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Booking EOR Reserves

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Disclaimer

- The information presented herein represents informed opinions about US SEC reserves reporting regulations but does not purport to be identical to advice or rulings that may be obtained from the SEC.
- The SEC interprets each case individually & may alter interpretations based on facts particular to each case.

Outline

- Reserves Definition
- SPE-PRMS Proved Reserves Definition
- What makes an EOR Project a PUD
  - Pilot Projects
  - Use of Analogies
  - Reliable Technology
- Major factors affecting EOR Reserves
- What else should we consider?

Who Defines Reserves?

SEC - Modernization of Oil and Gas Reporting; Final Rule


Federal Register

Wednesday,
January 14, 2009

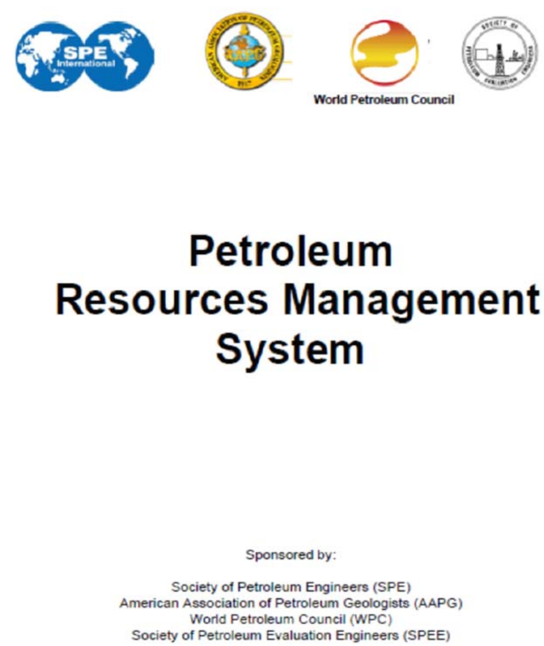
Part II

Securities and Exchange Commission

17 CFR Parts 210, 211 et al.
Modernization of Oil and Gas Reporting; Final Rule

- Rules & Regulations for Oil and Gas Reserve Reporting and Disclosures
- Amends and Implements New Standards
- Issued January 2009

SPE/WPC/AAPG/SPEE PRMS


World Petroleum Council

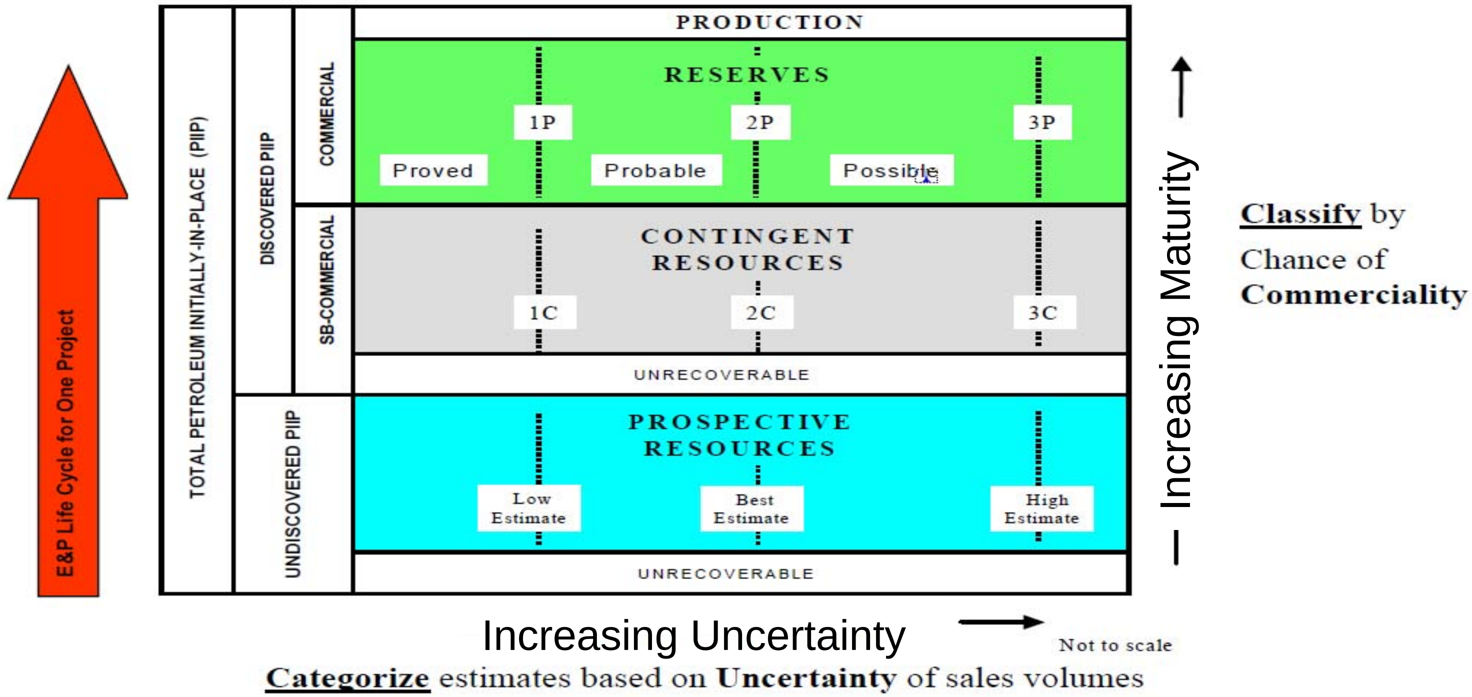
Petroleum Resources Management System

Sponsored by:

Society of Petroleum Engineers (SPE)
American Association of Petroleum Geologists (AAPG)
World Petroleum Council (WPC)
Society of Petroleum Evaluation Engineers (SPEE)

- Oil and Gas Resources & Reserves Definitions and Guidelines.
- Amends and Updates Prior 1997 & 2000
- Issued 2007

Reserves and Resources Classification Framework



- Uncertainty terms are applicable to recoverable volumes in each of the Reserves and Resource Classes.
- Represented by Proved, Probable or Possible reserves categories.
- May be also expressed by cumulative volumes such as 1P, 2P and 3P.

Reserves Definition

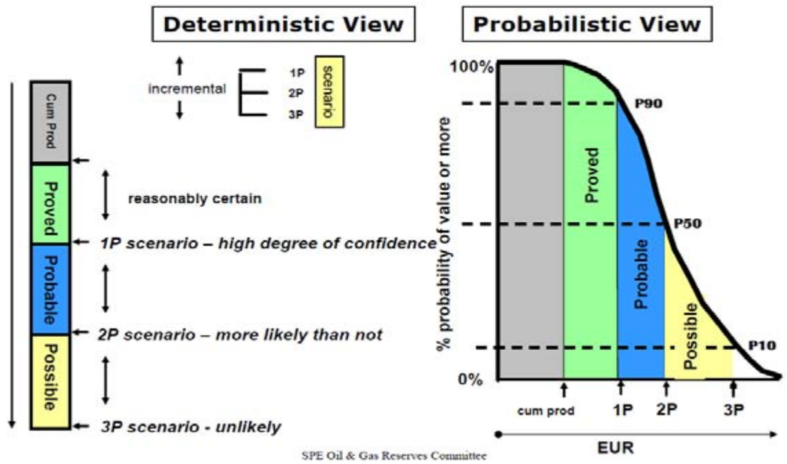
- "**Reserves** are those quantities of petroleum anticipated to be commercially recoverable by application of development projects from known accumulations from a given date forward under defined conditions." (Must satisfy four criteria)
  1. **Discovered**
  2. **Recoverable**
  3. **Commercial**
  4. **Remaining based on the development projects applied**

Source: SPE/AAPG/WPC/SPEE PRMS   Appendix A

Range of Uncertainty

- **Deterministic Methodology**
  - Best estimates of reservoir parameter combined to achieve a single result.
- **Probabilistic Methodology**
  - Ranges are determined for all reservoirs parameters and probabilities are assigned to various configurations.

	Deterministic	Probabilistic
Proved	Reasonable Certainty	At least 90% probability
Probable	More likely than not	At least 50% probability for sum of proved plus probable
Possible	Less likely than not	At least 10% probability for sum of proved plus probable plus possible



Proved, Probable & Possible Reserves

- "**Proved Reserves** are those quantities of oil petroleum, which, by analysis of geoscience and engineering data, can be estimated with *reasonable certainty to be commercially* recoverable.."
- **Probable Reserves are *those additional Reserves* which analysis of geoscience and engineering data indicate are *less likely to be recovered than Proved Reserves but more certain to be recovered than Possible Reserves.***
- **Possible Reserves** are those additional reserves which analysis of geoscience and engineering data suggest are *less likely to be recoverable than Probable Reserves*.

Source: SPE/AAPG/WPC/SPEE PRMS Table 3

Improved Recovery

- Includes the incremental recovery from:
  - Waterflooding
  - Secondary Recovery
  - Tertiary Recovery
  - Pressure Maintenance
- *May be Proved, Probable, Possible Reserves* or *Contingent Resources* based on the certainty derived from available data.

Source: SPE/AAPG/WPC/SPEE PRMS 2.3.4

EOR Proved Reserves Definition - SEC

Reserves which can be produced economically through the application of *EOR techniques* (such as fluid injection) are included in the proved classification only after:

- ✓ Successful testing by a *pilot project.*
- ✓ The operation of an *installed program* in the reservoir or analogous reservoir provides support for engineering analysis.
- ✓ Other evidence using *reliable technology.*
- ✓ The project has been *approved* by all parties.

Source: SEC 210.4-10(a)(22)

EOR Proved Undeveloped Reserves - SEC

- "Under no circumstances should estimates for undeveloped reserves be attributable to any acreage for which an application of fluid injection or other EOR technique is contemplated, unless such techniques have been *proved effective by actual projects in the same reservoir or an analogous reservoir* or by other evidence using *reliable technology* establishing *reasonable certainty*."

Source: SEC 210.4-10(a)(31)

What Makes an EOR Project a PUD

- May be **Proved Reserves** if:
  - Favorable response from either a successful *pilot project* in the subject reservoir or
  - *An installed program* in the reservoir with favorable response
  - Or comparison to an established analogous program in an *analogous* reservoir.

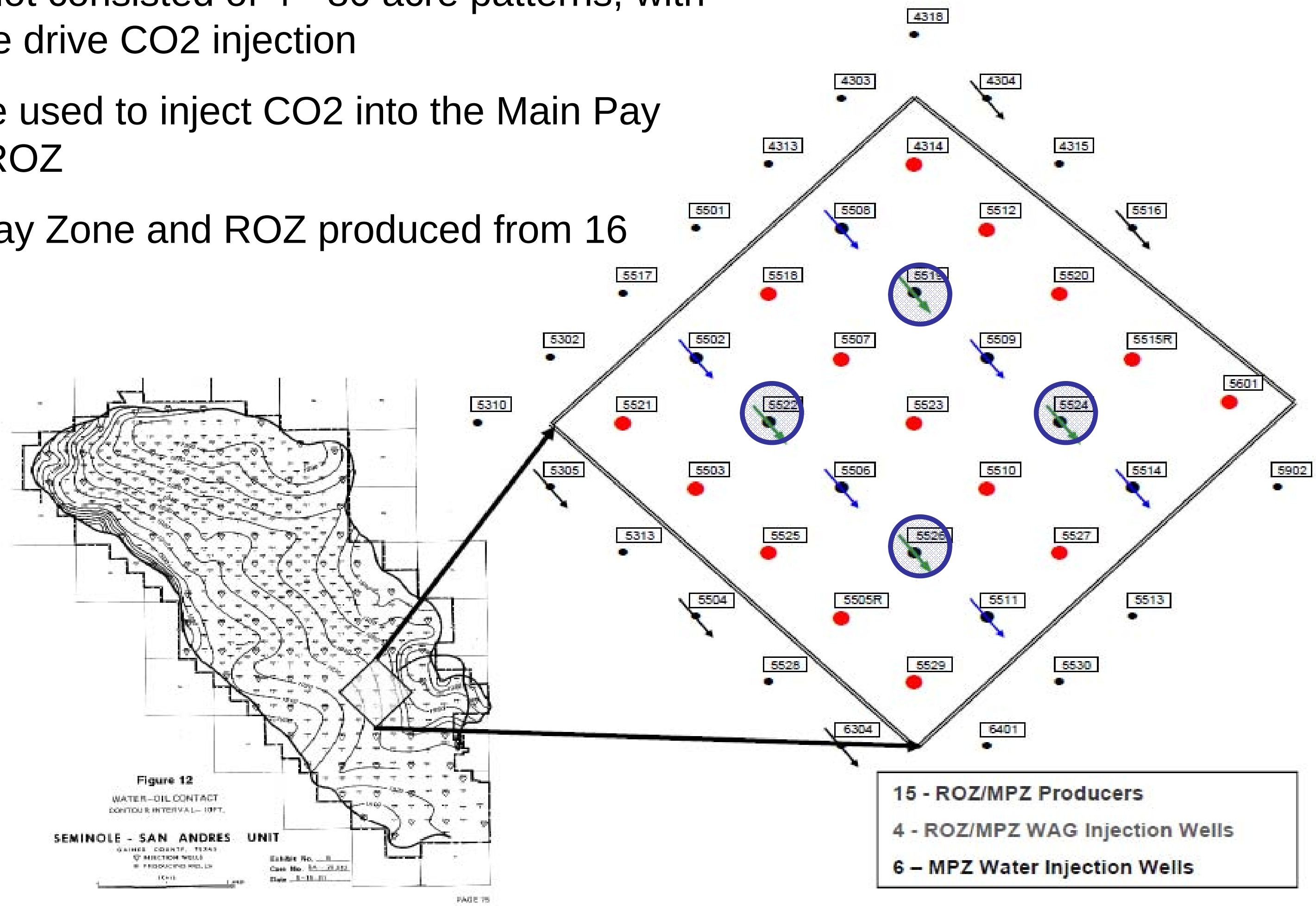
Source: SPE/AAPG/WPC/SPEE PRMS 2.3.4

Pilot Testing

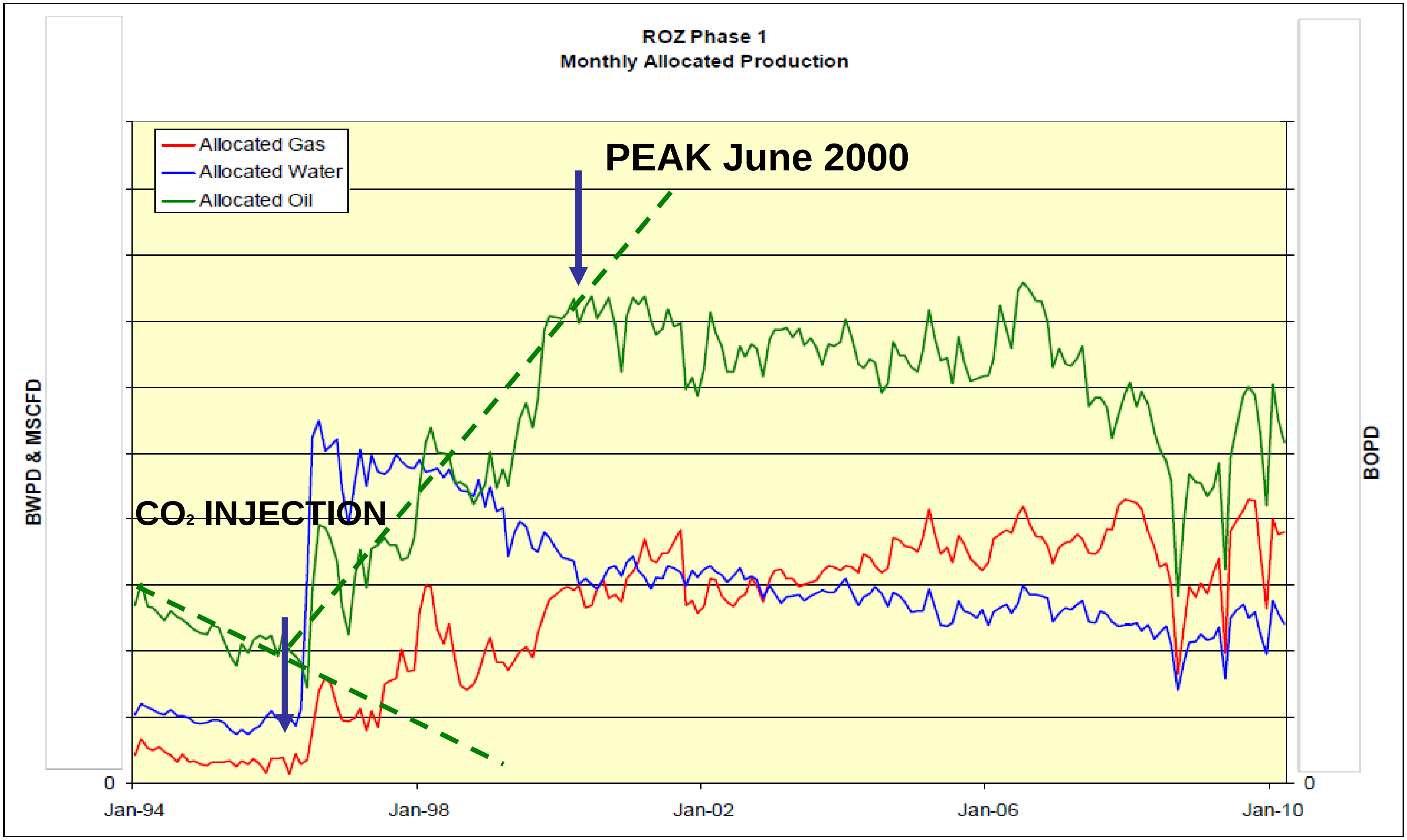
- *Pilot:* A small-scale test or trial operation that is used to assess the suitability of a method for commercial application.
- PRMS require a “favorable” response
  - May be a BHP response
  - May be a change in GOR
  - May be a production response
- SEC has required production response or a successful commercial analogy with a production response.
- The SEC ***may*** be open to a combination of “favorable” responses similar to the PRMS, but this is an opinion, document your work and conclusions to present a “compelling case”

Phase I Pilot Seminole San Andres Unit ROZ

- The ROZ pilot consisted of 4 - 80 acre patterns, with modified line drive CO2 injection
- 4 wells were used to inject CO2 into the Main Pay Zone and ROZ
- The Main Pay Zone and ROZ produced from 16 wells



Pilot Favorable Response



Courtesy of Scott Biagiotti,
Hess Corporation

SPE Gulf Coast Permian Study
Group – May 2010

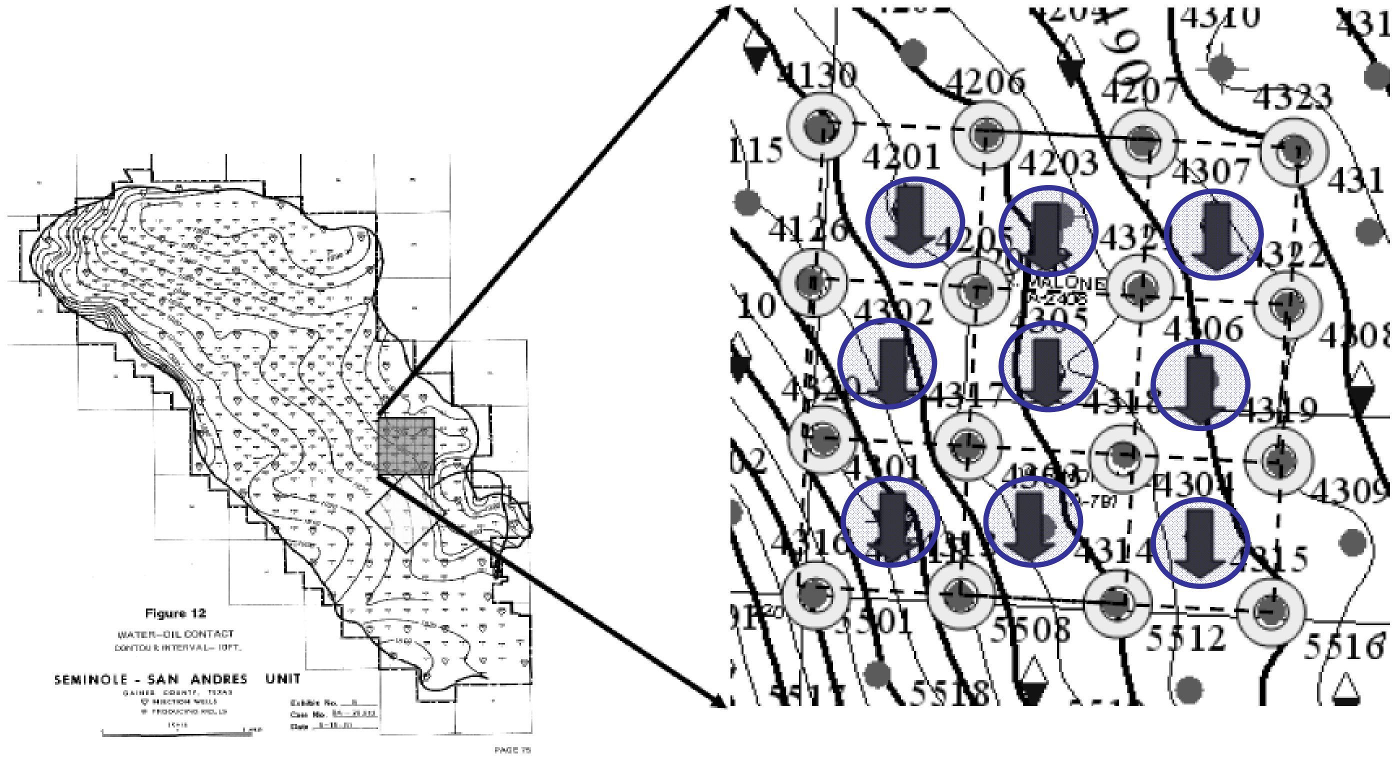
Phase II Pilot
Seminole San Andres Unit ROZ

The ROZ pilot consisted of 9 - 40 acre patterns, with inverted five-spot CO2 injection

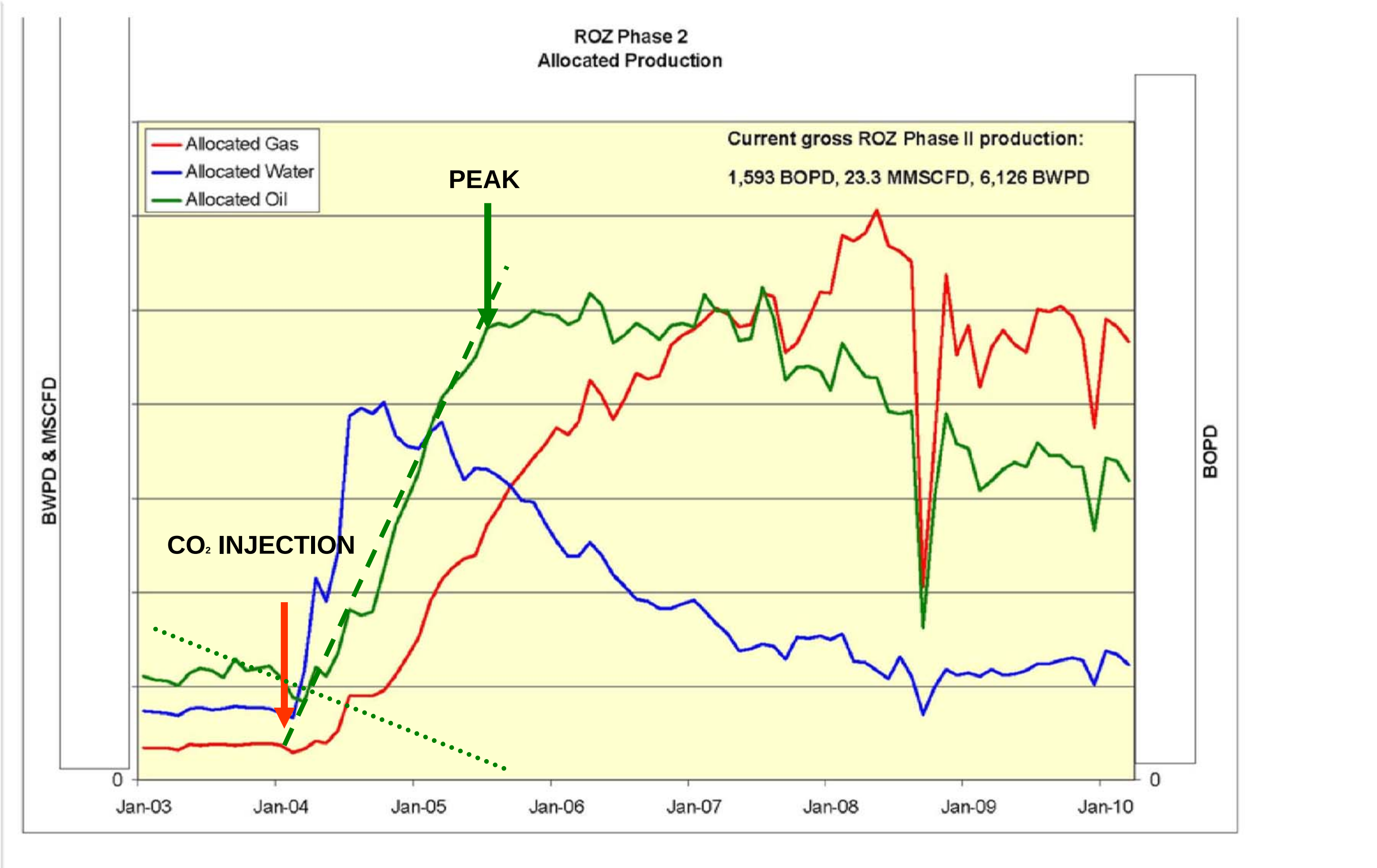
9 wells were used to inject CO2 into only the ROZ

The Main Pay Zone and ROZ produced from 16 wells

16 - MPZ/ROZ Producers
9 - WAG ROZ Only Injectors



Pilot Favorable Response



Courtesy of Scott Biagiotti,
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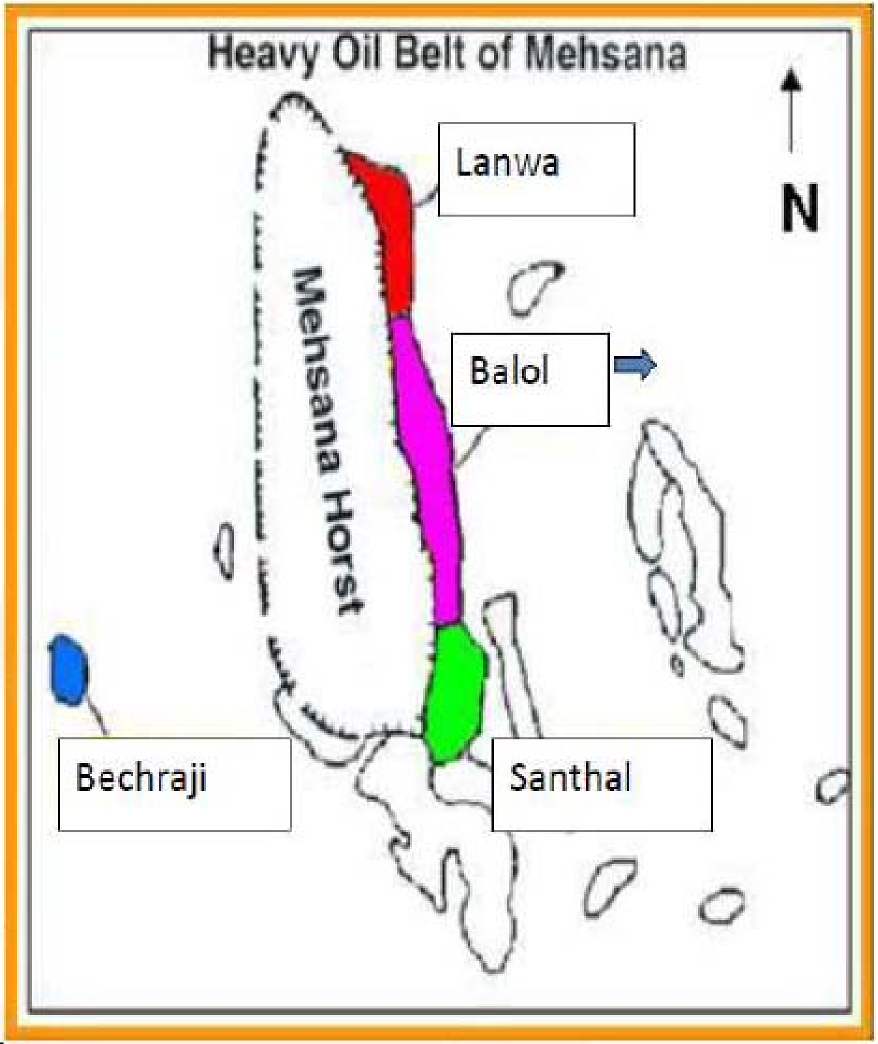
SPE Gulf Coast Permian Study
Group – May 2010

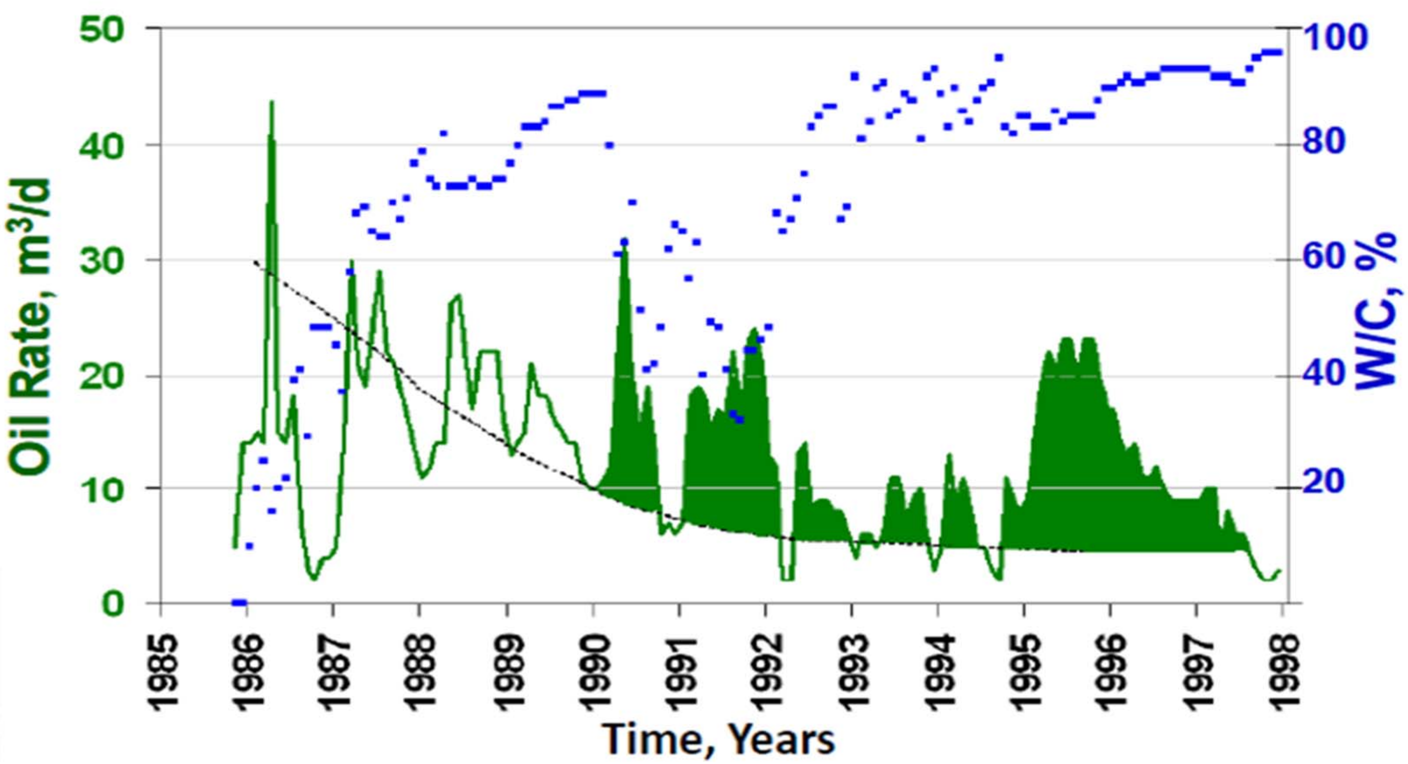
Pilot Testing Balol Field



Nelson & McNeil, "How to engineer an in – situ combustion pilot", Oil & Gas Journal, June 1961

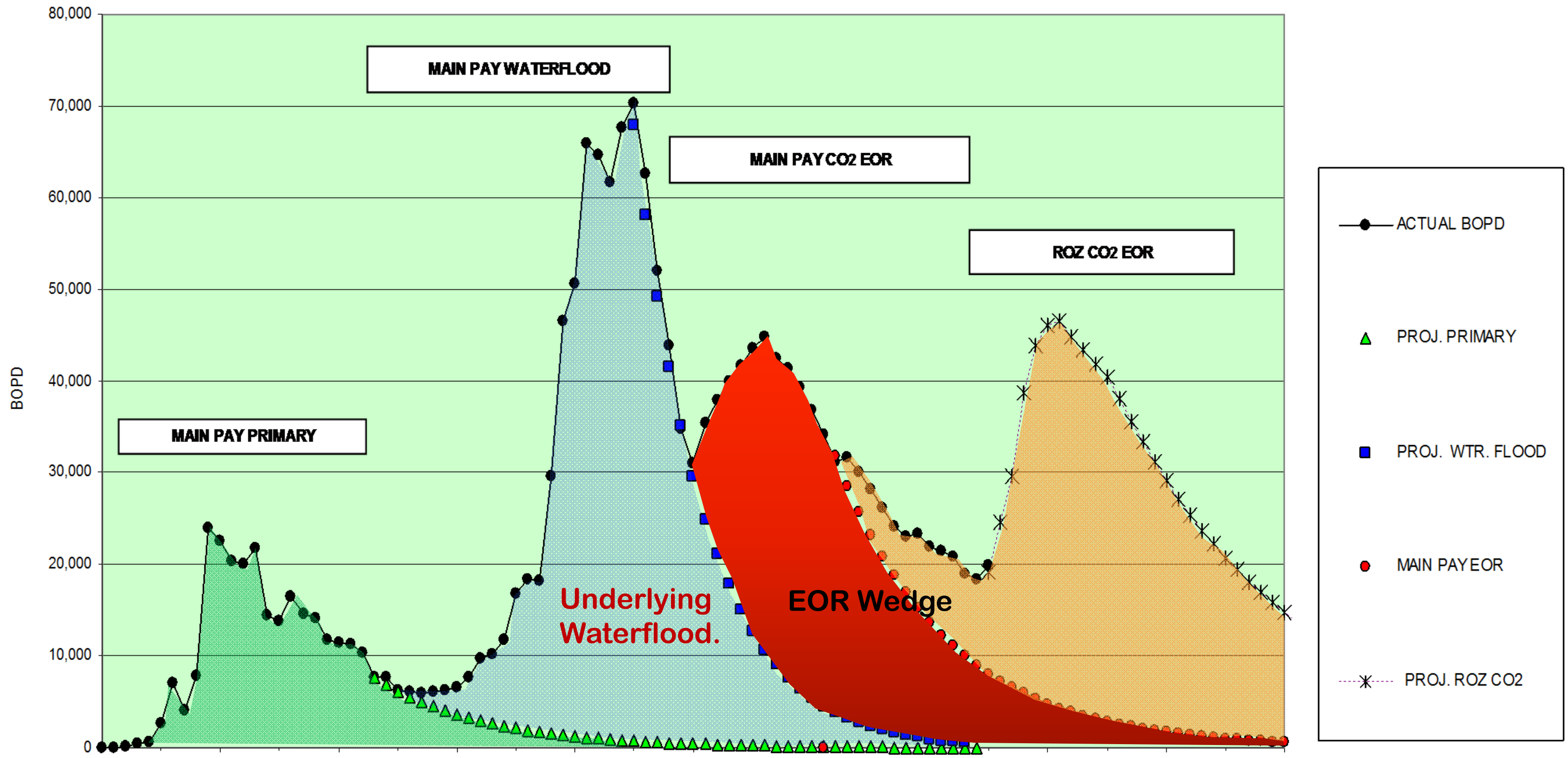
Pilot Favorable Response

Size : 5.5 Acres
Type : Inverted 5 spot, 1 Injector, 4 Producers,
1 Temperature Observation well



Nelson & McNeil, "How to engineer an in – situ combustion pilot", Oil & Gas Journal, June 1961

Production Baseline



Subtract baseline WF from total oil production to determine EOR wedge

Melzer CO2nsulting

Analogs

- Valid analogs are important to validate incremental recovery from EOR projects.
- Having a supporting analog is a critical element in each case for the application of an incremental recovery.
- Evaluators must have a clear understanding of the use and selection of a valid analog.

Analogs are also usually a common thread

to demonstrate incremental recovery !

What is an Analogous Reservoir ?

- **Analogous Reservoirs** have *similar* rock and fluid properties, reservoir conditions, (depth, temperature and pressure) and drive mechanism.
- Typically at a *more advance stage* development than the reservoir of interest.
- May provide concepts to *assist the interpretation* of more limited data and estimation of recovery.

Source: SPE/AAPG/WPC/SPEE PRMS Appendix A

Purpose of Analogies

- *Apply knowledge* gained from analogous and mature reservoirs or recovery processes to estimate the performance in the reservoir of interest.
- Analogies have proved to be important *early during the field life* where no definitive performance and/or geologic data is available.
- Also important when *new EOR techniques* are introduced to a field.
- Review of analog reservoir performance is useful in quality assurance of resource *assessments at all stages of development.*

SEC Additional Criteria about Analogs

- "When used to support reserves*, [the target reservoir and analog must have] the (i) same geological formation…, (ii) same environment of deposition, (iii) similar geological structure, and (iv) same drive mechanism."
- "Reservoir properties must, in the aggregate*, be no more favorable in the analog than in the reservoir of interest."

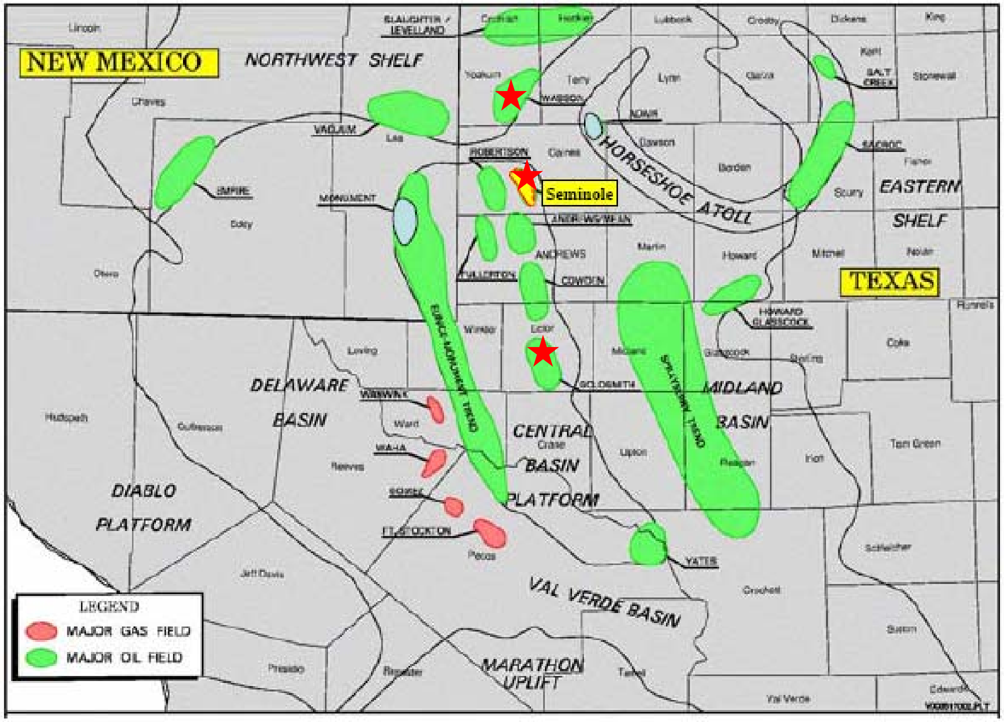
* emphasis added

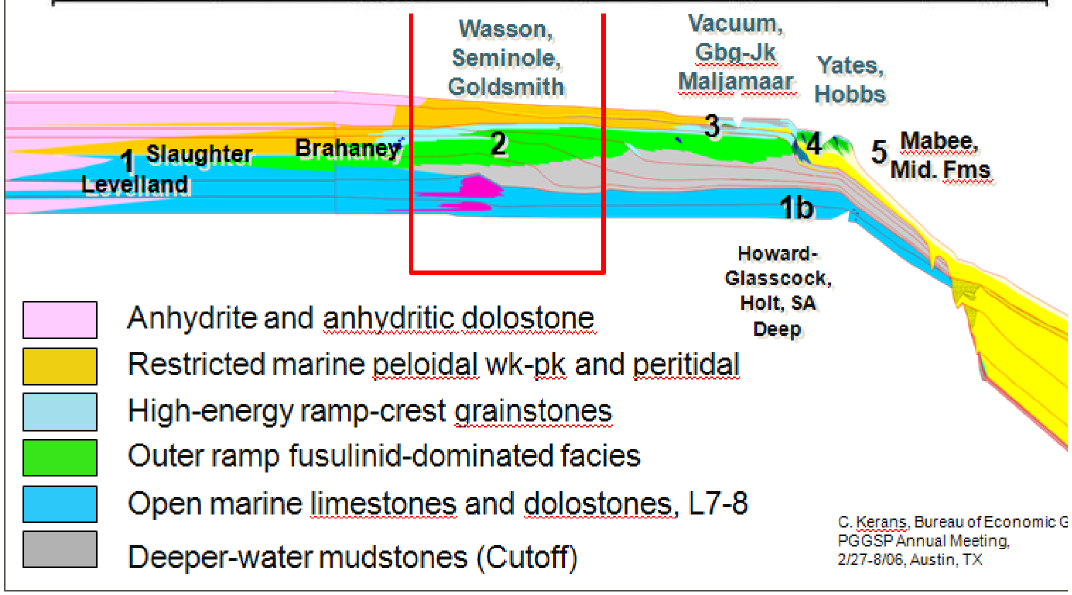
Establishing the Analogy

- Critical Parameters to review:

Geoscience	Engineering	Operational
Structural Configuration	Pressure and Temperature	Well Spacing
Lithology and Stratigraphy	Fluid Properties	Artificial Lift Methods
Principal Heterogeneities	Recovery Mechanism	Pattern Type and Spacing
Reservoir Continuity	Fluid Mobility	Injector to Producer Ratio
Average Net Thickness	Fluid Distribution	Annual Injection Volumes
Water Saturation	Reservoir Maturity	Fluid Handling Capacity
Permeability	Well Productivity	Stimulation Design
Porosity	EOR Specifications	Areal Proximity
Areal Proximity	Areal Proximity	

Analog Comparison





		Goldsmith	Seminole
Formation	(name)	San Andres	San Andres
Discovered	(year)	1935	1936
Avg IP	(bopd)	960	630
Unitized	(year)	1963	1969
Depth	(ft)	4200	5200
Pinit	(psi)	1712	2020
Temp	(F)	95	108
API	(gravity)	34	35
Rsi	(scf/bbl)	757	730
Rs	(scf/bbl)	590	580
Boi	(rb/stb)	1.36	
Bo	(rb/stb)	1.3	1.27
Swc	(%)	15-20	16
Sorw_MP	(%)	39%	38%
Sorw_ROZ	(%)	35%	35%
Porosity	(frac)	0.105	0.124
Net/Gross	(frac)	0.77	0.8
Net h	(ft)	195	329
Perm	(md)	8	11
MMP	(psi)	1150	1300
Bco2	(rb/mcf)	0.43	0.41
MAIN PAY			
Gross h_MP	(ft)	105	160
N/G_MP	(frac)	0.78	0.78
Net h_MP	(ft)	82	126
Porosity_MP	(frac)	0.110	0.12
Perm_MP	(md)	11	9
ROZ			
Gross h_ROZ	(ft)	150	245
N/G_ROZ	(frac)	0.76	0.8
Net h_ROZ	(ft)	113	203
Porosity_ROZ	(frac)	0.102	0.126
Perm_ROZ	(md)	6	12

* Similar depositional environments & deliverability (rb/ft)

What is Reliable Technology

- Reliable technology is a grouping of one or more technologies (including computational methods) that has been field tested and has been demonstrated to provide reasonably certain results with consistency and repeatability in the formation being evaluated or in an analogous formation."

Source: SEC 210.4-10(a)(25)

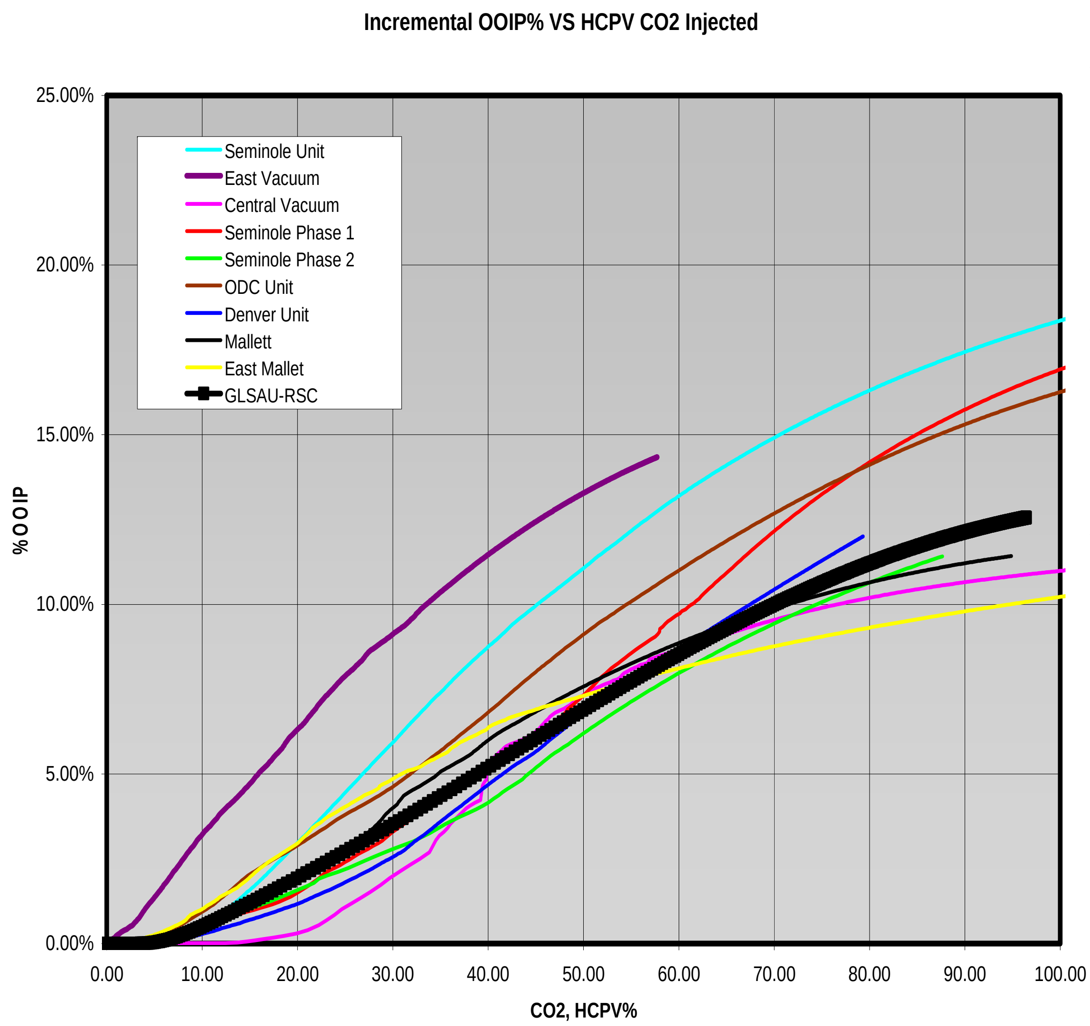
What is Reliable Technology

- The SEC rules do not specify the technologies (or set of technologies) that can be used to establish reasonable certainty for proved reserves.
- The evaluator has the responsibility of establishing and documenting the technology that provides reliable results.

Major Factors Affecting EOR Reserves

- Project Maturity: The project is too immature to have established a definitive trend for the current or planned development phase.
- No favorable response from the producing wells for a new waterflood or EOR project.
- Lack of an established production baseline.
- In these cases analogy is often the most appropriate method of analysis.

EOR Recovery Factor and Dimensionless Recovery Curves



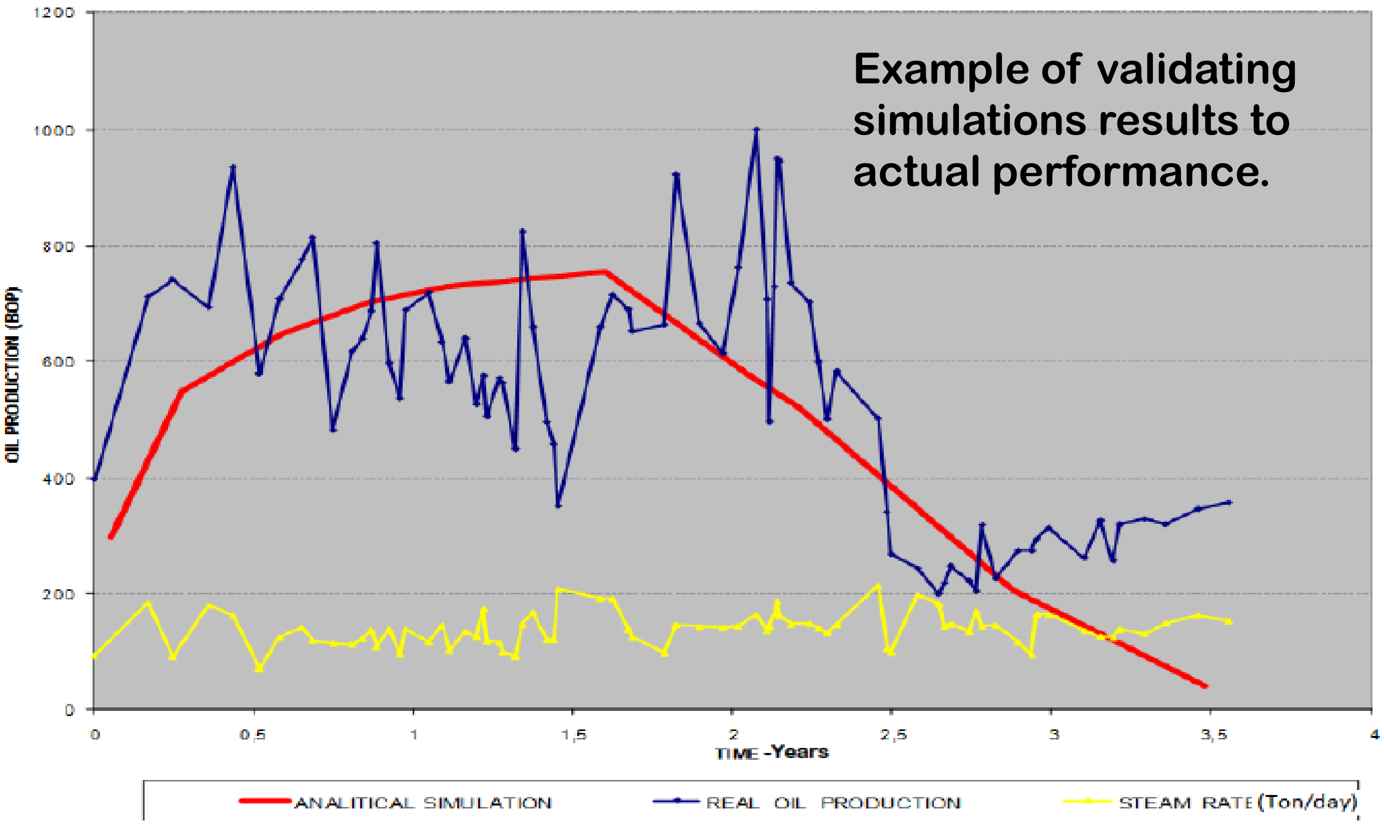
- Plot cumulative recovery vs. cumulative injection on HCPV basis.
- Then, scale to the reservoir of interest on HCPV basis.
- Premise: Patterns in reservoir with the same geology will perform similarly on a dimensionless basis.

Incorporating Simulation Results

- "If simulation results were to be used for reserves certification,…a strong critique of the model (and history match) would most likely be warranted" SPE 96410
- Models have to be history matched.
- If for proved reserves, history match must include EOR response from pilots or installed programs.
- If there is no EOR history, only probable and possible reserves can be included. Not Proved reserves.
- It is highly recommended that the recovery factor generated from simulation be compared to analogous fields.

Production History Match

- **Tia Juana Field, Venezuela**



Items that Limit or Prohibit Booking Proved Undeveloped EOR Reserves

- No Successful EOR pilot in the reservoir
- No Successful EOR analog reservoir
- Poor Knowledge of the reservoir
  - Sor
  - Major geologic features
  - Reservoir connectivity

US EOR Production

EOR	Type	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012
Thermal													
	Steam	444,137	454,009	415,801	419,349	439,010	417,675	365,717	340,253	286,668	275,192	273,698	300,762
	Cumbustion in situ	6,090	4,702	2,520	4,485	4,760	2,781	2,384	1,901	13,260	17,025	16,868	3,869
	Hot water	3,985	1,980	250	250	2,200	306	3,360	3,360	4,370	1,776	1,776	1,703
	Total thermal	**454,212**	**460,691**	**418,571**	**424,084**	**445,970**	**417,675**	**371,461**	**345,514**	**304,298**	**293,993**	**292,342**	**306,334**
Chemical													
	Micellar-polymer	617	254	64	0	0	0						
	Polymer	11,219	1,940	1,828	139	139	1,598						
	Caustic/alkaline												
	Surfactant	20					60	60	60				
	Total chemical	**11,856**	**2,194**	**1,892**	**139**	**139**	**1,658**	**60**	**60**	**0**	**0**	**0**	**0**
Gas													
	Hydrocarbon miscible/												
	immiscible	55,386	113,072	99,693	96,263	102,053	124,500	95,300	97,300	95,800	81,000	81,100	81,100
	CO2 miscible	95,591	144,973	161,486	170,715	179,024	189,493	187,410	205,775	235,344	240,313	248,699	308,564
	CO2 immiscible	95	95				66	66	102	2,698	9,350	11,450	43,657
	Nitrogen	22,260	22,580	23,050	28,017	28,117	14,700	14,700	14,700	14,700	19,700	9,000	8,000
	Flue gas (miscible and												
	immiscible)	17,300	11,000	-	-	-	-						
	Other		6,300	4,400	4,350	4,350	-						
	Total gas	**190,632**	**298,020**	**288,629**	**299,345**	**313,544**	**328,759**	**297,476**	**317,877**	**348,542**	**350,363**	**350,249**	**441,321**
Other													
	Carbonated waterflood												
	Microbial		2	2									
	Total other		2	2									
	Grand total	**656,700**	**760,907**	**709,094**	**723,568**	**759,653**	**748,092**	**668,997**	**663,451**	**652,840**	**644,356**	**642,591**	**747,655**

Table 1 US EOR Production

As published in Oil & Gas Journal, April 2, 2012

Active US EOR Projects

EOR	Type	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012
	Steam	137	119	109	105	92	86	55	46	40	43	45	48
	Cumbustion in situ	8	8	5	8	7	5	6	7	12	12	12	11
	Hot water	9	6	2	2	1	1	4	3	3	3	3	2
	Total thermal	**154**	**133**	**116**	**115**	**100**	**92**	**65**	**56**	**55**	**58**	**60**	**61**
Chemical													
	Micellar-polymer	5	3	2									
	Polymer	42	44	27	11	10	10	4	4	0	1	1	
	Caustic/alkaline	2	2	1	1	1							
	Surfactant	1									1	2	3
	Total chemical	**50**	**49**	**30**	**12**	**11**	**10**	**4**	**4**	**0**	**2**	**3**	**3**
Gas													
	Hydrocarbon miscible/ immiscible	23	25	15	14	11	6	7	8	13	13	12	13
	CO2 miscible	52	52	54	60	66	63	66	70	79	101	103	112
	CO2 immiscible	4	2	1	1		1	1	1	2	5	5	8
	Nitrogen	9	7	8	9	10	4	4	4	3	4	3	3
	Flue gas (miscible and immiscible)	3	2										
	Other		1	1									
	Total gas	**91**	**89**	**79**	**84**	**87**	**74**	**78**	**83**	**97**	**123**	**123**	**136**
Other													
	Microbial		2	1	1	1							
	Total other	0	2	1	1	1	0	0	0	0	0	0	0
	Grand total	**295**	**273**	**226**	**212**	**199**	**176**	**147**	**143**	**152**	**183**	**186**	**200**

Table 2 ACTIVE US EOR PROJECTS

As published in Oil & Gas Journal, April 2, 2012

Conclusions

- The determination of reasonable certainty should based on geological and engineering data.
- Having a successful pilot or a valid analogy are very important to justify proved reserves.
- Analogs should be chosen carefully.
- Document analog similarities and differences to assure compliance with the definitions.
- Keep reserve definitions in mind all the time while estimating reserves and their uncertainty.
- Simulation results can be used for proved reserves only if the model has been history matched with EOR response.

Recommendations

- Validation of assumptions are necessary.
- Where supporting data is scarce and validation difficult, a conservative approach must be used until this data is available.
- With validation, reserves should increase rather than decrease.
- The documentation must be kept for audit purposes.

Thank You!

QUESTIONS?