Prado Dam Operation Overview

6th Annual Forecast Informed Reservoir Operations (FIRO) Workshop

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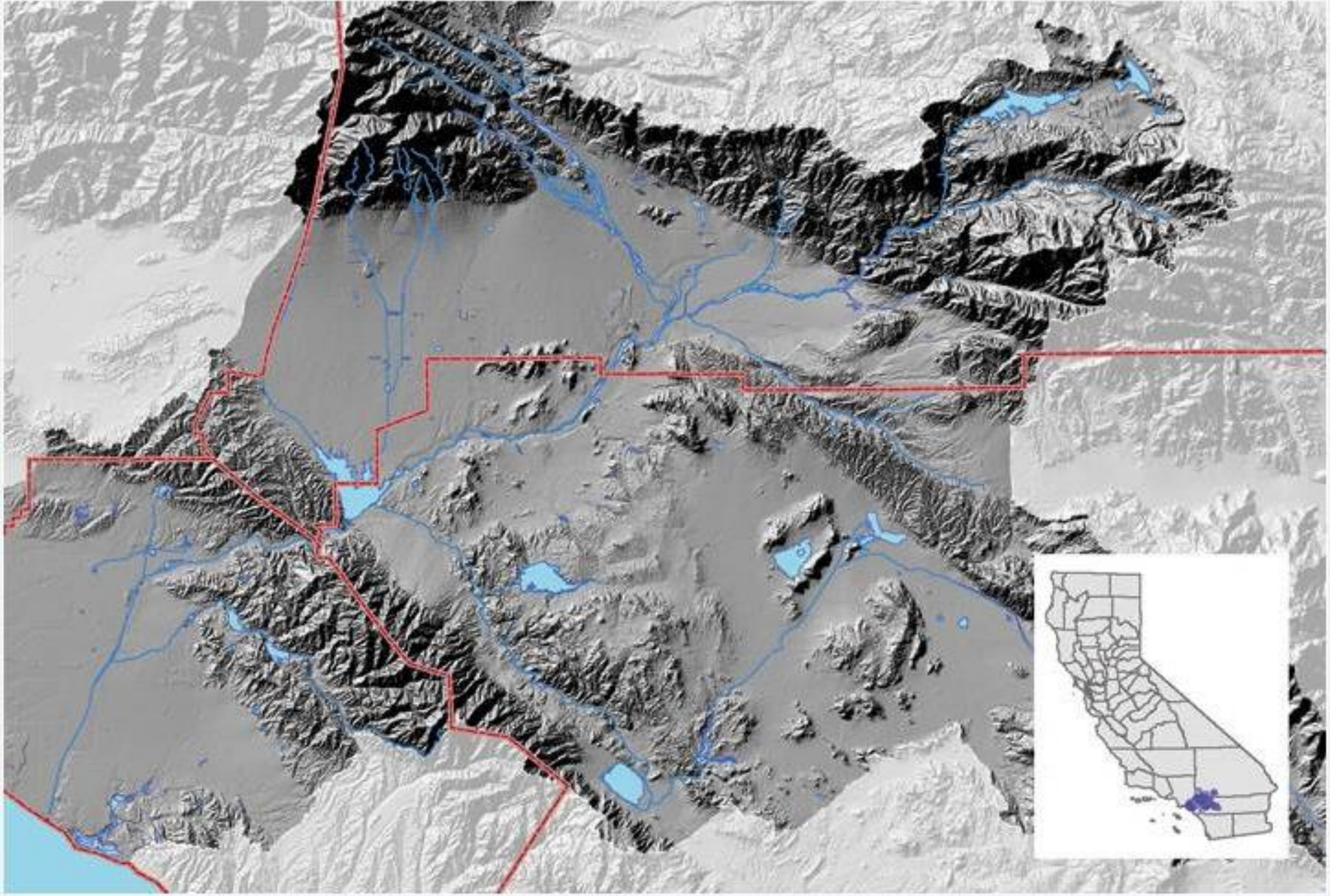
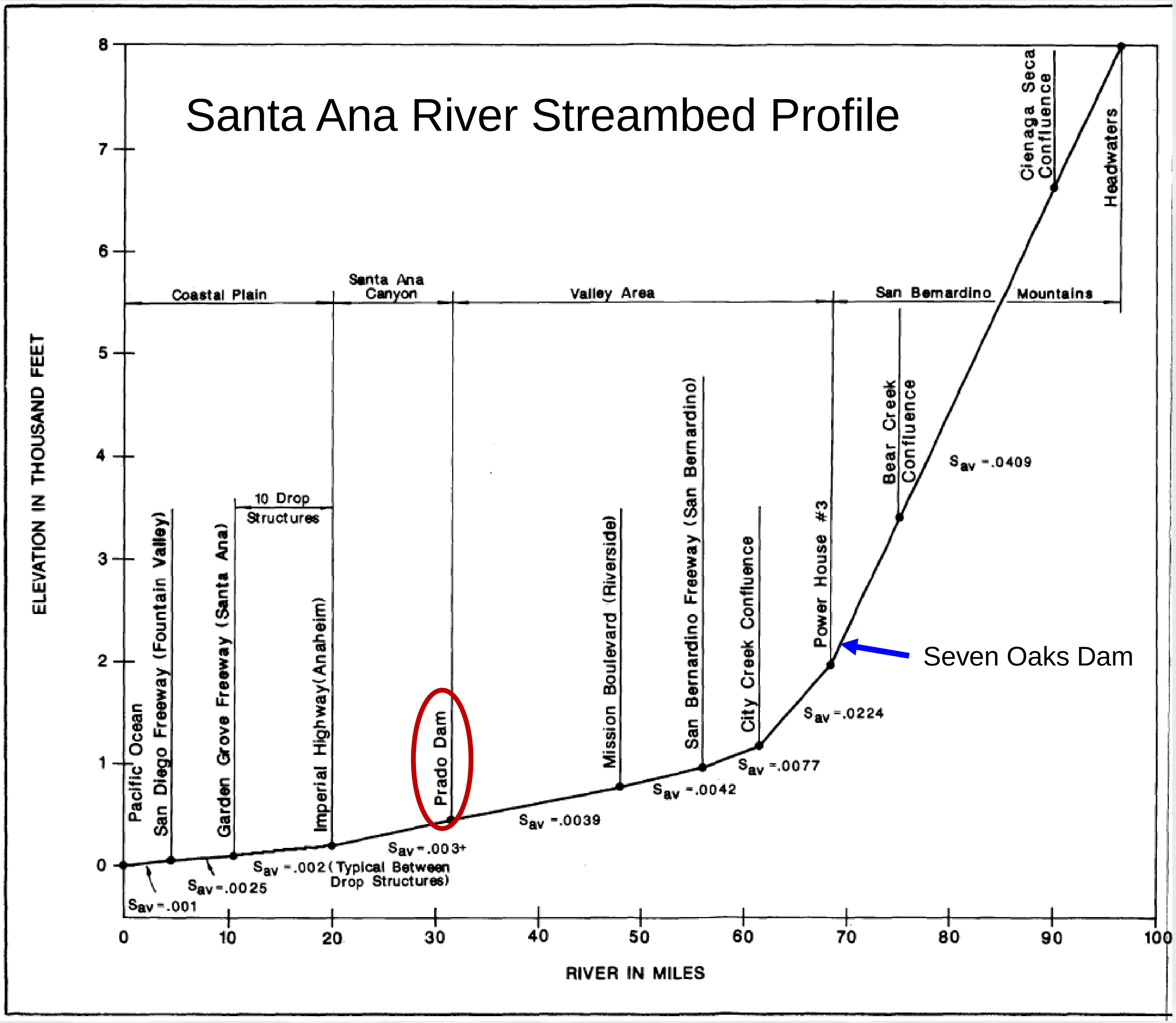
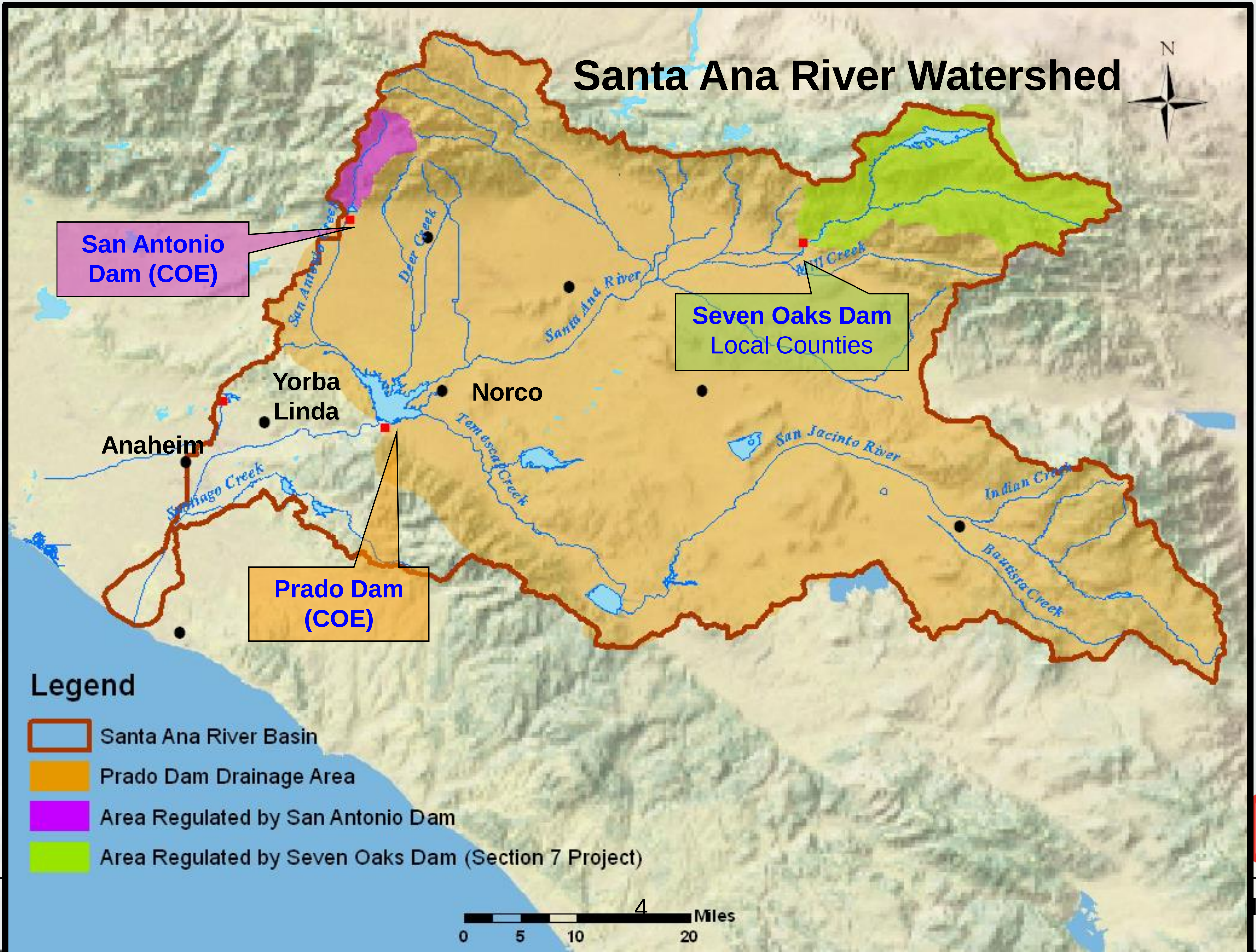
U.S. ARMY

US Army Corps of Engineers ®



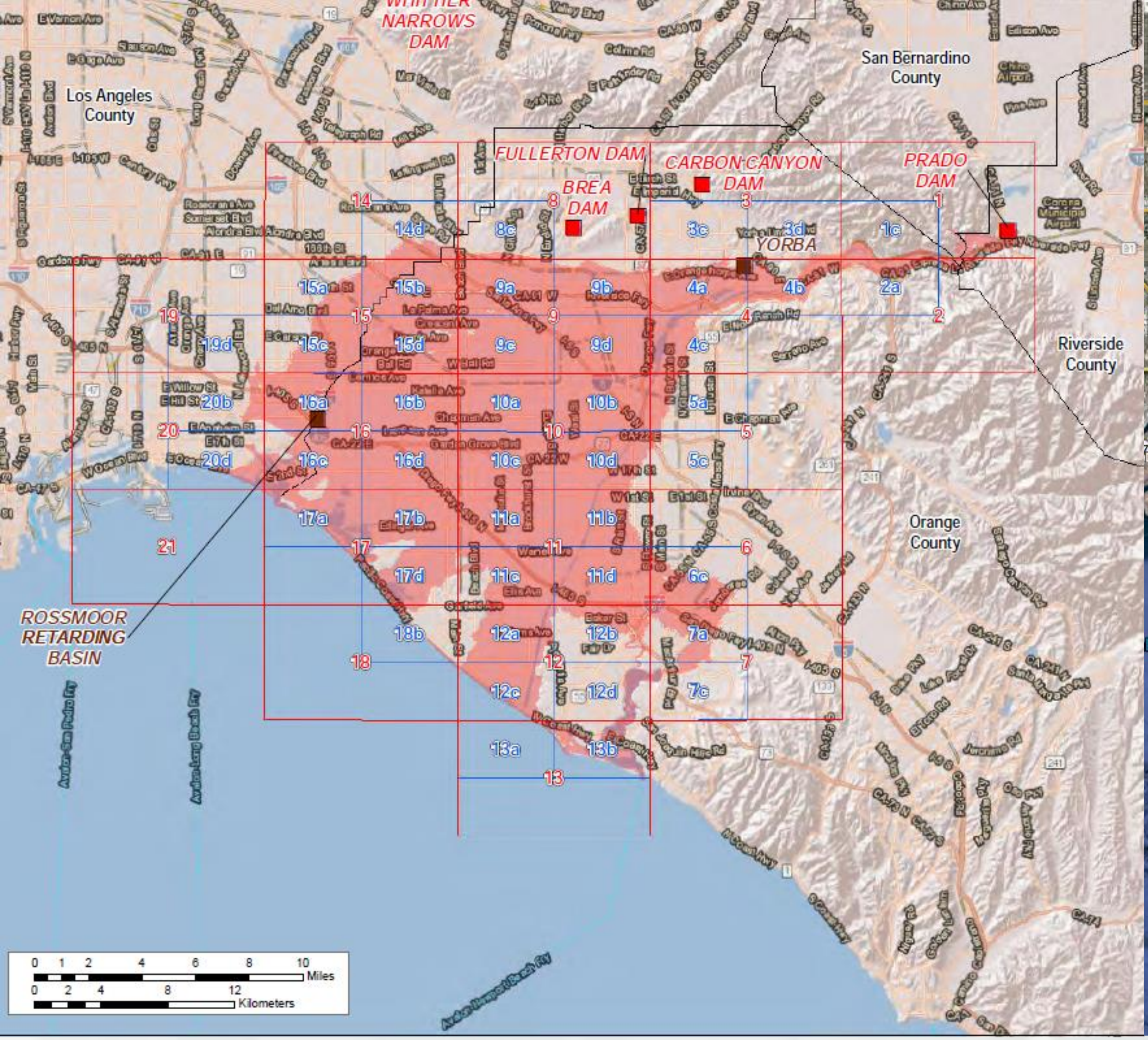
Santa Ana River Streambed Profile

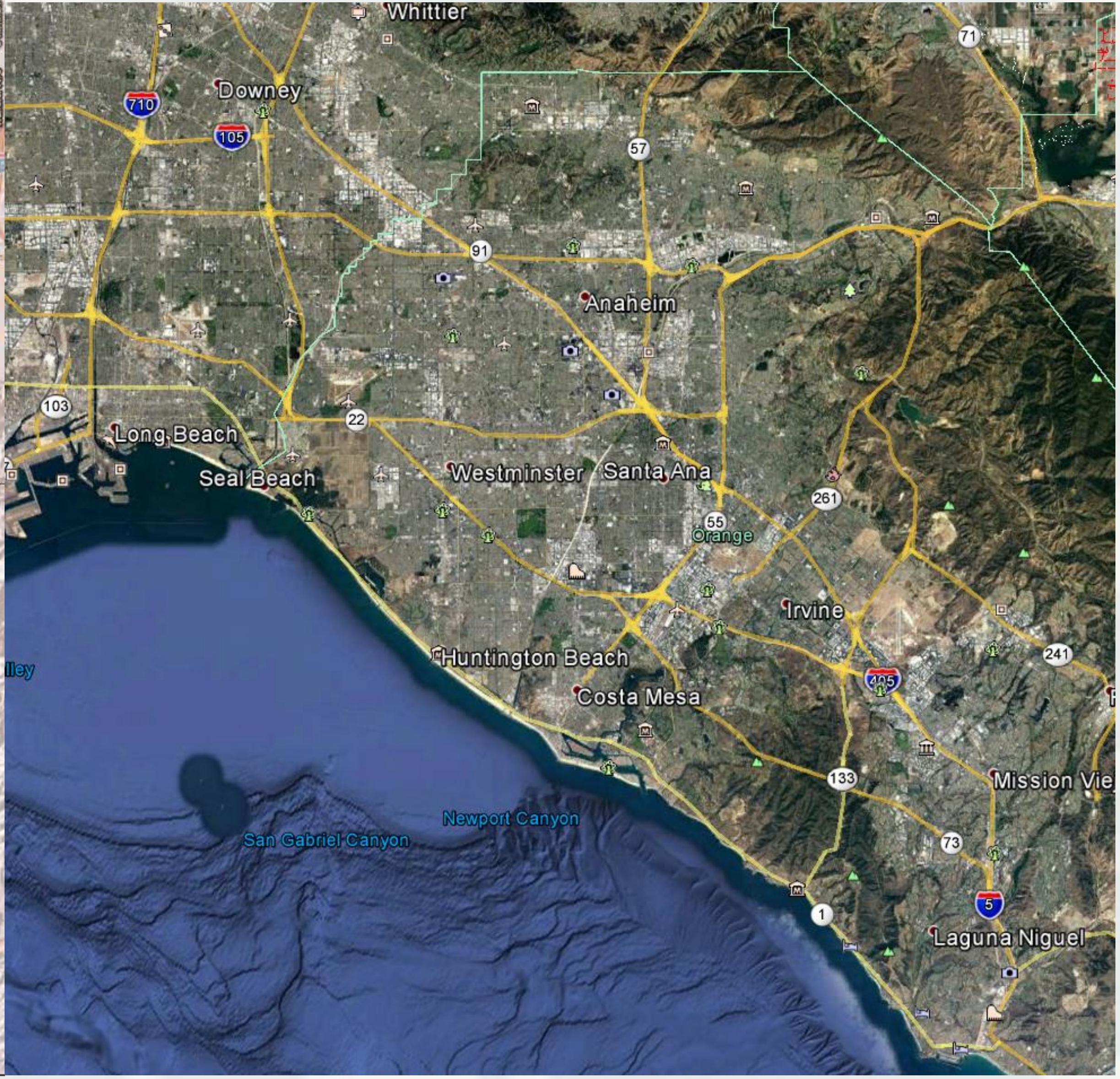



Santa Ana River Watershed
N
San Antonio Dam (COE)
Seven Oaks Dam Local Counties
Yorba Linda
Norco
Anaheim
Prado Dam (COE)
Santa Ana River
Deer Creek
San Antonio Creek
Mill Creek
Temescal Creek
San Jacinto River
Indian Creek
Bautista Creek
Santiago Creek
Legend
Santa Ana River Basin
Prado Dam Drainage Area
Area Regulated by San Antonio Dam
Area Regulated by Seven Oaks Dam (Section 7 Project)
Miles
0
5
10
20

Prado Dam Watershed & Reservoir

- Drainage Area = 2,255 mi^2
- The majority is uncontrolled w/ steep headwaters
- Reservoir @ 566’ covers 10,400 acres & holds 368,000 AF
- Highest historic water surface elevation is 530 feet
- Primary flood control beneficiary is Orange County [downstream]
- OCWD owns water rights to storage in Prado Reservoir

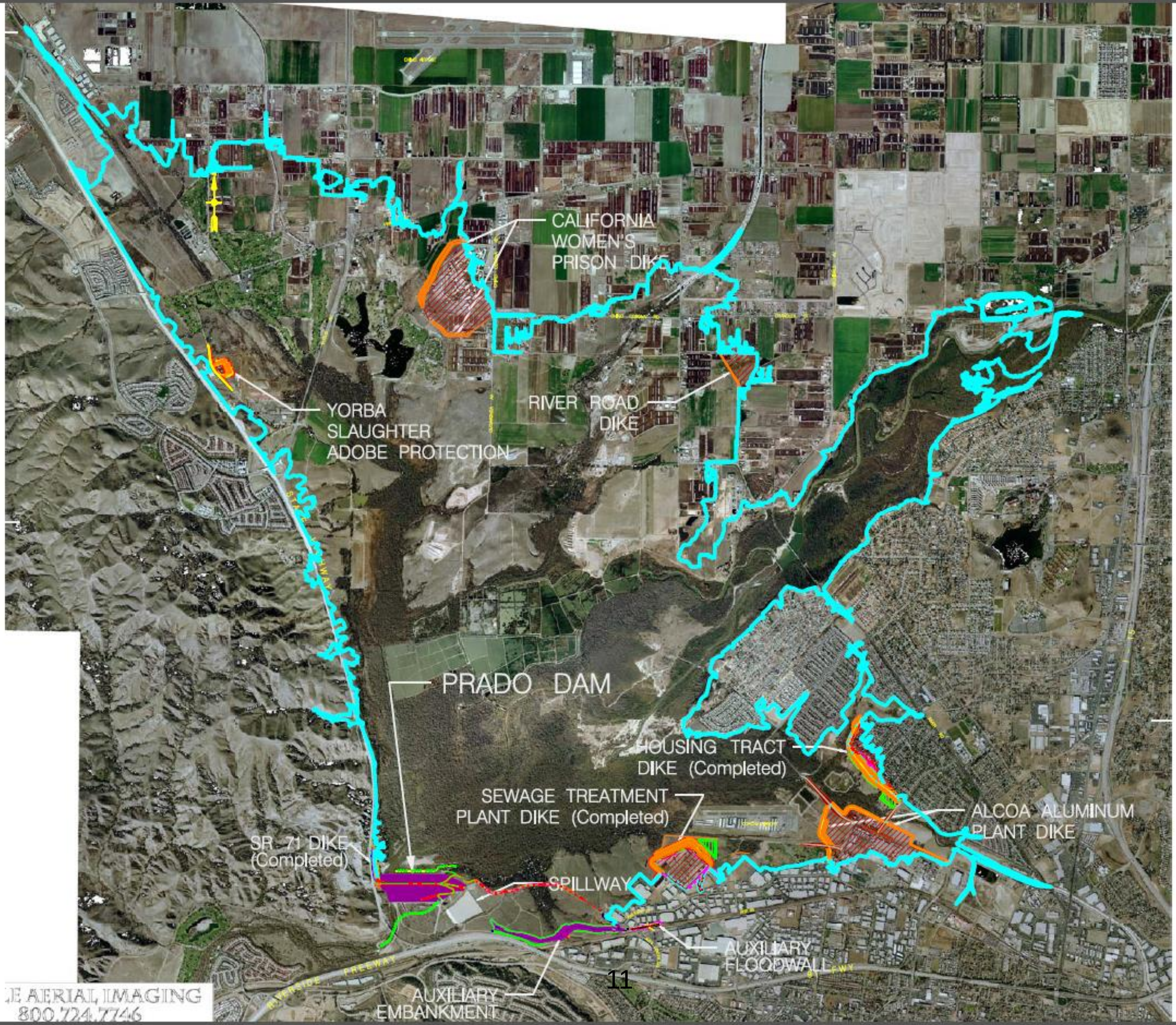

WHITTIER NARROWS DAM
Los Angeles County
San Bernardino County
FULLERTON DAM
BREA DAM
CARBON CANYON DAM
PRADO DAM
YORBA
Riverside County
Orange County
ROSSMOOR RETARDING BASIN
0 1 2 4 6 8 10 Miles
0 2 4 8 12 Kilometers


Whittier
Downey
Anaheim
Long Beach
Seal Beach
Westminster
Santa Ana
Orange
Irvine
Huntington Beach
Costa Mesa
Mission Vie
Laguna Niguel
San Gabriel Canyon
Newport Canyon

Prado Dam is One Component of the Santa Ana River Mainstem Project

What's left to complete this project:

- ✓ Complete downstream channel improvements [Reach 9]
- ✓ Finish interior dike construction in Prado Reservoir
- ✓ OCPW to acquire remaining flood easements, which will allow…
- ✓ Raising the Spillway Crest elevation by 20 feet


CALIFORNIA
WOMEN'S
PRISON DIK
YORBA
SLAUGHTER
ADOBE PROTECTION
RIVER ROAD
DIKE
PRADO DAM
HOUSING TRACT
DIKE (Completed)
SEWAGE TREATMENT
PLANT DIKE (Completed)
ALCOA ALUMINUM
PLANT DIKE
SR 71 DIKE
(Completed)
SPILLWAY
AUXILIARY
FLOODWALL
AUXILIARY
EMBANKMENT
RIVERSIDE FREEWAY
E AERIAL IMAGING
800.724.7746

FIRO Forward Looking Phases

The prior remaining tasks create roughly 3 stages of FIRO future analysis

A. **→ 2023** Reach 9 completion – constrains discharge

B. **2023 → 2028** Finish interior dikes and raise spillway – w/o raised spillway project not @ full flood protection

C. **2028 →** Project fully functional – doubles the flood storage capacity

Operational Considerations

- Primary purpose is flood control
- Water Con ‘borrows’ flood control space
- Only in wet years would an elevated pool be held for months
- USFWS interested in frequency & duration of higher pool due to potential impacts on critical habitat. This influences the upper limit on maximum water conservation storage
- Discretionary vs non-discretionary operations

Reservoir Design Flood Components

- The design storm defines the needed flood control storage and ultimate level of flood protection downstream

- The Flood Control storage is the reservoir capacity up to the spillway crest

- The Design Storm features:

  11 inches of rain over the watershed in 2 days

  254,000 cfs peak inflow to the reservoir

  416,000 AF of total inflow volume

  30,000 cfs controlled releases from Prado

  190 year level of protection

- The key thing is all releases from the dam are controlled

Probable Maximum Flood [PMF] design

- If a second huge storm occurred you don't want the dam to overtop and fail catastrophically
- Spillway flow avoids this. Releases are uncontrolled and damaging downstream but the dam retains much of the flood runoff
- The Spillway design flood features:

  22 inches over the watershed in 3 days

  630,000 cfs peak inflow / 480,000 cfs peak outflow from spillway

  1.5 million AF of runoff into reservoir over 10 days

- Prado's maximum impoundment was 58% over its 78 year history
- Only 1 dam has ever spilled in the LA District

Are the design storms realistic?

- In the Great Flood of 1862, between 24Dec1861 & 21Jan1862 it rained 28 out of 30 days, totaling 35 inches in LA.
- Estimated peak flow on the Santa Ana River near Prado was 320,000 cfs.
- Six mega-storms greater than 1861-62 have occurred in the last 1800 years.*
- Hurricane Harvey [Houston, 2017] far exceeded a design event.
- No one today can personally recall the floods of the 1930s & 40s. These projects were built for just such events.

* "The Big Ones–How Natural Disasters Have Shaped Us (and What We Can Do About Them)" Dr. Lucy Jones, 2018

Flood Control vs Water Conservation

- Holding a pool at 505 in the flood season when releases are limited to 2,500 cfs due to downstream construction. It takes 4 days to draw the pool down to make that space available for an incoming storm.
- This is within the forecast window.
- How actionable is the forecast?
- Drawing the pool down sends 5,000 AF to the ocean/day with a nominal value of $5 million.
- **Question #1**: Will the forecast storm hit us & is its magnitude on par with the project's design storm?

  If **YES** – Must dump the pool to avoid damaging spillway flow

  If **NO** – Holding the pool might mean higher reservoir inundations than would have otherwise occurred.

To Pre-Release or Not?

- **Question #2**: In a moderate storm, do I allow the inflow to arrive and transition to flood control releases [rain on the ground] when the pool rises above 505 or plan for a flood control release in advance?

If we **allow the storm to dictate the timing** we may start larger releases at night. Less preferable for public safety and OCWD staff. When the pool starts rising quickly we end up 'chasing' it.

If we **pre-plan releases** in anticipation of the storm's arrival we might:

- <u>Release water that isn't refilled</u> because
  - The storm fails to materialize or it misses us.
  - It isn't as strong as expected.
  - We released more than is refilled.

<u>Benefits</u>: We pick when & how much, likely a lower peak release.

Can schedule with OCWD & local police. More control.

Problems Can be Avoided or Created

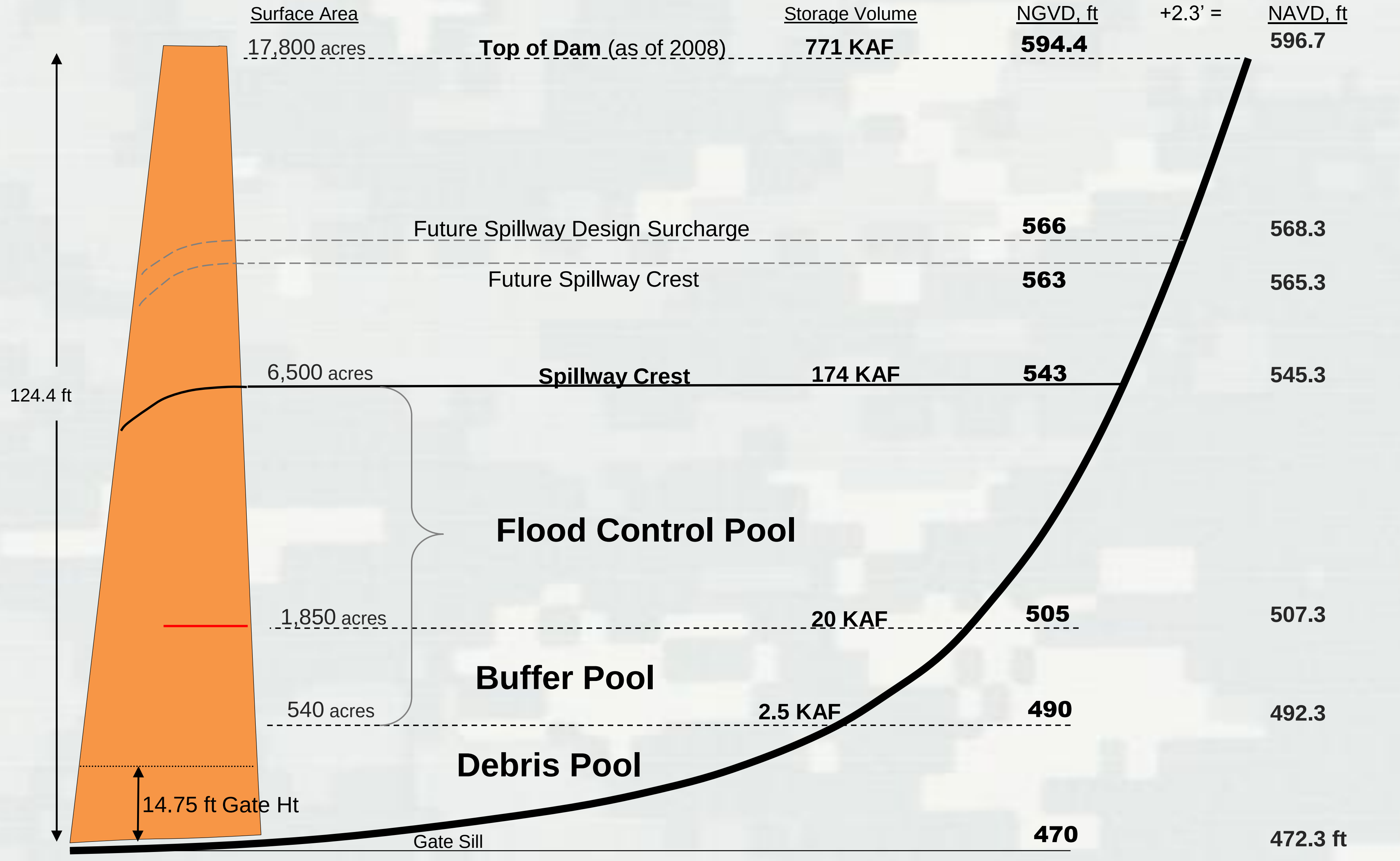
- Feb 2017 we made notifications for a larger release in response to a forecast storm. We learned OCPW's contractor had piled dredged material in the mouth of the channel and had equipment at risk. We postponed the release to allow contractor to secure the site.
- We previously were required to provide 24 hour advance notice to the police so they could warn/evacuate the homeless.
- Releasing water in the absence of rain can catch people off guard. Skateboarders, bicyclists, film shoots, driving instructions are all activities that routinely take place in the otherwise dry channel.

Reservoir Regulation Targets

- In the past ResReg's objective was to make a controlled release in advance so the storm would refill the buffer pool but not exceed it, thus triggering more flood releases.
- In the past the goal was to stay 'under' 505 after the pre-release.
- Now the goal is to end the storm 'at' 505 to maximize conservation capture for the benefit of OCWD.
- We may try creating an elevation 'zone' that complies with the USFWS conditions but allows more operational leeway. Maybe on the receding hydrograph limb we use a soft max pool limit of, say, 506 as long as we hit 505 within 12 hours.

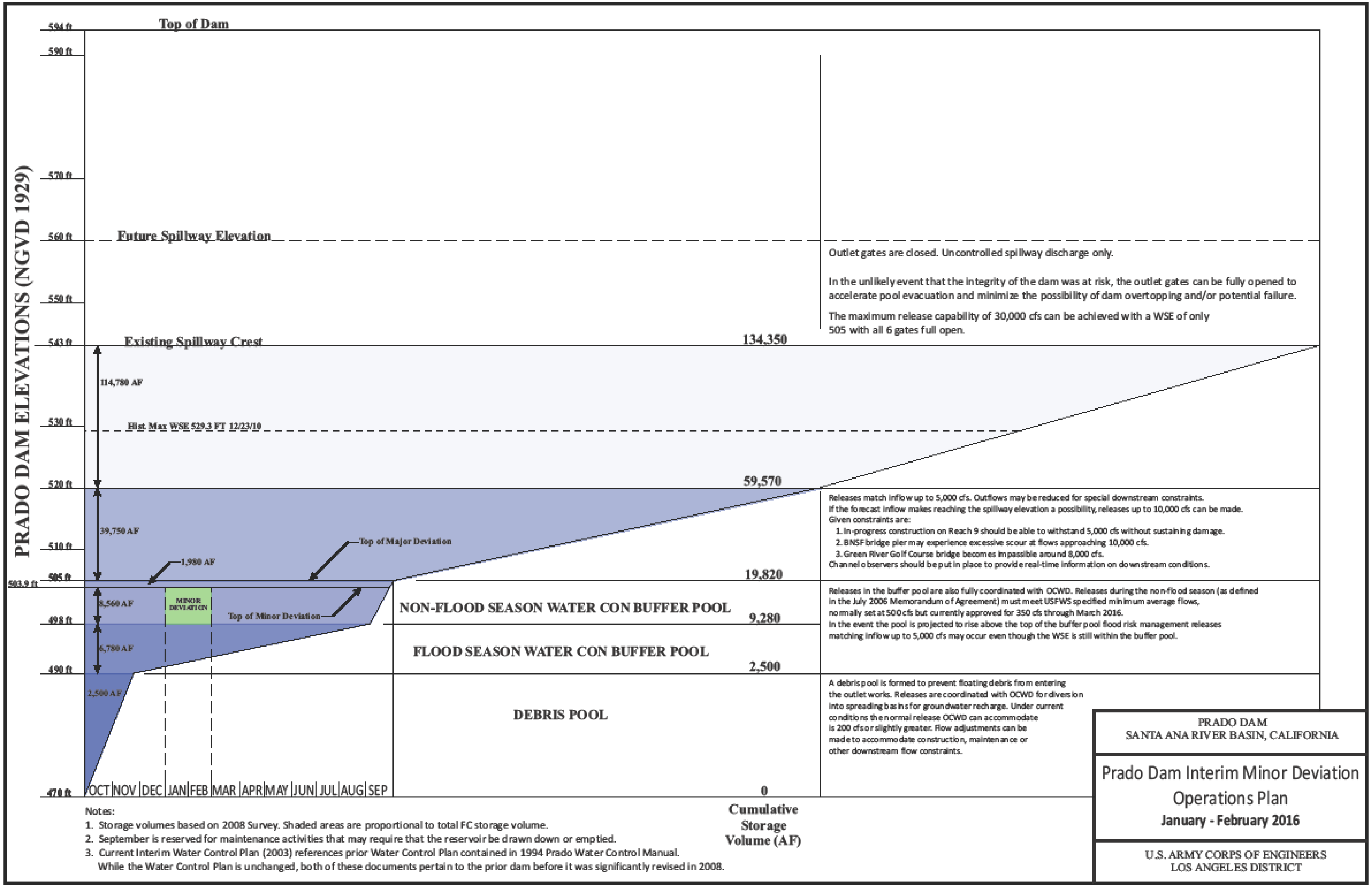
PRADO RESERVOIR STORAGE PROFILE

Santa Ana River, CA

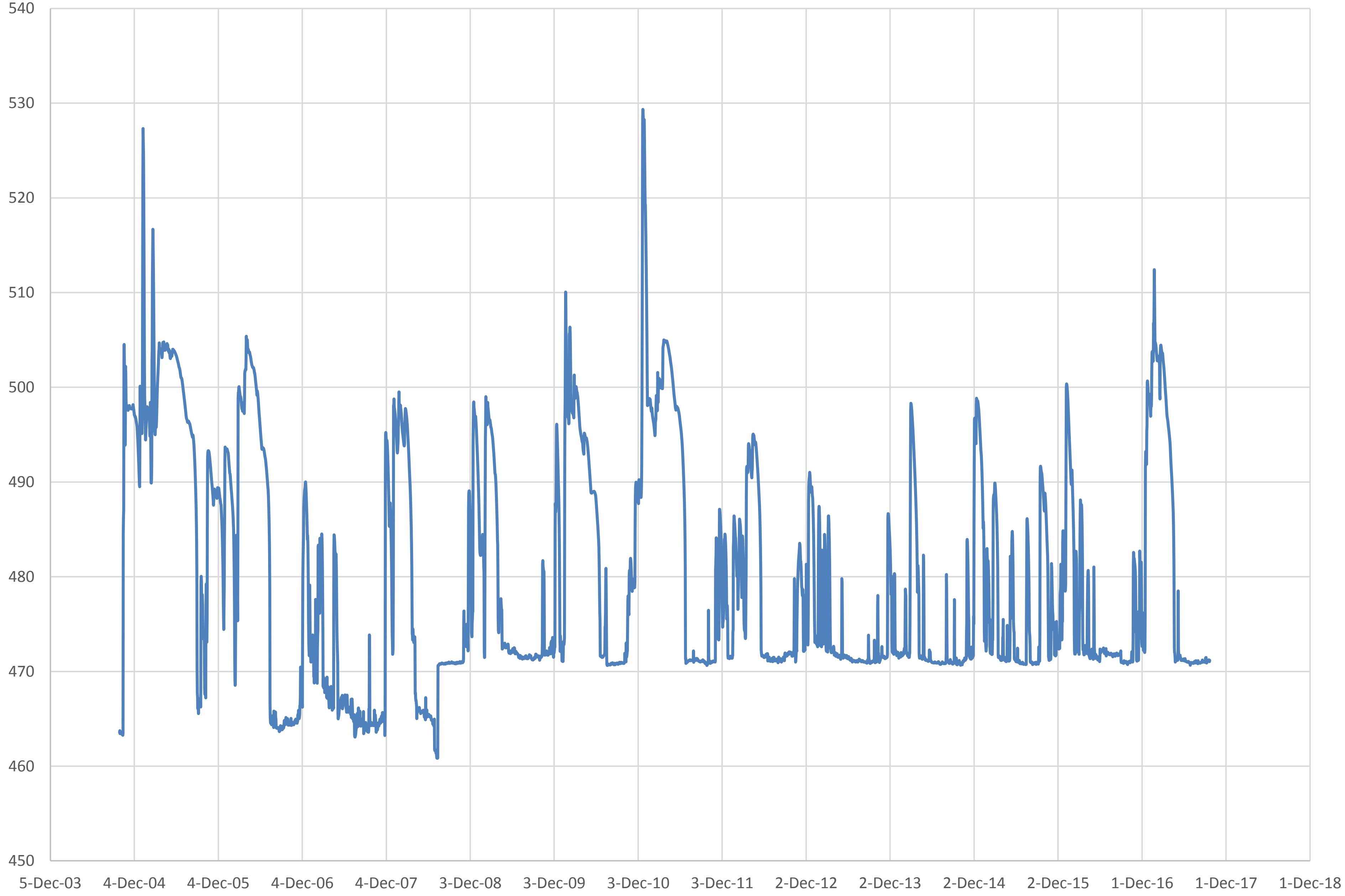


Based on **2008** Survey

Alternate Op Plan Layout



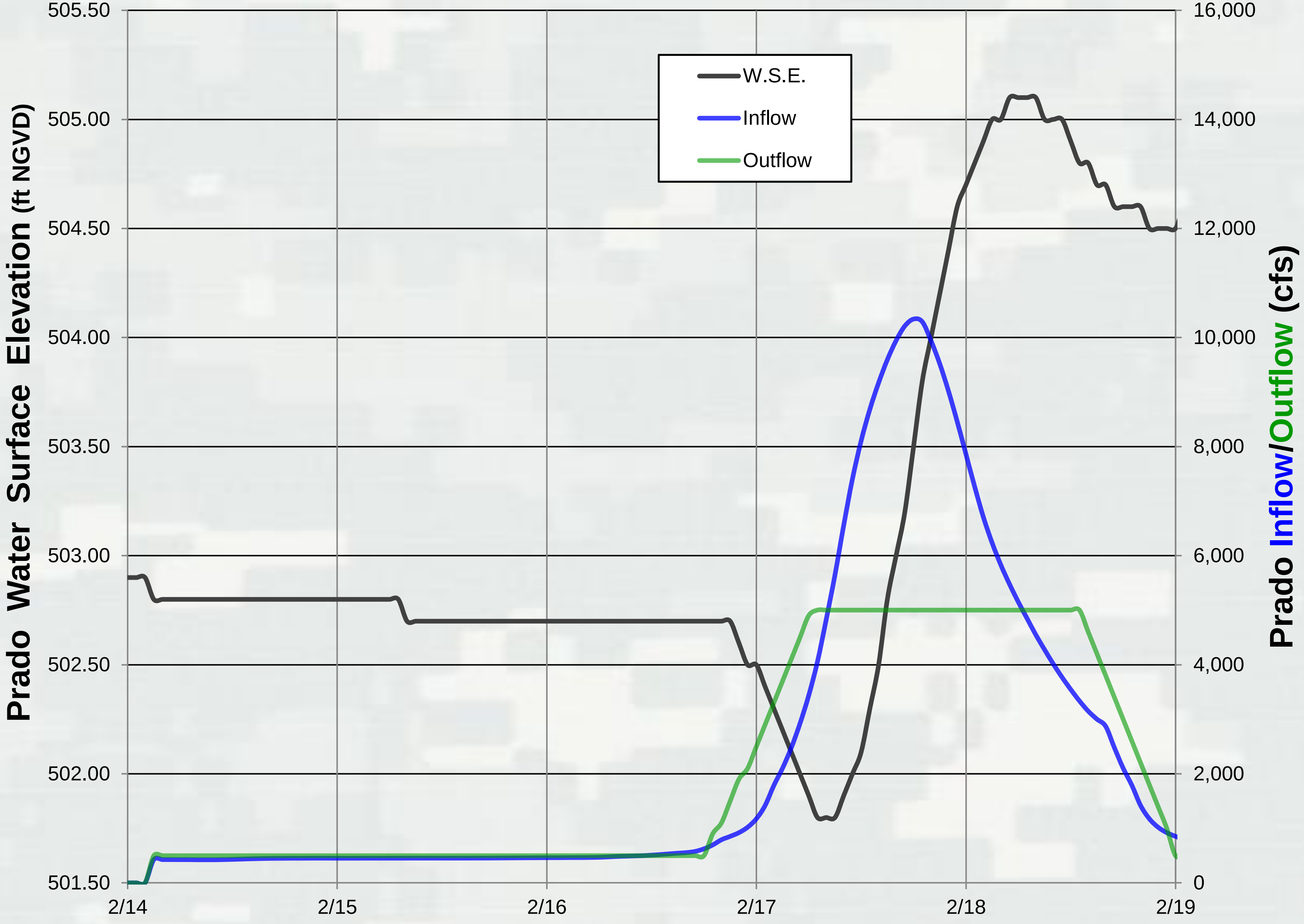
Prado WSE 2004 - 2017



Operations Forecasting Challenges

- How to interpret and act on 15-day ensemble forecast
- Need to build interface for 15-day ensemble forecast as input to CWMS model
- For extreme events it may allow project operation to get ahead of the storm instead of responding to it
- Infrequency of actual events makes model calibration difficult
- Need for a pilot phase to understand risks of incorporating forecast information into operations

Projected Prado Elevation with Deviation



Current Operational Constraints

- <u>Downstream channel capacity</u> (drives decisions)
  - Reach 9 still under construction
  - BNSF bridge retrofit just begun
  - Raising spillway dependent on OCPW acquiring right to flood additional land on periphery
  - Higher releases not entirely 'non-damaging'
- <u>In-reservoir impacts</u> (considered but not decisional)
  - Corona Airport at 514 feet
  - Other impacted users
  - Impounding water for water con alters ESA habitat

Corona Airport under water

Prado Dam High Water Marks

Xmas 2010/January 2011

- Max pool elevation 529.3 feet, highest since dam was built 1940.
- On a frequency scale it was about a 35 yr event.
- The maximum inflow was 45,000 cfs

Other recorded high marks

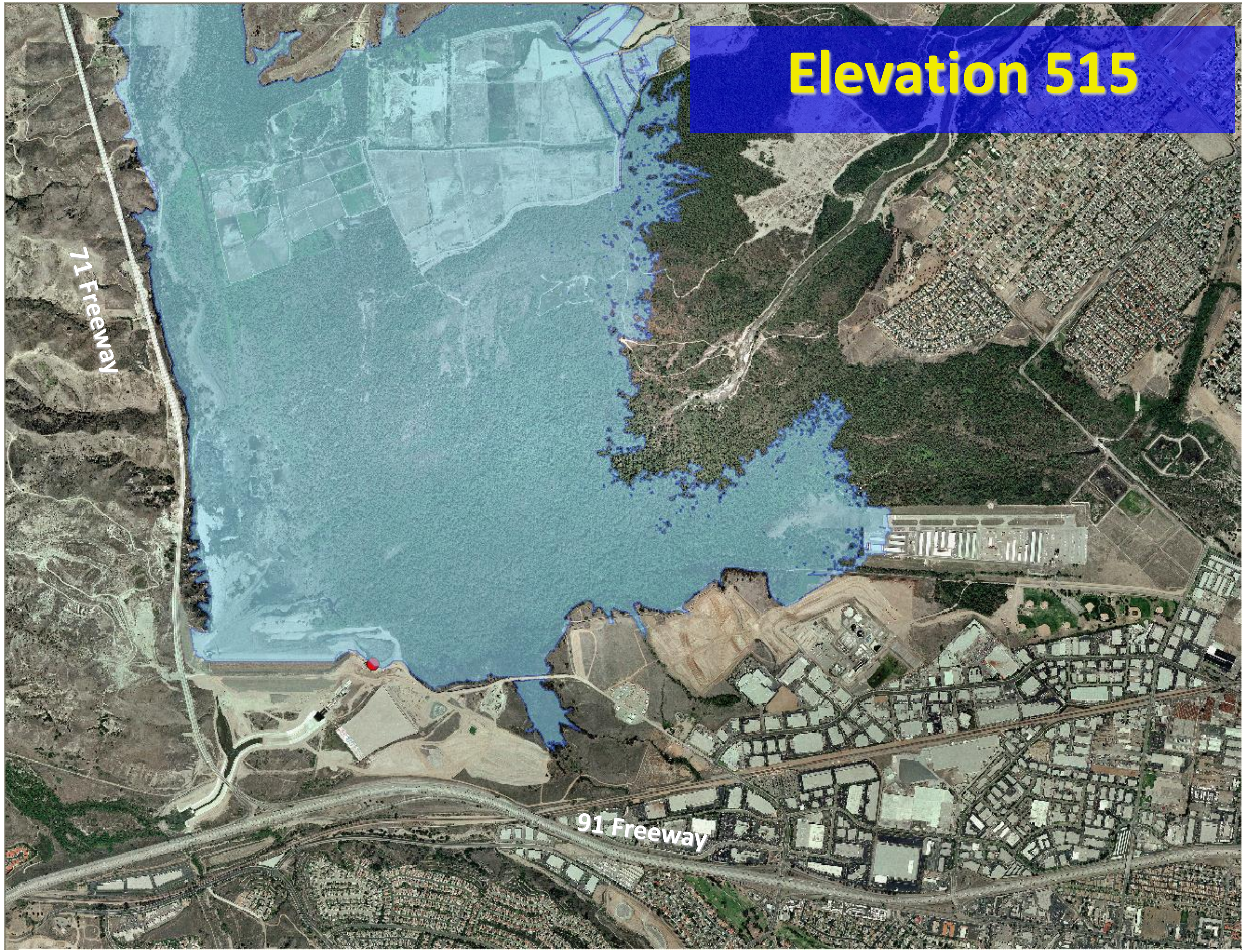
527.4 ft. [2005]

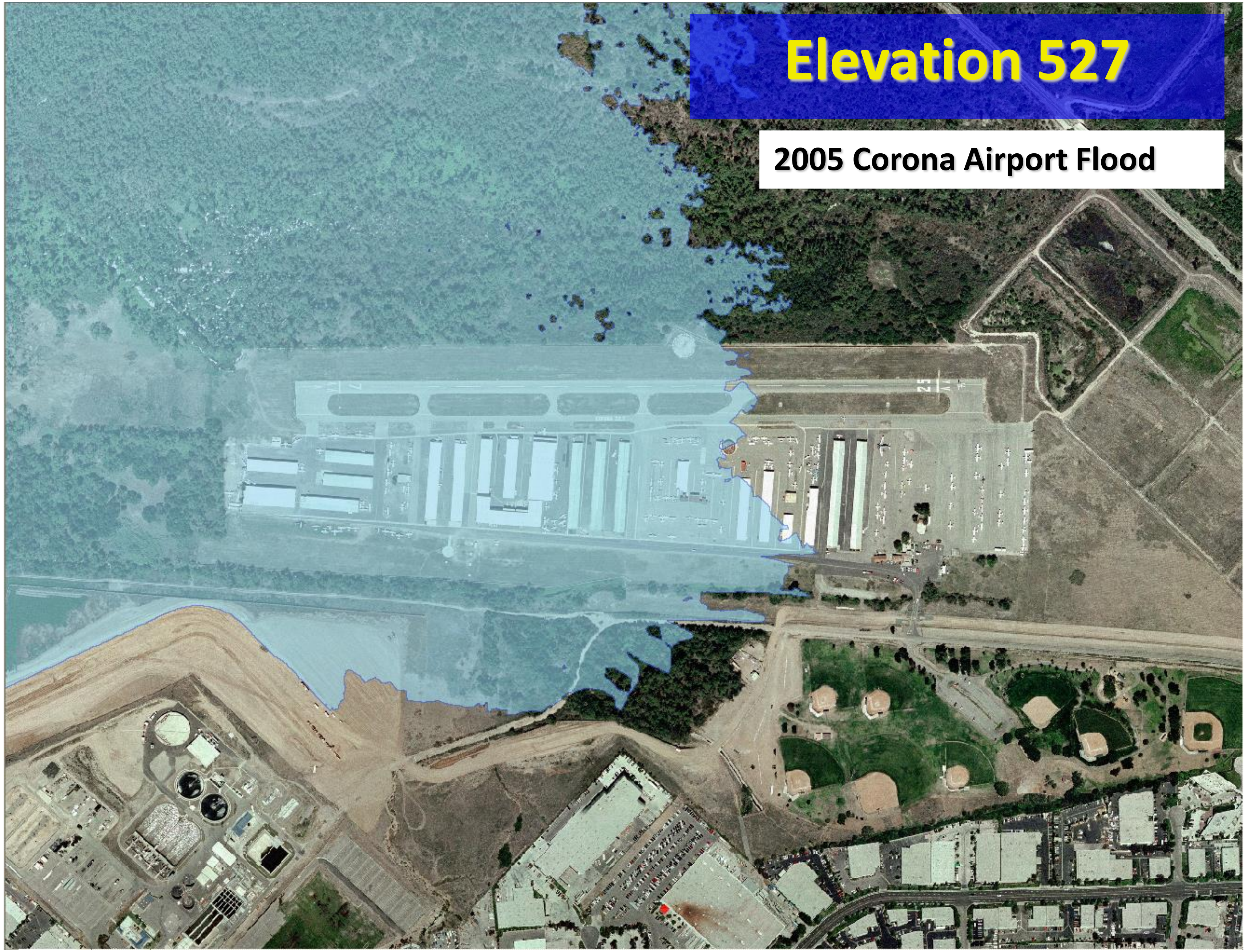
528.0 ft. [1980]

520.5 ft. [1978]

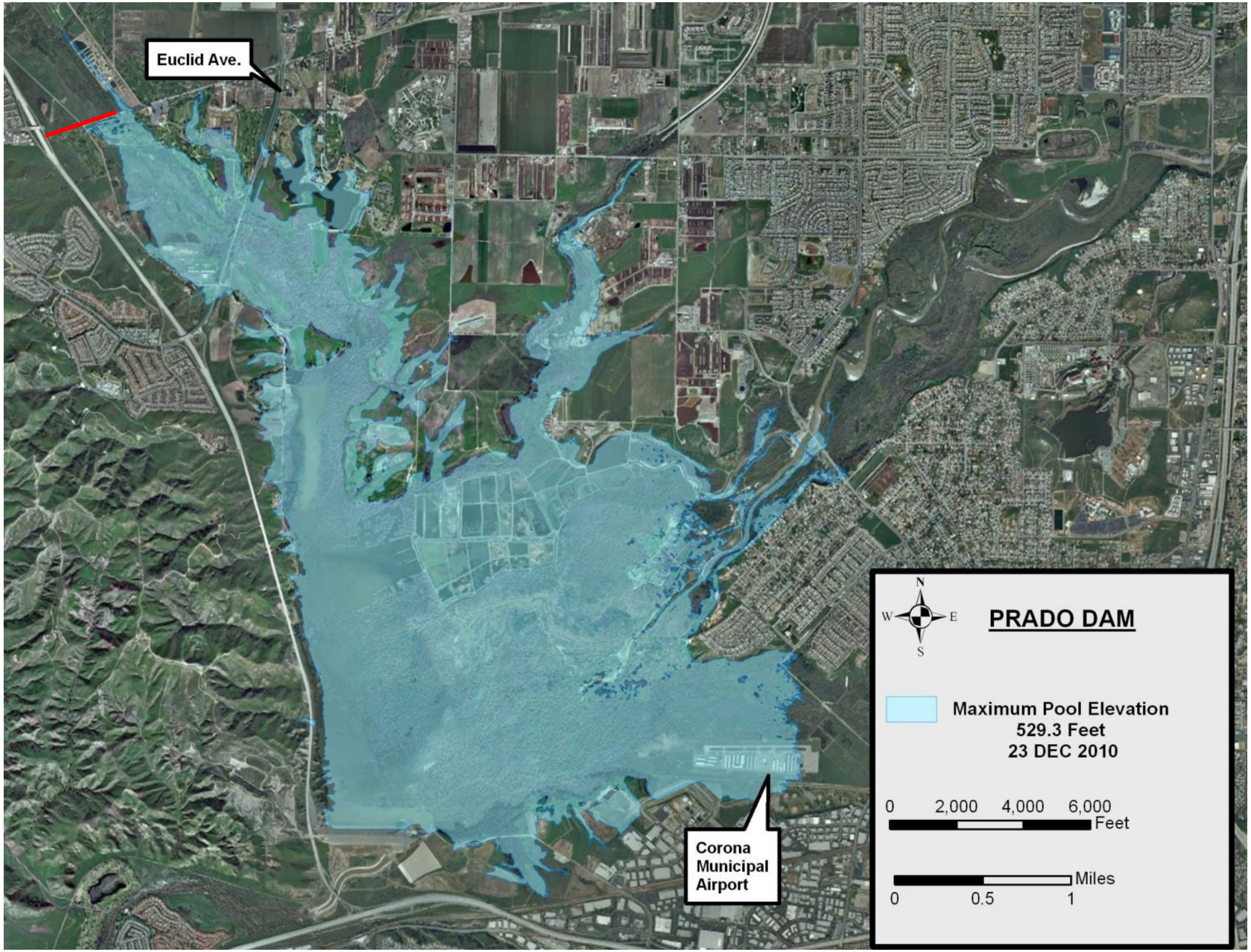
527.6 ft. [1969]

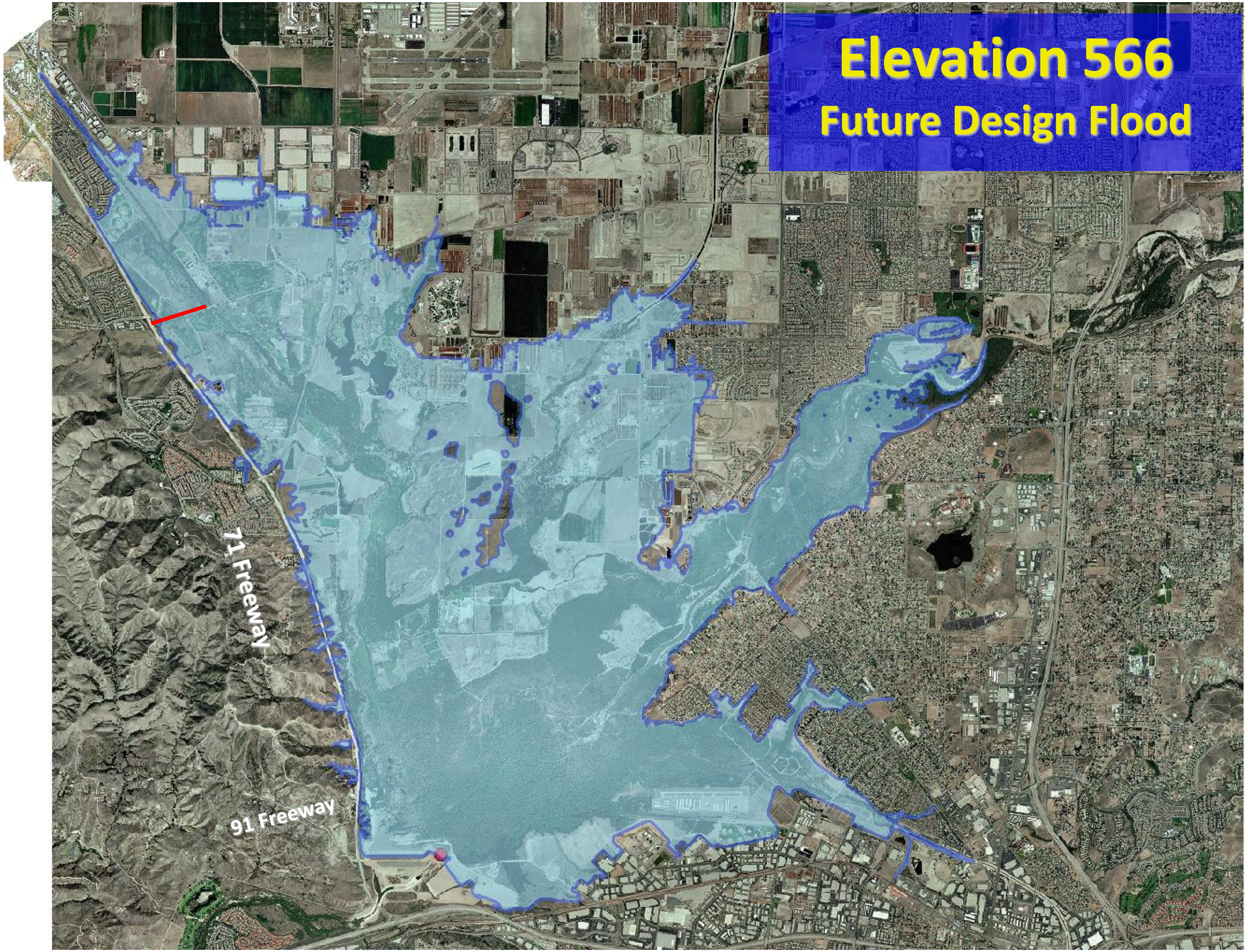
- Prior to dam in 1938 a peak flow of 100,000 cfs was measured.
- In the Great Flood of 1862 a peak of 320,000 cfs was estimated by USGS at Agua Mansa, south of Colton (u/s from Prado)


Elevation 515
71 Freeway
91 Freeway


Elevation 527
2005 Corona Airport Flood

2010 Maximum Pool Inundation




Elevation 566
Future Design Flood
71 Freeway
91 Freeway

Questions?

Visit the USACE Los Angeles District Reservoir Regulation website

http://resreg.spl.usace.army.mil/