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Arizona's First APP for Well Stimulation - A Case Study

14th Annual Gatekeeper Regulatory Roundup

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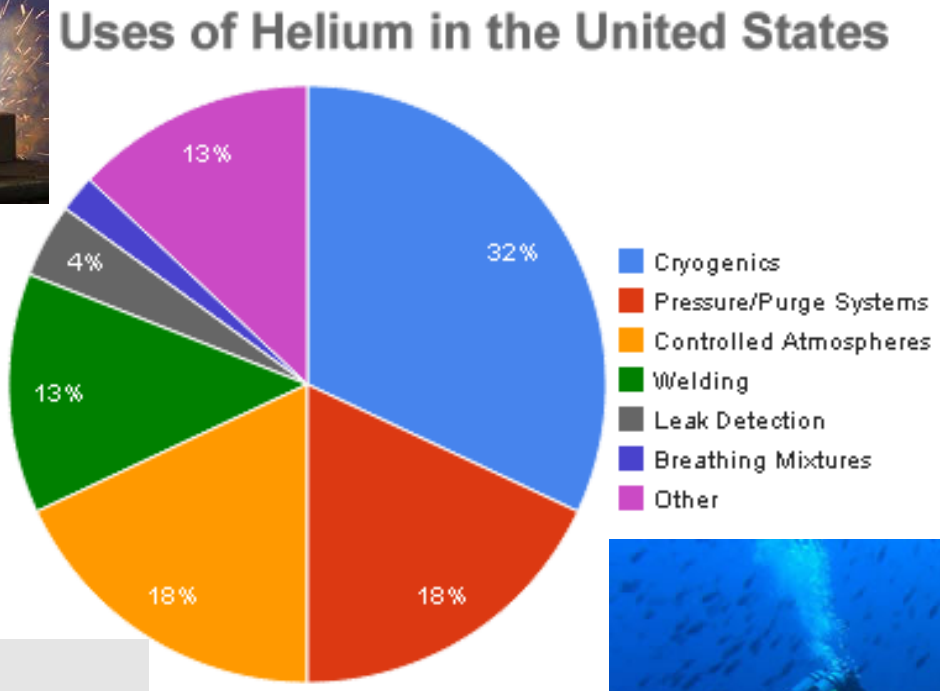
Discussion Items

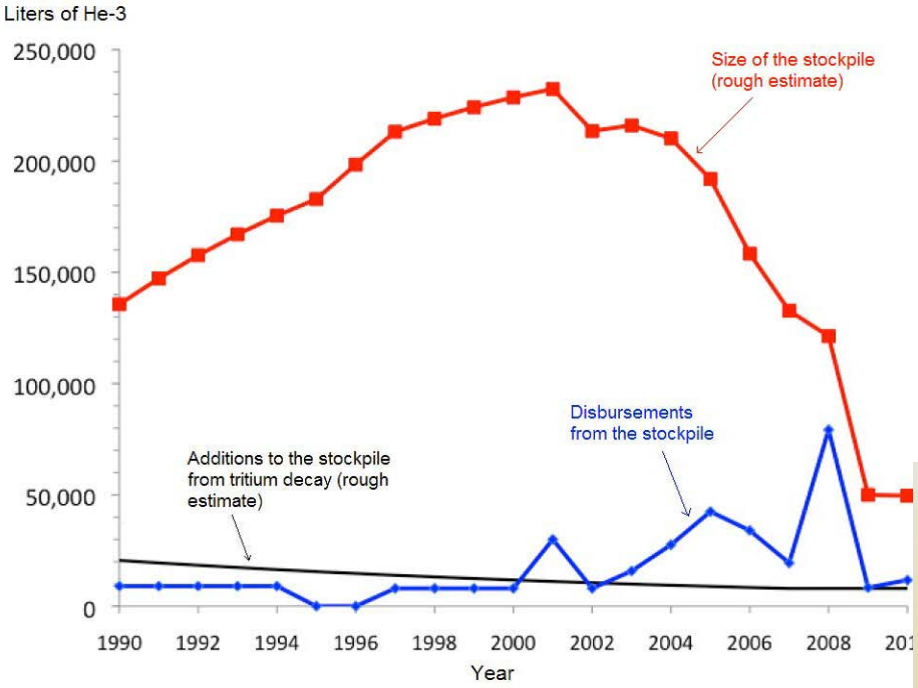
- Overview of Helium Uses, Recent Trends, & Location in AZ
- Overview of Well Stimulation
- Overview of APP Applicability to Stimulation
- Overview of Challenges Associated with APP & Stimulation
- Overview of Final APP Permit & Obligations

Uses of Helium

https://geology.com/articles/helium/



U.S. Helium Trends



https://enveconunca.wordpress.com/2013/04/16/u-s-helium-shortage-economic-and-policy-issues-2/

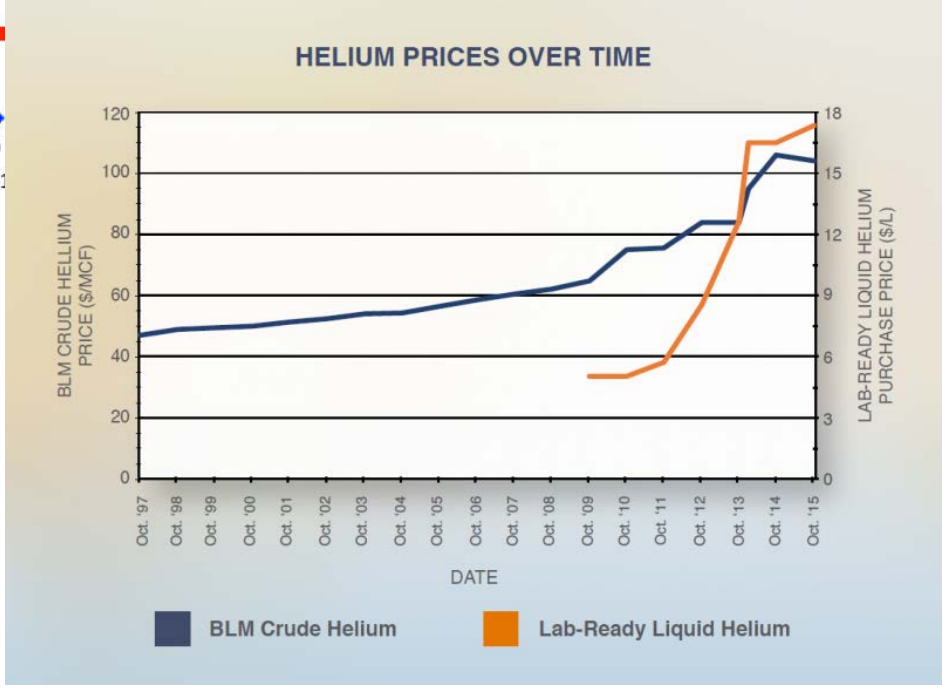
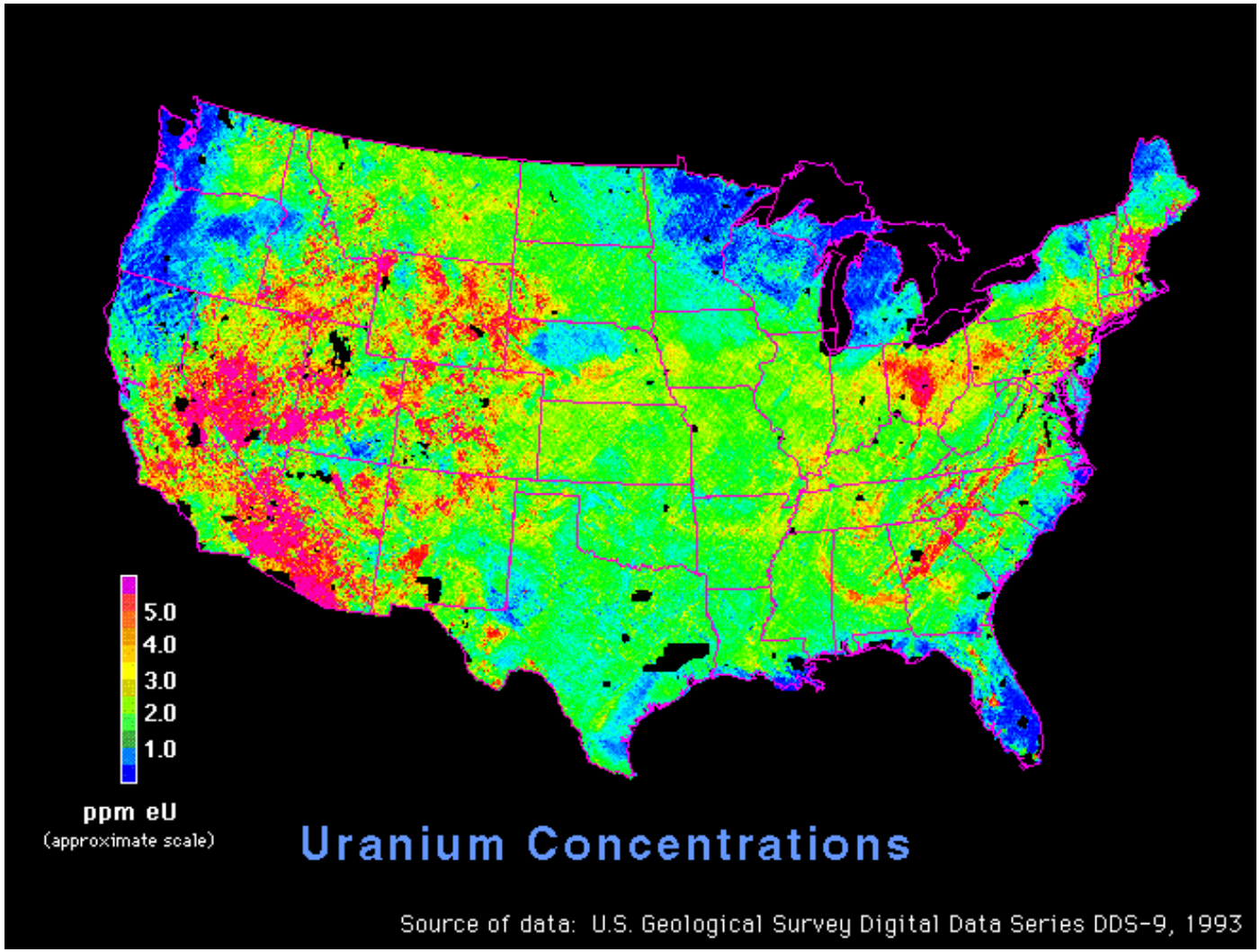


Image credit – APS, ACS, and MRS

Helium Formation

Uranium ⟶ Helium + Thorium



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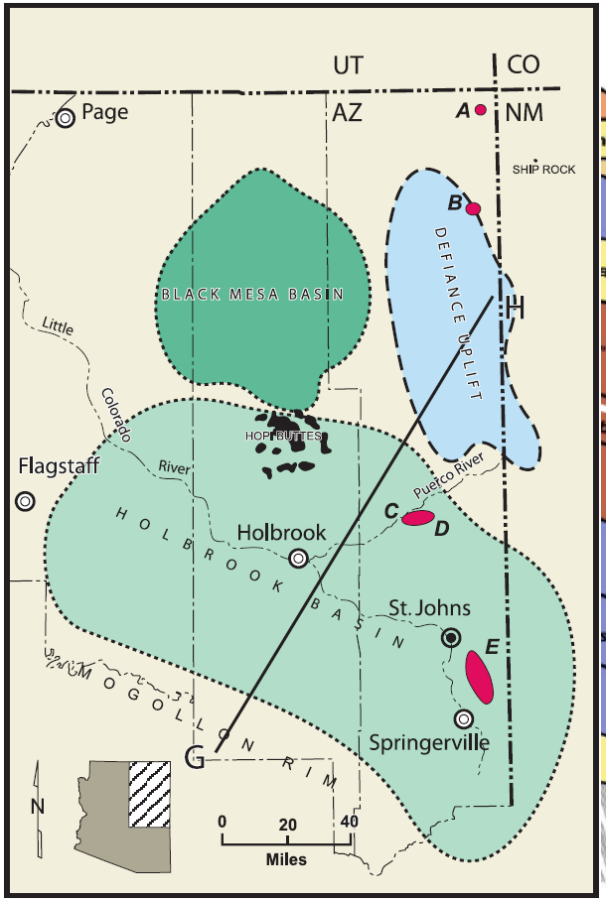
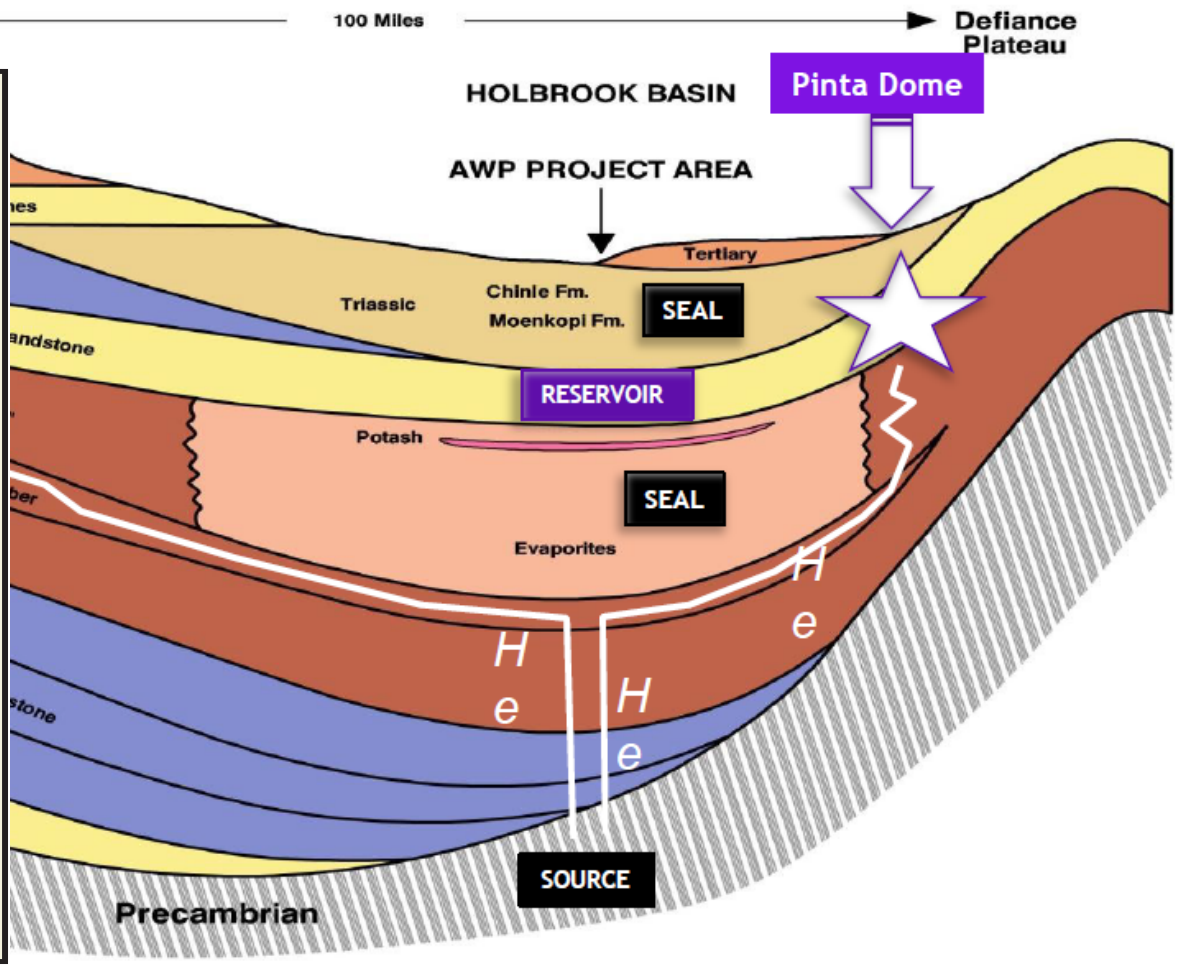
HELIUM - HOLBROOK BASIN

Holbrook Basin Stratigraphy - Helium Source, Reservoir & Seal System

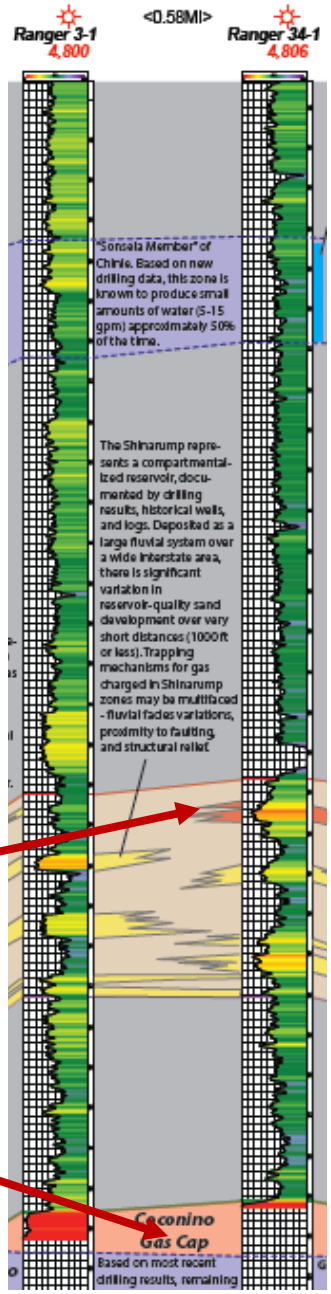




Pinta Dome is ideally placed to receive helium charge from lateral migration beneath Supai Formation evaporites and short distance vertical migration above Precambrian crystalline basement. The Coconino Sandstone and Shinarump Conglomerate are effectively sealed by the Moenkopi and Chinle Formations, respectively. Note that the Coconino Sandstone cannot be sealed toward the Mogollon Rim in this figure because the Kaibab is a fractured limestone. The search for helium in these parts of the Mogollon Rim should be focused on the Supai Group and lower.

Where is the Underground Helium in AZ?

Drinking water wells at ~ 50 ft



Target Helium (through stimulation)

Target Helium (No stimulation)

Chinle

Chinle – Water Zone (at 350 – 450 ft)

Chinle (at 450 to 700 ft)

Shinarump (at 700 to 850 ft)

Moenkopi (at 850 to 950 ft)

Coconino (at > 950 ft)

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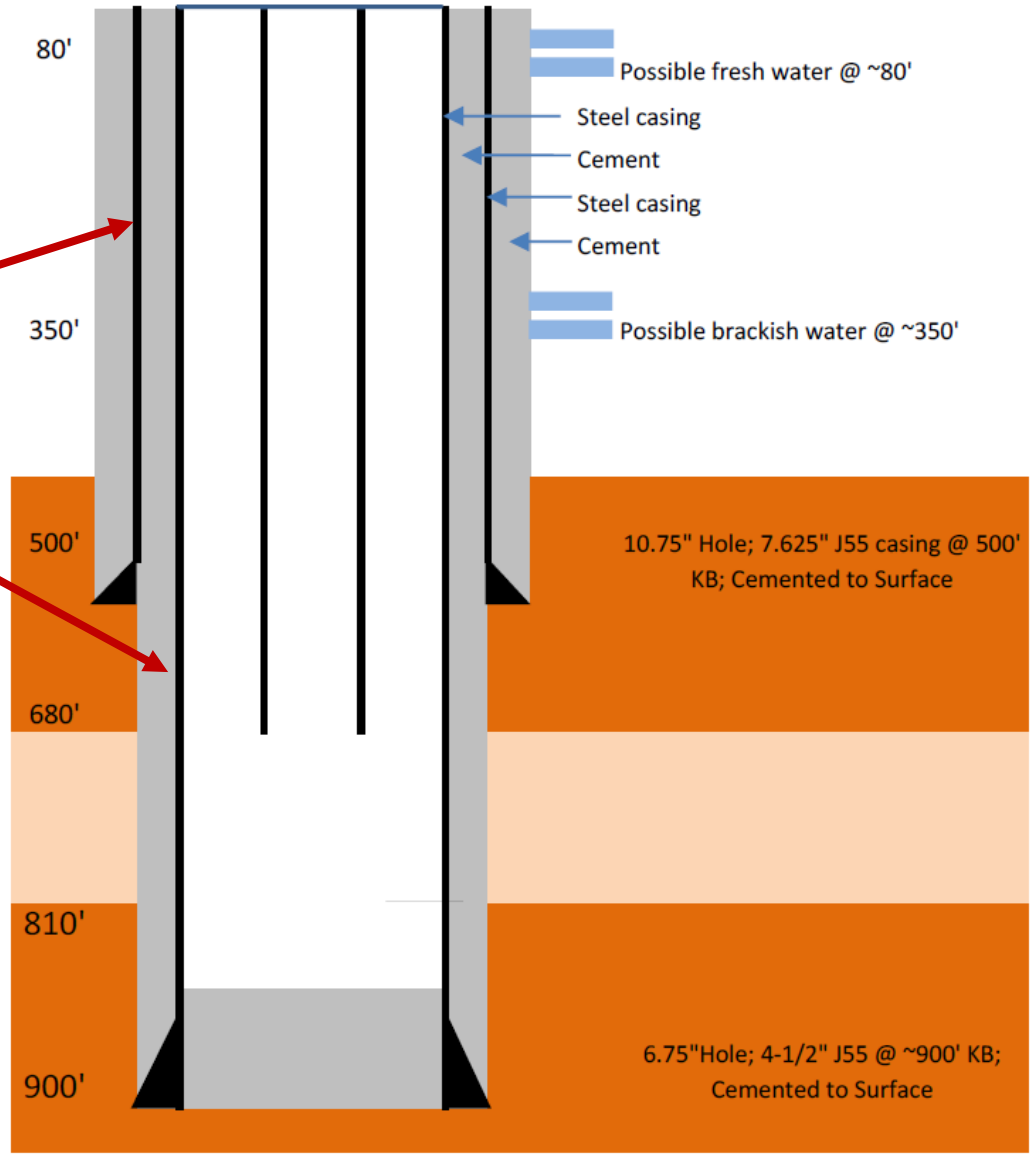
Anatomy of a Helium well

“Surface” Casing

“Production” Casing



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OGCC Sample Requirements

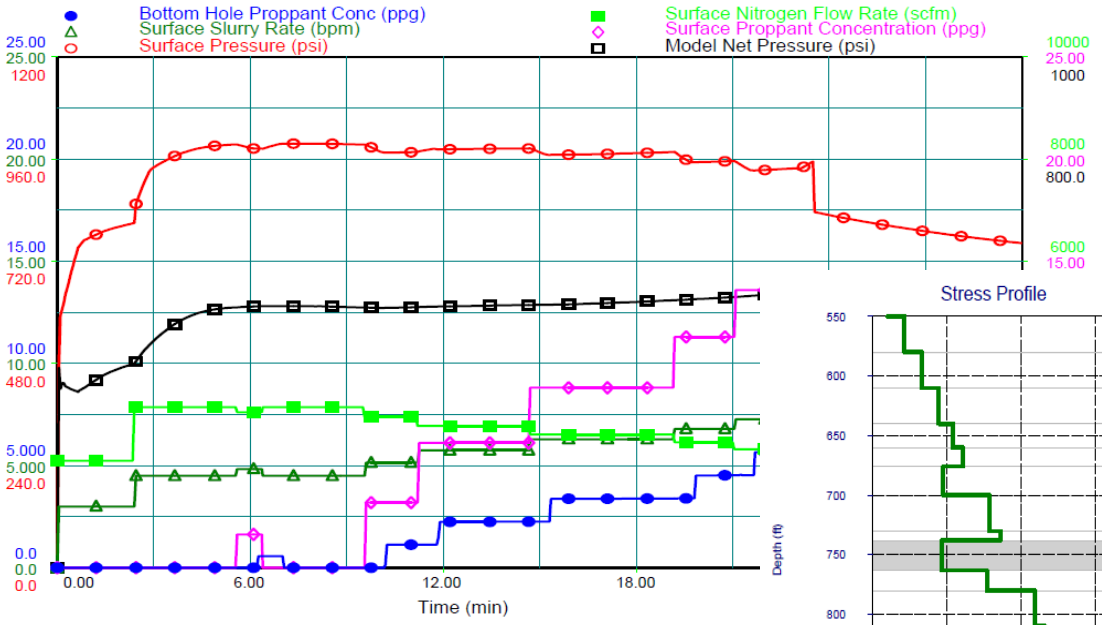
- R12-7-110 - Surface Casing
  - Minimum depths surface casing in order to protect freshwater zones
  - Cement setting time ≥ 12 hrs
  - Casing pressure testing
  - OGCC onsite review of casing
- R12-7-111 - Intermediate and Production Casing
  - Cementing of casing
  - Tubing requirements
  - Cement setting time ≥ 12 hrs
  - Casing pressure testing
  - OGCC onsite review of casing
- R12-7-112 Defective Casing or Cementing
  - Immediate action to correct
  - Reporting requirements
- R12-7-114 Recovery of Casing
  - Recovery of inside or outside strings prohibited
  - Agency approval needed

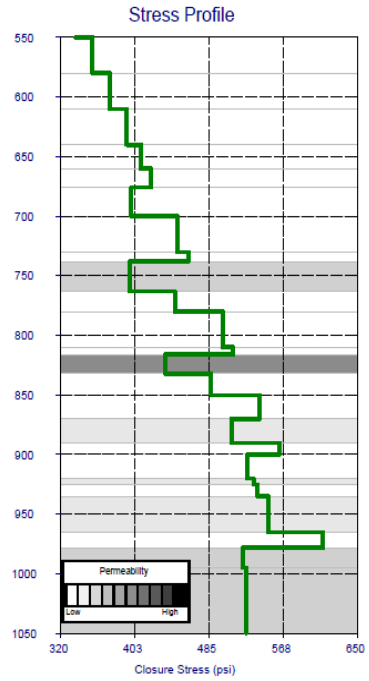
Stimulation Background

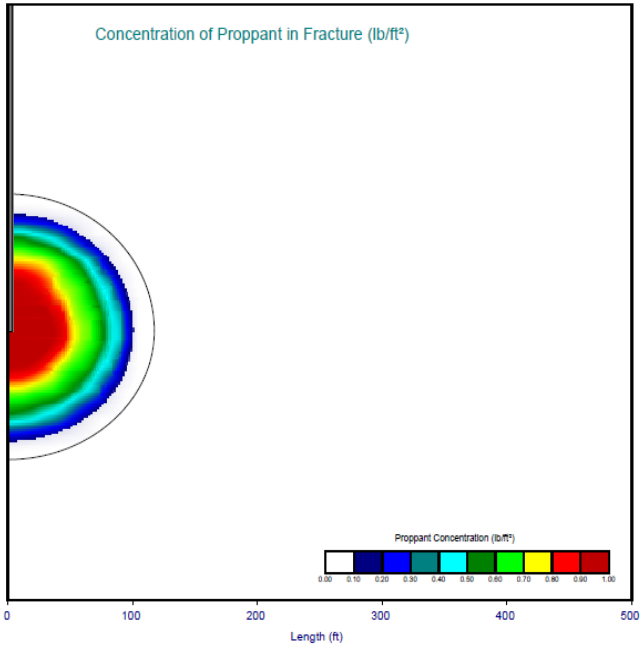
- Has been conducted since 1940s
- Also known as “hydraulic fracturing” or “fracking”
- Used to extract oil and natural gas from shale rock
- Two types
  - “Acid” - Used to “etch” channels in the rock
  - “Proppant” – Propping agent (e.g., sand) “props” open the fracture

How to Stimulate a Well?

- Duration is 45 to 60 minutes and follows a specific design
  (Conducted once during the life of a well for a specific depth)

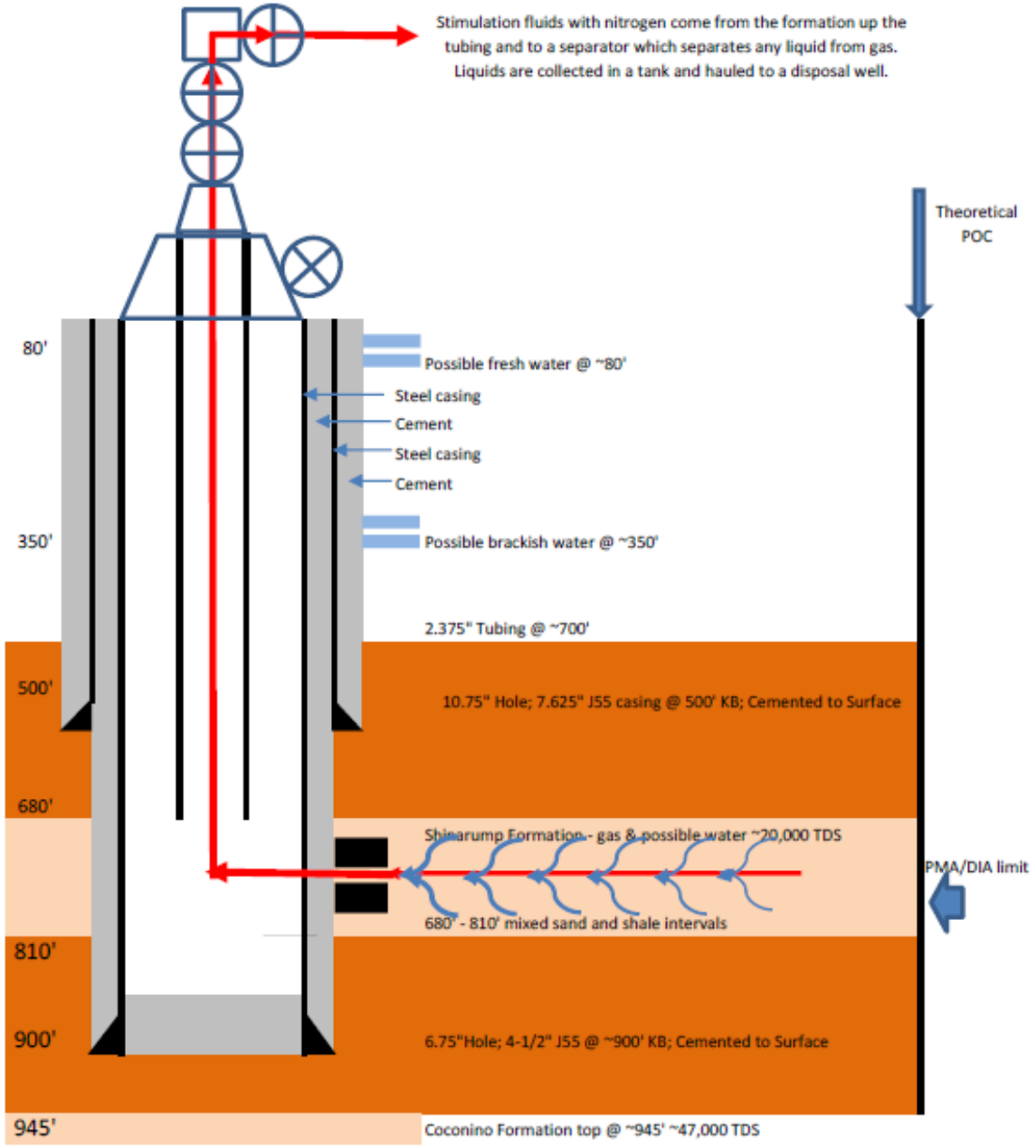






- Efforts are made to pull all stimulation materials (other than proppant) back to the surface

Stimulation Goal



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Does APP Apply to Stimulation?

(1 of 3)

- Depends on what is an "aquifer"
  - Coconino could be classified as an "aquifer" but
  - Is the Shinarump an "aquifer"?

- ARS §49-201.2 - "Aquifer means a geologic unit that contains ***sufficient saturated permeable*** material to yield ***usable quantities*** of water to a ***well or spring***."

- What is considered "sufficient saturated permeable"?
  - "Permeable" material (e.g., sand) must contain water
  - If there is not a "sufficient" amount of sand then not an "aquifer"
  - What if sand is not continuous with minimal water flow?

Does APP Apply to Stimulation?

(2 of 3)

- What is considered "yield usable"?
  - Groundwater under review has TDS > ocean
  - ARS and preamble do not define "usable quantities"
  - ADEQ does not have guidance on what is "usable quantities"
  - Should economics determine "sufficient" amounts of "usable" quantities?

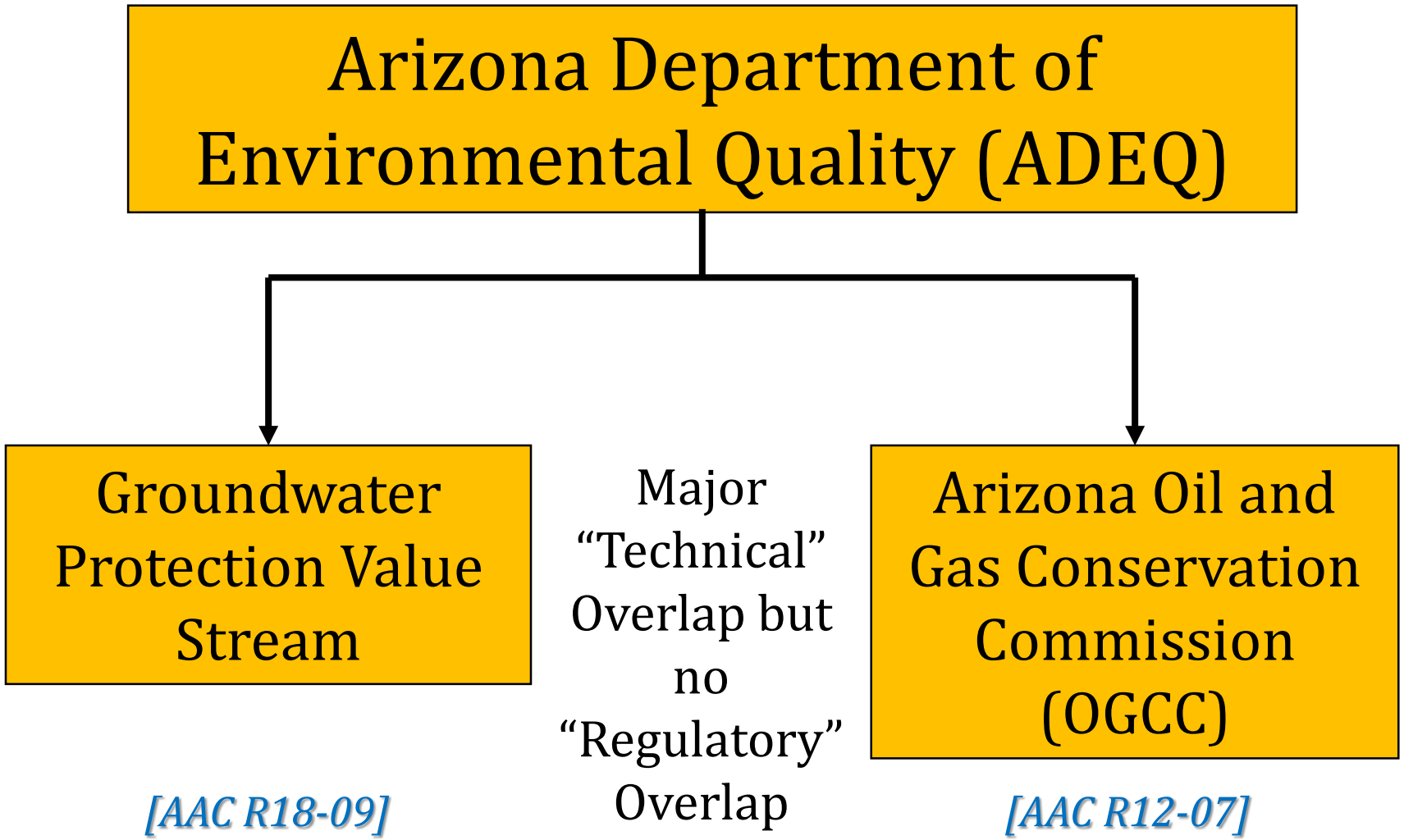
- What is considered "well or spring"?
  - Does formation provide water on its own energy or should man intervene?
  - What if formation does not have enough pressure on its own?

Does APP Apply to Stimulation?

(3 of 3)

- Formal determination that formation is not an aquifer must be made through ARS §49-224 "*Aquifer identification, classification and reclassification*."
- ARS §49-224 would trigger engaging a "*groundwater users advisory council*" as well as an extensive public notice and/or hearing.
- A "*groundwater users advisory council*" has never been compiled
- Stimulation may be considered a "discharge" per ARS definitions
- **Timing** – Obtaining APP permit is faster than ARS §49-224 procedures

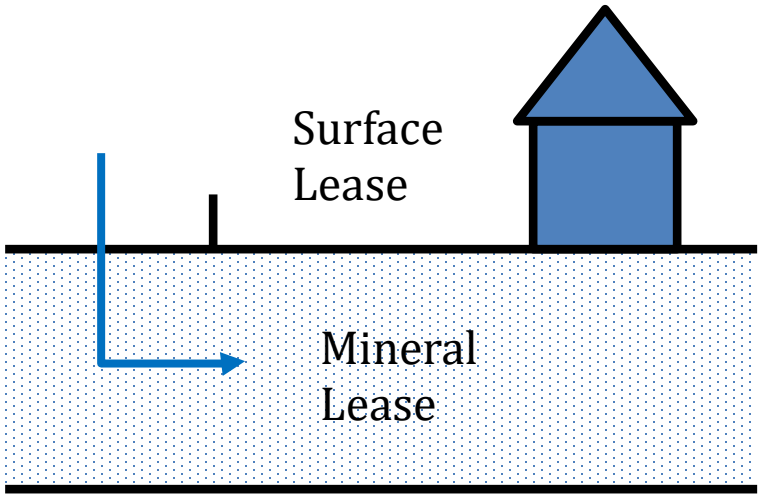
Stimulation APP – Agencies Involved



APP & Stimulation - Challenges

(1 of 6)

- Definition of "lease"
  - Surface lease
  - Mineral lease



- Also, identification of future wells to stimulate is not possible

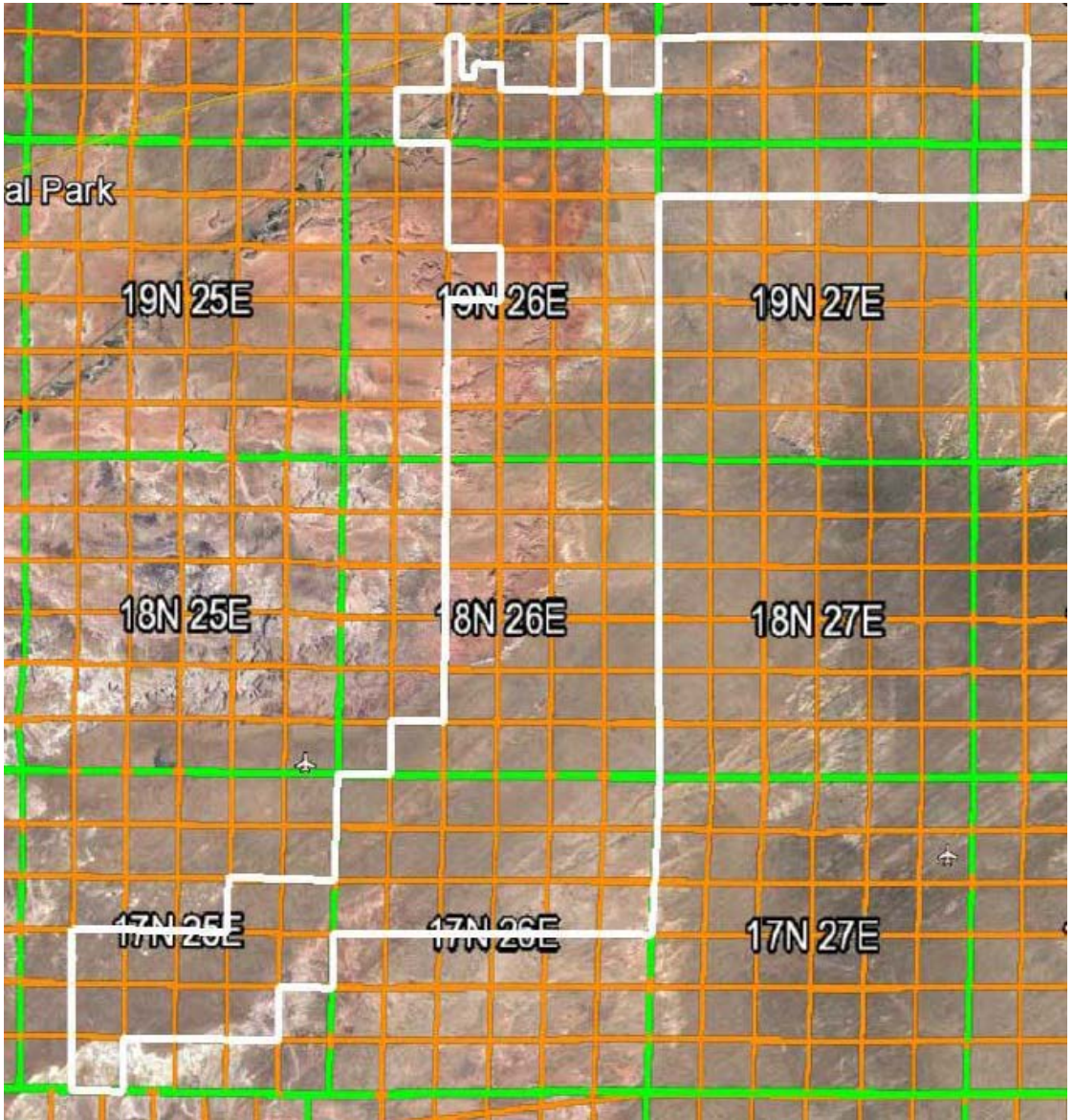
- APP application is designed for "surface" activities

- Challenges
  - How to apply APP application "zoning" requirements
  - How to apply APP application "Landowners" requirements
  - Who does the Public Notice go to?

APP & Stimulation - Challenges

(2 of 6)

- Well stimulation is "not guaranteed" + Location, or depth, of stimulation is also unknown
  (depends on initial drilling results)
- Challenge – Cannot identify "exact" location of stimulation
- Remedy - Define "area" of possible well locations



APP & Stimulation - Challenges

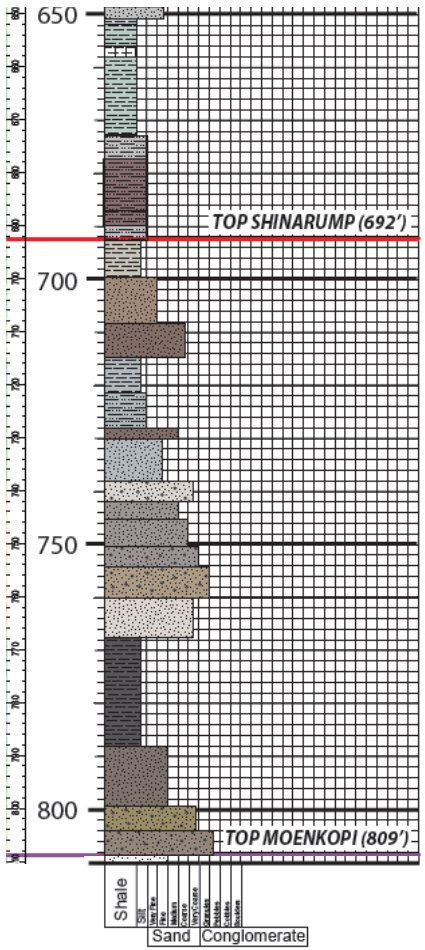
(3 of 6)

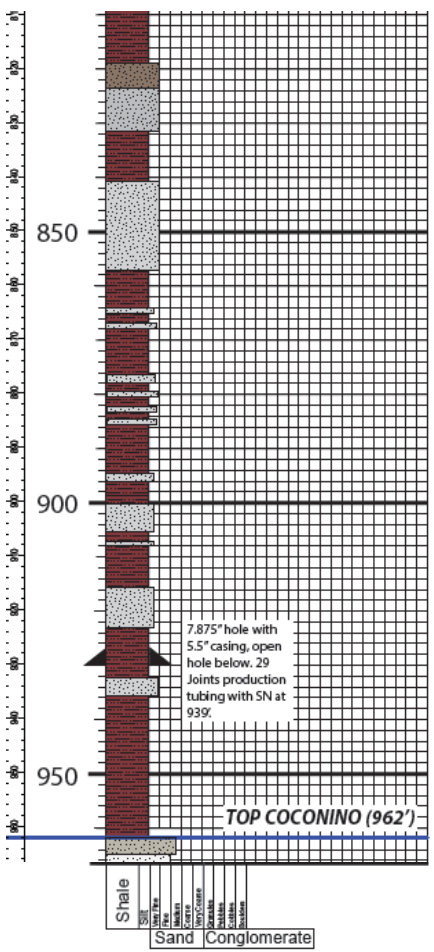
- Demonstration of no migration
  - Shales and silts are 100 to 10,000 times less permeable than sands
  - Minimal travel in non-Shinarump formations

Range of Permeability for Various Soils

Soil	*Permeability Coefficient, k (cm/sec)*	*Relative Permeability*
Coarse gravel	Exceeds 10^{-1}	High
Sand, clean	10^{-1} to 10^{-3}	Medium
Sand, dirty	10^{-3} to 10^{-5}	Low
Silt	10^{-5} to 10^{-7}	Very low
Clay	Less than 10^{-7}	Impervious

http://courses.washington.edu/cm420/lec11/sld009.htm





APP & Stimulation - Challenges

(4 of 6)

- What is the "Design Flow"?
  (used to calculate Annual Registration Fees)
  - Number of stimulations per day – unknown
  - Flow from each event – unknown (based on stimulation design)

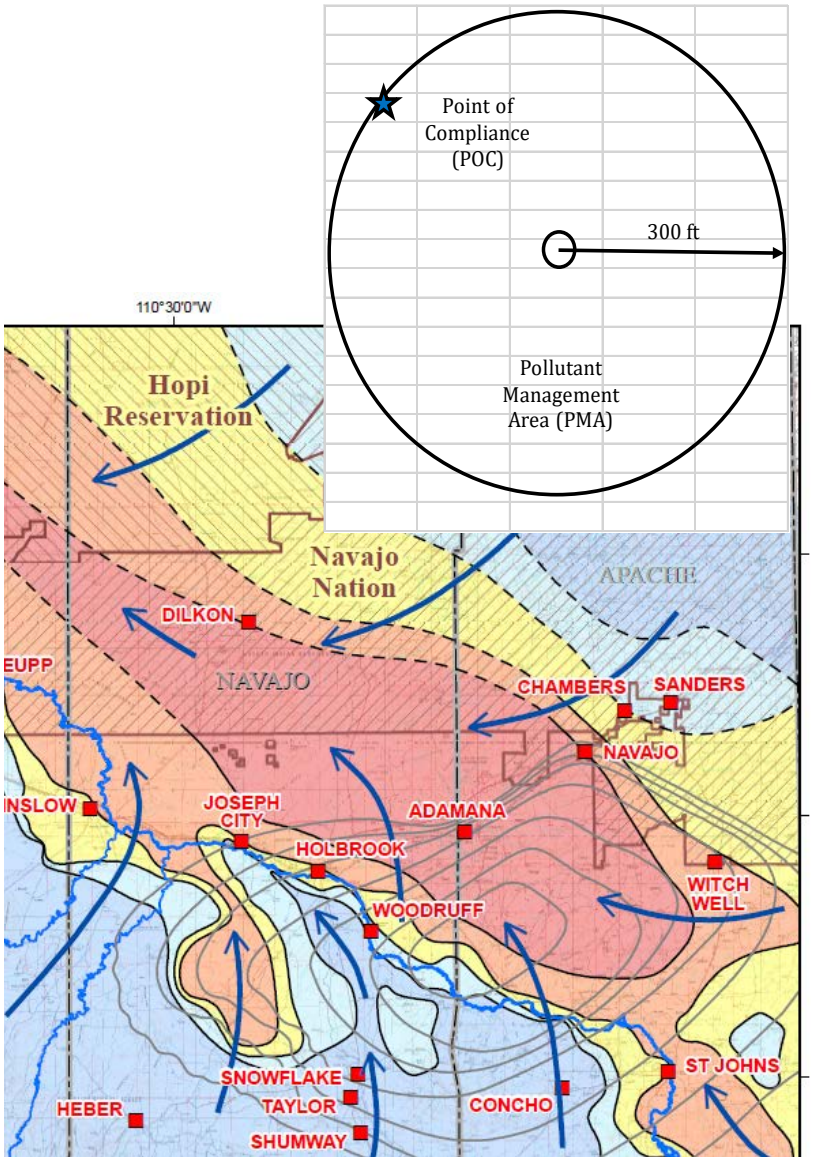
- Remedy – Develop a range
  - Low end – Based on typical design
  - High end = 5x low end

Material Function	Volume (gal)	Volume (bbl)	Volume (vol %)	Comments
Acid Stimulation				
Corrosion Inhibitor	1	0.024	0.20%	
Raw Acid	195	5	39%	
Surfactant	2	0.048	0.40%	
Mixing Fluid	302	7	60%	
Total - Acid Stimulation	**500**	**12**	**100%**	Sample Stimulation Design
Fracture Stimulation				
Surfactant	5	0.12	0.13%	
Clay Control	20	0.48	0.53%	
Breaker	1	0.019	0.02%	
Foamer	25	0.60	0.66%	
Crosslinker	10	0.24	0.26%	
Gelling Agent	16	0.39	0.43%	
Delayed-Release Breaker	1	0.019	0.02%	
Proppant	1,357	32	36%	
Mixing Fluid	2,365	56	62%	
Total - Fracture Stimulation	**3,800**	**90**	**100%**	From Sample Stimulation Design
Acid + Fracture Stimulation				
Total - Acid + Fracture Stimulation	**4,300**	**102**		Sample Stimulation Design
Total - Acid + Fracture Stimulation	**21,500**			High End Estimate

APP & Stimulation - Challenges

(5 of 6)

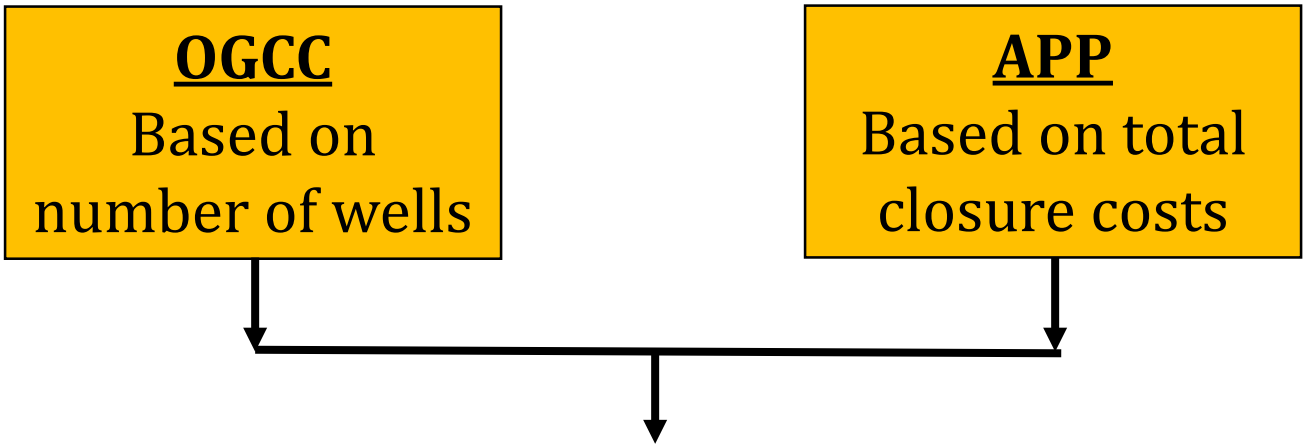
- What is the "Pollutant Management Area" (PMA)
  - Changes with every well (based on porosity, permeability, etc.)
  - Remedy – Develop a "worst case" fracture of 300 ft
- Where is the "Point of Compliance" (POC)
  - Changes with every well
  - Remedy – Develop virtual POC at edge of the PMA
  - Which edge? Look at groundwater travel



APP & Stimulation - Challenges

(6 of 6)

- Financial assurance



APP Bond Value = # of Wells x Closure Costs – OGCC Bond Value

APP & Stimulation – Other Considerations

(1 of 2)

- Best Available Demonstrated Control Technology (BADCT)
  - Well design and construction per ***OGCC requirements***
  - Recover of stimulation materials
  - Stimulation only in the Shinarump formation
  - Low permeability of non-Shinarump formations

- Contingency plan – Follow ***OGCC requirements***
  (immediate notification, remedial action, well closure)

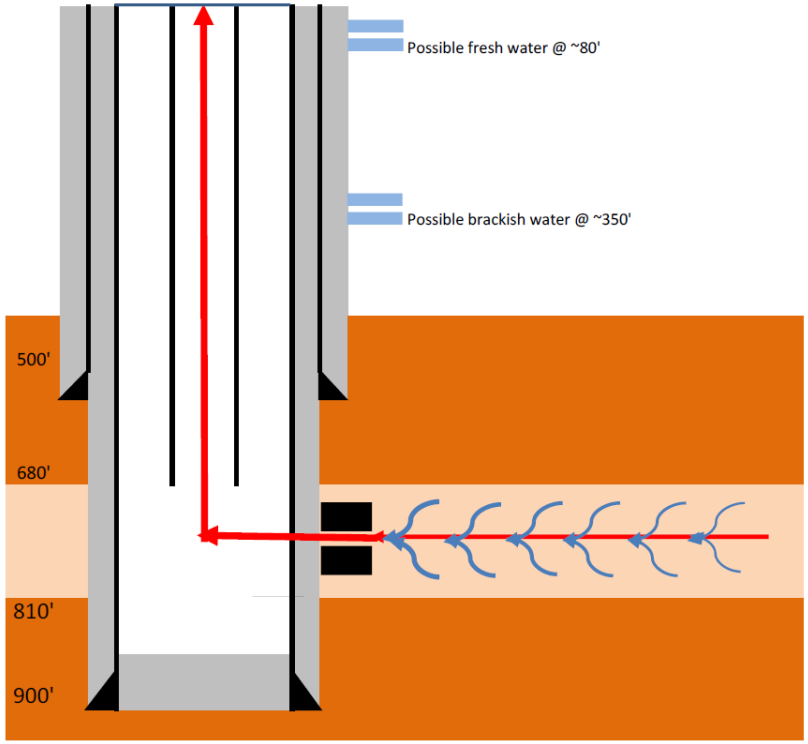
- Compliance Schedule – Follow ***OGCC requirements***
  (Notify agency within 15 days of stimulation campaign)
  - Type of stimulation;
  - Amounts and types of materials used;
  - Stimulation pressures applied; and
  - Flow and pressure results before and after stimulation.

APP & Stimulation – Other Considerations

(2 of 2)

- Closure & Post-Closure – Follow ***OGCC requirements***
  - Submit application to plug and abandon to include mechanical condition of the well and description of proposed work
  - Obtain OGCC approval

- Flow always towards well
  - No Monitoring Requirements
  - No alert levels (ALs)
  - No aquifer quality limits
  - No hydrogeological study (Discharge Impact Area, DIA ≤ PMA)



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APP & Stimulation – Reporting/Recordkeeping

- Self-Monitoring Report Forms - *Not required*
- Operational Inspections and a Log Book - *Not required*
- Permit Violation Status Reporting
  - Notify ADEQ in writing within 5 days of becoming aware
  - Written report to ADEQ within 30 days of becoming aware
- Annual report by January 30th to include
  - Operational status of each well (installed, operational, closed, etc.)
  - Date(s) each well was installed and stimulated, or state that the well was not installed and/or not stimulated
  - Certification statement that stimulation was conducted in accordance with BADCT and operated per Discharge Limitations

APP & Stimulation – Every 6 Years Update

- Amendment application to include
  - Updated cost estimates for well closure and post-closure
  - Updated financial assurance demonstration
  - Statement if closure and post-closure strategy has not changed
  - Statement if permitted wells have not been altered in a manner that would affect the closure and post-closure costs

Stimulation APP Permit – Future Wells

- Obtain OGCC Approval
  - Application for permit to drill or re-enter
  - Archaeology report
  - Botany report
  - Wildlife report
  - Surveys
  - Notice of intent to clear land
  - Pictures
- Submit APP "other" amendment ***90 days*** before activity
  - Update list of stimulated wells
  - Update lat/long of stimulated wells
  - Update lat/long of points of compliance (POCs) for wells
  - Remove list of closed wells
  - Update financial demonstration letter
  - Update financial assurance mechanism

Conclusion

- The APP permitting process difficult to apply to well stimulation in Arizona
- Compliance with OGCC requirements meets APP program requirements
- Stimulation is not a "discharge" as material is always flowing back to the well and the surface
- *Is it possible to interpret the ARS definitions such that "stimulation" is not a "discharge"?*

Questions?

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- Eddie is a principal at Trinity Consultants and manages Trinity's Arizona consulting operations. With about 20 years of experience, Eddie specializes in providing consulting services for clients related to environmental permitting and compliance, as well as strategies for managing environmental obligations. He also advises clients on matters involving environmental policy, rulemaking, compliance, permitting, and enforcement. Eddie has assisted clients in many states and EPA regions, and has experience with a wide range of industries.
- Eddie has substantive experience in the permitting and compliance requirements of the Clean Air Act and has taught and presented on that subject at various venues.