of appropriate values for a large embankment failure (e.g. FEMA, 2013; Table 9-3), but are more in line with a recently constructed or improved dam. Key parameters for the three scenarios are listed in Table 1.

TABLE 1 PARAMETER VALUES FOR INUNDATION SCENARIOS

Parameter	Existing (DSOD Inundation Map)[1]	Enlarged [2]	
		WSE @ 440 ft	WSE @ 455 ft
Dam Crest Elevation (ft NAVD88)	387.5	466	466
Spillway Crest Elevation (ft NAVD88)	380.4	456	456
Upstream Toe Elevation (ft NAVD88)	332.4	330	330
Barrier Height[3] (ft)	52	111.6	126.6
Downstream Toe Elevation (ft NAVD88)	328.4	328.4	328.4
Dam Height (ft)	59	136	136
Dam Crest Length (ft)	843	~1,300	~1,300
Average Breach Width Coefficient	5	1.5	1.5
Average Breach Width (ft)	295	204	204
Breach Side Slope (H:V)	0.5:1	0.5:1	0.5:1
Bottom Breach Elevation[4] (ft NAVD88)	332.4	330	330
Breach Height (ft)	55.1	136	136
Breach Duration (hrs)	0.1	0.5	0.5
Breach Volume (ac-ft)	578	3,690	4,880
Simulated WSE during Breach (ft NAVD88)	380.4	440	455

Notes:
1. Parameters developed per DSOD emergency regulations (DWR, 2018a; Stetson, 2018d).
2. Parameters provided by IRWD.
3. Barrier height is the difference between the maximum water surface elevation and the downstream toe.
4. Bottom breach elevation is lower in the enlarged scenarios: the proposed project assumes excavation of the reservoir and a lower minimum storage elevation.

2.0 DAM FAILURE INUNDATION MODEL DESCRIPTION

This study utilized the Hydrologic Engineering Center River Analysis System (HEC-RAS) version 5.0.5, released June 2018. Model setup and configuration of the existing dam failure model is documented in detail in the technical study report submitted to DSOD (Stetson, 2018d). The model setup is reviewed and summarized here, and modifications made to simulate the future scenarios are described.

The HEC-RAS model used a high-resolution digital elevation model (DEM) obtained from Orange County Public Works (OCPW, 2017). All modeling was done in the California Teale Albers (ft) projection, as required by DSOD. The DEM resolution is 1 meter (3.28 ft). The model horizontal datum is North American Datum 1983 and the vertical datum is NAVD88. The extent of the DEM is shown in Figure 3. The model domain extends from Syphon Canyon Dam to the Pacific Ocean and includes Peters Canyon Wash, San Diego Creek, and Newport Bay.

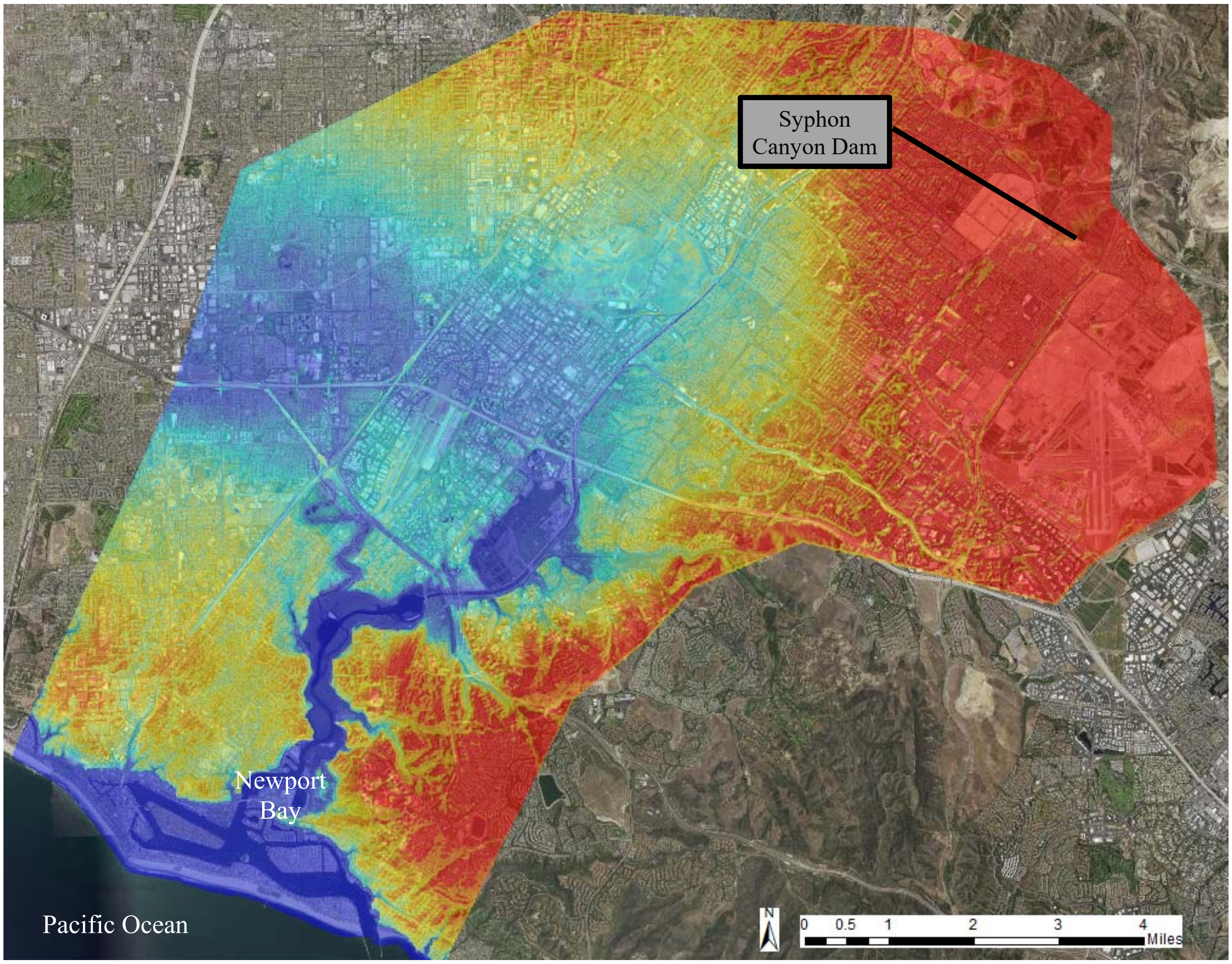


FIGURE 3 EXTENT OF TERRAIN DATA (DEM) USED IN MODEL

The unsteady, two-dimensional HEC-RAS model was configured for sunny day failure scenarios. Sunny day baseflow of 14.5 cubic feet per second (cfs) was included in Peters Canyon Wash and San Diego Creek, but did not significantly affect the model results. The Mean Higher High Water (MHHW) level was used as the initial water surface elevation in Newport Bay. The MHHW elevation is 5.23 ft NAVD88, per data at the National Oceanic and Atmospheric Administration (NOAA) station No. #9410580 at Newport Beach (NOAA, 2018).

The model was run for a duration of 48 hours. A regular model grid size of 50 ft was used, though refinements were made in some areas of the model to capture smaller terrain features. Hydraulic structures such as culverts and storm drains were not added to the model geometry, as they were assumed to be clogged due to the potential for high loads of sediment and debris during a breach. Road overpasses and bridges were modeled as open; if necessary, the DEM was modified to open the flow path under the overpass or bridge.

Manning's *n* roughness values were developed with land use and vegetation coverages. A spatially-varying roughness layer was created. Manning's *n* values range from 0.016 for roads up to 0.09 for urban areas with many obstructions. Sensitivity testing was done in the existing dam model to determine the best approach for selecting Manning's *n* values.

Breach parameters were configured to simulate a piping failure on a sunny day. HEC-RAS 5.0.5 was used with the 'User Entered Data' breach method. Values from Table 1 were configured for each scenario. Figure 4 shows the breach configuration for the existing dam. The initial WSE in this scenario was 380.4 ft, the crest of the existing spillway.

Figures 5 and 6 show the breach configurations for the enlarged dam scenarios with initial WSE at 440 ft and 455 ft, respectively. In both of the future scenarios, the dam height, crest length, and breach geometry are the same size, but the initial WSEs differ.

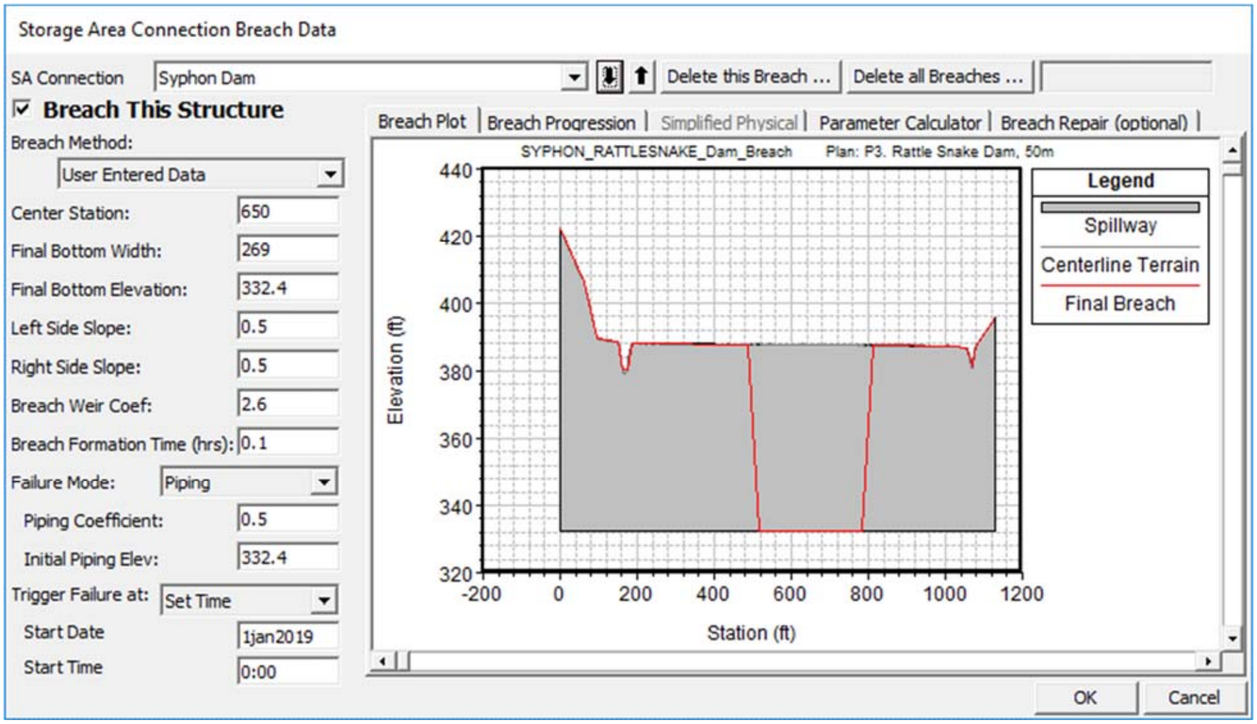


FIGURE 4 SCREEN CAPTURE OF BREACH PARAMETERS USED FOR EXISTING DAM SUNNY DAY FAILURE

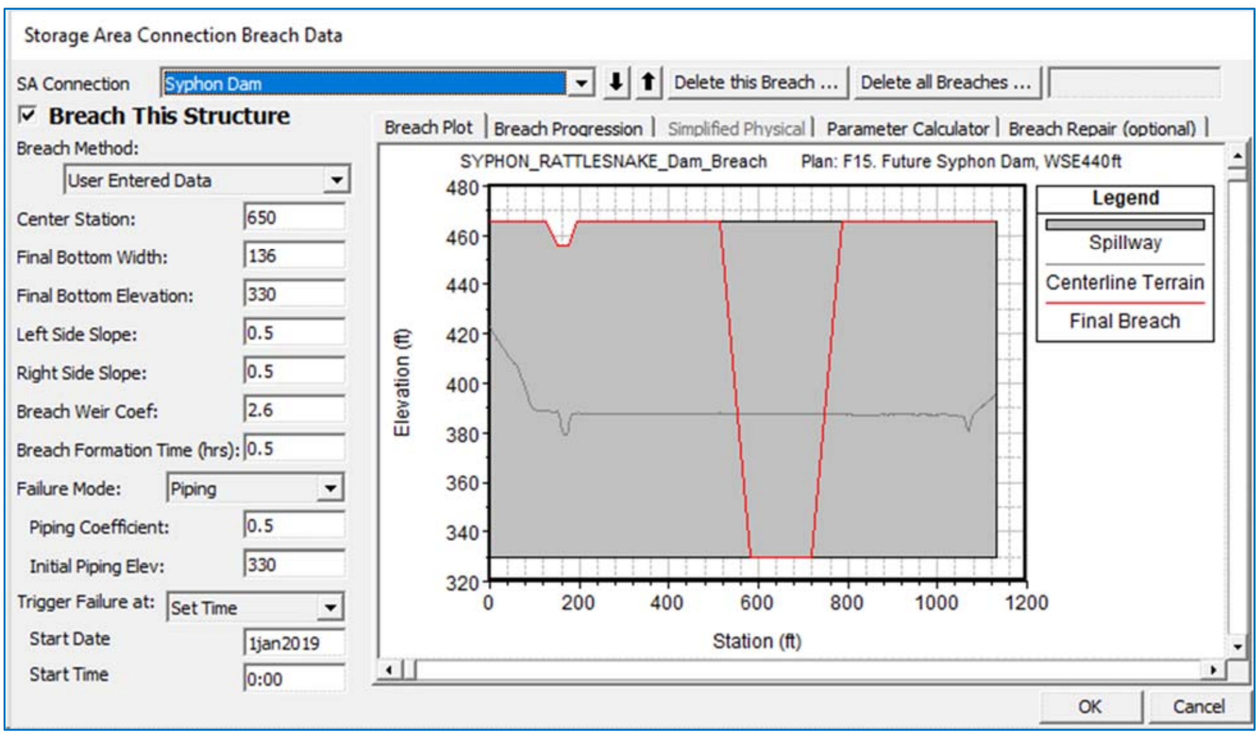


FIGURE 5 SCREEN CAPTURE OF BREACH PARAMETERS USED FOR ENLARGED DAM (WSE@440 FT NAVD88) SUNNY DAY FAILURE

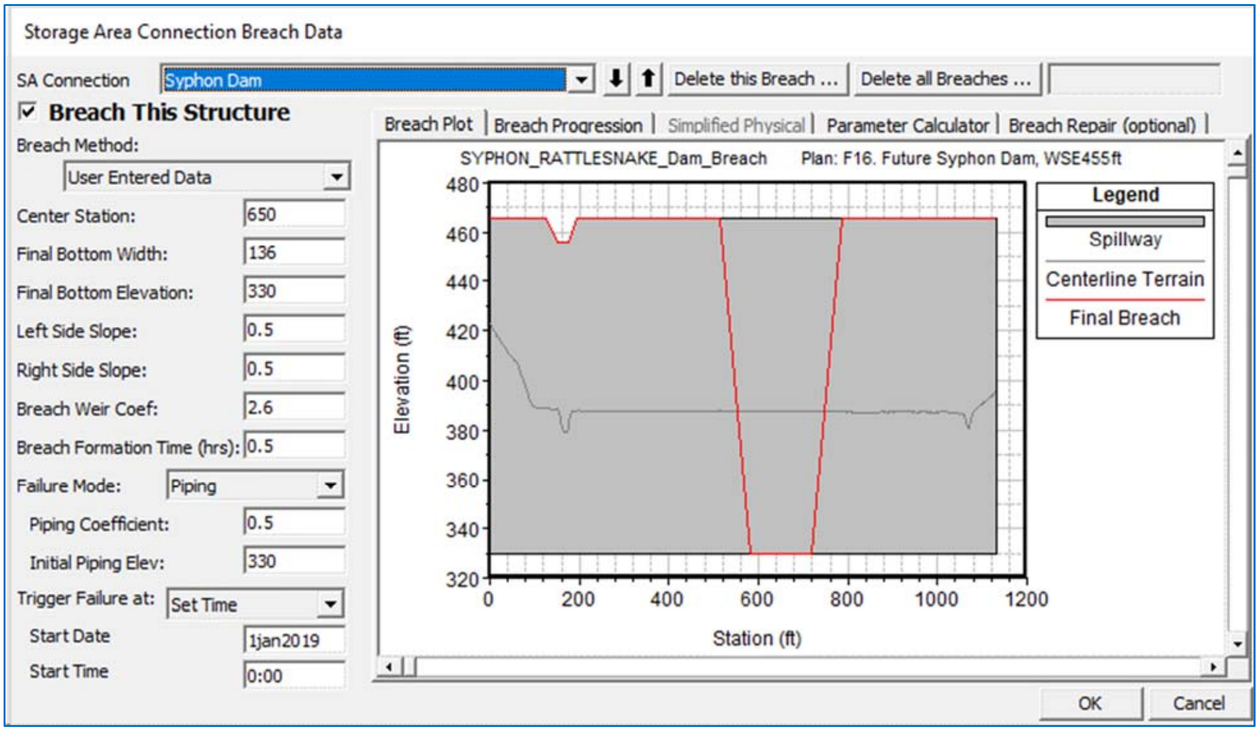


FIGURE 6 SCREEN CAPTURE OF BREACH PARAMETERS USED FOR ENLARGED DAM (WSE@455 FT NAVD88) SUNNY DAY FAILURE

3.0 MODEL RESULTS

The model and breach parameters were configured as described in the previous section. Each scenario was run with a 48-hour duration, and several types of model output were utilized to map and compare the scenarios. The following raster data sets were generated for each scenario:

- Maximum depth
- Flood arrival time
- Flood recession time
- Maximum velocity

A vector inundation boundary was also generated. For comparison purposes, the boundary was defined based on a 1-ft inundation depth, so as to be consistent with the latest emergency regulations (DWR, 2018a). All three inundation extents have been mapped using the 1-ft depth criterion. Flood arrival and recession times were also defined using a 1-ft depth criterion.

Eight cross-sections were established in the inundation floodplain, and flood characteristics, including peak discharge and peak arrival times, were determined at each cross-section for the three scenarios.

Resulting breach hydrographs for the three scenarios are shown in Figure 7. The existing dam breach has a peak of about 107,000 cfs and a total breach volume of about 580 ac-ft. The peak occurs about 6 minutes after the start of the breach, which is coincident with the breach formation time.

The enlarged dam failure with WSE = 440 ft has a peak of about 190,000 cfs. The peak occurs about 20 minutes after the start of the breach, prior to full formation of the breach. The breach volume is about 3,700 ac-ft.

The enlarged dam failure with WSE = 455 ft peaks at 243,000 cfs, about 22 minutes after the start of the breach. The breach volume is about 4,800 ac-ft. In both enlarged dam scenarios, the peak outflow from the breach occurs as the full breach is still developing.

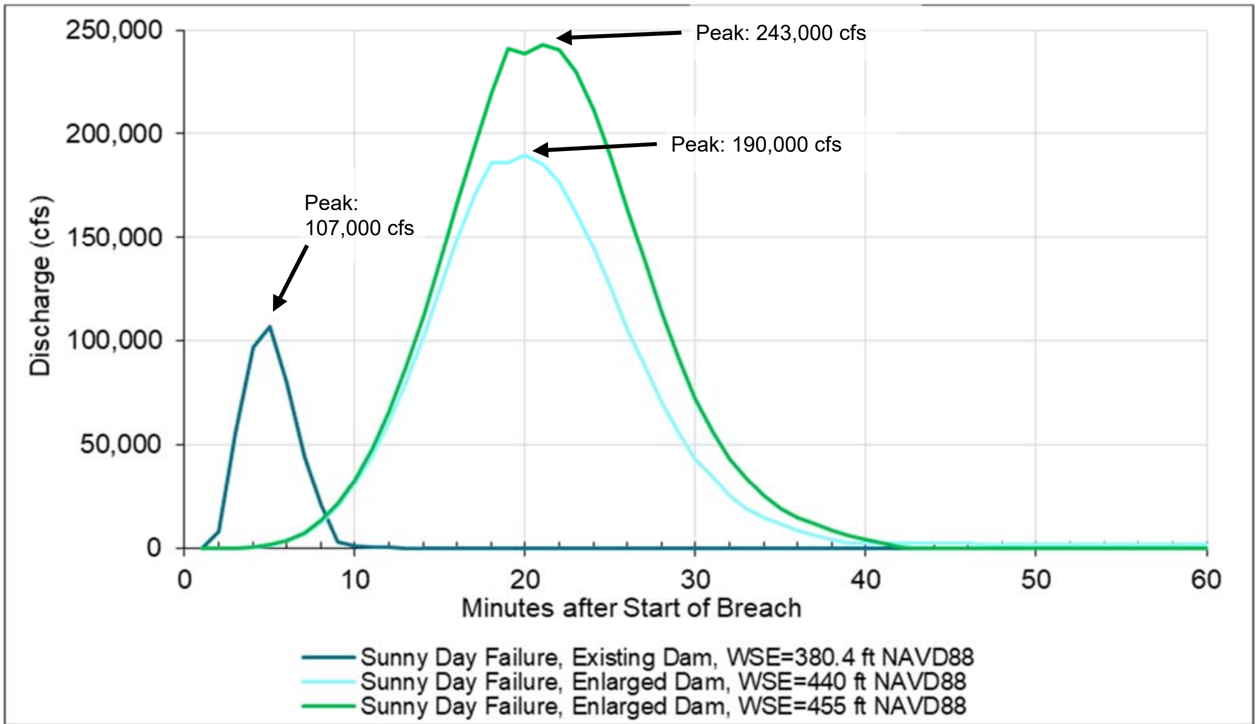


FIGURE 7 BREACH HYDROGRAPHS FOR SUNNY DAY FAILURE SCENARIOS

Attachment A contains inundation maps comparing the three failure scenarios. Figure A-1 compares the existing dam inundation to the enlarged dam inundation with WSE = 440 ft. Figure A-2 compares inundation for the existing dam and enlarged dam with WSE = 455 ft. Each map shows comparative statistics at eight cross-sections. The cross-sections are located 1 to 2 miles apart, with cross-section 1 (XS1) just downstream of the dam and XS8 on San Diego Creek near the outlet at upper Newport Bay. Arrival time, recession time, maximum depth, and maximum velocity were interpreted from the raster model outputs. Arrival time and recession time were defined with a depth criterion of 1 ft: the arrival time was computed as when the flood depth reached 1 ft above the pre-flood WSE. Similarly, recession time was computed as when the flood depth receded to less than 1 ft above the pre-flood WSE. Peak discharge and time to peak were calculated in HEC-RAS after setting cross-sections at the eight locations shown in Figures A-1 and A-2.

Table 2 lists the statistics at the eight cross-sections for the three scenarios. Five of the cross-sections (XS1, XS2, XS3, XS4, and XS6) are located across the lateral floodplain where there are no major creeks or channels. In these areas, the cross-sectional statistics represent typical values over the bare earth floodplain. Each statistic represents the maximum or minimum value appropriate for that statistic (i.e. the maximum depth across the cross-section is the maximum value typically seen along that cross-section; the arrival time is the minimum arrival time typically occurring along that cross-section).

The three remaining cross-sections (XS5, XS7, and XS8) are located across defined channels, XS5 at Peters Canyon Wash and XS7 and XS8 at San Diego Creek. At these locations, statistics in Table 2 represent values within the channel. Baseflow and/or estuary tides are included in the statistics (i.e. the maximum depth includes the depth due to baseflow and tide plus dam breach inundation).

TABLE 2 FLOOD WAVE CHARACTERISTICS AT MODEL CROSS-SECTIONS

Cross-Section[1]:	XS1	XS2	XS3	XS4	XS5	XS6	XS7	XS8
Distance from Dam (mi)	0.2	1.1	2.3	3.9	5.3	7.1	7.3	8.7
Statistic (units)	**Existing Dam Inundation – WSE @ 380.4 ft NAVD88**							
Flood Arrival Time[2] (hr)	0.05	0.25	0.7	2.0	2.7	n/a[3]	4.5	7.0
Flood Duration[2] (hr)	0.3	0.9	1.7	10	14	n/a[3]	13	8.0
Max Depth (ft)	25	9	4	5	11	n/a[3]	6	4
Max Velocity (ft/s)	30	18	4	5	3	n/a[3]	2	3
Peak Discharge (cfs)	99,000	29,000	8,500	2,600	950	n/a[3]	490	330
Time to Peak (hr)	0.1	0.3	0.8	2.2	3.2	n/a[3]	5.4	7.9
Recession Time[2] (hr)	0.4	1.1	2.4	12	17	n/a[3]	17	15
Statistic (units)	**Enlarged Dam Inundation – WSE @ 440 ft NAVD88**							
Flood Arrival Time[2] (hr)	0.20	0.35	0.6	1.1	1.5	6.0	2.1	2.8
Flood Duration[2] (hr)	1.1	2.3	2.6	6.9	13	10	14	18
Max Depth (ft)	28	15	8	8	24	2	15	15
Max Velocity (ft/s)	40	30	32	16	7	1	4	6
Peak Discharge (cfs)	188,000	163,000	102,000	42,000	17,000	86	11,000	8,800
Time to Peak (hr)	0.3	0.5	0.7	1.3	2.1	7.5	2.9	3.5
Recession Time[2] (hr)	1.3	2.6	3.2	8	14	16	16	21
Statistic (units)	**Enlarged Dam Inundation – WSE @ 455 ft NAVD88**							
Flood Arrival Time[2] (hr)	0.15	0.35	0.6	1.0	1.4	4.1	1.9	2.6
Flood Duration[2] (hr)	1.4	2.9	4.3	9.0	14	12	15	19
Max Depth (ft)	30	17	9	9	26	3	20	17
Max Velocity (ft/s)	45	34	35	17	7	3	4	6
Peak Discharge (cfs)	242,000	218,000	140,000	63,000	23,000	890	12,000	10,000
Time to Peak (hr)	0.4	0.5	0.7	1.2	2	5.9	2.7	3.3
Recession Time[2] (hr)	1.5	3.2	4.8	10	15	16	17	22

Notes:

1. Cross-sections 1, 2, 3, 4, and 6 are located across lateral extents of a wide floodplain; statistics at this location represent typical maximum or minimum values across the bare earth floodplain. Cross-sections 5, 7, and 8 are located across the defined channels of Peters Canyon Wash and San Diego Creek, and statistics at these locations are typical values within the channel, including pre-flood water depth due to baseflow and/or the estuary tide.
2. Flood arrival and recession times are computed based on a 1-ft depth criterion, i.e. the flood wave arrival time is when the depth rises to 1 ft above the pre-flood water level. Recession time is similarly calculated. Flood duration is the difference between these two times.
3. Not applicable: the existing dam inundation does not extend to this area of the floodplain.

The enlarged dam breach scenarios represent a significant increase in storage volume compared to the existing dam: with WSE at 440 ft, the storage volume increases from 578 ac-ft to 3,690 ac-ft, by more than a factor of six. With WSE at 455 ft, the increase is up to 4,880 ac-ft, more than a factor of eight. The increased breach volumes mean higher peaks and larger flood extents compared to the existing dam breach. Table 3 compares the breach volume and inundation area[3] for the three scenarios. The existing dam breach has a total inundation area of 1.5 square miles (mi^2). The two future scenarios have inundation areas of 4.5 mi^2 for WSE at 440 ft and 5.8 mi^2 for WSE at 455 ft.

TABLE 3 BREACH VOLUMES AND INUNDATION AREAS

Scenario	Breach Volume (ac-ft)	Inundation Area[1] (square miles)
Existing Dam, WSE 380.4 ft	578	1.5
Enlarged Dam, WSE 440 ft	3,690	4.5
Enlarged Dam, WSE 455 ft	4,880	5.8

Note:
1. Inundation area is the model domain between the dam and XS8 which has a simulated inundation depth of 1 ft or greater.

Larger inundation areas mean that a potential breach will impact more people, requiring more extensive emergency planning. A breach of the existing dam has the potential to affect people and structures within the Orange County Flood Control District (OCFCD), City of Irvine and City of Tustin. With an enlarged dam, the extent of flooding would generally be confined to those jurisdictions, but would affect a larger area. Figures A-1 and A-2 show the increased areas. A breach of the existing dam would generally be confined to areas east of Peters Canyon Wash and San Diego Creek. With the enlarged dam, a breach could inundate areas west of those channels, primarily the area north of interstate 405 and west of San Diego Creek (near XS6).

Results showed that the enlarged dam inundation may overtop the banks along San Diego Creek near the MWRP. During the enlarged dam breaches, the model showed that the peak flood stage and top of levee elevations are similar in the area near the MWRP. For example, in the enlarged scenario with WSE at 455 ft, the maximum flood stage in the creek near MWRP is about 29.8 ft NAVD88. The DEM data (OCPW, 2017) showed top of levee elevations in that area ranging from 28 to 30 ft NAVD88. The potential for flooding in this area may be further assessed using the HEC-RAS model: a survey could be conducted to confirm or adjust the levee elevations in the DEM. The model grid could also be refined in this area. This would allow for a more detailed assessment of the potential for flooding at MWRP.

The enlarged dam breaches would generally have larger depths and larger peak flows. For example, in the existing breach scenario, the peak flow attenuates from 99,000 cfs at XS1 down to 330 cfs at XS8. For the enlarged scenario with initial WSE at 440 ft, the peak would be 188,000 cfs at XS1 and 8,800 cfs at XS8, indicating that flows in Peters Canyon Wash and San

[3] Inundation area defined as locations where simulated depth would be 1 ft or greater.

Diego Creek would be much higher compared to the existing dam scenario. The enlarged scenario with initial WSE at 455 ft would have even higher peaks: 242,000 cfs at XS1 and 10,000 cfs at XS8. The maximum depths associated with these increased peaks are given in Table 2.

Arrival times immediately downstream of the dam (XS1) are controlled primarily by the breach formation time. Downstream of the dam (XS2+), flood arrival times would be shorter for the enlarged dam breaches. For example, at XS 4, the existing dam breach would arrive in 2 hours. The enlarged dam breaches would arrive faster due to their larger breach volumes: 1.1 hours for WSE at 440 ft and 1.0 hour for WSE at 455 ft. The faster-moving flood wave would also have higher velocities, as indicated in Table 2. The maximum velocity in the existing dam breach was 30 feet per second (ft/sec) while the two enlarged scenarios have maximum velocities up to 40 ft/sec and 45 ft/sec. The enlarged dam breaches would also take longer to recede compared to the existing dam breach: flood waters would generally recede within 15 hours after the existing dam breach, but would require up to 22 hours to recede in the enlarged dam failures[4].

The model is subject to the limitations described in the Syphon Canyon Dam inundation technical study report submitted to DSOD (Stetson, 2018d). Because this is a hypothetical flow event, with no known data with which to compare, the model has not been calibrated. However, several steps were completed in the development process to test model sensitivity and improve accuracy. Model grid refinements and spatially-varying Manning's *n* values were two methods used to improve accuracy. The results presented here are approximate and should be used for planning purposes only. Actual inundation extents, depths, arrival times, and velocities would vary depending on the characteristics of a breach and how quickly it develops.

Inundation results are affected by model assumptions for flood control and drainage structures. In the HEC-RAS model, bridges and overpasses were simulated as open. Culverts, street stormwater drains, and underground conveyances were modeled as closed due to the potential for high sediment and debris load in a breach. Changes in these model assumptions may affect the depth, timing, and location of the flood wave inundation.

Attachment B is a collection of electronic files related to the inundation mapping. Because HEC-RAS now has two-dimensional flow simulation and GIS-based modeling capabilities, inundation during a flood may be visualized using animations. Demonstration animations have been included which compare two breach scenarios over the same model time-frame. Each animation first shows the flood progression over the entire model domain; then the

[4] Note that recession times are based upon short breach formation times (0.1 and 0.5 hours); if a breach were to occur more slowly, recession times could be much longer than those given here.

flood progression over the primary area of inundation between Syphon Canyon Dam and Peters Canyon Wash; finally, each animation shows the particle tracing (i.e. direction of flow) at the 1-hour mark. The demonstration animations may be refined for use as planning tools to explain the impacts of an enlarged dam.

HEC-RAS model files for the two enlarged dam breach scenarios are included, as are the associated output files. All GIS files are in the California Teale Albers (ft) projection. Arrival and recession time raster values are in hours; maximum depth raster values are in ft; and maximum velocity raster values are in ft/sec. The inundation boundary vector files are delineated with a minimum 1-ft inundation criterion.

References

GEI Consultants. January 2012. *Syphon Reservoir Expansion Engineering Feasibility Study*. Prepared for Irvine Ranch Water District. Prepared by GEI Consultants.

Department of Water Resources (DWR). 2018a. *California Code of Regulations,* Title 23, Division 2, Chapter 1, Article 6, Sections 335 through 335.20. Emergency Regulations Effective July 18, 2018.

_______. 2018b. *Draft Inundation Map Regulations*. Proposed June 8, 2018. Revised August 17, 2018. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/All-Programs/Division-of-safety-of-dams/Files/Statutes-and-Regs-docs/Draft-Inundation-Map-Regulations-08-17-18.pdf?la=en&hash=F8CC04ECD57E67D67DC26562697F9C1E307D44A5

Federal Emergency Management Agency (FEMA). 2013. *Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures*. FEMA P-946. First Edition. July 2013.

National Oceanic and Atmospheric Administration (NOAA). *Tides/Water Levels for Station 9410580, Newport Beach*. Accessed July 11, 2018 at https://tidesandcurrents.noaa.gov/datums.html?id=9410580

Stetson Engineers Inc. 2018a. *Dam Failure Analysis and Inundation Mapping for San Joaquin Reservoir*. February 21, 2018. Prepared for Irvine Ranch Water District. Prepared by Stetson Engineers Inc. Submitted to Department of Water Resources, Division of Safety of Dams.

_______.2018b. *Dam Failure Analysis and Inundation Mapping for Sand Canyon Dam*. Revised June 12, 2018. Prepared for Irvine Ranch Water District. Prepared by Stetson Engineers Inc. Submitted to Department of Water Resources, Division of Safety of Dams.

_______.2018c. *Dam Failure Analysis and Inundation Mapping for Santiago Creek Dam*. February 21, 2018. Prepared for Irvine Ranch Water District. Prepared by Stetson Engineers Inc. Submitted to Department of Water Resources, Division of Safety of Dams.

_______.2018d. *Dam Failure Analysis and Inundation Mapping for Syphon Canyon Dam*. October 9, 2018. Prepared for Irvine Ranch Water District. Prepared by Stetson Engineers Inc. Submitted to Department of Water Resources, Division of Safety of Dams.

The Irvine Company (TIC). August 1949. *Syphon Canyon Dam Plans, Profiles, Sections and Detail of Dam and Appurtenances as Constructed*. Tustin, California.

Attachment A: Inundation Maps

Contents

Cross-Section 1 0.2 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=440 ft
Flood Arrival Time (hr)	0.05	0.2
Flood Duration (hr)	0.3	1.1
Max Depth (ft)	25	28
Max Velocity (ft/s)	30	40
Peak Discharge (cfs)	99,000	188,000
Time to Peak (hr)	0.1	0.3

Cross-Section 2 1.1 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=440 ft
Flood Arrival Time (hr)	0.25	0.35
Flood Duration (hr)	0.9	2.3
Max Depth (ft)	9	15
Max Velocity (ft/s)	18	30
Peak Discharge (cfs)	29,000	163,000
Time to Peak (hr)	0.3	0.5

Cross-Section 3 2.3 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=440 ft
Flood Arrival Time (hr)	0.7	0.6
Flood Duration (hr)	1.7	2.6
Max Depth (ft)	4	8
Max Velocity (ft/s)	4	32
Peak Discharge (cfs)	8,500	102,000
Time to Peak (hr)	0.8	0.7

Cross-Section 4 3.9 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=440 ft
Flood Arrival Time (hr)	2.0	1.1
Flood Duration (hr)	10	6.9
Max Depth (ft)	5	8
Max Velocity (ft/s)	5	16
Peak Discharge (cfs)	2,600	42,000
Time to Peak (hr)	2.2	1.3

Cross-Section 5 5.3 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=440 ft
Flood Arrival Time (hr)	2.7	1.5
Flood Duration (hr)	14	13
Max Depth (ft)	11	24
Max Velocity (ft/s)	3	7
Peak Discharge (cfs)	950	17,000
Time to Peak (hr)	3.2	2.1

Cross-Section 6 7.1 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=440 ft
Flood Arrival Time (hr)	n/a	6.0
Flood Duration (hr)	n/a	10
Max Depth (ft)	n/a	2
Max Velocity (ft/s)	n/a	1
Peak Discharge (cfs)	n/a	86
Time to Peak (hr)	n/a	7.5

Cross-Section 7 7.3 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=440 ft
Flood Arrival Time (hr)	4.5	2.1
Flood Duration (hr)	13	14
Max Depth (ft)	6	15
Max Velocity (ft/s)	2	4
Peak Discharge (cfs)	490	11,000
Time to Peak (hr)	5.4	2.9

Cross-Section 8 8.7 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=440 ft
Flood Arrival Time (hr)	7.0	2.8
Flood Duration (hr)	8.0	18
Max Depth (ft)	4	15
Max Velocity (ft/s)	3	6
Peak Discharge (cfs)	330	8,800
Time to Peak (hr)	7.9	3.5

FIGURE A-1
SYPHON CANYON DAM
SUNNY DAY FAILURE
FOR DAM ENLARGEMENT
WSE = 440 FT NAVD88

STATE DAM NO. 1029.004
NATIONAL DAM NO. CA00749
ORANGE COUNTY, CALIFORNIA

DAM OWNER
IRVINE RANCH WATER DISTRICT
PO BOX 57000
IRVINE, CA 92619-7000
(949) 453-5300

Legend

- Fire Station
- Police Station
- Medical Facility
- School
- Creek
- Cross section
- Existing Dam Inundation (WSE 380.4 ft)
- Enlarge Dam Inundation (WSE 440 ft)
- City Boundary

NOTES:
1. The information shown is approximate and should be used as a guideline for planning purposes.
2. The North American Vertical Datum of 1988 was used for inundation modeling and mapping.
3. Grid lines show latitude and longitude at 1-minute spacing in the WGS84 horizontal datum.
4. Inundation extents include areas where simulated maximum flood depth is 1 foot or higher.

12/4/2018

STETSON ENGINEERS INC.

Scale 1:18,000

N

0 600 1,200 1,800 Feet
0 175 350 525 700 Meters

Cross-Section 1 0.2 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=455 ft
Flood Arrival Time (hr)	0.05	0.15
Flood Duration (hr)	0.3	1.4
Max Depth (ft)	25	30
Max Velocity (ft/s)	30	45
Peak Discharge (cfs)	99,000	242,000
Time to Peak (hr)	0.1	0.4

Cross-Section 2 1.1 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=455 ft
Flood Arrival Time (hr)	0.25	0.35
Flood Duration (hr)	0.9	2.9
Max Depth (ft)	9	17
Max Velocity (ft/s)	18	34
Peak Discharge (cfs)	29,000	218,000
Time to Peak (hr)	0.3	0.5

Cross-Section 3 2.3 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=455 ft
Flood Arrival Time (hr)	0.7	0.6
Flood Duration (hr)	1.7	4.3
Max Depth (ft)	4	9
Max Velocity (ft/s)	4	35
Peak Discharge (cfs)	8,500	140,000
Time to Peak (hr)	0.8	0.7

Cross-Section 4 3.9 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=455 ft
Flood Arrival Time (hr)	2.0	1.0
Flood Duration (hr)	10	9.0
Max Depth (ft)	5	9
Max Velocity (ft/s)	5	17
Peak Discharge (cfs)	2,600	63,000
Time to Peak (hr)	2.2	1.2

Cross-Section 5 5.3 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=455 ft
Flood Arrival Time (hr)	2.7	1.4
Flood Duration (hr)	14	14
Max Depth (ft)	11	26
Max Velocity (ft/s)	3	7
Peak Discharge (cfs)	950	23,000
Time to Peak (hr)	3.2	2.0

Cross-Section 6 7.1 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=455 ft
Flood Arrival Time (hr)	n/a	4.1
Flood Duration (hr)	n/a	12
Max Depth (ft)	n/a	3
Max Velocity (ft/s)	n/a	3
Peak Discharge (cfs)	n/a	890
Time to Peak (hr)	n/a	5.9

Cross-Section 7 7.3 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=455 ft
Flood Arrival Time (hr)	4.5	1.9
Flood Duration (hr)	13	15
Max Depth (ft)	6	20
Max Velocity (ft/s)	2	4
Peak Discharge (cfs)	490	12,000
Time to Peak (hr)	5.4	2.7

Cross-Section 8 8.7 Miles Below Dam	Existing Dam WSE=380.4	Enlarged Dam WSE=455 ft
Flood Arrival Time (hr)	7.0	2.6
Flood Duration (hr)	8.0	19
Max Depth (ft)	4	17
Max Velocity (ft/s)	3	6
Peak Discharge (cfs)	330	10,000
Time to Peak (hr)	7.9	3.3

FIGURE A-2
SYPHON CANYON DAM
SUNNY DAY FAILURE
FOR DAM ENLARGEMENT
WSE = 455 FT NAVD88

STATE DAM NO. 1029.004
NATIONAL DAM NO. CA00749
ORANGE COUNTY, CALIFORNIA

DAM OWNER
IRVINE RANCH WATER DISTRICT
PO BOX 57000
IRVINE, CA 92619-7000
(949) 453-5300

Legend

- Fire Station
- Police Station
- Medical Facility
- School
- Creek
- Cross section
- Existing Dam Inundation (WSE 380.4 ft)
- Enlarged Dam Inundation (WSE 455 ft)
- City Boundary

NOTES:
1. The information shown is approximate and should be used as a guideline for planning purposes.
2. The North American Vertical Datum of 1988 was used for inundation modeling and mapping.
3. Grid lines show latitude and longitude at 1-minute spacing in the WGS84 horizontal datum.
4. Inundation extents include areas where simulated maximum flood depth is 1 foot or higher.

12/4/2018

STETSON ENGINEERS INC.

Scale 1:18,000

0 600 1,200 1,800 Feet
0 175 350 525 700 Meters