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Protecting Water from Water: Assessing Braided System Bank Erosion Threatening Water Supply in a Mediterranean Climate

8th Conference on Natural Channel Systems

Overview

- Background Information
- 2023 Flood and Pipeline Failure
- Initial Hazard Screening
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- Topographic Survey
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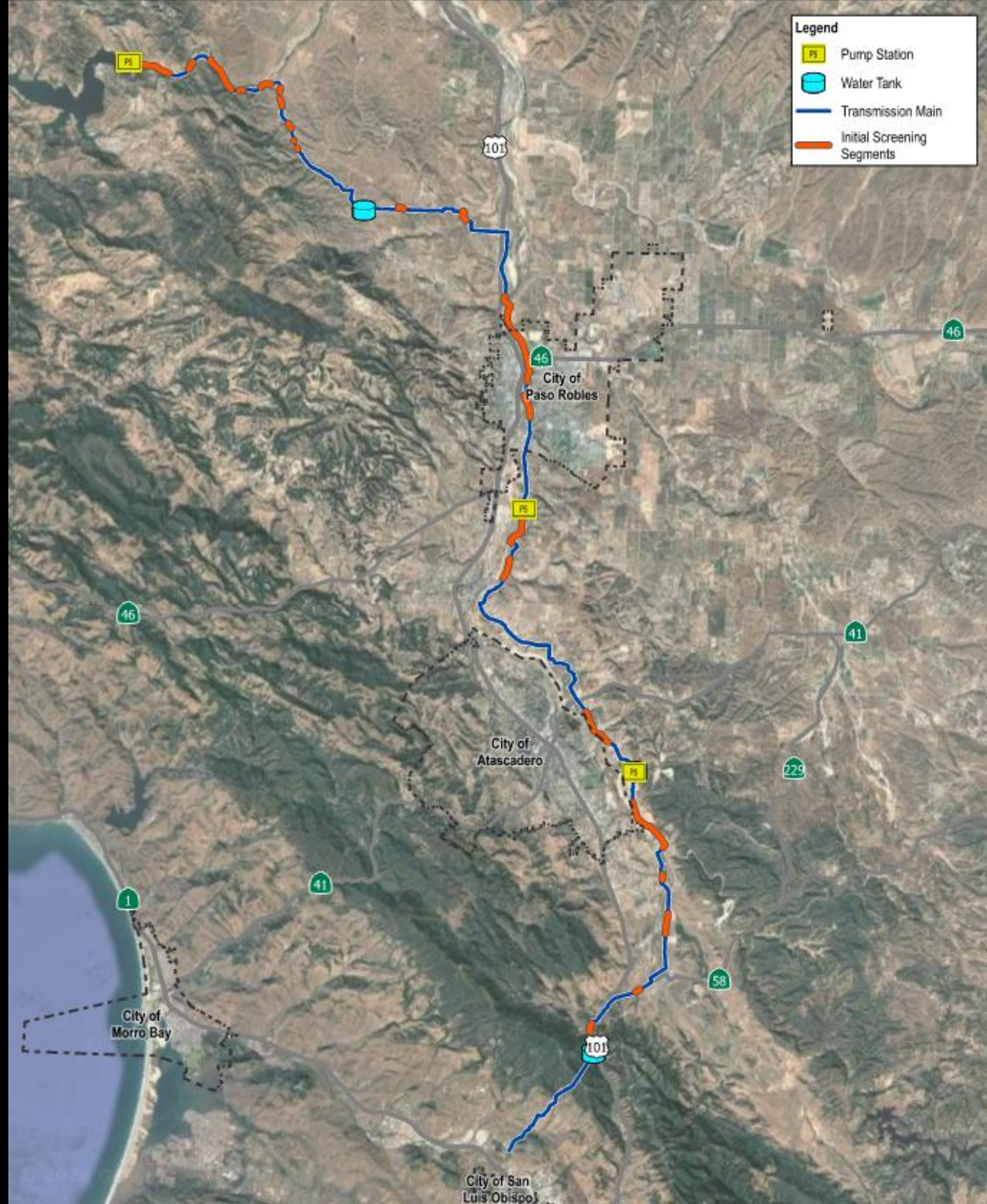


NWP Repair Project

→ Background Information

The Nacimiento Water Project supplies water from Lake Nacimiento, California to:

- City of Paso Robles
- Templeton CSD
- Atascadero Mutual Water Company
- Santa Margarita Ranch
- City of San Luis Obispo

72 km of pipeline (12” to 36” diameter)

Constructed from 2007-2011

San Luis Obispo County Flood Control and Water Conservation District

Source: County of San Luis Obispo

NWP Repair Project

→ 2023 Flood and Pipeline Failure

January 9, 2023 Storm

Intense rainfall led to widespread flooding throughout SLO County

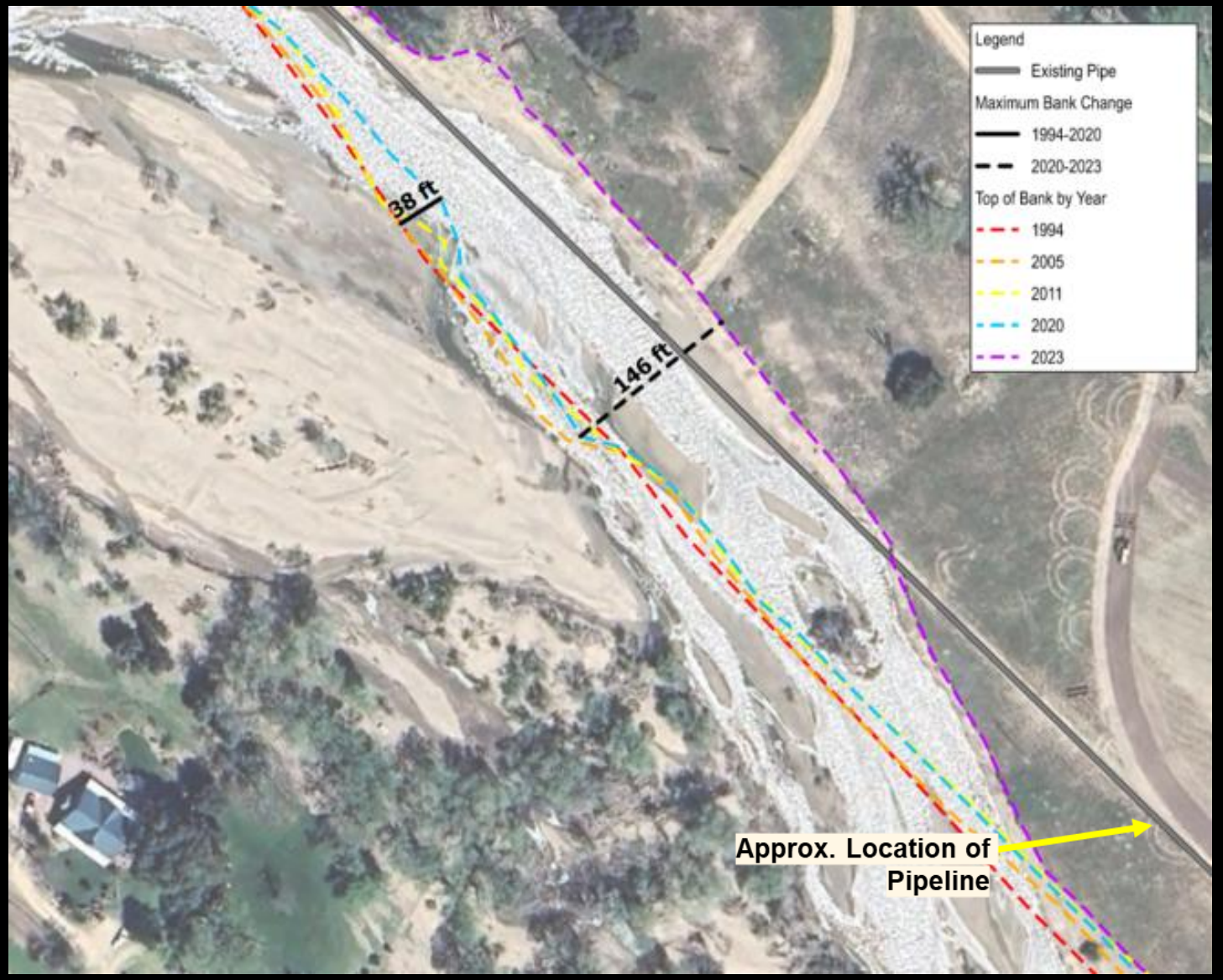
Highest Rainfall in 25 yrs

350 m^3/s flow

Nacimiento Water Pipeline Damage

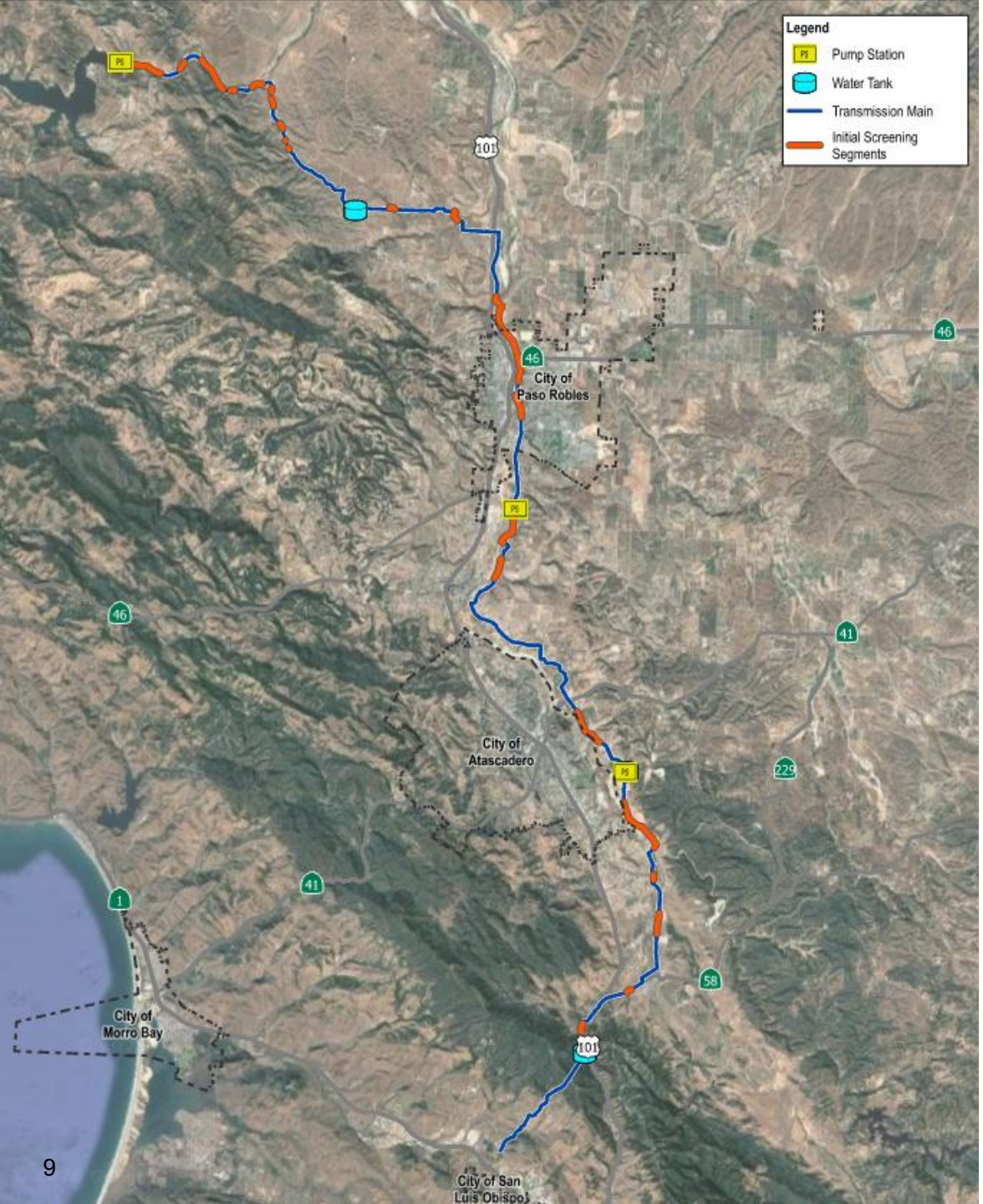
February 2021

April 2023



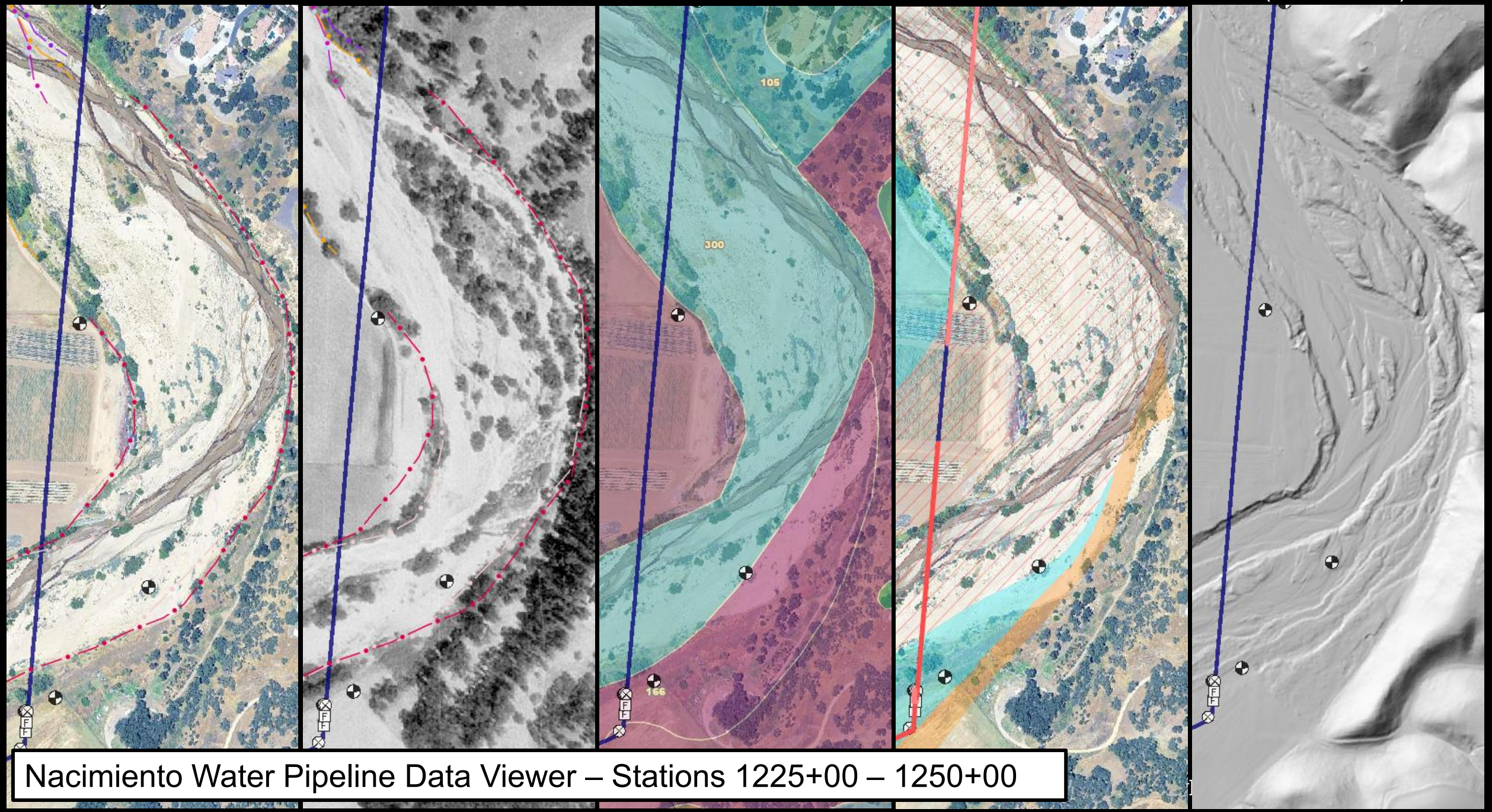
Erosion Hazards Assessment

→ Initial Screening



The Initial Screening used a geospatial data viewer to identify sections of the pipeline that were:

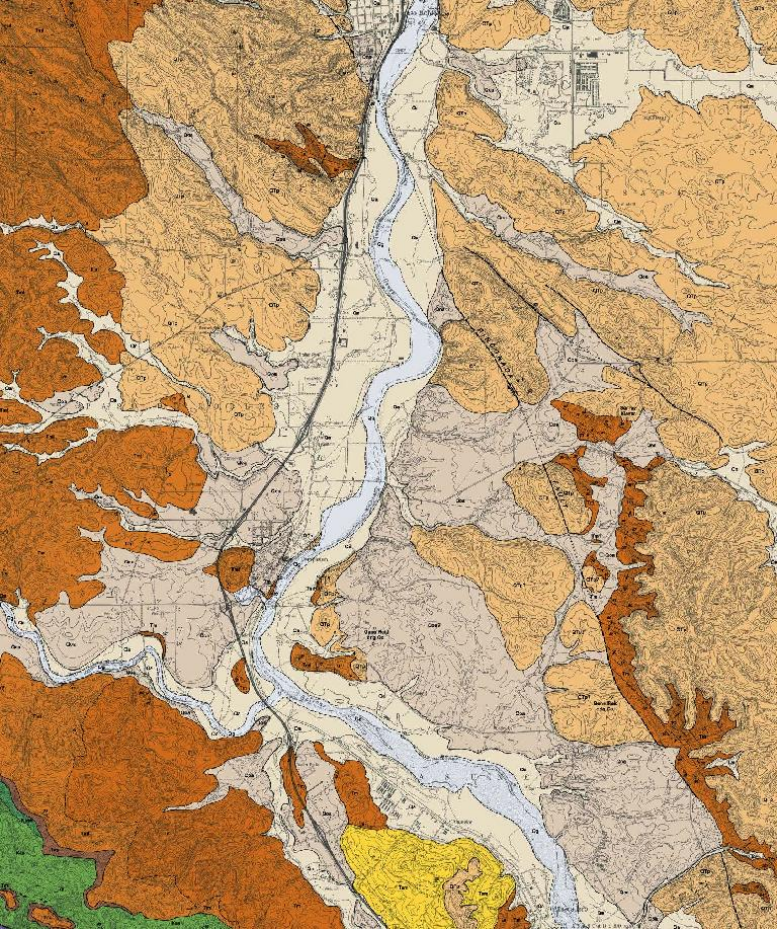
- Within the 100-year flood limit of nearby creeks and rivers.
- Within 200 ft of large watercourses (Salinas River and Nacimiento River)
- Within 100 ft of smaller watercourses and tributaries.
- Under large river crossings.

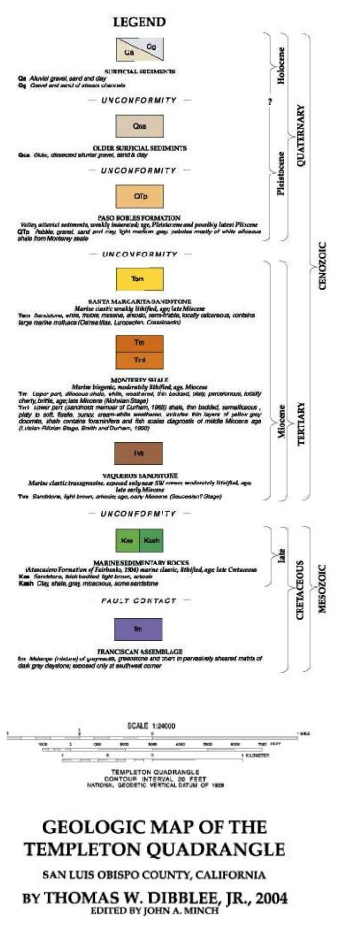


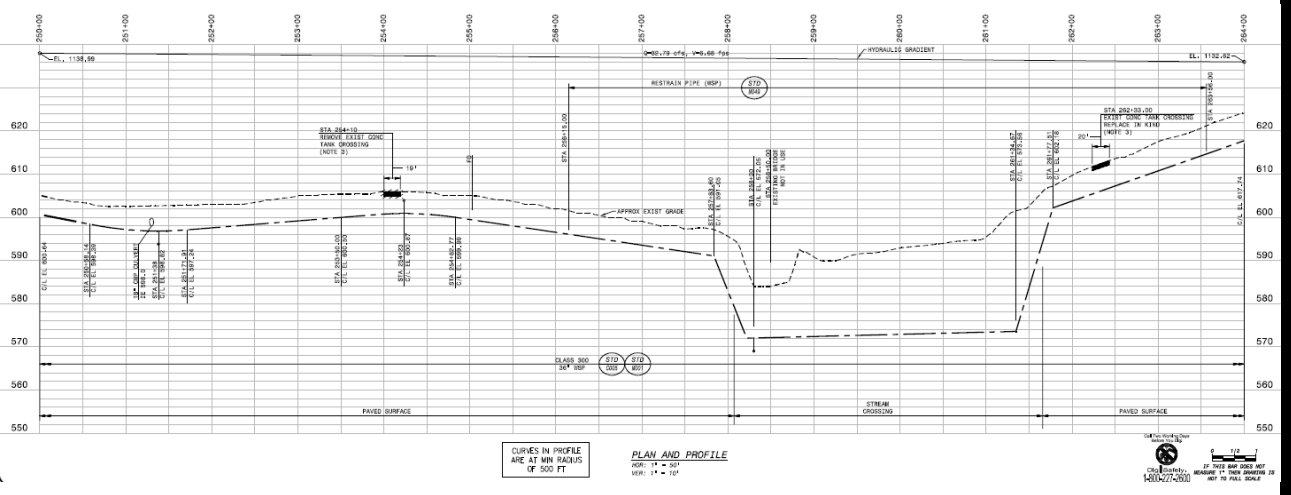
Nacimiento Water Pipeline Data Viewer – Stations 1225+00 – 1250+00

Erosion Hazards Assessment

→ Advanced Screening







An advanced screening took place to identify more areas of concern along the pipeline. These sites were identified through:

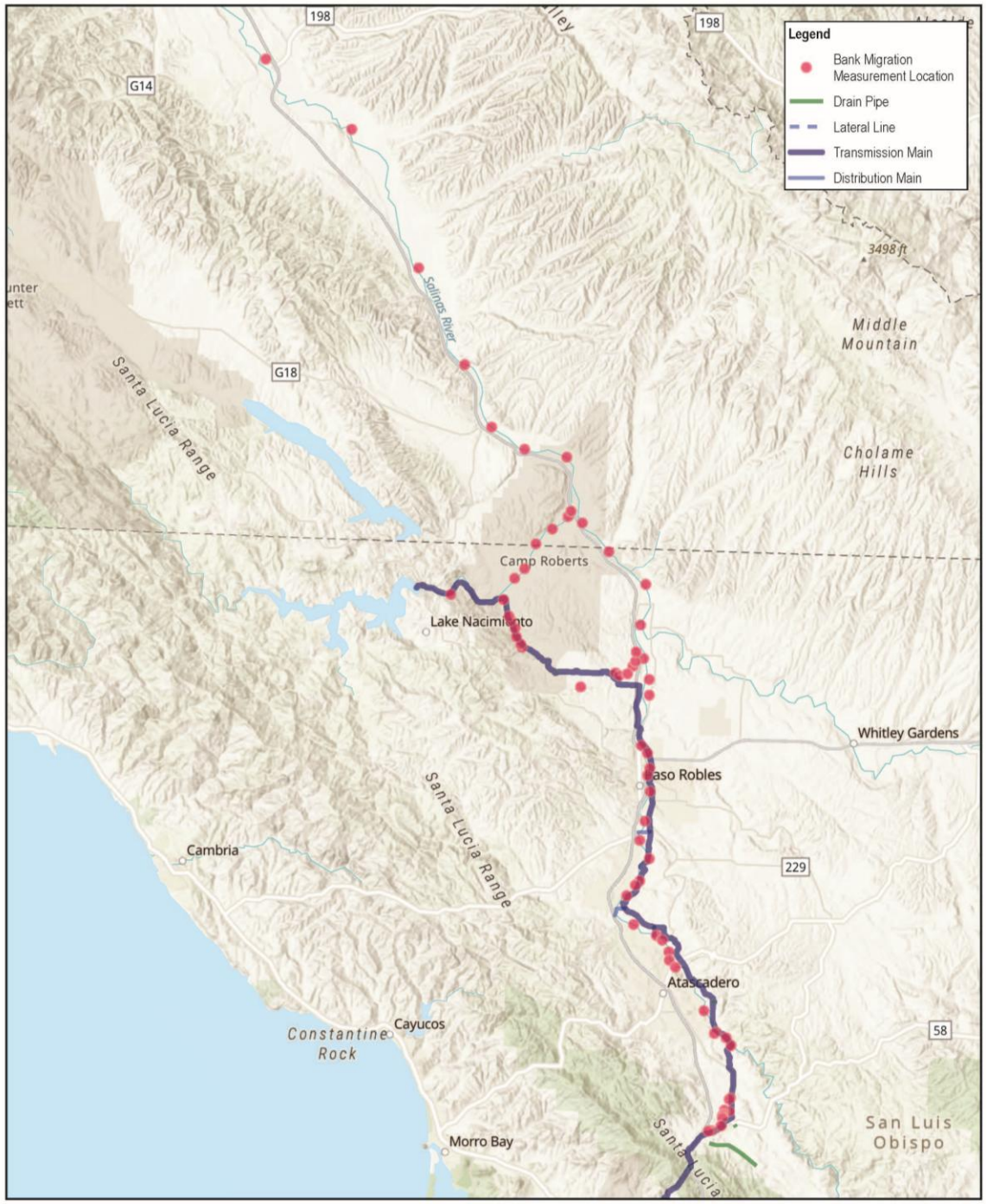
- type of surficial geology
- riparian vegetation density
- burial depth of the pipeline using as-built drawings
- geotechnical advice

The final number of areas of concern was 59, including:

- 24 sites with potential vertical scour hazard.
- 35 sites with potential bank erosion hazard.

Erosion Hazards Assessment

→ Bank Erosion Analysis



Historical aerials from 1981 through 2024 were used to estimate the magnitude of local bank erosion occurrences along the following watercourses:

- Salinas River
- Nacimiento River
- San Marcos Creek
- Santa Margarita Creek
- Yerba Buena Creek
- Other Nearby Tributaries

Banks were traced by hand along 72 watercourse sections and 131 examples of bank erosion were observed.

Figure 1

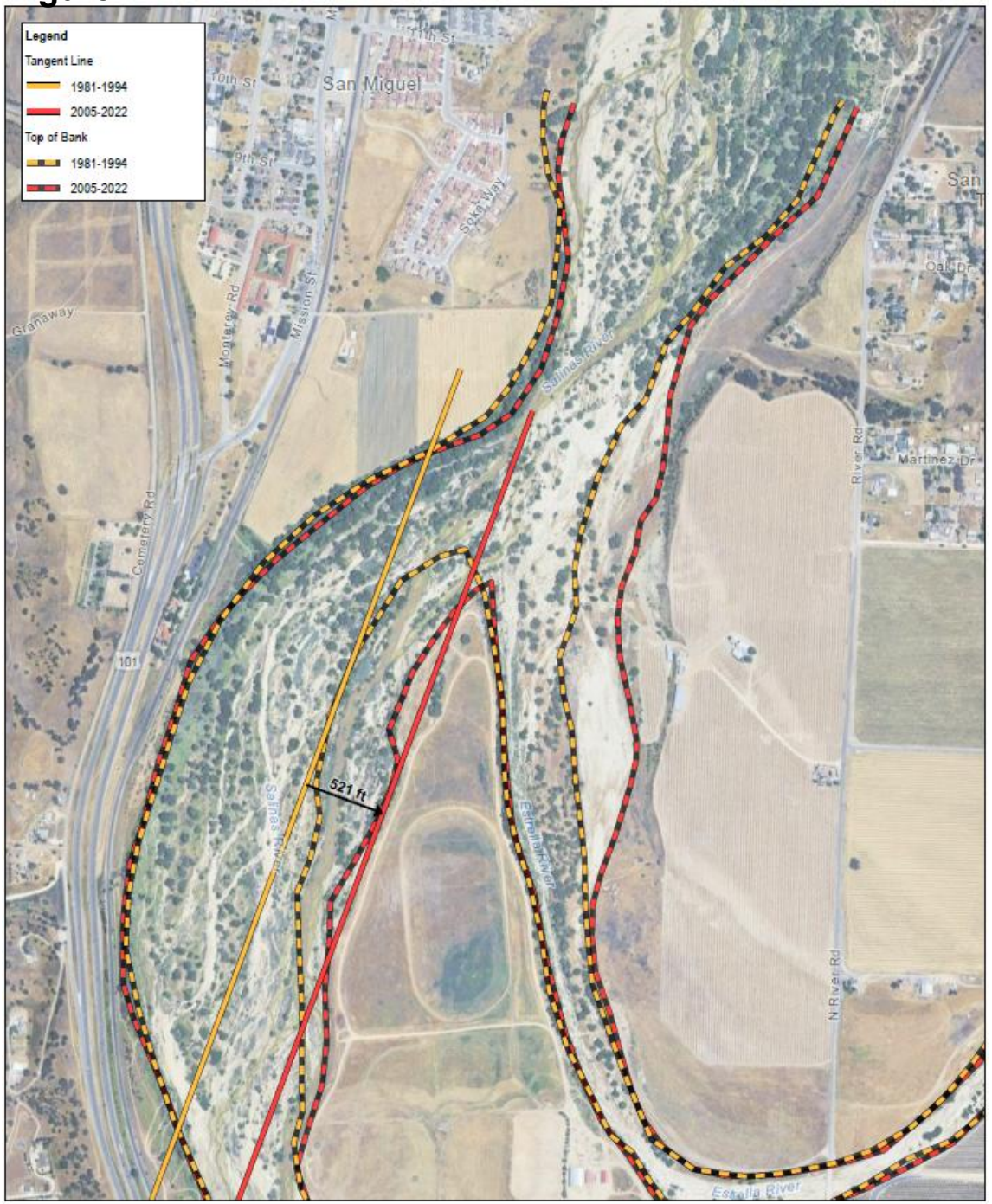
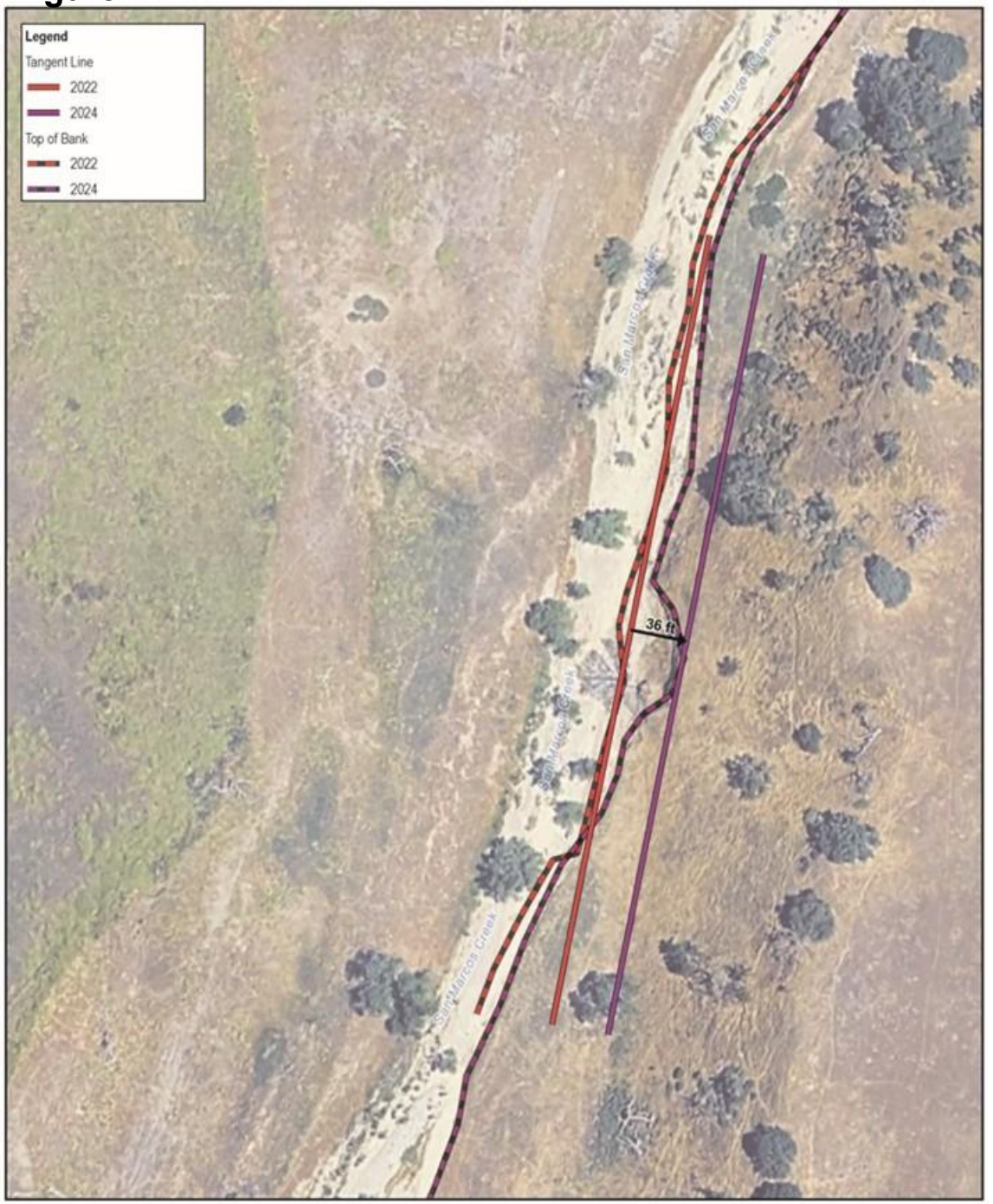


Figure 2

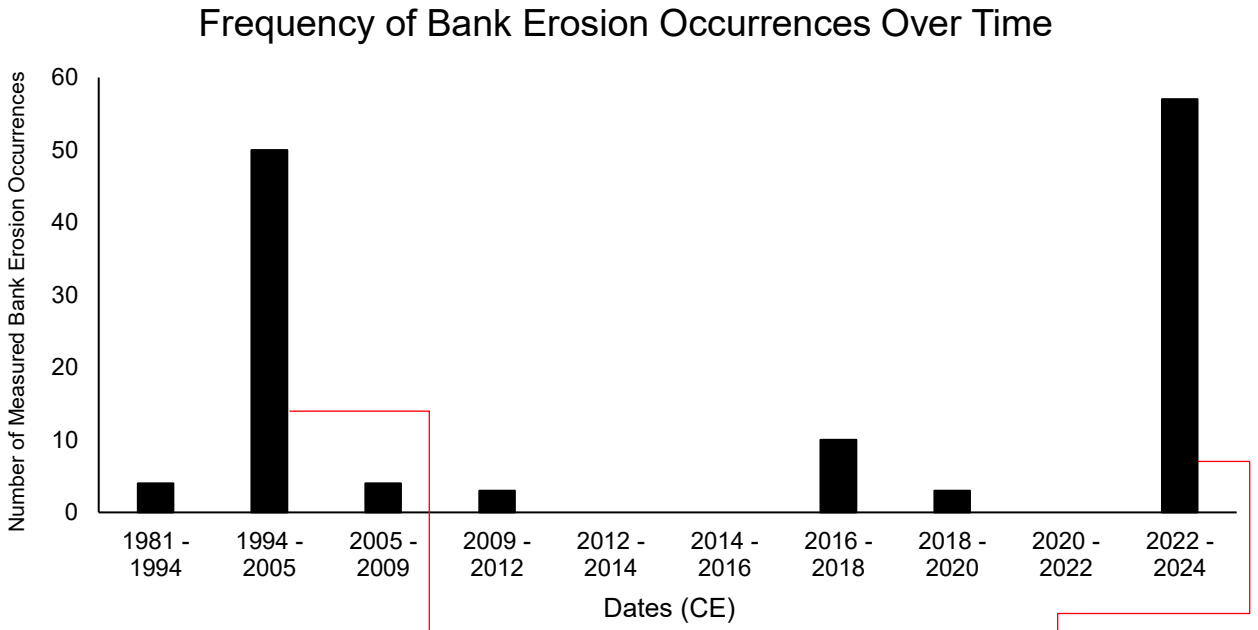


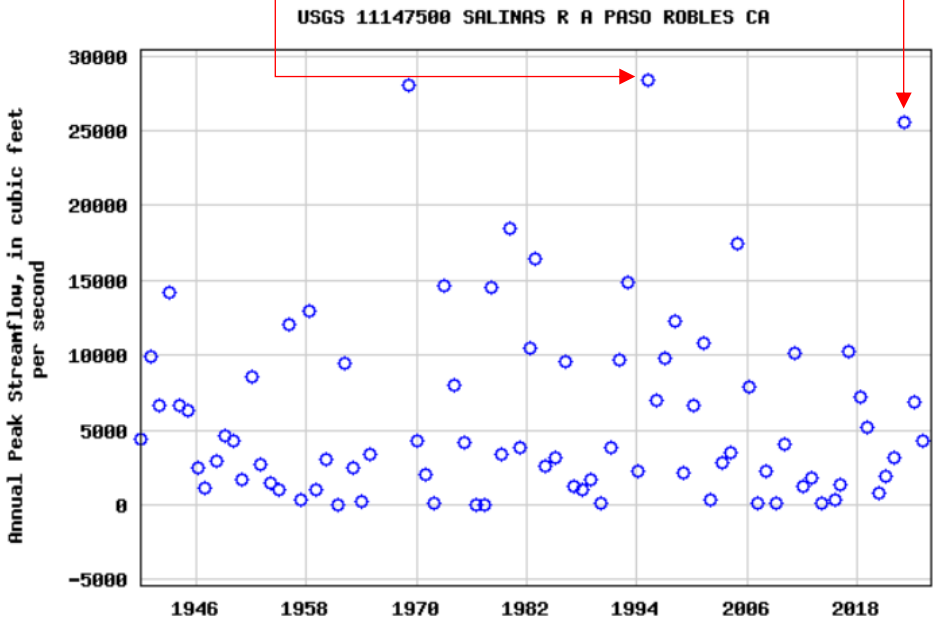
Out of 131 examples of bank erosion observed:

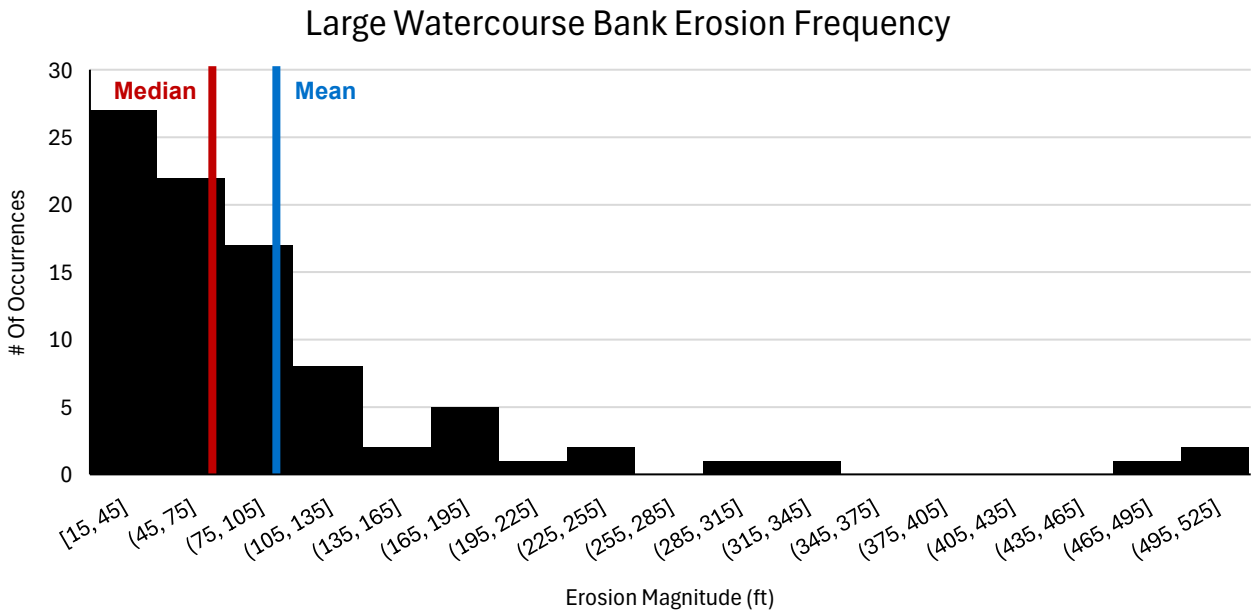
- 50 occurred between 1994 and 2005
- 57 occurred between 2022 and 2024

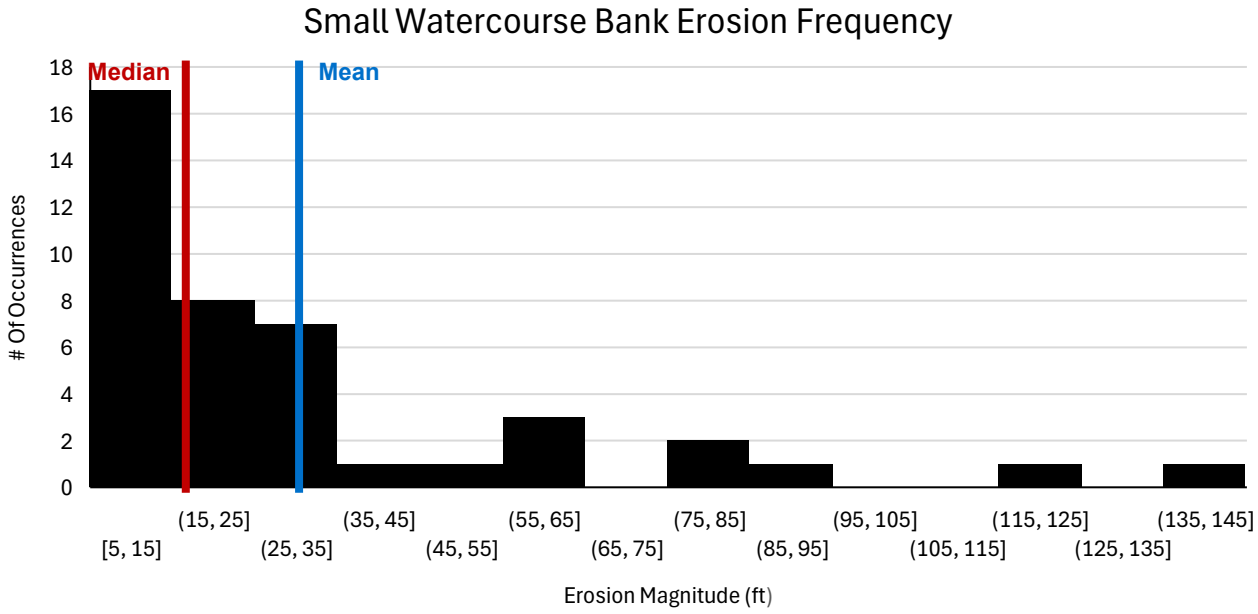
This coincides with two of the largest streamflow events on record along Salinas River at Paso Robles:

- 28,400 cfs (~800 m^3/s) in March, 1995
- 25,600 cfs (~725 m^3/s) in January, 2023









The average bank erosion magnitudes along larger watercourses (Nacimiento River and Salinas River) and smaller watercourses were 98 ft and 31 ft respectively.

Additionally, the standard deviations for these erosion magnitudes were 99 ft and 30 ft respectively.

Erosion Hazards Assessment

→ Vertical Scour Analysis

An initial vertical scour assessment was completed for the 24 crossings identified during the advanced screening.

Rough vertical scour rates were estimated based on the difference between as-built (2007) cover and LiDAR (2018) cover.

Localized hydraulic models were developed for five locations selected for further analysis.

Multiple scour calculation methods were then used to estimate the following types of scour:

- General Scour
- Bend Scour
- Local Scour
- Long-term Scour

Total scour formula: $T_{s\ avg}$ = Average(*Local*) + Average(*Long-term*) + Maximum{Average(*General*), Average(*Bend*)}

Erosion Hazards Assessment

→ Risk Evaluation

The following criteria were used to rate the risk to the NWP and the consequence of failure of the NWP at each area of concern.

General Risk Criteria:
- Watercourse gradient
- Surficial geology

Bank Erosion Risk Criteria:
- Length of pipeline at risk
- Pipeline distance from watercourse / valley wall
- Density of riparian vegetation

Vertical Scour Risk Criteria:
- Pipeline burial depth
- Pipeline casing
- Rate of scour

General Consequence Criteria:
- Stationing
- Access Difficulty
- Other Nearby Infrastructure

Risk Criteria

	Lower Risk	Higher Risk
Gradient	Low Gradient	High Gradient
Surficial Geology	Bedrock	Fine-grained Sediment
Length at Risk	Smaller Length	Larger Length
Distance from Watercourse	Larger Distance	Smaller Distance
Riparian Vegetation Density	High Density Vegetation	No Vegetation
Pipeline Burial Depth	High Burial Depth	Low Burial Depth
Pipeline Casing	Strong Pipeline Casing	No Pipeline Casing
Rate of Scour	Slow Rate of Scour	Fast Rate of Scour

Consequence Criteria

	Lower Consequence	Higher Consequence
Stationing	Failure Further Down Pipe	Failure Further Up Pipe
Access Difficulty	Failure Near Main Road	Failure Far From Roads
Other Nearby Infrastructure	No Other Infrastructure	Lots of Nearby Infrastructure

Aggregated risk and consequence scores were determined using the previously mentioned risk and consequence criteria

Scores out of 30 were given to each site. Scores ranged from 2 to 22 in practice.

Scores were given ratings of Very Low, Low, Moderate, High, and Very High.

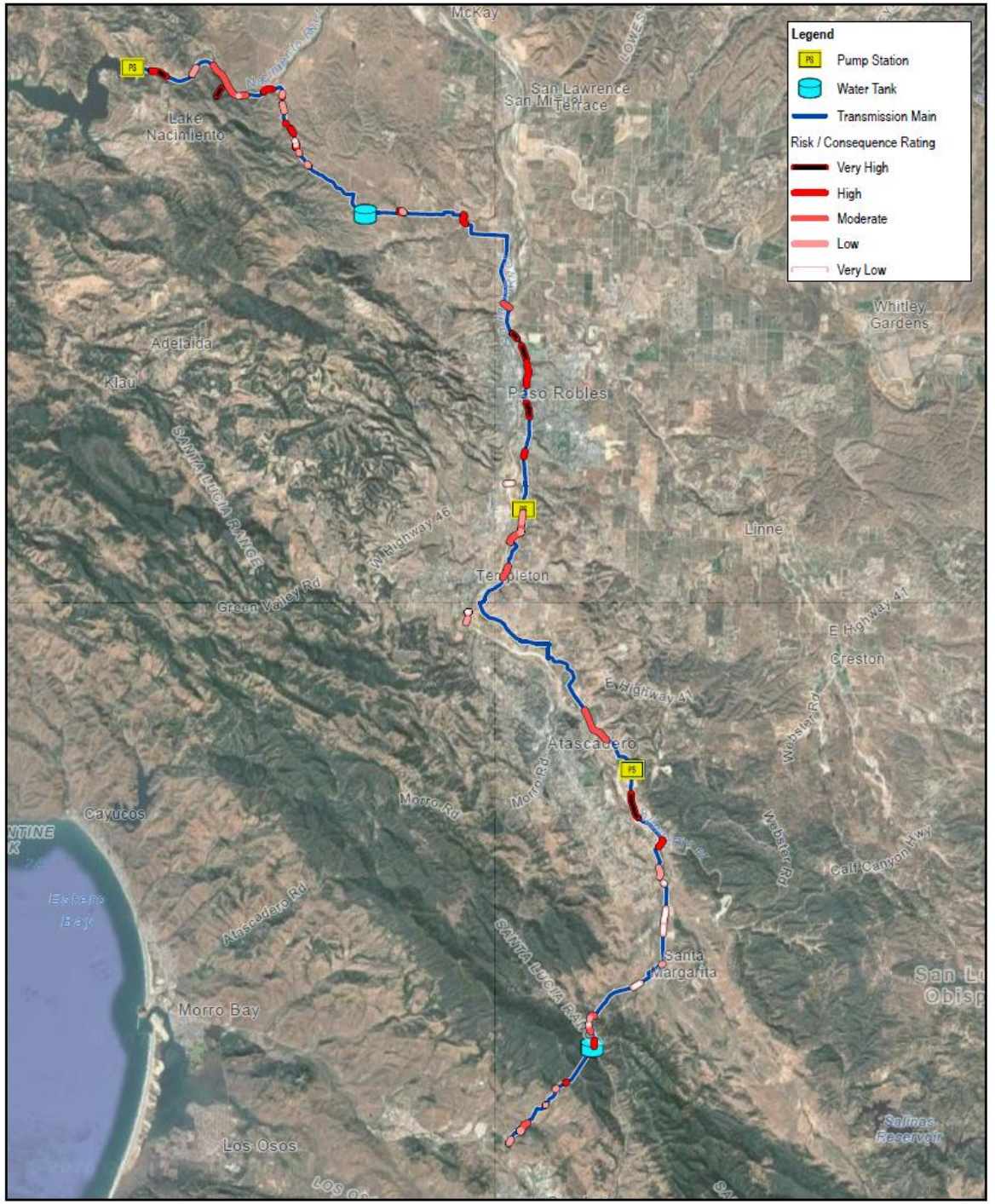
Very Low: 2 – 6

Low: 6 – 10

Moderate: 10 – 14

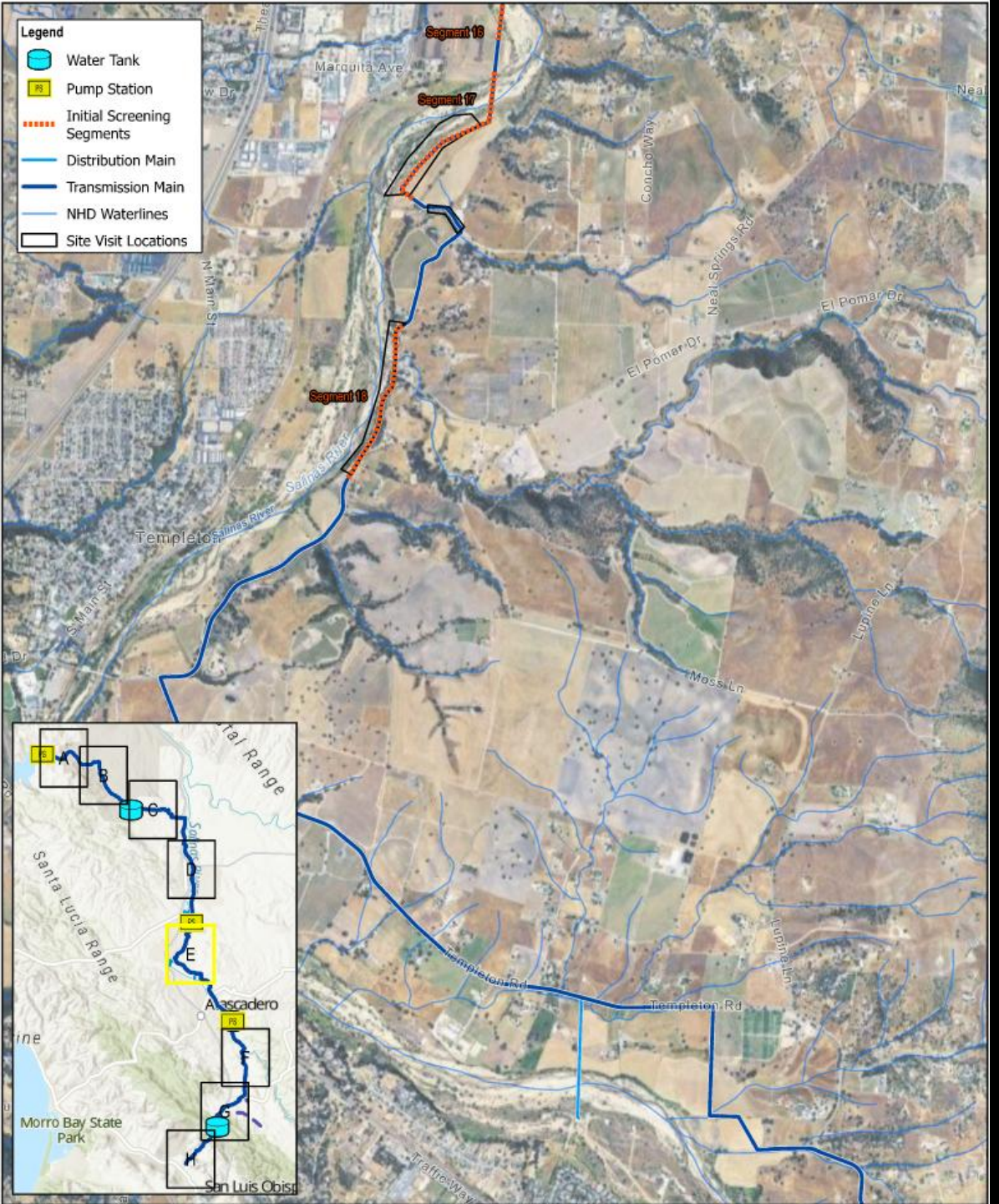
High: 14 – 18

Very High: 18 – 22



Erosion Hazards Assessment

→ Field Assessments Screening



A field assessment took place to observe conditions in the field at key locations.

Field sites were chosen based on criteria used during the initial and advanced screening

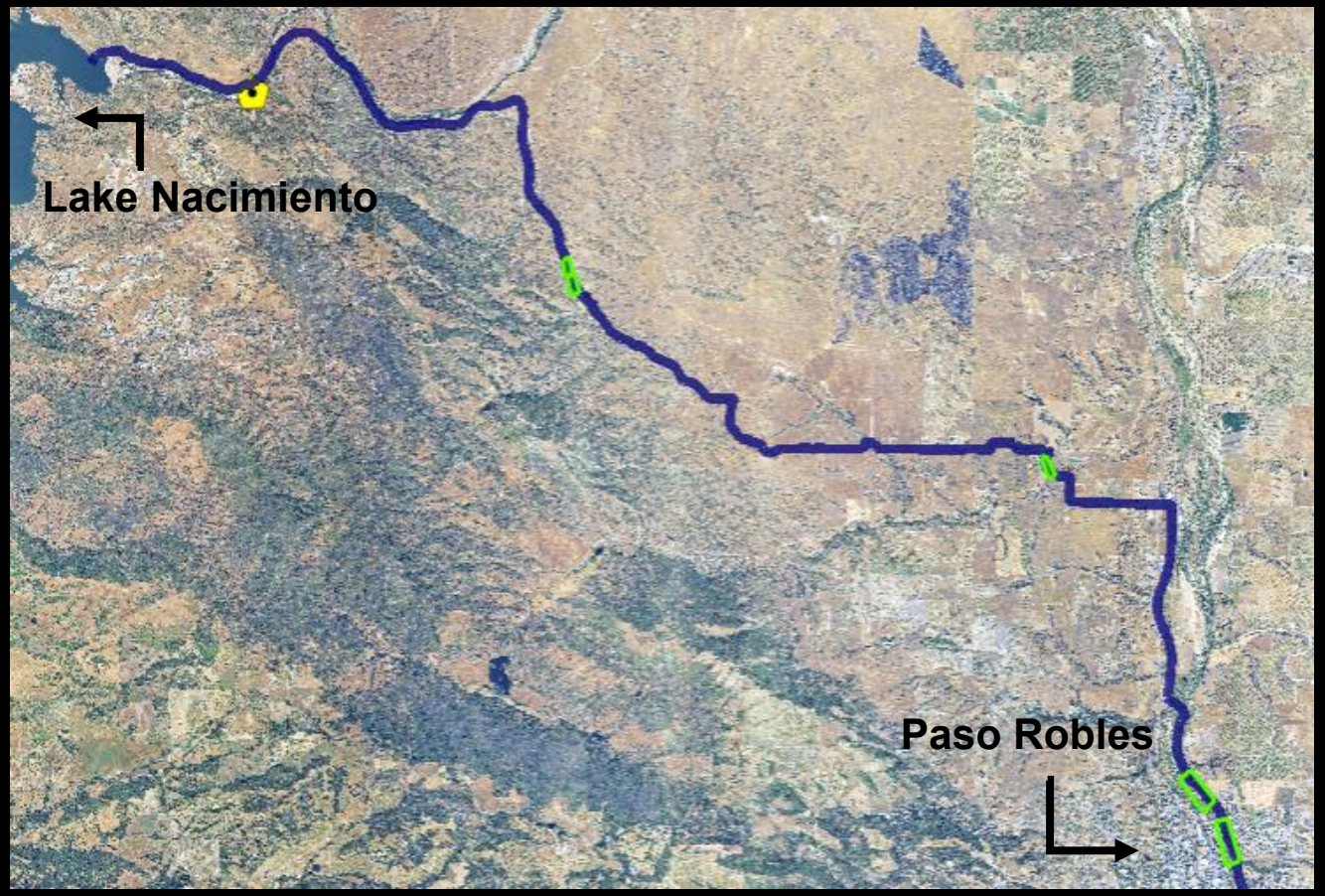
- Visited 33 locations over 3 days along entire alignment
- Observed current condition of channel with a focus on:
  - Slope instability
  - Evidence of erosion
  - Geologic conditions

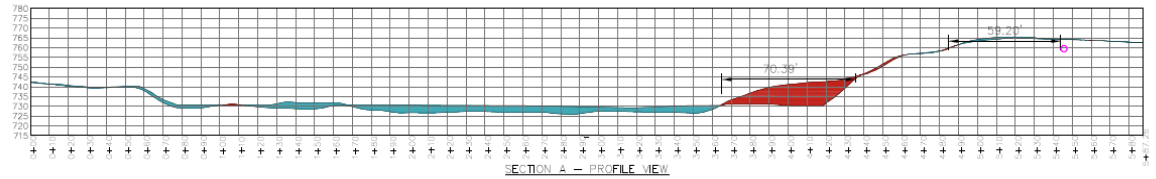
Erosion Hazards Assessment

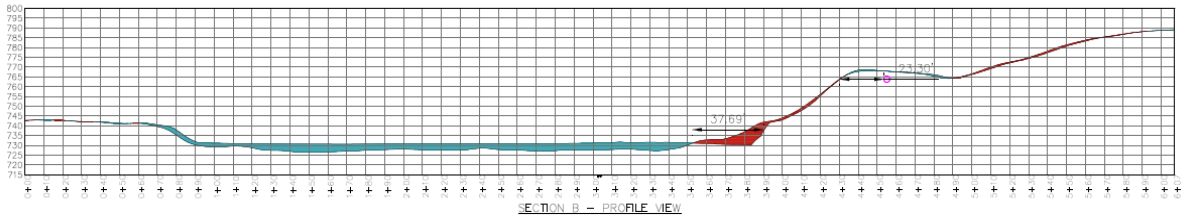
→ Topographic Survey

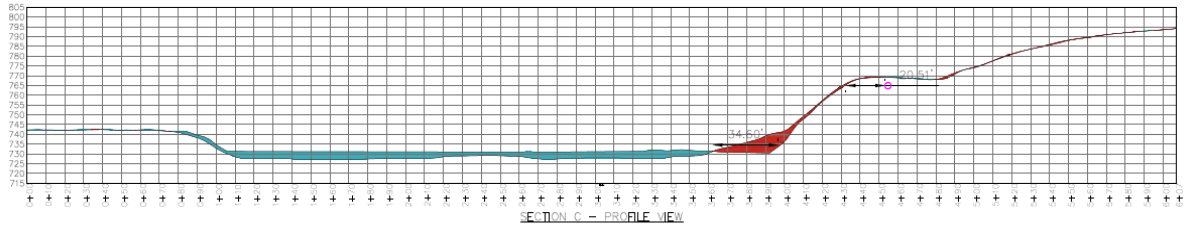
Final risk / consequence ratings were adjusted based on field investigations to achieve a final priority rating for each field site.

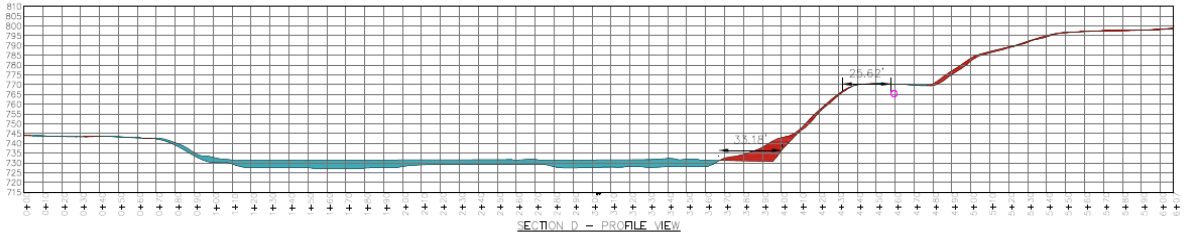
10 of the highest priority sites (highlighted in green) were put forward for detailed topographic surveying.



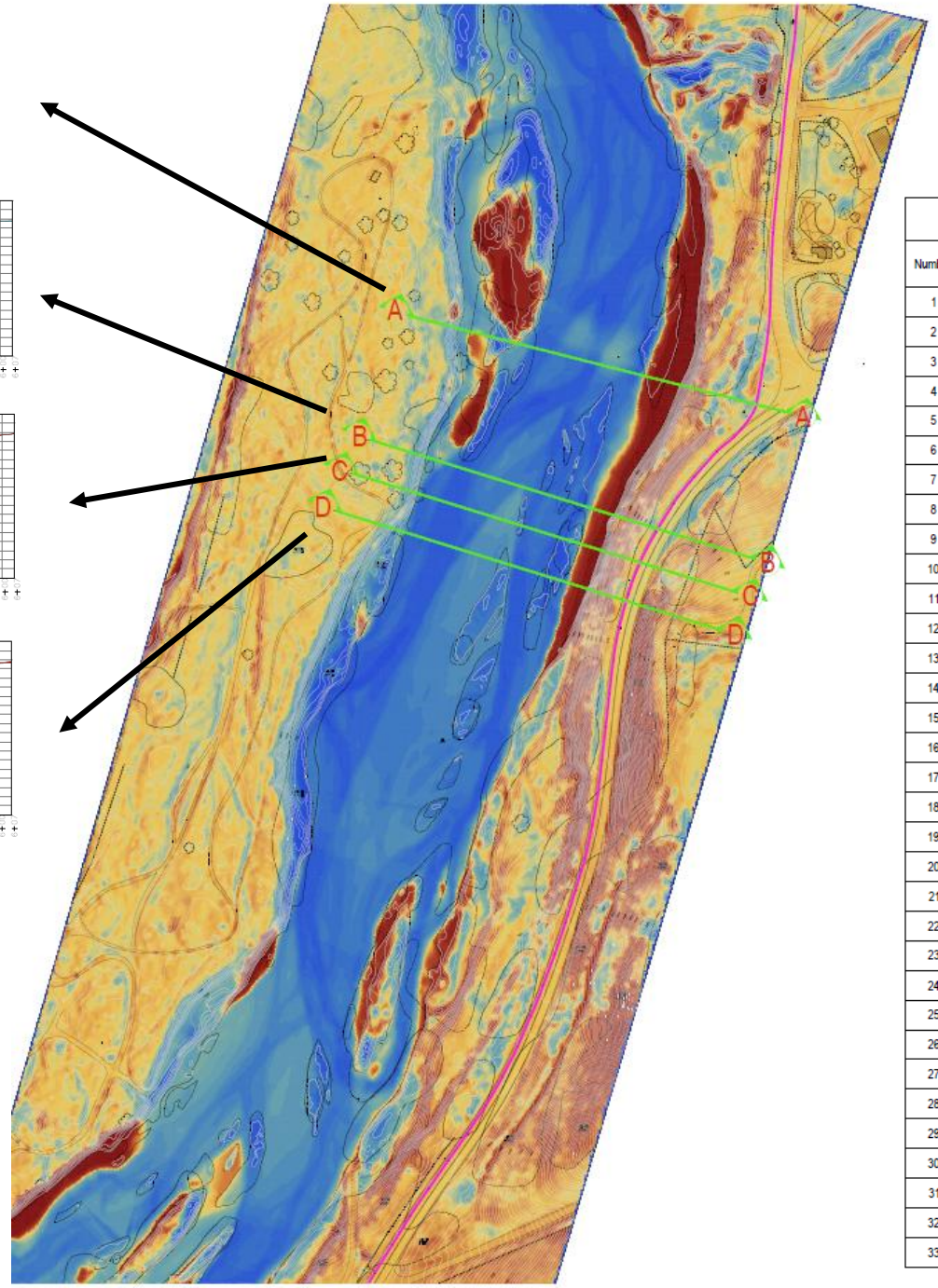








Stations 1306+00 and 1331+00



Surface Analysis: Elevation Ranges			
Number	Color	Minimum Elevation (ft)	Maximum Elevation (ft)
1		-5.00	-4.40
2		-4.40	-2.30
3		-2.30	-1.70
4		-1.70	-1.30
5		-1.30	-1.00
6		-1.00	-0.80
7		-0.80	-0.70
8		-0.70	-0.60
9		-0.60	-0.50
10		-0.50	-0.40
11		-0.40	-0.30
12		-0.30	-0.20
13		-0.20	-0.10
14		-0.10	0.00
15		0.00	0.10
16		0.10	0.20
17		0.20	0.30
18		0.30	0.40
19		0.40	0.50
20		0.50	0.60
21		0.60	0.70
22		0.70	0.90
23		0.90	1.20
24		1.20	1.50
25		1.50	1.90
26		1.90	2.30
27		2.30	2.60
28		2.60	2.90
29		2.90	3.30
30		3.30	3.60
31		3.60	3.90
32		3.90	4.50
33		4.50	5.50

Erosion Hazards Assessment

→ Next Steps

Top priority sites were selected through discussion with the client .

Alternatives are being developed for three of the highest priority sites to mitigate erosion risk to the NWP.

Proactive approach to avoid loss of water supply to many communities.

Thank you

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