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The Reno Creek Project

Update on the Reno Creek Project

August 31, 2011

Presentation Outline

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- Introduction of participants
- Update on hydrologic studies and ground water modeling
- Proposed statistical treatment of ground water data for the Reno Creek project
- AUC's proposed application schedule
- Questions?

Reno Creek
Hydrogeological Characterization

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- Historical Hydrogeological Characterization;
- Current Hydrogeological Characterization Program Update;
- Summary of Hydrogeological Characterization

Historical Hydrogeological Characterization

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- Hydrogeologic characterization primarily focused on the Production Zone Sand, Overlying Aquitard and Overlying Aquifer;
- Majority of historical hydraulic testing consisted of small scale multi-well and single-well tests;
- Production Zone Aquifer (PZA) is geologically confined; however, groundwater occurs under fully saturated and partially saturated aquifer conditions; and
- Integrity testing identified no communication between the PZA and the Overlying Aquifer.

Historical Potentiometric Surface (1993) and Approximate Location of Saturated/Partially Saturated Boundary

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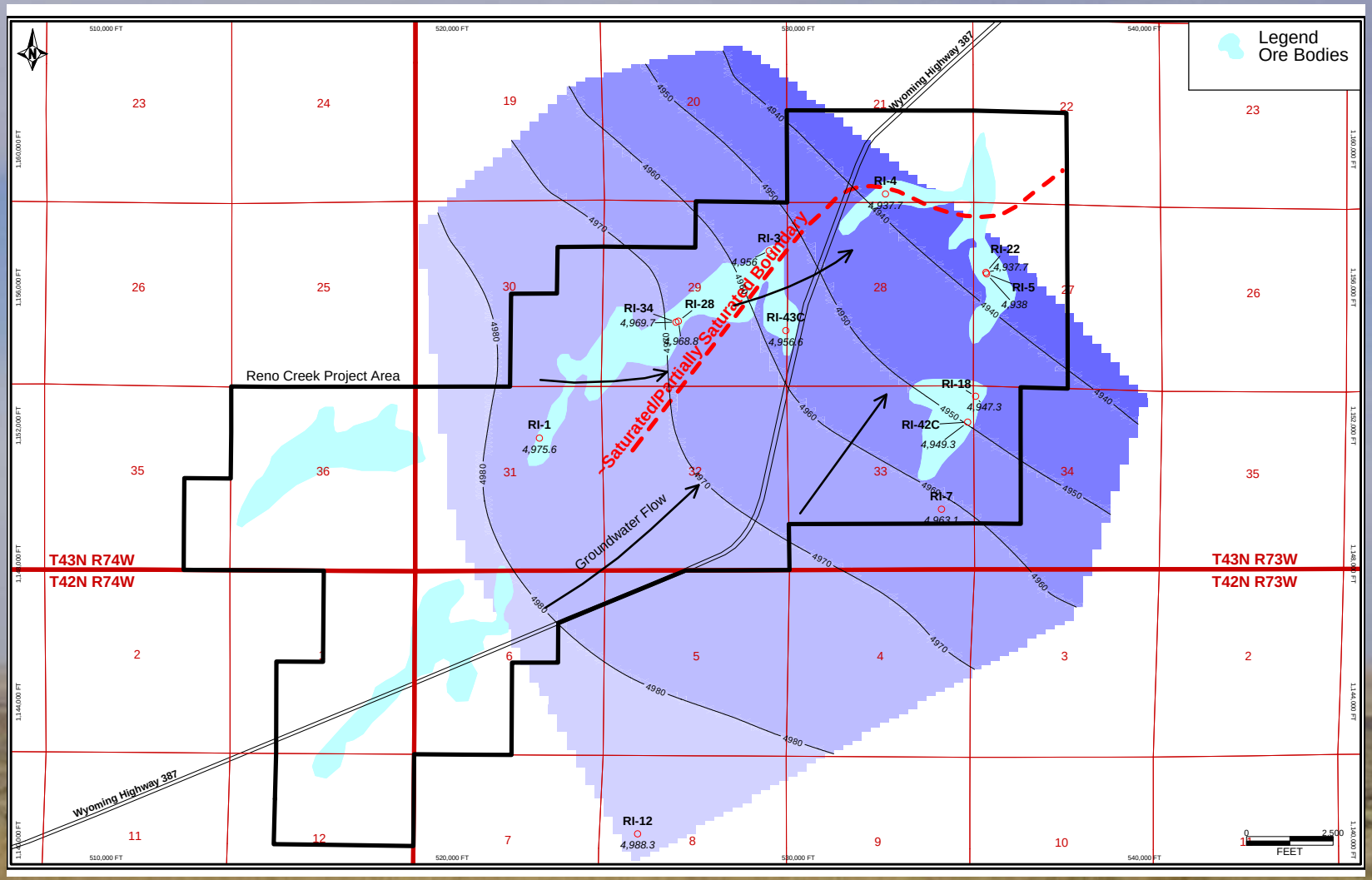

Summary of Historical Pump Tests Results

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- **Results are similar to aquifer properties where ISR has been successfully performed:**

Year	Test	Range of Values	Representative Value
1979 - 1980	**RME Single and Multi Well Tests - PZA**		
	Transmissivity (T; ft^2/d)	72 to 867	200
	Hydraulic Conductivity (k; ft/day)	0.6 to 5.3	2.0
	Storativity (S)		
1982	**Hydrogeologic Integrity Evaluation - PZA**		
	Transmissivity (T; ft2/d)	149 to 555	272
	Hydraulic Conductivity (k; ft/day)	0.9 to 4.1	2.3
	Storativity (S)	4.0E-05 to 1.0E-03	5.50E-04
1993	**Hydro/EFNI Single-well Tests - PZA**		
	Transmissivity (T; ft^2/d)	85 to 639	200
	Hydraulic Conductivity (k; ft/day)		2.0
	Storativity (S)		
1993	**Hydro/EFNI Single-well Tests - Overlying Aquifer**		
	Transmissivity (T; ft2/d)	0.24 to 164	uncertain
	Hydraulic Conductivity (k; ft/day)		
	Storativity (S)		
1994	**EFNI Mine Unit I Test - PZA**		
	Transmissivity (T; ft^2/d)	47.4 to 52.5	50.7
	Hydraulic Conductivity (k; ft/day)	0.46 to 0.51	0.5
	Storativity (5)	6.9E-05 to 1.4E-04	1.40E-04

Current Hydrogeological Characterization Program

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- Drilled and logged 7 strat holes to Badger Coal for geologic control;
- Installed 41 new monitor wells (including shallow water table and overlying, production zone and underlying aquifers) for aquifer testing and baseline monitoring;
- Completed three of four multi-well long-term pump tests, fourth test to commence in 2 – 3 weeks;
- Single-well tests on shallow water table (2), overlying (4) and underlying (4) aquifers to commence in 2 – 3 weeks;
- Core analysis on overlying aquifer, overlying aquitard and underlying aquitard at PMZ4 location.

Status of Reno Creek Pump Tests

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- **PZM1 Pump Test**
  - Completed in December 2010.
- **PZM5 Pump Test**
  - Completed in February 2011.
- **PZM4 Pump Test**
  - Completed in August 2011; final downloads collected 08/25/11.
- **PZM3 Pump Test**
  - Wells have been installed; waiting on water quality results for securing temporary WYPDES permit. Pump test expected to commence in the next 2 – 3 weeks.
- **Over and Underlying Single-well Tests**
  - Wells have been installed; tests expected to commence in the next 2 – 3 weeks.

Baseline and Pump Test Well Locations

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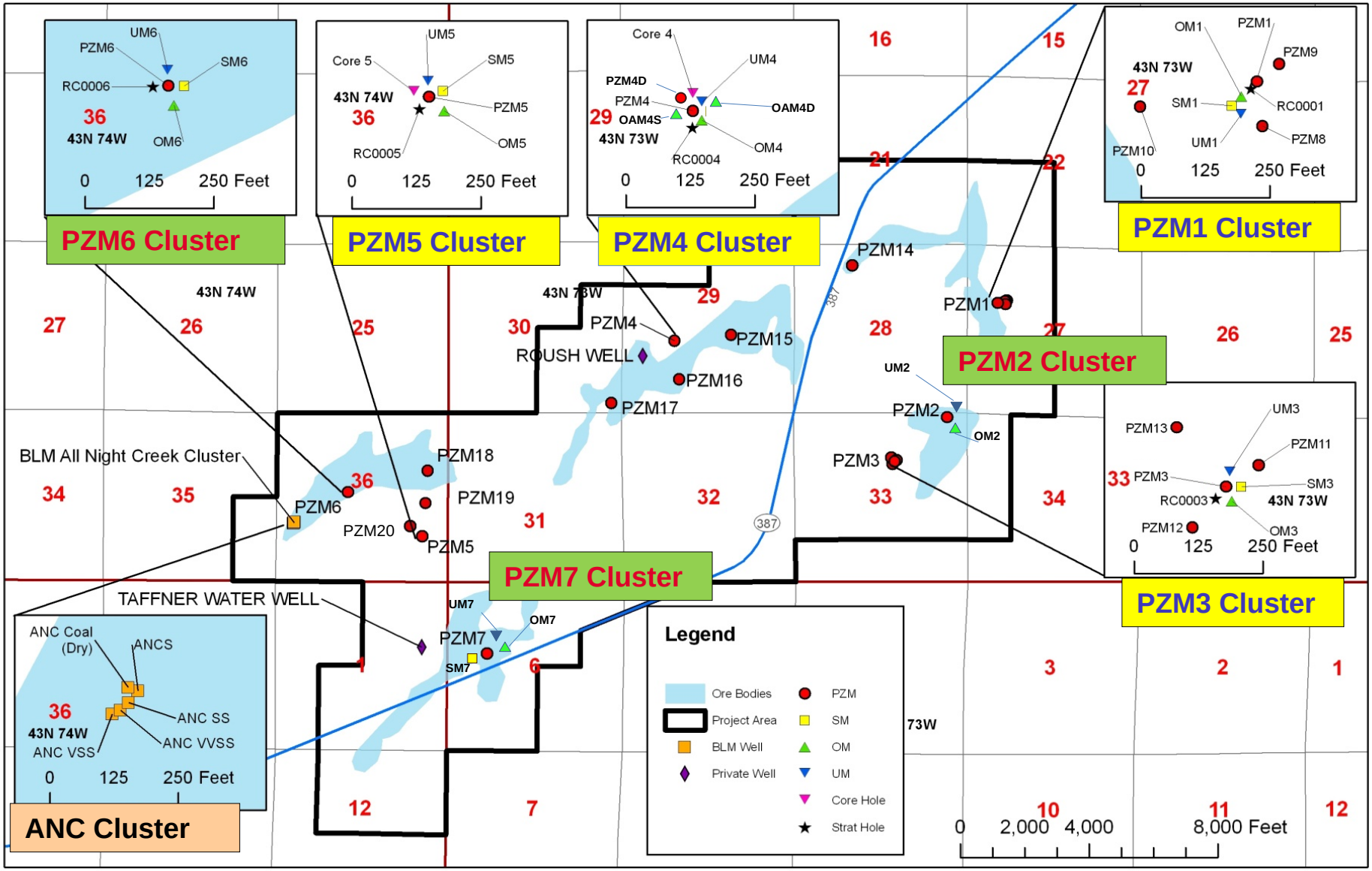

Regional Hydrostratigraphic Cross Section A-A' Location Map

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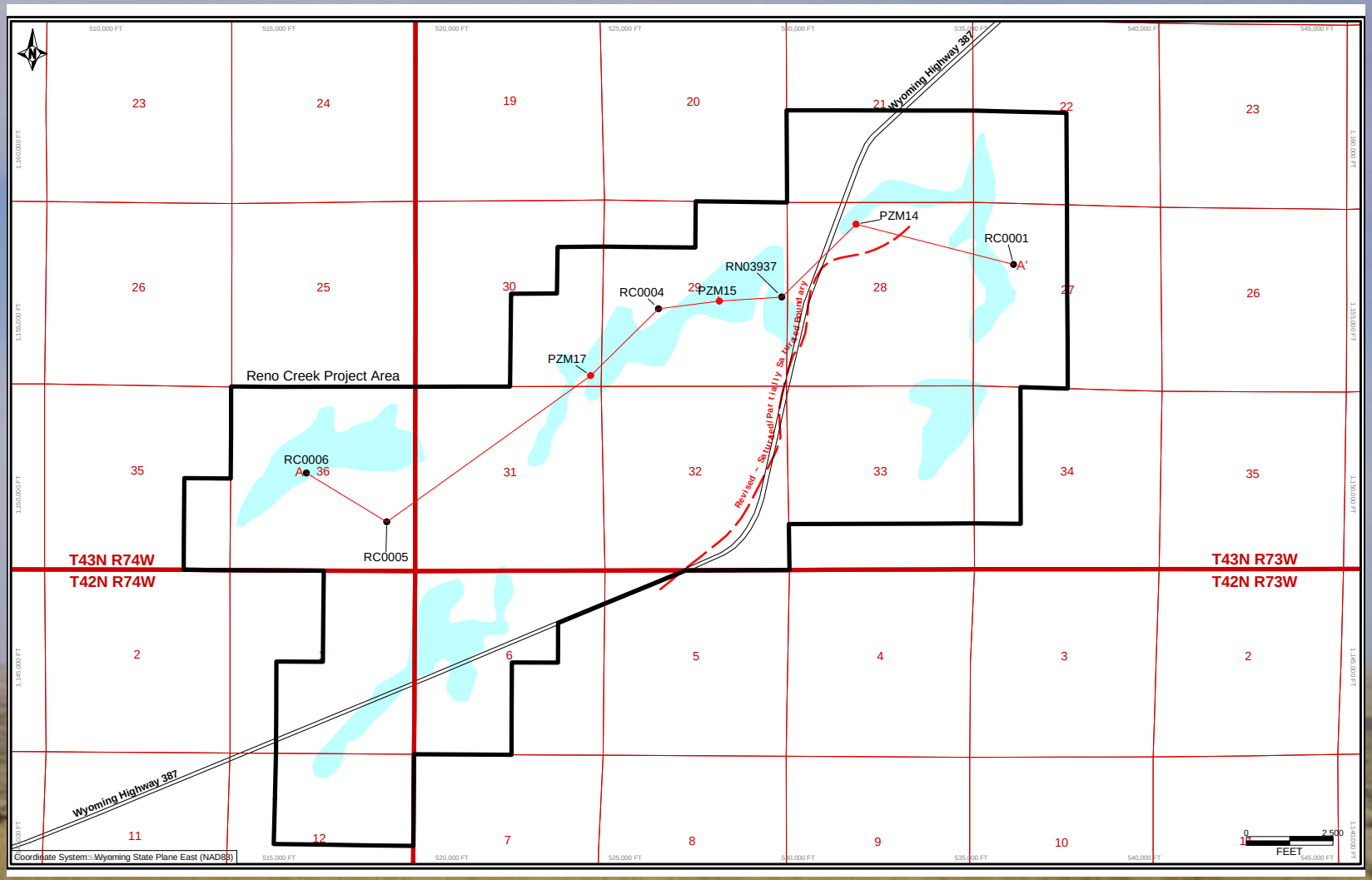

Regional Hydrostratigraphic Cross Section A-A'

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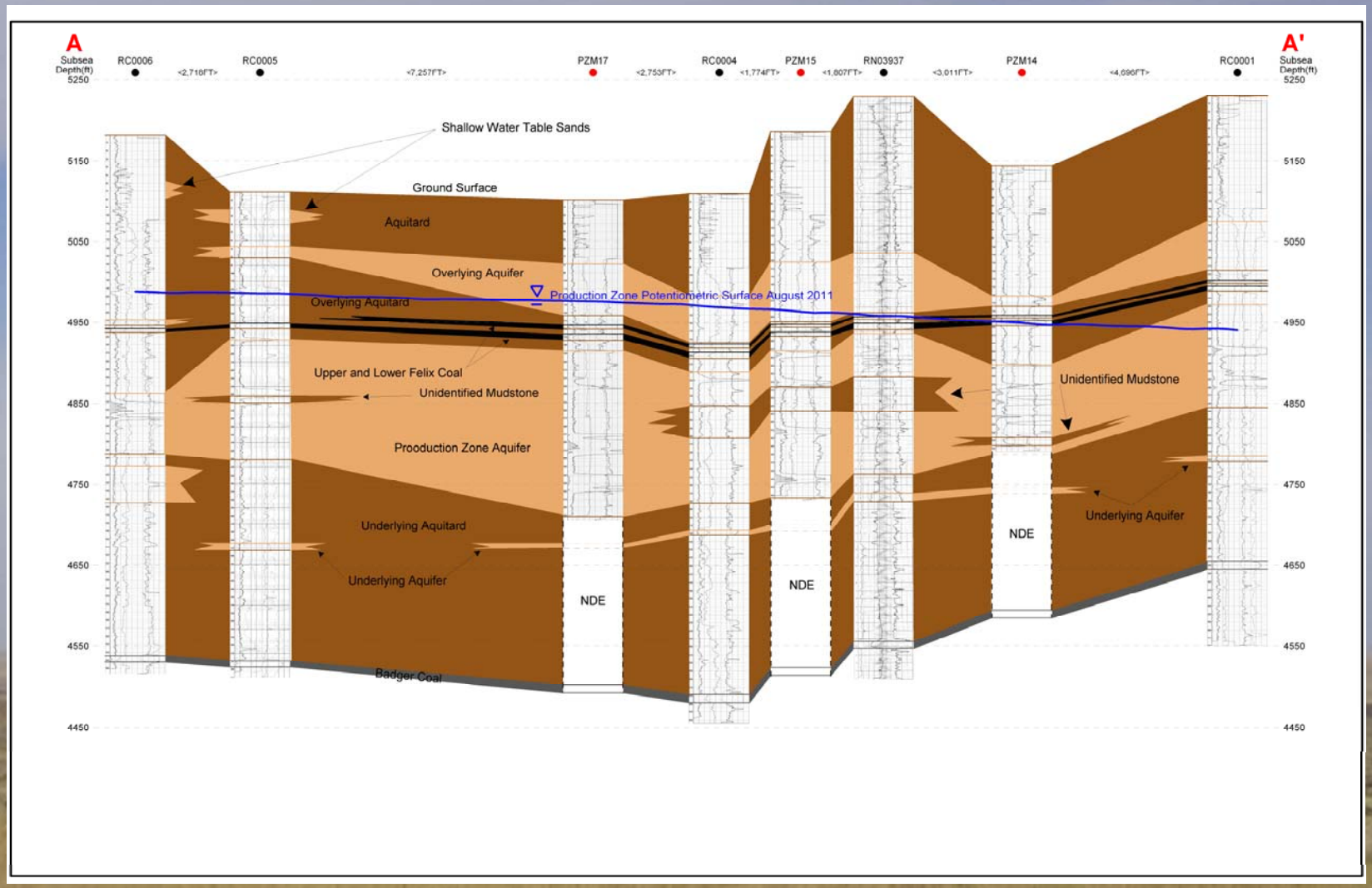

PZM1
Hydrostratigraphic Diagram

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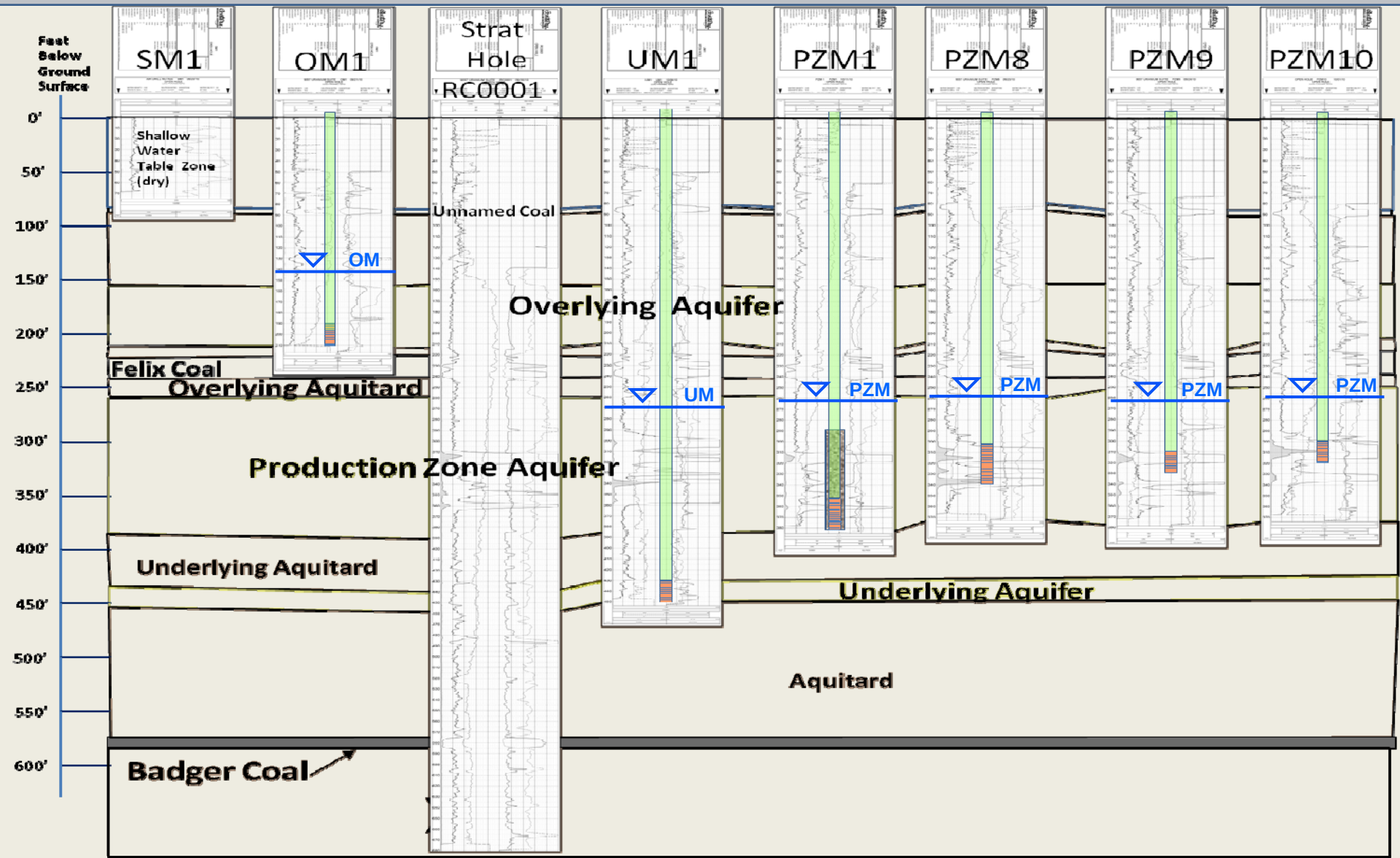

PZM5
Hydrostratigraphic Diagram

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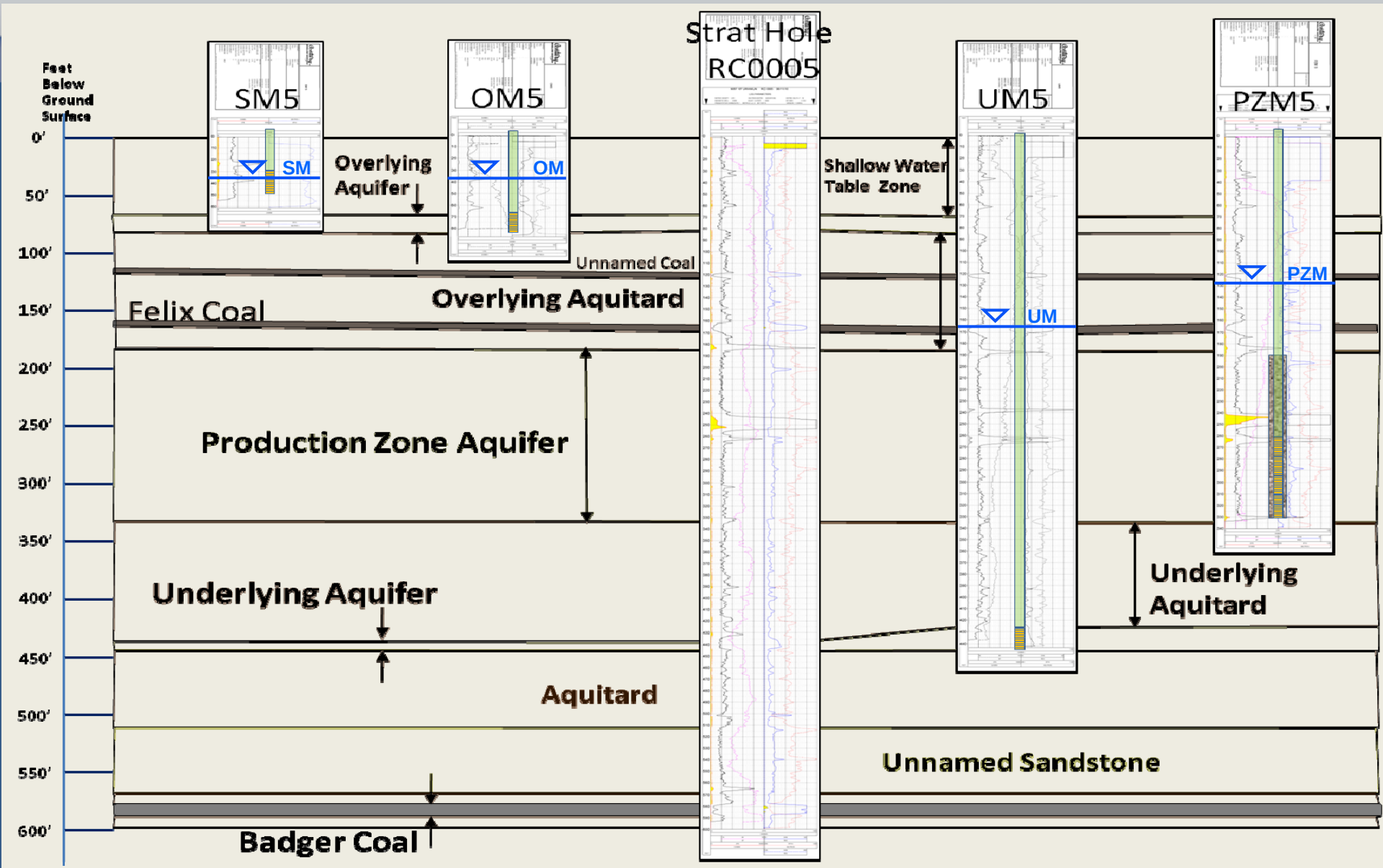

PZM4
Hydrostratigraphic Diagram

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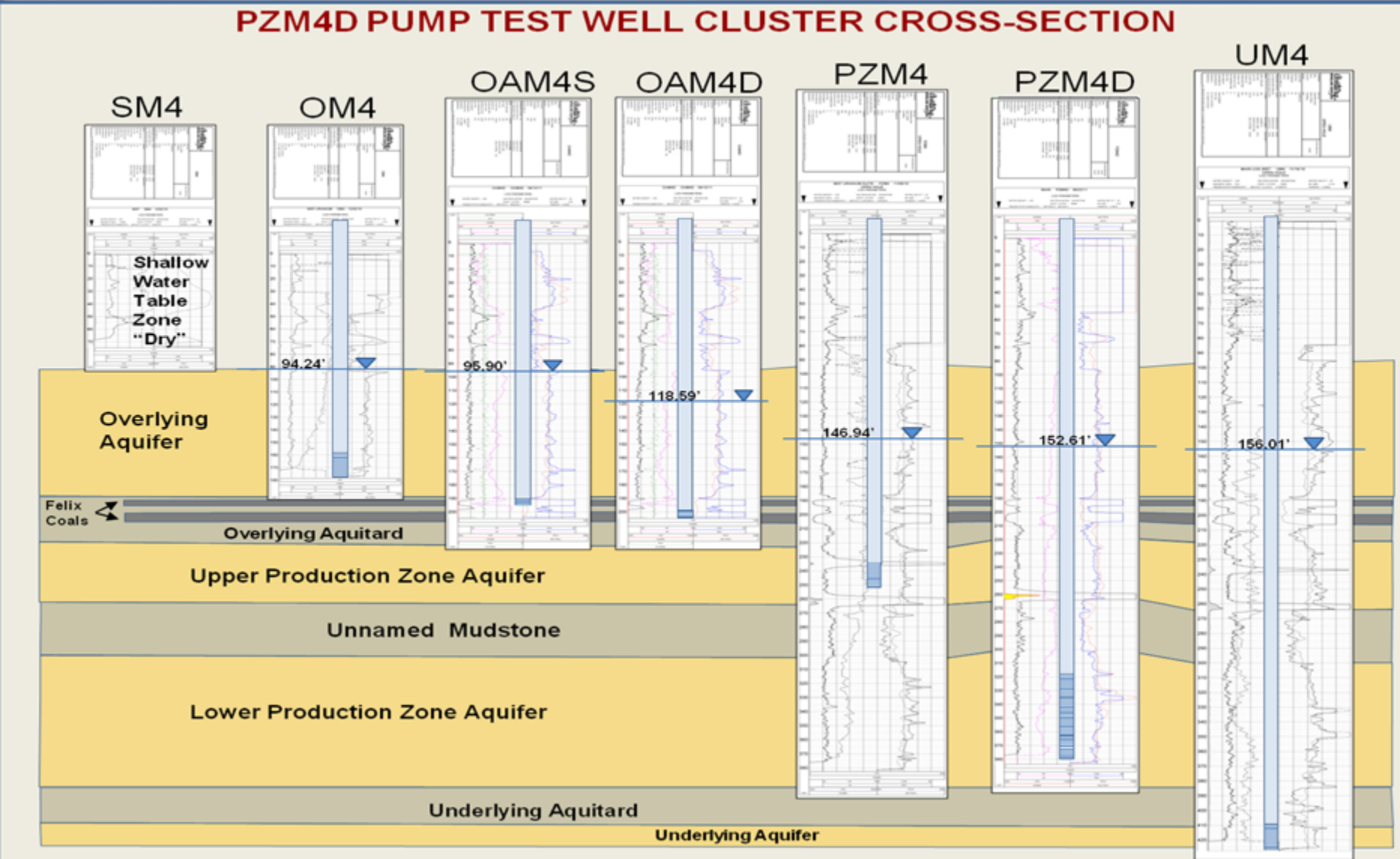

PZM3
Hydrostratigraphic Diagram

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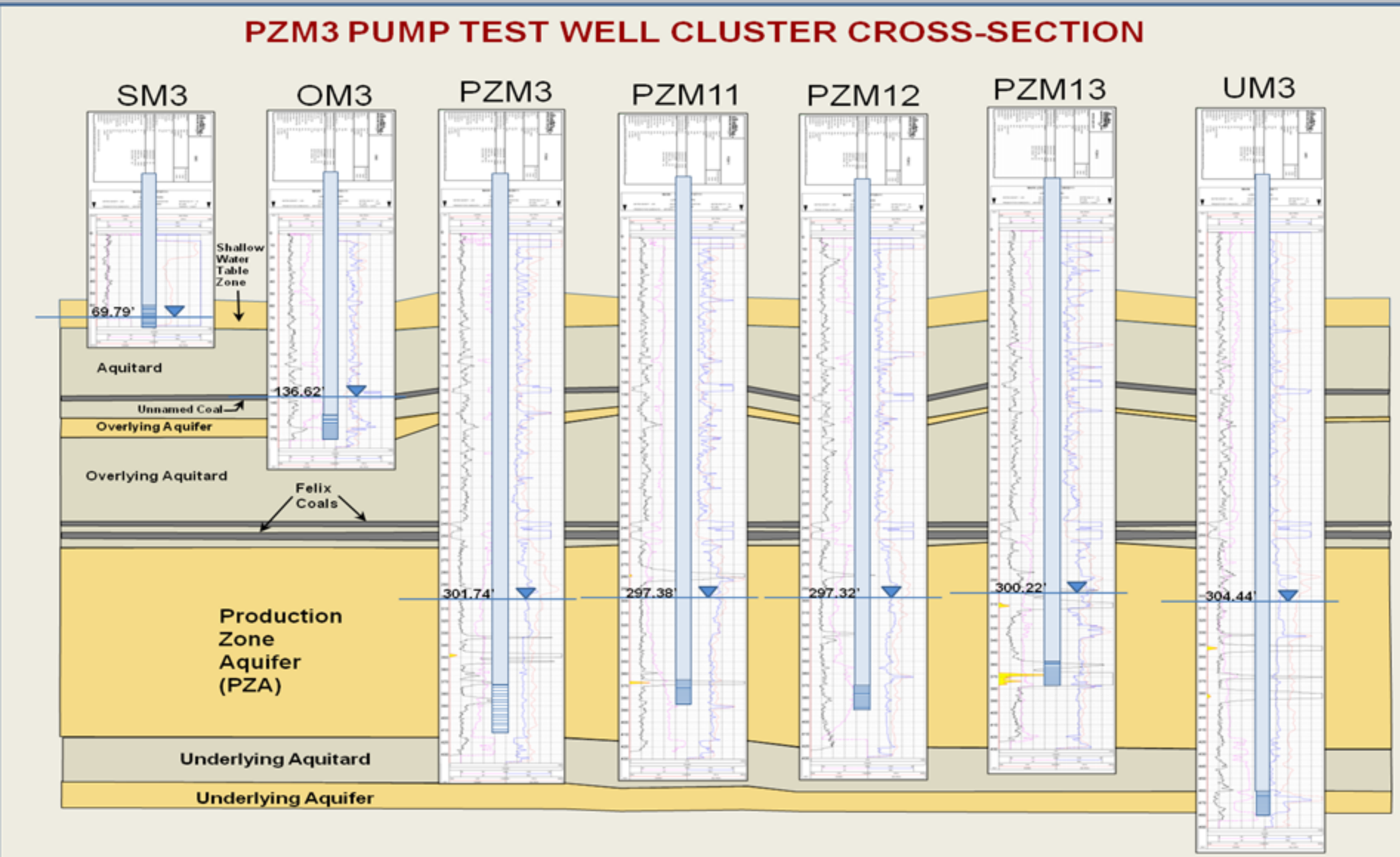

PZM1 Pump Test
Production Zone Aquifer
Potentiometric Surface 11/30/10

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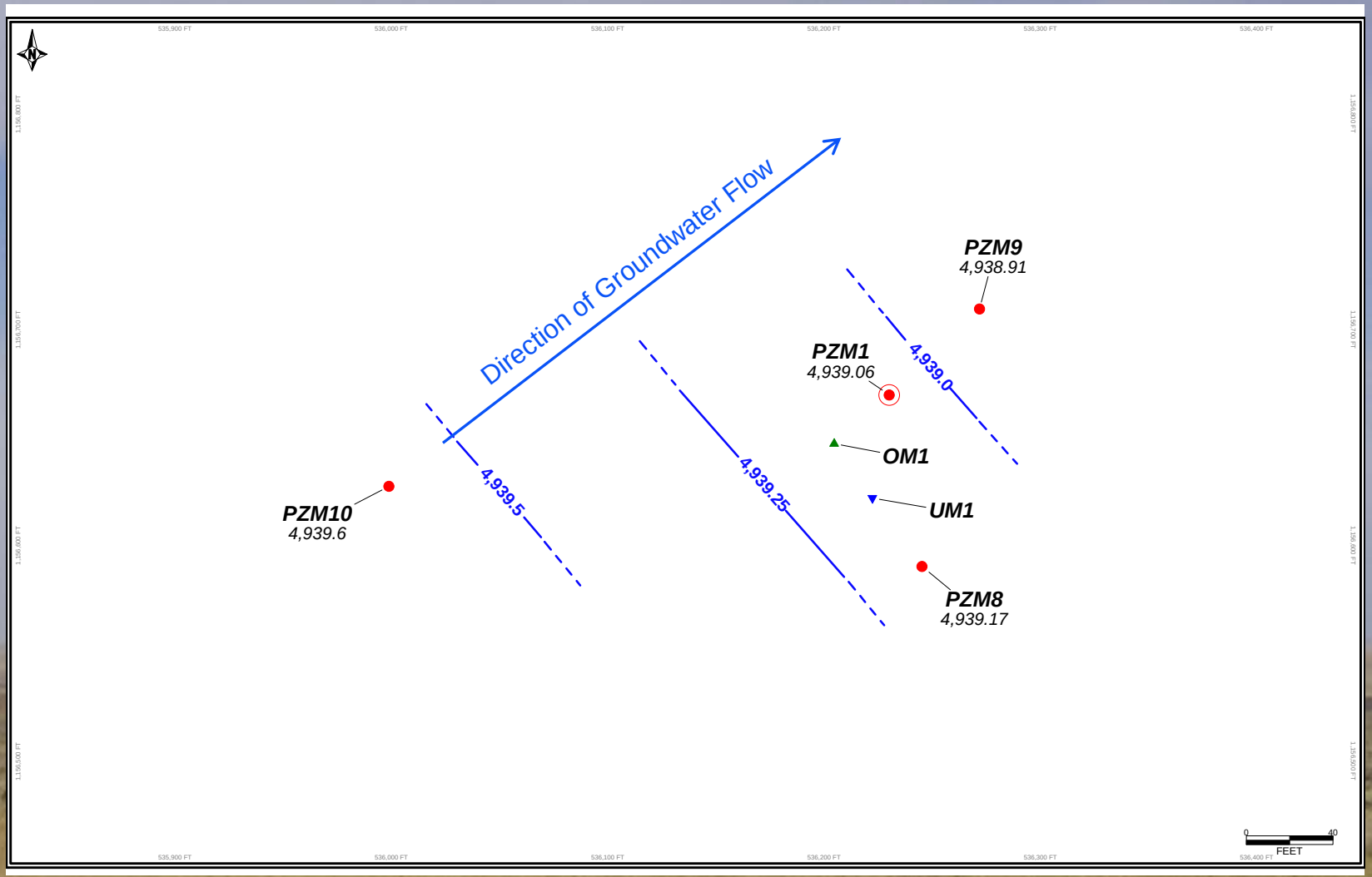
- Current and historical potentiometric surfaces of Production Zone Aquifer are consistent.



PZM1 Pump Test
Preliminary Results

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- Partially saturated aquifer 95 ft thick;
- Three observation wells in production zone aquifer (58 ft, 81 ft, and 235 ft from pumping well)
- One observation well in overlying and underlying aquifer;
- Pumped PZM1 at 8.9 gpm for 2,595 min (1.8 days);
- Responses observed in all PZ wells;
- No observed response in overlying and underlying aquifer;
- Barometric efficiency of overlying aquifer and production zone aquifer is high; data were corrected for barometric pressure.

Barometric Efficiency

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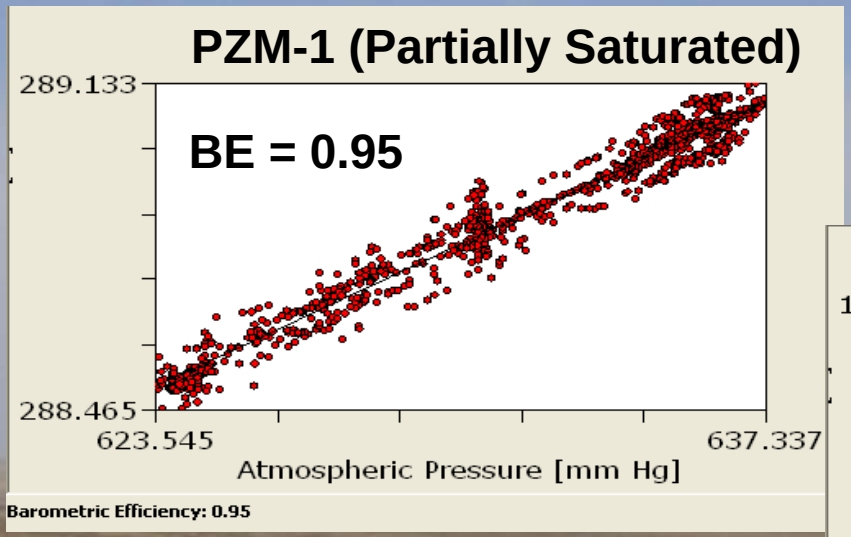
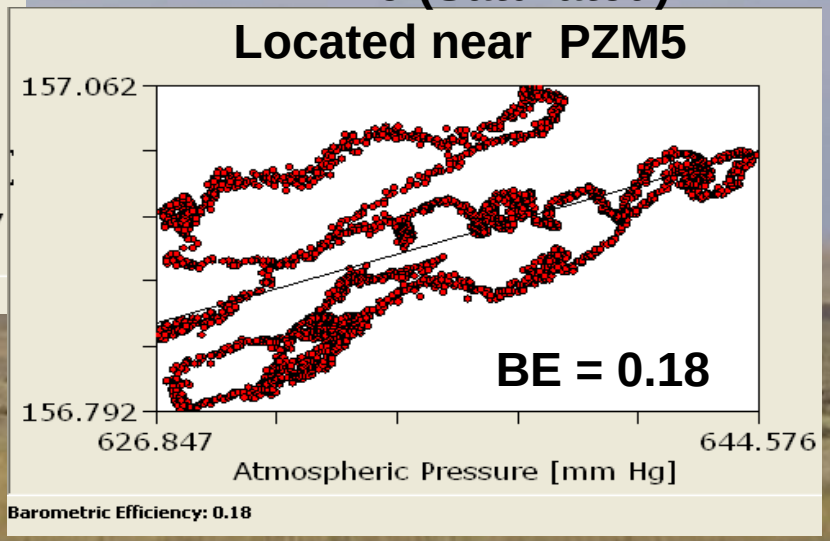
- Evaluate water level versus atmospheric pressure on baseline water levels prior to testing;
- Typical barometric efficiency for saturated aquifers range from ~ 0.20 – 0.75;
- Typical barometric efficiency for partially saturated aquifers range from ~ 0.80 – 1.0





PZM8
Barometric Corrections

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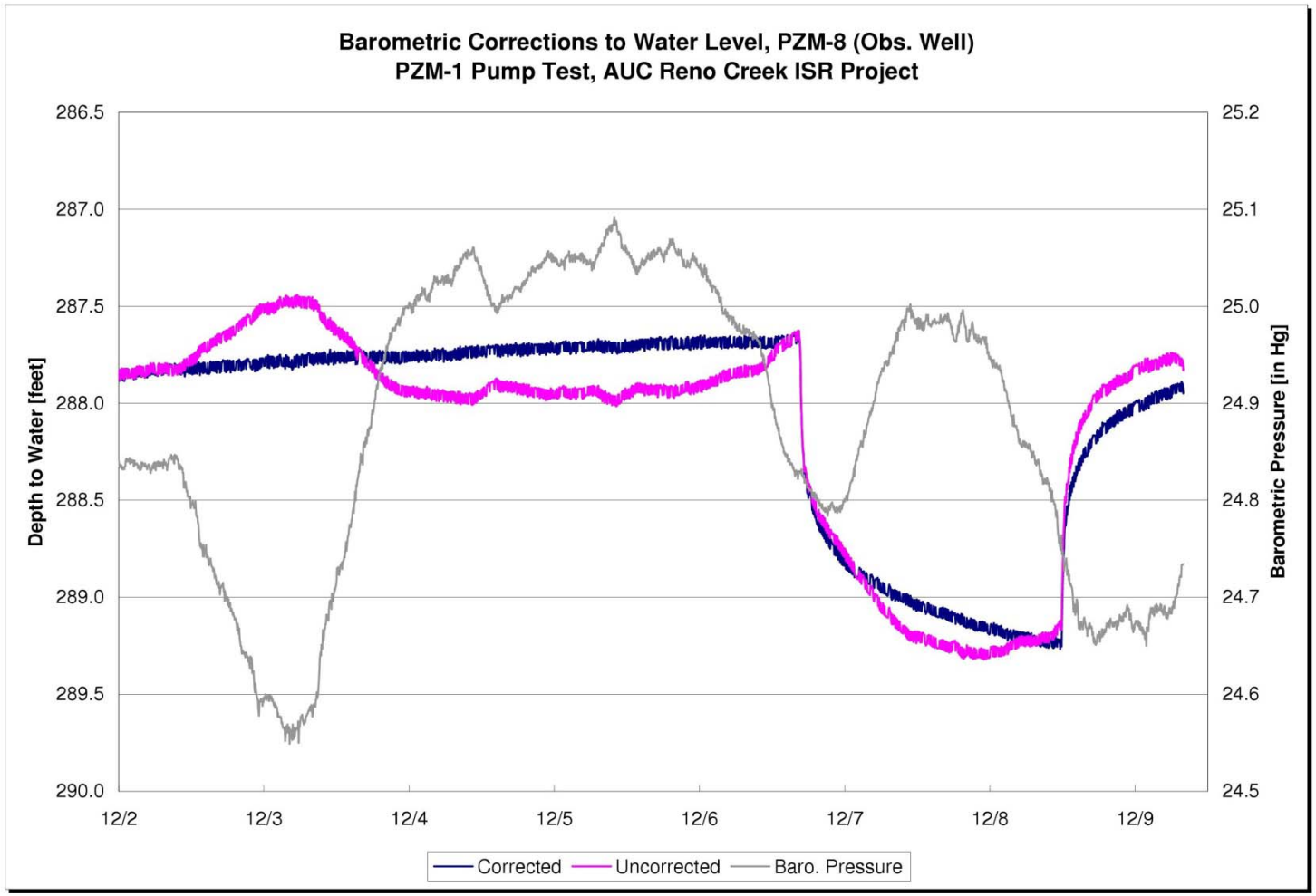

PZM1 Pump Test Drawdown Observed in Production Zone Aquifer

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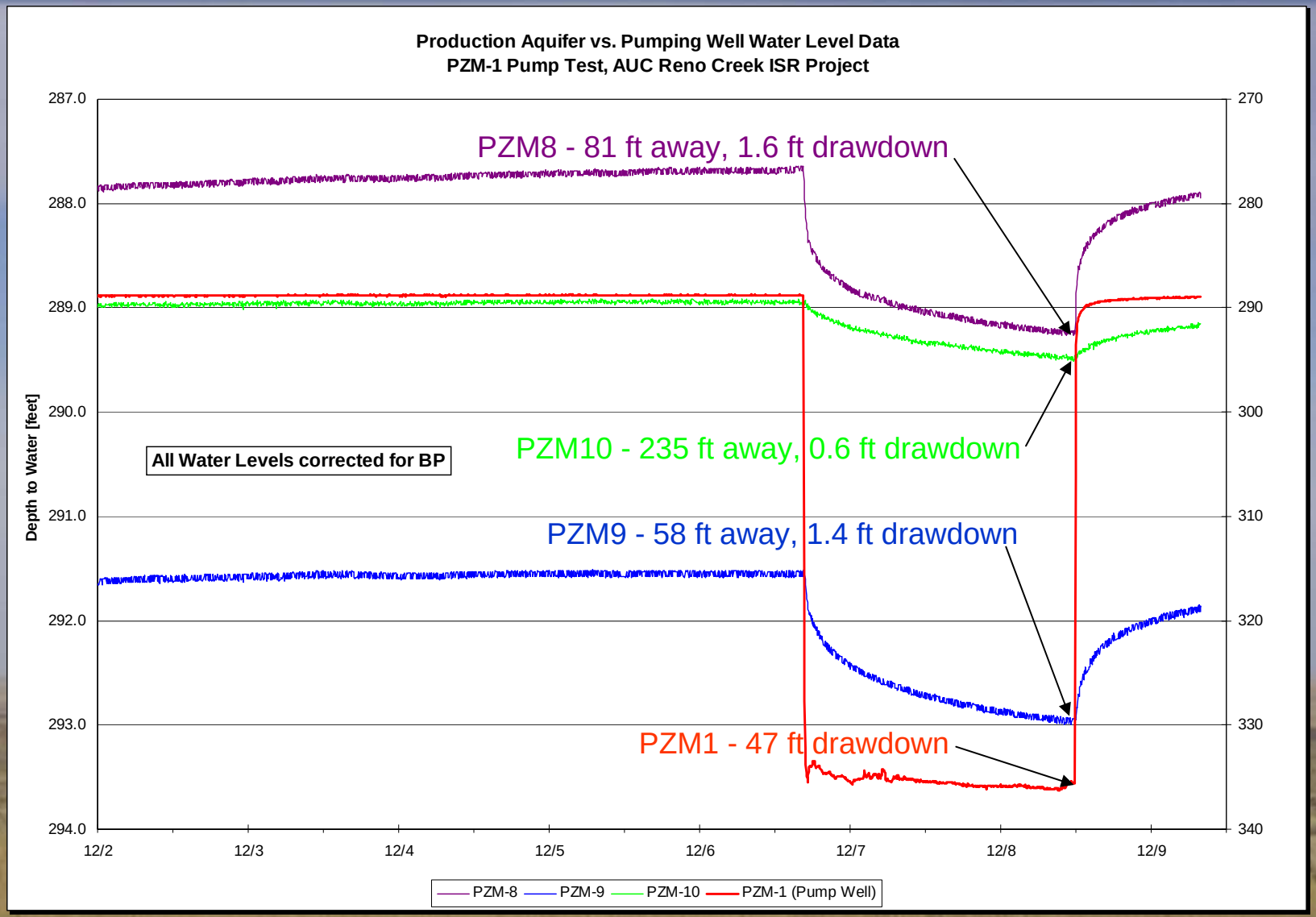

PZM1 Pump Test
Water Levels Observed in Overlying Aquifer

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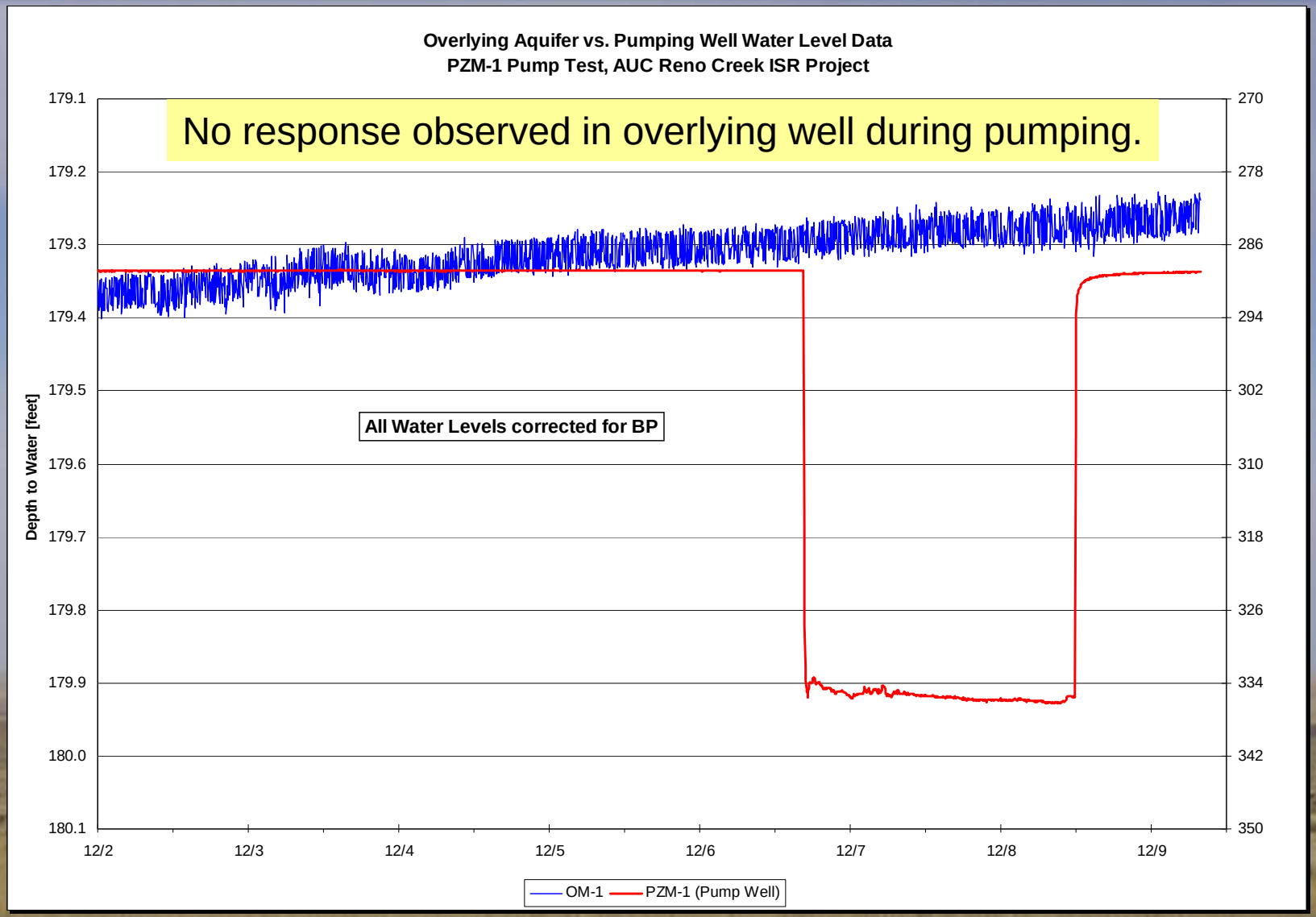

PZM1 Pump Test
Water Levels Observed in Underlying Aquifer

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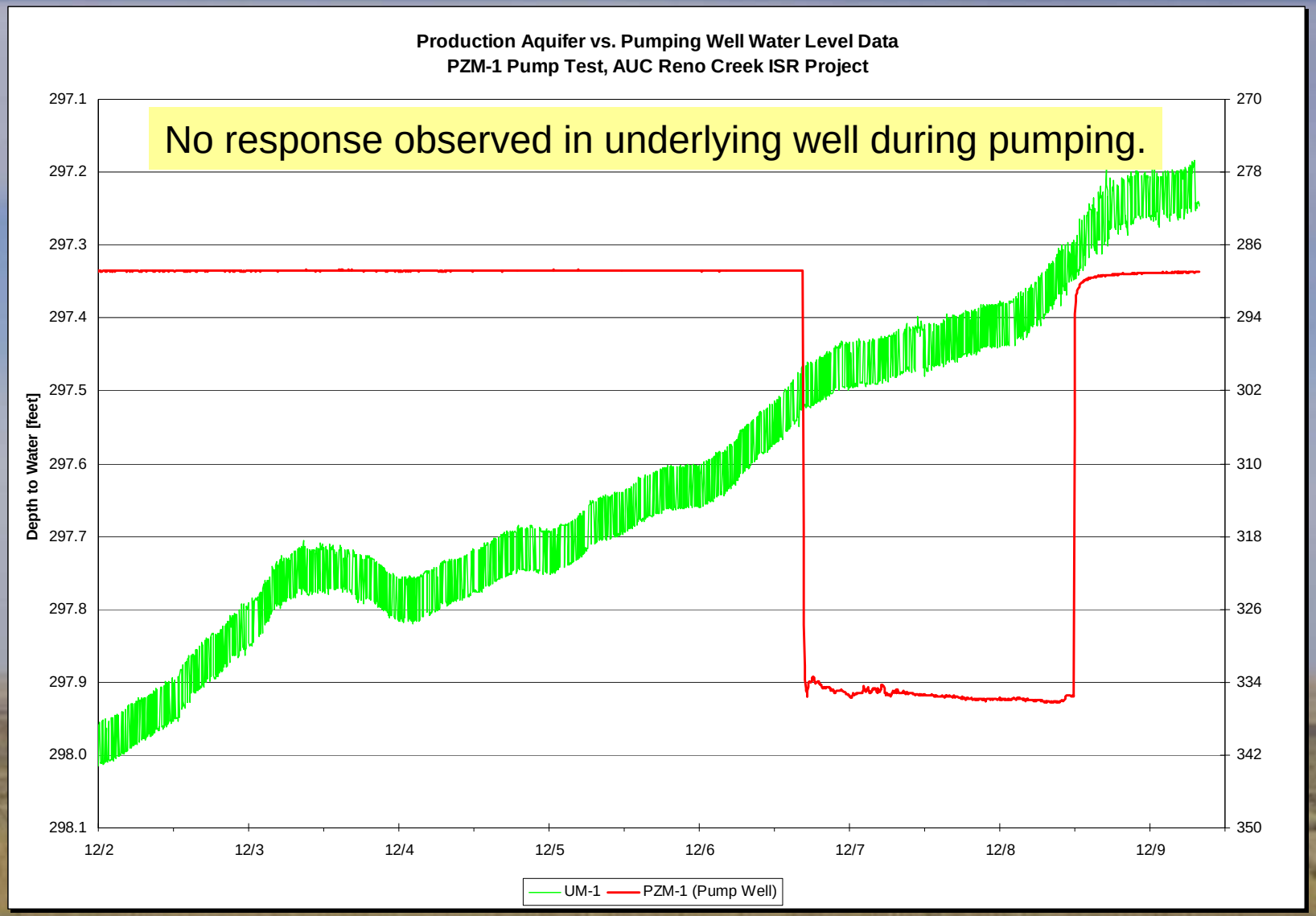

Preliminary Aquifer Properties
PZM1 Pump Test

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Well Name	Well Type	Distance from PW (feet)	Theis Drawdown, Jacob Corrected			Theis Recovery	
			T (ft^2/d)	K (ft/d)	S	T (ft^2/d)	K (ft/d)
PZM1	Pump	0	--	--	--	384	4.0
PZM9	Obs.	58	460	4.8	4.5E-03	456	4.8
PZM8	Obs.	81	537	5.7	7.5E-04	604	6.4
PZM10	Obs.	235	798	8.4	2.7E-03	895	9.4
		Averages:	**598**	**6.3**	**2.7E-03**	**652**	**6.9**

- Results are similar to historical testing conducted at RI-5 and RI-22 located approximately 1,000 feet southwest of PZM1;
- Results indicate that aquitards above and below the production zone aquifer are adequate; and
- Permeability results calculated from pump test fall within the ideal range for successful ISR mining and restoration operations.

PZM5 Pump Test

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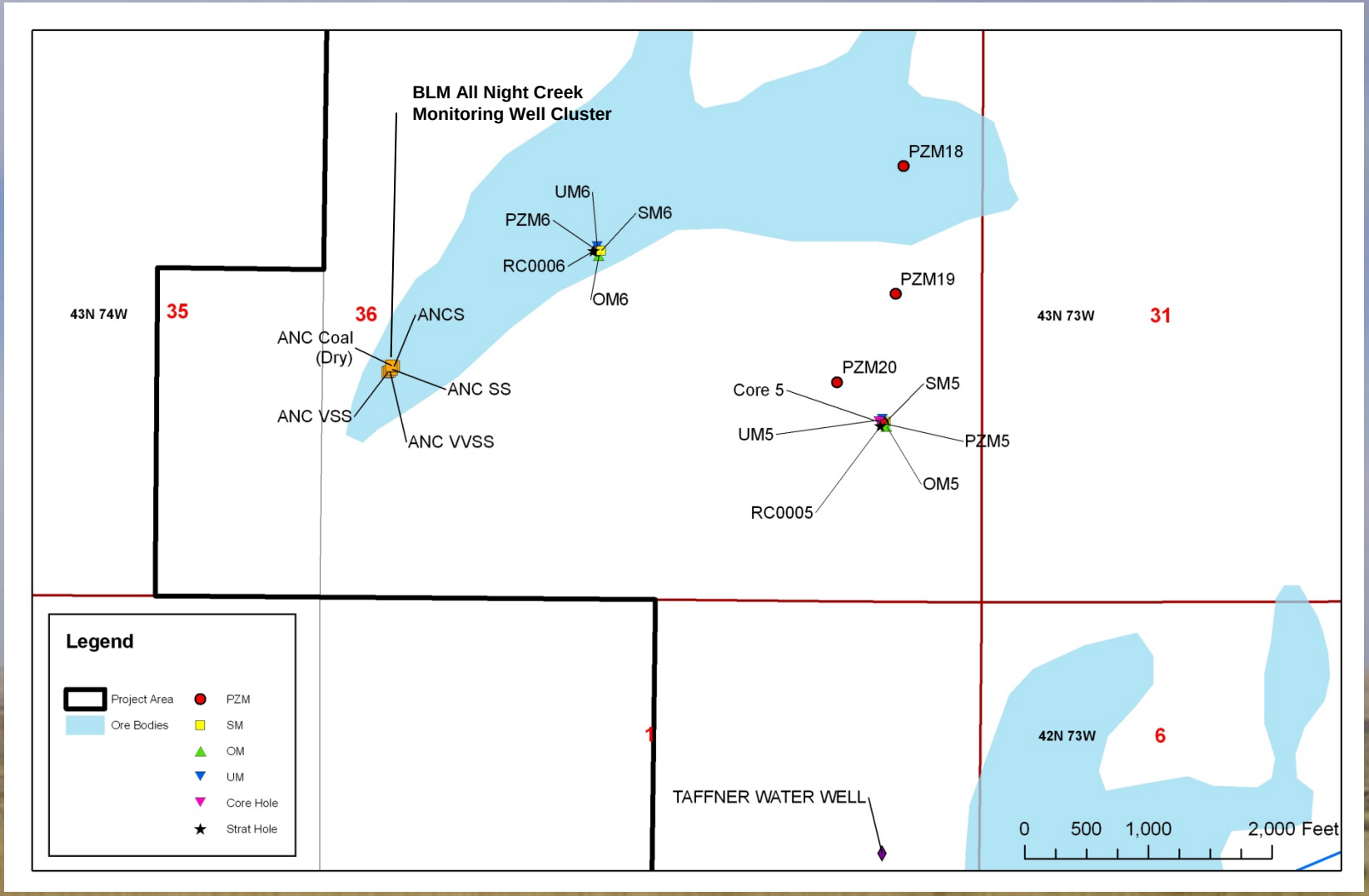

PZM5 Pump Test Status

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- First test attempt initiated on 02/07/11 at 16:00 prematurely ended on 02/09/11 at 09:45 due to generator failure associated with sub-zero temperatures;
- Second test attempt initiated on 02/16/11 at 12:00;
- Duration of second test = 8 days at 10 gallons per minute;
- Drawdown observed in production zone aquifer at 2,700 feet from pumping well;

PZM5 Distance Drawdown Plot

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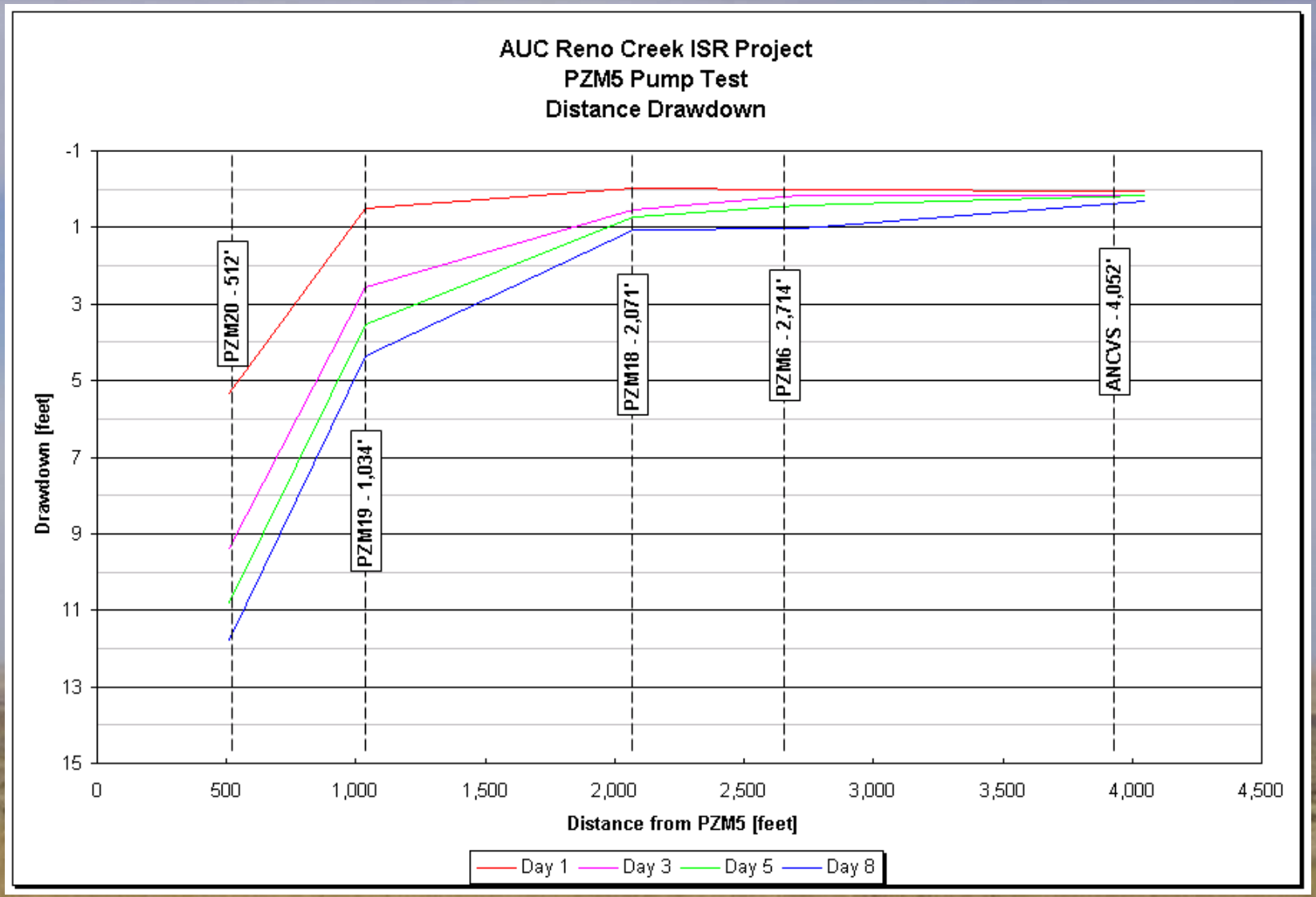

PZM5 Pump Test
Production Zone Aquifer
Potentiometric Surface 02/07/11

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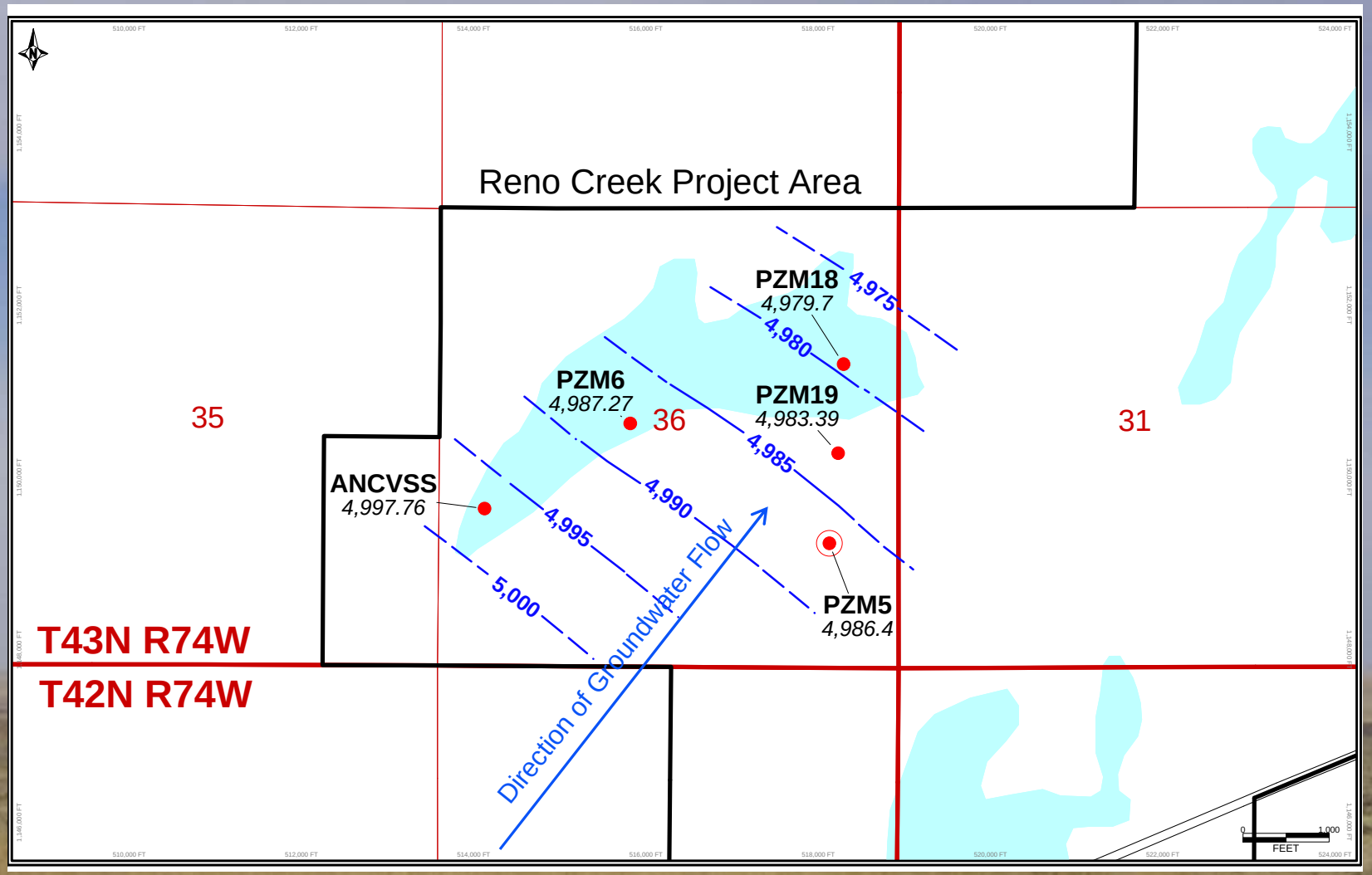

PZM5 Pump Test
Water Levels Observed in Shallow Water Table

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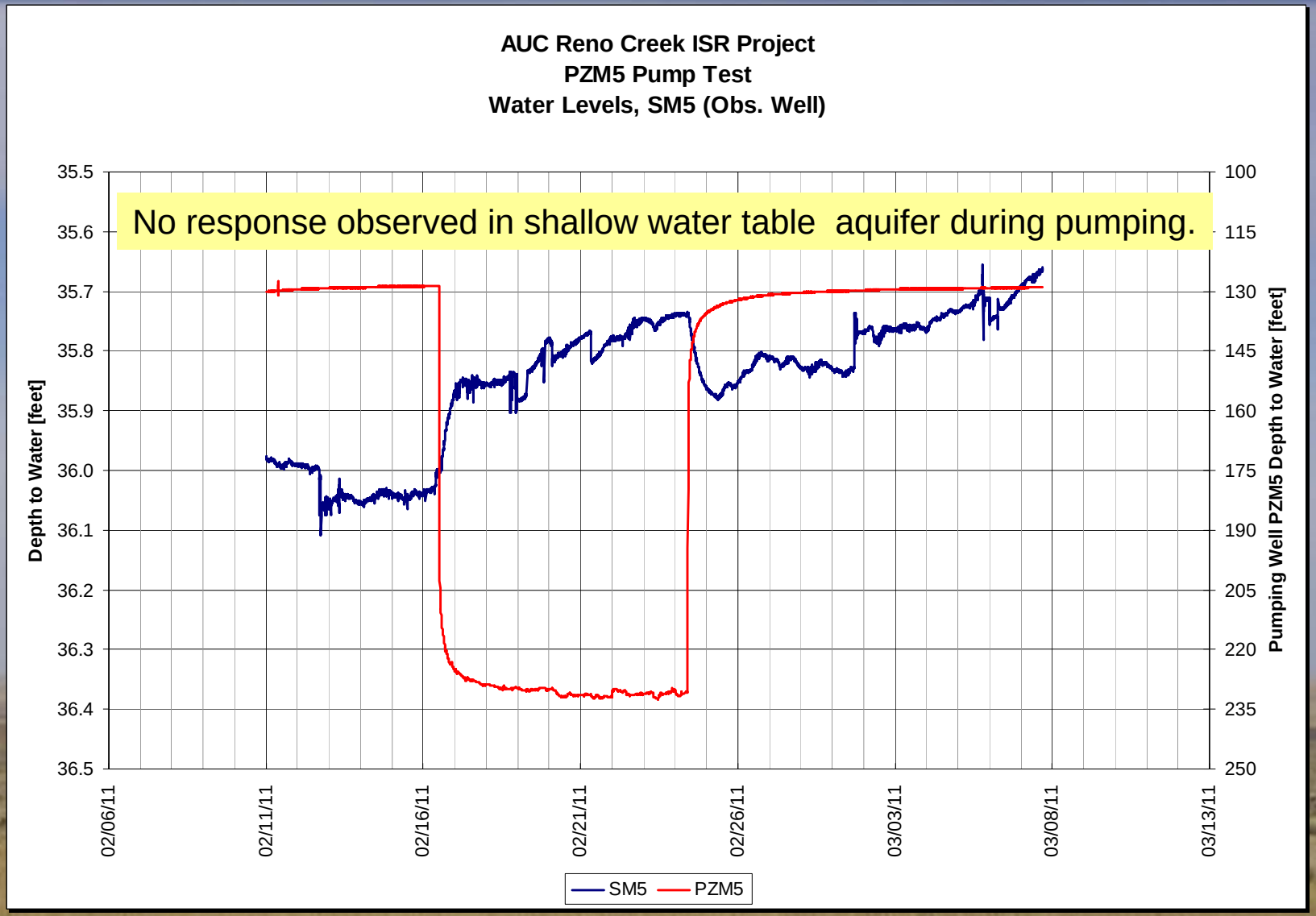

PZM5 Pump Test
Water Levels Observed in Overlying Aquifer

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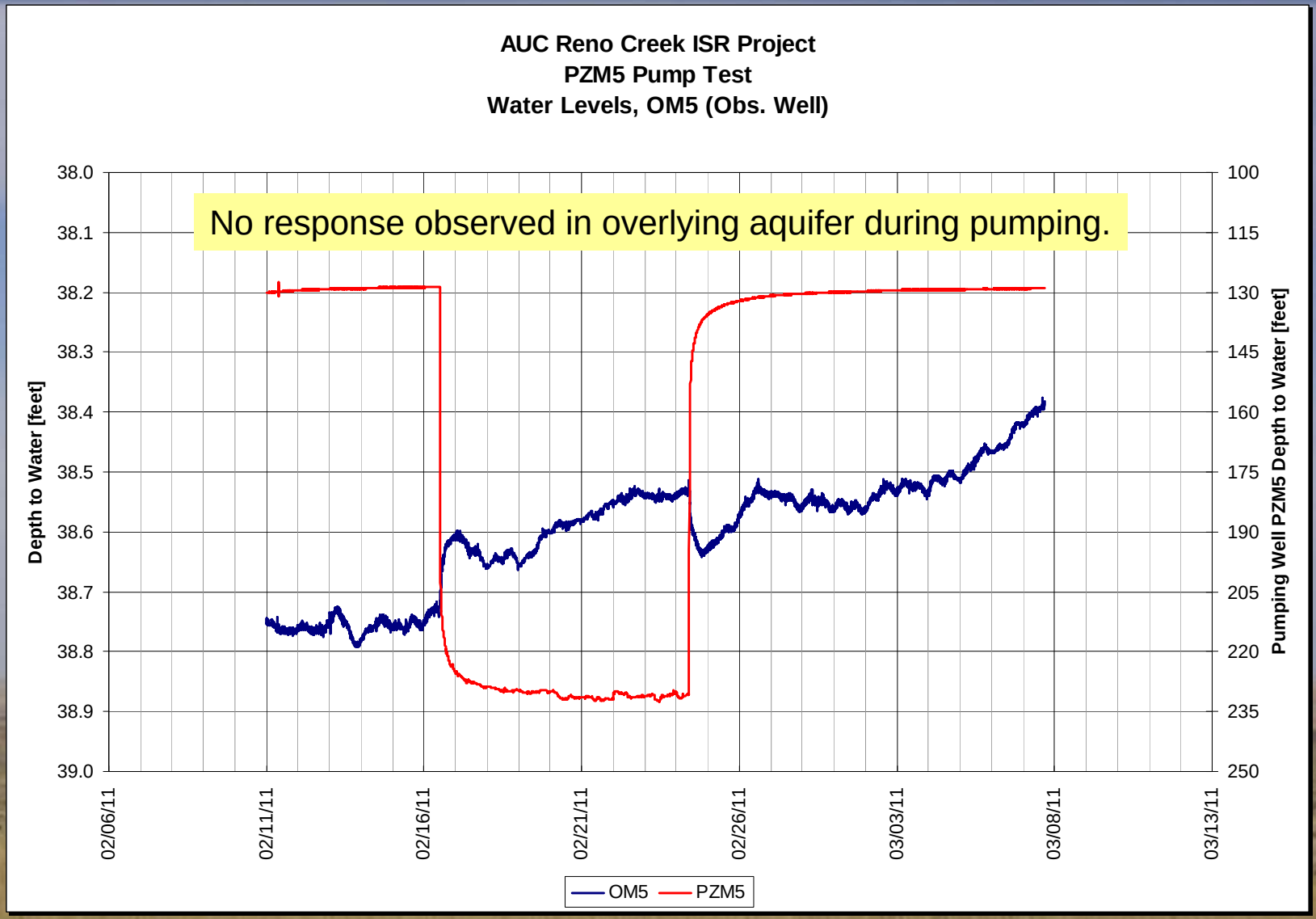

PZM5 Pump Test
Water Levels Observed in Underlying Aquifer

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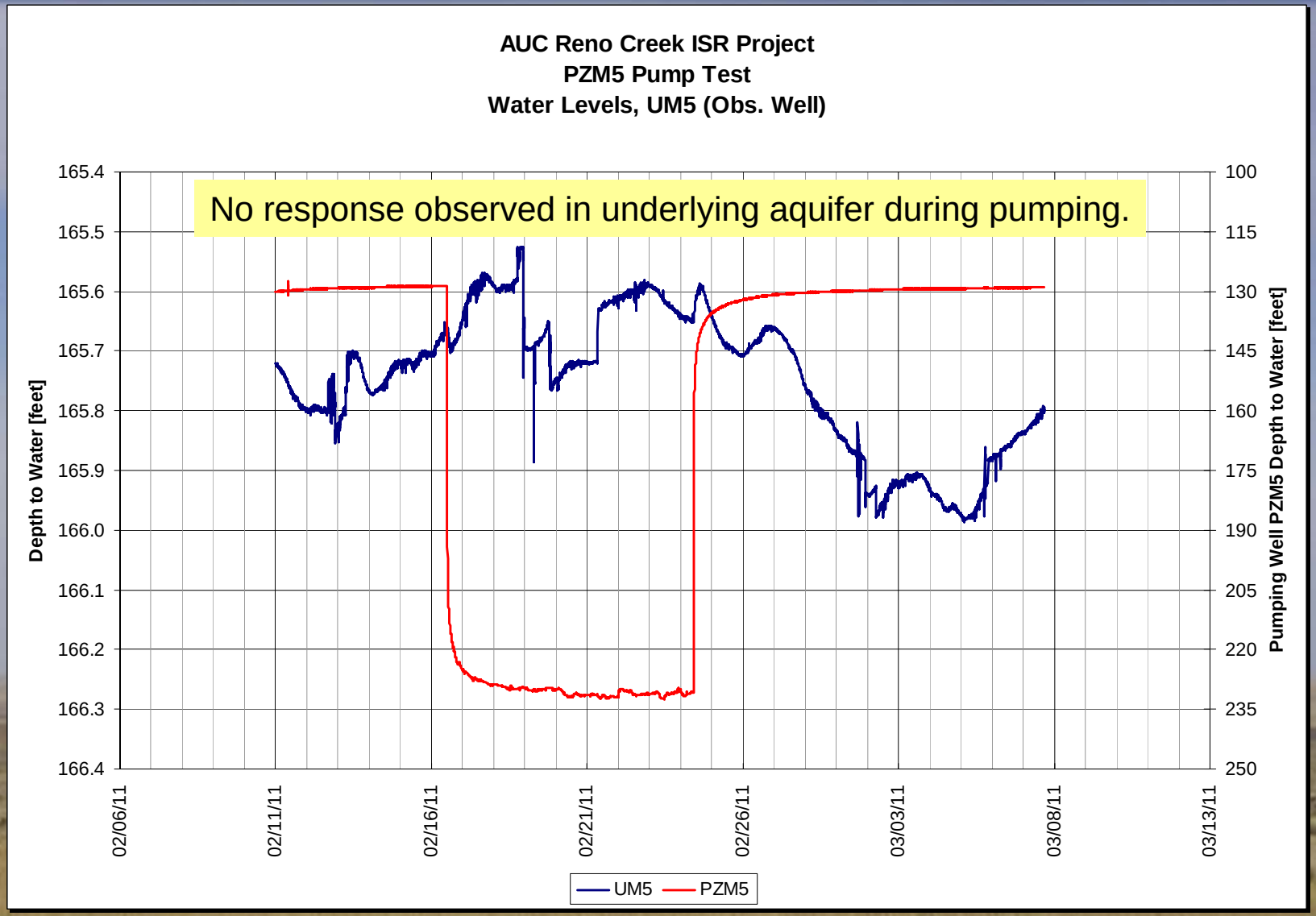

PZM5 Pump Test Results:

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- Hydraulic conductivity values range from 0.3 – 0.4 feet/day;
- Storativity values range from 7.9E-05 – 1.3E-04
- Radius of influence during pumping exceeded 2,700 feet;
- Lack of response in overlying and underlying aquifers during test indicates that overlying and underlying aquitards provide adequate confinement.

PZM4 Pump Test Layout

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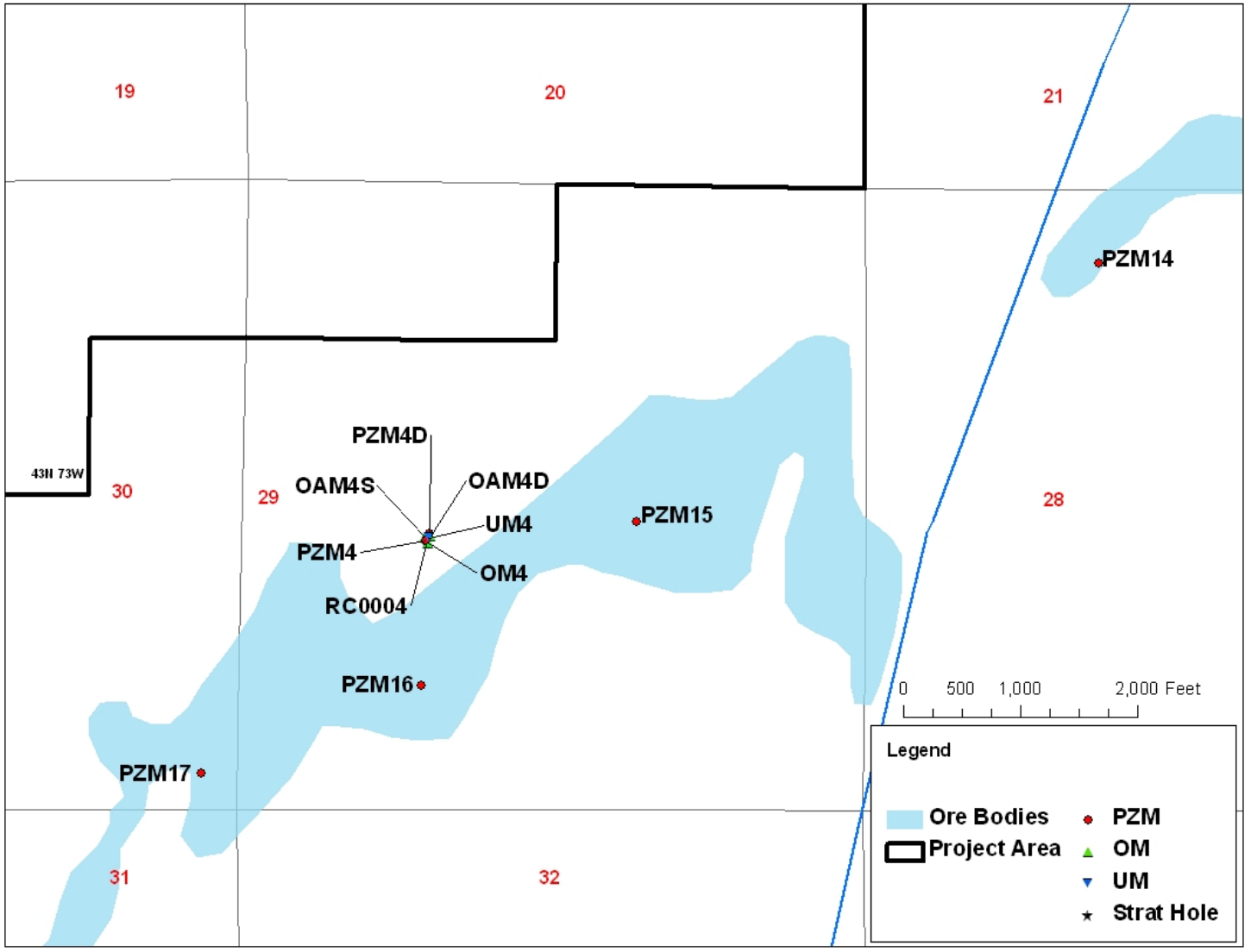

PZM4 Pump Test

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- Long-term test initiated on 8/9/2011;
- Duration of pumping = 7 days;
- Average pumping rate = 17.6 gpm;

PZM4 Pump Test
Production Zone Aquifer
Potentiometric Surface August 2011

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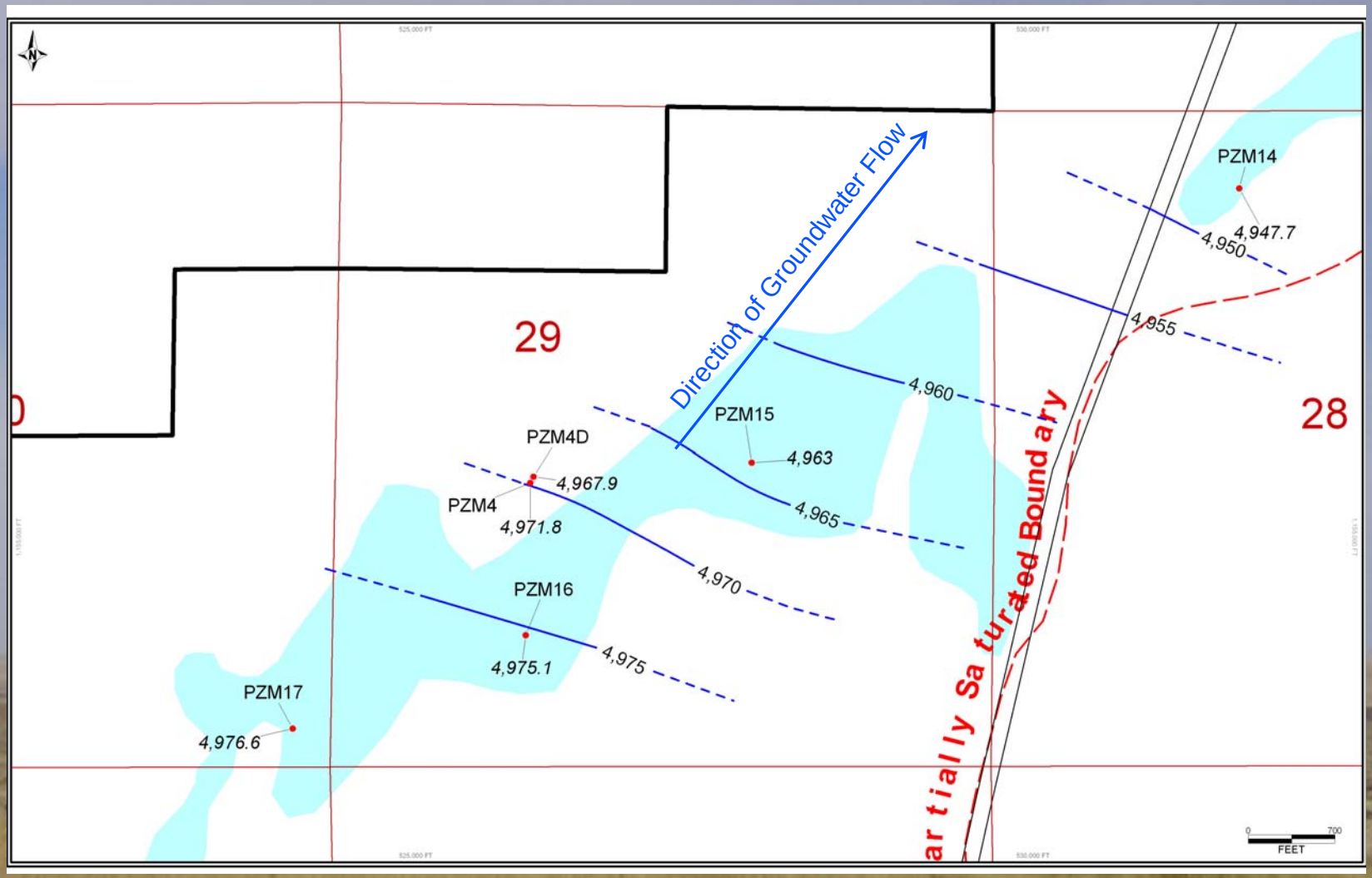

PZM4 Pump Test
Water Levels Observed in Overlying Aquifer

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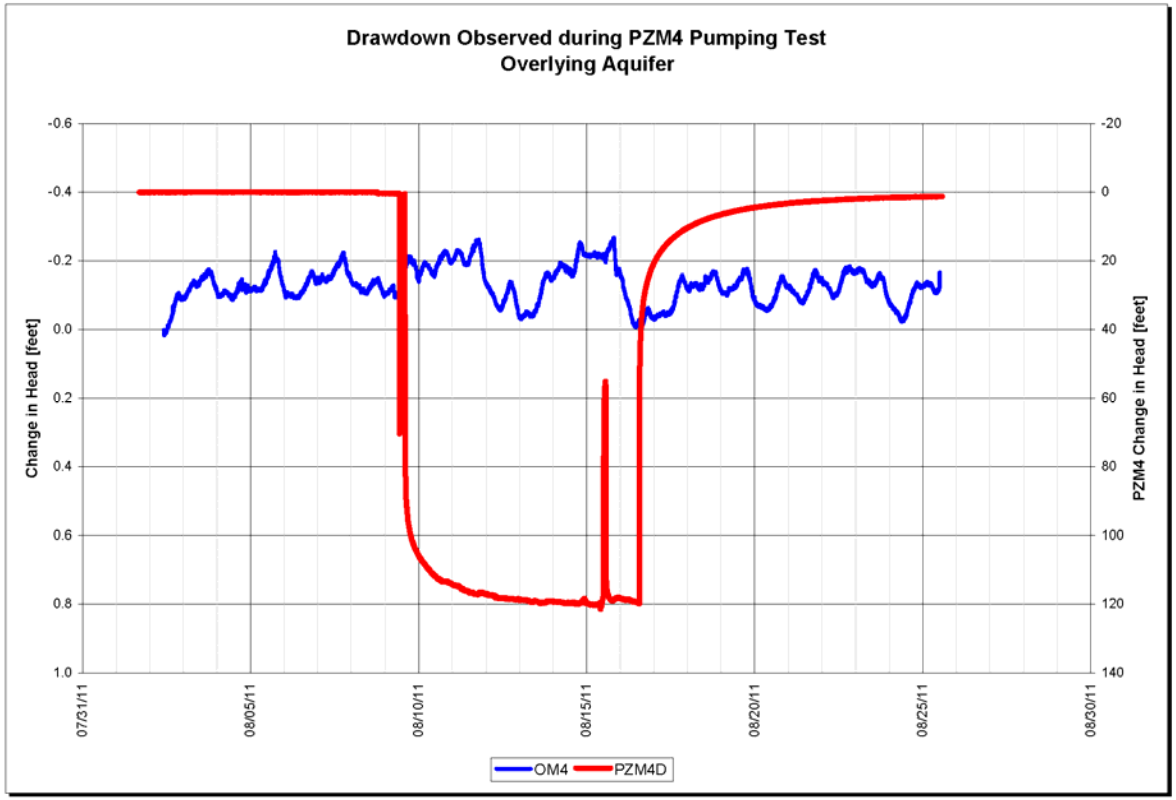
No response observed in overlying aquifer during pumping.



PZM4 Pump Test
Water Levels Observed in Felix Coal

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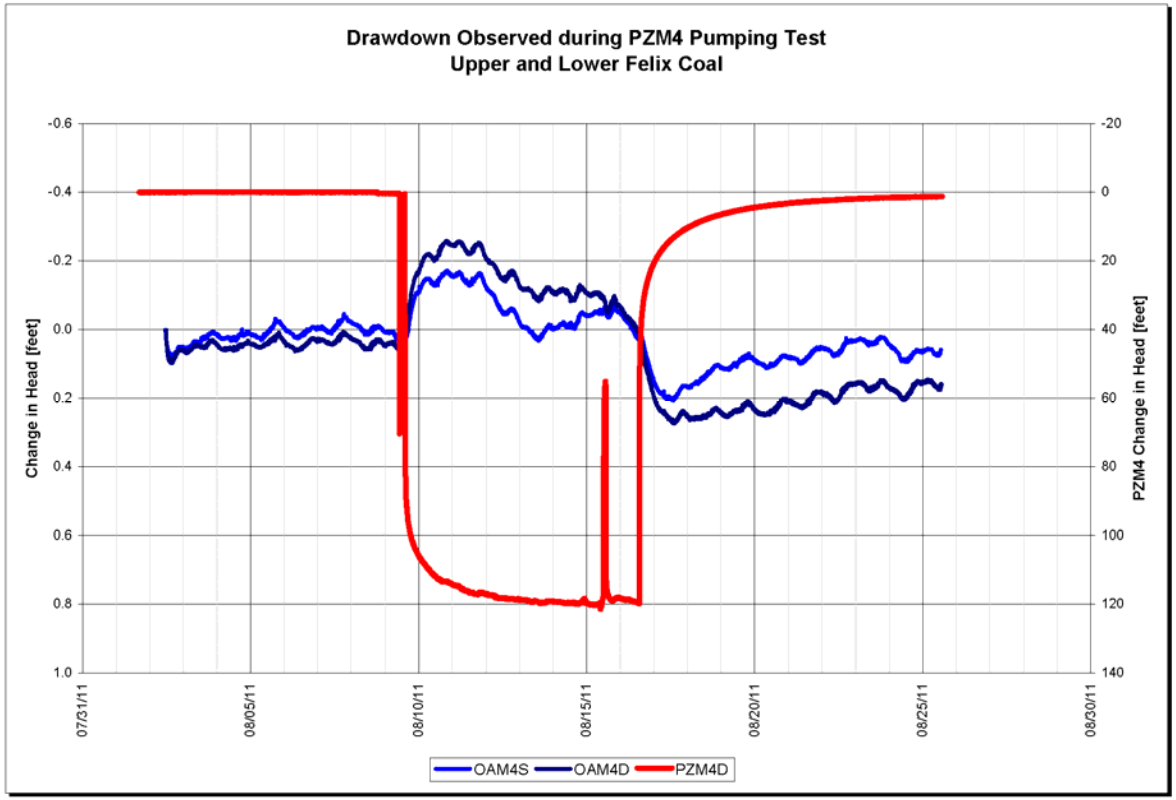
No response observed in Upper or Lower Felix Coal piezometers during pumping.



Felix Coal Characterization Summary

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- During the early stages of the project, the WDEQ asked if the Felix Coal was water bearing;
- AUC shared a similar interest as WDEQ in determining the Felix characteristics and installed piezometers in the upper and lower Felix Coal seams at the PZM4 cluster which are located in the overlying aquitard;
- During development, the Upper and Lower Felix Coal piezometers yielded less than 0.25 and 1.0 gpm respectively and went dry.

Felix Coal Characterization Summary Continued

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The Upper and Lower Felix Coals are not considered aquifers because:

- The definition of an aquifer per NRC: 10 CFR Part 40 Appendix A states: *'Aquifer means a geologic formation, group of formations, or part of a formation capable of yielding a significant amount of ground water to wells or springs.' and*

- The definition of an aquifer per DEQ/LQD Guideline 8 Hydrology Coal and Non Coal states: '*A zone, stratum, or group of strata that stores and transmits water in sufficient quantities for a specific use.'*

PZM4 Pump Test
Water Levels Observed in
Upper Production Zone Aquifer

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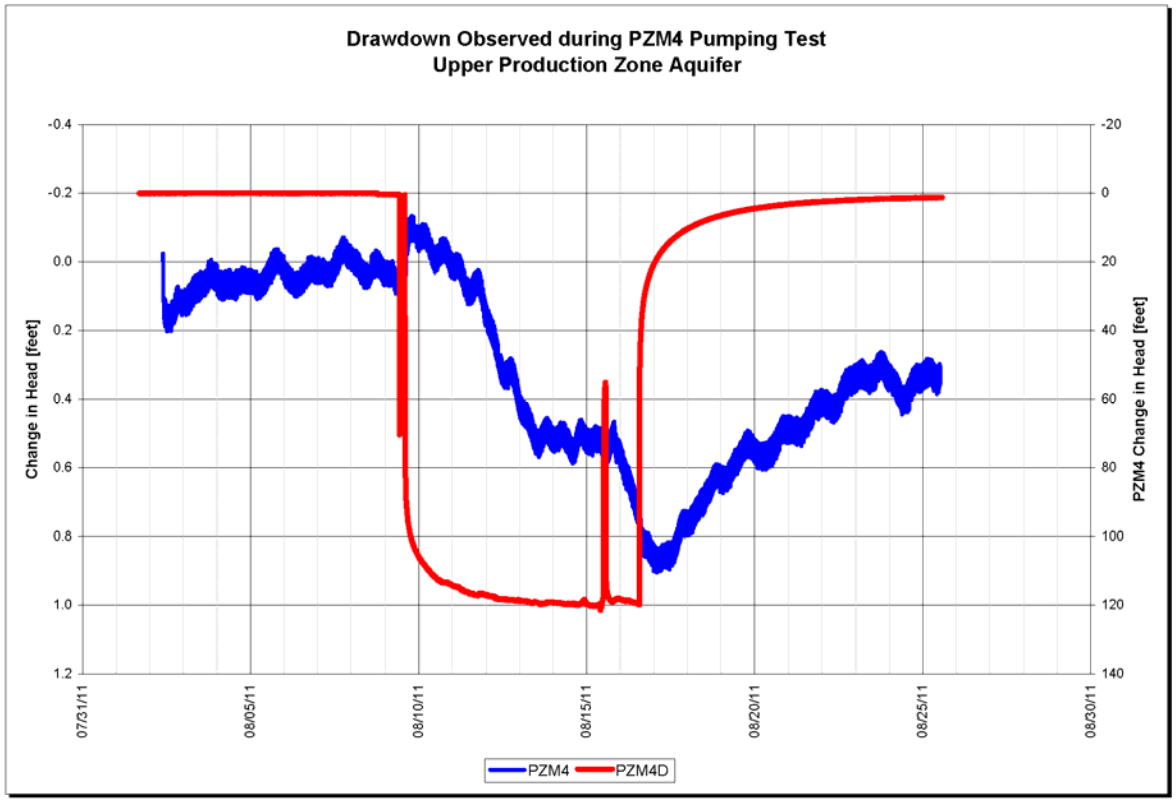
Small response observed in Upper Production Zone Aquifer



PZM4 Pump Test
Water Levels Observed in Production Zone Aquifer

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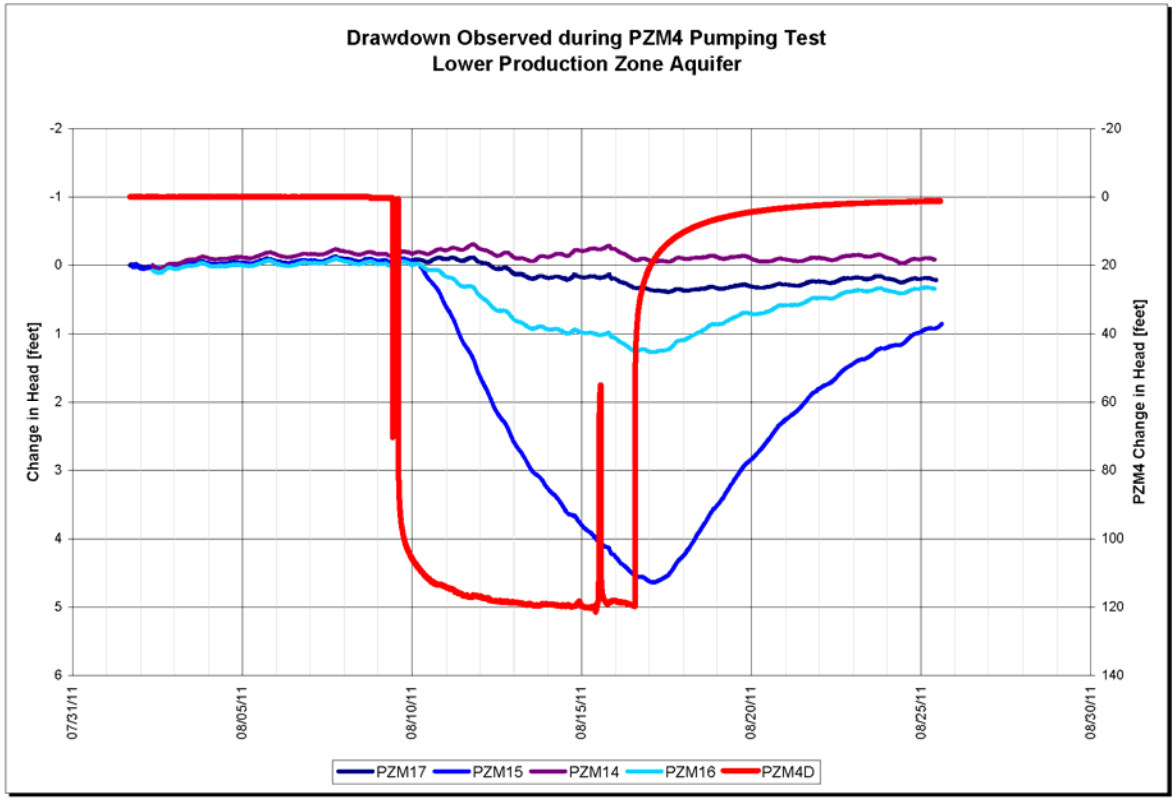

PZM4 Pump Test
Water Levels Observed in Underlying Aquifer

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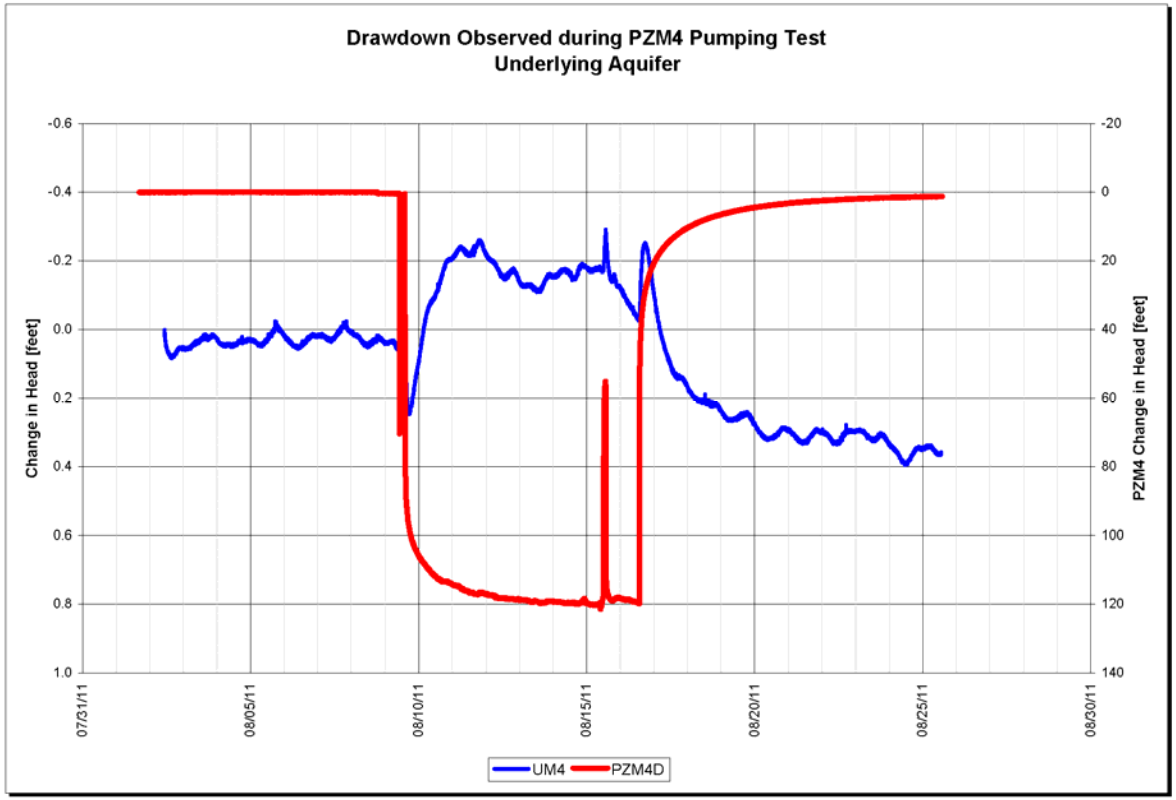
No response observed in underlying aquifer during pumping.



PZM4 Pump Test Preliminary Aquifer Properties/Observations

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- Final downloads recently received;
- Theis recovery results (K = 0.4 feet/day) from short-term water quality sampling test indicates that aquifer properties are similar to historical multi-well test conducted in the area at MP-9 located approximately 1,500 feet east/northeast of PZM4D;
- Drawdown observed in production zone aquifer at 1,800 feet from pumping well;
- Results demonstrate no measurable communication between the Production Zone aquifer and either the Overlying or Underlying aquifers;
- Analysis of drawdown data in progress.

Core Analyses
Permeability and Porosity

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Coring conducted at the PZM4 Cluster

- Overlying Aquitard
  - Vertical Liquid Permeability (specific to brine): 0.000877 md
- Underlying Aquitard
  - Vertical Permeability (Klinkenberg, 2 samples): Results Pending
  - Porosity (2 samples): Results Pending
  - Vertical Liquid Permeability: Results Pending

Regional Potentiometric Surface
Production Zone Aquifer – August 2011

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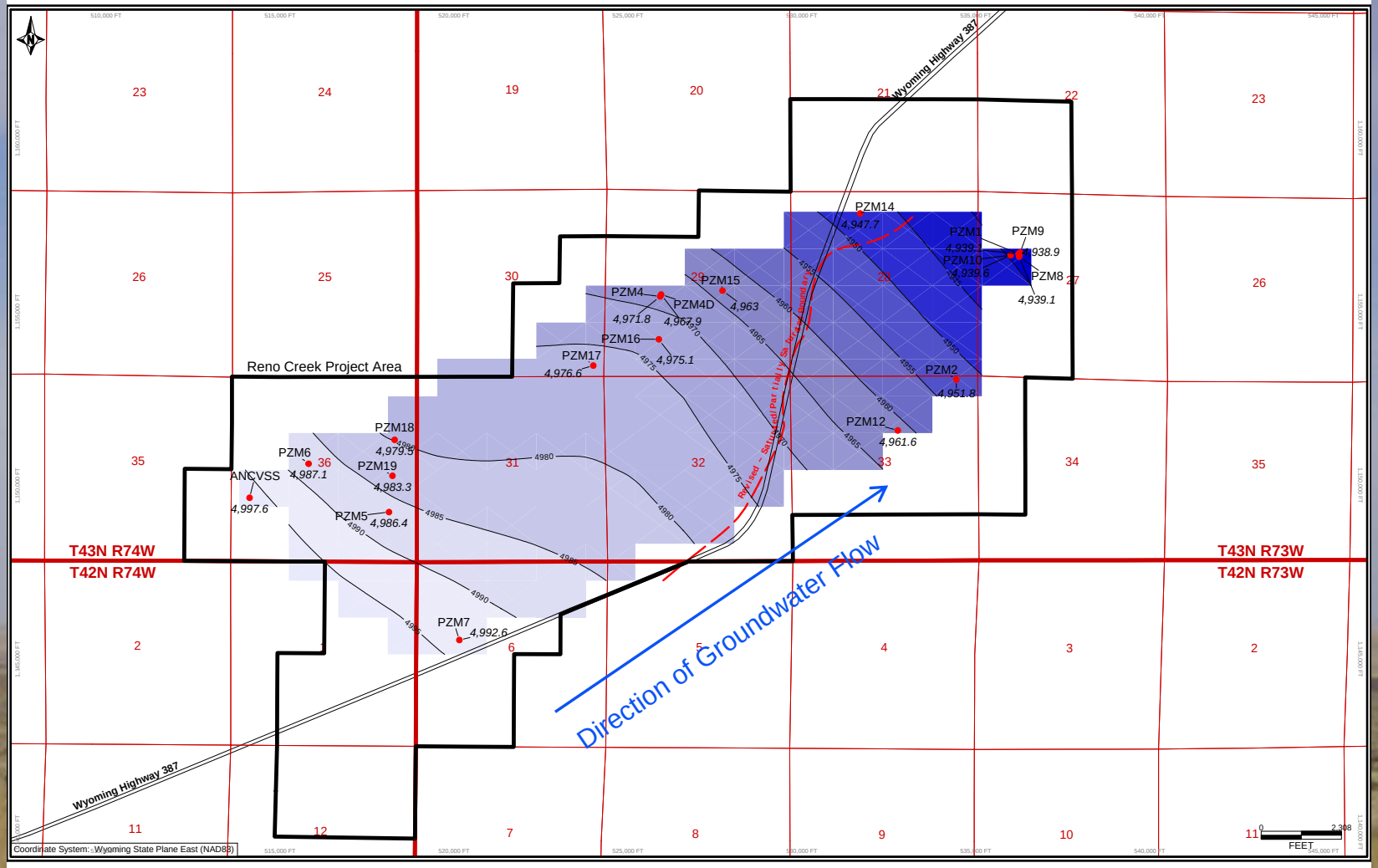
- Current and historical potentiometric surfaces of Production Zone Aquifer are consistent.



Additional Coal Bed Natural Gas Groundwater Monitoring

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- Regional groundwater monitoring conducted by BLM to assess four aquifers overlying the Fort Union, Big George Coal.
- Monitoring is conducted at the All Night Creek monitor well cluster located in Section 36 of T43N R74W of the Reno Creek Project Area.
- 1993 – 2006 Coalbed Natural Gas (CBNG) Regional Groundwater Monitoring Report: Powder River Basin, Wyoming, Keith E. Clarey, P.G., July 2009.
- This report represents one of the most complete groundwater studies performed in the Powder River Basin.
- Over nine years of water level data collected at the All Night Creek monitor well cluster indicate that four overlying Wasatch aquifers, including the overlying and production zone aquifer, are unaffected by CBNG production within the Big George at Reno Creek.

Location of BLM All Night Creek Monitoring Well Cluster

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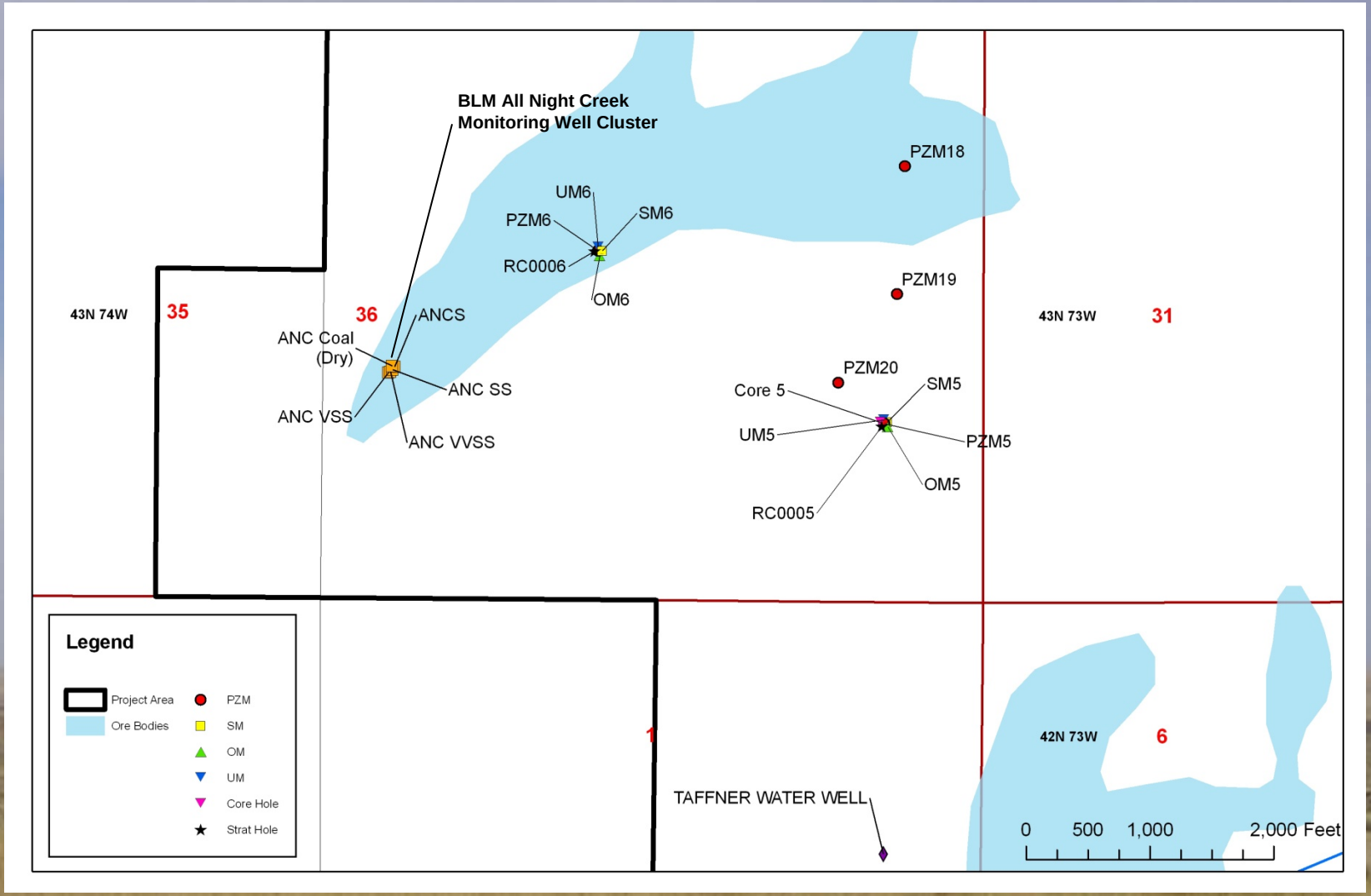

ANCVVSS (Wasatch Very Very Shallow Sand) Screen Interval = 215 – 235 ft bgs Reno Creek Overlying Aquifer

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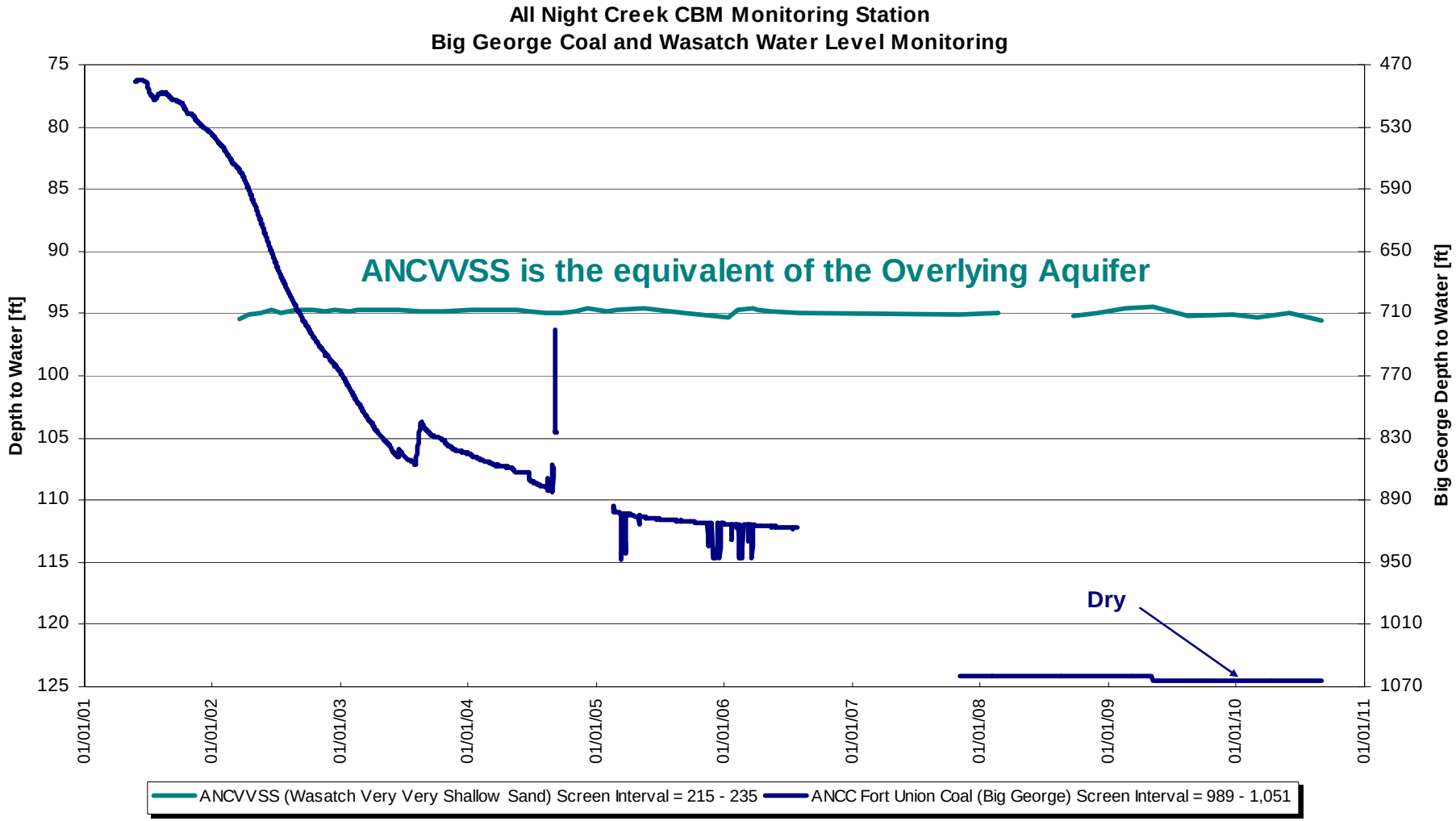

ANCVSS (Wasatch Very Shallow Sand) Screen Interval = 362 – 462 ft bgs Reno Creek Production Zone Aquifer

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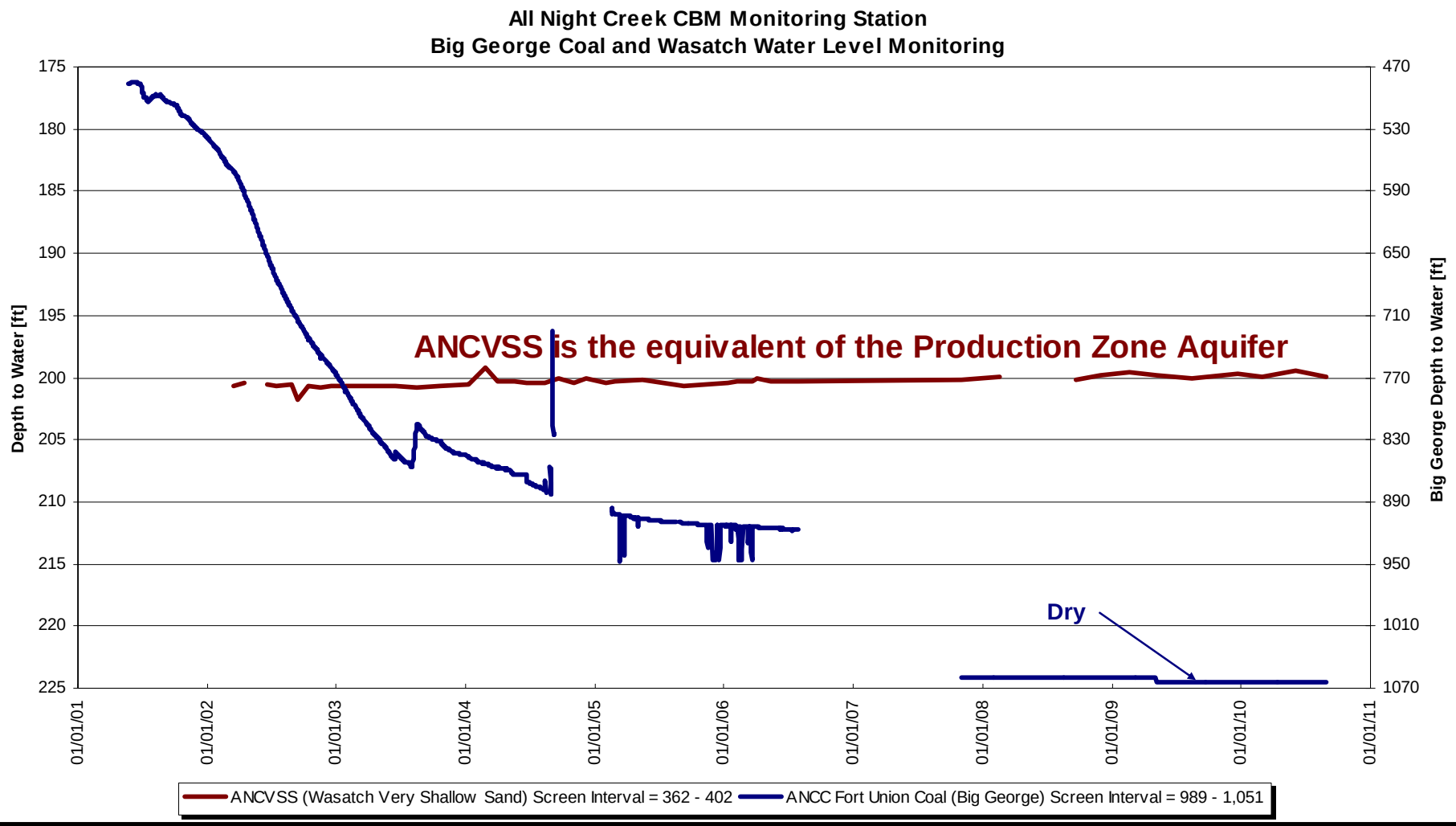

ANCSS (Wasatch Shallow Sand)
Screen Interval = 598 – 638 ft bgs

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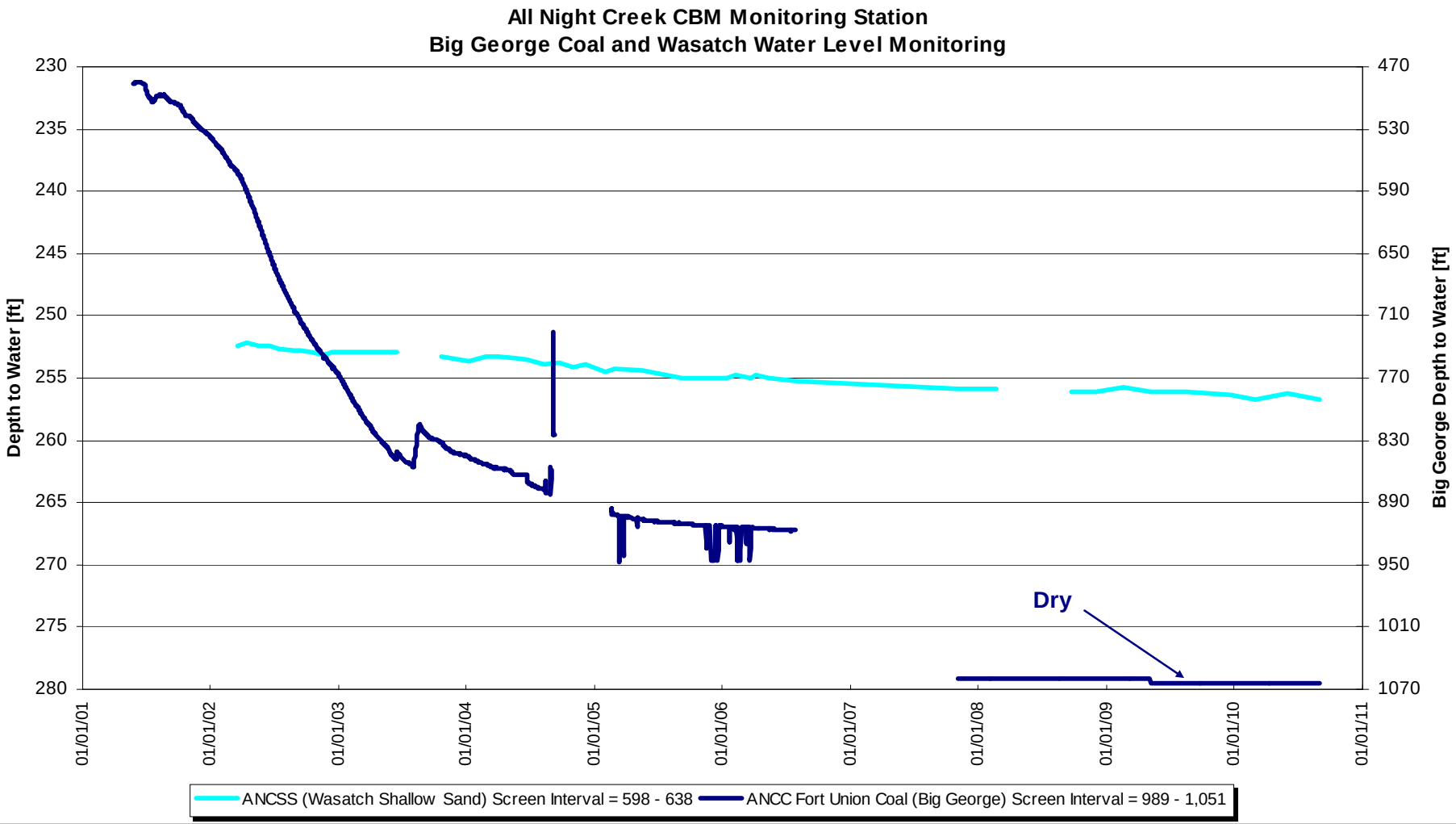

ANCS
(Wasatch Deep Sand)
Screen Interval = 840 – 860 ft bgs

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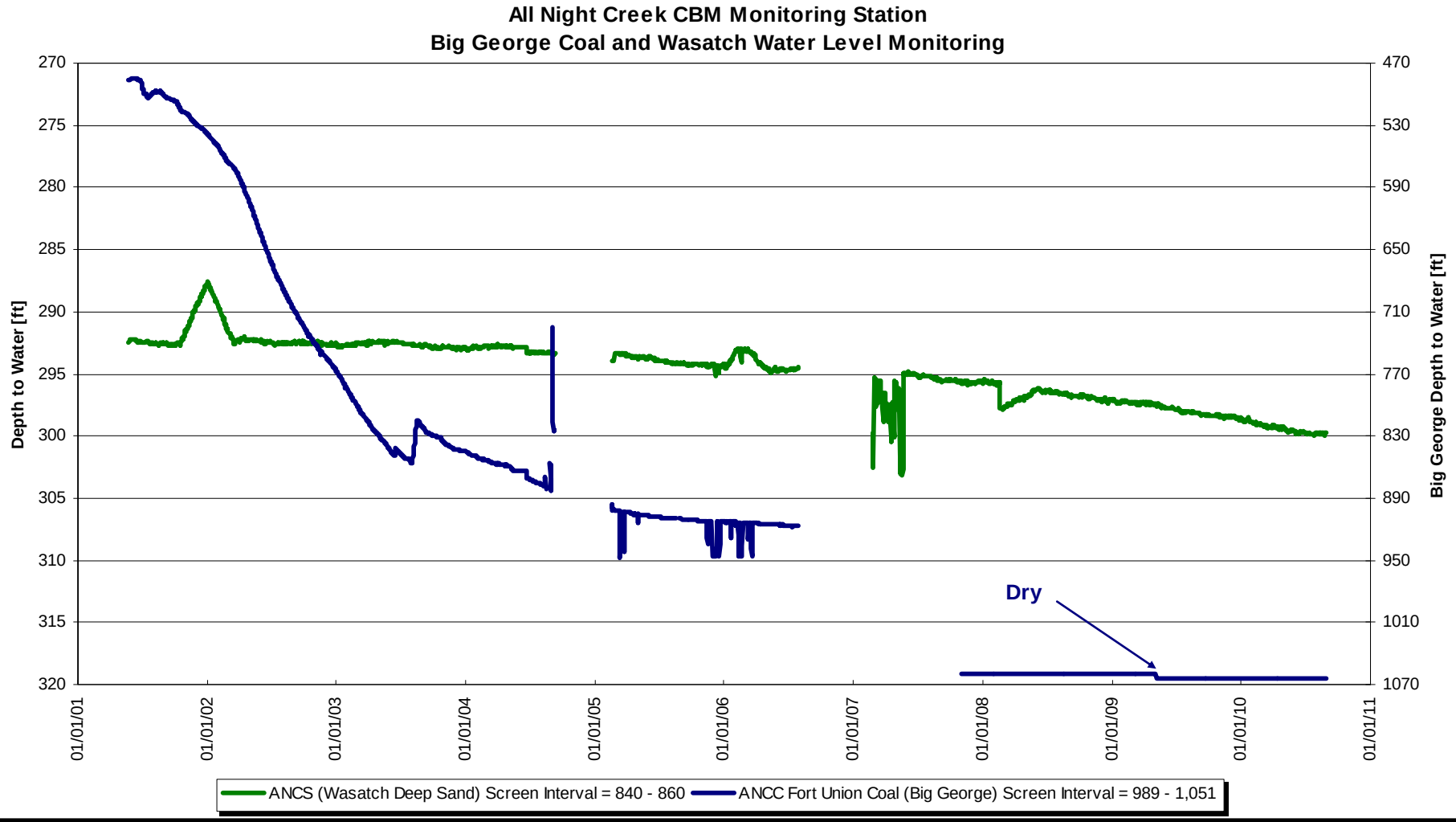

Remaining Hydrogeological Characterization Tasks

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- Complete PZM3 Pump Test;
- Complete single-well tests on shallow water table (if present), overlying and underlying aquifers at each pump test location;
- On-going water level monitoring;
- Aquifer test analyses;
- Groundwater modeling.

Groundwater Modeling

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Groundwater modeling for both the fully saturated and partially saturated portions of the Production Zone Aquifer will address the following issues:

- Monitor well ring spacing (adequacy for excursion detection);
- Excursion control/recovery;
- Drawdown impacts to potentially affected hydrologic units in response to production and restoration activities;
- Hydraulic control;
- Water balance during:
  - Production
  - Concurrent production and restoration
  - Restoration
- Drawdown life of mine.
- Determine monitor well placement;
- Optimize sweep efficiency;
- Demonstrate excursion control; and
- Enhance restoration activities

General Summary of 2010 – 2011 Hydrologic Testing

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- Current and historical potentiometric surfaces are similar;
- Most recent hydrologic testing supports the findings of the Hydrogeologic Integrity Evaluation in that there is adequate confinement above and below the Production Zone Sand;
- Based on the data presented from BLM's All Night Creek well cluster, no cumulative impacts of ISR production and CBM operations are expected in the Reno Creek Project Area;
- Results of core analyses for overlying aquitard (0.00088 md) are very favorable for controlling mining fluids and protecting the overlying aquifer. Results of underlying aquitard analyses are pending.
- Aquifer properties derived from the 2010 – 2011 hydrologic testing are similar to historical values. These values are consistent with aquifer properties at other ISR facilities where ISR production and restoration has been successfully implemented.

Groundwater Statistics - Overall Strategy

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1. **Regional Baseline Monitoring**
   - Conduct sufficient sampling events to establish statistically defensible baseline concentrations
   - Characterize data distributions, spatial and temporal dependencies for each parameter and well grouping
   - Where justified, subdivide well groupings to assure representative populations
   - Treat non-detects and outliers consistent with EPA and WDEQ guidance
   - Use ProUCL and EPA's Unified Guidance to establish statistical consistency with background concentration range
2. **Production Unit Baseline Monitoring**
   - Use ProUCL and EPA's Unified Guidance to establish individual UCL's and target restoration values
3. **Compliance Monitoring**
   - Apply the same principles used for background monitoring, on a production basis
4. **Stability Monitoring**
   - Apply the same principles used for background monitoring

Data Classification

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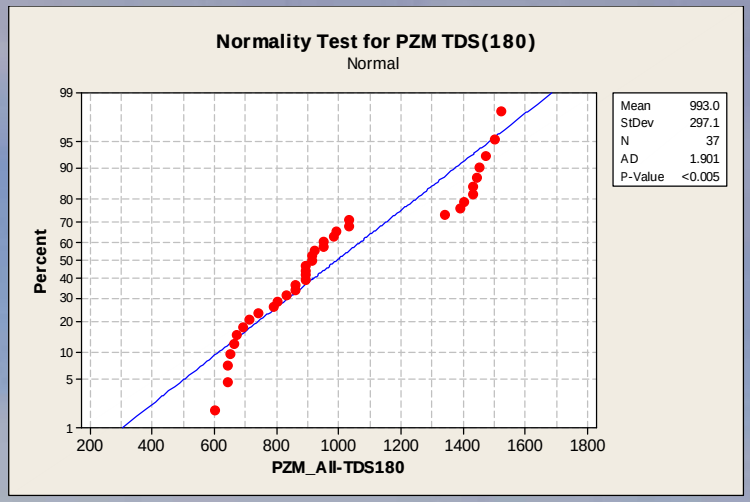
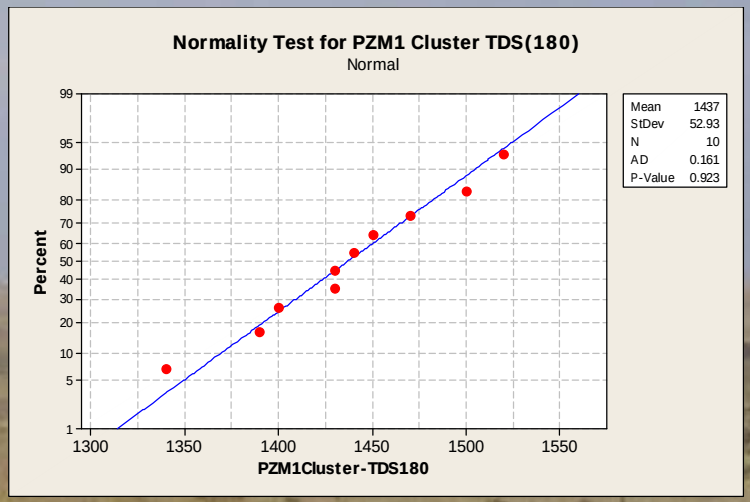
1. Spatial Grouping Methods
   - Aquifer designation
   - Unique zones within aquifer
   - Analysis of Variance (ANOVA)
2. Temporal Variations
   - Trending not feasible due to limited period of record
3. Data Distribution
   - Normal: Shapiro-Wilk test
   - Lognormal: Shapiro-Wilk test
   - Gamma: Anderson-Darling test
   - Other parametric distributions
   - Nonparametric (ranked) distributions
4. Constituent Parameters
   - WDEQ Guideline 8
   - NUREG 4.14 with radon added





Data Quality Assurance

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1. Data Quality Management
   - Field quality control
   - Laboratory quality control
   - Input only validated results into analytical database
2. Objectives
   - Generate a reliable data set for statistical analysis
   - Reduce the occurrence of outliers due to error
   - Treat data as indicative of hydrogeochemistry

Handling Non-Detects

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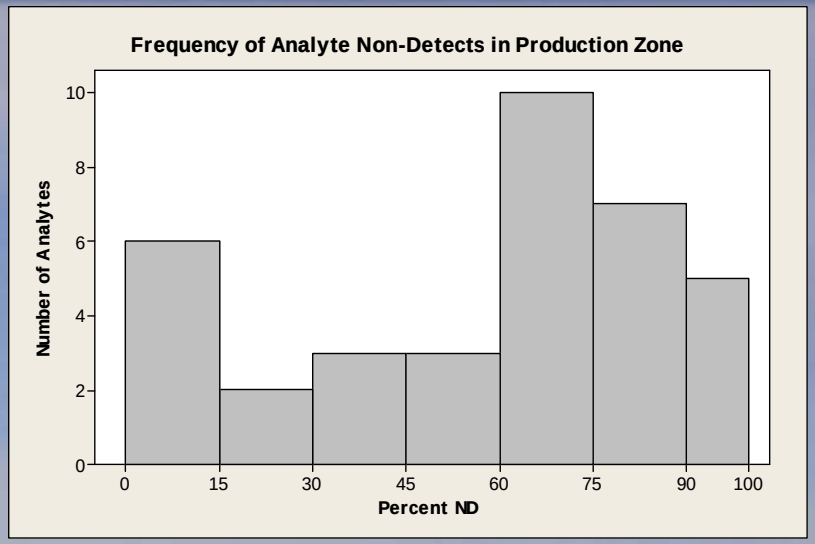
1. Non-detect Data Distribution
   - Where present, non-detects (ND) often dominate; cannot establish data distribution for detects
   - Non-detects are present for over one third of the parameters
2. Non-detect Treatment Strategy
   - Do not substitute detection limit (DL) or half the DL (must have < 15% ND's to justify substitution)
   - Define a derived variable as the proportion of non-detects and treat as a binomially distributed variable
   - Examine detects for plausibility, consider outlier analysis if not "believable"
   - Treat values > ND same as ND if concentrations are much less than MCL (not material)



PARAMETER	ND_Ratio
Bicarbonate as HCO3	6.67%
Dissolved Manganese	6.67%
Total Manganese	6.67%
Total Iron	13.33%
Lead 210 (Dissolved)	13.79%
Radium 226	14.29%
Lead 210 (Suspended)	20.69%
Fluoride	26.67%
Dissolved Arsenic	33.33%
TSS	33.33%
Radium 228 (Dissolved)	40.00%
Dissolved Molybdenum	54.84%
Uranium Suspended	55.17%
Radium 226 (Suspended)	58.62%
Ammonia Nitrogen (As N)	60.00%
Total Radium 228	62.50%
Dissolved Iron	63.33%
Dissolved Barium	66.67%

PARAMETER	ND_Ratio
Dissolved Boron	66.67%
Dissolved Selenium	66.67%
Dissolved Vanadium	70.00%
Polonium 210 (Suspended)	72.41%
Dissolved Aluminum	73.33%
Dissolved Copper	73.33%
Carbonate as CO3	76.67%
Nitrate-Nitrite (as N)	76.67%
Dissolved Lead	80.00%
Thorium 230 (Suspended)	82.76%
Dissolved Chromium	83.33%
Polonium 210 (Dissolved)	86.21%
Dissolved Cadmium	86.67%
Dissolved Zinc	90.00%
Thorium 230 (Dissolved)	93.10%
Dissolved Mercury	100.00%
Dissolved Nickel	100.00%
Nitrite Nitrogen (as N)	100.00%

Handling Outliers

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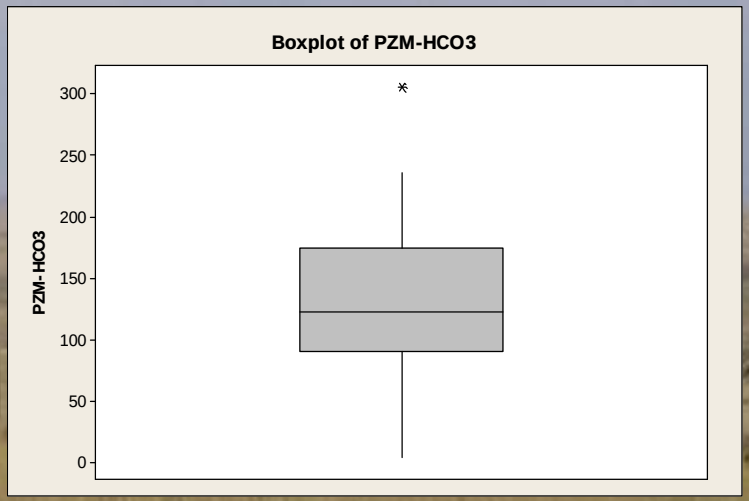
1. Ranking Data Set
   - Look for large gaps at the beginning and end of the data
   - Identify candidates for further analysis
2. Box Plot
   - ProUCL box plot shows potential outliers and general shape of data distribution
   - Refine candidates for further analysis
3. Rosner Test
   - Assumes normal (or log-normal) distributed data
   - Identifies potential outliers at 5% and 1% significance levels
4. WDEQ Guidance
   - Loftis tolerance limit formula recommended
   - Method generally leads to fewer outliers than ProUCL methods (higher burden of proof)
5. Technical Support
   - Explain and retain high values attributable to geochemistry
   - Do not eliminate data as outlier without implausibility argument
6. Example: HCO_3 in production zone
   - Ranking suggests outliers (5,5,8,305)
   - Box plot narrows candidates to one (305)
   - EPA and WDEQ guidance indicate no outliers (tolerance limits of 324 and 358, respectively)

5	91	114	130	197
5	91	115	131	209
8	92	120	134	212
69	92	126	135	232
71	96	129	174	236
78	112	129	175	305



General Approach

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- This will describe a general approach to the hydrogeochemical/hydrostratigraphic characterization
- Work still underway for site characterization
  - More data expected
  - Approximately 50% data collected
  - This is a work in progress
  - Other methods may be employed later depending upon data and project requirements

Geochemical Fingerprinting
Major Ions

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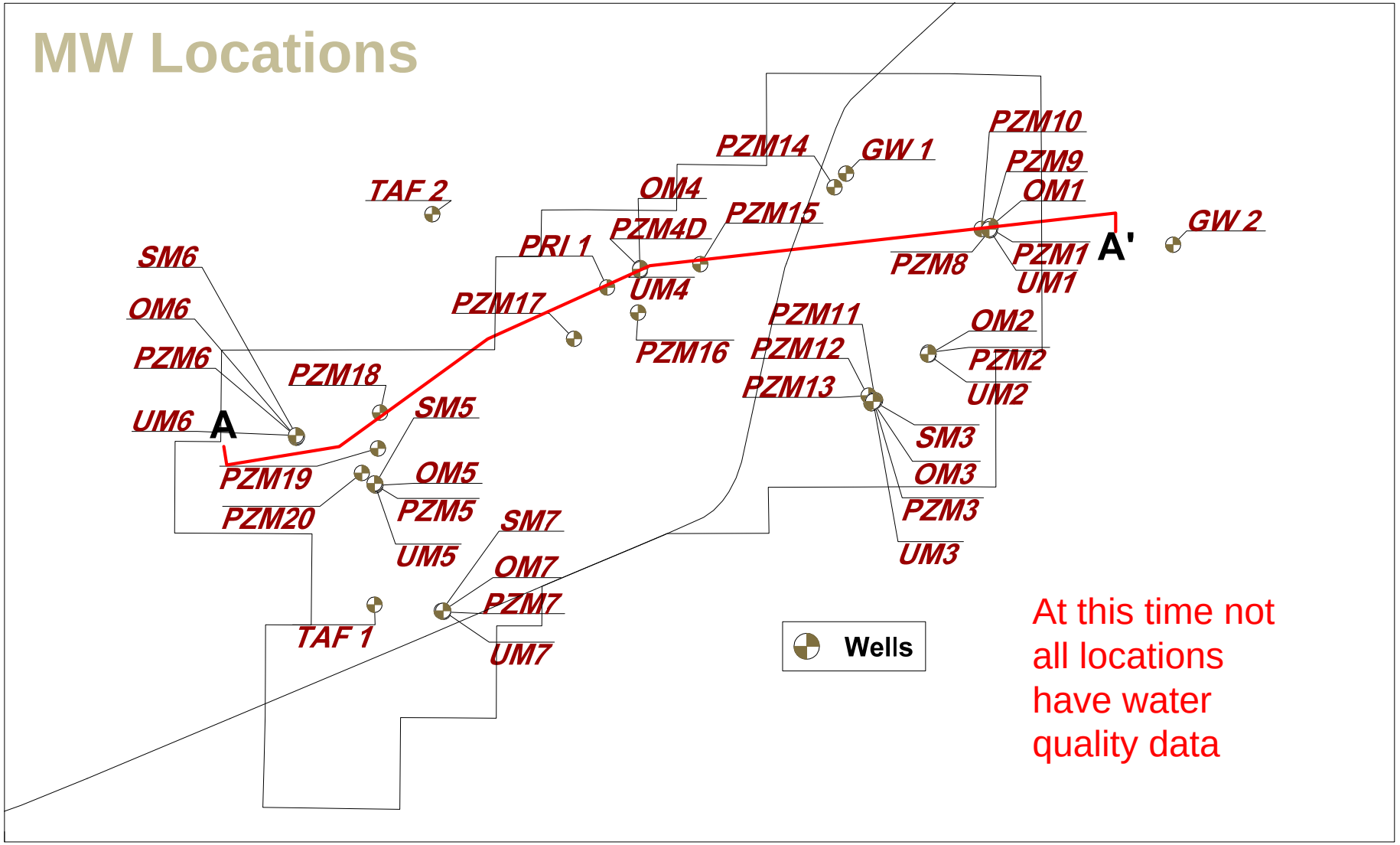
- Piper Diagram and Stiff Diagram Analysis
  - Provides graphical means to evaluate major ion (Ca^{+2}, Mg^{+2}, Na^{+} plus K^{+}, HCO_3^{-} plus CO_3^{-2}, Cl^{-} and SO_4^{-2}) data
  - Both methods use similar major ion data
  - To accommodate different purposes and preferences both methods are included
  - Prepared using Enviroinsite
- Methods allow for discrimination of different water types
- Relations to hydrogeologic setting
- Supports statistical analysis with ProUCL methods

MW Locations



Reno Creek Sample Locations

Recent Samples

Piper Diagram – All Samples

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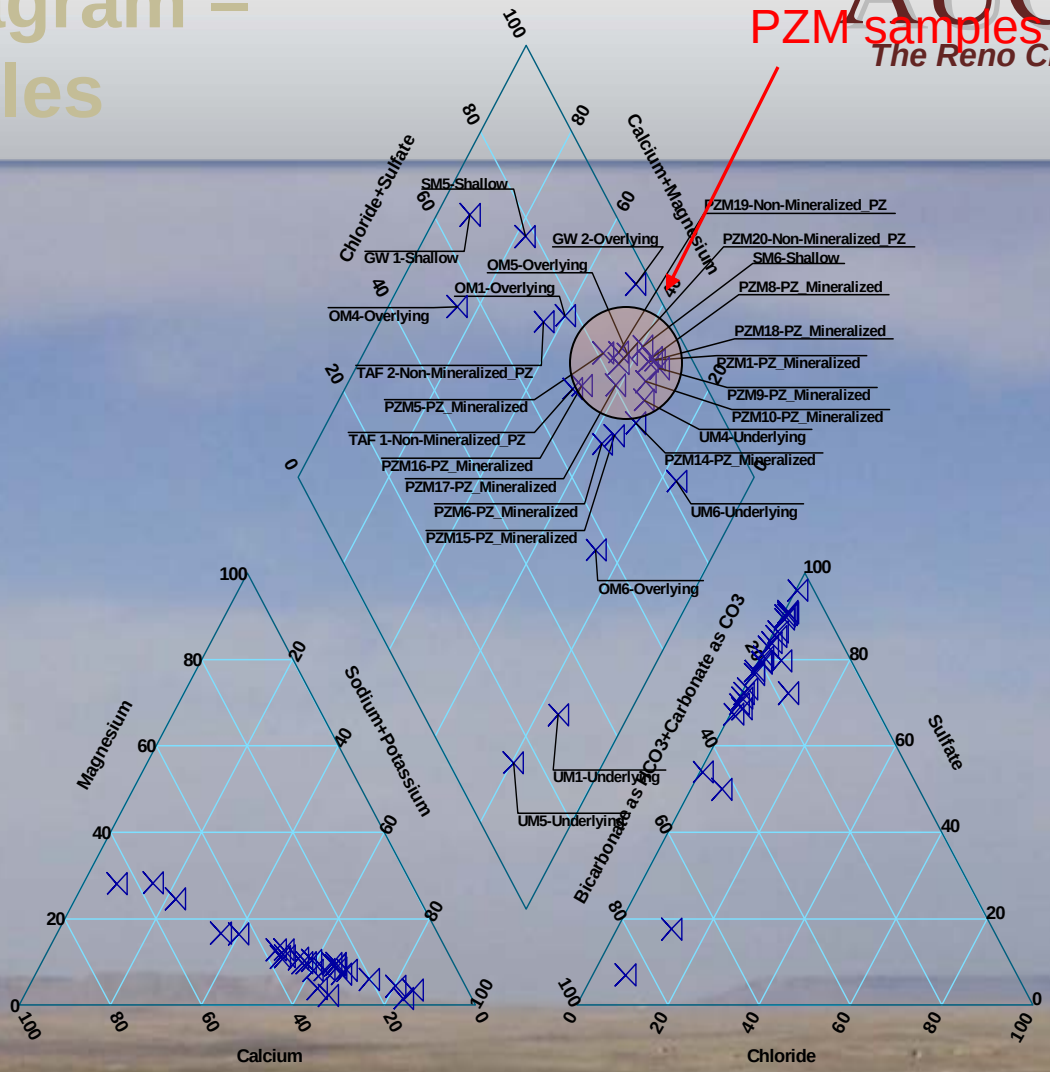
PZM samples fit within oval



Reno Creek Piper Diagram

All Waters

Shallow, Overlying and Underlying Samples

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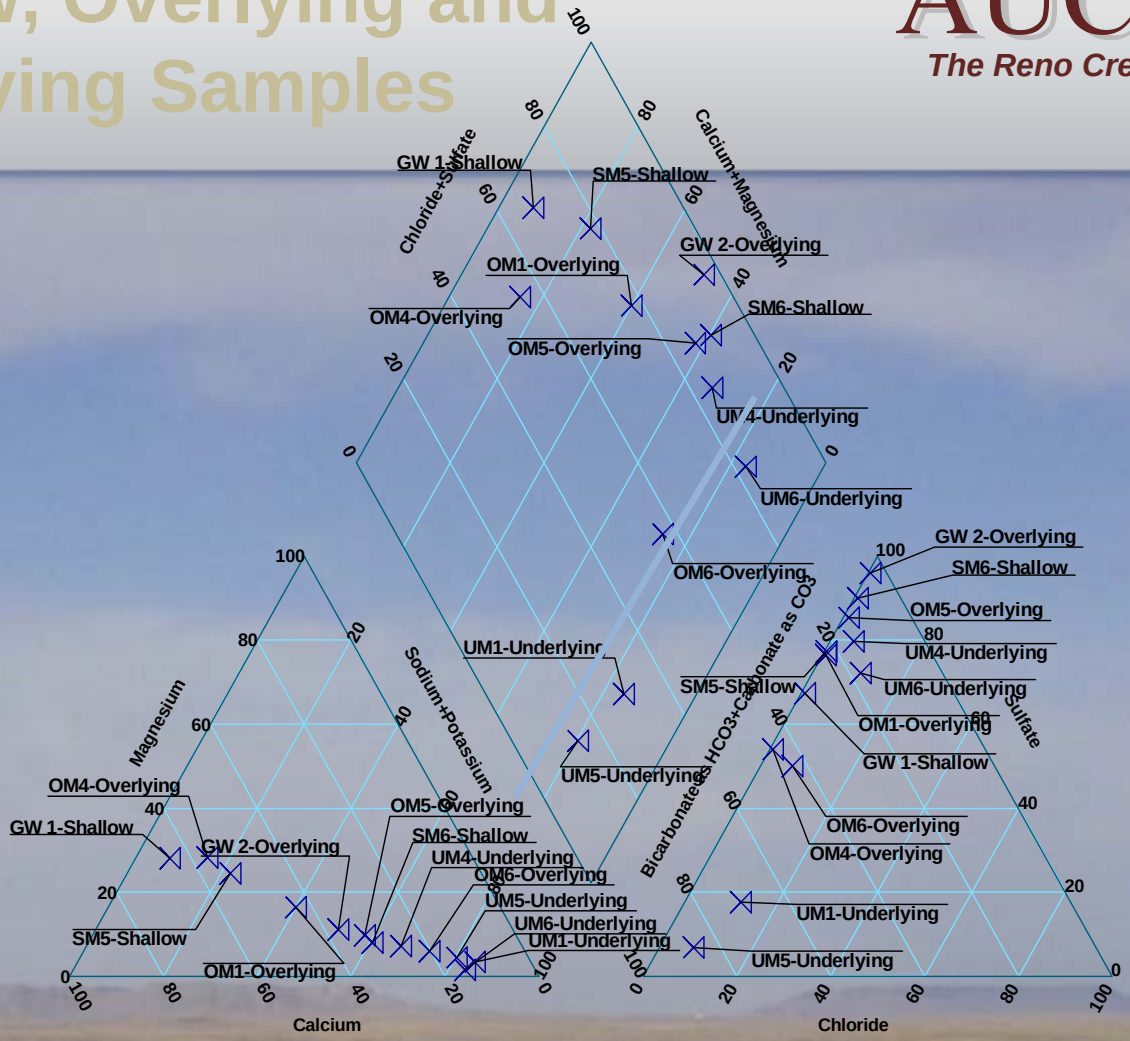

Reno Creek Piper Diagram

Shallow, Overlying and Underlying Waters
Recent Samples

Stiff Diagrams
Recent Data

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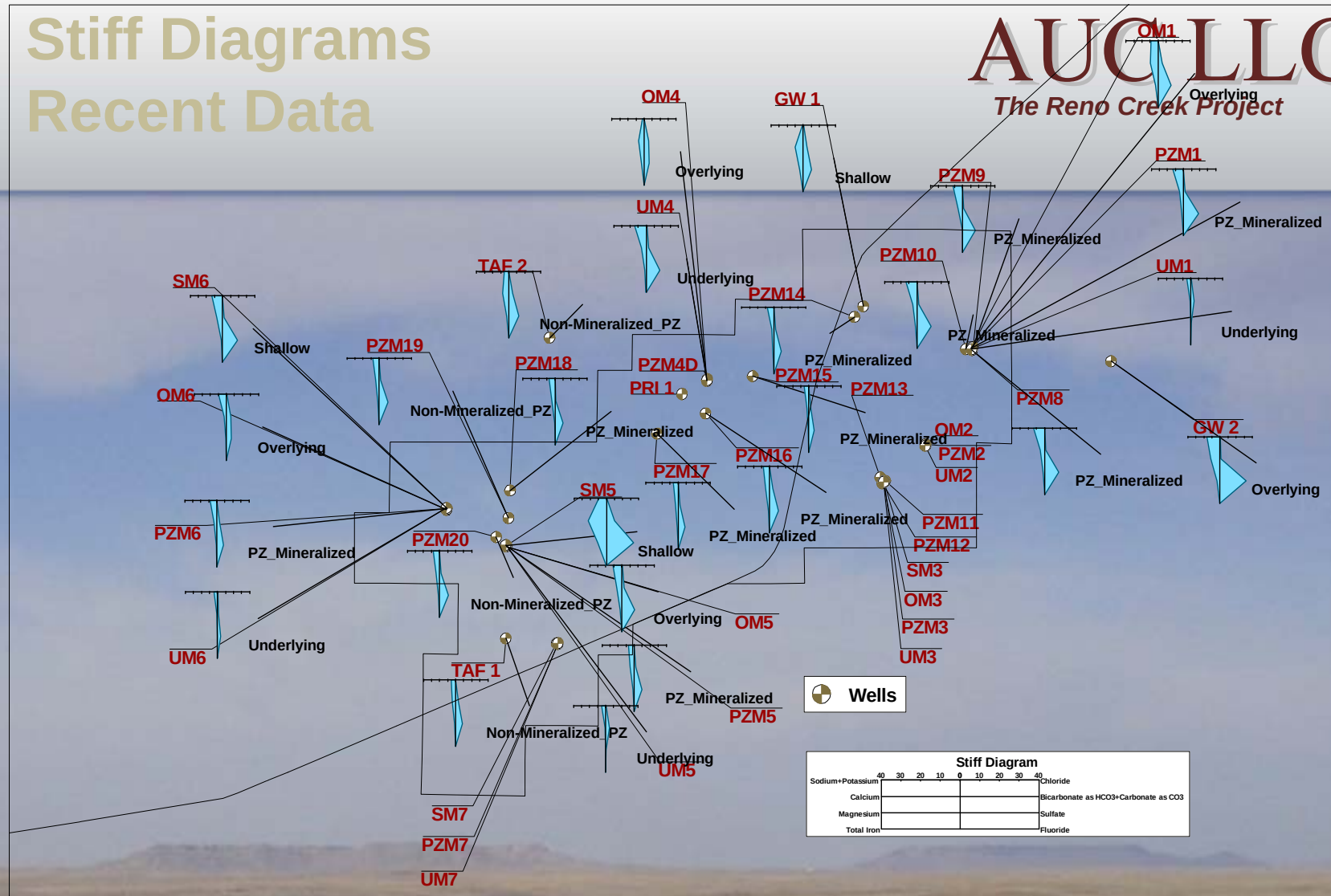
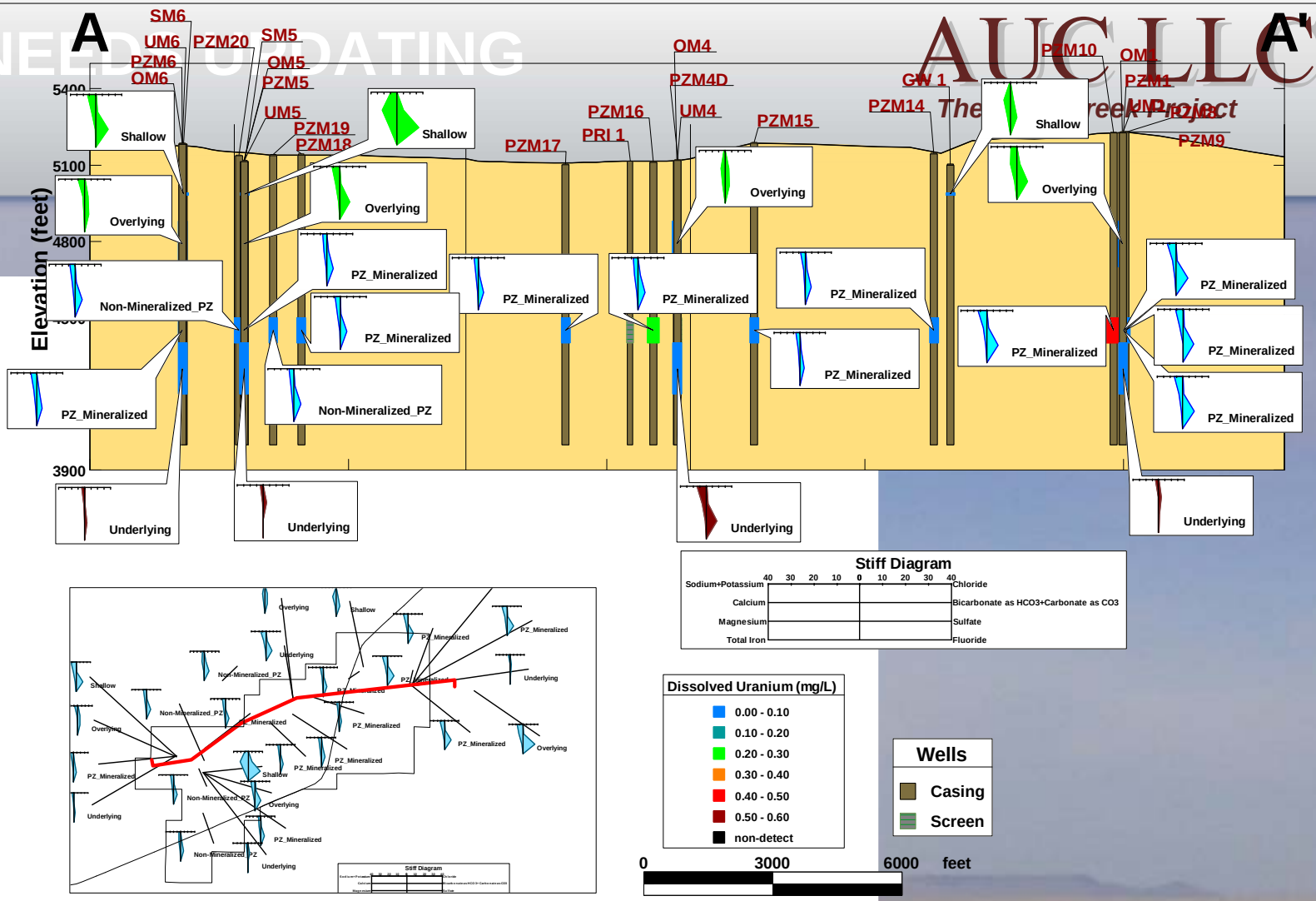


Reno Creek Stiff Diagram

Recent Samples

Subtitle 2



Reno Creek Groundwaters

Cross Section

Stiff Diagrams

Historical Samples

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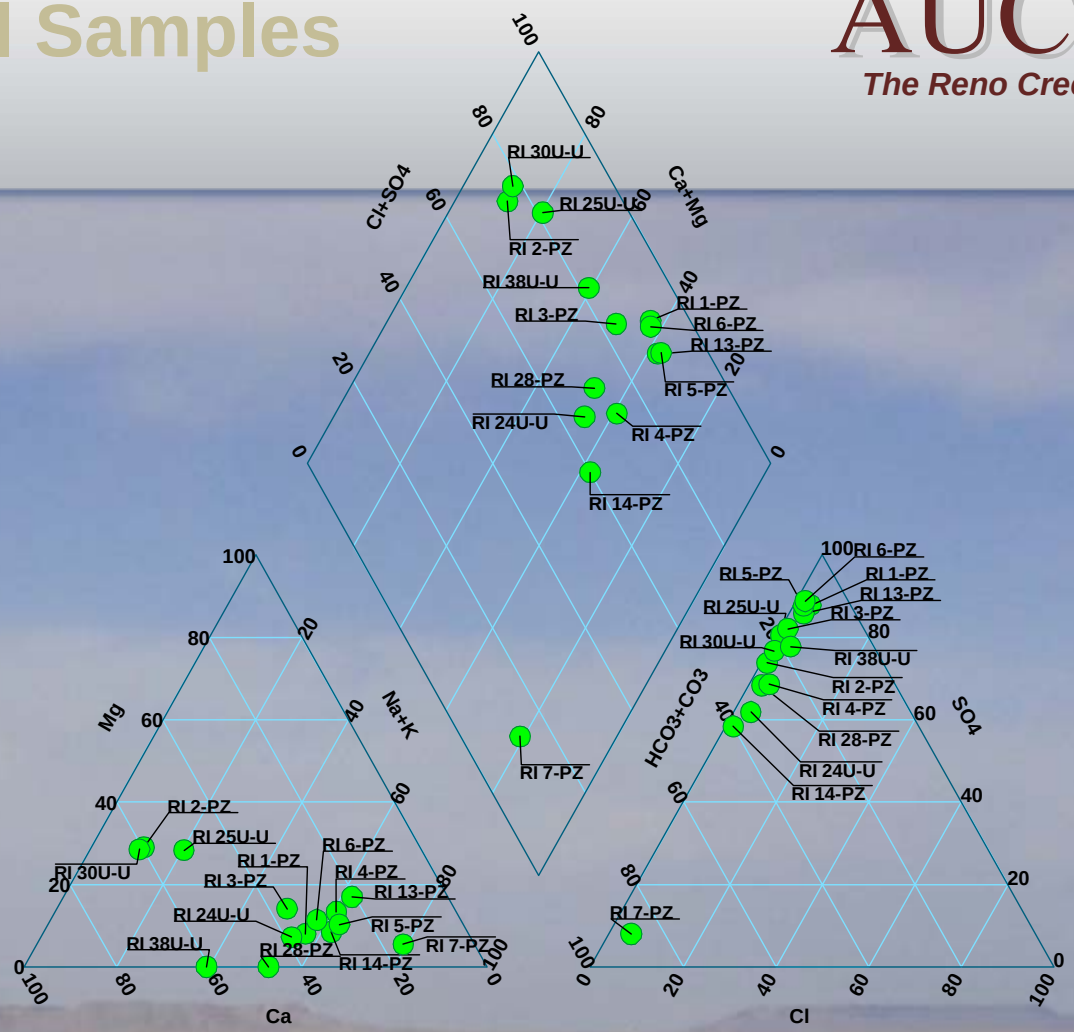

Reno Creek Piper Diagram

Historical Samples
1978 through 1993

Stiff Diagrams – Historical Data

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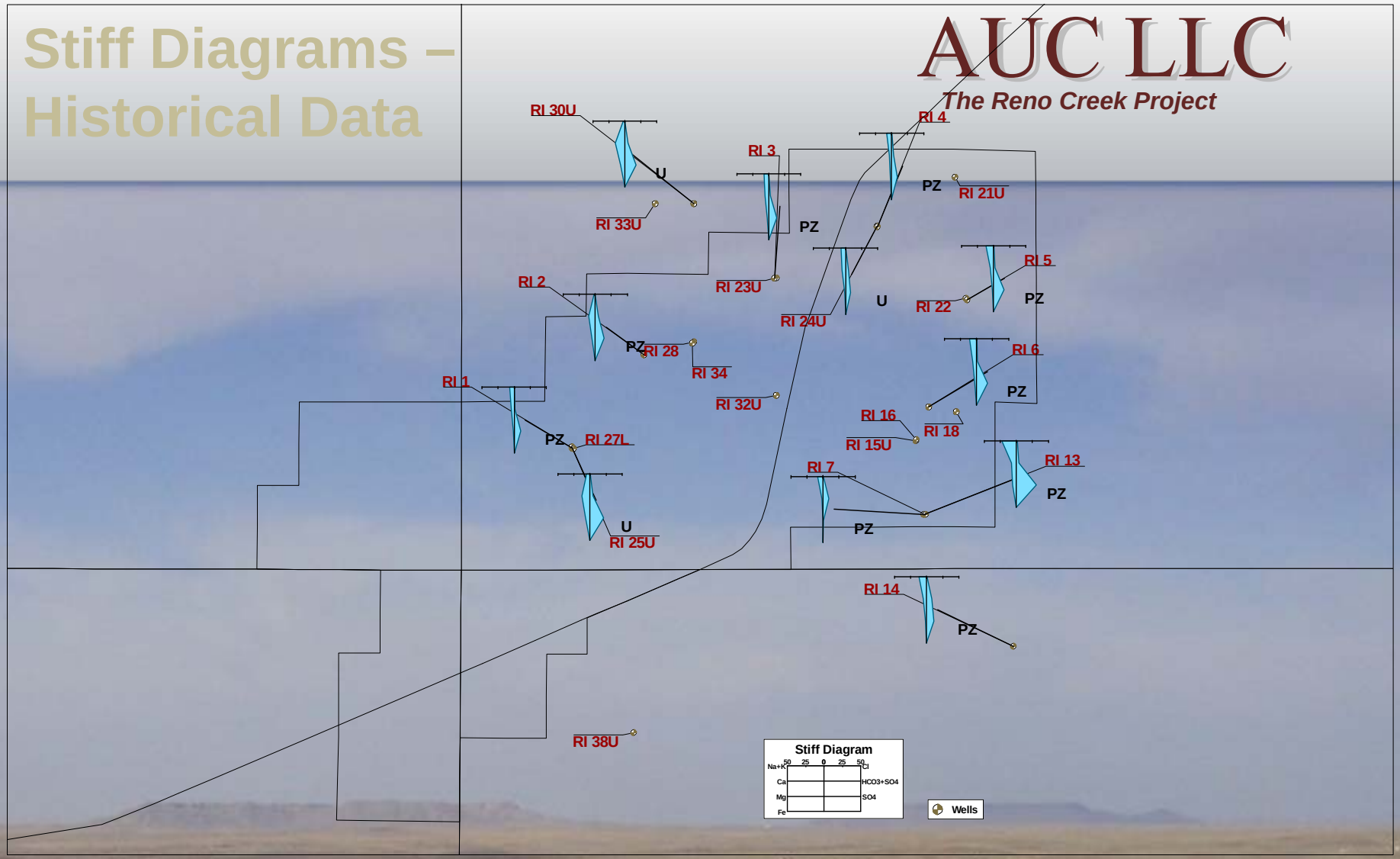

Reno Creek Stiff Diagrams

Historical Samples

1978 -1993

Geochemical Fingerprinting Conclusions

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- Piper Diagrams demonstrate consistent composition among PZ waters for Mineralized and Non-mineralized samples
  - Trend to increasing sulfate (TDS) as we move east
  - Does this show continued groundwater evolution?
- Shallow and overlying waters show greater variability in composition
  - Ca and Mg - dominant cations
  - Sulfate - dominant anion
- Underlying Waters
  - Na+K - dominant cations
  - Bicarbonate - dominant anion
- Historical Samples
  - Similar patterns emerge
- Demonstrates consistent hydrogeochemical behaviors among different stratigraphic zones

Schedule

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- Field visit/Document Audit: November 1-3, 2011—Wright WY
- AUC intends to submit its TR/ER at the end of January, 2012
- Following submittal, AUC will provide the 4th quarterly sampling results for 10 MWs (Baseline includes 29 wells):
  - 3 OM wells
  - 3 UM wells
  - 2 PZM wells
  - 2 SM wells
- These represent ~ 10% of the GW baseline program
- The data will be provided in April, 2012

Thank you!