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Geotechnical Challenges Related to the TBM for the Alaska Way Viaduct Replacement Project

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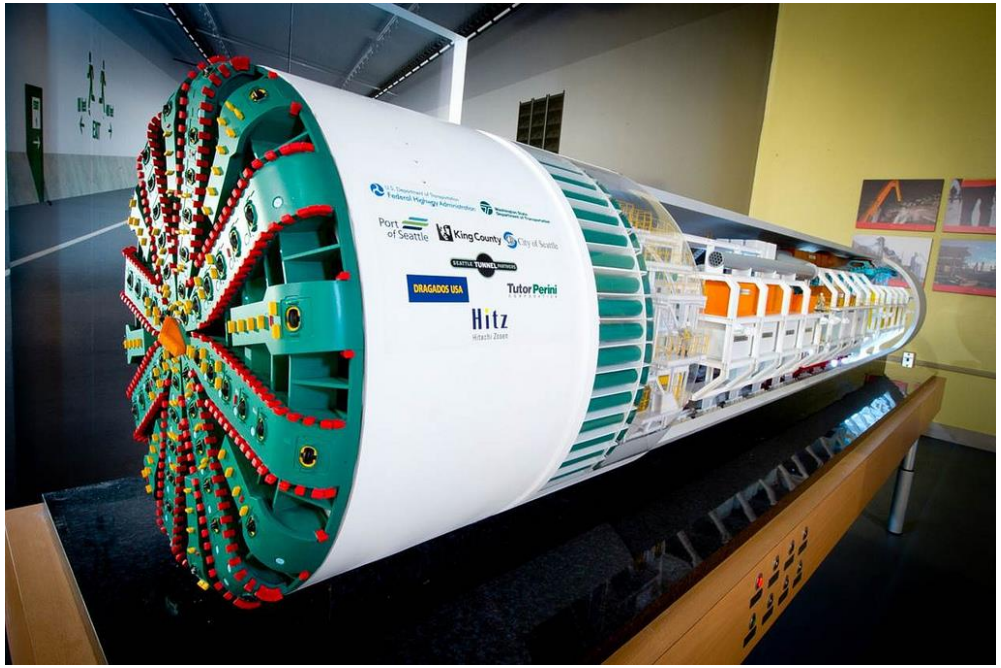
The Tunnel

- **Length: 9,270 feet (1.7 miles)**
- **Diameter: 56 feet (inside finished)**
- **Volume: 850,000 yd^3**
- **Concrete Liner Rings: 1426**

The TBM "Big Bertha"



- **Length: 326 feet**
- **Diameter: 57.5 feet**
- **Weight: 7000 tons**
- **Cutterhead Teeth: 260**
- **Diameter of Boulder Bertha Can Swallow: 3 feet**

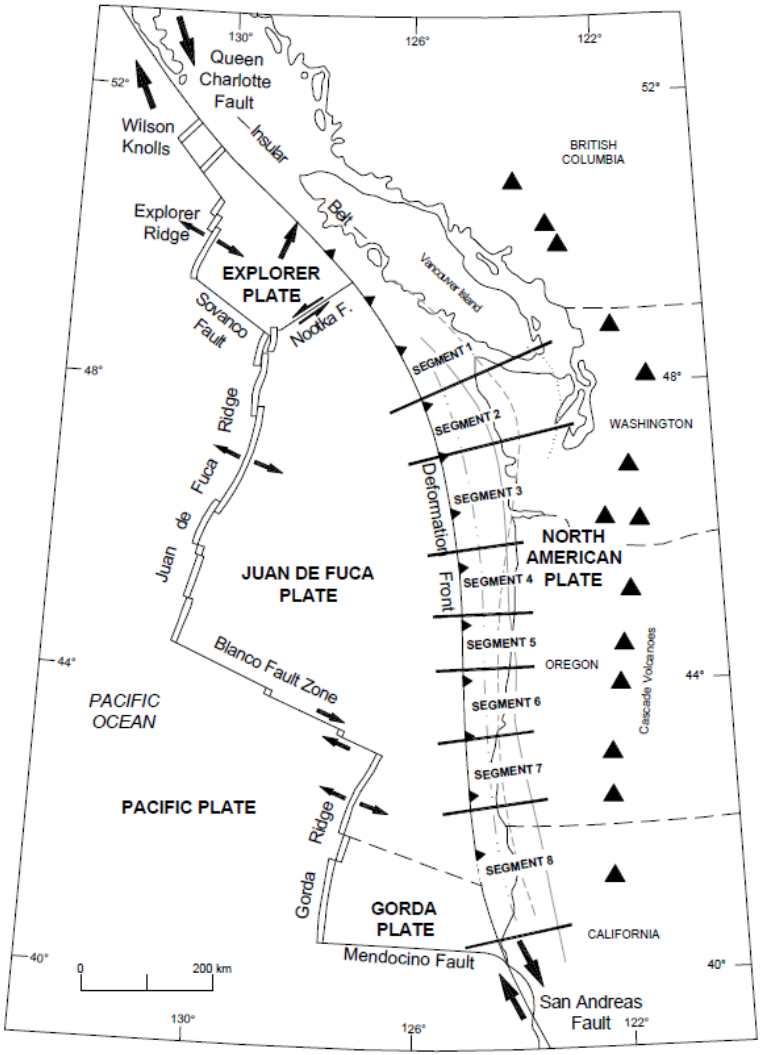
Geotechnical Risk

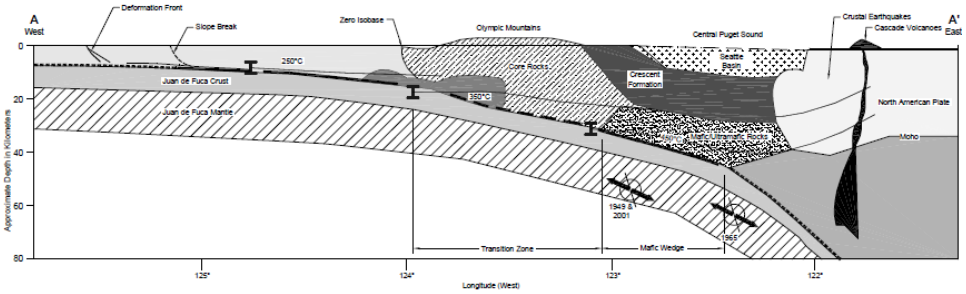
- **Earthquake Hazards**
- **In-Ground Geotechnical (Geologic Risks)**
  - Design
  - Construction

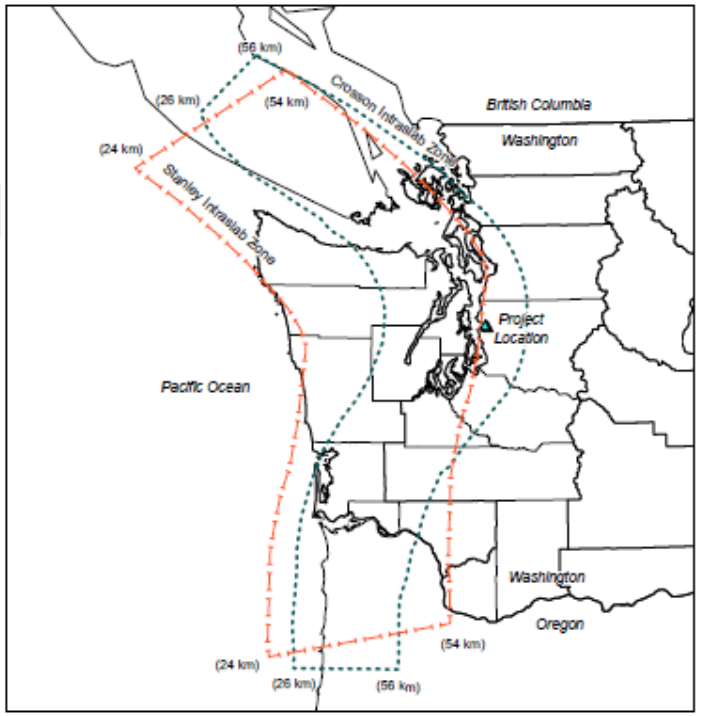
Earthquake Risk

- **Primarily a Design Consideration**
- **Considers Earthquakes from Multiple Fault Sources**
  - Large coastal subduction quakes (~ M_0 8.8)
  - Deep “Nisqually-type” earthquakes (~ M_0 7.0)
  - Individual known faults (~ M_0 6.8)
  - Random crustal earthquakes (~ M_0 6.5)
- **Risk Level**
  - 2,500-year return (no collapse)
  - Slightly greater than “Major Earthquake” design level in China

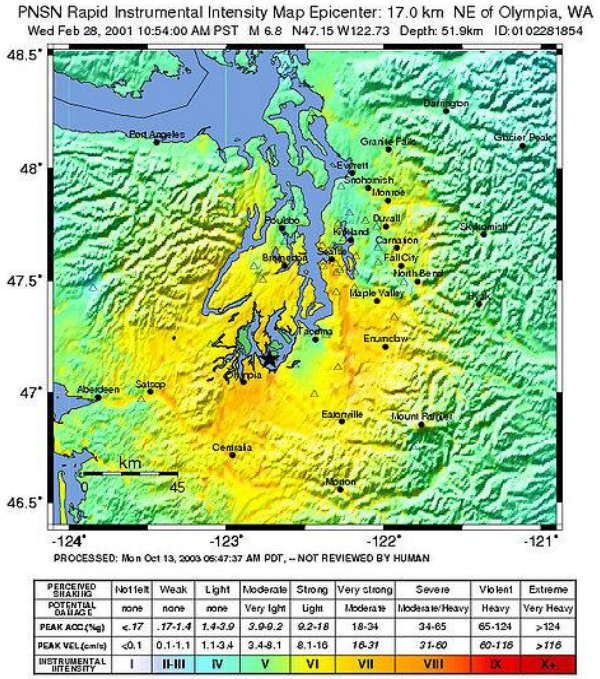
Earthquake Sources – Coast Subduction (~M 8.8)



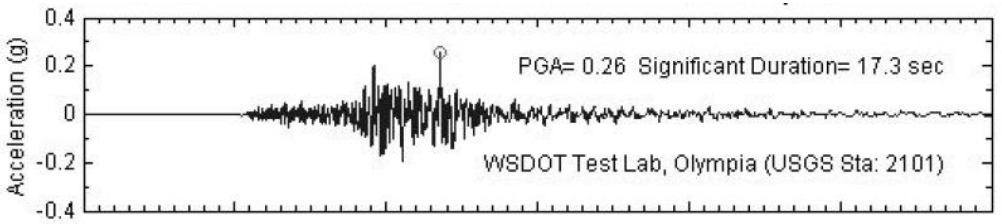




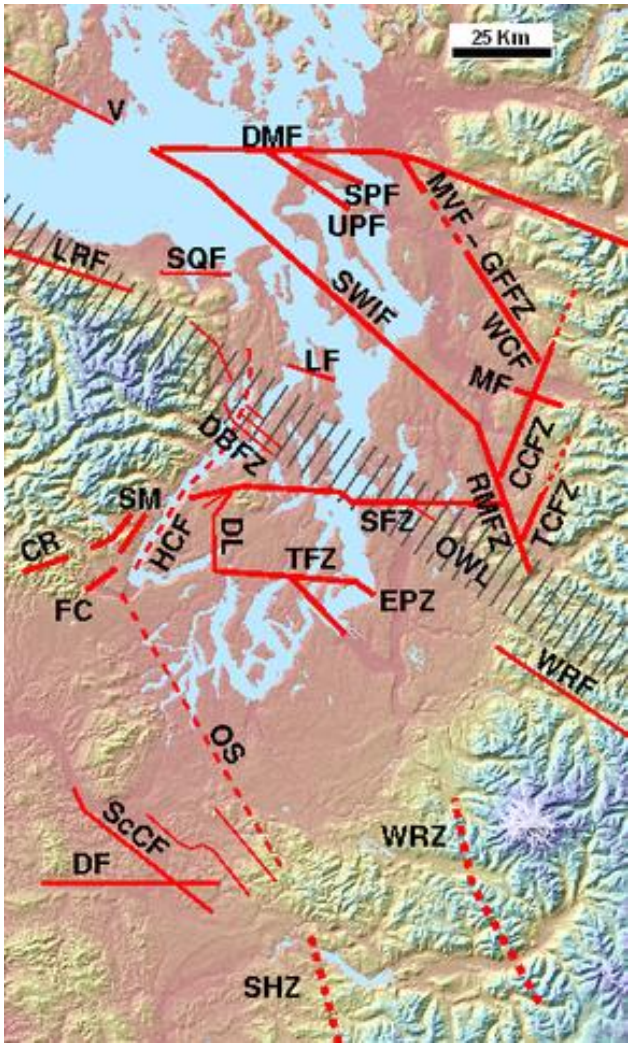
Earthquake Sources – Nisqually (~M 7.0)

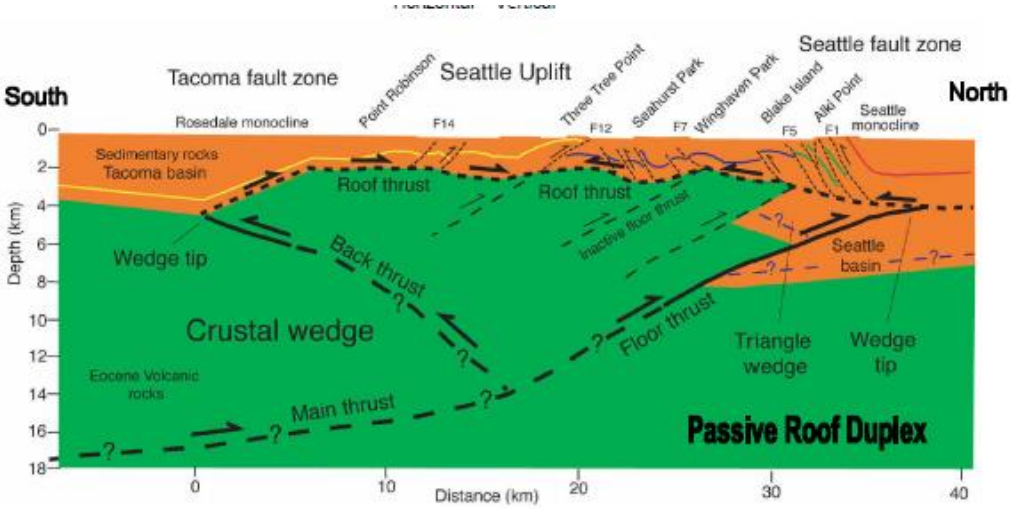


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

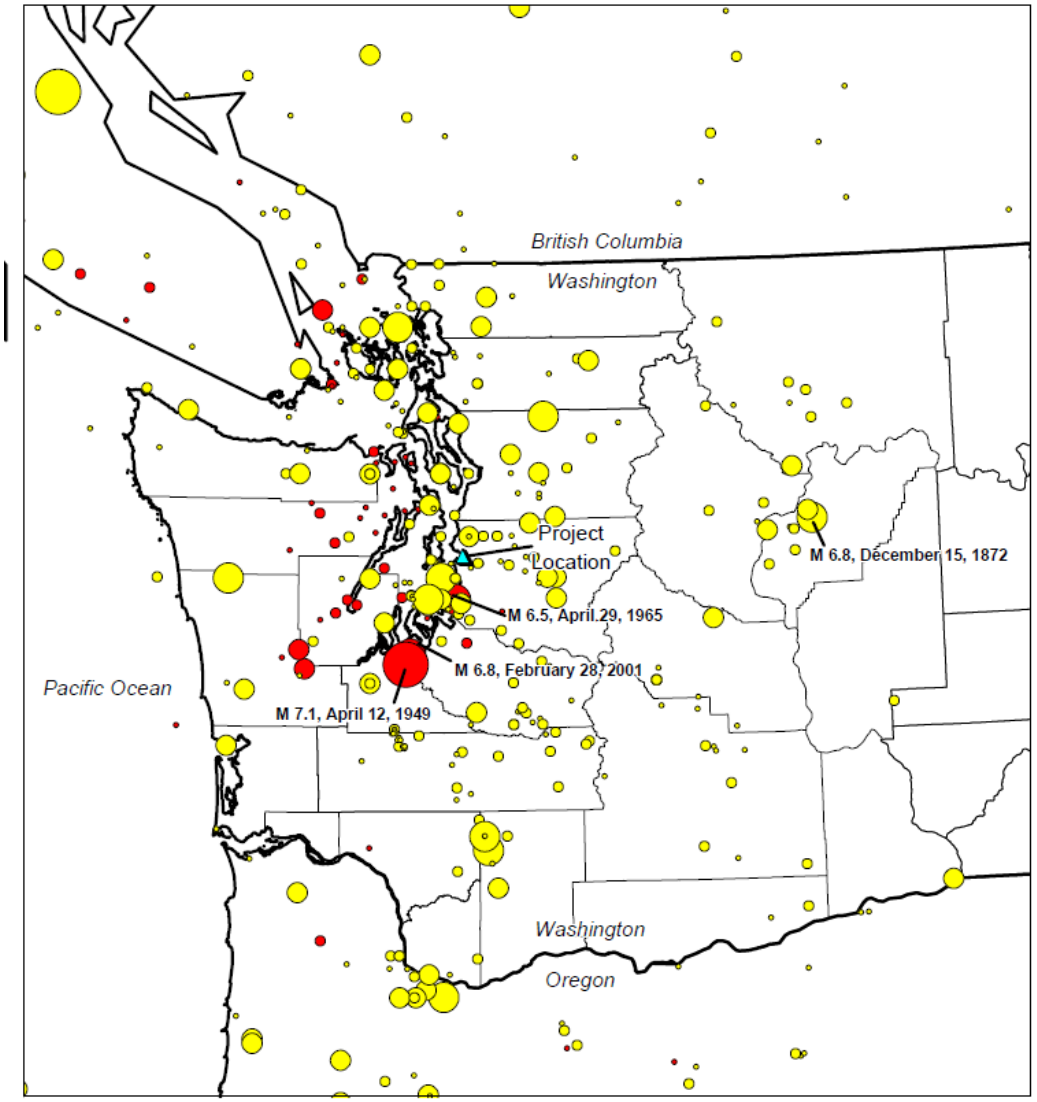


Earthquake Sources – Individual Faults (~M 6.8)





Random Earthquakes (~M 6.5)



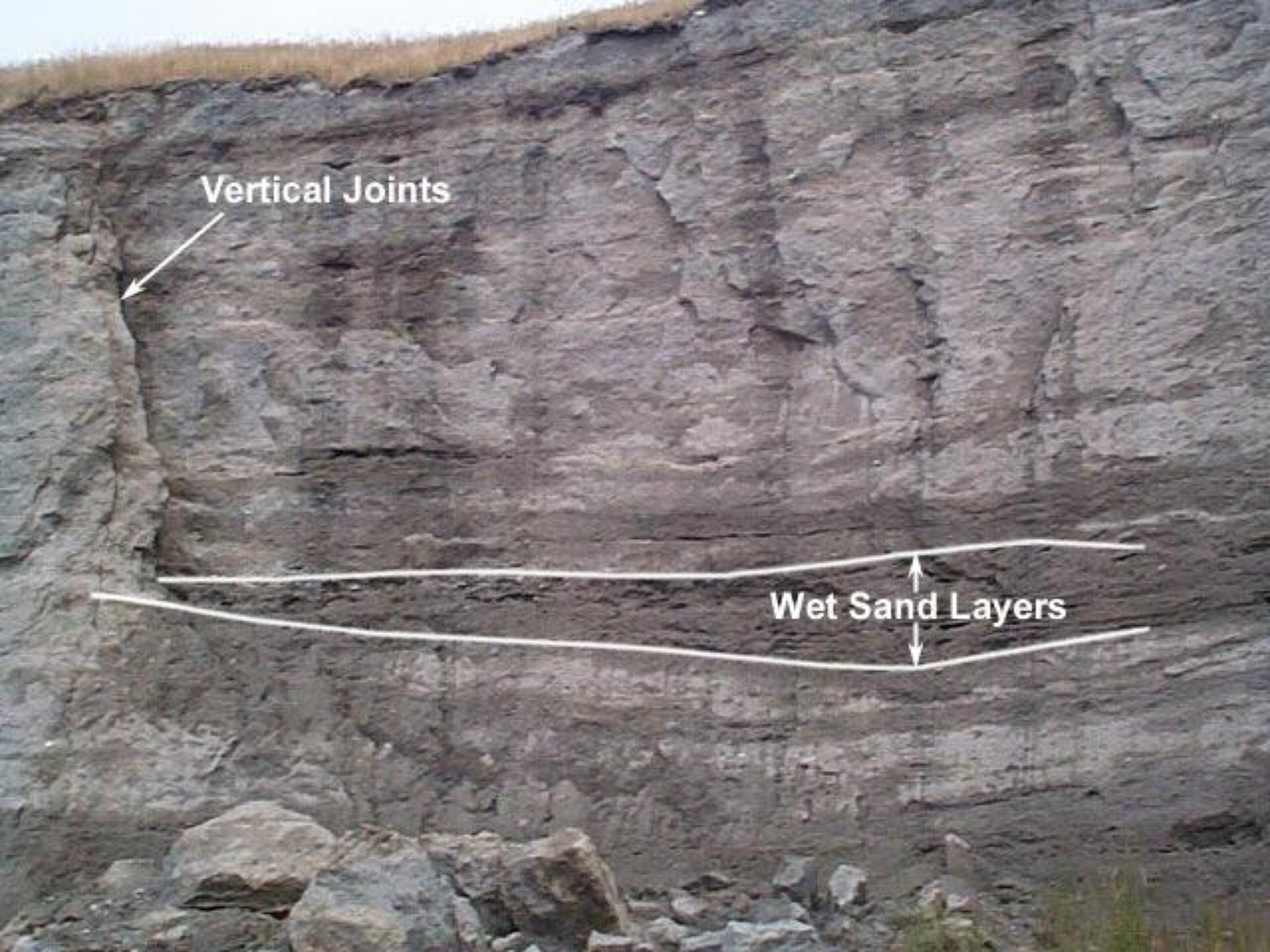
In-Ground Geotechnical Risk

- **Highly Variable Geologic Conditions**
- **Poor Soil Conditions in South End of Project**
- **High Groundwater Conditions**

Geotechnical Setting

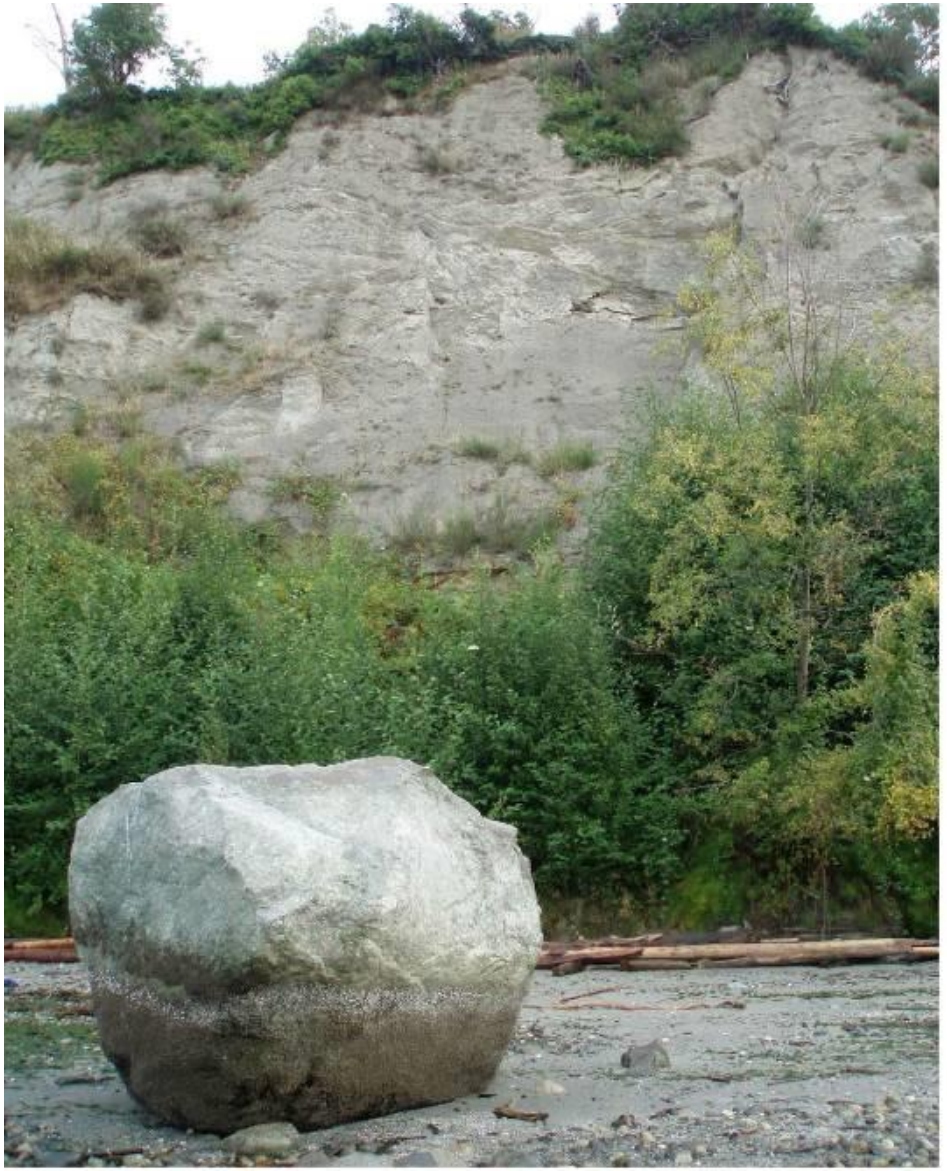
- **Glacially Sculpted and Overridden**
  - At least 6 glacial advances and retreats in last 2 M years
  - Up to 3,000 feet of ice loading
  - Over 3,000 feet of glacial and nonglacial soils north of Seattle Fault
  - Typical sequence – lacustrine clay, outwash, till, recessional
- **Glacially Eroded Troughs**
  - Duwamish filled with Mt. Rainier sediments
  - Historically-filled tidal flats

Vashon Glacial Till


Vertical Joints
Wet Sand Layers

Glacial Outwash

Boulders



Approximate nine-foot boulder erratic from glacial deposit (Qvd) (in background) on beach at southern end of Magnolia Bluff.

Hard Laminated Glacio-lacustrine Clays

Fractured Glacio-lacustrine Clay

Property of Museum of History & Industry, Seattle

Wood in Starbucks Excavation

Denny/Mercer St. CSO Tunnel - 2002

Denny/Mercer St. CSO Tunnel - 2002

Face Support in Slickensided Clay

Flowing Sand

Geotechnical Exploration

Geotechnical Exploration

- 123 mud rotary borings to depths of up to 300 feet
- 84 Sonic core borings with continuous sampling in tunnel horizon
- Hydraulic testing at 65 location; including long-term pumping tests
- Downhole geophysics at 20 locations
- Extensive pressure-meter testing
- Robust laboratory testing program

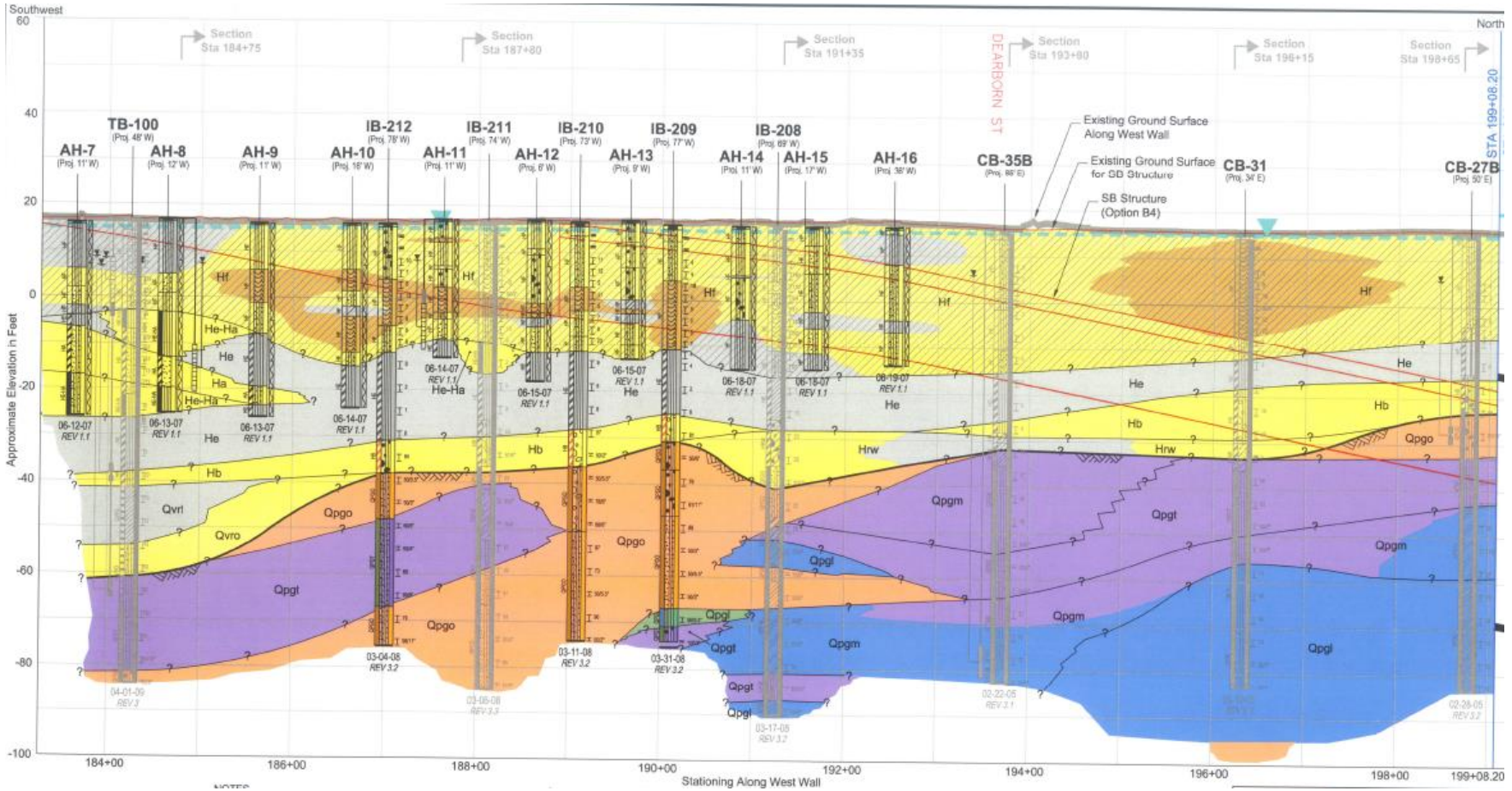
Ground Conditions

- **Tunnel Alignment in Glacially Overridden Soils:**
  - Mixed face
    - Hard clay and till
    - Dense silt, sand, and gravel
  - Perched groundwater & inflows
  - Flowing sands
  - Clogging sticky clays
  - Abrasive silt, sand, gravel, and till
  - Boulders

Geotechnical Contract Documents

- **Geotechnical Data Report (GDR)**
- **Geotechnical Baseline Report (GBR)**

South Portal Profile



Soil Unit Related Tunnel Construction Issues

- **ESU-1 (Recent Granular)** – loose to dense, sand and gravel, wet, flowing, wood debris
- **ESU-2 (Recent Clay & Silt)** – soft to stiff, squeezing, wood debris
- **ESU-3 (Till)** – hard, abrasive, impermeable, cobbles and boulders
- **ESU-4 (Sand & Gravel)** – dense, abrasive, high permeability, cobbles and boulders
- **ESU-5 (Cohesionless Silt & Fine Sand)** – dense, abrasive, medium permeability, organics, cobbles and boulders
- **ESU-6 (Cohesive Clay & Silt)** – hard, low permeability, fractured and sheared, sticky and clogging, organics, cobbles and boulders
- **ESU-7 (Dirty Sand & Gravel)** – dense, abrasive, medium to low permeability, cobbles and boulders

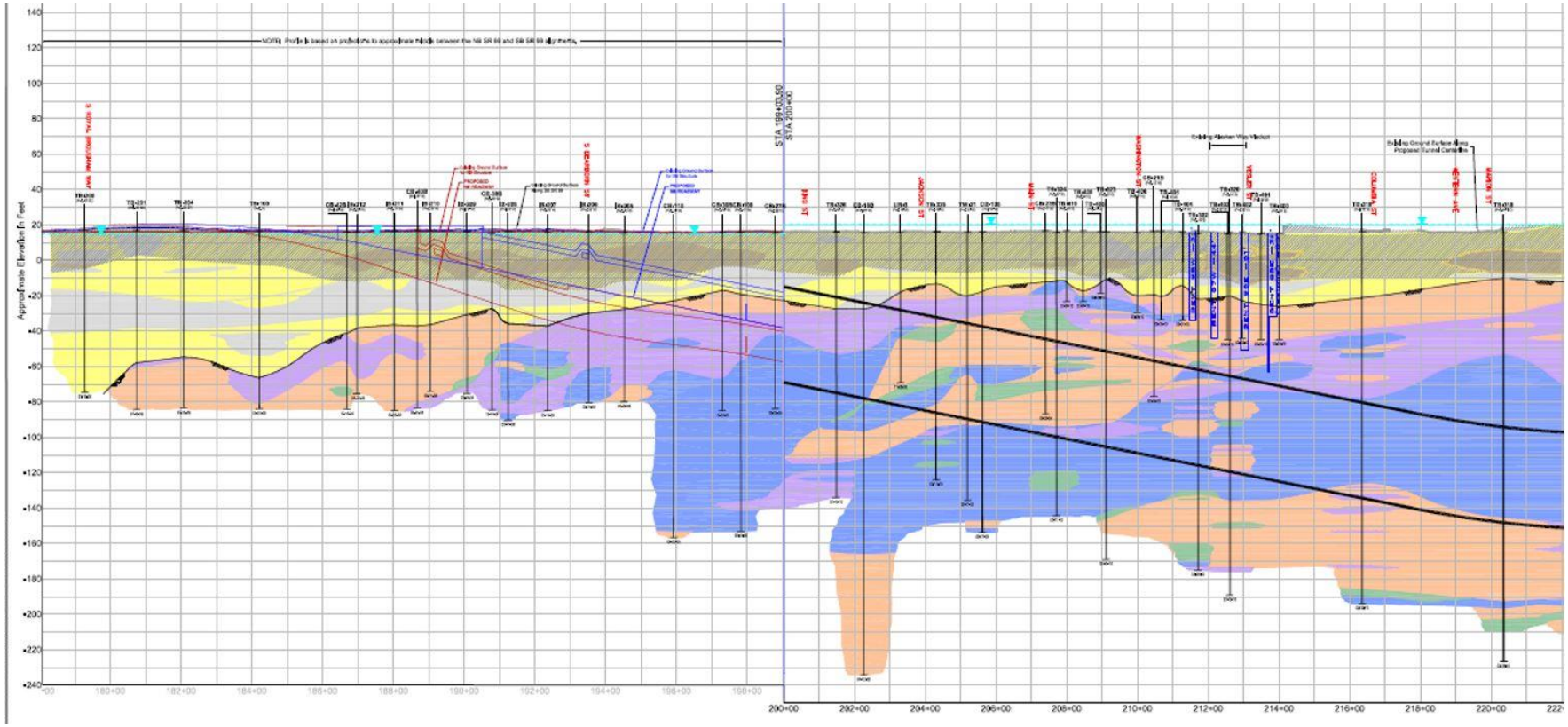
Geotechnical Contract Documents

Geotechnical Baseline Report (GBR)

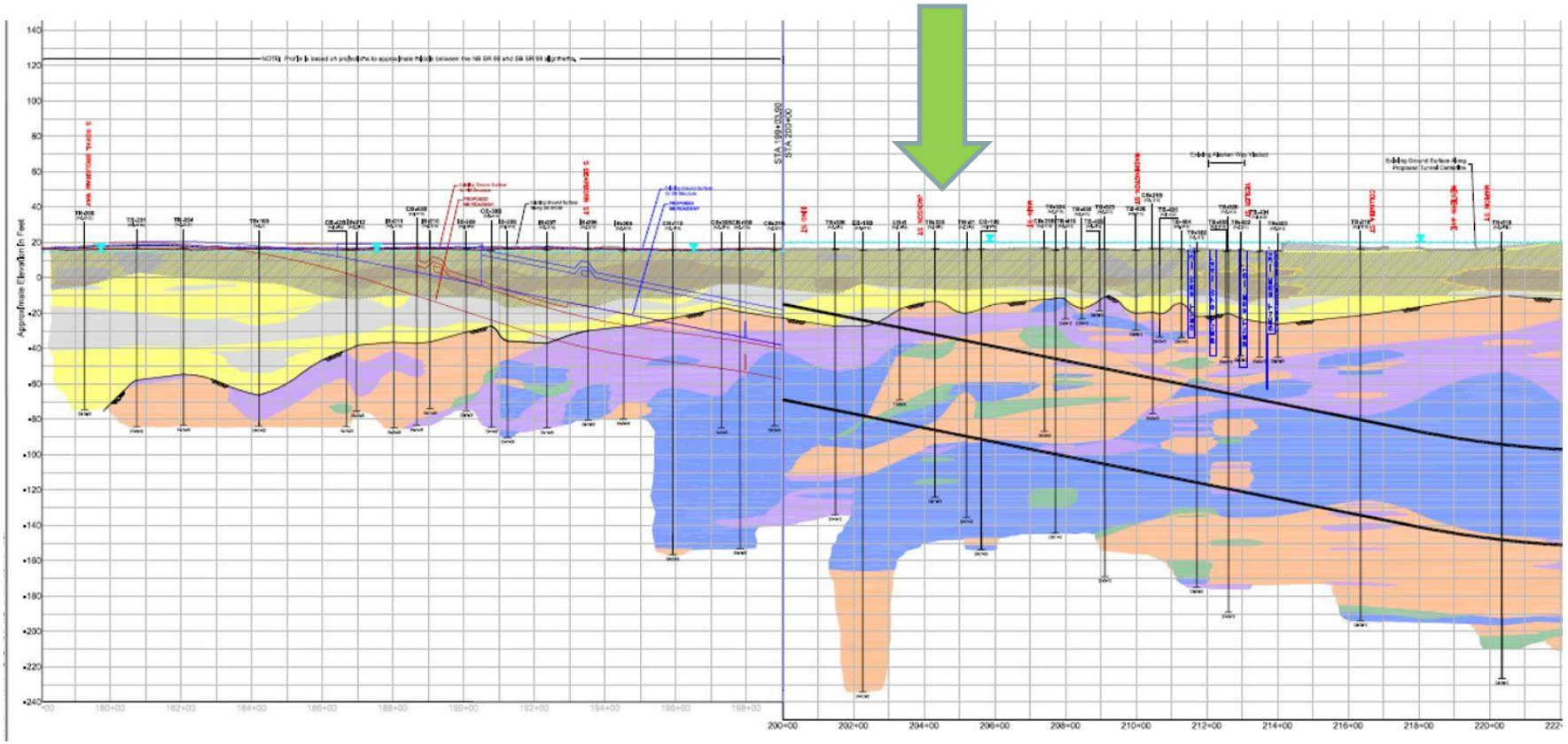
Table 10. Baseline Quantities of Boulders-Temporary Lateral Support Walls

Boulder Size	Number per 100,000 cubic yards of Excavation for temporary lateral support walls
	Baseline Value
1 to 2 feet in size	400
2 to 5 feet in size	40
Greater than 5 feet in size	4

Tunnel Profile - South



Tunnel Profile - South



Cross Section 201+50

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Questions?

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