STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION COMMISSION

APPLICATION OF GOODNIGHT MIDSTREAM PERMIAN LLC FOR APPROVAL OF A SALTWATER DISPOSAL WELL, LEA COUNTY, NEW MEXICO. **COMM. CASE NO. 24123**

APPLICATIONS OF GOODNIGHT MIDSTREAM PERMIAN LLC FOR APPROVAL OF SALTWATER DISPOSAL WELLS, LEA COUNTY, NEW MEXICO. **DIV. CASE NOS. 23614-23617**

APPLICATION OF GOODNIGHT MIDSTREAM PERMIAN, LLC TO AMEND ORDER NO. R-22026/SWD-2403 TO INCREASE THE APPROVED INJECTION RATE IN ITS ANDRE DAWSON SWD #1, LEA COUNTY, NEW MEXICO. **DIV. CASE NO. 23775**

APPLICATIONS OF EMPIRE NEW MEXICO LLC TO REVOKE INJECTION AUTHORITY, LEA COUNTY, NEW MEXICO. **DIV. CASE NOS. 24018-24020, 24025**

EMPIRE
PETROLEUM CORPORATION EST. 1983

Part 5 of 6 - Exhibits D & E

Direct Testimony and Exhibits

August 26, 2024

Table of Contents

Tab

Tab

Tab

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SELF-AFFIRMED STATEMENT OF ROBERT C. TRENTHAM

1. My name is Robert Craig Trentham. I am over eighteen years of age and have personal knowledge of the facts herein. I am a geologist with 44 years' experience in, or with the petroleum industry, having worked for Gulf (1980-1985), Chevron (1985-1992), Muskoka Consultants (1992-2001), and University of Texas Permian Basin, Director Center for Energy and Economic Diversification, Senior Lecturer and Research associate and Professor of Practice (2001- Present). My expertise is in reservoir characterization and Residual Oil Zones.

2. I hold a Bachelor of Science (January, 1970) and Masters of Arts (June 1976) degrees in Geology from City College of New York, and a Doctor of Geological Sciences degree from the University of Texas El Paso (August, 1981).

3. I worked in both exploration and production geology in the Permian and surrounding basins from February 1980 to April 2001. I had new field and new pool discoveries and worked on a number of well-established fields (Sand Hills, North Ward Estes, Wagon

EXHIBIT D

Wheel Penn, and W. A. Estes, amongst others). I left Chevron in 1992 and completed contract work on various fields for several companies in the basin. I was PI or Co-PI for:

- Department of Energy (DOE) sponsored project - "**An Integrated Study of The Grayburg/San Andres Reservoir, Foster and South Cowden Fields, In Ector County, Texas".** DOE Class III, Shallow Shelf Carbonate Reservoirs Project, 2000.
- The Research Partnership to Secure Energy for America (RPSEA) sponsored project - **"Commercial Exploitation and the Origin of Residual Oil Zones: Developing a Case History in the Permian Basin of New Mexico and W. TX -A Modeling Study".** 2011.
- DOE sponsored project - "**A Modular Curriculum for Training University Students in Industry Standard CO2 Sequestration and Enhanced Oil Recovery Methodologies".** 2013.
- Research Partnership to Secure Energy for America (RPSEA) sponsored project - **"Identifying and Developing Technologies for Enabling Small Producers to Pursue the Residual Oil Zones (ROZ) Fairways in the Permian Basin, San Andres".** 2015a, and
- National Energy Technology Laboratory (NETL). **"Using Next Generation CO2 EOR Technologies to Optimize the Residual Oil Zone CO2 Flood at Goldsmith Landreth Unit, Ector County, Texas"** 2015b.

I completed most of these projects while teaching geology classes and being Director of the Center For Energy And Economic Diversification at UTPB and working on a number of other projects. Since 2005, I have continued to work with industry and academic researchers and companies on the development of Residual Oil Zones (ROZs) in the Permian Basin.

4. I am a member of the following: 1) American Association of Petroleum Geologists (AAPG); 2) Society for Sedimentary Geology (SEPM); 3) Geological Society of America (GSA); 4) Past-president and honorary life member of the West Texas Geological Society (WTGS); 5) Past-president and honorary life member of the Permian Basin Section–SEPM (PBS-SEPM); on the board of the CO_2 Conference in Midland since 2001, and on the board of the Midland Energy Library, since 1997 (president from 2004-2008) 5. I served my country in the Nation Guard as a Second Lieutenant in an armored cavalry squadron.

A. THE PROPOSED SWD WELLS WOULD INJECT INTO SAN ANDRES FORMATION WHICH CONTAINS A RESIDUAL OIL ZONE (ROZ)

My testimony will cover a number of topics:

- Background of Residual Oil Zone Development
- Science of ROZs
- Types of ROZs
- Example of a Historic Attempted Completion – Before We Knew What We Know About ROZs – Anschutz #1 Keating, Gaines County, TX
- Proof of Concept – Seminole Field, Gaines County, TX
- Early ROZ CO_2 EOR Pilots – Seminole Field, Gaines County, TX
- Waterflood vs Mother Nature's Waterflood Oil Saturations - Goldsmith Landreth San Andres Unit (GLSAU)
- Modeling of Meteoric Derived Flushing - Mother Nature's Waterflood
- Tectonics and Stacked ROZ's – North Ward Estes, Ward County, TX.
- Sulfur rich water in the San Andres.
- Types of San Andres Tertiary EOR Projects that could be applied on Empire's properties and Why Injection Will Be Detrimental to Each.

Background of Residual Oil Zone Development

A large new resource of recoverable oil has been identified in the San Andres Formation. Residual Oil Zones (ROZs) up to 300' thick containing 20-40% oil saturation in pores of the dolomitic reservoir are present both below, and between, presently productive fields. The oil in the ROZs is residual, i.e., not recoverable by primary production methods or water flooding, but oil is recoverable using enhanced oil recovery (EOR) methods such as CO_2 EOR. Although preliminary at this stage, the estimated oil in place in the ROZ's likely exceeds 100 million of barrels of oil and equal to the original oil in place in the zones with mobile oil present (main pay zones, MPZs).

The results of the above studies, and others, shows the identification of an ROZ is not necessarily difficult, or expensive, and can be undertaken by either large or small operators, and can add value to both mineral leases and mineral ownership.

ROZs have as their analog, oil fields that possess mobile oil (main pay zones or MPZs), originally flowed oil naturally and then were secondarily waterflooded until oil production neared zero. The "waterflooded (swept) intervals" still have 20-40% residual oil in the pore space. These swept zones can be revived using CO_2 EOR. In fact, by 2015, the Permian Basin (PB) was producing >200,000 barrels of oil per day from main pay CO_2 floods. On average, an additional recovery of 10-20% of the original oil in place in a field is possible using CO_2. This is oil that would not be recoverable without the aid of an injectant that liberates the oil.

What the industry has learned is that there is not a lot of difference between oil saturations in a Main Pay Zone (MPZ) interval that has been waterflooded and in ROZs. The Modeling Study (below) conducted as part of the ongoing study of ROZs was to confirm that the ROZs have been flooded by Meteoric Derived Fluids, due to tectonic changes that have occurred after the establishment of a large ancestral oil trap. The movable oil was swept by a natural waterflood leaving behind the ROZs, hence the name,

Mother Nature's Water flood (MNW).

Presently, there are 18 ROZ CO_2 EOR projects underway in the Permian Basin proving that the naturally waterflooded intervals can be as commercially attractive as existing waterfloods. ROZs are evidenced during drilling by "shows" of oil in mud, in cuttings and cores, and by log calculations showing residual oil saturations. Because of the shows, well completions or drill stem tests have often been attempted in the swept interval but result in recoveries of black sulfur water, and minimal oil and gas recoveries leading to expensive dry holes (see Anschutz #1 Keating below).

ROZ CO_2 EOR Projects in the Permian Basin Region of the U.S.

It is now realized that Residual Oil Zones, ROZs, contain oil that is recoverable by the use of miscible CO_2 enhanced oil recovery (EOR). Of the 20% to 40% oil trapped in ROZs some 10% to 20% can be recovered by CO_2 flooding. The CO_2 enters the oil causing it to swell, becomes less viscous and be forced out of pores and toward the producing wells. The process also change the surface tension of the oil and its attraction to the rock. A percentage of the oil is forced from the pores and the CO_2 is trapped, becoming incidentally sequestered.

The concept of post-entrapment tectonic adjustments to oil bearing basins was beginning to be brought to more widespread attention in 2006 wherein three mechanisms for readjustments of paleo entrapments was proposed (Melzer, 2006).

Results of the above studies confirmed the presence of thick and extensive ROZs, i.e., where no main pay zones are present. The hydrodynamic modeling, Melzer, 2006, demonstrated that the mechanics of flushing are measured in units of tens to hundreds of feet (movement) of water per 1000 years.

THE SCIENCE OF RESIDUAL OIL ZONES

The ROZ science is based upon the observation that oil emplacement in reservoirs is not final and the oil can episodically migrate in the subsurface. The displaced oil can move from an interim trap before it finally finds its way to 1) the surface, 2) near surface in the form of oil (tar) sands, or 3) another entrapment 'home' in a modern trap. What sets up the episodic movement are successive stages of tectonism. Identification of the Artesia Fairway and the others across the basin are favorable for ROZ development and should allow explorationists to focus exploratory efforts to identify and exploit them.

For more than 100 years, the U.S. oil industry has made an impressive series of technological advances in finding, describing and producing modern oil and gas entrapments. The Enhanced Oil Recovery (EOR) technologies were designed to take advantage of the oil that was bypassed in the waterflood stage because water and oil did not mix. The application of EOR technologies recognized at this stage that the properties of the oil needed to be altered to be producible. Recent work in the Permian Basin (Melzer, 2006 and Biagiotti, 2009) has shown that those zones, herein called residual oil zones (ROZs),

During the latter half of the last century, industry demonstrated that commercial EOR projects can follow waterfloods. Worldwide, over 120 CO_2 EOR projects are active today (ARI, 2023). EOR in naturally waterflooded intervals has just begun but, it can be said today, that economically producing naturally waterflooded zones is beyond a theory now. More than a dozen projects are now underway in the Permian Basin, ***Exhibit D-1***, and, at the time of the original report (2011), were making in excess of 11,000 barrels of oil per day. The oil and gas industry may have been somewhat slow in recognizing that large EOR targets exist in the subsurface, but as success continues so do new projects.

BACKGROUND AND KEY EVIDENCE FOR THE PRESENCE OF ROZS

During the early 2000's, Steve Melzer and Advanced Resources International completed a study of ROZ's Stranded Oil In The Residual Oil Zone, Melzer, 2006 and concluded that the presence of an oil bearing Transition Zone (TZ) beneath the traditionally defined base oil-water contact (OWC) of an oil reservoir is well established. What is now clear, and as established by Trentham (2011), is that, in certain geologic and hydrodynamic conditions, an additional ROZ may exist below this TZ. This zone may be extensive, thick, and filled with a residual oil that may be recoverable using CO_2 Enhanced Oil Recovery (EOR). These thick residual oil zones exist where nature has waterflooded the lower portion of an oil reservoir.

We are only now beginning to understand the impact Mother Nature's Waterflood had on Permian Basin reservoirs and the potential for EOR and carbon capture use, and storage (CCUS) this creates. Estimates, (Koperna and Kuuskraa (2006)), have made indicates that there are 5 to 15 billion barrels of CO_2 EOR recoverable reserves in ROZ's around the basin. What brings even more attention to this resource is the possible associated CO_2 storage capacity in these targets, perhaps doubling the value of the ROZ reservoir assets

In the Permian Basin the San Andres Formation has the reputation that it seemingly always yields good "shows" of oil and gas. This observation occurs both beneath established producing fields and in areas away from production. These are ROZs and often are incorrectly interpreted as oil productive from the shows in the cuttings and porosity readings and oil saturation calculations from wireline logs. As a result, well completions have often been attempted with frustrating results. Many yield "black" or sulfur rich water, a key indicator that the reservoir has been swept. The nature of an ROZ is that it will not yield oil in commercial quantities in either primary or secondary operations. The oil that is present takes exposure to an injectant to alter its properties to make it moveable.

In case after case and area after area, the characteristics of ROZ's seem the same. There is: good odor, cut, fluorescence, and gas shows in samples, calculations of 20% or much higher oil saturations from logs, 15-40% oil saturation from core analyses; predominance of dolomite over limestone; and production of sulfur water on DST's or completions.

During the course of the past 20 years, the number of successful CO_2 EOR projects in Permian Basin fields have been slowly changing the perception of the potential of ROZ's. What has been learned is that commercial oil can be produced from ROZs in the intervals below the main pay zones.

SCIENCE

During the 1990's, Alton Brown, while working for ARCO, documented the effects of hydrodynamics on Cenozoic oil migration in the Wasson Field area in Yoakum County, TX, elsewhere on the Northwest Shelf, and on the eastern side of the Central Basin Platform. Using available data, Brown proposed hydrodynamics as a more reasonable mechanism to explain the presence of an OWC tilt of 30' per mile in the Wasson Field in Yoakum County, ***Exhibit D-2***. He believed that the movement of meteorically-derived waters fifty to hundreds of miles distant was a better explanation than capillary "smearing" of oil saturation from top down. He also postulated that the hydrodynamic charge model also explains that the thick (250- 300') ROZ in any field is a relic from a previous (paleo) static trapping condition using unitization agreements and other data. He went on to document the presence of tilted OWCs in a number of fields on the Northwest Shelf and Central Basin Platform. It has since been postulated and now recognized that the amount of tilt is a function of the flow path (the "fairway") and proximity to a source of meteoric recharge. In the Permian Basin at least, the direction of flow is controlled by regional shelf to basin relationships.

The Artesia Fairway, ***Exhibit D-2***, a major pathway of meteoric derived flushing, was found to extend from Northwest Shelf of New Mexico east to the Central Basin Platform and then south along the west side of the platform to Pecos County. The EMSU, EMSU B, and AGU are located in the Artesia Fairway.

At about the same time, another researcher Robert Lindsay (2000) working at Chevron, looked at outcrop-to-core-to-production relationships in San Andres and Grayburg fields and documented meteorically-driven water sweep and the development of thick columns of residual oil in a number of fields on the Central Basin Platform. He recast the sweep history by documenting that there were two key periods of oil migration (post-Permian & Cretaceous/Tertiary) commonly proposed for Permian fields in the basin, resulting in the establishment of "filled" structural and strato-structural traps. Lindsay envisioned massive recharge of meteoric waters through Permian shelf carbonates and into the subsurface during the mid- to late-Tertiary as a result of uplift in the Rio Grande Rift trend to the west in New Mexico. The lower portion of established oil columns in a number of fields was swept out of the structural and strato-structural traps. The later extensional development of the Basin and Range structures west of the Guadalupe and Sacramento Mountains reduced the "hydraulic head". Some oil was left behind on the downdip flanks, and meteoric related waters introduced "bugs" which further reduced the volume of oil. Following the reduction in head, and the tectonically associated enhancement of structure, new oil/water contacts were established in the fields with significant thicknesses of partially oil saturated reservoir now below the oil/water contact.

Geographic Distribution of ROZ Fairways – The Artesia Trend

The presence of thick, ROZ's in the Permian Basin is only possible because there are regional pathways of migration for fluids, both water and oil, to flow into through and away from traps. The model for regional flushing of all, or portions, of these reservoirs, developed herein and by Lindsay and Brown (1998, 2001, 2004), identifies the pathway of eastward migrating meteoric waters moving down dip away from the recharge areas between the present day Rio Grande Rift and what is now identified as the western margin of the Northwest Shelf of the Permian Basin (prior to the Laramide orogeny, the Permian Basin reservoir trends extended much further to the west). The late stage (Tertiary), lower salinity waters were following regional aquifer pathways that were entirely different than those followed by the oil during migration into the reservoirs. The initiation of this meteoric-driven flushing was coincident with initial phase of Rio Grande Uplift and Tertiary volcanism in the Trans Pecos, ***Exhibit D-3***.

The original recharge surface extended essentially from the area west of a line from El Paso to Socorro, NM to a line from Carlsbad to north of Roswell. This potential recharge area was half the height of the Permian Basin. During that time, large volumes of initially fresh but soon mixed waters swept through the porous and permeable reservoirs. The mixing occurred rapidly so that the majority of the flushing was with relatively saline, oxygen rich subsurface waters, and referred to as "Mother Nature's Waterflood" (MNW). The MNWs swept oil out of the plaeo entrapments and created the ROZs seen in the Permian Basin today. This MNW process resulted in the re-positioning and tilting of the oil-water contacts which are now identified and described in the Permian reservoirs in modern times.

Along the eastern margin of the Central Basin Platform, it has been postulated, adapted from Lindsay (1998), that the oil remigrated, at least in part, from the closures in the shelf carbonates eastward down dip into the shelf margin and slope carbonates and interbedded clastics before rebounding into the San Andres reservoirs as the hydraulic head was reduced by the fragmentation of the flow path.

The major San Andres ROZ projects on the Central Basin Platform and Northwest Shelf have ROZs with variable thickness, ***Table D-1***. However in many cases the ROZ is as thick as or thicker than the main pay. This was controlled by a combination of the porosity/permeability relationships within the reservoir interval and the strato-structural nature of other major producing fields. The fact that the documented thickness of the Greenfield ROZ at Tall Cotton, Platang, EMSU, EMSU B, and AGU are as thick or thicker than the Brownfield ROZs suggest that similar original oil saturation profiles were present in both Greenfield and Brownfield ROZs.

The upper Guadalupian rocks were typically deposited in sabkha and fluvial environments, are devoid of significant production, and would not have served as pathways for sweep waters. In many fields, the ROZ is mostly, if not completely confined to the San Andres portion of the reservoir.

Types of ROZs

During the earth 2000's, Melzer (2006) and others developed a model of the types of ROZs that can be identified in the Permian Basin and elsewhere. Three types of ROZs were identified: Basin Tilt (Type 1 ROZ); Breached and Reformed Reservoir Seals (Type 2 ROZ); and Altered Hydrodynamic Flow Fields (Type 3 ROZ).

Basin Tilt (Type 1 ROZ).

The entrapment is subsequently subjected to a regional westward basinal tilt, ***Exhibit D-4a***. This imaginary situation preserves the identical spill point for the original hydrocarbon accumulation and illustrates that the oil column has been thinned on the west side leaving behind a zone of "water swept" oil. The base of oil saturation, wherein So is zero, has also been tilted therefore a measure of the degree of tilt that has occurred. The oil/water contact (of movable oil) is controlled by gravity alone and is horizontal. The resulting ROZ is wedge shaped with the downdip side being thicker.

Breached and Reformed Reservoir Seals (Type 2 ROZ).

Exhibit D-4b presents a second source of residual oil zones. Here, the original oil entrapment has been breached. This can occur, for example, by buildup of fluid pressures during the formative reservoir stage, escape of a portion of the hydrocarbons, subsequent healing of the seal, and re-entrapment of hydrocarbons. If the second entrapment contains a thinner oil column than was originally present, a residual oil zone would be present. Proving the transient loss of seal integrity would be difficult of course, but many cases exist in the field that point toward this type of ROZ. In this case, both the base of oil saturation that was controlled by the bottom of the transition zone in the original entrapment, and the oil-water contacts, controlled by base of the undisplaced and re-accumulated mobile oil phase, are horizontal. Gas-oil ratios of these reservoirs are often anomalously low due to the weaker seal capacity. Tar mats and other solid hydrocarbons present within the oil column are observed on occasion.

Altered Hydrodynamic Flow Fields (Type 3 ROZ).

The general lack of commercial interest in deep oil basin aquifers has generated little research, at least as is evidenced by only scattered references in the petroleum geology literature. However, one notable exception to that lack of interest is the collection of studies devoted to understanding hydrodynamically trapped hydrocarbons (examples of which are Brown (2001), Berg et al, (1994), and Hubbert, M.K. (1953)). ***Exhibit D-4c*** shows the same original entrapment seen earlier but uses an example west-to-east hydrodynamic flow-field to explain the tilted oil-water contact. This type of ROZ is now understood to be the prevalent type in at least one very important region, the Permian Basin. As a result, it forms the basis for this entire report. The difference between the examples in ***Exhibit D-4a, 4b, 4c***, can be seen in that the oil-water contact for Type 3 is not horizontal but is tilted, in this case owed to the hydrodynamic forces on the oil column. Hubbert (1953) provides analytical methods (Equation 1 below) to determine contact tilts based upon the flow-field and densities of the oil and water. Since many oilfields were unitized for reasons of planned water flooding, rigorous calculations of oil-in-place were necessary which would require detailed structural contouring of the oil-water contact. The two ROZ demonstration projects at Wasson and Seminole have OWC structure maps filed for record in Texas Railroad Commission unitization filings ROZ demonstration projects which show this tilted OWC attribute. With that information and knowledge of the oil and water densities, one can calculate the hydrodynamic flow field responsible for the contact tilt beneath the oil leg through the use of the following formula, Melzer, 2006.

Oil-water Contact tilt = dz/dx = - dp/dx x (rho_w/(rho_w - rho_o))......... Equation 1

where: dp/dx = Pressure (Potentiometric) Gradient of the Aquifer
rho_w = Density of the Water in the Aquifer
rho_o = Density of the Oil

One should assume that the documented OWC tilt is due to current hydrodynamic gradients. The original hydrodynamic conditions is assumed to have resulted in a maximum gradient as there was a longer fluid pathway and a larger elevation differences than the present day tilt defined by Brown, ***Exhibit D-2***. The current gradients can be lower (or even non-existent if fluid withdrawals are significant). Time, varying gradients due to climatic variations, subsequent tectonics, and denudation at sources and outcrops all likely play into the distribution of variable oil saturations throughout the ROZs in the Permian Basin.

Mother Nature's Waterfloods (Type 3 ROZ) are developed is a Dynamic System, ***Exhibit D-5***, associated with Basin Margin uplift and long-term meteoric flushing. Greenfields are areas where high oil saturation (So) was established by the end of the Mesozoic. As a result of Laramide thru Basin and Range uplifting, Greenfield ROZs have been established in intervals without associated economic oil production (Main Pays) in response to meteoric derived flushing, and reduction of oil saturations to values similar to residual to waterflood saturations (Sorw) results in the development of a Type 3 ROZ. Brownfields are essentially the same but were developed where economic production has been established (Main Pays). In some cases, the oil was also flushed out of the Main Pay but the oil re-migrated back in to the main pay and re-saturated the reservoir.

Historic Examples of ROZ's

The presence of reduced oil saturations in intervals below main pays and in large areas where no main pays exist have been identified throughout the Permian Basin. For decades, most explorationists have struggled to complete intervals, primarily in the San Andres but in other intervals as well, where they encountered shows of oil in samples, recovered core with oil saturation, encountered drilling breaks (porosity), observed oil on the pits and calculated producible oil saturations on logs. An example of this behavior is the Anschutz #1 Keating (42-165-34134) well in Gaines County, ~20 northeast of the Eunice Monument area, ***Exhibit D-6 & Exhibit D-7***. The Anschutz #1 Keating is a true ROZ. It was drilled on a seismic anomaly in 1990. Whole core was recovered from 2 intervals in the San Andres after mud log shows and a drilling break were encountered. The upper interval, 5464-5503' had oil saturations ranging from a trace to 37%, with 40-60% Bright Yellow Fluorescence, good dry and wet cut, and some gas. The well was then drilled for 47'. Then the interval 5550–5601' was cored with additional oil saturation noted. Based on the core and log analysis Anschutz, attempted to complete the well. They perforated 5434-5540', acidize, and swabbed 656 BW W/Trace of oil over 2 weeks. Perfs, 5616–5628', were added, acidized, and 135 BW were swabbed W/ Trace of oil. The well was shut in for evaluation and Anschutz placed the well on pump. A total of 1195 BW were recovered before any oil was seen. Over 45 days, the well recovered 2606 BW and 8 BO before Anschutz P&A'd the well. This is now understood to be classic ROZ response to an attempted completion in the ROZ.

SEMINOLE FIELD – Early Example of ROZ Development

It was not until the 1980's that companies began to separately evaluate the "Wet" interval below the Oil/Water contact as defined is the depth of the last oil production on initial completion. (See ***Exhibit D-8***) Hess Corporation, was at the time the operator of the Seminole Field in Gaines County. In addition to San Andres production, there was Clearfork, Wolfcamp, and SiluroDevonian production in the field. While drilling the deeper horizons, Hess encountered "shows" in the San Andres below the Oil/Water contact. During the mid-1980's Hess undertook a project to evaluate this interval. They recovered a number conventional core, sponge core, and pressure core in different wells. In addition, they took complete log suites thru the interval. The project was to evaluate the oil saturation in the interval. They determined that the Oil Saturation (S_o) in conventional core averaged ~15-20%, in sponge core 22-27% and in the pressure core 30-35%, *Pers.Comm. Hess engineers, 2007-2010*.

COMMERCIAL DEMONSTRATIONS OF OIL RECOVERY FROM RESIDUAL OIL ZONES.

Seminole Field

Since, by definition, residual oil zones are at waterflood residual oil saturation (Sorw), it is not possible to produce commercial quantities of oil from the intervals in either primary or secondary phases of production. Thus, the commercial importance has to be due solely to enhanced oil extraction. If the intervals were insignificant in thickness and/or extent, their potential contributions to oil resources would be negligible. What has become very obvious during the course of this subject study is, however, that the ROZ resources are very, very large in an aerial sense and of sufficient vertical thickness to potentially contribute billions of barrels of oil reserves to the Permian Basin. Considerable future work will be necessary to spatially map and quantify these resources.

It was not until 1999 that Hess began CO_2 Pilot tests in the ROZ, ***Exhibit D-9***. The first test flooded the Main pay and ROZ together. Although successful, the decision was made to complete a ROZ only CO_2 Pilot flood to better evaluate the ROZ potential alone. The success of the 2004 "ROZ only" flood led to the initiation of a series of "Phases" with Main Pay and ROZ floods using comingled injectors and individual producers beginning in 2007. CO_2 flood of the ROZ allowed for total field production to be maintained close to 20,000 barrels oil per day from 2008 to 2020, with current production 15,349 barrels oil per day. Over this past 16 years since Jan-2008, a total of 114,815,141 barrels oil has been produced. (***Exhibit D-10***) This project stands as proof of concept that CO_2 EOR floodable pay exists below main pays in San Andres reservoirs.

GOLDSMITH LANDRETH SAN ANDRES UNIT (GLSAU) – DETAILED STUDY OF Oil Saturation in a "Brownfield" ROZ

Legado Petroleum and later Kinder Morgan studied ROZ CO_2 EOR potential in the Goldsmith Landreth San Andres Unit (GLSAU). After recovering a number of cores as part of their CO2 EOR project in the San Andres Main Pay and ROZ in the Goldsmith Landreth Unit of the Goldsmith Field the oil saturations Legado plotted the oil saturation vs depth, ***Exhibit D-11***. The plot of the oil saturation in the re-saturated Gas Cap, waterflooded Main Pay and ROZ, confirms the conclusion that, based on the core analyses, similar oil saturations exist in an older waterflooded SADR pay, re-saturated gas cap and the Brownfield ROZ. The variation in saturations from 20 to almost 50% verifies the conclusion seen at Seminole and elsewhere that saturations in the ROZ as similar to those found in waterflooded main pays and as such are CO_2 EOR targets.

Tall Cotton Field – The First Greenfield Only ROZ Field.

Tall Cotton Field, ***Exhibit D-6***, west-central Gaines County, TX, is an example of production from a Greenfield ROZ ONLY with no associated main pay production. The nearest "Main Pay" SADR Field is the Seminole West Field ~3 miles to the east. The Seminole Field is ~9 miles to the east on the northeast corner of the Central Basin Platform. Kinder Morgan became interested in the area due to the results of the Anschutz #1 Keating (previously discussed) well, and the Read & Stevens #1-427 Charlene "Bittner Field" which IP'd for 15 BO, 5 MCF, and 55BW but produced only 138 BO before being plugged, is within a location of the CO_2 EOR project at Tall Cotton. These two wells encouraged Kinder Morgan to initiate a project of the area and develop a "classic" 5 spot vertical flood in the ROZ. Currently there are 39 producing wells and 27 injectors in the field. KM initiated CO_2 injection in Nov 2014. Production peaked at 3038 BOPD in October 2018 with 40 oil producers. The field is in the process of being sold to Atlas Energy. To date the Tall Cotton Field has produced 5,153,787 BO, 7,493,051 MCF gas. The nearest "Main Pay" SADR Field is the Seminole West Field is ~2 miles to the east.

Mother Nature's Waterflood

The RPSEA sponsored research expanded on the initial DOE/NETL work by Melzer (2006) and Advanced Resources International (2006). It has documented the evidence for, and characteristics of, ROZs below major San Andres reservoirs in the Permian Basin. There is significant anecdotal evidence for the presence of ROZs from exploration wells in "goat pasture" areas adjacent to and at distance from existing fields, in what has become known as "Greenfields." After discussions with a number of exploration and production geologists, and having viewed cores, logs and mud logs from a number of documented ROZs, some characteristics are beginning to stand out as the properties of, and evidence for, the presence of a ROZ. The rock and fluid properties are the same whether looking at Brownfield or Greenfield ROZ's. These ROZ's are now being very privately documented over wide areas of the northern Central Basin Platform (CBP) and Northwest Shelf and, with this study, on the west side of the CBP. In addition to their extensive presence in the San Andres, our study has identified the presence of ROZ's in the Abo (Wichita Albany), Lower and Upper Clearfork, Glorieta/San Angelo and Grayburg. Additionally, ROZ's are believed to be present in the basinal sand reservoirs in the Delaware Basin.

ROZ fluid properties include: overwhelmingly high water cuts (typically 'skims' of oil) during drill stem testing (DST) or attempted completions; log calculations that suggest producible hydrocarbons; mixed or changed wettabilities; hydrogen sulfide–rich waters produced in DSTs or attempted production tests; spotty oil stain/saturations near the base of the ROZ; the presence of sulfur/oil compounds in the produced waters of the ROZ; and historically documented tilted oil/water contacts.

On the western margin of the Central Basin Platform there is substantial evidence of the effects of meteoric derived flushing and identified ROZ's. In the Monument to Eunice Monument South area, work by Lindsay has documented that there is a thick San Andres ROZ beneath a minor San Andres and major Grayburg Main Pay Zone (mostly in the Grayburg, although the production is comingled). He also documented that the San Andres has a sulfate rich "bottom water drive" which is sourced from the Sacramento Mountains and a sulfate poor "edge water drive" in the Grayburg, sourced from the Guadalupe Mountains. This supports the concept that the San Andres is hydrologically separated from the Goat Seep Reef (Grayburg) and therefore separate from the Capitan Reef.

FAIRWAY BOUNDARIES

The limits of the fairway on the west side of the Central Basin Platform were defined as the San Andres shelf to basin transition on the basin side, and the transition from the intertidal carbonate dominated faces to the evaporite dominated sabkhas facies tract on the platform side. This facies tract extends from the Ft Stockton Uplift on the south to the Gaines/Lea County line east of Hobbs, and separates the San Andres and Grayburg production on the eastern side of the Central Basin Platform from the Artesia Fairway on the western side.

FAIRWAY BOUNDARIES (VERTICAL)

From bottom to top, the San Andres can be divided into a number of pay units, all of which are productive somewhere within the San Andres on the Northwest Shelf and/or Central Basin Platform. These are the Holt, McKnight, Intermediate, Judkins, and Lovington.

Residual Oil Zones within the Upper Carbonates of the Permian Basin

The origin and distribution of ROZs is now only beginning to be understood. However, some conceptual models exist that are based on what is known about hydrocarbon migration and distribution, as well as the hydrodynamic changes in the basin resulting from tectonism and subsequent horst and graben formation. Thick intervals of immobile oil at or near residual saturation are common in Guadalupian strata and are found where no hydrocarbon entrapment is observed and well beyond the footprint of producing oil fields. Static reservoir modeling has been used to explain these residual oil zones as transition zones even when evidence of hydrodynamic displacement is clearly present. All oil reservoirs have an interval below the oil-water contact where the oil saturation decreases rapidly with depth (transition zones). The thickness of this interval is controlled by capillary forces and as a function of fluid dynamics, as rocks with thicker zones developing when rocks are oil-wet as opposed to those with pores that are water-wet (Melzer, 2006). ROZs include the transition zones but also include residual oil within intervals that have been subjected to hydrodynamic displacement processes and exist at thicknesses much greater than what would be attributed to normal capillary effects. The hydrodynamic processes for ROZ formation can be described as either regional or local basin tilt, breached and reformed seals, or altered hydrodynamic flow fields (Melzer, 2006). These processes have been described as "Mother Nature's Waterflood" that occurs after an initial accumulation of oil in the subsurface trap. For a more detailed description of ROZ types, see Melzer et.al. (2006).

The hydrocarbons in the San Andres Formation became trapped at the shelf due to the loss of porosity and permeability from infilling by evaporites and secondary recrystallization, and sealed above and below by relatively impermeable evaporite and other carbonate deposits.

Modeling of the San Andres Residual Oil Zones

Now that it was recognized that, lateral flushing mechanics was a plausible explanation for the ROZs, such a process might be modeled in a hydrological sense to attempt to better understand the process, characterize the reservoirs, and explain the nature of the economic potential of the intervals. This study was designed as an attempt to model a specific fairway of flushing rimming the Delaware Basin portion of the greater Permian Basin and would require an extensive data collection effort from historical wells and studies in an attempt to characterize both the input rock properties and fluid characteristics.

The investigation of ROZs requires a multidisciplinary team. The science of lateral oil flushing has components of geochemistry, biochemistry, reservoir engineering, and geology including tectonic stage reconstruction. This team gathered data from the Artesia Fairway, ***Exhibit D-12***, of interest and consisted of well logs, formation tops, drill stem tests, core data, geological and hydrological studies. Essential data also came from earlier studies having to do with Capitan Reef hydrology, professional association compendia and their oil field studies, and regulatory agency required oil and gas data reporting.

The Arcadis modeling team, were faced with the unenviable task of characterizing not only the modern fairway hydrodynamics but also the Tertiary aged flushing mechanics that would be so important to the sweeping of the paleo traps and formation of the ROZs.

Their work required a geologic reconstruction to a level and purpose that had never been accomplished before. A USGS developed modeling package, ModFlow, was chosen as it was developed for modeling groundwater flow over large area such as the Artesia Trend.

The results of the data collection formed the basis for a hydrological model simulation wherein modern hydrological conditions were used to calibrate the model in order to project back in geological time to the predominate period of entrapment flushing. The results of the model work would be subject to a large number of assumptions, but could be constrained by the observations of tilted oil water contacts, sulfur occurrences, water salinities, and other anecdotal data that, taken in aggregate, provides confidence of the model and flushing process.

Results of the study confirmed the presence of thick and extensive greenfield ROZs, i.e., where no main pay zones are present. The hydrodynamic modeling demonstrated that the mechanics of flushing are measured in units of tens to hundreds of feet (movement) of water per 1000 years. This agreed with independent, analytical calculations of piezometric head effects on oi/water contact tilts and attempts to model the process using modern first-principle physics and simulators (Koperna and Kuuskraa, 2006).

The Artesia Fairway, ***Exhibit D-12*** was found to extend from Northwest Shelf of New Mexico east to the Central Basin Platform and then south along the West side of the platform to Pecos County. The lateral limits of the fairway on the west side of the Central Basin Platform were defined as the San Andres shelf to basin transition on the basin side, and on the east platform side transition from the intertidal carbonate dominated faces to the evaporite dominated sabkhas facies tract.

In addition to horizontally dividing the trend based on facies and permeabilities, the trend was divided vertically into a number of different, stratigraphically distinct, intervals within the San Andres, ***Exhibit D-13***. The middle – upper San Andres "Judkins" interval has been identified as the "flow path". Careful investigation of present Hydrologic regime and of the hydrologic regime before the withdrawal of water for agriculture and water flooding of oil fields has allowed calculation of rock and water properties to put into models of water flow in past geologic time. The model calculates tilt in oil water contacts as exist in a number of fields. It is determined that between 46 and 17.3 pore volumes of water have passed through the Artesia trend!

Identification of the Artesia Fairway favorable for individual ROZ deposits should allow explorationists to focus exploratory efforts to find them. Dissemination of information about ROZs through lectures and symposiums both locally and country wide has led to new CO_2 EOR projects targeting just ROZs in addition to adding stratigraphic sections of ROZs to the CO_2 floods already underway in old producing fields of the Permian basin.

Once the presence of widespread ROZ's was recognized, modeling of the development of how the ROZ's formed was necessary.

The simulated gradient through Ward and Winkler County was 6.1 feet/mile. The flow rate through Ward and Winkler County was 6.3 gpm. Flow moving southward through the Fairway in Ward and Winkler traveled to the discharge points in the San Andres in northern Pecos County represented by the sulfur mine locations. The water from Ward and Winkler County combined with water discharge from the reef complex in northern Pecos County to provide a total discharge of 891 gpm at the sulfur deposit locations. The simulated water budget for the geologic past is summarized in ***Table D-2***.

The simulated groundwater flow velocity through the Artesia Fairway in Ward and Winkler County in the geologic past was also estimated from the model. Because groundwater velocity is proportional to the permeability of the formation, the velocities were different for each permeability zone of the Artesia Fairway assigned to the model (***Exhibit D-13***). Groundwater flow velocity is also proportional to the porosity (n) of the formation. Porosities of the San Andres were assumed to range from 6 percent to 16 percent with an average porosity of 10 percent (Summers, 1972). A range of velocities for each permeability zone was obtained from the model using the low range, average, and high range porosities. The ranges of simulated velocities are summarized in ***Table D-2***. The number of pore volume flushes that have occurred through the Artesia Fairway in Ward and Winkler County in the geologic past was also estimated using the model to determine if sufficient flushing of the Fairway could have occurred to reduce hydrocarbon accumulations to residual saturation. The pore volume calculations were performed for the permeability zone at the center zone of the porosity zone (layer two) of the Fairway in Ward and Winkler County in ***Table D-2***. Most of the flushing through the Fairway would have occurred through this zone. The total pore volume was estimated by calculating the average thickness of the center zone of the porosity zone in layer two of the model, multiplying by the horizontal extent of the zone, and multiplying by the estimated porosity. The calculation was performed for the low range, average, and high range porosities described above. The total estimated pore volume ranged from 122 to 326 billion cubic feet, ***Table D-3***. The total flow volume through center zone of the porosity zone of the Fairway was calculated by taking the simulated flow rate through the center zone (5.35 gpm) and multiplying by the time period over which most of the flushing was assumed to have occurred. Assuming most of the flushing occurred in the late Oligocene and early Miocene, the time period of interest is approximately 15 million years. The total flow volume that would have occurred over 15 million years at 5.35 gpm is 5,642 billion cubic feet. The number of pore flushes that would result ranges from 17 for the high range porosity to 46 for the low range, ***Table D-3***. This is how much compared to usual commercial waterflood? Mother Nature is a very patient waterflood engineer. One important concept to keep in mind, despite the large number of pore flushes and the long time frame, ROZs are NOT flushed to 0 – 10% oil saturations. This is because most San Andres carbonate reservoirs are mixed wet and have more than one porosity/permeability relationship. The presence of this set of reservoir properties ***Exhibit D-14*** is the reason ROZs and long term waterfloods have similar responses to CO_2 EOR.

The impact on Permian reservoirs of recurrent movement on deep-seated faults.

The impact of recurrent movement of deep-seated Fault "A the Goldsmith Landreth San Andes unit (GLSAU) CO2 EOR project, Goldsmith Field, Ector County, TX" serves as an example of how complex the San Andres Reservoir in the Empire properties could potentially be. In GLSAU there are 12 producers north, 14 producers south, and 7 injectors directly above the Ouachita age Fault "A" identified in seismic. (***Exhibit D-15***) The producers south of the position of Fault "A" at depth took only 5 months to respond to CO_2 injection with a steady increase in oil and gas production. The injectors north of Fault "A" took 16 months to respond. This supports the hypothesis that reactivation of the fault altered the facies distribution and resulted in the development of fractures at the reservoir level. These fractures were later filled by anhydrite as serve as a barrier to flow. This response is also reported to be present at West Seminole Field. The faults do not appear to penetrate thru the San Andres in either the 3D survey at GLSAU or, as reported, in the 3D survey completed in the Goldsmith San Andres Unit to the south. Faults are reported to penetrate as shallow as the Clearfork but not the San Andres. The response to this movement in the San Andres therefore is "Flexing" or folding with associated fracture development.

There are examples basin wide of the impact of the periodic rejuvenation of Ouachita Tectonic elements on upper Permian reservoir distribution. The responses vary but there is widespread development of fracture sets in the San Andres, ***Exhibit D-16***. The response ranges from complete filling of the features creating barriers to horizontal and/or vertical flow, to partial filling or "Bridging" of open fractures allowing vertical and/or horizontal fluid flow, to the rock failing and simply fracturing with no later activity, to solution enhanced fractures that create high permeability pathways for fluid movement.

North Ward Estes - Guadalupian Response to Periodic Rejuvenation of Ouachita Tectonic Elements

There are examples basin wide of the impact of rejuvenation of Ouachita Tectonic elements on upper Permian reservoir distribution. In the North Ward Estes area, there are several Queen Sand fields at depths of ~3000', the Monahans South, Monahans, Monahans West and East Flat Fields whose location are correlated to position of the Quachita tectonic elements at depths of 8500'. This relationship strongly suggests that there was periodic rejuventation of these deeper elements throughout the upper Permian. From the original discoveries North Ward Estes in 1935 in the Yates and Queen sands thru the deeper (7800 - 8500') Pennsylvanian discoveries in the 1950's and 1970's, there has been only a scattering of wells that produced economic quantities of oil from the Wolfcamp thru the Grayburg. These reservoirs were assumed to be non-productive or with only isolated producing wells. This interval is now known to be a series of reservoirs with swept, stacked ROZs.

NORTH WARD ESTES – Multiple Stacked ROZ's

At North Ward Estes Field there is long established production from the Yates and Queen Sands (1935), Pennsylvanian Clastics (1950's) and Pennsylvanian Carbonates (1950's and 1970's), and minor production from a number of mid.-upper Permian reservoirs. It was not until the early 1990's, however, that more widespread production from the middle Permian (Tubb, Clearfork, San Angelo and upper and lower San Andres) was established.

The interval between the Pennsylvanian and Queen was evaluated as Chevron was considering not re-leasing the Hutchin Stock Association lease (47 Sections) in the heart of the North Ward Estes Field. Although a number of wells resulted in successful completions, there were a larger number of wells that bore the characteristics of high producing ROZ's.

In December 1991, Chevron completed the first of the recommended re-completions, a plug back to the San Angelo/Glorieta of a Penn gas well that was scheduled to be plugged. After Christmas, the first plug back, the Gulf #79 W. A. Estes (Strawn Detrital), flowed oil, and was completed a new pool discovery for IPF 149 BO, 175 MCF, 81 BW on January 3, 1992. This led to recommendations for a number of plug backs and deepenings, and new drills being made as a result of the evaluation.

There is a relationship, between the distribution of these new discoveries in the middle to late Permian carbonate and the location of the Ouachita related structures, ***Exhibit D-18***.

This distribution is similar to that seen in the Queen, ***Exhibit D-17***, but in addition has a correlation to the distribution of Canyon and Cisco carbonate production.

Between 1991 & 2015, over 160 wells were plugged back, deepened, or drilled, in the Leonardian & L. Guadalupian resulting in the discovery of >7.8 MMBO & 8.75 BCFG (RRC, 2023). Including 34 wells in the lower San Andres (McKnight) and 41 wells in the upper (Judkins) San Andres. Interestingly, only 23 of the >160 wells had IP's with oil cuts >50%. Why such odd results? The reservoirs are a mix of stacked ROZ's & Open and Restricted Marine, Tidal Flat Capped Main Pays, ***Exhibit D-19***.

With the exception of the 11 wells in the W. A. Estes (San Angelo) Field, four (4) wells completed in the McKnight (lower San Andres), four (4) wells completed in the Judkins (upper San Andres), and one (1) in the Tubb Carbonate (lower Clearfork), all wells have high water cut and should be considered as high saturation ROZ's. The wells in the W. A. Estes Field in the San Angelo have the highest oil cuts, whereas the wells in the Tubb/WichitaAlbany have the lowest. These 4 reservoirs are therefore a mix of strato-structural traps and ROZs with variable oil saturations.

Of most interest in this dispute is the production, ***Table D-4 & Table D-5***, from the McKnight (lower), and Judkins (upper) San Andres. The North Ward Estes area is part of the Artesia Trend and was part of the modeling study. At North Ward Estes, the upper and lower San Andres form two separate reservoirs. The wells with the higher oil cuts are on the flanks of low relief structures. The bulk of these wells represent ROZ with variable saturations. It is unknown at this time if the upper and lower San Andres in Empires fields are separated by tighter rock, or if those same members, JDKN & MCKT members act as a single reservoir or if the fracturing seen in the available core at EMSU connects the reservoirs. What this study does indicate is that there is a high probability that there is potentially a thick ROZ in San Andres.

Sulfur Water & Where did the Oil Go?

R. Lindsay in his testimony has noted the presence of waters with distinctive chemistries in the Grayburg, Goat Seep and San Andres. The waters in the San Andres in AGU, EMSU, and EMSU B are identified as "sulfate rich", and chloride poor. The Grayburg water is identified as chloride rich, possibly due, in part, to injection into the Grayburg of San Andres water. The Goat Seep is classified as "Fresh". Bob Lindsay has informed me that there is considerable barium in the connate waters in the Grayburg due to dissolution of feldspars in arkosic-rich intervals. By injecting sulfate rich water from the San Andres into the Grayburg, Barium sulfate scale is generated.

The presence of "sulfur water" in the San Andres ROZ has been identified (Trentham, 2015a) as a key indicator of meteoric derived sweep in the San Andres elsewhere in the basin. There is anecdotal evidence from discussion with a number of operators of a "different" water chemistry in the ROZ in many of the Brownfield ROZ CO_2 EOR projects on both the Central Basin Platform and the Northwest Shelf. This difference is usually manifests as "a different scale than seen in the Main Pay. The scale in ROZs is typically sulfate rich.

During the evaluation of the Leonardian and lower Guadalupian at North Ward Estes in the early 1990's, one of the characteristic of the fluids recovered on Drill Stem Tests in the San Andres and Grayburg was the presence of Sulfur Water of Black Sulfur Water, ***Table D-6*** is a partial set of the recoveries in DST from the Grayburg, U. San Andres (JDKN), and lower San Andres (MCKT), ***Exhibit D-20***. The formation waters recovered in DSTs from these wells were reported as being Sulfur Water. The work of Vance (2015, 2017) supports the change in the water chemistry from pre to post Meteoric Sweep.

Native sulfur is also present in the lower ROZ in a large percentage of cores, recovered from Tall Cotton, GLSAU, McCamey, and North Ward Estes upper and lower San Andres, San Angelo and Queen.

Two questions need to be asked, why is the San Andres formation water different than the Grayburg, and where did the oil go when it was flushed from the San Andres? Having an understanding of Sulfur Biogeochemistry is critical to understanding why the connate waters are sulfate rich in the San Andres. Sulfate Reducing Bacteria (SRB) were present in the San Andres and when the meteoric derived flushing fluids entered the San Andres initiated the reaction to consume oil and generate H_2S, ***Exhibit D-21***. Hydrocarbons are consumed and graded by sulfate reducing microbes. That process generates hydrogen sulfide that inhibits microbial activity at concentrations over 100 to 200 mg/L – which prevents total hydrocarbon consumption. Sulfate reducing microbes also generate biosurfactants that enhance the mobility of petroleum in the flow system and help drive changes in carbonate porosity and mineral suites.

To reduce the oil saturations from the initial 70-85% in the ROZ interval before flushing to ROZ type saturations, the two processes: activity of SRBs and the flushing of oil thru the system must go hand in hand. At the southern end of the Artesia Trend in Pecos County, there are a number of uneconomic sulfur deposits that represent one of the exit points of the system where mobile oil was, in part, converted to sulfur. It is estimated

(Eager, 2015, Pers. Comm.) that potentially a billion barrels of oil was necessary to generate the sulfur deposits seen there. This would also support the flushing of oil from ROZ intervals up trend.

Methodologies Employed to Produce Oil from the ROZ

In the San Andres, on the Central Basin Platform and Northwest Shelf, there are a number of methodologies being tested or employed to produce oil from San Andres ROZs. *All of these projects would be impossible, or would be severely economically challenged, if Goodnight's produced water were to be continued to be injected into the ROZ the AGU, MSU, MSUB reservoir interval prior to, or during, the chosen EOR effort.*

ROZ Only Vertical flood

Tall Cotton Field essentially mimics a classic main pay CO_2 flood. *The injection by Goodnight of any additional produced water into either the ROZ CO_2 flood interval, or beneath it would destroy the effectiveness of a classic WAG pattern of alternating CO_2 and water injection, rendering the project uneconomic.*

Mixed CO2 Flood - Main Pay & ROZ Single Produced and Separate Injectors

Seminole Field is an examples of "Mixed" Main Pay and ROZ (see above) produced together, At Seminole, the operator is employing dual injectors (one in the main pay and one in the ROZ) and single producers, open in both the main pay and ROZ across much of the field. *If Empire were to attempt to inject into both the Grayburg and San Andres at the same time and have producing wells open in both zones, the presence of Goodnights SWD wells would have the potential to render this type of flood uneconomic.*

Single Vertical Injectors and Producers Open in Main Pay and ROZ

Goldsmith Landreth San Andres Unit in northwestern Ector County, TX is an example of Co-mingled Main Pay and ROZ with vertical injectors and producers open in both intervals in the San Andres. *The injection of any additional produced water into either the ROZ or main pay CO_2 flood interval, or beneath it would destroy the effectiveness of this classic WAG pattern of alternating CO_2 and water injection, rendering the project uneconomic.*

Depressuring the Residual Oil Zone - DUROZ

Platang Field in southwestern Yoakum County, TX is an example of a DUROZ production method, Depressuring the Upper Residual Oil Zone, that does not use CO_2. The method employs horizontal wells land high in the ROZ/Oil Column that cannot be economically produced with vertical wells. Initially, the operator will use submersible pumps to produce 500 – 2,000 barrels of fluid a day. Often the well is pumped for 30 to 60 days before the first oil is produced. The drop in pressure associated with the high volumes of water produced would result in swelling the oil and the development of a solution gas drive. Since the only way to produce economic volumes of oil is by reducing the pressure. Platang Field total Production >72,000,000 BO since 2006. *Continued injection of produced water by Goodnight into the San Andres in Empire's San Andres would render DUROZ impossible.*

Platang Field – Brushy Bill CO_2 Flood

Riley Permian, in southcentral Yoakum in the eastern portion of **Platang Field** has initiated the Brushy Bill pilot with vertical CO_2 injectors and horizontal producers in the San Andres. This is a modification of the DUROZ production method by adding vertical CO_2 injectors. As in any of the CO_2 EOR methods in the San Andres ROZ, the injection of any additional produced water into the ROZ flood interval, or beneath it would destroy the effectiveness of this classic WAG pattern of alternating CO_2 and water injection being initiated in the field, rendering the project uneconomic.

EMSU Huff-n-Puff

Empire proposed a "CO_2 Huff-n-Puff" in EMSU with vertical wells to test the concept of developing EMSU SA ROZ CO_2 Flood. Testing the San Andres ROZ with vertical Huff-n-Puff well(s) is a method used elsewhere to test the viability of a CO2 Flood in the ROZ. The success of this type of test requires Static Conditions. *Goodnight's injection of produced water would render this test invalid.* A Huff-n-Puff CO_2 test has been used to evaluate the CO_2 potential by Texaco in **Vacuum & in Slaughter Levelland Fields.**

"Bubble Up"

In the Sable Field (San Andres) in central Yoakum County, ER Operating is initiating a project with horizontal CO_2 injection wells landed deep, and producing wells shallow in the San Andres Greenfield ROZ in the ROZ and utilizing the presence of good Kv/Kh to drive the oil upward to the 9 producing wells in the upper ROZ. *Continued injection of produced water by Goodnight into the San Andres in Empire's San Andres would render a "Bubble Up" CO_2 flood impossible.*

In summary, ROZ intervals are very prevalent in the Permian Basin. *Core and log information confirms the presence of a ROZ at EMSU, EMSU-B, and AGU. Goodnight's continued injection of off lease produced water into the San Andres reservoir within and near EMSU will greatly diminish or destroy Empire's ability to employ any potential EOR* *methodology in their properties. Disposal of off lease saltwater by a 3rd party Company should be terminated inside the waterflood units where a Main Pay Zone or ROZ interval exist so that EOR processes can be properly implemented.*

I understand this Self-Affirmed Statement will be used as written testimony in this case. I affirm that my testimony above is true and correct and is made under penalty of perjury under the laws of the State of New Mexico. My testimony is made as of the date next to my signature below.

Robert C. Trentham

Date: August 21, 2024

Curriculum Vitae

ROBERT C. TRENTHAM
Professor of Practice in Geosciences
University of Texas Permian Basin
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Education

January 1970	B.S., Geology	City College of New York
June 1976	M.A., Geology	City College of New York
August 1981	D.G.S., Geology	University of Texas El Paso

Academic Experience (recent)

September 2023 – Present Professor of Practice, Geosciences Department, UTPB.

September 2019–August 2023 Senior Lecturer & Research Associate, Geosciences Dept, UTPB.

April 2001- Aug 2019 Director of CEED, Senior Lecturer in Geology at UTPB.

Continue to work with industry and faculty to develop research in state-of-the-art Enhanced Oil Recovery and Carbon Capture and Storage. Teach part of Industry classes: CO2 Flooding School, Young Professional Field Trip, Carbon Capture, Utilization, and Storage (CCUS) classes.

Revised and taught Graduate Courses in Advanced Subsurface Methods, and Petroleum Geology. Developed and taught Arid Lands Hydrology, and Exploration and Production Logging. Added to the curriculum and taught Undergraduate Courses in Geology of the Permian Basin, Sample Description, Core Description, Sequence Stratigraphy, and Sedimentary Rocks for Engineers. Revised and taught Sedimentary Rocks for Geologist included adding Lab.

CEED director duties included coordinating with local industry and governmental entities to study oil and gas and alternative energy issues and promote economic development and diversification.

January - April 2001 Adjunct Lecturer, Geosciences, UTPB.

Industry Experience

August 1992 – April 2001	Consulting Geologist, DBA Muskoka Consultants.	Midland, TX
July 1985 - July 1992	Senior Geologist, Chevron, U.S.A.	Midland, TX
February 1980 - June 1985	Project Geologist, Gulf Oil Co.	Midland & Odessa, TX

Significant Professional Achievements and Areas of Specialization

- Expertise in Carbon Capture Utilization & Storage
- Expertise in Residual Oil Zones.
- Expertise in CO2 Enhanced Oil Recovery.
- Instructor at numerous Petroleum Industry CO2 Flooding schools, including international schools.
- Instructor at numerous CO2 Carbon Capture Storage and Utilization schools.
- Board Member, Annual CO2 Flooding Conference 2001 - Present.

Department of Energy grant - Carbon Utilization and Storage Partnership (CUSP) of the Western United States, Awarded October 2019, Principal Investigator, Robert Balch PRRC, New Mexico Tech. Drs. R.

Trentham & M. Henderson are Subcontractors. UTPB has received, from the original grant, and subsequent modifications, an awarded of ~$450,000 for 3 years.

Principal Investigator or Investigator for several completed Department of Energy/Research Partnership to Secure Energy for America Residual Oil Zone CO2 related projects. Including:

- Department of Energy, DE FOA 0000080. Recovery Act: Regional Sequestration Technology Training **"Carbon Capture and Storage in the Permian Basin, A Regional Technology Transfer and Training Program."** Co-PI's: Petroleum Technology Transfer Council, American Association of Petroleum Geologists, Applied Petroleum Technology Academy. Total Funding Requested: $994,998.00 UTPB/CEED as Subcontractor: $84,270, for 3 years. Period of Performance: November 1, 2009 – September 30, 2013.

- The Research Partnership to Secure Energy for America (RPSEA) Number: RFP2008SP001. Application to Improved Oil Recovery for Small Producers. **"Commercial Exploitation and the Origin of Residual Oil Zones: Developing a Case History in the Permian Basin of New Mexico and W. TX".** Co-PI's Robert C. Trentham, Steve Melzer. Funds Requested: $961,934.00. RPSEA Share: $630,934.00. Industry Match: $331,000.00. Period of Performance: April 01, 2009 – March 31, 2011.

- Department of Energy DE FOA 0000032. Recovery Act: **"A Modular Curriculum for Training University Students in Industry Standard CO2 Sequestration and Enhanced Oil Recovery Methodologies".** Co-PI's: Dr Emily Stoudt, Dr Robert Trentham, Funds Requested $ 296,000.00, for 3 years. Period of Performance: Dec 1, 2009 - May 31, 2013.

- The Research Partnership to Secure Energy for America (RPSEA). Application to Improved Oil Recovery for Small Producers. **"Identifying and Developing Technologies for Enabling Small Producers to Pursue the Residual Oil Zones (ROZ) Fairways in the Permian Basin, San Andres".** Co-PI's Robert C. Trentham, Steve Melzer .Funds Requested: $1,243,369.98, RPSEA Share $859,269.98. Industry Cost Share $ 374,100.00. Period of Performance: May 1, 2011 – December 21, 2015. RPSEA 10123.17.FINAL

- National Energy Technology Laboratory. Number: Unconventional Fossil Energy Funding Opportunity. **"Using Next Generation CO2 EOR Technologies to Optimize the Residual Oil Zone CO2 Flood at Goldsmith Landreth Unit, Ector County, Texas"** PI: Robert Trentham. DOE Funds Requested: $1,198,547.00, Industry Match $654,563.00. Period of Performance: Feb 23, 2011 - June 30, 2015. DE FOA 0000312.

- Member Permian Basin FutureGen Task Force 2005-2008.

- Manager and Principal Investigator. Department of Energy, Class II Shallow Shelf Carbonate Study, Foster-South Cowden (Grayburg and San Andres) Field, Ector Co., TX. 1994 - 2000.

- Industry Highlights:
    - Exploration Pathfinder, Chevron with exploration experience in Permian, Palo Duro, Dalhart, and Hardeman Basins of West Texas and SE New Mexico.
    - Discovered Wolf Flat Field in Pennsylvanian (Cisco) carbonates, Motley Co., TX, and W. A. Estes (Holt) Field and Monahans, N.W. (San Angelo) Field, Ward Co., TX.
    - Reservoir Geologist at Sand Hills (San Andres, Tubb, Ellenburger) Crane Co., TX; Wagon Wheel (Canyon & Cisco) and North Ward Estes (Yates & Queen) Ward Co., TX. Project

- Core and reservoir studies of numerous Upper Permian Reservoirs:
    - Leamex Field, Lea Co., NM, for Phillips Petroleum.
    - McCamey Field, Upton Co., TX, for Burlington Resources.
    - East Cowden Field, Ector Co., TX, for Conoco.
    - Fuhrman Mascho Field, Andrews Co., TX, for Conoco.
    - Sand Hills Field, Crane Co., TX, for Burlington Resources.
    - Outcrop study of the Apache Mountains, Culberson Co. TX. Studying outcrop analogs to producing Permian Basin fields. 1998 – 2003.
    - Local expertise in Karsted Reservoirs (Ellenburger, Pennsylvanian, and Permian).

Awards

- **The 2023 Grover E. Murray Memorial Distinguished Educator Award. From the American Association of Petroleum Geologists.** A 40,000 member professional association. 1-2 Awards given a year.
- ***Energy and Technology Award***, by The Permian Basin Petroleum Pioneers along with Steve Melzer, received October, 2019.
- The ***A. I. Levorsen Memorial Award*** recognizes the best paper presented at each AAPG Section meeting, *"with particular emphasis on* creative thinking *toward* new ideas *in exploration"*. Southwest Section, American Association Petroleum Geologists, May 2017.
- ***Volunteer of the Year Award,*** by Permian Basin Section SEPM, 2014-2015.
- ***Distinguished Educator Award*** by the Southwest Section, American Association of Petroleum Geologists, April 8, 2013. Given *"in recognition of distinguished and outstanding contributions to geological education with respect to petroleum geology in the Southwest Section area."*
- ***Top Speaker, "General Geology of the Southwest",*** Southwest Section, American Association of Petroleum Geologists, Ruidoso, 2011.
- ***Best Paper,*** West Texas Geological Society Fall Symposium 2008
- ***Honorary Life Member,*** Permian Basin Section S. E. P. M, 2008.
- ***Honorary Life Member***, West Texas Geological Society, 2008.
- ***Dedicated Service Award***, West Texas Geological Society, 2004-2005.

Professional Societies Membership

American Association of Petroleum Geologists (AAPG),
Society of Sedimentary Geology (SEPM),
West Texas Geol. Society (WTGS) – Past President & Honorary Life Member,
Permian Basin Section-SEPM – Past President & Honorary Life Member
Geological Society of America (GSA).

Professional Society/Organization Activities

Annual CO2 Flooding Conference, Board Member, 2001 to Present.
Applied Petroleum Technology Academy (APTA), Board Member, 2002 to Present.
PBS-SEPM Young Professional & Intern Field Trip Co-Leader 2011-Present
Midland Energy Library, Past-President (2004 -2008), Board Member 1997 - Present

Recent UTPB Classes

Current - Spring 2024

GEOL 3212 Sedimentary Rocks for Engineers

*GEOL 6346 Petroleum Geology of the Permian Basin***

*GEOL 4346 Petroleum Geology of the Permian Basin***

GEOL 4101 Sample Description**

GEOL 6170 Sample Description**

GEOL 6399 Master's Thesis

** Stacked Classes*

***Stacked Classes*

Fall 2023

*GEOL 4317 Geology of the Permian Basin**

*GEOL 6317 Geology of the Permian Basin**

GEOL 1301 Physical Geology

GEOL 6399 Master's Thesis

** Stacked Classes*

***Stacked Classes*

Spring 2023

GEOL 3212 Sedimentary Rocks for Engineers

GEOL 3304 Igneous & Metamorphic Petrology

GEOL 4102 Core Description

Fall 2022

*GEOL 4349 Well Logging**

*GEOL 6349 Exploration & Production Logging**

GEOL 6357 Volcanology

** Stacked Classes*

Spring 2022

GEOL 3212 Sedimentary Rocks for Engineers

GEOL 6347 Subsurface Methods*

GEOL 4389 Subsurface Mapping*

GEOL 4101 Sample Description**

GEOL 6101 Sample Description**

** Stacked Classes*

***Stacked Classes*

Fall 2021

*GEOL 4317 Geology of the Permian Basin**

*GEOL 6317 Geology of the Permian Basin**

*GEOL 6346 Petroleum Geology of the Permian Basin***

*GEOL 4389 Petroleum Geology of the Permian Basin***

GEOL 6399 Master's Thesis

** Stacked Classes*

***Stacked Classes*

Spring 2021

GEOL 3212 Sedimentary Rocks for Engineers

GEOL 3304 Igneous & Metamorphic Petrology

GEOL 4102 Core Description

GEOL 6102 Core Description

GEOL 6699 Master's Thesis

Publications:

A total of over 90 publications and numerous oral presentations on CO2 EOR, Residual Oil Zones, & Carbon Capture Utilization & Storage associated with Permian Basin reservoirs, including Queen, Grayburg and San Andres (Guadalupian), Pennsylvanian and Ellenburger (lower Ordovician). Additional studies of uranium in volcanics and volcano clastics and feldspar geochemistry.

-

Recent Conference Presentations and Schools

Melzer, L.S., Wackowski, R., Trentham, R.C. CO2 EOR School for Hilcorp, Presented by Applied Petroleum Technology Academy(APTA), Houston, TX, May, 2024.

Lindsay, R. F., R. C. Trentham, West Texas Geological Society 100 Year Anniversary: A Core Workshop of Early Permian Basin Field Discoveries. Presented at the Southwest Section American Association Petroleum Geologists, Abilene, TX, April 2024.

Lindsay, R. F., R. C. Trentham, West Texas Geological Society 100 Year Anniversary: A Core Workshop of Early Permian Basin Field Discoveries. Presented at the West Texas Geological Society 2023 Fall (WTGS) Symposium, Midland, TX. September, 2023.

Trentham, R. C., CCUS: Emerging Professionals and Workforce Development. Invited panel chaired by Denise Hills, with John Grimmer, Paiden Pruett, Conn Wetherington, Priyank Jaiswal, at American Association of Petroleum Geologists Annual Convention.

Verma, Sumit,* , Esra Yalçın Yılmaz, Laura Ortiz Sanguino , Justin Yandell, Miles A. Henderson, Robert C. Trentham, 2023, Seismic attribute and well-log analysis for channel characterization in the upper San Andres and Grayburg formations of the Midland Basin, Texas, Energy Geosciences https://doi.org/10.1016/j.engeos.2023.100188

Trentham, Robert C., Cory Hoffman, Robert Campbell, Chris Fling, presented each year: June 2023. Previously presented June 2008, June 2010 - June, 1215, 2017 -2019, *PBS-SEPM Summer Intern and New Hire Field Trip, Guadalupe Mountains, Texas and New Mexico.* Field Guide and References, 1 volume.

Trentham, R.C. 2023, CCUS, A View From The Oil Patch. Abilene Geological Society. April, 22, 2023.

Kalina, M.T., Trentham, R.C., and Henderson, M.A. (2022). Evaluation of cementing phases in the Cherry Canyon Formation of the Delaware Mountain Group, Ford Geraldine Field, Texas. Geological Society of America Abstracts with Programs. Vol 54, No. 5, https://doi.org/10.1130/abs/2022AM-380656

Henderson, M.A., Lindsay, R.F., and Trentham, R.C. (2022). Treating carbon sequestration in heterogeneous reservoirs as a water alternating gas (WAG) CO_2 enhanced oil recovery flood. Geological Society of America Abstracts with Programs. Vol 54, No. 5, https://doi.org/10.1130/abs/2022AM-382814

Henderson, M.A., Brain, E.M, and Trentham, R.C. (2022). Reservoir properties of the Lower San Andres Formation on the Northwest Shelf of the Permian Basin. Geological Society of America Abstracts with Programs. Vol 54, No. 5, https://doi.org/10.1130/abs/2022AM-383632

Trentham, R. C., Tracy, D. 2022, TMBR-Sharp/Staley #2-22 Ligon St: An Example of lower Cherry Canyon Age Tectonism. Trentham, Robert C., Presented at the West Texas Geological Society 2022 Fall (WTGS) Symposium, Midland, TX.

Aminu, Abdulmutallib, A., Zobaa, Mohamed, K., Trentham, Robert C., 2022, Visual Kerogen Analysis of the Woodford Formation in the Superior #1 Richburg well, Delaware Basin. Poster Presented at the American Association of Petroleum Geologists, Southwest Section, Midland, TX.

Kalina, M., Trentham, R.C., and Henderson, M.A. (2022). Evaluation of cementing phases in the Cherry Canyon Formation, of the Delaware Mountain Group, Ford Geraldine Field, Texas. Southwest AAPG Convention, Midland, TX.

Fuller, M., Trentham, R.C., and Henderson, M.A. (2022). Understanding the Geochemistry of the Limestone-Dolostone Transition in the Residual Oil Zone in the lower Permian San Andres Formation, Permian Basin, Texas. Southwest AAPG Convention, Midland, TX.

Brain, E.M., Trentham, R.C., and Henderson, M.A. (2022). Reservoir Characterization of the Lower San Andres Residual Oil Zone for Utilization and Storage of Carbon Dioxide in Cochran and Yoakum Counties, Texas. Southwest AAPG Convention, Midland, TX.

Trentham, R.C., Brain, E.M., Kalina, M., Fuller, M., and Henderson, M.A. (2022). The Carbon Utilization and Storage Project of the Western USA: A View from the Oil Patch. Southwest AAPG Convention, Midland, TX.

Trentham, R.C. and Henderson M.A. (2022). The Carbon Utilization and Storage Partnership of the Western USA: A view from the oil patch. Geological Society of America Abstracts with Programs. Vol 54. No. 1. https://doi.org/10.1130/abs/2022SC-374287

Brain, E.M, Trentham, R.C., and Henderson, M.A. (2022). Reservoir characterization of the Lower San Andres residual oil zone for utilization and storage of carbon dioxide in Cochran and Yoakum Counties, Texas. Geological Society of America Abstracts with Programs. Vol. 54, No. 1. https://doi.org/10.1130/abs/2022SC-374225

Kalina, M.T., Trentham, R.C., and Henderson M.A. (2022). Evaluation of cementing phases in the Cherry Canyon Formation of the Delaware Mountain Group, Ford Geraldine Field, Texas. Geological Society of America Abstracts with Programs. Vol. 54, No. 1. https://doi.org/10.1130/abs/2022SC-373990

Fuller, M.J., Trentham, R.C., and Henderson, M.A. (2022). Petrographic and geochemical evaluation of the limestone-dolostone transition beneath the residual oil zone of the Lower Permian San Andres Formation, Ector County, Texas. Geological Society of America Abstracts with Programs. Vol. 54, No. 1. https://doi.org/10.1130/abs/2022SC-374266

Henderson, M.A., Fuller, M.J.*, and Trentham, R.C. (2021). Petrography and geochemistry of the limestone-dolostone transition in the residual oil zone of the early Permian San Andres Formation, Permian Basin, Texas. Geological Society of America, Abstracts with Programs, Vol. 53 (6). https://doi.org/10.1130/abs/2021AM-369364

Szypulki, J.*, Trentham, R.C., Henderson, M.A., and Verma, S. (2021). The effect of deep early Paleozoic faulting on Permian-aged strata with seismic attribute analysis in Ector County, Texas. Geological Society of America, Abstracts with Programs, Vol 53 (6). https://doi.org/10.1130/abs/2021AM-368033

Trentham, R. C., Miles A. Henderson 2021, Assessing Collapse Risk in Evaporite Sinkhole-prone Areas Using Commonly Available Oil Field Data in the Area of the Winks Sinks, Winkler County, Texas, *in* Evaporite Karst in the Greater Permian Evaporite Basin (GPEB) of Texas, New Mexico, Oklahoma, Kansas, and Colorado. K. S. Johnson, L. Land, and D. D. Decker; Editors, Oklahoma Geological Survey, Circular 113, p. 111 - 123.

Trentham, R. C., L. S. Melzer, M. A. Henderson, 2021, Stacked Greenfield & Brownfield Residual Oil Zones. North Ward Estes area, Western Margin of the Central Basin Platform, Permian Basin, Texas. Presented at the West Texas Geological Society Fall (WTGS) Symposium.

Brain, E, M.A. Henderson, R.C. Trentham, 2021, Facies of the Hudson #601 H Core, Cochran County, Poster presented at the West Texas Geological Society Fall (WTGS) Symposium.

Trentham, R.C., 2021, Kinder Morgan (Legado Resources) A CO2 Flood Front Caught in the Act, #203 RW GLSAU, San Andres Fm., Ector County, TX. Core presented at the West Texas Geological Society Fall (WTGS) Symposium post Symposium Core Workshop.

Brain, E., R. C. Trentham, 2021, Mammoth Exploration #601-H Hudson, San Andres Fm., Sable Field, Cochran Co., TX. Core presented at the West Texas Geological Society Fall (WTGS) Symposium post Symposium Core Workshop.

Lindsay, R.F., R.C. Trentham, L.S. Melzer, 2021 San Andres Residual Oil Zone (ROZ) Core Workshop. PBS-SEPM pub #21-54, vol. 1, 29 pages.

Lindsay, R.F., R.C. Trentham, L.S. Melzer, 2021, San Andres Residual Oil Zone (ROZ) Field Trip. PBS-SEPM pub #21-54, vol. 2, 84 pages.

Johnson, J.M., Trentham, R.C., and Henderson, M.A. (2020). Investigating the nature of the limestone-dolostone transition in the early Permian San Andres Formation, Goldsmith Landreth Field, Ector County, Texas. Geological Society of America, Abstracts with Programs, 52 (6). https://doi.org/10.1130/abs/2020AM-359649

Trentham, Robert C., 2020, *Carbon Utilization from the Permian Basin Perspective*. SEG Post Convention Workshop – CO2 Geophysical Monitoring: Achievements, Challenges and the Road Ahead (Virtual).

Trentham, Robert C., 2020 *A View of Carbon Utilization from the Oil Patch*. Unconventional Resources: Shale Gas & CBM Exploration & Exploitation, Virtual International Workshop.

Trentham, Robert C., 2019, *Tectonic History Considerations and Flow Fields*. Presented at the 2019 New Insights on Transmissive Faults/Fractures from the ROZ Studies and Horizontal Well Revolution Short Course, 25th Annual CO2 Conference, Midland.

Trentham, Robert C., L. Stephen Melzer, and David Vance, 2019, *Whose Fault Is It?* Presented at the West Texas Geological Society Fall (WTGS) Symposium, Midland Texas.

Trentham, Robert C., and L. Stephen Melzer, 2019, *A "Cookbook" Approach to Evaluating Residual Oil Zones completed by Horizontal Depressurizing of the Upper San Andres (DUROZ)*, American Association of Petroleum Geologists - Southwest Section Annual Meeting, Dallas, TX. AAPG Search and Discovery #51570.

Trentham, Robert C., 2018, *The Importance of a Well Developed Profile in the Horizontal San Andres Play in Yoakum Co., TX*. Presented at the West Texas Geological Society Fall (WTGS) Symposium, Midland.

Trentham, Robert C., Cory Hoffman, Robert Campbell, Chris Fling, 2018, *PBS-SEPM Summer Intern and New Hire Field Trip, Guadalupe Mountains, Texas and New Mexico*. Field Guide and References, 2 volumes.

Trentham, Robert C., 2018, *ROZs: Science and Fairways - An Update*. American Association of Petroleum Geologists - Southwest Section Annual Meeting, El Paso, TX. AAPG Search and Discovery #70353.

Trentham, Robert C., 2017, *Greenfield ROZ: Science and Fairways*. Presented at the 23rd Annual CO2 ROZ Conference, Midland, TX.

Trentham, Robert C., 2017, *Upper Leonardian on the Central Basin Platform, ROZs to Max Floods*. September 2017, presented at the West Texas Geological Society Fall (WTGS) Symposium, Midland, TX.

Melzer, L. Stephen, and Bob Trentham (Presenter), 2017, *ROZs in the Permian Basin: Exploiting via Horizontals and EOR.* presented at the International Association of Drilling Contractors (IADC) Shale Energy Workshop, Midland, TX.

Trentham, Robert C., Emily Stoudt, Robert Campbell, Chris Fling, presented each year: 2008, 2010 - June, 1215, 2017, *PBS-SEPM Summer Intern and New Hire Field Trip, Guadalupe Mountains, Texas and New Mexico.* Field Guide and References, 2 volumes.

Trentham, Robert C., 2017, *The Relationship Between the San Andres Regional Setting and Residual Oil Zones (ROZs) in the Permian Basin.* American Association of Petroleum Geologists - Southwest Section Annual Meeting, Midland, TX. AAPG Search and Discovery #51400.

Bennett, Craig E. (presenter), Benjamin W. Cleveland, and Dr. Robert C. Trentham, 2017, *The Victorio Peak, Cutoff, and Cherry Canyon Formations in the Apache Mountains: After Fifty Years, A New Look.*, American Association of Petroleum Geologists - Southwest Section Annual Meeting.

Trentham, Robert C., 2017, *Wolf Flat Field: Depositional Facies and Diagenetic Overprint of a Palo Duro Basin lower Cisco Shelf Margin, Motley County, Texas.* Abilene Geological Society (AGS).

Melzer, L. Steve, and Robert Trentham, David Vance, 2017, San Andres: the New Frontier, Horizontals, Residual Oil, and Core Workshop. Day-long Seminar and Core Workshop for PBS-SEPM.

Trentham, Robert, C., 2016, Residual Oil Zones (ROZ's) - From Science to Commercial Exploitation. 22nd Annual CO2 ROZ Conference, Midland, TX.

Trentham, Robert C., 2016, *The I-20 corridor: A Historical and Core Based Look at the San Andres, and SADR ROZ's, Across the Central Basin Platform.* West Texas Geological Society Fall (WTGS) Symposium, Midland, TX.

Trentham, Robert C., 2016, *A Residual Oil Zone (ROZ) History Lesson, ROZ Terminology, Geology, Mapping and Resource.* Society of Petroleum Engineers Liquids-Rich Basins Conference-North America, Midland TX.

Trentham, Robert C., 2016, *A "Cookbook" Approach to Exploring for, and Evaluating, Residual Oil Zones in the San Andres Formation of the Permian Basin.* American Association of Petroleum Geologists - Southwest Section Annual Meeting, Abilene, TX. AAPG Search and Discovery #51259.

Afuape, Olakemi, and Robert C. Trentham *Depositional Lithofacies and Diagenetic Overprints of Pennsylvanian Lower Cisco Shelf Margin Carbonates, Wolf Flat Field, Motley County, Texas, USA,* American Association of Petroleum Geologists - Southwest Section Annual Meeting, Abilene, TX. AAPG Search and Discovery #20352 (2016).

Trentham, Robert, C., 2011, "Residual Oil Zones (ROZ's) and the Long Term Future of the Permian Basin (and Elsewhere)", SPE Permian Basin Study Group of Gulf Coast Section.

Harouaka, A., B. Trentham and S. Melzer (2013). Long overlooked residual oil zones (ROZ's) are brought to the limelight. *SPE Unconventional Resources Conference Canada*, Society of Petroleum Engineers.

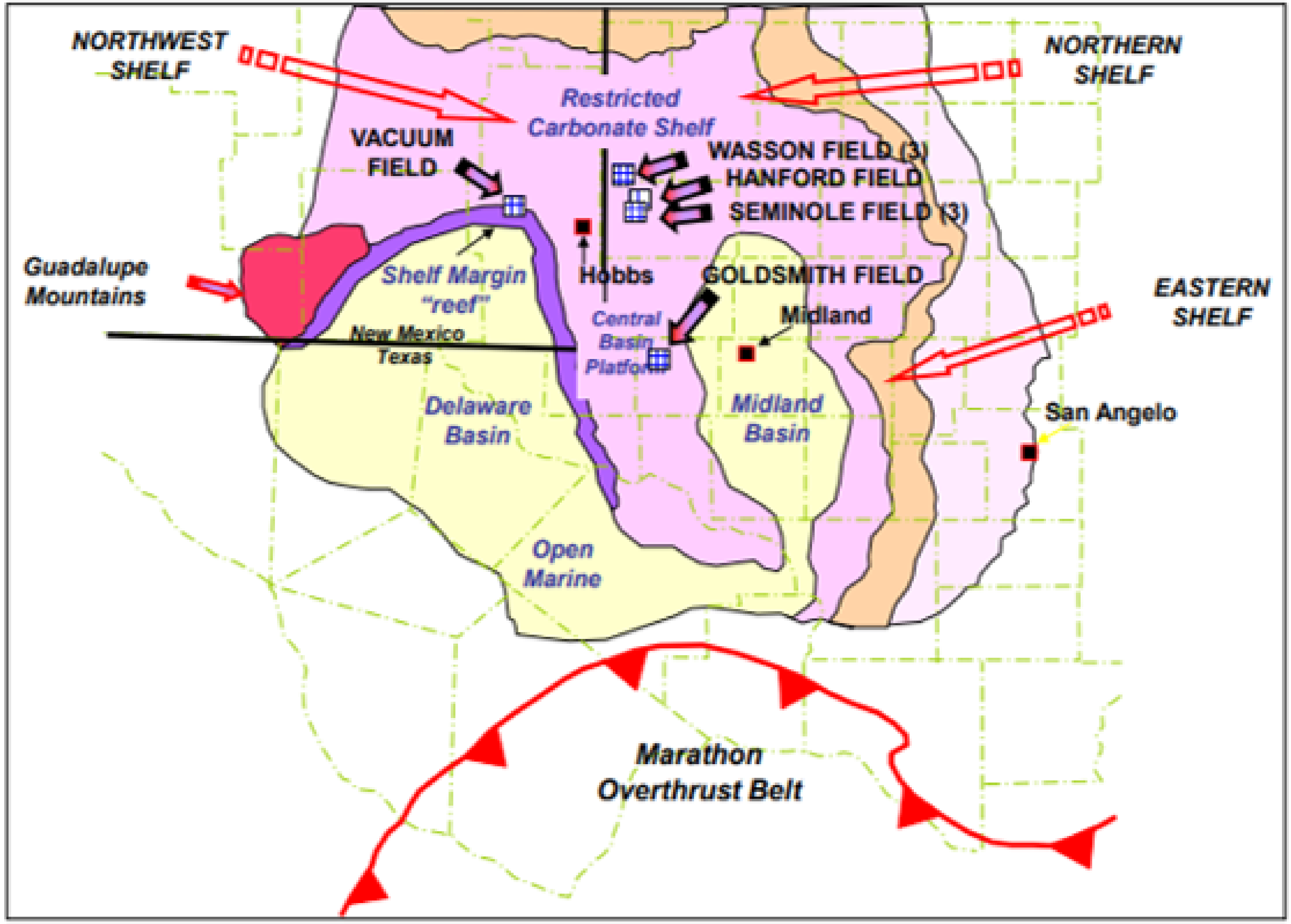
A series of presentations made as part of the 2016-2021 CO2 Flooding School held August each in Midland, TX:
"A Quick Look at Residual Oil Zones";
"Key Elements of Reservoir Geology";
"Flow Units and Reservoir Compartmentalization";
"Cycles, Stratigraphy, and the Geologic Reasons Why CO_2 *Floods Fail";*
"Geophysical and Geochemical Techniques for Monitoring CO_2 *Floods";*
"The Science of ROZs"; and
"The Permian Basin and an Update on Current ROZ RPSEA & Field CO_2 *Project Results"*

Part of the faculty of the PBS-SEPM "Intern and New-Hire Field Trip" a 4 day interactive training for summer hire and young professional Geologists, Engineers and Land Personnel. Team taught with Geologists, Engineers and Land Personnel. 2008 – 2019.

Military

1970 – 1976, New York Army National Guard. 101st Armored Calvary, 42nd Division. Highest rank - Second Lieutenant. Assistant Squadron Training Officer and Platoon Leader. In part, responsible for scheduling and presenting unit classroom training. Platoon Leader of 32 man platoon.

Exhibit D-1



Middle San Andres paleotopography illustrating the location of major ROZ projects.

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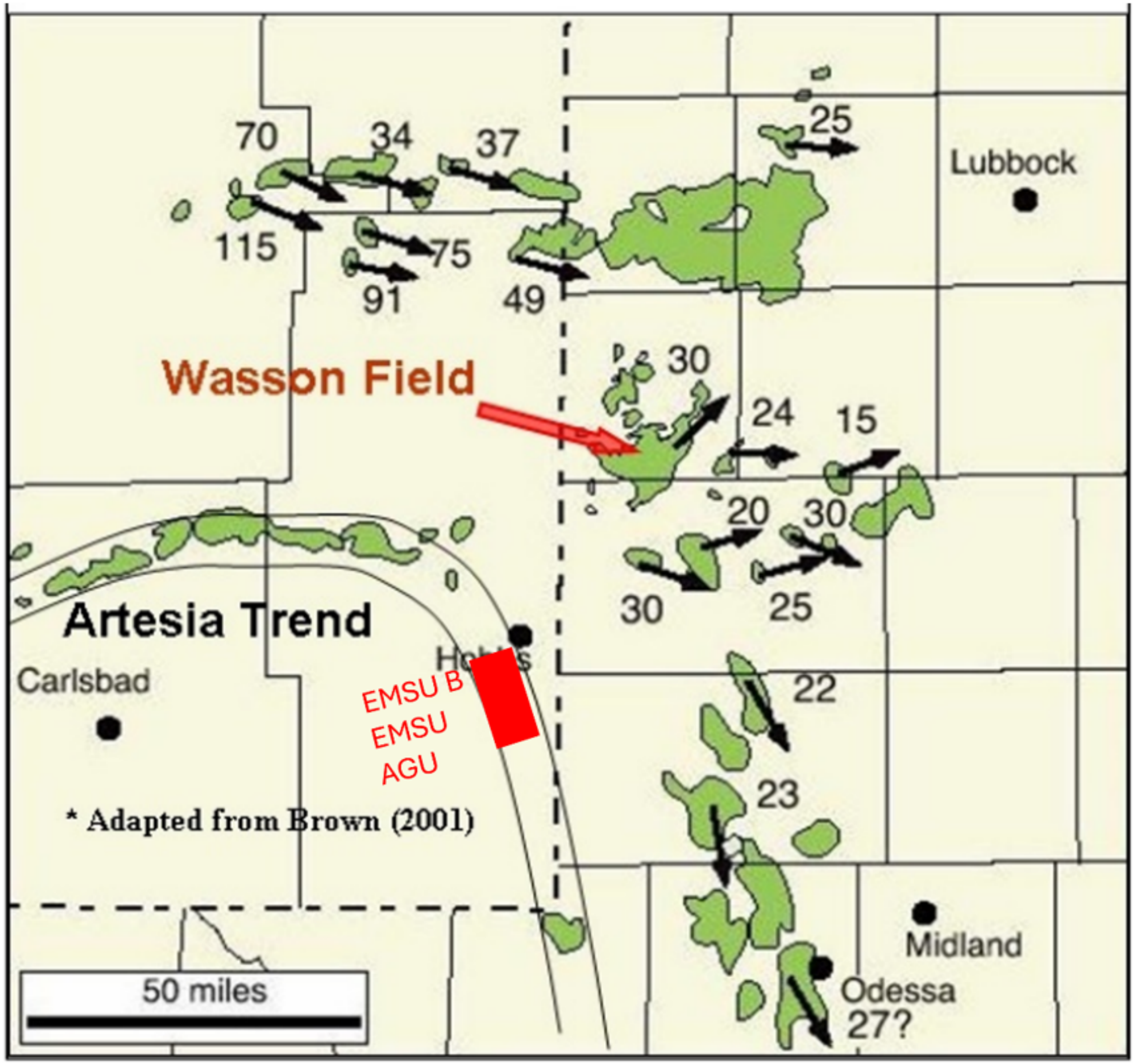
Exhibit D-2



Distribution of tilted oil/water contacts in the Northwest Shelf and Central Basin Platform areas of the Permian Basin. After Brown, 1999.

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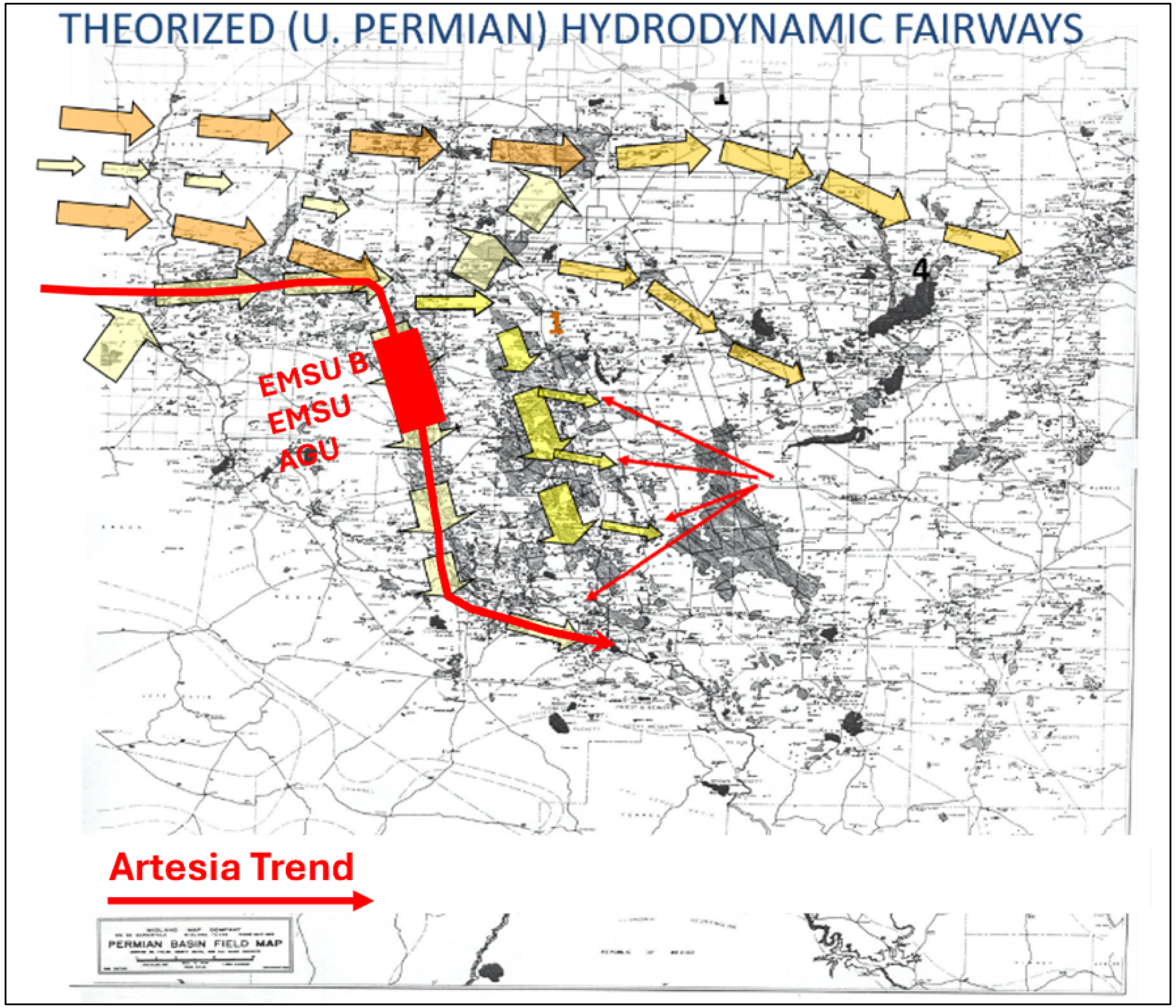
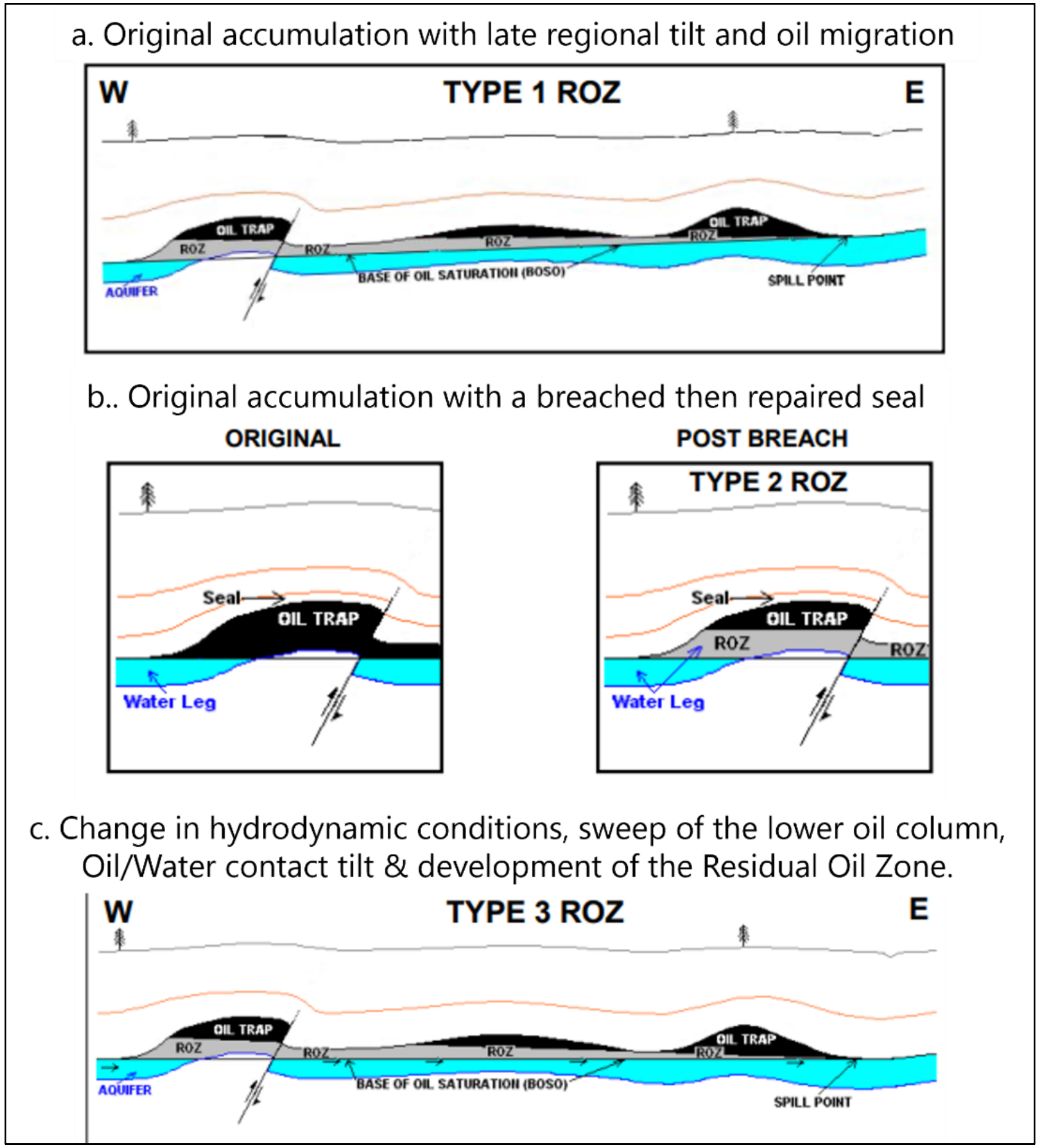
Exhibit D-3



Location (red box) of EMSU B, EMSU, and AGU along Artesia Fairway.

Exhibit D-4

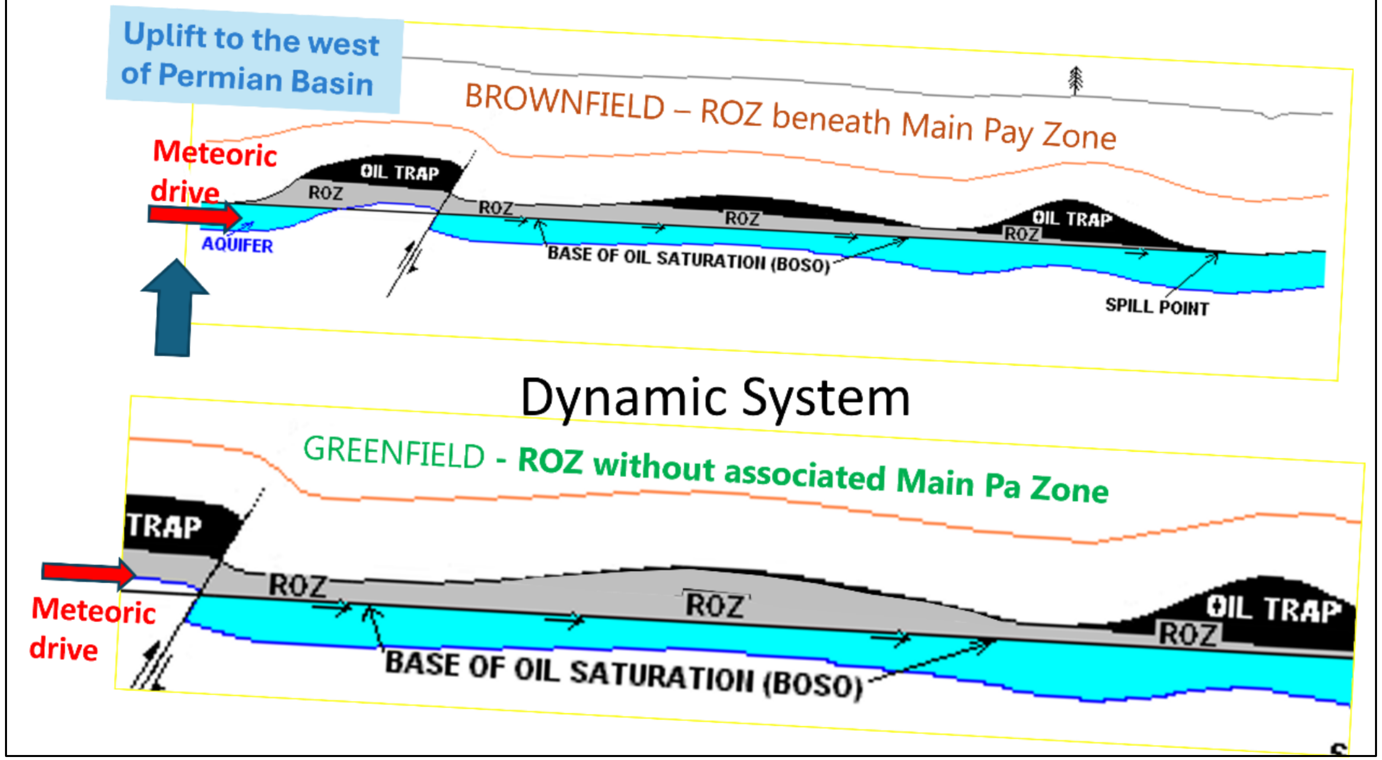


Types of ROZs. Type 3 are prevalent in the Permian Basin. Melzer, various.

Exhibit D-5

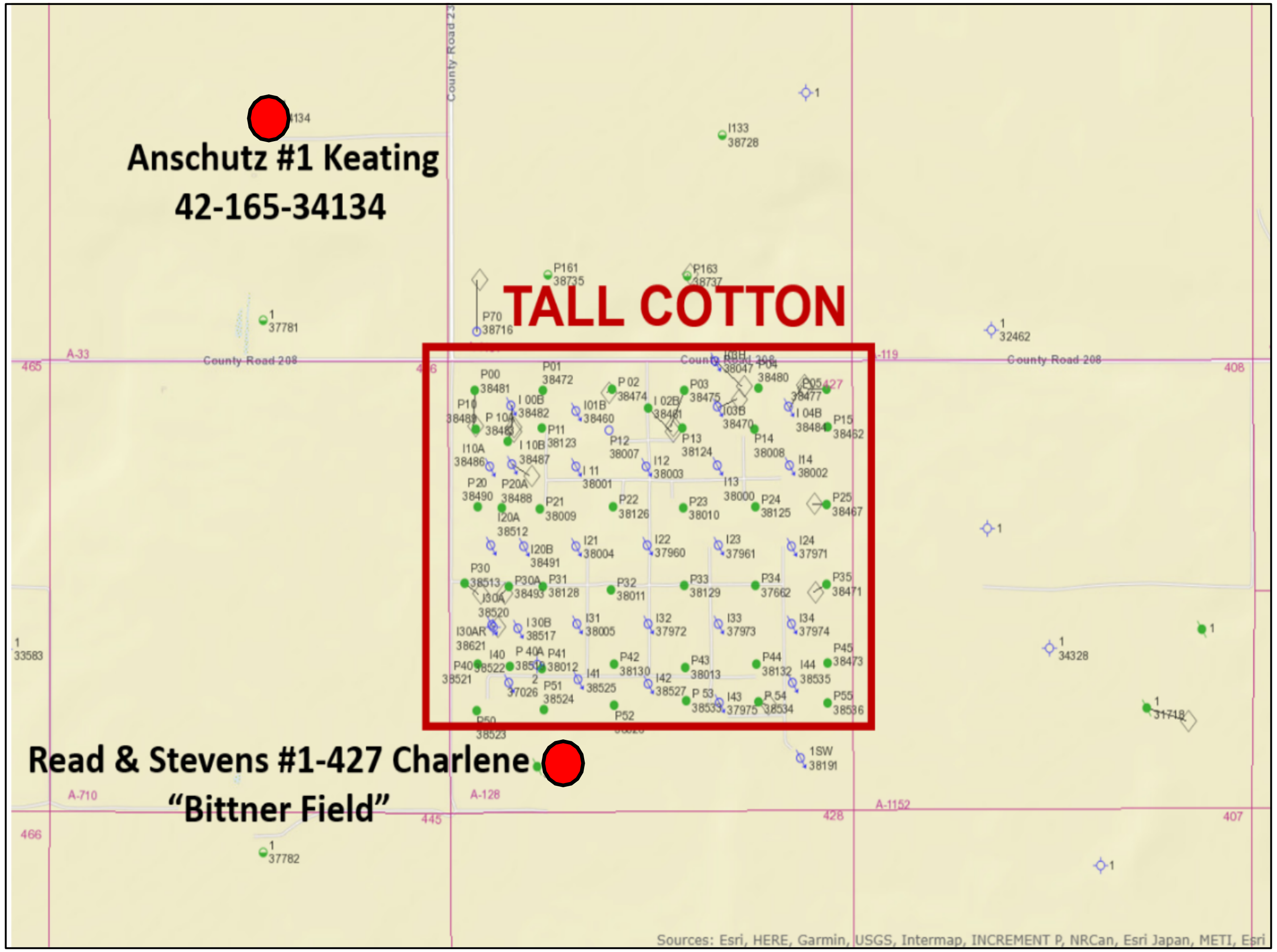
Mother Nature's Waterflood

Changes in Hydrodynamic Conditions, Sweep of the lower part of the Oil Column, and Development of a Residual Oil Zone.



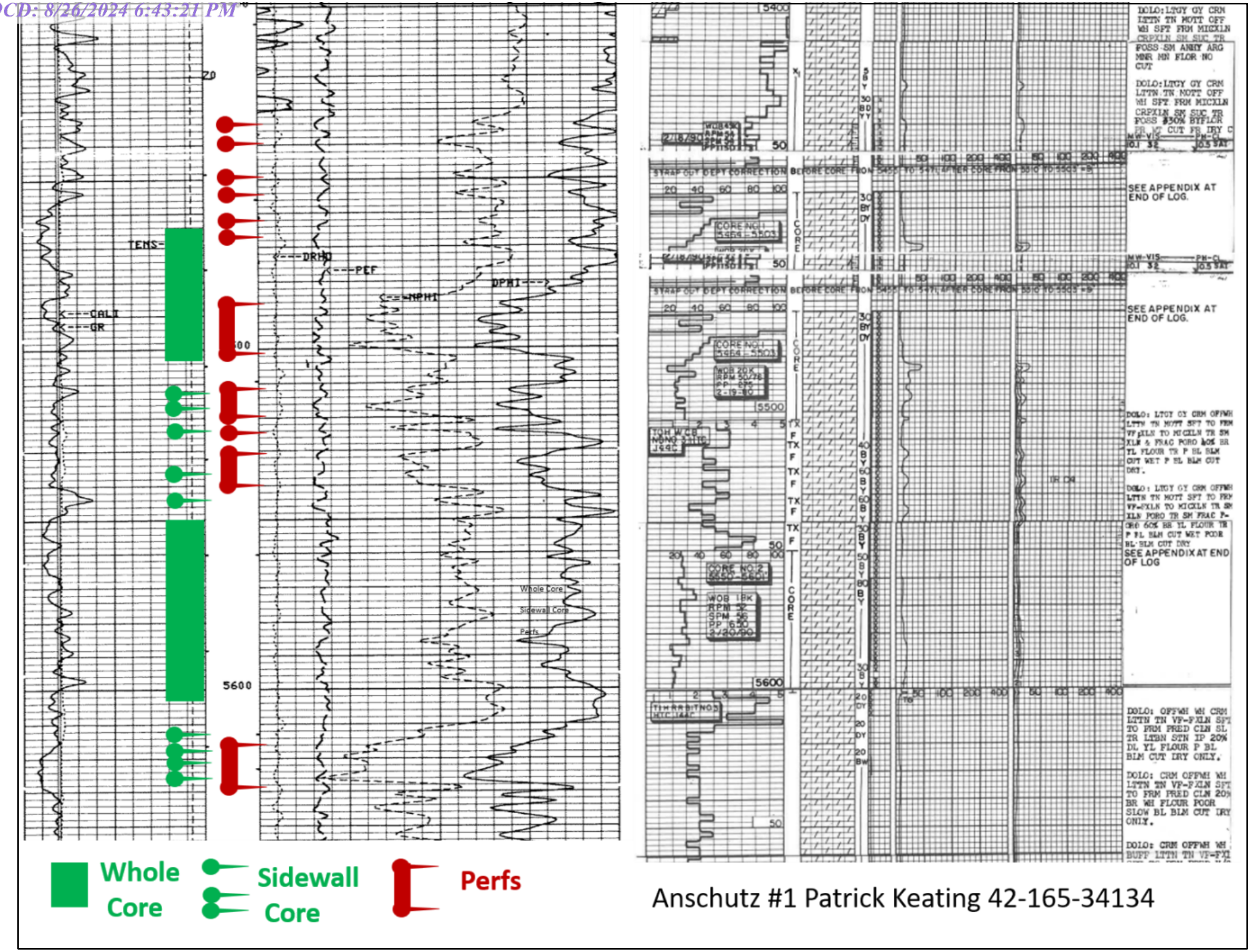
Mother Nature's Waterfloods (Type 3 ROZ) are developed is a Dynamic System associated with Basin Margin uplift and long-term meteoric flushing. Greenfields are areas where ROZs have been established without associated economic oil production (Main Pays). Brownfields are ROZ's where economic production has been established (Main Pays) prior to the field development of the ROZ.

Exhibit D-6



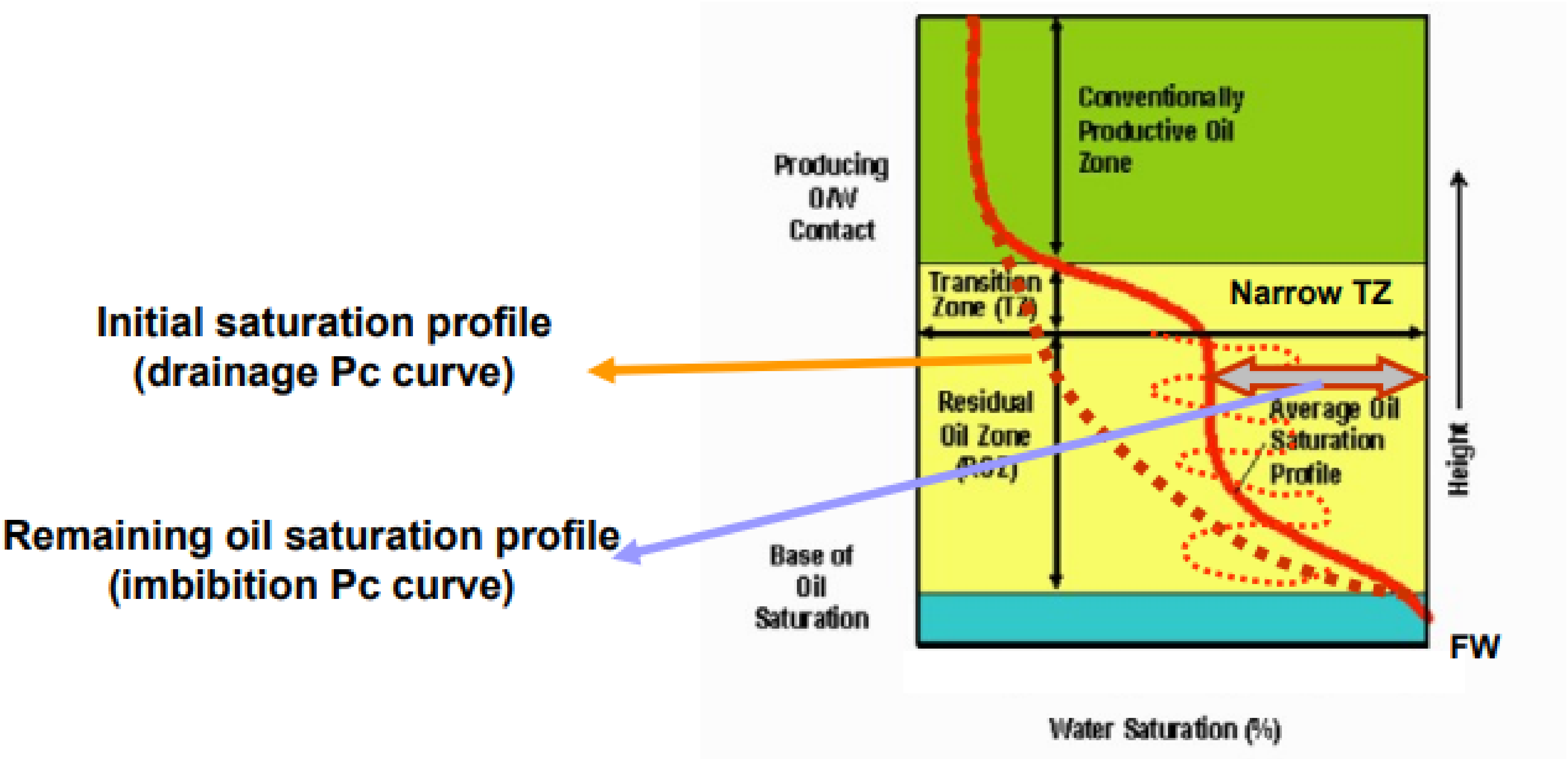
Location of the Anschutz #1 Keating, and Rear & Stevens #1-427 Charlene. These two wells focused Kinder Morgan's interest in the Tall Cotton area as a potential Greenfield New Field Target.

Exhibit D-7



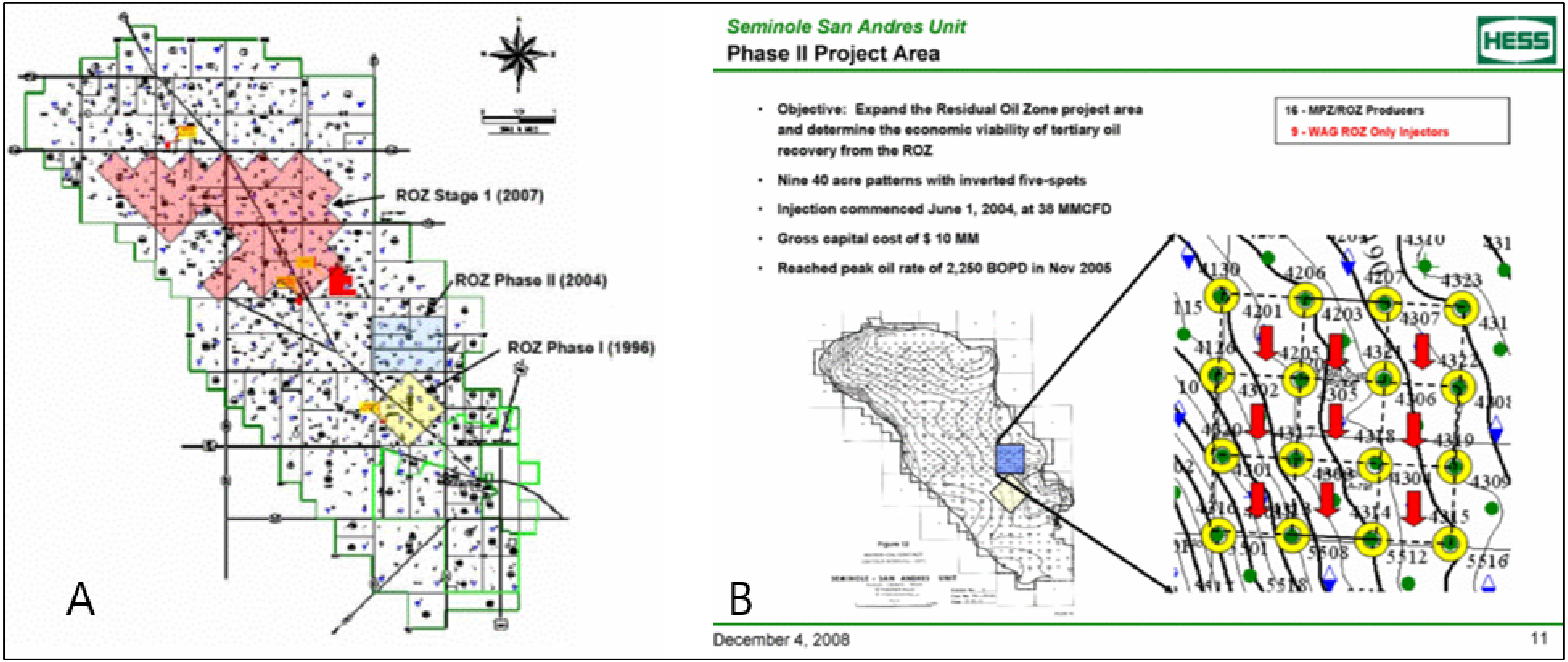
Annotated Well log and Mudlog for the Anschutz #1 Keating 42-165-34134, Gaines County Texas.

Exhibit D-8



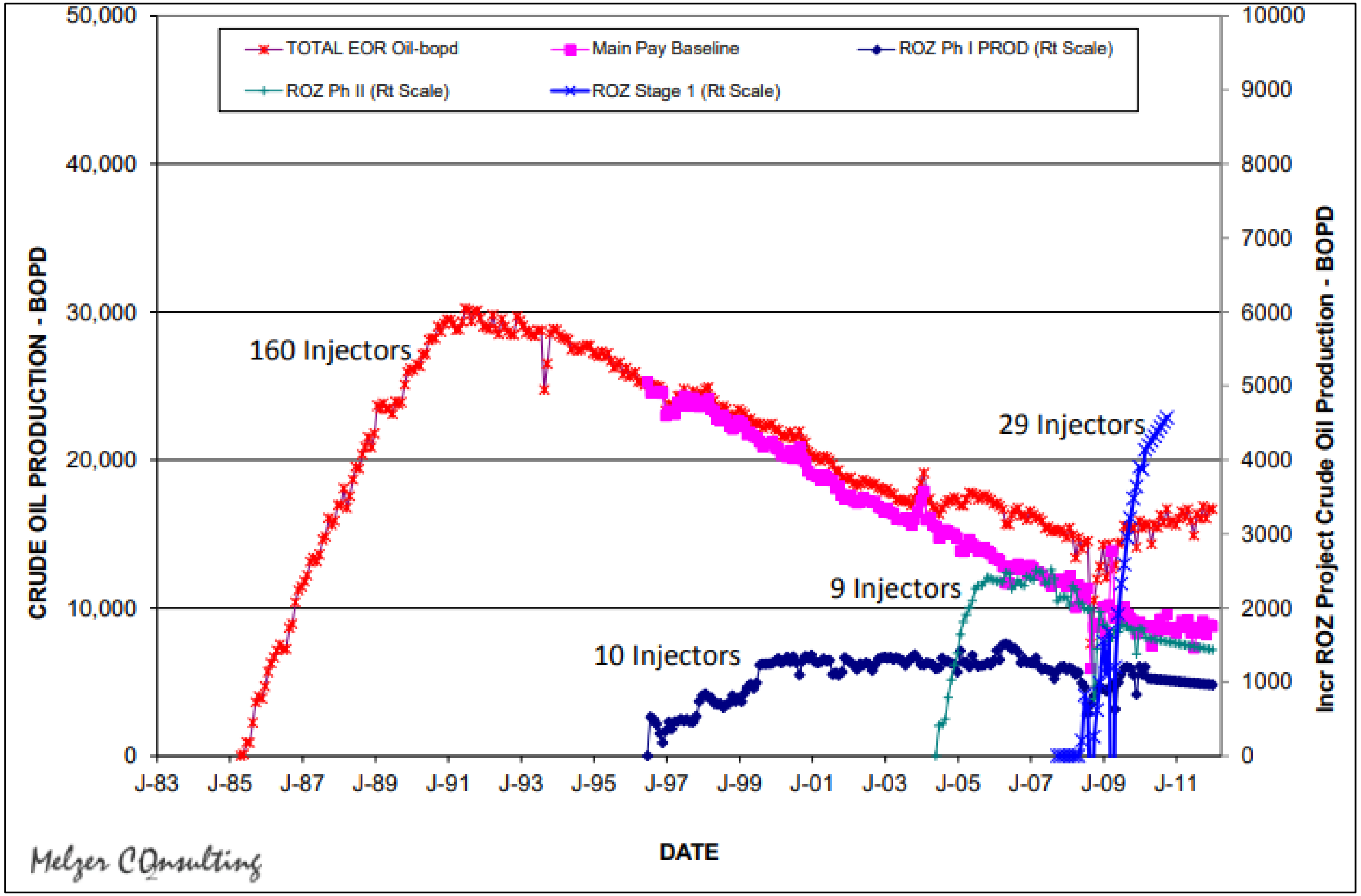
Typical ROZ Saturation profile at Seminole Field for Main Pay & ROZs. Modified after Brown, 1999. Honarpour, et.al., 2010, Modified after Brown

Exhibit D-9



Locations for ROZ Phase 1 and Phase 2 ROZ Pilots, and Stage 1 of the full filed implementation of the ROZ CO2 EOR Flood. B Phase 2, ROZ Only CO2 Pilot with Dual injectors and single, main pay and ROZ producers.

Exhibit D-10



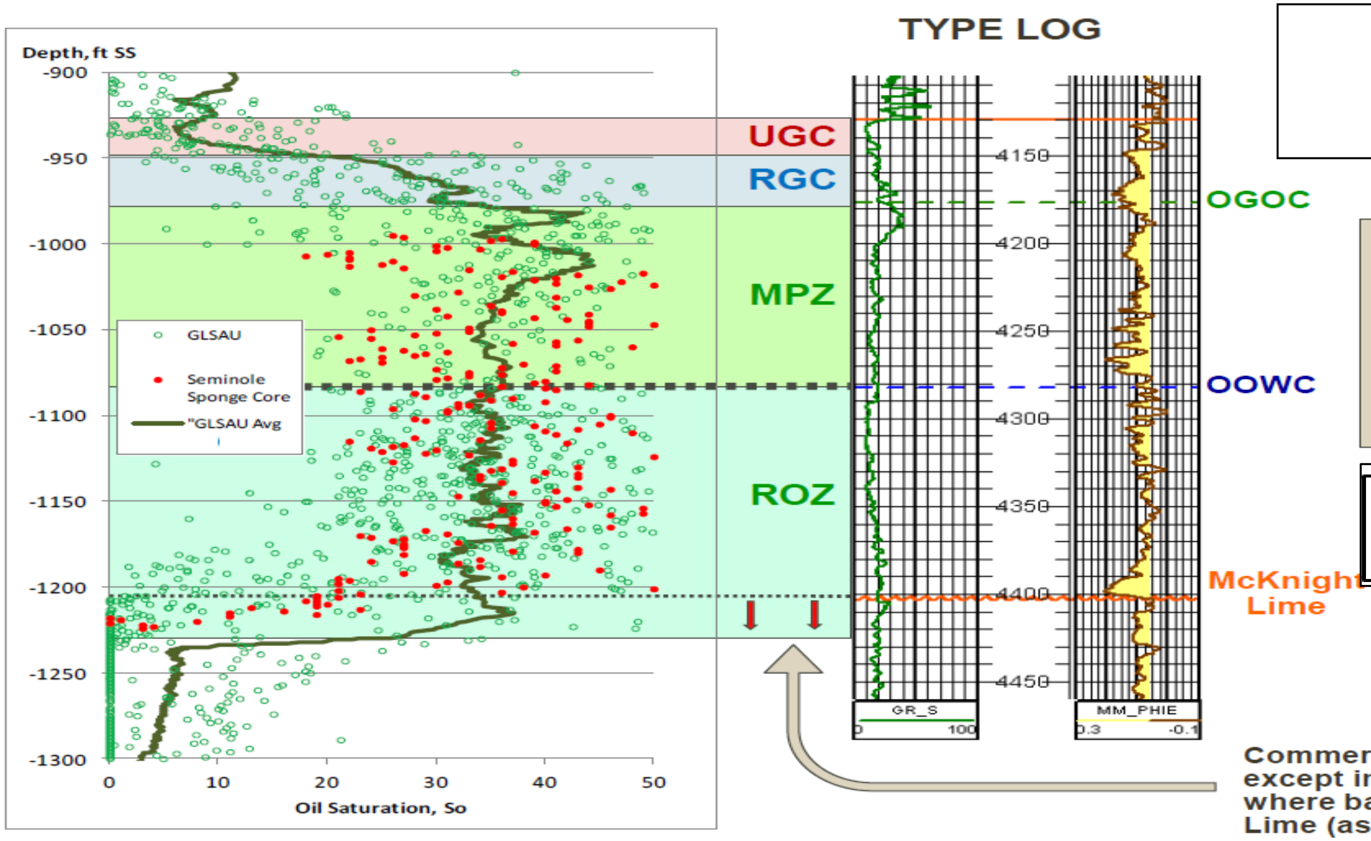
Seminole San Andres Unit Tertiary & Quaternary (CO2) Phase Oil Production and Analyses.

Exhibit D-11

GLSAU Oil Saturations GC, MPZ and ROZ

LEGADO resources

- Similar remaining oil saturation in Main Pay and ROZ
- Significant oil volume re-saturated into Gas Cap (RGC) adds to remaining CO2 flood target



From wells drilled/deepened since 2008

- Core data corrected to in-situ conditions
- Includes 7 recent vintage (since 2009) cores
- Excellent match to Seminole core data

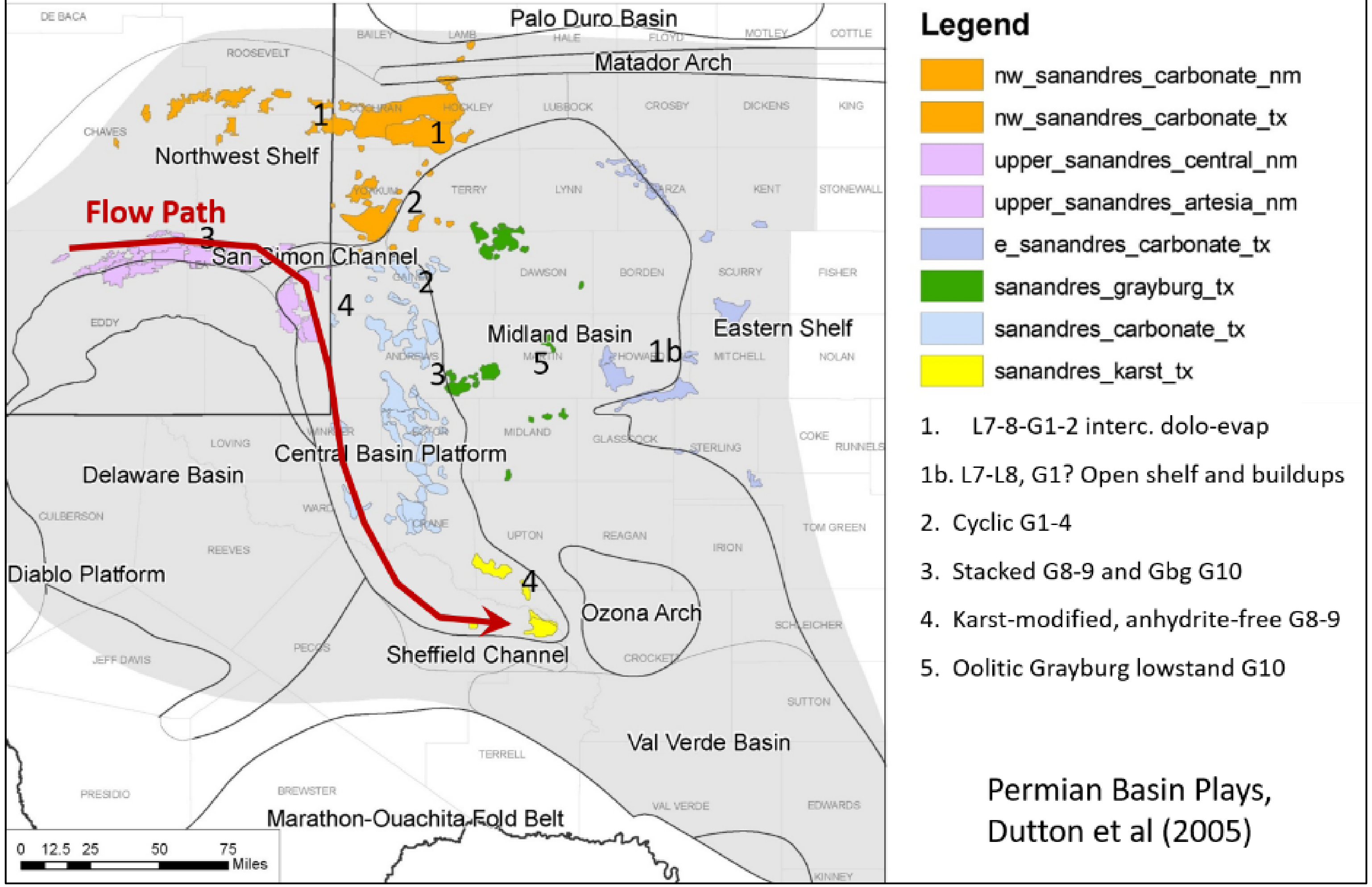
204R	58	126

Commercial saturations to -1,230 SS except in structurally high areas where base truncated by McKnight Lime (as depicted in Type Log)

Core Oil Saturations Resaturated Gas Cap, Main Pay, and ROZ for Goldsmith Landreth San Andres Unit, Goldsmith Field, Ector County, TX.

Exhibit D-12

Classification of San Andres Reservoirs on basis of Stratigraphic Setting



Permian Basin Plays, Dutton et al (2005)

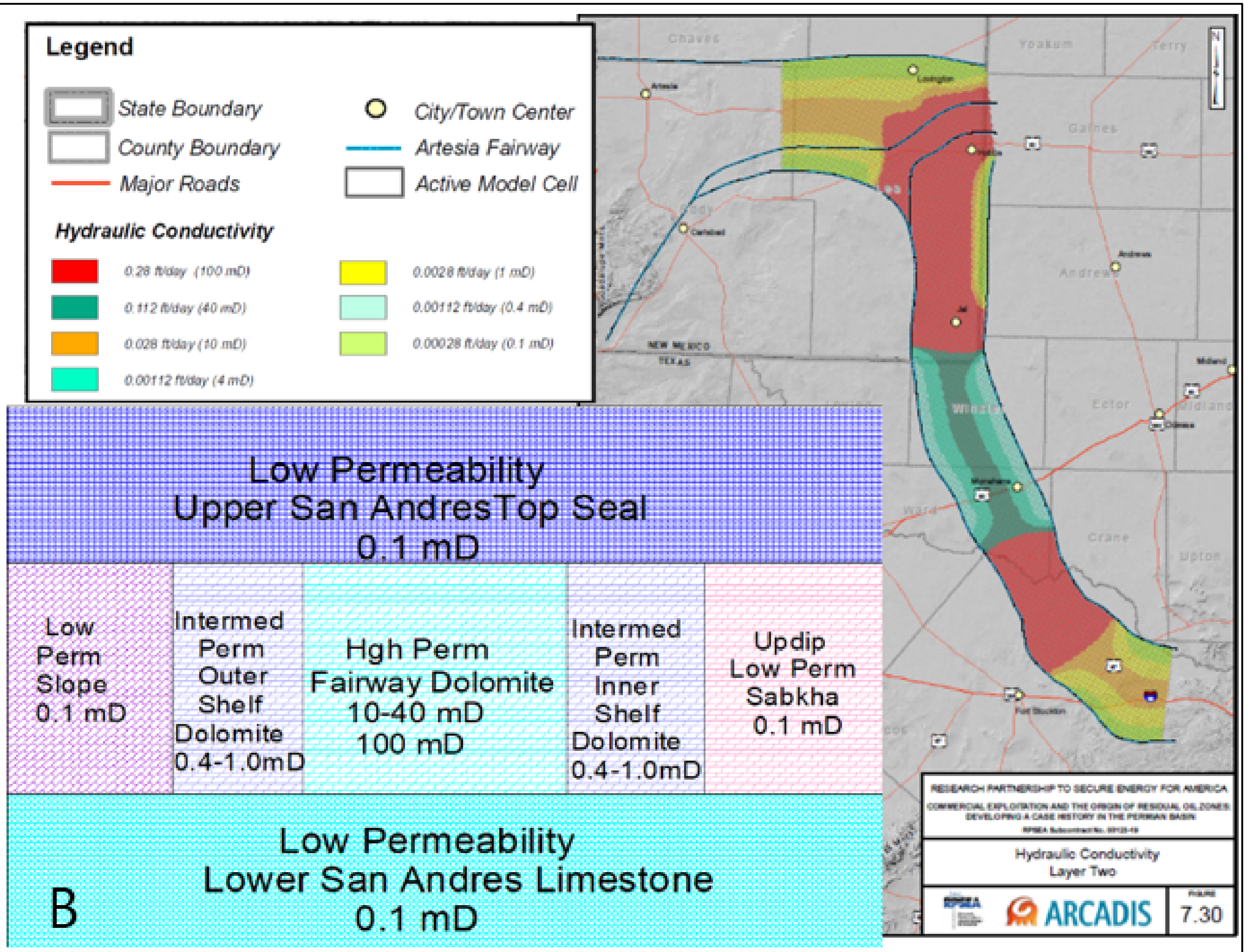
Location of San Andres reservoir types. Most of the San Andres in the Artesia Fairway has been identified as upper San Andres Stacked G8-9 and Grayburg 10, and upper San Andres Karst-modified, low Anhydrite G8-9.

Exhibit D-13

The Modeling Effort

- Used Groundwater Modeling package.
- Input Core, DST, Produced Water, Ground Water, Log Tops.
- Included pre-existing data sets
- Developed a three layer model with variable permeability.

A



A. The Modeling Effort parameters. B. The Artesia Trend which did not include the Capitan or Goat Seep Reefs and the defined porosity and permeability boundaries of the flow path.

Exhibit D-14

"Late" Reservoir Parameters

Waterflooded Main Pay

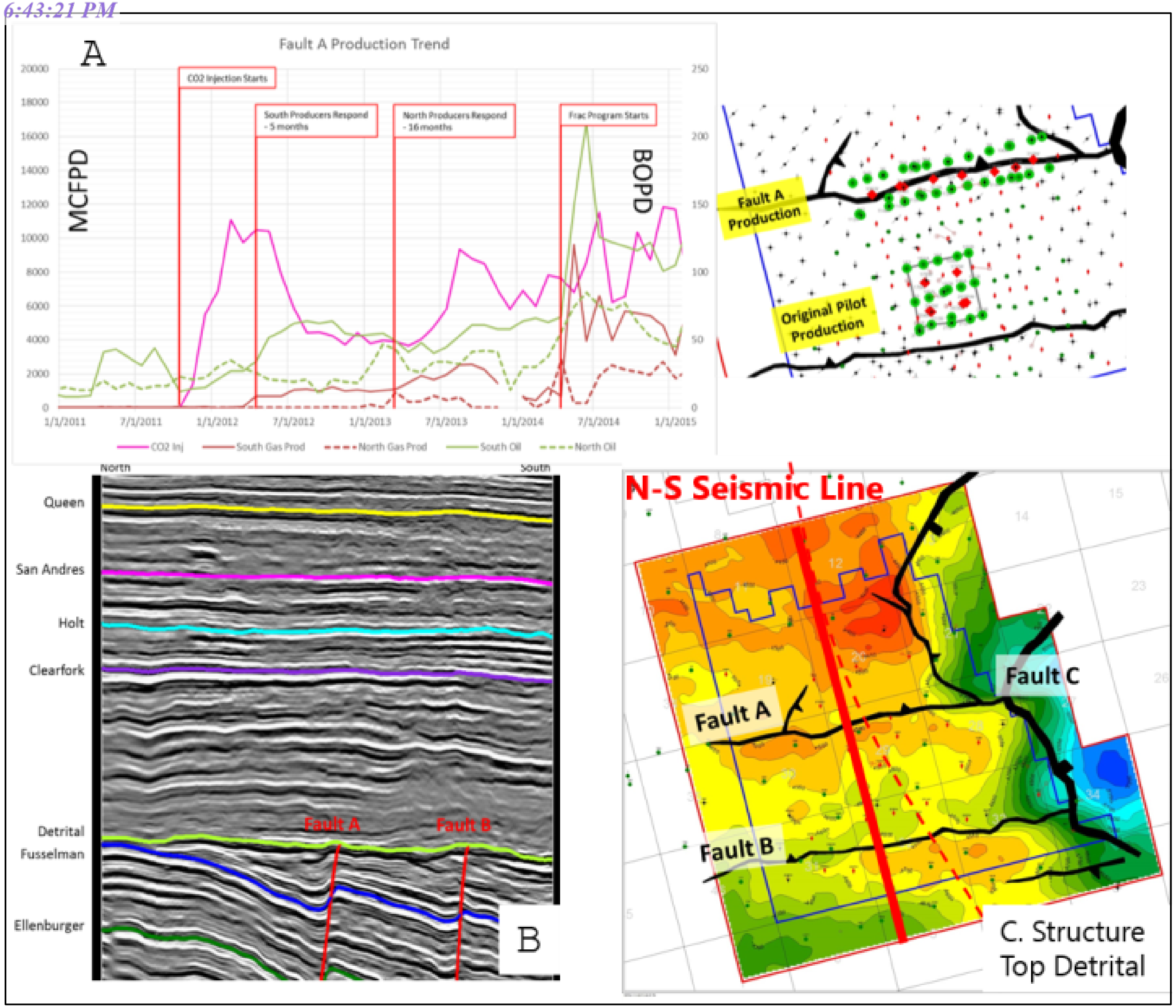
- 20 to 40% So
- Salt Water – ???? TDS
- Some remaining Waterflood Potential
- CO_2 EOR Potential
- Well known reservoir parameters
- Enhanced high perm streaks
- Mixed wetability
- Man made flowpaths /fractures

Residual Oil Zone

- 20 to 40% So
- Sulfur Water – lower TDS
- NO waterflood potential
- CO_2 EOR Potential
- Estimated reservoir parameters
- Potentially more homogeneous
- Wettability questions
- Untouched

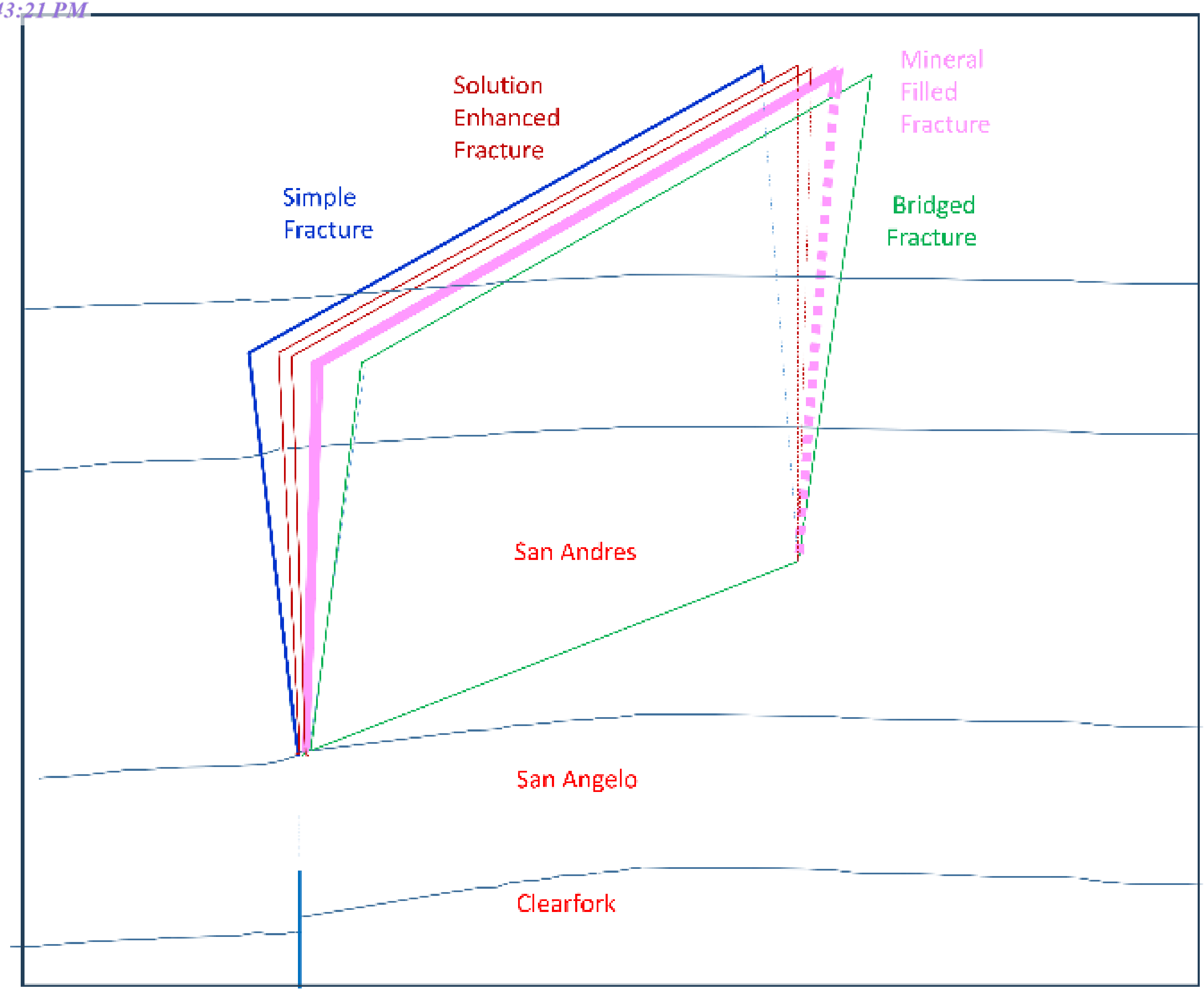
Comparison of long term waterflood and ROZ parameters.

Exhibit D-15



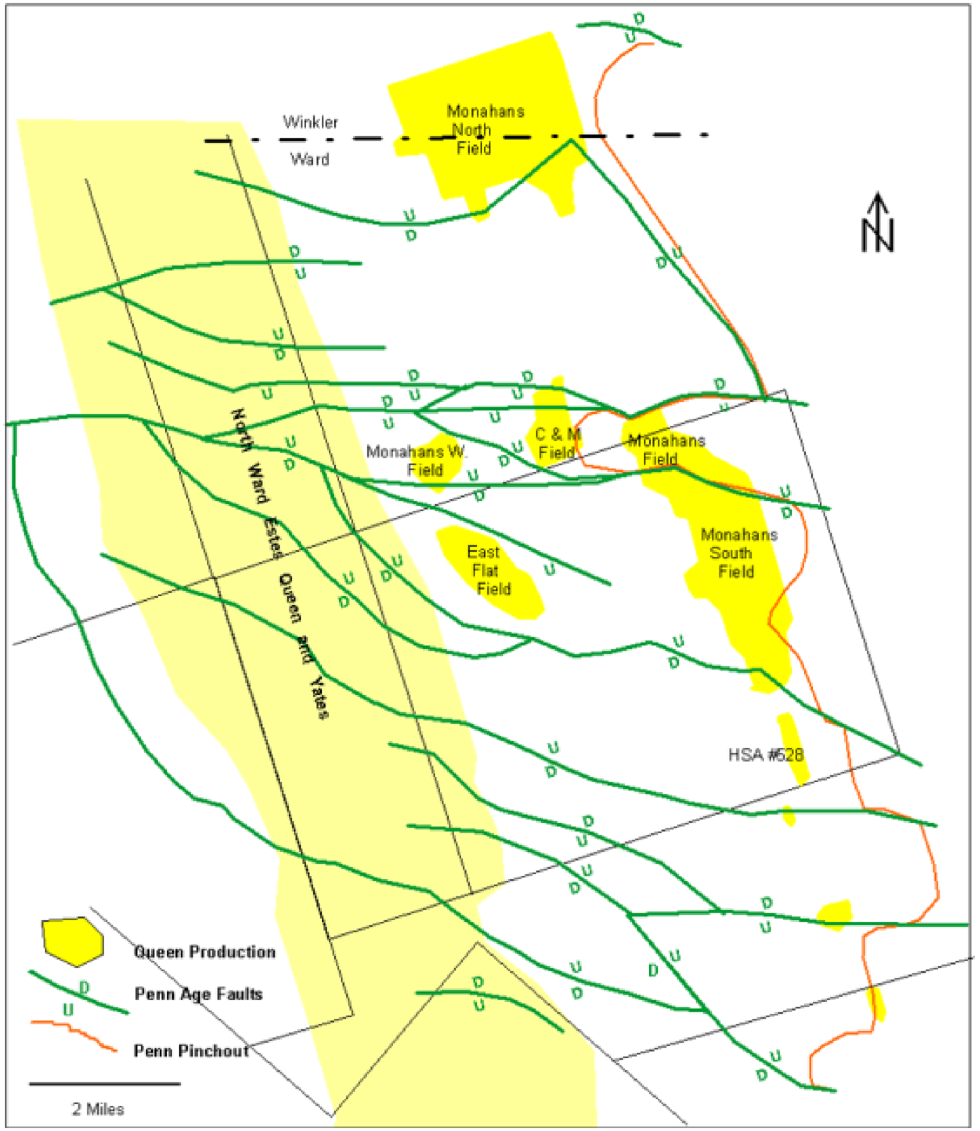
A. Fault "A" Production Trend showing delayed response of wells north of deep-seated fault and shallow fractures. B North-South Seismic Line. C. Top Pennsylvanian Detrital structure map with north-South seismic line.

Exhibit D-16



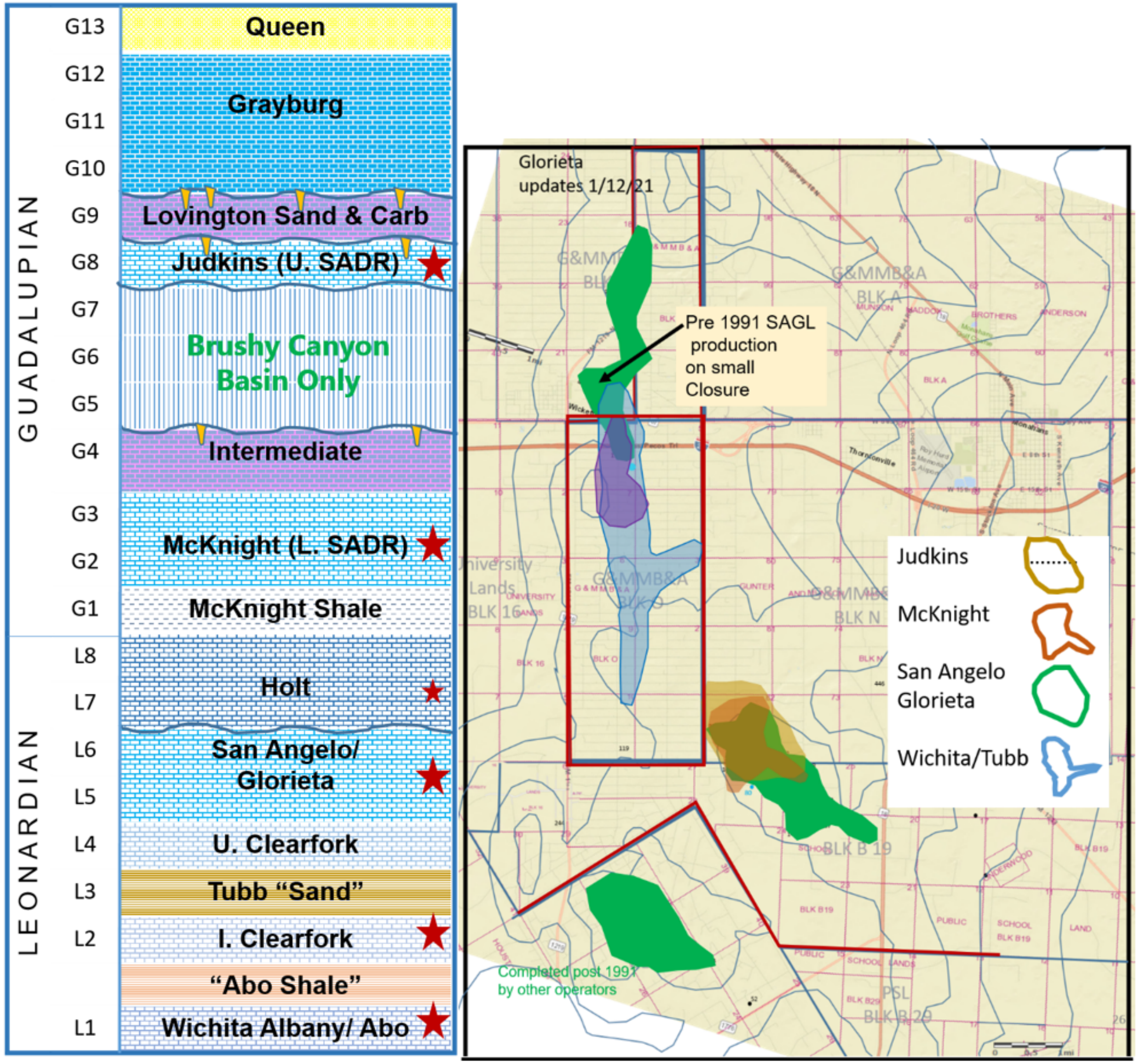
Different responses to the development of the folding and fracturing in the San Andres associated with deep movement. The response ranged from simple failure, to mineral filled fracture, to bridged/open fracture, or solution enhanced fracture development.

Exhibit D-17



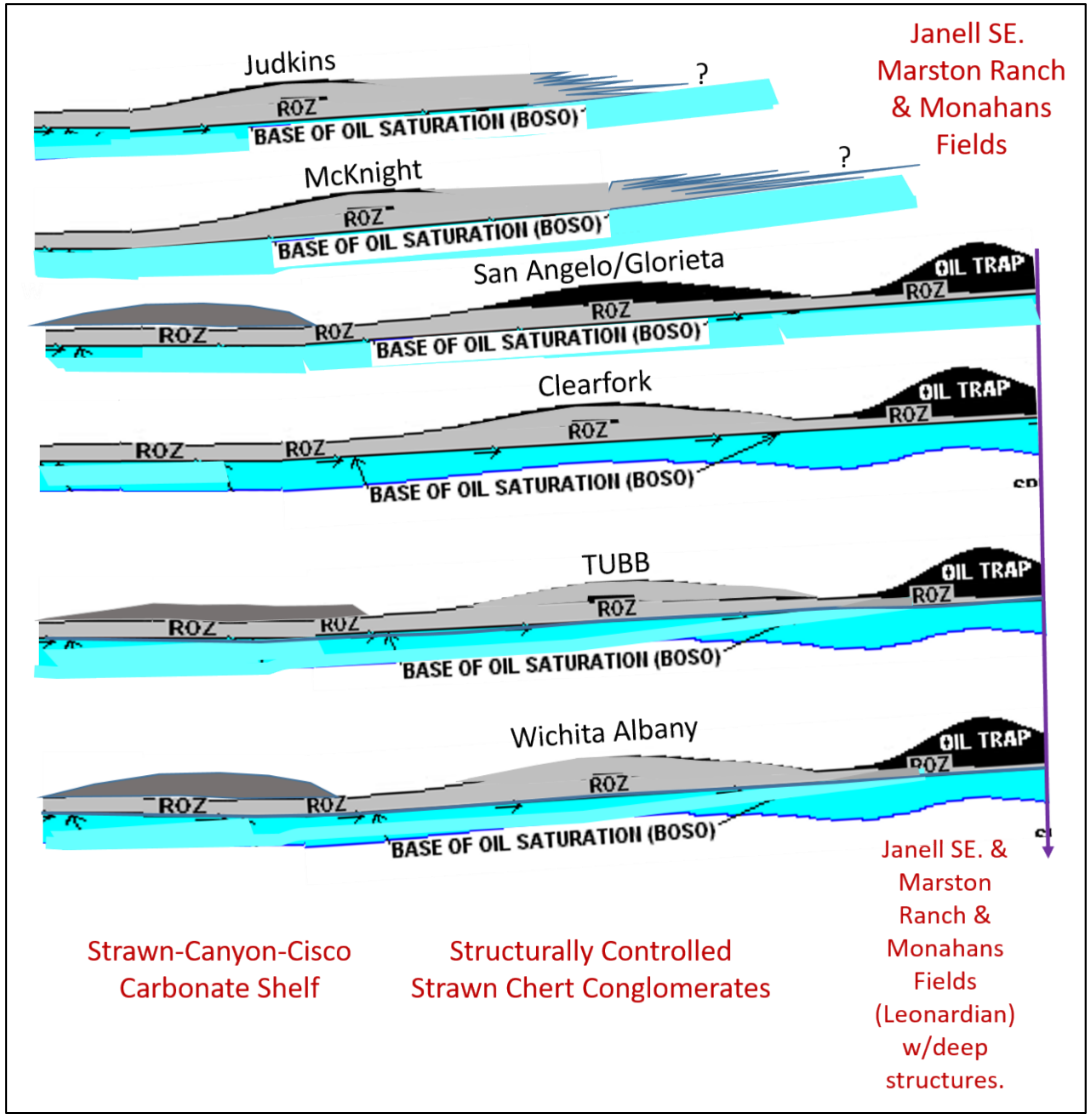
Relationship of Queen Sand Fields to deep structural elements that strongly suggests movement on these deeper tectonic elements throughout the late Permian.

Exhibit D-18



Outline of the post 1992 new pool discoveries in the middle Permian carbonates in the North Ward Estes area. The wells are dominated by high water cuts (>50%) which are essentially higher saturation ROZs.

Exhibit D-19



Model of the Stacked pays in the Leonardian and lower Guadalupian in the North Ward Estes area. Each of these reservoirs have both minor strato-structural traps and ROZ's with variable saturations.

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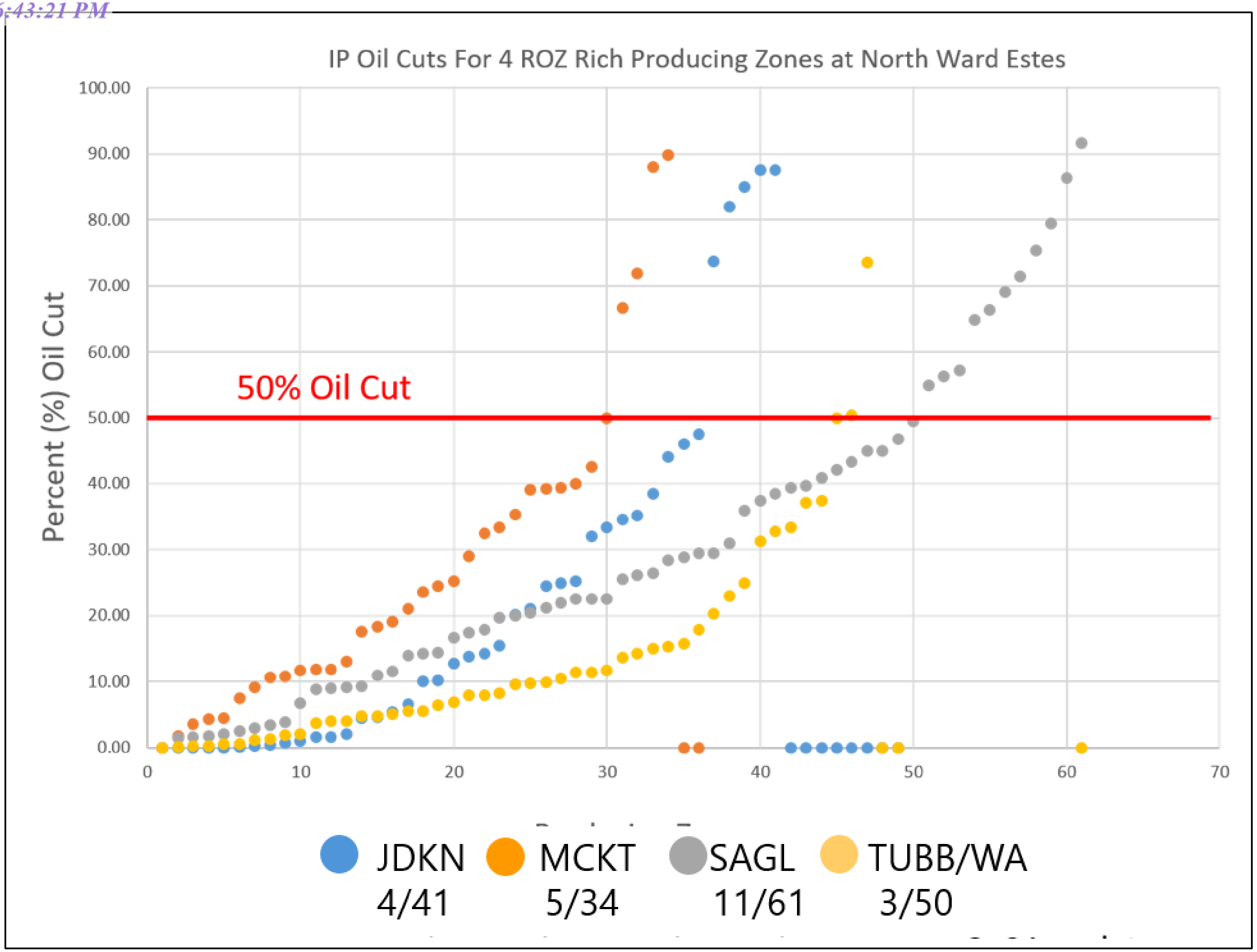
Exhibit D-20



Plot of percent oil cut on IP's for ROZ Rich Clearfork thru San Andres carbonates in the North Ward Estes area drilled and completed since 1991.

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Exhibit D-21

$$CaSO_4 + CH_4 \Rightarrow CaCO_3 + H_2O + H_2S$$

S is +6

C is -4

C is +4

S is -2

Microbes remove 8 Electrons from the Carbon and transfer them to the Sulfur

Redox Based Biogenic Reaction which results in a sulfate –rich formation water following meteoric derived flushing.

Exhibit D-22

Core with native sulfur and calcite filling voids from interval below the main pay in the lower San Andres in McCamey Field.

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Table D-1

Field	Main Pay	ROZ
EMSU	0	370
Tall Cotton	0	400
Platang	0	250
Seminole	160	245
Vacuum	355	240
Wasson	250	200
GLSAU	130	150
Seminole East	70	50
McCamey	275	50

Thickness of Main Pay & ROZ in San Andres reservoirs.

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Table D-2

Conductivity Zone	Velocity (n = 6) (ft/1,000 years)	Velocity (n = 10%) (ft/1,000 years)	Velocity (n = 16%) (ft/1,000 years)
Layer One	1.9	1.1	0.7
Layer Two – Center Zone	**738**	**446**	**278**
Layer Two – Intermediate Zone	72	44	27
Layer Two – Edge Zone	7.2	4.3	2.7
Layer Three	1.9	1.1	0.7

Simulated Groundwater Flow Velocities in the Geologic Past

Table D-3

	N = 6%	N = 10%	N = 16%
Total Pore Volume	1.22×10^{11}	2.04×10^{11}	3.26×10^{11}
Flow Rate (ft^3/day)	1,030		
Time Period (MM years)	15		
Total Flow (cu ft)	5.64×10^{12}		
# of Pore Flushes	46	27.7	17.3

Simulated Number of Pore Flushes in the Geologic Past

Table D-4

Judkins	API	IP	Oil	Gas	Water	O/W Ratio
H.S.A. 875	30213	IPP 0 BO, 2 MCF, 51 BW	0	2	51	0.00
H.S.A. 1566	34688	IPP 0 BO, 2 MCF, 343 BW	0	2	343	0.00
H.S.A. 976	30622	IPP 4 BO, 9 MCF, 2977 BW	4	9	2977	0.13
H.S.A. 965	30588	IPP 1 BO, 0 MCF, 410 BW	1	0	410	0.24
H.S.A. 838	11225	IPP 2 BO, 6 MCF, 441 BW	2	6	441	0.45
H.S.A. 876	30215	IPP 2 BO, 20 MCF, 288 BW	2	20	288	0.69
W.A.E. 80	10597	IPP 5 BO, 1 MCF, 508 BW	5	1	508	0.97
W.A.E 113	32482	IPP 3 BO 187 BW	3	0	187	1.58
W.A.E. 141	34331	IPP 1 5BO, 3 MCF, 61 BW	1	3	61	1.61
W.A.E. 59	1279	IPP 1 BO, 1 MCF, 48 BW	1	1	48	2.04
H.S.A. 3000	34896	IPP 29 BO, 1 MCF, 612 BW	29	1	612	4.52
Richter 116	35359	IIP 3 BO,10 MCF, 63 BW	3	10	63	4.55
W.A.E. 18	1247	IPP 20 BO 1 MCF 351 BW	20	1	351	5.39
H. S. A.876	30215	IPP 2 BO, 20 MCF, 288 BW	2	20	28	6.67
W.A.E. 86	10907	IPP 8 BO, 6 MCF, 72 BW	8	6	72	10.00
H.S.A 694	10848	IPP 53 BO, 2 MCF, 360 BW	53	2	360	12.83
W.A.E. 141	34331	IPP 15 BO, 3 MCF, 93 BW	15	3	93	13.89
H.S.A 709	10918	IPP 5 BO, 1 MCF, 30 BW	5	1	30	14.29
H.S.A. 700	10877	IPP 38BO, 2 MCF, 207 BW	38	2	207	15.51
H.S.A. 1218	32882	IPP 58 BO, 2 MCF, 230 BW	58	2	230	20.14
H.S.A. 701	10878	IPP 109 BO, 2 MCF, 36 BW	109	2	410	21.00
W.A.E. 13	1243	IPP 39 BO, 25 MCF, 120 BW	39	25	120	24.53
H.S.A. 1551	34476	IPP 14 BO, 2 MCF, 42 BW	14	2	42	25.00
H.S.A 485	2488	IPP 69 BO, 12 MCF, 205 BW	69	12	205	25.18
H.S.A 475	2478	IPP 114 BO, 6 MCF, 242 BW	114	6	242	32.02
H.S.A. 3014	35172	IPP 13 BO, 10 MCF, 24 BW	12	10	24	33.33
W.A.E. 14	1244	IPP 95 BO, 4 MCF, 180 BW	95	4	180	34.55
H.S.A 3017	35158	IPP 13 BO, 10 MCF, 24 BW	13	10	24	35.14
H.S.A. 965	30588	IPP 10 BO, 6 MCF, 16 BW	10	6	16	38.46
W.A.E. 84	10797	IPP 11 BO, 1 MCF, 14 BW	11	1	14	44.00
H.S.A 1548	34315	IPP 149 BO, 2 MCF, 175 BW	149	2	175	45.99
H.S.A. 282	2284	IPP 67 BO, 1 MCF, 74 BW	67	1	74	47.52
H.S.A. 1550	34783	IPP 14 BO, 1 MCF, 5 BW	14	1	5	73.68
H.S.A. 700	10877	136 BO, 2 MCF, 30 BW	136	2	30	81.93
H.S.A. 280	2282	IPP 259, BO, 5 MCF, 46 BW	259	5	46	84.92
H.S.A. 1218	32214	IPP 56 BO, 3 MCF, 8 BW	56	3	8	87.50

IP's and Oil/Water cut for wells completed in the upper San Andres (Judkins Formation). Note that only 4 wells have oil cuts >50% and none made water free completions.

Table D-5

McKnight	API	IP	Oil	Gas	Water	Oil Cut
H.S.A. 1552	34452	IPP4 BO, 40 MCF, 224 BW	4	40	224	1.75
H. S. A. 1567	34689	IPP 22 BO, 4 MCF, 598 BW	22	4	598	3.55
H.S.A. 1567	34689	IPP 106 BO, 4 MCF, 2378 BW	106	4	2378	4.27
H. S. A. 1038	31929	IPP 12 BO, 8 MCF, 148 BW	12	8	148	7.50
H. S. A. 1350	33059	IPP 1 BO, 20 MCF, 10 BW	1	20	10	9.09
W.A.E. 86	10907	IPP 8 BO, 6 MCF, 72 BW	8	6	72	10.00
H.S.A. 985	30711	IPP 9 BO, 3 MCF, 76 BW	9	3	76	10.59
H.S.A. 875	30213	IPP 10 BO, 0 MCF, 82 BW	10	0	82	10.87
E.J.Marston 1	32346	IPP 8 BO, 0 MCF, 60 BW	8	0	60	11.76
H. S. A. 1031	34712	IPP 5 BO, 5 MCF, 37 BW	5	5	37	11.90
H.S.A. 1031	31841	IPP 5 BO, 5 MCF, 37 BW	5	5	37	11.90
W.A.E. 14	1244	IPP 26 BO, 4 MCF, 172 BW	26	4	172	13.13
E.J.Marston 1	32065	IPP 40 BO, 60 MCF, 187 BW	40	60	187	17.62
H. S. A. 1041	31935	IPP 15 BO, 75 MCF, 67 BW	15	75	67	18.29
H.S.A. 1106	32148	IPP 53 BO, 118 MCF, 224 BW	53	118	224	19.13
H. S. A.1566	34688	IPP 4 BO, 15 BW	4	0	15	21.05
H. S. A. 3017	35158	IPP 85 BO, 47 MCF, 375 BW	85	47	275	23.61
W.A.E. 13	1243	IPP 39 BO 25 MCF 120 BW	39	25	120	24.53
H. S. A. 485	2488	IPP 69 BO, 12 MCF, 205 BW	69	12	205	25.18
Richter 79	34592	IPP 93 BO 183 MCF 227 BW	93	183	227	29.06
Richter 33	2853	IPP 95 BO 97 MCF 197 BW	95	97	197	32.53
W.A.E. 47	1267	IPP 3 BO, 1 MCF, 6 BW,	3	1	6	33.33
Marston 1-C	10013	IPP 6 BO 4 MCF 11 BW	6	4	11	35.29
Richter 33	2853	IPP 66 BO 42 MCF 103 BW	66	42	103	39.05
H. S. A.3015	35171	IPP 78 BO, 37 MCF, 121 BW	78	37	121	39.20
H.S.A. 1106	32148	IPP 61 BO, 220 MCF, 94 BW	61	220	94	39.35
H. S. A. 1037	31910	IPP 70 BO, 0 MCF, 105 BW	70	0	105	40.00
H. S. A. 1548	34315	IPP 17 BO, 13 MCF, 23 BW	17	13	23	42.50
E.J.Marston	32346	IPP 8 BO, 0 MCF, 8 BW	8	0	8	50.00
H.S.A. 1164	32570	IPP 24 BO, 163 MCF, 12 BW	24	163	12	66.67
Richter 77	32734	IPP 97 BO 75 MCF 38 BW	97	75	38	71.85
H. S. A. 1164	32570	IPP 88 BO, 163 MCF, 12 BW	88	163	12	88.00
Richter 76	32735	IPP 96 BO 48 MCF 11 BW	96	48	11	89.72
G.W.O. 990	11086	IPF 2,337 MCF	0	2337	0	
H. S. A. 1214	32755	IPF 1367 MCF	0	1367	0	

IP's and Oil/Water cut for wells completed in the lower San Andres (McKnight Formation. Note that only 5 wells have oil cuts >50% and none made water free completions.

Table D-6

Lease/Well	API	FORM	DST Results
H. S. A. 1033	31834	GRBG	DST 3480-3555 rec 3232' Sul Wtr.
G.W.O. 535	O1920	JDKN	DST 3305-3410 rec 1340' Sul Wtr.
H. S. A. 876	30215	JDKN	DST 3610-3691 rec 120' DF, 402' Sul Wtr.
H. S. A. 1035	33709	JDKN	DST 3890-4010 rec 350' DF, 3150 'Sul Wtr\tr oil.
W. A .E. 44	O1264	MCKT	DST(4440-4560) 1350' Salty Sul Wtr, 60'DM
H. S. A.1032	31852	MCKT	DST 4460-4550 rec 3150' Sul Wtr
H. S. A. 1033	31834	MCKT	DST 4495-4534 rec 70' DF, 160' Sul Wtr.
H. S. A.1032	31852	MCKT	DST 4555-4650 2690' Sul Wtr.
H. S. A.1071	34712	MCKT	DST 4600-4725 rec 900' Sul Wtr.

Results of DST's in the Grayburg, upper San Andres (JDKN), and the lower San Andres (McKT). Note that in each DST, the water was reported as Sulfur water.

STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION COMMISSION

APPLICATION OF GOODNIGHT MIDSTREAM PERMIAN LLC FOR APPROVAL OF A SALTWATER DISPOSAL WELL, LEA COUNTY, NEW MEXICO. **COMM. CASE NO. 24123**

APPLICATIONS OF GOODNIGHT MIDSTREAM PERMIAN LLC FOR APPROVAL OF SALTWATER DISPOSAL WELLS, LEA COUNTY, NEW MEXICO. **DIV. CASE NOS. 23614-23617**

APPLICATION OF GOODNIGHT MIDSTREAM PERMIAN, LLC TO AMEND ORDER NO. R-22026/SWD-2403 TO INCREASE THE APPROVED INJECTION RATE IN ITS ANDRE DAWSON SWD #1, LEA COUNTY, NEW MEXICO. **DIV. CASE NO. 23775**

APPLICATIONS OF EMPIRE NEW MEXICO LLC TO REVOKE INJECTION AUTHORITY, LEA COUNTY, NEW MEXICO. **DIV. CASE NOS. 24018-24020**

SELF-AFFIRMED STATEMENT OF JAMES L. BUCHWALTER

A) My name is James Buchwalter. I am over eighteen years of age, have personal knowledge of the matters addressed herein, and am competent to provide this Self-Affirmed Statement. I have not previously testified before the New Mexico Oil Conservation Division ("Division").

B) I am a reservoir engineer with 43 years of experience in the petroleum industry. I was employed at Texaco from 1981-1997. In 1998, I formed Gemini Solutions Inc. (GSI) where I have served as President from 1998 to the present.

C) I hold BS and MS degrees from Ohio State University and a PhD degree from Rice University. My degrees are in Chemical Engineering with an emphasis on reservoir engineering applications. I developed an improved compositional simulation formulation for my PhD thesis. I am a member of the Society of Petroleum Engineers (SPE), and a registered Professional Engineer in Texas. I have authored a variety of reservoir engineering papers published in SPE over the past 40+ years and co-authored the reservoir engineer book "Practical Enhanced Reservoir Engineering" published by PennWell and taught at universities.

D) At Texaco I co-developed the in-house simulator, completed simulation studies worldwide for Texaco US and international assets, and taught simulation schools.

E) In 1998, I co-founded GSI and reached an agreement with Texaco to outsource Texaco's in-house simulator and, in return, supported more than 300 Texaco users worldwide.

EXHIBIT E

F) At GSI we develop reservoir simulation, geostatistical, and mapping software for the petroleum industry and complete reservoir simulation consulting studies. Over the past 35 years I have completed more than 350+ consulting studies, sold licenses to more than 40 companies, and assisted users in reviewing thousands of studies.

G) GSI clients include the US Federal Bureau of Safety and Environmental Enforcement (BSEE). BSEE uses GSI technology for verifying wellbore integrity and calculating maximum blowout discharge rates. All wells drilled since 2010 in offshore federal waters including the Gulf of Mexico, California, and Alaska have a GSI model constructed by BSEE engineers to meet government safety requirements. I studied the BP blowout for the US Bureau of Ocean Energy Management (BOEM) and provided documentation used by the US government to calculate damages from the spill.

H) DESCRIPTION OF RESERVOIR MODEL STUDY AREA

A reservoir simulation study was conducted for an area encompassing the Eunice Monument South Unit (EMSU), Eunice Monument South Unit Expansion Area B (EMSU-B), and Arrowhead Grayburg Unit (AGU), located on the northwest corner of the Central Basin Platform (CBP).

I) DESCRIPTION OF THE MODEL

Production and injection data for 638 wells within the Empire units were included in the study along with injection volumes from 23 saltwater disposal wells. Goodnight Midstream Permian, LLC currently has 10 wells (4 inside EMSU unitized interval) injecting saltwater in the San Andres at an estimated rate of 215,000 BWPD. Rice Operating Company has 10 wells included in the model which injects 18,000 BWPD and it is believed they have under their control 3 other wells operated under the names of Owl / Pilot (P 15 #1) and Permian Line Service, LLC (N-11 #1, EME #21) which inject an additional 30,000 BWPD. The water disposal rates on these Permian Line Service wells which are inside the EMSU unitized interval have increased to a total of 29,000 BWPD total over the past few months. Well production/injection records from 1938 through 2023 were used for history matching purposes. A ten-layer model was constructed with 350K cells to properly model the physics of the reservoirs, composed of 2 Penrose layers, 5 Grayburg layers, and 3 San Andres layers. A residual oil saturation was included under the Empire units in the San Andres reservoir based on core and log results. The Penrose is included because it has communication with the Grayburg and a number wells were completed in both intervals, producing a large gas cap and oil rim which had to be filled up with water during the waterflood.

J) HISTORY MATCH RESULTS

1. The model was initialized to determine original oil-in-place and it indicated that there is 894 million barrels oil and 464 BCF gas in the Penrose and Grayburg using gas-oil contact at -100’ subsea (3725’ TVD) and oil-water contact at -366’ subsea (3991’ TVD), with elevation of 3625’ used for the model. The San Andres has 900 million barrels of residual oil in the model where an oil-water contact of -660’ subsea (4285’ TVD) is used. Oil was recovered down to -762’ subsea (4358’ measured depth) in EMSU-679 core so there could potentially be a larger resource. One of the most significant findings of the study was that water production from wells in the central portions of the field at EMSU and AGU could not be matched without allowing some water to

migrate from the San Andres to Grayburg by adjusting the vertical permeability between zones. Without adjusting the vertical permeability of layer 8 (top of San Andres) and allowing water to move into the Grayburg, there were over 100 wells in the central portions of EMSU and AGU which produced very limited amounts of water when there was no communication between zones. By adjusting the vertical permeability based on historical production performance, a fieldwide match was obtained both on production and pressures. The San Andres pressure dropped from 1527 psi initial to 1245 psi in April 1986 as seen by pressure measurements taken when the EMSU-211 well was drilled. This indicates there is communication between the San Andres and Grayburg intervals.

2. The model produces 185 million barrels of oil and 1,842 million barrels of water as of 1/1/2024 versus 183 million barrels oil and 1,841 million barrels water historical from the EMSU, EMSU-B, and AGU, for a variance of 1% on oil and 0% on water. A key element of the study was including 435 million barrels water produced from the San Andres by the water supply wells primarily during the 1986 to 2005 period to inject into the Grayburg. As a result of communication between the San Andres and Grayburg, approximately 161 million barrels of water also entered the Grayburg through natural fractures prior to the waterflood (1/1/1986) and an additional 111 million barrels has entered since that time. Prior to 1986, the model predicts that water was entering the Grayburg at a rate of more than 16,000 BWPD due to the 676 psi pressure difference between the San Andres (1245 psi) and Grayburg (569 psi). This water supply well production from the San Andres, and migration of water from the San Andres into the Grayburg, dropped San Andres reservoir pressure. With the disposal of 570 million barrels of water by Goodnight and Rice, the San Andres reservoir pressure has now increased above original reservoir pressure in some areas. The model predicts that the rate of water influx into the Grayburg will increase from 24,000 BWPD to 46,000 BWPD by Jan-2028 and 52,000 BWPD by Jan-2033, assuming that the seven application SWD wells are not drilled. Not all of this water influx into the Grayburg will be produced unless downhole pumps are modified to handle more water. The water influx which is not produced will slowly pressure up the Grayburg. This water influx assumes in the Base Case that 220,000 BWPD is being withdrawn from the San Andres by other oil fields or migrates to pressure depleted portions of the reservoir. Migration into the Grayburg in other areas outside EMSU and AGU is likely, and losses into shallow zones near the outcrop of the San Andres could also be occurring as reservoir pressure increases. Simulation results indicate that once San Andres pressure increases above 2500 psi near EMSU, that approximately 50,000 BWPD will migrate into the Grayburg with or without the 220,000 BWPD spillover to other remote areas of the San Andres. The spillover rate only impacts the disposal rates of the wells over time as the reservoir pressures up.

K) SUMMARY OF STUDY RESULTS

1. **The San Andres is in hydraulic communication with the Grayburg through natural fractures which are most prevalent at the crestal portions of the field. Cumulative water production volumes as of 1/1/1986 prior to the waterflood were used to determine the vertical permeability necessary to match historical well performance and reservoir pressure.** To determine the degree of communication between the San Andres and Grayburg, a simulation run was made with no vertical communication between the two intervals. The 1/1/1986 modeled

cumulative water production was about half the actual volume and there were over 100 wells which produced excessively low water production volumes when compared to actual. Since Chevron previously reported communication between the San Andres and Grayburg in their 1996 paper entitled "Utilization of Geological Mapping Techniques to Track Scaling Tendencies in the Eunice Monument South Unit Waterflood, Lea County, New Mexico", it is justified to assume that communication occurred prior to the waterflood and continues to be a factor in Grayburg production. Adjustments to the vertical permeability of layer 8 was made to match water production and reservoir pressures of the Grayburg and San Andres.

2. **The match model requires a large San Andres water volume in communication with the Grayburg reservoir.** To match reservoir pressures in the Grayburg and San Andres, an aquifer 38.5 miles in length was attached to the western edge of the model. Smaller and larger size aquifers were attached to the model and the results indicated the 38.5 mile aquifer provides a match of the historical San Andres reservoir pressure. Aquifer volume is impacted by the 50% net-to-gross and permeability of the aquifer is also important since it is what determines the flowrate of water from the large aquifer towards EMSU. Grid blocks in the model are 295 feet in the X direction and 297 feet in the Y direction except for columns 1 through 5 which are 125,000', 50,000', 25,000', 2500', and 1000' in the X direction and 297 feet in the Y direction to represent the aquifer to the west where the reservoir dips down. The 158 billion barrel San Andres water volume in the model allows the water supply wells to produce the 435 million barrels of water without drawing down the San Andres pressure excessively low, and provide some pressure support to the Grayburg through water influx through natural fractures. The San Andres has a residual oil column down to -660 subsea in the model, with 50% net-to-gross, 30% connate water saturation and 30% oil saturation, resulting in 900 million barrels oil-in-place.

3. **The San Andres reservoir pressure has increased back to original virgin pressure near EMSU as a result of SWD injection and this is causing more water to migrate into the Grayburg and produced by Empire's oil wells.** Bottomhole pressure measurements taken in January 2024 indicate that the San Andres has reached a pressure of approximately 1557 psi. Since San Andres water production from Empire's water supply well EMSU-459 has been limited over the past few years, there is no place for the 263,000 BWPD saltwater disposal to go but into the Grayburg interval or to further migrate and compress the San Andres fluids away to other areas of the reservoir. Since the disposal wells are injecting the water at low wellhead pressures, it appears that the water is not only pressuring up the reservoir but also leaking off to other remote areas, therefore we introduced the 200,000 BWPD spillover in the model. The proof that water is entering the Grayburg from the San Andres, as seen by crestal wells producing water prior to the waterflood, should be sufficient evidence to shut down water disposal in the San Andres within 5 miles of the EMSU, EMSU-B, and AGU waterfloods. Even at these distances, Empire's operations will be impacted by continued reservoir pressure increase and water influx into the Grayburg. By pressuring up the San Andres, more CO_2 purchase will be required to conduct the CO2 flood. Operating the San Andres CO_2 flood at 3000 psi instead of 2000 psi will require 10% more CO_2 due to the change in CO_2 volume factor from 2.35 MCF/barrel to 2.59 MCF/barrel. In addition, higher San Andres pressures may require lower CO_2 injection pressures to prevent fracturing of the reservoir.

4. **If we remove the Goodnight and Rice SWD injection wells from the model, the model produces 23,000 BWPD less water since water influx from the San Andres is less. By 2030 this volume increases to 40,000 BWPD assuming only the current SWD wells.** The model indicates that we are currently producing roughly 23,000 BWPD more than if no water disposal had occurred in the past. Since water influx is increasing, the model indicates that this excess water production volume will increase to 40,000 BWPD by 2031 and to 44,000 BWPD if the new 7 wells are drilled. (The new SWD wells add 102,000 BWPD average increase in disposal rate the first year but add only 14,000 BWPD increase in later years due to the total disposal being controlled by whether or not a spillover volume (discussed in item #5 below) occurs and reservoir pressure as shown in Exhibits E-18, E-19, and E-20. Approximately 50,000 BWPD water influx from San Andres will be occurring by 2030, but not all of it will be produced unless higher capacity pumps (ESP's) are run into the Grayburg wells. If increased withdrawals are not made, the Grayburg pressure will slowly increase over time.

5. **The Base Case reservoir model assumes that there are 11 San Andres water producers placed 26.7 miles from the western edge of the base grid to represent what may occur as water disposal continues. Without water being produced from the San Andres by these "spillover" wells which represent (a) production withdrawals from other oil fields, (b) unknown sources such as migration into other zones, or (c) re-pressurization of depleted areas, the San Andres pressures up very quickly and the saltwater disposal rates drop off. Since the current SWD wells are injecting with low wellhead pressure, we feel substantial fill-up volume still exists in the San Andres but there is uncertainty in how much.** Even with a very large aquifer volume, the model indicates that the high rates of water disposal are not sustainable unless the San Andres is impacted by other fluid withdrawals, migration out of zone, or compression/migration of the fluid column to where it outcrops with possible leakoff into shallow zones. Water producers were added to the Base Case model to provide some room for this to occur. If we assume that 220,000 BWPD leaks off from the San Andres to other oil fields or migrates into other zones as a result of the high water disposal rates, 46,000 BWPD migrates into the Grayburg beneath EMSU, EMSU-B, and AGU by Jan-2028 with 263,000 BWPD disposal and increases to 52,000 BWPD by Jan-2033 with 250,000 BWPD disposal. If we assume that this leakage does not occur and the reservoir pressures up with the existing SWD wells, 46,600 BWPD influx into the Grayburg occurs on Jan-2028 with 236,600 BWPD disposal and increases to 52,000 BWPD influx with only 160,000 BWPD disposal on Jan-2033 due to the increased pressure. This indicates that disposal rate drops by 90,000 BWPD (36%) if no spillover occurs and the reservoir pressures up more quickly. In both cases, there is a high rate of water influx caused by the disposal volumes. (See Exhibits E-18, E-19, and E-20) **These results indicate that the re-pressurization of the San Andres reservoir near EMSU will result in high water influx into the Grayburg even if some of this re-pressurization is dissipated to other parts of the reservoir. SWD wells, if utilized, should be moved far away from EMSU.**

L) CONCLUSIONS

1. **The reservoir model has confirmed Chevron's 1996 statement made in paper entitled "Utilization of Geological Mapping Techniques to Track Scaling Tendencies in the Eunice Monument South Unit Waterflood, Lea County, New Mexico" [1] that "During the time of primary production, prior to unitization and initiating the waterflood in the Eunice Monument field, barium sulfate scale deposition was experienced in a number of producing wells. Although the drilling was confined to Penrose and Grayburg formations, apparently some San Andres water was finding its way into the wellbore of these wells and resulted in barium sulfate scale, barite, deposition problem."** The reservoir model requires communication between the San Andres and Grayburg to match historical water production volumes and pressure prior to the waterflood. The San Andres water contains sulfate ions and the Grayburg contains barium ions, so when they were mixed barium sulfate scale was precipitated. Scale deposition in certain wells was clear evidence that San Andres water was invading the Grayburg.

2. **If water disposal into the San Andres is not shut down, reservoir pressure will continue to rise and increased water volumes will enter the Grayburg, not considering that fracturing which could occur due to the excessive pressures.** The reservoir model indicates San Andres reservoir pressure will build very quickly with continued disposal of 263,000 BWPD unless there is some spillover of water to other remote areas. The 263,000 BWPD does not include the 5 new wells which we assume inject at 25,000 BWPD in the model, an additional 125,000 BWPD. The model uses 3000 psi as maximum downhole injection pressure and each well's disposal rate as of June 1, 2024, with 25,000 BWPD assumed for the Andre Dawson and Ernie Banks wells. As the reservoir pressure builds, the water disposal rate drops off unless there is some spillover to other parts of the large San Andres aquifer. Exhibits E-18, E-19, and E-20 show that with or without spillover, and with or without the new wells being drilled, the rate of water influx into the Grayburg will increase from the current rate of 24,000 BWPD to over 50,000 BWPD by the increase in reservoir pressure to over 2500 psi. The San Andres to Grayburg water influx is like fluid flow through a choke. Increased pressure increases the water influx but the choke size (natural fracture flow capacity) controls the water influx rate. If the formation is fractured by exceeding the fracture pressure which could be 3000 to 3500 psi (0.6 to 0.7 psi/ft gradient), increased flow into the Grayburg occurs. To be able to handle this additional water influx, Empire will have to start-up additional water injection pumps and change out downhole equipment so that the oil wells can handle the additional water. This will require capital investment and will increase operating expenses.

3. **SWD water influx from the San Andres to the Grayburg is not improving the waterflood recovery in the Grayburg, but actually making it worse due to non-uniform sweep.** Exhibit E-1 shows the locations where the vertical permeability of layer 8 was modified to allow communication between the San Andres and Grayburg. These well locations represent less than 15% of all Grayburg wells and required San Andres water influx to match cumulative water production prior to the waterflood. This small percentage of wells indicates that the water invasion from the San Andres into the Grayburg is non-uniform and therefore hinders oil recovery more

than it helps. SWD should not be allowed inside the unitized interval and if required, should be placed miles from the unit boundary.

M) DISCUSSION OF EXHIBITS

1. Exhibit E-1 shows the simulation grid without modification on the western edge for the aquifer. The blue dots show areas of the reservoir where the vertical permeability was adjusted to allow for 1/1/1986 cumulative water production to be matched by allowing communication between the San Andres and Grayburg. Without these modifications, the cumulative water volume could not be matched.

2. Exhibit E-2 shows the layering scheme for the simulation model. By modifying the vertical permeability of layer 8 (top San Andres layer), water influx into the Grayburg from the San Andres occurs and water production from the Grayburg is matched. This is also required to obtain a pressure match of the San Andres and Grayburg.

3. Exhibit E-3 shows the reservoir model match of oil, water (includes water supply well volumes), gas and water injection (includes SWD volumes) and a prediction if oil rate is maintained. This case assumes no spillover of water to remote areas and therefore water injection rate declines due to a decline in SWD injection. The increased water influx from the San Andres results in an increase in water production.

4. Exhibit E-4 shows the water supply wells volumes used in the model. Water production volume from the San Andres peaked at over 100,000 BWPD in 1996 when EMSU-B and AGU waterfloods became active.

5. Exhibit E-5 shows the saltwater disposal volumes used in the model. It assumes Rice Operating began water disposal in 1994 and Goodnight Midstream in 2012 when Penroc State E Tract 27-2 started. Water disposal volumes are based upon NMOCD reported volumes.

6. Exhibit E-6 shows the model's calculated water influx into the Grayburg from the San Andres. It is determined by using the model's (1) calculated change in San Andres aquifer volume, (2) minus water supply well volume, (3) plus salt water disposal well volume over time. It can be seen that the rate of water influx increases rapidly as the high SWD volumes are injected.

7. Exhibit E-7 shows the average reservoir pressure for the Grayburg (layers 3 through 7) and San Andres (layers 8 through 10) for the Base Case model with 220,000 BWPD spillover. It shows the San Andres pressures up even with leakoff of this 220,000 BWPD to other remote areas.

8. Exhibit E-8 shows the wells at EMSU which produced at least 500,000 barrels of water by 1/1/1986. It is seen that EMSU-262H and EMSU-362 produced over 2.5 million barrels of water each. This abnormally high water production in the central portions of the field can only be explained by San Andres and Grayburg communication through natural fractures near the crest of

the structure. It is believed that flexing of the structure during deposition (as presented by Bob Lindsay) caused numerous natural fractures to occur in the rock and this allowed communication between the two zones. In the model run where there is no communication between the San Andres and Grayburg, these wells produce limited amounts of water before 1986, a clear sign that communication has to have occurred prior to the waterflood.

9. Exhibit E-9 shows the wells at AGU which produced at least 500,000 barrels of water by 1/1/1986. AGU-127, 159, 167, and 168 produced abnormally high volumes of water which can only be explained by communication between the San Andres and Grayburg intervals.

10. Exhibit E-10 shows the history match and prediction for the Base Case where 220,000 BWPD is produced from the 11 wells located in the aquifer to represent leakage to other remote areas. The existing SWD wells are able to maintain their injection rates as a result of this spillover of fluids to other areas. The large water production increase includes the 220,000 BWPD from these 11 spillover wells.

11. Exhibit E-11 shows the model grid with the aquifer attached and shows the location of the 11 spillover wells. The grid block in column 1 is 125,000' (23.67 miles) in the X direction so it places the spillover producers 26.7 miles west of the original base grid. This demonstrates that the San Andres is hydraulically connected over very large distances.

12. Exhibits E-12(a) and E-12(b) shows the history match with and without hydraulic communication between the San Andres and Grayburg for EMSU-104. By applying a vertical permeability of 0.375 md to layer 8 grid block (2 acre area) where the well is located, the cumulative water volume is matched. Exhibit E-12(a) is with the modification and I-12(b) is without. The upper left chart is oil rate (BOPD) versus time (model – solid line, historical – dots). The bottom left is Cumulative oil (thousand barrels) versus time. The upper right is water rate (BWPD) and bottom right is cumulative water (thousand barrels).

13. Exhibit E-13(a) shows how the water production profile was modified for EMSU-259 by applying a vertical permeability of 0.25 md to layer 8 grid block where the well is located. Exhibit E-13(b) shows the result if KZ=0 for layer 8.

14. Exhibit E-14(a) shows how the water production profile was modified for EMSU-362 by applying a vertical permeability of 6 md to layer 8 grid block where the well is located. Exhibit E-14(b) shows the result with no modification.

15. Exhibit E-15(a) shows how the water production profile was modified for EMSU-368 by applying a vertical permeability of 6 md to layer 8 grid block where the well is located. Exhibit E-15(b) shows the result with no modification.

16. Exhibit E-16(a) shows how the water production profile was modified for EMSU-B #889 by modifying the vertical permeability in other areas of the model. Exhibit E-16(b) shows the original production profile when KZ=0.

17. Exhibit E-17(a) shows how the water production profile was modified for AGU-177 by applying a vertical permeability of 0.375 md to layer 8 grid block where the well is located. Exhibit E-17(b) shows the result with no modification.

18. Exhibit E-18 shows the water disposal rate forecast for (1) existing SWD wells with no spillover volume, (2) existing SWD wells with 220,000 BWPD spillover to remote areas, and (3) existing plus 7 new SWD wells with 220,000 BWPD spillover, and (4) existing plus 7 new SWD wells with no spillover. It shows that the case with the 7 new SWD wells can inject at a much higher rate for a short period but is then governed by spillover rate and rate of water influx into the Grayburg. Without the spillover volume, the rate of disposal declines.

19. Exhibit E-19 shows the water influx rate into the Grayburg for the same four cases discussed above. There is some difference in the rate of influx, but in general, 50,000 BWPD of influx will occur once the reservoir pressure is built to a certain level and influx is controlled by the pressure difference between Grayburg and San Andres and the vertical permeability values. If the injection pressure exceeds fracture pressure, which could be approximately 3500 psi based on 0.7 psi/ft fracture gradient, then hydraulic fractures could occur and communication between the Grayburg and the San Andres will increase dramatically. All cases are run with a maximum sand face injection pressure of 3000 psi to avoid fracturing the formation.

20. Exhibit E-20 shows the San Andres average reservoir pressure under the four different scenarios. If no spillover occurs to other areas of the reservoir, the pressure will continue to build. If spillover does occur, the average pressure can remain relatively constant but we are uncertain where the water is going.

21. Exhibits E-21(a) to E-21(p) shows individual history and forecast plots for 31 additional wells in the model, showing good match of oil and water production during the waterflood period. (The forecast uses the case with existing SWD wells and spillover of 220,000 BWPD.) The permeability of layers 3 and 4 in the model (top 2 layers of the Grayburg) were increased to allow for the high water cycle volumes experienced during the waterflood. Production prior to the waterflood was key to determining vertical permeability between the San Andres and Grayburg. The waterflood history was key to determining horizontal permeability of the Grayburg to allow for high water cycle rates.

22. Based on the above analysis and data, it is my conclusion that the San Andres and Grayburg intervals are in communication and that saltwater disposal within or near EMSU will result in reservoir pressure increase and increase water influx into the Grayburg. This increase in San Andres reservoir pressure will impact Empire's CO_2 flood design for the San Andres ROZ interval and the increased migration of water into the Grayburg will impact their waterflood operations.

23. The attached exhibits were either prepared by me or under my supervision, utilizing structure maps and historical production and injection data provided by Empire. I worked closely with Empire personnel to make sure that historical information is accurate in the model.

References

1.) L. N. Strickland, D. W. Beaty, A. B. Carpenter; "Utilization of Geological Mapping Techniques to Track Scaling Tendencies in the Eunice Monument South Unit Waterflood, Lea County, New Mexico" Paper 181 presented at Corrosion 96 – The NACE International Annual Conference and Exposition March 24-29, 1996 Denver, Colorado

I understand this Self-Affirmed Statement will be used as written testimony in this case. I affirm that my testimony above is true and correct and is made under penalty of perjury under the laws of the State of New Mexico. My testimony is made as of the date next to my signature below.

James L. Buchwalter

Date:___8/23/2024_______________

Curriculum Vitae

James L Buchwalter
President, Gemini Solutions, Inc.
702 Morton Street
Richmond Tx
281-238-5252

Education

May 1979	B.S., Chemical Engineering	Ohio State University
May 1981	M.S., Chemical Engineering	Ohio State University
May 1994	PhD, Chemical Engineering	Rice University

Industry Experience

1998 – Present	President. Gemini Solutions Inc.
1986-1998	Reservoir simulation engineer, Texaco Houston offices
1981-1986	Reservoir engineer, Texaco Harvey District office

Significant Professional Achievements and Areas of Specialization

- Expertise in reservoir simulation studies
- Expertise in developing reservoir simulation interfaces/calculation engine
- Expertise in managing software development and consulting studies
- Contributing author for the applied reservoir engineering book "Practical Enhanced Reservoir Engineering" published by PennWell and used by both universities and industry personnel.
- Instructor for industry reservoir simulation schools taught over the past 40 years
- Publications in compositional simulation, rapid engineering workflows using downhole gauge data, dual porosity/fracture reservoir applications, WCD workflows, optimizing tight asset evaluation workflows, and rapid simulation workflows

Prior to founding Gemini Solutions Inc. I was employed as a reservoir engineer in the Texaco Harvey district from 1981 to 1986. In 1986 I moved to Houston and was selected to attend Texaco's 9-month advanced engineering/geology program where I built a CO2 flood simulation model for Texaco's Paradis field.

Following the conclusion of the 9-month training program I joined Texaco's Engineering Technical Services Group in 1987 where I co-developed Texaco's in-house simulator that was used by more than 400 Texaco engineers globally. From 1987 to my departure in 1998 I traveled the globe and completed more than 70 simulation studies in the US and worldwide. International studies included reservoirs in Russia, the North Sea, the Middle East, Sakhalin, Columbia, Kazakhstan, Malaysia, Indonesia, Nigeria, Myanmar, and Vietnam.

I co-founded Gemini Solutions Inc (GSI) in 1998. Over the past 26 years I have managed software development, written codes for GSI software, sold licenses, and completed and/or assisted clients in more than 1000 studies globally.

ATTACHMENT

Gemini Solutions Inc (GSI) was selected as the simulation provider to the US Federal MMS agency (Minerals Management Service) in 2004. Following the BP Macondo spill, I was chosen by MMS to study the Macondo spill. I delivered a report detailing Macondo spill rates for different possible wellbore restrictions.

GSI clients include the US Federal Bureau of Safety and Environmental Enforcement (BSEE). BSEE uses GSI technology for verifying wellbore integrity and calculating maximum blowout discharge rates. All wells drilled since 2010 in offshore federal waters including the Gulf of Mexico, California, and Alaska have a GSI model constructed by BSEE engineers to meet government safety requirements.

Exhibit E-1: Simulation Grid with areas (Blue Dots) where Vertical Permeability Has Been Modified

Columns 1 through 5 along western edge of model were enlarged (not shown) to represent San Andres aquifer

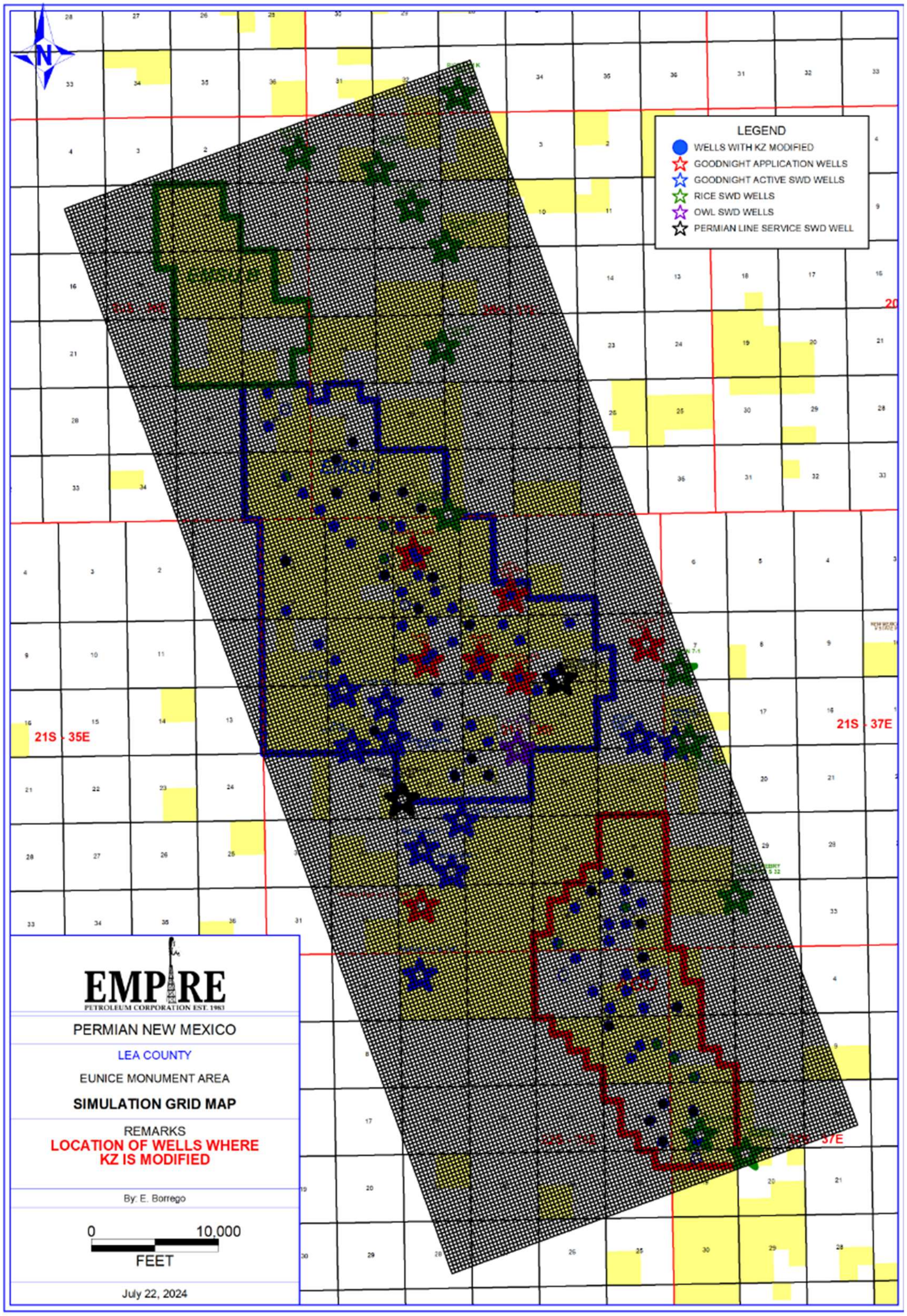


Exhibit E-2: Reservoir Model Layering and Vertical Permeability Modification

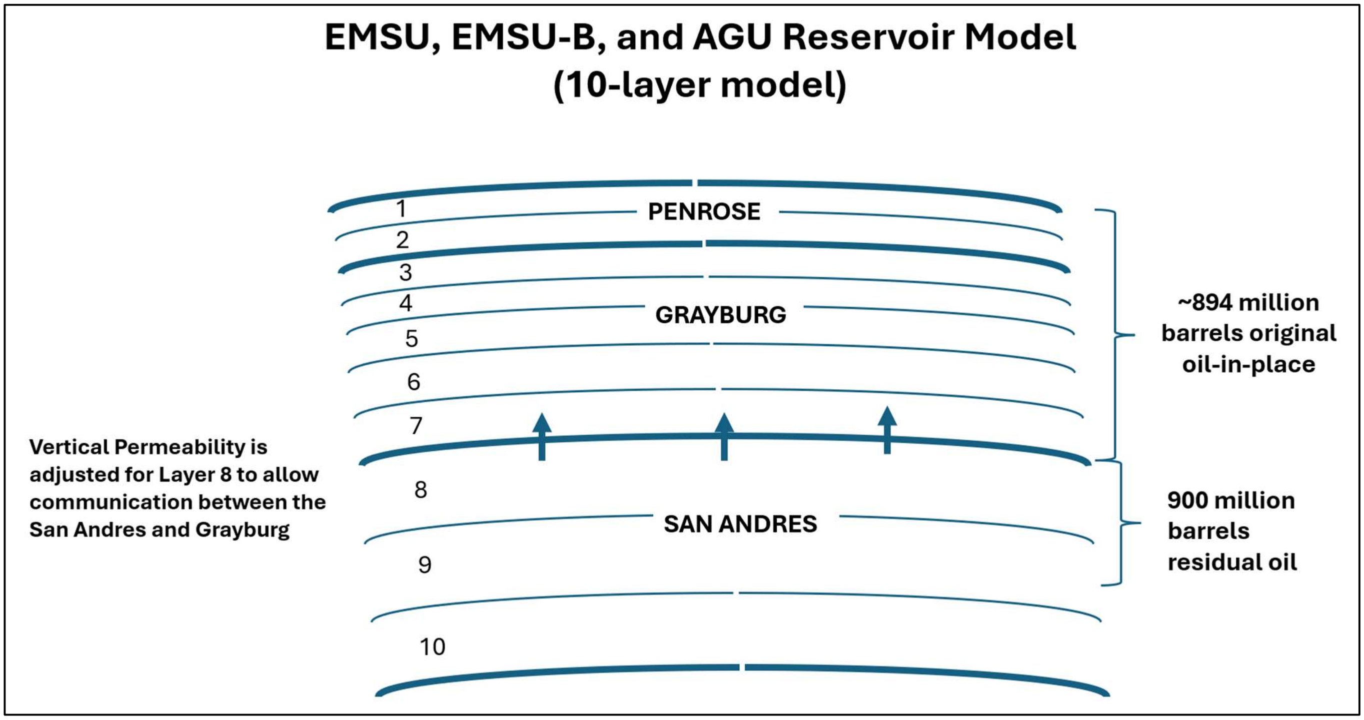


Exhibit E-3: Simulation History Match and Prediction

Water Disposal Rates Decline starting in 2027 Due To San Andres Pressuring Up (No Spillover)

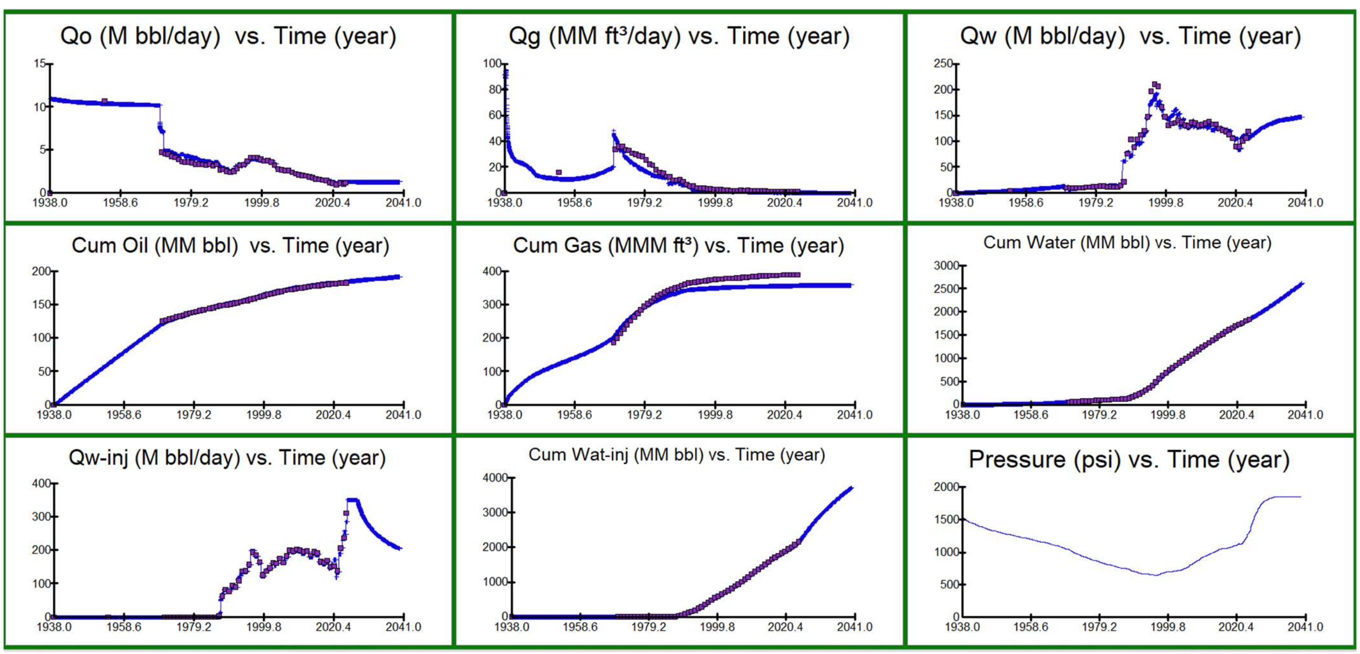


Exhibit E-4: Water Supply Well Volumes

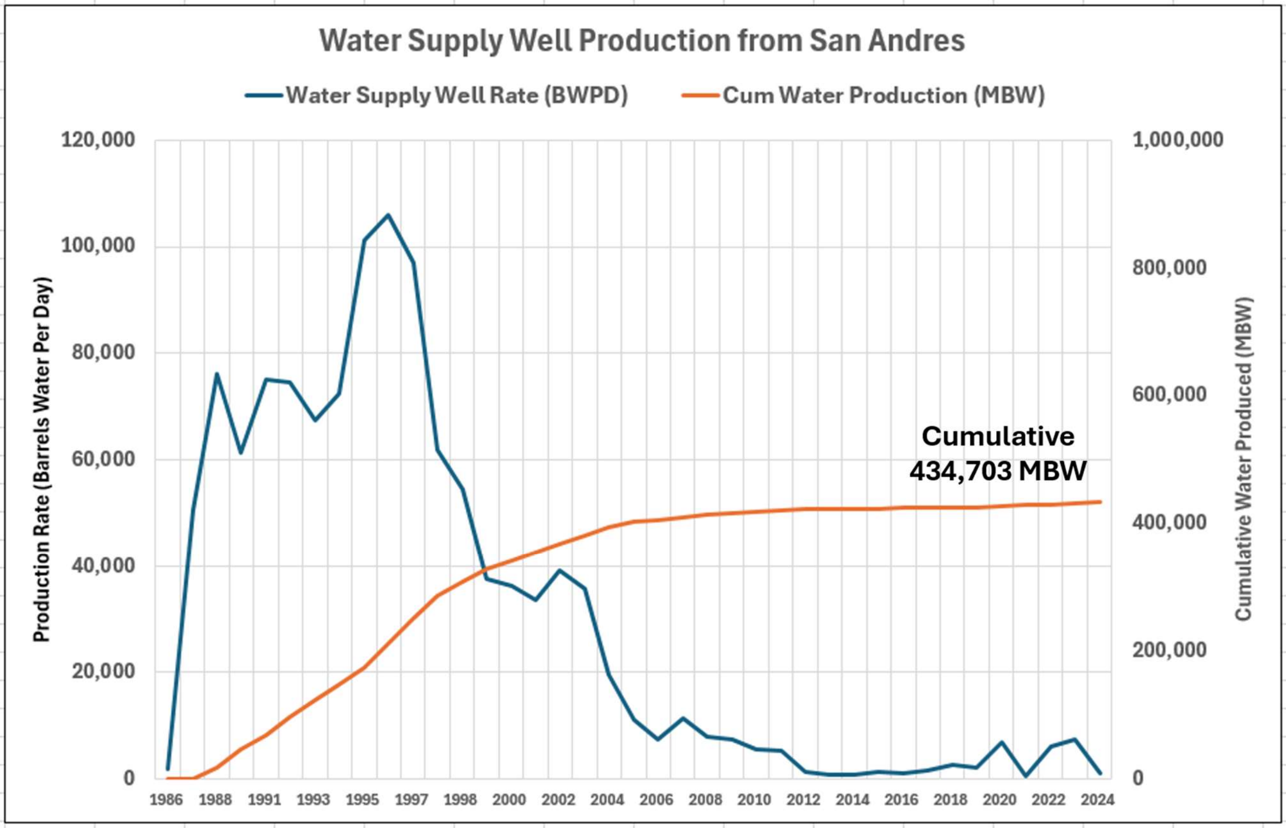


Exhibit E-5: Salt Water Disposal Volumes

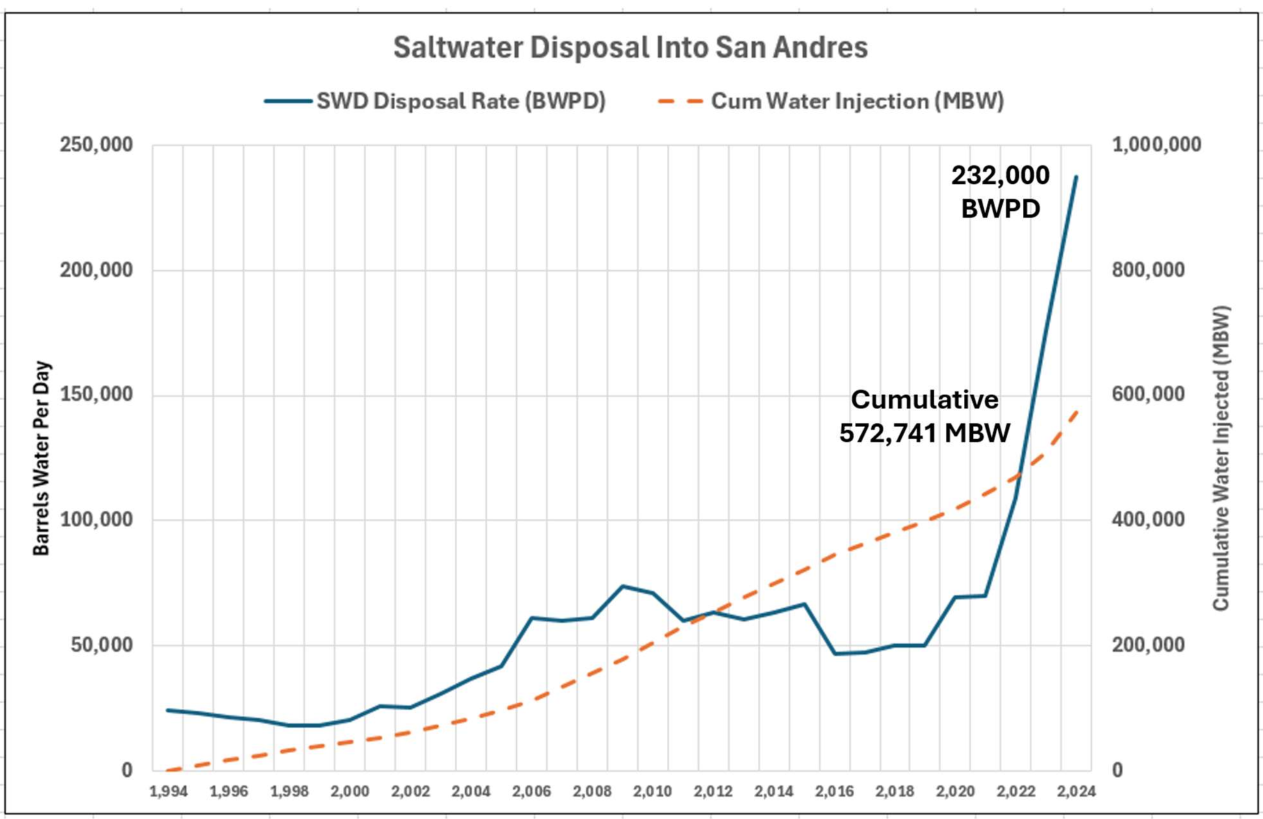


Exhibit E-6: Water Influx Entering Grayburg – Impacted By Water Supply Wells & SWD Volumes

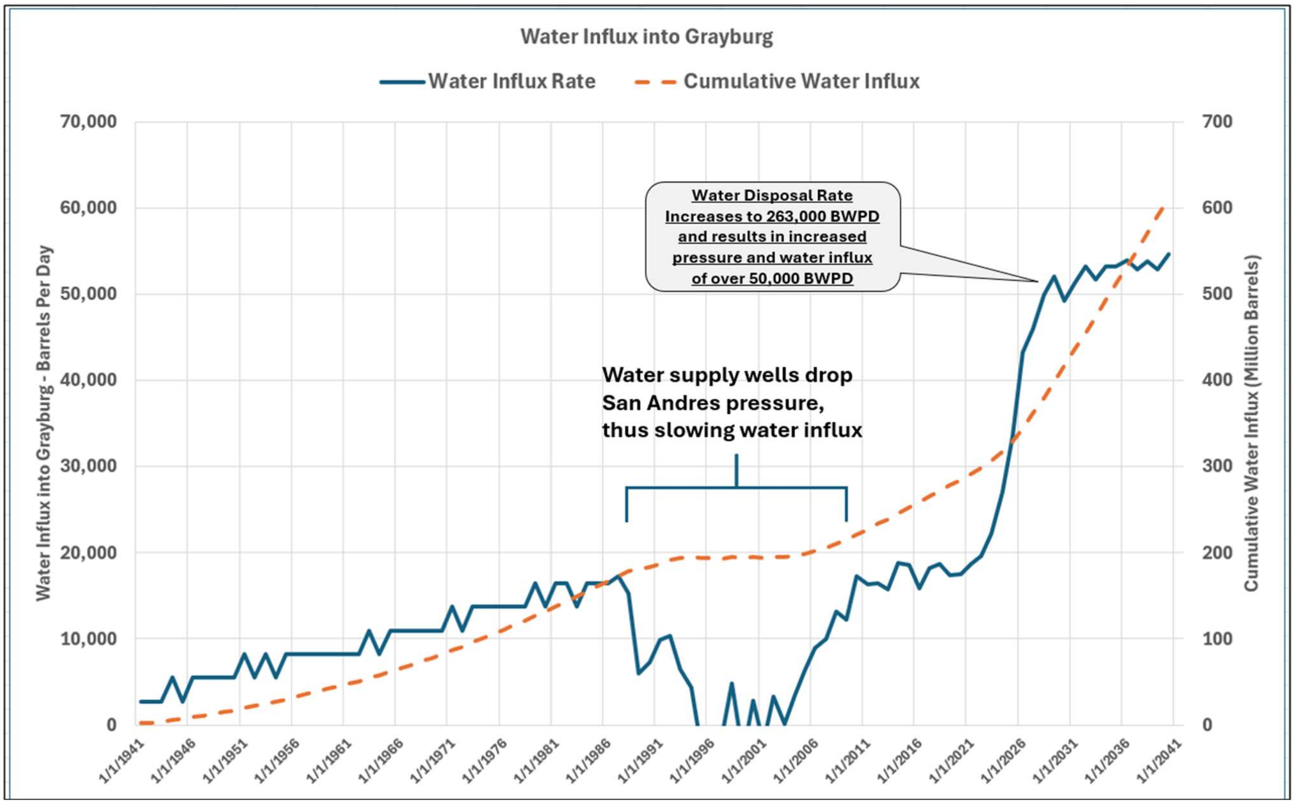


Exhibit E-7: Simulation Model Average Reservoir Pressure

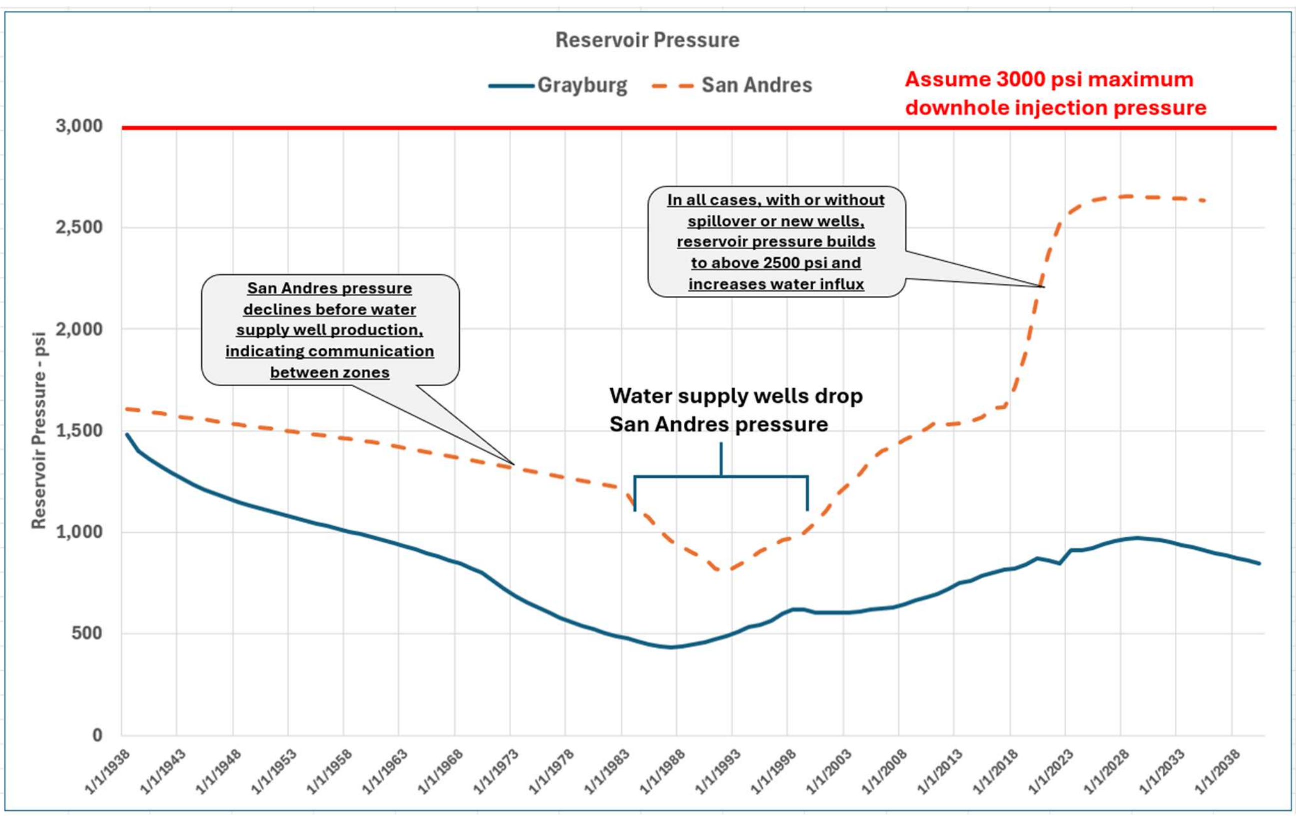


Exhibit E-8: EMSU High Water Producers Prior to Waterflood 1/1/1986 Cumulative Volumes

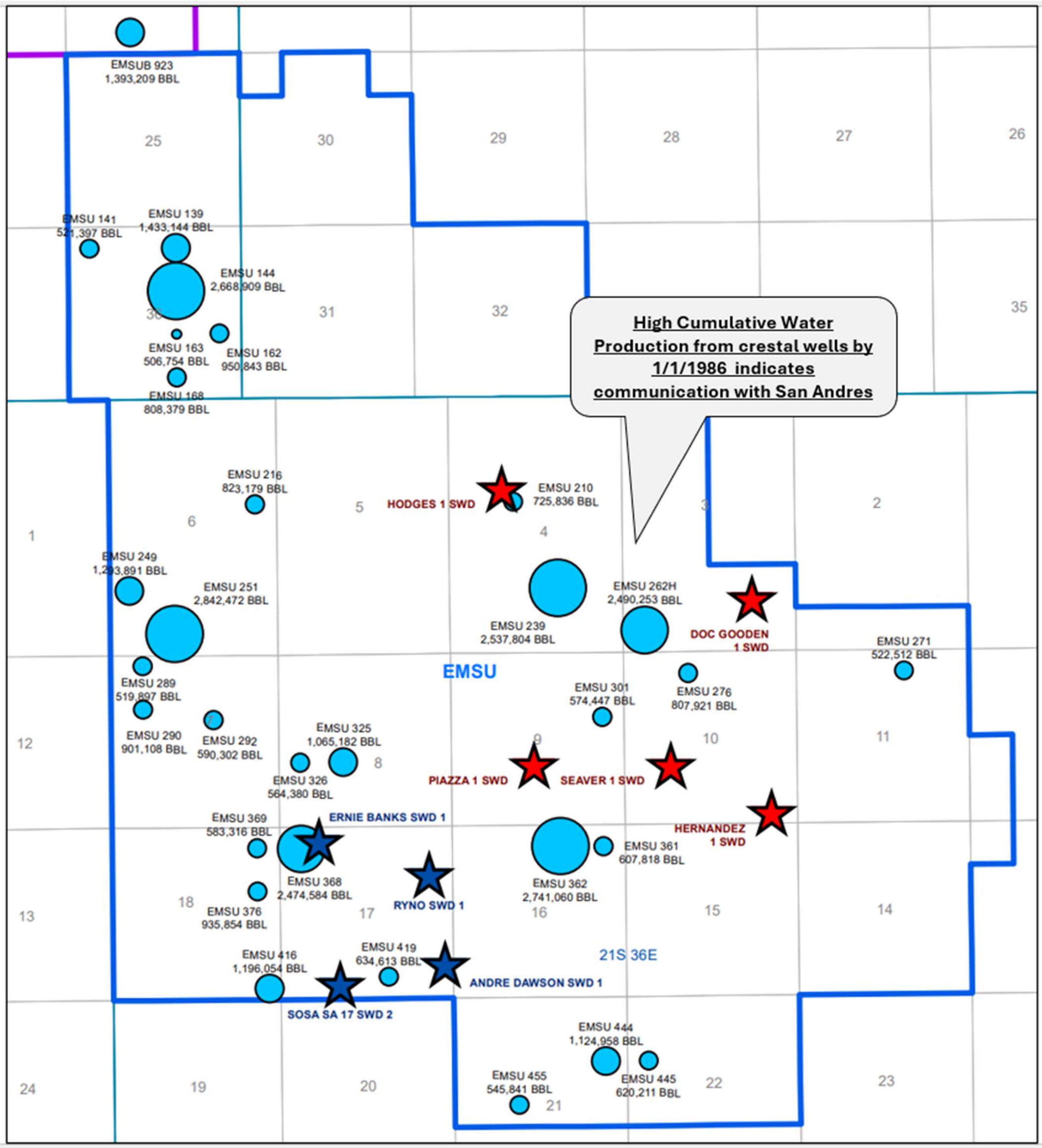


Exhibit E-9: AGU High Water Producers Prior to Waterflood 1/1/1986 Cumulative Volumes

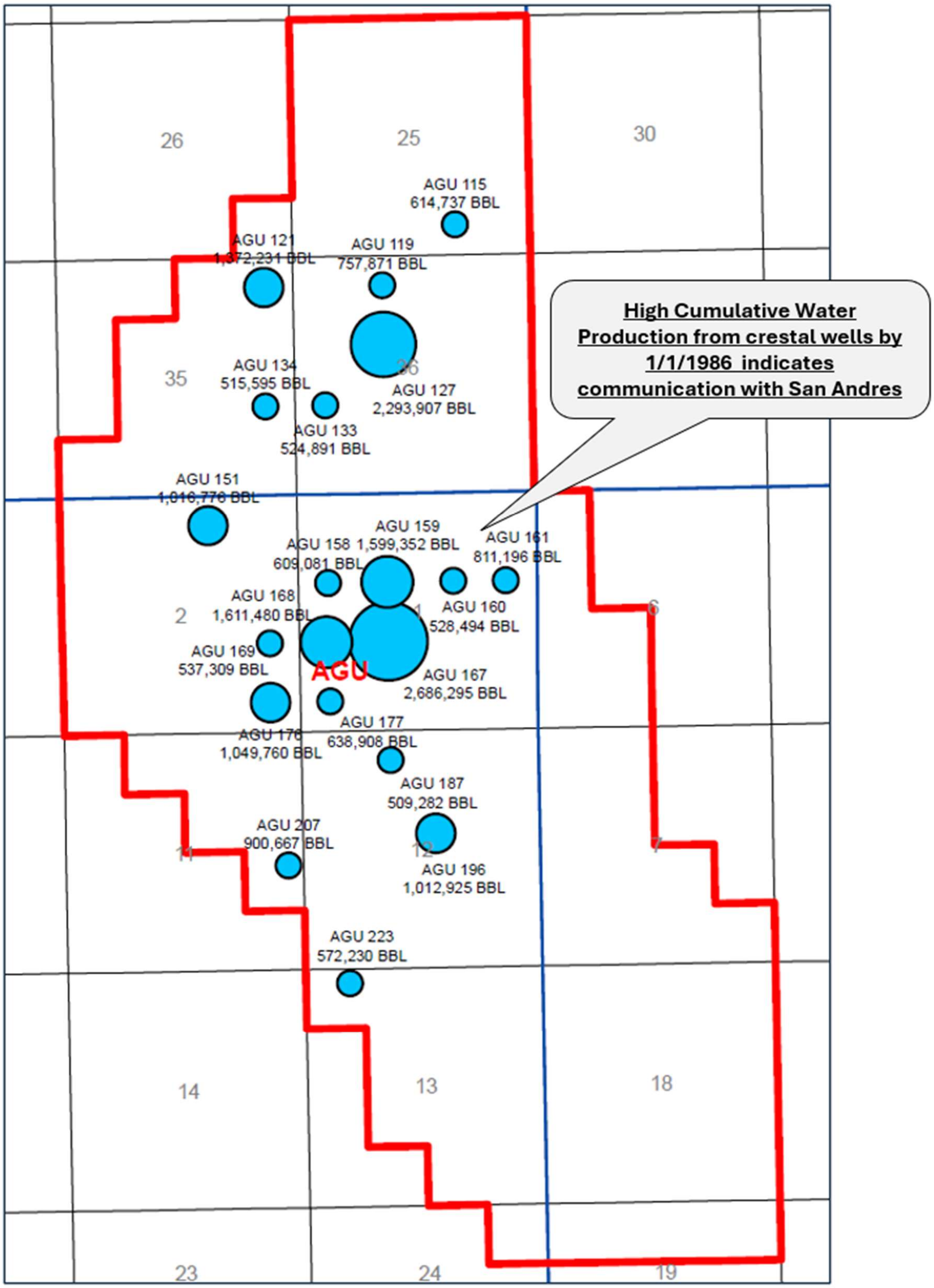


Exhibit E-10: EMSU, EMSU-B, and AGU History Match Base Case (220,000 BWPD Spillover)

The water production rate increases 1/1/2024 by 220,000 BWPD from the 11 spillover wells located in the aquifer. This allows for the increased SWD rates to be maintained longer, felt to be possible by the very large San Andres aquifer.

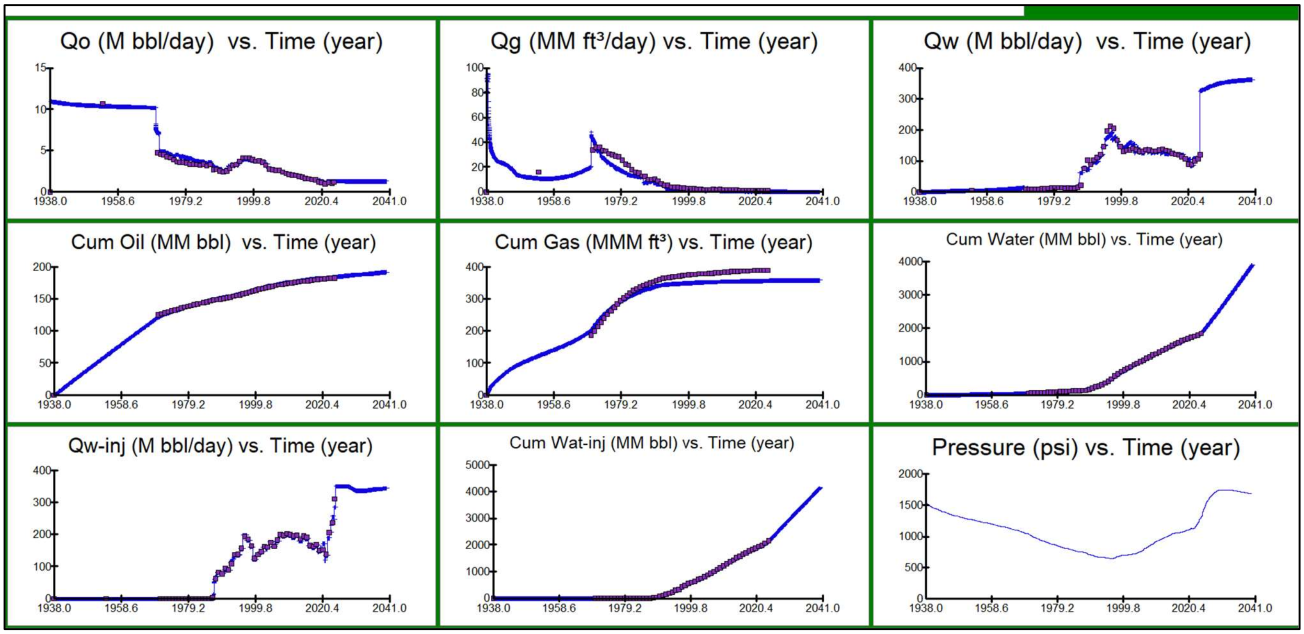
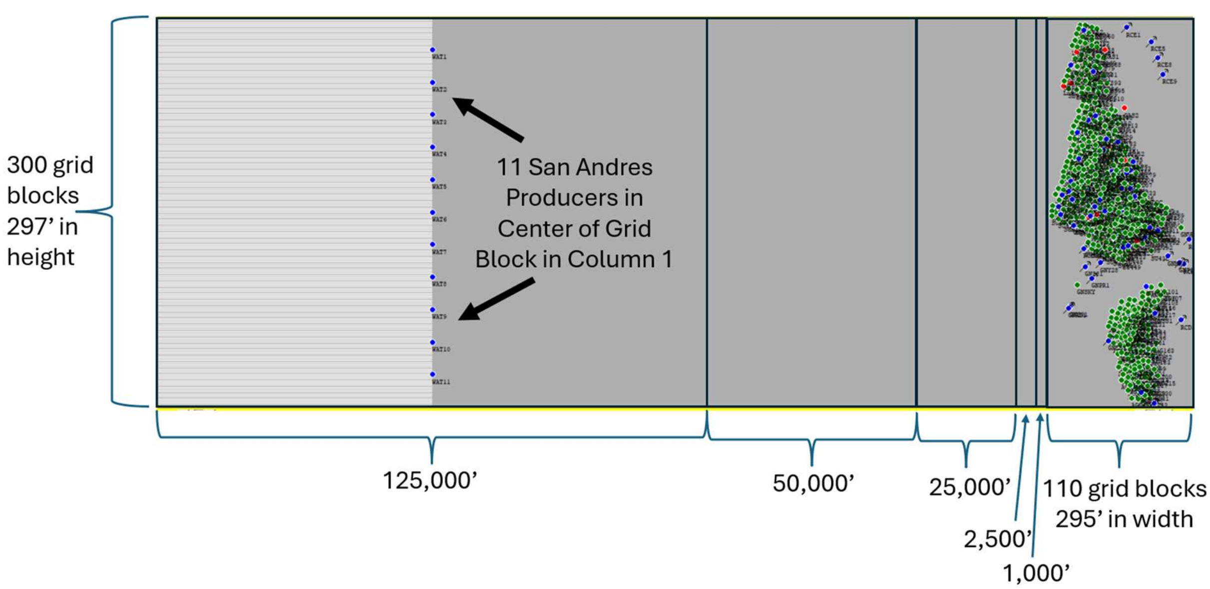


Exhibit E-11: Location of Spillover San Andres Producers in Model (220,000 BWPD withdrawal)

Large aquifer on western edge of model has 11 water producers which allows for 220,000 BWPD to leak off into other oil fields or migrate into other zones. The wells are located in the center of the grids blocks in column 1 and are therefore 26.7 miles west of the base grid, with total distance to the edge of the model being 38.5 miles.



History Match For Individual Wells With and Without San Andres/Grayburg Communication

Exhibit E-12(a): EMSU-104 History Match with KZ Greater Than Zero

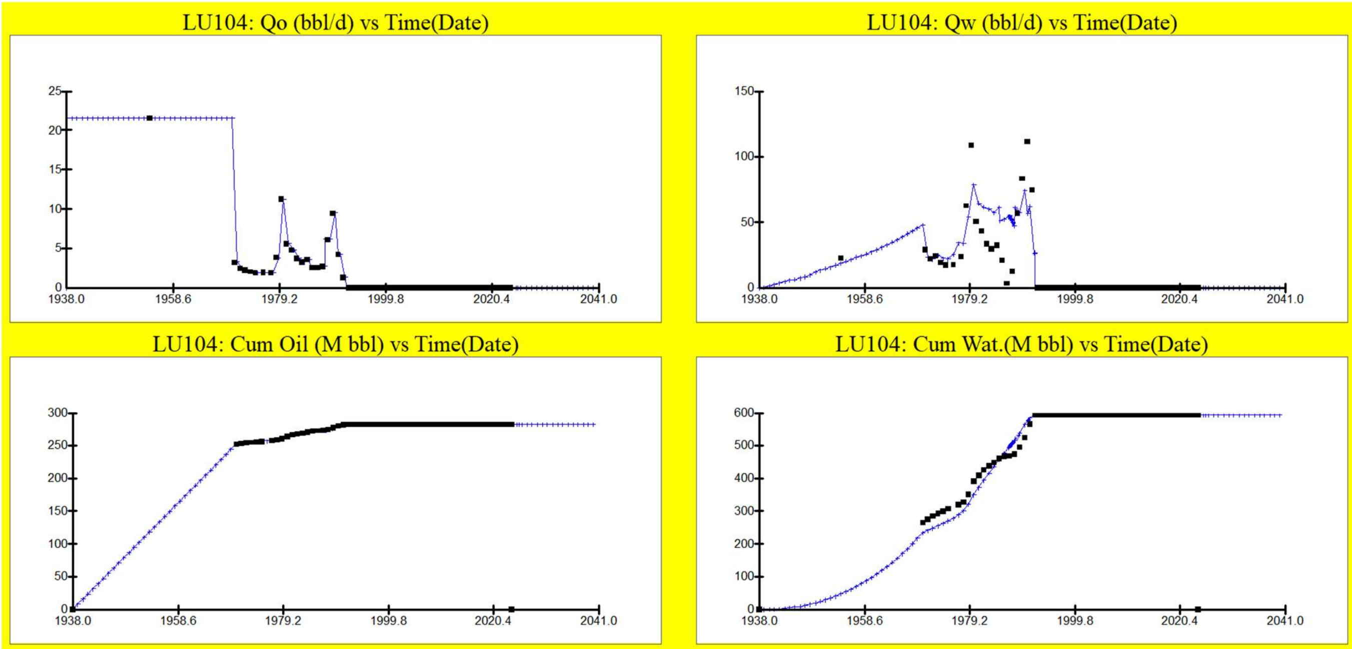
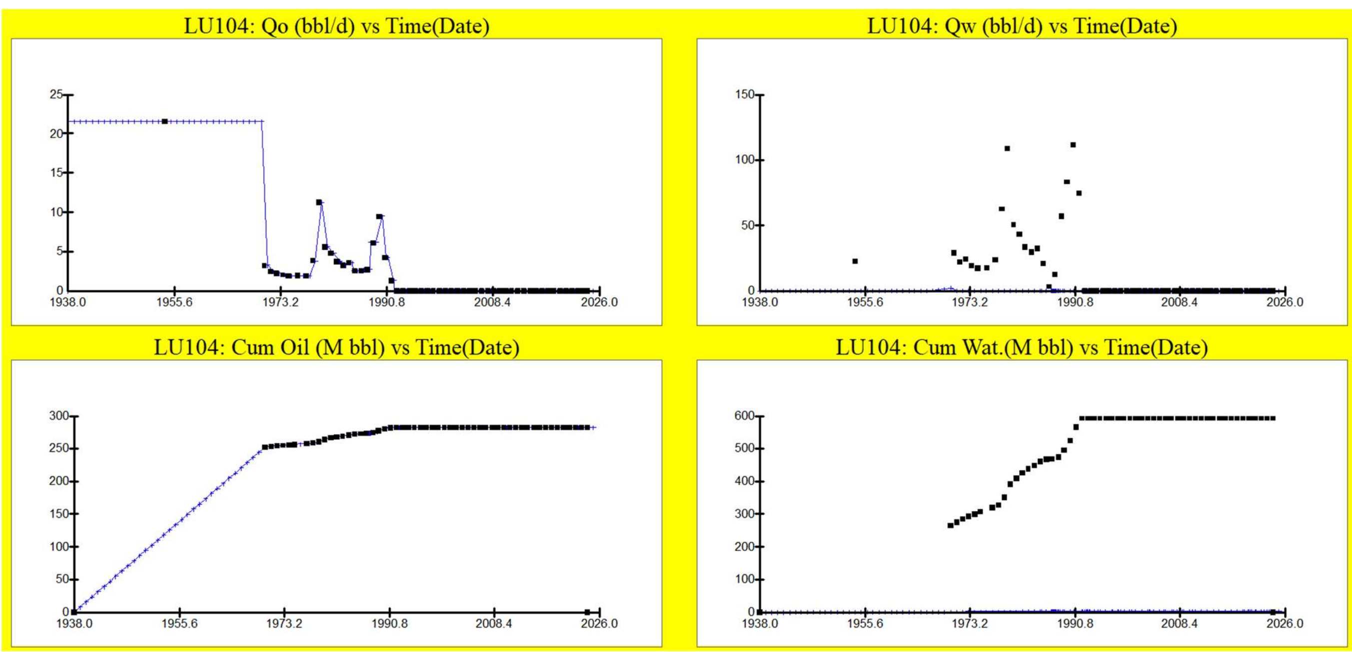


Exhibit E-12(b): EMSU-104 History Match with KZ Equal to Zero



History Match For Individual Wells With and Without San Andres/Grayburg Communication

Exhibit E-13(a): EMSU-259 History Match with KZ Greater Than Zero

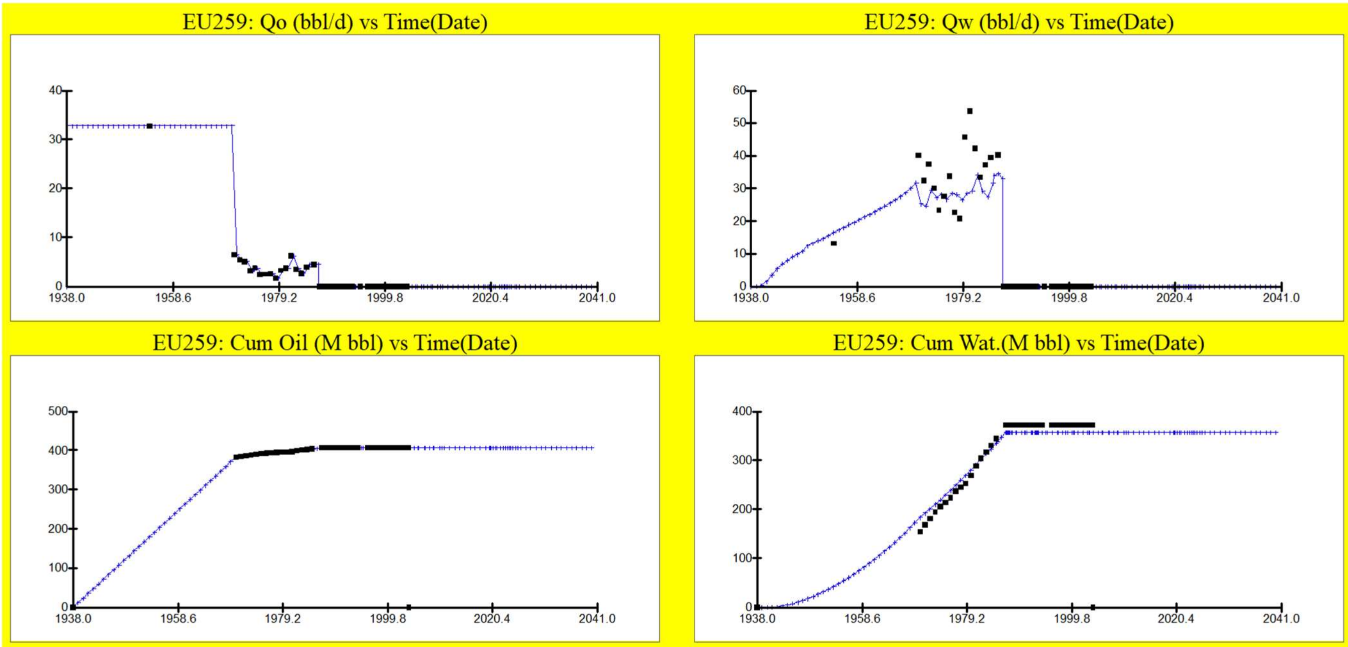
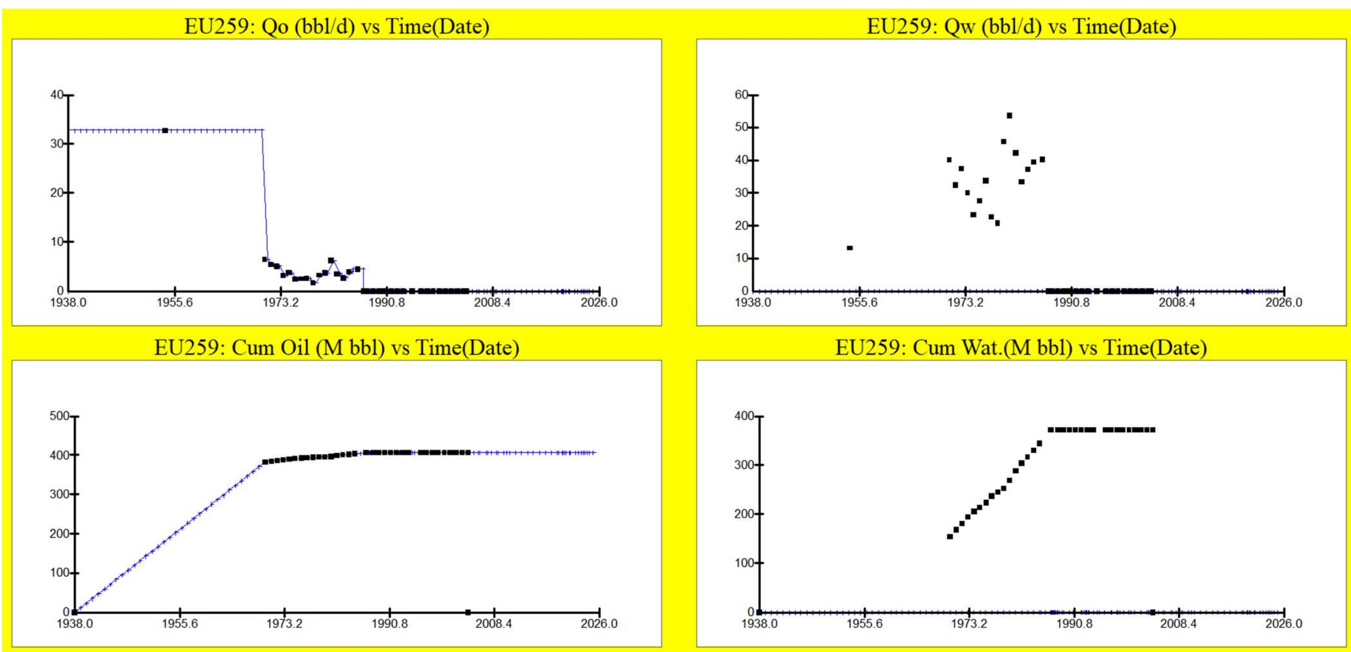


Exhibit E-13(b): EMSU-259 History Match with KZ Equal to Zero



History Match For Individual Wells With and Without San Andres/Grayburg Communication

Exhibit E-14(a): EMSU-362 History Match with KZ Greater Than Zero

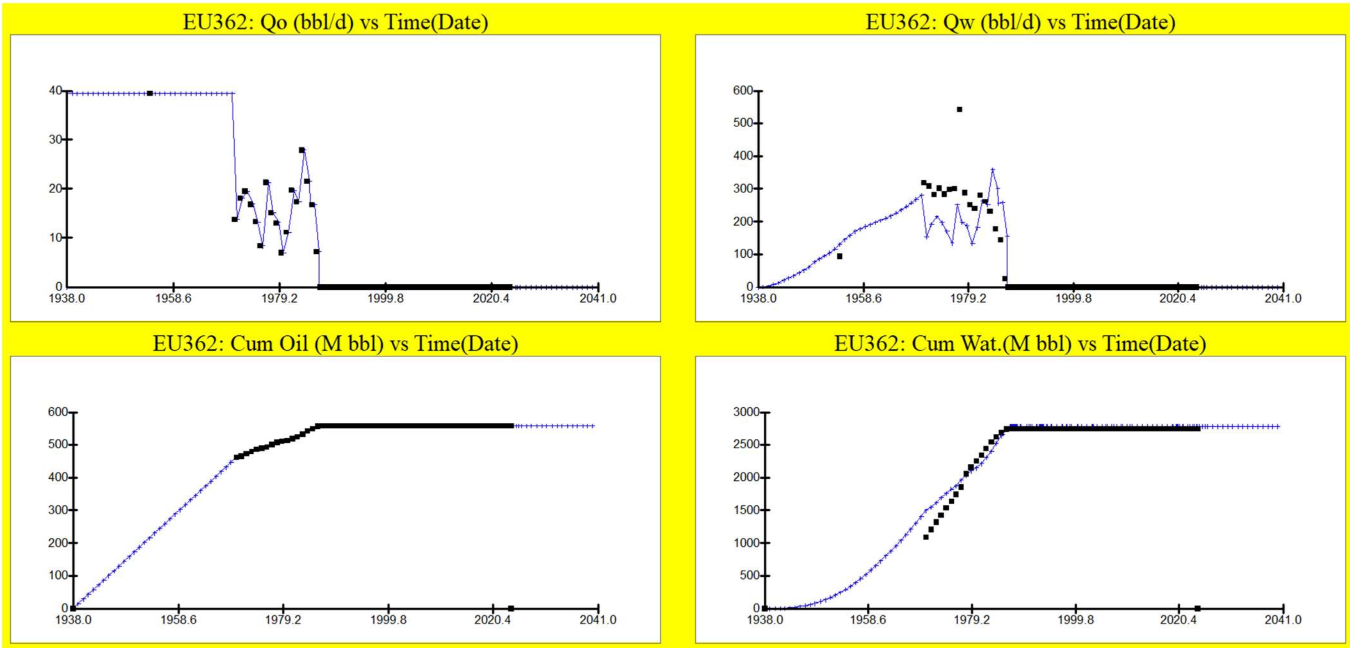
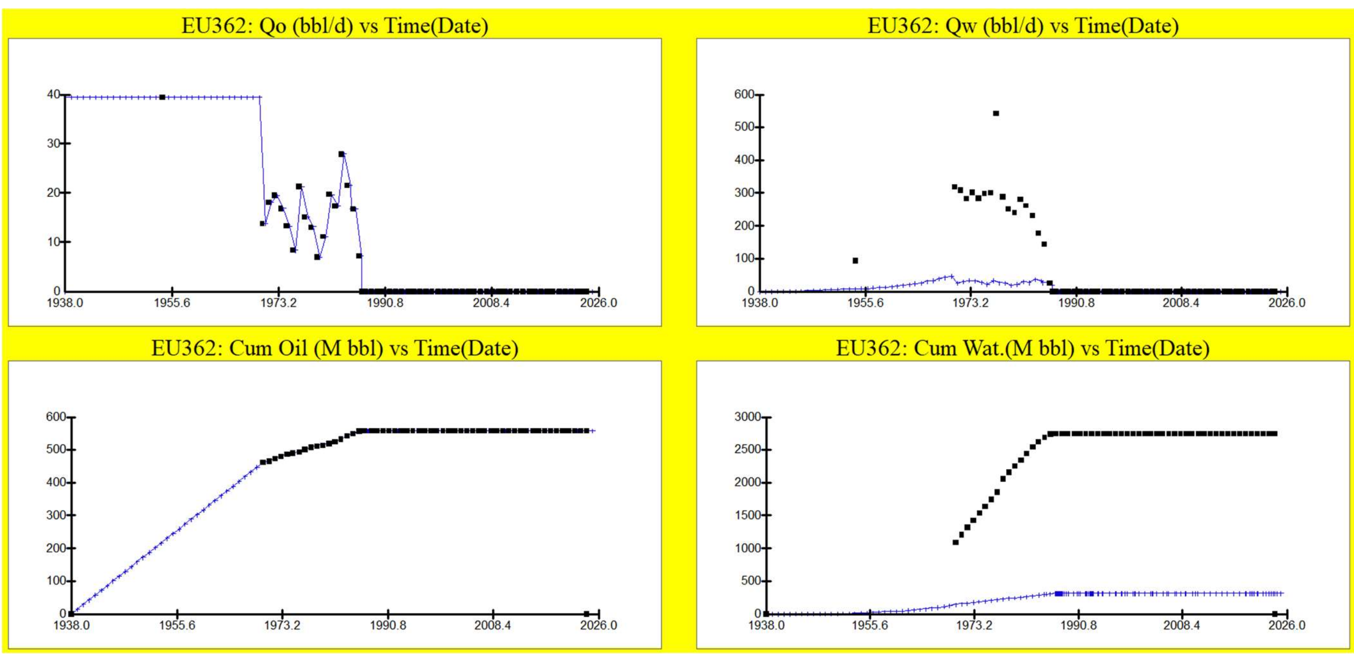


Exhibit E-14(b): EMSU-362 History Match with KZ Equal to Zero



History Match For Individual Wells With and Without San Andres/Grayburg Communication

Exhibit E-15(a): EMSU-368 History Match with KZ Greater Than Zero

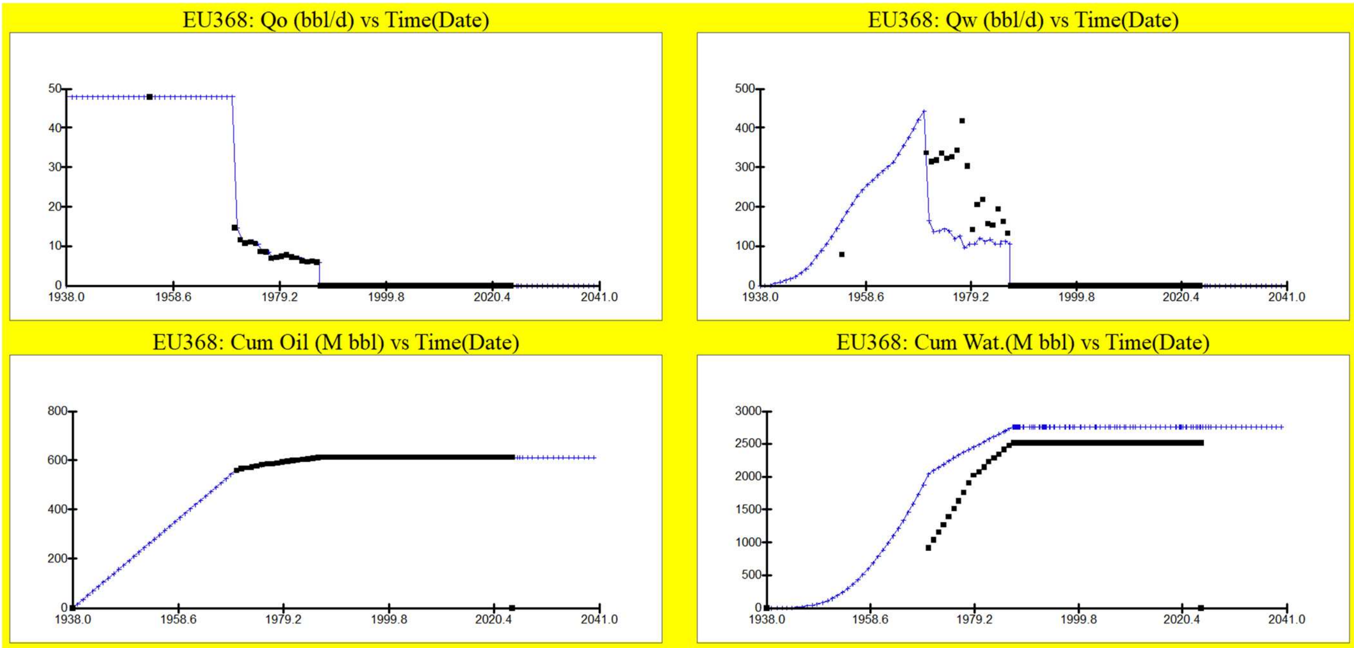
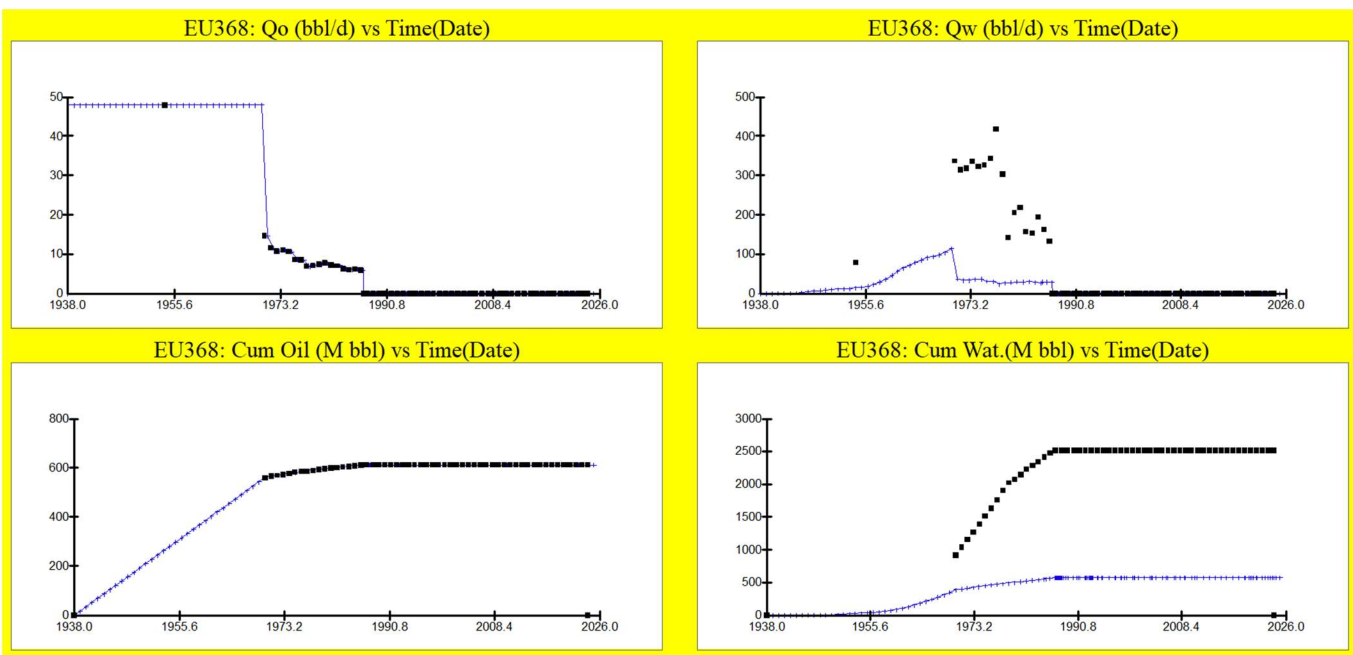


Exhibit E-15(b): EMSU-368 History Match with KZ Equal to Zero



History Match For Individual Wells With and Without San Andres/Grayburg Communication

Exhibit E-16(a): EMSU-B #889 History Match with KZ Greater Than Zero

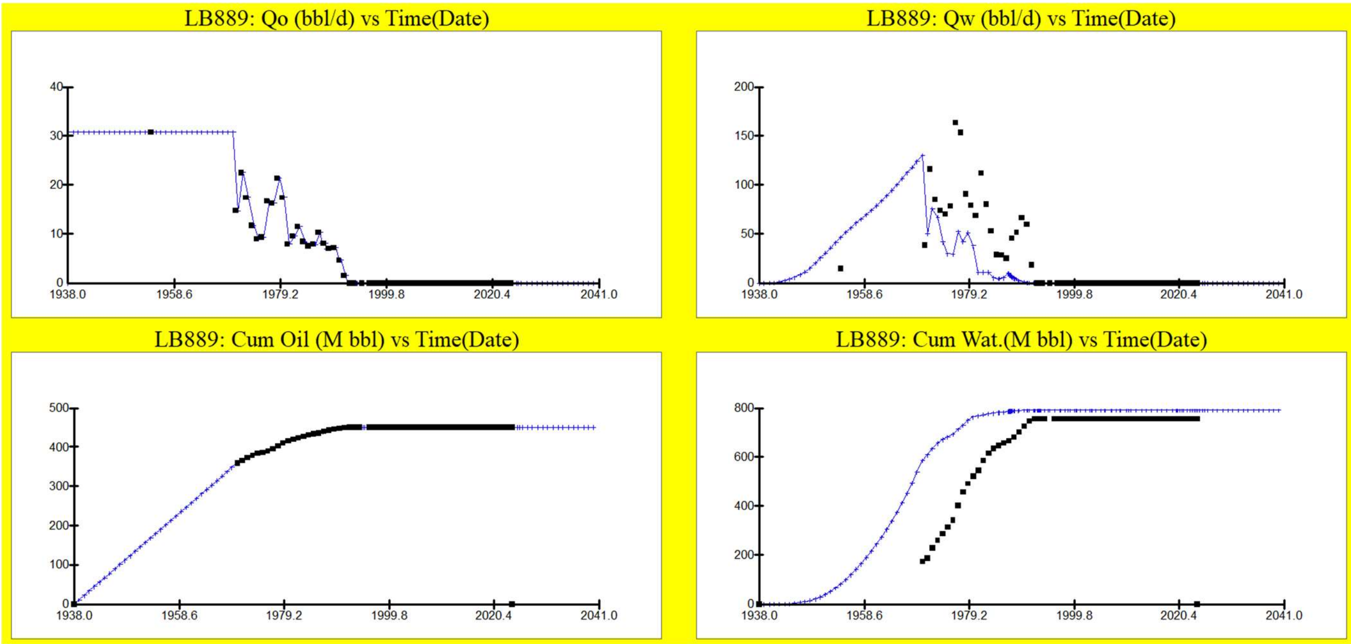
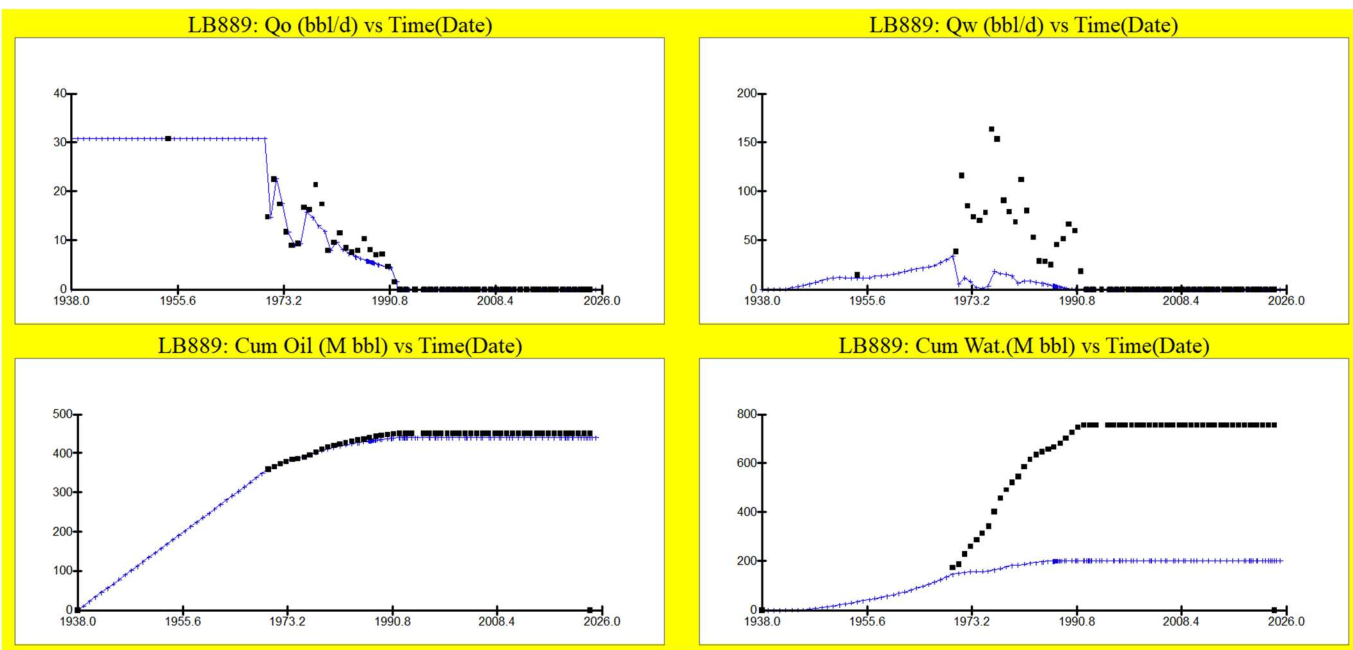


Exhibit E-16(b): EMSU-B #889 History Match with KZ Equal to Zero



History Match For Individual Wells With and Without San Andres/Grayburg Communication

Exhibit E-17(a): AGU-177 History Match with KZ Greater Than Zero

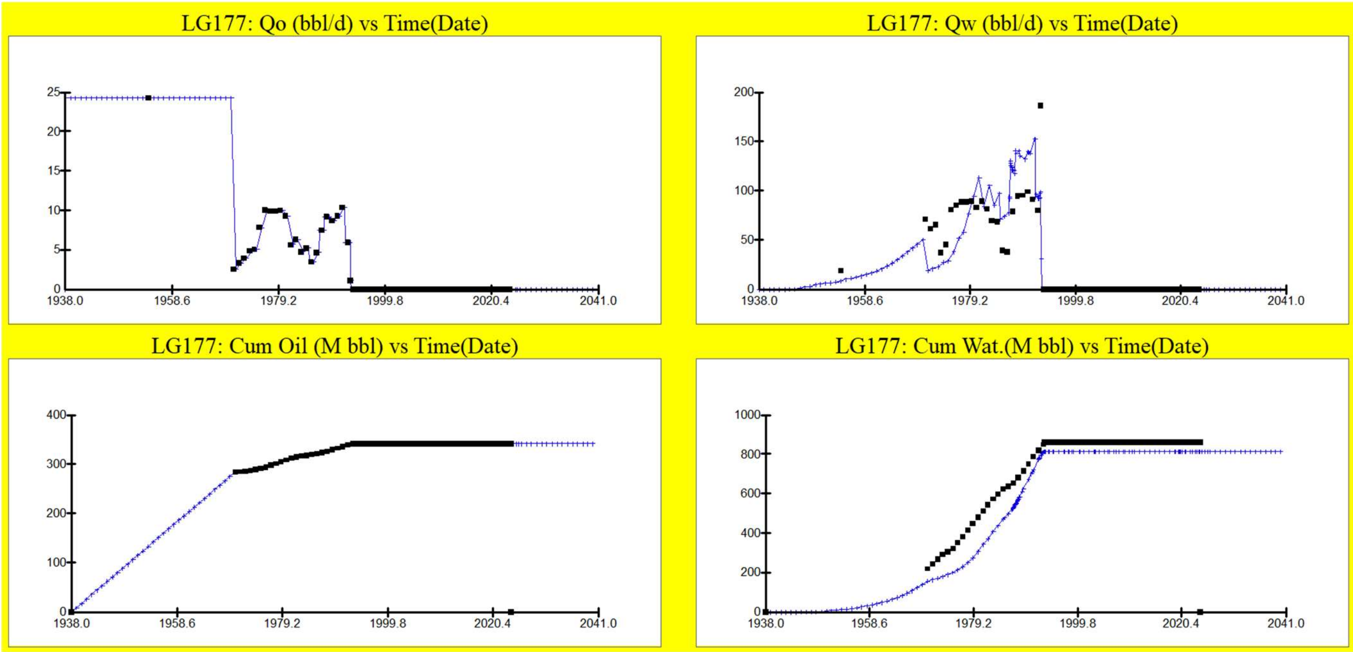


Exhibit E-17(b): AGU-177 History Match with KZ Equal to Zero

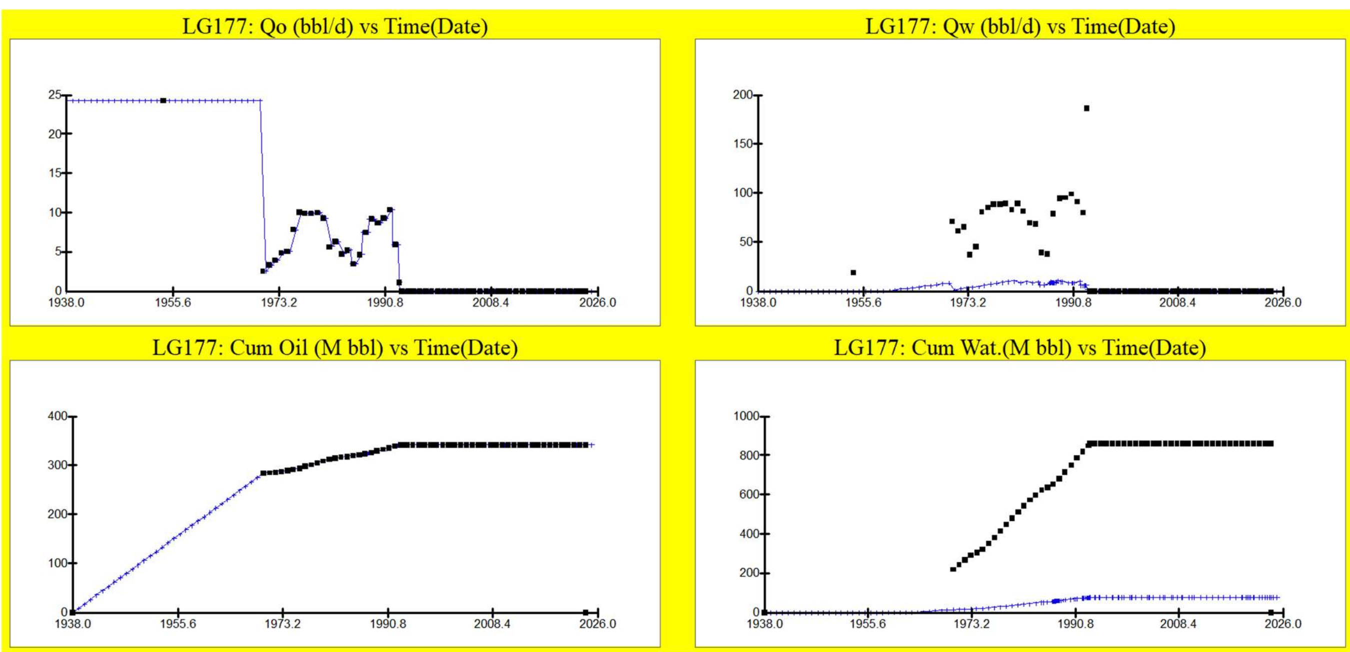


Exhibit E-18: Water Disposal Rates for Various Cases

By adding the 7 new application SWD wells there is a temporary large increase in disposal rate but ultimately the overall rate will be governed by how much spillover occurs from the San Andres into other producing oil fields or migration out of zone (i.e into the Grayburg). Without assumed spillover of 220,000 BWPD, the water disposal rate drops off over time due to injectors reaching 3000 psi maximum sand face injection pressure constraint and reservoir pressure increase. The new SWD wells don't add any additional rate after pressure reaches a certain level. (red curve versus green dashed)

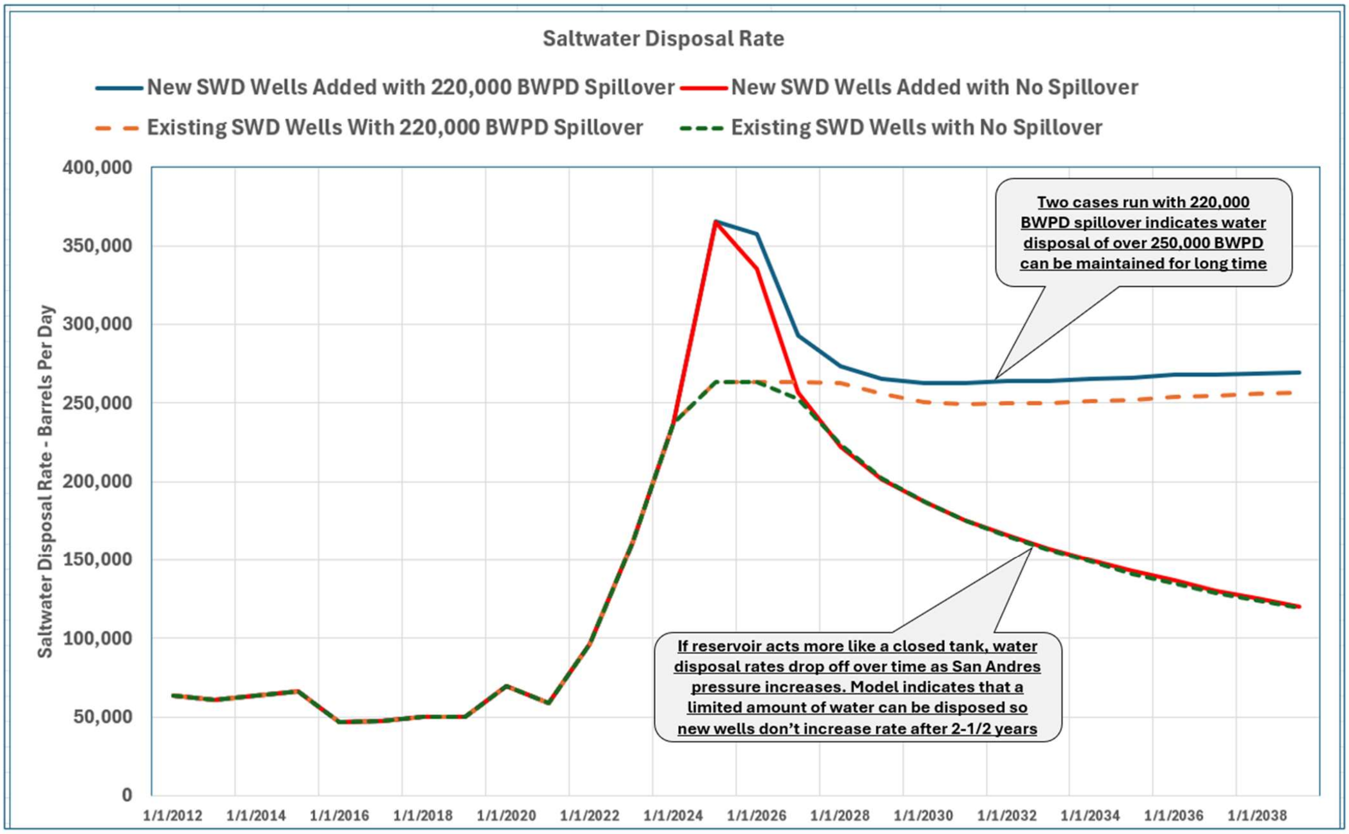


Exhibit E-19: Water Influx into Grayburg at EMSU, EMSU-B, and AGU for Various Cases

Since water influx into the Grayburg is controlled by the pressure difference between the San Andres and Grayburg, distributed according to the vertical permeability modifications, water influx rates are similar for all 4 cases. The sharp rise in water influx into the Grayburg occurs as a result of the large increase in reservoir pressure (see Exhibit E-20) due to the increase in disposal rate inside EMSU.

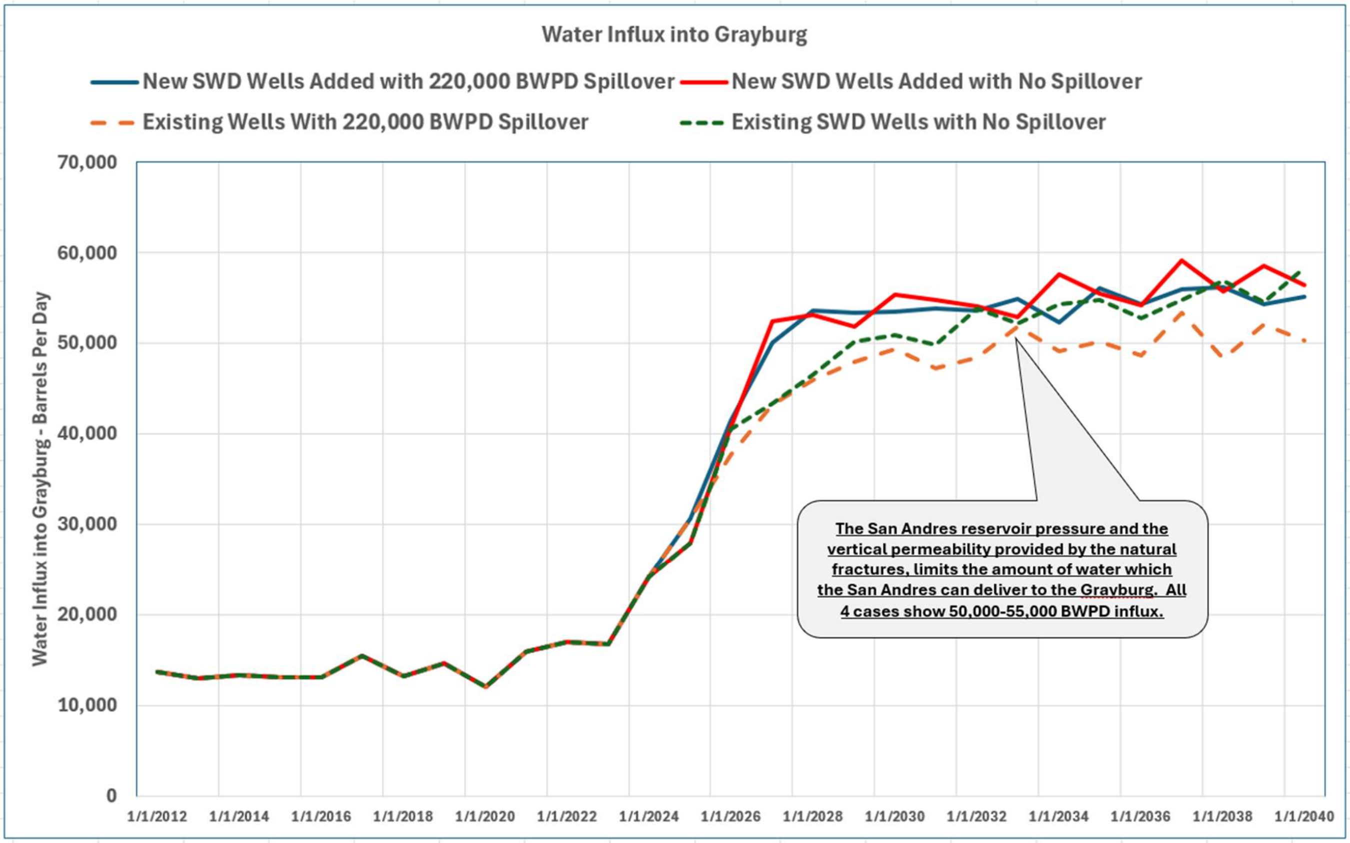


Exhibit E-20: Increase in San Andres Reservoir Pressure as a Result of SWD

The San Andres reservoir pressure has increased rapidly due to Goodnight SWD. By adding the 7 new SWD wells, reservoir pressure will increase an additional 200-300 psi and if there is no spillover (leakoff) to other remote areas, the reservoir pressure will continue to increase as shown by the red and dashed green curves. If there is spillover, the pressure remains relatively steady as the water is forced to other areas in the system. A 3000 psi maximum sand face injection pressure is used for all SWD wells.

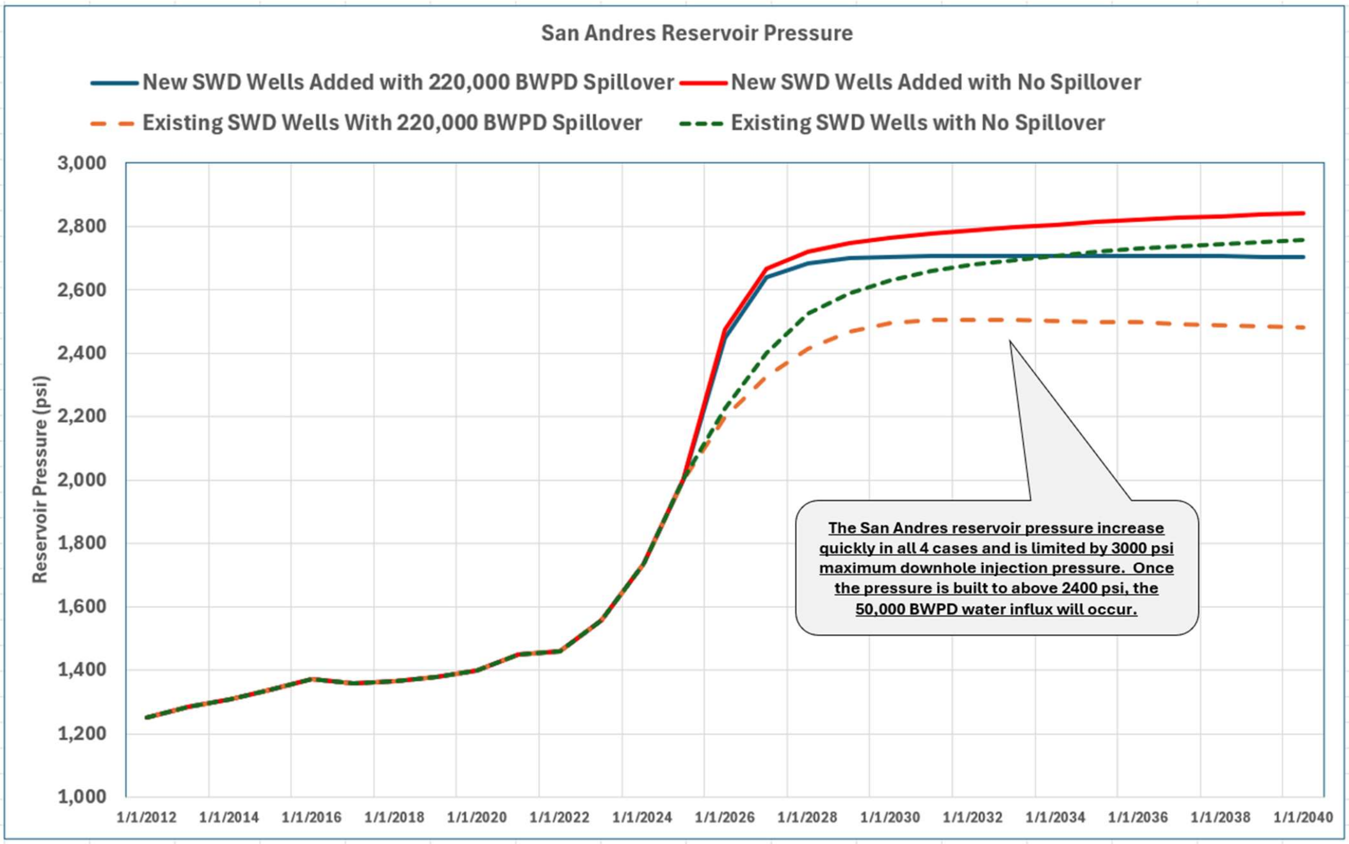
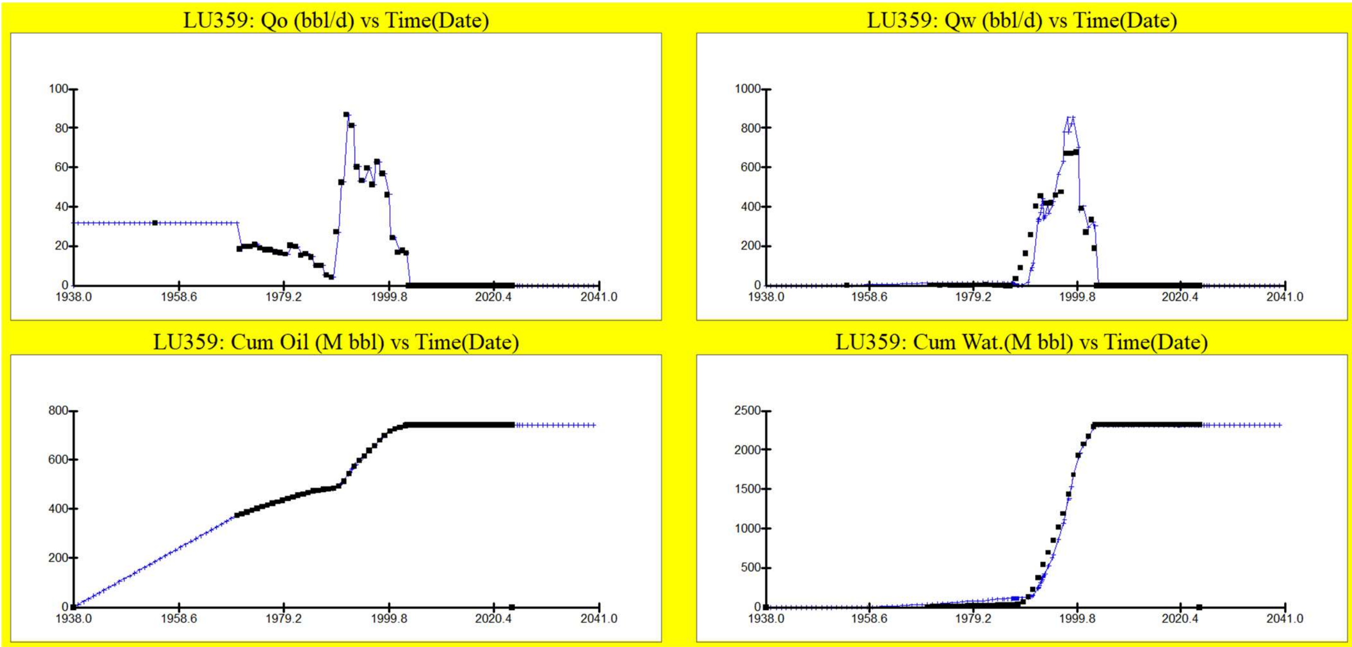


Exhibit E-21(a): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-359



EMSU-B #908

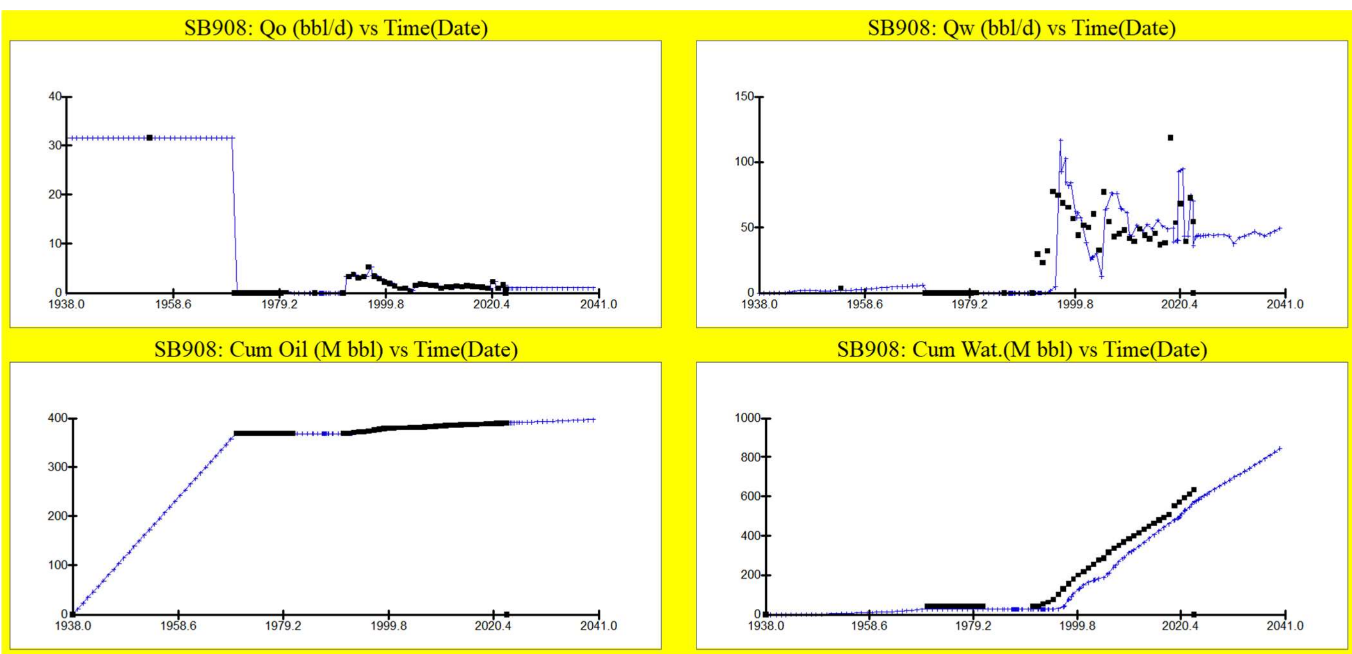
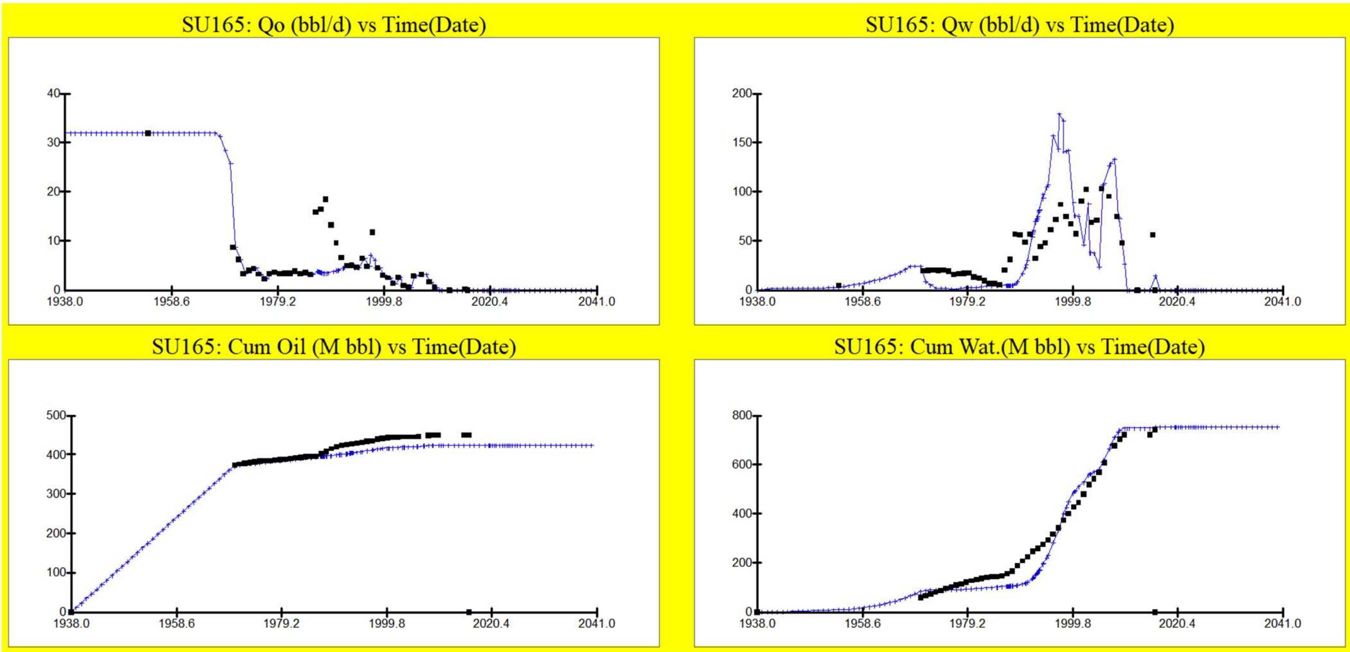


Exhibit E-21(b): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-165



EMSU-200

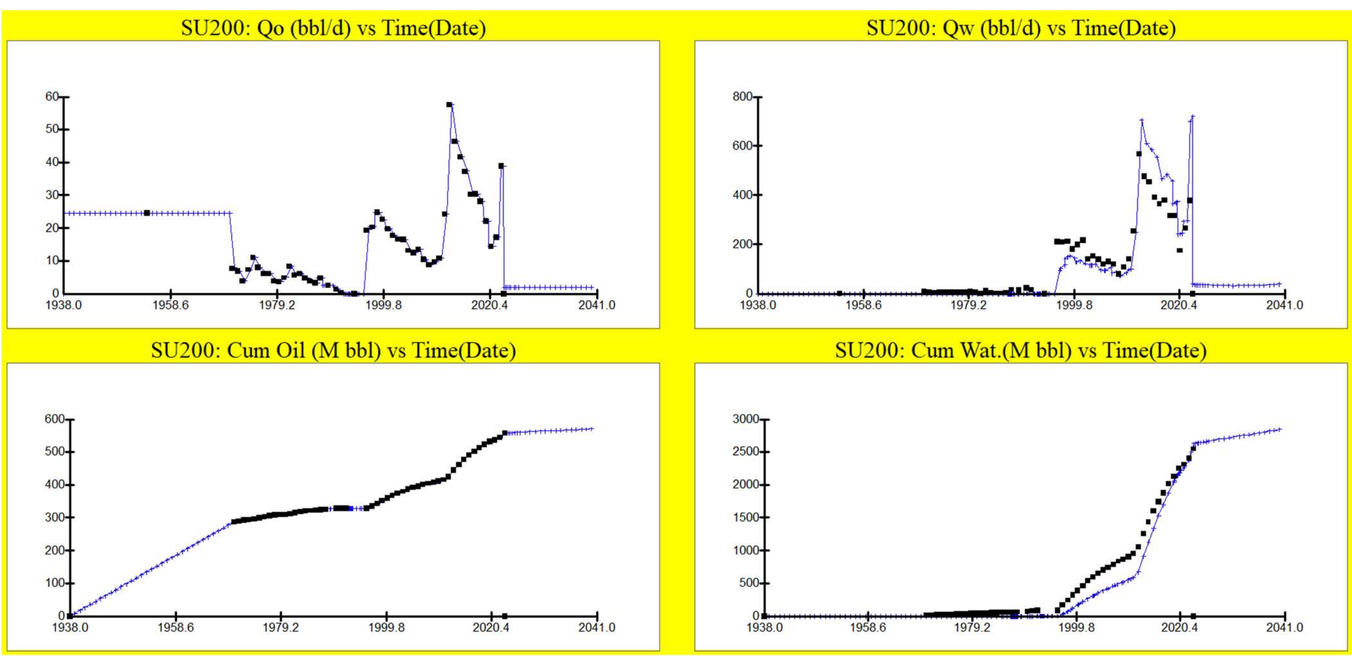
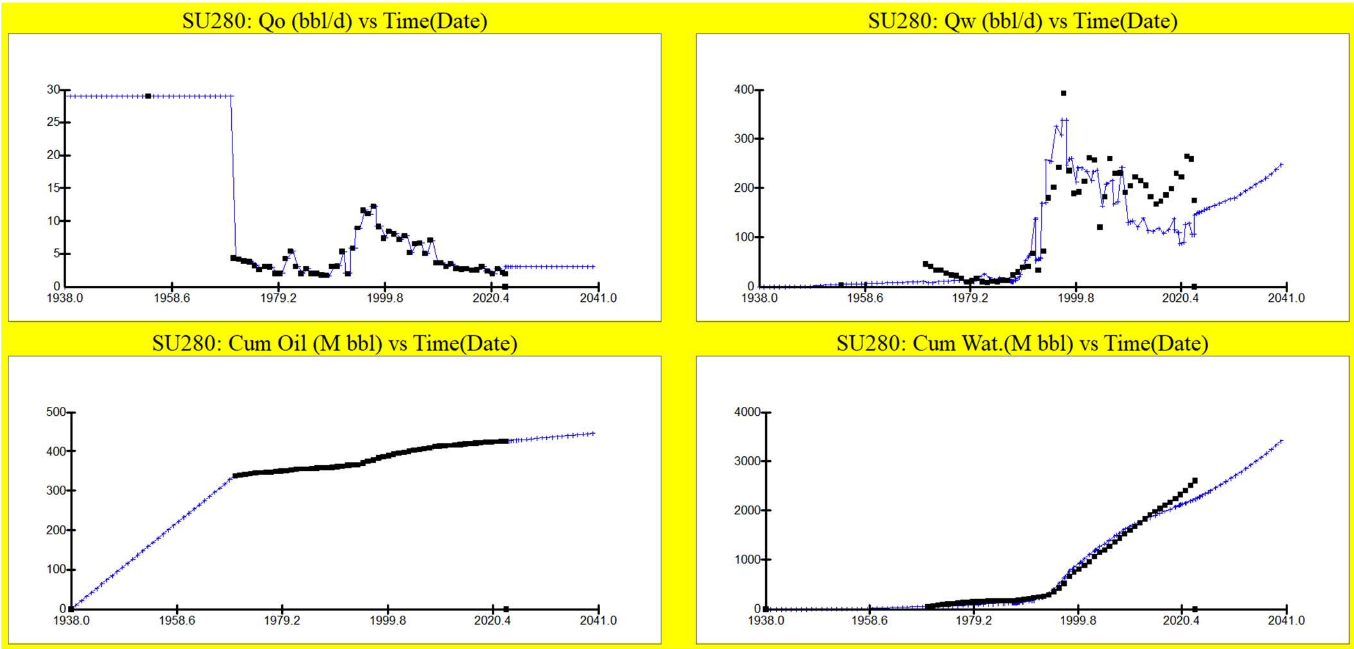


Exhibit E-21(c): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-280



EMSU-282

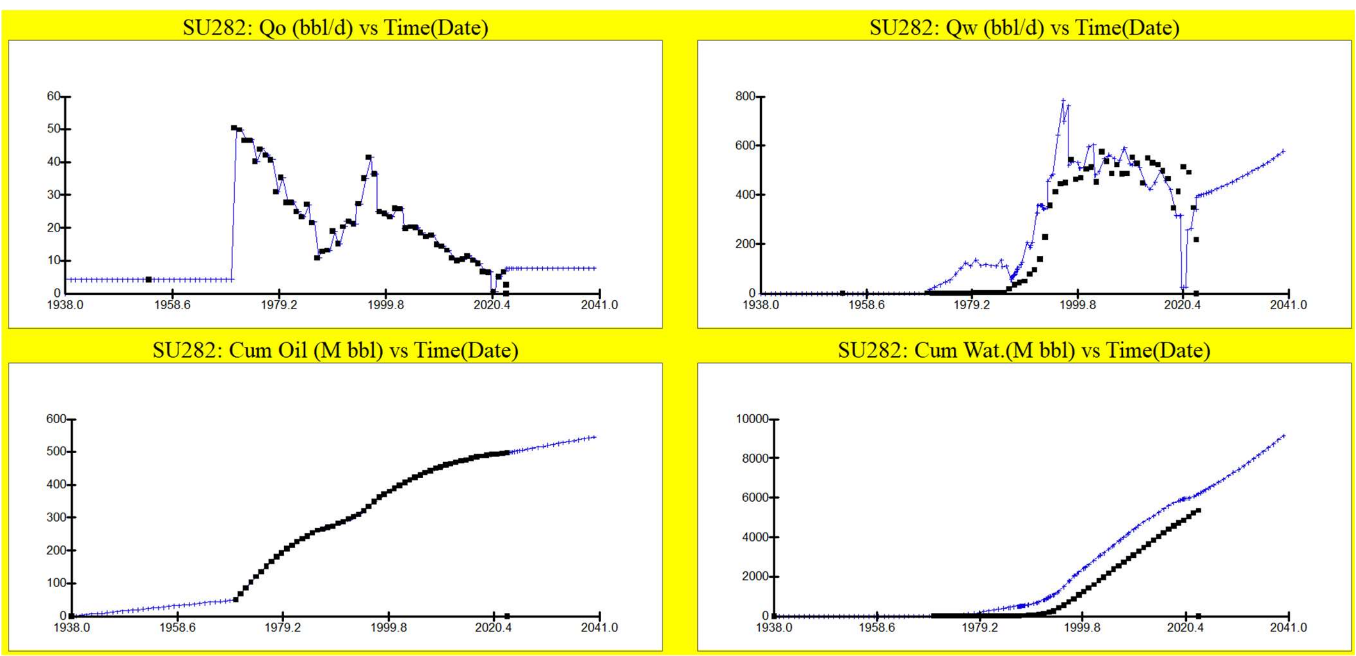
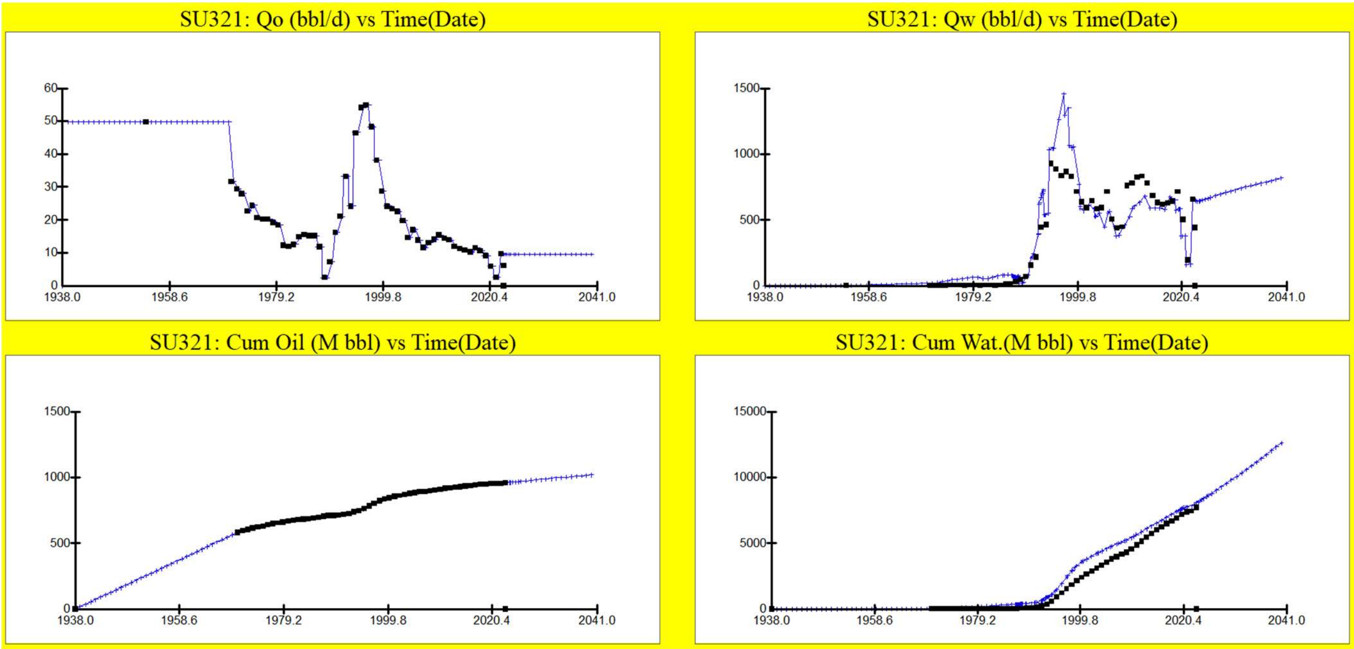


Exhibit E-21(d): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-321



EMSU-708

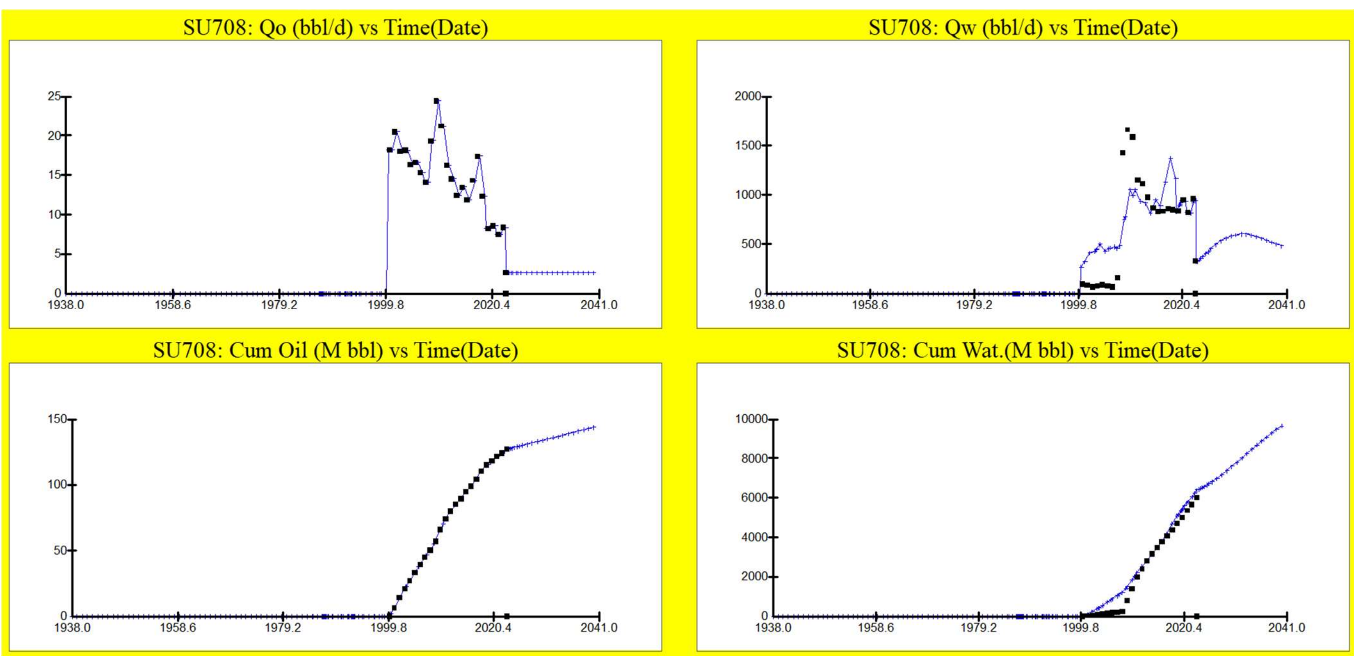
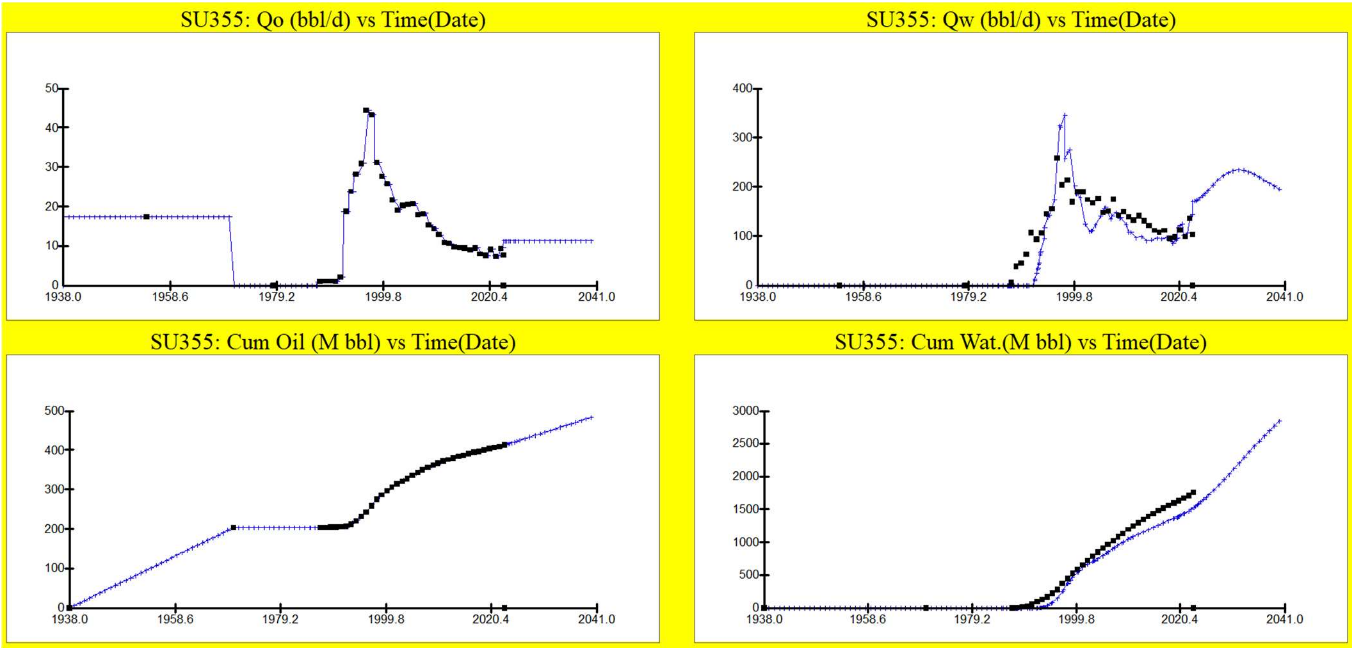


Exhibit E-21(e): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-355



EMSU-409

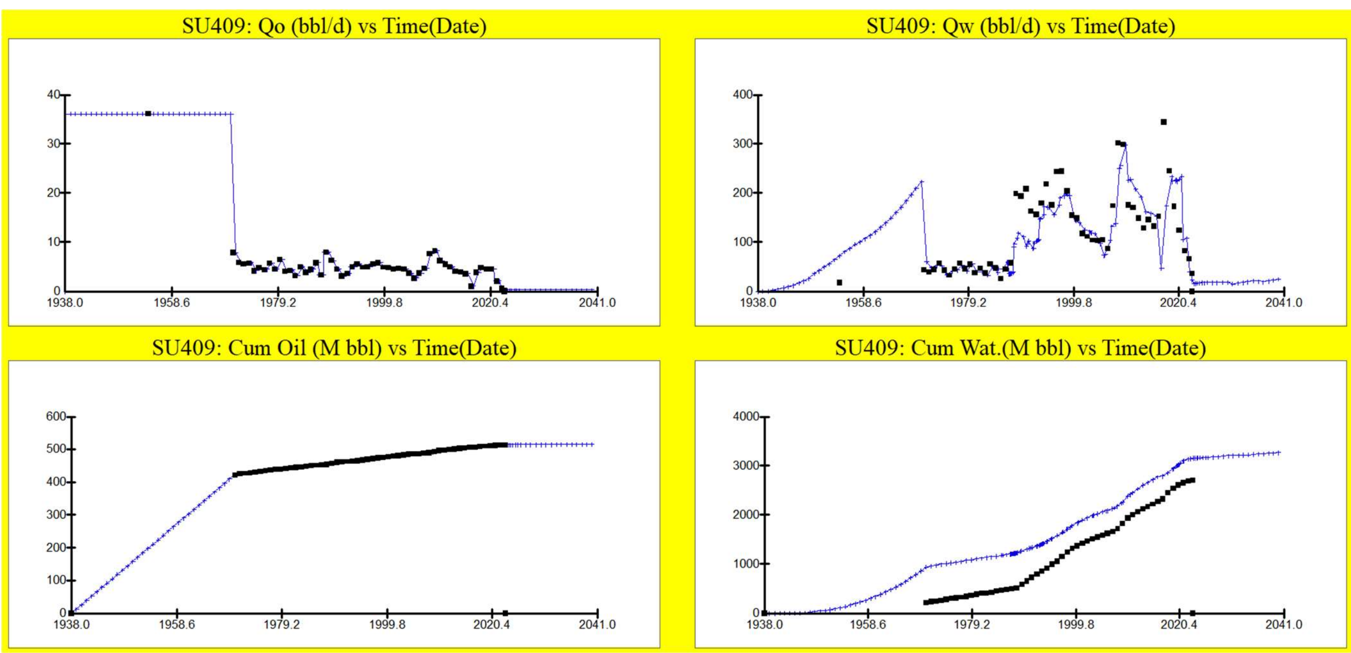
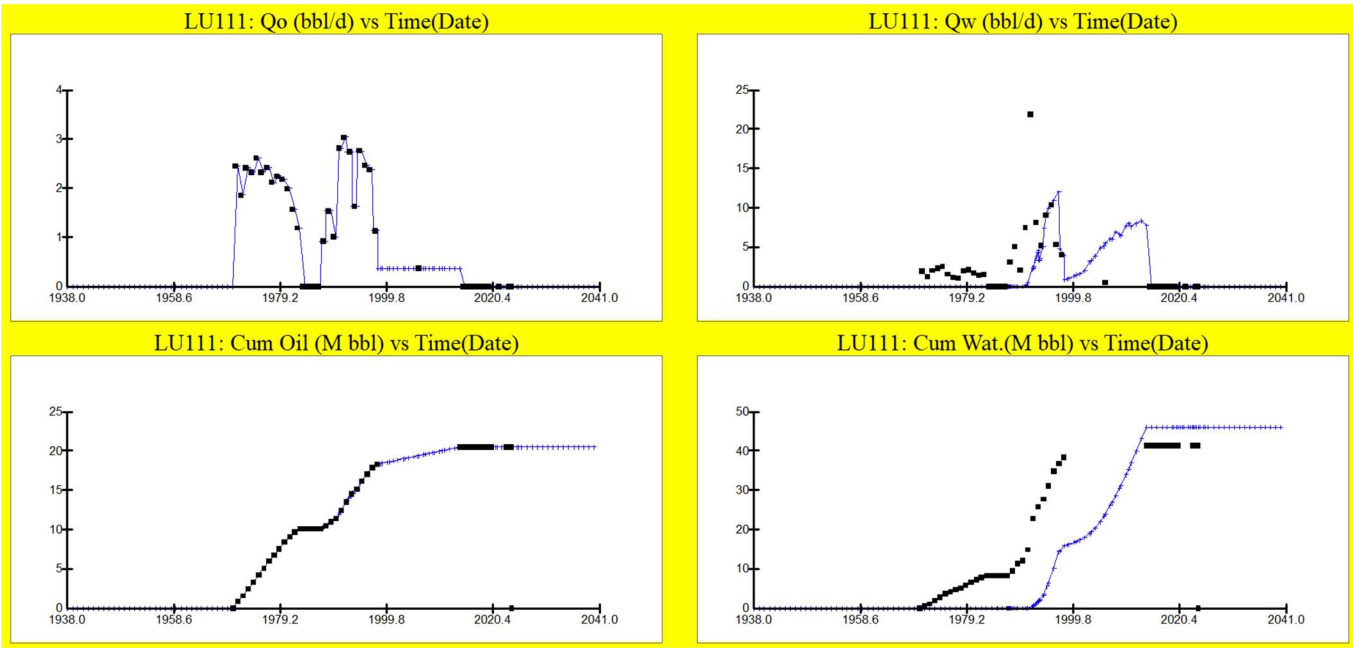


Exhibit E-21(f): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-111



EMSU-B #863

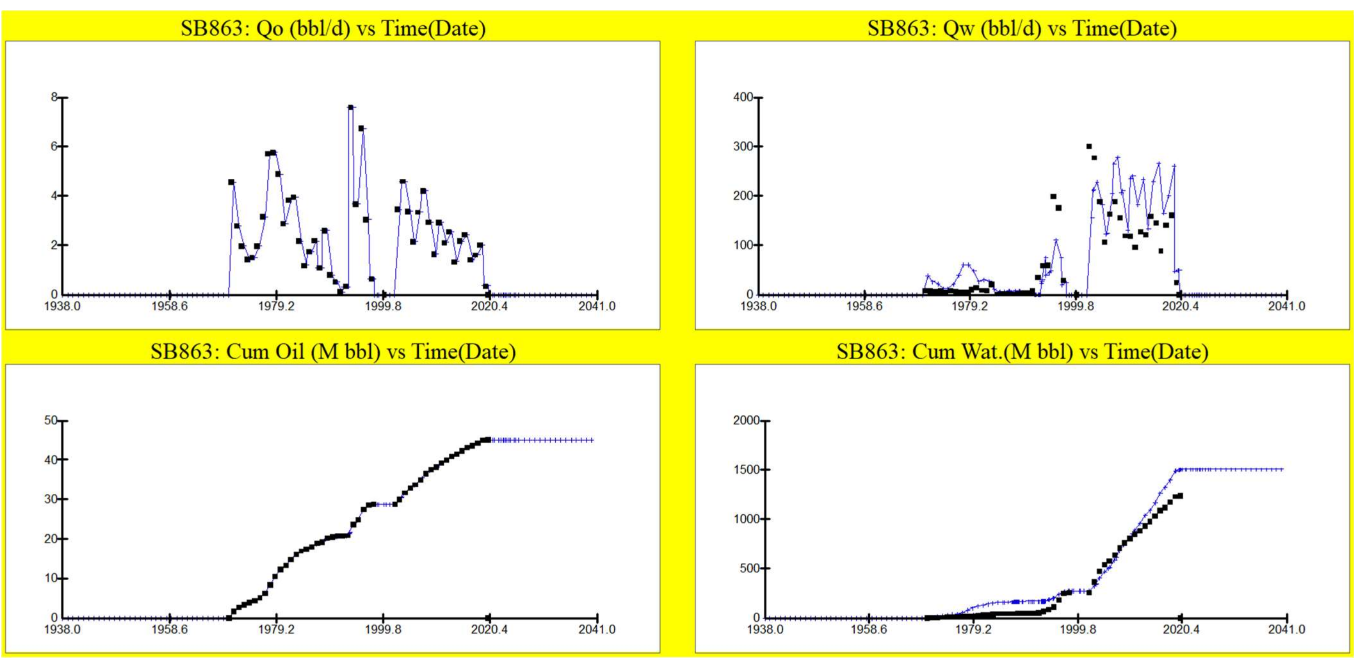
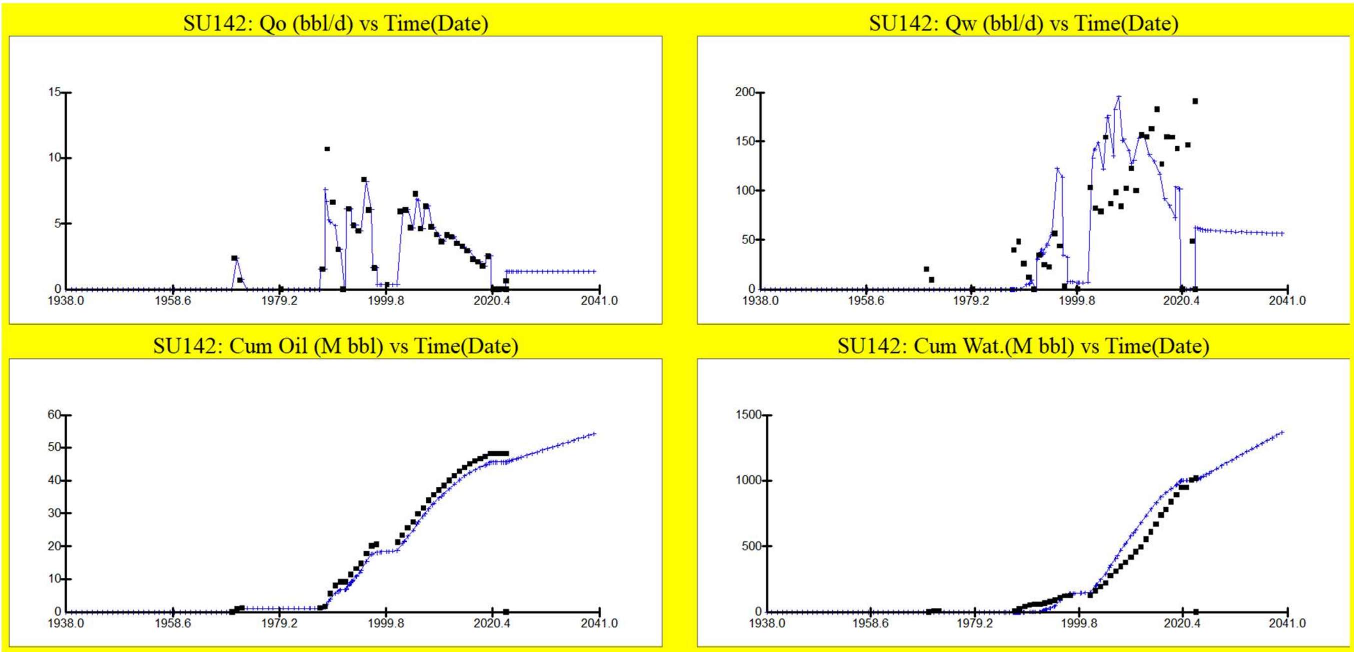


Exhibit E-21(g): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-142



EMSU-266

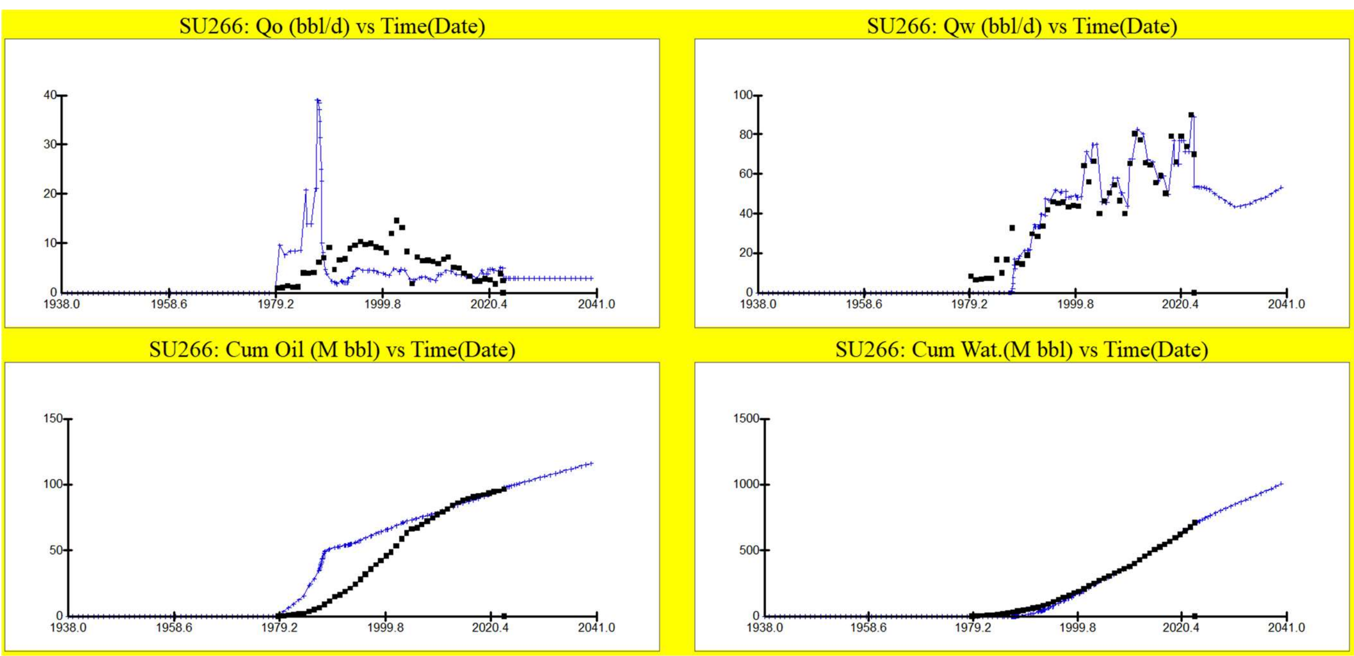
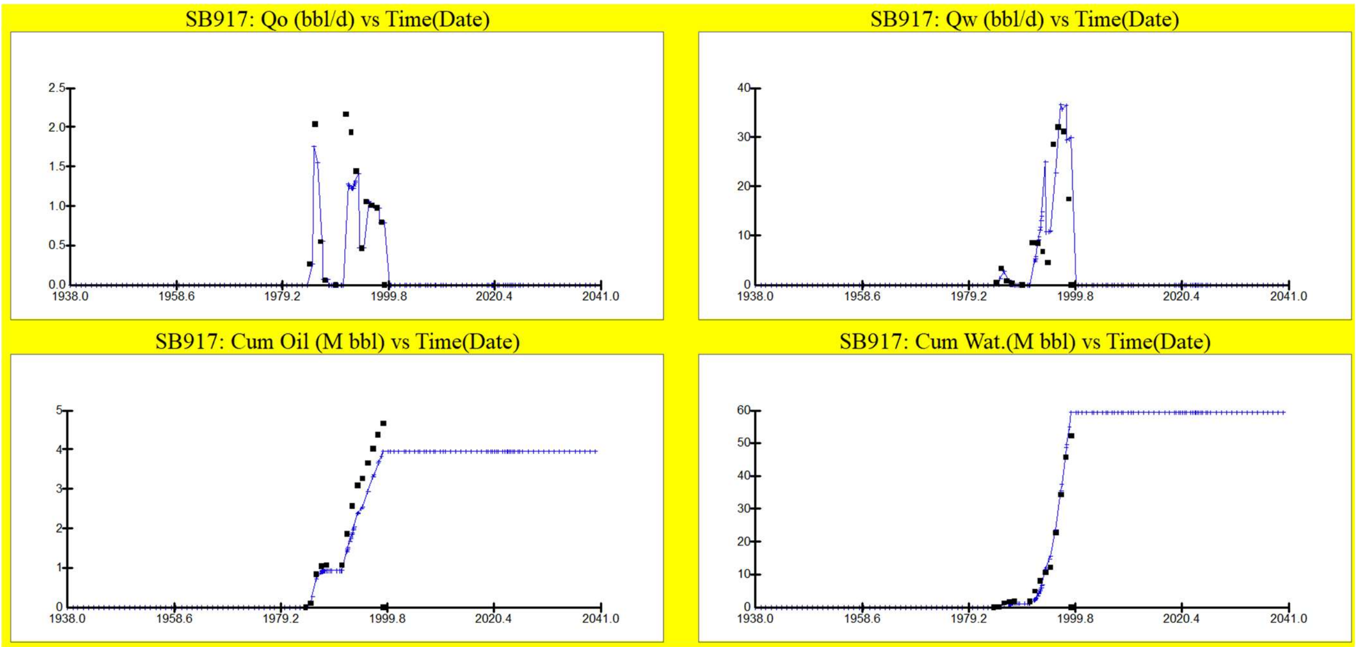


Exhibit E-21(h): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-B #917



EMSU-679

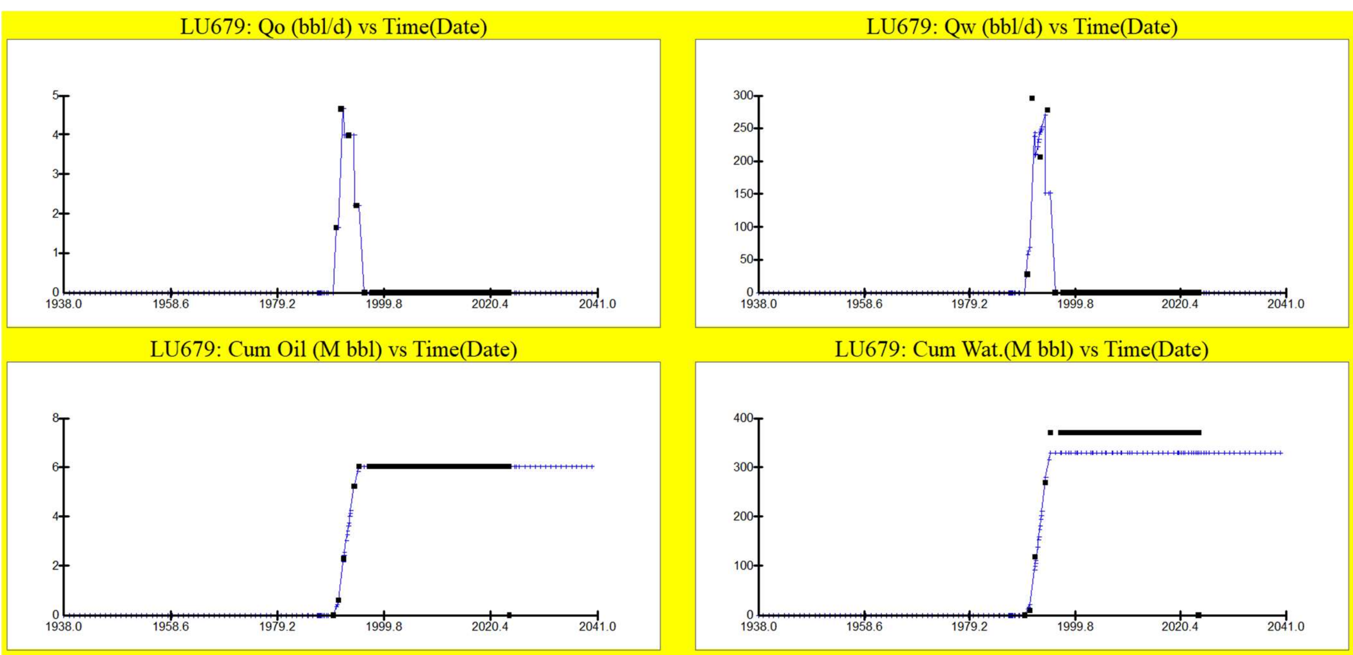
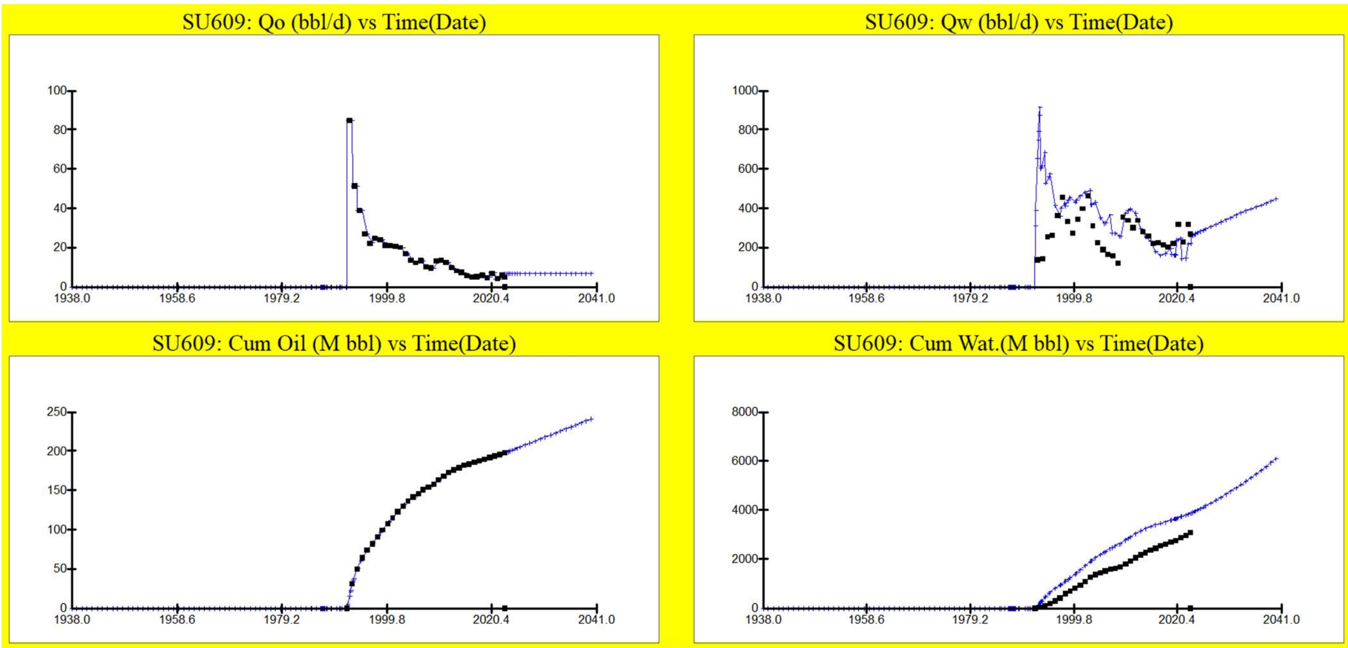


Exhibit E-21(i): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-609



EMSU-610

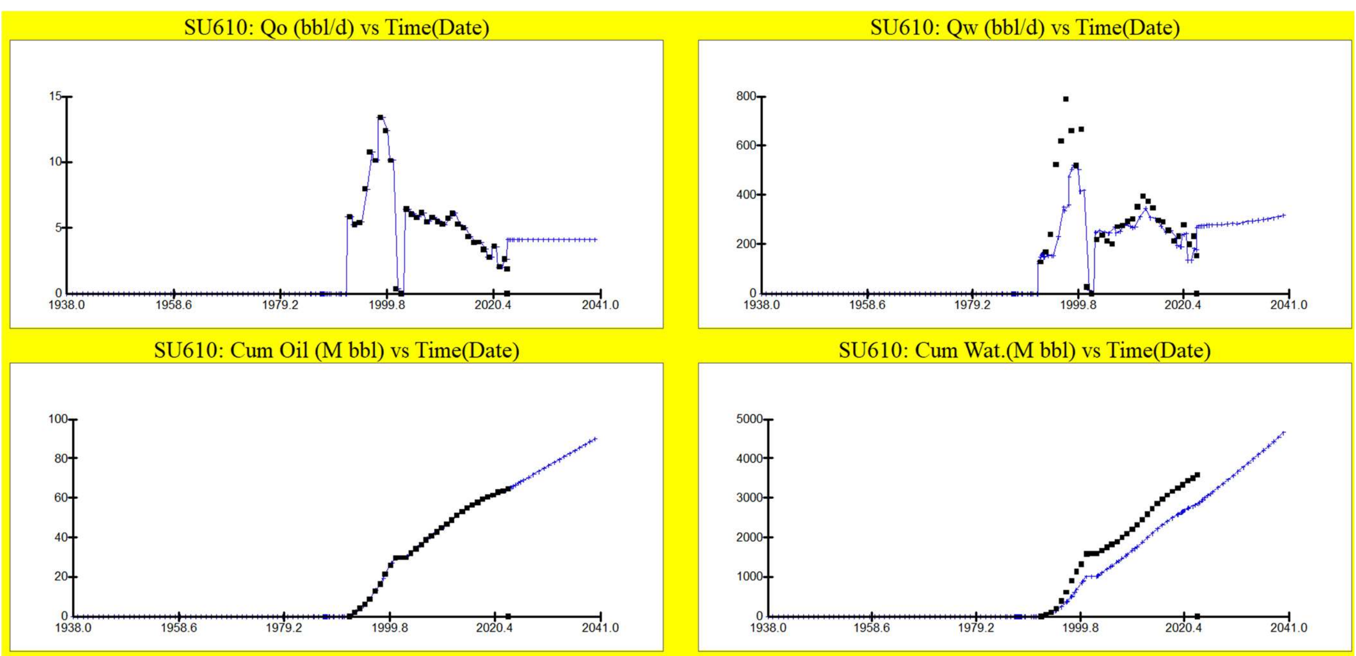
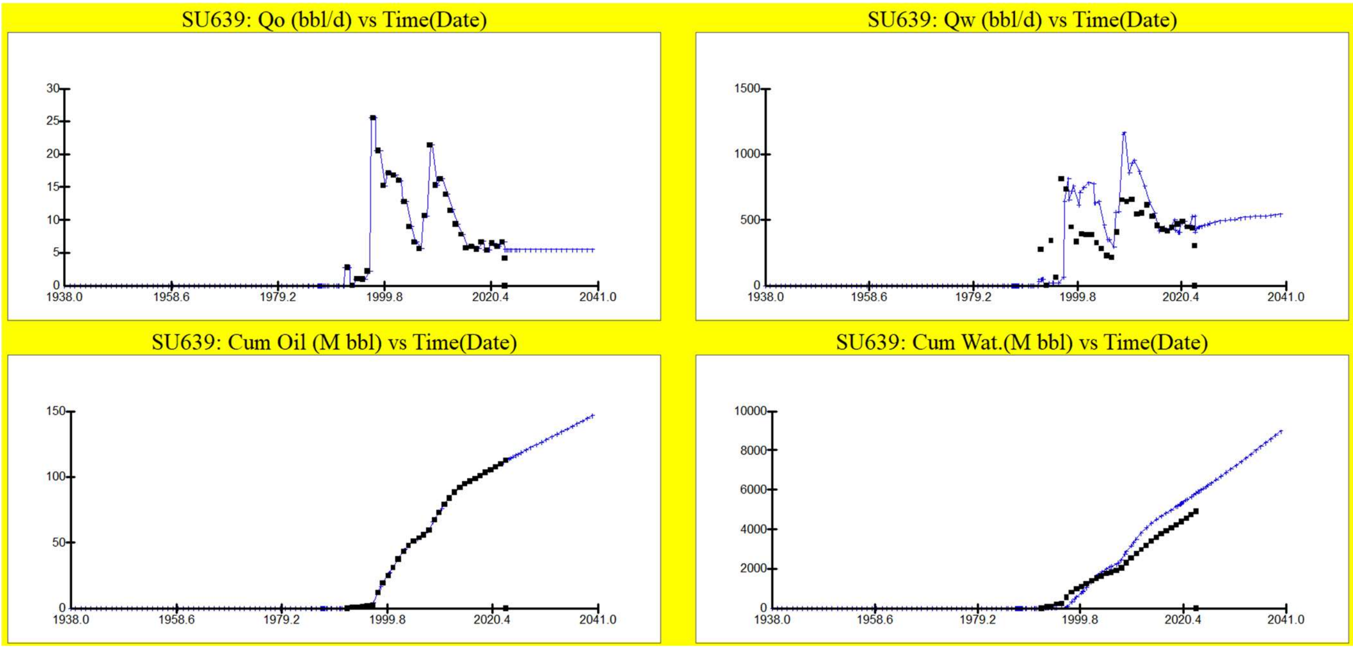


Exhibit E-21(j): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-639



EMSU-670

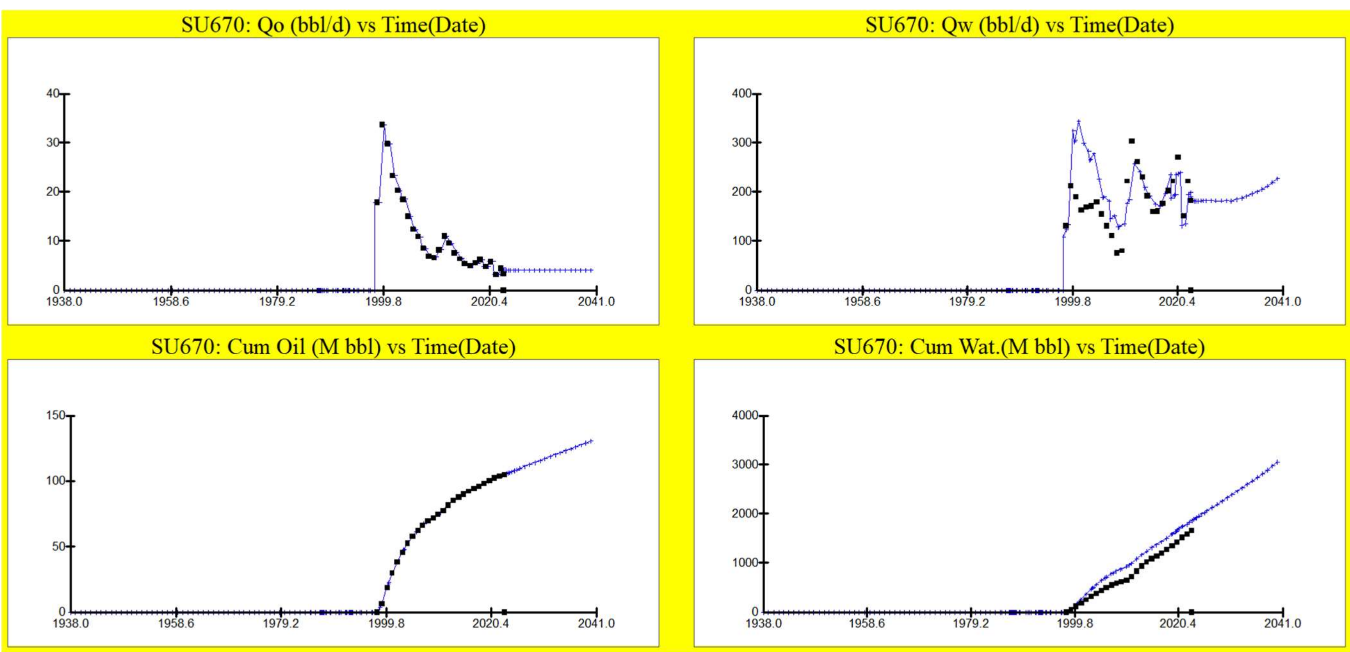
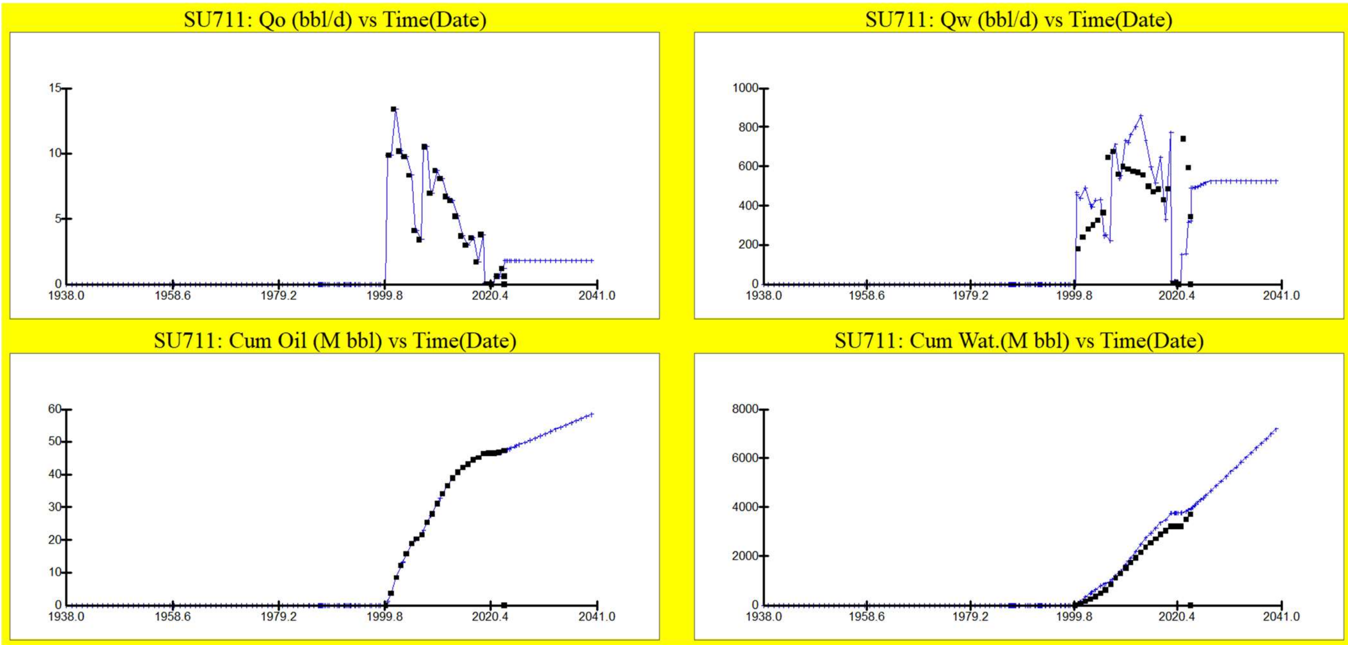


Exhibit E-21(k): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-711



EMSU-735

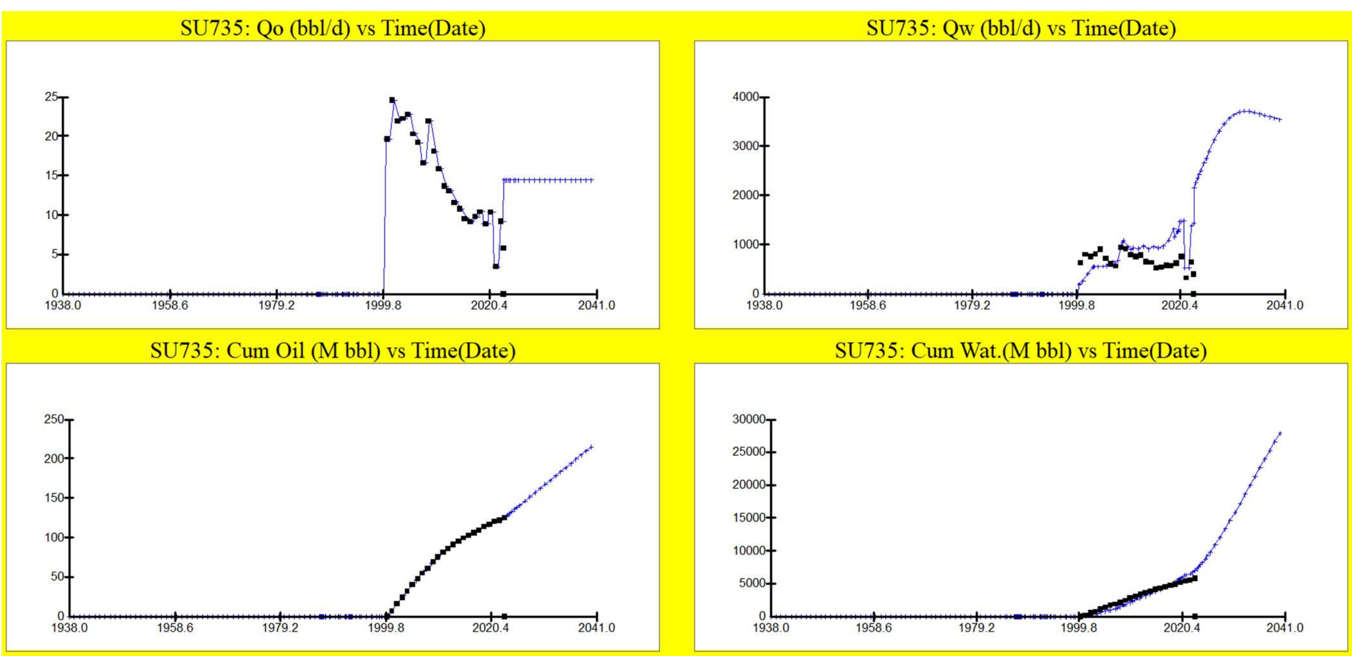
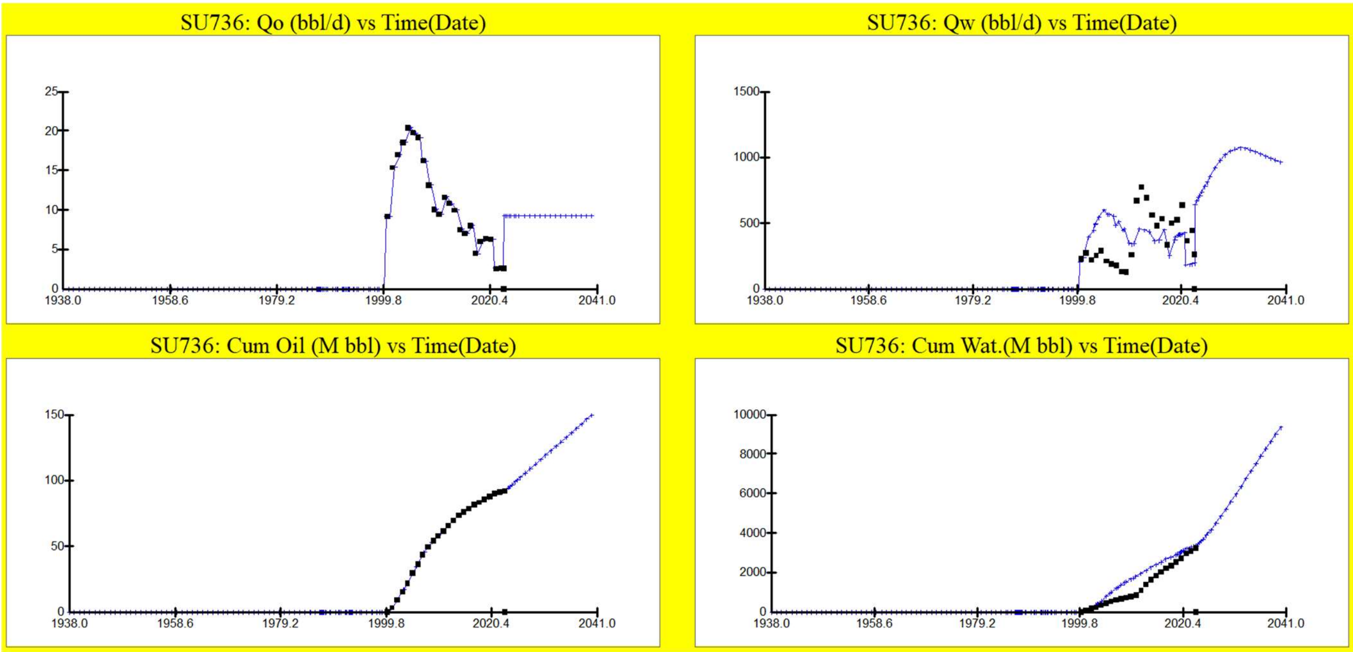


Exhibit E-21(l): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-736



EMSU-774

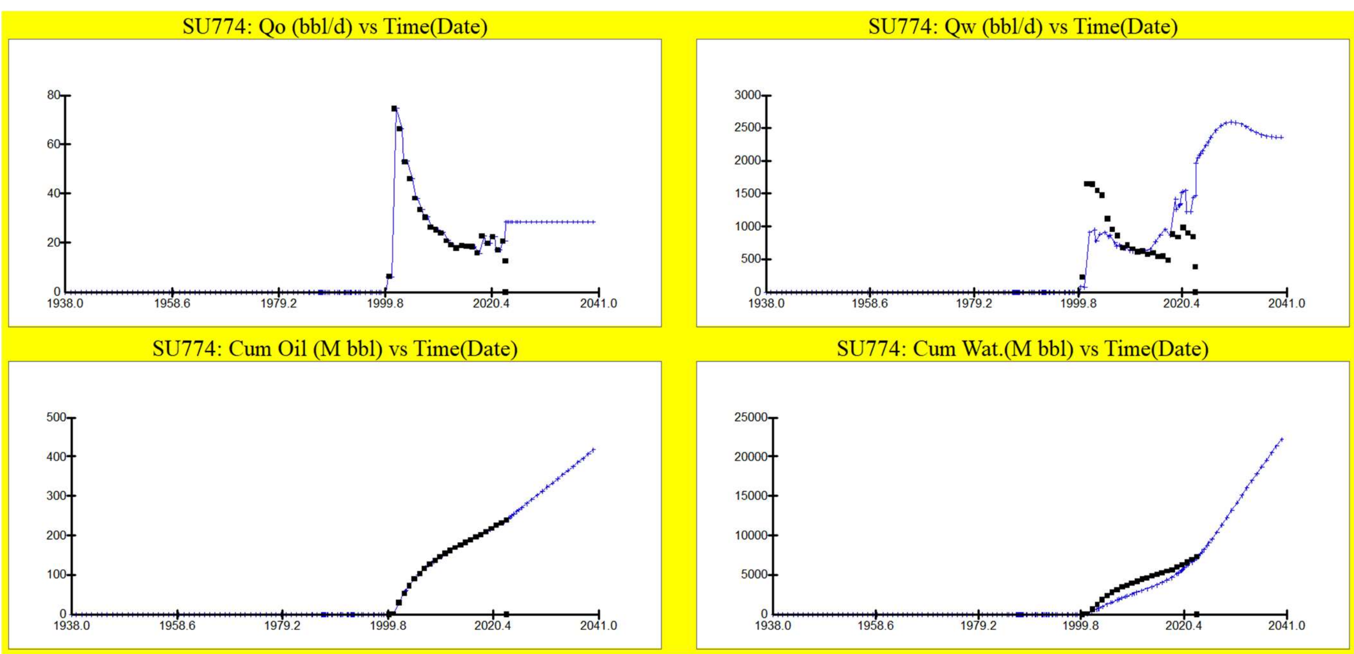
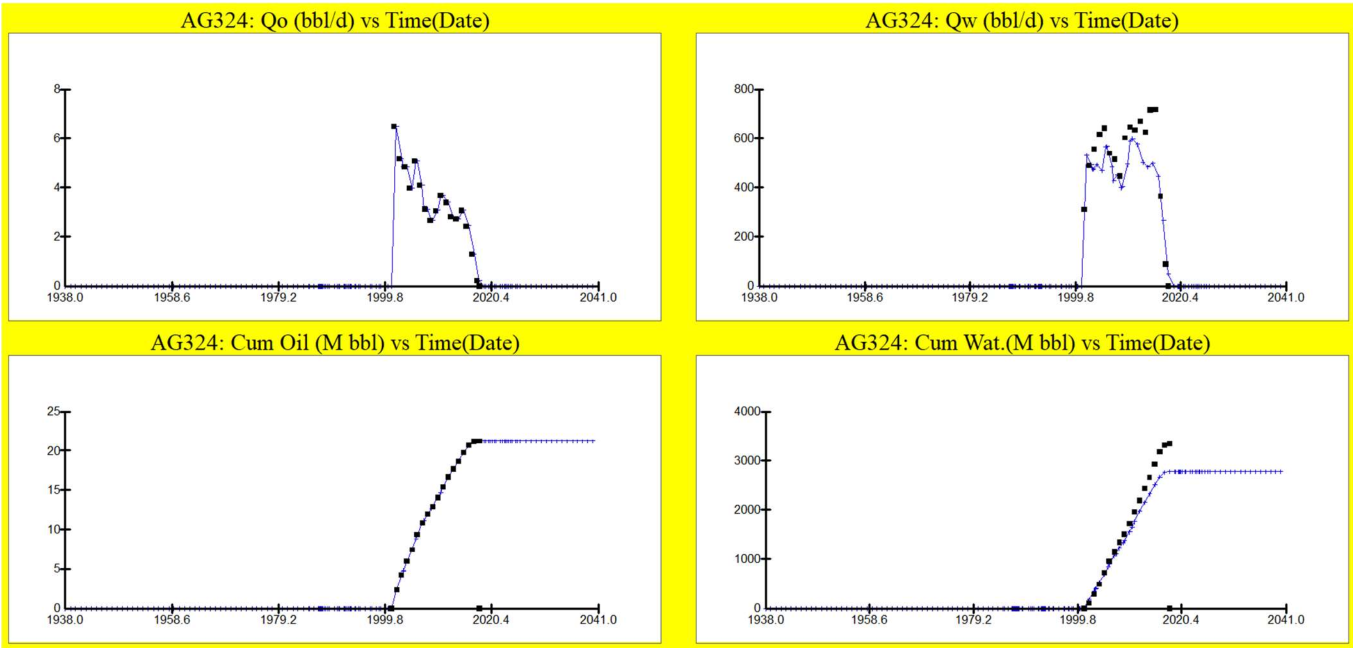


Exhibit E-21(m): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-324



EMSU-614

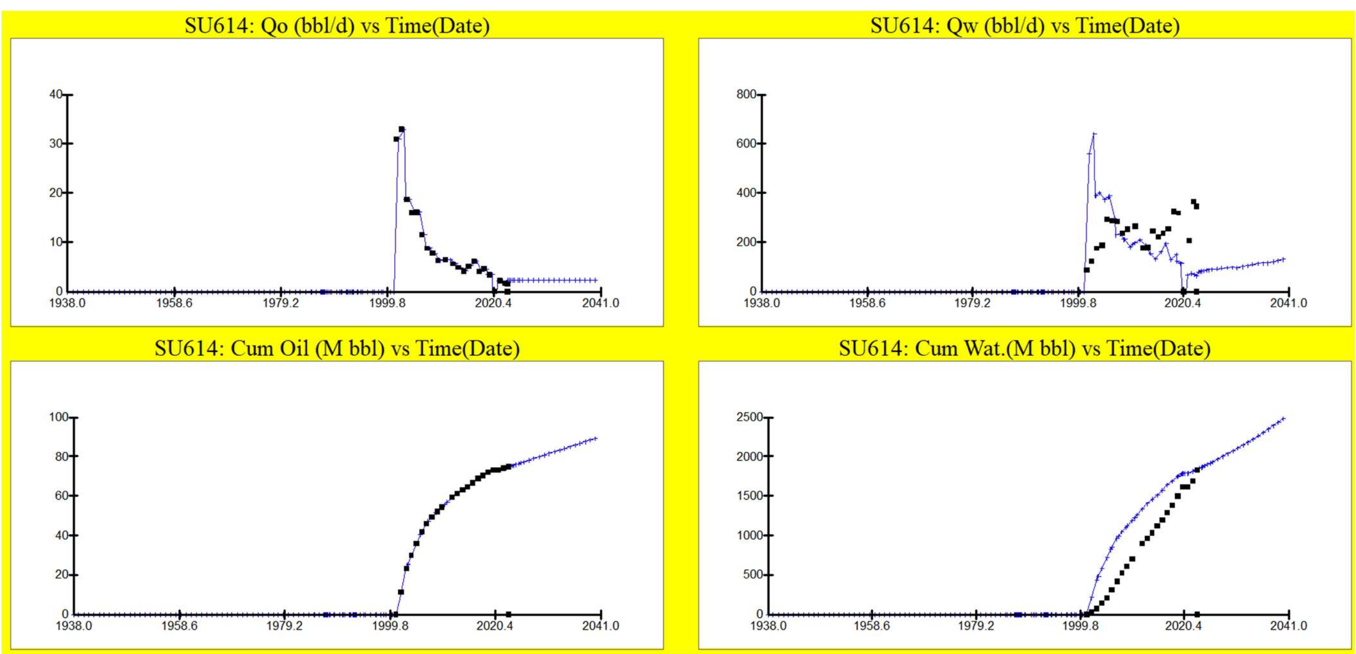
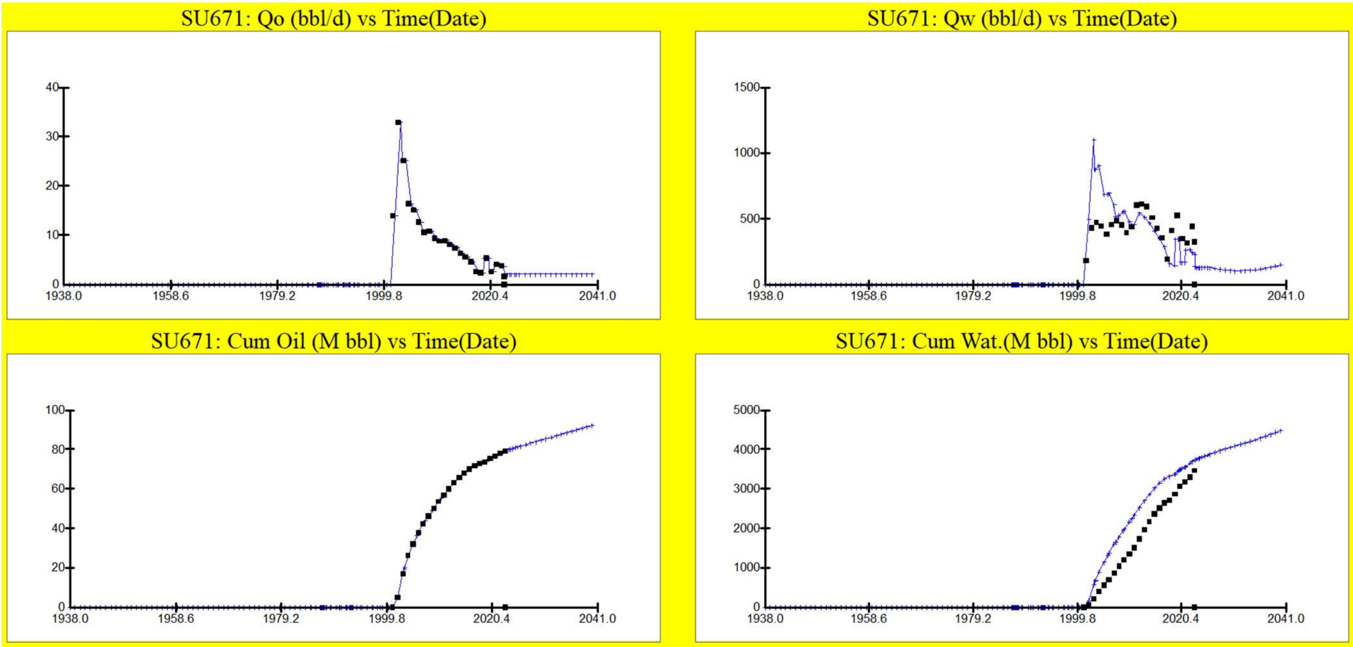


Exhibit E-21(n): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-671



EMSU-739

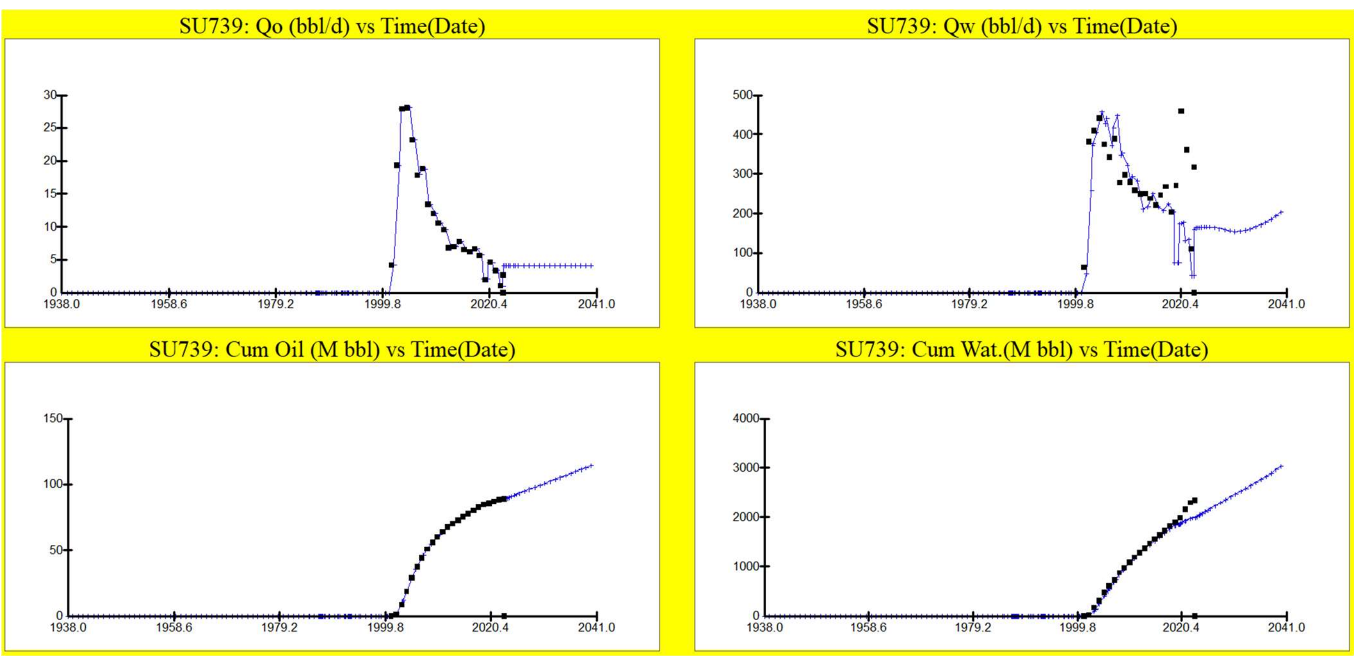
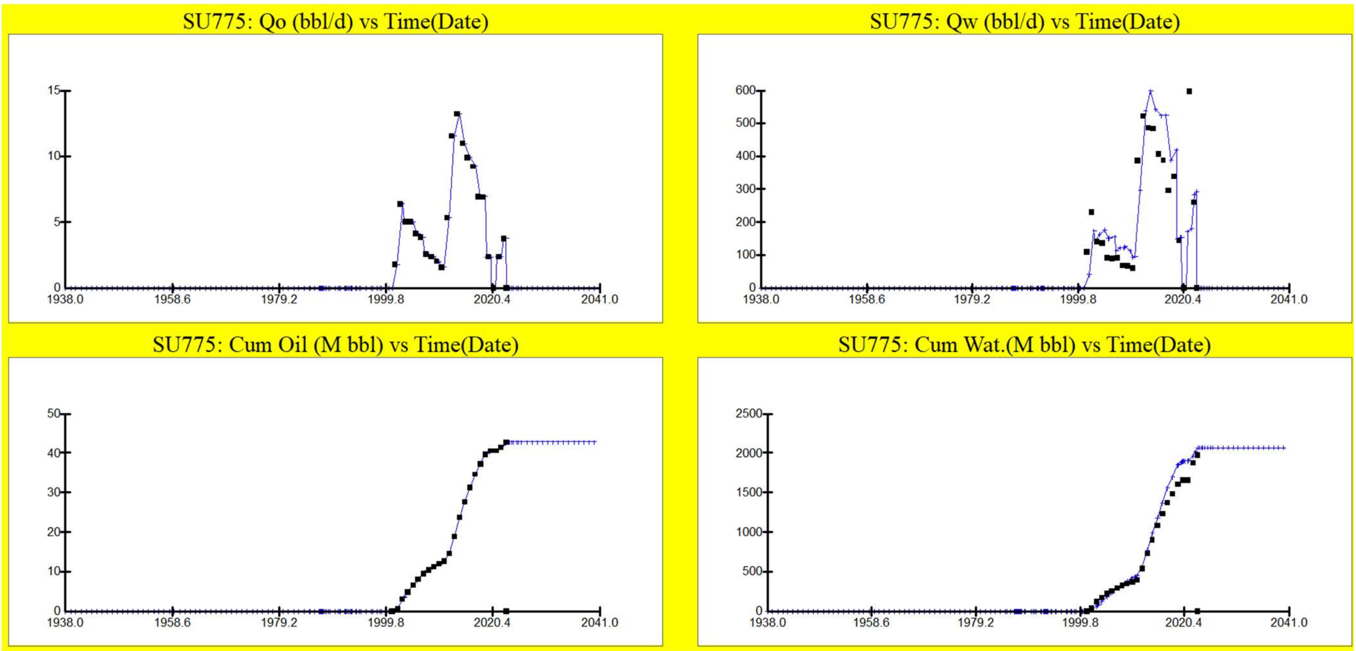


Exhibit E-21(o): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

EMSU-775



AGU-344

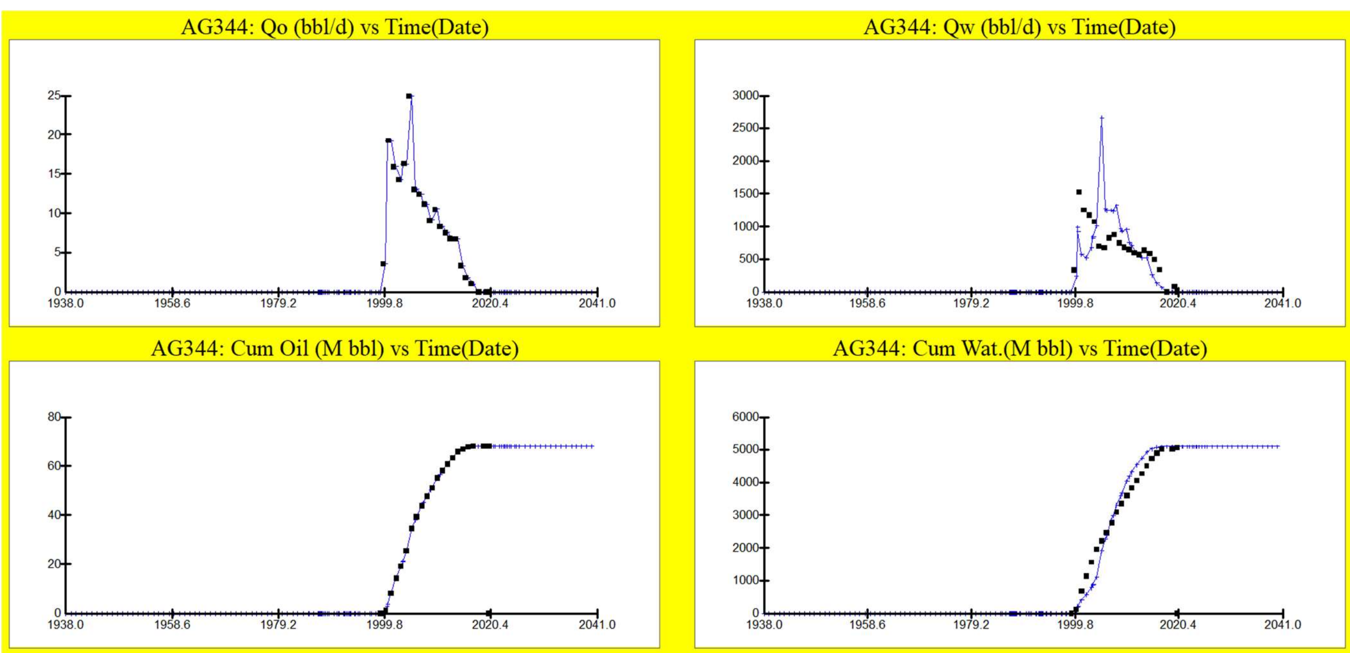


Exhibit E-21(p): Simulation History Match and Prediction Plots For Various Wells

Exhibits to Show History Match During Waterflood Period 1986 – 2024 and Prediction to 2040

AGU-352