Seismic Resiliency: Upgrading a Treated Water Reservoir and Transmission Pipelines for the Big One

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San Francisco Water Power Sewer
Services of the San Francisco Public Utilities Commission

Kennedy/Jenks Consultants

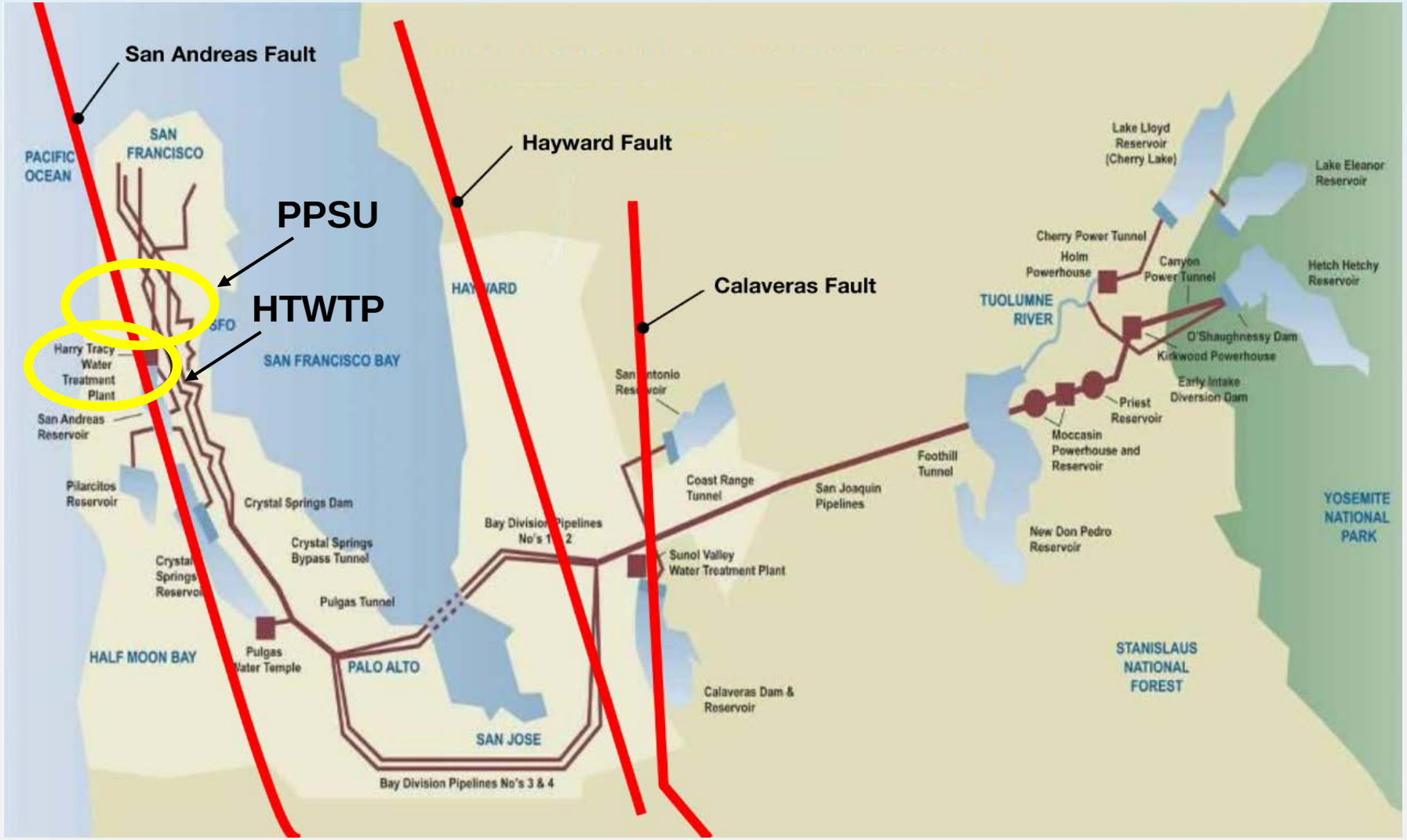
Presentation Outline

- Overview of SFPUC's Water System Improvements Program (WSIP)
- Harry Tracy Water Treatment Plant (HTWTP) - Long Term Improvements Project (LTIP)
  - Design
  - Construction
- Peninsula Pipeline Seismic Upgrades (PPSU) Project
  - Design
  - Construction

SFPUC Hetch Hetchy Water System

- 260 millions gallons per day
- To over 2.5 million Bay Area residents
- Travels 167 miles by gravity
- Crosses 3 faults

SFPUC Hetch Hetchy Water System



SPFUC's Water System Improvements Program (WSIP)

- $4.8 billion water system improvement program, implemented in 2002
- WSIP Goals
  - Seismically protect the water system
  - Assure reliable and adequate supply in case of catastrophic event or drought conditions
- One of the largest infrastructure programs in the country

WSIP Seismic Design Criteria

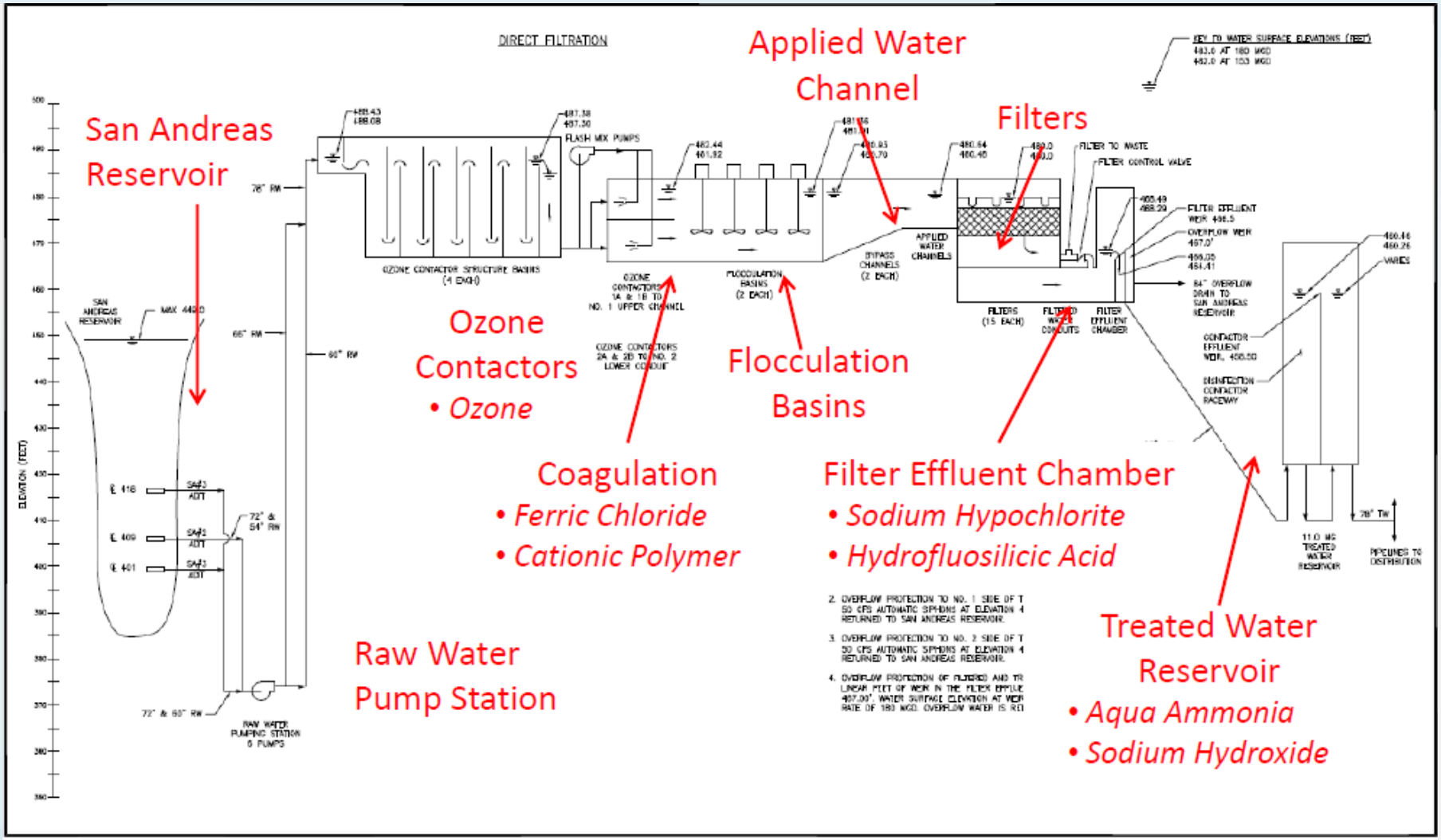
- BSE-2 (Basic Safety Earthquake-2) per ASCE 41
  - 2,475 year return period earthquake
  - 2% occurrence in 50 years
  - Maximum Credible Earthquake of 7.9
- Seismic Reliability:
  - Transmission pipelines to provide service within 24 hours of a Maximum Credible Earthquake on San Andreas Fault
  - Deliver 140 MGD within 24 hours after event

HARRY TRACY WATER TREATMENT PLANT LONG TERM IMPROVEMENTS PROJECT

Harry Tracy WTP Overview

- Built in 1972 and expanded in 1988, 1992 and 2011-2015
- Direct filtration plant
- Rated capacity: 140 MGD
  - Sustainable capacity: 90 MGD
  - Average Flow: 20 - 40 MGD
- Plant challenges
  - San Andreas Fault
  - Site limitations

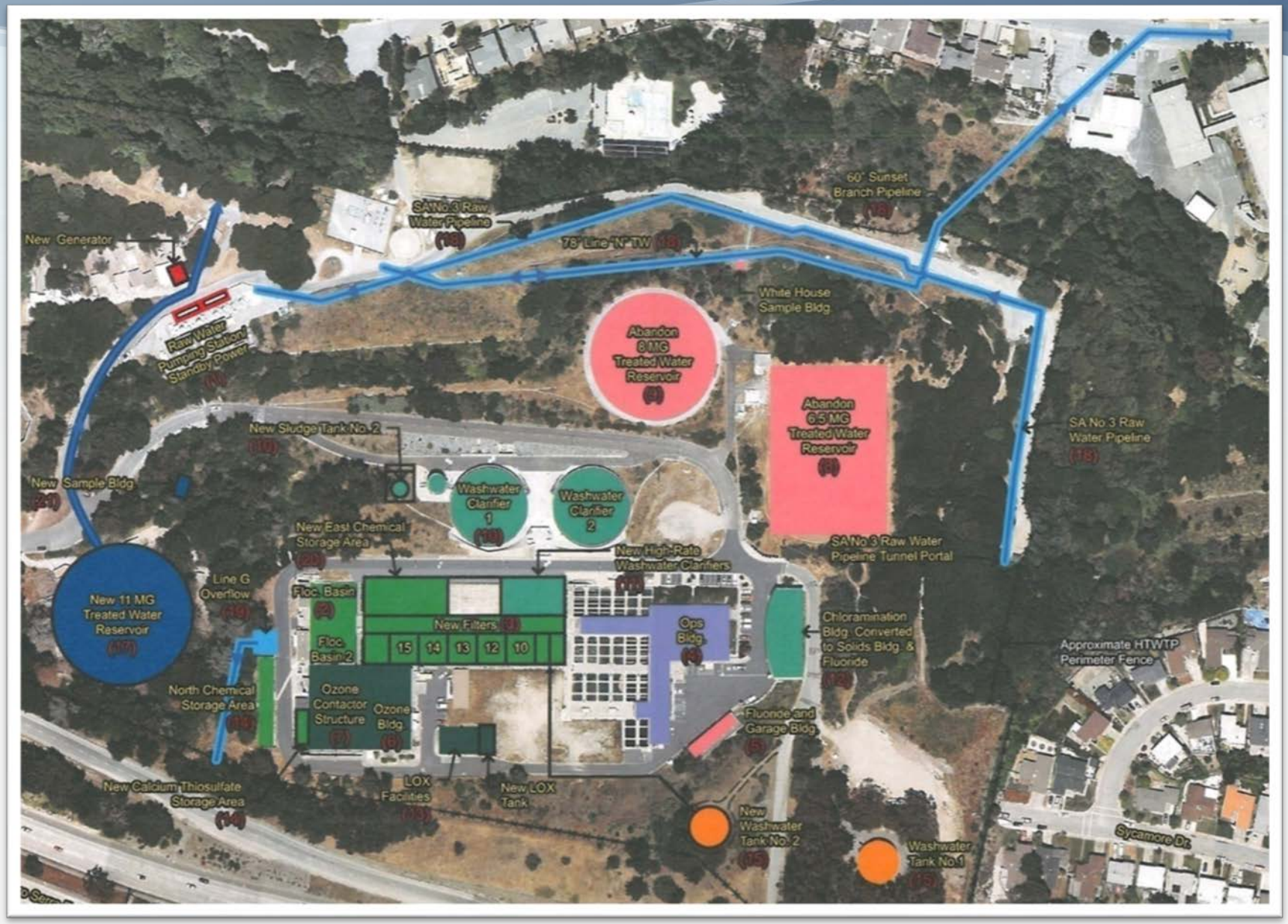
Process Flow Diagram



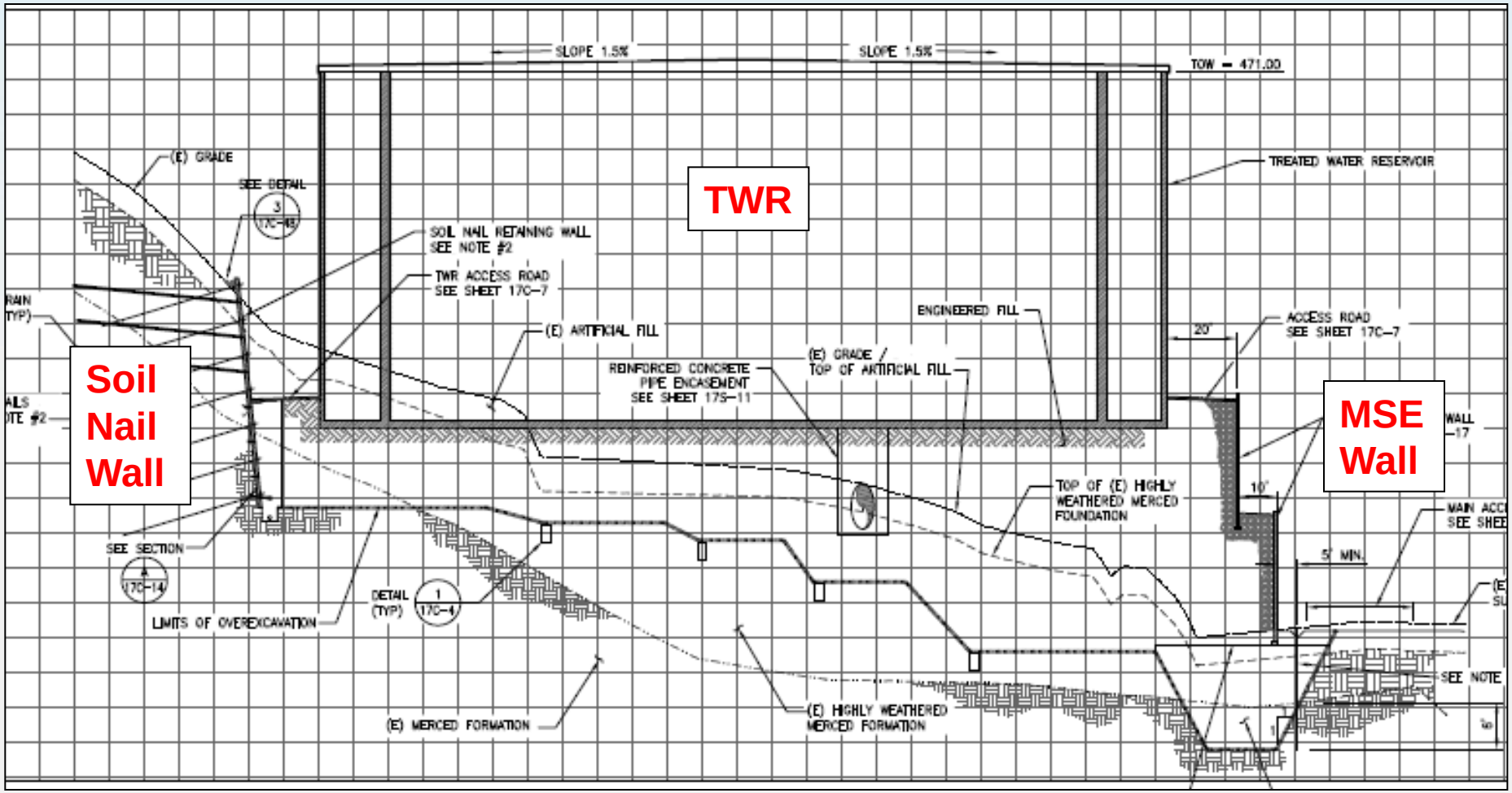
HARRY TRACY WTP

FIGURE 2.2-3 HYDRAULIC PROFILE
JUNE 2014

Harry Tracy WTP Project Map

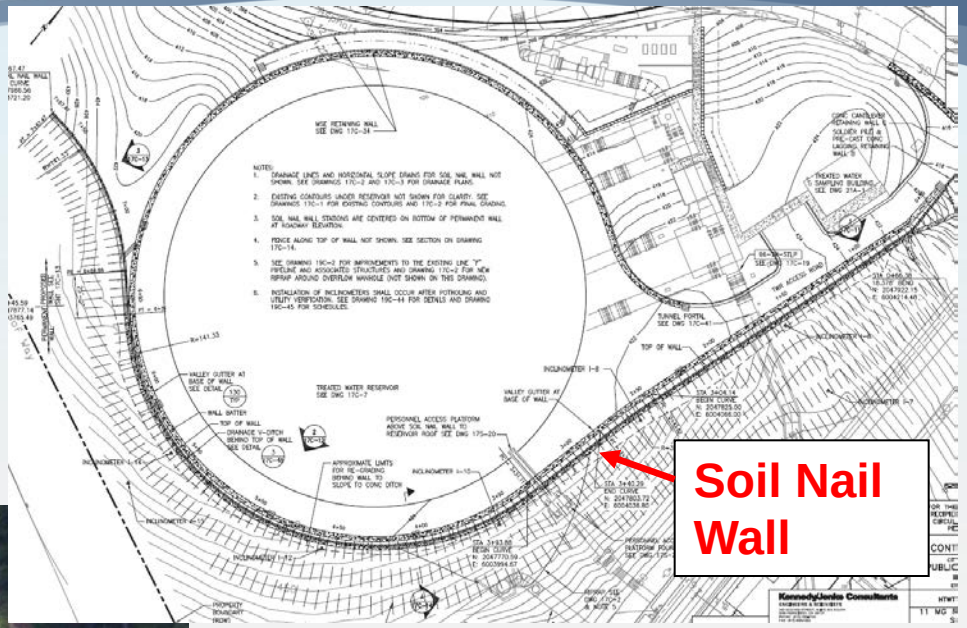


Earthwork Required to Support TWR



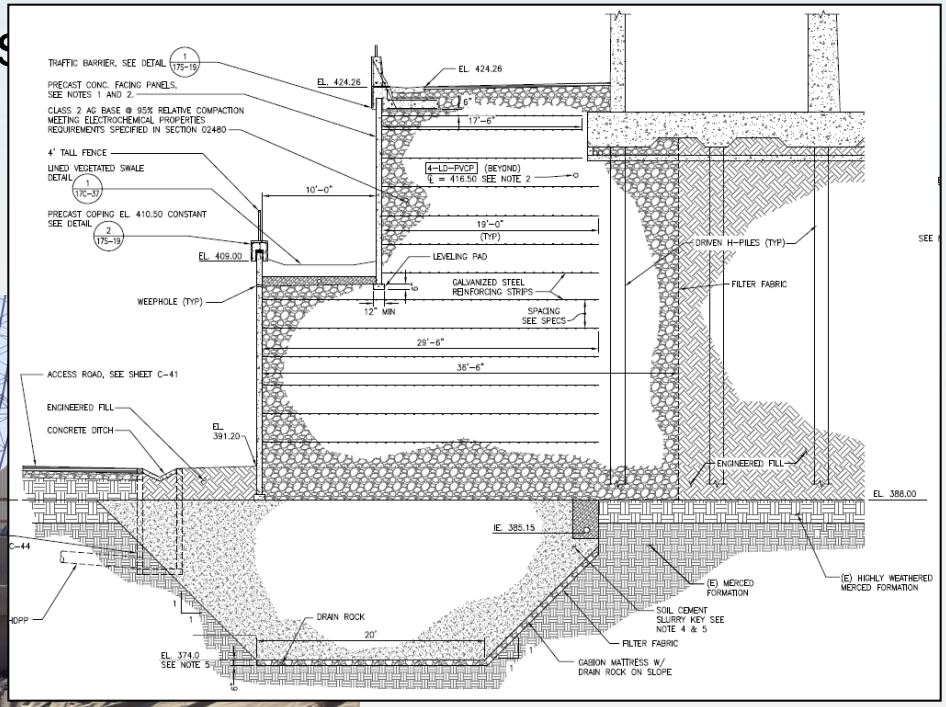
Soil Nail Retaining Wall

- Length: ~700 feet long
- Height: 20 to 65 feet tall
- Anchored by ~1,000 soil nails
- Nail length: 25 to 70 feet

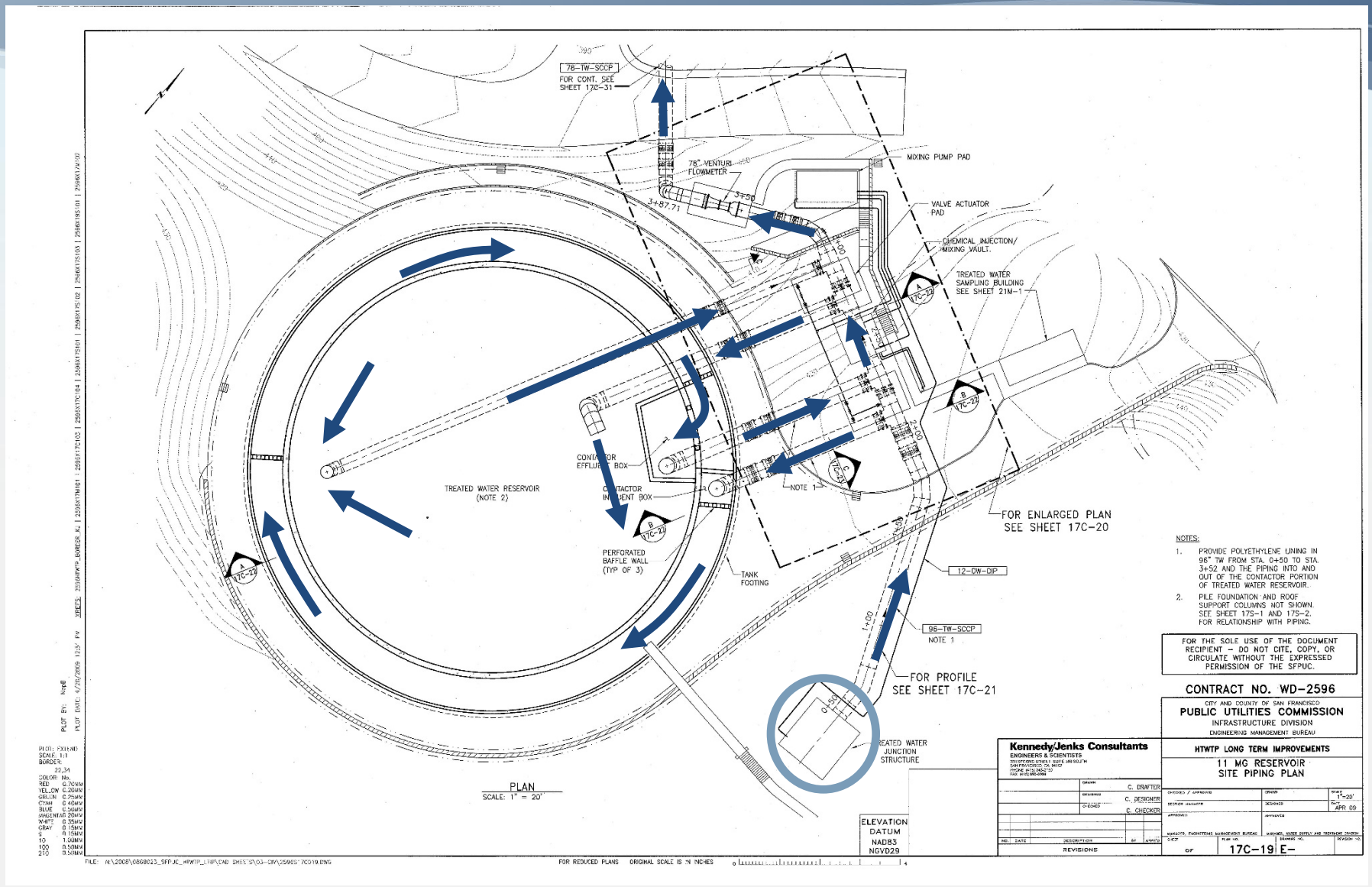


Mechanically Stabilized Earth (MSE) Wall

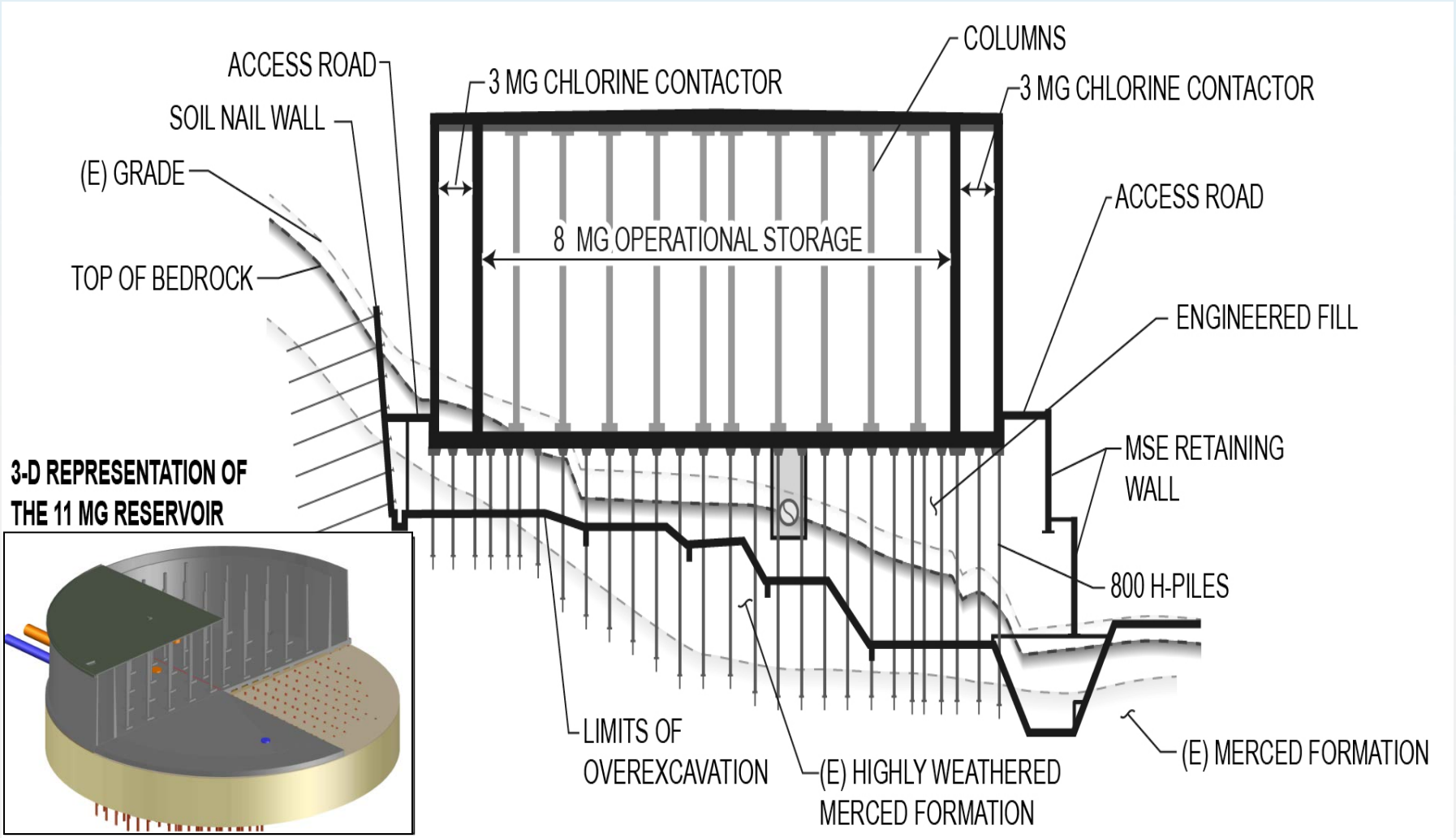
- Two tiers - upper & lower walls
- Precast concrete facing panels
  - 5’ by 5’ face area
  - Architectural detailing



11 MG TWR - Process Flow



11 MG TWR - Components



Piles, Pile Caps and Foundation

- 800+ Piles
  - HP-14 x 117
  - Depth: 12 to 61 feet
  - Depth to bedrock varies by 40’ over

- Pile-caps to connect piles to floor slab
- Foundation
  - 2’-3” thick slab

11 MG TWR – Outer Wall

- Contain chlorine raceway contactor (3 MG)
- Strand-wound circular prestressed concrete wall
- Cast-in-place concrete core
  - 12” thick at top
  - 18” thick at bottom
- Vertical post-tensioning tendons
- Circular prestressed reinforcement
  - 4 layers of strands wrapped around wall base
  - 3/8” thick shotcrete layer between wraps

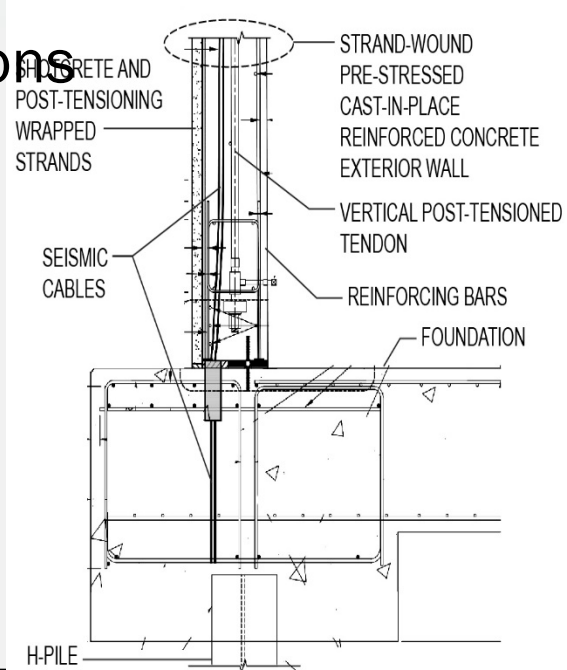
11 MG TWR – Inner Wall

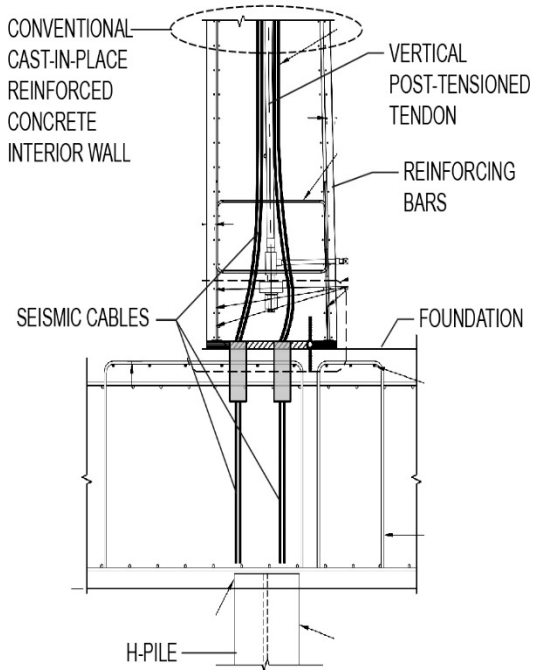
- Contain operational storage reservoir (8 MG)
- Cast-in-place concrete wall
- No prestressed reinforcement

- Vertical post-tensioning tendons
- Tapered wall
  - 12” thick at top
  - 34” thick at bottom

11 MG TWR - Wall Connections

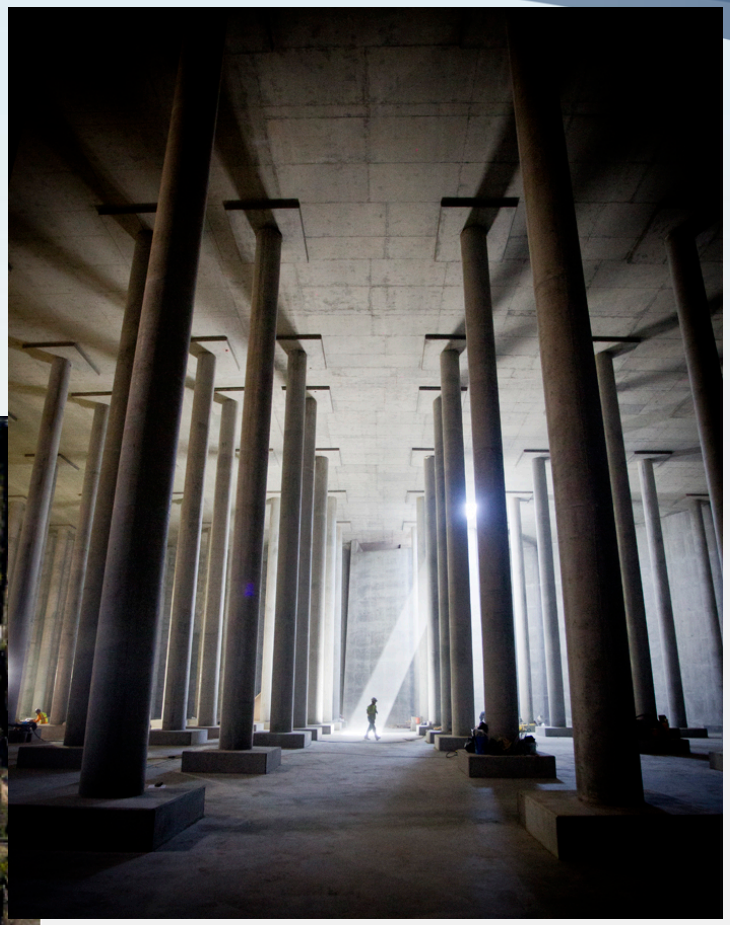
- Connections to floor slab and roof slab
  - Designed as unrestrained conditions
  - Allows tank to expand and contract when filling or draining the tank
  - Seismic cable connections
    - Transfer seismic load of wall to foundation
    - Prevents sliding of tank off foundation





11 MG TWR - Roof and Columns

- Roof designed as two-way slab
  - Rebar resists bending stresses in each directions
  - Reduces thickness of concrete



- 88 columns
- 30” diameter

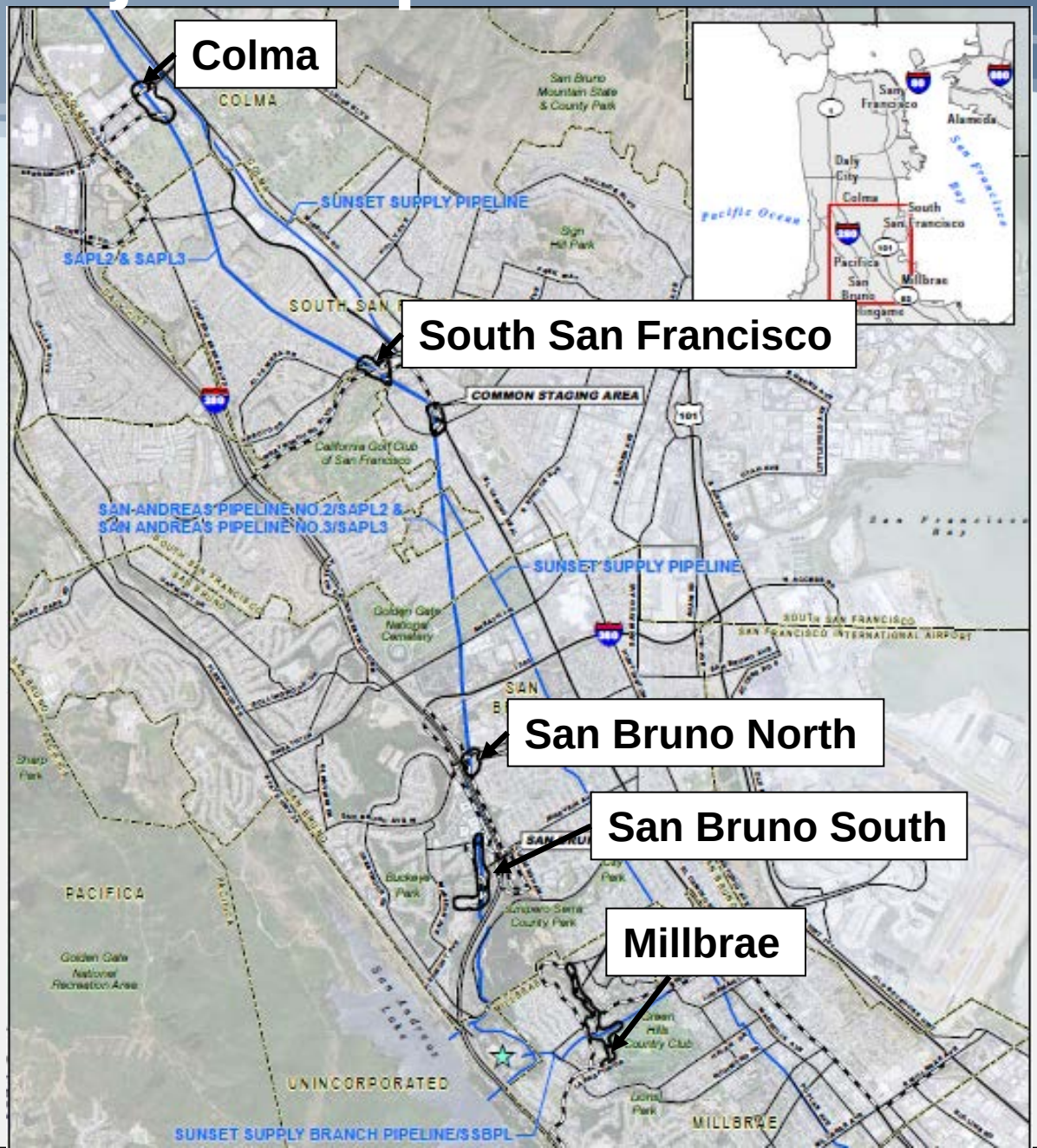
Project Completed in April 2015!

PENINSULA PIPELINE SEISMIC UPGRADES PROJECT

Peninsula Pipeline Seismic Upgrades Overview

- Transmission pipelines from HTWTP
  - San Andreas Pipeline No. 2 (SAPL2)
  - San Andreas Pipeline No. 3 (SAPL3)
  - Sunset Branch Pipeline (SSBPL)
- Cross the Serra Fault
- Traverse areas of potential liquefaction in the Colma Valley

PPSU Project Map



PPSU Project Description

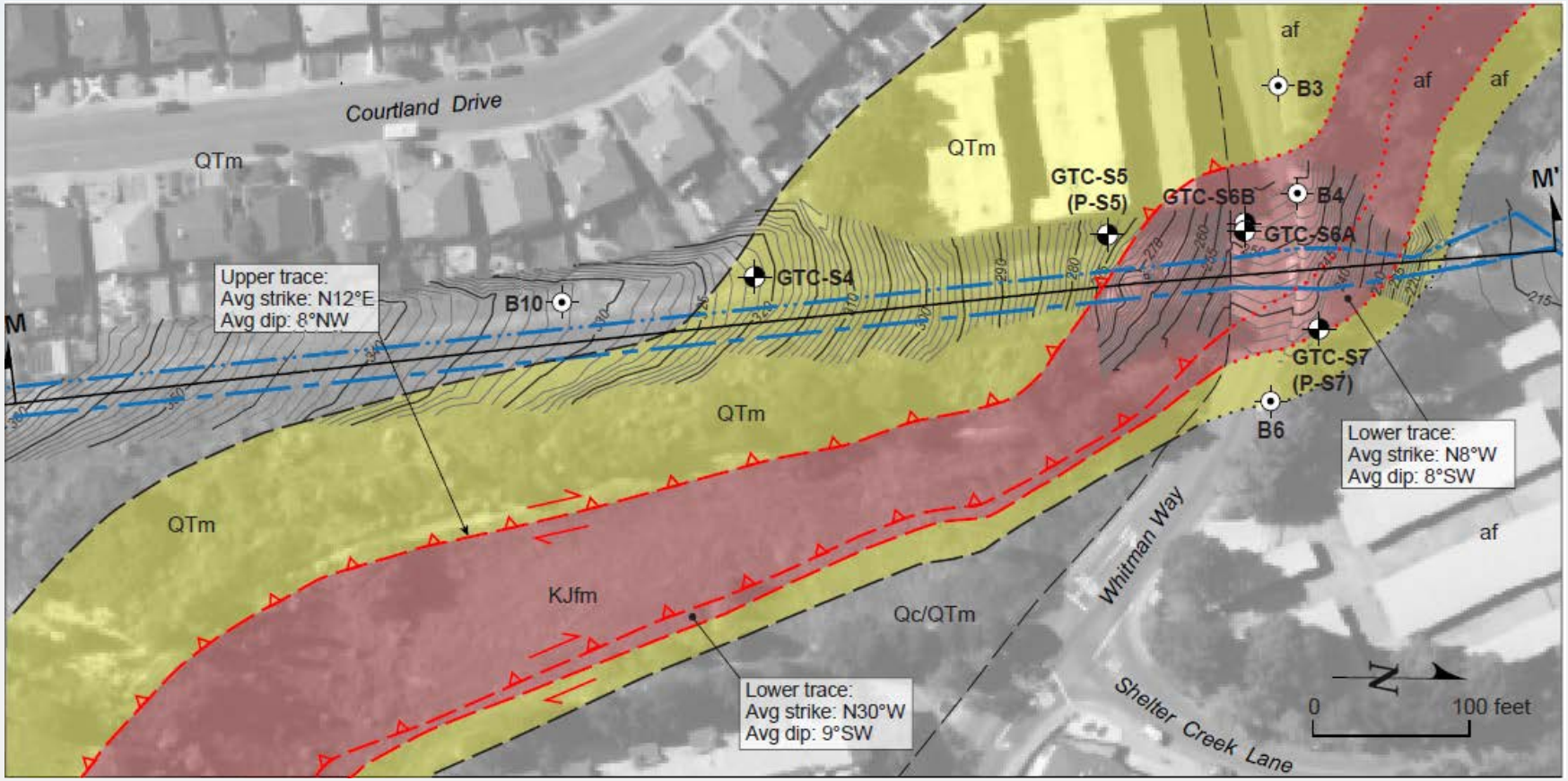
- Millbrae Site
  - Replacement of approximately 900 feet of SSBPL at the Serra Fault Crossing
- San Bruno South Site
  - Replacement of approximately 1,120 feet of SAPL2 and approximately 990 feet of SAPL3 at the Serra Fault Crossing
- San Bruno North Site
  - Structural support of SAPL2 within an existing concrete box tunnel

PPSU Project Description, Cont.

- South San Francisco Site
  - Replacement of 665 feet of SAPL 2 located in the Colma Valley liquefaction zones
- Colma Site
  - Replacement of approximately 685 feet located in the Colma Valley liquefaction zones

Serra Fault Hazard Zones

- Seismic hazard zones
  - Serra Fault primary rupture hazard zone
  - Serra Fault secondary deformation hazard zone



Basis of Design

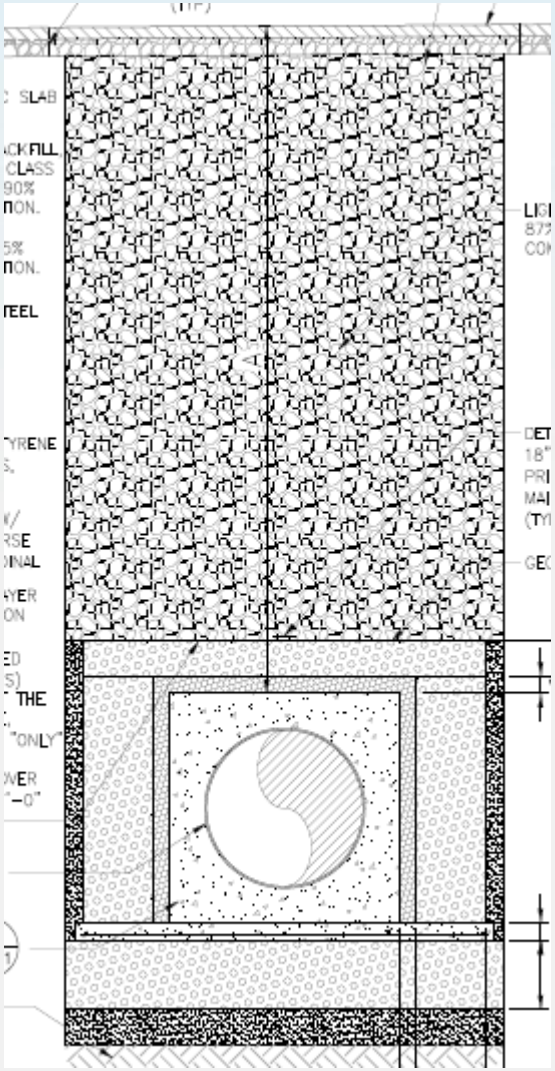
- Hazard zones and geotechnical parameters determined design requirements
  - Pipe thickness
  - Connection welds
  - Specialized trench backfill material
- Finite element modeling was performed using ABAQUS
  - Confirm the design will perform as expected under a seismic event

PPSU Design Concepts: Strengthen Pipes

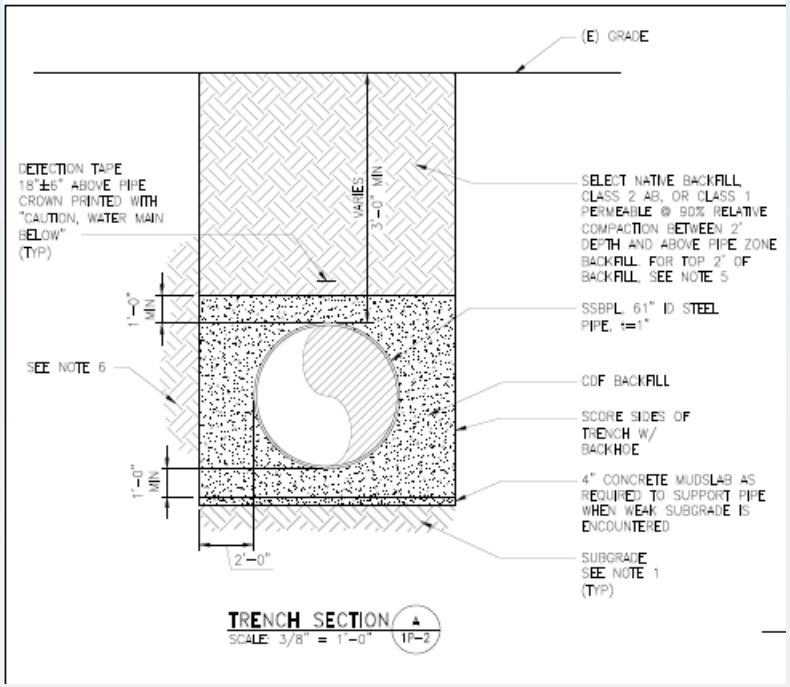
- Steel pipe thicknesses between 5/8 and 1-1/4 inch thick
- Butt-welded joints between pipe segments
- Butt strap connections encased in concrete between new and existing pipes
- Reinforced concrete-encased miter bends with welded 'shear studs'

PPSU Design Concepts: Flexible Trench Backfill Material

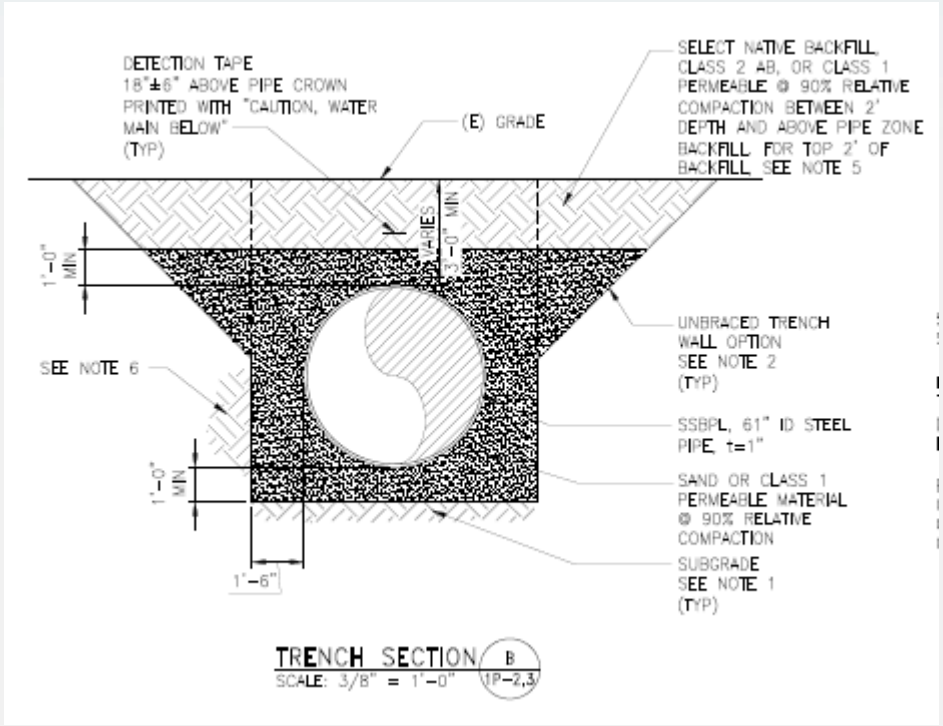
- Provide flexibility for pipe movement within trench
- Unconventional trench materials
  - Gravel
  - Expanded polystyrene geofoam (EPS foam)
  - Cellular concrete
  - Light weight aggregate
- Polyurethane lined and coated
- Multiple trench section designs
  - Dependent on hazard zones



Trench Section in Secondary Deformation Hazard Zone

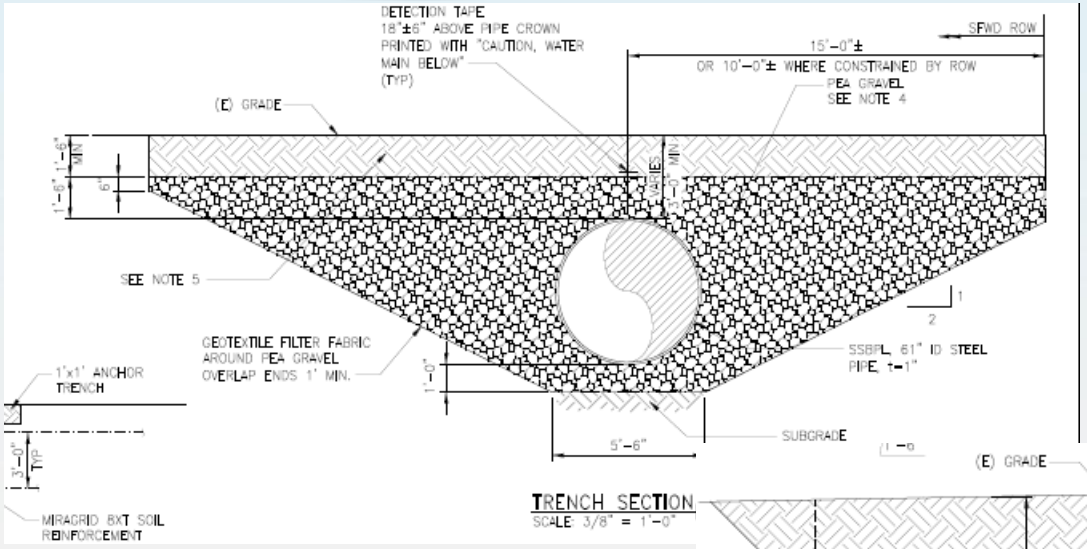


- Pipe Bedding
  - Sand
  - Controlled Density Fill (CDF)
  - Class 1 permeable material

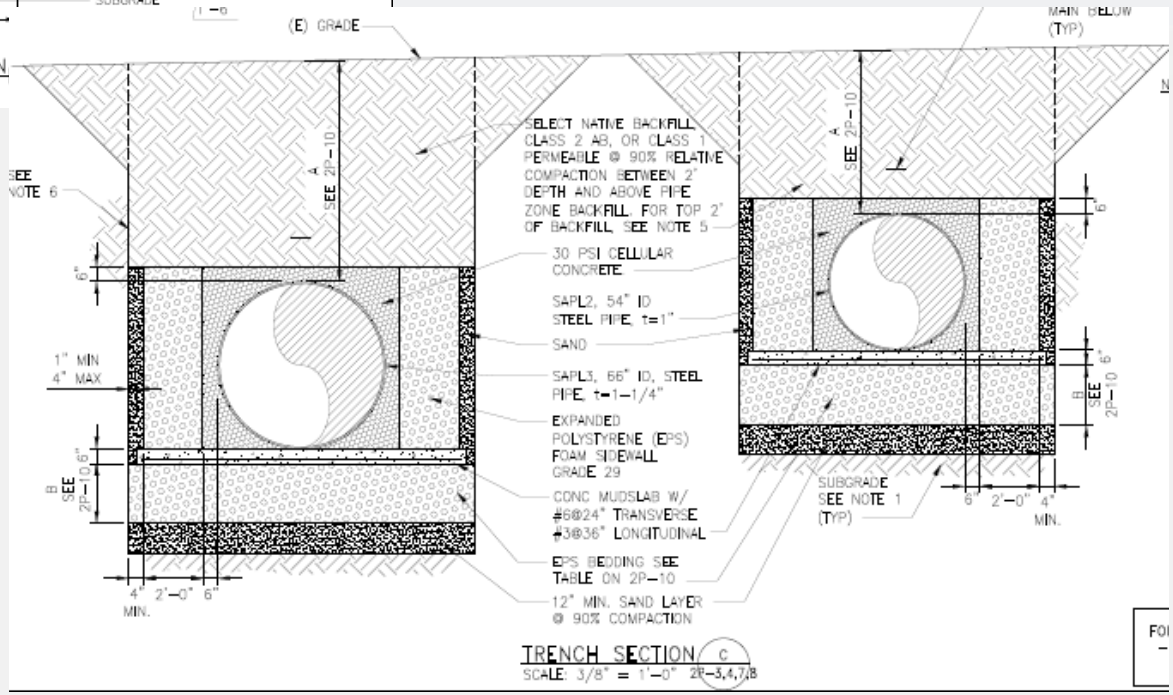


- Trench Backfill
  - Select native
  - Class 1 permeable material
  - Class 2 aggregate base

Trench Sections in Primary Rupture Hazard Zone



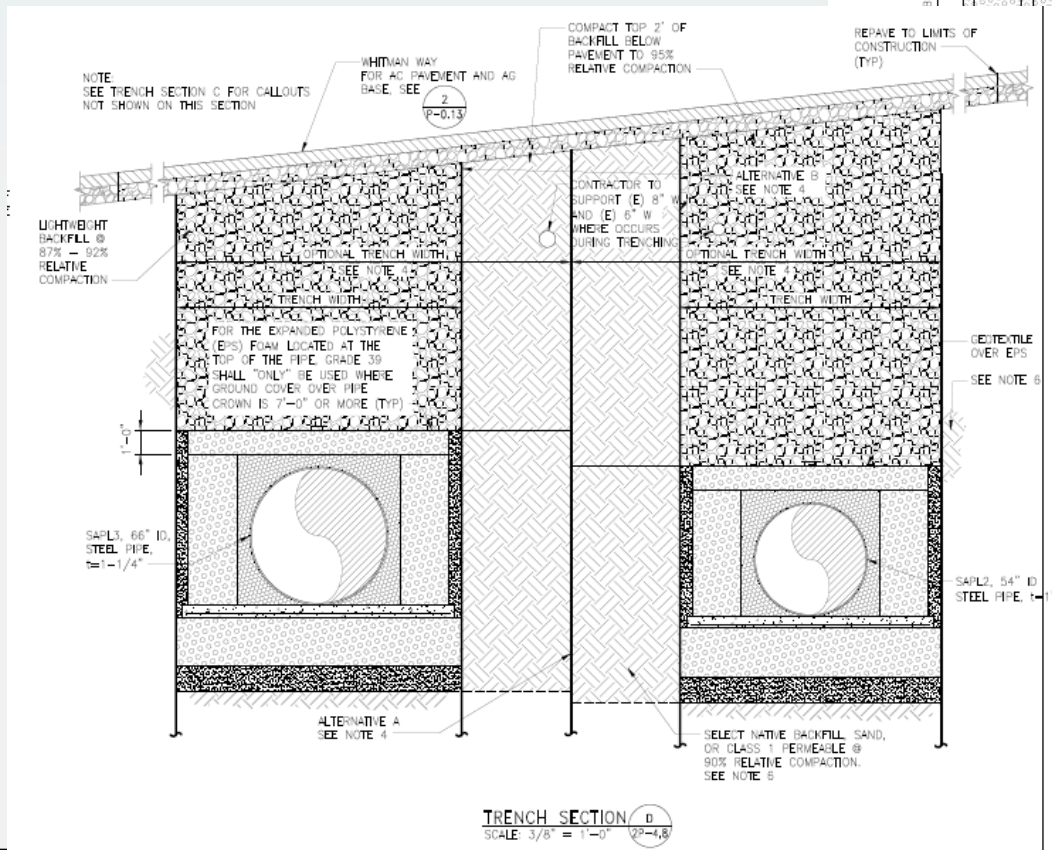
- Pipe Bedding
  - Gravel

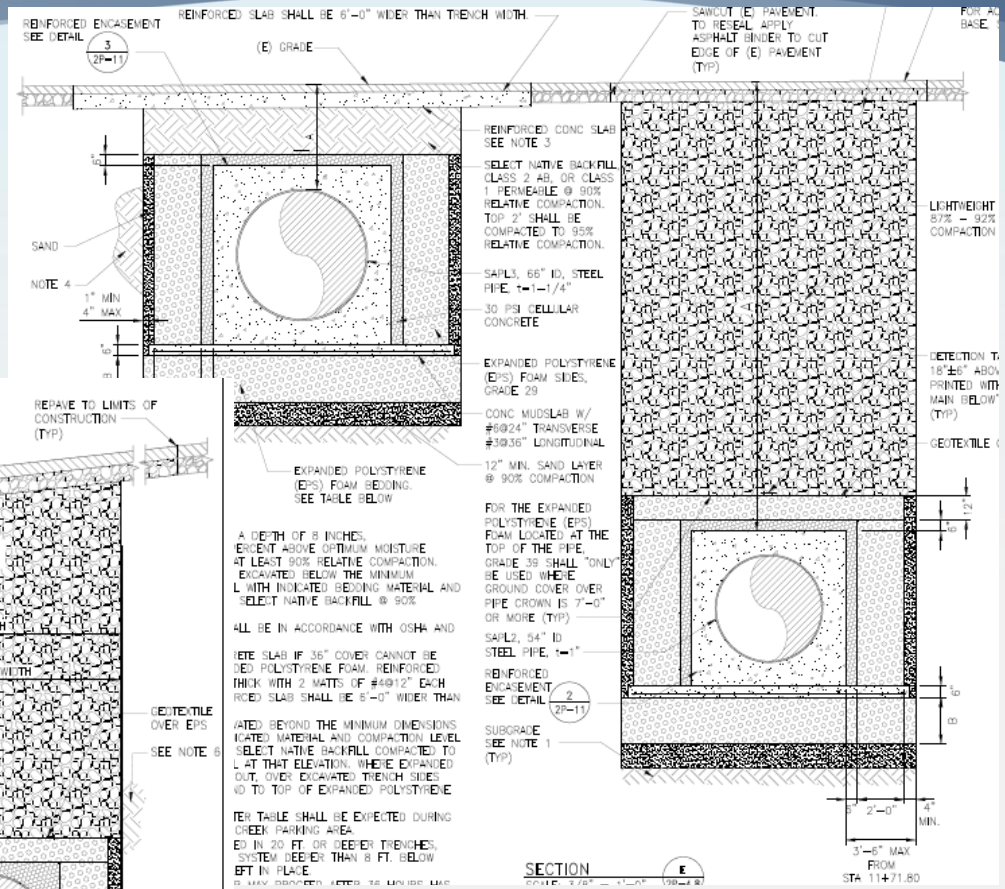


- Pipe Bedding
  - EPS foam
  - 30 psi cellular concrete
  - Sand

Trench Sections in Primary Rupture Hazard Zone, Cont.

- Specialty Trenches
  - SAPL2/SAPL3 close together at varying elevations
  - SAPL2 is >20 feet deep



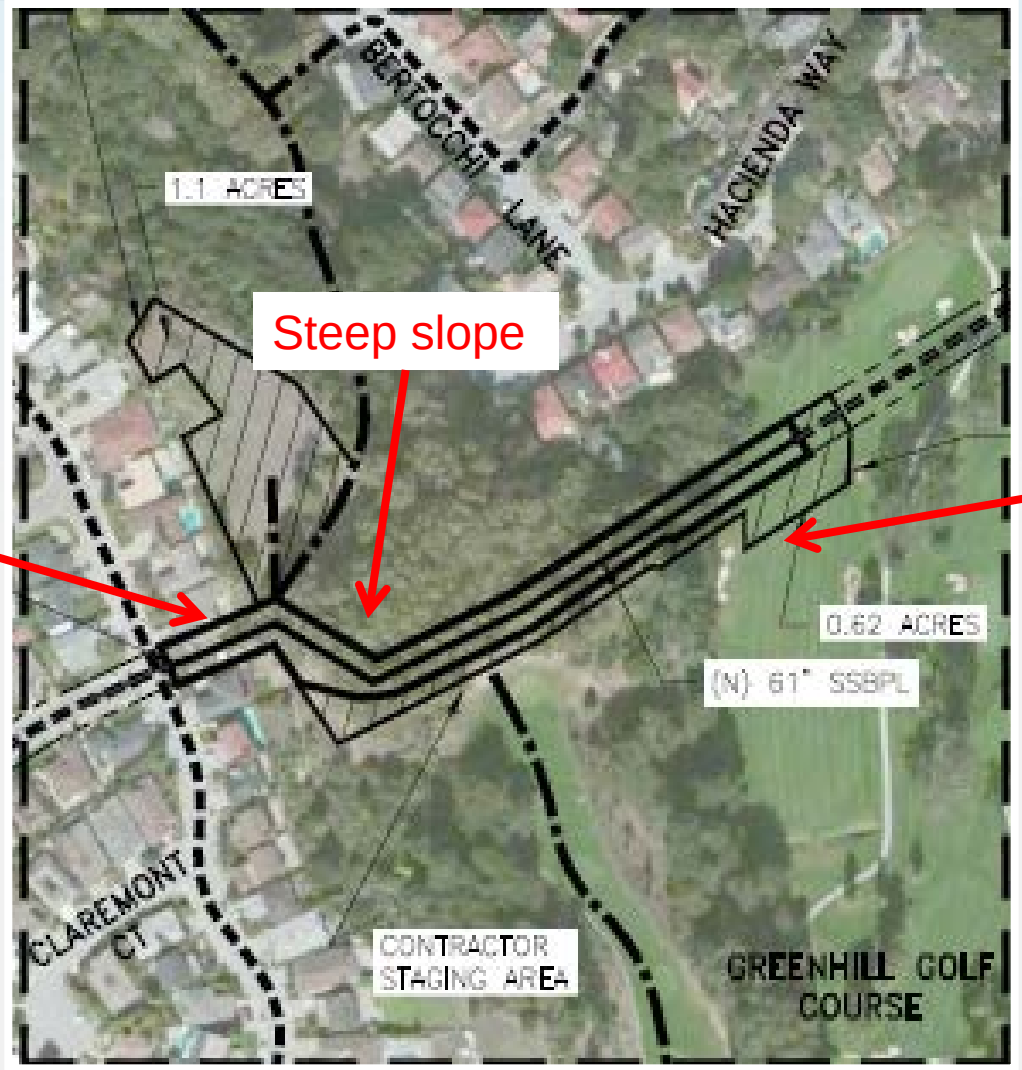


- Trench Backfill
  - Light weight aggregate

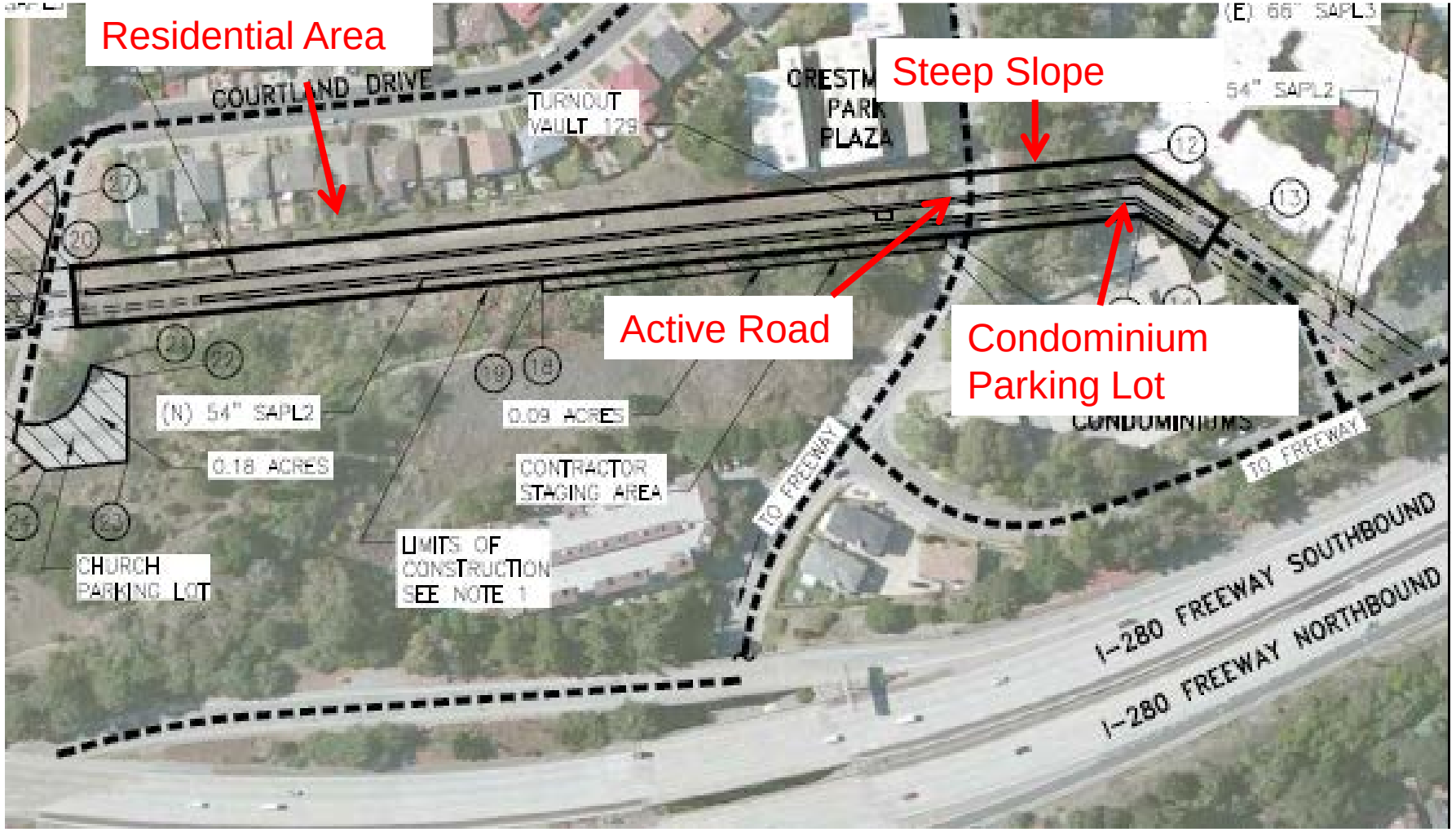
Construction Challenges

1. Pipeline alignment
2. Erosion control/Inclement weather
3. Unconventional backfill materials

Construction Challenge 1: Alignment Millbrae Site



Construction Challenge 1: Alignment
San Bruno South Site



Construction Challenge 1: Alignment, Cont.

Construction Challenge 2: Erosion Control/Inclement Weather, cont.

Construction Challenge 2: Erosion Control/Inclement Weather, cont.

Construction Challenge 3: Unconventional Materials - EPS Foam

- Expanded polystyrene geofoam (EPS foam)
  - Cut material on site to required dimensions
  - Limit weight on foam

Construction Challenge 3: Unconventional Materials - EPS Foam, Cont.

Construction Challenge 3: Unconventional Materials - Lightweight Aggregate

- Light weight aggregate
  - No appropriate ASTM standard for in-situ compaction testing
  - Concern for settlement of parking lot/road

Construction Challenge 3: Unconventional Material - Cellular Concrete

- Cellular Concrete
  - Difficulties meeting low strength requirements
  - Optimized strength/weight ratio

Questions?

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