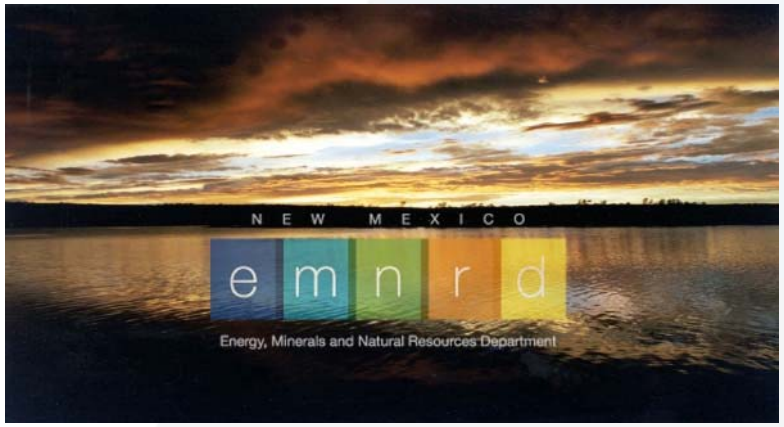


Carlsbad Brine Well Remediation Project - Carlsbad, New Mexico
State of New New Mexico - Energy, Minerals and Natural Resources Department (EMNRD)

Presentation to the Carlsbad Brine Well Remediation Authority

April 23, 2019

Presentation Outline

- **Jim Griswold – EMNRD Environmental Bureau Chief**
  - Project Overview
  - Project Funding & Expenditures
  - Project Activity Timeline
- **Dan Kwiecinski – Project Manager, Wood Environment & Infrastructure Solutions Inc.**
  - Technical Overview
  - Site Monitoring and Data Collection
  - Understanding of Brine Cavity Stability
  - Proposed Remedy
  - Risk Management
  - Traffic Control
  - Project Team

Why do we need brine wells?

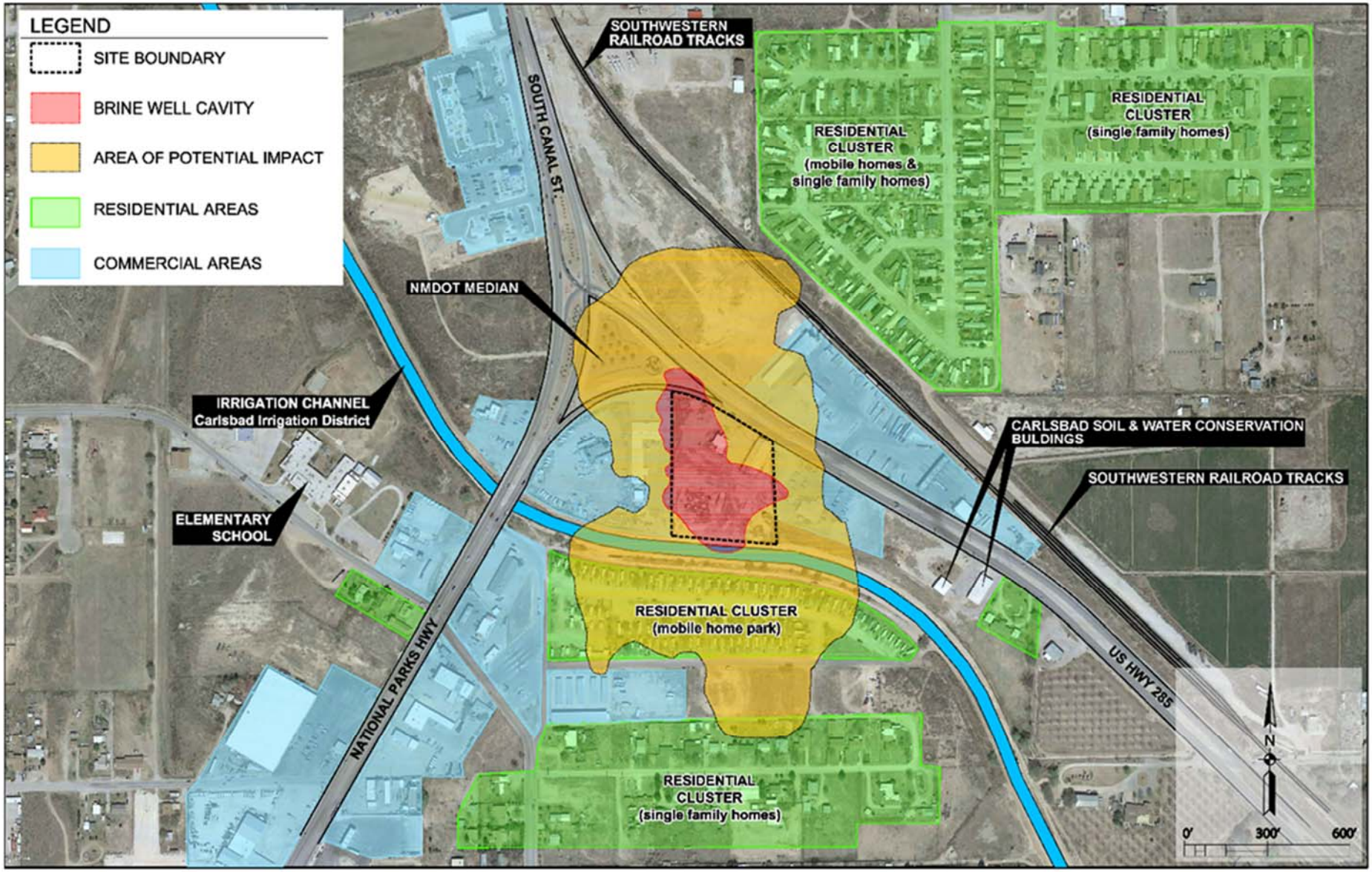
Recent Brine Well History

Photos courtesy of NCKRI

Jim's Water Service – July 2008

Loco Hills Water Disposal – November 2008

I&W Brine Cavern in Carlsbad

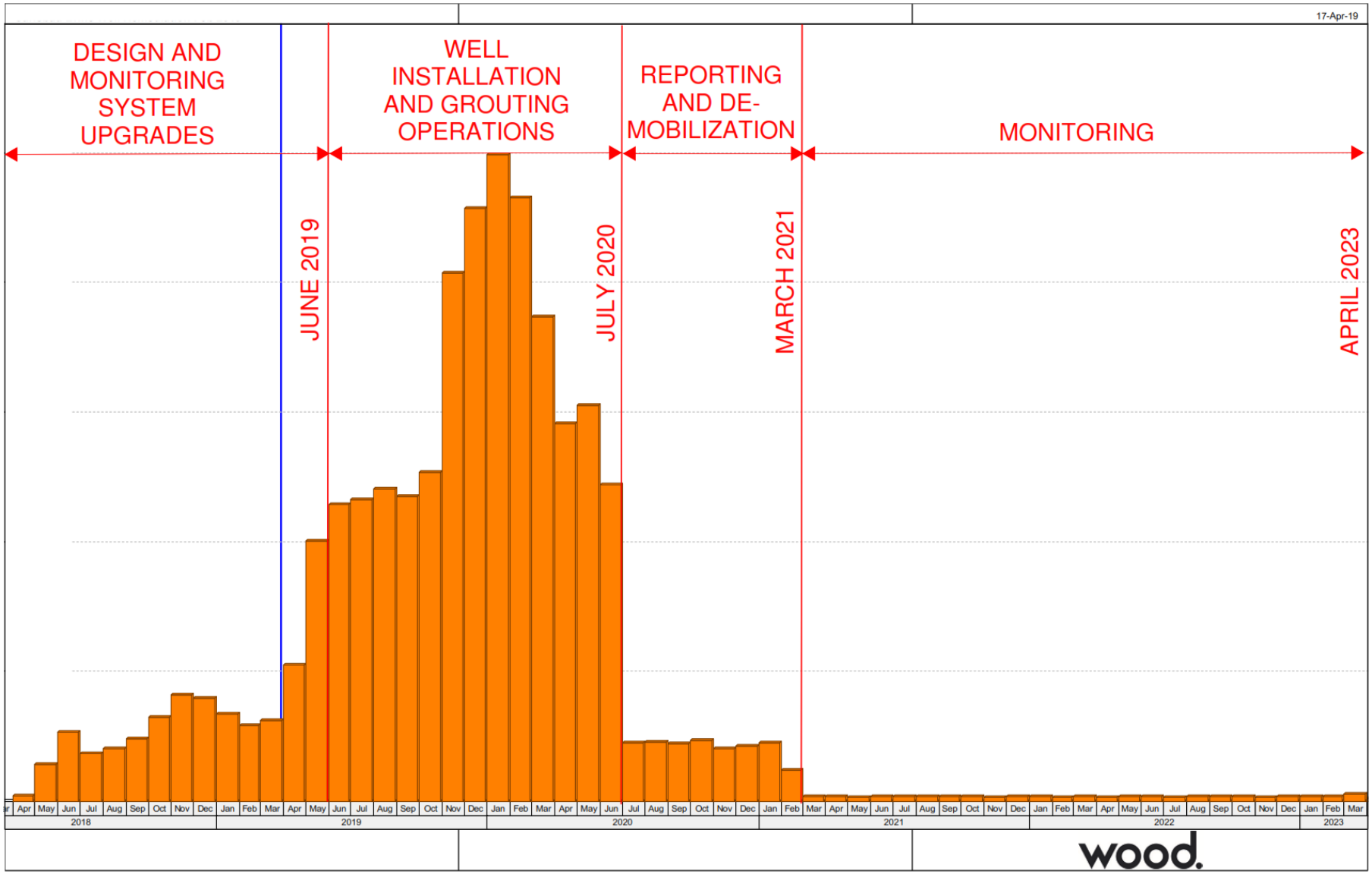


Monitoring & Early Warning

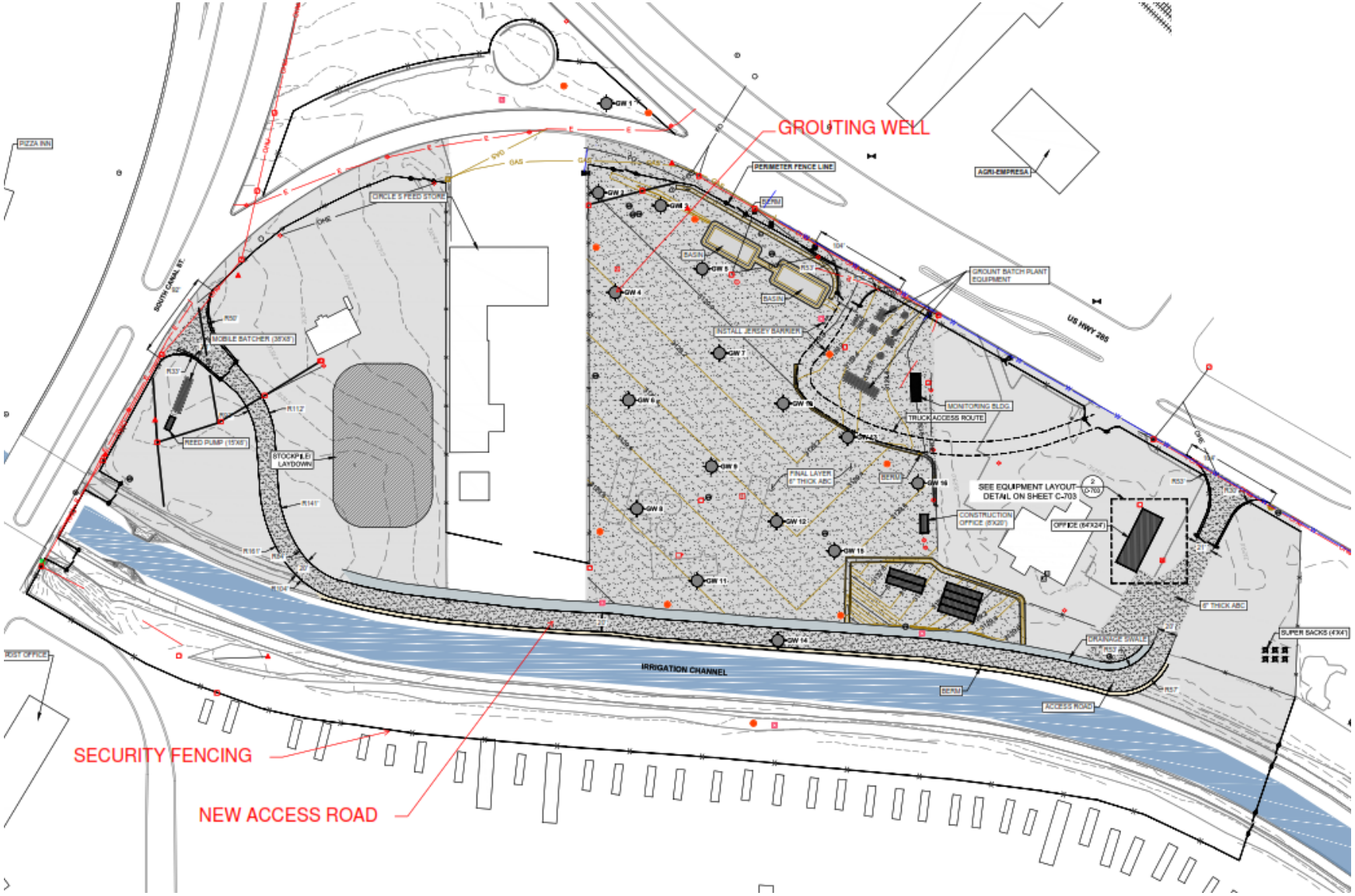
Project Funding & Expenditures

- City of Carlsbad - $4,000,000 (phased over 3 years)
- Eddy County - $4,000,000 (phased over 3 years)
- NM Dept of Transportation - $30,000,000 (phased over 3 years)
- NM Environment Dept - $2,000,000 (phased over 2 years)
- General Fund - $3,500,000
- Bonds - $1,958,000
- Total Funding - $45,458,000
- Expenditures to Date - $4,556,668

Project Activity Timeline



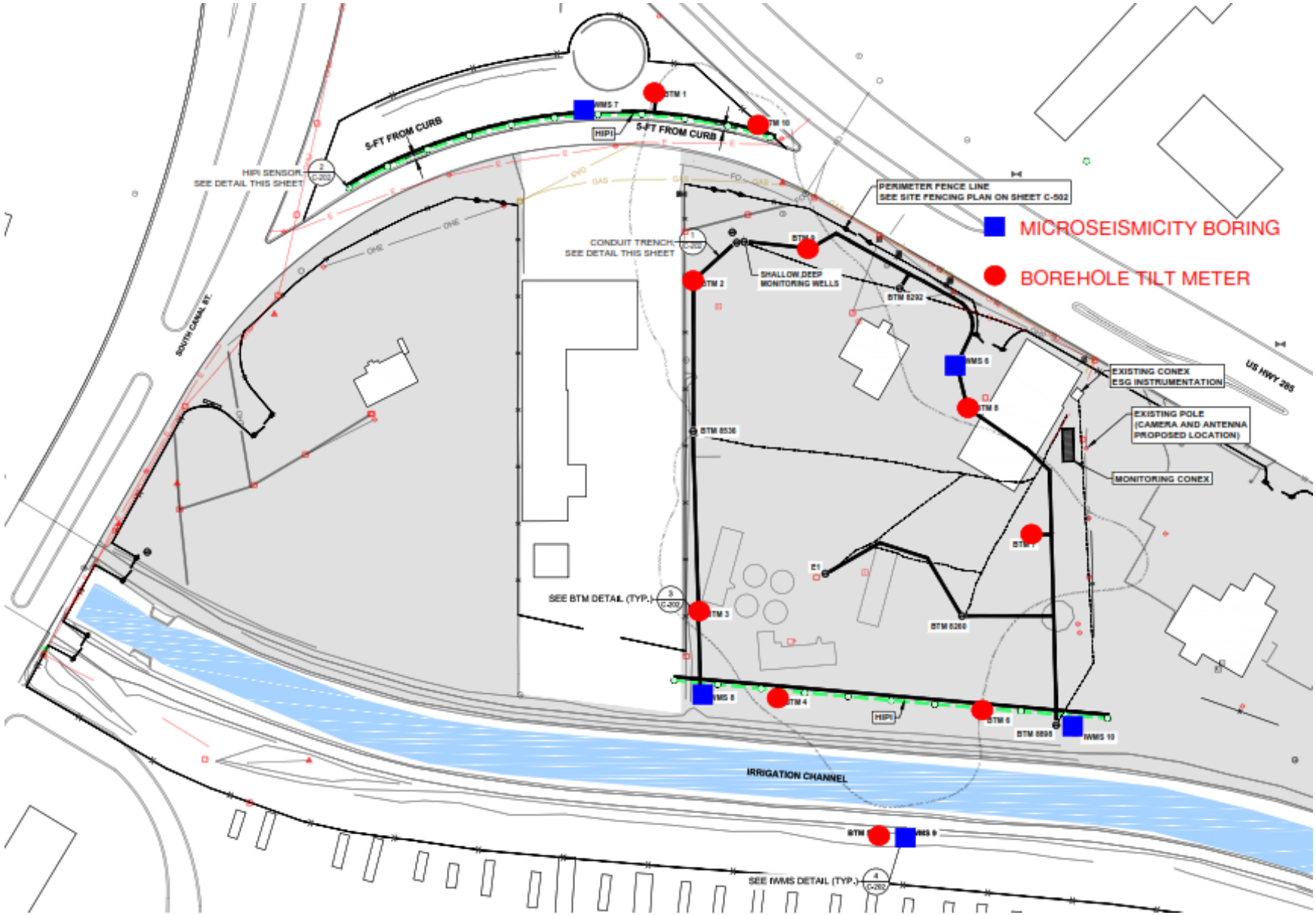
Project Site Map



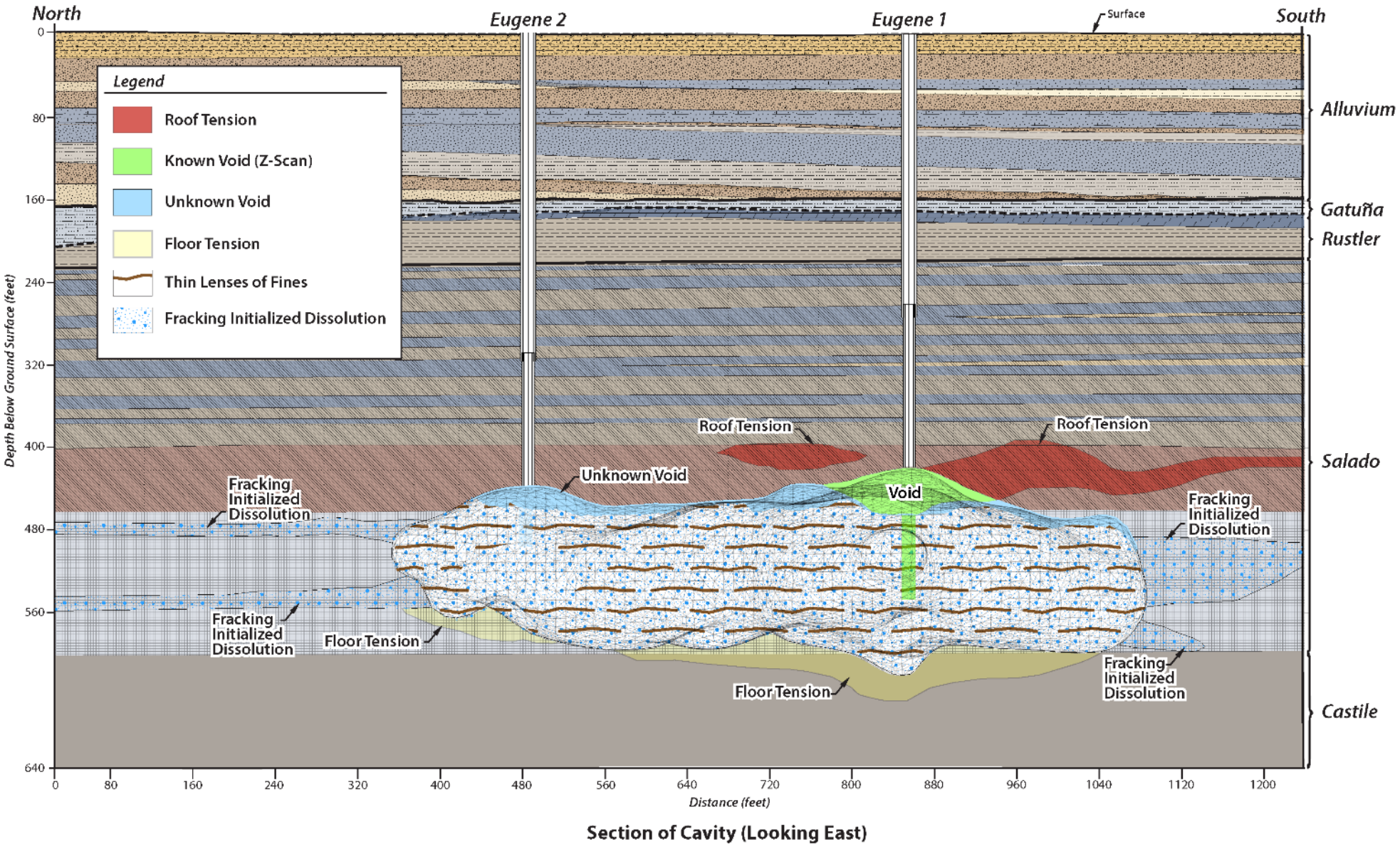
Site Monitoring and Data Collection

- Borehole Cores
  - Documenting lithological profile
- Microseismic (MS)
  - Four MS monitoring stations
  - One below cavity, three above roof
  - Recorded April 12, 2019 6.8 magnitude earthquake in eastern Indonesia
- Atlas Monitoring System (24 hours/7 days)
  - Nine borehole tilt meters
  - Continue pressure measurement at Eugenie #1
  - Continue groundwater depth measurements
  - Continue to measure depth of water in canal
  - Log barometric pressure, air & soil temperatures, rain gauge

Site Monitoring System



Understanding of Brine Cavity Stability



Section of Cavity (Looking East)

Example Roof Rock and Halite

Corehole IWMS-08
southwest of Eugenie #1

443 ft

438 ft

5-ft section of Intact roof rock

459 ft

454 ft

Top of halite with Dissolution zone

First corehole; bottom was cemented to control brine pressure

Corehole IWMS-06
northeast of Eugenie #1

433 ft to 437.8 ft roof rock core 437.8 ft to 443 ft

No core loss, so no void, fracture near bottom of the anhydrite, about 449.4 ft. About 3 inches of soft clay at 449.8; then an inch of anhydrite, and below that is the halite. Near contact, halite looks partially dissolved.

448.2 ft to 453 ft showing Anhydrite above halite and upper few feet of halite in pressurized brine zone. 100% core recovery. Second corehole, brine pressure was controlled using barite

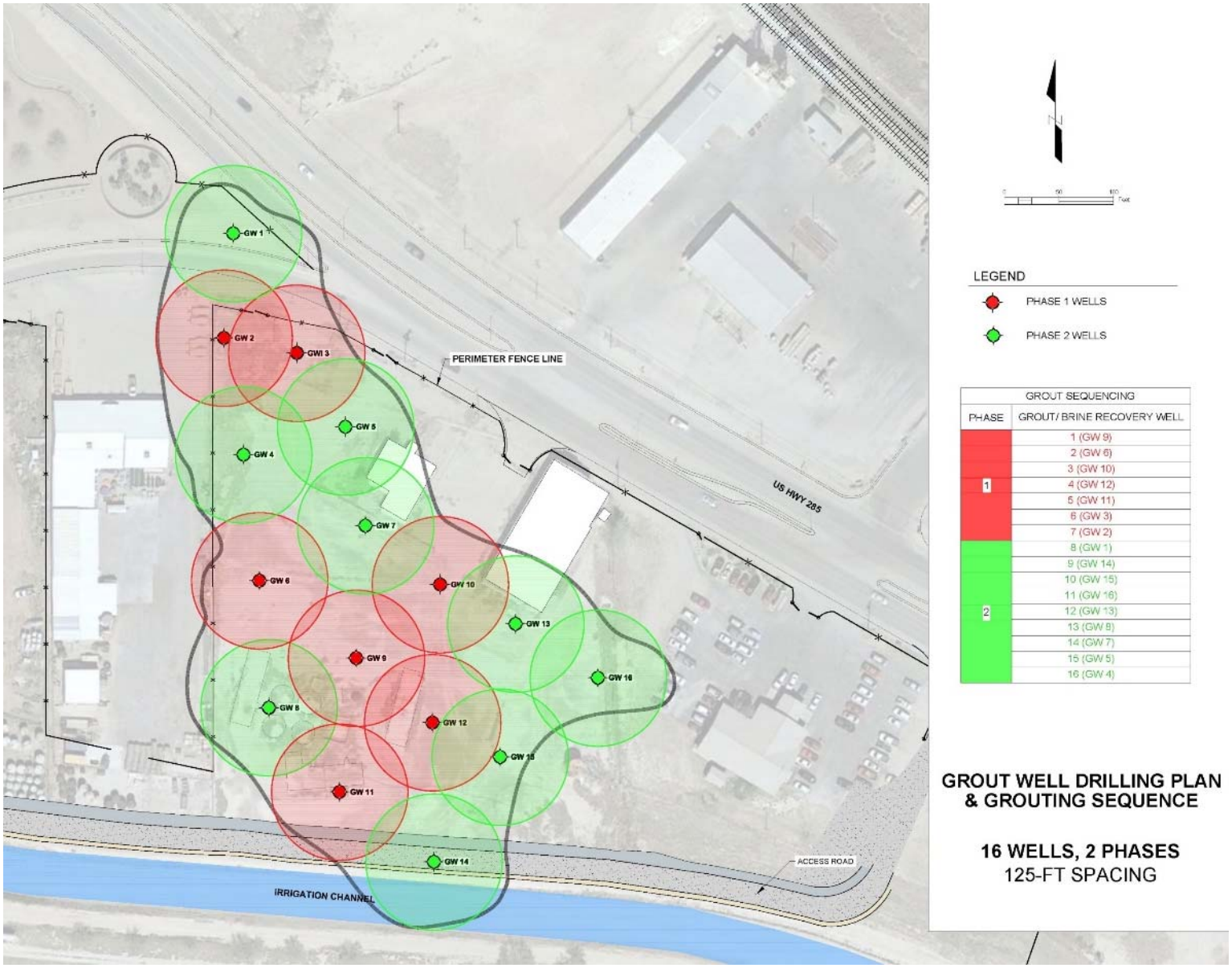
Understanding of Brine Cavity Stability

- **Finite Element Modeling.** Results indicate that cavity roof is stronger than previously estimated.
- **Improved Factor of Safety.** Recent coring results indicate cavity roof span is less than previously estimated thus yielding an improved factor of safety.
- **Roof Structure Composite**. Qualitative assessment of high-strength intact gypsum horizons, with interbedded claystone breccias (subject to plastic flow), inhibit development of tensile strain concentrations in the high-strength gypsums, and thus inhibit potential for tensile failure in roof.
- **Safe Cavity Criteria**. Safe cavity criteria ratio of roof span depth to roof span width criteria indicates “safe” condition with improved understanding of cavity dimensions.

Proposed Remedy

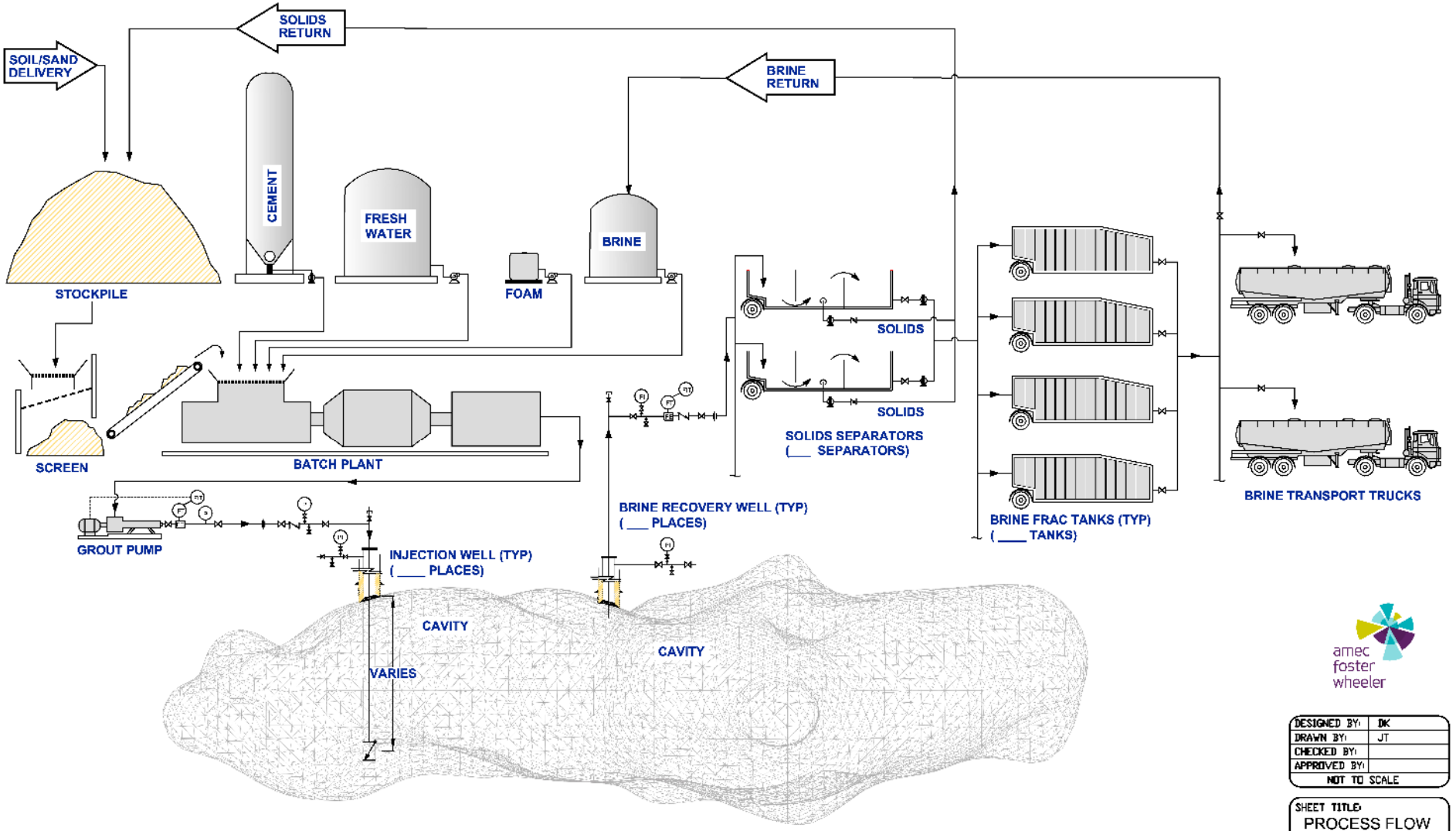
- Install a series of wells to extract brine and inject grout
  - Maintain cavity pressure
  - Balance volume of brine removed with volume of grout injected
  - Install a grout cap using high mobility grout to support cavity roof
  - Install grout columns using low mobility grout to support grout cap

Grout Well Installation

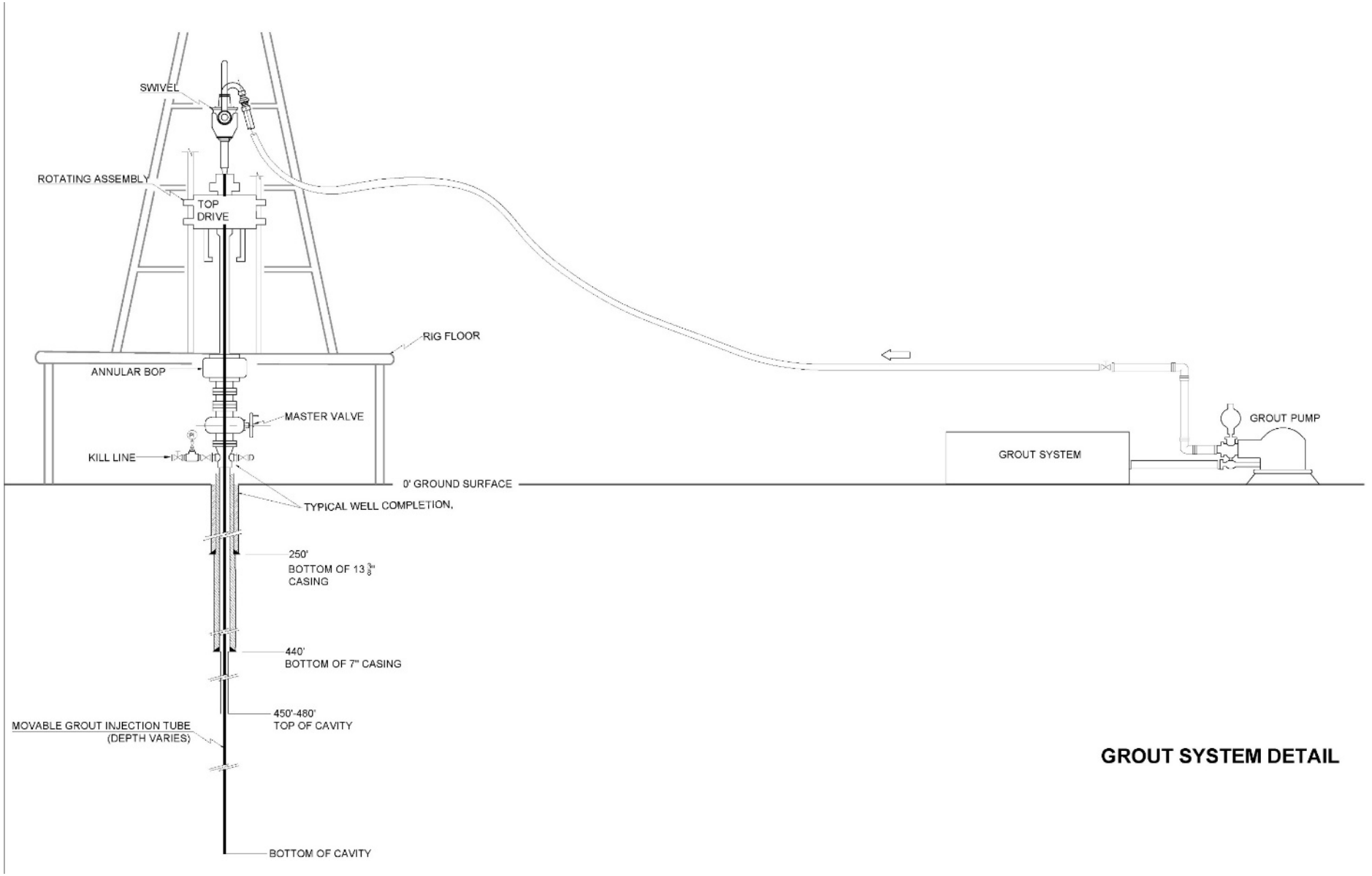


Cavity Filling Process

Process Flow Diagram



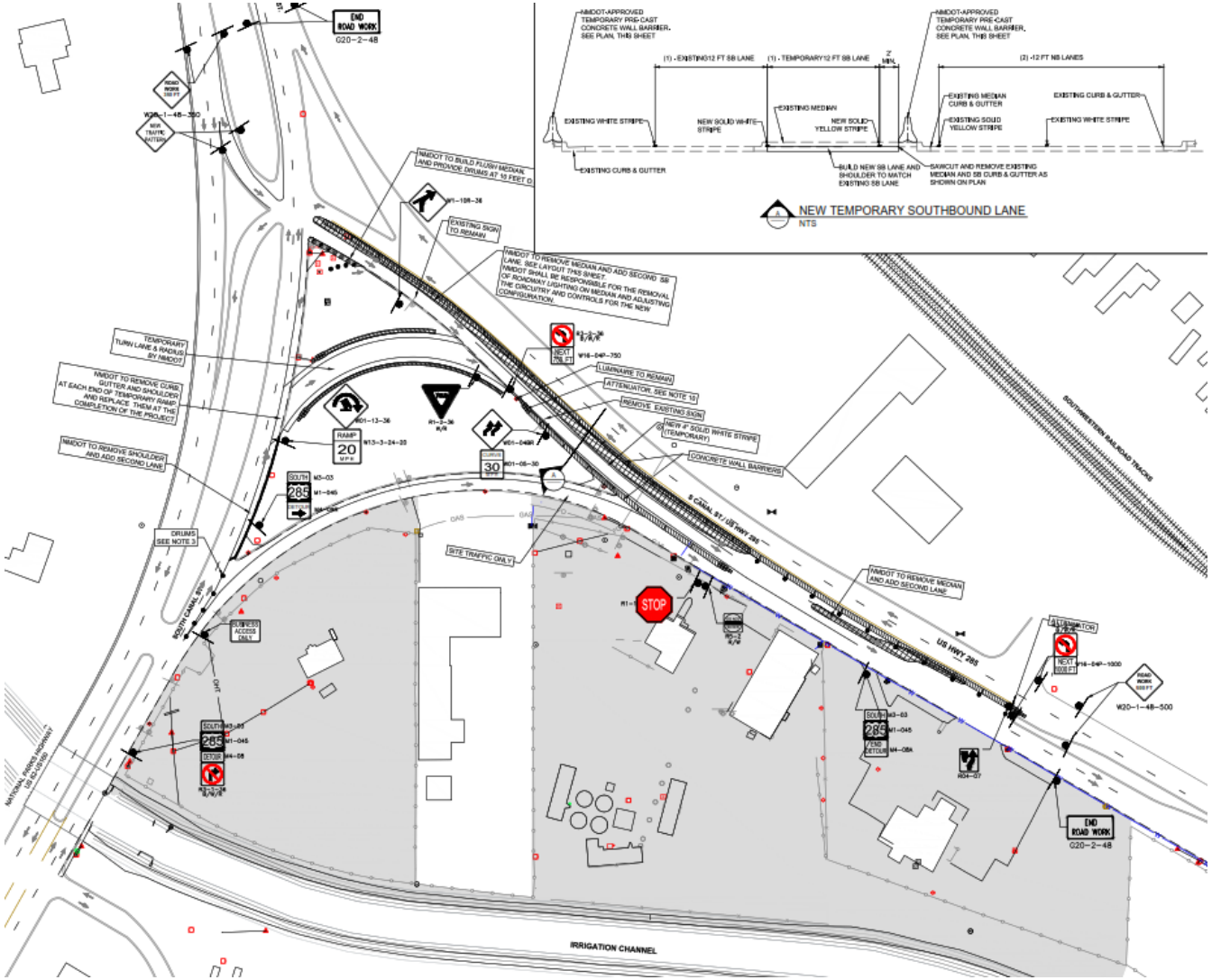
Grout System Detail



Risk Management

- Keep public safe
- Close monitoring during remedy implementation
  - Borehole Tilt Meters
  - Grout pressure monitoring
  - Ground level movement
  - Monitor grout volume injected
  - Constant feedback of advanced warning for emergency management
- Post remedy monitoring
  - Remedy confirmation
    - 2-yr monitoring period

Traffic Control Plan



Project Team for Implementation of Remedy

- New Mexico Energy, Minerals and Natural Resources Department (ENMRD)
  - Site coordination and overall program management
- Wood
  - Design and construction oversight
  - On-site monitoring and long-term monitoring
  - Site Health & Safety management
- Drilling Subcontractor
  - Drilling of grout wells
  - Support to grouting operations
- Hayward Baker – Grouting Subcontractor
  - Mixing and placement of grout materials
    - High mobility grout
    - Low mobility grout
- Constructors, Inc.
  - Local contractor/borrow material
- ESG Solutions
  - Microseismic instrumentation and data acquisition
- New Mexico DOT
  - Traffic control modifications
- City of Carlsbad
  - Community services
- Eddy County
  - Emergency management resources