PNWS-AWWA ♦ 2011 SPRING CONFERENCE ♦ May 4-6, 2011

Go Deep

5,000 GPM Cascade Well No. 5

Session FA1 ♦ 9:45-10:45 AM ♦ Friday, May 6, 2011

Go Deep: 5,000 GPM Cascade Well No. 5

Presented by

Harvey Barnes • Rockwood Water PUD

Walter Burt, LHG • GSI Water Solutions, Inc.

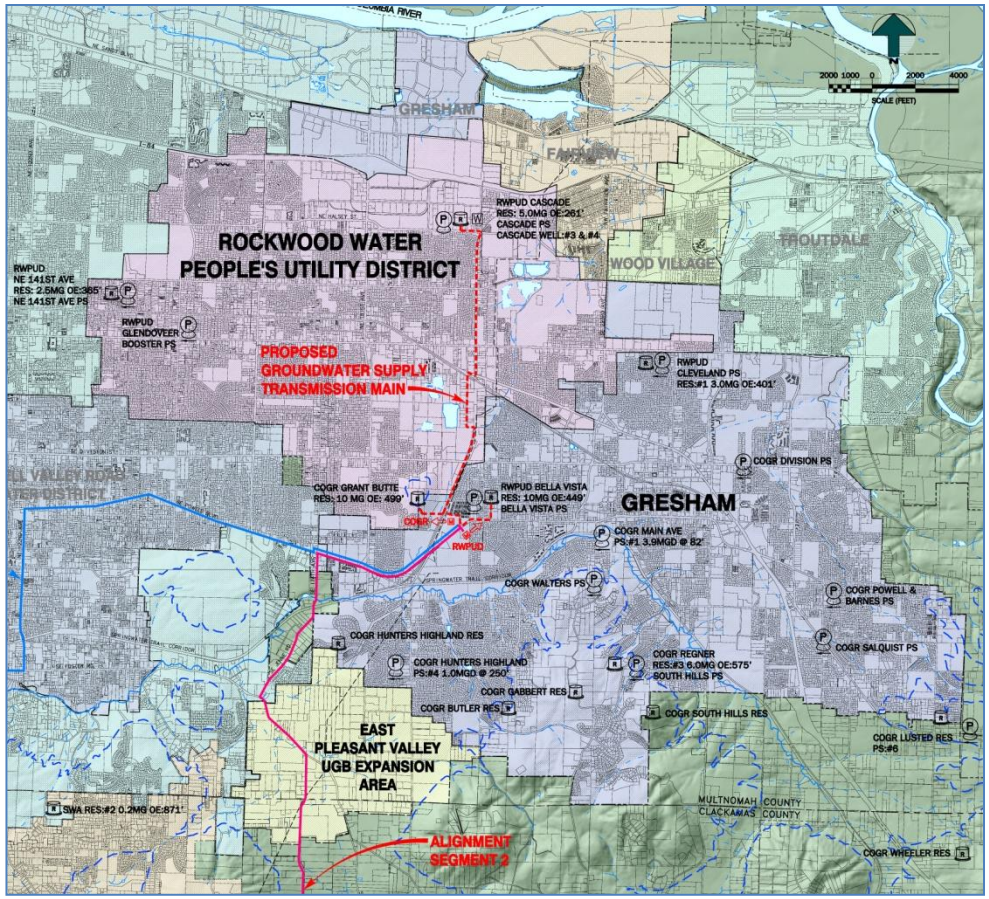
Matt Hickey, P.E. • Murray, Smith & Associates, Inc.

Project Team

- Rockwood Water PUD
- City of Gresham
- GSI Water Solutions, Inc.
- Murray, Smith & Associates, Inc.
- S&B, Inc.
- Ward-Henshaw Construction Co., Inc.
- Boart Longyear Company

5,000 GPM CASCADE WELL NO. 5

- Very successful project undertaken by Rockwood Water PUD and the City of Gresham
- A key water supply project for the two entities
- Challenging project due the size and depth and capacity of the well and the constrained site



PEOPLE SERVED

- Gresham 56,000
- Rockwood 35,000 Gresham

  18,000 Portland/Fairview

ROCKY RELATIONSHIP

- Aggressive annexation
- Reorganizing as a new form
- Dispute over governance

WORKING TOGETHER

- Lower costs
- Improve security
- Better coordination
- Increase customer value

SIMILAR NEEDS

- Wholesale water costs
- Water right permits
- Alternate water supplies
- Sharing costs

MAJOR SAVINGS

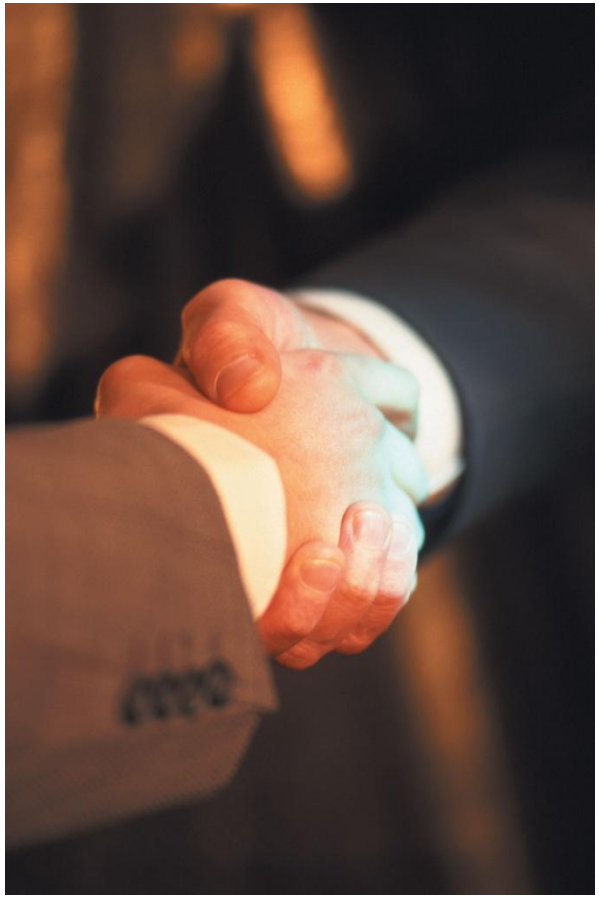
- Capital (for 11.5 mgd)
- $10 million together
- $25 million separately

OPERATIONAL SAVINGS

- Routine monitoring/maintenance
- Groundwater protection
- Water management/ conservation plan

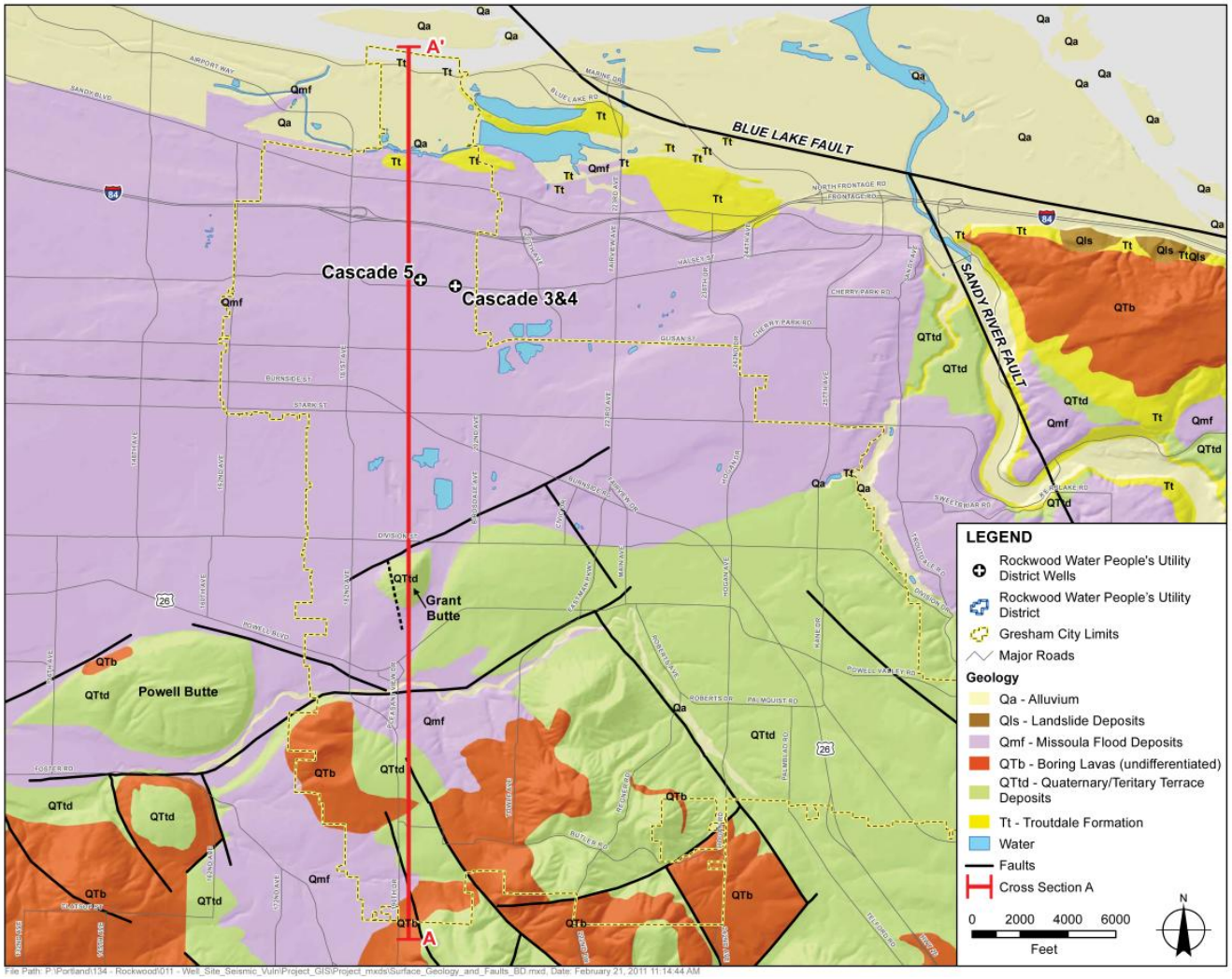
ANCILLARY BENEFITS

- Mutual customers
- Urban trail construction
- Relationship



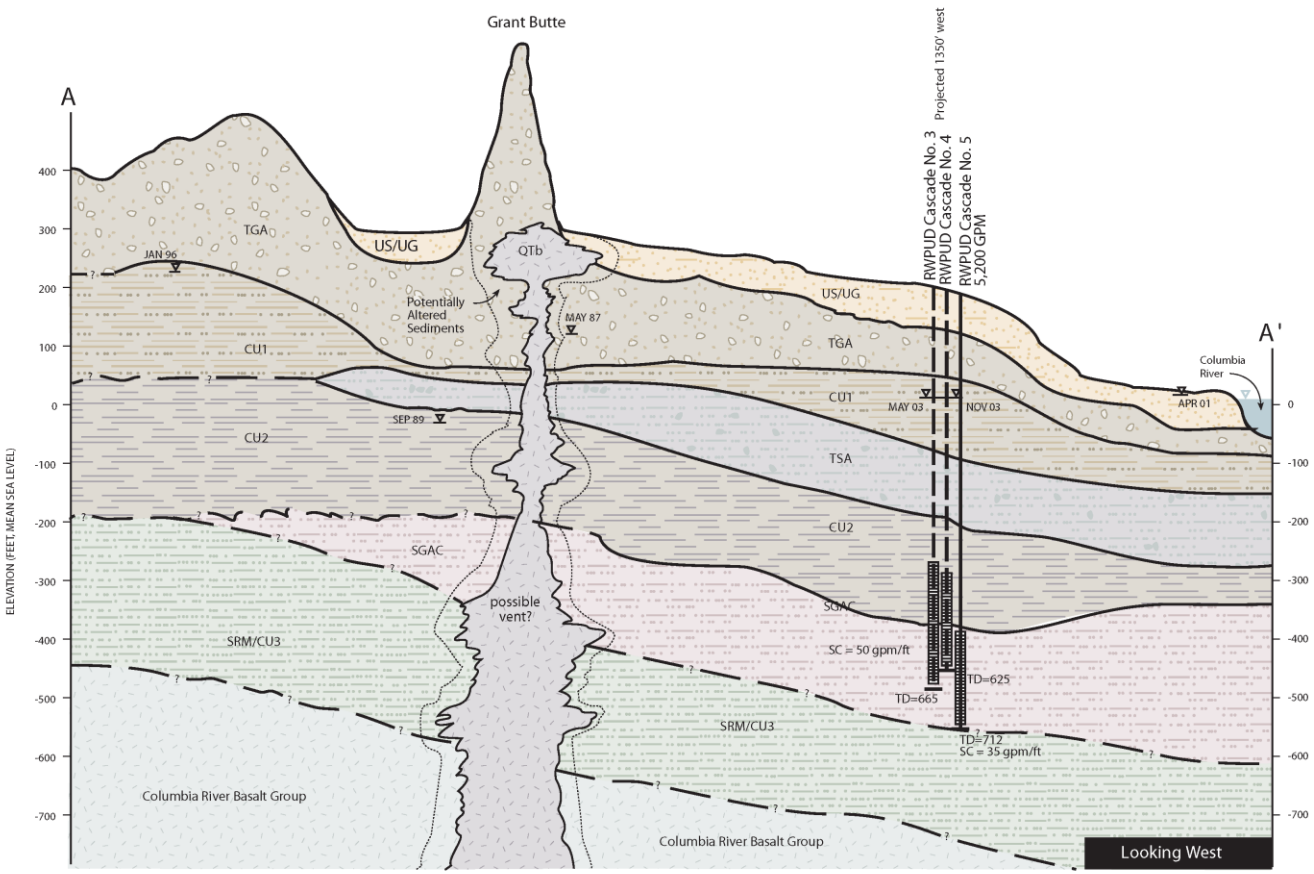
AREA HYDROGEOLOGY AND PROJECT BACKGROUND

- Hydrogeology
- Other wells
- PUD's water rights
- Partnering of the two entities for mutual benefit

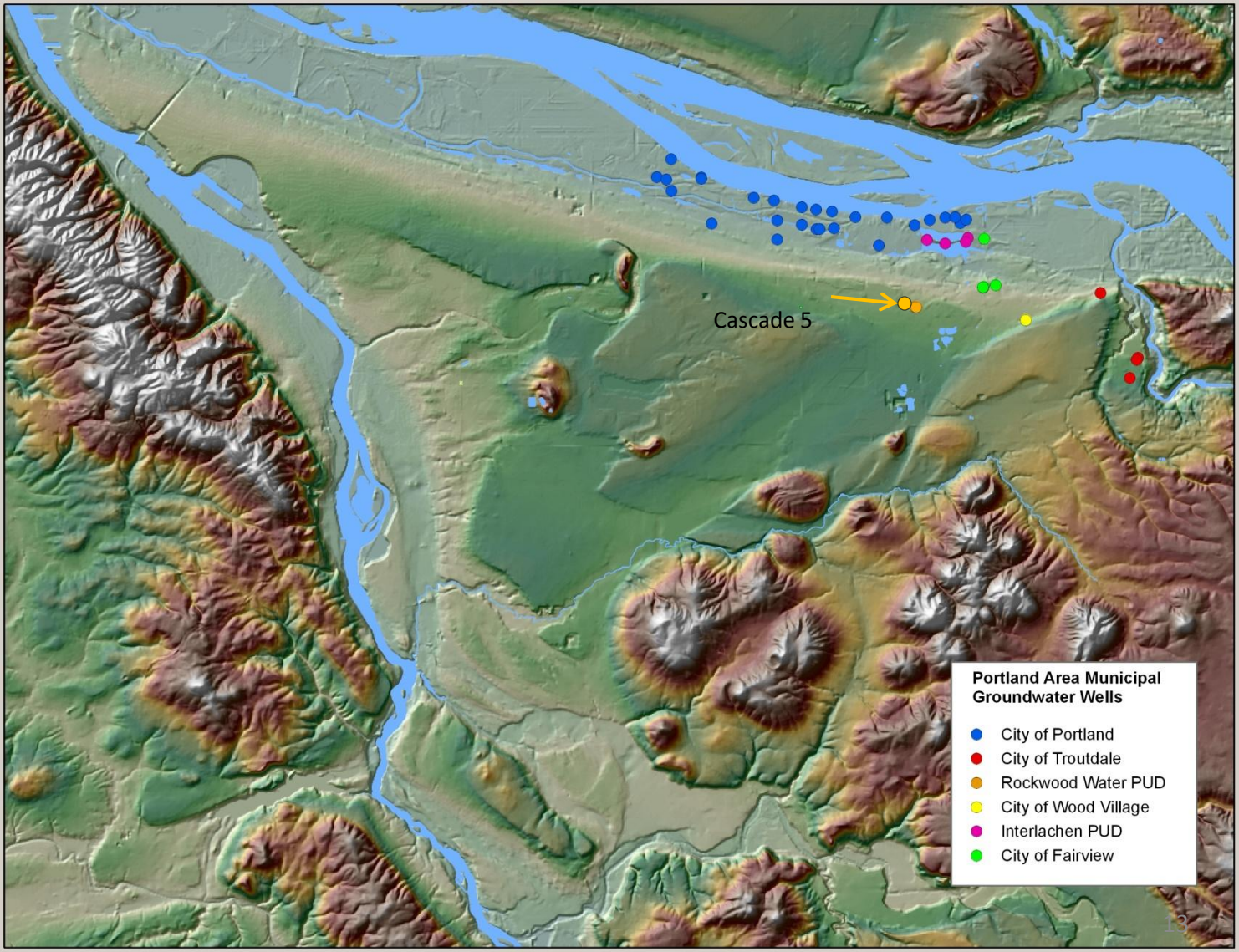


SAND AND GRAVEL AQUIFER (SGA)

- Pliocene (~2 mya) Ancestral Columbia River Deposits
- Major Basin-Wide Deep Aquifer
- Typical Well Capacity 700 – 3,500 gpm

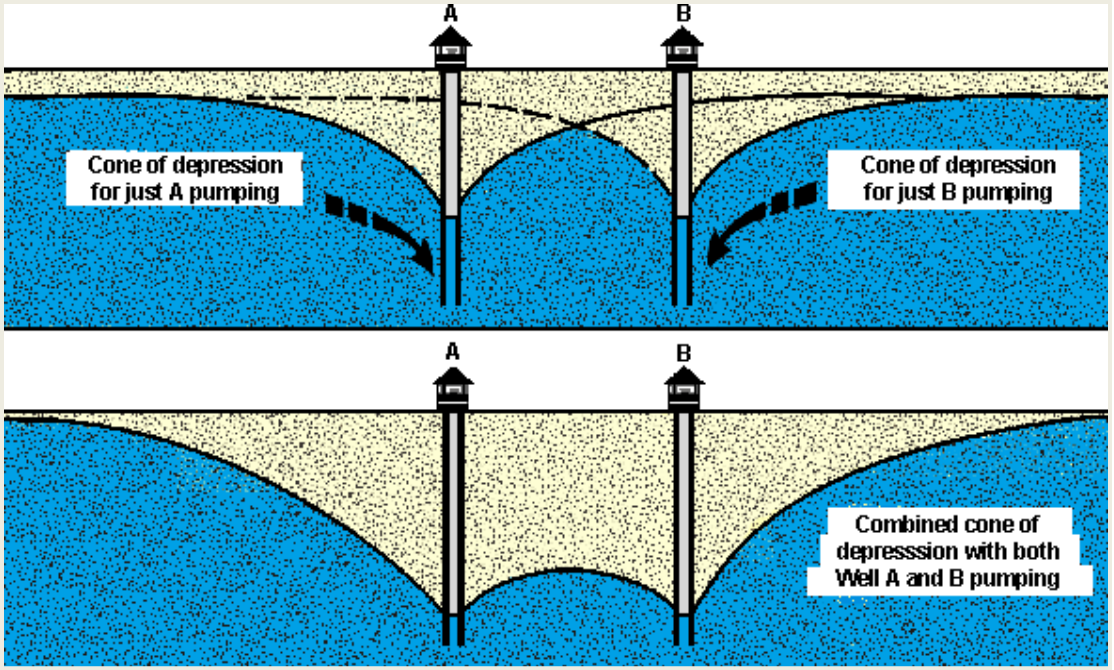


SOME OF THE OTHER WELLS



WELL SITING

- Cascade 3 and 4 observations
- Great Aquifer (T ~130,000 – 150,000 gpd/ft; no nearby boundaries)
- Testing and interference analysis



LOCAL SETTING

FIGURE 1

Site Location and Well Site Map

Rockwood PUD Cascade 5
Multnomah County, Oregon

LEGEND

- Proposed Well Location "Cascade #5" City of Gresham, Fire Station #74 1520 NE 192nd Ave Portland, Oregon 97230 SW1/4 SE1/4, SEC 29, T1N, R3E
- Other Rockwood PUD Production Wells
- Property Boundary
- Streets

N

Scale
1:2,400

0 100 200 300 400
Feet

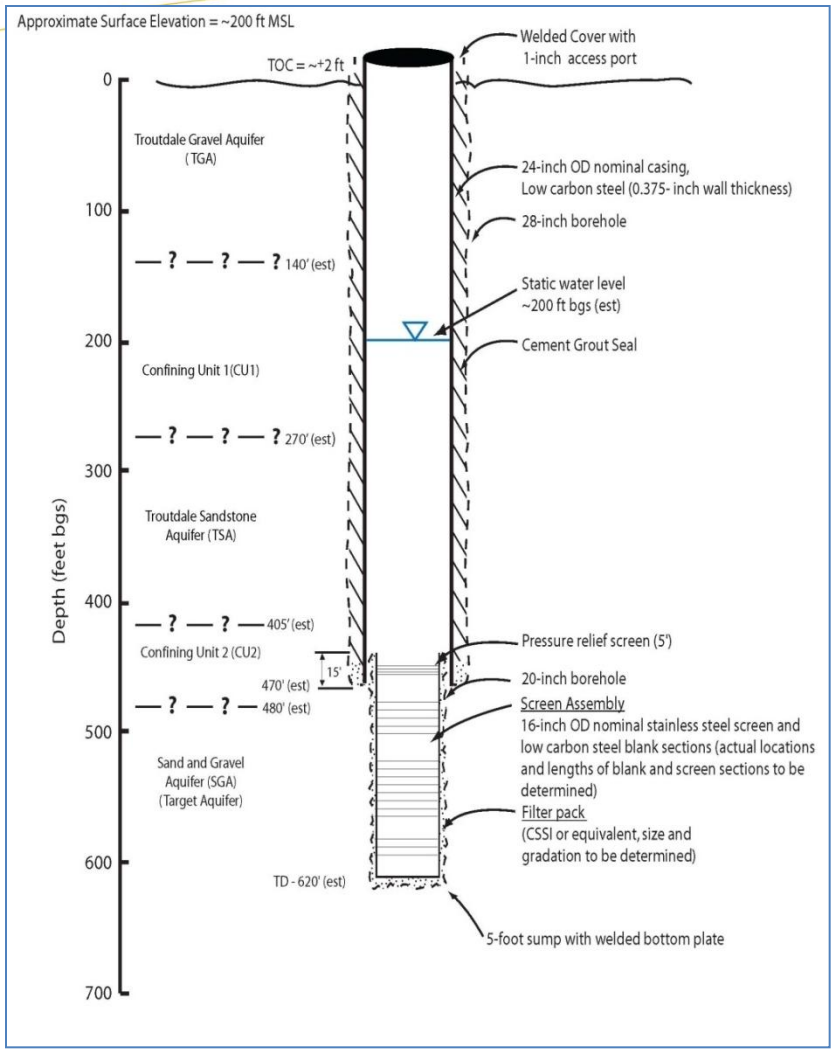
MAP NOTES:
Projection: Oregon State Plane North Zone
Datum: North American Datum of 1983
Date: August 27, 2008
Data Sources: METRO RLIS, Golder Associates

GSI Water Solutions, Inc.

WELL DESIGN

- Depth
- Diameter
- Screen design
- Anticipated aquifer characteristics
- Drilling challenges

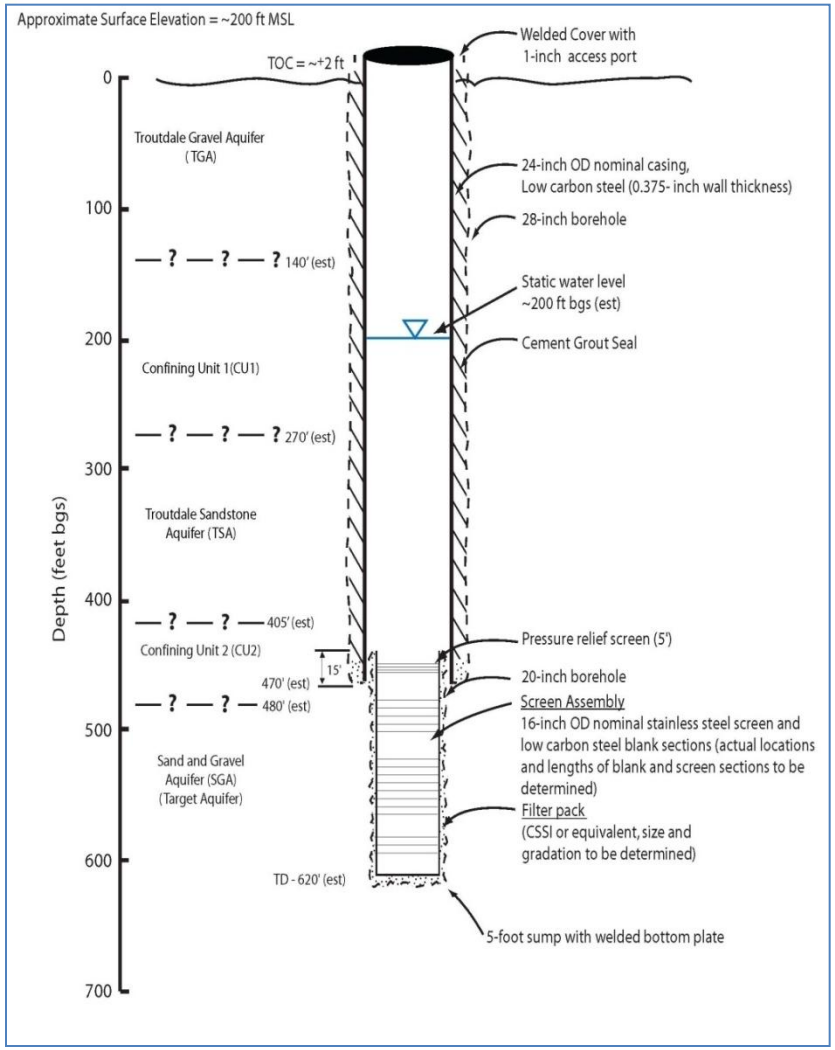
THE PLAN

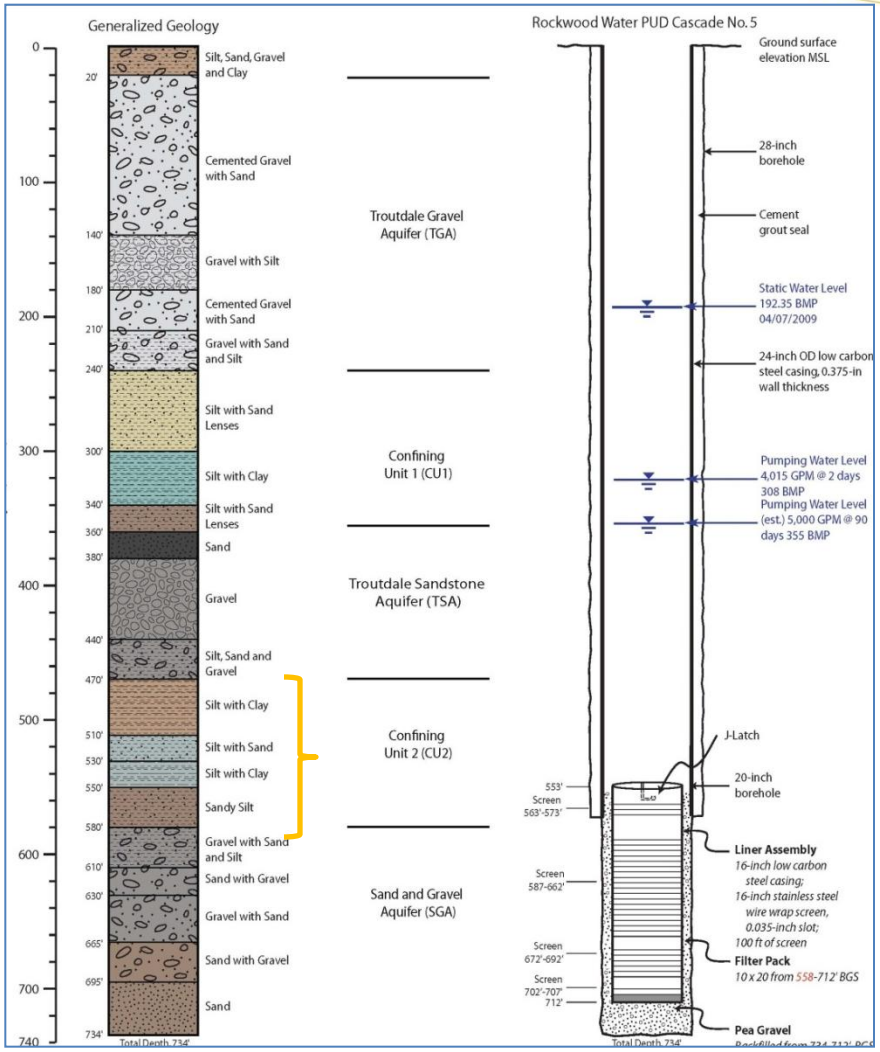


- 620 feet deep (just like the last one…)
- 28-inch upper borehole/24-inch production casing
- 20-inch lower borehole/16-inch screen
- Mud Rotary upper borehole
- Dual rotary RC lower borehole

PRELIMINARY DESIGN

THE REALITY





PRELIMINARY DESIGN

AS-BUILT

UPPER BOREHOLE CHALLENGES

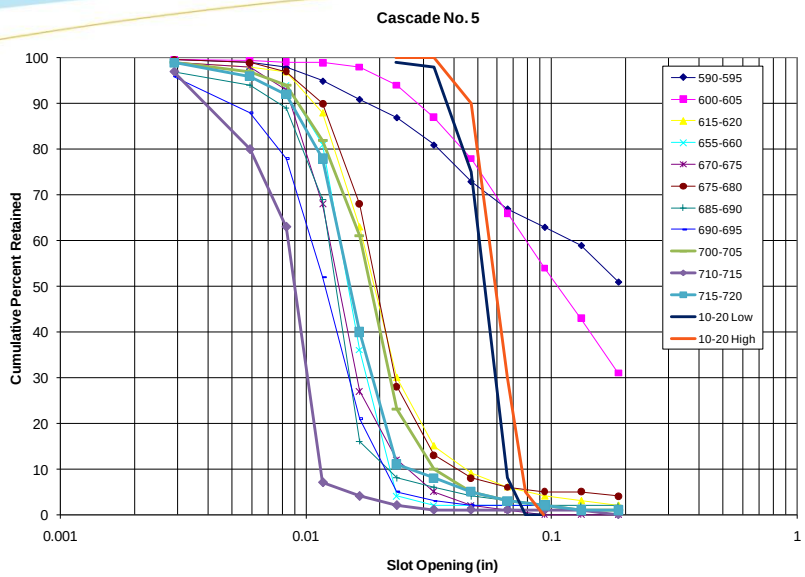
PILOT BIT

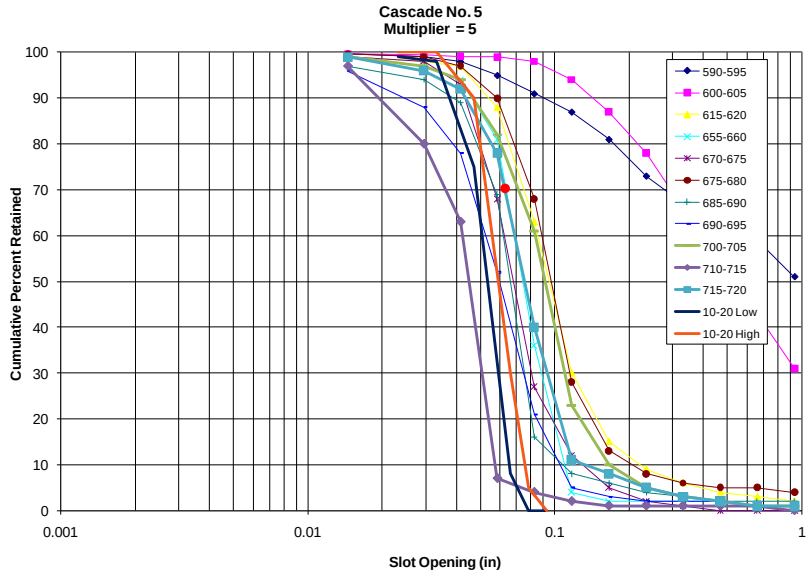
REAMING BIT

LOWER BOREHOLE DRILLING AND CONSTRUCTION

- Dual rotary RC
- 16-inch SS v-wire screen

SCREEN AND FILTER PACK DESIGN





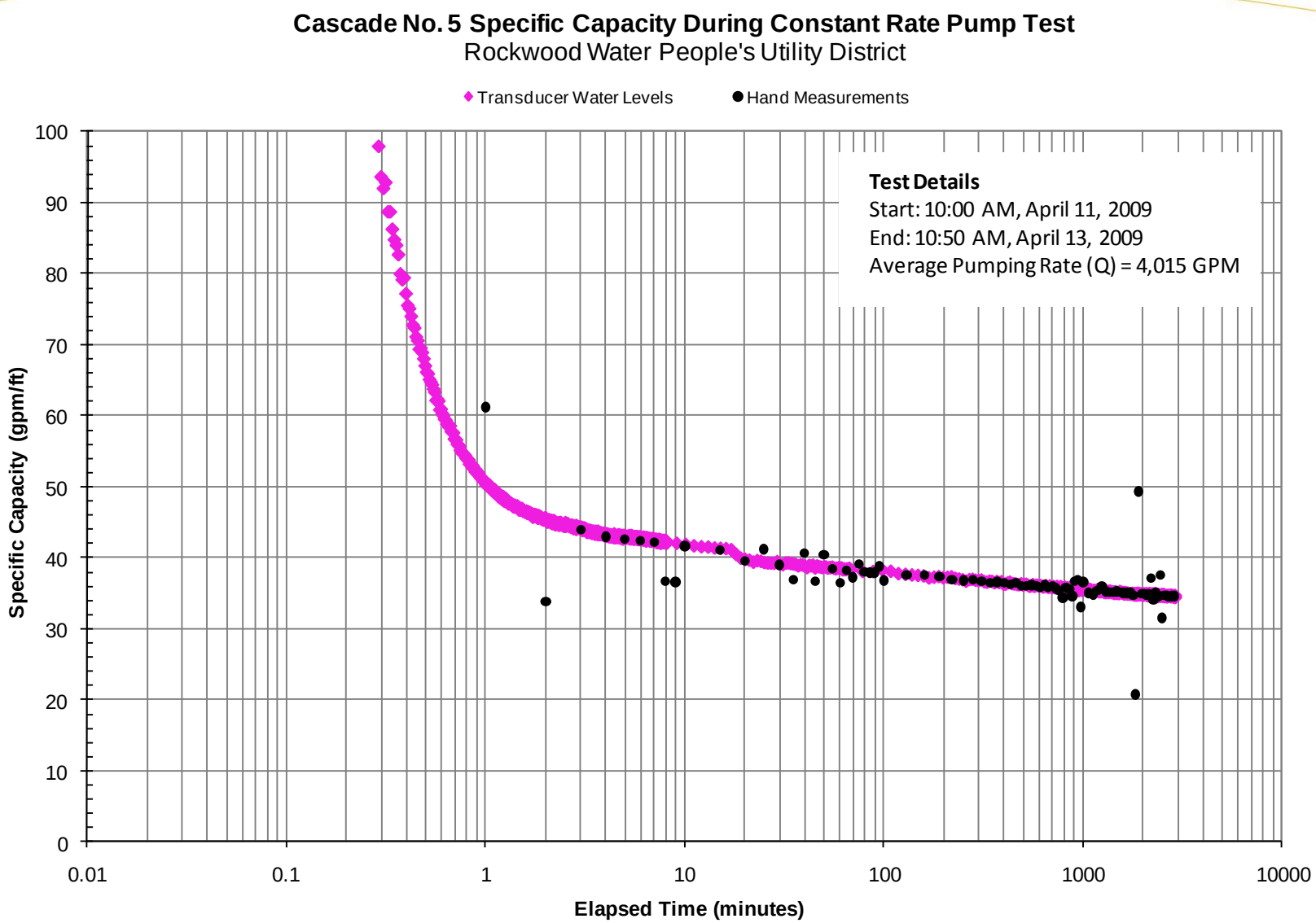
Top	Bottom	Lithology	Color	Interpreted Hydrostratigraphic Unit	Generalized Group	Color				
0	10	Clayey Silt with Sand and Gravel		Pleistocene Flood Deposits	Silt, Sand, Gravel and Cobbles	Brown				
10	20	Cobbles								
20	30	Gravel with Sand		Troutdale Gravel (TGA)	Cemented Gravel with Sand	Gray				
30	40	Gravel with Sand								
40	50	Sandy Gravel								
50	100	Gravel with Sand								
100	120	Gravel with Sand								
120	140	Sandy Gravel			Gravel with Silt					
140	160	Silty Gravel								
160	180	Clayey Gravel								
180	200	Sand and Gravel			Cemented Gravel with Sand					
200	210	Gravel								
210	220	Gravel with sand and silt			Gravel with Sand and Silt					
220	230	Silt with Gravel	Light brown							
230	240	Gravel with sand and silt								
240	250	Silt with Sand	Dark gray and tan to light brown	CU1	Silt with Sand Lenses	Tan				
250	260	Silt with Sand	tan and brown							
260	270	Silt	Grayish green							
270	280	Silt with Sand	Grayish green							
280	290	Silt	Grayish green							
290	300	Silt	Grayish green							
300	310	Siltstone	Blue-green		Silt with Clay	Blue				
310	320	Siltstone	Blue green							
320	330	Siltstone	Blue green							
330	340	Siltstone	Blue green							
340	350	Silt and Sandstone	Green Gray		Silt with Sand Lenses	Dark Brown				
350	360	Silt and Sandstone	Black							
360	370	Sandstone	Black	TSA Sandstone	Sand	Black				
370	380	Fine Sand with Gravel		TSA Conglomerate	Gravel	Dark Gray				
380	390	Gravel								
390	400	Gravel								
400	410	Gravel								
410	420	Gravel								
420	430	Gravel								
430	440	Gravel								
440	450	Gravel with Sand			Silt, Sand, and Gravel					
450	460	Silty Sand with Gravel								
460	470	Clayey, Sandy Silt with Gravel	Light Brown							
470	480	Sandy Silt with Clay	Light Brown	CU2	Silt with Clay	Brown				
480	490	Clayey Silt	Light Brown and Greenish Gray							
490	500	Gravel with Sandy Silt	Greenish Gray							
500	510	Clayey Silt to Silty Clay	Green Gray							
510	520	Sandy Silt	Blue Gray		Silt with Sand	Blue Gray				
520	530	Sandy, Clayey Silt	Blue Gray							
530	540	Clayey Silt	Blue Green to Blue Gray		Silt with Clay					
540	550	Clayey Silt	Blue Gray					559		
550	560	Sandy Silt	Blue Gray		Sandy Silt	Dark Brown		569	10	RISER
560	570	Sandy Silt	Tan and Blue Gray					574	5	RELIEF SCREEN
570	580	Sandy Silt	Tan and Blue Gray							BLANK
580	585	Silty Gravel with Sand		SGA	Gravel with Sand and Silt	Dark Gray		588	14	
585	590	Sandy Gravel, cemented								Sieve
590	595	Gravel with Sand, cemented								Sieve
595	600	Gravelly Sand								
600	605	Gravelly Medium to Coarse Sand								Sieve
605	610	Silty Gravel with Sand								
610	614	Fine to Coarse Sand with Gravel			Sand with Gravel	Dark Gray				
614	623	Medium Sand								Sieve
623	625	Sand with Gravel								
625	630	Sand with Gravel								
630	635	Gravel with Sand, cemented			Gravel with Sand					
635	640	Gravel with Sand, cemented								
640	645	Gravel, cemented								
645	650	Gravel, cemented								
650	657	Gravel with Sand								
657	660	Fine to Medium Sand with Gravel								Sieve
660	665	Gravel with Sand, cemented						663	75	
665	670	Fine Sand with Gravel			Sand with Gravel	Dark Brown		673	10	BLANK
670	675	Fine to Medium Sand								Sieve
675	680	Fine to Medium Sand with Gravel								Sieve
680	685	Medium to Coarse Sand								
685	690	Fine to Medium Sand with Gravel								Sieve
690	695	Fine to Medium Sand with Gravel						693	20	Sieve
695	700	Fine Sand			Sand			703	10	BLANK
700	703	Fine to Medium Sand								Sieve
703	705	Gravel (indicated by rig action)						708	5	Sieve
705	710	Fine to Medium Sand						713	5	SUMP
710	715	Fine Sand with Gravel					X			Sieve
715	720	Fine to Medium Sand					X			Sieve
720	725	Fine Sand					X			
725	730	Fine Sand with Gravel								
730	735	Fine Sand						BOTTOM OF BORING		

Relief and Blank	15
Total Screen	100
Total Blank	39
Screen assembly length	154

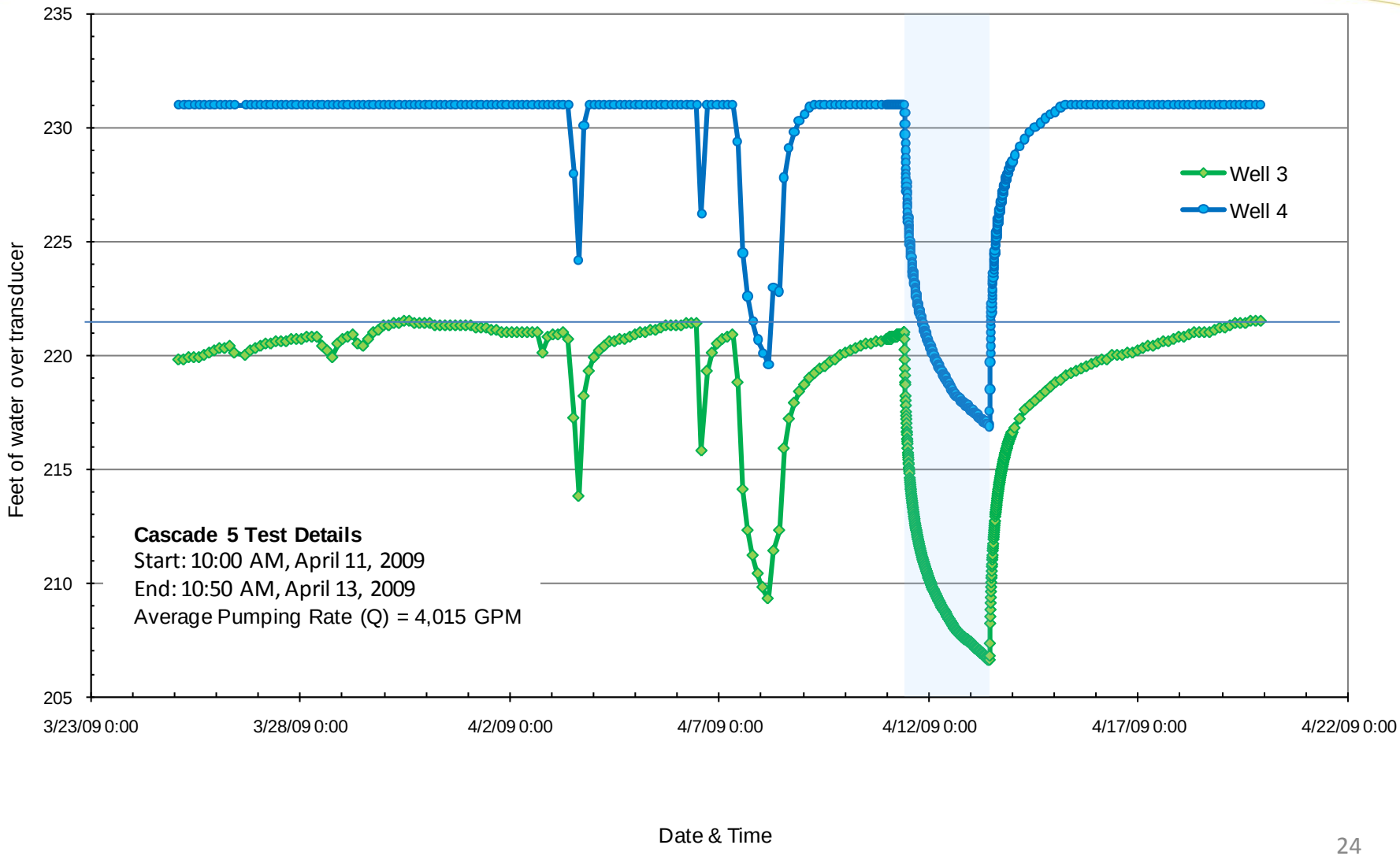
WELL TESTING

- Well testing through new pipeline (5,400 gpm)
- Emergency production during well testing
- Cost $1,000,000

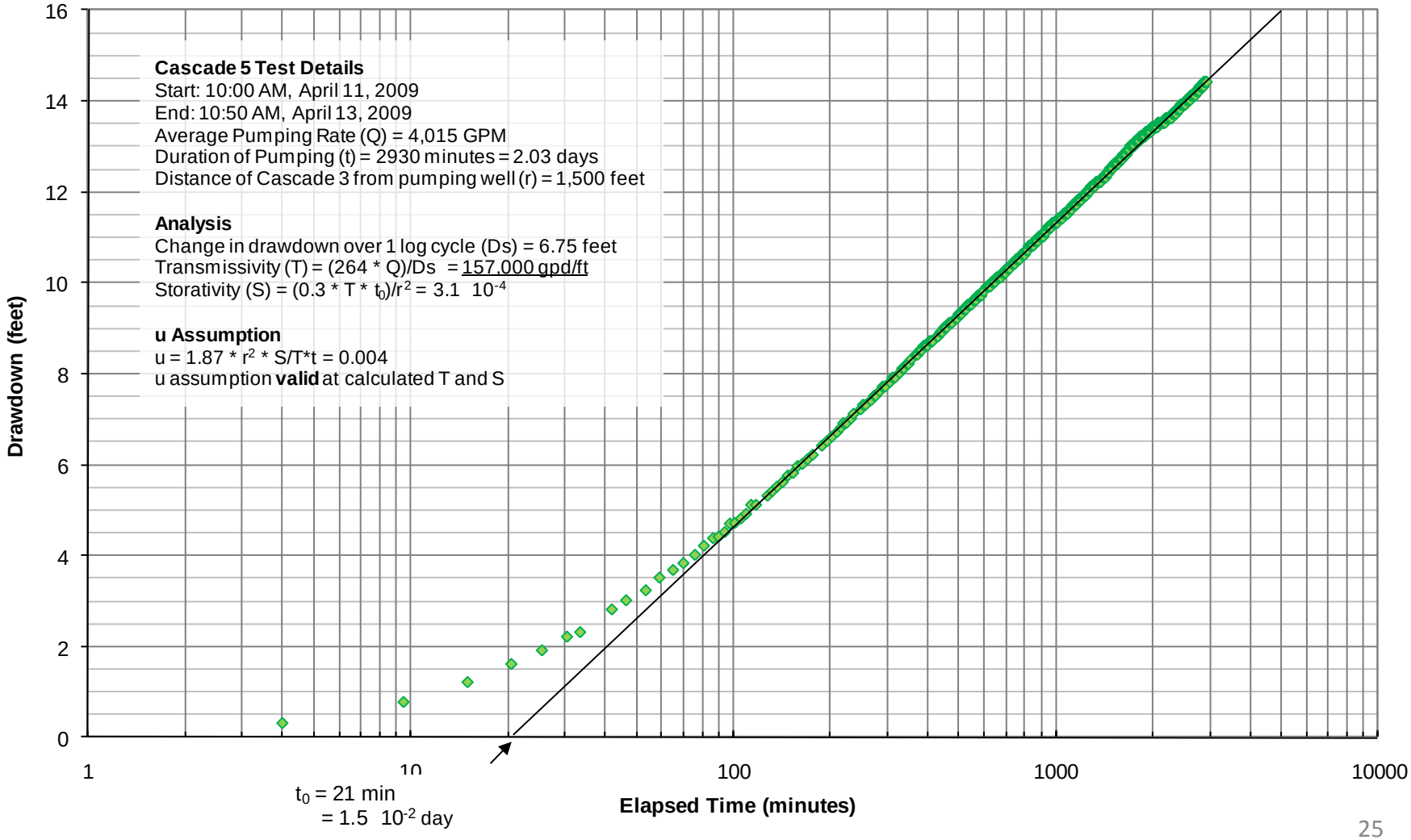
SPECIFIC CAPACITY TRENDS



AQUIFER RESPONSE AT CASCADE 3 AND CASCADE 4



CASCADE 3 RESPONSE – AQUIFER PARAMETERS



PRE-DESIGN CALCULATIONS

		Cascade 5 Production Rate (gpm)			
		4,000	4,500	5,000	5,500
		Maximum Predicted Drawdown (ft) at 90 days			
Cascade 5		130.0	146.3	162.5	178.8
Well Inteference Estimates (at 120 days of pumping)					
Cascade 3 or 4 (pumping at 4,500 gpm)	*31*	161.0	177.3	193.5	209.8
Other SGA users (Fairview, Troutdale, Wood Village)	*10*	140.0	156.3	172.5	188.8
Portland Water Bureau	*60*	190.0	206.3	222.5	238.8
Estimated Total Drawdown (with total interference)		231.0	247.3	263.5	279.8
Estimated Final Water Level (ft-bgs) assuming SWL of 194 ft-bgs		425.0	441.3	457.5	473.8

Notes:

1. SWL = static water level, ft-bgs = feet below ground surface, gpm = gallons per minute
2. Interference estimates from GSI 2003 technical memorandum "Evaluation of Potential Effects of Pumping New Wells in Sand and Gravel Aquifer Unit on RWPUD and Proposed City of Gresham Wells".
3. Top of screen assembly at 553 ft-bgs

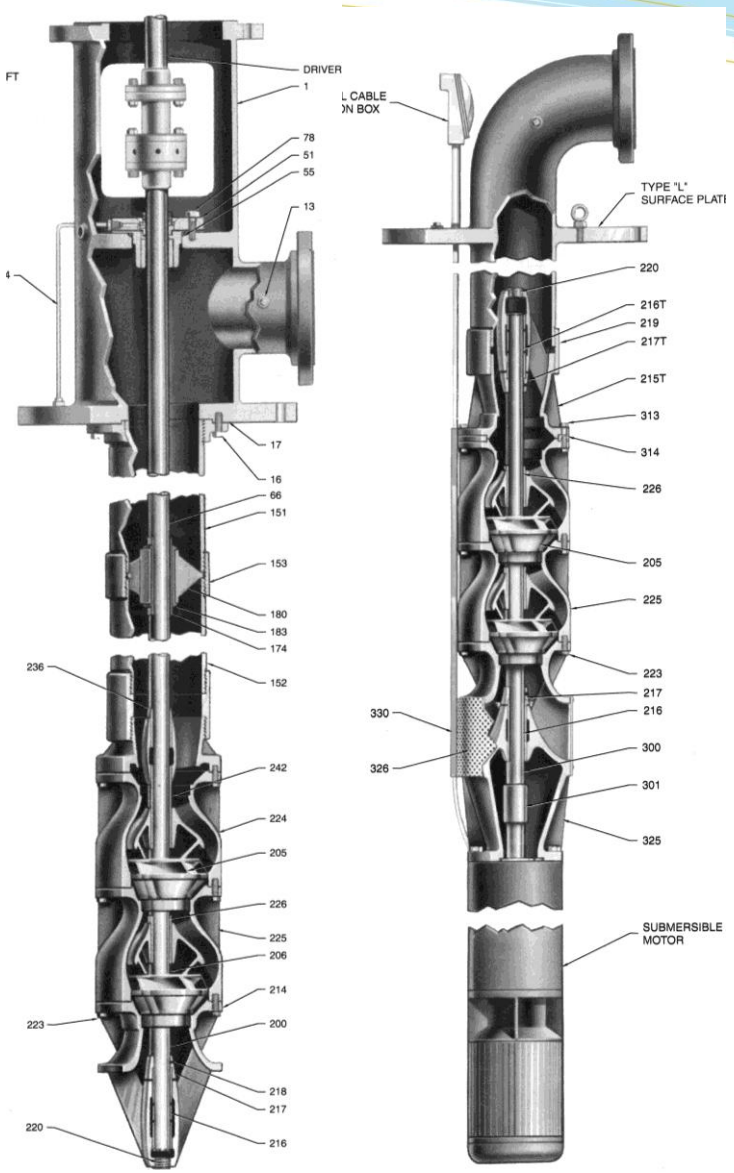
WELL HEAD IMPROVEMENTS DESIGN

Improvements includes

- 734’ deep well, 24” diameter casing with capacity of 5000 gpm +
- 1050 lf of 20” DI waterline with CP designed by Gresham (cost $170,000)
- Site Improvements, limited site (35’ x 35’), parking lot improvements for Fire Dept.
- Well House
- Vertical line shaft pump and motor
- 1,000 kW Generator

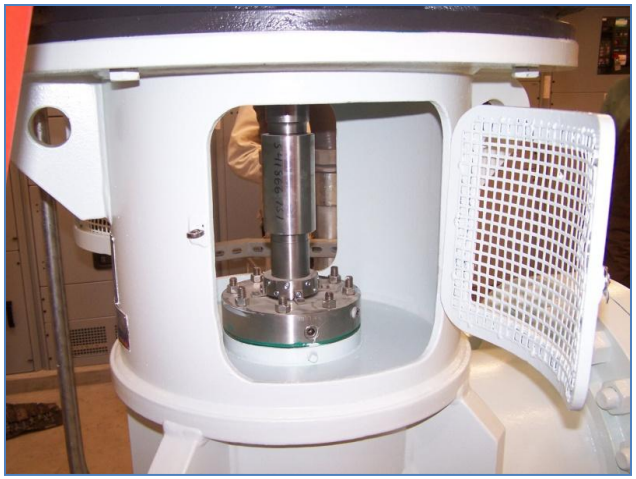
PUMP SELECTION

- Vertical line shaft vs. Submersible
  - Issues with other submersible pumps
  - Motor for vertical line shaft easier to access and maintain
  - Selection process
- Motor type and power supply selection
  - Low voltage vs. medium voltage
  - Selection process



VERTICAL LINE SHAFT PUMP

- 5,000 gpm at 566 TDH (actual 6,000 gpm)
- Weir-Floway 18 MKH
- Five Stage 1,755 rpm
- Open line shaft
- 550’ 14-inch threaded column
- Stainless steel 17-4PH line shaft
- Prelube of open line shaft



LINESHAFT AND COLUMN INSTALLATION

COLUMN INSTALLATION

VERTICAL AC MOTOR

- 480 V 900 HP by US Motors
- Premium efficiency
- Inverter duty rated
- Class H insulation for long life
- VPI coating on windings for long life
- RTD's in windings and bearings
- Non-reverse ratchet
- Driven by 1000 HP rated VFD

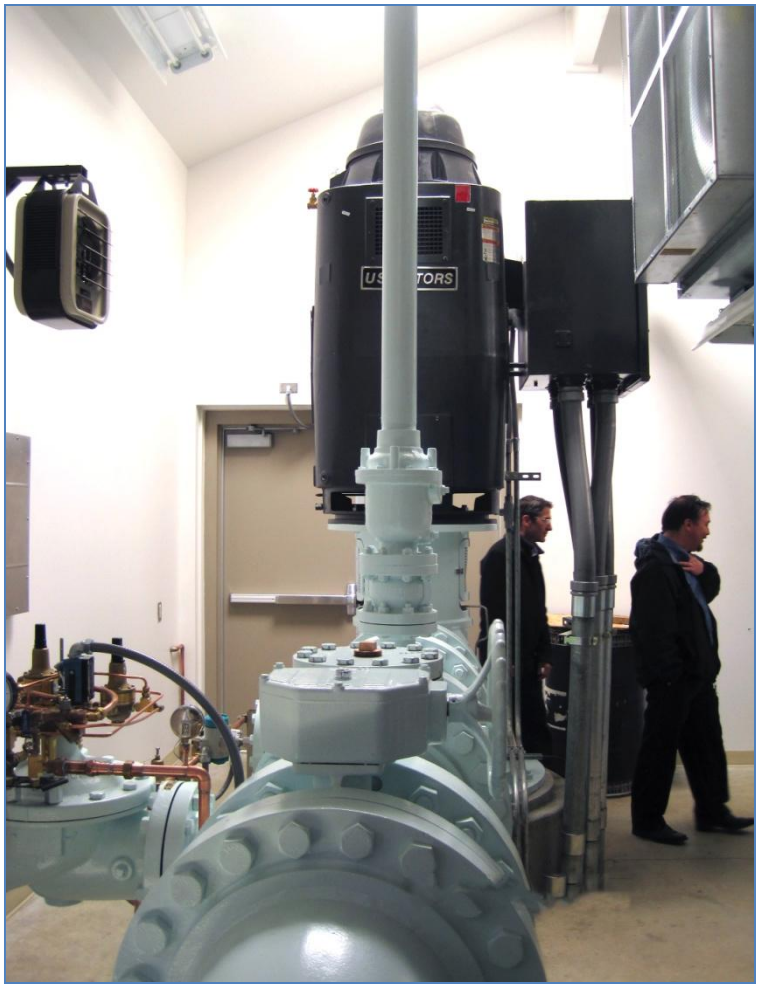
HYDRAULICS

- Discharge through approx 1200 feet of 20” pipe to the PUD’s Cascade site
- Through chlorination building and into 5 MG reservoir
- Potential surge in the event of a power failure during well operation

PUMP CURVES AT VARIABLE SPEED CONTROLLED WITH VFD

MECHANICAL SYSTEMS

- Deep well ARV
- Pressure relief/surge anticipator valve – pressure relief valve to protect piping and pump due to high pump shut off head.
- Avoiding starting pump against closed valve due to shaft stretch and possible damage to pump



PLANT PIPING AND HYDRAULIC SURGE CONTROL

VENTILATION SYSTEM

- 4’ diameter two-speed fan
- Intake louvers and ventilation penthouse (18,000 CFM)
- Separate ventilation for VFD
- Extensive sound attenuation due to proximity to Fire House

VENTILATION SYSTEM

ELECTRICAL DESIGNS

- 480V three phase power
- MCC/VFD
- 1000 kW generator
- 1000-hp rate VFD, oversized to improve power quality
  - Reduces inrush of power during start-up
  - VFD to control upsurge and downsurge /coast to stop to eliminate potential shaft damage
  - 70% turndown
- Control System
  - Local VFD control
  - Local monitoring via PLC
  - Fiber link to PUD Ops Center for remote monitoring and set-point control

ELECTRICAL EQUIPMENT

SWITCH GEAR

VFDs

WELL HOUSE DESIGN

- Limited area for well house
- Challenge to fit the needed mechanical and electrical equipment in the building
- Special egress requirements due to electrical equipment in the building

SITE IMPROVEMENTS

BEFORE

AFTER

START-UP

- Contracting
- Start-up (pump mfr/supplier /contractor)
- Lessons learned

PUMP AND MOTOR PRE-START CHECKS

CONCLUSION

- Successful teaming realizing mutual benefits and efficiencies
- A number of challenges associated with well design and drilling and well head improvements due to the size of the well and certain site constraints
- Very successful project providing significant cost savings for the PUD and the City