The Oroville Dam Spillway Incident

International Workshop on Overflowing Erosion of Dams and Dikes

Aussois, France
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by
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California State Water Project

- Largest state owned and operated water system in the U.S.
- Multiple purposes and benefits
- Serves 25 million people
  over 750,000 acres of farmland
- 32 storage facilities
  21 pumping plants
  4 pumping-generating plants
  8 Hydroelectric plants
  700 miles (1100 km) of canals and pipelines

Facilty Description

- Embankment dam – 770 feet (235 m) high, tallest dam in the United States
- Gate-controlled, concrete chute service spillway
- Uncontrolled, overflow emergency spillway
- Powerplant
- Designed and constructed in the 1960s

Oroville Dam

Service Spillway (SS) Description

- Eight top-seal radial gates, each 17 ft 8 in (5.4 m) wide x 33 ft 6 (10.2 m) in high
- Concrete chute – 179 ft (54.6 m) wide with drop of 500 ft (152 m)
- Slopes of 5-2/3 % in upper chute and 24.5 % in lower chute
- Four chute blocks at downstream end of the chute
- ~300,000 cfs (8,500 cms) discharge for PMF

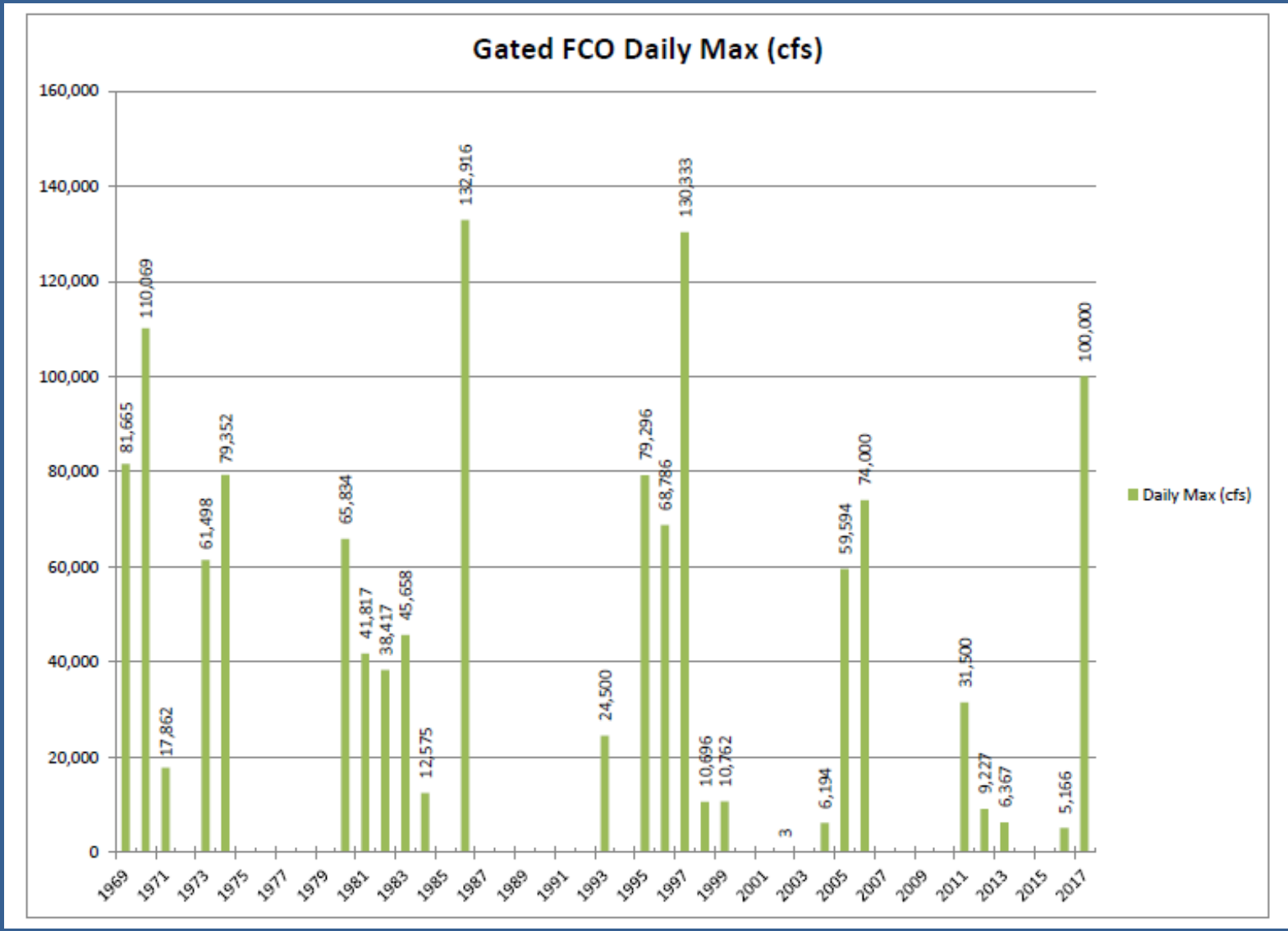
Service Spillway in Better Days

Emergency Spillway (ES) Description

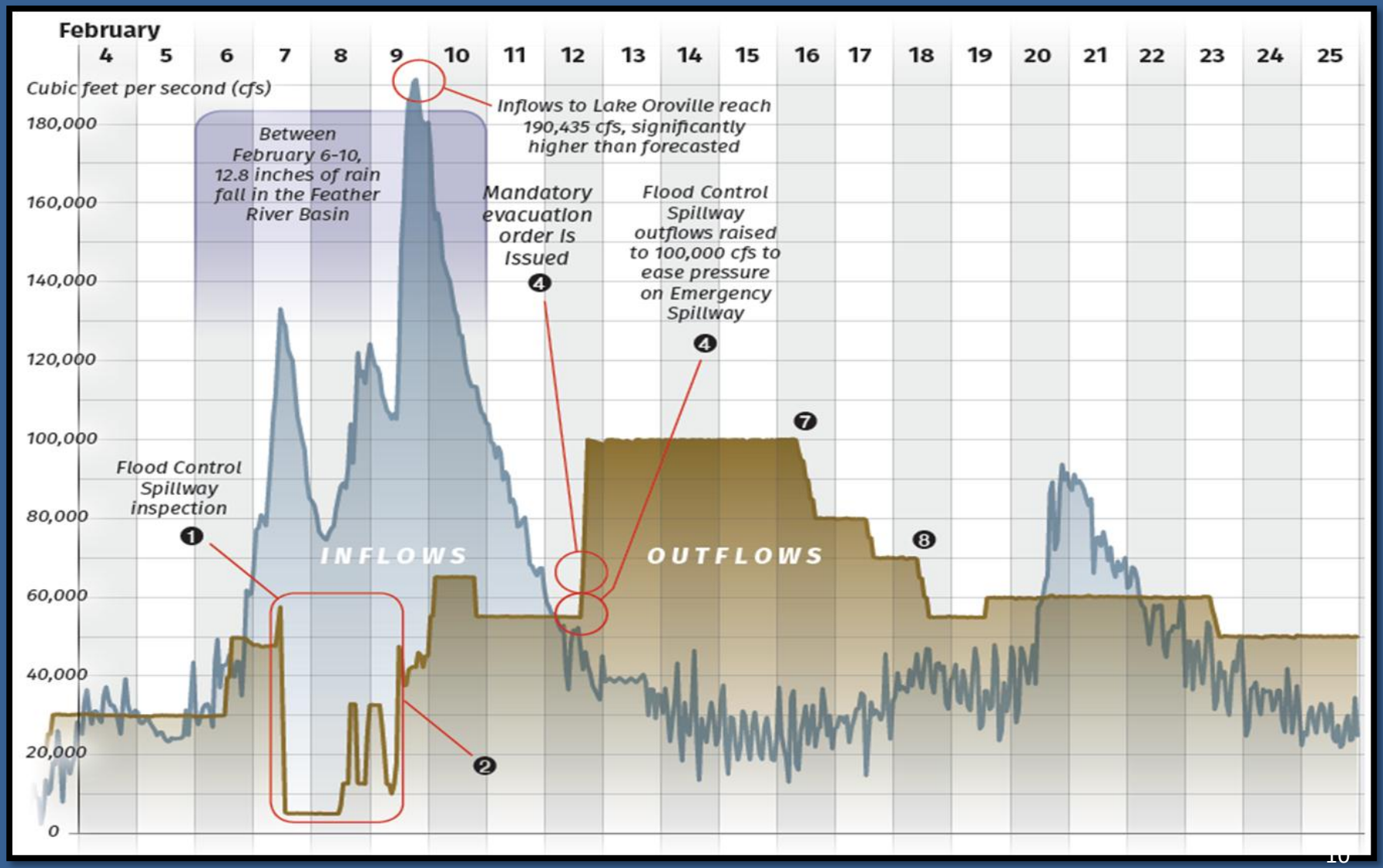
- Uncontrolled overflow structure
- Two sections:
  - 930-foot (283-m) long concrete gravity weir
  - 800-foot (244-m) long broad-crested weir
- Maximum weir height of about 50 feet (15.2 m)
- ~350,000 cfs (9,910 cms) discharge for PMF

Emergency Spillway

Spillway Operation History



Incident Chronology



Spillway Flow Disturbance

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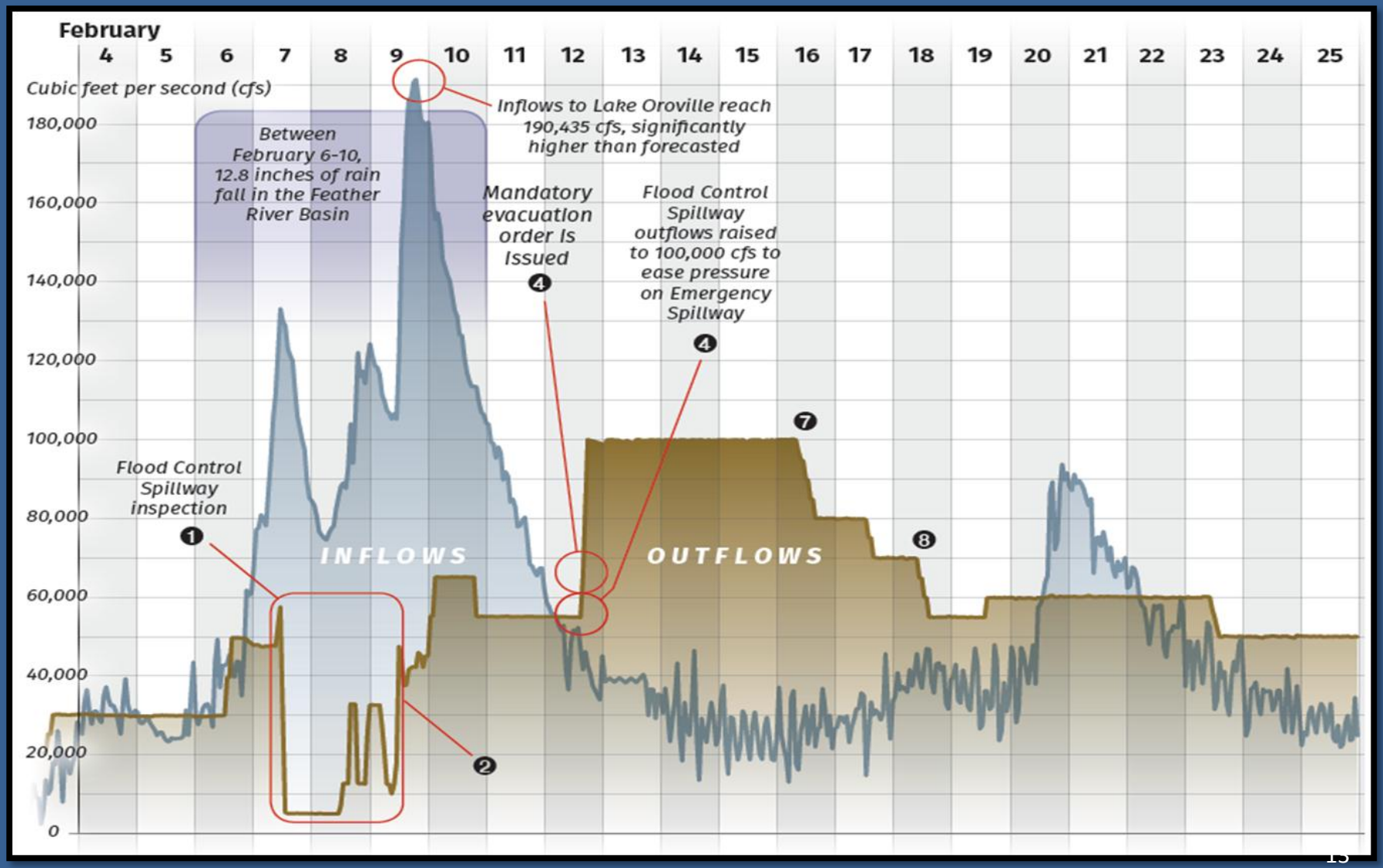
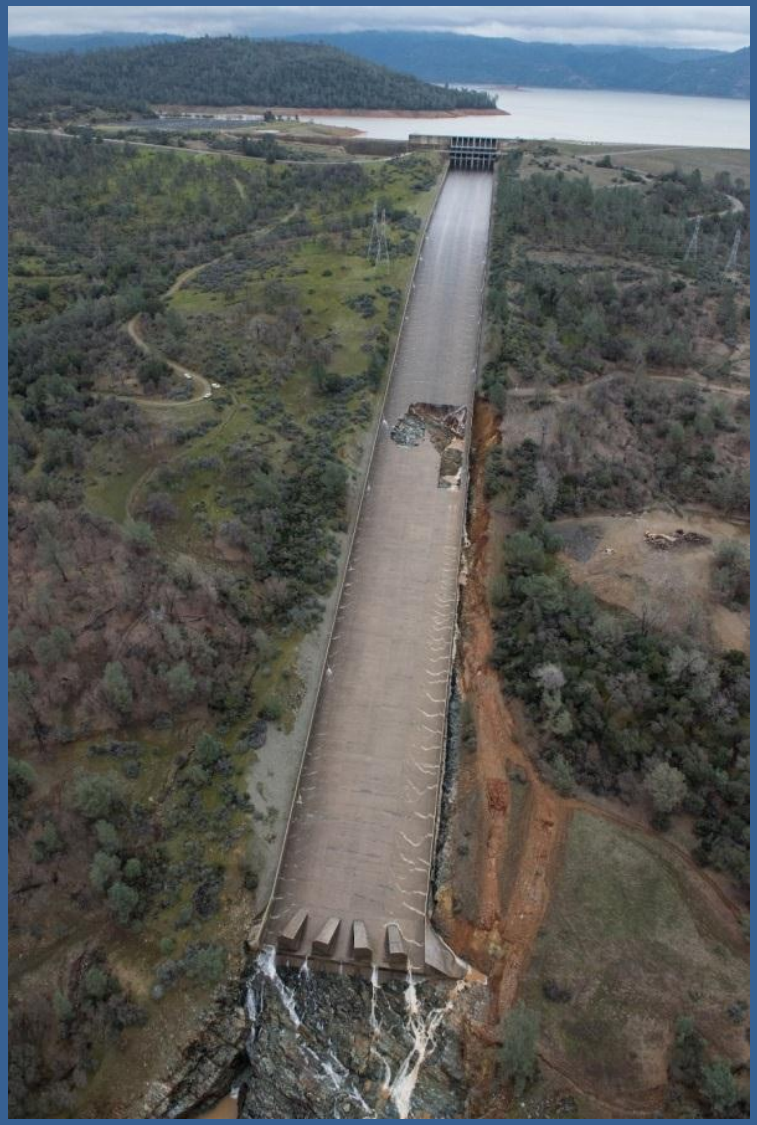
Incident Chronology



Gates Nearly Closed

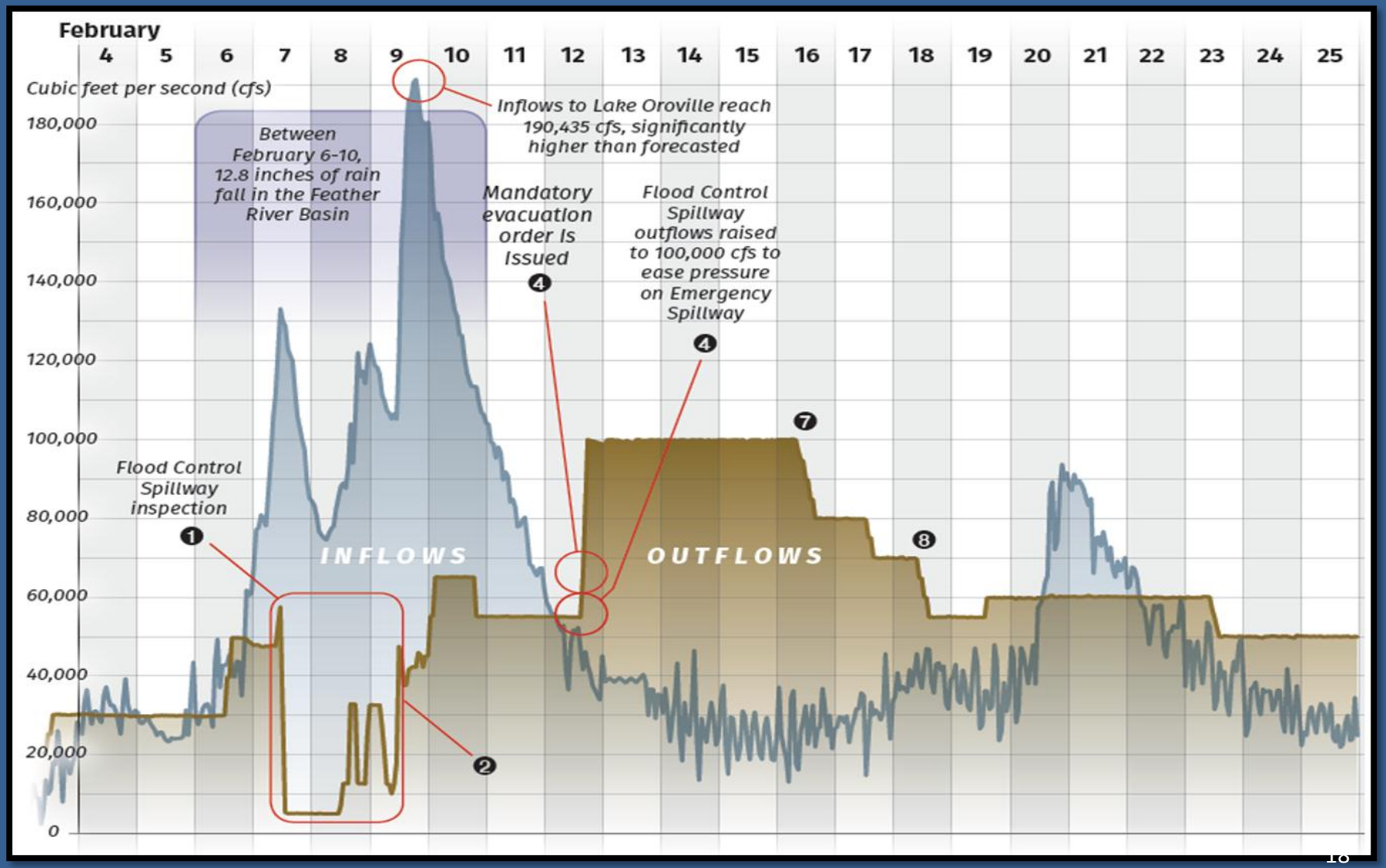
Initial Damage – February 7



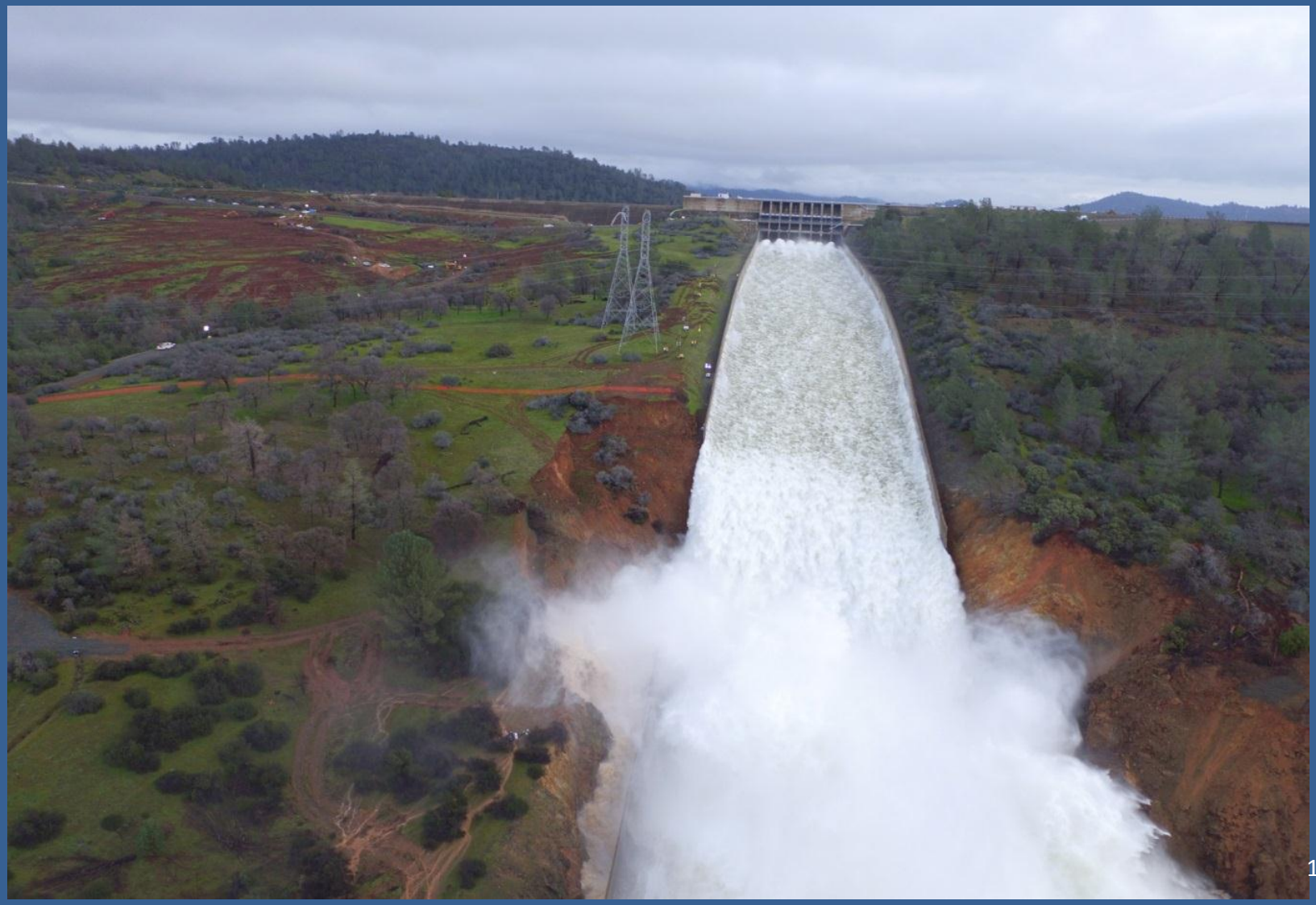
Initial Damage – February 7

Climb Team Inspection

Incident Chronology



SS Discharge at 55,000 cfs



Balancing Risk

Additional SS Damage

Emergency Spillway Operation

Powerplant Flooding

Power Transmission Towers

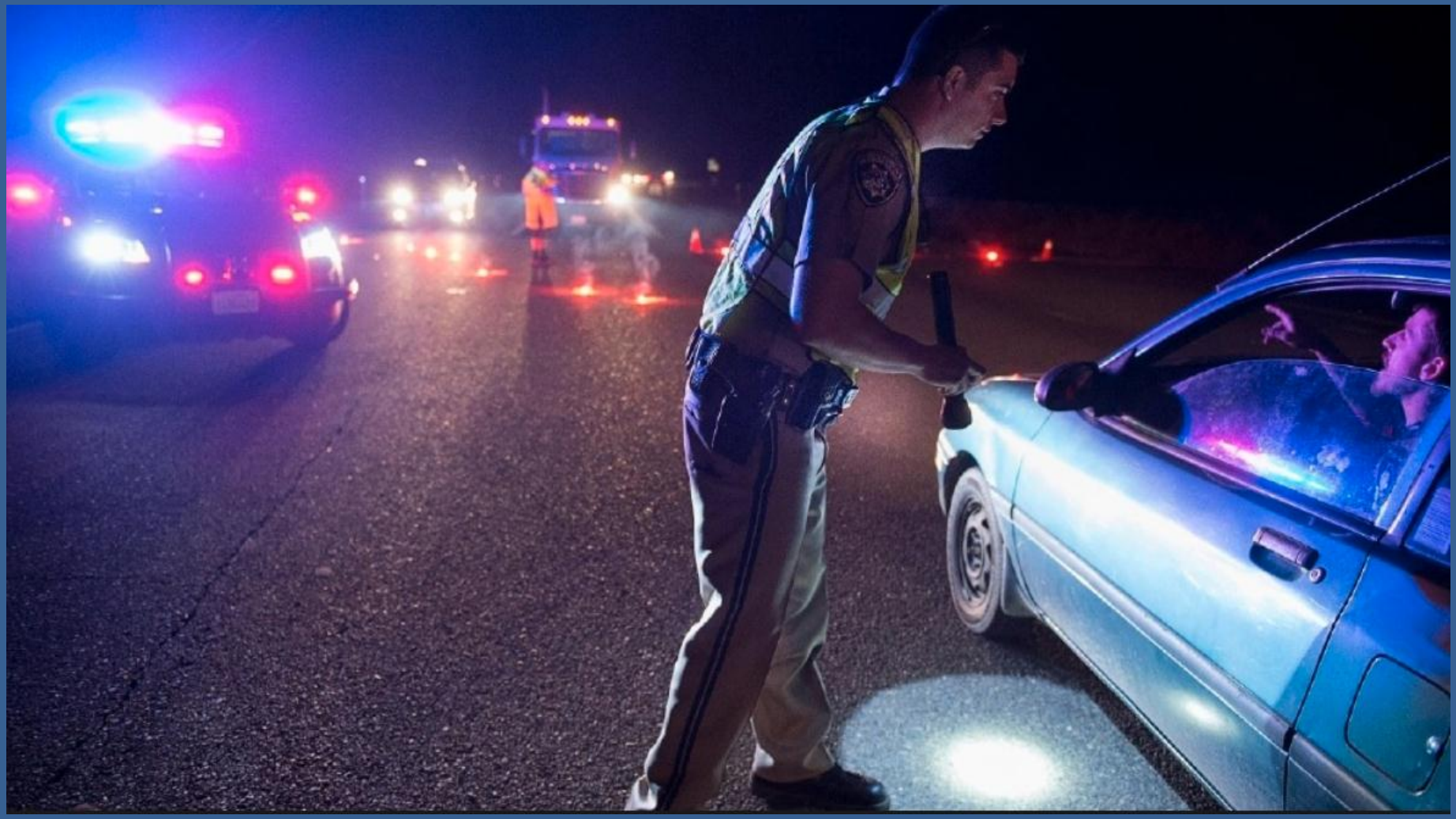
Flow Begins Over Emergency Spillway

Headcutting Erosion at ES

ES Overtopping

- Duration of 36 hours
- Maximum depth of 1.6 feet (0.5 m)
- Maximum discharge of 12,500 cfs (354 cms) – about 3.5 percent of estimated PMF discharge

Evacuation



Increased Flows Through SS

Erosion Debris in the River

Service Spillway Damage

Physics of SS Damage

Contributory Physical Factors

- Foundation conditions (geology)
- Cracks in the slab
- Joints without waterstops
- Leakage through chute slab
- Corrosion and failure of reinforcing
- Slab delaminations

SS Chute Foundations

- Conditions varied
- Areas of “compacted clayey fines”
- Areas of severely weathered and decomposed rock

Foundation Preparation

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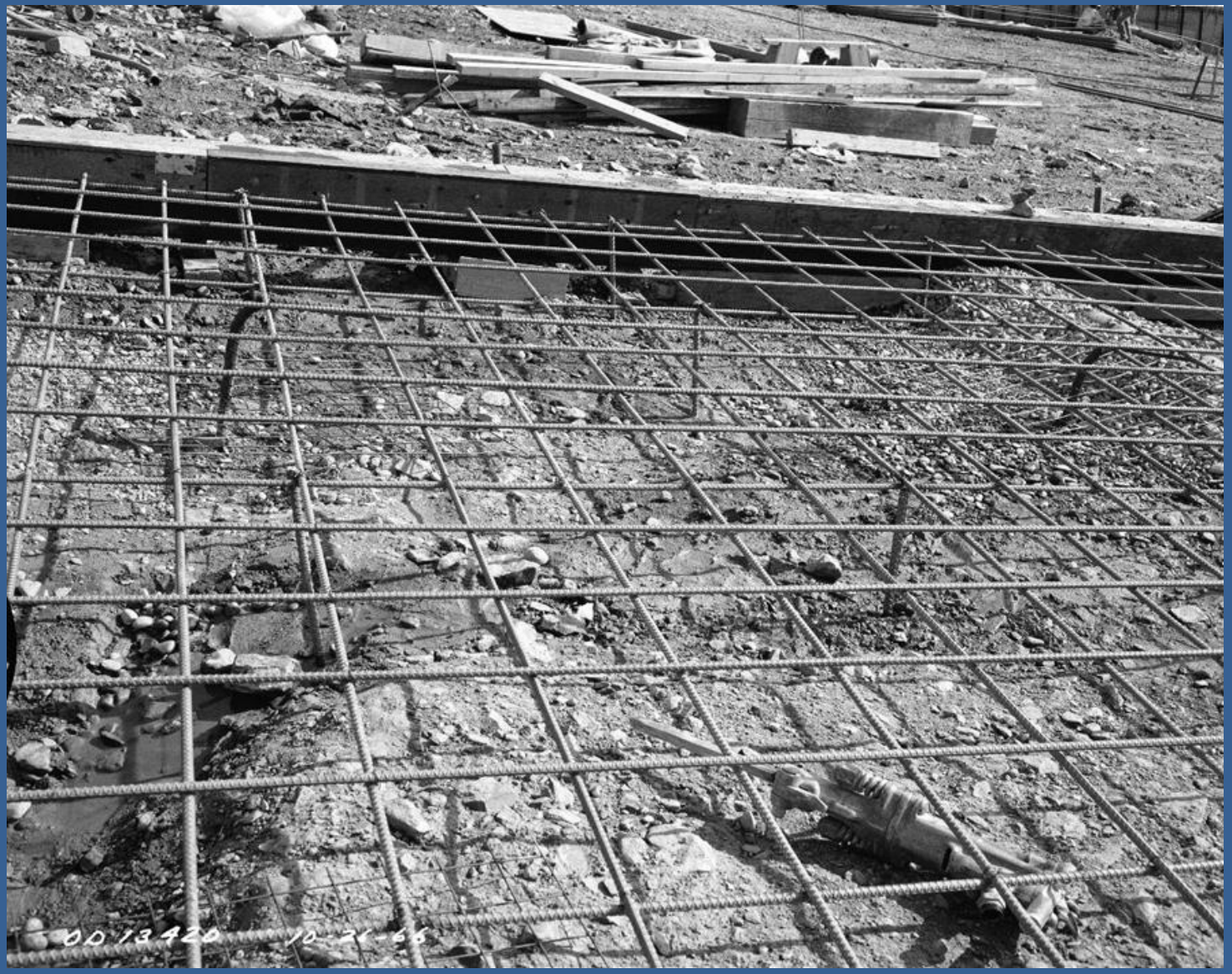


Foundation Preparation

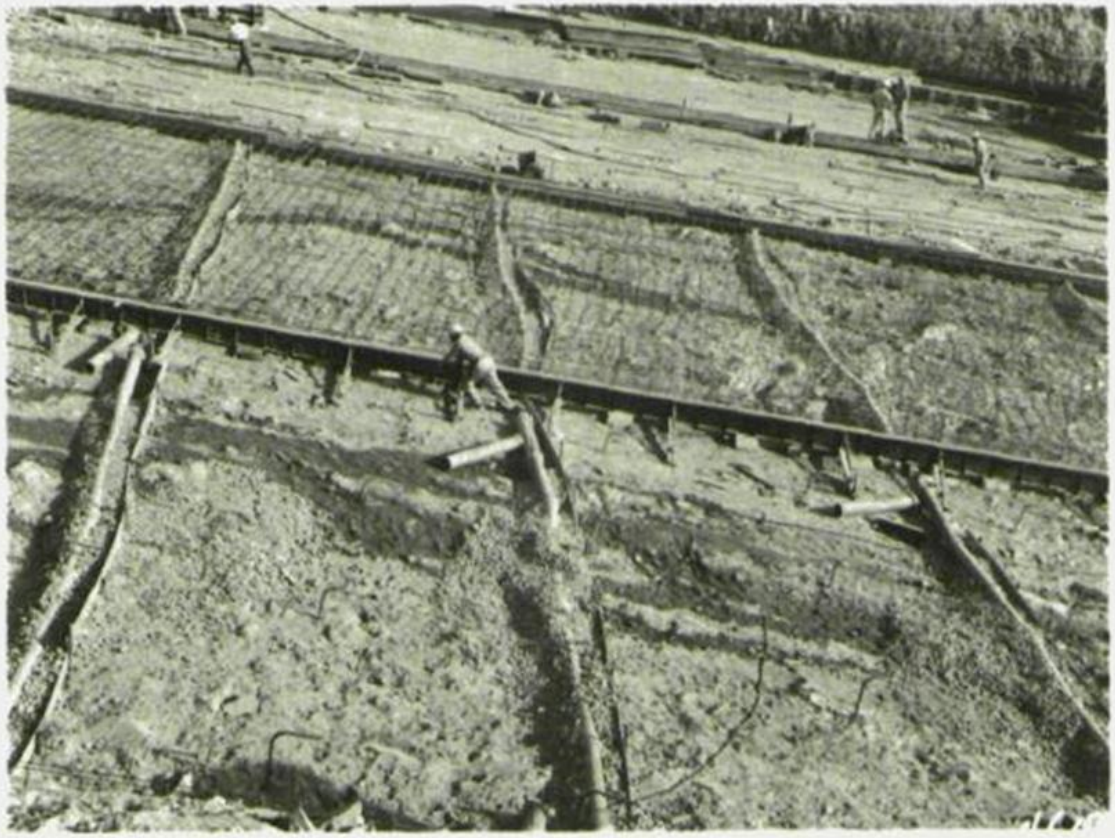
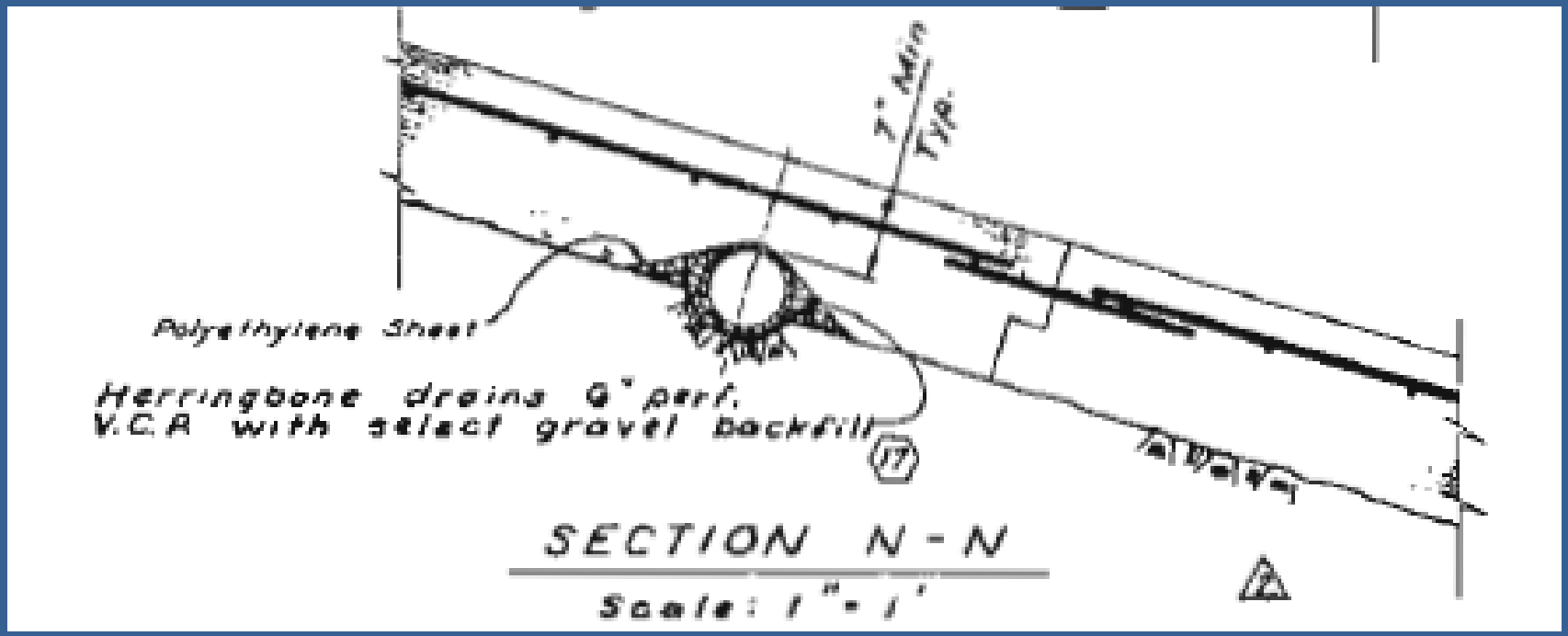


Photo 39. Chute foundation in vicinity of Sta. 33+60. Tile and gravel underdrains in lanes 2 and 3, rebar in lane 3. View southeast.
Neg. No. 4644 11-2-66

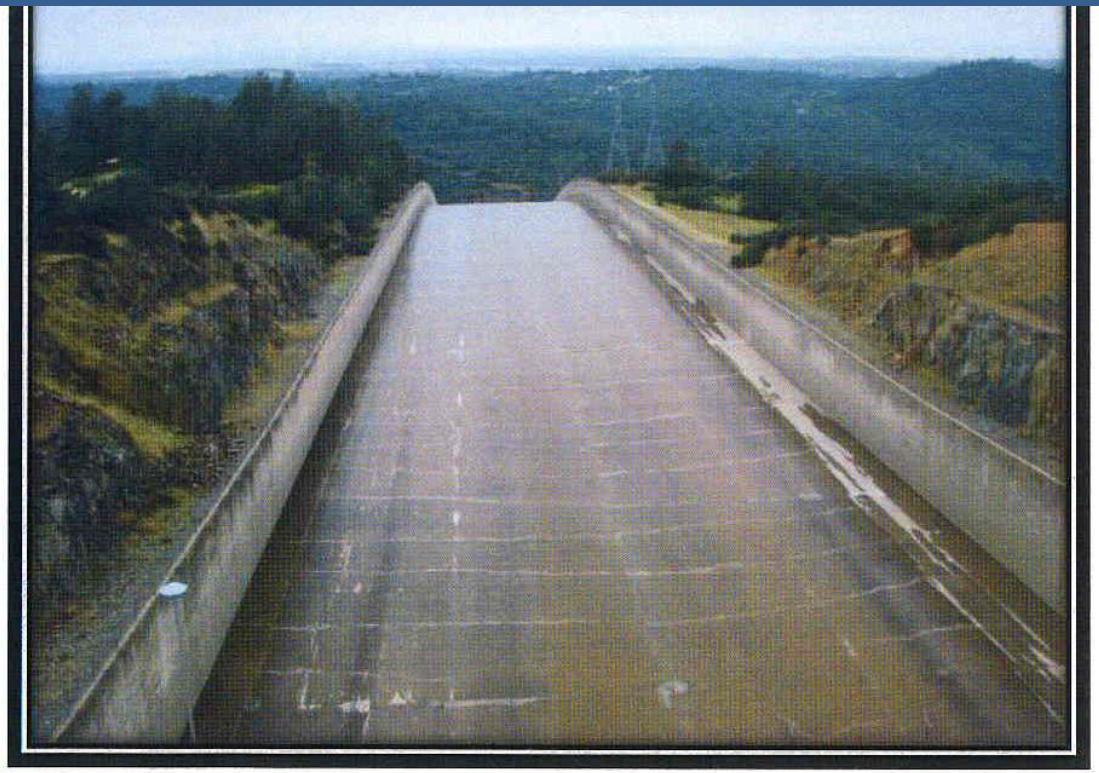
SS Design

- Nominal 15-inch (0.38 m) thickness
- No waterstops in joints
- Unbonded dowels in joints
- Lapped keys in lateral joints
- VCP drains protruding into the slab
- Foundation anchors at 10-foot (3.05-m) spacing

Drain and Joint Details



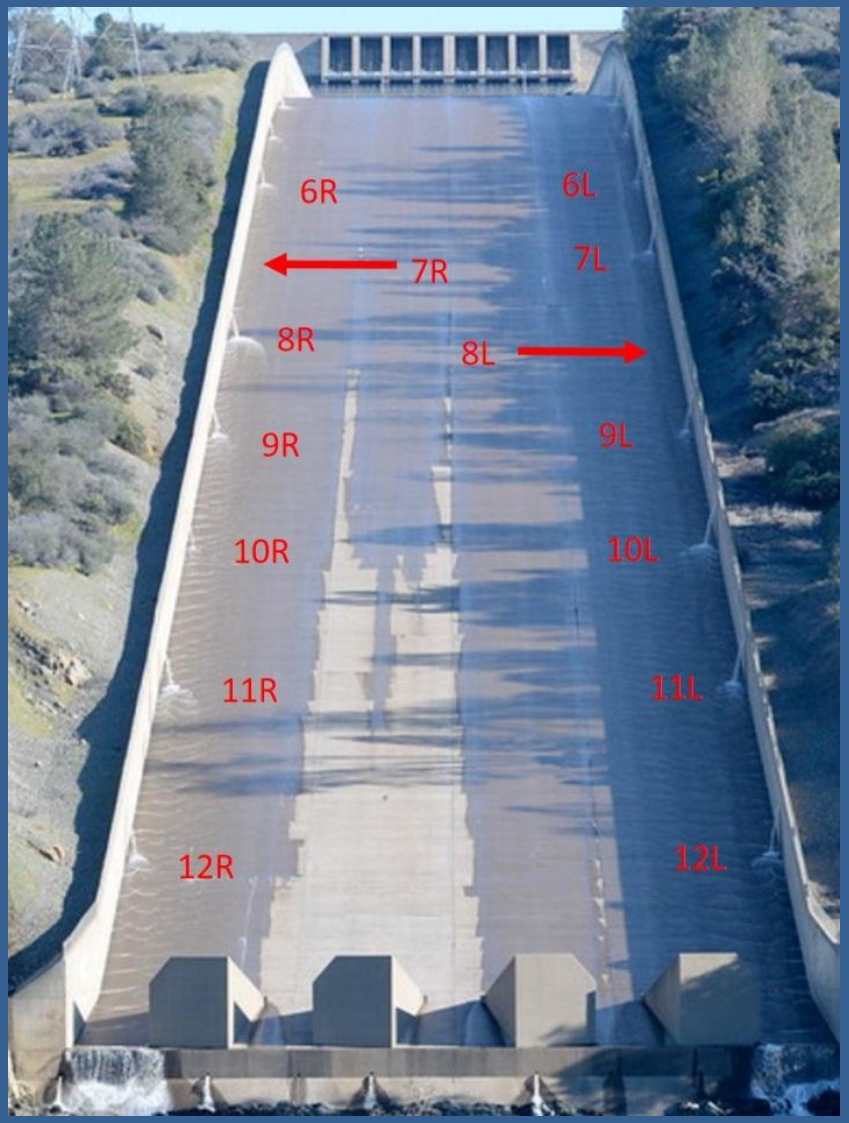
Crack Pattern



12. The concrete along the spillway chute has been repaired. The repaired herringbone crack pattern is said to reflect the underlying drain system.

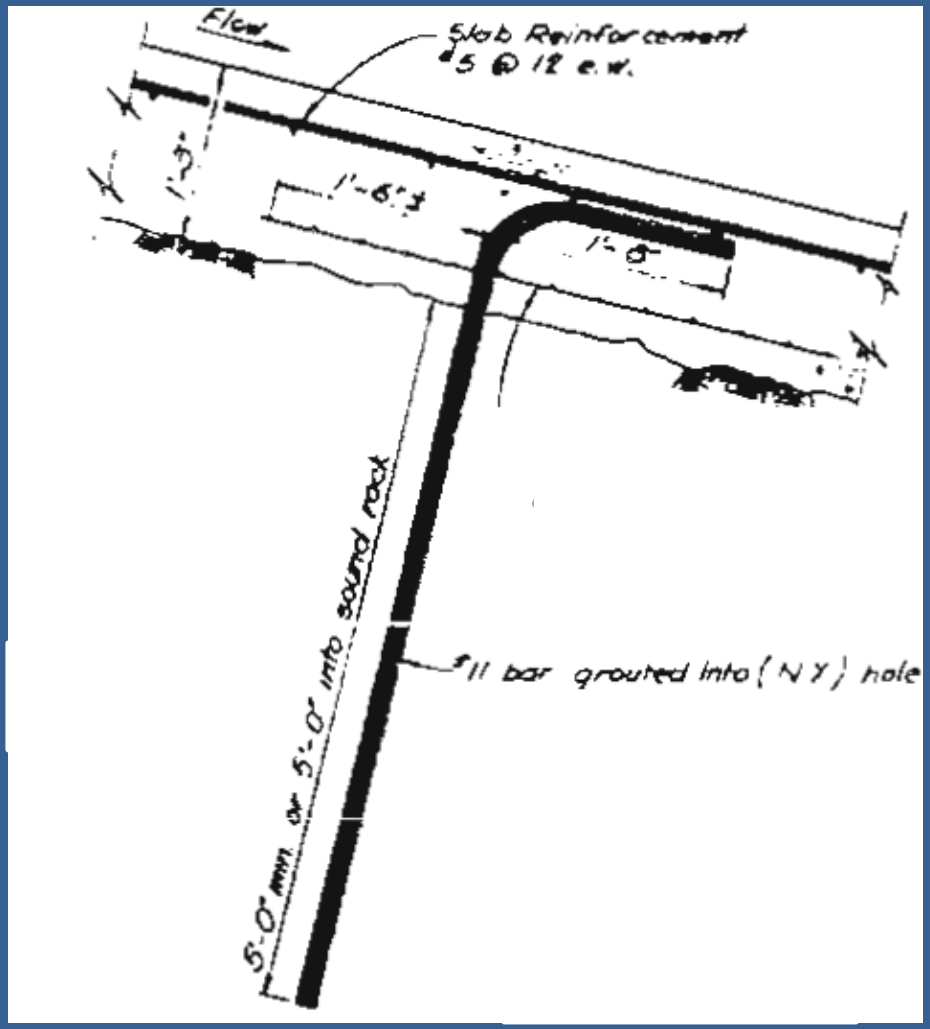
Ruptured Rebar

Underdrain Flows



Cracks Over Drains

Chute Slab Anchors



Physics of ES Damage

Lessons to be Learned

- Physical inspections necessary, but not sufficient to identify risks and manage safety
- Periodic comprehensive reviews needed