Santa Rosa Subregional Long-Term Wastewater Project

DAM BREAK INUNDATION ANALYSIS

SANTA ROSA SUBREGIONAL
LONG-TERM WASTEWATER PROJECT

Prepared for

City of Santa Rosa
and
U.S. Army Corps of Engineers

November 29, 1995

Prepared by

DAMES & MOORE, INC.
221 Main Street, Suite 600, San Francisco, CA 94105 • 415/896-5858

For

HARLAND BARTHOLOMEW & ASSOCIATES, INC.

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Final

TECHNICAL MEMORANDUM
Dam Break Inundation Analysis

TO: Harland Bartholomew & Associates, Inc.

FROM: Gregg Cummings - Dames & Moore, San Francisco
Patrick Kaspari - Dames & Moore, San Francisco

DATE: November 29, 1995

RE: Santa Rosa Subregional Long-Term Wastewater Project
Dam Break Inundation Analysis

SUMMARY

A hydrologic and hydraulic analysis was performed to estimate the approximate depth of flooding and approximate limits of inundation caused by a main dam break at each of ten (10) proposed reservoir sites. For each reservoir, five breaching alternatives were analyzed. It was assumed that, for purposes of these analyses, the initial water level in each reservoir was at the spillway crest elevation. The peak stage elevations, flooding depths, and inundation limits were calculated using the flood hydrograph computer model HEC-1 developed by the U.S. Army Corps of Engineers. Because the spillway for each dam will be designed to handle the Probable Maximum Flood (PMF), it was assumed that the dams would not be overtopped during the PMF. Therefore, an overtopping analysis was not conducted. Also, at several sites there are one or more supplementary side dams in addition to the main dam. However, only the main dam was analyzed (except at Tolay C where the back dam was also analyzed), since its failure would result in the largest flood levels.

PURPOSE

A hydrologic analysis was performed to estimate the approximate depth of flooding and approximate limits of inundation from a dam break at each of ten (10) proposed reservoir sites. The results of the analysis are shown on the attached figures and summarized in this memo.

METHODOLOGY

The scope of work for this task included:

1. Failure analysis of a maximum of ten dam and reservoir sites using the HEC-1 computer model developed by the U.S. Army Corps of Engineers.

2. Preparation of HEC-1 computer model input information, including reservoir storage versus elevation, dam dimensions and breach parameters;

3. Calculation of the flood elevations at selected points downstream of the dam, based on five (5) breaching scenarios; and

4. Plotting of the flood inundation limits, for the worst case breaching scenario, on USGS based maps.

FINDINGS

Modeling Input Data

Table 1 lists the ten reservoir sites analyzed and pertinent reservoir data provided by Rust Environment & Infrastructure for each site.

Each dam was analyzed for 5 breaching plans:

- Plan 1 - 15 minute failure of the full dam
- Plan 2 - 3 hour failure of the full dam
- Plan 3 - 15 minute failure of part of the dam
- Plan 4 - 3 hour failure of part of the dam
- Plan 5 - 12 hour failure of part of the dam

The plans can be divided into total and partial failure plans. The total failure plans were run for 15 minutes and 3 hours. Fifteen minutes was selected as representative of the minimum time in which failure could occur. Three hours was selected in order to provide the ability to compare the effects of time on the downstream flood inundation. The partial failure plans were also run for 15 minutes and 3 hours. In addition, the partial failure plan was run for 12 hours in order to determine how much downstream inundation would be caused by a slow failure.

The breaches in plans 1 and 2 were assumed to be rectangular shaped with vertical sides. For plans 3, 4, and 5, the breach was assumed to have a 2H:1V side slope. The breaching scenarios are summarized in Table 2.

For each reservoir, the channel downstream of the dam was divided into reaches. For each reach, a typical cross-section was developed, based on topography from the appropriate USGS map. The reach information for each reservoir is summarized in Table 3.

Modeling Results

The HEC1 modeling input and output files for each reservoir are contained in the Appendices. Each output file contain the following information for the applicable reservoir:

- Input data for each reservoir;

- Summary of peak flows and stages at each reach for all 5 plans.

The peak stage elevations and depths of flow for each of the breaching plans and for each of the reservoirs are given in Tables 4(a) through 4(j). The inundation elevations and flow depths given are at the center line of each reach.

The occasional increase in flow depths from an upstream reach to a downstream reach is due to the flood waters flowing from a reach with a wide cross section into a much narrower cross section. A balancing of the flow and energy equations yields an increase in the depth of flow although the energy gradient slope is still negative in the downstream direction. The magnitude of the depth of flow increases may in some cases be due to instabilities in the computer program.

Instabilities occur in the modeled flows for some reaches. This occurs because the model is unable to converge the continuity equation in the imposed time step and reach length. This can be resolved by decreasing the time step, which has already been decreased to the lowest possible value, or increasing the reach lengths, which would decrease the definition of the water surface elevations along the flood path. It is our experience that the removal of this instability would not appreciably affect the peak water surface elevations plotted on the enclosed figures. The accuracy of the model output is well within the limitations of the topographic mapping. The mapping contour interval is 20 feet. Any refinement of the flood elevations would not significantly change the limits of inundation that can be shown on topographic mapping with 20 foot contour intervals. If a higher level of accuracy is required, then more detailed topographic mapping should be obtained for this analysis.

It should also be noted that the water surface energy gradient has been estimated using the channel bed slope from the topographic mapping. For some reaches, on flood plains for example, when the ground surface slope approaches zero, the upstream bed slope has been used to approximate the energy gradient slope for the downstream reach.

Flood Inundation Limits

Based on the modeling results for each reservoir, the flood inundation limit for the worst case scenario (Breaching Plan 1) for each reservoir was plotted on U.S.G.S. base maps. These are attached as Figures 1 to 10. The flood inundation limits for the worst case for each reservoir are discussed below.

<u>Adobe Road (AD-1B):</u> The Adobe Road dam would be sited on Washington Creek upstream of the City of Petaluma. Discharge from the reservoir would flow down Washington Creek through Petaluma to the Petaluma River. As shown on Figure 1, the worst case scenario dam break would cause the inundation of most of Petaluma between Ely Road and the Petaluma River. The estimated water depth would range between 7 feet and 17 feet within Petaluma.

<u>Bloomfield (B1-A):</u> The Bloomfield dam would be sited on a tributary of Americano Creek northwest of the town of Bloomfield. Discharge from the reservoir would flow down the tributary to the main branch of Americano Creek. From there, the discharge would flow down past the town to Bodega Bay. As shown on Figure 2, the worst case scenario dam break would

cause the Americano Creek to inundate the town of Valley Ford. The flood waters would also back up Americano Creek, Bloomfield Creek, and Ebabias Creek, as well as several other tributaries to Americano Creek. The backup along Americano Creek and Bloomfield Creek would inundate most of the town of Bloomfield. There are other buildings scattered along Americano Creek that would be inundated. The estimated water depth would be 13 feet at Valley Ford and 20 feet at Bloomfield.

Carroll Road North (V7): The Carroll Road North dam would be sited on a tributary of Americano Creek between the towns of Bloomfield and Valley Ford. Discharge from the reservoir would flow down the tributary to the main branch of Americano Creek. From there, the discharge would flow down past Valley Ford to Bodega Bay. As shown on Figure 3, the worst case scenario dam break would cause the Americano Creek to inundate the town of Valley Ford. The flood waters would also back up Americano Creek, Bloomfield Creek, and Ebabias Creek, as well as several other tributaries to Americano Creek. The backup along Americano Creek and Bloomfield Creek would inundate most of the town of Bloomfield. There are other buildings scattered along Americano Creek that would be inundated. The estimated water depth would be 17 feet at Valley Ford and 26 feet at Bloomfield.

Huntley (T-1): The Huntley dam would be sited on a tributary of Stemple Creek along Martinoni Road near the Sonoma-Marin County line. Discharge from the reservoir would flow down the tributary into Marin County and to the main branch of Stemple Creek. From there, the water would flow into Estero de San Antonio to Bodega Bay. As shown on Figure 4, the worst case scenario dam break would cause the Estero de San Antonio to partially flood the town of Fallon. The flood waters would also back up Stemple Creek and would flood scattered buildings near Two Rock School. The flood waters would also back up several tributaries to Stemple Creek and Estero de San Antonio and would flood several buildings between Huntley Dam and Bodega Bay.

Lakeville Hillside (L-2A): The Lakeville Hillside dam would be sited on a tributary of the Petaluma River near the Lakeville Highway and Hog Island. Discharge from the reservoir would flow down the tributary into the Petaluma River, and from there into San Pablo Bay. As shown on Figure 5, the worst case scenario dam break would cause flooding between Lakeville Highway and the Petaluma River. No towns would be inundated and few buildings would be flooded.

Sears Point (SP-1): The Sears Point dam would be sited on Tolay Creek northwest of the intersection of Highways 37 and 121. Discharge from the reservoir would flow down Tolay Creek to San Pablo Bay. As shown on Figure 6, the worst case scenario dam break would cause Tolay Creek to flood Sears Point and scattered buildings along Highway 121 and on Tubbs Island. The estimated water level at Sears Point would be less than 5 feet.

Tolay A (S39): The Tolay A dam would be sited on Tolay Creek northwest of the intersection of Highways 37 and 121. Discharge from the reservoir would flow down Tolay Creek to San Pablo Bay. As shown on Figure 7, the worst case scenario dam break would cause Tolay Creek to flood Sears Point and scattered buildings along Highway 121 and on Tubbs Island. The estimated water level at Sears Point would be 11 feet.

Tolay C (S39C): The Tolay C dam would be sited on Tolay Creek northwest of the intersection of Highways 37 and 121. Discharge from the reservoir would flow down Tolay Creek to San

Pablo Bay. As shown on Figure 7, the worst case scenario dam break would cause Tolay Creek to flood Sears Point and scattered buildings along Highway 121 and on Tubbs Island. The estimated water level at Sears Point would be 12 feet.

Two Rock (T6A): The Two Rock dam would be sited a tributary of Stemple Creek north of Two Rock in the Roblar De La Miseria. Discharge from the reservoir would flow down the tributary into the main branch of Stemple Creek near Two Rock. From there, the water would flow through Marin County into Estero de San Antonio to Bodega Bay. As shown on Figure 9, the worst case scenario dam break would cause Stemple Creek to flood the town of Two Rock and part of Dos Piedras. The flood waters would also back up Stemple Creek and would flood scattered buildings near Two Rock School. The flood waters would back up several tributaries to Stemple Creek and Estero de San Antonio and would flood several buildings between Two Rock and Bodega Bay.

Valley Ford East (V4): The Valley Ford East dam would be sited on a tributary of Americano Creek in the Canada De Pogolimi area northeast of Valley Ford. Discharge from the reservoir would flow down the tributary to the main branch of Americano Creek. From there, the discharge would flow down past Valley Ford to Bodega Bay. As shown on Figure 10, the worst case scenario dam break would cause the Americano Creek to inundate the town of Valley Ford. The flood waters would also back up Americano Creek, Bloomfield Creek, and Ebabias Creek, as well as several other tributaries to Americano Creek. The backup along Americano Creek and Bloomfield Creek would inundate part of the town of Bloomfield. There are other buildings scattered along Americano Creek that would be inundated. The estimated water depth would be approximately 15 feet at Valley Ford and approximately 17 feet at Bloomfield.

Tolay C Back Dam Analysis

In addition to the analysis conducted for the main dams, an analysis was conducted for the Tolay C back dam. A failure of the back dam would flood the area north of the back dam. Based on a comparison of the storage capacity curves for Tolay A and Tolay C reservoirs, the resulting water surface elevation in this area would be at 240 feet NGVD. This water surface elevation would result in flow over the 230 foot saddle at Tolay Creek and the 235 foot saddle into a tributary of Stage Gulch Creek.

Due to the multiple discharge points and the large volume of water going into storage in the area behind the back dam, this dam break scenario would be difficult to model using the HEC-1 computer model. The inundation limits were instead determined using engineering judgment based on the depth of flow over the saddles.

The water would back-up beyond the headwaters of Tolay Creek and flow down a creek along the south side of Adobe Road and down to the Petaluma River near Browns Lane and the Lakeville Highway. Also, the water would flow over a saddle north of Cannon Lane and into a tributary of Stage Gulch Creek. As shown on Figure 11, most of the flooding would be limited to adjacent to the two creeks. However, several buildings near the Lakeville School would be flooded.

CONCLUSION

The estimated peak stage and depths of flow were calculated using the HEC-1 computer model, based on input provided by Parsons Engineering Science, Inc. and Rust Environment & Infrastructure. The results show that breaching plan 1 (15 minute total failure of dam) causes the highest peak stage elevations. The estimated limits of flood inundation due to breaching plan 1 are shown on the attached figures.

REFERENCES

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3. Revised Table 2 from Project Description Summary. Parsons Engineering Science, Inc., Alameda, California, September 1, 1995.

4. Santa Rosa Subregional Long-Term Wastewater Project, Proposed Alternatives. City of Santa Rosa, California, September 25, 1994.

5. Reservoir Drawings. Parsons Engineering Science, Alameda, California, Sept. 18, 1995.

6. USGS Maps: Cotati, Glen Ellen, Petaluma, Petaluma River, Sears Point, Two Rock, and Valley Ford Quadrants. U.S. Geological Survey, Denver, Colorado, latest revisions.

7. Reservoir Storage Capacity and Elevation Data. Rust, Environmental and infrastructure, Walnut Creek, California, July 21, 1995

8. Reservoir Area-Capacity Curves. Rust Environment & Infrastructure, Walnut Creek, California, August, 1995.

9. Reservoir Spillway Hydrology Analysis. Dames & Moore, San Francisco, California, August, 1995.

10. Reservoir Inflow Analysis. Dames & Moore, San Francisco, California, August, 1995.

11. HEC1 Food Hydrograph Package, Users Manual. U.S. Army Corps of Engineers, The Hydrologic Engineering Center, Davis, California, 1987 Revision.

12. Design of Small Dams. U.S. Bureau of Reclamation, U.S. Government Printing Office, Washington, D.C., 1977.

13. Guide for Selecting Mannings Roughness Coefficients for Natural Channels and Flood Plains, Water-Supply Paper 2339. U.S. Geological Survey, Denver, Colorado, 1989.

14. Spillway widths. Phone conversation with Rich Mauer, Parsons Engineering Science, Alameda, California, 8/9/95.

15. Flood Insurance Study, Sonoma County, California (unincorporated areas). Federal Emergency Management Agency, Sept. 2, 1994.

APPENDICES

LIST OF TABLES

LIST OF FIGURES

TABLE 1

SUMMARY OF RESERVOIR AND DAM DATA

Reservoir	Dam Crest Elevation (feet)	Dam Height (feet)	Spillway Crest Elevation (feet)	Storage Volume at Spillway Crest Elevation (acre-feet)
Adobe Road (AD-1B)	355	205	340	11,300
Bloomfield (B1-A)	270	190	255	13,800
Carroll Road North (V7)	270	195	255	14,400
Huntley (T-1)	300	210	285	13,800
Lakeville-Hillside (L-2A)	215	135	200	4,600
Sears Point (SP-1)	155	115	140	11,600
Tolay A (S39)	260	90	245	17,200
Tolay C (S39C)	285	115	270	13,800
Two Rock (T6A)	375	225	360	13,800
Valley Ford East (V4)	175	140	160	15,600

Source: Table 2, Reservoir Summary Table, provided by Rust Environment & Infrastructure, September 1, 1995.

(a) Dam height is the elevation difference between the dam crest and the downstream toe.

TABLE 2

SUMMARY OF BREACHING PLANS

Plan	Breach Depth from Crest of Dam, feet	Breach Width at Bottom of Breach, feet	Failure Time, hours	Side Slope H:V
ADOBE ROAD (AD-1B)				
1	205	2,250	0.25	0:1
2	205	2,250	3.0	0:1
3	50	50	0.25	2:1
4	75	400	3.0	2:1
5	75	400	12.0	2:1
BLOOMFIELD (B1-A)				
1	190	3,000	0.25	0:1
2	190	3,000	3.0	0:1
3	50	50	0.25	2:1
4	75	400	3.0	2:1
5	75	400	12.0	2:1
CARROLL ROAD NORTH (V7)				
1	195	2,350	0.25	0:1
2	195	2,350	3.0	0:1
3	50	50	0.25	2:1
4	75	400	3.0	2:1
5	75	400	12.0	2:1
HUNTLEY (T-1)				
1	210	2,720	0.25	0:1
2	210	2,720	3.0	0:1
3	100	50	0.25	2:1
4	75	400	3.0	2:1
5	75	400	12.0	2:1
LAKEVILLE HILLSIDE (L-2A)				
1	135	1,020	0.25	0:1
2	135	1,020	3.0	0:1
3	50	50	025	2:1
4	75	400	3.0	2:1
5	75	400	12.0	2:1

TABLE 2

SUMMARY OF BREACHING PLANS

Plan	Breach Depth from Crest of Dam, feet	Breach Width at Bottom of Breach, feet	Failure Time, hours	Side Slope H:V
SEARS POINT (SP-1)				
1	115	1,750	0.25	0:1
2	115	1,750	3.0	0:1
3	50	50	0.25	2:1
4	95	400	3.0	2:1
5	95	400	12.0	2:1
TOLAY A (S39)				
1	90	550	0.25	0:1
2	90	550	3.0	0:1
3	60	50	0.25	2:1
4	40	200	3.0	2:1
5	40	200	12.0	2:1
TOLAY C (S39C)				
1	115	1,150	0.25	0:1
2	115	1,150	3.0	0:1
3	60	50	0.25	2:1
4	40	200	3.0	2:1
5	40	200	12.0	2:1
TWO ROCK (T6A)				
1	225	1,370	0.25	0:1
2	225	1,370	3.0	0:1
3	50	50	0.25	2:1
4	95	400	3.0	2:1
5	95	400	12.0	2:1
VALLEY FORD EAST (V4)				
1	140	2,700	0.25	0:1
2	140	2,700	3.0	0:1
3	50	50	0.25	2:1
4	75	400	3.0	2:1
5	75	400	12.0	2:1

TABLE 3

SUMMARY OF REACHES

Reservoir	Location of Last Downstream Reach	Number of Reaches	Total Length of Stream Model, feet	Maximum Reach Width, feet	Minimum Reach Width, feet	Maximum Reach Slope, feet/feet	Minimum Reach Slope, feet/feet
Adobe Road (AD-1B)	Petaluma River at Petaluma	9	18,080	37,300	900	0.067	0.005
Bloomfield (B1-A)	Americano Creek at Bodega Bay	7	52,400	5,850	900	0.0085	0.001
Carroll Road North (V7)	Americano Creek at Bodega Bay	6	47,700	5,150	1,050	0.014	0.001
Huntley (T-1)	Estero de San Antonio at Bodega Bay	7	146,351	3,000	600	0.01	0.0017
Lakeville-Hillside (L-2A)	Petaluma River at Hog Island	8	21,625	14,250	800	0.03	0.001
Sears Point (SP-1)	Tolay Creek at San Pablo Bay	4	18,570	19,800	2,200	0.0071	0.001
Tolay A (S39)	Tolay Creek at San Pablo Bay	7	26,400	20,500	500	0.023	0.001
Tolay C (S39C)	Tolay Creek at San Pablo Bay	7	26,400	20,500	900	0.023	0.001
Two Rock (T6A)	Estero de San Antonio at Bodega Bay	14	94,150	9,800	800	0.012	0.0009
Valley Ford East (V4)	Americano Creek at Bodega Bay	6	41,400	5,150	1,000	0.0055	0.001

TABLE 4(a)

ADOBE ROAD RESERVOIR (AD-1B)
PEAK STAGE ELEVATIONS AND DEPTHS OF FLOW AT REACHES FOR EACH BREACHING PLAN

		Breaching Plan									
		1		2		3		4		5	
Reach	Channel Bottom Elevation (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)
1	160	232	72	187	27	179	19	178	18	169	9
2	140	169	29	152	12	148	8	147	7	144	4
3	120	137	17	128	8	126	6	125	5	123	3
4	100	118	18	109	9	107	7	106	6	104	4
5	80	94	14	87	7	85	5	85	5	83	3
6	70	81	11	75	5	73	3	73	3	72	2
7	60	67	7	64	4	62	2	62	2	61	1
8	40	50	10	45	5	43	3	43	3	42	2
9	20	28	8	24	4	22	2	23	3	21	1

TABLE 4(b)

BLOOMFIELD RESERVOIR (B1-A)
PEAK STAGE ELEVATIONS AND DEPTH OF FLOW AT REACHES FOR EACH BREACHING PLAN

		Breaching Plan									
		1		2		3		4		5	
Reach	Channel Bottom Elevation (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)
1	80	128	48	99	19	91	11	92	12	86	6
2	40	68	28	50	10	45	5	46	6	41	1
3	20	61	41	38	18	31	11	32	12	27	7
4	20	53	33	34	14	27	7	29	9	24	4
5	20	49	29	31	11	24	4	26	6	23	3
6	20	62	42	38	18	27	7	30	10	24	4
7	20	72	52	46	26	30	10	34	14	26	6

TABLE 4(c)

CARROLL ROAD NORTH RESERVOIR (V7)
PEAK STAGE ELEVATIONS AND DEPTHS OF FLOW AT REACHES FOR EACH BREACHING PLAN

		Breaching Plan									
		1		2		3		4		5	
Reach	Channel Bottom Elevation (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)
1	60	112	52	79	19	71	1	72	12	66	6
2	40	74	34	52	12	47	7	47	7	43	3
3	20	57	37	35	15	27	7	29	9	24	4
4	20	53	33	31	11	24	4	26	6	23	3
5	20	67	47	38	18	27	7	30	10	24	4
6	20	77	57	49	29	30	10	35	15	26	6

TABLE 4(d)

HUNTLEY RESERVOIR (T-1)
PEAK STAGE ELEVATIONS AND DEPTHS OF FLOW AT REACHES FOR EACH BREACHING PLAN

		Breaching Plan									
		1		2		3		4		5	
Reach	Channel Bottom Elevation (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)
1	80	118	38	93	13	98	18	87	7	83	3
2	40	76	36	55	15	59	19	50	10	45	5
3	40	91	51	61	21	60	20	53	13	45	5
4	20	71	51	46	26	44	24	39	19	29	9
5	20	61	41	39	19	37	17	33	13	26	6
6	20	46	26	33	13	31	11	29	9	22	2
7	20	56	36	43	23	38	18	35	15	26	6

TABLE 4(e)

LAKEVILLE-HILLSIDE RESERVOIR (L-2A)
PEAK STAGE ELEVATIONS AND DEPTHS OF FLOW AT REACHES FOR EACH BREACHING PLAN

		Breaching Plan									
		1		2		3		4		5	
Reach	Channel Bottom Elevation (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)
1	100	140	40	113	13	113	13	109	9	104	4
2	70	112	42	84	14	84	14	81	11	76	6
3	60	87	27	70	10	70	10	67	7	63	3
4	40	67	27	49	9	49	9	46	6	43	3
5	30	60	30	39	9	39	9	37	7	33	3
6	10	23	13	15	5	15	5	14	4	12	2
7	0	6	6	3	3	2	2	2	2	1	1
8	0	4	4	3	3	2	2	2	2	1	1

TABLE 4(f)

SEARS POINT RESERVOIR (SP-1)
PEAK STAGE ELEVATIONS AND DEPTHS OF FLOW AT REACHES FOR EACH BREACHING PLAN

		Breaching Plan									
		1		2		3		4		5	
Reach	Channel Bottom Elevation (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)
1	35	86	51	52	17	48	13	50	15	43	8
2	25	47	22	33	8	31	6	32	7	28	3
3	5	22	17	10	5	7	2	9	4	6	1
4	1	10	9	6	5	4	3	6	5	3	2

TABLE 4(g)

TOLAY A RESERVOIR (S39)
PEAK STAGE ELEVATIONS AND DEPTHS OF FLOW AT REACHES FOR EACH BREACHING PLAN

		Breaching Plan									
		1		2		3		4		5	
Reach	Channel Bottom Elevation (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)
1	140	193	53	168	28	162	22	157	17	151	11
2	100	138	38	119	19	114	14	110	10	107	7
3	60	93	33	77	17	73	13	69	9	66	6
4	10	30	20	18	8	17	7	15	5	13	3
5	5	21	16	11	6	9	4	8	3	7	2
6	0	11	11	6	6	4	4	3	3	2	2
7	0	7	7	5	5	3	3	2	2	2	2

TABLE 4(h)

TOLAY C RESERVOIR (S39C)
PEAK STAGE ELEVATIONS AND DEPTHS OF FLOW AT REACHES FOR EACH BREACHING PLAN

		Breaching Plan									
		1		2		3		4		5	
Reach	Channel Bottom Elevation (ft.)	Stage Elev. (ft.)	Depth (ft.)	Stage Elev. (ft.)	Depth (ft.)	Stage Elev. (ft.)	Depth (ft.)	Stage Elev. (ft.)	Depth (ft.)	Stage Elev. (ft.)	Depth (ft.)
1	140	204	64	165	25	153	13	158	18	147	7
2	100	145	45	117	17	108	8	111	11	104	4
3	60	98	38	75	15	67	7	70	10	64	4
4	10	32	22	17	7	13	3	15	5	11	1
5	5	22	17	10	5	7	2	8	3	6	1
6	0	11	11	5	5	2	2	3	3	1	1
7	0	7	7	4	4	1	1	3	3	1	1

TABLE 4(i)

TWO ROCK RESERVOIR (T6A)

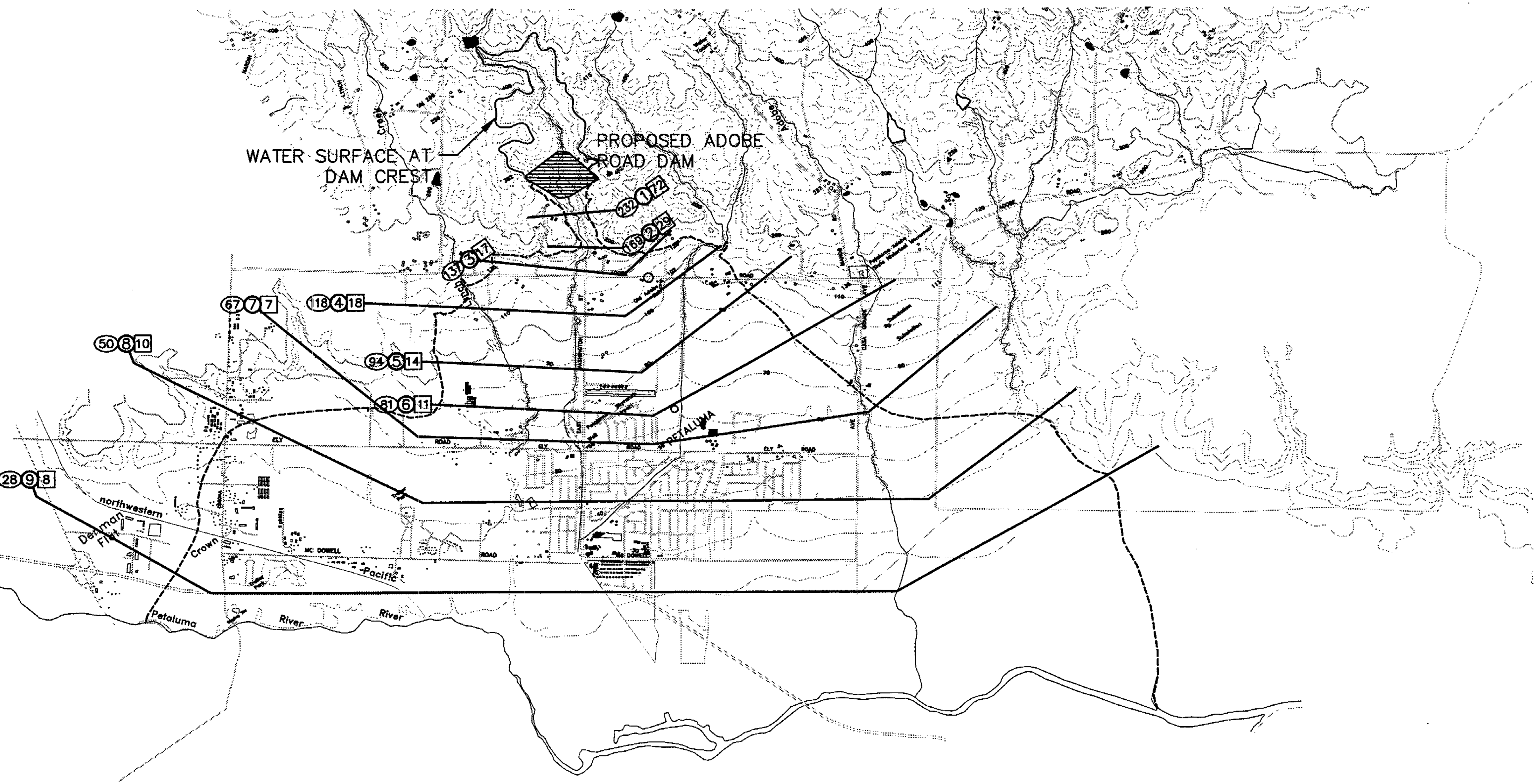
PEAK STAGE ELEVATIONS AND DEPTHS OF FLOW AT REACHES FOR EACH BREACHING PLAN

		Breaching Plan									
		1		2		3		4		5	
Reach	**Channel Bottom Elevation (ft.)**	**Stage Elev. (ft.)**	**Max. Depth (ft.)**	**Stage Elev. (ft.)**	**Max. Depth (ft.)**	**Stage Elev. (ft.)**	**Max. Depth (ft.)**	**Stage Elev. (ft.)**	**Max. Depth (ft.)**	**Stage Elev. (ft.)**	**Max. Depth (ft.)**
1	160	229	69	183	23	174	14	175	15	166	6
2	120	163	43	137	17	131	11	132	12	125	5
3	120	156	36	130	10	125	5	126	6	122	2
4	100	133	33	113	13	108	8	109	9	103	3
5	100	134	34	110	10	105	5	106	6	102	2
6	80	124	44	97	17	90	10	92	12	86	6
7	80	108	28	88	8	84	4	85	5	82	2
8	80	97	17	85	5	82	2	83	3	81	1
9	60	86	26	73	13	66	6	68	8	64	4
10	40	92	52	75	35	59	19	65	25	54	14
11	40	89	49	75	35	53	13	63	23	50	10
12	20	43	23	39	19	28	8	34	14	27	7
13	20	44	24	39	19	27	7	34	14	27	7
14	20	57	37	49	29	30	10	43	23	27	7

TABLE 4(j)

VALLEY FORD EAST RESERVOIR (V4)
PEAK STAGE ELEVATIONS AND DEPTHS OF FLOW AT REACHES FOR EACH BREACHING PLAN

		Breaching Plan									
		1		2		3		4		5	
Reach	Channel Bottom Elevation (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)	Stage Elev. (ft.)	Max. Depth (ft.)
1	40	75	35	53	13	49	9	49	9	44	4
2	30	63	33	41	11	38	8	38	8	34	4
3	20	55	35	32	12	27	7	29	9	24	4
4	20	52	32	29	9	25	5	26	6	22	2
5	20	66	46	35	15	27	7	30	10	24	4
6	20	77	57	43	23	30	10	34	14	26	6



N
E
W

0 1500 3000 6000

SCALE IN FEET
1" =3000'

LEGEND:

49 5 10

MAXIMUM FLOOD DEPTH (FT.)
REACH LOCATION NUMBER
MAXIMUM FLOOD ELEVATION (FT.)(NGVD.)

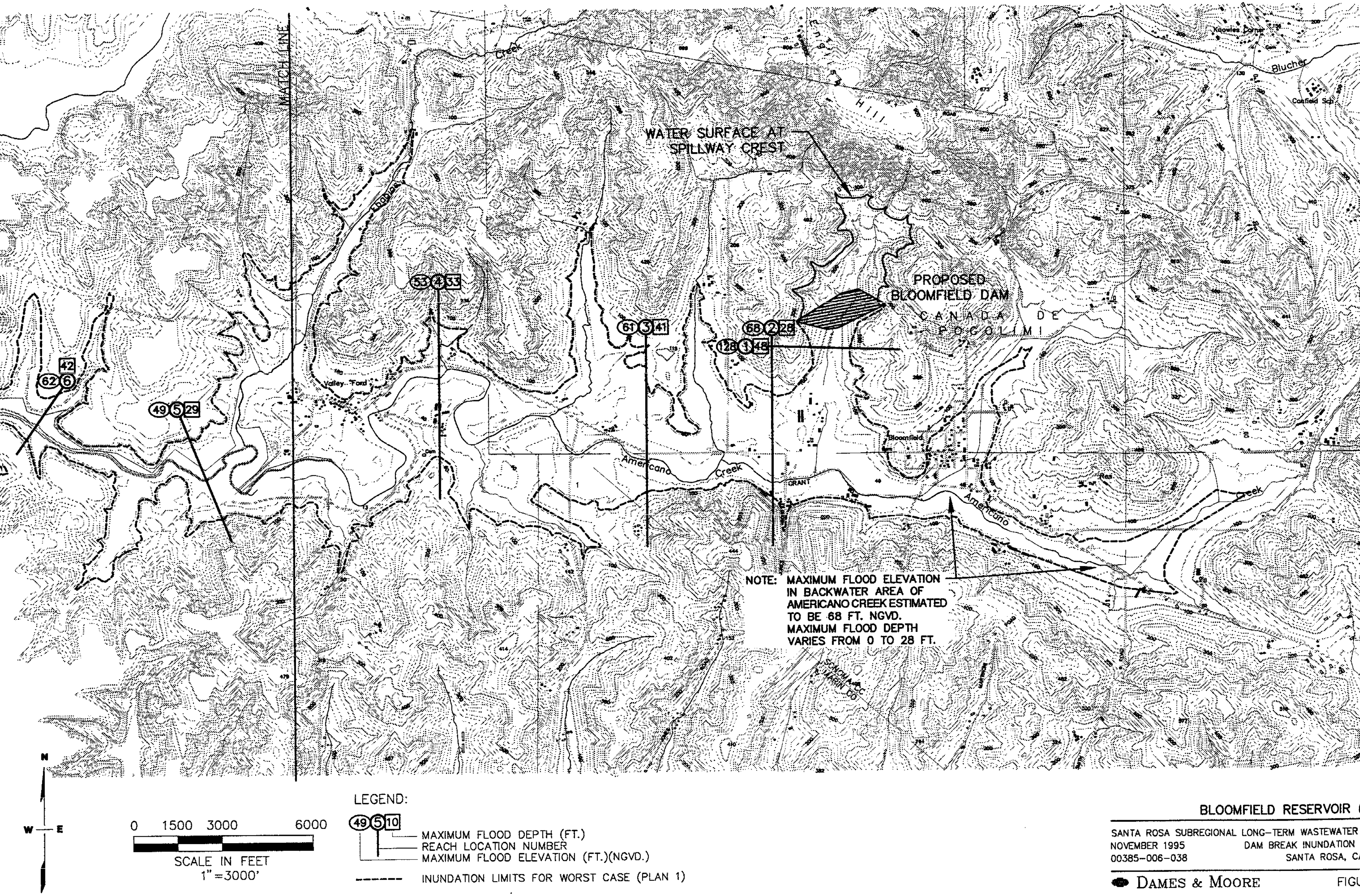
------ INUNDATION LIMITS FOR WORST CASE (PLAN 1)

ADOBE ROAD RESERVOIR (AD–1B)

SANTA ROSA SUBREGIONAL LONG–TERM WASTEWATER PROJECT
NOVEMBER 1995 DAM BREAK INUNDATION ANALYSIS
00385–006–038 SANTA ROSA, CALIFORNIA

DAMES & MOORE

FIGURE 1



LEGEND:

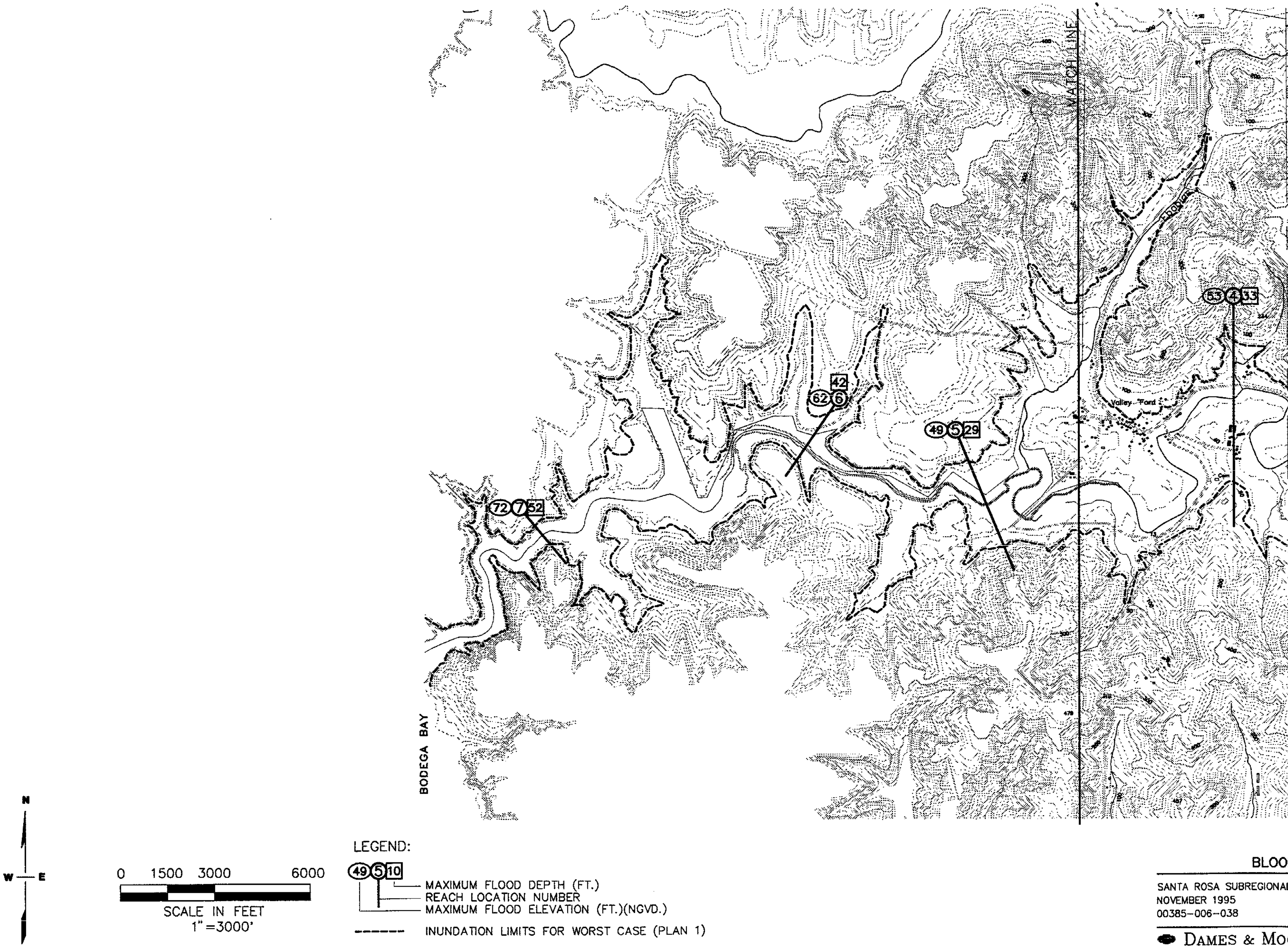
49 5 10
- MAXIMUM FLOOD DEPTH (FT.)
- REACH LOCATION NUMBER
- MAXIMUM FLOOD ELEVATION (FT.)(NGVD.)
- - - - - - INUNDATION LIMITS FOR WORST CASE (PLAN 1)

BLOOMFIELD RESERVOIR (B1–A)

SANTA ROSA SUBREGIONAL LONG–TERM WASTEWATER PROJECT
NOVEMBER 1995 DAM BREAK INUNDATION ANALYSIS
00385–006–038 SANTA ROSA, CALIFORNIA

DAMES & MOORE

FIGURE 2a

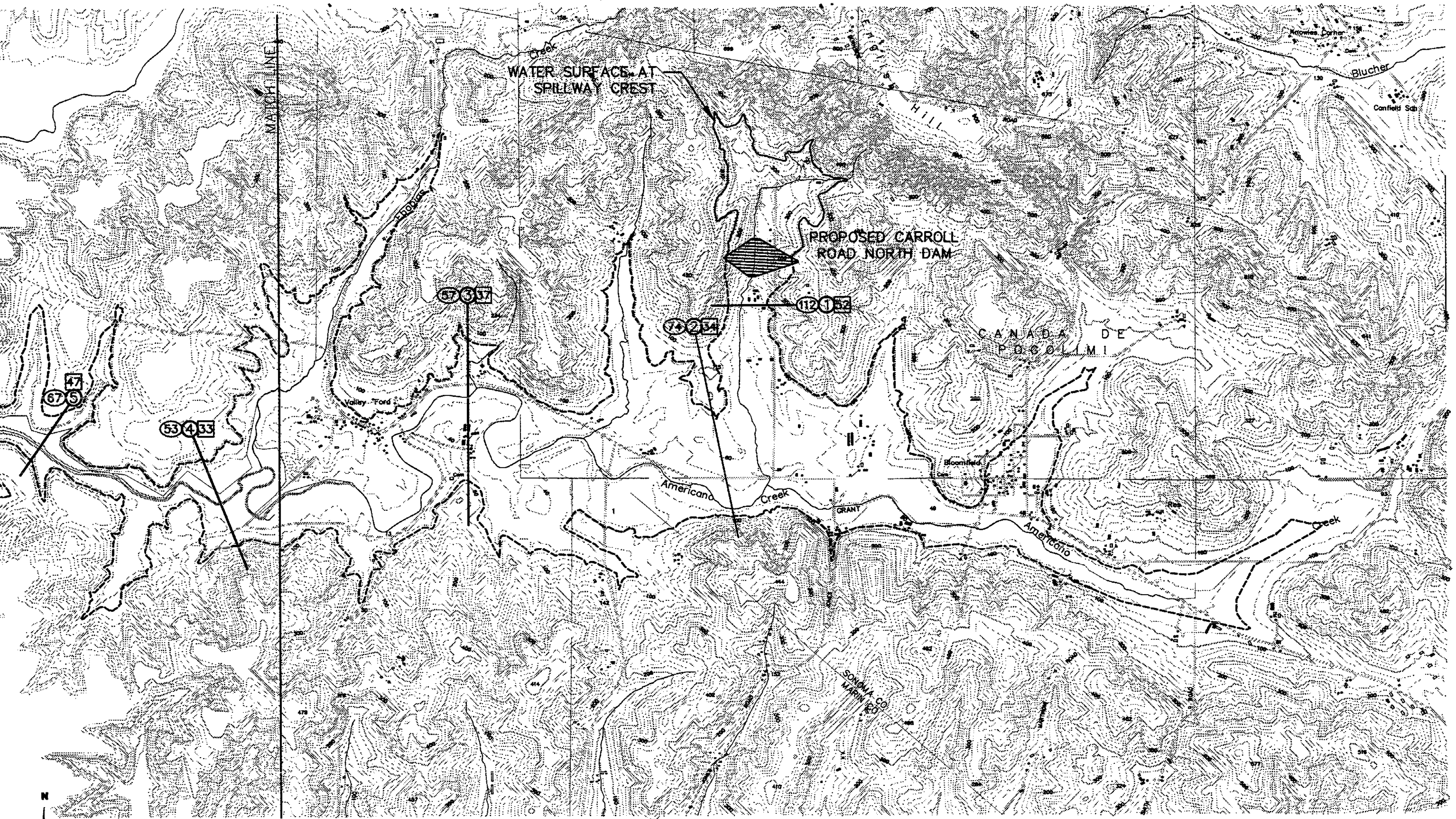


BLOOMFIELD RESERVOIR (B1-A)

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT
NOVEMBER 1995 DAM BREAK INUNDATION ANALYSIS
00385-006-038 SANTA ROSA, CALIFORNIA

DAMES & MOORE

FIGURE 2b



N

W E

0 1500 3000 6000

SCALE IN FEET
1" =3000'

LEGEND:

49 5 10

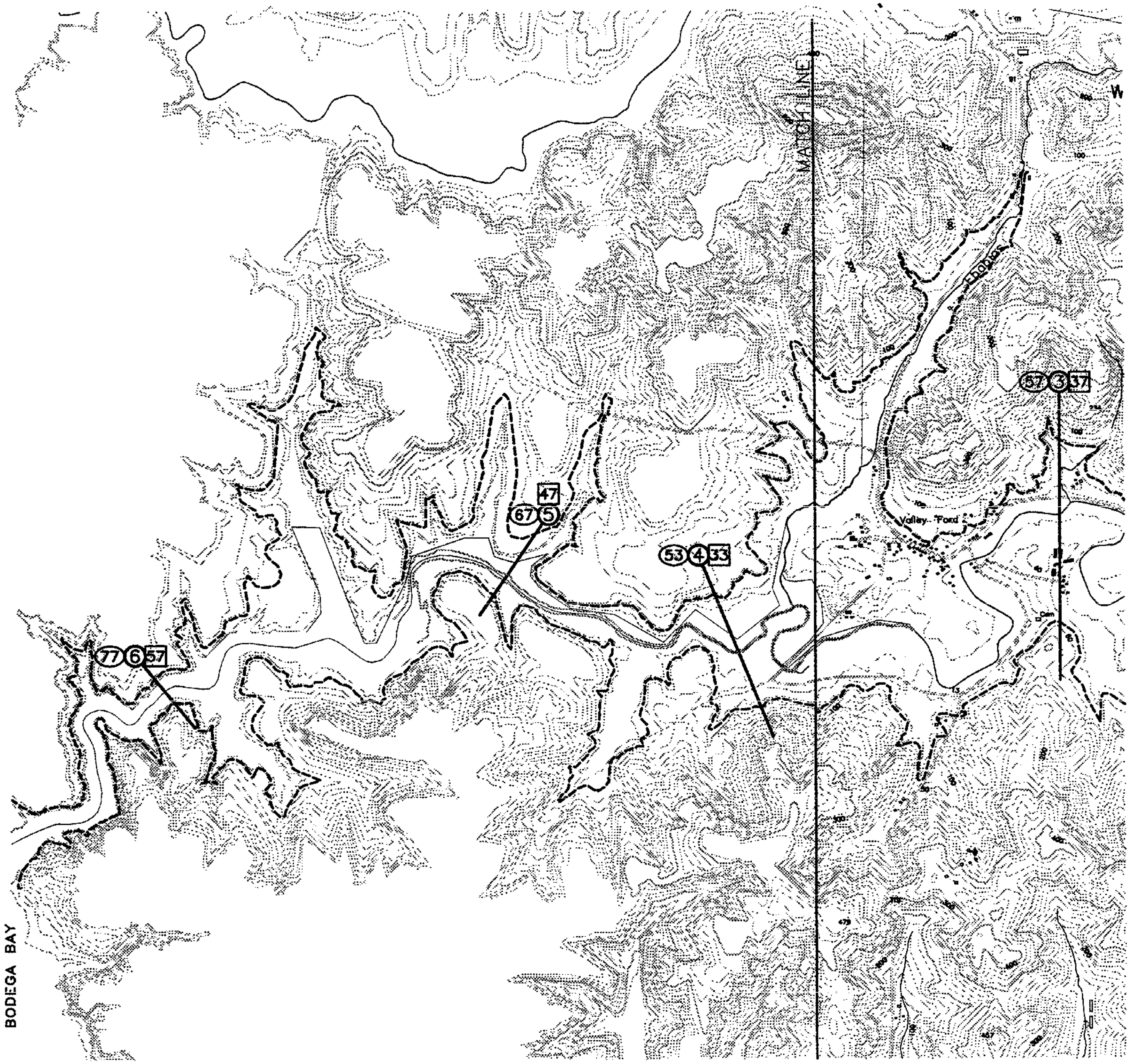
- MAXIMUM FLOOD DEPTH (FT.)
- REACH LOCATION NUMBER
- MAXIMUM FLOOD ELEVATION (FT.)(NGVD.)

------ INUNDATION LIMITS FOR WORST CASE (PLAN 1)

CARROLL ROAD NORTH RESERVOIR (V7)

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT
NOVEMBER 1995 DAM BREAK INUNDATION ANALYSIS
00385-006-038 SANTA ROSA, CALIFORNIA

DAMES & MOORE FIGURE 3a



0 1500 3000 6000

SCALE IN FEET
1" =3000'

LEGEND:

49 5 10

MAXIMUM FLOOD DEPTH (FT.)
REACH LOCATION NUMBER
MAXIMUM FLOOD ELEVATION (FT.)(NGVD.)

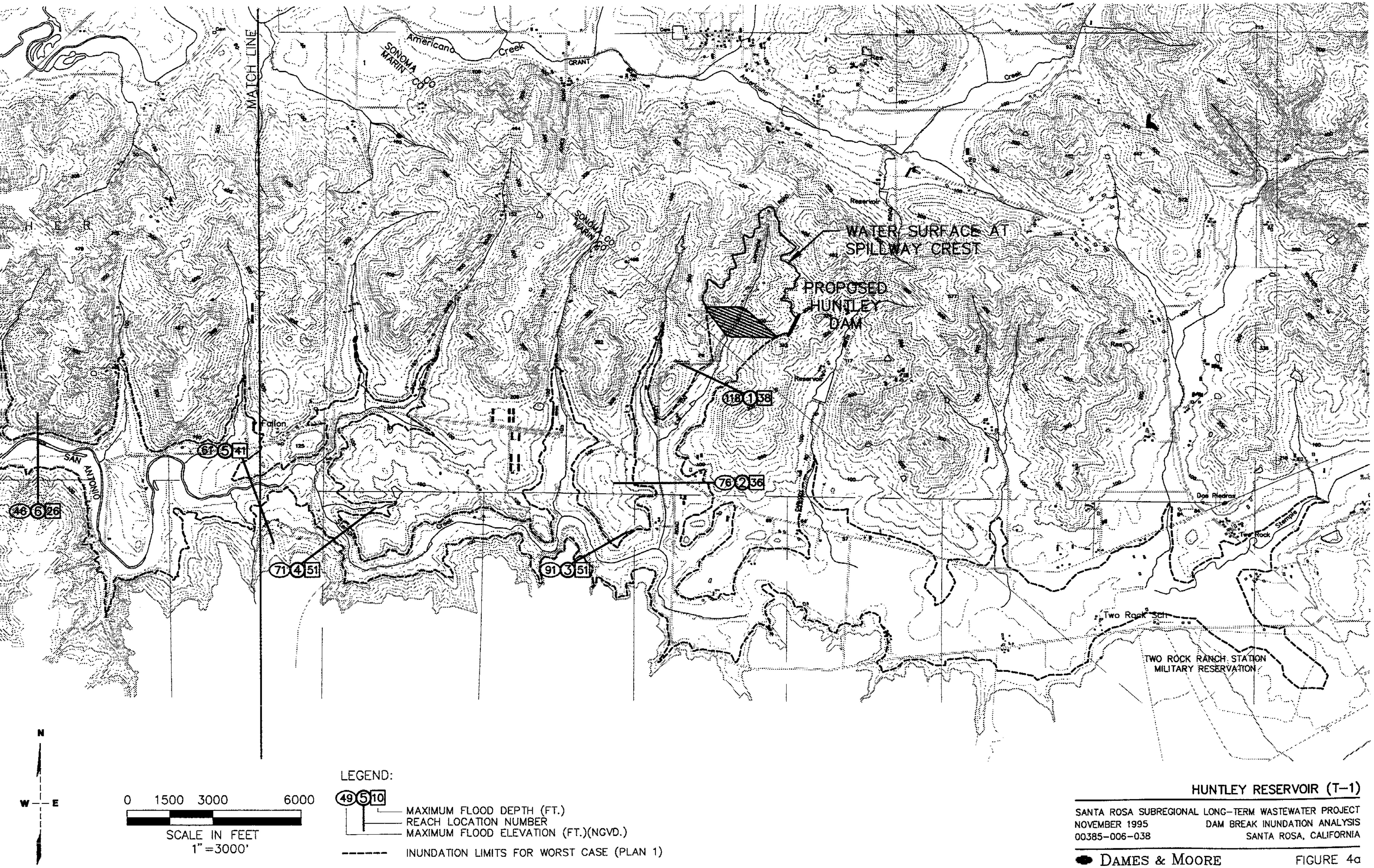
------ INUNDATION LIMITS FOR WORST CASE (PLAN 1)

CARROLL ROAD NORTH RESERVOIR (V7)

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT
NOVEMBER 1995 DAM BREAK INUNDATION ANALYSIS
00385-006-038 SANTA ROSA, CALIFORNIA

DAMES & MOORE

FIGURE 3b



LEGEND:

49 5 10
- MAXIMUM FLOOD DEPTH (FT.)
- REACH LOCATION NUMBER
- MAXIMUM FLOOD ELEVATION (FT.)(NGVD.)

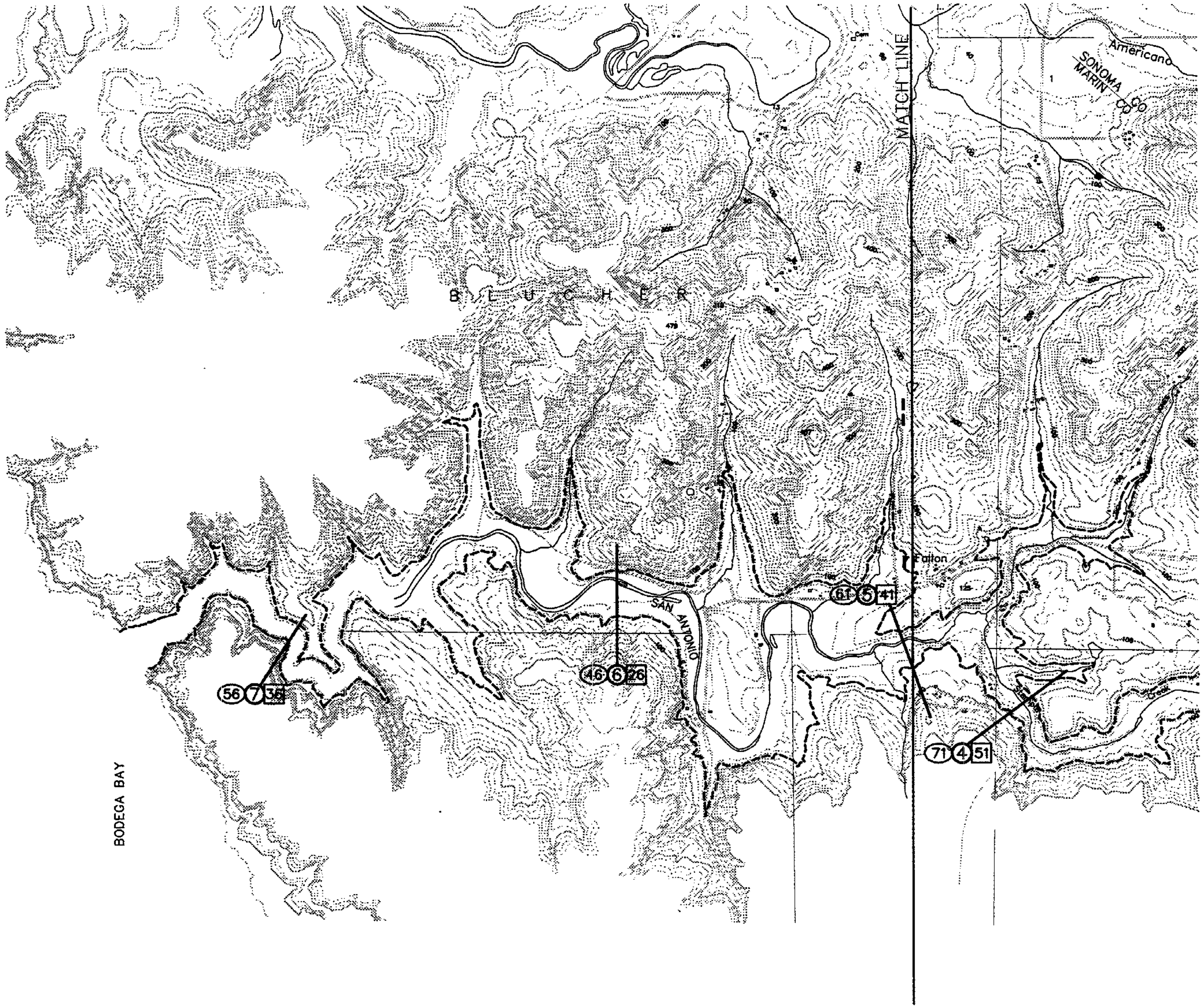
------ INUNDATION LIMITS FOR WORST CASE (PLAN 1)

HUNTLEY RESERVOIR (T-1)

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT
NOVEMBER 1995 DAM BREAK INUNDATION ANALYSIS
00385-006-038 SANTA ROSA, CALIFORNIA

DAMES & MOORE

FIGURE 4a



N
W E

0 1500 3000 6000
SCALE IN FEET
1" = 3000'

LEGEND:

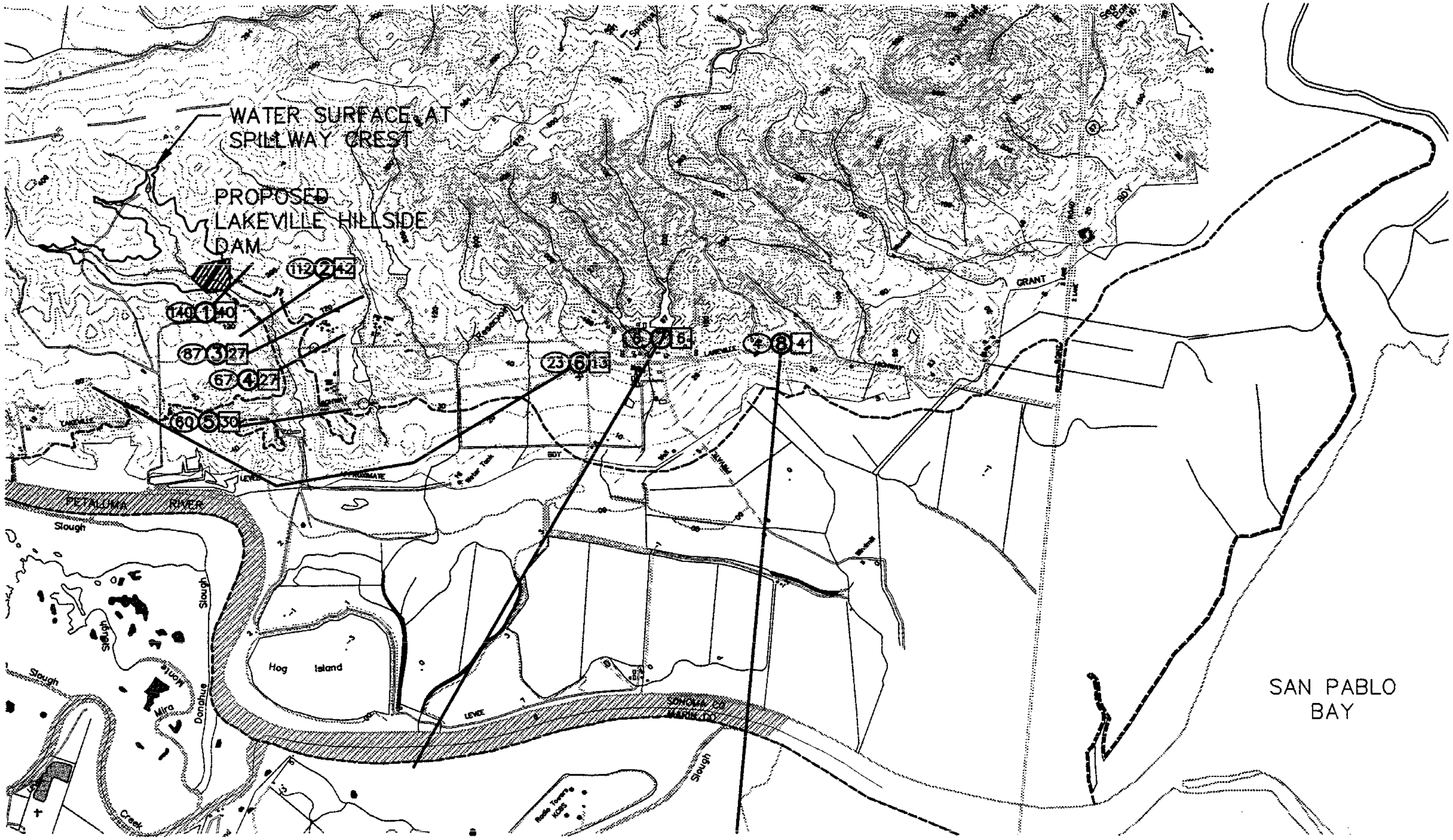
49 5 10
MAXIMUM FLOOD DEPTH (FT.)
REACH LOCATION NUMBER
MAXIMUM FLOOD ELEVATION (FT.)(NGVD.)

------- INUNDATION LIMITS FOR WORST CASE (PLAN 1)

HUNTLEY RESERVOIR (T-1)

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT
NOVEMBER 1995 DAM BREAK INUNDATION ANALYSIS
00385-006-038 SANTA ROSA, CALIFORNIA

DAMES & MOORE FIGURE 4b



0 1500 3000 6000
SCALE IN FEET
1"=3000'

LEGEND:

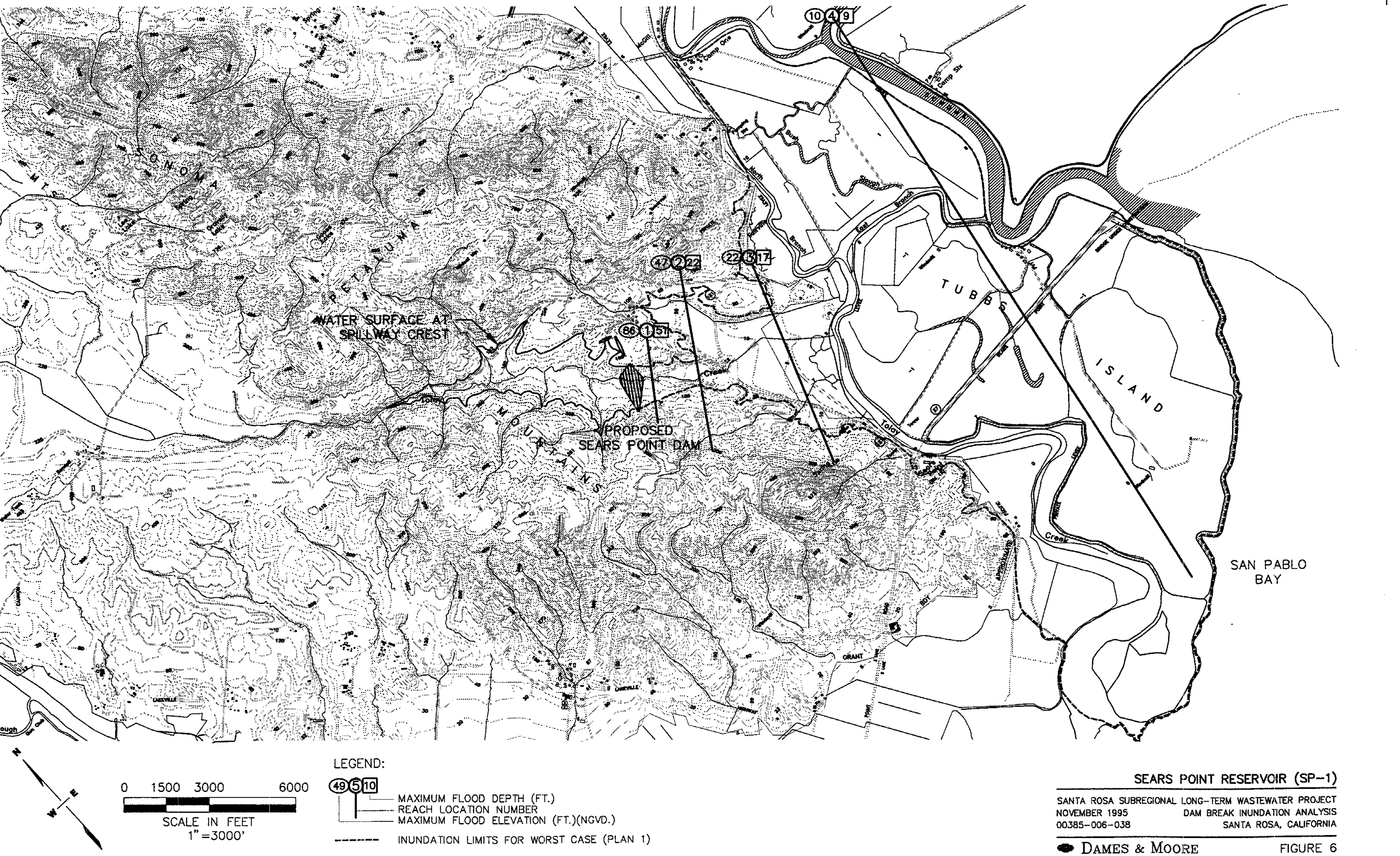
49 5 10
MAXIMUM FLOOD DEPTH (FT.)
REACH LOCATION NUMBER
MAXIMUM FLOOD ELEVATION (FT.)(NGVD.)
------ INUNDATION LIMITS FOR WORST CASE (PLAN 1)

LAKEVILLE HILLSIDE RESERVOIR (L2A)

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT
NOVEMBER 1995 DAM BREAK INUNDATION ANALYSIS
00385-006-038 SANTA ROSA, CALIFORNIA

DAMES & MOORE

FIGURE 5

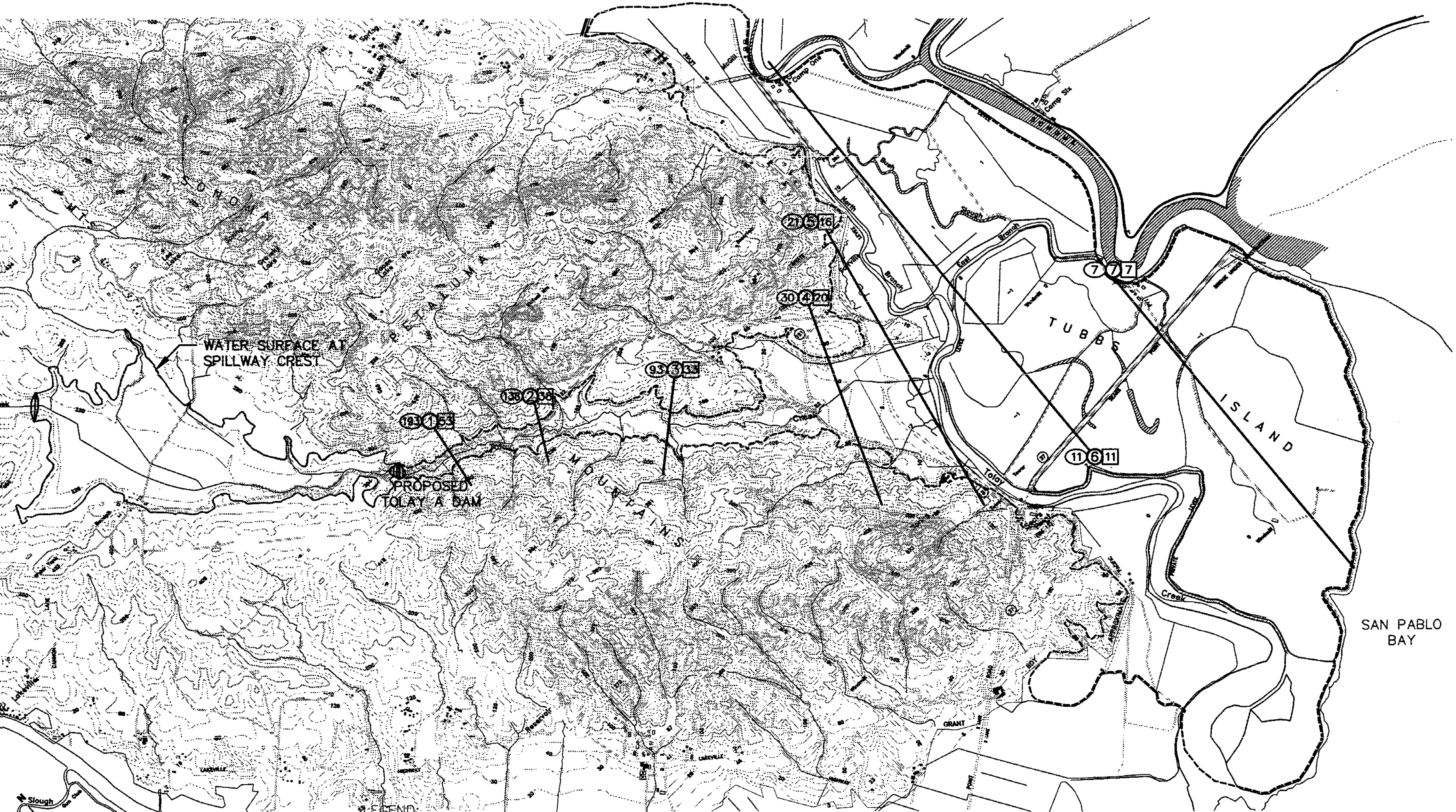


SEARS POINT RESERVOIR (SP-1)

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT
NOVEMBER 1995 DAM BREAK INUNDATION ANALYSIS
00385-006-038 SANTA ROSA, CALIFORNIA

DAMES & MOORE

FIGURE 6



LEGEND:

49 5 10
MAXIMUM FLOOD DEPTH (FT.)
REACH LOCATION NUMBER
MAXIMUM FLOOD ELEVATION (FT.)(NGVD.)

------ INUNDATION LIMITS FOR WORST CASE (PLAN 1)

0 1500 3000 6000

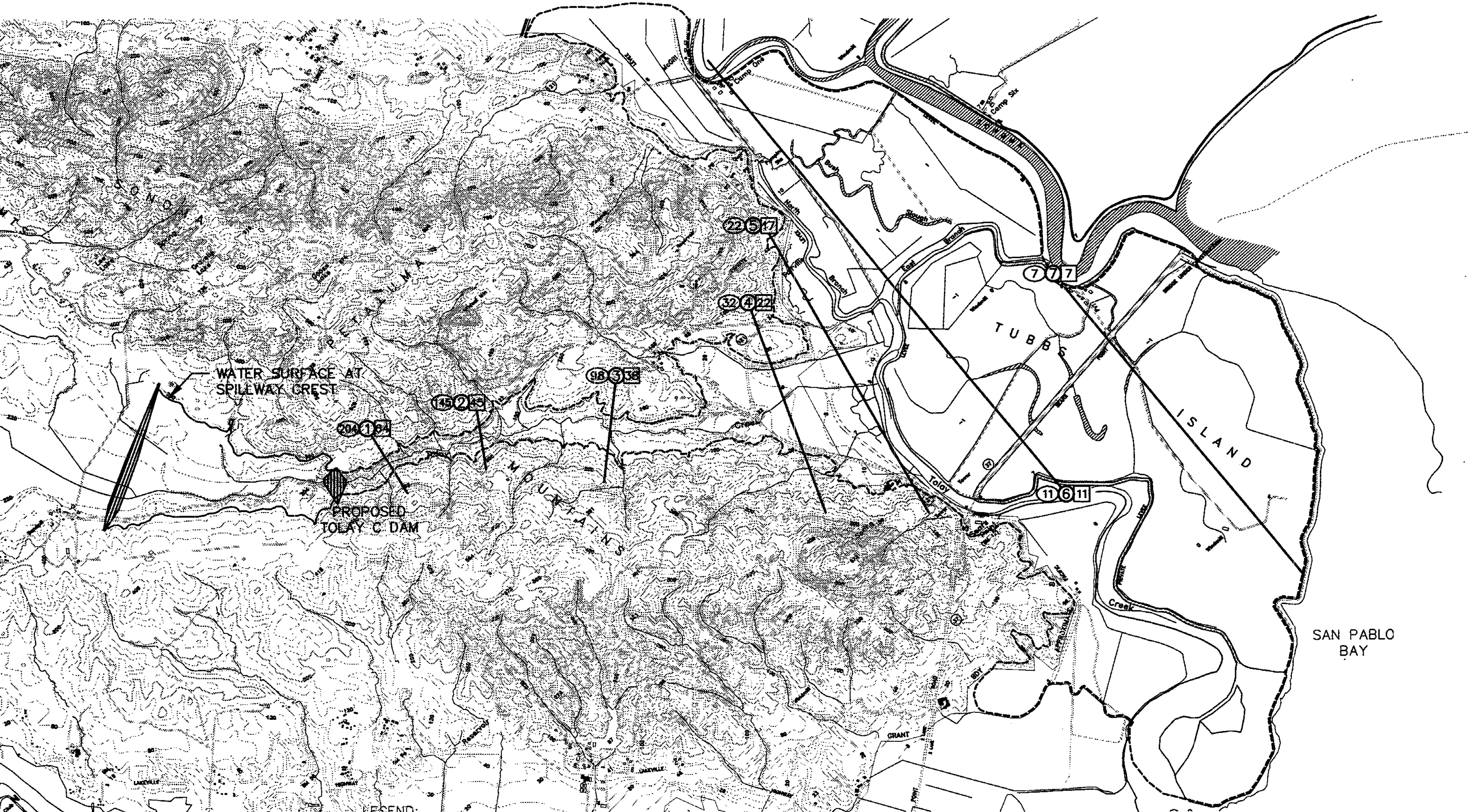
SCALE IN FEET
1" =3000'

TOLAY A RESERVOIR (S39)

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT
NOVEMBER 1995 DAM BREAK INUNDATION ANALYSIS
00385-006-038 SANTA ROSA, CALIFORNIA

DAMES & MOORE

FIGURE 7



0 1500 3000 6000

SCALE IN FEET
1"=3000'

LEGEND:

49 5 10

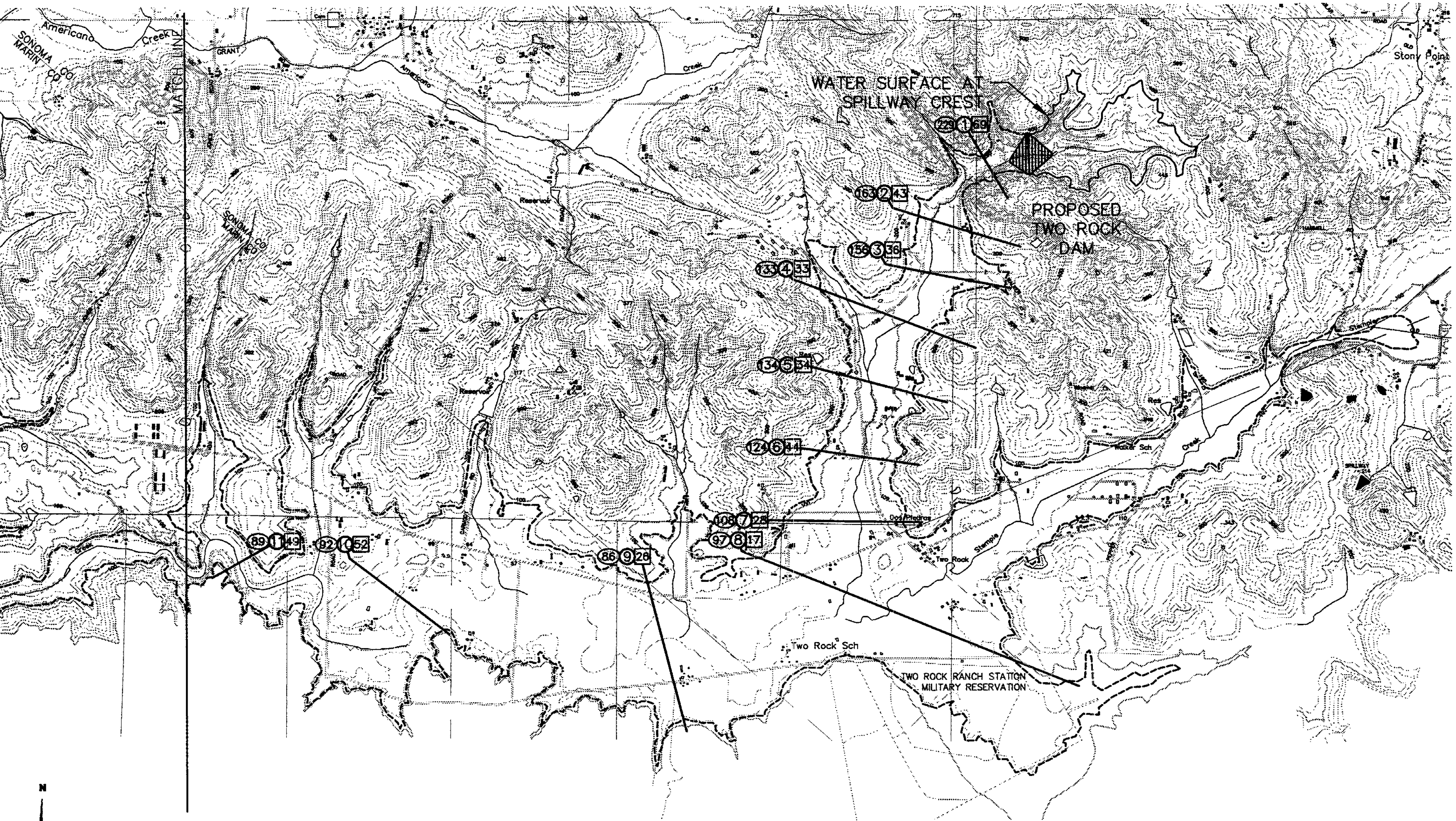
MAXIMUM FLOOD DEPTH (FT.)
REACH LOCATION NUMBER
MAXIMUM FLOOD ELEVATION (FT.)(NGVD.)

INUNDATION LIMITS FOR WORST CASE (PLAN 1)

TOLAY C RESERVOIR (S39C)

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT
NOVEMBER 1995 DAM BREAK INUNDATION ANALYSIS
00385-006-038 SANTA ROSA, CALIFORNIA

DAMES & MOORE FIGURE 8



N

W E

0 1500 3000 6000

SCALE IN FEET
1" =3000'

LEGEND:

(49)(5)[10]
[10] — MAXIMUM FLOOD DEPTH (FT.)
(5) — REACH LOCATION NUMBER
(49) — MAXIMUM FLOOD ELEVATION (FT.)(NGVD.)

------ INUNDATION LIMITS FOR WORST CASE (PLAN 1)

TWO ROCK RESERVOIR (T6A)

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT
NOVEMBER 1995 — DAM BREAK INUNDATION ANALYSIS
00385-006-038 — SANTA ROSA, CALIFORNIA

DAMES & MOORE — FIGURE 9a

0 1500 3000 6000

SCALE IN FEET
1" =3000'

LEGEND:

49 5 10

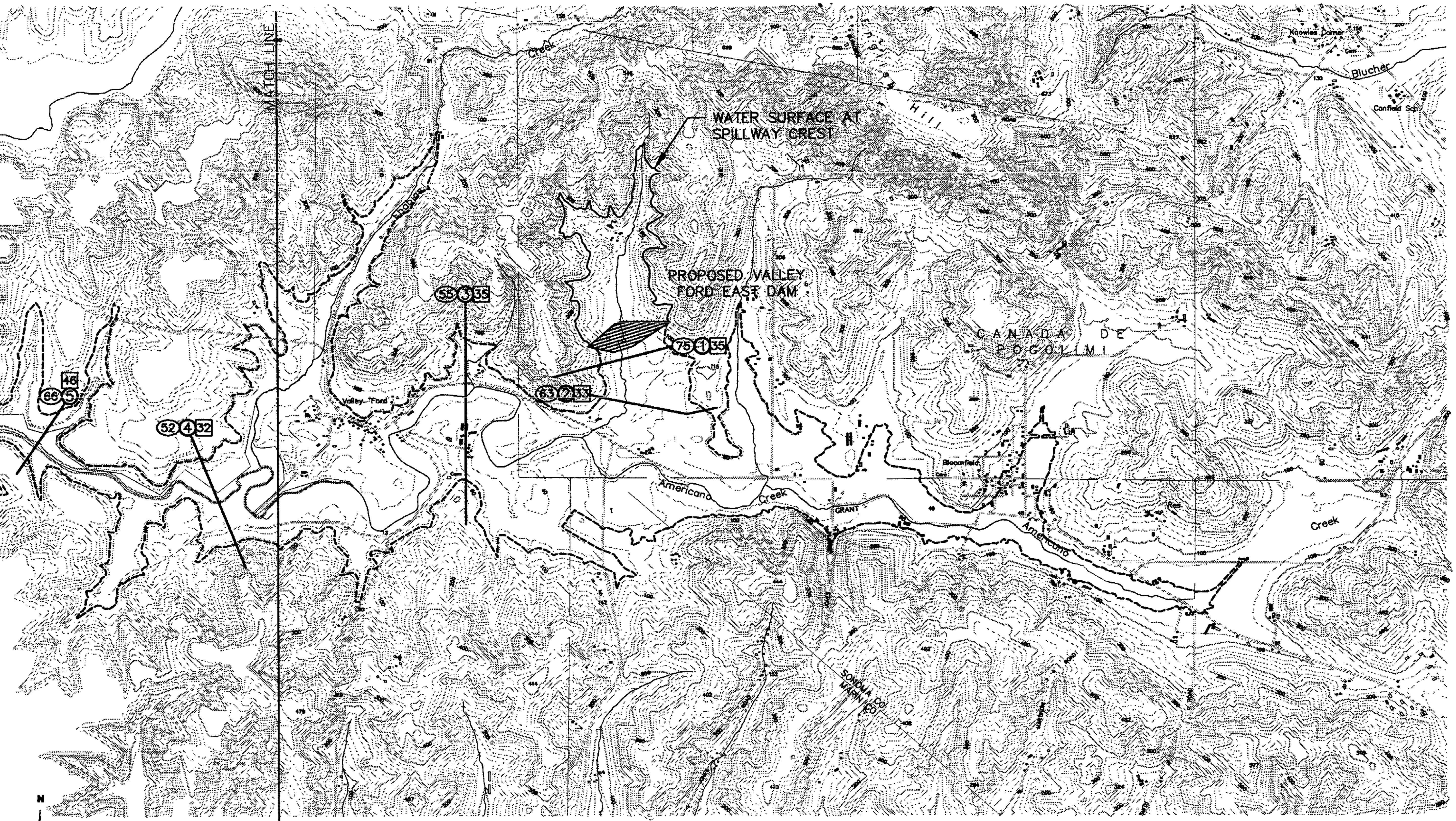
- MAXIMUM FLOOD DEPTH (FT.)
- REACH LOCATION NUMBER
- MAXIMUM FLOOD ELEVATION (FT.)(NGVD.)

------- INUNDATION LIMITS FOR WORST CASE (PLAN 1)

TWO ROCK RESERVOIR (T6A)

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT
NOVEMBER 1995 DAM BREAK INUNDATION ANALYSIS
00385-006-038 SANTA ROSA, CALIFORNIA

DAMES & MOORE FIGURE 9b



N
W — E

0 1500 3000 6000

SCALE IN FEET
1" =3000'

LEGEND:

49 5 10
MAXIMUM FLOOD DEPTH (FT.)
REACH LOCATION NUMBER
MAXIMUM FLOOD ELEVATION (FT.)(NGVD.)

INUNDATION LIMITS FOR WORST CASE (PLAN 1)

VALLEY FORD EAST RESERVOIR (V4)

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT
NOVEMBER 1995 DAM BREAK INUNDATION ANALYSIS
00385-006-038 SANTA ROSA, CALIFORNIA

DAMES & MOORE

FIGURE 10a

LEGEND:

49 5 10

MAXIMUM FLOOD DEPTH (FT.)
REACH LOCATION NUMBER
MAXIMUM FLOOD ELEVATION (FT.)(NGVD.)

INUNDATION LIMITS FOR WORST CASE (PLAN 1)

0 1500 3000 6000

SCALE IN FEET
1" =3000'

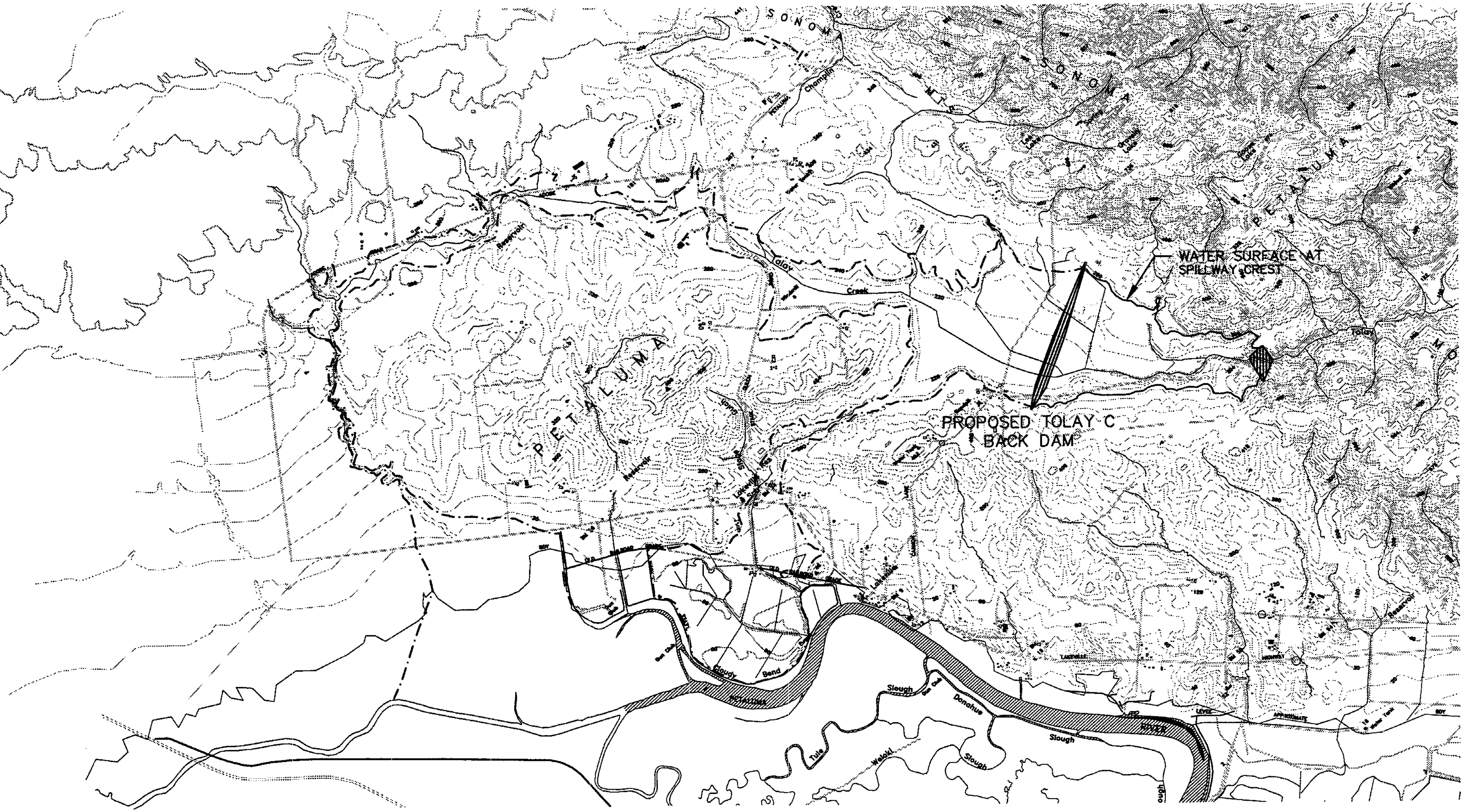
N
W E

VALLEY FORD EAST RESERVOIR (V4)

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT
NOVEMBER 1995
DAM BREAK INUNDATION ANALYSIS
00385-006-038
SANTA ROSA, CALIFORNIA

DAMES & MOORE

FIGURE 10b



N E W

0 1500 3000 6000

SCALE IN FEET
1"=3000'

LEGEND:

-·-·- ESTIMATED INUNDATION LIMITS FROM TOTAL BACKDAM FAILURE

TOLAY C BACKDAM

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT
NOVEMBER 1995 DAM BREAK INUNDATION ANALYSIS
00385-006-038 SANTA ROSA, CALIFORNIA

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FIGURE 11