AN UPDATED ASSESSMENT OF THE CO_2 ENHANCED OIL RECOVERY POTENTIAL IN THE VICINITY OF THE WASTE ISOLATION PILOT PLANT, EDDY COUNTY, NEW MEXICO

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Final Report

July 31, 2018

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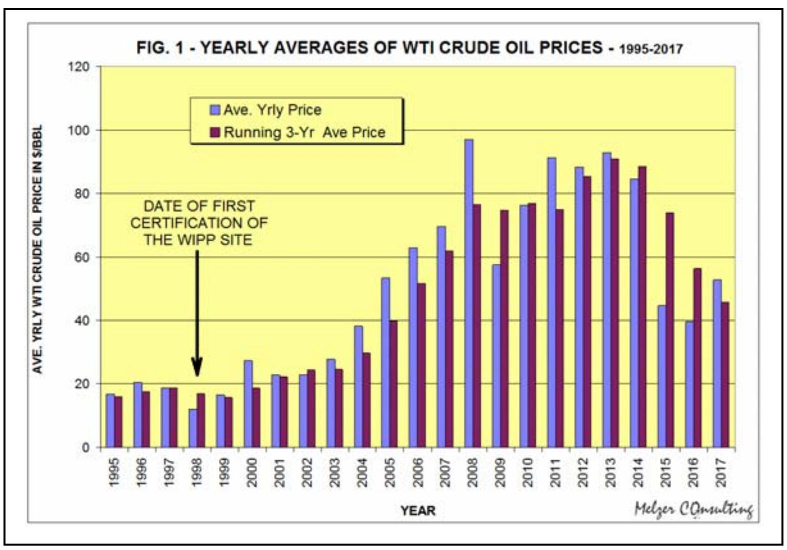
Melzer Consulting, June 2018

I. OVERVIEW AND THE CURRENT STATUS OF THE OIL INDUSTRY

The Permian Basin region of the southwestern United States has undergone profound changes in the last five years. It has always been considered one of premier oil and gas provinces in the world but many recognize it today as being one of the top five oil "superbasins"[1] throughout the world. That modern recognition is new and redefines the status it possessed as recently as 2010. At that time, production in the Basin was continuing to decline from its peak in the early 1970's at about 2 million barrels of oil per day (bopd) to a level of less than one million bopd. The general consensus of the industry was that the expansion days were over and the Basin was in a lasting decline. The decline occurring in both oil and gas production was evident for nearly four decades. During that same time, however, it was viewed as home to pioneering water flood projects and where commercial CO_2 flooding (also known as CO_2 enhanced oil recovery {CO_2 EOR}) had become a proven technology. The traditional oil industry[2] realized that those technologies were the cause for flattening of the decline curve and extending the productive life of the Basin and its oilfields.

It was during this time of falling production that the Waste Isolation Pilot Plant (WIPP) site was first certified in 1998 (Ref. 1). Subsequent to the initial certification, the Compliance Recertification Applications of 2004 (Ref. 2) and assessments of CO_2 EOR (Refs. 3, 4, 5) were performed in 2003, 2008, and then again in 2013 as they pertained to the local area around the WIPP site. An assessment of water flooding for EOR near the WIPP site was also included in the Compliance Recertification Application of 2009 and 2014 (Refs. 6, 7).

Worldwide crude oil supplies, although declining in the Permian Basin, remained in relative abundance in the 1990's and holding throughout part of the next decade. That oversupply held oil prices in the $15-30/barrel (bbl) range. Fig. 1 tracks the oil prices since 1995 as measured by the West Texas Intermediate (WTI) oil price index. WTI had become a worldwide index price in the last half of the 20th century and still remains a relatively good worldwide index of oil prices. Since oil is truly a globally transported and traded commodity, differences between WTI and other indices such at Brent and Arab light



[1] Superbasin as defined has more than 5 billion bbls oil equivalent in both cumulative and remaining production, an assemblage of conventional & unconventional reservoirs, stacked pays, along with established infrastructure, access to markets, and service sectors and supply chains (www.aapg.org)

[2] Traditional defined herein as that part of the oil and gas industry concentrated on drilling (i.e., primary recovery)

all follow similar curves but differentiated by costs of transportation to localized markets.

Recognition of more limited oil supplies began to show its effect starting about 2005. This was attributed, in large measure, to a significant worldwide growth in the transportation fuels sector led by crude oil demand in China and India. The effect of this demand growth struck a tighter balance between oil supply and consumption and gave rise to increases in oil prices to nearly $100/bbl and well over the prices seen at the time of the initial certification of the WIPP site. But the year 2014 provided another profound change as the world witnessed a collapse in oil prices to about half its past value in just one year. Many experts attribute this collapse in oil prices to the recognition of large oil reserve additions due to the so-called 'shales' and the horizontal drilling revolution led in large measure by the Permian Basin but also the Eagle Ford formation in Texas and the Bakken formation in North Dakota. The first several months of 2018 saw a further rebalancing of supply and demand for oil again and prices are starting to hover around $50-70/bbl today. It is probably fair to surmise from Fig. 1 that the steep incline of prices around $15-$20/barrel since the initial certification date has given way to a new tier of pricing averaging around $60-70/barrel since 2008 but accompanied by the classic cyclicity often noted in the commodities.

These broader observations have a relationship to oil activity related to the WIPP site area. The new age brought on by horizontal drilling in the last 10 years is reflected in the region around the WIPP site. The Permian Basin, and specifically the Delaware Basin surrounding the WIPP site, is ideally suited for this technological revolution. The formations being drilled are of the right composition of oil and gas to be very high on the list of criteria for continued exploitation. The oil is sweet (i.e., low in sulfur content), intermediate in composition, and with lots of entrained gas that provides the solution gas drive for pushing the oil to the well bores. Perhaps the best measure of this Permian Basin excitement in drilling is the percentage of worldwide rigs active in the Permian Basin. Fig. 2 displays that changed status of the last decade in a profound way. The WIPP site sits in the most active region of drilling, the Delaware Basin. Another metric of significance is the rise in oil production. Fig 3 illustrates the growth in Permian Basin production from before the peak in 1974 and illustrates the tremendous growth over the last decade and establishment of new daily oil production records. Fig. 4 illustrates the growth in the inclusive counties of Eddy and Lea surrounding the WIPP site.

Fig. 2 – The Percentage of Active Drilling Rigs in the Permian Basin vs. Worldwide Rigs

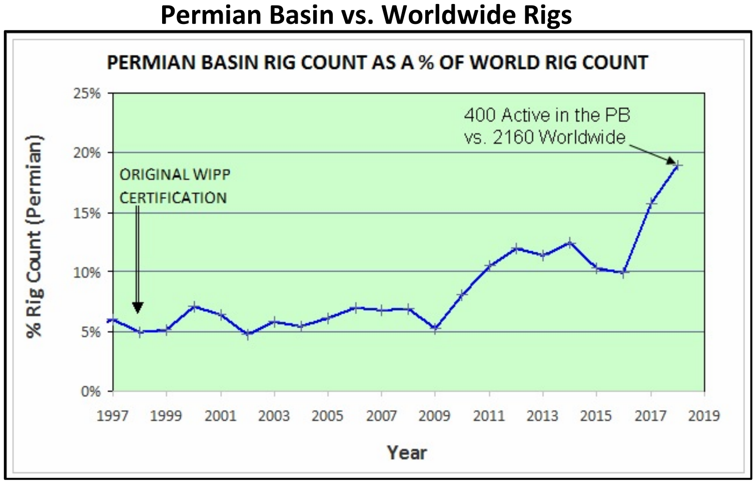


Fig. 3 -Growth in Permian Basin Oil Production

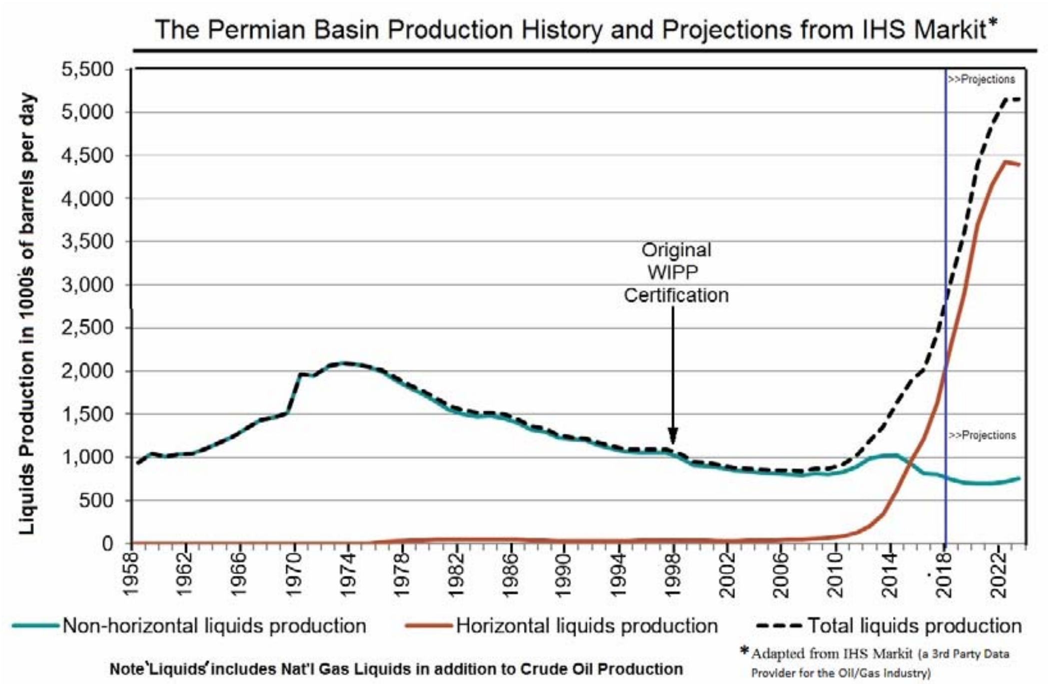
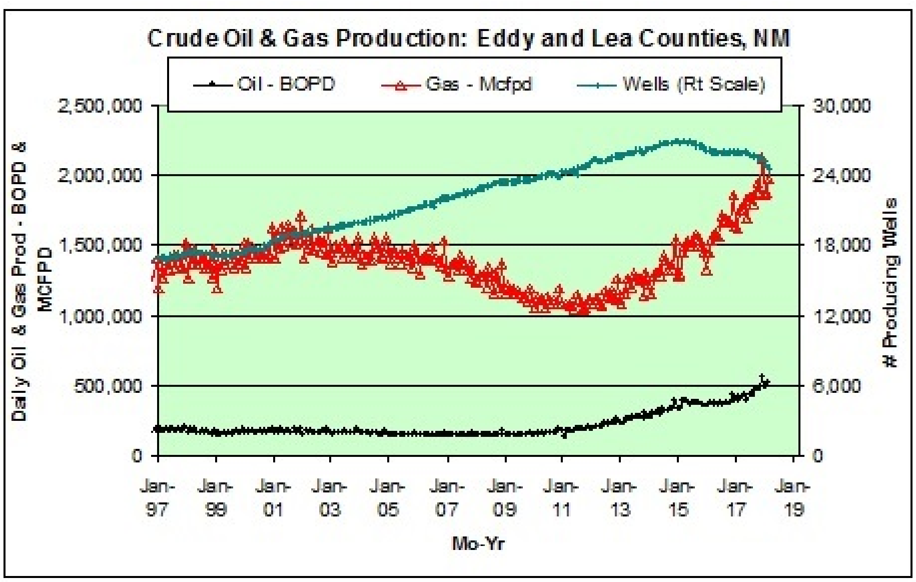


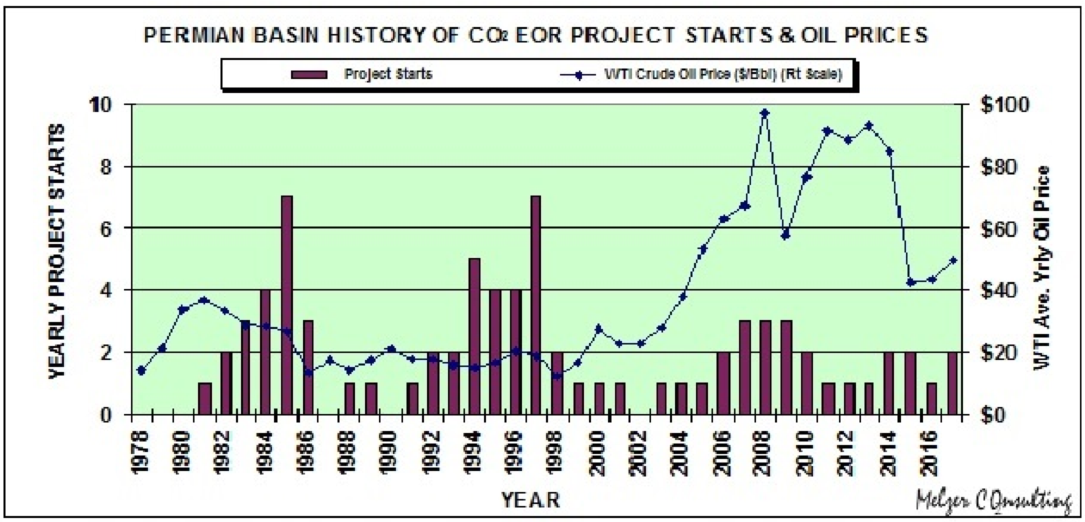
Fig 4 – Growth of Crude Oil & Nat'l Gas Production in Eddy and Lea Counties

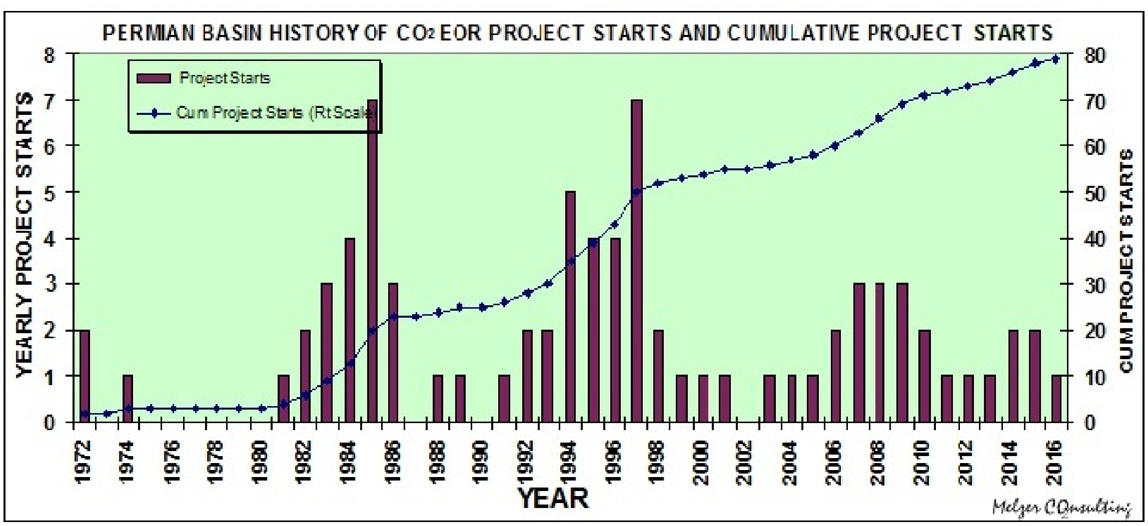


II. PAST AND CURRENT CO_2 FLOODING STATUS

There was an implication in the last section that the 'conventional' oil industry (composed of vertical drilling, primary + secondary +tertiary production sectors) is in decline. The quick returns coming to the companies doing horizontal drilling in the so-called unconventional reservoirs, are replacing those projects and companies attempting to find ways to get more oil from an existing conventional reservoir using water flooding and EOR sub-industries. The historical success of those conventional sub-industries led to a thousand or more water floods starting in the 1960's and over 87 currently active CO_2 EOR projects in the Permian Basin starting from the early 1970's. As the conventional fields decline, a need is created to move into more advanced recovery which can include CO_2 EOR. Otherwise, the field must be plugged and abandoned. The conventional sub-industry was very successful in moving into CO_2 EOR in the Permian Basin. Fig. 5 tracks all of the CO_2 EOR flood starts in the Permian Basin and relates that to the oil price at the time and the various stages of development. Note that in the top chart, the flood starts are, in general, aligning quite naturally with higher oil prices[3] but, as shown in the lower chart, the cumulative count in CO_2 projects always increases. The reason for this is that these are long-term projects that need to be continued even in very difficult oil price times. Fortunately, history has repeatedly shown that better times do, in fact, lie ahead and the chart tracking growth in active projects (Fig. 6, Ref. 8) shows that the Permian Basin now has 87 active projects today producing approximately 208,000 bopd. The Appendix to this report is a detailed listing of those projects and their attributes.

Fig. 5 – CO_2 Flood Starts over Time Shown with Prevailing Oil Prices and Cumulative Flood Starts

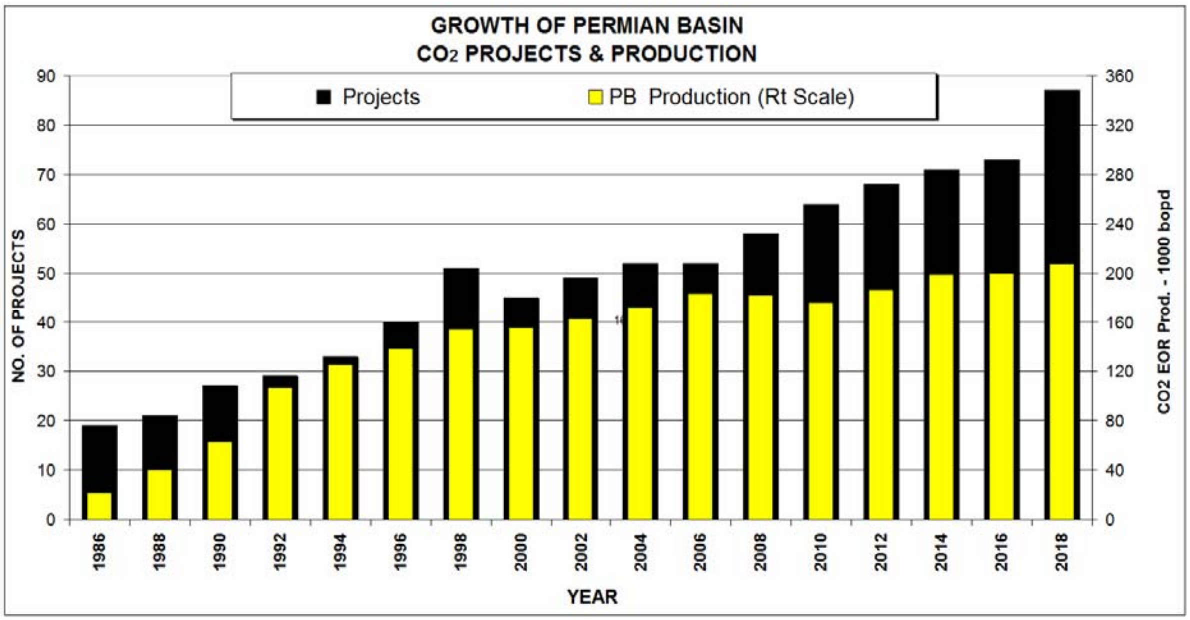




[3] The 2nd cluster of project starts seems to contradict the need for high oil prices but many believe it was the maturation of CO_2 flooding technology that led to this "boom" in new project implementations

The active CO_2 projects are primarily concentrated in the eastern portion of the Permian Basin (Fig. 7). There are but a very few anywhere near the WIPP site, as shown in Fig. 7. There are two primary reasons for this. First, the WIPP site lies with the Delaware Basin and is somewhat distant from the carbonate shelf reservoirs that host most of the CO_2 projects. Secondly, there are some issues with reservoir fracturing as one nears the effects of the uplift in central New Mexico related to tectonics occurring in the Tertiary period. The Texas counties are not exempt from natural fracture complications, but experience has shown fewer fractures are encountered that confound successful CO_2 flood operations.

Fig. 6: History of Active CO_2 EOR Projects and EOR Production in the Permian Basin



The downturn in oil prices from their $90-100/bbl levels since 2014 has created considerable distress in the companies doing CO_2 EOR. The best evidence of that is in the reduced numbers of CO_2 EOR operating companies within the Permian Basin. Fig. 8 attempts to capture the changes in CO_2 operations by using the number of sponsoring companies for the CO_2 Conference week in Midland each December. Note that in 2013 there was a peak of 32 companies sponsoring the Carbon Management Workshop portion of the week, the CO_2 EOR Theme Session portion or both. The total numbers of sponsors dropped by half in December 2016 when compared to the peak year of 2013.

Fig. 7 – Permian Basin Map Showing Location of CO_2 Floods

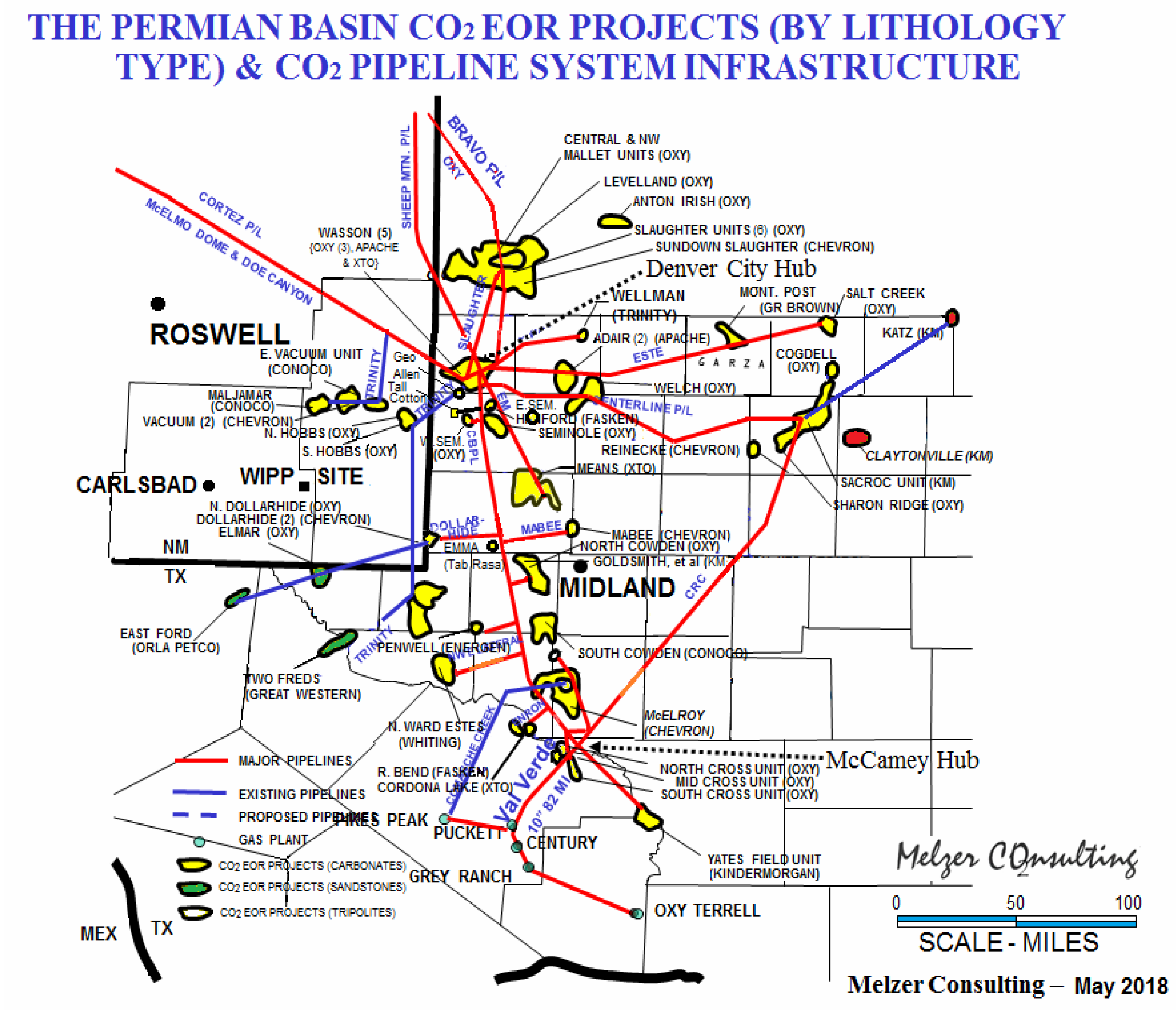
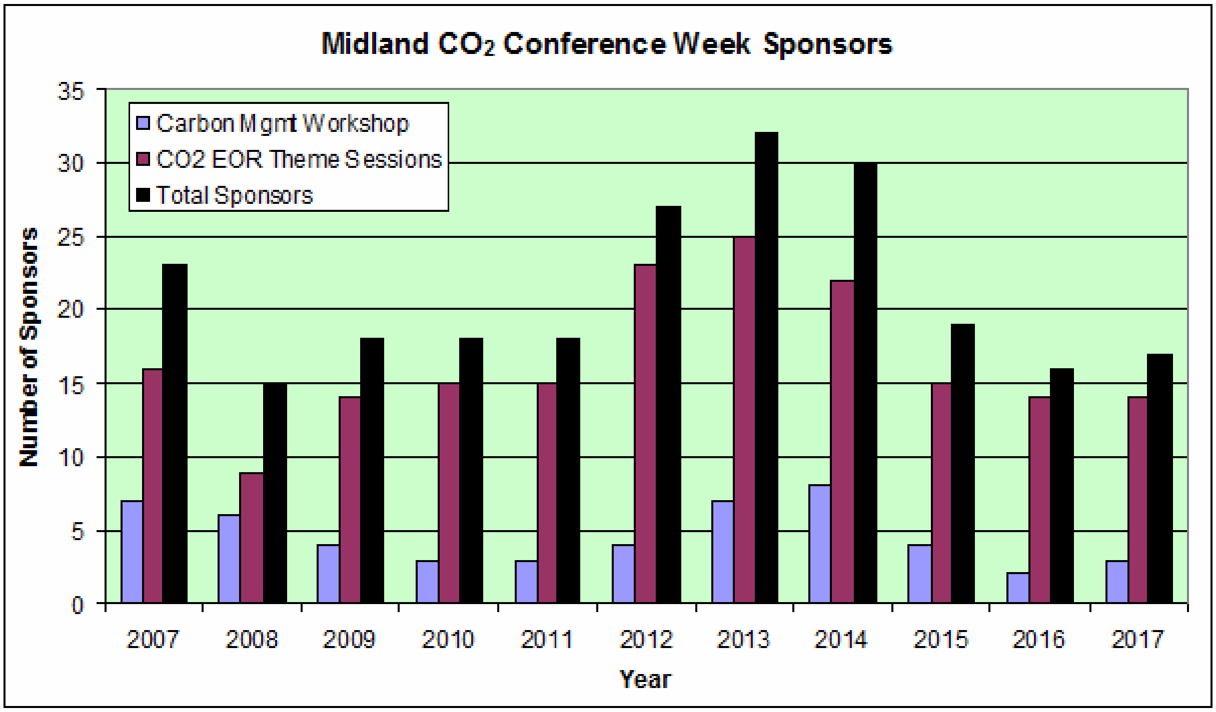


Fig. 8: Sponsorship History of the CO_2 Flooding Conference in Midland, Tx



One of the most interesting Permian Basin trends has to do with the availability for contracting new volumes of CO_2 for a project. The common contract formula for pricing CO_2 utilized in the past can be simply expressed as 2% of the oil price where oil is in units are $/bbl and CO_2 dimensions are $/mcf. So, if oil were priced at an average of $50/bbl then CO_2 would be selling at ~$1.00/mcf. These are project gate prices so actual numbers will vary according to location of the project, total pipeline tariffs to get the CO_2 to the project, and other minor factors such as delivery pressure. CO_2 was in short supply during the $80-100/bbl days of 2010-2013 since new projects were coming on line. When the oil price crash of 2014 hit, all new projects in planning were put on hold or cancelled. One would normally expect that CO_2 pricing for a new project would drop and follow the oil price decline, but it was not to be the case. Most contracts are long term and CO_2 purchases were still under contract. Operators generally dropped back to minimum required ("take or pay") volumes. Suppliers could 'choke back' deliveries but were not able to contract the excess volumes since they were effectively fully contracted. As a result, the prices for new CO_2 held strong or, in some cases, even ratcheted up slightly to 2.1 or 2.2% of the oil price. Time will tell if those prices will hold but, as the next section infers, new CO_2 supplies could be coming soon from anthropogenic sources incentivized by a new Federal tax credit.

III. NEW TRENDS AND GROWTH POTENTIAL OF CO_2 EOR

As mentioned above and shown in Fig. 7, most of the operated CO_2 floods in the Permian Basin have been deployed in carbonate reservoirs. At current count, there are 53 of the active 87 floods in the San Andres dolomite formation and 19 others in other dolomite or limestone reservoirs. The clastic (sandstone) reservoirs have been fewer since they are generally smaller oil targets and somewhat more challenging (Ref 3) to get commercial sweep efficiencies[4]. The carbonate reservoirs owe their origin to shallow shelf environments rather than in the deeper basins with their finer-grained clastics and clays such as the shales. Previous assessments of the nearby CO_2 flooding potential to the WIPP site have stressed this fact suggesting nearby CO_2 floods are quite unlikely given the state of CO_2 EOR technology today.

Several things are worth noting that are different now than in previous WIPP CO_2 assessments. The first is the concept of using geologic formations to permanently store CO_2 that is captured from surface emission streams. Climate change concerns have advanced to a degree that a variety of solutions are being proposed to reduce greenhouse gas emissions. Some governmental entities such as Norway have moved to assess a tax on CO_2 to induce an emitter to capture their emissions and inject it underground. The U.S. has approached the concerns over accelerating emissions in a different way. The U.S. Senate and House recently passed an enhanced tax credit incentive trying to achieve the same result. The provision, called 45Q, was included in the Future Act passed in February of 2018 and provides a Federal tax credit of $10/ton ($0.55/mcf) if the CO_2 is captured from an anthropogenic source, injected into a CO_2 EOR project, and monitored for assurance of permanent storage. The credit can go to any of the parties involved in the project: capturer, transporter, and/or injector and ramps up to $25/ton by 2023. If the injected CO_2 goes into a deep saline aquifer, the credit starts at $20/ton and ramps to $35/ton over the same time frame. Time will tell if this new tax credit will lead to significant capture and geologic storage but the first indications are that the planning for field capture and storage projects for the easiest[5] sources of emitted CO_2 are already underway.

The question to address with this new 45Q provision is whether nearby Permian Basin sources of emission streams of CO_2 will take advantage of the credit and begin CO_2 capture, pipeline, and injection planning of a project. The Permian Basin companies operating within several tens of miles from the WIPP site have all the technologies and experience to begin the planning. The aforementioned basin sediments in the near vicinity of the WIPP site are not ideal formations to conduct the injection and a preference to carbonate reservoirs will likely be the reservoir option. The nearest carbonate reservoir looks to be the Yeso carbonates and will be addressed further in this section of the report.

The second feature of CO_2 has to do with the evolution of CO_2 flooding in what have come to known as the residual oil zones (ROZs). These intervals have been shown to be widespread in the Permian Basin (Refs. 9a, 9b, 9c). They exist in the same formations below the pay intervals of the carbonate reservoirs and they also exist out in what have become known as "greenfields" where they do not have intervals with mobile oil above them. Both types are now known to be the remnants of a paleo oil trap that has been laterally flooded by water at some time after the paleo oil entrapment. Work is ongoing around the U.S. and the world to identify these zones as they have been shown to be commercial via CO_2 flooding in the Permian Basin. To date, the ROZs are especially prevalent in the San Andres formation along the carbonate shelf regions that rim the deeper basins such as the Delaware and Midland Basins but work is underway showing that the same mechanics of natural paleotrap sweep was present in deeper intervals below the San Andres formation, also in the rimming carbonate shelves of Permian age.

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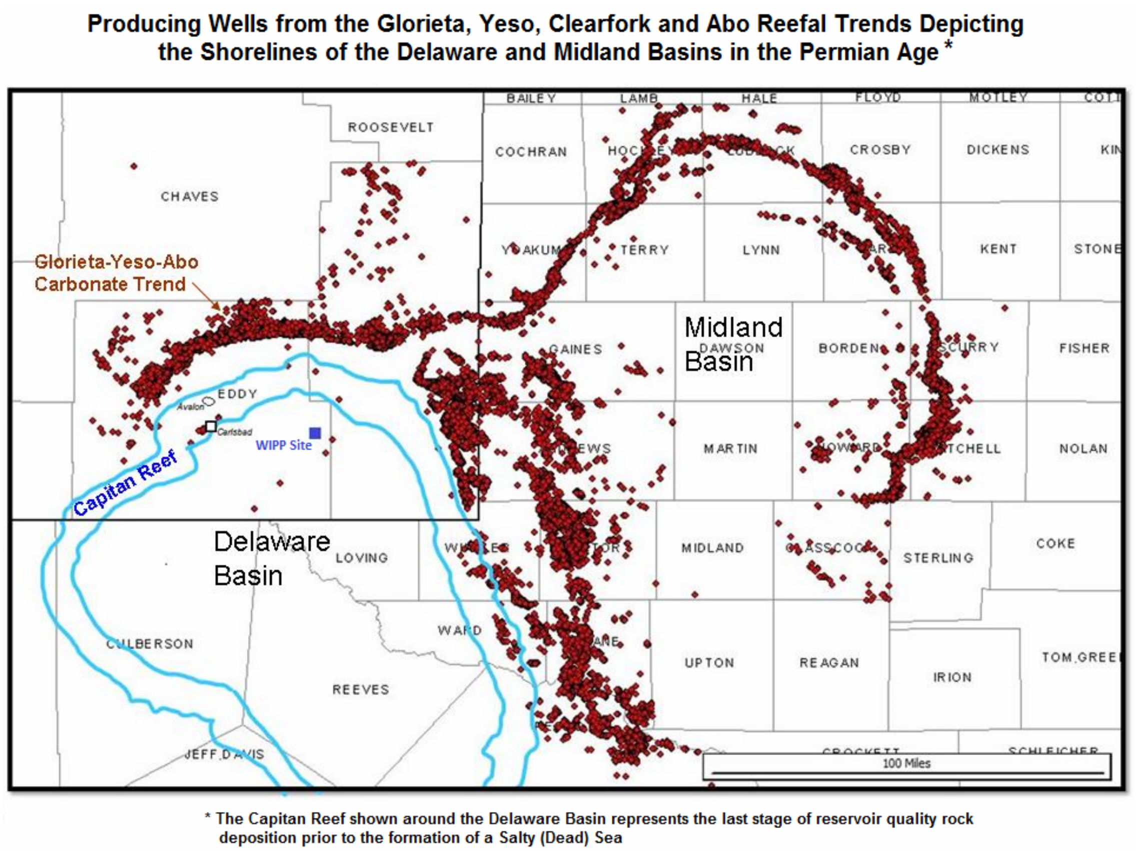
[4] Sweep efficiency is a term used to quantify the ability for the CO_2 to spread out in the formation from an injection well to the nearby (injection pattern) producer wells and contact oil left behind by the previous stage waterflood. 'Channeling' from injector to producer wells can cause poor sweep efficiencies and render a project uneconomic.

[5] Those emission streams of relatively pure CO_2 with volumes in excess of 0.1 million tons of CO_2 per year (5 million cubic feet per day).

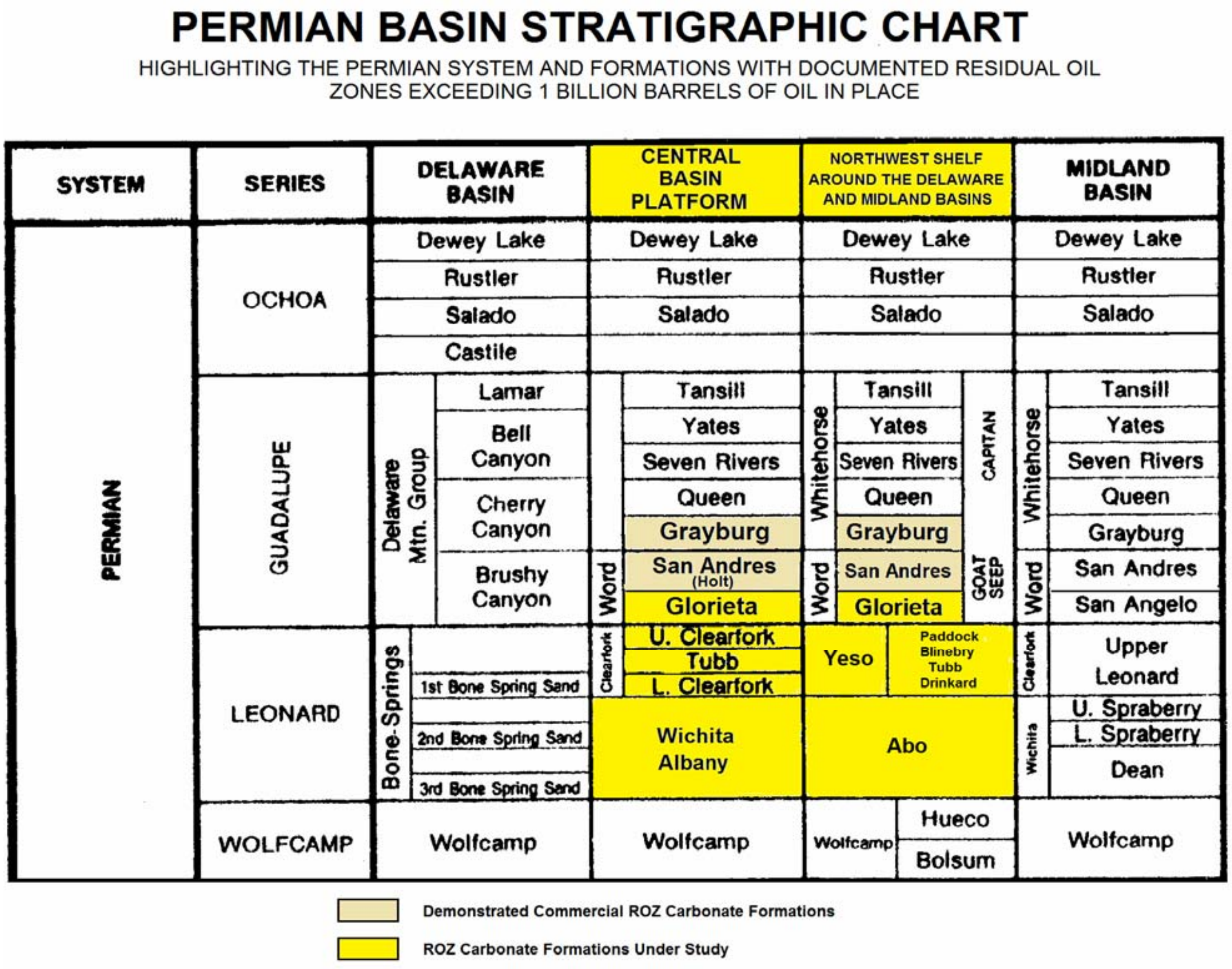
Note that in Fig. 9, the position of the Permian shelf carbonates is defined for Abo/Wichita, Yeso/Clearfork, and Glorieta formations representing the shoreline rim of the Delaware Basin. Fig. 10 provides the stratigraphic column illustrating the vertical reservoir sections of interest. All of these formations outcrop to the west of Carlsbad, Artesia and Roswell allowing influx of meteoric derived water to laterally flush these reservoirs of their paleotrapped oil and forming a residual oil zone. Because these formations are carbonates, it is likely they will emerge as the targets for CO_2 EOR rather than the clastic basin sediments closer to the WIPP site.

Fig. 9 – Map of the Position of the Delaware and Midland Basin Shorelines in Permian Epoch and Corresponding to Trends of Reservoir Quality Rocks for possible Future CO_2 Flooding
(note: points denote positions of vertical wells)



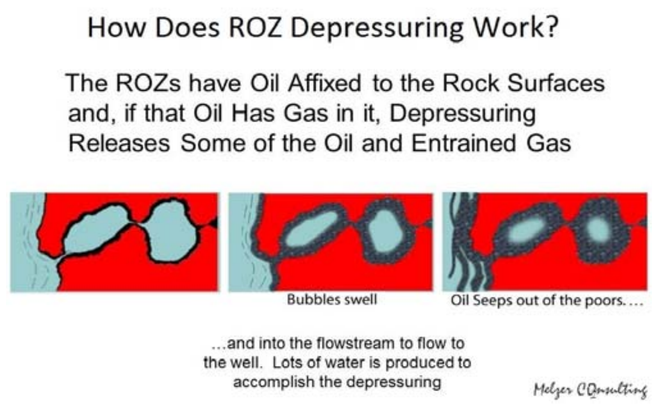
In the very recent time interval from 2014 until now, a new horizontal well depressuring play has emerged in the carbonates. The horizontal well revolution in the shales discussed earlier is responsible for a similar breakthrough in horizontal well commerciality in the carbonates. Both the shales and the carbonates possess "immobile" oil which can be liberated when the gas in the oil expands as a result of reservoir fluid pressures being reduced by production of reservoir fluids. The gas expansion forces water, gas and some oil to the horizontal well lateral (well bore) and to the surface. In the shales, the hydrofracturing of the reservoir is critical but, in a more conventional reservoir like the rimming carbonate shelf formations, a large hydrofracture treatment is not necessary. This is being shown to be commercial in reservoirs that have no mobile oil at original formation pressures but can be quite commercial upon depressuring. Fig. 11 illustrates the process in cartoon form.

Fig. 10 – Permian Stratigraphic Columns



One particular carbonate play and ROZ interval is of possible special significance here. It has been dubbed the "Yeso play" by industry and is located as close as 30 miles from the WIPP site. Our study shows that over 100 wells have been drilled in the play. All wells are depressuring the formation fluids by removing water and disposing of the water in nearby disposal wells. The process offers some considerable pore space for the injection and storage of CO_2 under the new tax credit provision (45Q). The Yeso is a more conventional reservoir than the shale formations closer the WIPP site and is capable of

Fig. 11: Conceptual View of the Depressuring Process in Gassy Oil



producing significant volumes of oil and water for longer periods of time. For that reason, we would expect the Yeso formation to be the closest undeveloped CO_2 EOR play and the most likely candidate in the general region of the WIPP site considering the new 45Q provision just passed into law. However, the reservoir quality (carbonate portion) formation only exists 30 miles or more from the WIPP site. Appendix 2 provides a closer examination at the Eddy County Yeso Formation characterization, activity and new developments.

IV. SUMMARY WITH A LOOK FORWARD AT CO_2 INJECTION PROJECTS

The implementation of CO_2 EOR projects has seen a steady rise from the start of commercial deployment in the early 1980's through the present time. The pace slows during the low oil price years but resumes when oil prices rebound[6]. Today, there are 87 CO_2 injection projects in the Permian Basin, more than any other region in the world.

EOR projects have always been sought by the oil and gas industry because of the desire to improve oil recovery from existing oil fields. Some of that impetus came from a feeling that oil was a limited resource. Today, with the explosion of new technologies in horizontal drilling and well completion techniques in the unconventional reservoirs (aka 'shales'), the concept of scarce oil has disappeared. The motivation to improve oil recovery in existing fields is therefore waning especially as it provides an expensive and longer-term project when compared to the success being seen in horizontal drilling.

By contrast, there is a new factor on the table today that may play a large role in balancing out the current negative dynamics for CO_2 flooding investments. CO_2 EOR has become widely recognized to provide the additional advantage of permanently storing CO_2 along with producing oil. With concerns over climate change and the role that atmospheric accumulations CO_2 emissions may play in warming temperatures globally, policies are being considered and enacted to encourage anthropogenic CO_2 capture so as to limit those emissions. CO_2 EOR can play a large role in finding a place to safely sequester captured CO_2. A bill entitled 45Q was recently passed by Congress and signed into law by the President that provides a tax credit incentive for the capturing company. That tax credit would likely be shared by the transport and injecting companies. The law has some details yet to be clarified but indications are that it may lead to an increase in CO_2 supply for injection projects.

The above paragraphs outline the two major and competing factors coming into play for affecting the future of CO_2 injection projects. As mentioned, the first has to do with the onset of the horizontal drilling age with its fast return on investments in the basin reservoirs (shales). One can argue this factor is already affecting CO_2 EOR deployment of new projects and even personnel availability for EOR. It is not only the shales but also the horizontal drilling in the San Andres carbonates that is having this effect on CO_2 EOR. For example, the lease terms for drilling projects tends to command a 1/4th royalty for the mineral owners while a CO_2 EOR project has considerable difficulty making profit goals at royalty rates above 1/5th. Since the horizontal wells and CO_2 EOR both have the ROZ targets in mind, challenges for implementing new CO_2 EOR projects are quite acute.

The second factor relates to the availability to contract CO_2 supplies needed for EOR. As discussed in Section II, supplies have remained tight even with the drop in oil prices seen in 2014. New supplies are

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[6] The exception to the correlation of growth during higher oil prices are the years 2010-2013 when shortages of CO_2 supply restricted new project starts

needed which leads to the discussion of the possible additional supplies from anthropogenic CO_2. The 45Q tax credit provision has the possibility of providing that needed CO_2 to the Permian Basin. Occidental Petroleum Company has recently publicized the need for a CO_2 pipeline from the Gulf Coast that would bring CO_2 from the industrial sources in the Houston and/or Corpus Christi area that are eligible for the 45Q tax credit. The many ethanol plants to the north of the Permian Basin are yet another possibility. Capturing smaller quantities of CO_2 from the emission streams of the gas plants gathering natural gas could also create supply for new CO_2 flooding projects.

Because of the larger reservoirs and more successfully CO_2 flooded carbonate formations, the likelihood of the additional supplies of CO_2 and CO_2 EOR's benefit of concurrent storage will still not affect CO_2 injection anywhere near the WIPP project area for at least ten years. And even then, the huge potential for EOR in the many carbonate reservoirs and their residual oil zones will take precedence over the many challenges of flooding the shales and Delaware sandstone reservoirs located closer to the WIPP site.

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9a Research Partnership to Secure Energy for America Project (2012) entitled "Commercial Exploitation and the Origin of Residual Oil Zones: Developing a Case History in the Permian Basin of New Mexico and West Texas"

9b U.S. Department of Energy's Research Project (2016) entitled "Using 'Next-Generation' CO_2 EOR Technologies to Optimize the Residual Oil Zone CO_2 Flood at the Goldsmith Landreth Unit, Ector County, Texas"

9c Research Partnership to Secure Energy for America Project (2017) entitled "Identifying and Developing Technology for Enabling Small Producers to Pursue the Residual Oil Zone (ROZ) Fairways of the Permian Basin, San Andres

APPENDIX 1: TABLE OF ACTIVE PERMIAN BASIN CO_2 EOR PROJECTS (2018)

Producing CO_2 EOR Projects in the Permian Basin

#	Flood Type / Operator	Field	State	County	Field Unit Orig Discovery date	Orig Oil in Place MMBbls	Project Start date	Project Area, acres	No. prod. Wells	No. inj. Wells	Formation Flooding	Formation	Ave Form'tn Porosity, %	Ave Form'tn Permeability, md	Resvr Depth, ft	Oil Gravity, °API	Oil Visc. cp	Res Temp °F	Oil Type	Prev. Stage of Prod.	Oil Satur. % start	Oil Satur. % end	Proj. matur.	Tot. Crude Oil Prod., bopd	Enh.Crude Oil Prod., bopd
	CO_2 miscible																								
1	Apache	Adair	Tex.	Gaines	4/47	168	1997	5,338	90	61	San Andres	Dolomite	14.1	4	4,789	34		104	Sour	WF			HF	2,300	1,600
2	Apache	Adair	Tex.	Gaines	9/50	102	2004	2,550	11	11	Wolfcamp	Dolomite	12.4	28	8,500	42		126	Sweet	WF			JS	282	200
3	Apache	Roberts	Tex.	Yoakum	7/59		2012	13,600	222	186	San Andres	Dolomite	8.5						Sour					2,085	1,685
4	Apache	Slaughter	Tex.	Hockley & Terry	1/40		5/85	569	43	21	San Andres	Dolomite	12.5	6.3	4,900	32	1.3	110	Sour	WF			HF	600	600
5	Apache	Slaughter	Tex.	Hockley & Cochran	1/40		6/89	8,559	259	164	San Andres	Dolomite	10	3	5,000	32	1.6	107	Sour	WF	45	8	JS	2,200	2,200
6	Chevron	Mabee	Tex.	Andrews-Martin	10/43	18	1/92	3,600	220	85	San Andres	Dolomite	9	4	4,700	32	2.3	104	Sour	WF	36	10	NC	1,810	1,800
7	Chevron	Vacuum	NM	Lea Co.			7/97	1,084	48	24	San Andres	Dolomite	12	22	4,550	38	1.0	101	Sour	WF	36	15	HF	4,000	3,200
8	Chevron	Dollarhide (Devonian) Unit	Tex.	Andrews	8/45	122	5/85	6,183	83	66	Devonian	Dolo./Tripolitic Chert	13.5	9	8,000	40	0.4	122	Sweet	Prim./WF	35	22	HF	1,755	1,755
9	Chevron	Dollarhide (Clearfork "AB") Unit	Tex.	Andrews	6/49	73	11/95	160	21	4	Clearfork	Dolomite	11.5	4	6,500	40	0.5	113	Sour	Prim./WF	30	10	JS	960	960
10	Reinecke Operating	Reinecke	Tex.	Borden	2/50	166	1/98	700	32	8	Cisco Canyon Reef	LS/Dolomite	10.4	170	6,700	44	0.4	139	Sour	WF	35	10	JS	530	530
11	ConocoPhillips	South Cowden	Tex.	Lea			2/81	4,900	43	22	San Andres	Dolomite	11.7	11	4,500	38	1.0	101	Sour	Prim.	70	50	JS	160	160
12	ConocoPhillips	Vacuum	NM	Lea			2/81	4,900	192	103	San Andres	Dolomite	11.7	11	4,500	38	1.0	101	Sour	Prim.	70	50	HF	6,000	5,500
13	Energen Resources	East Penwell (SA) Unit	Tex.	Ector	3/27	188	5/96	1,020	49	30	San Andres	Dolomite	10	4	4,000	34	2.0	86	Sour	WF	55	40	HF	1,220	700
14	ExxonMobil	Means (San Andres)	Tex.	Andrews	1/34	402	11/83	8,500	484	284	San Andres	Dolomite	9	20	4,300	29	6.0	97	Sour	WF			HF	5,818	5,000
15	Fasken	Abell (Devonian)	Tex.	Crane	9/53	46	4/09	809	18	14	Devonian	Tripolitic Chert	21.9	3	5,300	42	0.5	105	Sweet	WF	45		JS	240	200
16	Fasken	Hanford	Tex.	Gaines	1/38		7/86	1,120	23	26	San Andres	Dolomite	10.5	4	5,500	32	1.4	104	Sour	Prim.	60.7	18.7	NC	400	400
17	Fasken	Hanford East	Tex.	Gaines	3/40		3/97	340	7	4	San Andres	Dolomite	10	4	5,500	32	1.4	105	Sour	WF	45	19	C	45	45
18	Fasken	Hanford (San Andres)	Tex.	Gaines	3/40		7/09	150	7	4	San Andres ROZ	Dolomite	10	5	5,700	32	1.0	105	Sour	Prim.	50		JS	280	80
19	Fasken	River Bend (Devonian)	Tex.	Crane	10/54		4/09	400	9	7	Devonian	Tripolitic Chert	23.7	5	5,500	42	0.5	105	Sour	WF	55	46	JS	290	180
20	Great Western Drilling	Twofreds	Tex.	Loving,Ward,Reeves	1/57	55	1/74	4,392	32	9	Delaware, Ramsey	SS	19.5	32	4,900	36	1.5	105	Sweet	WF	50		NC	100	100
21	George R. Brown	Garza	Tex.	Garza	8/35		11/09	1,778			San Andres	Dolomite			3,000				Sour					1,500	1,000
22	Hunt Oil	Anne Tandy Burnett Ranch)	Tex	King	5/55	5	3/14	10,750	53	23	Twin Peaks, L. Strawr	LS	15	50	5,150	38			Sweet	WF			JS	3,000	3,000
23	Kinder Morgan	SACROC	TX	Scurry	9/48	2113	1/72	49,900	390	503	Canyon	LS	4	19	6,700	39	0.7	135	Sweet	Prim / WF	78	39	HF	30,800	28,300
24	Kinder Morgan	Katz	TX	Stonewall, King			1/11	5,000	156	101	Strawn	LS	17	75	4,950	38	2.2	117	Sweet	Prim, WF	70	40	JS	3,700	3,700
25	Kinder Morgan	Goldsmith-Landreth	TX	Ector	5/35	246	5/09	21,205	637	389	San Andres	Dolomite	12	32	4,100	35	1.3	95	Sour	Prim, WF	80	35	HF	2,100	2,067
26	Orla Petco	East Ford	Tex.	Reeves	9/63	10	7/95	1,953	8	4	Delaware, Ramsey	SS	23	30	2,680	40	0.8	82	Sweet	Prim.	49	36	HF	50	50
	Oxy (See Below)																								
76	Sabinal Energy Operating	Slaughter Sundown	Tex.	Hockley Co	4/37		1/94	5,500	155	144	San Andres	Dolomite	11	6	4,950	33	1.4	105	Sour	WF	41	25	HF	3,540	3,500
77	Tabula Rasa	East Seminole	Tex.	Gaines	5/59	19	10/13	160	12	4	San Andres	Dolomite	10	6	5,400	33	2.2	108	Sour	Prim./WF	80	43.9	JS	533	433
78	Tabula Rasa	Emma Pilot	Tex.	Andrews			2015	100	5	10	San Andres	Dolomite							Sour	Prim./WF				incl below	incl below
79	Tabula Rasa	Emma	Tex.	Andrews			12/17	200	8	16	San Andres	Dolomite							Sour	Prim./WF				470	450
80	Tabula Rasa	Lindoss	Tex.	Gaines	5/59	19	10/13	160	12	4	San Andres	Dolomite	10	6	5,400	33	2.2	108	Sour	Prim./WF	80	43.9	JS	300	267
81	Trinity	Wellman	Tex.	Terry	7/50	164	7/1/83	1,400	14	9	Wolfcamp	LS	9.2	100	9,800	43.5	0.5	151	Sweet	WF	35	10	HF	1,930	1,930
82	Whiting Petroleum	North Ward Estes	Tex.	Ward/Winkler	4/29	1,200	5/07	16,300	816	816	Yates	SS	16	37	2,600	36	1.6	83	Sour	Prim./WF	26.5	21	JS	10,194	7,700
83	XTO Energy Inc.	Goldsmith	Tex.	Ector	1/35	1,000	12/96	330	16	9	San Andres	Dolomite	11.6	32	4,200	35		105	Sour	WF			JS	1,620	1,620
84	XTO Energy Inc.	Cordona Lake	Tex.	Crane	10/49	68	12/85	2,084	44	23	Devonian	Tripolitic Chert	22	4	5,500	40	0.5	101	Sweet	WF			HF	910	500
85	XTO Energy Inc.	Wasson (Cornell Unit)	Tex.	Yoakum	1/37	141	7/85	1,923	96	64	San Andres	Dolomite	8.6	2	4,500	33	1.0	106	Sour	WF			HF	2,000	1,350
86	XTO Energy Inc.	Wasson (Mahoney)	Tex.	Yoakum	1/37	90	10/85	640	49	27	San Andres	Dolomite	13	6	5,100	33	1.0	110	Sour	WF	54.4	39.2	HF	1,500	1,300
	CO_2 immiscible																								
87	Kinder Morgan	Yates	Tex.	Pecos	10/26	4,000	3/04	26,000	606	123	San Andres	Dolomite	17	175	1,400	30	6.0	82	Sour	GI	75	54	HF	17,000	16,000

Producing CO_2 EOR Projects in the Permian Basin (Cont'd)

	Flood Type / Operator	Field	State	County	Field Unit Orig Discovery date	Orig Oil in Place MMBbls	Project Start date	Project Area, acres	No. prod. Wells	No. inj. Wells	Formation Flooding	Formation	Ave Form'tn Porosity, %	Ave Form'tn Permeability, md	Resvr Depth, ft	Oil Gravity, °API	Oil Visc. cp	Res Temp °F	Oil Type	Prev. Stage of Prod.	Oil Satur. % start	Oil Satur. % end	Proj. matur.	Tot. Crude Oil Prod., bopd	Enh.Crude Oil Prod., bopd
	CO_2 miscible (Cont'd)																								
27	Occidental Permian Ltd	Anton Irish	Tex.	Hale	12/44		4/97	4,437	199	93	Clearfork	Dolomite	7	4	5,800	30	3.0	109	Sour	Prim., WF	50	30	HF	3,631	3,500
28	Occidental Permian Ltd	Cedar Lake	Tex.	Yoakum	8/39		8/94	2,870	235	96	San Andres	Dolomite	14	5	4,800	32	2.3	102	Sour	WF	50	35	HF	3,049	3,049
29	Occidental Permian Ltd	Cogdell Canyon Reef Unit	Tex.	Scurry/Kent	12/49		10/01	2,684	119	90	Canyon Reef	LS	13	6	6,800	40	0.7	130	Sweet	WF	46	15	HF	6,333	5,800
30	OXY USA WTP, LP	El Mar	Tex.	Loving	1/59		4/94	7,100	8	8	Delaware	**SS**	16	20	4,500	41	1.1	97	Sweet	Prim./WF	40		NC	34	34
31	OXY USA WTP, LP	G-M-K South	Tex.	Gaines	5/57	47	1982	1,143	30	26	San Andres	Dolomite	10	3	5,400	30	3.0	101	Sour	Prim.	55	28	HF	364	300
32	Occidental Permian Ltd	Levelland (Levelland Unit)	Tex.	Hockley	2/45	170	9/04	1,179	137	110	San Andres	Dolomite	12	2	4,900	34	1.4	108	Sour	WF	45	26	JS	2,340	1,675
33	OXY Permian Ltd	Mid Cross Dev Unit	Tex.	Crane, Upton & Crockett			7/97	1,326	9	6	Devonian	Tripol.	18	2	5,400	42	0.4	104	Sweet	Prim., GI	60	20	HF	244	240
34	OXY Permian Ltd	North Cross /Dev./ Unit	Tex.	Crane & Upton	5/44	51	4/72	1,155	25	16	Devonian	Tripol.	22	5	5,300	44	0.4	104	Sweet	Prim., GI	49	21	NC	839	839
35	OXY USA WTP, LP	North Cowden	Tex.	Ector	9/30	107	2/95	465	30	15	Grayburg	Dolomite	10		4,200	34	1.5	91	Sour	WF	40	25	**Term.**		
36	OXY USA WTP, LP	North Dollarhide Devonian	Tex.	Andrews	8/45	94	11/97	1,280	23	16	Devonian	Tripol.	22	5	7,500	40	0.5	123	Sweet	WF	38	23	HF	563	350
37	OXY Permian Ltd	North Hobbs	NM	Lea			3/03	3,300	134	83	San Andres	Dolomite	15	15	4,200	35	0.9	102	Sour	WF	35	24	HF	7,860	6,445
38	OXY Permian Ltd	South Cross Unit	Tex.	Crockett			6/88	2,090	76	43	Devonian	Tripol.	21	4	5,200	43	0.6	104	Sour	Prim., GI	43	24	**NC**	4,194	4,194
39	OXY Permian Ltd	Salt Creek Field Unit	Tex.	Kent	5/50	500	10/93	12,000	170	145	Canyon	LS	20	12	6,300	39	1.0	125	Sweet	WF	89	15	HF	6,390	6,390
48	OXY USA WTP, LP	Sharon Ridge Canyon Unit	Tex.	Scurry	3/49	369	2/99	1,400	37	43	Canyon Reef	LS	10	70	6,600	43	0.4	125	Sweet	WF	39	26	HF	1,264	1,264
49	Oxy USA Inc.	Seminole Unit-Main Pay Zone	Tex.	Gaines	11/36	971	7/83	15,699	370	110	San Andres	Dolomite	12	1.3-123	5,300	35	1.1	104	Sour	WF	84		HF	8,500	8,150
50	Oxy USA Inc.	Seminole Unit-ROZ Phase 1	Tex.	Gaines	11/36	980	7/96	500	15	10	San Andres	Dolomite	12	1.3-123	5,500	35	1.1	104	Sour	none	30		HF	1,000	1,000
51	Oxy USA Inc.	Seminole Unit-ROZ Phase 2	Tex.	Gaines	11/36	980	4/04	480	16	9	San Andres	Dolomite	12	1.3-123	5,500	35	1.1	104	Sour	none	30		HF	1,500	1,500
52	Oxy USA Inc.	Seminole Unit-ROZ Stage 1	Tex.	Gaines	11/36	980	10/07	2,320	44	29	San Andres	Dolomite	12	1.3-123	5,500	35	1.1	104	Sour	none	30		HF	7,800	7,800
53	Oxy USA Inc.	Seminole Unit-ROZ Stage 2	Tex.	Gaines	11/36	980	5/11				San Andres	Dolomite	12	1.3-123	5,500	35	1.1	104	Sour	none	30		HF		
54	Oxy USA Inc.	Seminole Unit-ROZ Stage 3	Tex.	Gaines	11/36	980	7/13				San Andres	Dolomite	12	1.3-123	5,500	35	1.1	104	Sour	none	30		HF		
55	Oxy USA Inc.	Seminole Unit-ROZ Stage 4	Tex.	Gaines	11/36	980	1/15				San Andres	Dolomite	12	1.3-123	5,500	35	1.1	104	Sour	none	30		JS		
56	Occidental Permian Ltd	Slaughter (Alex Slaughter Estate)	Tex.	Hockley	1/37	13	8/00	246	18	18	San Andres	Dolomite/LS	10	5	4,950	31	1.8	105	Sour	WF	40	25	HF	123	123
57	Occidental Permian Ltd	Slaughter (Central Mallet Unit)	Tex.	Hockley	4/37	139	1984	6,412	157	116	San Andres	Dolomite	10	2	4,900	31	1.8	105	Sour	WF	48	25	HF	2,102	2,000
58	Occidental Permian Ltd	Slaughter (Frazier, W.G. Lease)	Tex.	Hockley	11/36		12/84	1,600	56	52	San Andres	Dolomite/LS	12	8	4,950	31	1.8	105	Sour	WF	38	23	NC	618	556
59	OXY USA WTP, LP	Slaughter (Boyd, H.T.)	Tex.	Cochran	4/37		8/01	1,240	37	22	San Andres	Dolomite	10	4	5,000	31	1.6	108	Sour	WF	47	36	HF	644	579
60	Occidental Permian Ltd	Slaughter (Igoe Smith Oper. Area)	Tex.	Cochran	4/37		9/05	1,235	45	34	San Andres	Dolomite	11	4	5,040	34	1.5	105	Sour	WF	47	36	HF	598	475
61	Occidental Permian Ltd	Slaughter (North West Mallet Unit)	Tex.	Cochran & Hockley	4/37		2008	1,048	94	30	San Andres	Dolomite	10	2	4,950	32	2.0	105	Sour	WF	47	31	JS	1,021	250
62	Occidental Permian Ltd	Slaughter (Slaughter Estate Unit)	Tex.	Hockley	4/37	300	12/84	5,700	171	140	San Andres	Dolomite/LS	12	5	4,950	31	1.8	105	Sour	WF	40	23	HF	2,325	2,093
63	Occidental Permian Ltd	Slaughter (Smith Igoe)	Tex.	Cochran	4/37		8/14	177	6	3	San Andres	Dolomite	10	4	5,000	31	1.6	108	Sour	WF	47	36	HF	151	110
64	Occidental Permian Ltd	Slaughter (West RKM Unit)	Tex.	Hockley	4/37	16	2006	1,561	145	48	San Andres	Dolomite	9	4	4,900	32	2.0	105	Sour	WF	42	29	JS	1,503	599
65	Occidental Permian Ltd	South Wasson Clearfork	Tex.	Yoakum	1/40	247	10/84	4,720	102	68	Clearfork	Dolomite	7	2	8,200	33	1.2	120	Sour	WF	70		Term.	1,757	0
66	OXY Permian Ltd	South Hobbs G/SA Unit	NM	Lea			7/15		57		Grayburg/San Andres	Dolomite	15	15	4,200	35	0.9	102	Sour	WF	35	24	JS	5,119	4,668
67	OXY USA WTP, LP	South Welch Unit	Tex.	Dawson	11/36	131	9/93	1,160	118	72	San Andres	Dolomite	11	4	4,900	34	2.3	98	Sour	WF	50	35	NC	610	500
68	Occidental Permian Ltd	Slaughter T-Star (Consolidated)	Tex.	Hockley			7/99	1,700	54	30	Abo	Dolomite	7	2	7,850	28	1.9	134	Sour	Prim./WF	75	45	HF	1,732	1,000
69	Occidental Permian Ltd	Wasson (Bennett Ranch Unit)	Tex.	Yoakum	1/36	301	6/95	2,154	173	150	San Andres	Dolomite	11	8	5,250	34	1.2	105	Sour	WF	55	37	HF	4,324	4,100
70	Occidental Permian Ltd	Wasson (Denver Unit)	Tex.	Yoakum & Gaines	4/36	2,108	4/83	27,848	73	70	San Andres	Dolomite	12	8	5,200	33	1.2	105	Sour	WF	51	31	HF	22,174	22,174
71	Occidental Permian Ltd	Wasson (ODC Unit)	Tex.	Yoakum	4/36		11/84	7,800	284	260	San Andres	Dolomite/LS	10	5	5,100	34	1.3	110	Sour	WF	49	34	HF	7,655	7,500
72	Occidental Permian Ltd	Wasson (Willard Unit)	Tex.	Yoakum	1/36	622	1/86	8,020	380	250	San Andres	Dolomite	9	2	5,100	32	1.2	105	Sour	WF	56	41	HF	6,488	6,350
73	OXY USA WTP, LP	West Welch	Tex.	Gaines	11/36	229	10/97	240	201	150	San Andres	Dolomite	10	3	4,900	34	2.3	98	Sour	WF	50	15	Term.	1,122	200
74	Occidental Permian Ltd	Levelland (South East Levelland)	Tex.	Hockley	1/45	144	4/14	1,184	186	40	San Andres	Dolomite	10	2	4,850	32	1.4	108	Sour	WF	30	15	JS	1,999	250
75	OXY USA WTP, LP	West Seminole San Andres Unit	Tex.	Gaines	6/48	154	7/1/13	1,620	81	50	San Andres	Dolomite	12	10	5,000	34	0.9	102	Sour	WF	65	30	JS	2,084	1,839
																								232,273	**207,955**

APPENDIX 2: NEW DEVELOPMENTS: YESO FORMATION STUDY IN EDDY COUNTY, NM

WIPP Report Appendix 2
New Developments: Yeso Formation Study in Eddy County, NM Yeso Study

Outline

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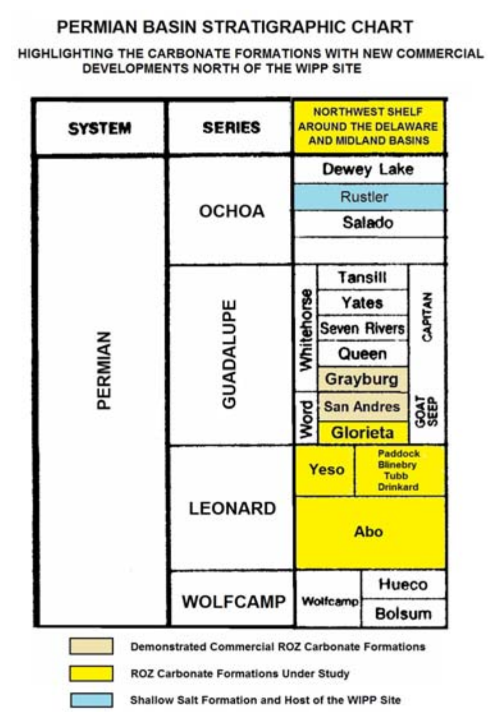
Appendix 2
to the Updated Assessment of The CO_2 Enhanced Oil Recovery Potential in the Vicinity of the Waste Isolation Pilot Plant, Eddy County, New Mexico

New Developments: Yeso Formation Study in Eddy County, NM Yeso Study

Introduction

The very recent advent of the horizontal well revolution has created an unprecedented level of new drilling activity in the U.S. Almost all of the reports have focused upon the so-called shales such as the Eagle Ford, Marcellus, Bakken and Spraberry/Wolfcamp formations with the last (Permian Basin) taking a strong, predominate role over the last four years or so. The activity in the Spraberry/Wolfcamp lies within both the eastern sub-basin, the Midland Basin and the western one, called the Delaware Basin, and site of the WIPP facility. However, the activity lies deep below the formation depths associated with the WIPP site (see Fig. A-1). Within the intermediate depths below the WIPP site's Rustler formation and above the Wolfcamp formation lie the Delaware Mountain Group of shales, siltstones and sandstones and the deeper Bone Springs Formation often consisting of a heterogeneous mixture of shales, siltstones and limestones. In the immediate vicinity of the WIPP site, the oil and gas industry has seen scattered and mixed results with both vertical and horizontal wells unless the wells extend deeper into the Wolfcamp formation. As one moves to the north of the WIPP site and onto the carbonate shelf just to the north and east of the deeper basin, one encounters the carbonate formations that have typically proven to be the better reservoirs for water and CO_2 flooding over the past 50 years. Of particular interest, and the subject of this appendix, the Yeso formation with its sister formation above, the Glorieta, and the underlying Abo formation, are those carbonate formations with accelerating commercial drilling activity especially with the Yeso seeing most of the interest and new drilling. Activity does not extend to CO_2 EOR project consideration at this time but could receive some injection project planning in the near future and perhaps some pilot testing.

Figure A-1 – NW Shelf Stratigraphic Section



Geologic Trends

Fig. A-1 illustrates the stratigraphic position of the Yeso formation, its overlying Glorieta and underlying Abo formations. The carbonate shelf rocks all lie to the north and east of the WIPP site. With the lone exception of the non-productive Capitan reef of upper Guadalupian age, the closest are stacked one upon another about 20-30 miles to the north.

Fig. A-2 maps the recent activity of both vertical and horizontal wells drilled in the formations while Fig. A-3 examines the accelerating production growth over the last several years.

Fig. A-2 – Map Illustrating the Trends of the Leonard Carbonate Shelves

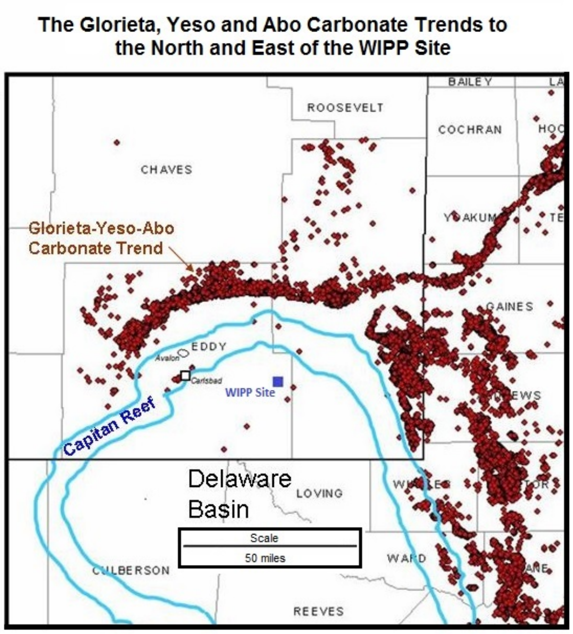
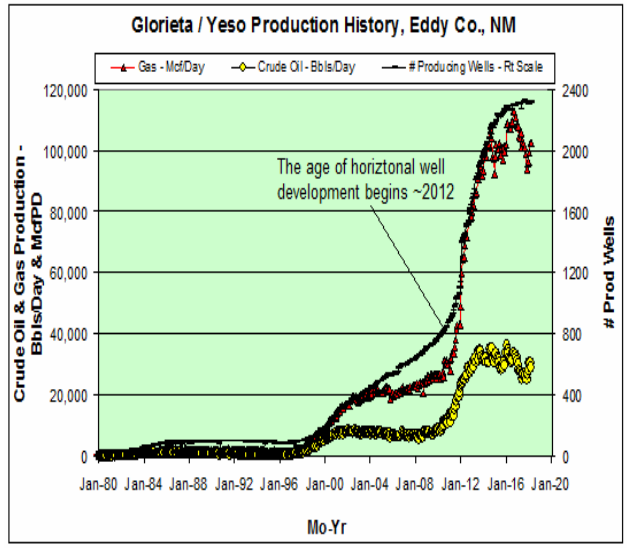


Fig. A-3 – Recent Accelerating Production Growth – Glorieta, Yeso Formations



Advanced Recovery and Development History

The Permian Basin has long maintained a worldwide reputation as one of the most active water flooding project regions and, perhaps, as the most successful water and CO_2 flooding region in the world. The carbonate reservoirs and, especially, the San Andres formation in particular, have been the mainstays of that success. A lot of that success has been occurring in the Texas side of the Permian Basin. The carbonate shelf formations in New Mexico have seen their share of projects but have not seen either the number or percent recovery success that the Texas counties have witnessed. The same can be said for CO_2 flooding projects. There are currently only four CO_2 EOR projects in New Mexico out of 75 total Permian Basin floods. Those four represent approximately 10% of the CO_2 EOR incremental production attributable to the Permian Basin. All New Mexico projects are in Lea county while none are located in Eddy County.

As shown in Fig. A-3 and contrary to the flooding history, drilling activity has heated up within the carbonate reservoirs in Eddy County. To date, this new activity includes both vertical and horizontal drilling and neither waterflooding nor CO_2 injection is occurring.

The new trend in CO_2 flooding has been centered on the Permian Basin residual oil zones wherein the oil present is immobile and requires either CO_2 or reservoir depressuring to make it move to producing wells. Sixteen of these ROZ projects are underway but the only ROZ flooding pilots that have been implemented in New Mexico are in the Vacuum field in Lea County. Reservoir depressuring wells utilizing horizontal drilling is rapidly advancing in the ROZ intervals in Yoakum County in Texas and some professionals familiar with those geologic conditions and wells are suggesting that residual oil zones (ROZs) are present in the Yeso formation in both Lea and Eddy counties. Some moveable (primary) oil is likely present but immobile (ROZ) oil likely does constitute part of the producing volumes associated with the newer vertical and horizontal wells there. We will examine the evidence for ROZs in the Abo and Yeso formations with the goal of understanding whether those typically better porosity reservoirs will be amenable for CO_2 flooding in the future.

Reservoir Aspects and Type Log Example

Several significant reservoir and fluid diagnostics have been recently identified that, taken in full, suggest the presence of a residual oil zone of the type found in the Permian Basin carbonate reservoirs. When keeping in mind that the ROZs are laterally flooded by natural water floods, both the reservoirs and fluids can be altered by microbial processes. Those are typically porosity enhancement processes and, with significant pore volumes of sweep, have modified the oil to remove some of the lighter-end components and make the oil more viscous and less mobile. Research is still immature but the important diagnostics to look for to identify a laterally swept ROZ are the following:

1. Open marine carbonate facies and laterally correlatable porosity zones,
2. A ‘bow’ shape porosity and resistivity log characteristics,
3. Tilted oil-water contacts,
4. The presence of H_2S in the gas and oil,
5. Sulfur-rich formation waters,
6. Lower water salinities when compare to the commonly recorded connate waters in the main pay zones that remain isolated from the lateral sweep,
7. Gas/oil ratios (GORs) of 300 cubic feet per barrel (ft^3/bbl) or greater,
8. Oil viscosities below 5 centipoises <u>or</u> with the proxy of oil gravity above 25^o API, and
9. Delayed onset of oil and gas production upon reservoir depressuring.

The critical attributes for reservoir depressuring are often the same as the ones for enhanced oil recovery but some important differences are notable as well. For one, CO_2 EOR can work with lower GORs than can reservoir depressuring. Current work suggests the 300 ft^3/bbl is the appropriate criterion for depressuring; EOR can be effective with much lower GOR values.

In many cases, older published reports can offer insights to the presence of ROZs. Two great examples of this were reports by William LeMay and Pat Gratton[7] citing detailed work done of the Abo formation in Eddy and Lea Counties, New Mexico. Fig. A-4 displays the Abo carbonate reef trend showing the tilted oil/water contacts. We interpret these to be caused by the west-to-east lateral sweep documented in the San Andres formation so thoroughly accomplished in the mapping within the RPSEA research reported on in 2007.[8] Note also the indications of a transition or residual oil zone below the oil/water contact. Fig. A-5 provides a closer look at the tilted contact studied in the Empire Abo field.

Equivalent Yeso open marine (reefal) observations are not documented in the literature to our findings. However, one would expect the open marine facies to be present. We do expect the trend to be much narrower that the corresponding and regionally broad San Andres shelf reservoirs as is hinted in Fig. A-2.

[7] LeMay, W.J. (1960), Southwestern Federation of Geological Societies Transactions, Oct 12-14, 1960;

Gratton, J.F. & LeMay, W.J. (1968), “San Andres Oil East of The Pecos,” Twenty-second Annual Meeting of the New Mexico Geological Society, at Hobbs, New Mexico, May 10, 1968.

[8] Identifying and Developing Technology for Enabling Small Producers to Pursue the Residual Oil Zone (ROZ) Fairways in the Permian Basin San Andres Formation, Coauthor with Trentham, R.C. & Vance. D. (2016) Research Partnership to Secure Energy for America and U.S. Dept of Energy Final Report, www.netl.doe.gov/file%20library/research/oil-gas/10123-17-final-report.pdf

In examining several of the mud and wireline logs acquired in recent years as a direct result of the accelerated drilling activity, we illustrate a type log in Section 17 of Township 17, Range 31E ~25-miles north of the WIPP site. Fig. A-6 displays the upper section of the Yeso formation.

Fig. A-4 – Reef Trend Abo fields displaying tilted Oil/Water Contacts (after Lemay)

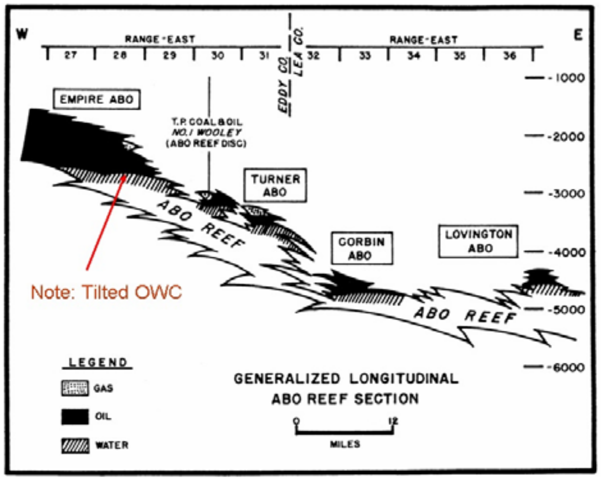


Fig. A-5 – Closer Look at the Tilted Oil/Water contact at the Empire Abo Field, (after Lemay)

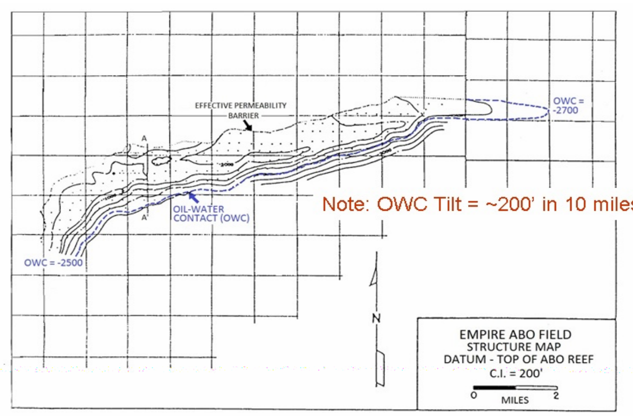
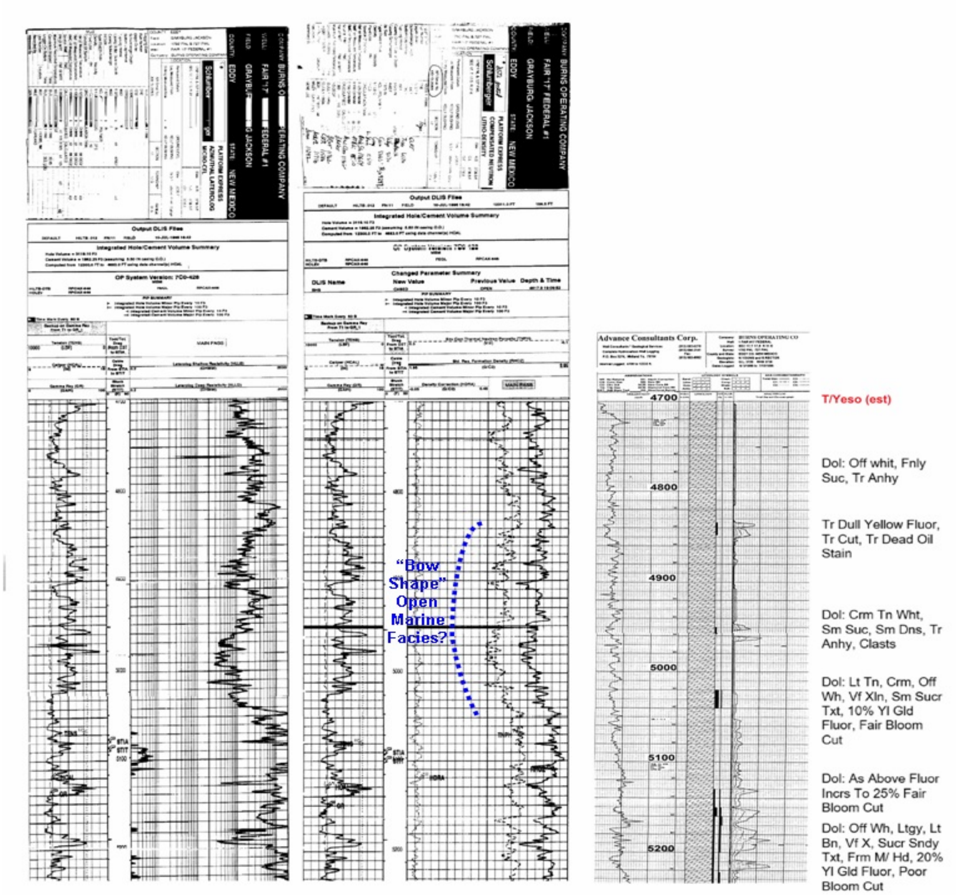


Fig. A-6 – Example Mud and Wireline logs in the Upper Yeso Formation in eastern Eddy County, NM



Projections for CO_2 Injection Possibilities in the Yeso Formation and the Presence of ROZs

Several of the critical evidentiary requirements for CO_2 flooding and the large volume reservoir generally associated with Permian Basin ROZs have now been established in Eddy County in the Yeso Formation. Careful work by several New Mexico researchers established tilted oil/water contacts, typical logs illustrate the reservoir quality open marine facies and bow shape log character, excellent gas/oil ratio which should qualify the oil as miscible with CO_2, oil gravities of 32-38^o API, and rumors of delayed onset of oil production usually reserved for depressuring of ROZ reservoirs.

Horizontal well completions in the Yeso formation are just 4-6 years old but indications are that decline curves would suggest the presence of large volume, conventional ROZ reservoirs like those being exploited in Yoakum County in the San Andres formation. Other work can be needed to determine if sour oil and gas is common, lower water salinities are present, and if a suppressed methane composition is present in the casinghead gas.

Finally, it is now in evidence that the extent of the Glorieta, Yeso and Abo trends will not extend any closer that within 20 miles of the WIPP site. For that matter, the geologically younger San Andres trend will not be any closer either leaving the risk of injection from water flooding and CO_2 EOR fairly minimal.