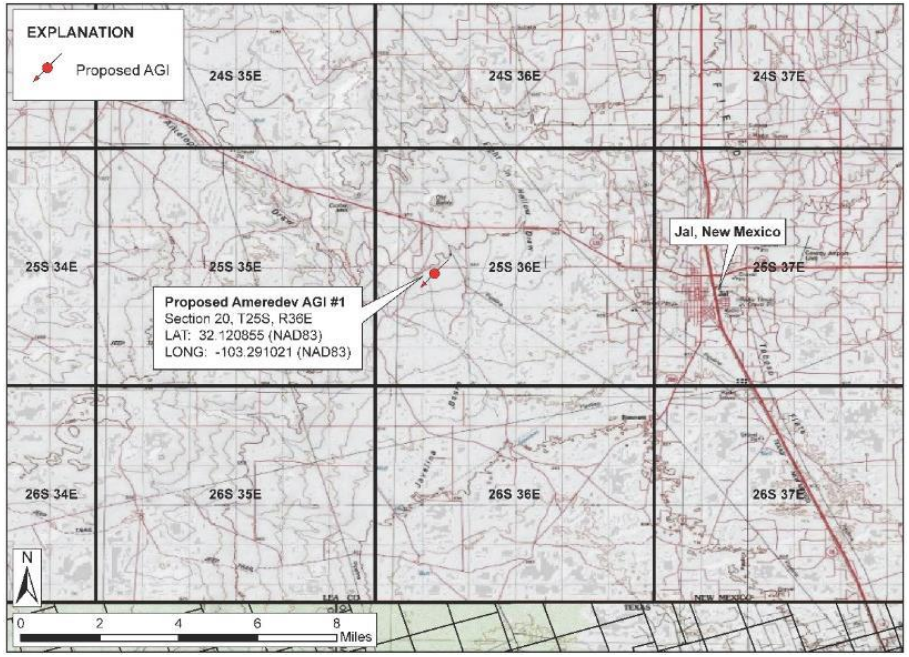
# APPLICATION FOR AUTHORIZATION TO INJECT

## C-108 Application for Class II AGI Well




Ameredev Operating, LLC
Independence AGI #1

Presented in Hearing Before the
New Mexico Oil Conservation Commission
Case #21381

September 17, 2020

GEOLEX INCORPORATED

**Application prepared by:**
Geolex, Inc.®
500 Marquette Ave NW, #1350
Albuquerque, NM 87102
(505)842-8000

# AMEREDEV OPERATING, LLC WITNESSES

- **FLOYD HAMMOND** – Ameredev Operating, LLC

- **ALBERTO A. GUTIÉRREZ, C.P.G.** – Geolex, Inc.®
  - M.S. Geology (UNM 1980)
  - Registered geologist in 21 states; 40 years experience
  - Petroleum geology and hydrogeology expert
  - Expert in permitting, design, construction, and operation of AGI wells

- **DAVID A. WHITE, M.S.** – Geolex, Inc.®
  - M.S. Geology (UNM 2018)
  - Extensive project management experience and geologic support for AGI projects
  - Permitted, designed, and installed AGI wells in Permian Basin
  - Expert in petroleum geology, seismic interpretation, and fault-slip probability modeling

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# PRESENTATION TOPICS FOR EACH WITNESS

- **FLOYD HAMMOND** – Describe history of Ameredev NM operations, overall benefits of Ameredev gas-treating plant and role of AGI project in gas facility operations

- **ALBERTO A. GUTIÉRREZ, R.G.** – Describe relevant site geology and hydrogeology, system design, operation, analyses of effect on injection zone, and all components of C-108 application

- **DAVID A. WHITE, M.S.** – Describe induced-seismicity risk assessment, assessment of local subsurface pressure conditions to assess reservoir containment potential, and injection modeling to predict resultant acid gas plume

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# PROPOSED GAS PLANT AND AGI WELL

- PLANT CAPACITY AND ASSOCIATED INFRASTRUCTURE
  - 12 MMSCF per day of treated acid gas (TAG) that will be generated by the processing plant
  - The AGI system is integral to assure and maintain plant capacity
- THE AGI IS NECESSARY TO SUPPORT PRODUCTION OF SOUR GAS
  - Minimizes environmental risks and permitting associated with other forms of sour gas handling
  - The well will provide capacity for sour gas production and future production increases
  - Independence AGI #1 will provide producers with increased processing capacity and minimizes potential associated costs
  - Complete sequestration of acid gases reduces the potential for field flaring and waste of resources
  - An adequate reservoir that lies well below any existing production has been identified

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# KEY ELEMENTS OF AMEREDEV'S C-108 APPLICATION

- AGI project has substantial environmental benefit of greenhouse gas reduction due to sequestration of $CO_2$ which otherwise would be released to atmosphere
- AGI project reduces waste and air emissions by eliminating flaring of acid gas or operation of a sulfur recovery unit as sulfur control measures
- Nearby oil and gas wells, water wells, and surface water in the area of the proposed AGI are protected by well design and geologic factors
- Detailed interpretation of seismic and available logs has permitted the accurate delineation of the reservoir assuring that nearby SWD and producing wells will be protected
- Fault-slip probability modeling demonstrates that proposed AGI and nearby SWD injection volumes and pressures will have only minimal (less than 0.05) probability of induced slip on identified faults in the area

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# KEY ELEMENTS OF AMEREDEV'S C-108 APPLICATION (cont.)

- Injection simulations completed utilizing Schlumberger Petrel and Eclipse platforms demonstrate that, after 30 years, the main body of the plume will extend between approximately 1 to 1.3 miles with diffuse concentrations extending between 1.6 and 1.8 miles
- Ameredev's C-108 application includes all required information needed to approve the installation of the proposed AGI well
- $H_2S$ Contingency Plan for the proposed Ameredev plant will be prepared, submitted, and approved by NMOCD prior to commencement of injection operations
- All parties requiring notification have been provided notice and complete copies of the Ameredev C-108 application and there are no objections to the proposed AGI project

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# PROJECT LOCATION AND BACKGROUND

- The Ameredev gas-processing facility will be located in Section 20, Township 25 South, Range 36 East in Lea County, New Mexico (see location map on next slide)
- When fully operational, the plant will sequester approximately 12 million cubic feet (MMSCF) of TAG per day
- The Independence AGI #1 well will be drilled at approximately 829' from the north line (FNL) and 1,443' from the west line (FWL) of Section 20, T25S, R33E
- The AGI well will be drilled as a vertical well from this surface location and completed in the Siluro-Devonian formations at approximately 16,230 to 17,900 feet

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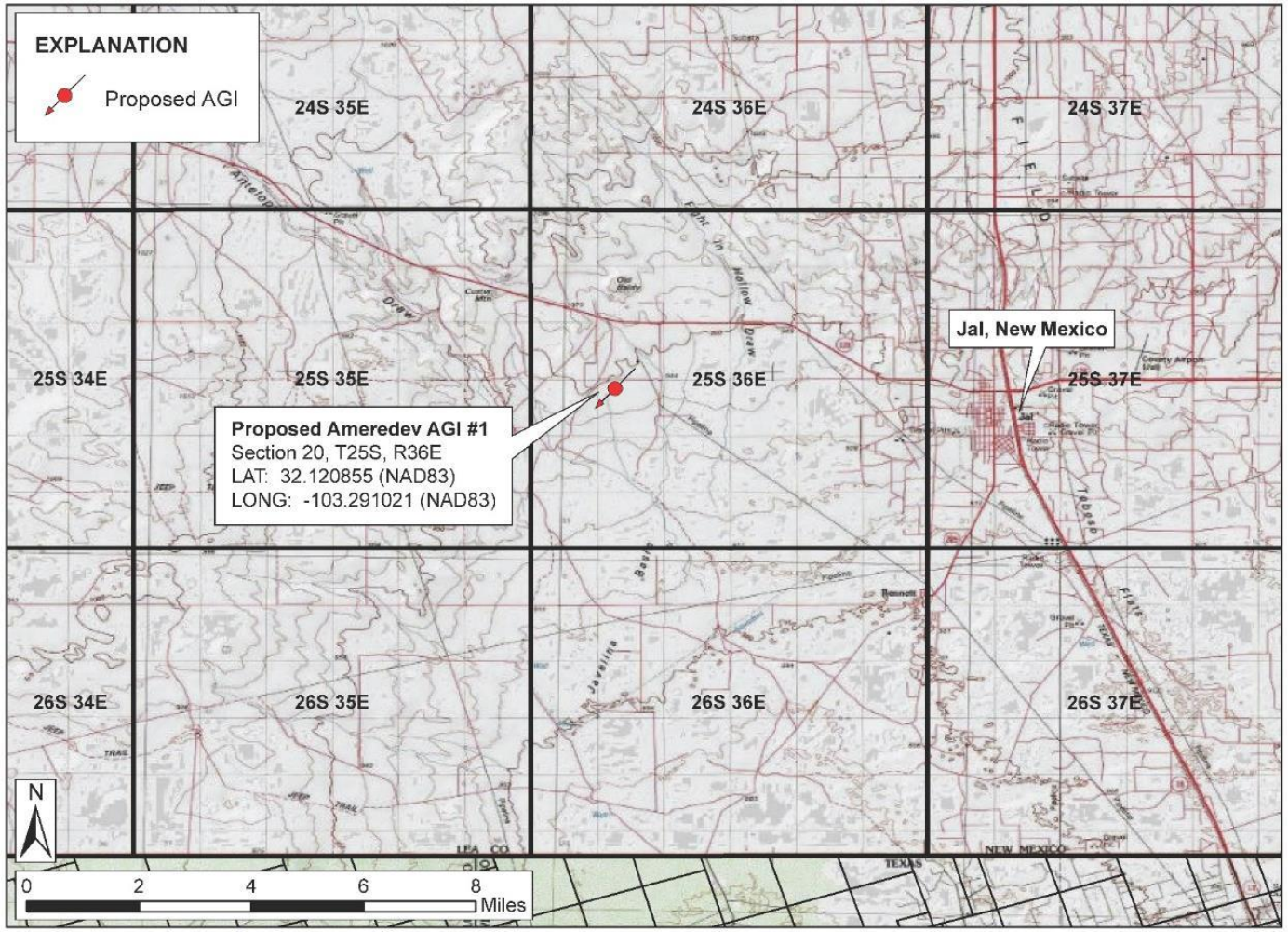


General location map for proposed AGI well in Section 20 (T25S, R36E) approximately six miles west of Jal, New Mexico

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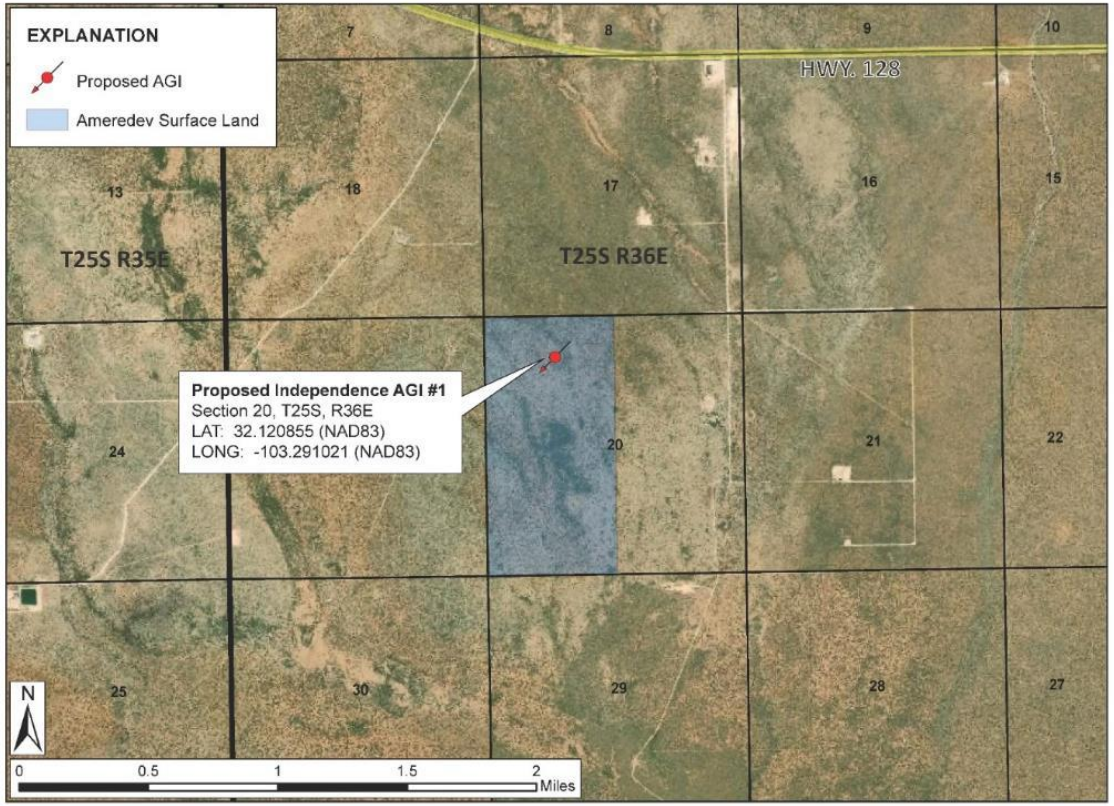
# AMEREDEV SITE DETAILS

- The overall site for the proposed processing facility encompasses approximately 320 acres and the AGI will be sited at the northern margin of Section 20
- All affected lands are owned by a wholly-owned subsidiary of Ameredev II, LLC
- Field gas will be "sweetened" by amine units and the TAG will then be compressed and piped to the AGI well
- The proposed well and all surface equipment will be contained within the plant area




Detailed location map showing the proposed Independence AGI #1 and Ameredev surface lands where plant facility will be constructed

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# MAXIMUM ALLOWABLE OPERATING PRESSURE

- Ameredev requests a maximum allowable operating pressure (MAOP) of 4,779 psig for the proposed Independence AGI #1
- MAOP calculated utilizing NMOCD-approved method for identifying maximum surface injection pressure
- Anticipated acid gas characteristics determined utilizing AQUAlibrium™ software

MAXIMUM ALLOWABLE OPERATING PRESSURE (MAOP) DETERMINATION

$$IP_{Max} = PG(D_{Top})$$

WHERE:

| | | |
|---|---|---|
| $IP_{Max}$ | = | Maximum Surface Injection Pressure (psi) |
| PG | = | Pressure Gradient of Injection Fluid (psi/ft) |
| $D_{Top}$ | = | Depth at top of injection zone |

AND

$$PG = 0.2 + 0.433\ (1.04 - SG_{TAG})$$

WHERE:

| | | |
|---|---|---|
| $SG_{TAG}$ | = | Average specific gravity of treated acid gas in the tubing ($SG_{TAG}$ at top = 0.76, and $SG_{TAG}$ at bottom = 0.88; see Table 3) |

For the maximum requested injection volume case, it is assumed that:

$$SG_{TAG} = 0.82\ (Average\ of\ 0.76\ and\ 0.88)$$

AND

$$D_{Top} = 16{,}230\ feet$$

THEREFORE

$$PG = 0.2 + 0.433(1.04 - 0.82)$$

$$PG = 0.294\frac{psi}{ft}$$

AND

$$IP_{Max} = 0.294\frac{psi}{ft} x\ 16{,}230\ feet$$

$$\boldsymbol{IP_{Max} = 4{,}779\ psi}$$

Determination of MAOP utilizing NMOCD-approved method

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# AGI SYSTEM DESIGN

- Anticipated composition of TAG will be approximately 70% $CO_2$ and 30% $H_2S$ with trace concentrations of nitrogen and light ($C_1$-$C_7$) hydrocarbons
- TAG will be transmitted from the amine system to compressors on the well site via low-pressure pipelines (see diagram on next slide)
- Acid gas will be compressed to approximately 2,000 to 2,500 psi and transmitted to the AGI well through corrosion-resistant tubulars protected by automatic safety valve
- Injection tree will be constructed utilizing corrosion-resistant alloys and elastomers
- A subsurface safety valve (SSSV) will be set at approximately 250' below the surface
- The permanent injection packer and the lower 300 feet of tubing and production casing will be constructed utilizing corrosion-resistant alloy materials
- Bottom-hole pressure and temperatures transducers will be installed on a mandrel overlying the packer to provide real-time monitoring of the injection zone

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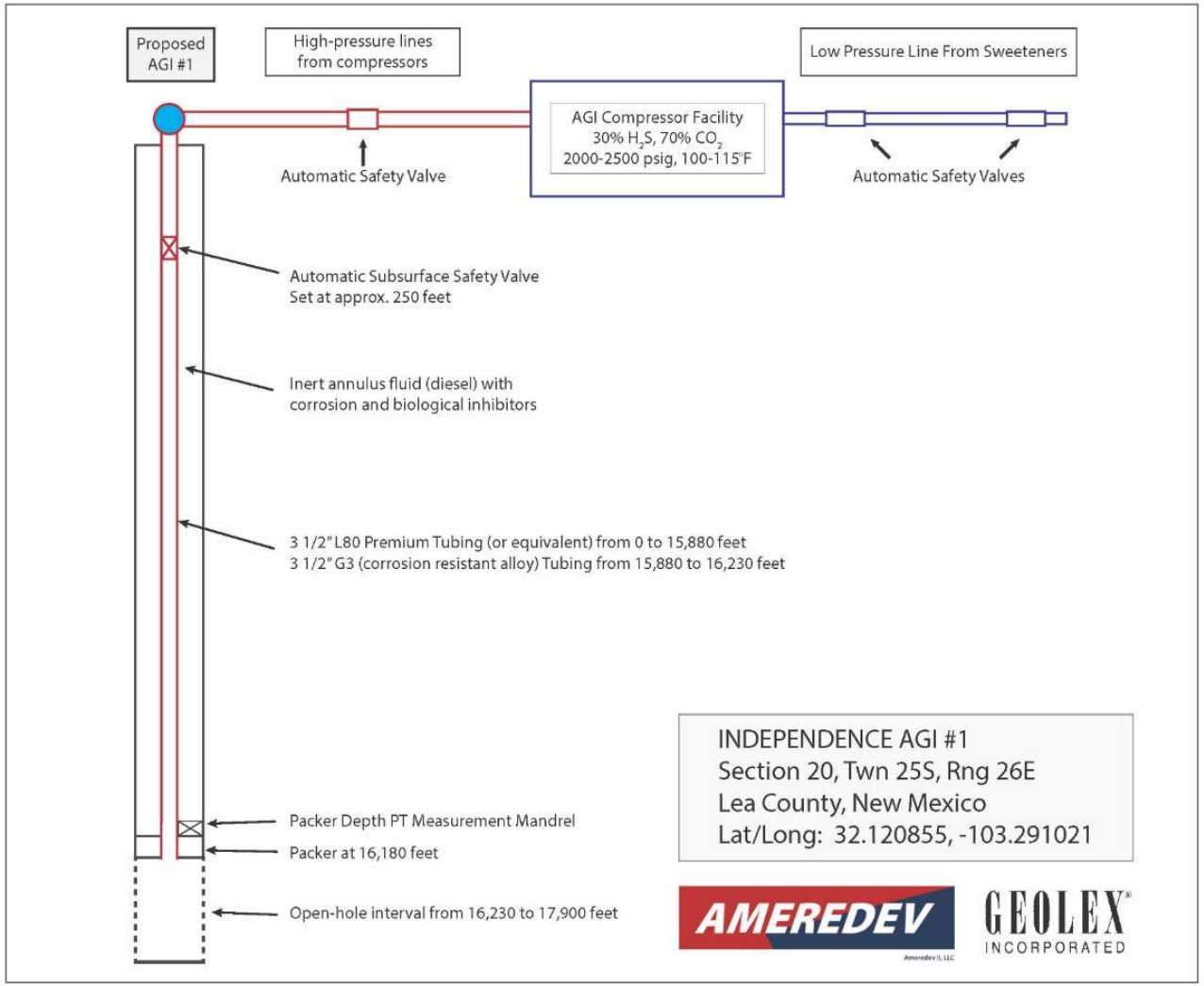


General schematic of surface facilities and proposed Independence AGI #1

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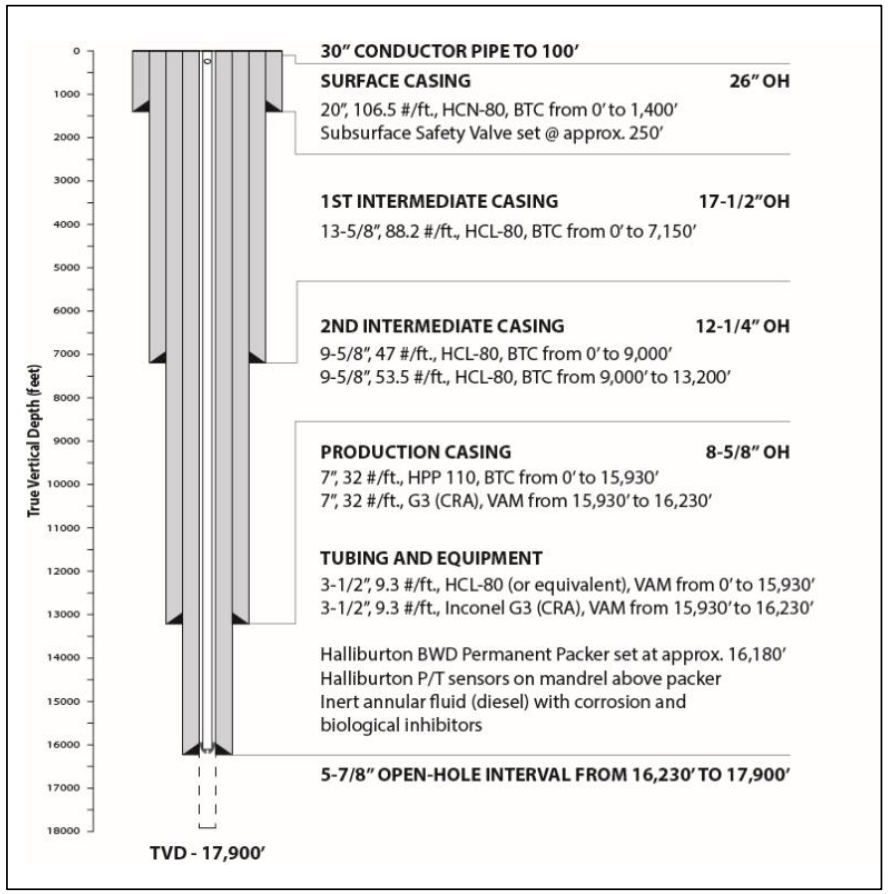
# DESIGN OF INDEPENDENCE AGI #1

- Surface casing to 1,400’ to protect fresh groundwater and shallow formations
- First intermediate to 7,150’ to protect Salado salt, Capitan, and Delaware Mountain Group formations
- Second intermediate to 13,200’ protecting B. Spring, Wolfcamp, Strawn, and Atoka producing zones
- Production casing to 15,930’ utilizing conventional HCL-80 casing and 300’ feet of corrosion-resistant alloy (CRA) casing from 15,930’ to 16,230’ to protect lower-well components
- Open-hole completion from 16,230’ to 17,900’
- All strings will be cemented to surface and verified by 360° cement bond logs




Proposed Independence AGI #1 well schematic including anticipated casing program

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# WELL LOGGING, RESERVOIR TESTING AND MONITORING

- Mud logging will be conducted during all depths below the conductor
- The borehole from 1,400' to total depth will be logged using gamma ray, formation density, resistivity, neutron density, and sonic tools
- The injection zone (16,230' to 17,900') and overlying caprock will also be logged using Fullbore Formation MicroImager (FMI), or equivalent
- Side-wall cores from selected intervals will be collected for laboratory porosity and permeability tests should the condition of the borehole be suitable for these operations
- Following an acid displacement in the injection zone, a work string and bottom-hole sensors will be installed to the base of the injection zone and a step-rate and warm-back test will be conducted
- Following the step-rate test, a 10-day fall-off test will be completed
- The permanent pressure/temperature sensors located at the permanent injection packer will be used for long-term monitoring of reservoir behavior during normal injection operations

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# ADJACENT OPERATORS AND SURFACE OWNER NOTIFICATION AND NOTICES

- Ameredev's complete C-108 application was sent to adjacent operators and surface owners within the one-mile radius of the proposed well via Certified Mail, return receipt requested
- Notice of the application and the Commission hearing were published in the local newspaper by NMOCC
- There are no outstanding objections to Ameredev's application
- Adjacent operators support the AGI project, which will:
  - Allow increased production capacity of sour gas resources
  - Increase royalties paid to the State of New Mexico
  - Protect freshwater resources and correlative rights
  - Avoid concerns about acid gas disposal in the Delaware Mountain Group

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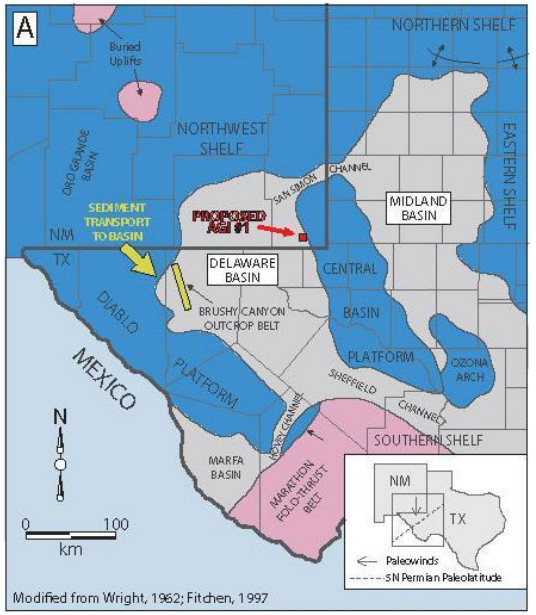
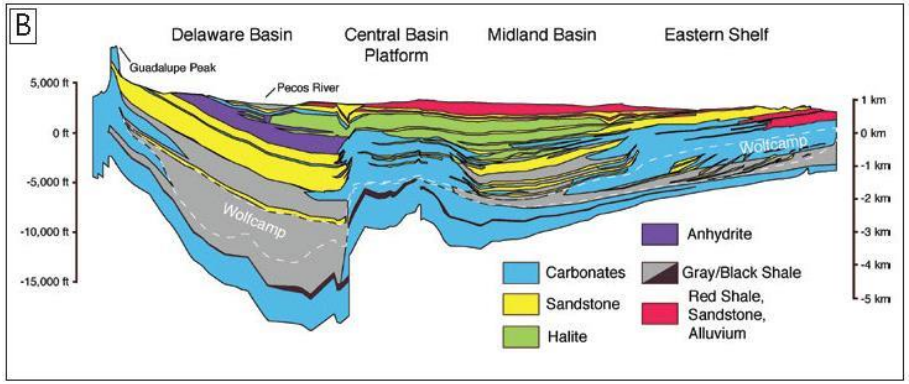
Exhibit 3
Ameredev Operating, LLC
Case No. 21381, Sept. 17, 2020

# GEOLOGY OF THE PROJECT AREA

- Proposed AGI located on the eastern margin of the Delaware Basin
- Surface deposits include aeolian and alluvial deposits, with local exposures of Triassic redbeds
- Approximately 9,000 feet of Permian strata overly approx. 8,000 feet of older Paleozoic strata (Penn. – Devonian)
- Devonian Woodford Shale (~300' thick) forms the local caprock that seals the injection reservoir
- Targeted injection reservoir includes upper Devonian, Wristen, Fusselman, and Montoya formation strata
- Local structure includes normal faults, typically oriented parallel to sub-parallel to the northerly trend of the Central Basin Platform




Structural setting (panel A) and general lithologies of the Permian Basin (panel B). Proposed AGI location annotated in Panel A

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# Generalized stratigraphic correlation chart for the Permian Basin region

| SYSTEM | SERIES/ STAGE | NORTHWEST SHELF | CENTRAL BASIN PLATFORM | MIDLAND BASIN & EASTERN SHELF | DELAWARE BASIN | VAL VERDE BASIN |
|---|---|---|---|---|---|---|
| PERMIAN | OCHOAN | DEWEY LAKE<br>RUSTLER<br>SALADO | DEWEY LAKE<br>RUSTLER<br>SALADO | DEWEY LAKE<br>RUSTLER<br>SALADO | DEWEY LAKE<br>RUSTLER<br>SALADO<br>CASTILE | RUSTLER<br>SALADO |
| | GUADALUPIAN | TANSILL<br>YATES<br>SEVEN RIVERS<br>QUEEN<br>GRAYBURG<br>SAN ANDRES<br>GLORIETA<br>CLEARFORK<br>YESO<br>WICHITA<br>ABO | TANSILL<br>YATES<br>SEVEN RIVERS<br>QUEEN<br>GRAYBURG<br>SAN ANDRES<br>GLORIETA<br>CLEARFORK<br>WICHITA | TANSILL<br>YATES<br>SEVEN RIVERS<br>QUEEN<br>GRAYBURG<br>SAN ANDRES<br>SAN ANGELO<br>LEONARD<br>SPRABERRY, DEAN | ★ DELAWARE MT. GROUP<br>BELL CANYON<br>CHERRY CANYON<br>BRUSHY CANYON | TANSILL<br>YATES<br>SEVEN RIVERS<br>QUEEN<br>GRAYBURG<br>SAN ANDRES |
| | LEONARDIAN | | | | ★ BONE SPRING | LEONARD |
| | WOLFCAMPIAN | WOLFCAMP | WOLFCAMP | WOLFCAMP | ★ WOLFCAMP | WOLFCAMP |
| PENNSYLVANIAN | VIRGILIAN | CISCO | CISCO | CISCO | CISCO | CISCO |
| | MISSOURIAN | CANYON | CANYON | CANYON | CANYON | CANYON |
| | DESMOINESIAN | STRAWN | STRAWN | STRAWN | ★ STRAWN | STRAWN |
| | ATOKAN | ATOKA | ATOKA | ATOKA | ATOKA | (ABSENT) |
| | MORROWAN | MORROW — BEND | (ABSENT) — BEND | (ABSENT ?) — BEND | MORROW — BEND | (ABSENT) |
| MISSISSIPPIAN | CHESTERIAN<br>MERAMECIAN<br>OSAGEAN<br>KINDERHOOKIAN | CHESTER<br>MERAMEC<br>OSAGE<br>KINDERHOOK | CHESTER<br>MERAMEC<br>OSAGE<br>"BARNETT"<br>KINDERHOOK | CHESTER<br>MERAMEC<br>OSAGE<br>"BARNETT"<br>KINDERHOOK | CHESTER<br>MERAMEC<br>OSAGE<br>"BARNETT"<br>KINDERHOOK | MERAMEC<br>OSAGE<br>"BARNETT"<br>KINDERHOOK |
| DEVONIAN | | WOODFORD<br>DEVONIAN | WOODFORD<br>DEVONIAN | WOODFORD<br>DEVONIAN | WOODFORD<br>DEVONIAN | WOODFORD<br>DEVONIAN |
| SILURIAN | | SILURIAN<br>(UNDIFFERENTIATED) | SILURIAN SHALE<br>FUSSELMAN | SILURIAN SHALE<br>FUSSELMAN | MIDDLE SILURIAN<br>FUSSELMAN | MIDDLE SILURIAN<br>FUSSELMAN |
| ORDOVICIAN | UPPER | MONTOYA | MONTOYA | SYLVAN<br>MONTOYA | SYLVAN<br>MONTOYA | SYLVAN<br>MONTOYA |
| | MIDDLE | SIMPSON | SIMPSON | SIMPSON | SIMPSON | SIMPSON |
| | LOWER | ELLENBURGER | ELLENBURGER | ELLENBURGER | ELLENBURGER | ELLENBURGER |
| CAMBRIAN | UPPER | CAMBRIAN | CAMBRIAN | CAMBRIAN | CAMBRIAN | CAMBRIAN |
| PRECAMBRIAN | | | | | | |

General stratigraphy and producing zones (red stars) in the immediate area of the proposed Independence AGI #1 (modified from Yang and Dorobek, 1995)

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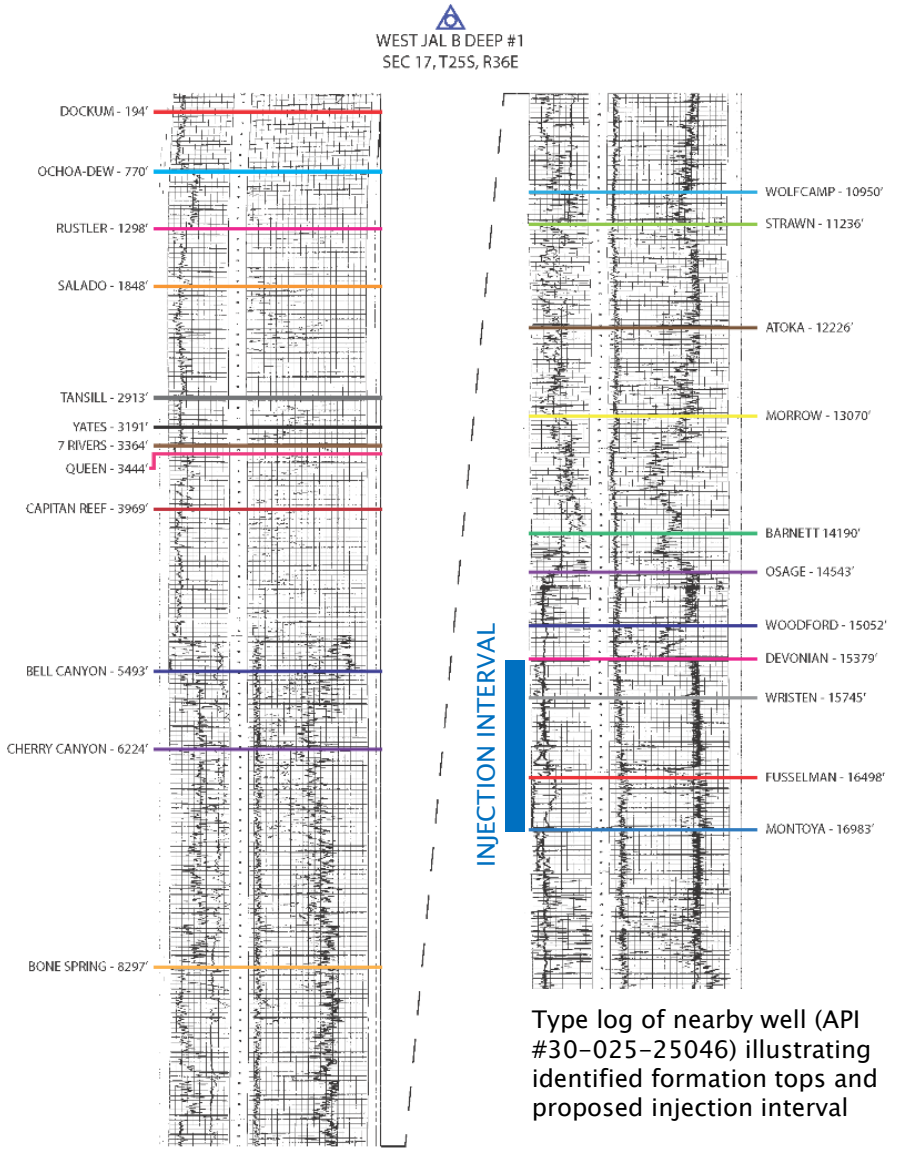
# ANTICIPATED FORMATIONS

Stratigraphy of the subsurface underlying the proposed AGI #1 location is demonstrated in nearby offset well logs of West Jal B Deep #1 (right). Proposed injection interval is annotated in the associated log (blue bar)

| FORMATION | DEPTH (FEET) | FORMATION | DEPTH (FEET) |
|---|---|---|---|
| Dockum | 246 | Bone Springs | 8,286 |
| Ochoa-Dewey | 867 | Wolfcamp | 10,979 |
| Rustler | 1,271 | Strawn | 11,340 |
| Salado | 1,825 | Atoka | 12,590 |
| Tansill | 3,124 | Morrow | 13,759 |
| Yates | 3,274 | Barnett | 14,941 |
| 7 Rivers | 3,454 | Osage | 15,388 |
| Queen | 3,541 | Woodford | 15,914 |
| Capitan Reef | 3,977 | Devonian | 16,230 |
| Bell Canyon | 5,469 | Wristen | 16,575 |
| Cherry Canyon | 6,246 | Fusselman | 17,320 |
| Brushy Canyon | 7,098 | Montoya | 17,820 |

Anticipated formation tops at the proposed Independence AGI #1 surface location




Type log of nearby well (API #30-025-25046) illustrating identified formation tops and proposed injection interval

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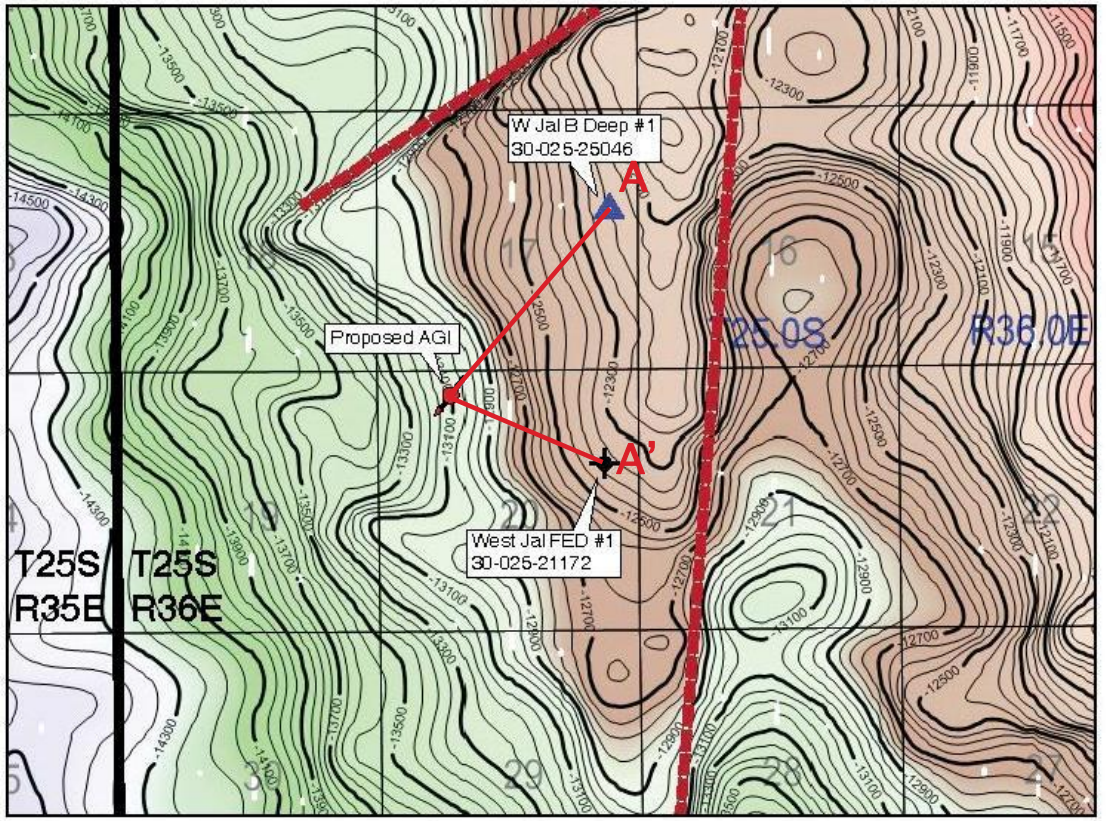
# STRUCTURAL GEOLOGY OF THE AREA

- Subsea elevations of the top of the Devonian (target reservoir) are shown in the following map (right)
- The proposed AGI location lies down-dip of a local structural high to the northeast approximately 1 mile from two faults identified in the area
- Faults identified in review of 3D seismic survey data covering the area of the proposed AGI
- Cross section A-A' is included on the following slide



Interpreted seismic map of subsea elevations of the top of the Devonian (targeted injection reservoir)

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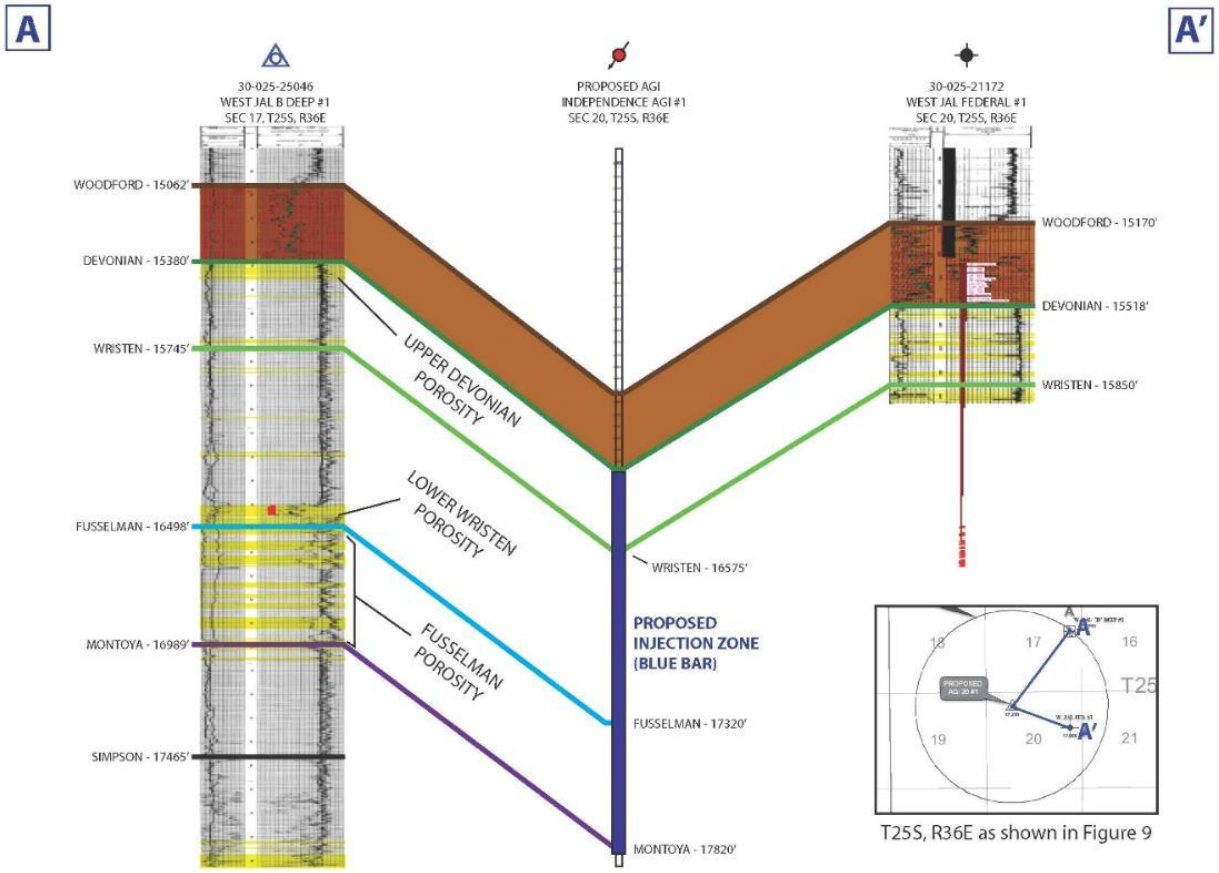
# STRUCTURAL GEOLOGY OF THE AREA

- Structural cross section A–A' illustrates porosity profile observed in nearby offset wells penetrating the proposed injection zone
- Proposed injection interval in the area of Independence AGI #1 is overlain by more than 300 feet of dense Woodford Shale and more than 950 feet of low-porosity, low-permeability Mississippian carbonates
- Targeted injection interval (blue bar) includes porous intervals identified within upper Devonian, Wristen, and Fusselman formation strata




Cross section showing cap rock (Woodford Shale) and porous zones (yellow) identified within the targeted injection interval

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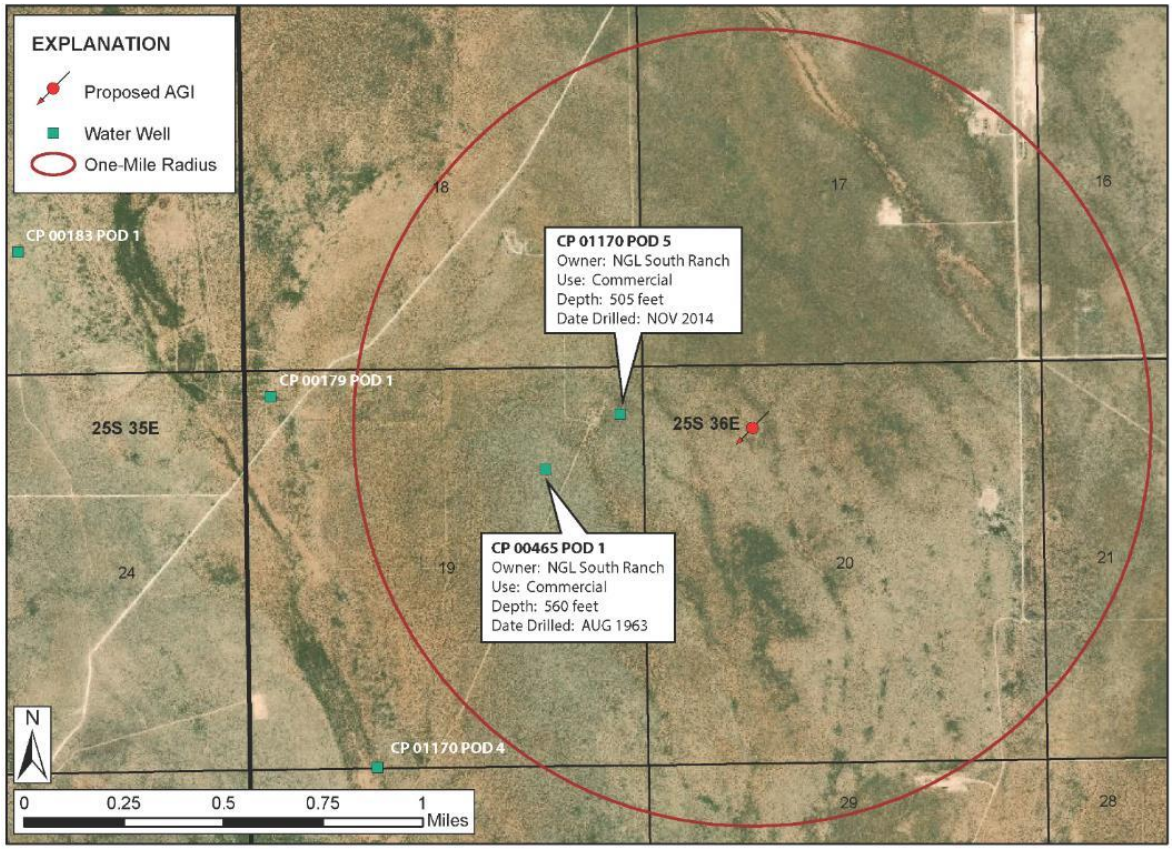
# GROUNDWATER CONDITIONS IN THE AREA OF REVIEW

- Based on the New Mexico Water Rights Database (NMOSE), there are two water wells within one mile of the proposed AGI well
- The nearest well lies 0.33 miles from the proposed AGI location
- Total depth of observed wells range from 505 to 560 feet and both are operated by NGL South Ranch
- These water-bearing zones will be protected by the surface casing of Independence AGI #1, which will extend approx. 1,400 feet within Rustler Formation strata




Water wells within one mile of the proposed Independence AGI #1 as recorded in the New Mexico Office of the State Engineer's records

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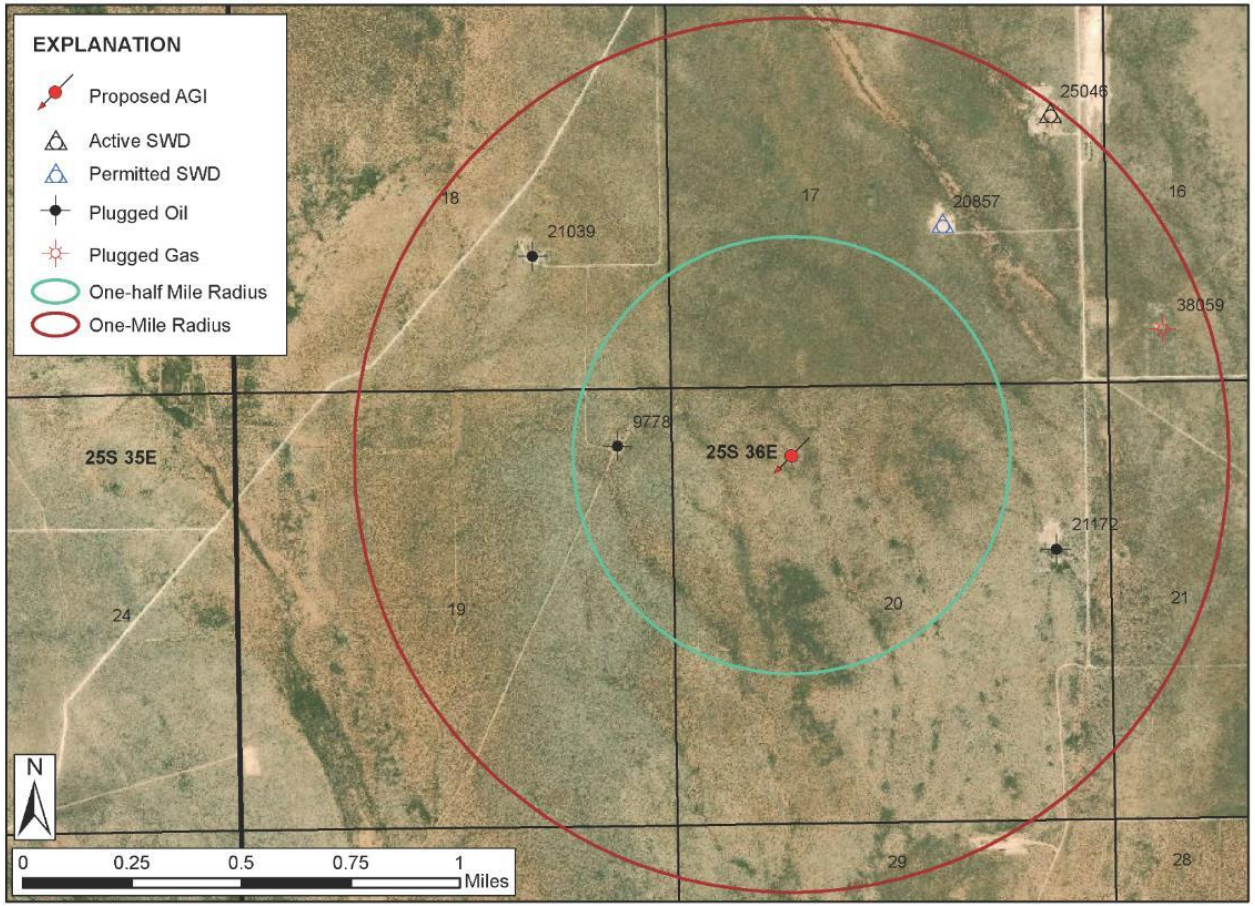
# WELLS WITHIN ONE MILE OF THE AGI

- There are six (6) existing wells within one mile of the proposed AGI, including one (1) active, one (1) permitted, and four (4) plugged wells
- Of these wells, two penetrate the proposed injection interval
- The West Jal Unit #1 (API #30-025-21172) is 0.64 miles from the proposed AGI well and was properly plugged an abandoned in 1984
- The West Jal B Deep Unit #1 (API #30-025-25046) lies 0.98 miles from the proposed AGI and is an active SWD. The operator, BC&D Operating, Inc. has been notified of the AGI project and has communicated they have no objection to the proposed well




Identified wells within one mile of the proposed Independence AGI #1. Wells shown are annotated with the last 5 digits of the API number 30-025-XXXXX.

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Exhibit 3
Ameredev Operating, LLC
Case No. 21381, Sept. 17, 2020

# REVIEW OF IDEAL CHARACTERISTICS OF A RESERVOIR FOR PERMANENT DISPOSAL OF ACID GAS ($CO_2/H_2S$)

1. Geologic seal to permanently contain injected fluid
2. Isolated from any fresh groundwater
3. No effect on existing or potential production
4. Laterally extensive, permeable, good porosity
5. Excess capacity for anticipated injection volumes
6. Compatible fluid chemistry

✓**AMEREDEV'S PROPOSED AGI #1 MEETS ALL OF THESE CRITERIA**

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# EVALUATING FAULT SLIP POTENTIAL

- To evaluate the potential for induced-seismic events in response to injected fluids, Geolex conducted an induced-seismicity risk assessment in the area of the proposed Independence AGI #1

- Components of Risk Assessment:

  1. Review and interpretation of licensed 3D seismic survey data to identify subsurface features in the area of the proposed AGI well (courtesy of Ameredev)

  2. Fault-slip probability modeling of a eight-well, 30-year injection scenario that simulates operation of the proposed AGI and nearby SWD operations and predicts the associated risk of induced-seismic events (Assessment completed utilizing Stanford FSP model)

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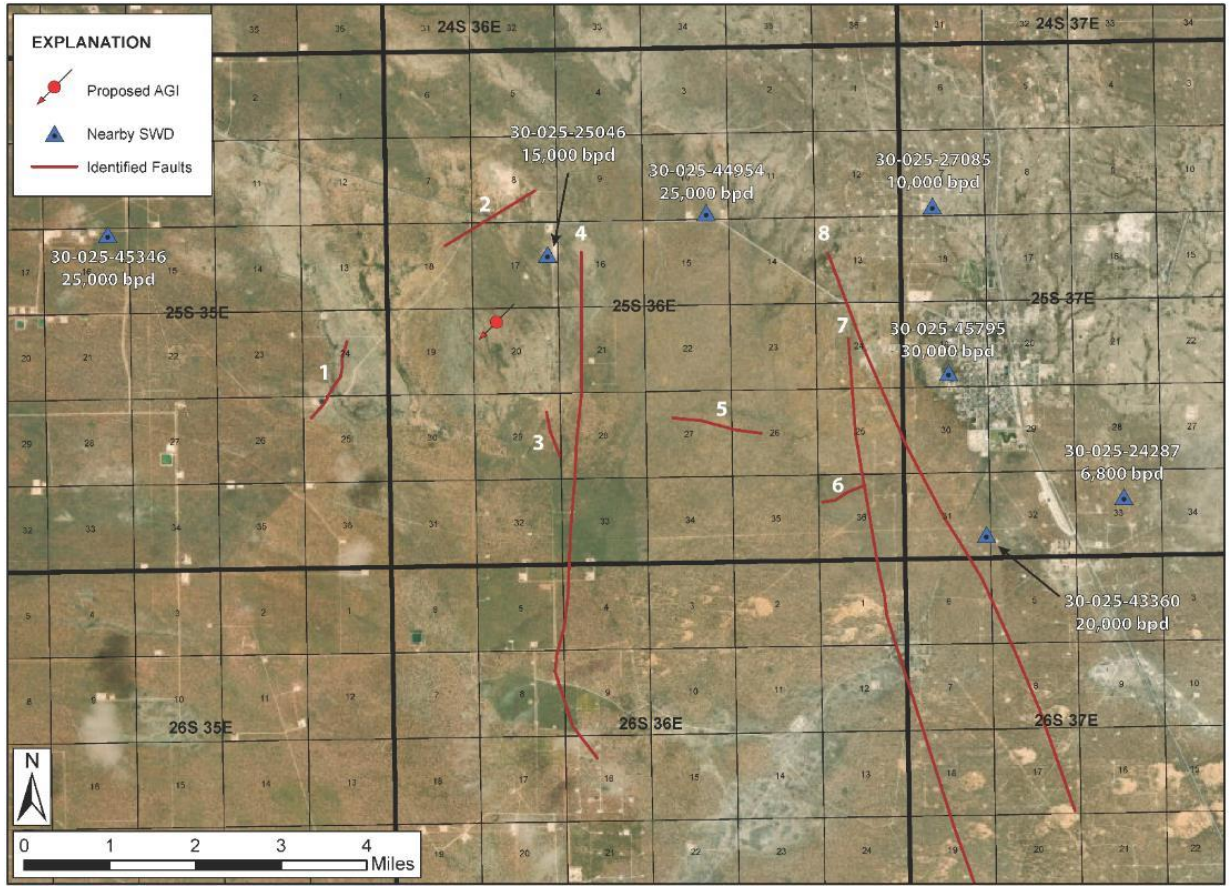
# SEISMIC SURVEY REVIEW AND NEARBY INJECTION WELLS

- Geolex evaluated and interpreted 3D seismic survey data to identify subsurface faults to be included in the FSP model evaluation
- Eight (8) faults typically trending NW-SE parallel to the trend of the Central Basin Platform with smaller features exhibiting general varying trends
- All identified faults were included in the FSP injection simulations, however, due to the relatively isolated location of the proposed AGI well, faults in the area are not anticipated to be significantly affected by the simulated injection scenario
- The nearest fault to the AGI location is observed to lie approximately one mile east of the proposed well location




Identified faults in the area of the proposed Independence AGI #1 well and nearby SWD wells included in slip-probability modeling simulations

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# MODEL INPUT PARAMETERS

- The FSP model first utilizes input parameters describing local stress conditions, fault geometry, and orientation to determine the required pressure increase to induce motion along each simulated feature

- Faults in the vicinity of the proposed Independence AGI #1 were observed to be steeply dipping (near vertical) with larger features trending approximately N-S and NW-SE

| Modeled Parameter | Input Value | Variability (+/-) | UOM | Source |
|---|---|---|---|---|
| *Stress* | | | | |
| Vertical Stress Gradient | 1.05 | 0.105 | psi/ft | Nearby well estimate |
| Max Horizontal Stress Direction | N75E | 5 | Deg | Lund Snee & Zoback, 2018 |
| Reference Depth | 17000 | | ft | Nearby well evaluation |
| Initial Res. Pressure Gradient | 0.43 | 0.043 | psi/ft | Lund Snee & Zoback, 2018<br>Nearby well evaluation |
| $A_\phi$ Parameter | 0.6 | 0.06 | - | Lund Snee & Zoback, 2018 |
| Reference Friction Coefficient ($\mu$) | 0.6 | 0.06 | - | Standard value |
| *Hydrologic* | | | | |
| Aquifer Thickness | 1500 | 0 | ft | Nearby well evaluation |
| Porosity | 3.5 | 0.35 | % | Nearby well evaluation |
| Permeability | 25 | 2 | mD | Nearby well evaluation |
| *Material Properties* | | | | |
| Density (Water) | 1040 | 40 | $Kg/m^3$ | Standard value |
| Dynamic Viscosity (Water | 0.0008 | 0.0001 | Pa.s | Standard value |
| Fluid Compressibility (Water) | $3.6 \times 10^{-10}$ | 0 | $Pa^{-1}$ | Standard value |
| Rock Compressibility | $1.08 \times 10^{-9}$ | 0 | $Pa^{-1}$ | Standard value |
| *Acid Gas Properties @ 8,800 psi & 210 ºF* | | | | |
| Density | 879.67 | - | $kg/m^3$ | AQUAlibrium™ |
| Dynamic Viscosity | $9.542 \times 10^{-5}$ | - | Pa.s | AQUAlibrium™ |

Input parameters and source material for FSP model simulations

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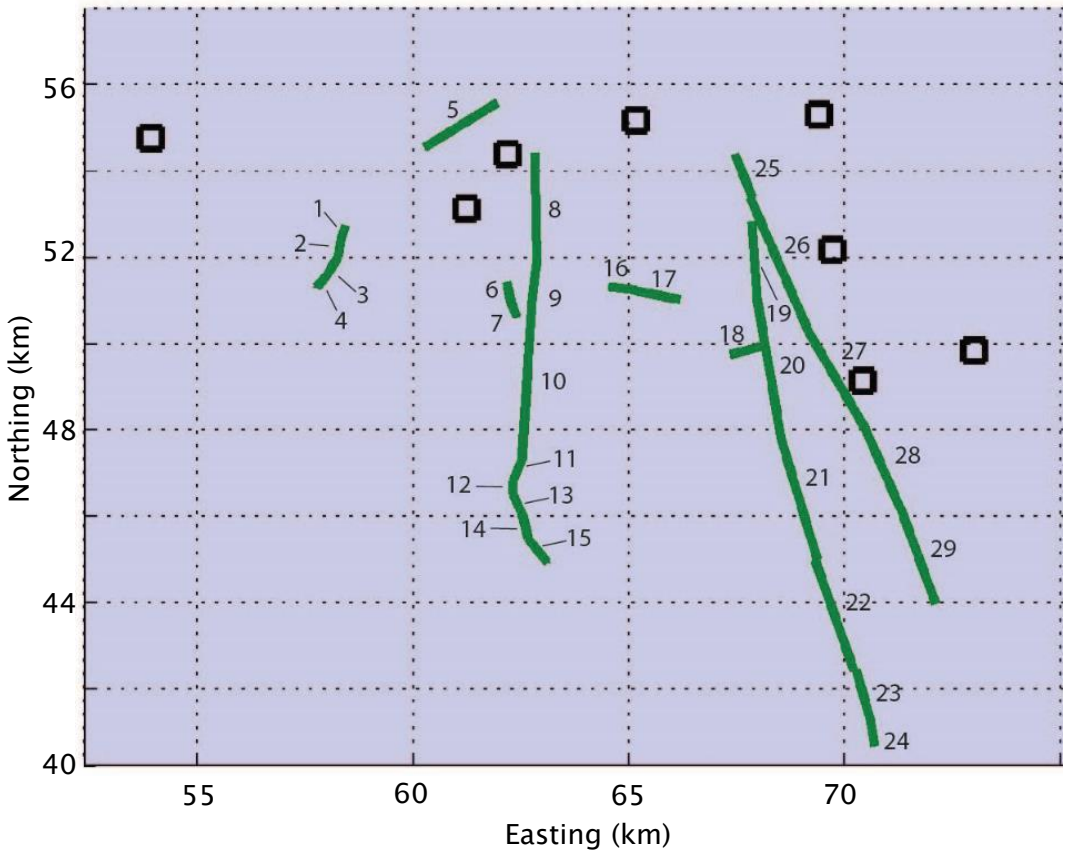
# DEFINING FAULTS FOR FSP SIMULATION

- To more accurately characterize their non-linear expression, the eight (8) identified faults were subdivided into 29 fault segments in slip modeling simulations




Subdivision of eight identified faults into 29 fault segments for simulation

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# REQUIRED CONDITIONS TO INDUCE SLIP

- To more accurately characterize their non-linear express, the 8 identified faults were subdivided into 29 fault segments in slip modeling simulations
- As shown in the Table, pore pressure increases required to induce slip, as predicted by the FSP model, range from approximately 1,080 to 6,930 psi
- Faults generally striking closer to orientation of maximum horizontal stress direction (N75E) are predicted to require less pore-pressure increase to induce slip than those features striking approx. N-NW

| Segment # | ΔPP Required to Slip (PSI) | Segment # | ΔPP Required to Slip (PSI) |
|---|---|---|---|
| 1 | 3137 | 16 | 1101 |
| 2 | 4357 | 17 | 1085 |
| 3 | 1786 | 18 | 1554 |
| 4 | 1201 | 19 | 6012 |
| 5 | 1197 | 20 | 6680 |
| 6 | 6869 | 21 | 6914 |
| 7 | 6298 | 22 | 6758 |
| 8 | 5645 | 23 | 6931 |
| 9 | 4610 | 24 | 6590 |
| 10 | 5005 | 25 | 6508 |
| 11 | 2709 | 26 | 6327 |
| 12 | 5302 | 27 | 5455 |
| 13 | 6339 | 28 | 6305 |
| 14 | 6899 | 29 | 6684 |
| 15 | 4197 | | |

Model-estimated pore-pressure increase required to induced slip along each fault segment included in FSP model simulations

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Exhibit 3
Ameredev Operating, LLC
Case No. 21381, Sept. 17, 2020

# INJECTION WELLS IN THE VICINITY OF THE PROPOSED AGI

- Geolex identified eight (8) Devonian injection wells within approx. eight miles that were included in FSP simulations (illustrated in slide 27) to predict the risk for injection-induced fault slip
- To provide a conservative estimate of risk, all included SWD and the proposed AGI were operated at their maximum anticipated daily injection rate, as recorded in their respective C-108 applications
- Daily injection volumes range from 5,250 to 30,000 barrels per day
- Model limitations require simulation of the AGI utilizing injectate characteristics of produced water, which provides additional assurance that a conservative estimate of risk is produced

INJECTION WELLS INCLUDED IN FSP MODEL SIMULATIONS

| Well # | API | Well Name | Volume (bbls/day) | Start (year) | End (year) |
|---|---|---|---|---|---|
| 1 | - | Independence AGI #1 | 5250 | 2020 | 2050 |
| 2 | 3002524287 | Crosby Deep #2 | 6800 | 2010 | 2050 |
| 3 | 3002525046 | West Jal B Deep #1 | 15000 | 2015 | 2050 |
| 4 | 3002527085 | Jal N. Ranch SWD #1 | 10000* | 2017 | 2050 |
| 5 | 3002543360 | Kimberly SWD #1 | 20000 | 2019 | 2050 |
| 6 | 3002544954 | Chapman SWD #1 | 25000 | 2020 | 2050 |
| 7 | 3002545346 | Screech State SWD #1 | 25000* | 2020 | 2050 |
| 8 | 3002545795 | Sholes Deep SWD #1 | 30000 | 2020 | 2050 |

*NMOCD records include no information regarding the maximum anticipated injection volume. Volumes estimated for these wells are based on reported injection data or max. rate simulated proposed by other wells

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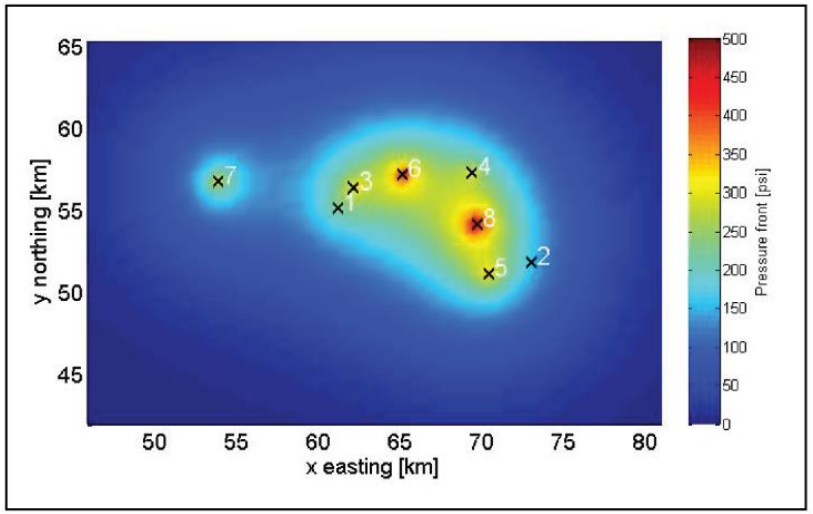
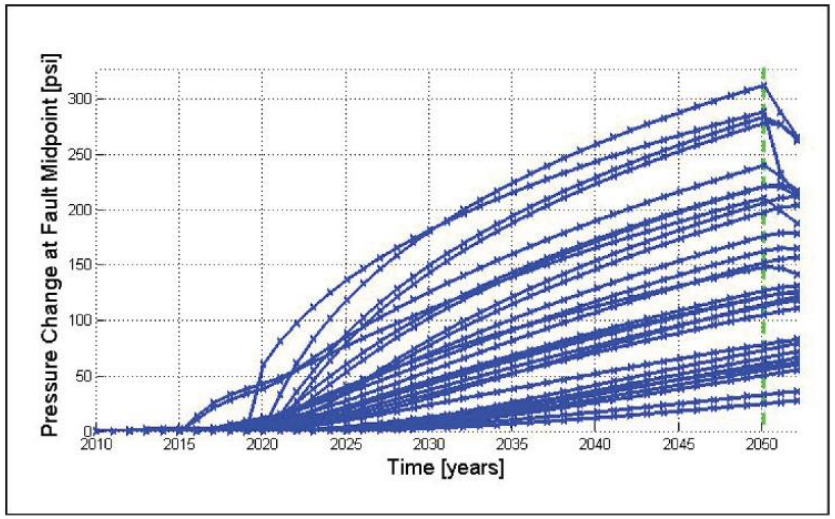
# INJECTION SIMULATION RESULTS

- Proposed Independence AGI #1 is located such that it is relatively isolated from the majority of pressure effects of nearby high-volume SWD wells
- After 40 years of simulated injection, model-estimated pressure increase experienced at fault midpoints ranges from approximately 25-315 psig
- These predicted pressure changes fall significantly short of the model-determined pressure required to induce slip along the most susceptible fault segment (Segment #17 – 1,085 psi)




Resultant pressure conditions after 30 years of AGI operations




Pressure change experienced at each fault segment throughout the simulated injection scenario

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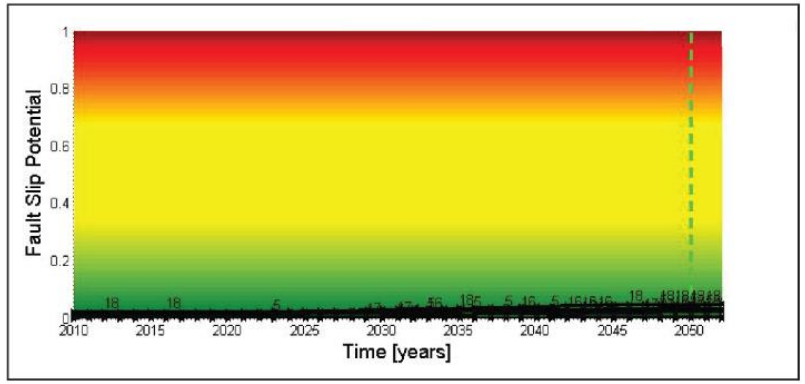
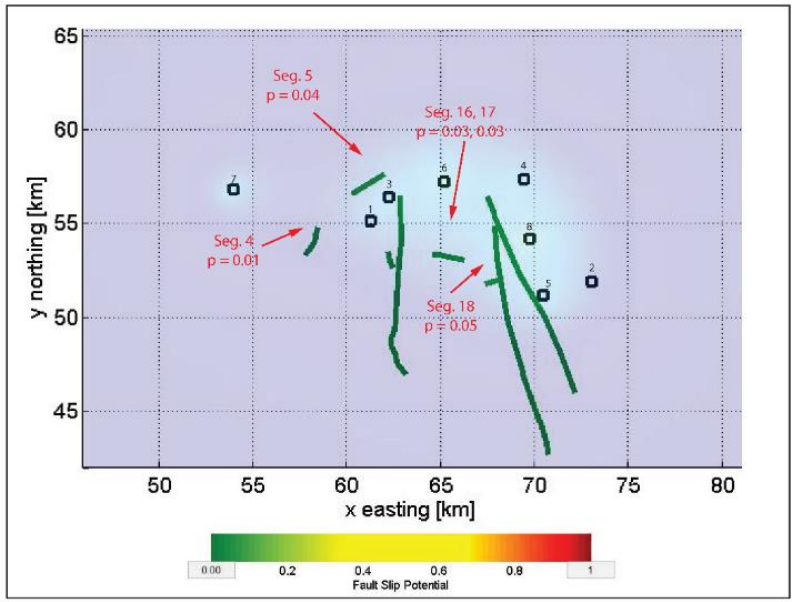
# FSP SIMULATION RESULTS

- In response to the simulation injection scenario (slide 30), the FSP model predicts non-zero slip probability estimates for five (5) fault segments
- Slip probability estimates for these fault segments range from 0.01 to 0.05
- The majority of fault segments (24) included are predicted by the FSP model to have **no potential** for injection-induced slip (p = 0.00)




Fault Slip Potential through the simulated injection period (2010-2050)




FSP fault map annotated with non-zero model predictions of slip potential

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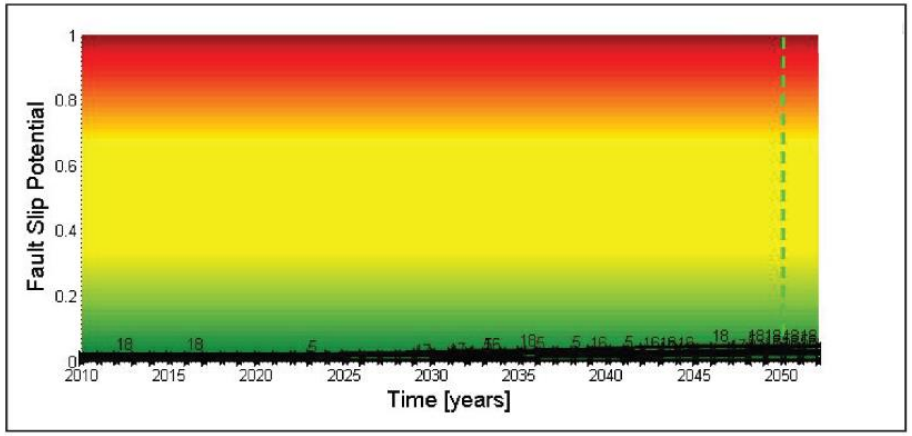
# FSP SIMULATION RESULTS

- Generally, faults identified in the area of the proposed Independence AGI #1 are not predicted to be at significant risk for injection-induced slip in response to the simulated injection conditions
- Fault-slip probability estimates range from 0.01 to 0.05 after 40 years of injection operations, with the majority of fault segments predicted to have zero probability for slip
- Subsequent simulation conducted that excludes the injection volume contributions of Independence AGI #1 demonstrate the minimal impact the proposed well will exert on the reservoir




Fault Slip Potential through the simulated injection period (2010-2050)

| Segment # | Predicted ΔPP (PSI) | Predicted ΔPP NO AGI (PSI) | ΔPP Required to Slip (PSI) | Probability of Slip | Probability (No AGI) |
|---|---|---|---|---|---|
| 4 | 105 | 92 | 1201 | 0.01 | 0.01 |
| 5 | 210 | 188 | 1197 | 0.04 | 0.03 |
| 16 | 197 | 186 | 1101 | 0.03 | 0.02 |
| 17 | 206 | 197 | 1085 | 0.03 | 0.02 |
| 18 | 220 | 216 | 1554 | 0.05 | 0.04 |

Tabulated summary of FSP model results for fault segments predicted by the to have non-zero estimates of fault-slip probability

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# POTENTIAL FOR VERTICAL MIGRATION

Greater than 300 feet of dense Woodford Shale is anticipated to serve as excellent caprock for the Devonian reservoir, however, additional characterization of local pressure conditions was conducted to assure acid gas has no potential to migrate vertically out of zone, including:

- Review of relevant studies characterizing regional pressure conditions in the Delaware Basin
- Compilation of drilling fluid records representing nearby wells to characterize local pressure conditions in the area of the proposed AGI
- Preparation of a preliminary drilling-fluids program to obtain specific drilling-fluid recommendations for drilling a Siluro-Devonian well in the location of the proposed Independence AGI #1

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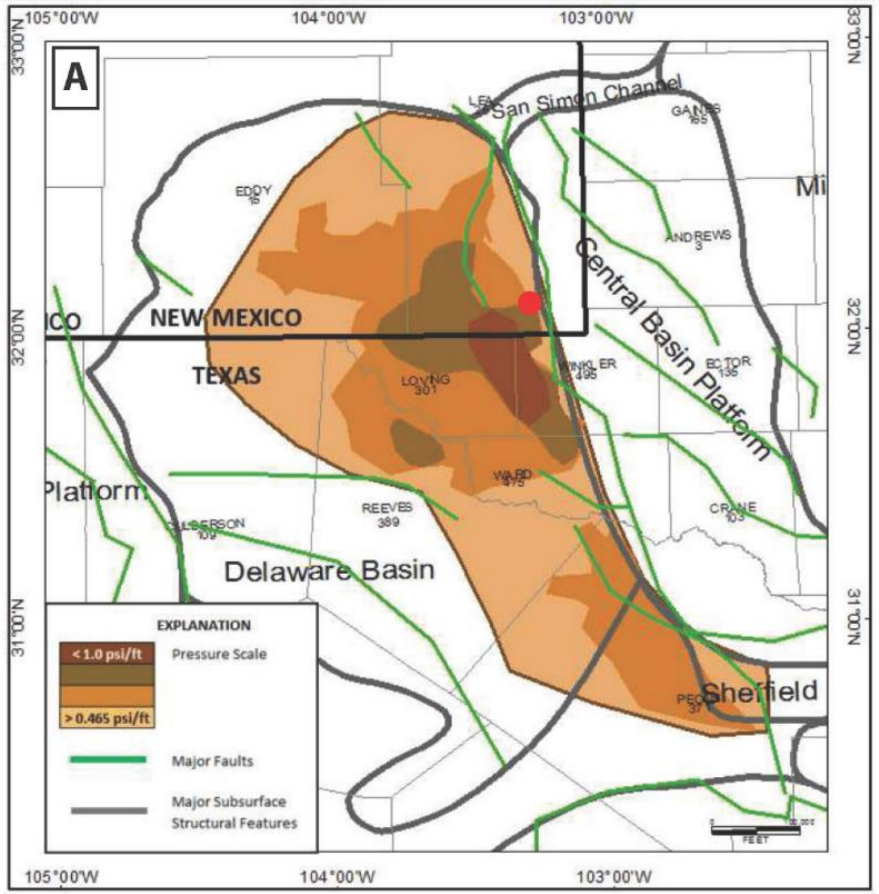
# OVERPRESSURE CONDITIONS IN THE DELAWARE BASIN

- Regional pore-pressure model of Delaware Basin generated by Rittenhouse et al. (2016), informed by:
  - >23,700 mud weight recordings
  - >4,000 DST and fracture injection tests
- Pore-pressure gradient increase observed from lower B. Springs to base of Woodford Shale
- Higher density mud weights required from Lower Wolfcamp to base of Woodford Shale
- Return to normal pressure conditions below Woodford Shale (proposed Independence AGI #1 injection zone)
- Results of this pore-pressure model indicate Devonian injection zone will be <u>under-pressured</u> relative to overlying producing zones




Mapped extent of present-day over-pressure conditions in the Delaware Basin (Rittenhouse et al., 2016). Proposed AGI location denoted by red circle.

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Ameredev Operating, LLC
Case No. 21381, Sept. 17, 2020

# OVERPRESSURE CONDITIONS IN THE DELAWARE BASIN

- Regional pore-pressure model of Delaware Basin generated by Rittenhouse et al. (2016), informed by:
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- Pore-pressure gradient increase observed from lower B. Springs to base of Woodford Shale
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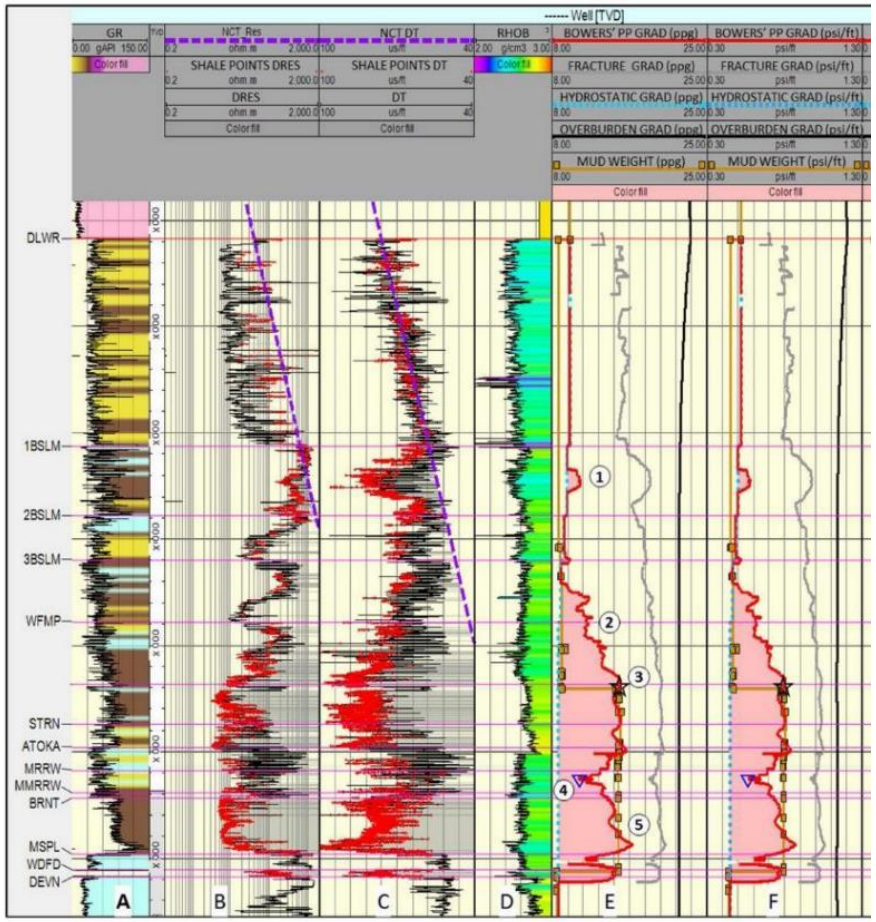
- Results of this pore-pressure model indicate Devonian injection zone will be <u>under-pressured</u> relative to overlying producing zones




Example log response illustrating stratigraphic onset of over-pressure conditions and associated drilling-fluid densities in strata overlying the proposed Devonian injection zone

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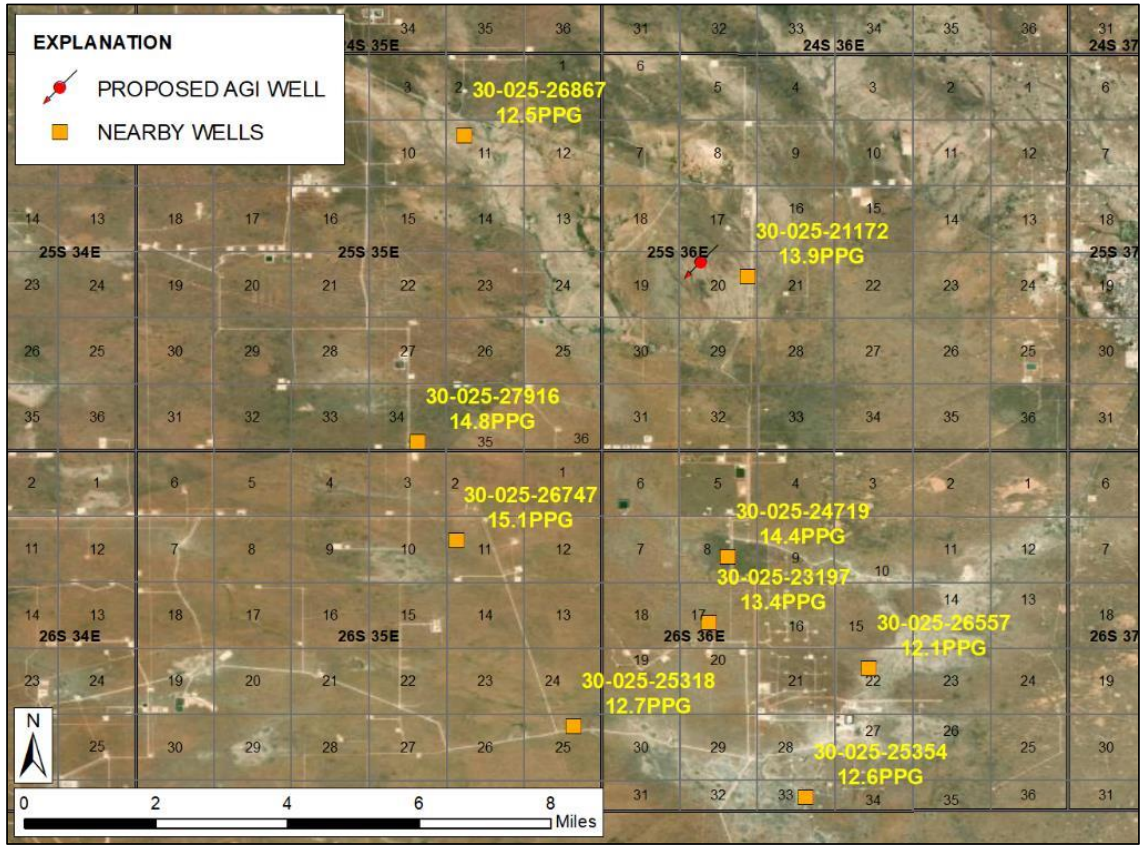
# LOCAL DRILLING FLUID RECORDS

- To verify pressure conditions indicated by regional pore-pressure model (Rittenhouse et al., 2016), available drilling fluid records in the area of the proposed AGI well were compiled
- Well data (shown right) illustrates significantly high fluid densities utilized while drilling Atoka/Strawn through Mississippian intervals:
  - Mud Density Range – 12.1 to 15.1 PPG
  - Average Fluid Density – 13.5 PPG
- Devonian drilling fluids in the area (when available) average 9.0 PPG
- Local drilling fluid records support expectation that targeted Devonian reservoir is under-pressured relative to overlying producing zones




Annotated map illustrating drilling fluid densities utilized in zones overlying the target Siluro-Devonian reservoir in the area of the proposed AGI well

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# INDEPENDENCE AGI #1 – FLUID PROGRAM

***12,300' – 16,000'***

| Fluid Type | Brine water / Xanthan Gum / Barite / Pac LV |
|---|---|
| Potential Hazards | Seepage / lost circulation / abnormal pressure / well bore cleaning |

12,300' – 16,000'.
***Drill an 8 5/8" well bore and set 7" liner from 12,100' to 16,000'.***

**Drilling Fluid Recommendations**

| Interval Depth (feet) (MD TVD) | Fluid Density (Ppg.) | Viscosity (sec/quart) | Plastic Viscosity (cps) | Yield Point (lbs/100 ft.²) | pH | Filtrate - API (Cm3/30 min.) | Drill Solids (% volume) | Chloride (mg/l) |
|---|---|---|---|---|---|---|---|---|
| 12,300' – 13,000' | 10.0 – 11.0 | 36 – 40 | 10 – 15 | 8 – 10 | 10.5 | 10 – 12 | < 5 | 165k – 185k |
| 13,000' – 16,000' | 12.4 – 12.9 | 40 – 45 | 12 – 18 | 10 – 15 | 10.5 | 8 – 10 | < 5 | 165k – 185k |

***16,000' – 17,600'***

| Fluid Type | Cut brine / Xanthan Gum / Pac LV / ***Acid Soluble LCM*** |
|---|---|
| Potential Hazards | Severe lost circulation |

16,000' – 17,600'.
***Drill a 5 7/8" well bore for open hole completion***

**Drilling Fluid Recommendations**

| Interval Depth (feet) (MD TVD) | Fluid Density (Ppg.) | Viscosity (sec/quart) | Plastic Viscosity (cps) | Yield Point (lbs/100 ft.²) | pH | Filtrate - API (Cm3/30 min.) | Solids (% volume) | Chloride (mg/l) |
|---|---|---|---|---|---|---|---|---|
| 16,000' – 17,600' | 9.0 – 9.2 | 32 – 34 | 6 – 10 | 4 – 8 | 10.5 | 10 – 15 | < 5 | 40k – 90k (*) |

- Shown above is a preliminary mud program generated by Artesia Lumber Co./Buckeye, Inc. for the proposed Independence AGI #1
- Recommendation includes utilization of 12.4 to 12.9 PPG drilling fluids in zones overlying Devonian injection reservoir in anticipation of high-pressure conditions
- Fluid density recommendation reduced to 9.0 to 9.2 PPG in the Devonian injection reservoir and program notes potential for "severe lost circulation"

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# VERTICAL MIGRATION POTENTIAL

- Upon review of regional and local pore-pressure conditions, operation of the proposed AGI well is not anticipated to present any risk for vertical migration of acid gas out of the intended reservoir
- Records of drilling-fluid characteristics, specific drilling fluid recommendations for the proposed AGI, and published literature demonstrate that the target Devonian injection reservoir is under-pressured relative to overlying producing zones
- Pressure differential between the target injection reservoir and overlying strata will aid in preventing vertical migration of acid gas out of the intended zone
- Furthermore, were conduits in fact present allowing for communication between zones, the pressure differential demonstrated by nearby drilling-fluid records would not be locally maintained

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# SIMULATING INJECTION OPERATIONS OF THE PROPOSED AGI WELL

- To characterize and predict the resultant acid gas plume after 30 years of operation, injection simulations were conducted utilizing Schlumberger modeling and simulation platforms
  - Schlumberger PETREL was utilized to construct a geologic simulation grid representing the subsurface strata
  - Injection simulations were conducted utilizing Schlumberger ECLIPSE and include relevant nearby wells with reasonable potential to affect the resultant AGI plume

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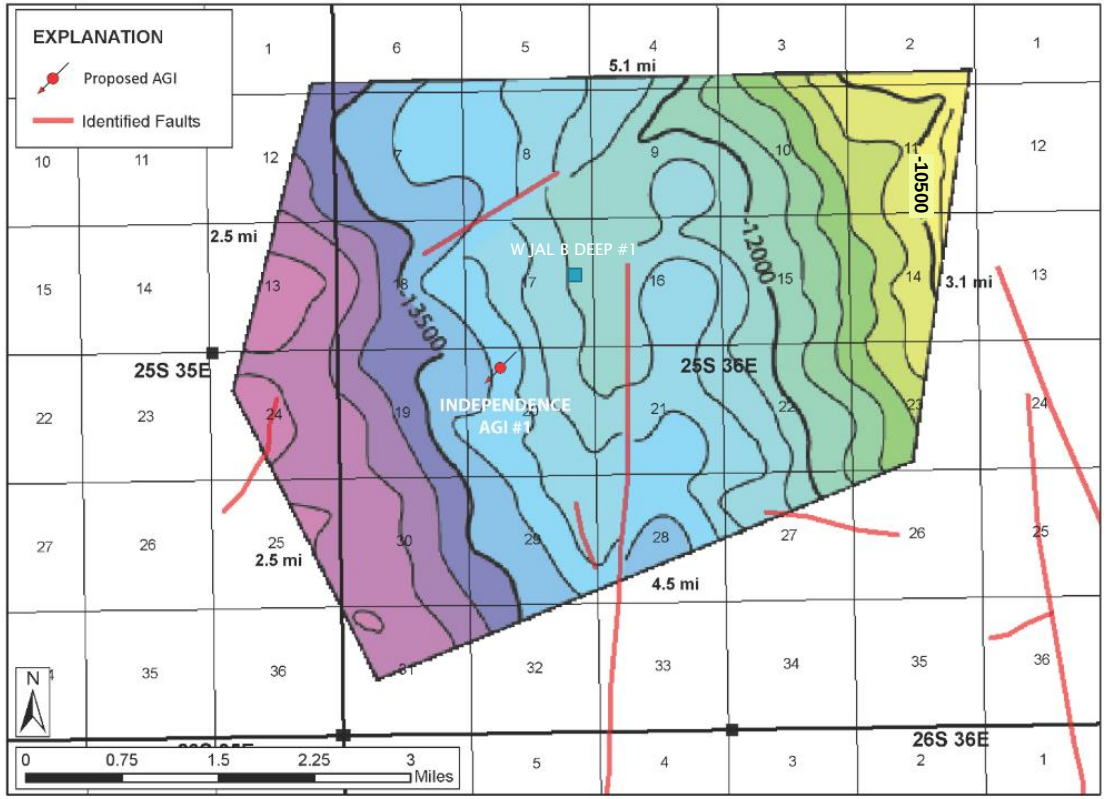
# GEOLOGIC SIMULATION MODEL

- A geologic simulation grid was constructed to simulate operation of the proposed Independence AGI #1
- Simulation grid constructed utilizing 3D seismic survey data and local well control
- The simulation area covers a total area of approximately 20 square miles in the area of the proposed Independence AGI #1
- Simulations consider operation of the proposed AGI well and the nearby West Jal B Deep #1 well




Location map illustrating areal extent of geologic simulation grid constructed to simulation operation of the proposed AGI well and the nearby West Jal B Deep #1 well

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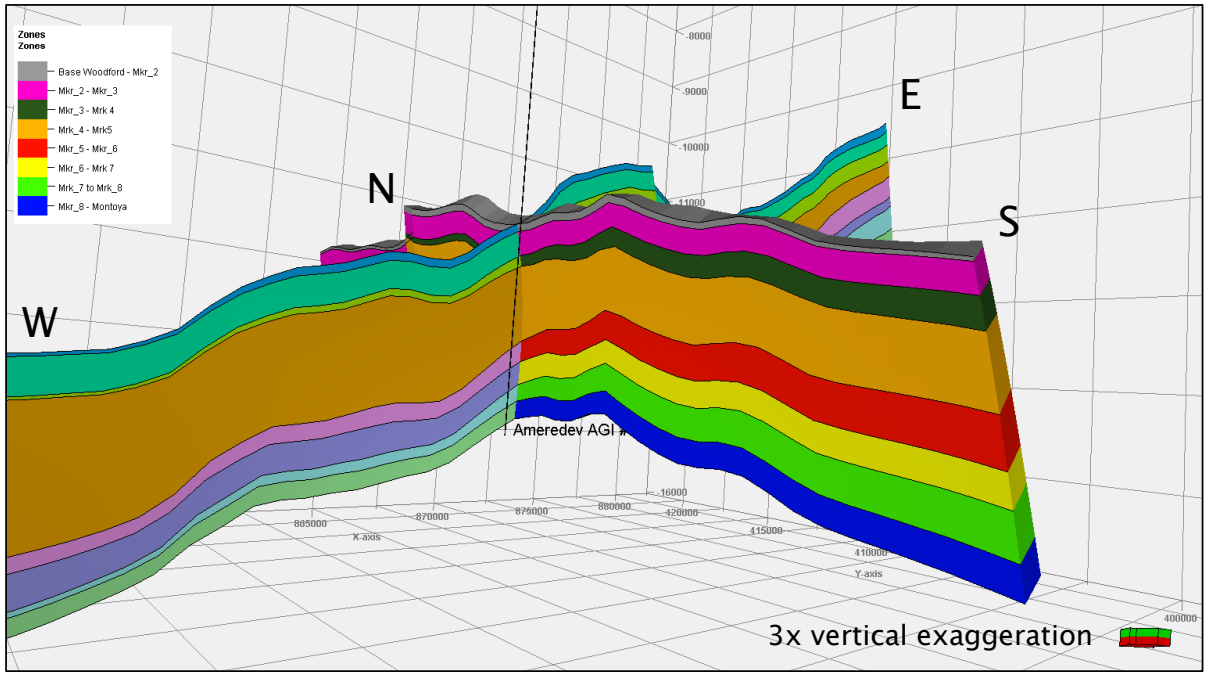
# GEOLOGIC SIMULATION MODEL

- Geologic simulation grid is comprised of 292 simulation layers characterizing eight (8) discrete zones identified in review of the injection reservoir
- Total simulation model includes 923,000 grid cells with areal dimensions of 500 x 500 feet
- Simulation area covers an area of approximately 20 square miles and includes relevant subsurface features and nearby injection wells




Three-dimensional render of the constructed geologic simulation grid representing eight discrete zone identified in the target reservoir and delineated based on porosity and permeability characteristics

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# INJECTION RESERVOIR CHARACTERISTICS

- Targeted injection reservoir subdivided into eight (8) zones based on interpreted porosity and permeability characteristics
- Average porosity estimates made for each identified zone based on available well-log data
- Average total injection zone porosity of approximately 3.9%
- Permeability values estimated based on available DST and injection test data and were further refined based on dolomite permeability studies of Lucia et al. (1995)

| Zone | Top | Base | Φ (Feet) | Avg. Φ | Φ Range | K Range (mD) | Avg. K (mD) |
|---|---|---|---|---|---|---|---|
| 1 | 16230 | 16294 | 64 | 5.0% | 3-10% | 10-100 | 40 |
| 2 | 16294 | 16497 | 203 | 2.0% | 0-10% | 0.1-10 | 1.0 |
| 3 | 16497 | 16584 | 87 | 4.0% | 1-7% | 0.1-10 | 3 |
| 4 | 16584 | 17218 | 634 | 1.0% | 0-3% | 0.1-5 | 0.75 |
| 5 | 17218 | 17378 | 160 | 8.0% | 1-20% | 10-400 | 140 |
| 6 | 17378 | 17561 | 183 | 6.0% | 1-8% | 10-100 | 50 |
| 7 | 17561 | 17684 | 123 | 8.0% | 1-16% | 1.0-200 | 100 |
| 8 | 17684 | 17820 | 136 | 8.0% | 1-16% | 1.0-200 | 100 |

Identified zones within the injection reservoir delineated based on interpreted porosity and permeability characteristics

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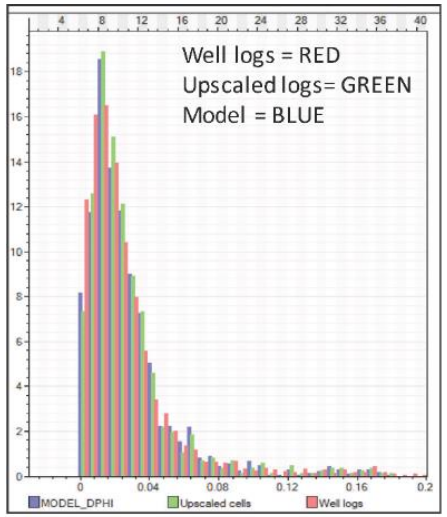
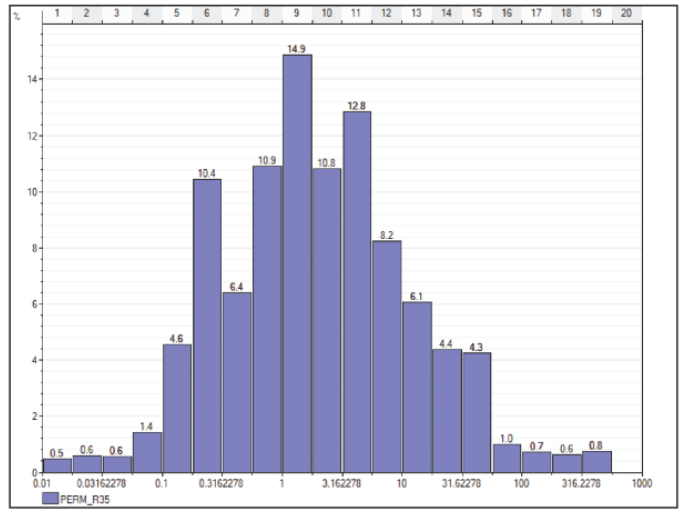
# GEOLOGIC MODEL CHARACTERISTICS

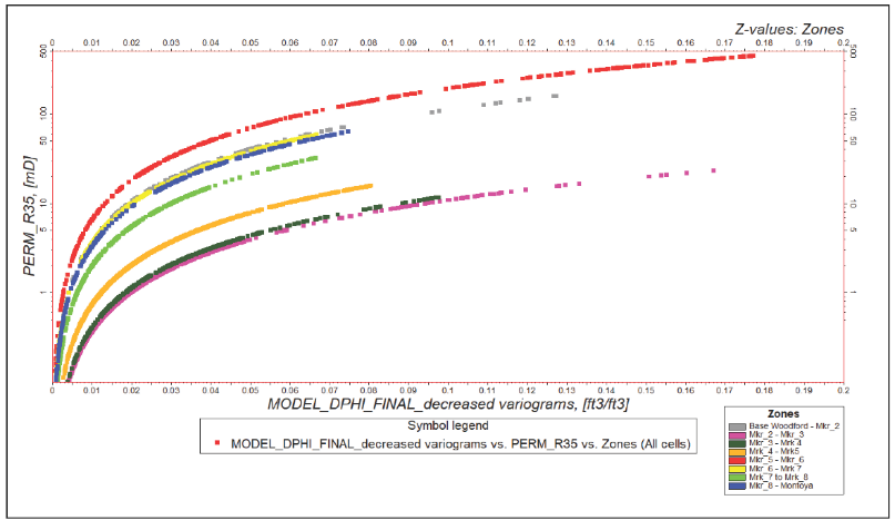
- Model porosity distribution generated from available well-log data (n=2), including West Jal B Deep #1 and West Jal Unit #1, as well as a synthetic log generated for the proposed Independence AGI #1
- Synthetic log representing the AGI location generated based on review of 3D seismic survey impedance data and local well data
- Model permeability distribution was generated using the Winland R35 method as normal and beta distributions generated no instances of permeability less than 0.1 mD
- As geophysical well log data were available for only two wells in the area of the proposed AGI, 3D seismic survey impedance data were utilized to define key intervals of low-porosity




DPHI Distribution
(2 available well logs)




Winland R35 Permeability Distribution




Permeability (Winland R35) vs. Model DPHI

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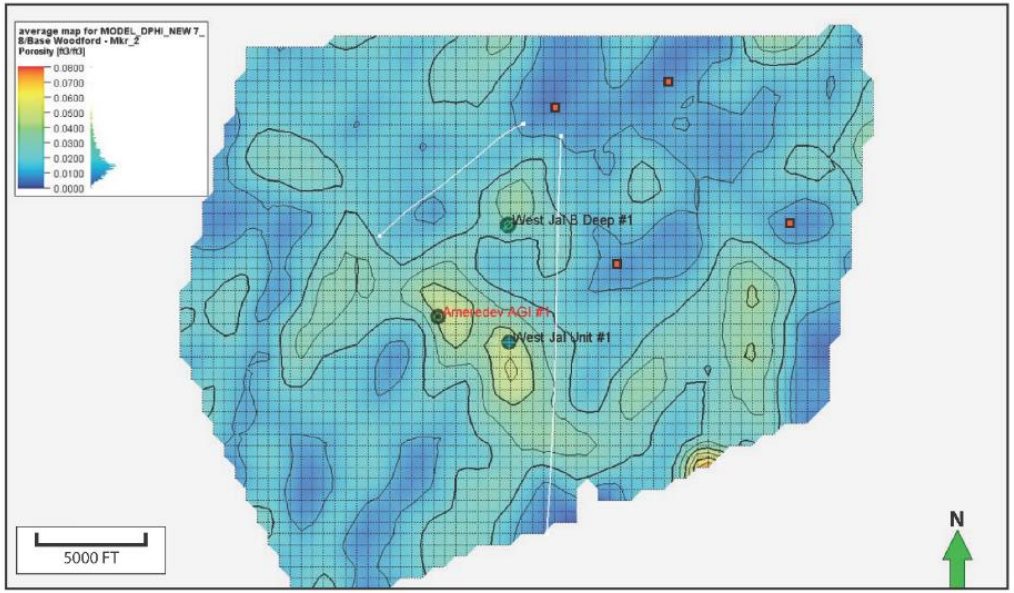
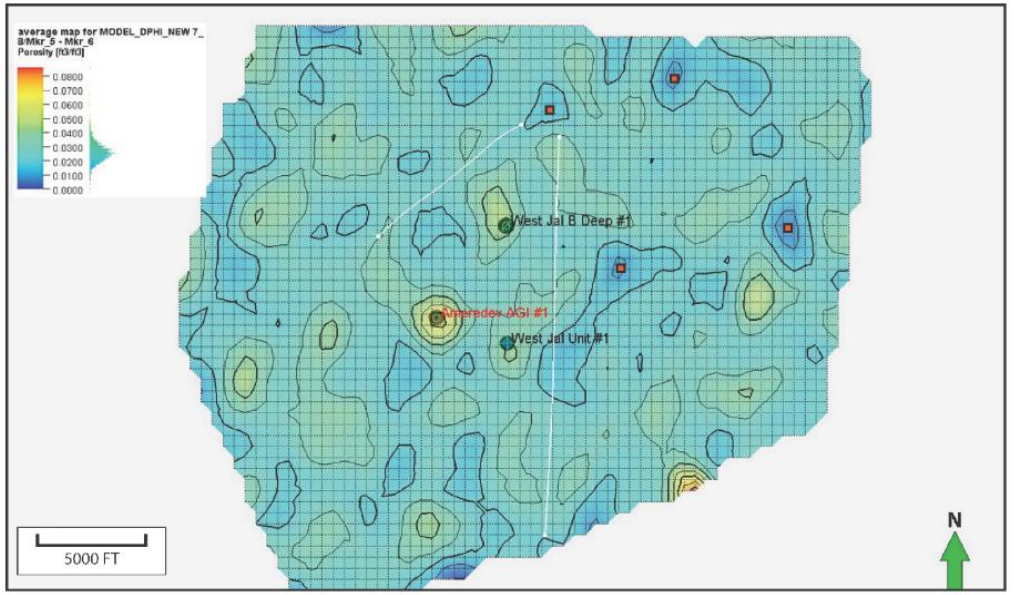
# GEOLOGIC MODEL CHARACTERISTICS




Zone 1 Porosity Distribution (upper Devonian)




Zone 5 Porosity Distribution Map (Wristen/Fusselman)

- Average porosity distribution maps for reservoir Zone 1 and Zone 5 are shown above as they are predicted to be the primary receivers of acid gas in this area (correlating to upper Devonian and Wristen/Fusselman strata)
- Synthetic wells implemented to characterize low-porosity zones identified in 3D seismic impedance data are denoted as orange squares (low-porosity zones interpreted from 3D seismic impedance data)

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# INJECTION SIMULATION PARAMETERS AND CHARACTERISTICS (ECLIPSE)

- Simulation considers injection of a mixed acid gas stream of approximately 70% $CO_2$ and 30% $H_2S$
- Total simulation duration of 30 years
- Proposed AGI and SWD (West Jal B Deep #1) operated at maximum anticipated injection rate continuously throughout simulation
  - Independence AGI #1 – 12 MMSCF per day (approx. 5,250 bpd)
  - West Jal B Deep #1 – 15,000 bpd
- Simulation assumes reservoir is 100% saturated with brine in hydrostatic equilibrium upon commencement of injection simulation
- Multiple case simulations were conducted to evaluate resultant plume with and without continuous and coincident operation of the West Jal B Deep #1 well

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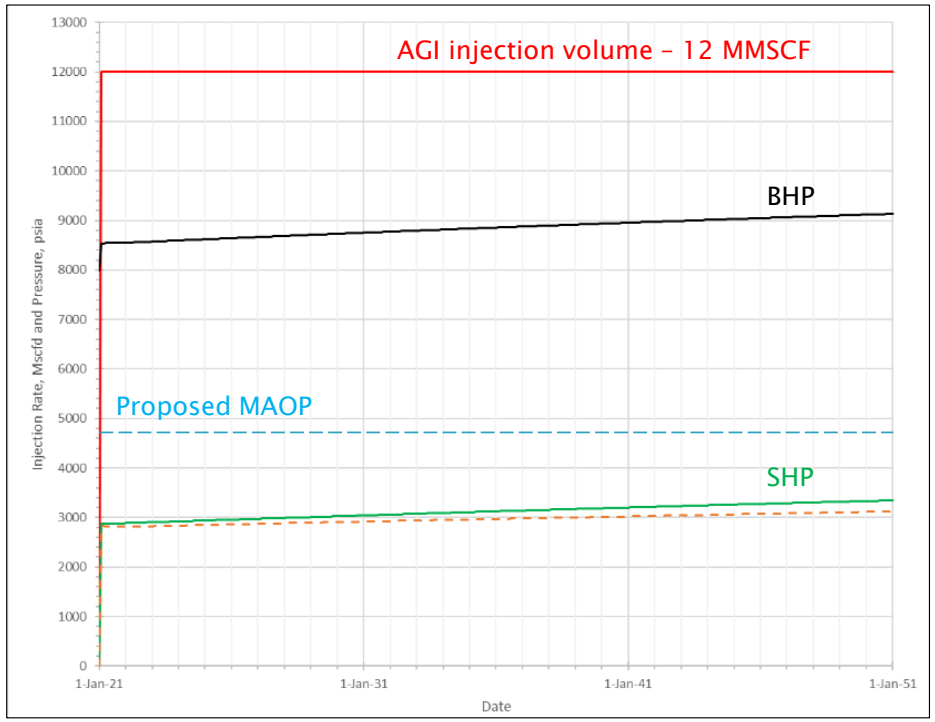
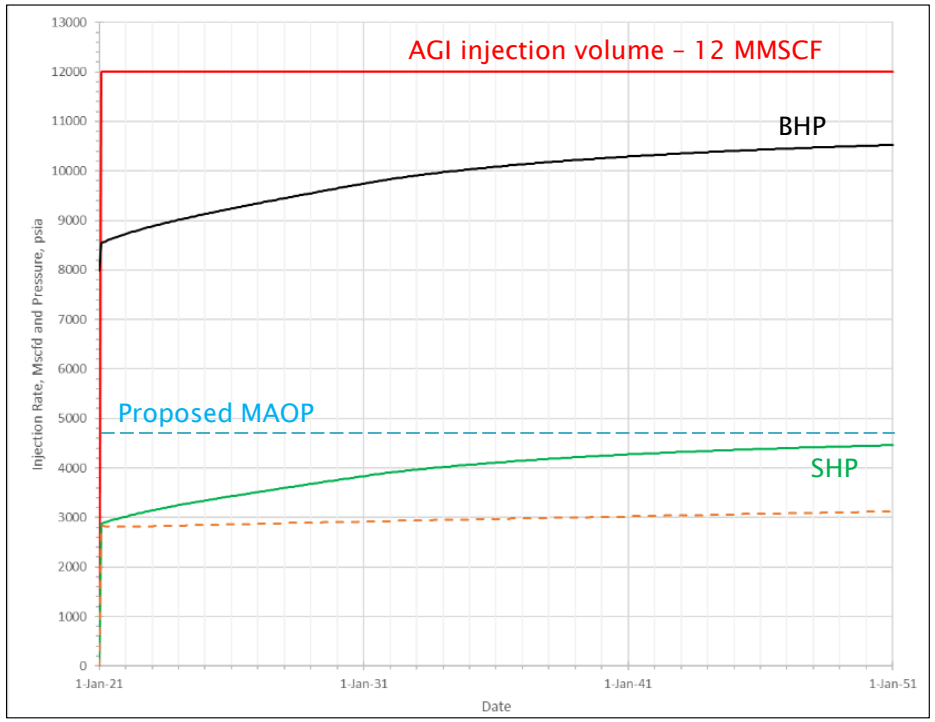
CASE SIMULATION 1 – EXCLUDING WEST JAL B DEEP #1




CASE SIMULATION 2 – INCLUDING JAL B DEEP #1




- In both case simulations (including/excluding West Jal B Deep #1), the reservoir is able to accommodate the proposed acid gas volumes without exceeding the requested MAOP of 4,779 psi. Acid gas injection rate, bottom-hole pressure, and surface injection pressure trends are shown in red, black, and green, respectively.

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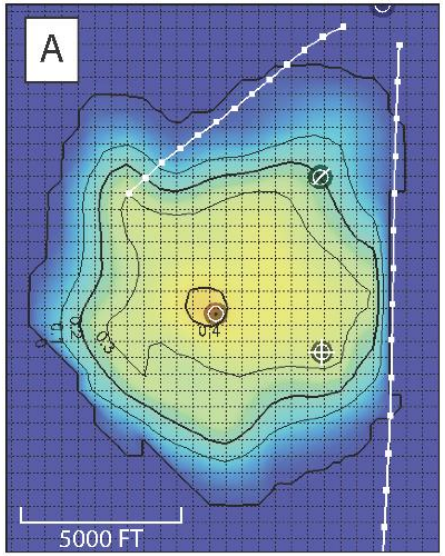
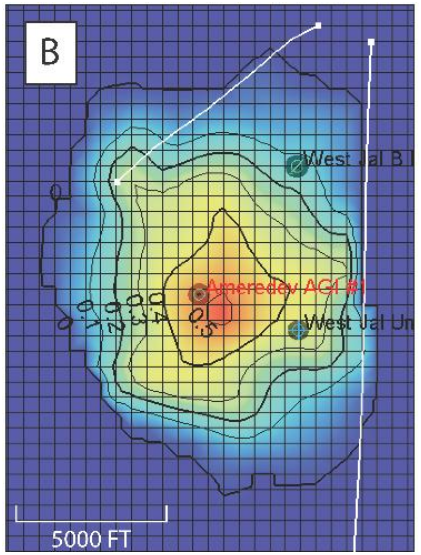
# RESULTS – CASE 1 (excluding SWD)

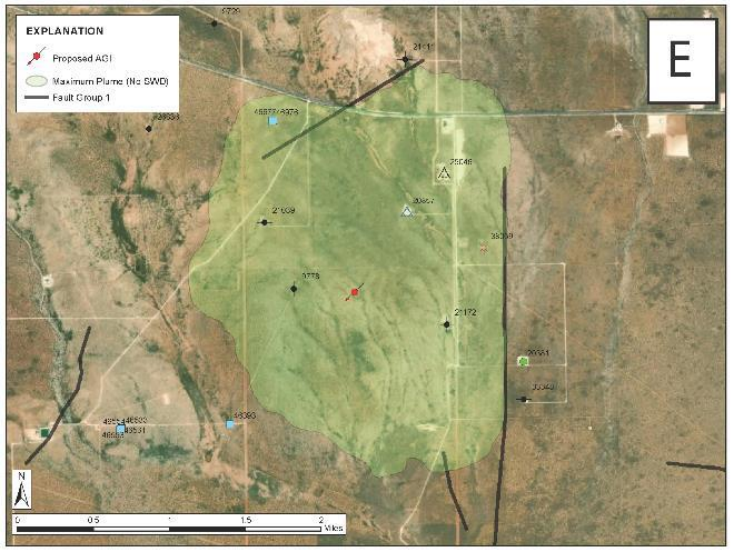
- Maximum lateral dispersion distance of acid gas is predicted to be 1.6 miles from the AGI well location
- Gas saturation distribution maps (panels A and B) demonstrate that relatively low concentrations of acid gas reach this maximum extent and that the main body of the plume (>20% saturation) only extends approximately one (1) mile from the AGI
- Cross-sectional views of the injection reservoir (panels C and D) demonstrate Zone 1 and Zone 5 are predicted to receive the greatest volume of acid gas



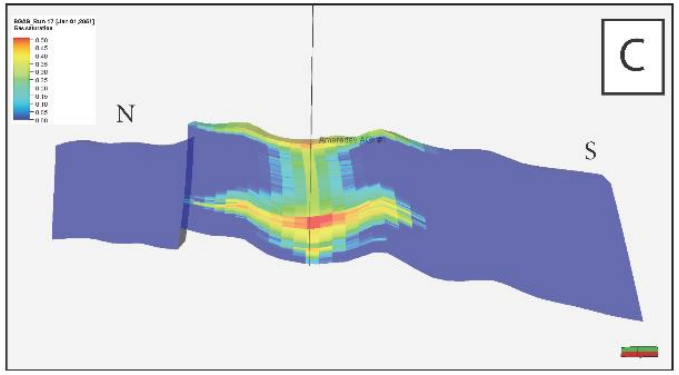
Zone 1 Gas saturation map



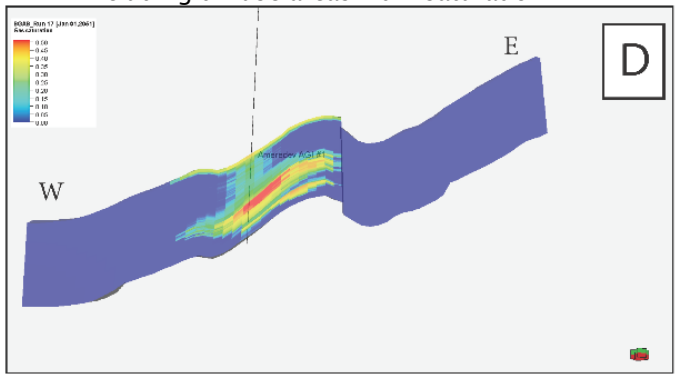
Zone 5 Gas saturation map



Total potential acid gas plume footprint (all zones) including diffuse areas <0.1 saturation



North-South cross-sectional view of resultant plume



West-East cross-sectional View of resultant plume

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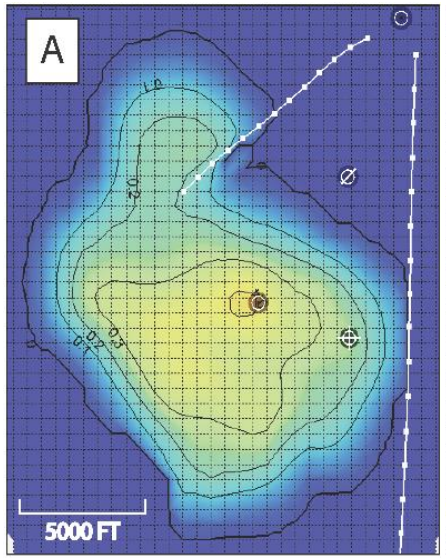
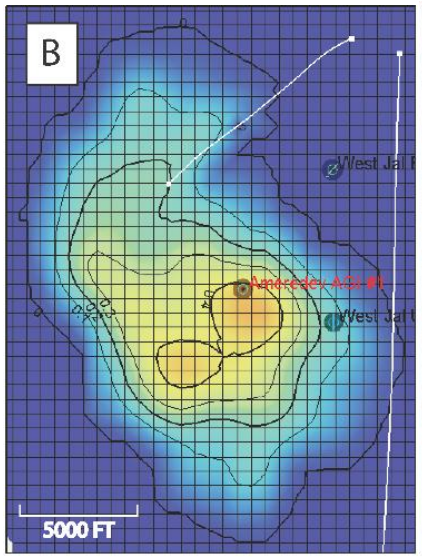
# RESULTS – CASE 2 (including SWD)

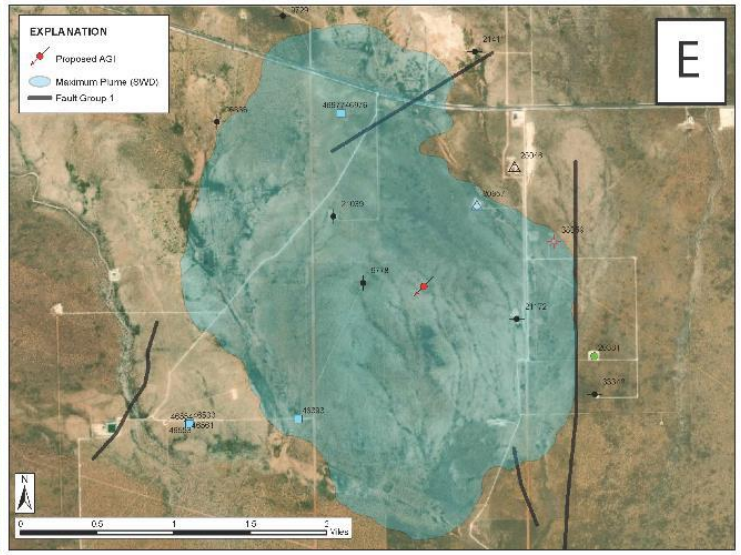
- Maximum lateral dispersion distance of acid gas is predicted to be 1.8 miles from the AGI well location
- Gas saturation distribution maps (panels A and B) demonstrate that relatively low concentrations of acid gas reach this maximum extent and that the main body of the plume (>20% saturation) only extends approximately 1.3 miles from the AGI
- Cross-sectional views of the injection reservoir (panels C and D) demonstrate Zone 1 and Zone 5 are predicted to receive the greatest volume of acid gas



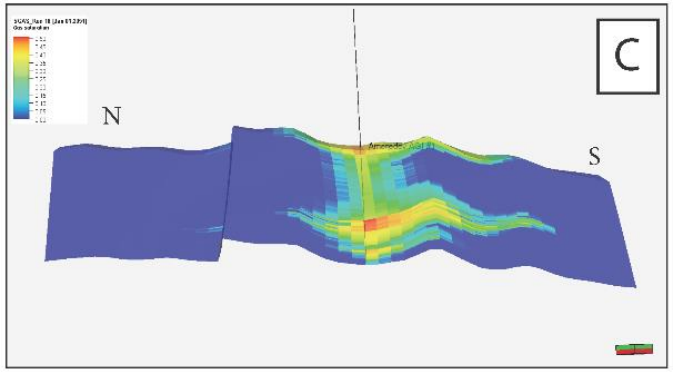
Zone 1 Gas saturation map



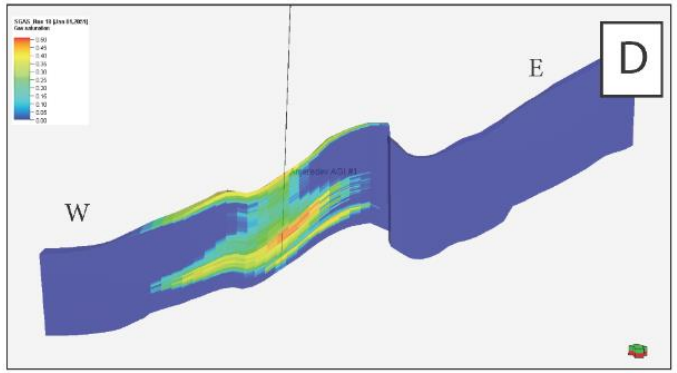
Zone 5 Gas saturation map



Total potential acid gas plume footprint (all zones) including diffuse areas <0.1 saturation



North-South cross-sectional view of resultant plume



West-East cross-sectional View of resultant plume

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# DISTRIBUTION OF ACID GAS BY ZONE

- Only minimal change in the distribution of acid gas by zone is observed between cases, indicating operation of the West Jal B Deep #1 primarily results in a deflection of the injected acid gas
- Pressure influence from West Jal B Deep #1 results in only minimal increase in acid gas received by minor zones identified within the Devonian reservoir
- Distribution of acid gas, as predicted by the injection simulations are in agreement with our experience operating Devonian AGI wells, in that upper Devonian and Wristen/Fusselman strata commonly accept the greatest proportions of acid gas

CASE SIMULATION 1 – EXCLUDING SWD

| ZONE # | CUMULATIVE INJECTION (MMSCF) | TOTAL PERCENT |
|---|---|---|
| 1 | 19,451 | 14.8 |
| 2 | 976 | 0.7 |
| 3 | 1,222 | 0.9 |
| 4 | 2,725 | 2.1 |
| 5 | 82,541 | 62.8 |
| 6 | 10,725 | 8.2 |
| 7 | 5,619 | 4.3 |
| 8 | 8,223 | 6.3 |
| TOTAL | 131,484 | 100 |

CASE SIMULATION 2 – INCLUDING SWD

| ZONE # | CUMULATIVE INJECTION (MMSCF) | TOTAL PERCENT |
|---|---|---|
| 1 | 21,852 | 16.6 |
| 2 | 1,207 | 0.9 |
| 3 | 1,532 | 1.2 |
| 4 | 3,190 | 2.4 |
| 5 | 82,293 | 62.6 |
| 6 | 11,731 | 8.9 |
| 7 | 4,090 | 3.1 |
| 8 | 5,588 | 4.2 |
| TOTAL | 131,484 | 100 |

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# SUMMARY – INJECTION SIMULATIONS

- Injection simulations to characterize the resultant acid gas plume after 30 years of operation were conducted utilizing Schlumberger PETREL and ECLIPSE modeling and simulation platforms
- All wells included were simulated at their maximum anticipated daily injection rates
- Two case studies were simulated to estimate the resultant acid gas plume when the nearby West Jal B Deep SWD was operating continuously and coincident with the AGI and when the SWD was offline
- In both cases, the target 12 MMSCF per day can be maintained for 30 years without exceeding the requested MAOP of 4,779 psig
- When the West Jal B Deep SWD is offline (Case #1), injection simulations predict a maximum lateral dispersion distance of 1.6 miles from the AGI wellbore, however, outer margins of the plume area characterized by diffuse concentrations (saturation less than 0.2) and the main body (saturation >0.2) of the plume extends approximately one mile from the AGI wellbore. A semi-radial dispersion pattern is observed with slight preferential dispersion in the up-dip (northeast) direction.
- When West Jal B Deep SWD #1 is actively injecting at 15,000 bpd (Case #2), pressure influence from West Jal B Deep inhibits northeast preferential dispersion and deflects plume approximately N-NW. The main body of the plume (saturation >0.2) extends approximately 1.3 miles from the AGI wellbore with more diffuse concentrations extending up to 1.8 miles.
- Zone 1 and Zone 5 are predicted by the simulations to be the primary receivers of acid gas, which is in agreement with injection patterns observed in other active Siluro-Devonian AGI wells

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# C-108 APPLICATION SUMMARY

- Ameredev is requesting authority to inject acid gas ($CO_2/H_2S$) into a deep, vertical well:
  - Into upper Devonian and Silurian Wristen and Fusselman formation strata at depths of approximately 16,230' to 17,900'
  - At a maximum injection rate of 12 MMSCF per day and maximum operating surface injection pressure of 4,779 psig (as determined by a NMOCD-approved method for determining max. surface injection pressure)
- The well and surface facilities have been designed to provide a safe and efficient injection system for the proposed gas-processing facility
- All identified surface and mineral owners and operators within one mile of the AGI have been properly notified
- There is no current or anticipated production in the Siluro-Devonian formations within at least two miles of the proposed injection site
- The proposed injection zone is capable of permanently containing the injected fluid due to low porosity and low permeability caprock above and below the injection zone and adequate capacity to sequester the anticipated volumes of acid gas
- Fresh groundwater resources are fully protected by the well design and deep (1,400') surface casing

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# C-108 APPLICATION SUMMARY

- Only two wells penetrate the proposed injection zone within the one-mile radius area of review, which include the properly plugged West Jal Unit #1 and the West Jal B Deep Unit #1, which is an active injection well located approximately one mile from the proposed AGI

- Fault slip probability simulations were conducted to evaluate the potential for induced-seismic events in response to the proposed injection scenario, which demonstrate that the proposed Independence AGI #1 can be operated without producing significant risk of injection-induced seismic events

- Injection simulation modeling to predict the resultant AGI plume after 30 years of injection at the maximum anticipated injection rate estimates the main body of the plume will extend 1 to 1.3 miles from the AGI wellbore with diffuse presence (saturation <0.2) extending approximately 1.6 to 1.8 miles from the AGI location

- A review of regional Delaware Basin pressure conditions, compiled drilling-fluid records, and recommended drilling procedures for the proposed AGI demonstrate that the targeted injection reservoir is under-pressured with respect to overlying producing strata. As such, this provides added assurance that injected acid gas will be contained as the pressure differential will impede and prevent vertical migration out of zone

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# AMEREDEV'S REQUEST FROM THE NMOCC

- Permission to drill, test, complete, and operate Independence AGI #1 as specified in Ameredev's C-108 application at the location identified in Section 20, Township 25 South, Range 36 East
- Ameredev requests permission to inject acid gas ($CO_2$, $H_2S$, trace hydrocarbons into the well at a MAOP of 4,779 psig and maximum average daily injection rate of 12 MMSCF per day for at least 30 years
- As proposed, this well will increase the processing capability of sour gas assets in the area and the project is supported by adjacent producers
- This proposed well will dispose of acid gas safely and effectively and assures the protection of surface and groundwater resources and correlative rights

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