Concrete Water Reservoir Foundation and Floor Slab Design Considerations

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GRI PSE

American Water Works Association

INTRODUCTION TO GRI and PSE

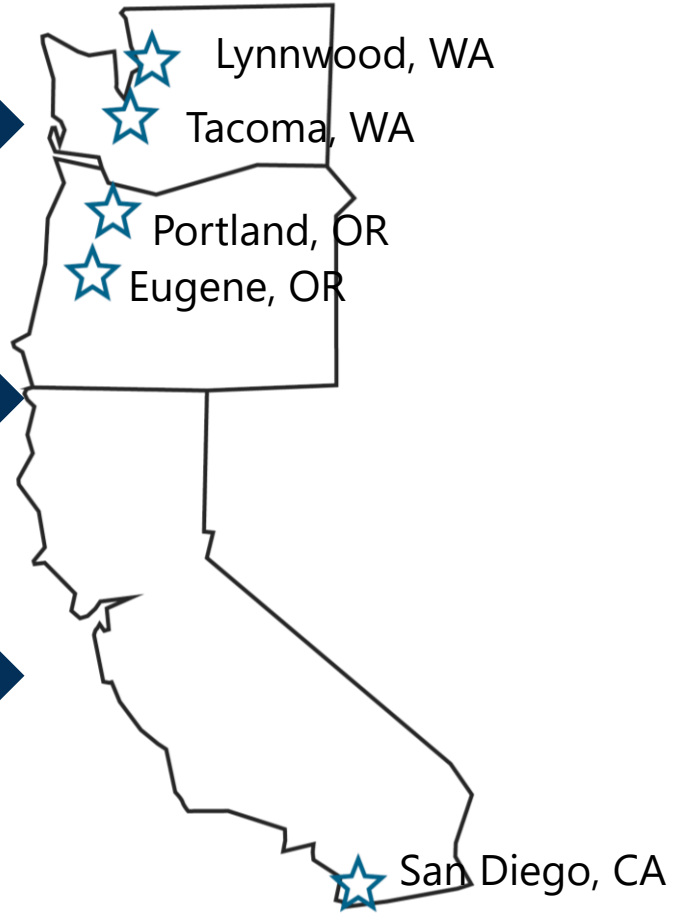
GRI

GRI has completed **over 150 reservoirs**

60+ water districts and authorities

PSE has completed **over 350 reservoirs**

GRI and PSE have partnered together on **40+ projects**



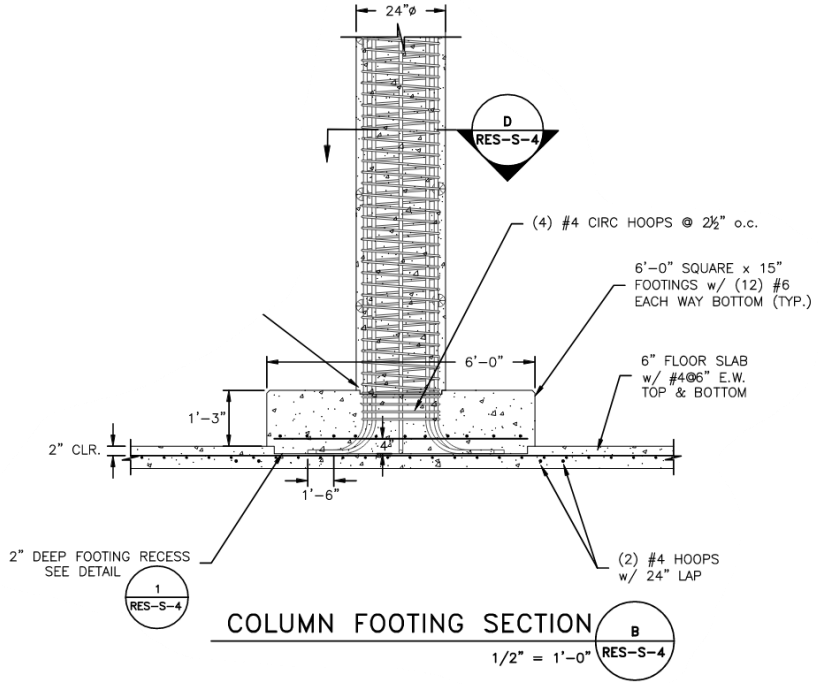
PSE

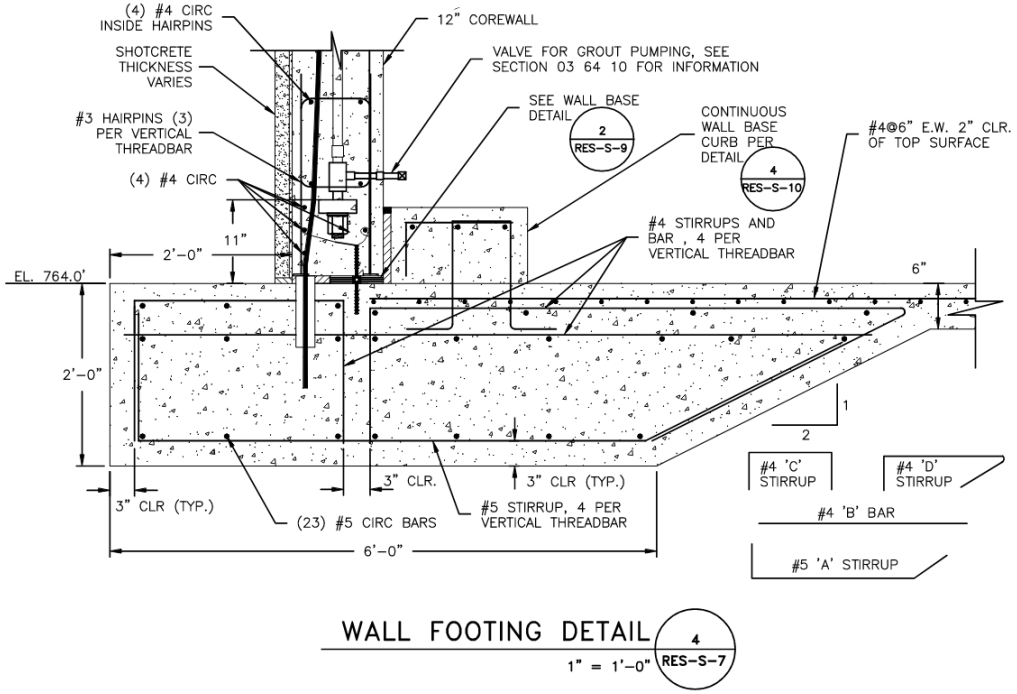
OUTLINE

- **Overview**
  - Foundation types and cost considerations
  - Allowable deformations
  - Site considerations and siting efforts
- **Case Histories**
  - City of Beaverton, OR Cooper Mountain Reservoir
  - City of Tigard, OR Cooper Mountain Reservoir
  - City of Lake Oswego, OR Waluga Reservoir No. 2
  - Willamette Water Supply, OR Reservoir 1
- **Conclusions**

FOUNDATION TYPES AND CONSIDERATIONS

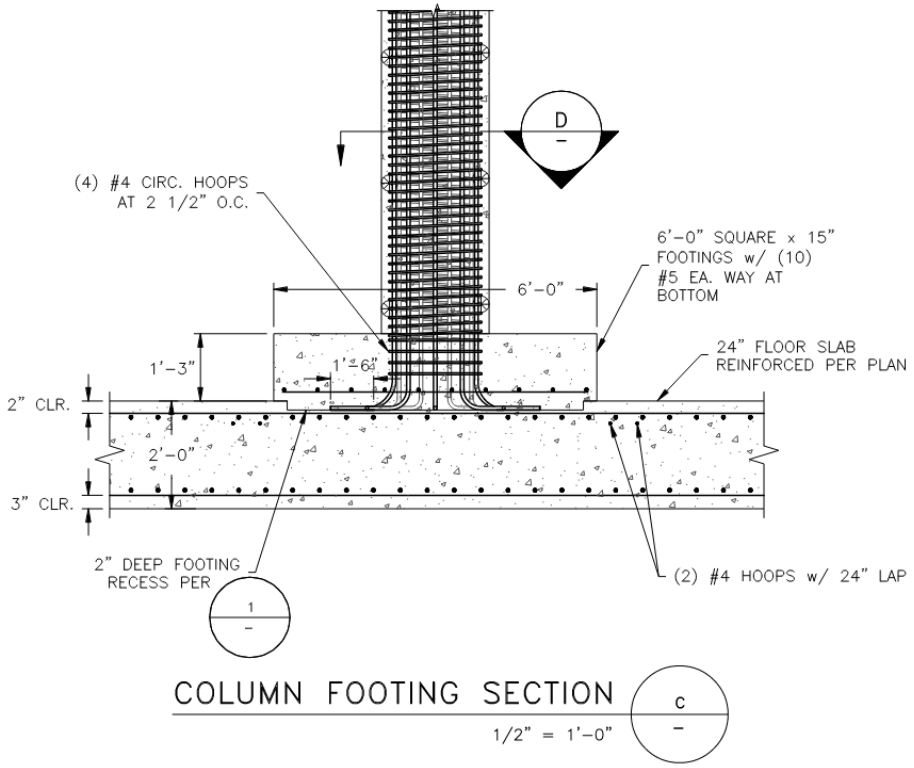
- **Membrane Slab**
  - Thin slab intended to act as a flexible, non-structural component and provide a membrane to retain water
  - Critical to limit differential deflection and cracking for water tightness. ¼" over 50' is our limit.
  - PSE limit thickness to 6" to preserve ductile behavior
  - Least expensive option, but often requires soil improvements which offset the savings.

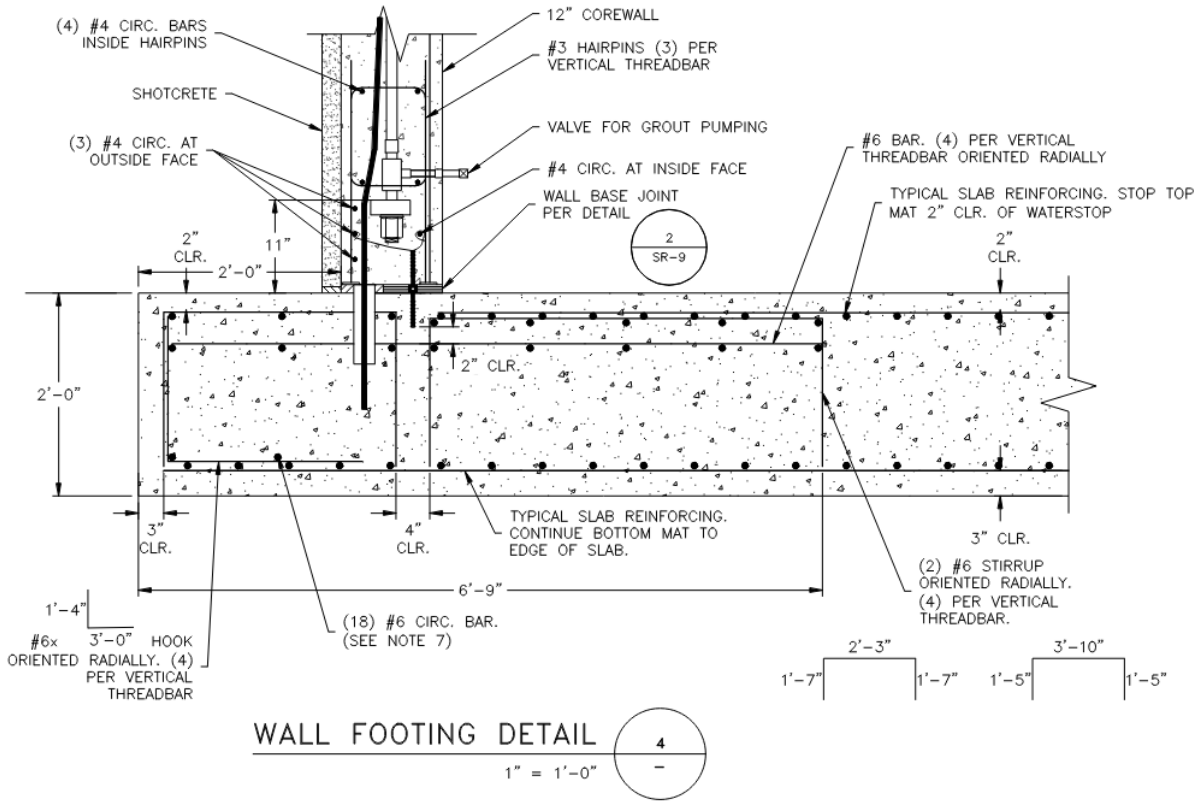




FOUNDATION TYPES AND CONSIDERATIONS

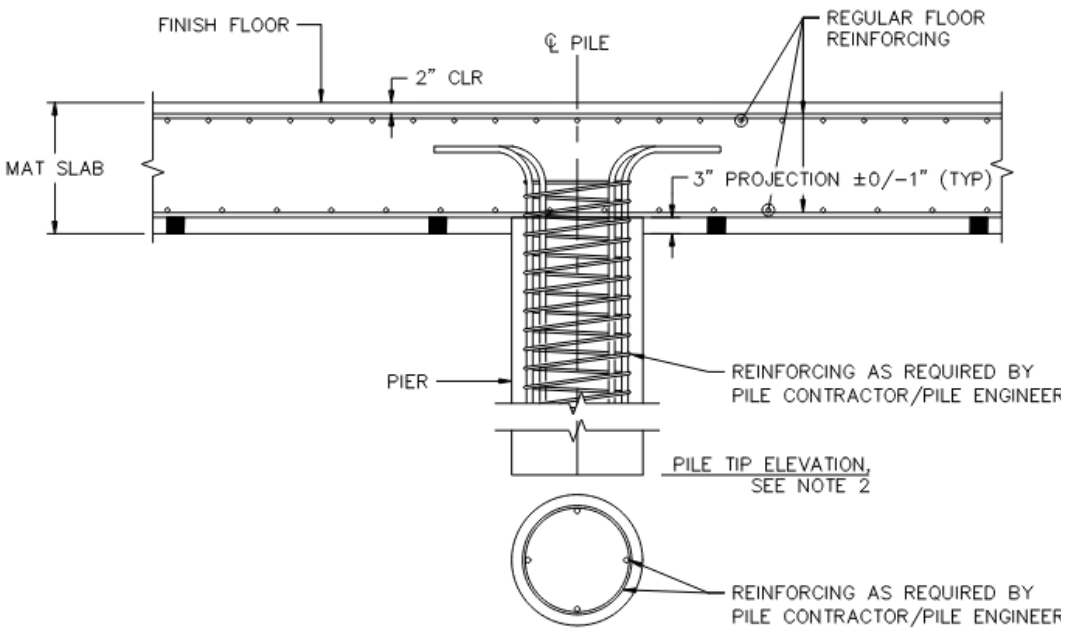
- **Mat Slab**
  - Thicker structural slab which redistributes the loads to the soils based on an interaction between the stiffness of the slab and the stiffness of the soils.
  - More resistant to differential seismic settlements and subsurface variability
  - Designed through a model with a 0.01" limit on crack widths. (0.009" for waste water)



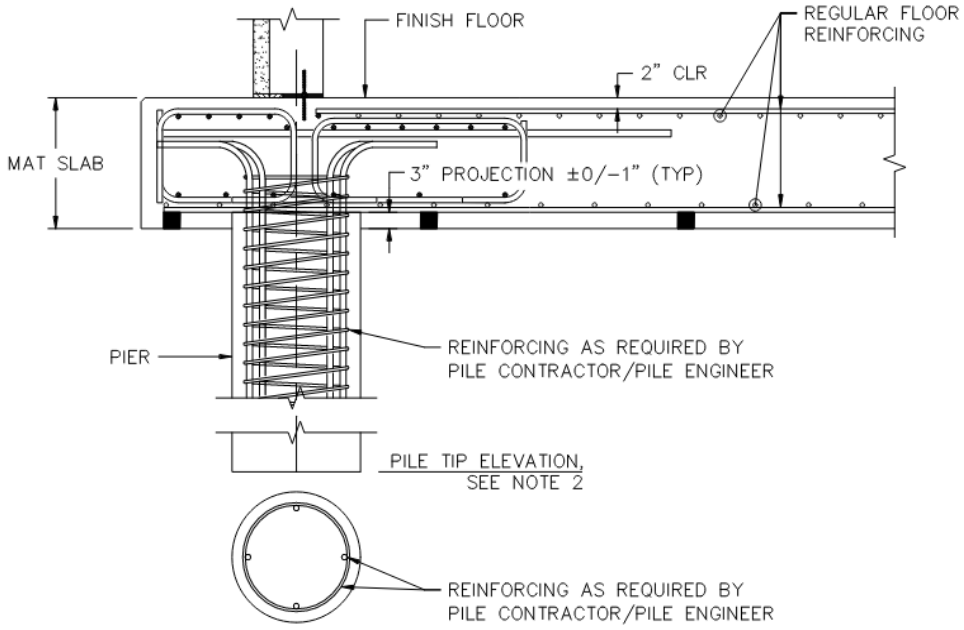


FOUNDATION TYPES AND CONSIDERATIONS

- **Deep foundations**
  - Piers, piles, and other deep foundation strategies.
  - A thick structural slab is required to span between the deep foundation elements.
  - Typically the most expensive option.



INTERIOR PILE DETAIL 1/–



PERIMETER PILE DETAIL 1/–

*Details curtesy of DN Tanks

FOUNDATION COSTS -

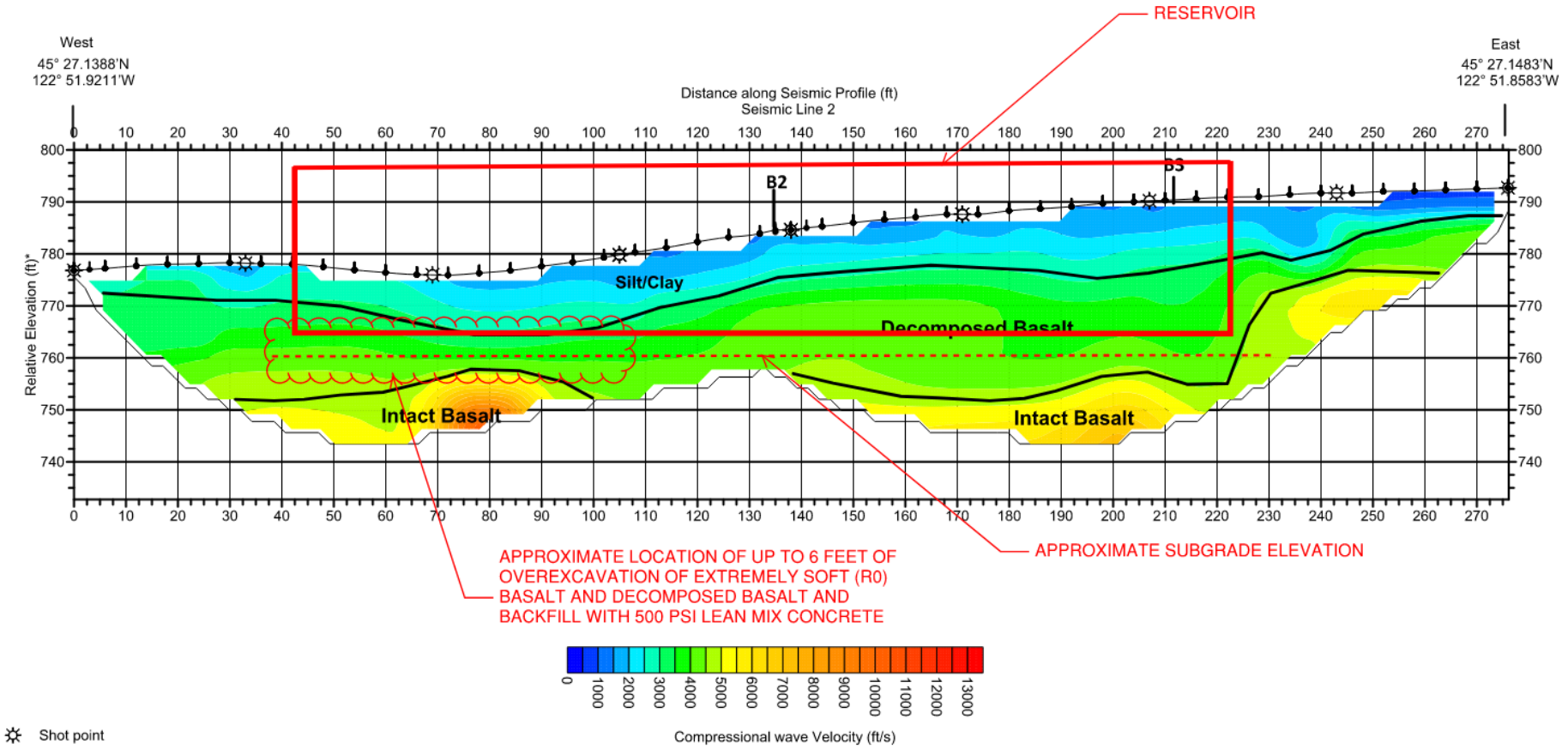
- Example comparison of:
  1) Membrane with assumed 5 feet of over-excavation
  2) Mat without over-excavation

Membrane			
	Volume (CY)	Cost/CY	Cost
Excavation, 9 feet	10,800	$25	$270,000
Backfill, Crushed Rock	5,400	$50	$270,000
Backfill, CLSM	3,600	$150	$540,000
Concrete slab	730	$1,000	$730,000
Total			$1,810,000
Mat			
	Volume (CY)	Cost/CY	Cost
Excavation, 4 feet	4,800	$25	$120,000
Backfill, Crushed Rock	3,000	$50	$150,000
Concrete slab	1,770	$860	$1,522,200
Total			$1,792,200

CITY OF BEAVERTON, COOPER MOUNTAIN RESERVOIR

- Construction 2023
- Type I, wire-wound, circular, pre-stressed concrete tank
- Capacity: 5.5 MG
- Diameter 180 ft, height 30 ft,
- 6-inch-thick concrete membrane slab foundation. Settlement criteria: ¼ inch over 50 feet or equivalent angular distortion across shorter distances
- General Geology: Columbia River Basalt

CITY OF BEAVERTON, COOPER MOUNTAIN RESERVOIR



- Variably weathered basalt
- Borings and geophysical showed variations
- Decomposed basalt better than in some other areas and decision to try and use membrane slab

CITY OF BEAVERTON, COOPER MOUNTAIN RESERVOIR

Subgrade typical R1 (very soft) or harder basalt

Overexcavation of decomposed basalt. Area backfilled with 500 psi lean mix

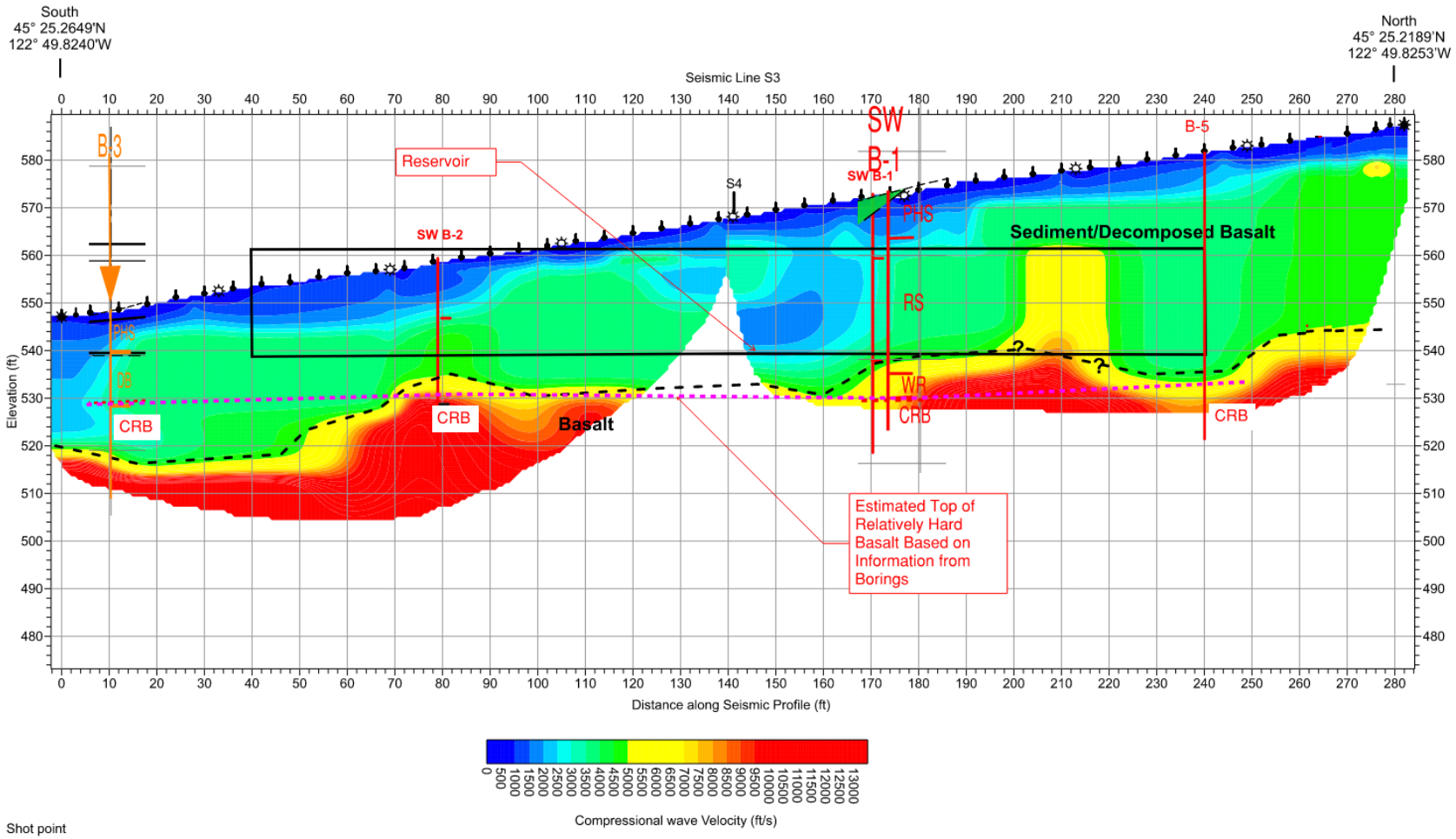
- Field judgement call to match design assumptions

CITY OF TIGARD, RESERVOIR 18

- Under construction
- Type I, wire-wound, circular, pre-stressed concrete tank
- Capacity: 4.5 MG
- Diameter 200 ft, height 24 ft,
- 2-ft-thick reinforced concrete mat slab foundation. Foundation design based on subgrade modulus and control of cracking for estimated differential settlements.
- General Geology: Columbia River basalt

Photo from Emery & Sons Construction site camera

CITY OF TIGARD, RESERVOIR 18



- Variably weathered basalt
- Borings and geophysical showed variations
- Subsurface data indicated material stiff enough for a membrane too deep to economically chase
- Decision made to use mat slab

CITY OF TIGARD, RESERVOIR 18

Finished Subgrade

CITY OF TIGARD, RESERVOIR 18

CITY OF LAKE OSWEGO, WALUGA RESERVOIR NO. 2

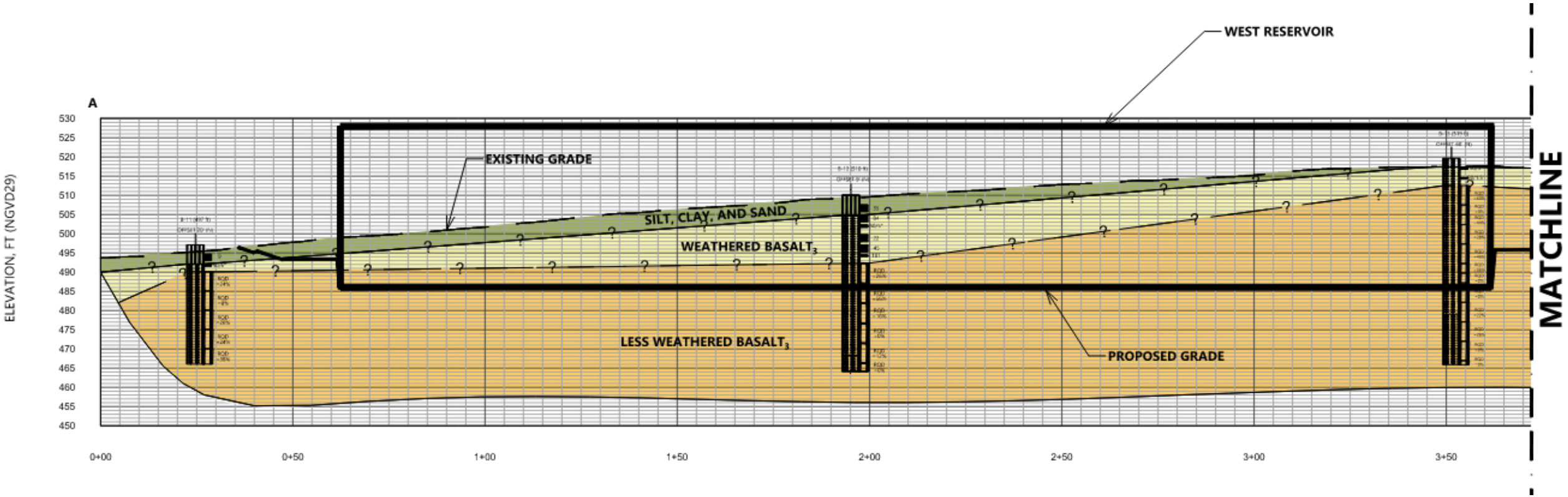
- Construction 2015
- Circular, pre-stressed concrete tank with dome roof and no interior columns
- Capacity: 3.5 MG
- Diameter 131 ft, Wall height 36 ft
- 6-inch-thick concrete membrane slab foundation. Settlement criteria : 1/300 (ratio of settlement to horizontal distance) from edge of reservoir to center of reservoir and 1/600 around the perimeter of the reservoir
- General geology: boring lava

- Hard Rock, Subgrade Preparation Considerations

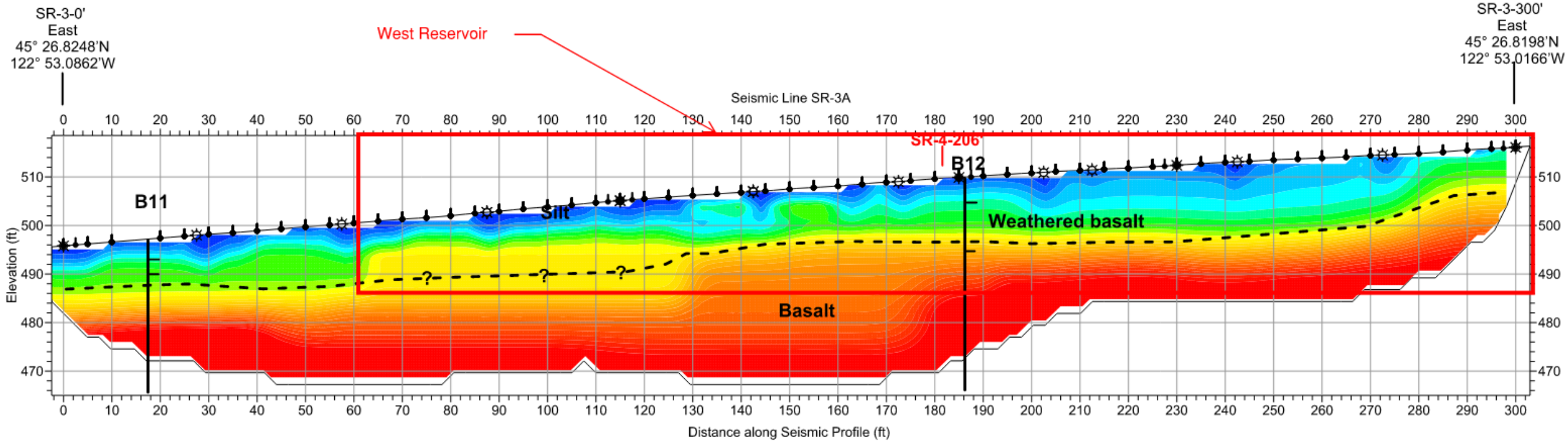
WILLAMETTE WATER SUPPLY PROGRAM, RES_1.0

- Construction underway
- Two, circular, pre-stressed concrete tanks
- Capacity: 15 MG each
- Diameter 300 feet, wall height 30 feet
- 8-inch-thick concrete membrane slab foundation. Settlement criteria: ¼ inch over 50 feet or equivalent angular distortion across shorter distances
- General geology: Columbia river basalt

WILLAMETTE WATER SUPPLY PROGRAM, RES_1.0



WILLAMETTE WATER SUPPLY PROGRAM, RES_1.0

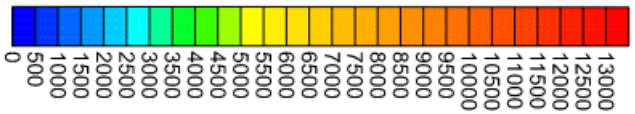


Shot point

Geophone

Horizontal Scale: 1" = 20'
Vertical Scale: 1" =20'

Horizontal Latitude and Longitude (WGS 1984) surveyed with
Trimble GeoXH 6000 GPS Receiver (Post-processed estimated horzontal accuracy < 1 foot)
Geophone elevations surveyed with level and rod (Tied to DOWL CP #57 Elevation 501.3')



Compressional wave Velocity (ft/s)

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Email: DLauer@earthdyn.com

Willamette Water Supply Program Res. 1.0
Washington County, OR

Seismic Profile SR-3A - SeisOpt2D Model

Job #:	Date:	Figure:
20204	4/9/2020	A-1

WILLAMETTE WATER SUPPLY PROGRAM, RES_1.0

WILLAMETTE WATER SUPPLY PROGRAM, RES_1.0

WILLAMETTE WATER SUPPLY PROGRAM, RES_1.0

- Blasting Considerations and Rock Removal can also impact foundation types

SUMMARY

- **Every Site is Different**
  - Sloping Conditions and Variable Weathering in Rock are Common Considerations
- **Cost/Risk Decision on Foundation Assumption needs to be made early**
  - Need enough geotechnical information
  - Coordination between structural and geotechnical assumptions are commonly critical path for the appropriate foundation type
- **Field Observations and Judgement Calls are Essential to Confirming Design Assumptions**

Questions?

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