SECOND AMMENDED PETITION TO AMEND 20.6.2.3000 NMAC AND 20.6.2.5000 NMAC

PREPARED BY
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JUNE 15, 2015

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Executive Summary

- This petition seeks adaptation of a permitting program for disposal wells used by oil refineries to dispose of wastes that may be classified as hazardous due to the concentration of chemical constituents caused by water conservation and reuse – Water Conservation Rule (WCR)
- Adopting a permitting program for these wells similar to that used by NMOCD for Class II disposal wells will provide a number of benefits to the State, oil refineries, and others in the industry, including water conservation, waste minimization, reduction of fresh water usage by oil refineries, preservation of disposal capacity, and increased operational flexibility at refineries
- Nearby water wells and surface and ground waters will be protected by well design and geologic factors
- The potential effect of these wells on the environment and waters of the state of New Mexico will be monitored as required by these regulations
- The adequacy of any proposed injection interval will be demonstrated by a full geologic review that will be submitted in a format similar to the current applications filed in support of Class II AGI wells that is needed to approve the installation and operation of an injection well pursuant to these regulations
- The proposed regulations sufficient protect groundwater and the environment by ensuring that injected fluids will not migrate out of the injection zone during operations or after well closure.

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- CLASSES OF UIC WELLS IN ALL EPA REGIONS

Classes	Use	Inventory
Class I	Inject hazardous wastes, industrial non-hazardous liquids, or municipal wastewater beneath the lowermost USDW	680 wells
Class II	Inject brines and other fluids associated with oil and gas production, and hydrocarbons for storage.	172, 068 wells
Class III	Inject fluids associated with solution mining of minerals beneath the lowermost USDW.	22,131 wells
Class IV	Inject hazardous or radioactive wastes into or above USDWs. These wells are banned unless authorized under a federal or state ground water remediation project.	33 sites
Class V	All injection wells not included in Classes I-IV. In general, Class V wells inject non-hazardous fluids into or above USDWs and are typically shallow, on-site disposal systems. However, there are some deep Class V wells that inject below USDWs.	400,000 to 650,000 wells Note: an inventory range is presented because a complete inventory is not available.
Class VI	Inject Carbon Dioxide (CO2) for long term storage, also known as Geologic Sequestration of CO2	6-10 commercial wells expected to come online by 2016. (Interagency Task Force on Carbon Capture and Storage)

(Source: http://water.epa.gov/type/groundwater/uic/wells.cfm)

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DISTRIBUTION OF UIC WELLS IN US EPA REGION

2010 UIC Well Inventory

Region	State	Population (,000)	Area (sq.mi)	Class I HW Wells	Class I Other Wells	Class II Wells	Class III Sites	Class III Wells	Class IV Sites	Class V Wells
6	AR	2673	53182	4	9	1093	0	0	0	281
6	LA	4469	49650	15	22	3731	17	89	0	213
6	NM	1819	109069	0	5	4585	9	10	0	1414
6	OK	3451	68164	0	6	10629	1	2	2	1928
6	TX	20852	267277	58	50	52016	79	6075	4	32594

(Source: http://water.epa.gov/type/groundwater/uic/upload/UIC-Well-Inventory_2010-2.pdf)

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CURRENTLY ACTIVE UIC WELLS IN THE STATE OF NEW MEXICO

CLASS I		CLASS II			CLASS III	CLASS V
NON-HW	HW WELLS	AGI WELLS	SWDW	EOR	BRINE	MISC.
5	0	15	911	3,521	36	1,005

(Source: New Mexico Oil Conservation Division and New Mexico Environment Department)

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How the Proposed Rules Protect Groundwater of the state of New Mexico

- Siting and geologic analyses
- Well design and construction
- Well operation and maintenance
- Closure, post-closure care, and financial assurance

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How the Proposed Rules Protect Groundwater of the state of New Mexico

- Geologic seal to permanently contain wastes (good caprock with no transmissive fractures or faults)
- Isolated from any fresh groundwater
- No effect on existing or potential production
- Laterally extensive, permeable, good porosity
- Excess capacity for anticipated injection volumes
- Compatible fluid chemistry

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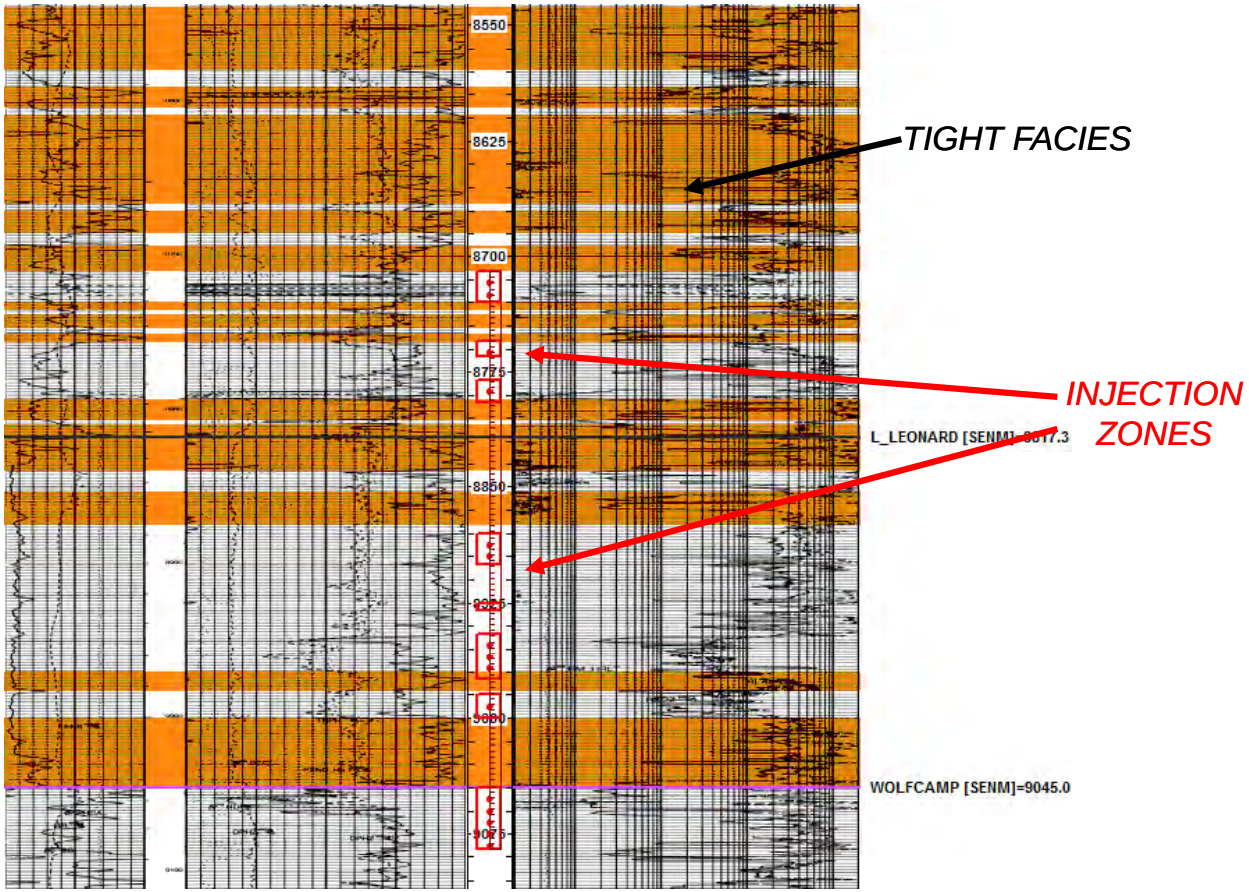
- Geologic seal to permanently contain wastes (example)



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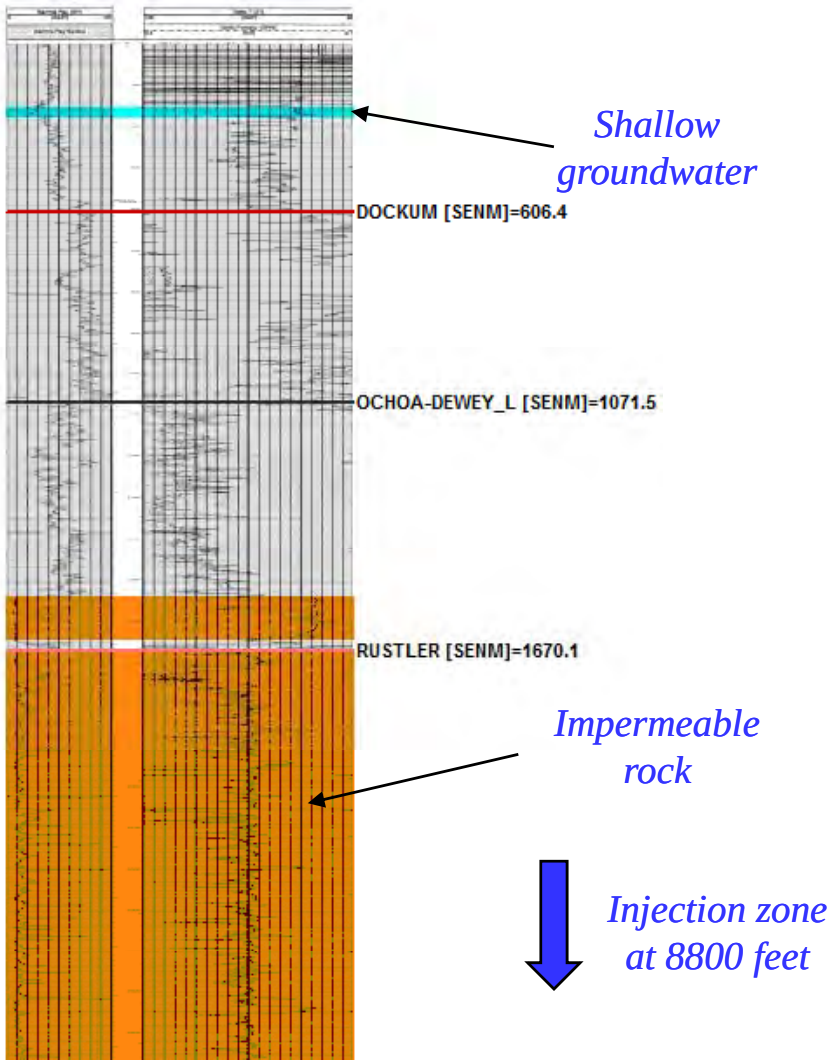
➢ Isolated from any fresh groundwater (example)



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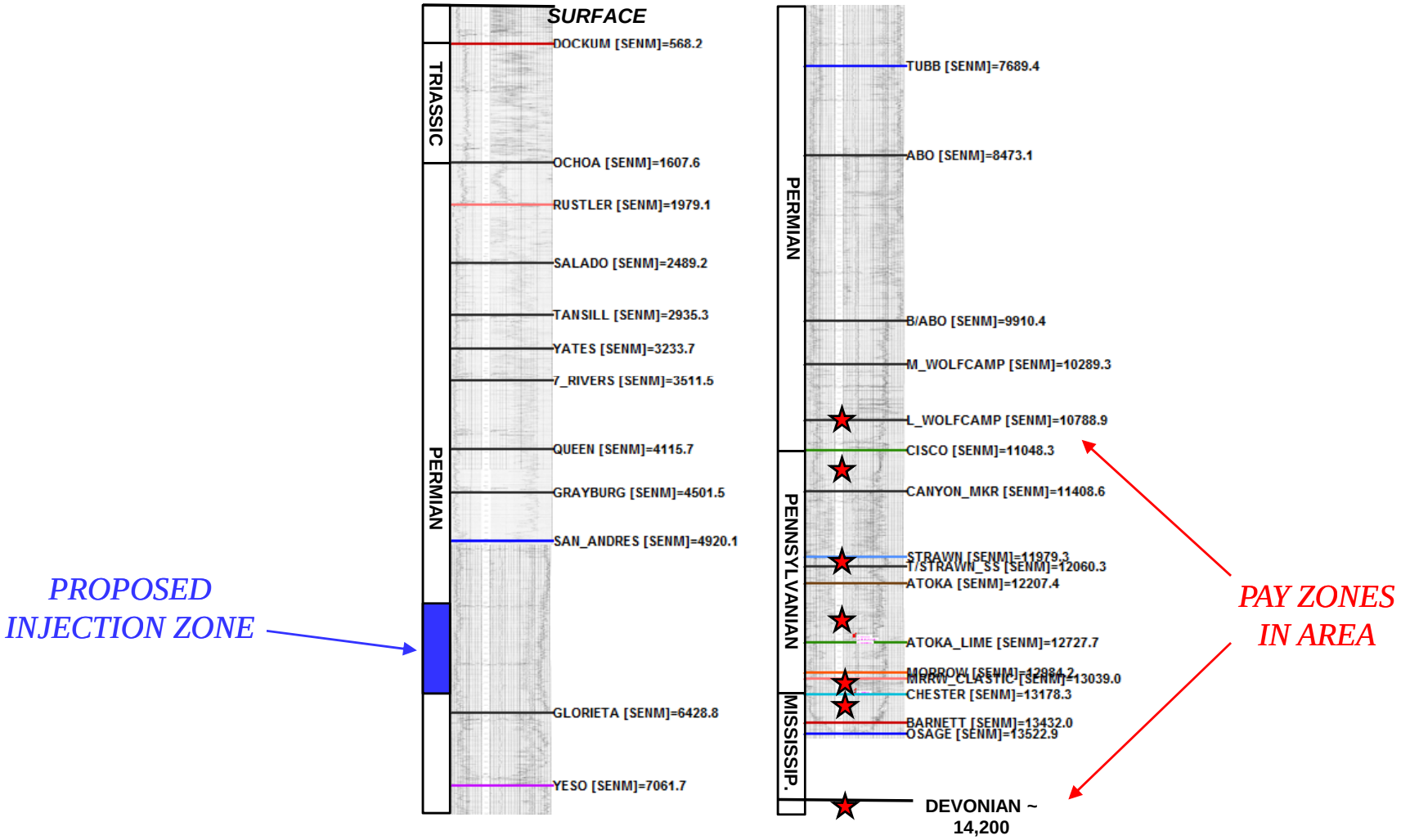
- No effect on existing or potential production (example)



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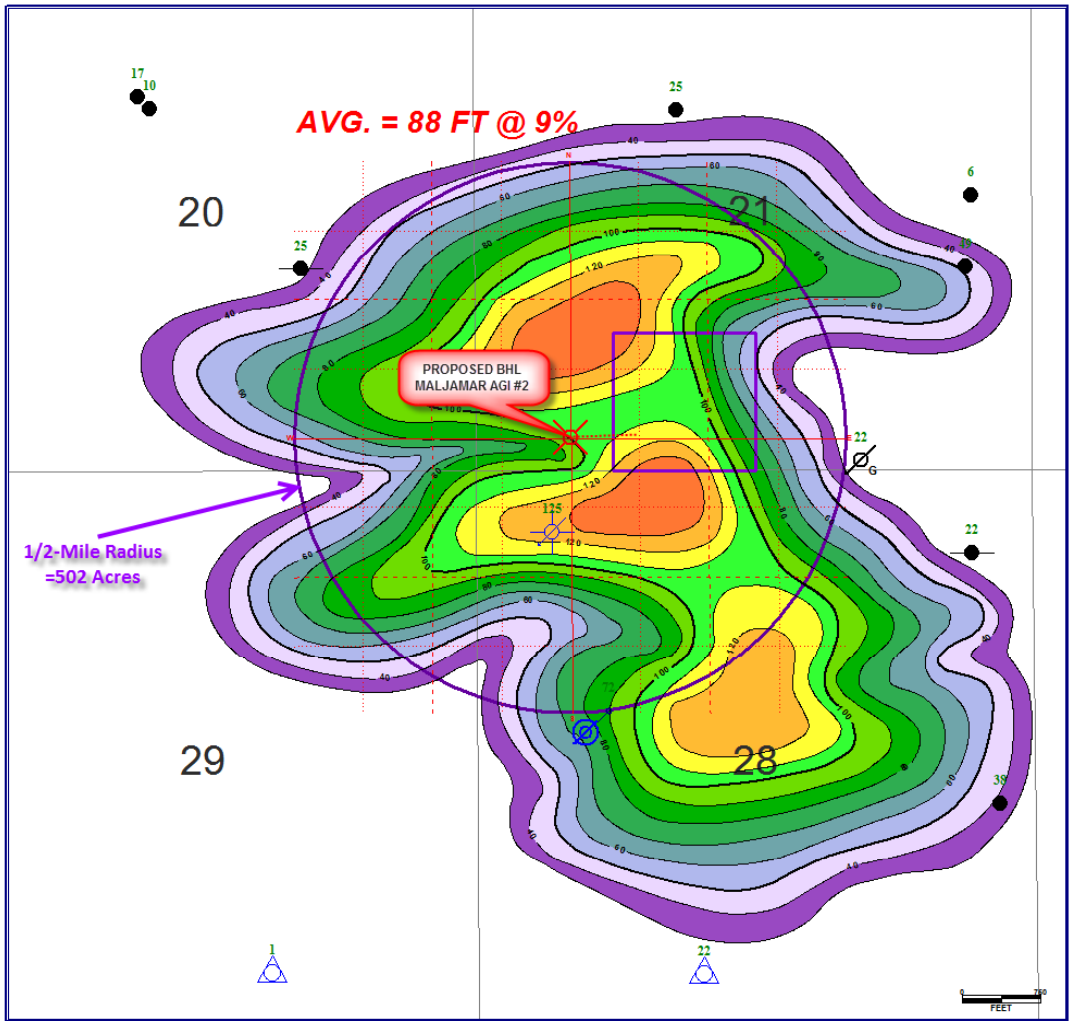
- Laterally extensive, permeable, good porosity (example)



- Excess capacity for anticipated injection volumes (example)

RESERVOIR PARAMETERS: LOWER CHERRY CANYON

- Effective injection area (1 mile radii) = 2,318 acres
- Average interval porosity = 15.0%
- Average reservoir thickness = 111 feet
- Bottom hole temperature = 122 F
- Rw @ BHT = 0.06
- Average Rt = 3 ohm-m
- Bottom hole pressure = 2,250 psi
- $F = 1.65/Por^{1.33}$ for shaly sandstones

$F = 1.65/0.15^{1.33} = 20.6$

$Sw = F\ (Rw_{BHT}/Rt) = 20.6\ (0.06/3) = 0.41$

$1\text{-}Sw = 0.59$

GAS IN PLACE CALCULATION:

GIP = 43,560 (Acre)(Ft) (Por) (1-Sw)
= 43560 (2318) (111) (0.15) (0.59)
GIP = 991,899,228 CFG

Example reservoir volume calculation

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➢ Compatible fluid chemistry (example)

Table A2: Formation Fluid Analysis Cherry Canyon Formation

Extract from C-108 Application to Inject by Ray Westall
Associated with SWD-1067 - API 30-025-24676

Water analysis:

Ray Westall Federal 30 #2
7335-45' Delaware

API 30-025-29069
Located 6.34 miles from Proposed
Agave Red Hills AGI #1

Sp. Gravity	1.125 @ 74	Resistivity	.07 @ 74
pH	7	Sulfate	1240
Iron	Good/Good	Bicarbonate	2135
Hardness	45000	Chloride	110000
Calcium	12000	Sod Chloride	180950
Magnesium	3654	Sod & Pot	52072

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Steps Required by Proposed Rule to Identify Potentially Suitable Injection Zones

- Identify and characterize wells, stratigraphy, and geologic structure in the project area
  - Identify and characterize fresh water supply wells in the area of review
  - Identify and characterize all fresh groundwater (<10,000 tds) and establish maximum depth
  - Review structural features of region in which the proposed injection well will be drilled
  - Identify plugged wells and dry holes in area of review, and provide documentation of wellbore integrity with well diagrams
  - Describe depositional environment(s) of proposed injection interval, to determine lateral extent of injection zones and caprock to evaluate containment of injected plume

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- Map structure of proposed interval to enable prediction of fluid flow and any potential influence on nearby producing zones

- Prepare cross-sections illustrating the vertical and lateral extents of proposed injection zones (IZs), porosity, and proposed injection perforations, and net porosity or reservoir fairway maps to illustrate lateral extents of IZs

- If applicable, develop seismic models to evaluate reservoir porosity and geometry

- Calculate available reservoir volume of each proposed injection zone, and total available reservoir volume for the entire injection interval

- Calculate reservoir area affected after 15 and 30 years of injection

- If evaluation confirms feasibility, prepare application and submit to NMOCD for approval

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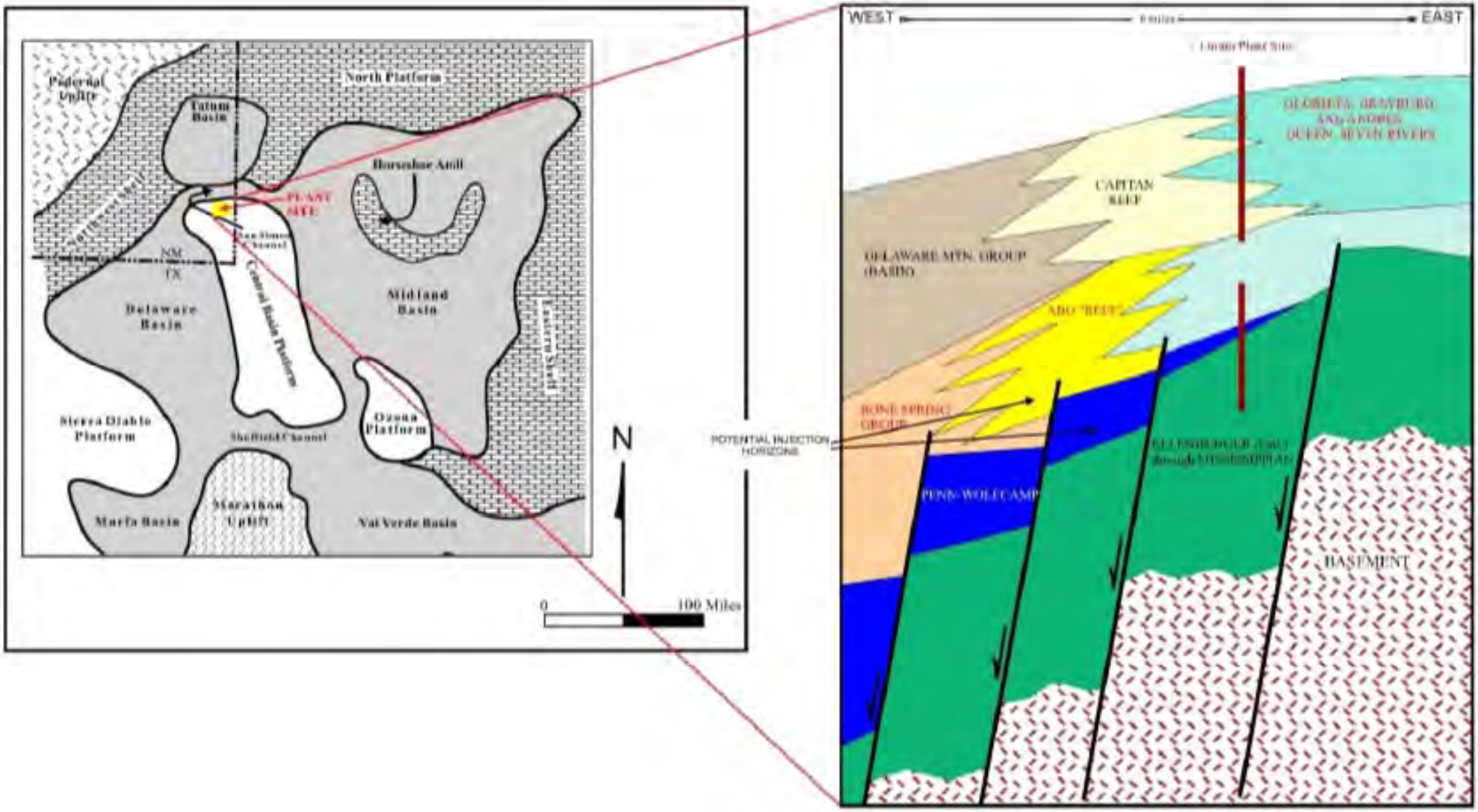
- Review structural features of region in which the proposed injection well will be drilled (example)



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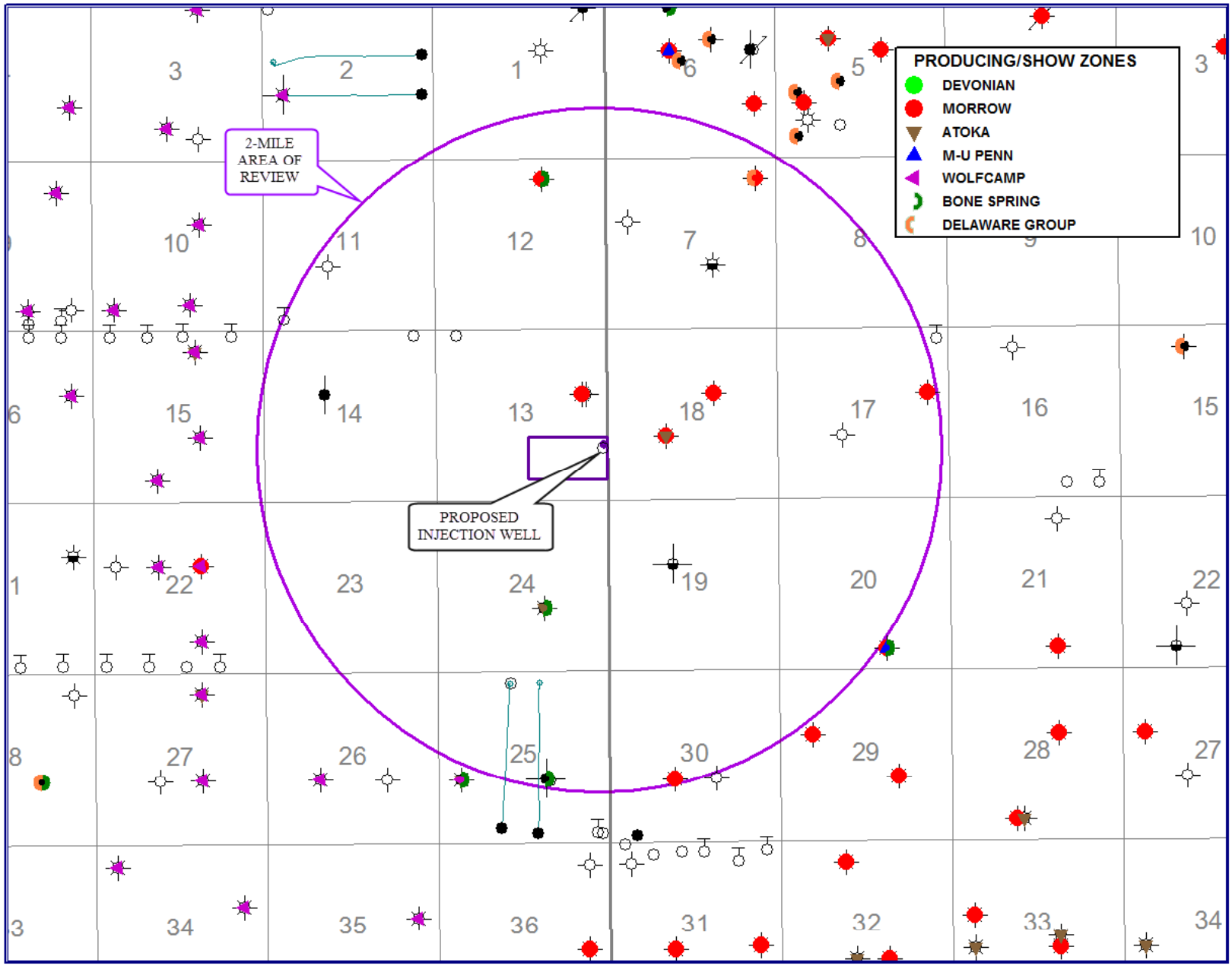
- Identify producing zones within the area of review ofthe proposed injection well (example)



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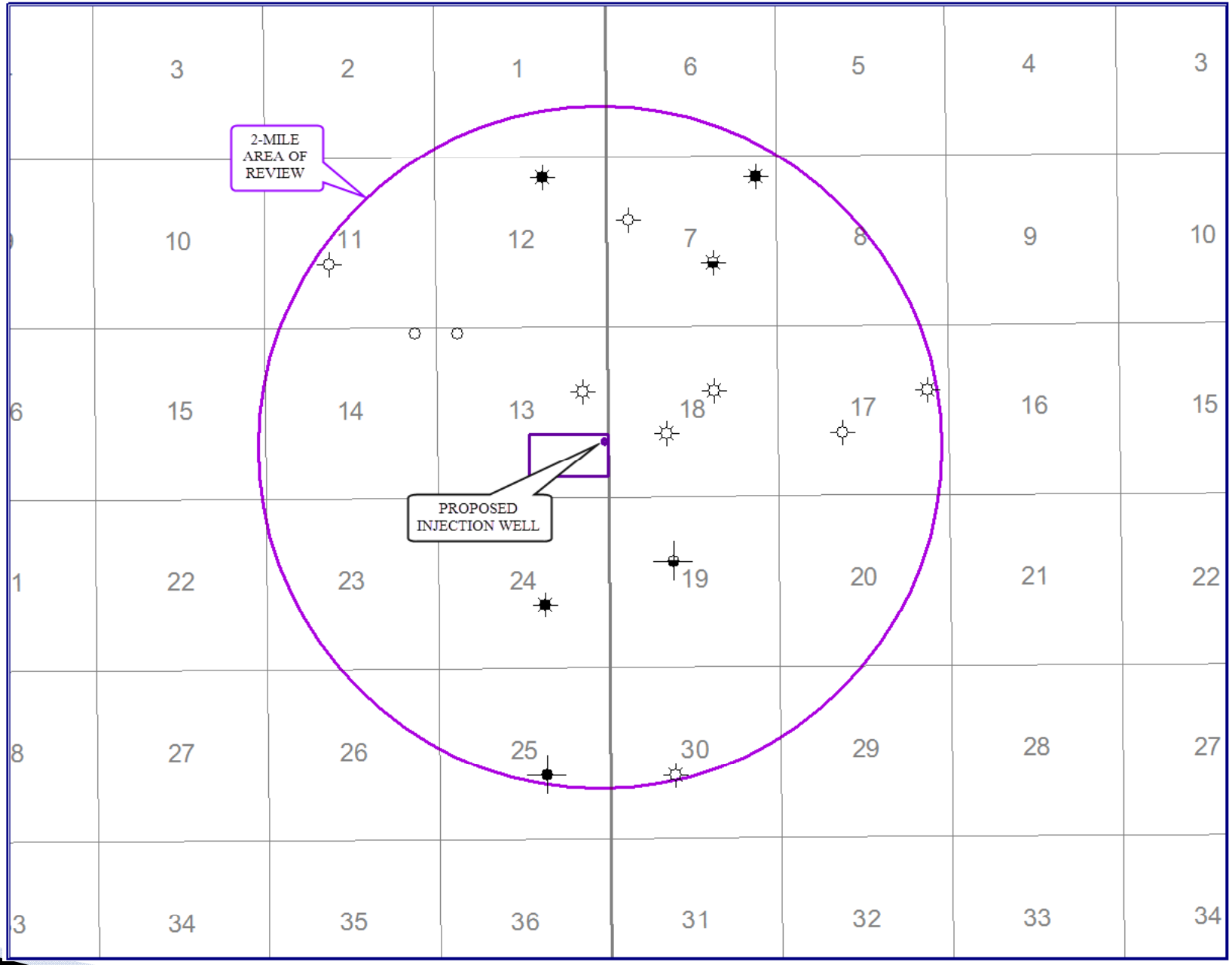
- Distribution of wells that penetrate through the proposed injection well (example)



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- Tabulation of all wells, showing well status and producing zones, and wells that penetrate the proposed injection interval (bold TDs) (example)

UWI (APINum)	Current/Last Operator	Well Name	Datum	Twp	Rge	Sec	N-S	E-W	TD*	STATUS	Prod Fm
30015057850000	TANDEM ENERGY	JONES FEDERAL #1	3552	19S	31E	24	1980 N	660 E	2635	ACT	YATES-7R
30015371850000	COG OPERATING LLC	LIBERATOR FEDERAL C #1	3617	19S	31E	13	330 N	380 E	**13680**	ACT	BONE SPG
30015406260000	DEVON ENERGY PROD	MIMOSA 24 FEDERAL C #1H	3563	19S	31E	24	582 N	275 W	**13679**	ACT	BONE SPG
30025009020000	TANDEM ENERGY	MILLER-FEDERAL #1	3553	19S	32E	19	1980N	660 W	2634	ACT	YATES-7R
30025009050000	COG OPERATING LLC	LUSK DEEP UNIT A #1	3601	19S	32E	19	660 N	660 E	**12453**	ACT	MORROW
30025200250000	CHISOS, LTD.	DELHI-FEDERAL #1	3546	19S	32E	30	660 N	1980 W	**11400**	ACT	STRAWN
30025201040000	OXY, USA	ELLIOTT-HALL #1	3567	19S	32E	30	660 N	660 E	**12473**	ACT	STRAWN
30025201220000	COG OPERATING LLC	LUSK DEEP UNIT #5	3566	19S	32E	19	1980 S	1980 E	**12560**	ACT	ATOK-MRRW
30025249740000	COG OPERATING LLC	LUSK DEEP UNIT `A` #13	3610	19S	32E	18	1980 S	1980 W	**12520**	ACT	BONE SPG
30025304900000	CIMAREX ENERGY COLO.	LUSK WEST DELAWARE #15	3581	19S	32E	20	330 S	1980 E	**7200**	ACT	YATES
30025340320000	CIMAREX ENERGY COLO.	LUSK WEST DELAWARE #6	3594	19S	32E	20	1650 N	1800 W	**7165**	ACT	DEL-BRUSHY
30025345730000	COG OPERATING LLC	LUSK DEEP UNIT `A` #14	3573	19S	32E	19	1650 N	990 W	**12540**	ACT	MORROW
30025350950000	COG OPERATING LLC	LUSK DEEP UNIT `A` #17	3580	19S	32E	20	660 S	890 W	**12750**	ACT	MORROW
30025352910000	COG OPERATING LLC	LUSK DEEP UNIT `A` #21	3573	19S	32E	19	660 S	1750 W	**12718**	ACT	MORROW
30025394410000	COG OPERATING LLC	SL DEEP FEDERAL #3	3554	19S	32E	30	990 N	1650 W	**9580**	ACT	BONE SPG
30025395380100	COG OPERATING LLC	SL DEEP FEDERAL #4H	3545	19S	32E	30	2310 N	660 W	**10858**	ACT	BONE SPG
30025398530000	CIMAREX ENERGY COLO.	SOUTHERN CALIFORNIA #16	3575	19S	32E	29	1980 N	375 W	**9550**	ACT	BONE SPG
30025398890100	CIMAREX ENERGY COLO.	SOUTHERN CALIFORNIA #18H	3369	19S	32E	29	1140 N	330 E	**13965**	ACT	BONE SPG
30025399600100	COG OPERATING LLC	CITATION X FEDERAL #1H	3641	19S	32E	8	990 S	1980 E	**12983**	ACT	BONE SPG
30025401540100	COG OPERATING LLC	SL EAST 30 FEDERAL #1H	3562	19S	32E	30	330 S	1670 E	**13540**	ACT	BONE SPG
30025402600000	COG OPERATING LLC	LUSK DEEP UNIT `A` #23H	3579	19S	32E	19	330 S	380 E	**13595**	ACT	BONE SPG
30025407050000	COG OPERATING LLC	LUSK DEEP UNIT A #22H	3627	19S	32E	17	330 N	1770 W	**13670**	ACT	BONE SPG
30025408630000	COG OPERATING LLC	LUSK DEEP UNIT A #24H	3587	19S	32E	19	330 N	660 W	**13660**	ACT	BONE SPG
30025009060000	TOM R. CONE	FEDERAL #1	3567	19S	32E	19	1980 N	1980 E	2715	TA	YATES-7R
30025009090000	TOM R. CONE	GULF-FEDERAL #1	3554	19S	32E	19	1980 N	1650 W	2487	TA	YATES-7R
30025009100000	TOM R. CONE	GULF-FEDERAL #2	3556	19S	32E	19	1980 N	2310 W	2500	TA	YATES-7R
30025208760000	TOM R. CONE	LUSK DEEP UNIT #10	3575	19S	32E	19	1650 N	1678 W	**11300**	TA	YATES-7R
30025214880000	CIMAREX ENERGY COLO.	LUSK DEL UNIT #10	3589	19S	32E	20	1980 S	1980 E	**11550**	TA	DEL-BRUSHY
30025208740000	CIMAREX ENERGY COLO.	LUSK DEEP UNIT `A` #7	3585	19S	32E	20	1650 S	990 W	**11467**	WSW	CAPITAN
30025350530000	COG OPERATING LLC	LUSK DEEP UNIT `A` #16	3595	19S	32E	18	785 S	660 W	**12780**	INJ	STRAWN

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- Tabulation of all plugged wells and dry holes, showing wells that penetrate proposed injection zone with bold TDs (example).

UWI (APINum)	Current/Last Operator	Well Name	Datum	Twp	Rge	Sec	N-S	E-W	TD*	STATUS	Prod Fm
30015057900000	PLAINS PRODUCTION CO	JONES #7	3548	19S	31E	24	2310 S	330 E	2876	P/A	
30025009000000	EL PASO NAT GAS CO	LUSK DEEP UNIT #2	3605	19S	32E	18	660 S	1980 E	**13974**	P/A	
30025009130000	EL PASO PRODUCTS CO	LUSK DEEP UNIT #3	3591	19S	32E	20	1650 N	660 W	**12623**	P/A	
30025081040000	SHELL OIL CO	MIDDELTON-FED A #1	3605	19S	32E	18	1980 N	990 E	**12515**	P/A	
30025201560000	EL PASO PRODUCTS CO	CALIF-FEDERAL #2	3567	19S	32E	29	990 N	990 W	**11407**	P/A	
30025202470000	EL PASO PRODUCTS CO	LUSK DEEP UNIT #6	3556	19S	32E	19	660 S	660 W	**11427**	P/A	
30025210420000	EL PASO PRODUCTS CO	LUSK DEEP UNIT-FED #11	3608	19S	32E	17	1650 S	990 W	**11470**	P/A	
30025248690000	CIMAREX ENERGY COLO.	LUSK DEL UNIT #7	3596	19S	32E	20	1660 N	2300 E	**12817**	P/A	
30025305230000	CIMAREX ENERGY COLO.	LUSK WEST DELAWARE #2	3598	19S	32E	20	330 N	1656 E	**7220**	P/A	
30025305240000	CIMAREX ENERGY COLO.	LUSK WEST DEL UNIT `A` #9	3590	19S	32E	20	2310 S	660 E	**7230**	P/A	
30025341720000	CIMAREX ENERGY COLO.	LUSK WEST DELAWARE #WI-903	3580	19S	32E	29	990 N	1880 W	**6635**	P/A	
30025341730000	CIMAREX ENERGY COLO.	LUSK WEST DELAWARE #WI-011	3591	19S	32E	20	1980 S	1980 W	**6630**	P/A	
30025352440000	COG OPERATING LLC	LUSK DEEP UNIT `A` #19	3584	19S	32E	17	660 S	1650 W	**12754**	P/A	
30025009010000	ENGLISH PAUL B	MILLER #1	3591	19S	32E	18	1980 S	660 E	4016	DRY	
30025009030000	CARPER ENGLISH&HINKL	MILLER #1	3565	19S	32E	19	660 N	660 W	2710	DRY	
30025009040000	CARPER DRLG CO	MILLER #2	3554	19S	32E	19	1980 S	1980 W	2682	DRY	
30025009070000	STOUT KELLY G	SOUTHERN CAL. FED. #2	3559	19S	32E	19	2310 S	2310 E	2736	DRY	
30025009080000	STOUT KELLY G	SOUTHERN CALIF #3	3577	19S	32E	19	990 N	2310 E	2695	DRY	
30025009110000	SIMMS & REESE OIL CO	GULF #1	3547	19S	32E	19	2310 S	990 W	2640	DRY	
30025305000000	POOL FRED DRLG INC	LUSK FEDERAL #1	3595	19S	32E	18	1980 S	1980 E	2820	DRY	

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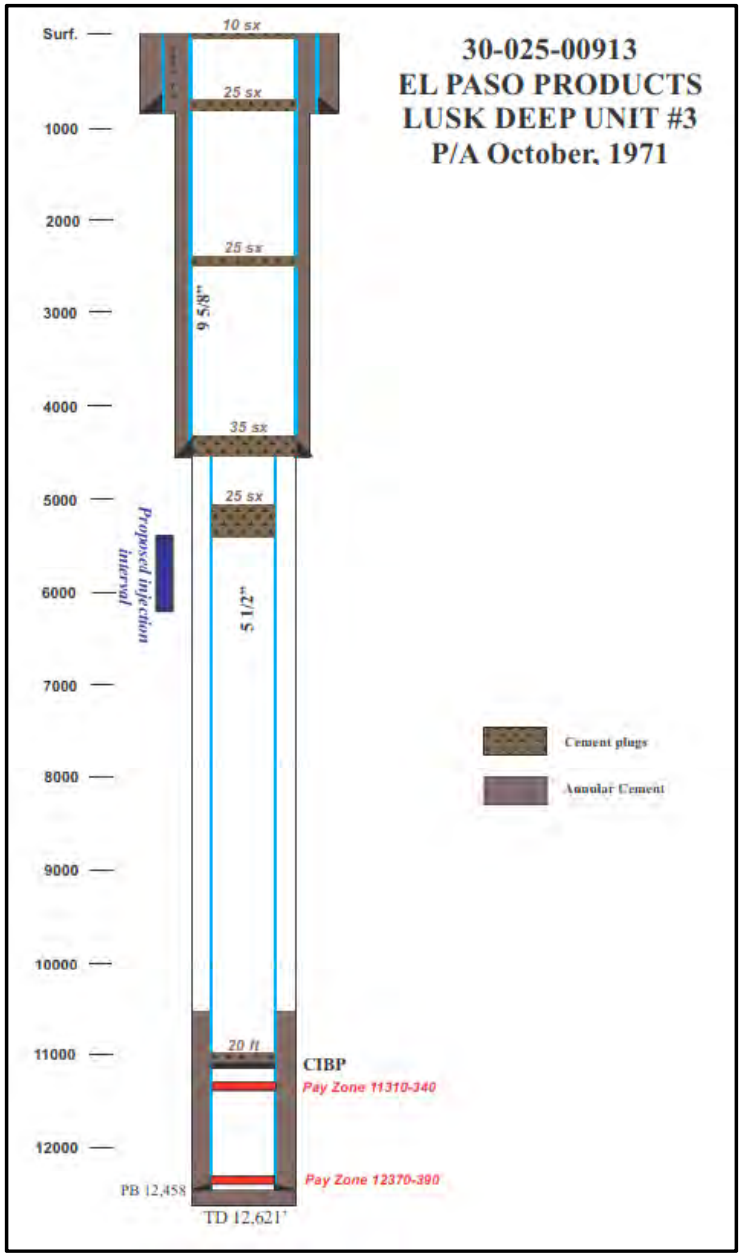

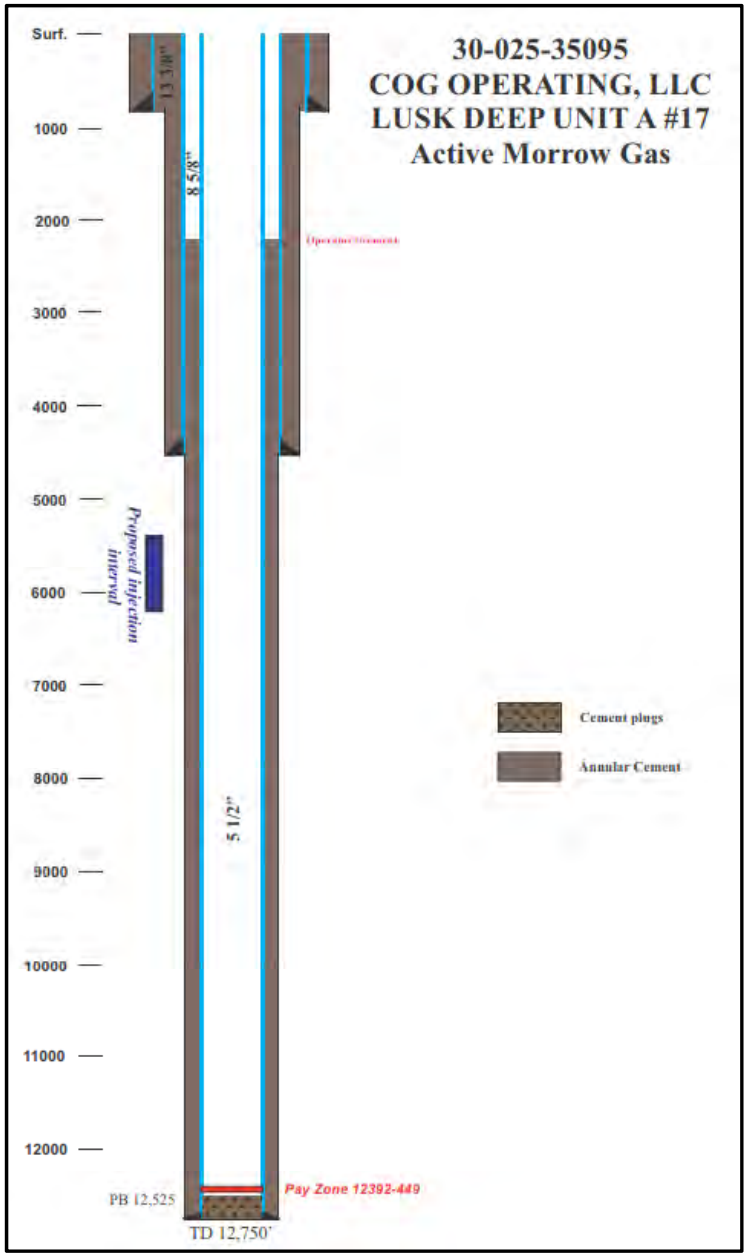

- Example of a plugged producing well (left) and active producing well diagram used to establish existing wellbore integrity across the proposed injection interval

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- **Identification of all fresh water supply wells within area of review of proposed injection well (example)**

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Characterize groundwater of the state of NM in area of review

- Establish maximum depth of fresh water in area of review.
- Identify lowermost aquifer to develop monitoring system.
- Establish geologic factors to isolate injection zone from fresh water zones.
- Determine geologic conditions of the stratigraphic section to assure protection of fresh water resources
- Consider determination of baseline water quality of waters of State of New Mexico in area of review.

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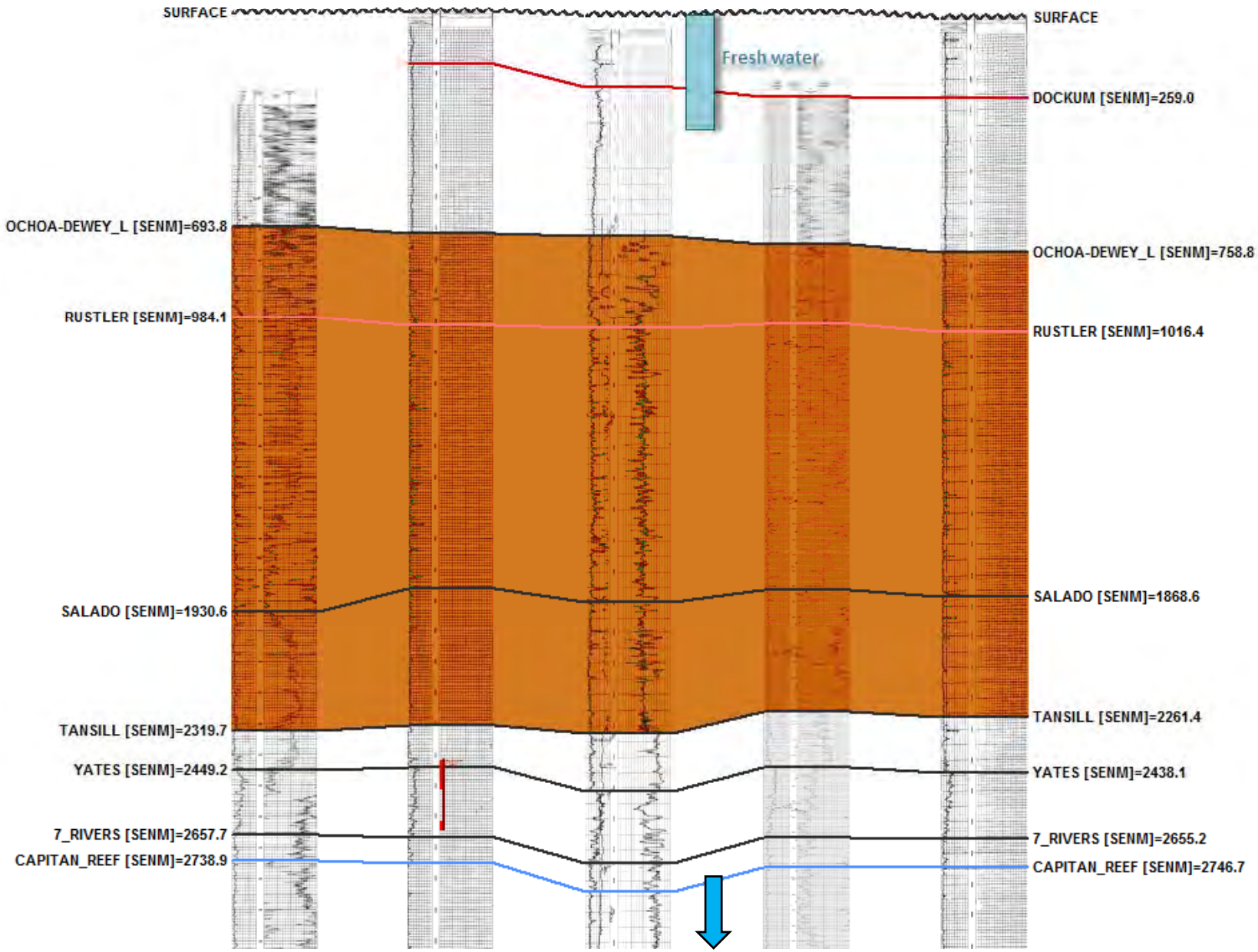
- Documentation of cap rock (brown shading) between proposed IZ (below blue arrow) and near-surface fresh-water aquifers (example)



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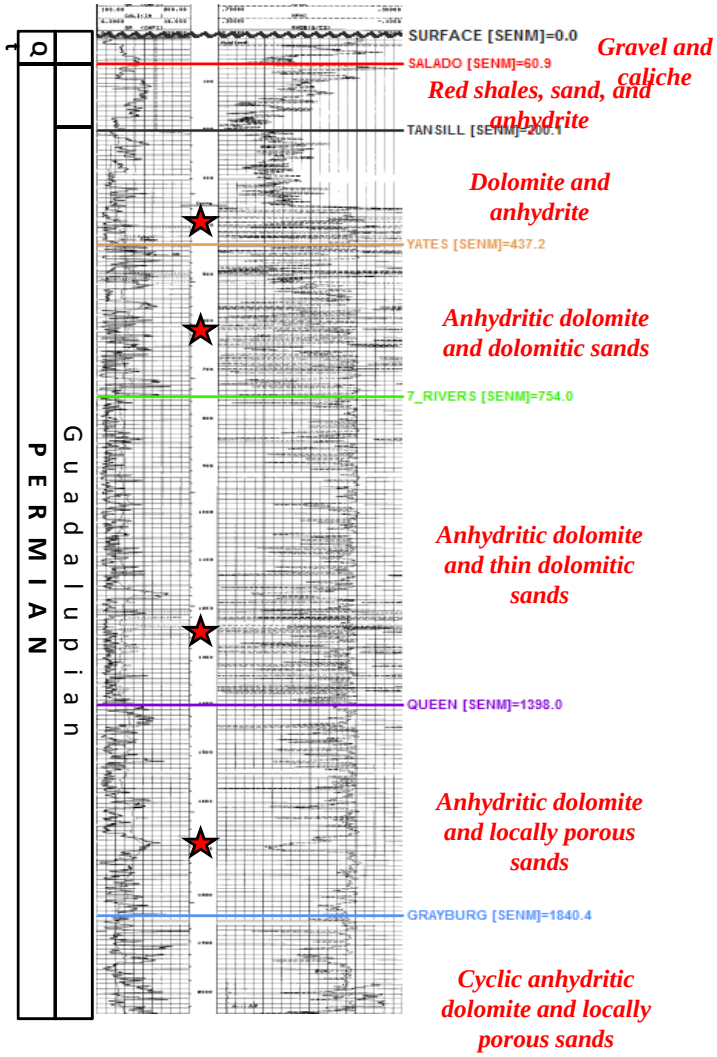
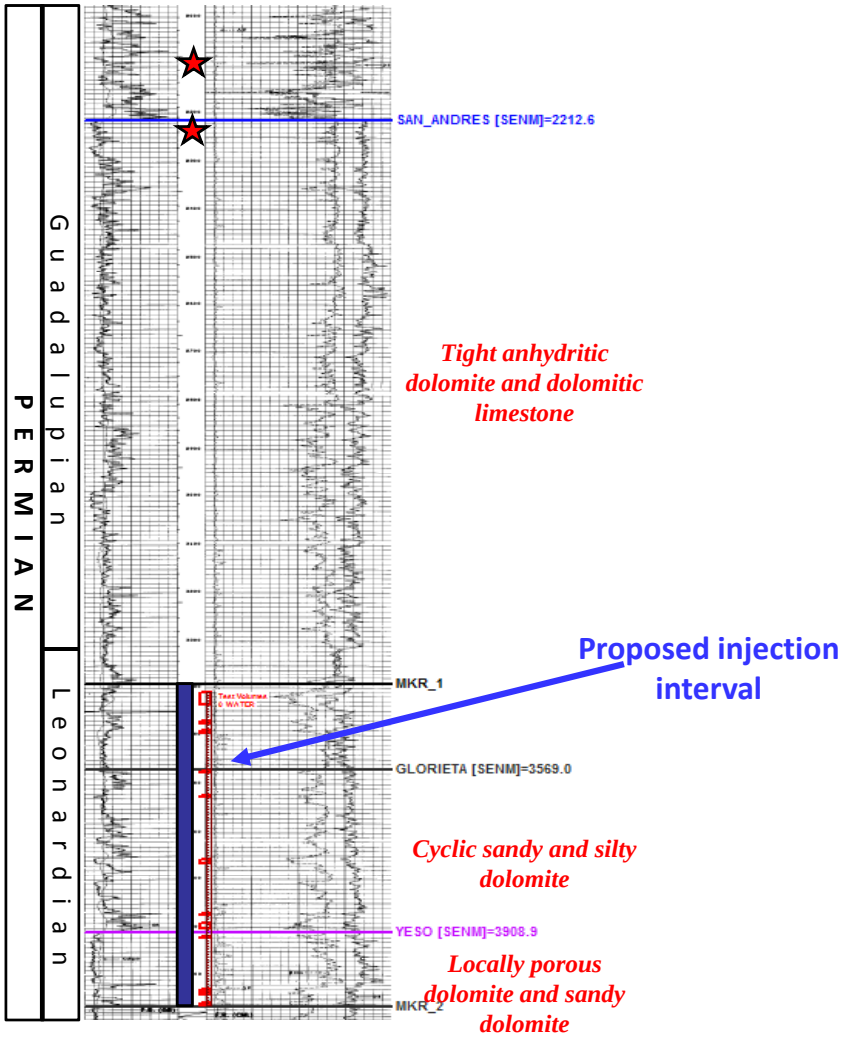
- **Identify stratigraphy, pay zones stars), and depositional environments above, below, and within proposed injection interval and isolation from groundwater of the state of New Mexico (example)**





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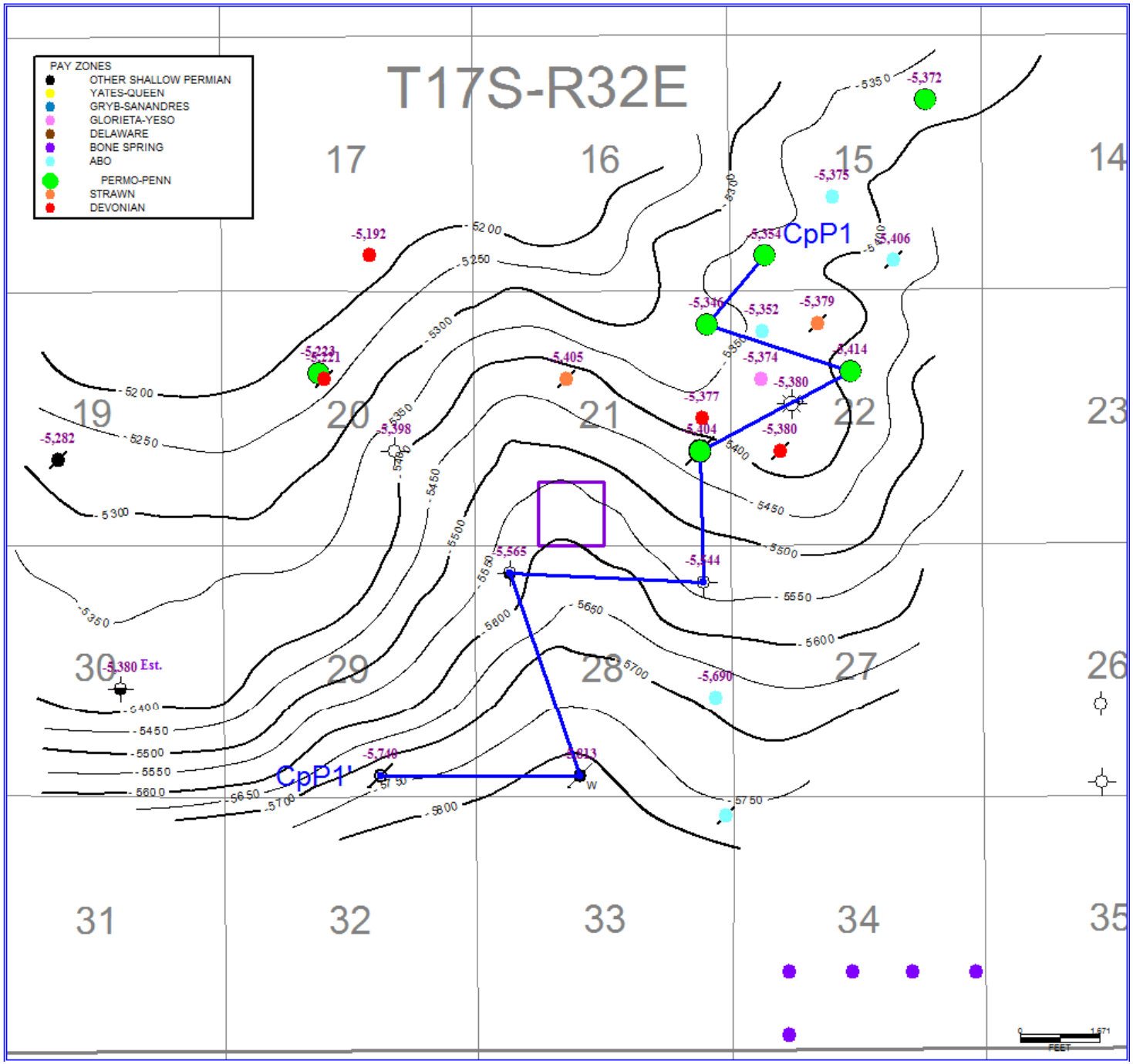
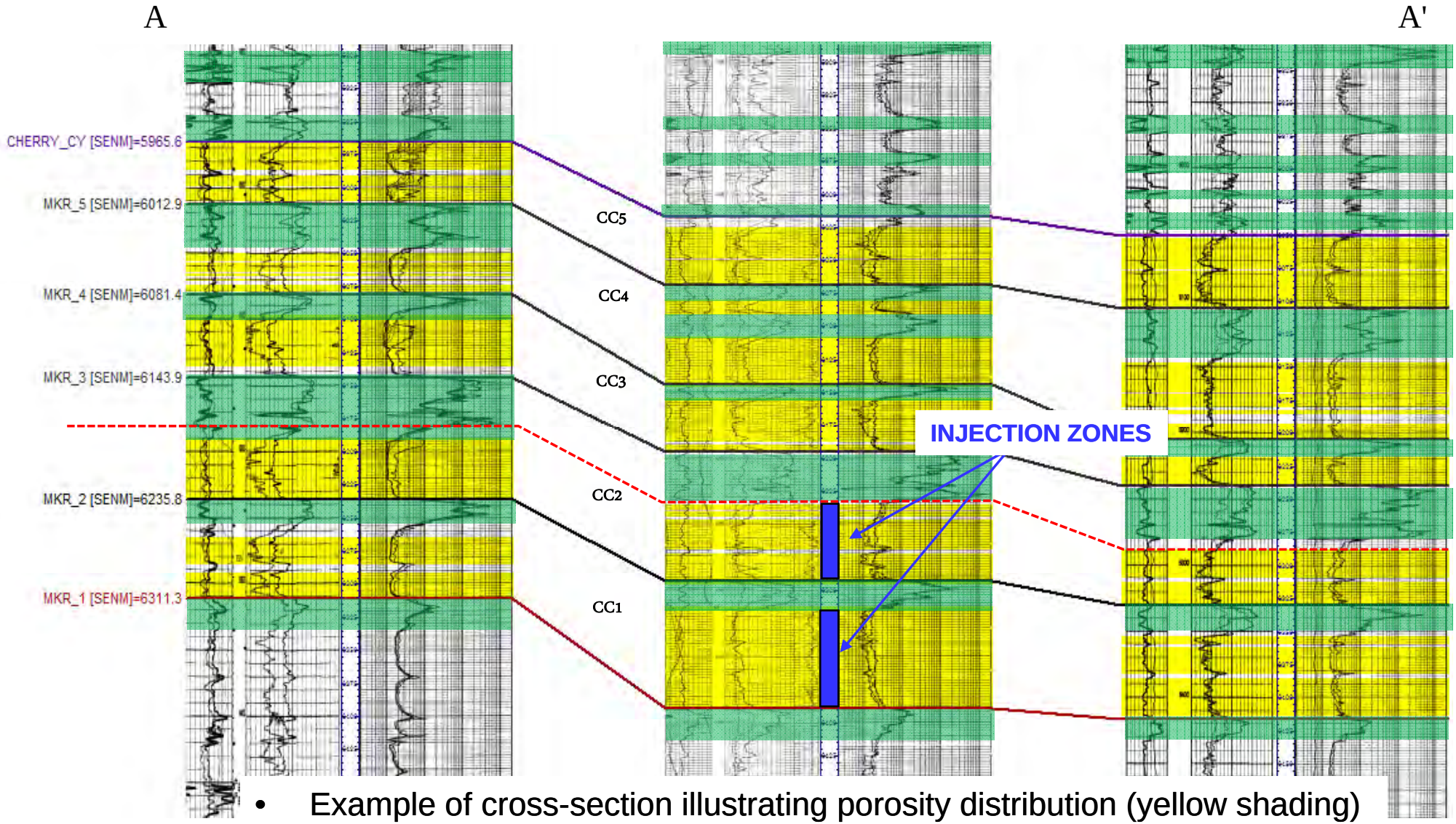
- Example of structure map on top of the proposed injection interval (IZ), showing wells productive from units immediately below the IZ.





- Example of cross-section illustrating porosity distribution (yellow shading) through the proposed IZ and caprock distribution (green shading) within and around the proposed IZ
- Caprock integrity will be confirmed with detailed logging and coring during drilling
- Injection zone capabilities and proof of non-producability will be verified by swabbing and step rate testing after drilling

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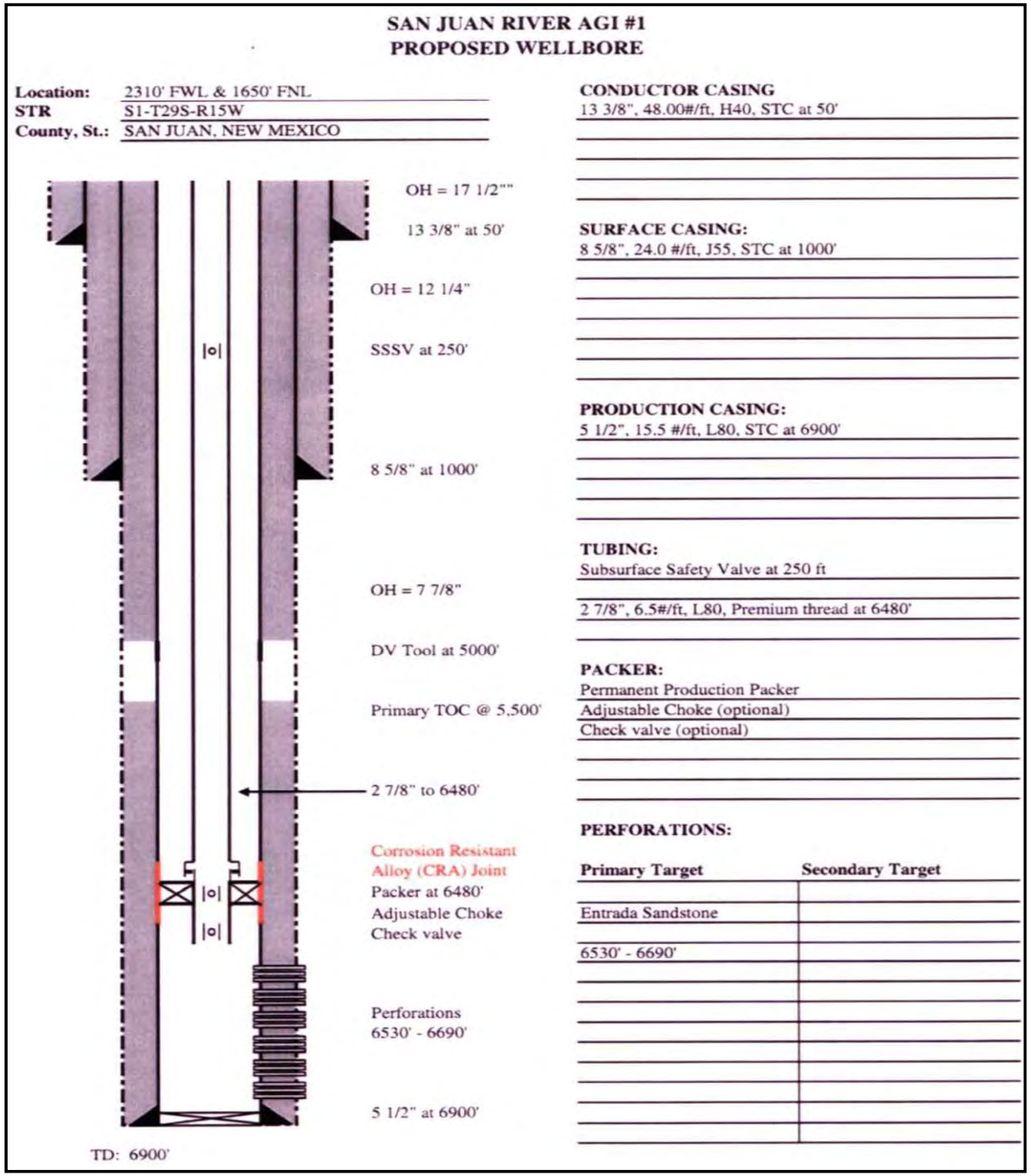
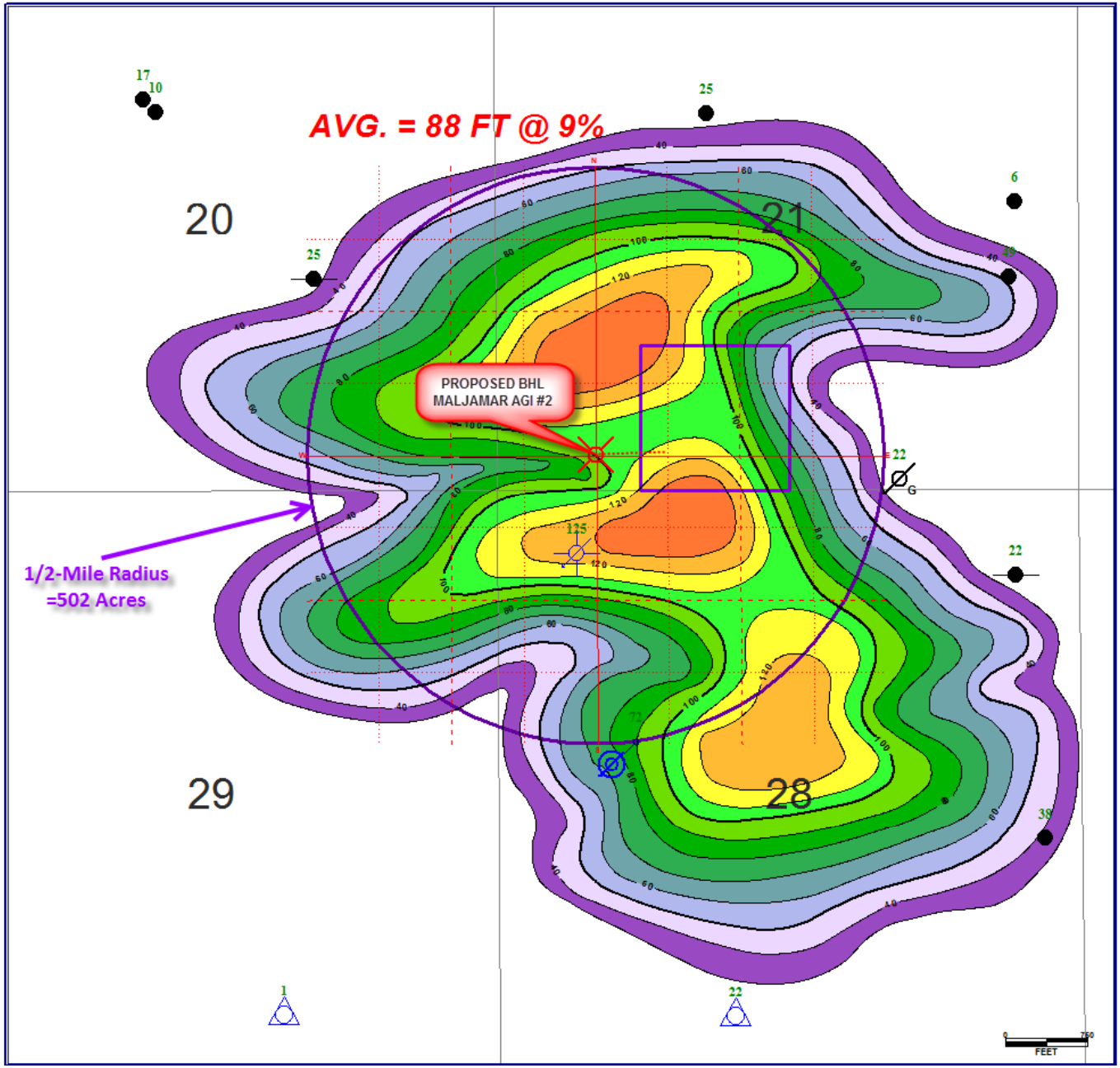
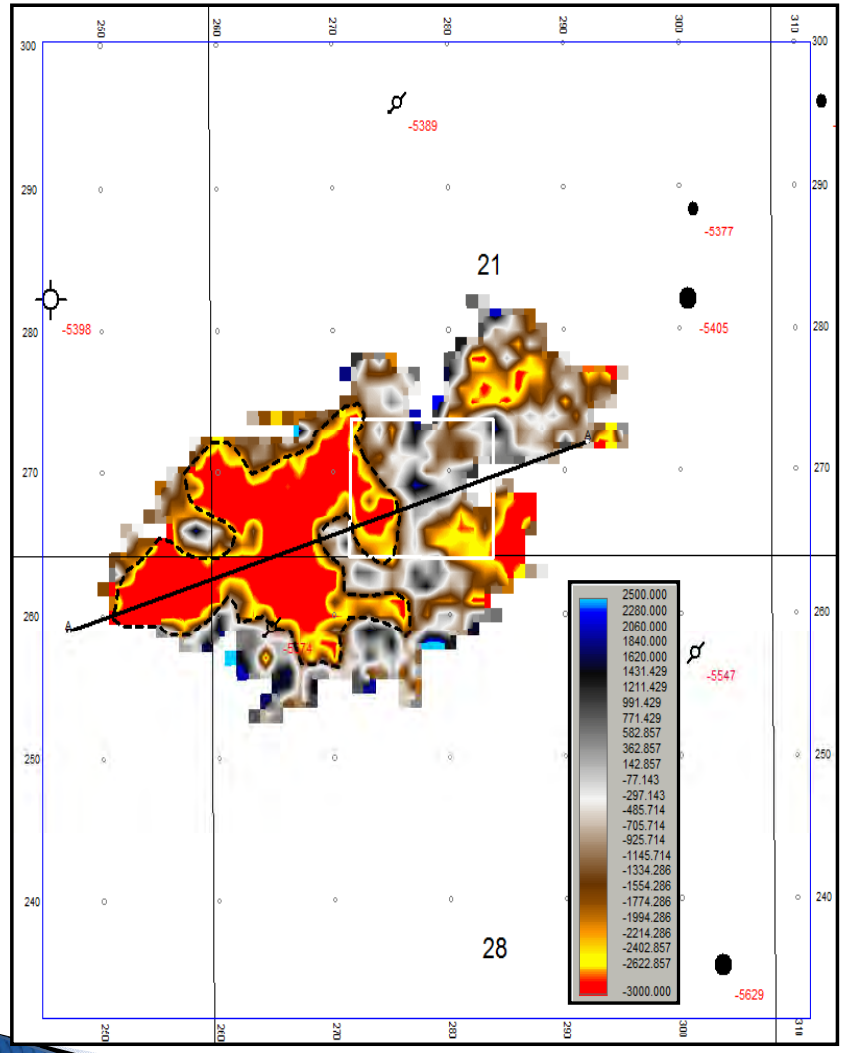
- Well design will optimize protection of near-surface and surface waters, and provide for protection of overlying and underlying producing zones (example)

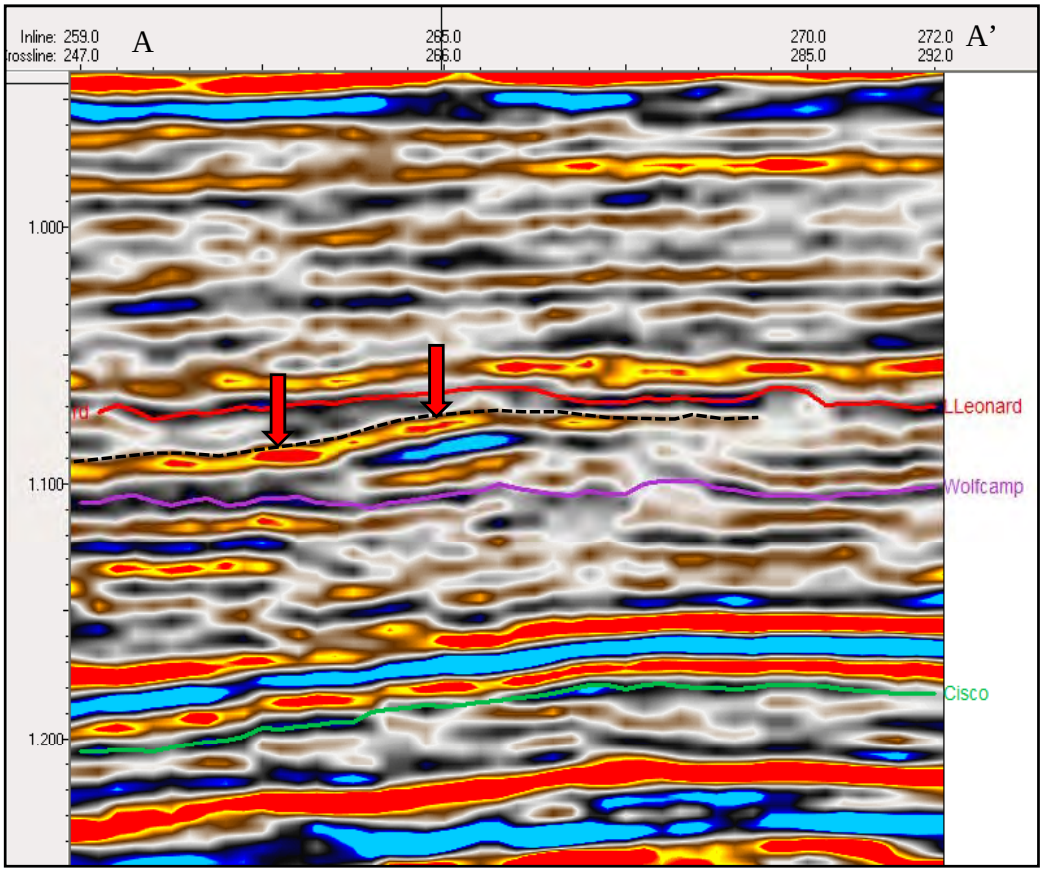


- Example of a net porosity map through a proposed IZ, based on subsurface control, showing average net feet and porosity percentage

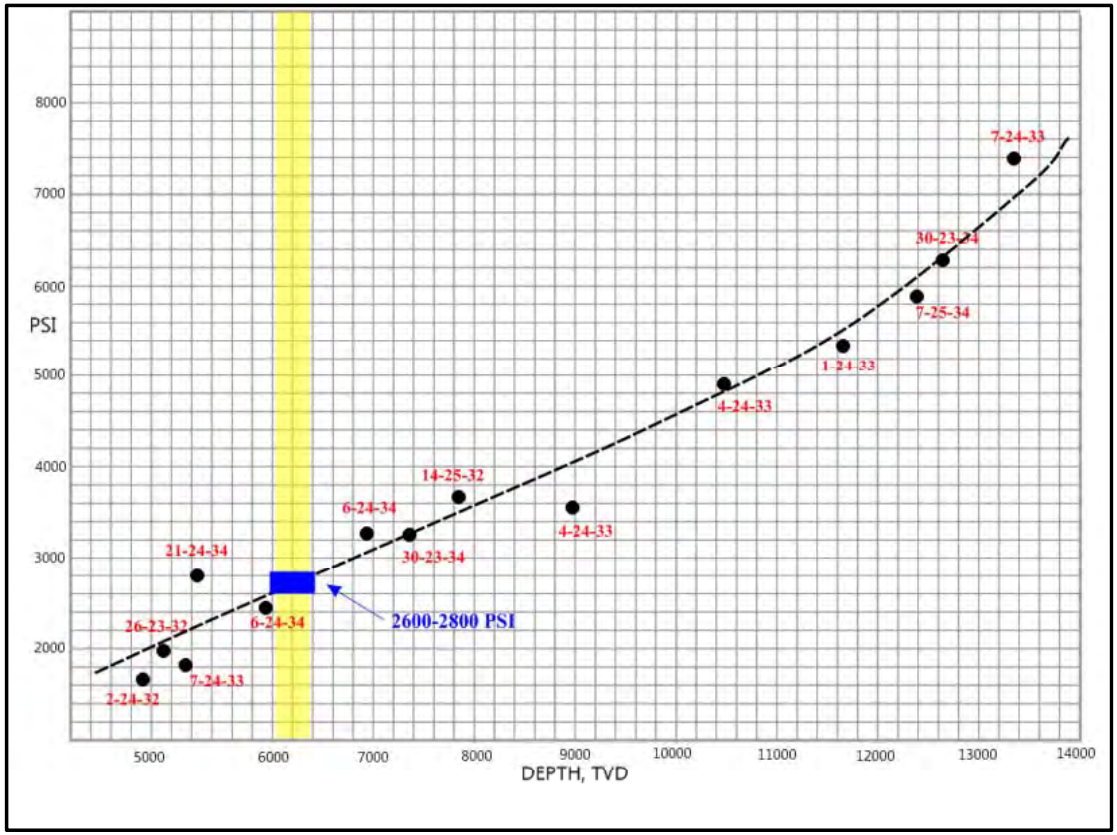


- Example of seismic amplitude slice map (left) illustrating extent of higher porosity in one zone of the IZ (red and yellow colors), and vertical seismic section (right) showing the extent of the mapped porosity zone (dashed black horizon)





- Example of bottom hole pressure determination using DST test data (left), and calculation of reservoir volume (in this case, for acid gas in the proposed injection zone based on geologic data (right)



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- Bottom hole pressure = 2,250 psi
- $F = 1.65/Por^{1.33}$ for shaly sandstones

$F = 1.65/0.15^{1.33} = 20.6$

$Sw = F\ (Rw_{BHT}/Rt) = 20.6\ (0.06/3) = 0.41$

$1\text{-}Sw = 0.59$

GAS IN PLACE CALCULATION:

GIP = 43,560 (Acre)(Ft) (Por) (1-Sw)
= 43560 (2318) (111) (0.15) (0.59)
GIP = 991,899,228 CFG

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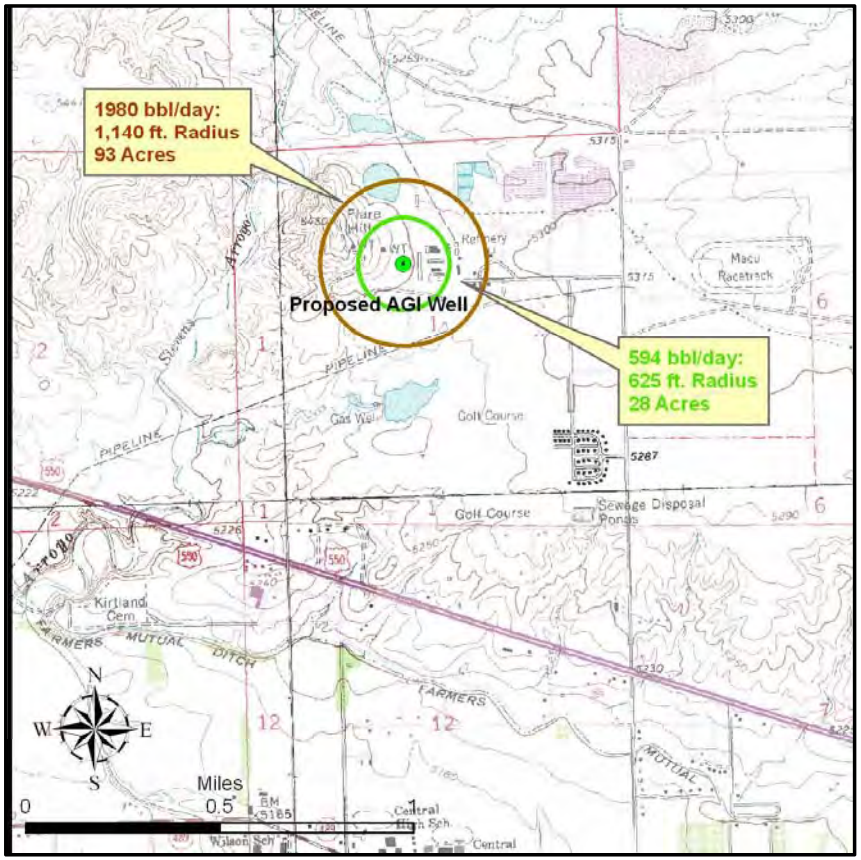
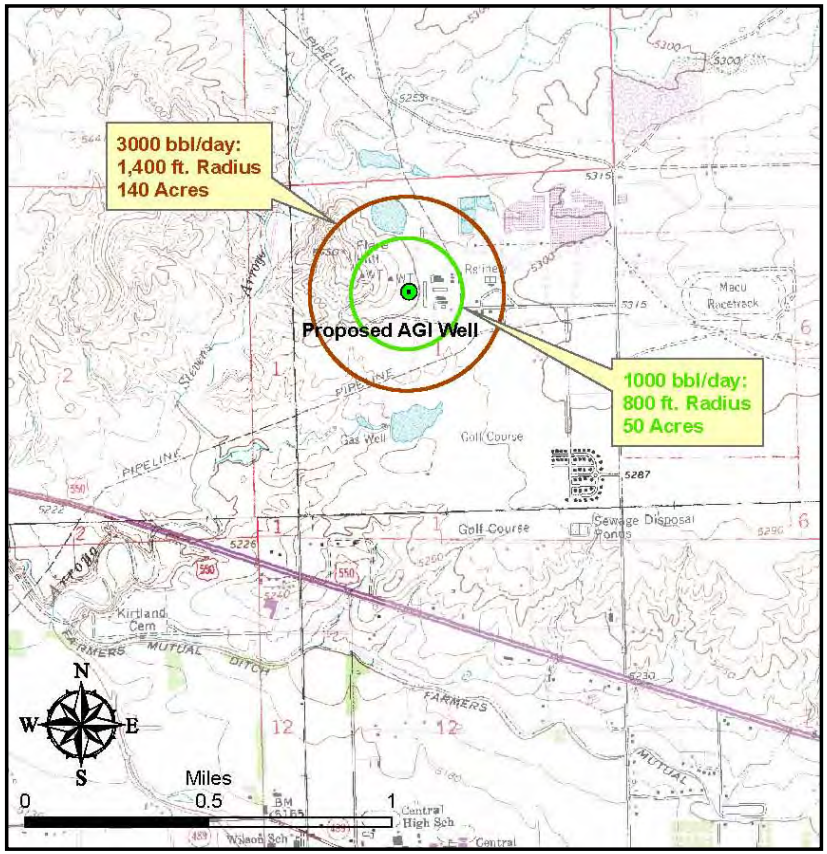
- Actual Area of Injection Plume Affected Over Life of Well Compared with Affected Area Safety Margin (example)

- 30-year Predicted Plume Area Based on Current Throughput



- 30-year Predicted Plume Area with Safety Margin as Shown on Figure 13 in C-108



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- Adjacent Operators and Surface Owner Notification and Notice

- Application details the full information needed to approve the installation of an injection well
- Notice of application must be provided to all adjacent operators and surface owners within half-mile radius of proposed well via web site link
- Surface owners and operators will receive notice via certified mail, return receipt requested
- Notice shall be published in local newspapers as required by NMOCD

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Summary of Well Design Factors Assuring Integrity and Safety of Injection Wells

- Well design will ensure setting of surface and, if necessary, intermediate casing in impermeable formation below lowest potable water source. Often includes multiple casing and cement intervals to isolate fresh groundwater.

- Production casing set within surface casing and cemented to surface constructed with materials which will assure the integrity of the base of the production casing exposed to waste stream in injection zone below the packer.

- Cement bond logs will assure casing seal to formations.

- Appropriate compatible tubing will be inside the production casing and stabbed into compatible packer with annular space filled with inert corrosion-inhibited fluid and monitored for pressure to indicate potential tubing leak before it can affect production casing.

- Similar designs have been implemented successfully without any leakage problems at similar and deeper zones in SE New Mexico, Texas and Alberta for many years including many such installations designed , permitted and completed by Geolex.

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Summary of Geologic Factors Assuring Integrity and Safety of Injection Wells

- Isolation of groundwater from disposal zones by caprock with good integrity and demonstrated lack of transmissive fractures or faults.
- Separation of disposal zone and base of groundwater by thousands of feet of formations which present numerous barriers to potential escape of pressure or fluid from injection zone.
- Demonstrated knowledge of stratigraphy and good well control in area of review of injection well.

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Well Design and Geologic Setting Ensures Protection of Groundwater

- Well Design
  - Groundwater protected by multiple strings of casing each cemented to surface
  - Cement in injection zone and caprock will be compatible with disposal fluids and corrosion resistant
  - Maximum depth of fresh groundwater in New Mexico typically less than 1000’
- Geologic Features
  - Injection zone significantly deeper than base of fresh water
  - Excellent quality of caprock which has been thoroughly characterized to assure no transmissive fractures or faulting which could affect overlying production or groundwater.

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