

MAPPING THE ST. FRANCIS DAM OUTBURST FLOOD WITH GEOGRAPHIC INFORMATION SYSTEMS

J. David Rogers

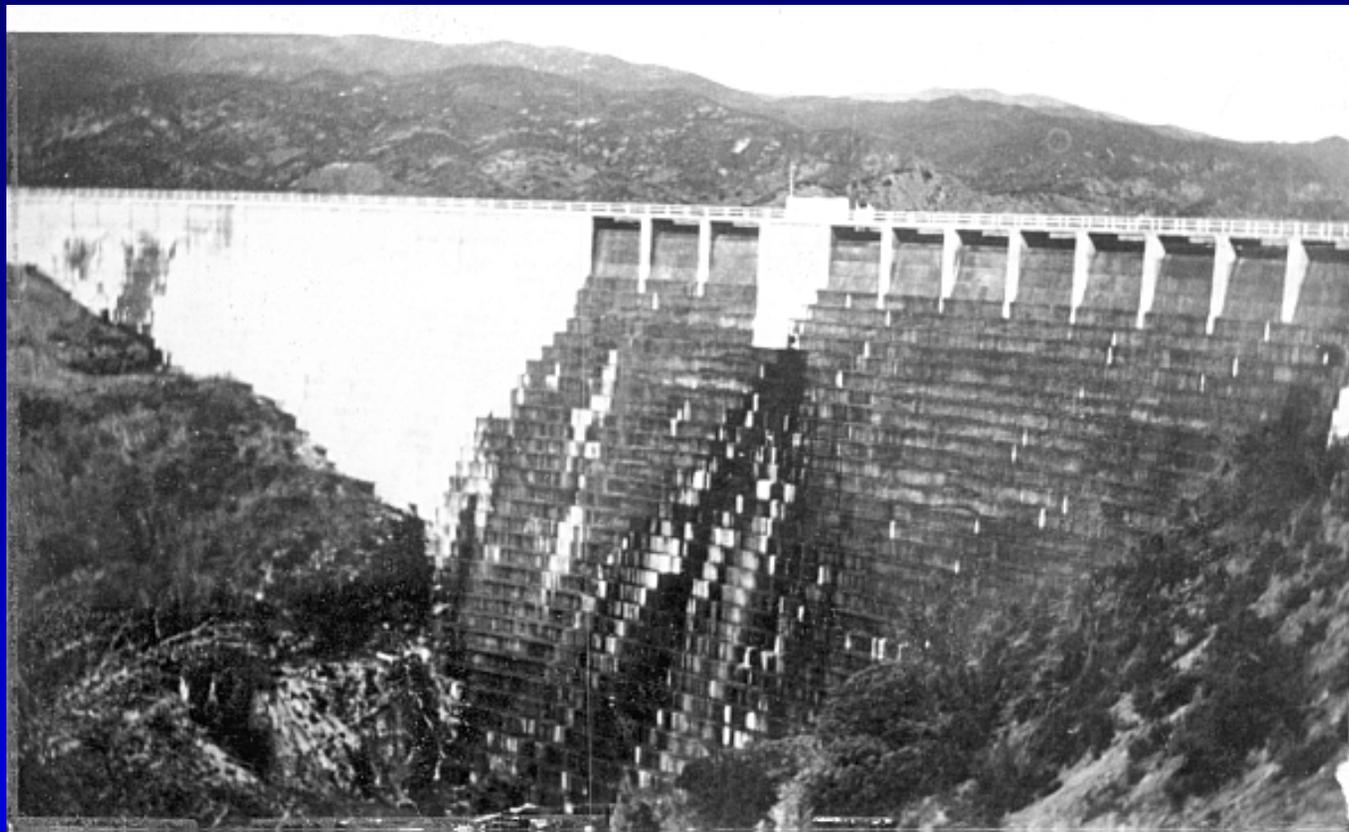
Kevin James

Department of Geological Engineering

University of Missouri-Rolla

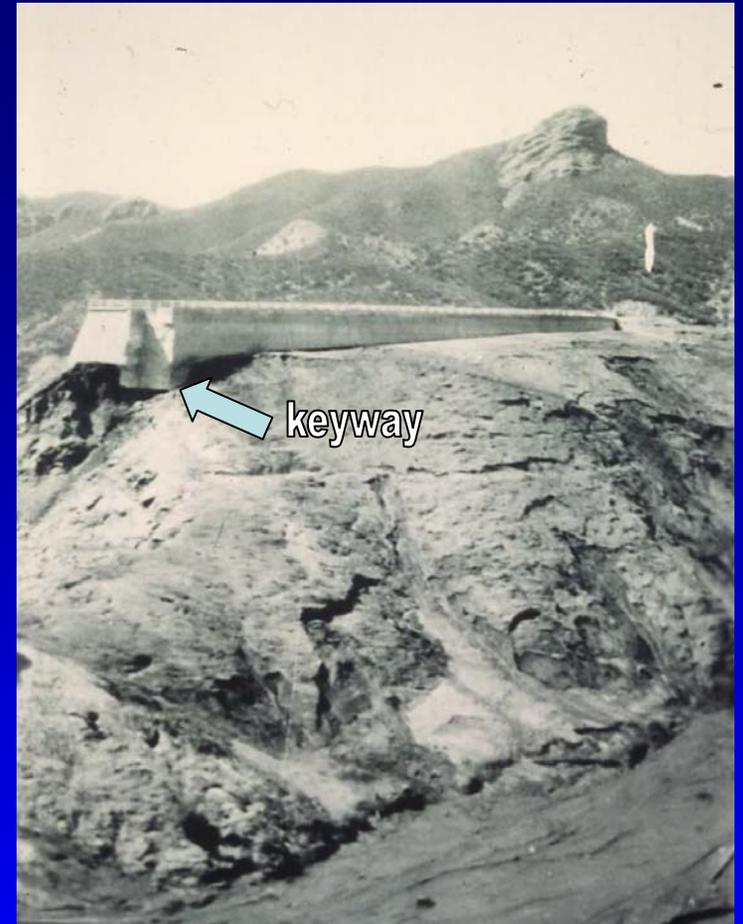


- **St. Francis Dam** was a 200-ft high concrete gravity-arch dam constructed by the City of Los Angeles between 1924-26
- It failed near midnight on March 12-13, 1928, killing at least 420 people, making it the worst American civil engineering failure of the 20th Century



- The reservoir was brought up to within 4 inches of spillway crest for the first time on Wed., March 7, 1928.
- The damkeeper called City engineers on the morning of the failure to report discharge of about 2 cfs from the right abutment area. This view shows wind-whipped waves splashing over the spillway panels about 12 hours before the failure.

Before and After



- Comparative views taken of the dam's upstream face looking at the right abutment, 12 hours before the failure (at left) and the day after (right)
- Note exposed keyway beneath right abutment dike

Back-analysis of the outbreak flood

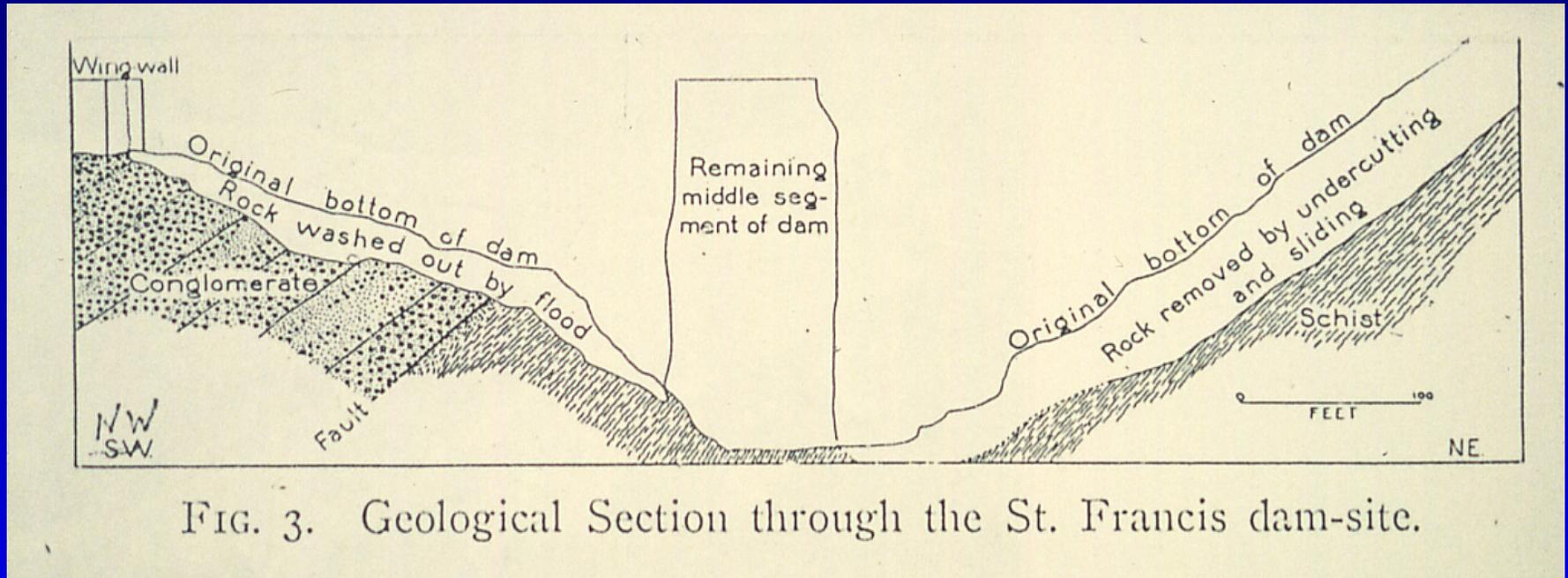


FIG. 3. Geological Section through the St. Francis dam-site.

- The dam site could not be used for a back-analysis of the outbreak flood hydrograph (quantity of flow versus time) because the cross-sectional area was varying with each passing minute of the failure, beginning with a small area and ending with the maximum area.

Establishing constraining data points



- According to eye witness accounts, the **reservoir was essentially empty by 1:09 AM**, as shown above
- The Lancaster 70 Kv power line went down at 11:57-1/2 PM in vicinity of the dam site
- Powerhouse 2, located 7300 feet downstream, went offline at 12:02-1/2 AM

Establishing constraining data points



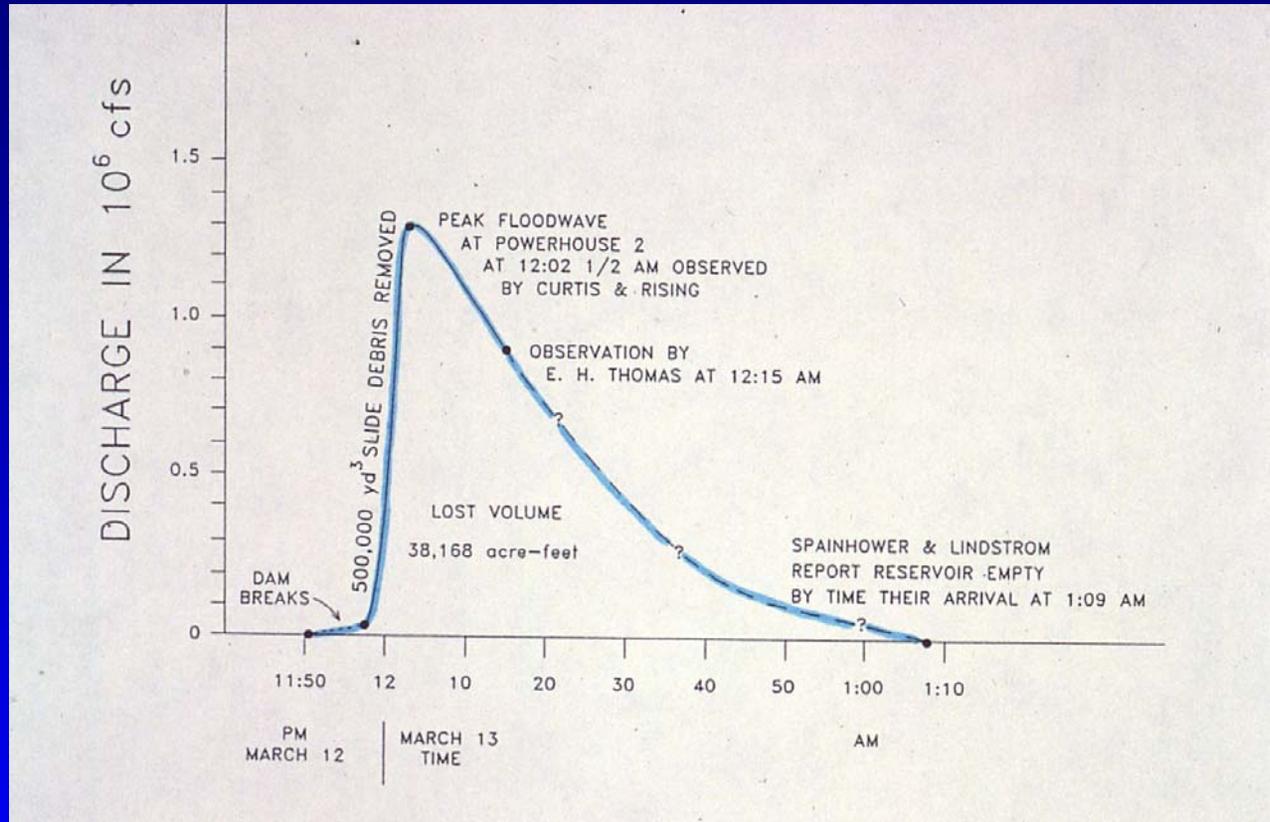
- The maximum depth of the outbreak flood was known from measurements made at the time and we used terrestrial photogrammetry to fill in the gaps
- The depth of flood water was about 140 feet just downstream of the dam and about 110 feet at Powerhouse 2, 1.4 miles downstream

Crucial data for back analysis

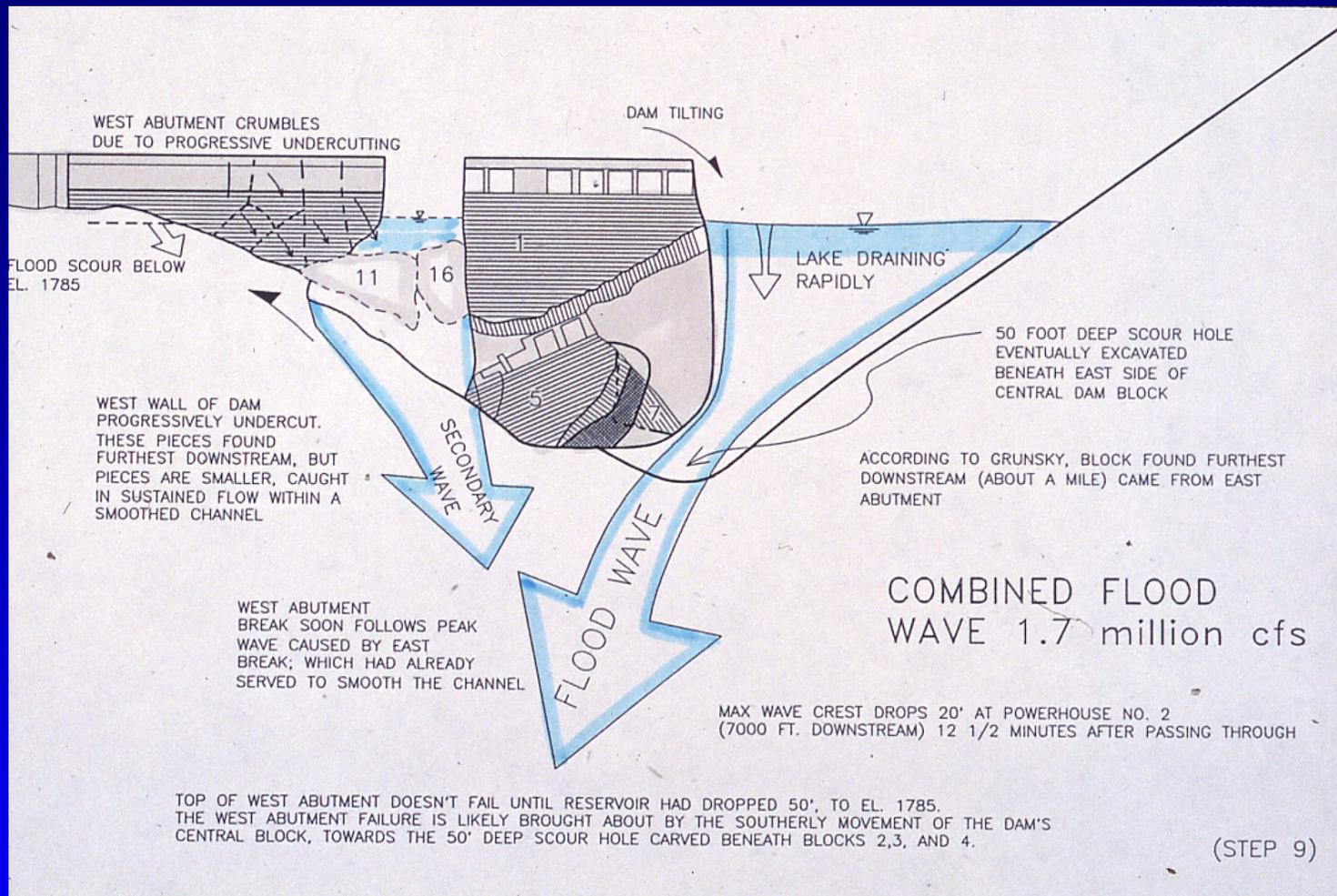


- At Powerhouse 2, the surge chamber attendant climbed down the tramway tracks during the flood, shown at left side of the photo at right (arrows)
- He reached the high water line at 12:15 AM, and noted that the level had already dropped 20 feet

Flood hydrograph at Powerhouse 2



- A peak flow of **1.3 million cfs** was calculated for Powerhouse 2, 1.4 miles downstream of the dam
- The peak flow at the damsite was likely close to **1.7 million cfs**



- As the left side of the main dam was undercut, it moved into the enlarging void, triggering a chain-reaction failure of the right abutment area after the reservoir had dropped about 75 to 85 feet.
- **The peak outflow at the dam site was likely something close to 1.7 million cfs.** The maximum outflow estimate in 1928 was only 400,000 cfs.



saddle



- As the flood moved downstream, the depth of flow diminished. This view shows a saddle 120 feet above the creek bed about $\frac{3}{4}$ mile downstream, which was overtopped by the outpouring waters.



- The flood swept 6 miles down San Francisquito Canyon to its junction with the much larger Santa Clara River, where it made a right-hand reverse turn through Castaic Junction.



camp at Kemp Siding

- At Castaic Junction, the flood turned west and swept down the Santa Clara River valley, through the Southern California Edison construction camp at Kemp Siding, **drowning 84 of the 140 workers** sleeping there.

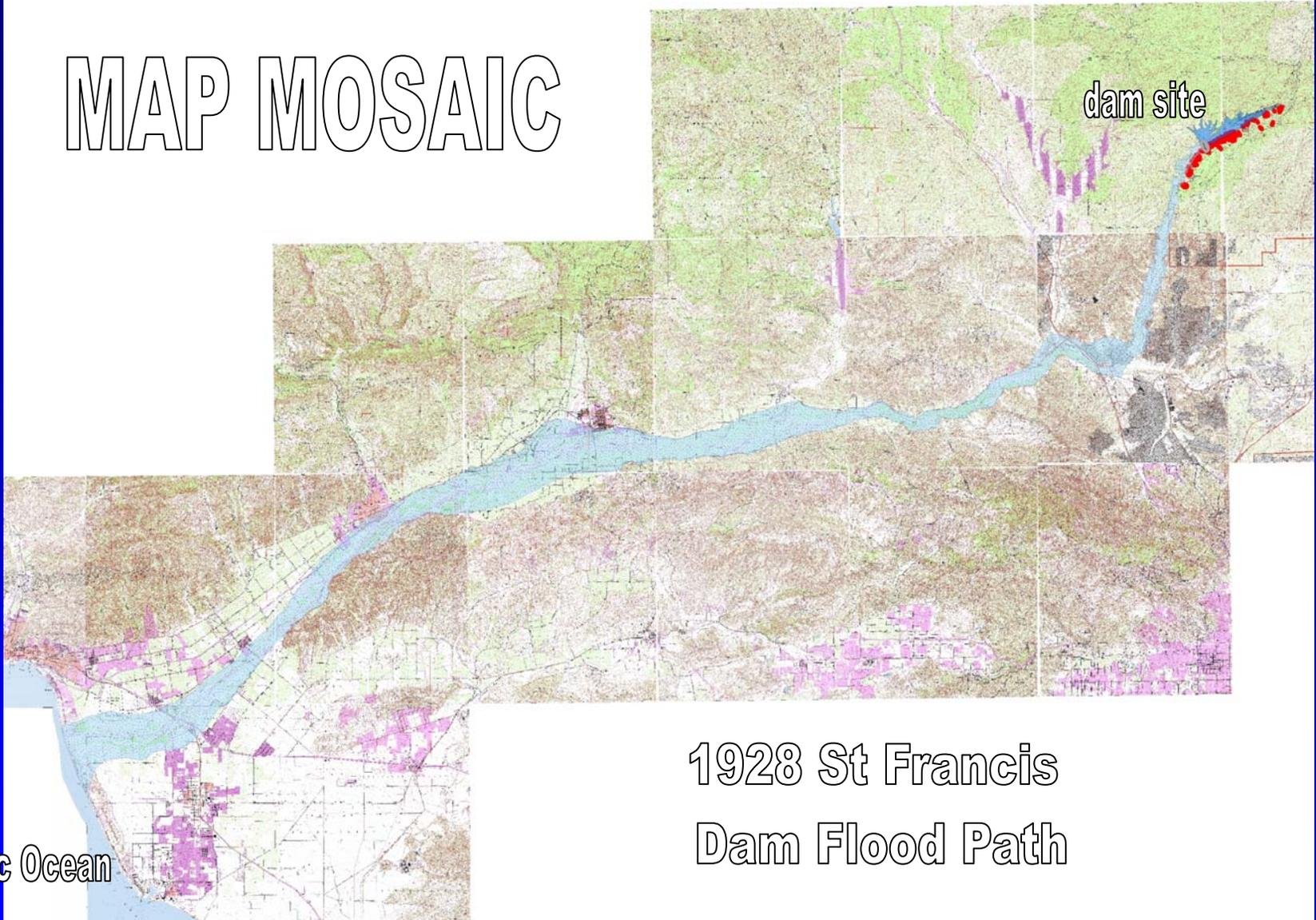


- The flood reached the Pacific Ocean at Montalvo around 5:30 AM. By this time the velocity had dropped to about 5 miles per hour and the flood was two miles wide. Both the railroad and highway bridges were washed out. Some bodies were recovered from the ocean as far south as San Diego.

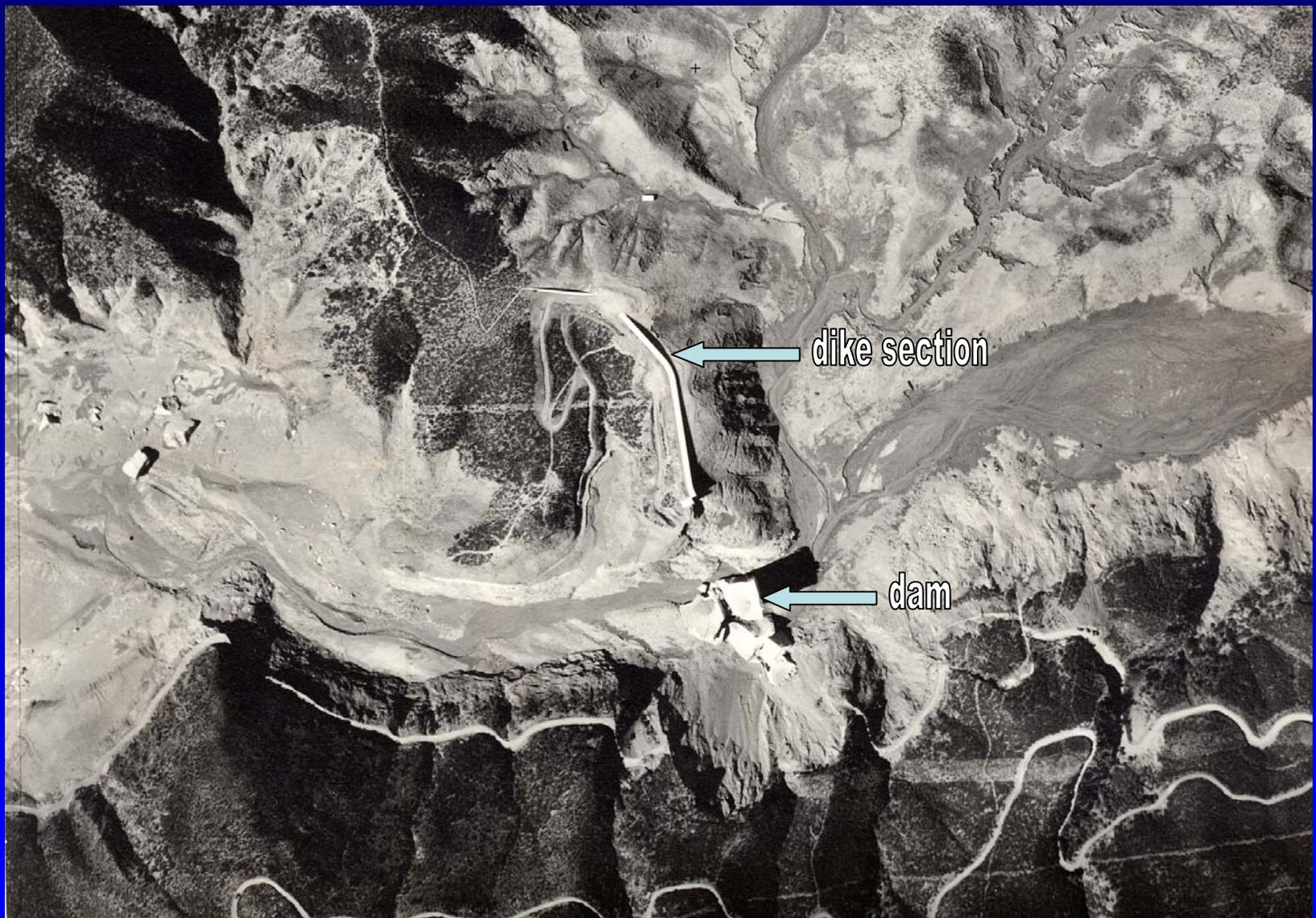


- Charles Lee's map of the flooded area, extending 54 miles from the St. Francis Dam site, through Castaic, Camulos, Filmore, Santa Paula, Saticoy and Montalvo. The smoothed flow distance was 52 miles.

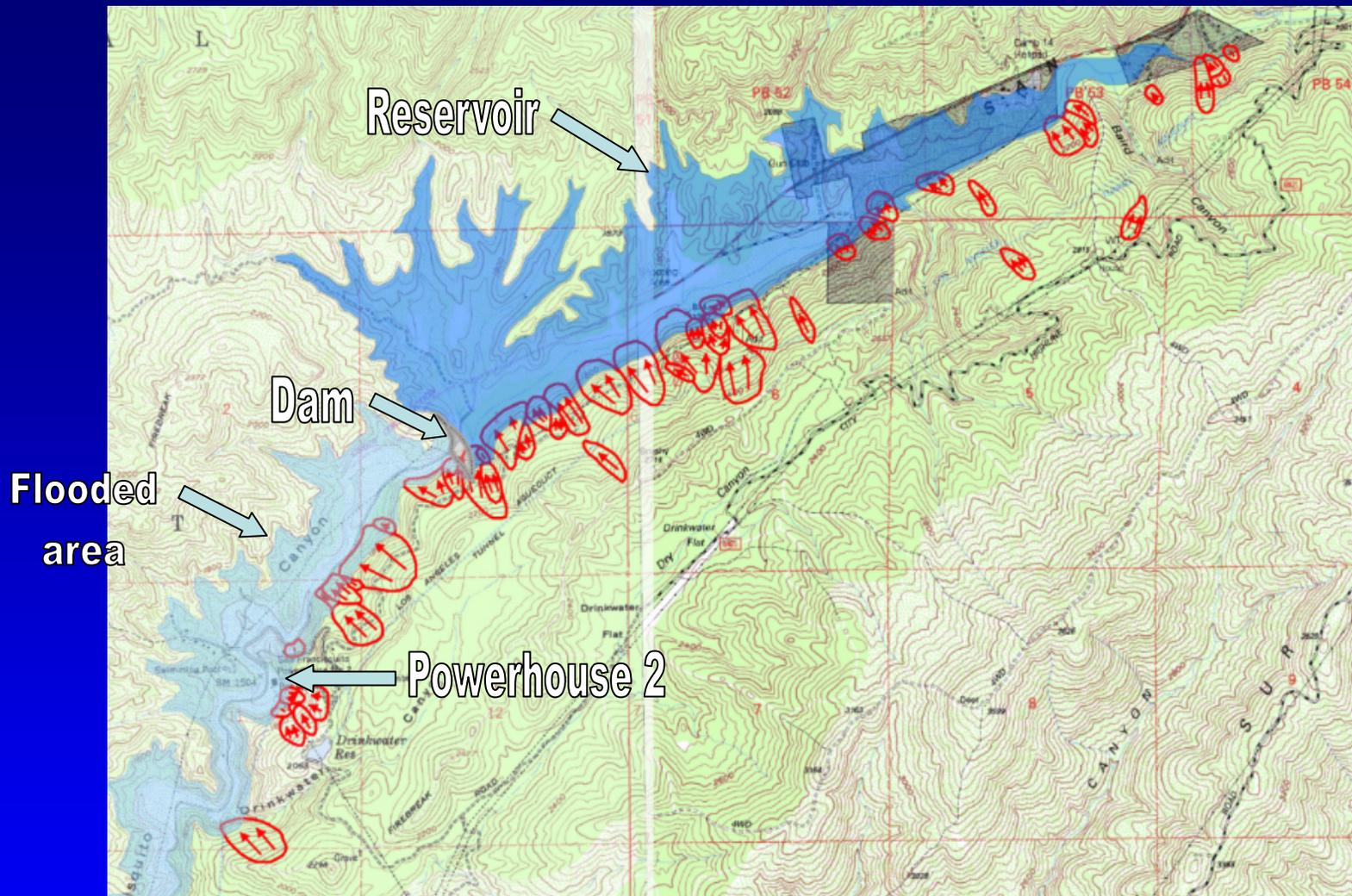
MAP MOSAIC



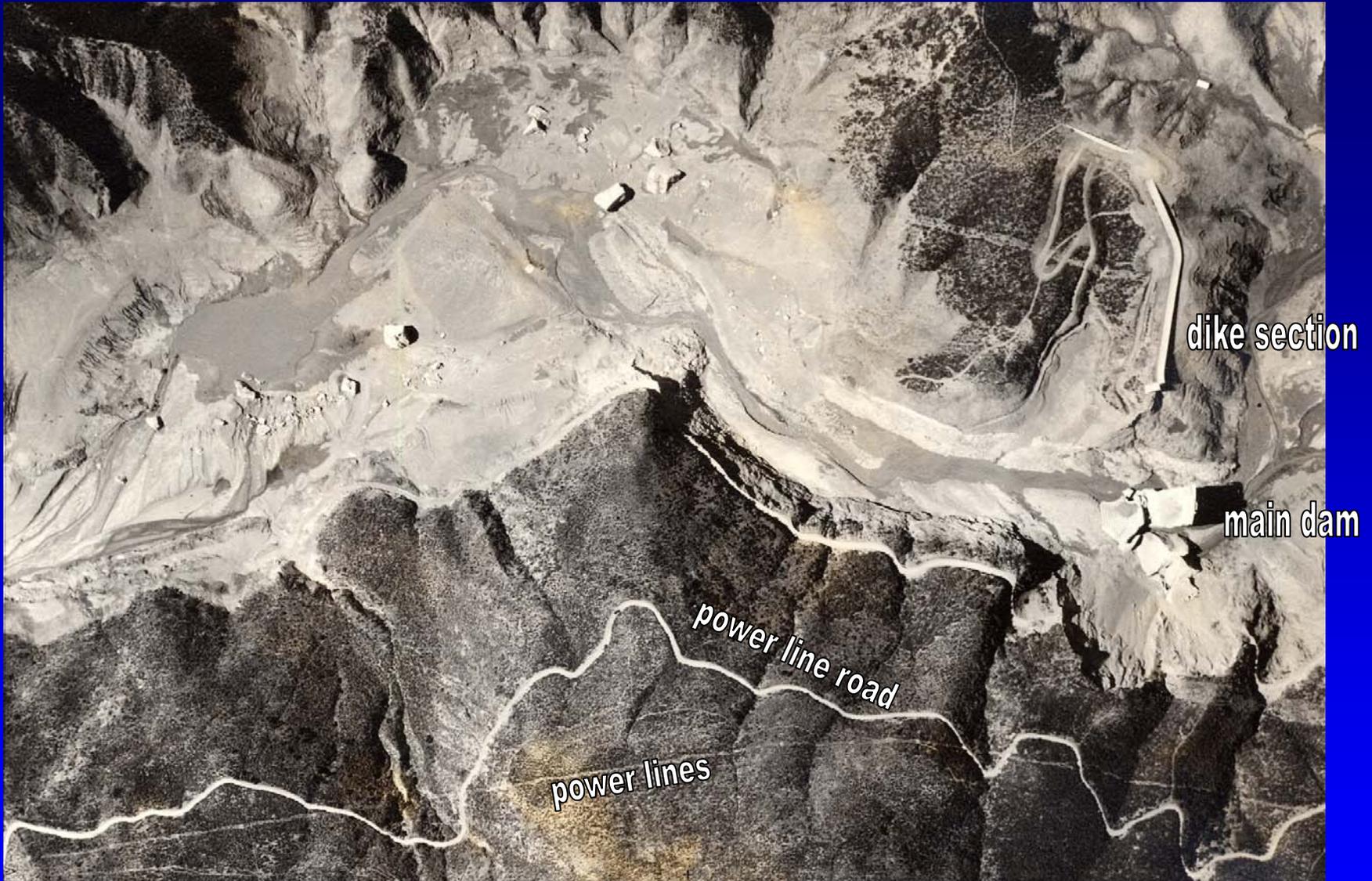
- 19 USGS 1:24,000 scale Digital Raster Graphic (DRGs) quadrangles were stitched to create a flood base map.



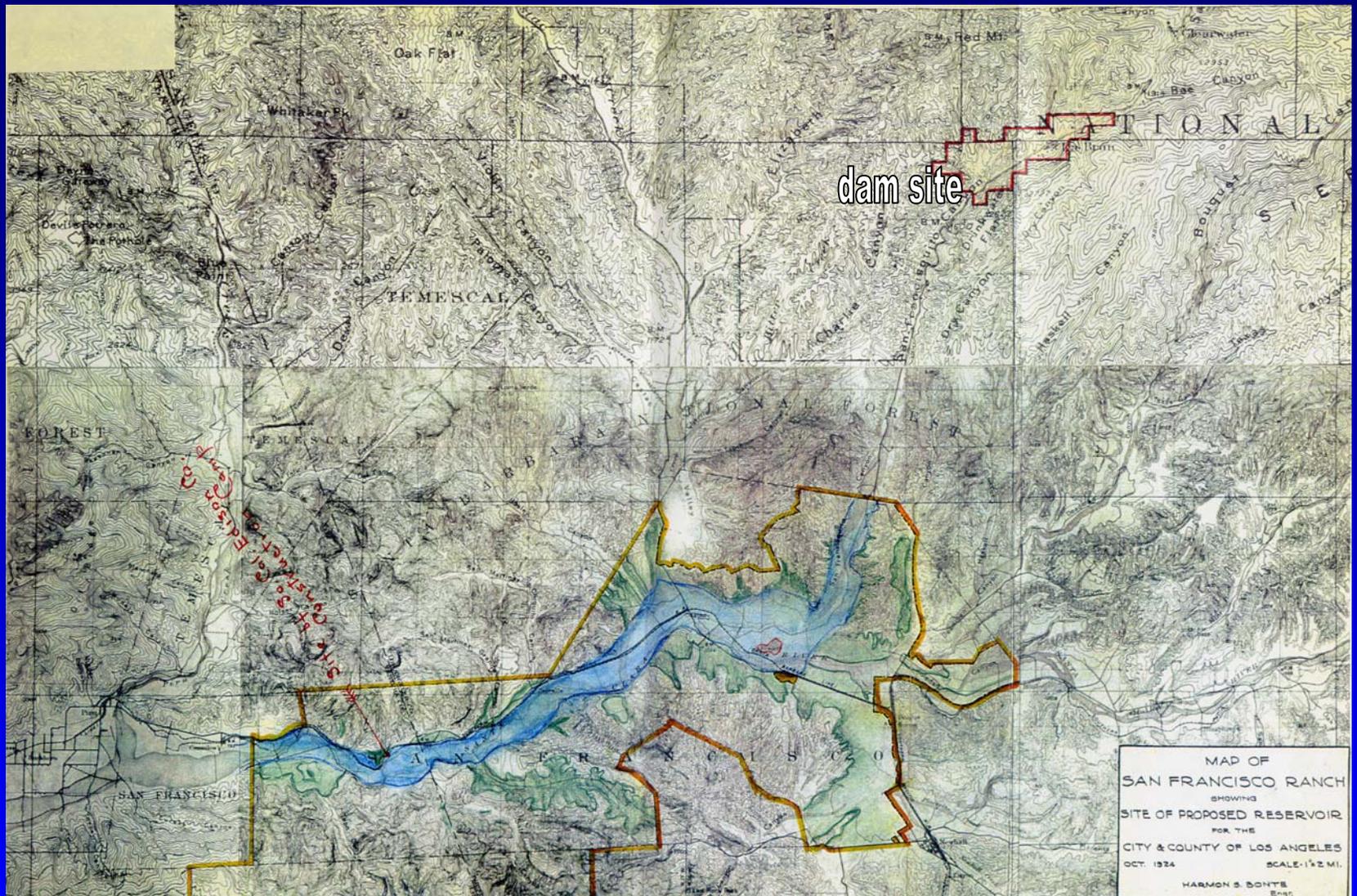
- Stereopair aerial photos were orthorectified on present-day DRGs to obtain areal limits of flood waters. This view shows the dam site and immediately downstream.



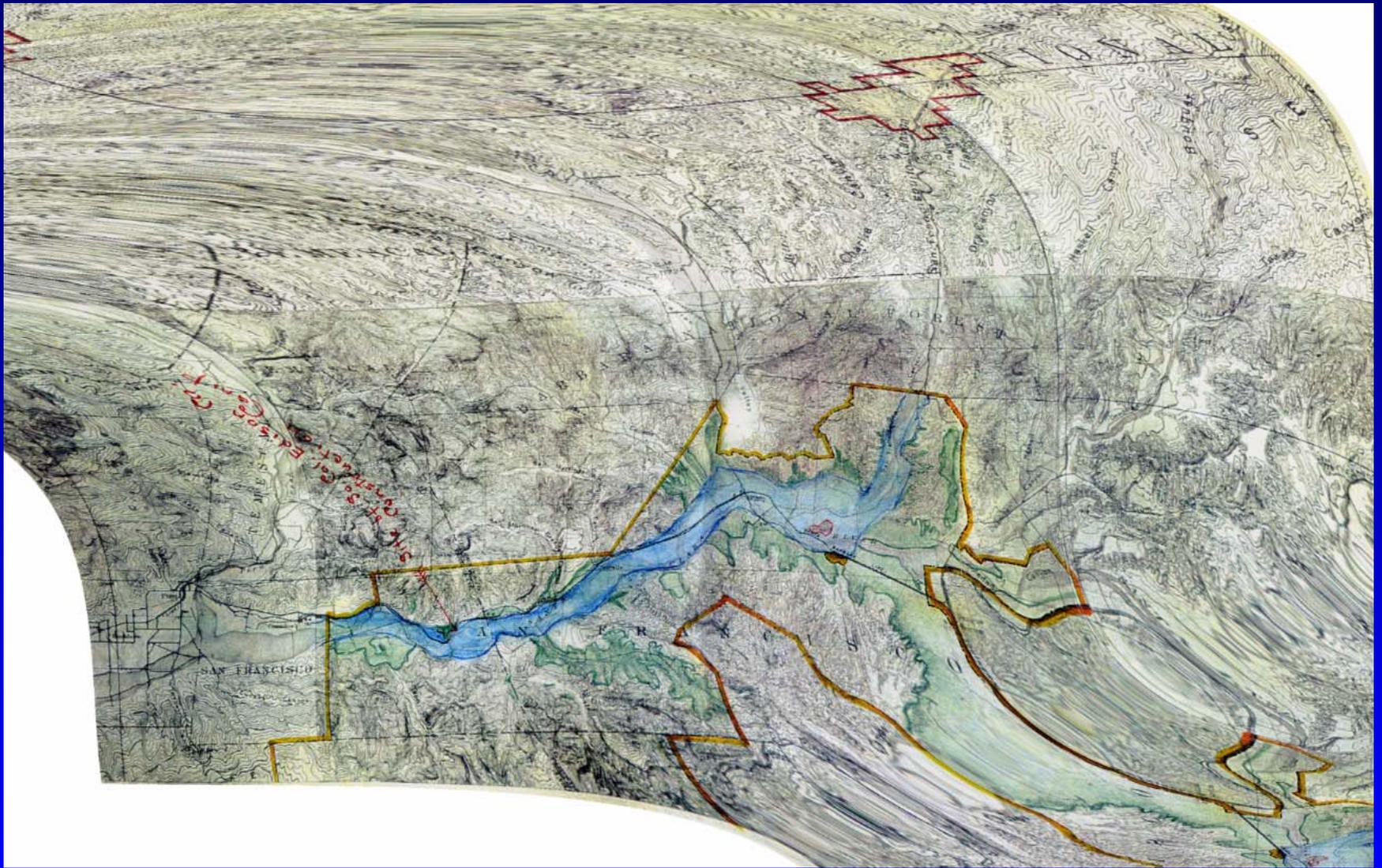
- This flood map was created in ArcGIS on USGS 7.5-minute DRGs. It shows the 1928 reservoir in dark blue and the flood limits in light blue. Landslides are shown in red.



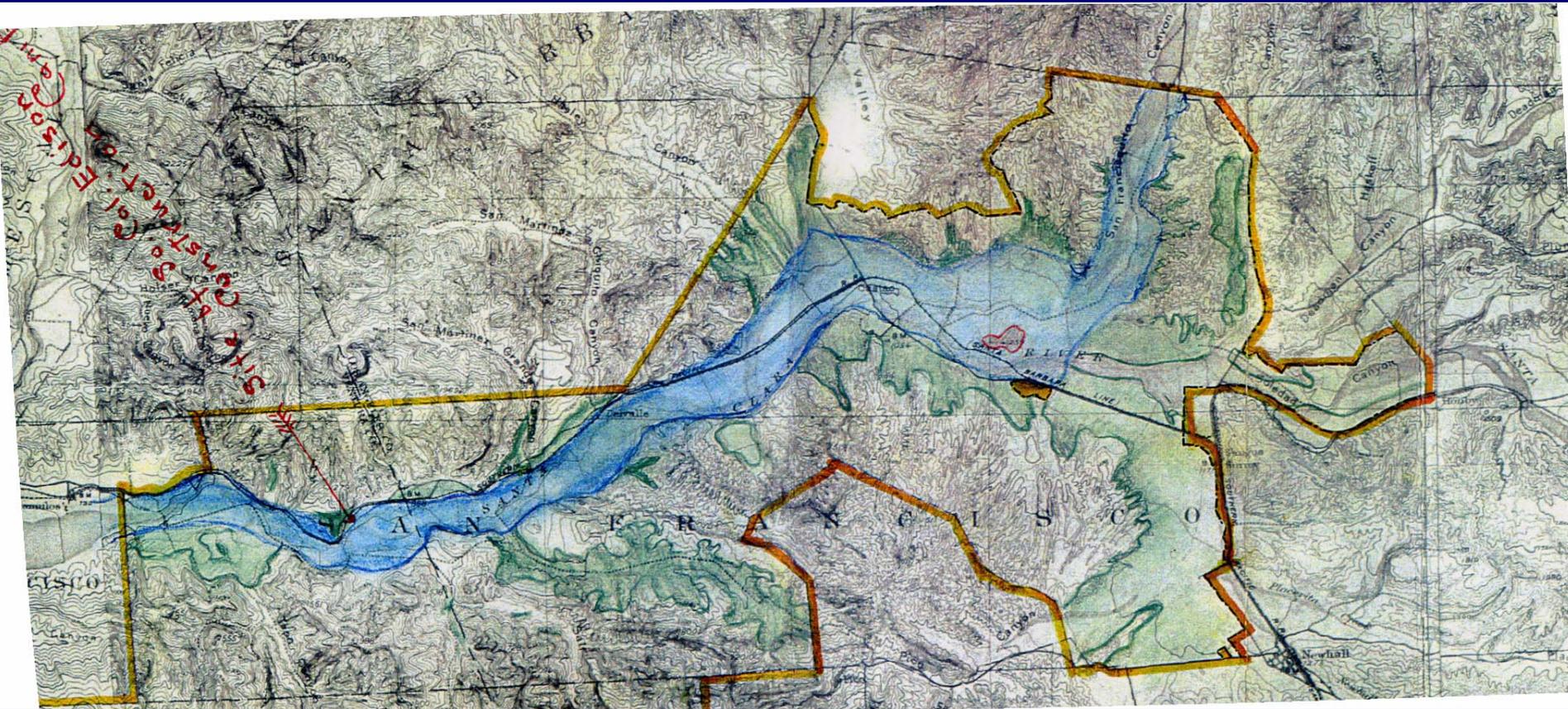
- Orthorectified flood images are overlain on present day DRGs using **control points** visible on both the photos and present day maps. In this case the power line road across the lower portion of the photo was useful.



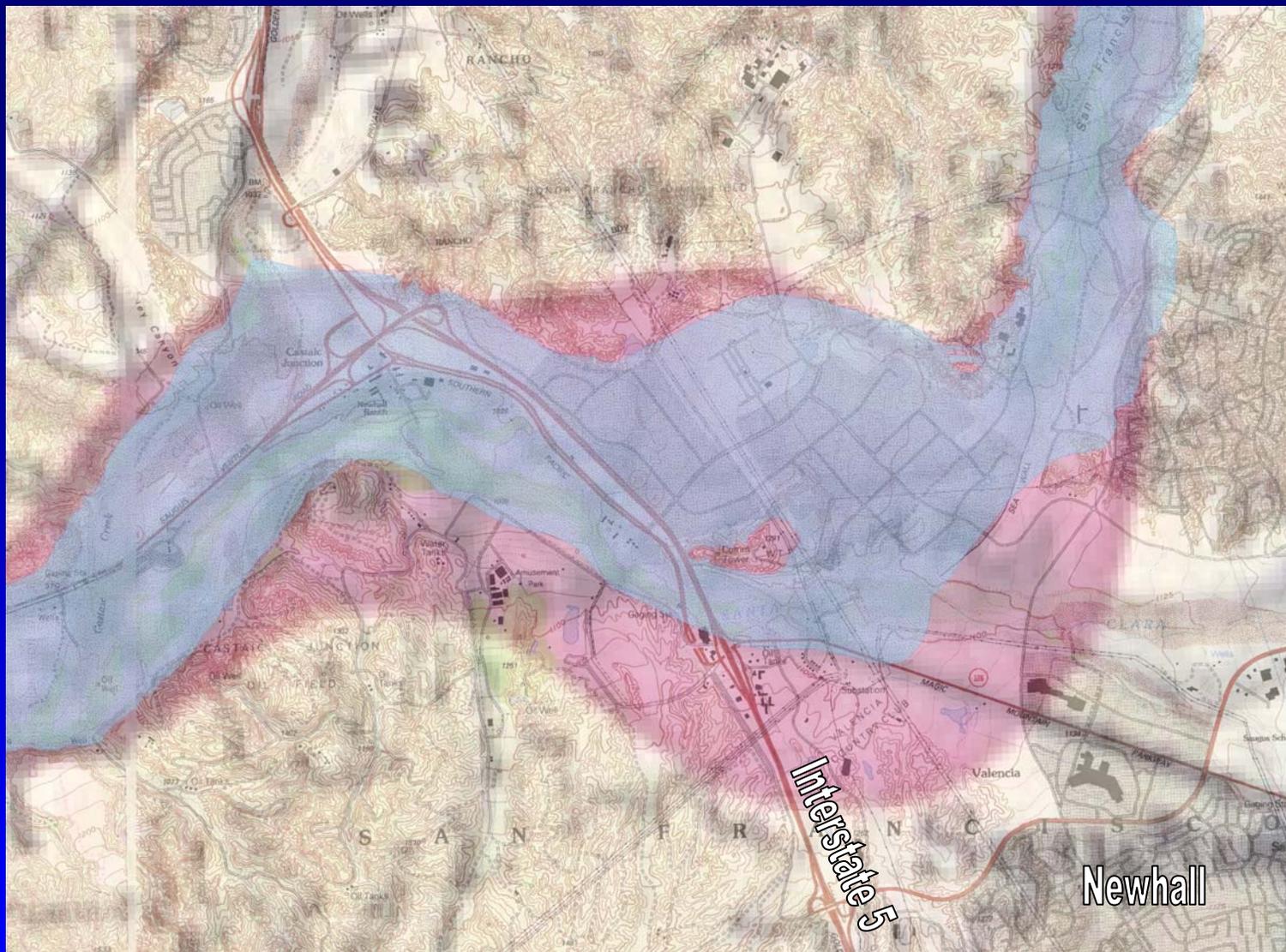
- Isolated flood damage maps were constructed by engineers for several of the larger ranches to document property damage. This map was made for the Newhall Land Company at a scale of 1" = 880 ft



- These more detailed inundation maps were orthorectified using cadastral features, such as section lines, latitude, longitude lines and county boundaries.



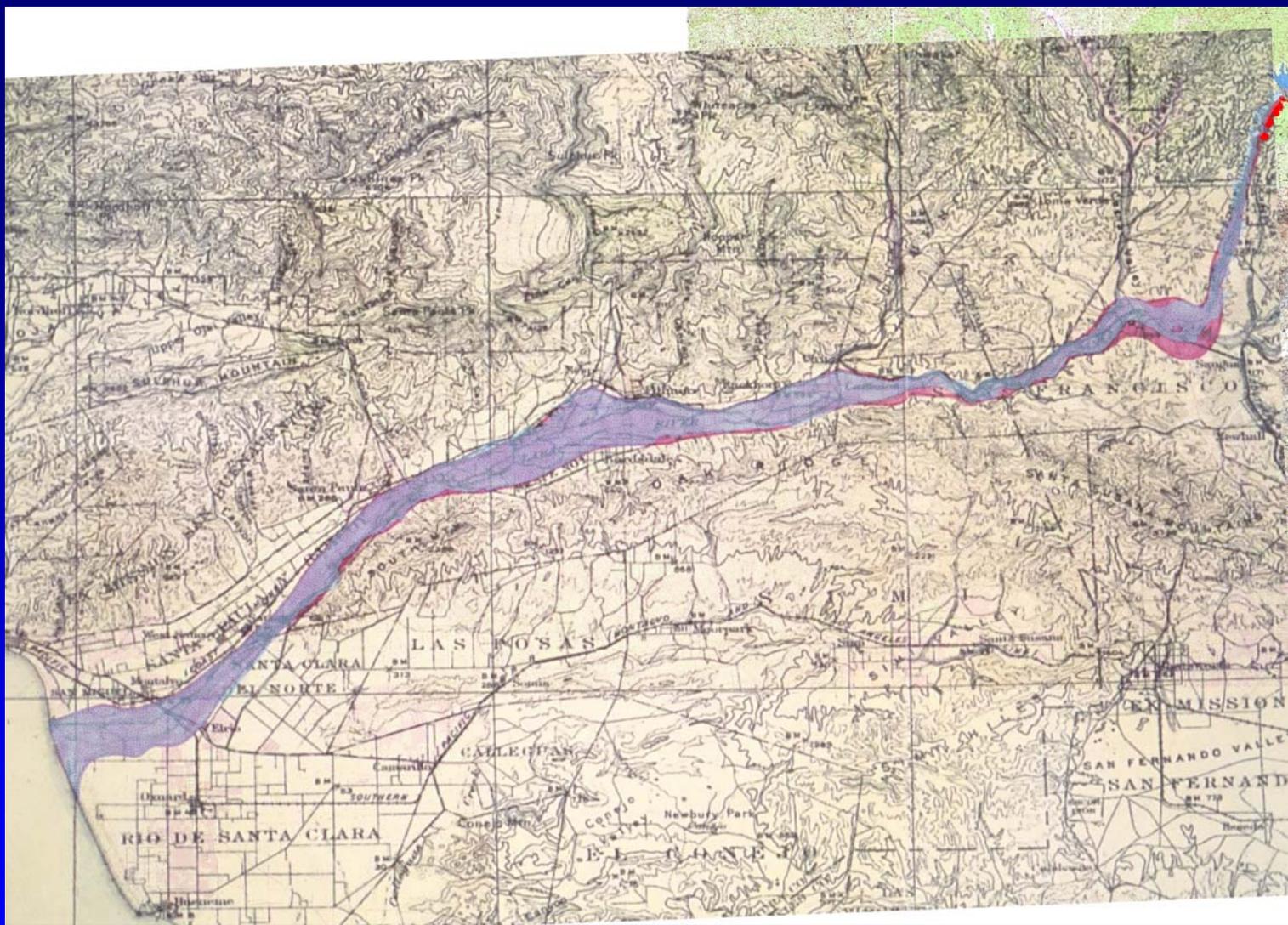
- **Orthorectified local flood map.** By applying Universal Transverse Mercator (UTM) Grid North American Datum (NAD) 1983 (83) geospatial controls, the 1928 planar map is skewed slightly when orthorectified to present-day map projection standards that account for the Earth's actual curvature.



- When our GIS map (blue) was overlain on Charles Lee's flood map (red); it appeared that he greatly overestimated the spatial limits of flooding in the Castaic Junction area.

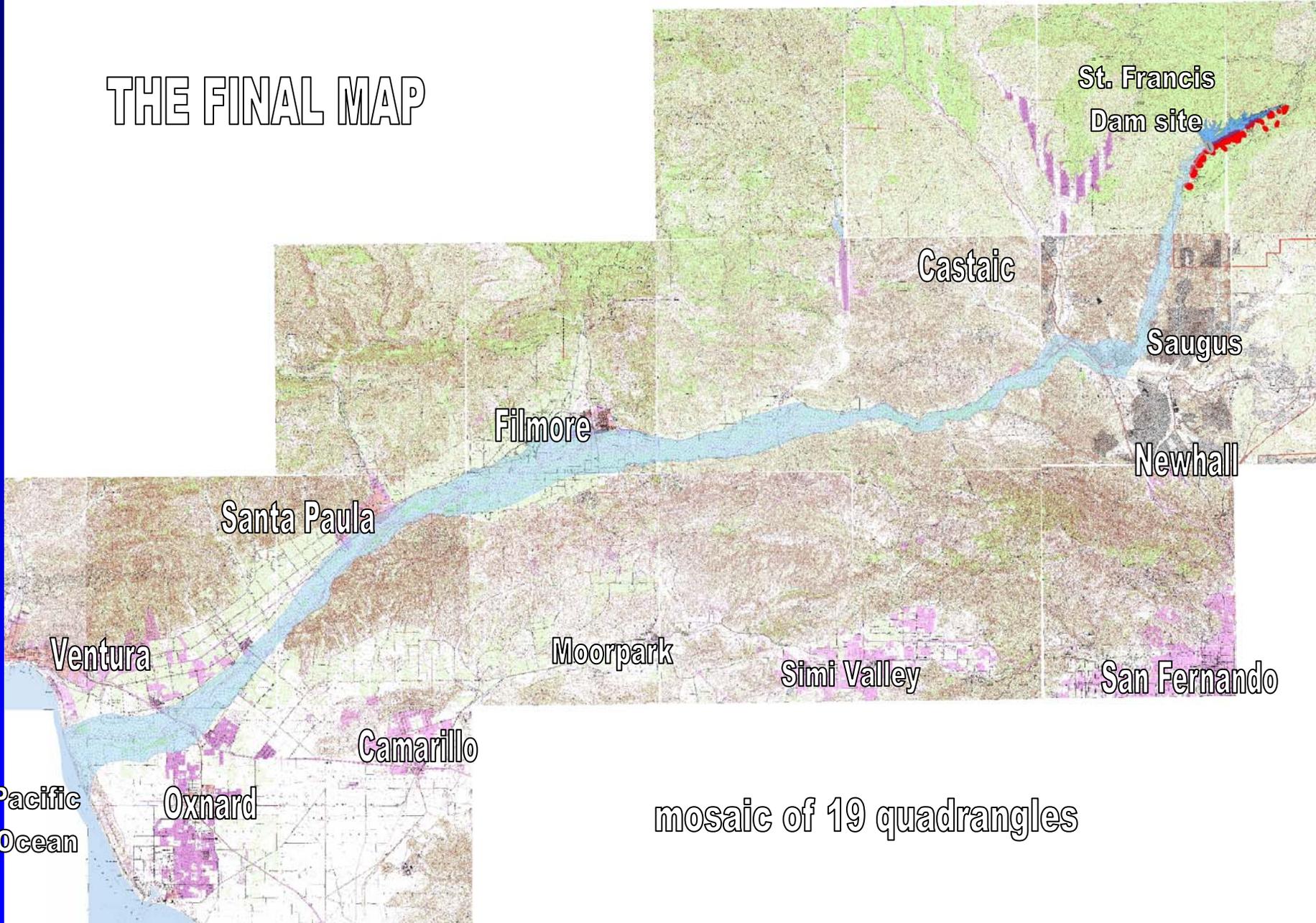


- The flood limits shown on our new map are very similar to those shown on the damage map prepared for the Newhall Land Company in the Castaic Junction area.



- Comparison between orthorectified version of Lee's flood map (red) and our new flood map (blue). Lee's map was prepared on a 1:250,000 scale base map (1 inch = 4 miles).

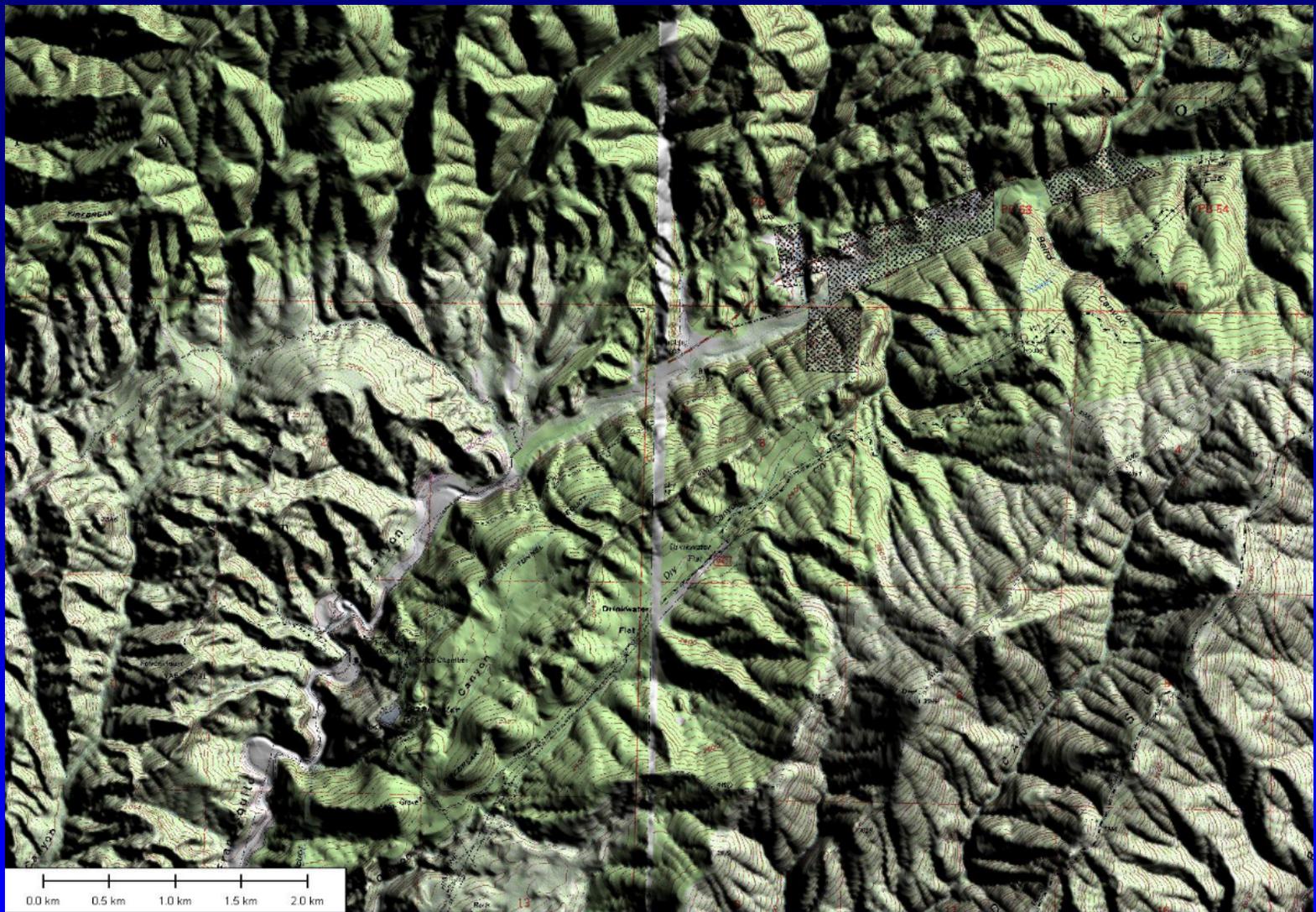
THE FINAL MAP



mosaic of 19 quadrangles



- San Francisquito Canyon as it appears today (photo by Rob Larson). The lower canyon is being developed



- Shaded 10 meter DEMs of the St. Francis Dam site overlain on USGS DRGs, created using Global Mapper. This combination can be useful for flood modeling.

