# MCWRA Innovative Water Technologies For California Workshop

**March 23, 2018**

## Improving Your Delivery System Resiliency: Hazard Evaluation and Mitigation of Canal and Tunnels

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Condor Earth

# Presentation Outline

- Need for Resiliency From Impoundment to Delivery
- Meeting the Need Through Hazard Evaluation and Mitigation
- Project Case Studies: TMWA and OID

# A Need for Resiliency From Impoundment to Delivery

- Recent Events and Stepped-up Oversight
  - Inundation Studies
  - Impoundment Facility Inspections and Responses

- Linear Delivery Systems: Often Forgotten Until a Problem Exists
  - Slides and Sloughs
  - Excessive Leakage
  - Increased Maintenance Requirements
  - Failure

# A Need for Resiliency From Impoundment to Delivery

- Funding Challenges
  - Often expensive with no new revenue stream
  - Competing for project funding
- Risk Management Often the Driver
  - Safety of Maintenance Workers
  - Delivery Dependability of Water/Power
  - Regulatory Oversight

# The Steps Toward the Solution

- Hazard Evaluation Study
  - Where and what are the hazards
    - Site Inspection by Agency and Experts
    - Review of Owner/Agency Records
  - Prioritize the hazards
    - Emergency/Urgent
    - Short Term (0 to 5 years)
    - Long Term (5 to 20 years)

# The Steps Toward the Solution

- Perform Conceptual Design for  Cost Planning
  - Difficult at Conceptual Phase
  - Many Unknows
    - Site Conditions Beneath the Observable
    - Poor Records
    - Repair upon Repair
    - Land Ownership Restrictions
    - Long Regulatory Reviews
    - Unknown Environmental Restrictions

# The Steps Toward the Solution

- Big Unknowns May Require Additional Investigation
  - Realignment of Canal or Tunnels
  - Rehabilitation versus Replacement
  - Expediency versus Cost

# The Steps Toward the Solution

- The Outcome
  - Urgent Repairs
    - Temporary Until Permanent Improvements Made
    - Seasonal Emergency Repairs
    - Agency Forces or On-call contractors
  - Short to Mid-term: Moderate Costs
    - Usually Permanent
    - Agency Forces or Contract Out
    - Likely Require Plans and Specs/Bidding

# The Steps Toward the Solution

- The Outcome
  - Long Term - High Capital Costs
    - Establish Funding Plan/Prepare your Board
    - Conventional Phased Approach in Design
    - Choose Construction Approach
    - Bidding and Contractor Selections
    - Construction

# Project Examples

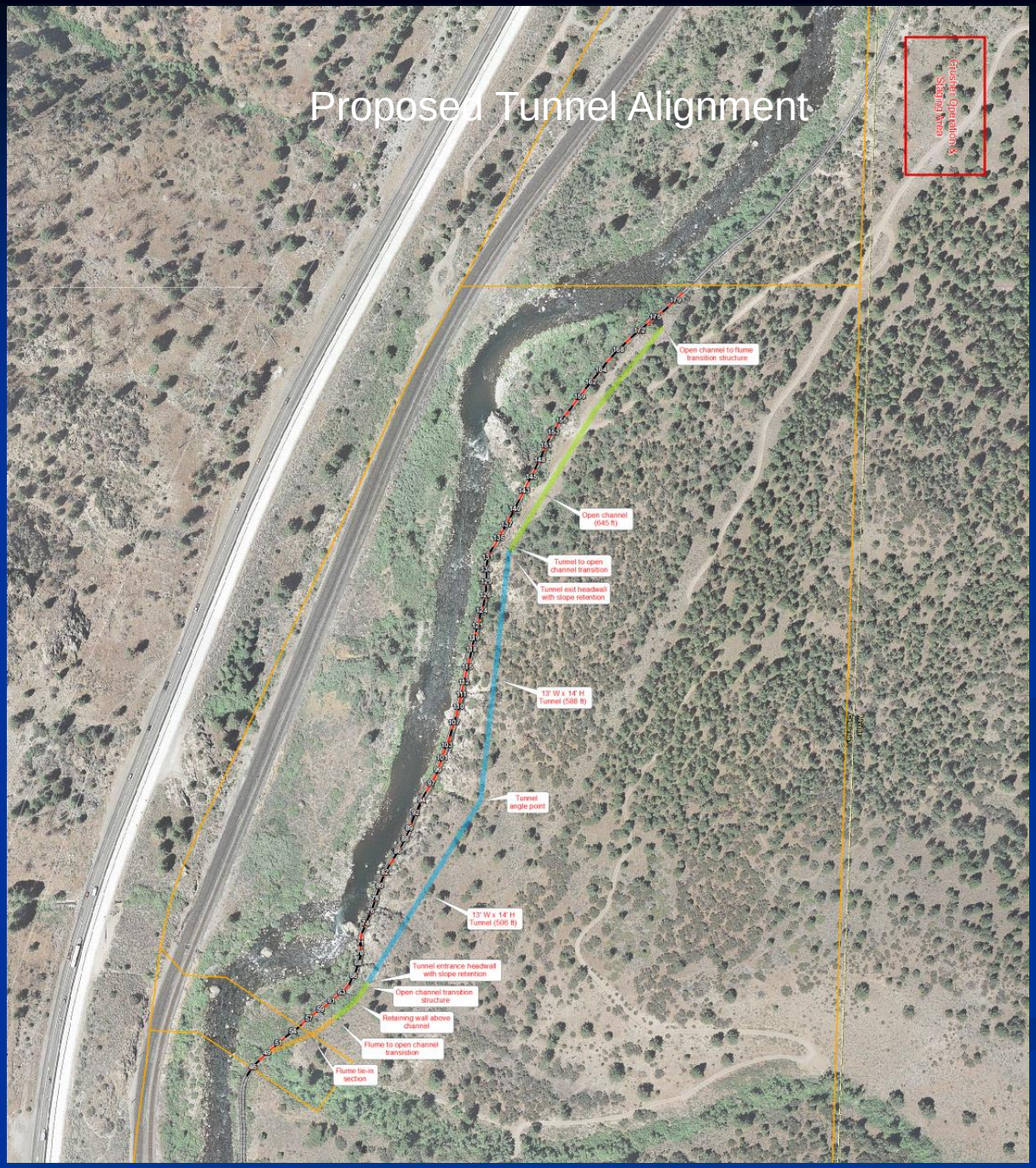
- Example #1 - Small Hydro Flume Realignment
  - Hazard Evaluation Minimal
    - Urgent
    - Long Term Return on Reliability and Financial Return
    - Easy Selection Process with Limited Alternatives
  - Good project background review by water authority and justification for flume replacement with tunnel

# Tunnel Replacement Section

# 2003 Slide Event

# Flood Prone Alignment

# Proposed Tunnel Alignment




09/30/2016


09/30/2016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09/30/2016


09/30/2016


FLEISH
TUNNEL
2014
09/30/2016

# Project Examples

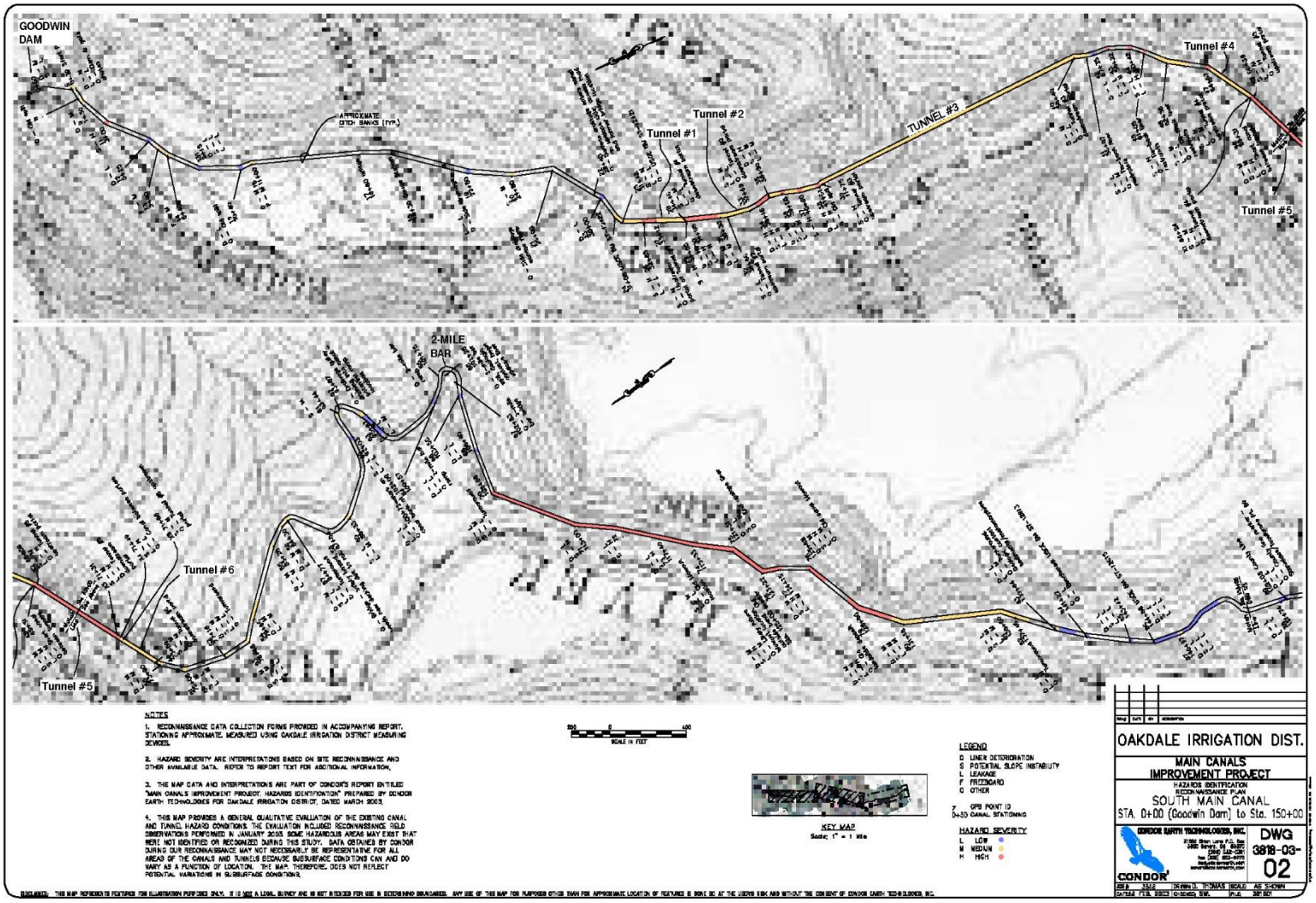
- Example #2 - OID Upper Main Canal and Tunnel System
  - Hazard Study
  - Rehabilitation Where Technically and Economically Feasible
  - New 6000-ft Tunnel Around a High Hazard Area
  - 20 Year Process


Ditch Exc
Tunnel,
Oakdale


# Field Data Collection Using GPS

- Hazard severity assessments were illustrated in
  - Maps
  - Photos
  - Data collection forms
- Map data were cross-referenced to field data sheets

# Reconnaissance Maps



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Project # 3818
Sheet: 1 of 2
By: SWL
Checked: RLS
Date: 1/14/03
Weather: Cool partly cloudy

# Engineering Geology Reconnaissance
# Data Collection Form

| | | | | |
|---|---|---|---|---|
| Canal | | X South Main | Joint | North |
| Main | | | | |
| Point ID | 47 | | | |
| Photo ID's | 2133-2135 | | | |
| Approx. Canal Station | 64+67 | | | |
| | | Severity | | |
| Liner Deterioration | | Low | Medium | High |
| Potential Slope Instability | X (above/below) | Low | Medium | X High |
| Leakage | X | Low | X Medium | High |
| Freeboard | | Low | Medium | High |
| Other (Incl. Historic Struct.) | X | Low | Medium | High |

Comments:

South Main Canal, 1/14/03

Potential Slope Instability above canal: High severity - Large blocks and wedges above portal with open cracks that Wayne Truit says have been opening over the years.

Leakage: Medium severity - Leakage near portal apparent due to lush berries on outside slope below.

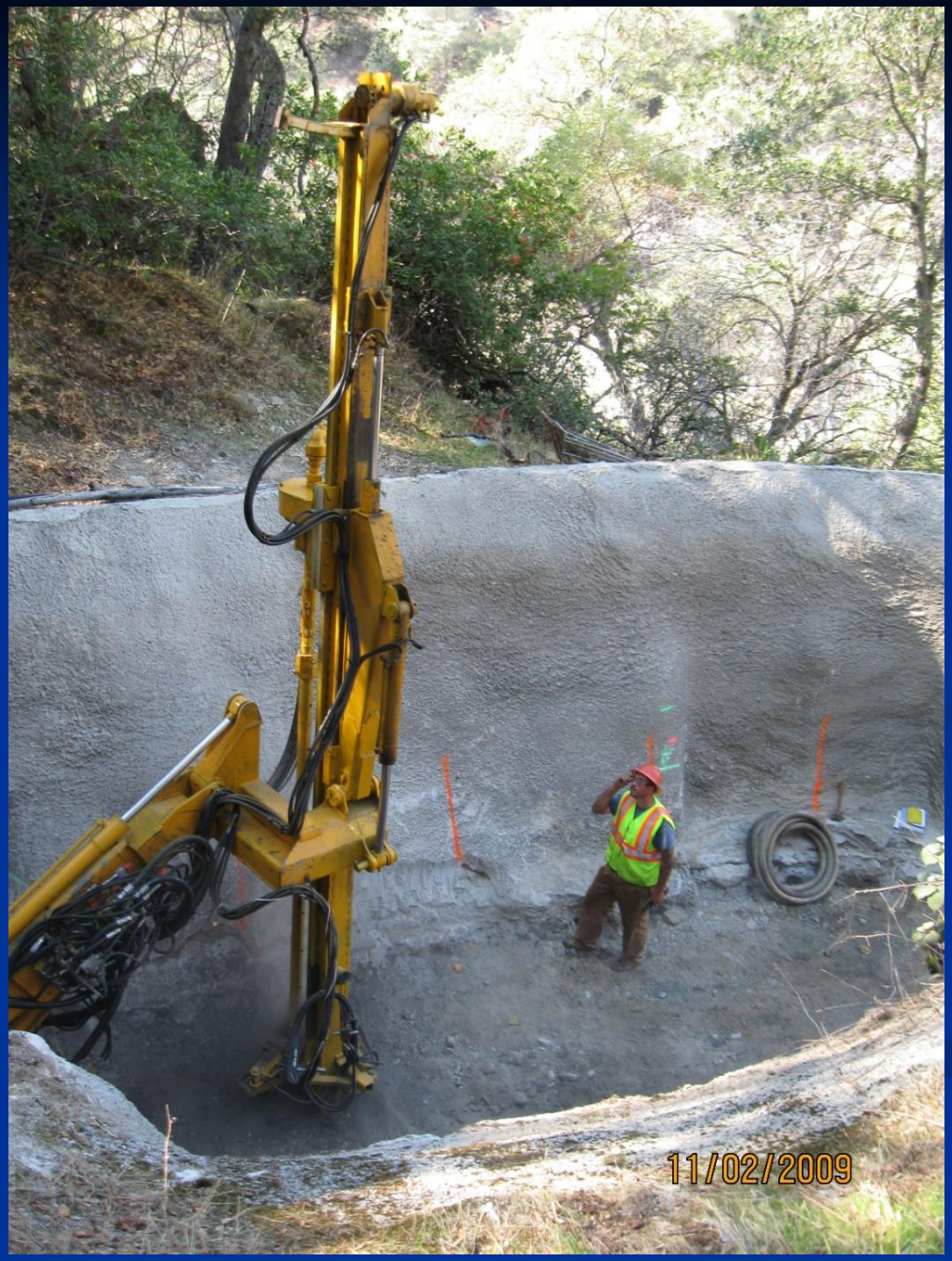
Other: Location of Tunnel #4 upstream portal.


**Segment 1: Canal Invert Demolition in Structural Rehab Area**

**Segment 1: Observation of Canal Invert Demolition in Structural Rehab Area**

## Segment 1:

## Micro-Pile Drilling Operation in Structural Rehab Area



Segment 1



Micro-Pile Installation and Grouting Operations


**Segment 1: Canal Invert Lateral Tieback Installation in Structural Rehab Area**

Segment 1

Tie-back for Structural Slab


Structural Rebar Installation After Micro-Pile Installation


**Segment 1: Structural Invert Concrete Placement After Micro-Pile Installation**


**Segment 1: Tunnel 4 Repair in Thin Cover Section – Wire Mesh and Reinforcement Installation**


**Segment 1: Tunnel 4 Repair in Thin Cover Section – Wire Mesh and Reinforcement Installation**


**Segment 1: Shotcrete Repair**


Segment 1 Structural Repairs

# Segment 2



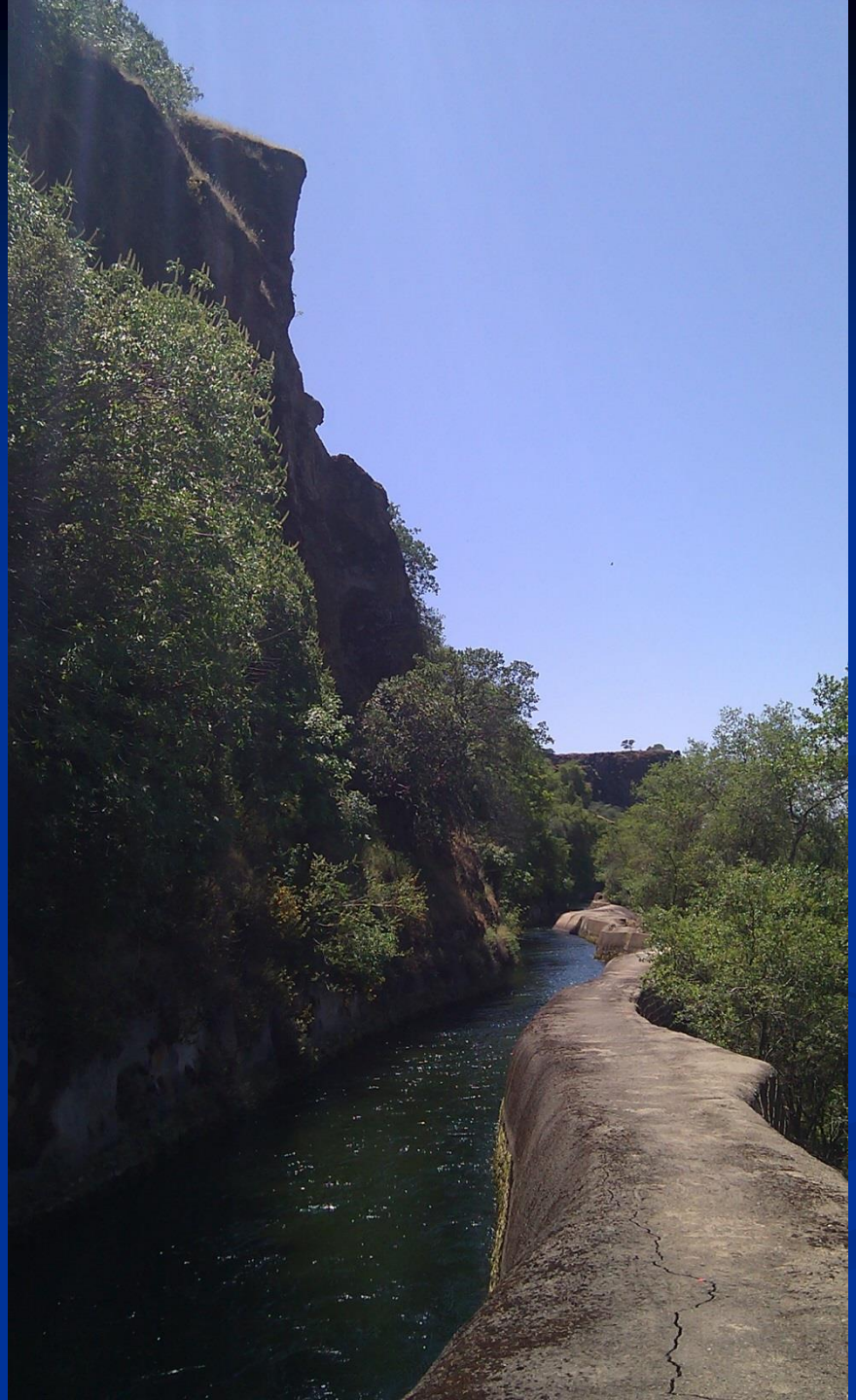
## Starting Conditions

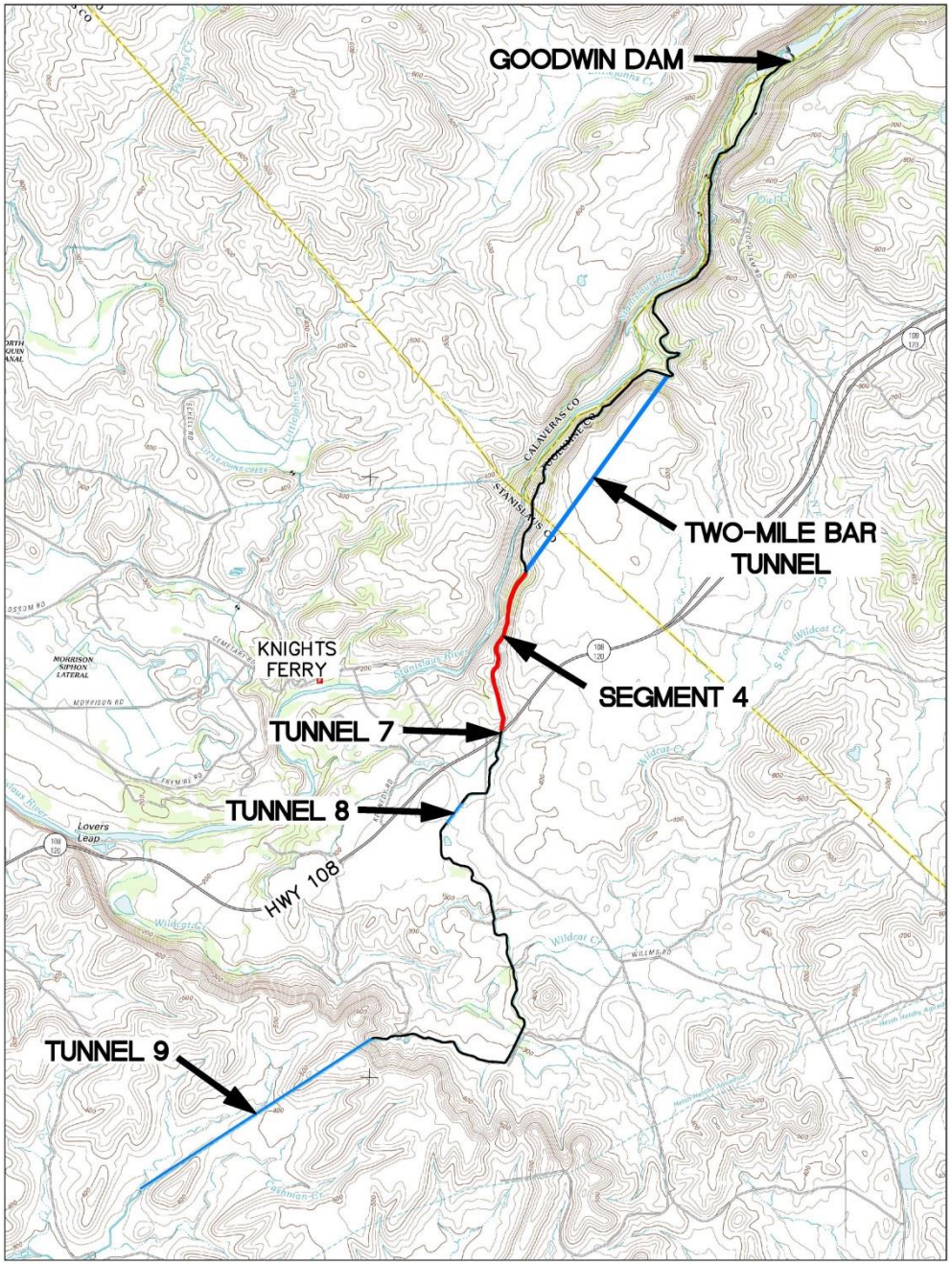

10/23/2009

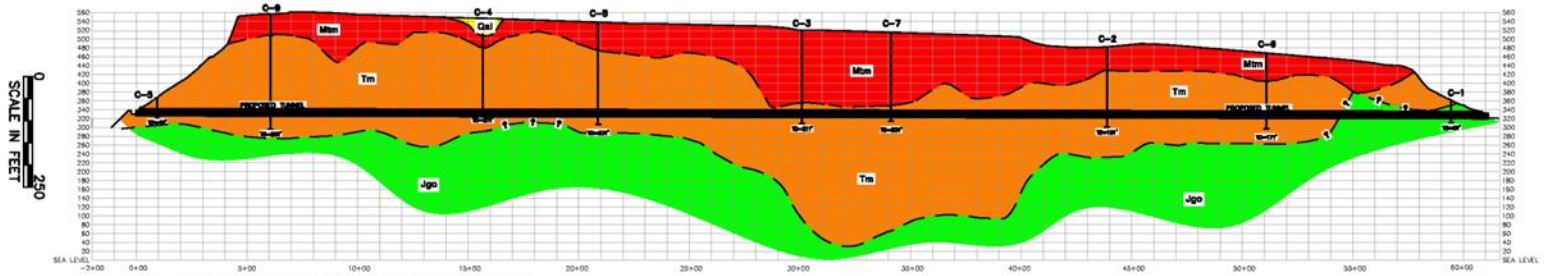
# Segment 2


## Shotcreting Operations


**Segment 2 – Lining and Invert Construction and Repair**




GOODWIN DAM
TWO-MILE BAR TUNNEL
SEGMENT 4
KNIGHTS FERRY
TUNNEL 7
TUNNEL 8
HWY 108
TUNNEL 9
Lovers Leap
MORRISON SIPHON LATERAL
CALAVERAS CO
STANISLAUS CO




A
01

## PROPOSED TUNNEL PROFILE

Scale: 1" = 500'

0 500
SCALE IN FEET

SCALE
HORIZONTAL – 1" = 500'
VERTICAL – 1" = 250'

**LEGEND**

—— TEM (TRANSIENT ELECTROMAGNETIC) CONTACT, DASHED WHERE APPROXIMATE

Qal ALLUVIUM

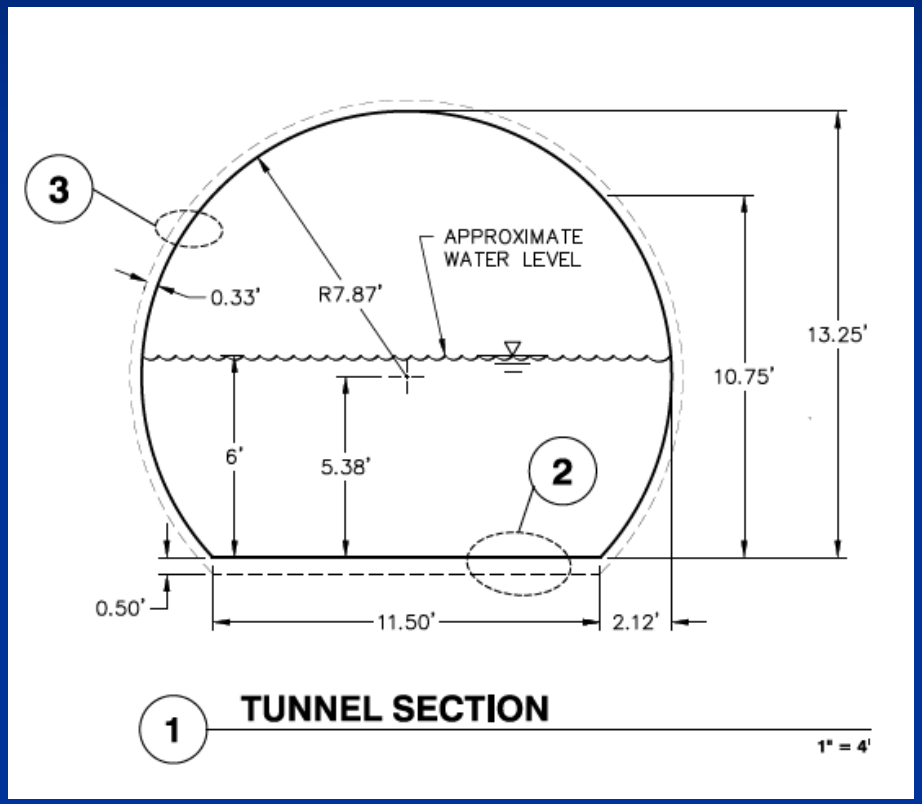
Mtm TABLE MOUNTAIN LATITE - PROMINENT FLOWS OF DARK LATITE CHARACTERIZED BY ABUNDANT LABRADORITE PHENOCRYSTS.

Tm MEHRTEN FORMATION - ANDESITIC CONGLOMORATE, TUFFACEOUS SANDSTONE, AND MUDFLOW BRECCIA (LAHAR); SOME TUFF AND RHYOLITE

Jgo GOPHER RIDGE VOLCANICS

NOTE: STRUCTURAL INTERPRETATION BETWEEN CORE HOLES BASED IN PART ON GEOPHYSICAL TEM DATA.

# Design Overview

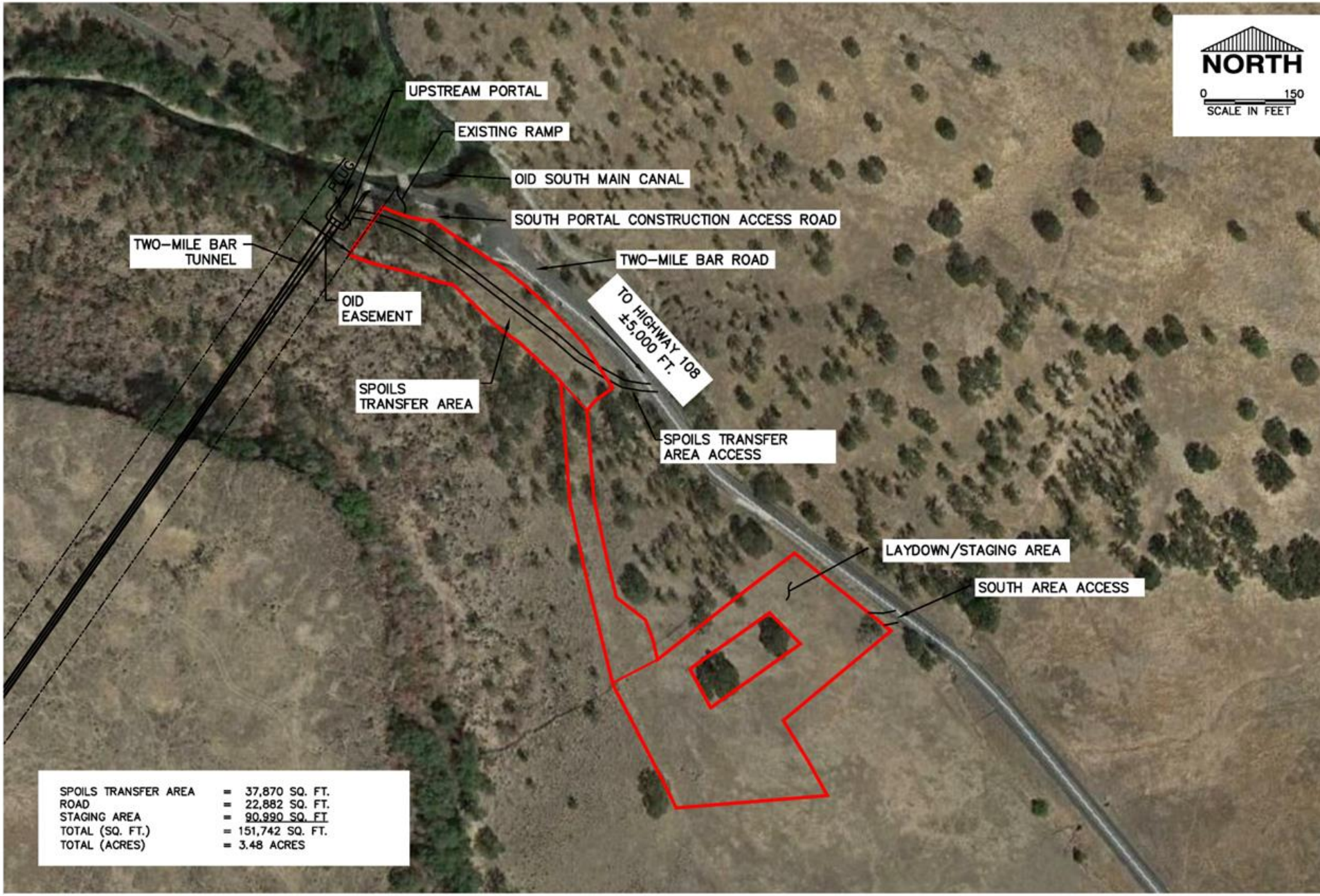



- ~16'(W) x 14'(H)
- "Free Channel Flow"

- Constructed using the Sequential Excavation Method (SEM)
- 4" shotcrete liner (2" initial + 2" final)

# Turning Under

# Applying the Shotcrete Liner


NORTH
0 150
SCALE IN FEET
UPSTREAM PORTAL
EXISTING RAMP
OID SOUTH MAIN CANAL
SOUTH PORTAL CONSTRUCTION ACCESS ROAD
TWO-MILE BAR TUNNEL
TWO-MILE BAR ROAD
OID EASEMENT
TO HIGHWAY 108 ±5,000 FT.
SPOILS TRANSFER AREA
SPOILS TRANSFER AREA ACCESS
LAYDOWN/STAGING AREA
SOUTH AREA ACCESS
SPOILS TRANSFER AREA = 37,870 SQ. FT.
ROAD = 22,882 SQ. FT.
STAGING AREA = 90,990 SQ. FT
TOTAL (SQ. FT.) = 151,742 SQ. FT.
TOTAL (ACRES) = 3.48 ACRES

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