Impacts of Wildfire on a California Reservoir: Water Quality Analysis

Kareem Hannoun, WQS

Imad Hannoun, WQS

Jordan Switzer, Casitas MWD

Ira Rackley, WQS

11/17/2022

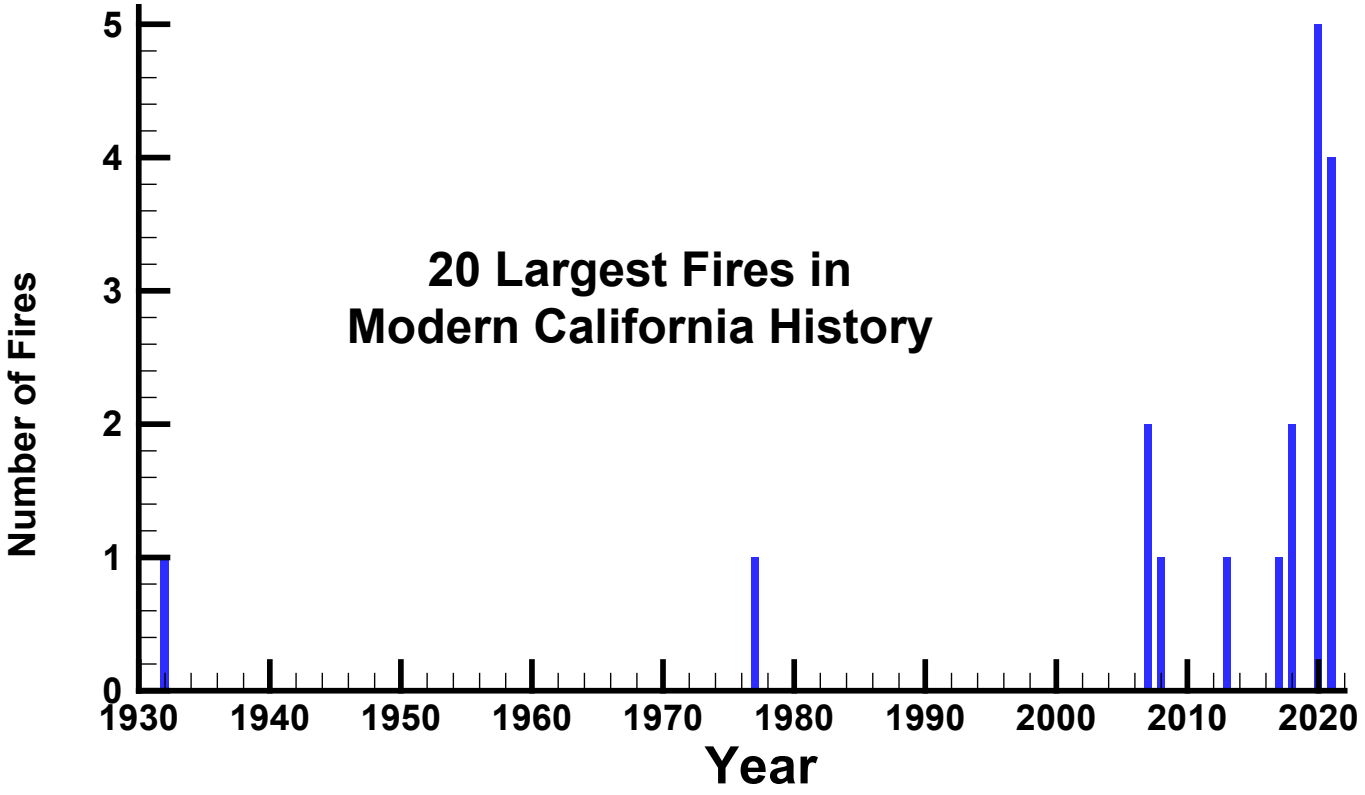
- Wildfire Effects
- Lake Casitas and Thomas Fire
- Water Quality
    - Inflow
    - In-Reservoir
- Conclusions

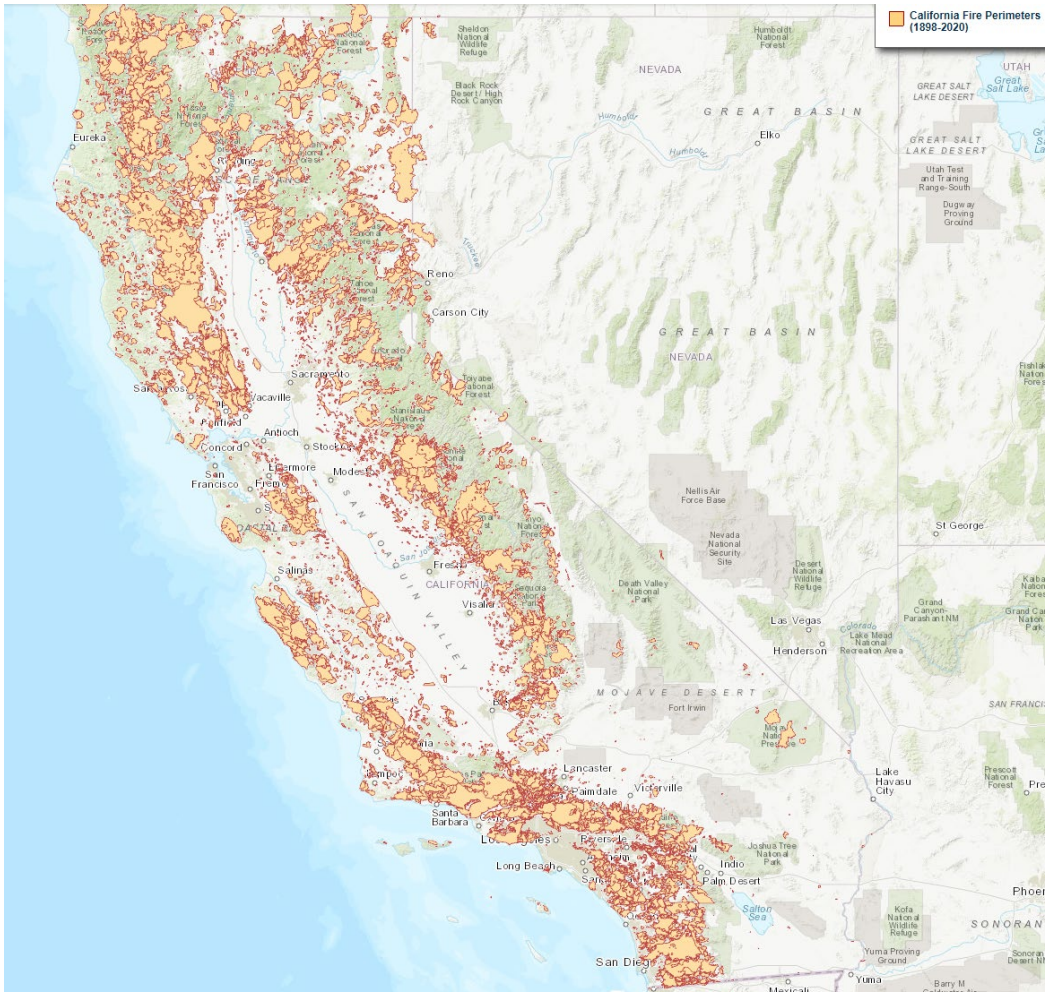
- Wildfire Effects
- Lake Casitas and Thomas Fire
- Water Quality
    - Inflow
    - In-Reservoir
- Conclusions

Wildfires in the West

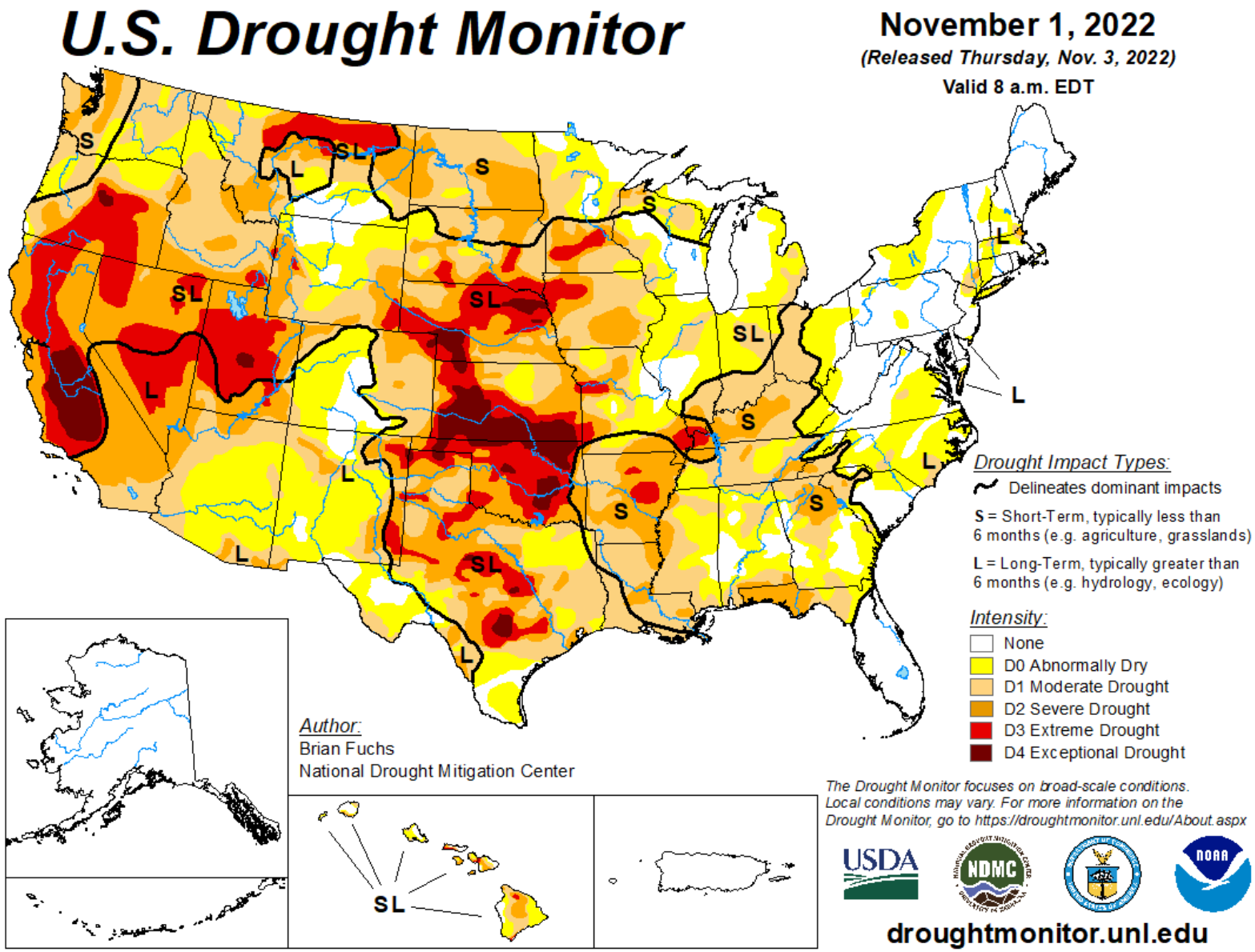
Wildfires Continue to Increase in Frequency and Severity

- Fire season extends later into year
- Megafires increasing significantly in last 20 years





Drought Continues in West



Wildfires and Water Quality: Rivers and Streams

Direct Effects

- Sediment loads
  - Anoxic inflows
  - Nutrient loading
  - Sedimentation
- High water temperatures
- Heavy metals

Lingering Effects

- Slope instability
- Continued nutrient loading

Ventura River March 2018
Photo Credit: Paul Jenkin
Venturariver.org

Wildfires and Water Quality: Reservoirs

Sediment Flows and Small Reservoirs

- Post-fire inflows can inundate reservoirs with sediment and nutrients
- Water can become untreatable

Medium and Large Reservoirs

- How does reservoir storage level and design effect post-fire water quality?

Wildfire and Drought

- Drought can exacerbate effects of wildfire on reservoirs
  - Low reservoir storage
  - Episodic inflows

Matilija Reservoir
Photo Credit: Paul Jenkin
Venturariver.org

- Wildfire Effects
- Lake Casitas and Thomas Fire
- Water Quality
    - Inflow
    - In-Reservoir
- Conclusions

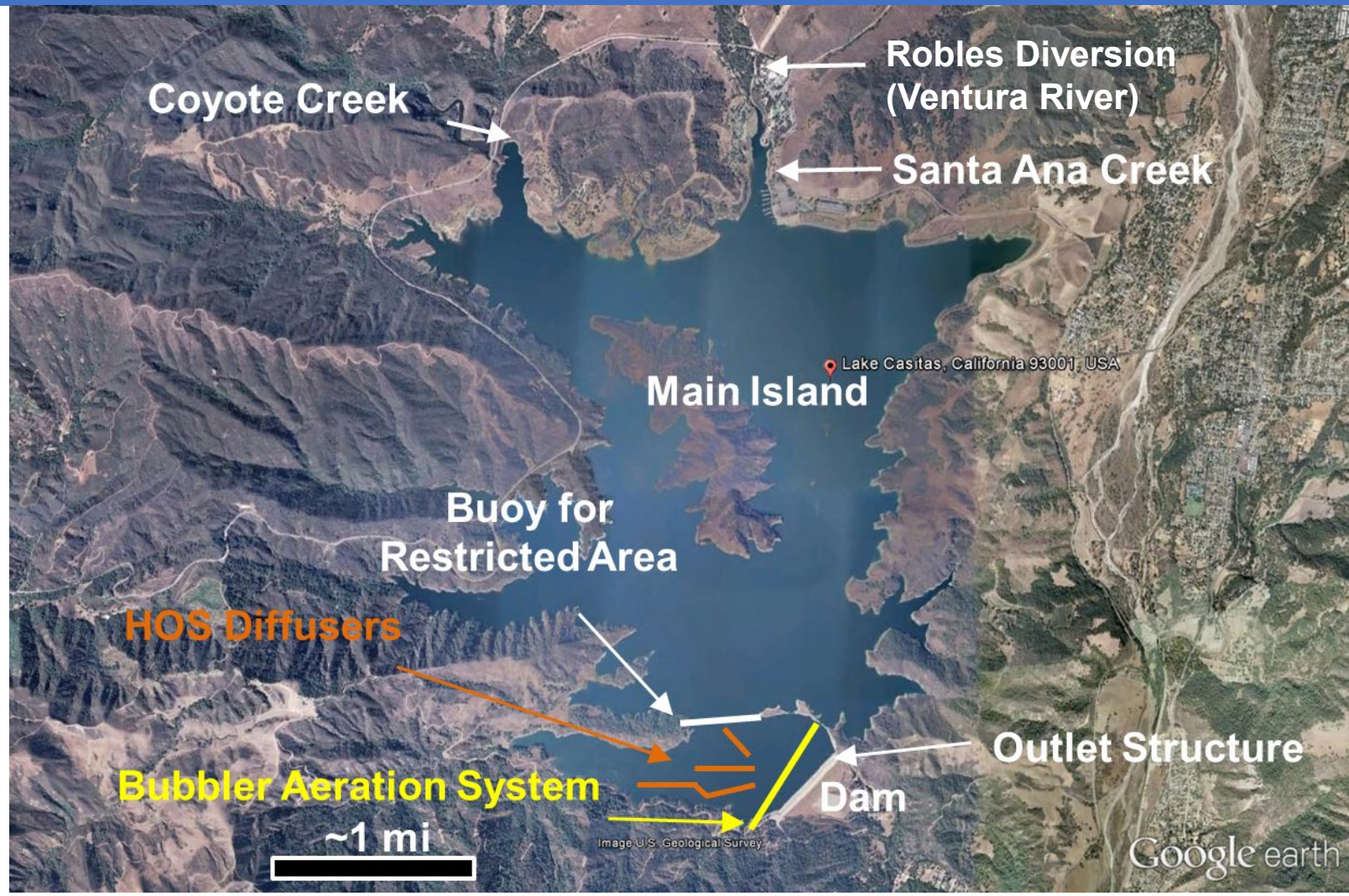
Lake Casitas

238,000 Acre-Feet Storage Volume

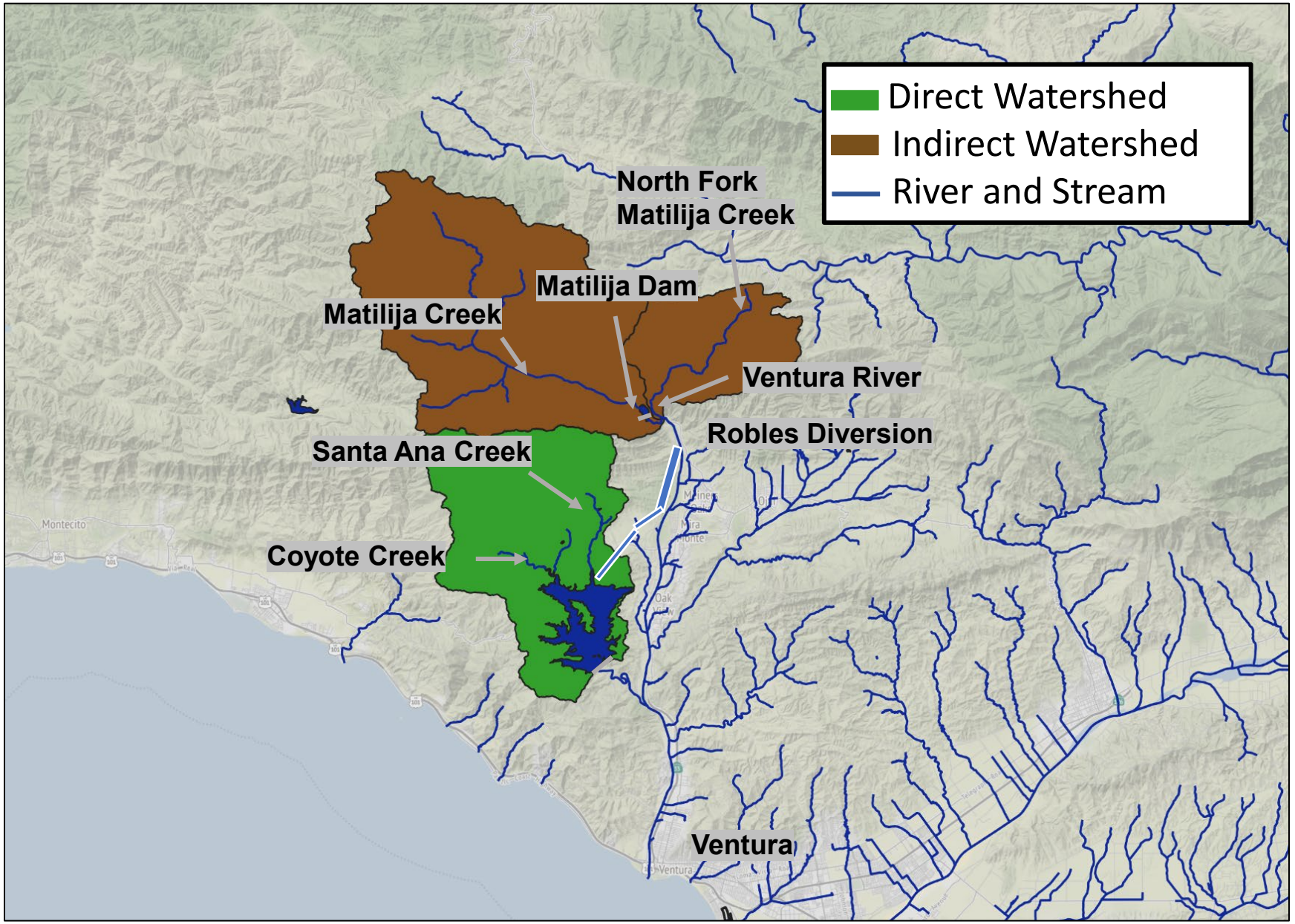
- Drinking water supply

Sustained Drought

- Reservoir level dropping since 2012
  - ~35% capacity before Thomas Fire
- Direct and indirect watershed
  - Direct
    - Coyote and Santa Ana Creeks
    - Direct rainfall and runoff
  - Indirect
    - Upper Ventura River
    - Matilija Creek
    - North Fork Matilija Creek
  - All flows episodic
  - Does not receive imported water



Lake Casitas Inflows



Robles Diversion and Fish Passage Facility

- Approximately two miles downstream of Matilija Reservoir
- Diverts water via 5.4-mile canal with 500 cfs capacity
- Modified in 2005 for passage of endangered Southern California Steelhead
- Majority of water enters reservoir through diversion structure
- Diversions typically occur following large storm events
- Diversion structure allows sediment to settle

Robles Diversion and Fish Passage Facility 2019

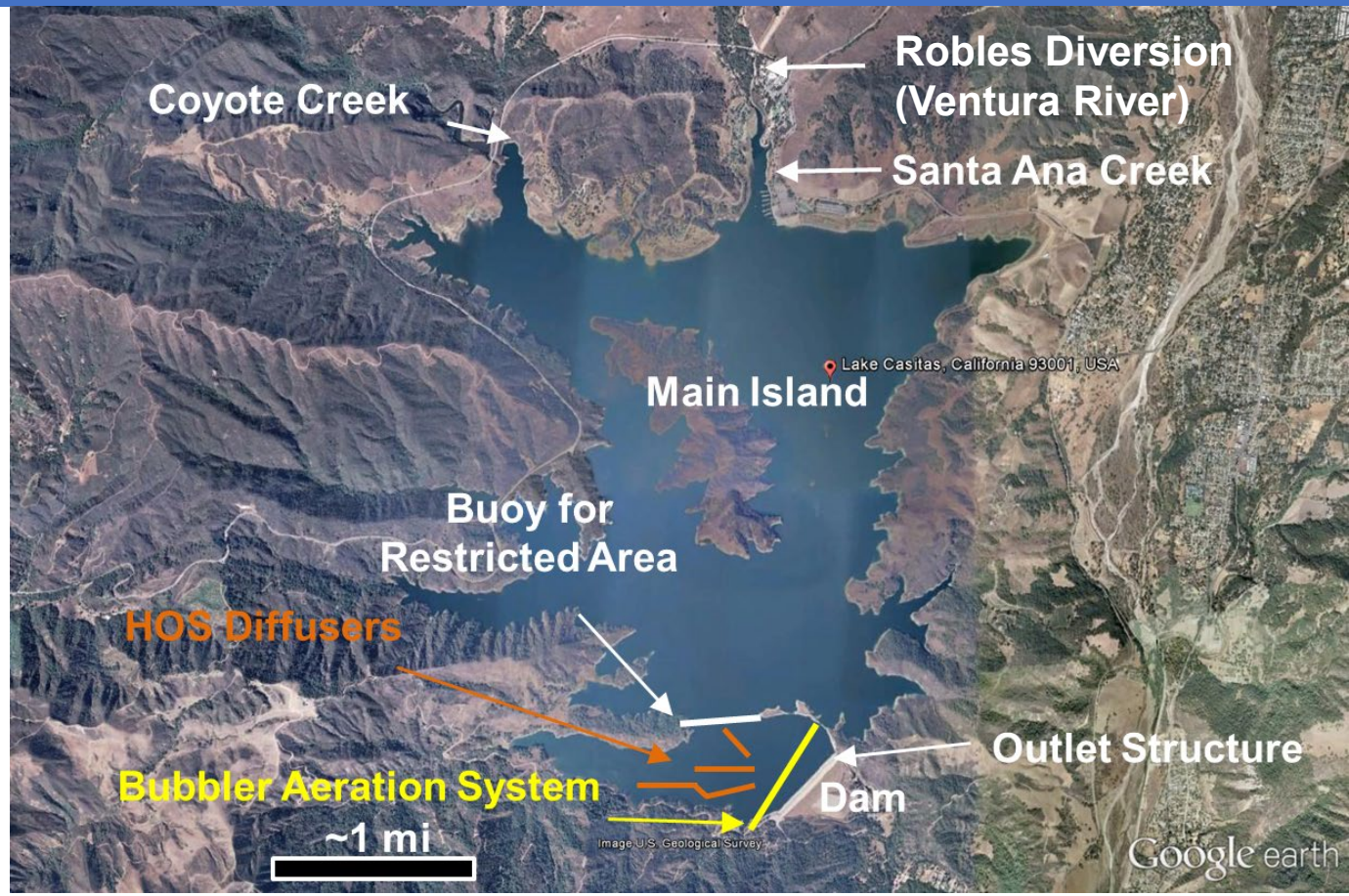
Additional Improvements

Hypolimnetic Oxygenation System

- Installed in 2015 to address water quality concerns

Other Infrastructure

- Multi-port outlet tower
- Robles Diversion

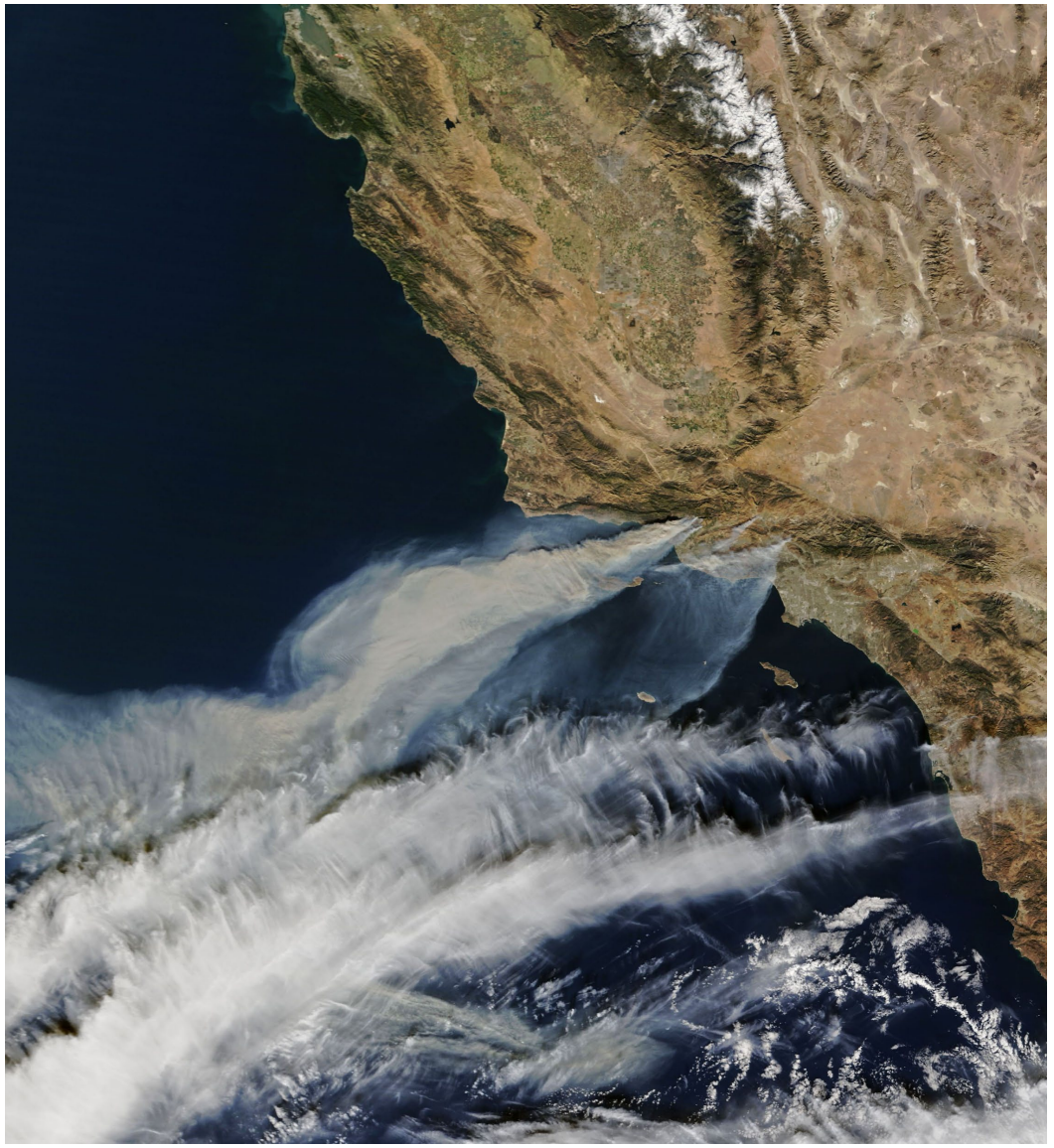


Mobley Engineering

Thomas Fire

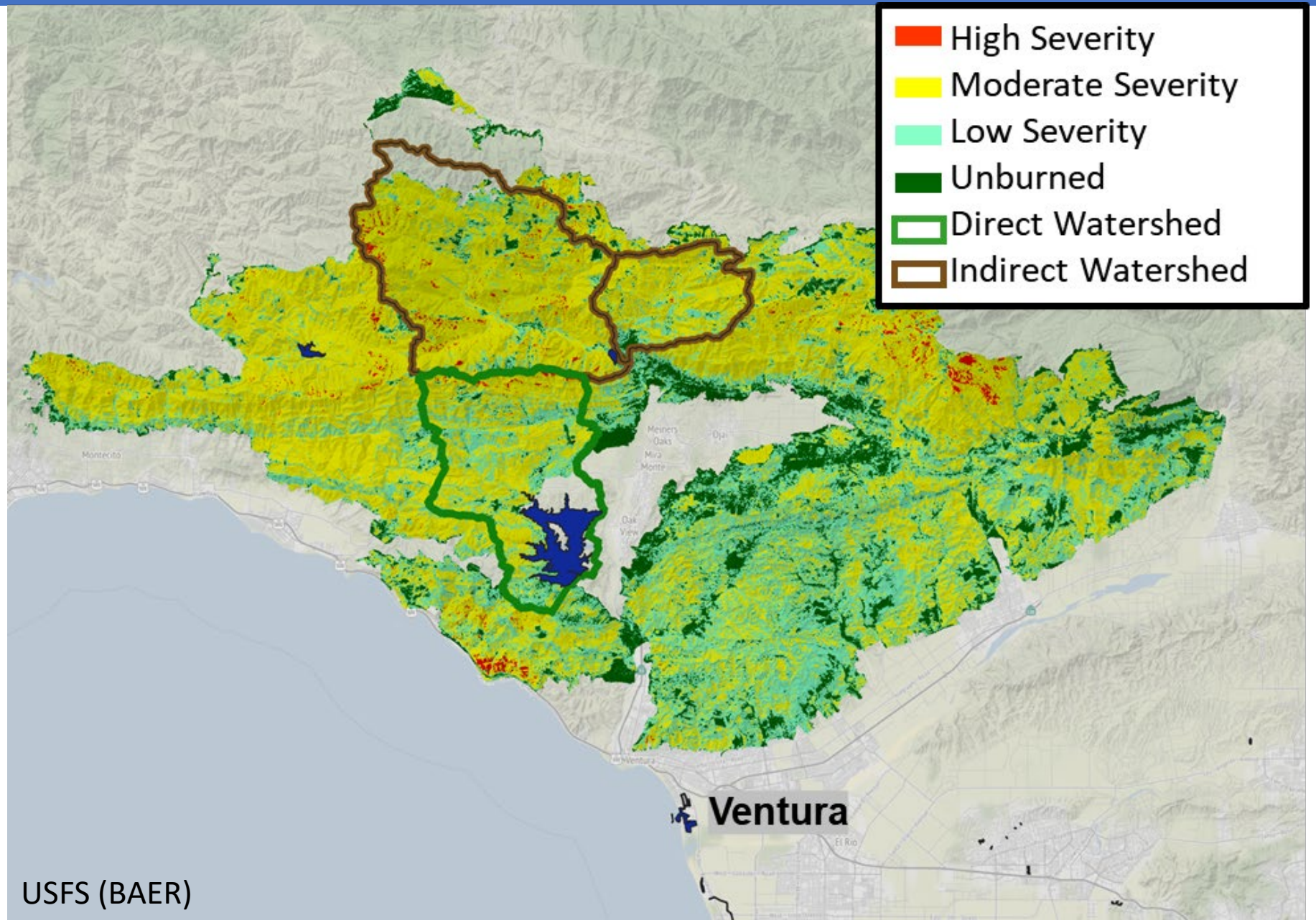
Largest Wildfire in Modern California History at the Time

- 282,000 acres
- Spread December 4 2017 – January 12 2018
- Burned majority of Lake Casitas direct and indirect watershed
- Immediately preceded typical winter rainfall season



Terra Satellite (December 5, 2017)

Thomas Fire Burn Severity



USFS (BAER)

- Wildfire Effects
- Lake Casitas and Thomas Fire
- **Water Quality**
    - **Inflow**
    - In-Reservoir
- Conclusions

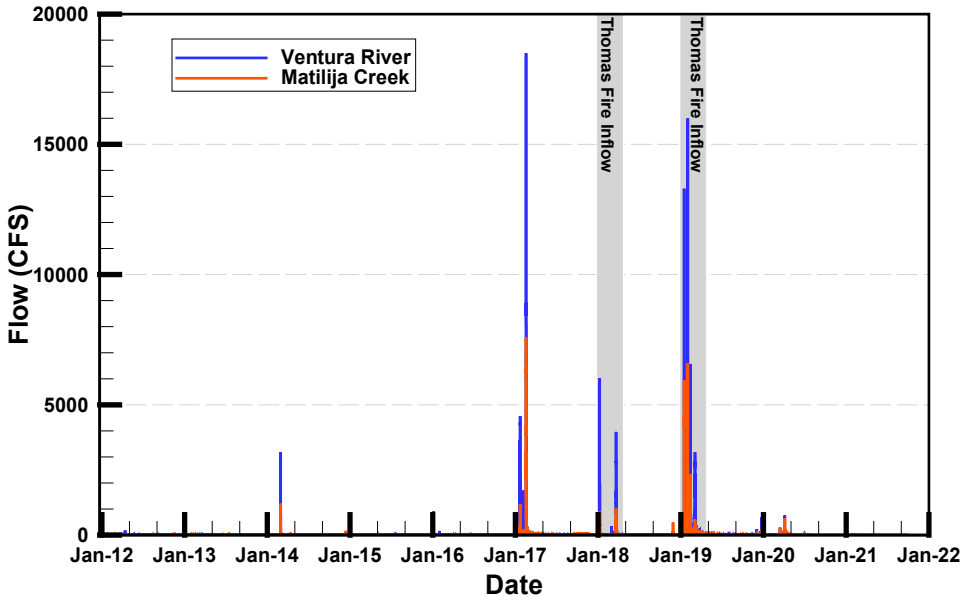
Inflow Water Quality: Flow and Turbidity

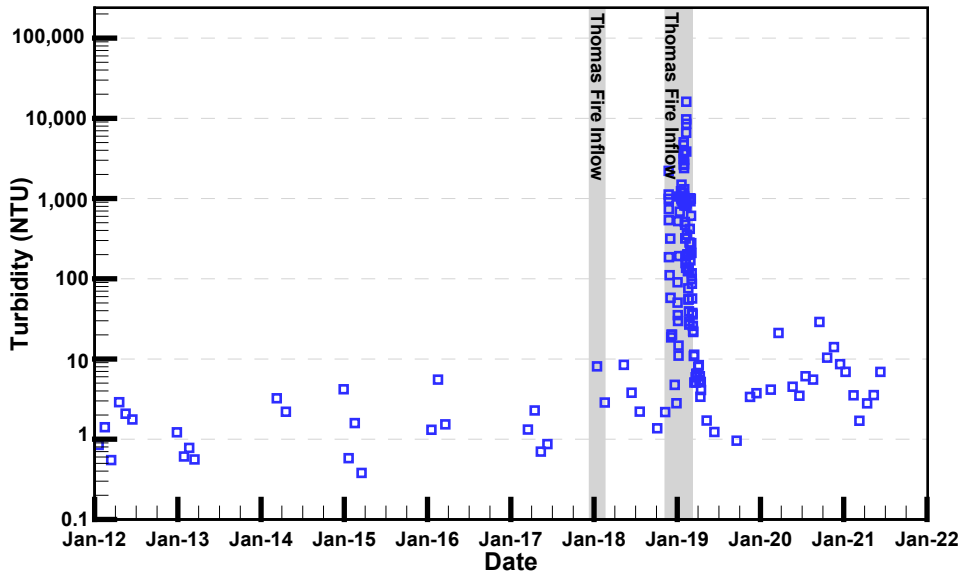
Inflows

- Lake Casitas receives winter inflows from direct and indirect watershed

Sediment

- High turbidity and sediment load measured during winter 2018/2019
  - Lower turbidity since 2019

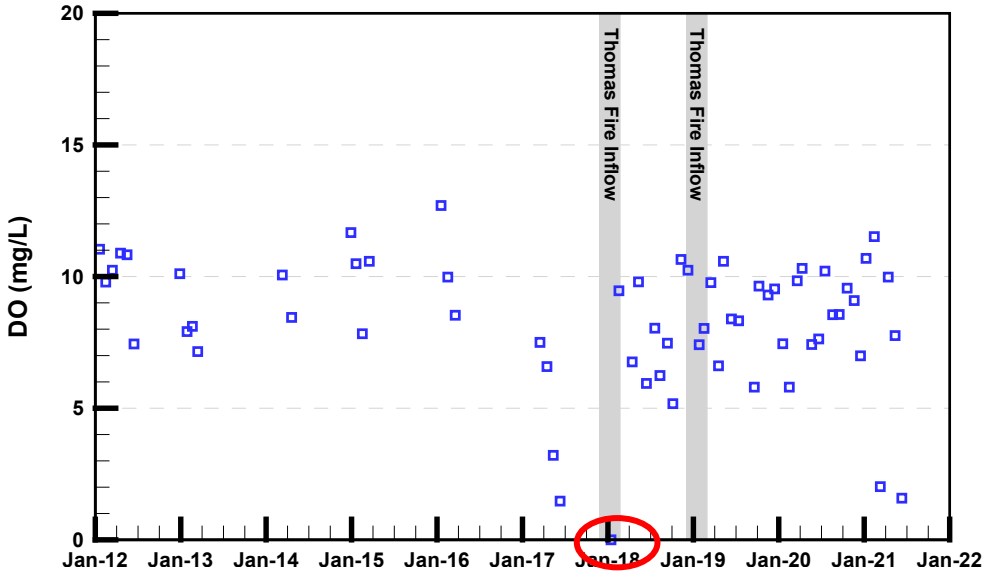




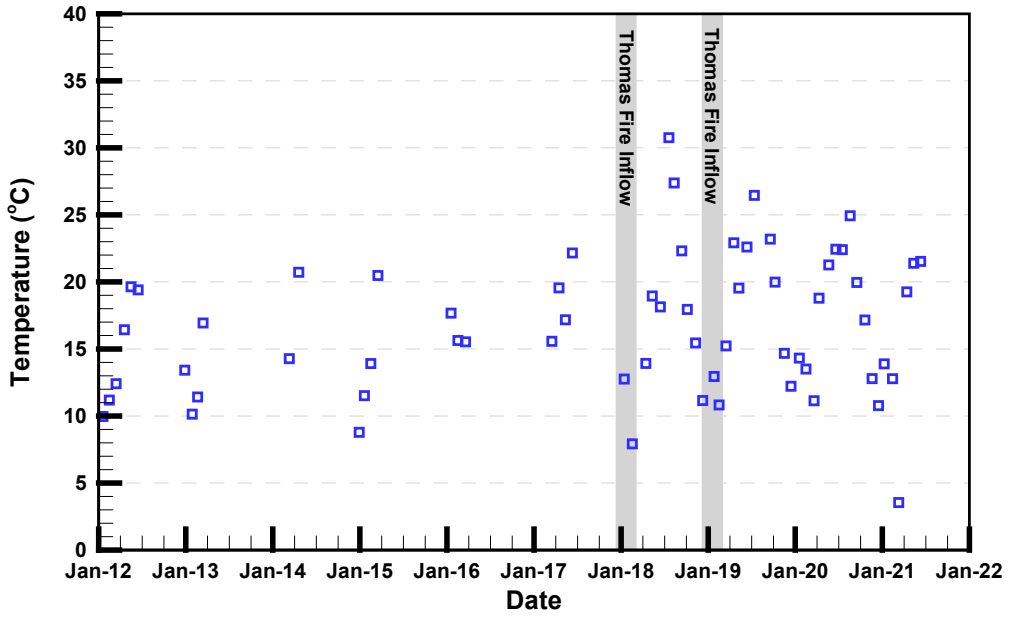
water Quality Solutions

Inflow Water Quality: DO and Temperature

Dissolved Oxygen Lower



Inflow Temperature Not Clearly Impacted



water Quality Solutions

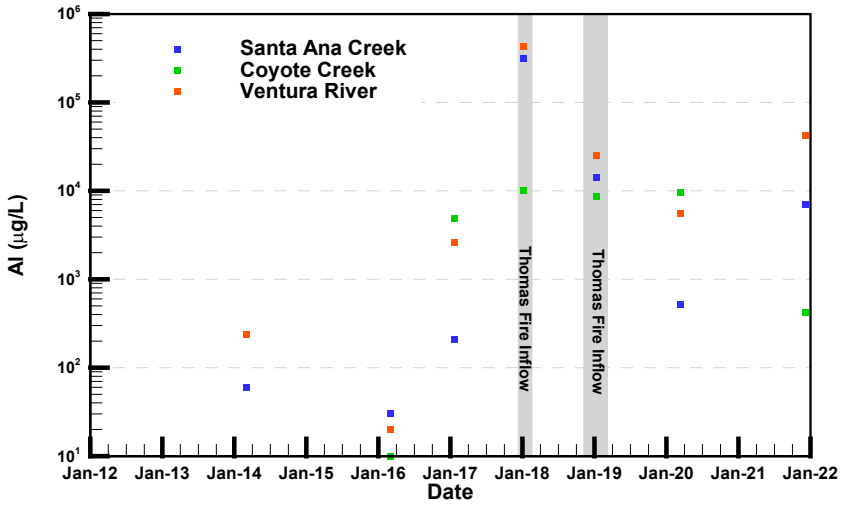
Inflow Water Quality: Metals and Nutrients

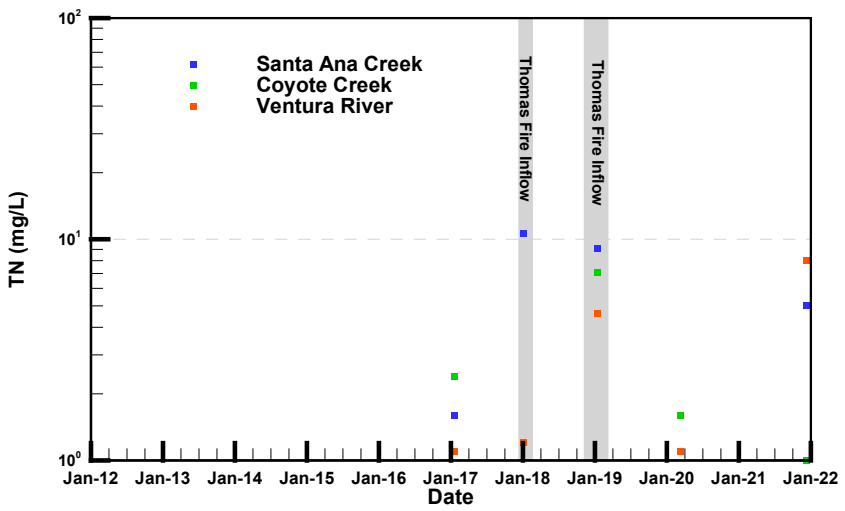
Metal Concentrations

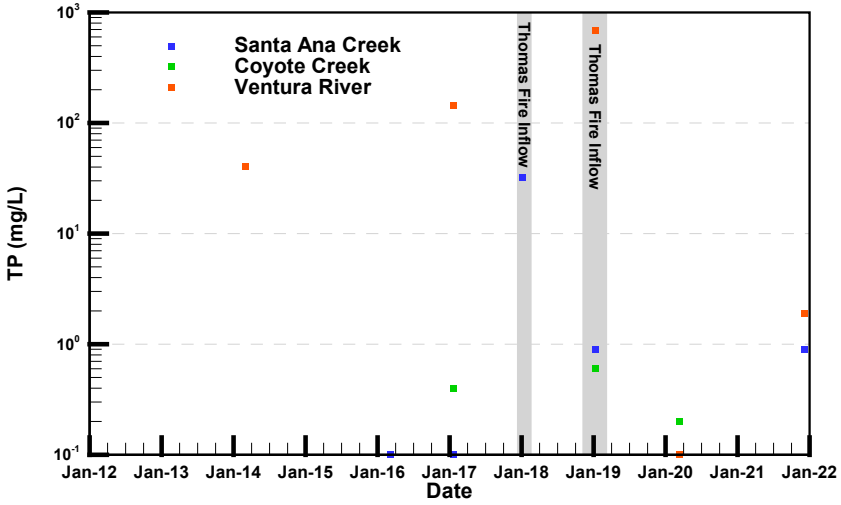
- Several orders of magnitude increase in concentrations of many metals

Nutrient Loads

- Nutrient concentrations increase by an order of magnitude following wildfire



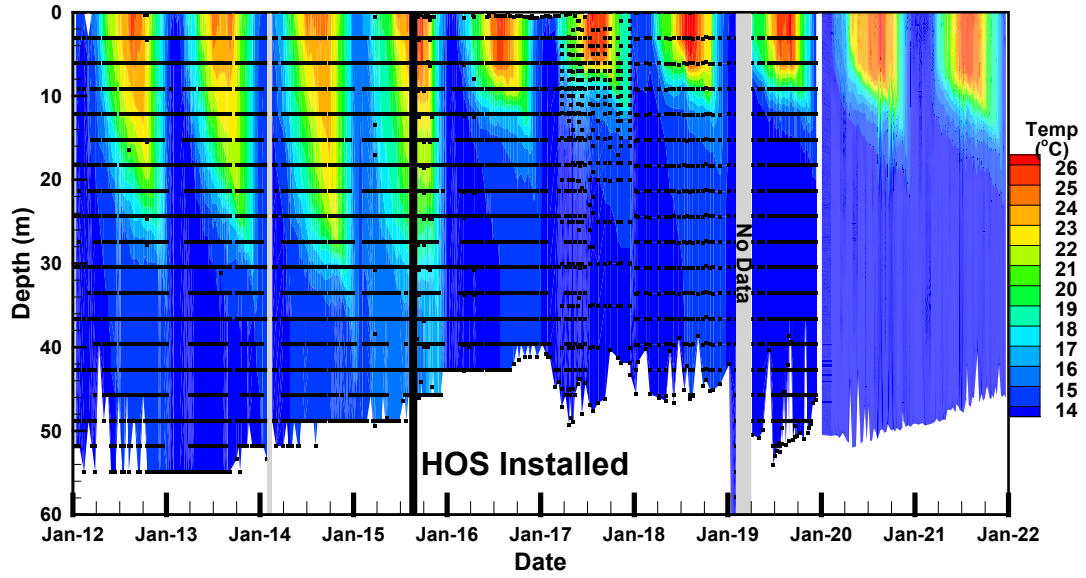




- Wildfire Effects
- Lake Casitas and Thomas Fire
- **Water Quality**
    - Inflow
    - **In-Reservoir**
- Conclusions

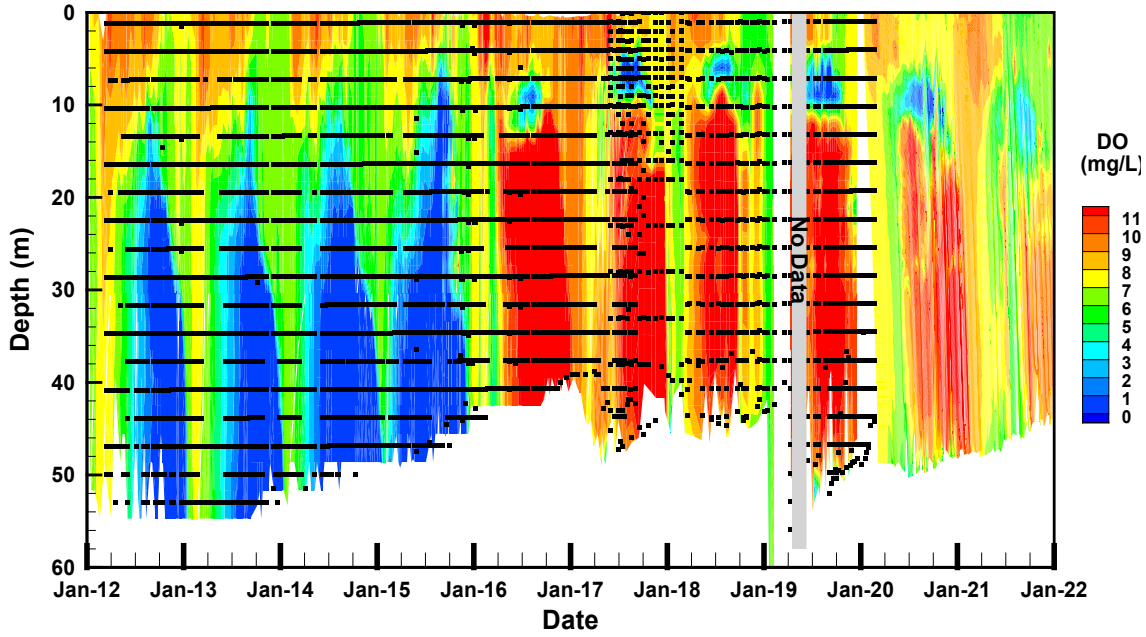
In-Reservoir Water Quality: Temperature and DO

Reservoir Temperature Unaffected



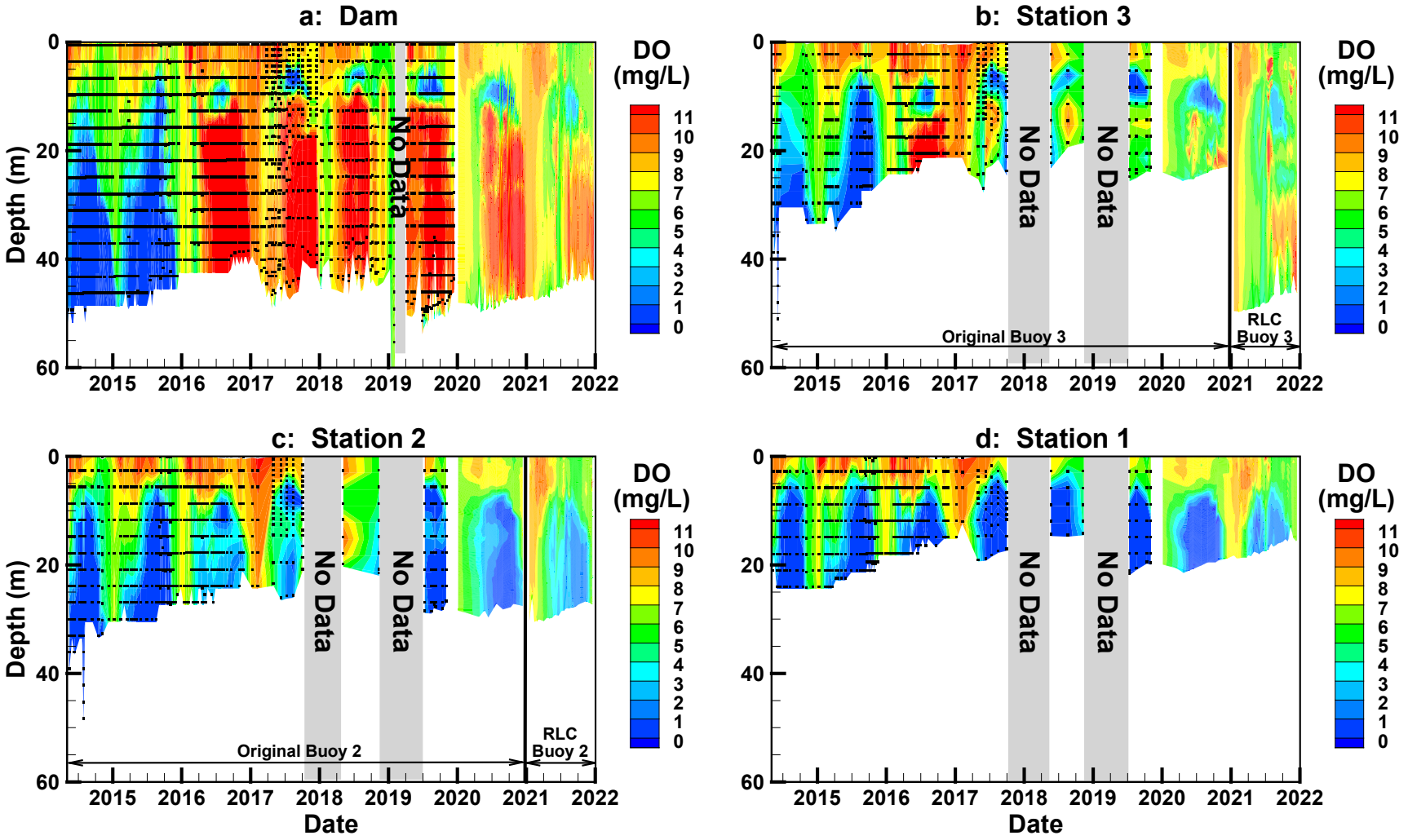
Dissolved Oxygen Remains High

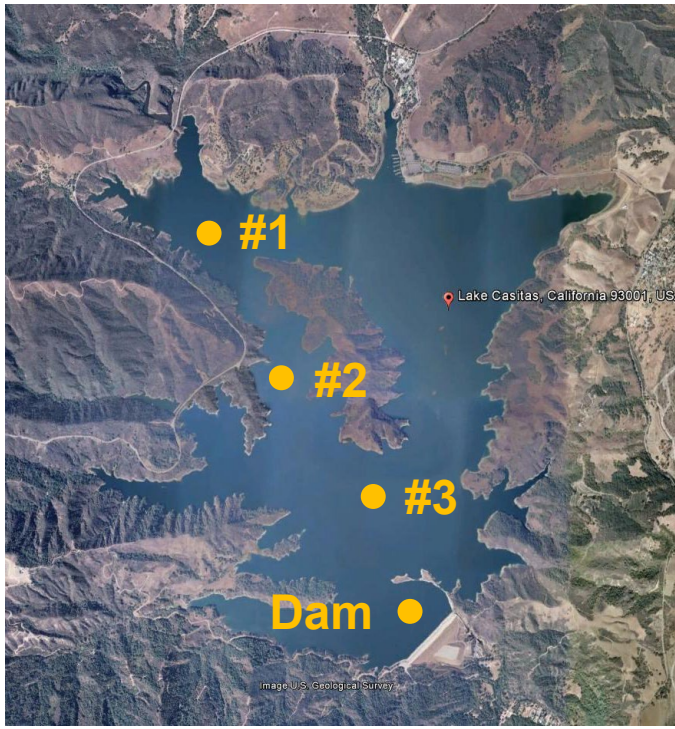
- Hypolimnetic Oxygen System (HOS) installed in 2015 to improve water quality
- HOS used extensively in 2018 and 2019
- Decreased oxygenation in 2021 correlated to lower HOS flow rates



water Quality Solutions

In-Reservoir Water Quality: DO Spatial Variation



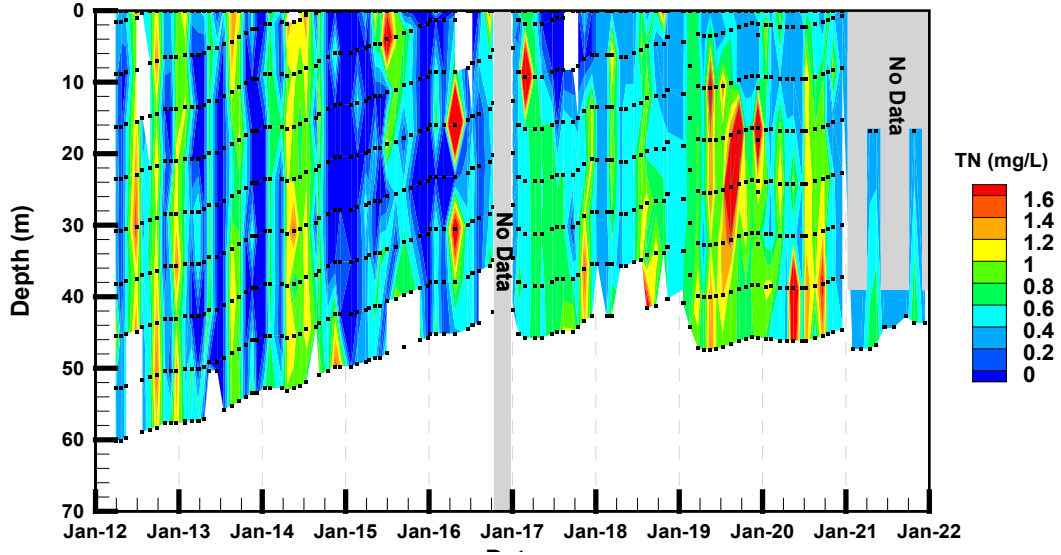


Approximate sampling locations 2014-2020

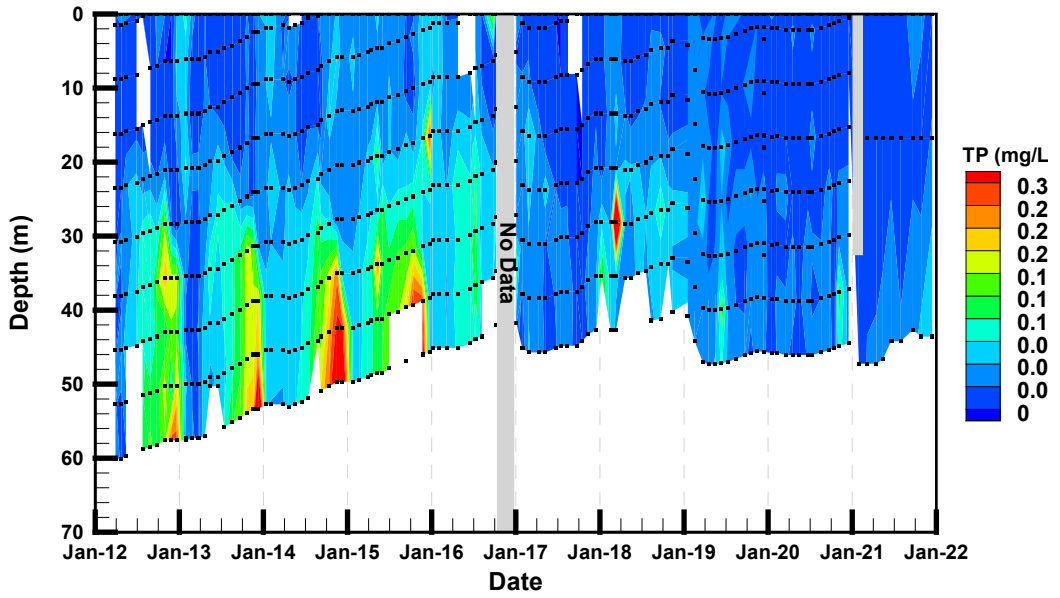
In-Reservoir Water Quality: Nutrients

Nitrogen Increased One Year Post-Fire

- Little increase immediately following wildfire



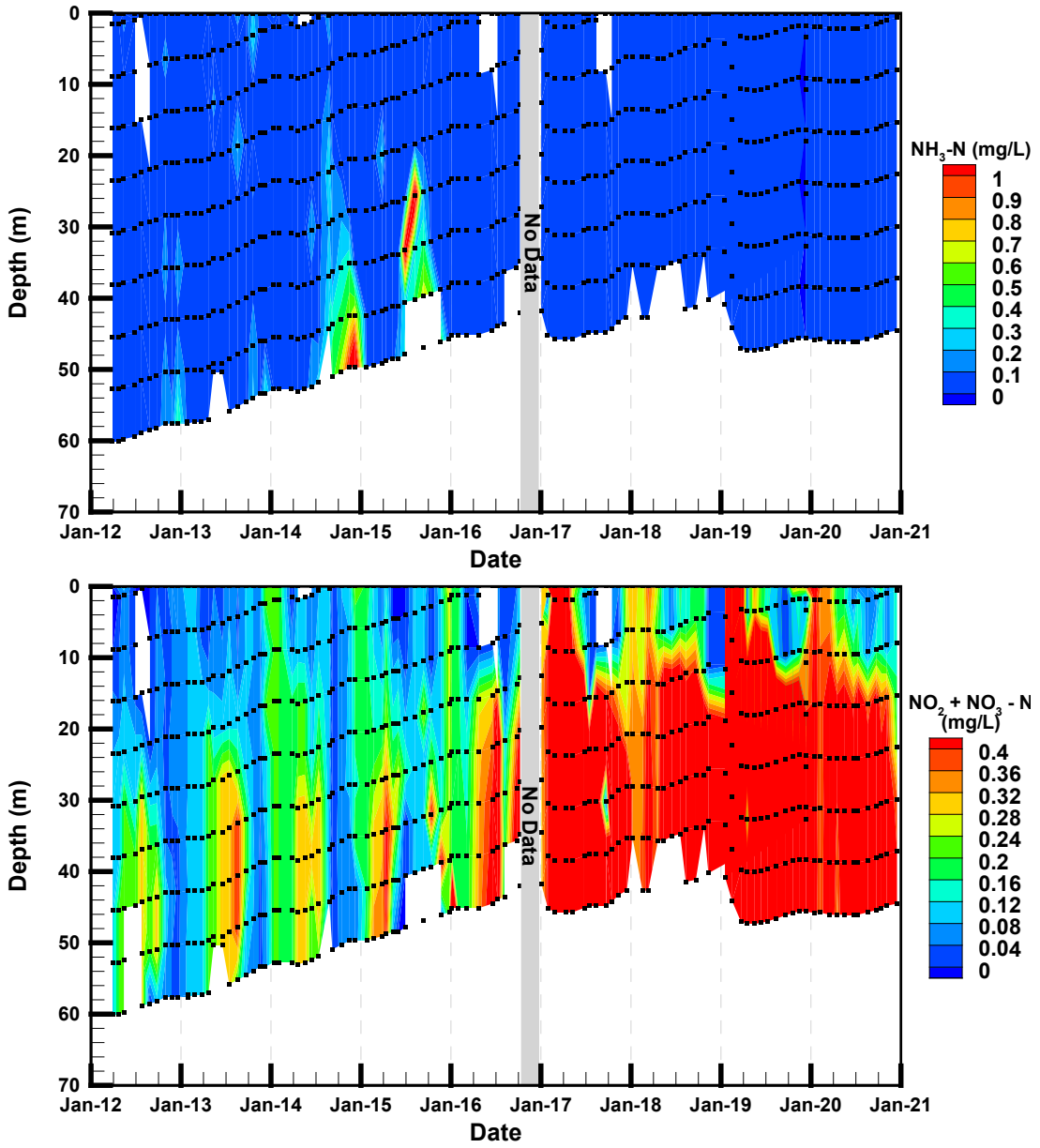
Phosphorus Concentrations Remain Low



In-Reservoir Water Quality: Nitrogen

Shift Towards NO_2 + NO_3 Post-HOS

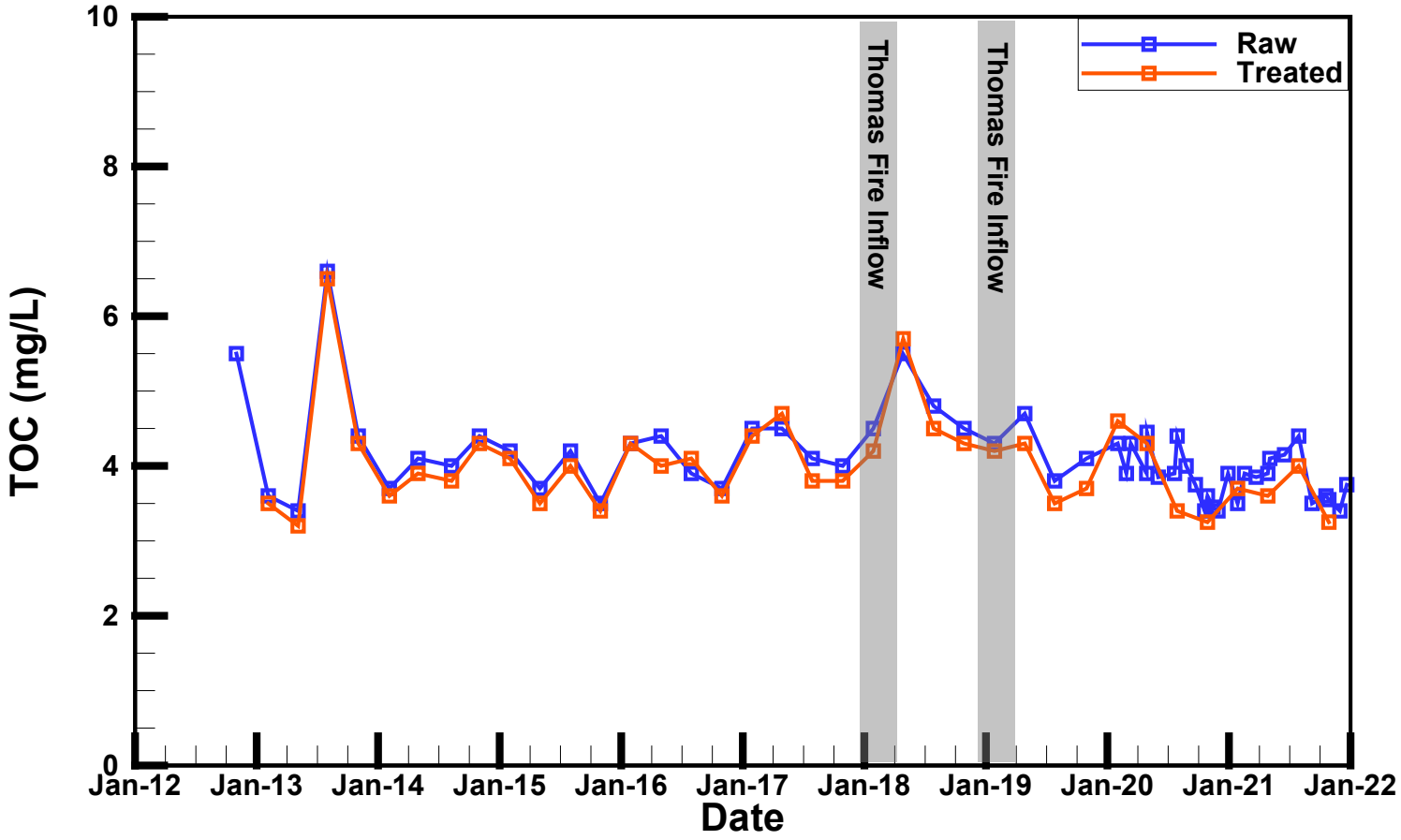
- No NH_3 observed at dam since HOS installation, including post-fire



In-Reservoir Water Quality: Carbon

TOC Increased Following Wildfire

- High Total Organic Carbon (TOC) can lead to concerns about disinfection byproducts in potable water
- TOC Increases in early 2018
  - Concentrations within 2012-2017 range
  - Water remains treatable
  - TOC has since decreased

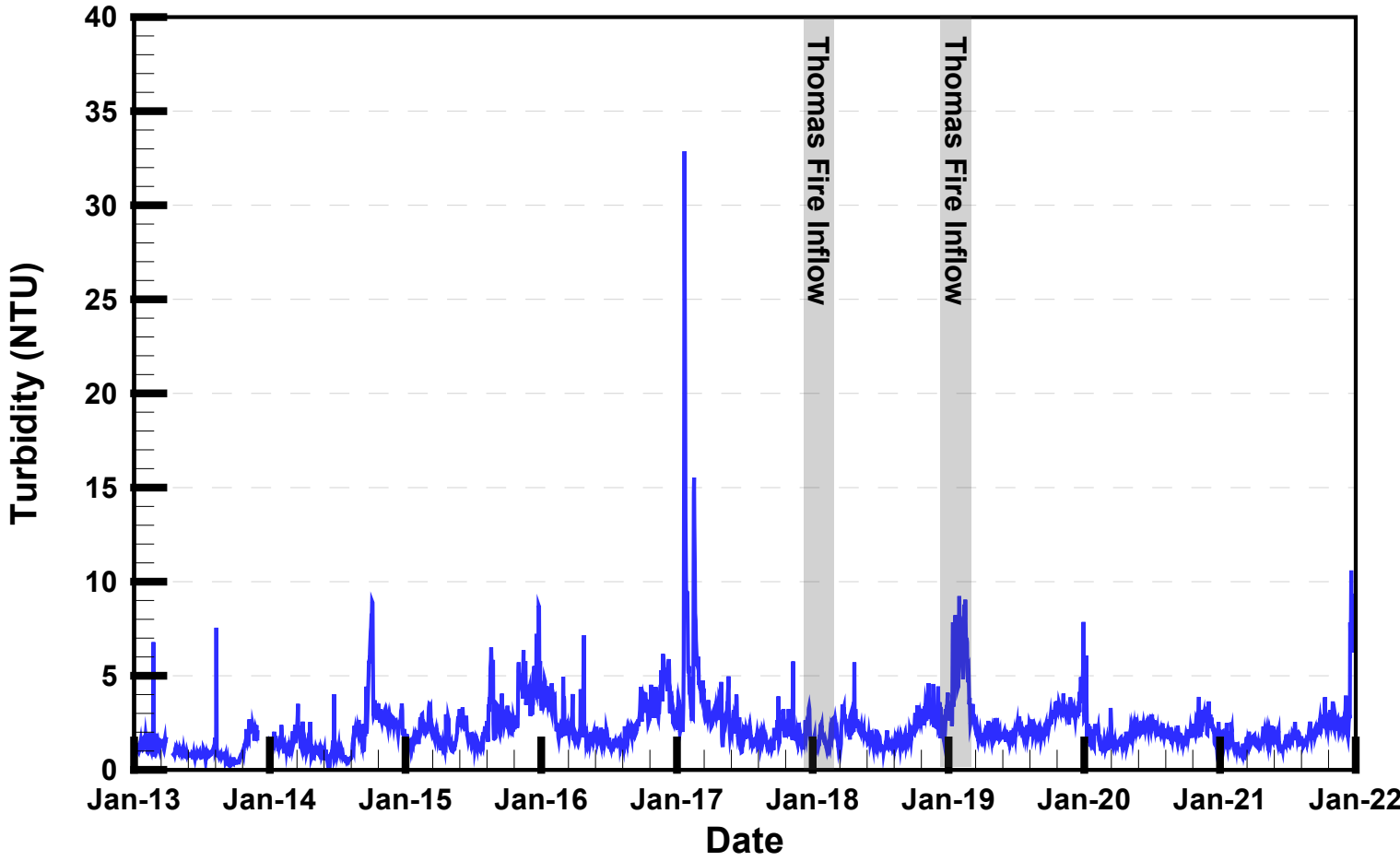


water Quality Solutions

In-Reservoir Water Quality: Outlet Turbidity

Reservoir Outlet Turbidity Remains Low

- Outlet port changed several times post-fire to select water with best treatability and lowest turbidity



- Wildfire Effects
- Lake Casitas and Thomas Fire
- Water Quality
    - Inflow
    - In-Reservoir
- Conclusions

Conclusions

Significant Impacts to Inflow

- High inflow turbidity
- Increased nutrient loading

Minimal Impacts to In-Reservoir Water Quality

- Water quality remained similar to pre-fire
- Dissolved oxygen remained high
- Nutrient concentrations similar to pre-fire levels

Mitigating Factors

- Large storage volume, with multi-year retention time
  - Distance from inlet to outlet (~3 miles)
- Robles Diversion
- HOS
- Multi-port outlet tower

Casitas Water

QUESTIONS?

Dr. Kareem Hannoun

Water Quality Solutions

Khannoun@wqsinc.com

Wqsinc.com