



# *North American CO<sub>2</sub> Status*

*Enhanced Oil Recovery Institute's  
3<sup>rd</sup> Annual CO<sub>2</sub> Conference  
Casper, Wy*

*Tom Doll, State Oil & Gas Supervisor  
Wyoming Oil and Gas Conservation Commission*

*Tracy Evans,  
Denbury Resources*

*L. Stephen Melzer,  
Melzer Consulting*

*June 2009*

# For Their Assistance, We Also Wish to Thank:

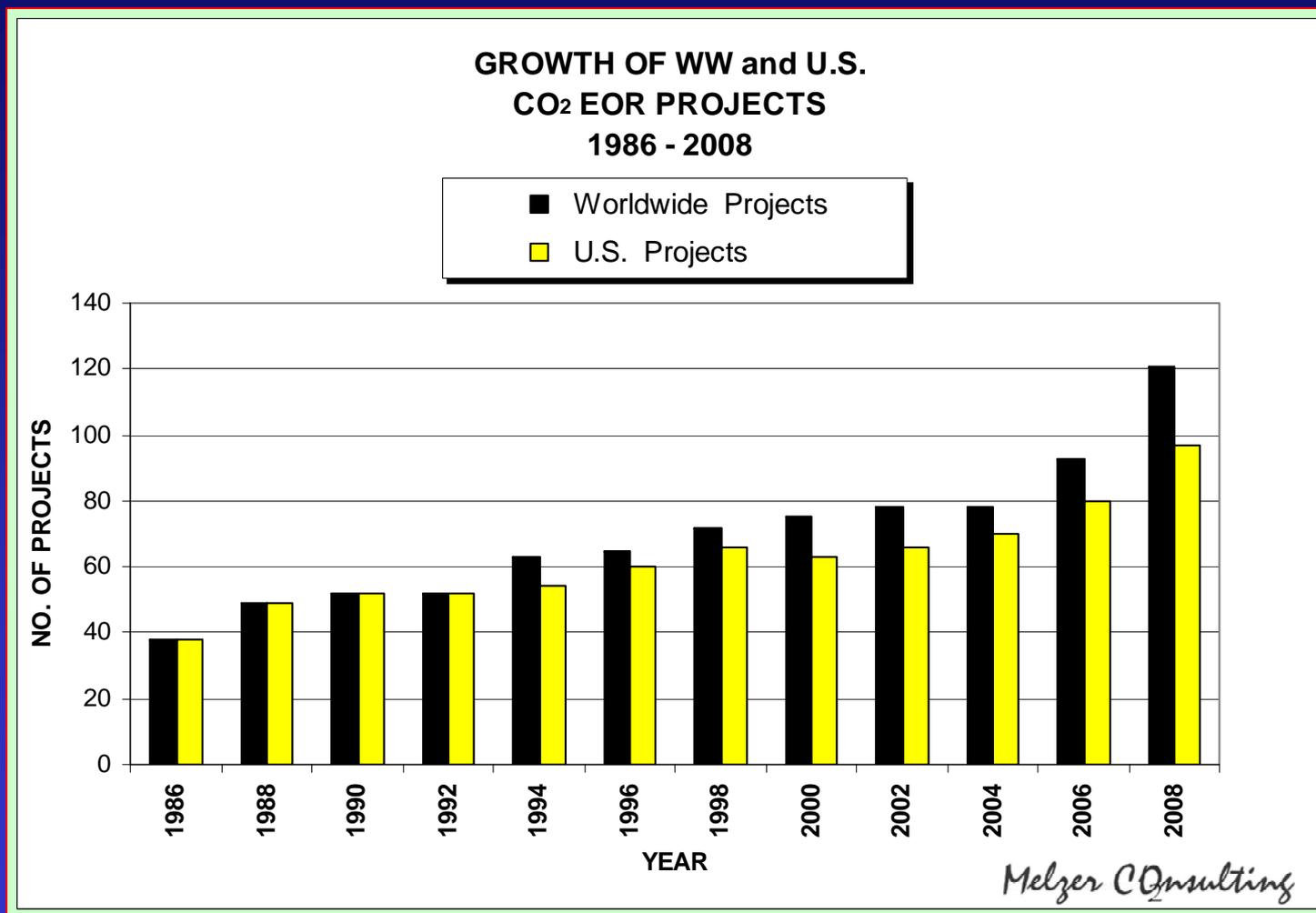
- Lon Whitman, EORI
- Bryan Hargrove, Trinity CO<sub>2</sub>
- Stefan Bachu, Alberta Research Council

# ***North American CO<sub>2</sub> Status***

## OUTLINE OF TALK

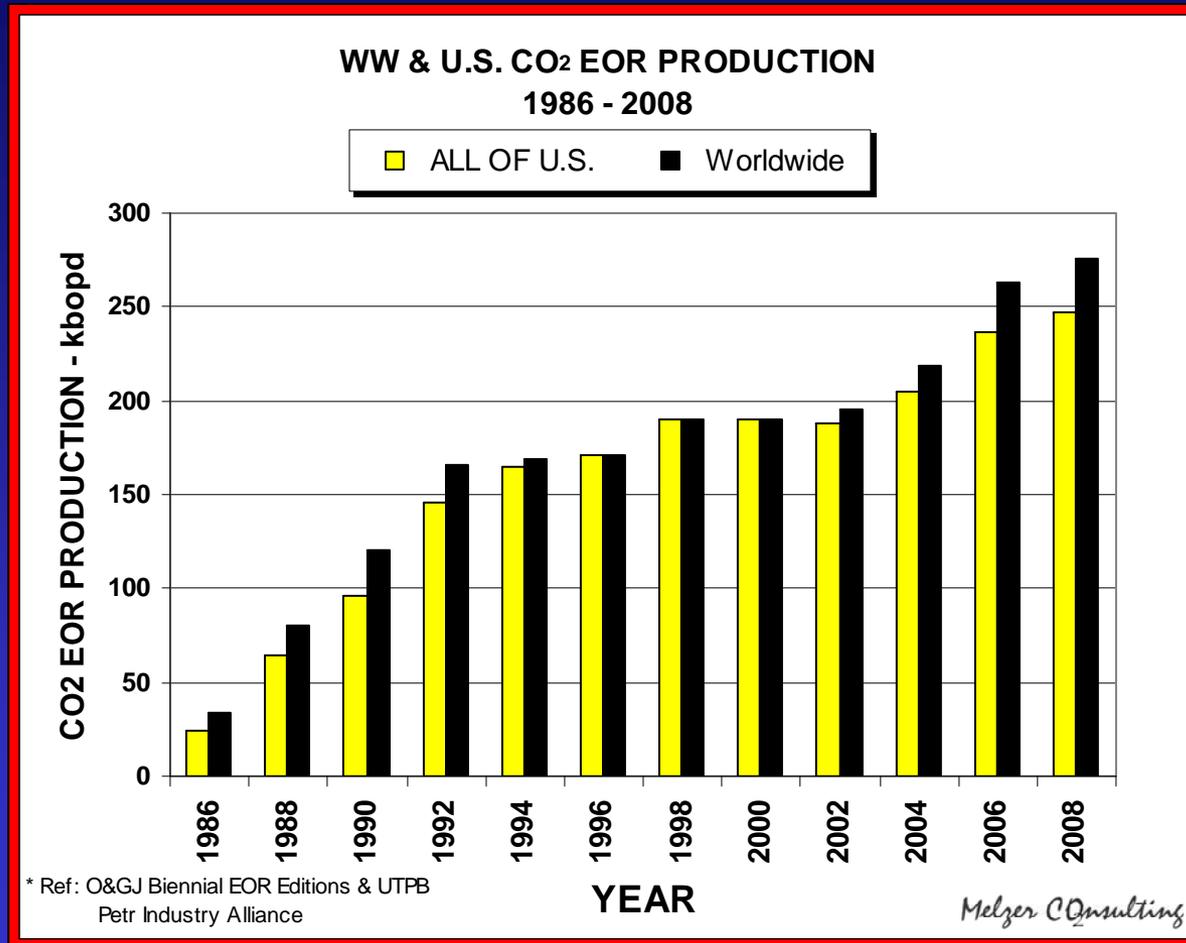
- CO<sub>2</sub> EOR Over The Past 2 Decades
- An Update On CO<sub>2</sub> Supply
- Areas Of Growth
- A Lead-in to the Rapidly Advancing Policy World

# Worldwide and U.S. CO<sub>2</sub> EOR Projects\*



\* Includes CO<sub>2</sub> only Miscible Floods (Source: OGJ 4/21/08 & APTA CO<sub>2</sub> School (Jan & Aug '08))

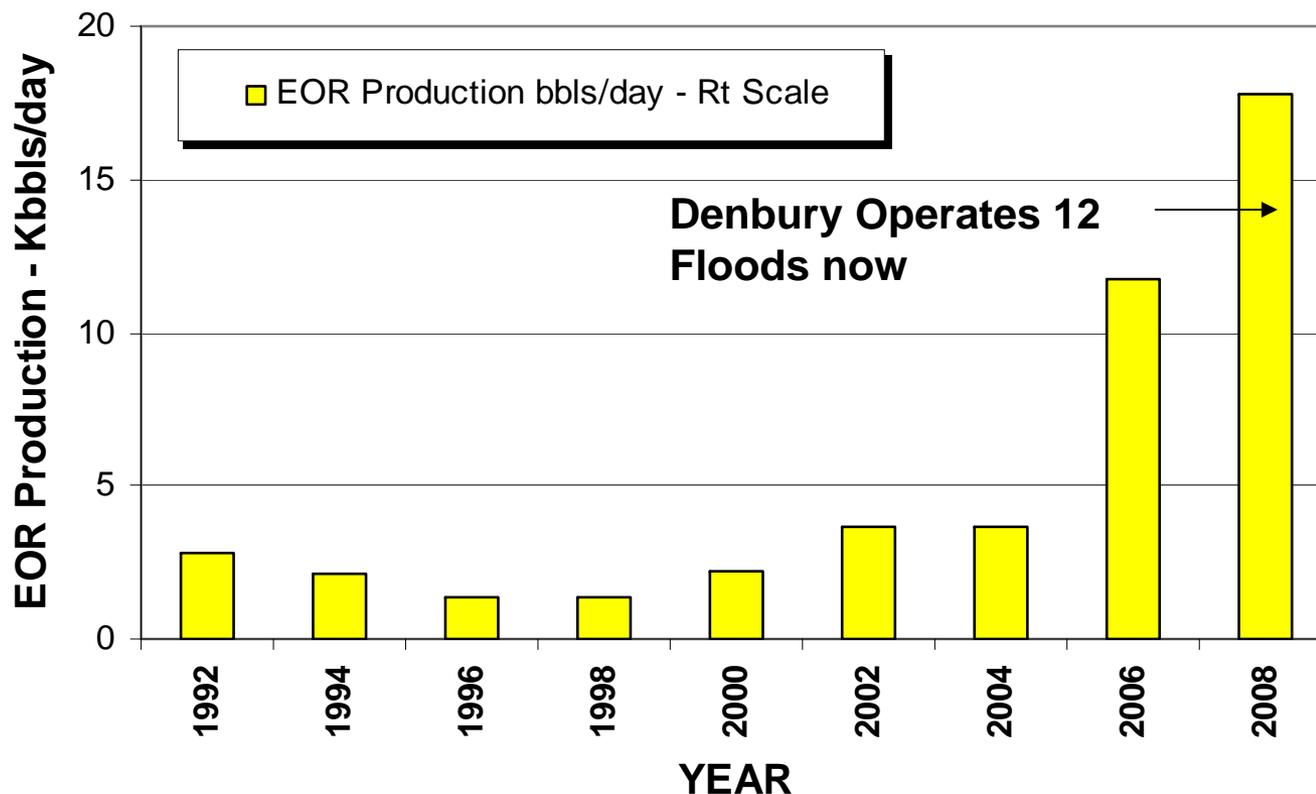
# Worldwide and United States CO<sub>2</sub> EOR Production\*



\* Includes CO<sub>2</sub> Miscible & Immiscible Floods (Source: OGJ 4/21/08 & APTA CO<sub>2</sub> School (Jan & Aug '08))

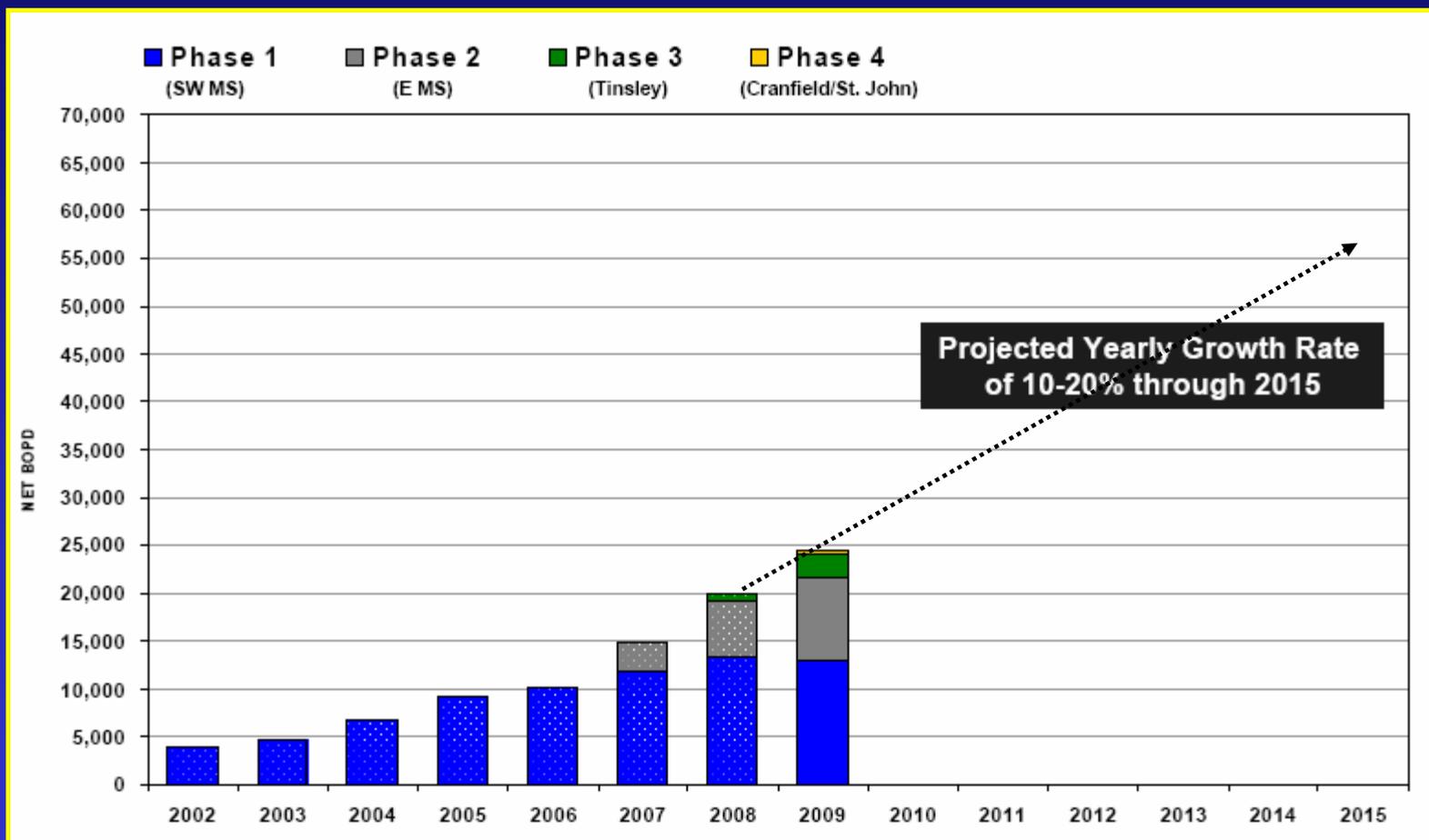
# New Developments in the Gulf Coast

## RECENT GROWTH OF MISSISSIPPI CO<sub>2</sub> PROJECTS & PRODUCTION 1992 - 2008

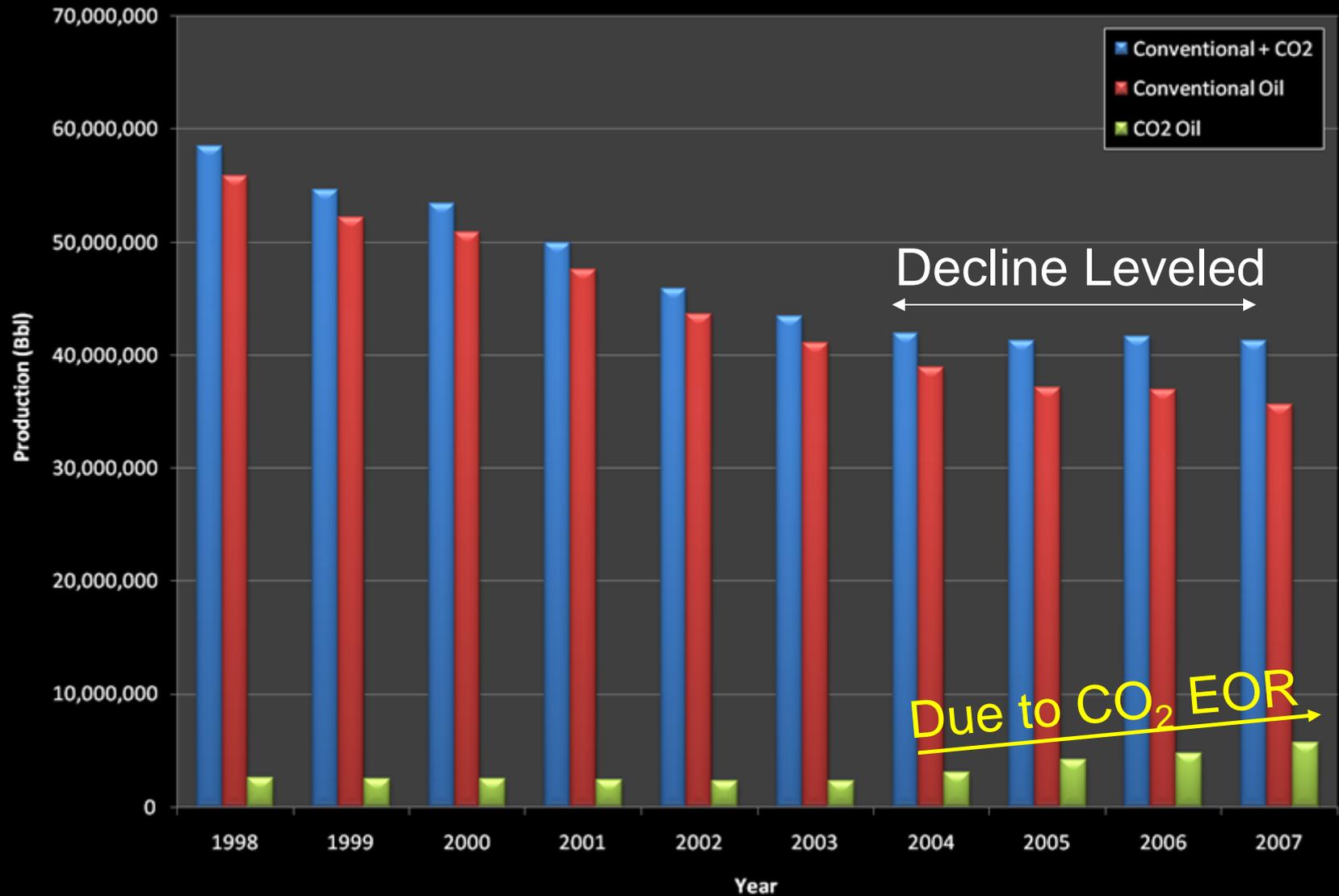


\* Source: OGJ 4/21/08 & APTA CO<sub>2</sub> School (Jan & Aug '08)

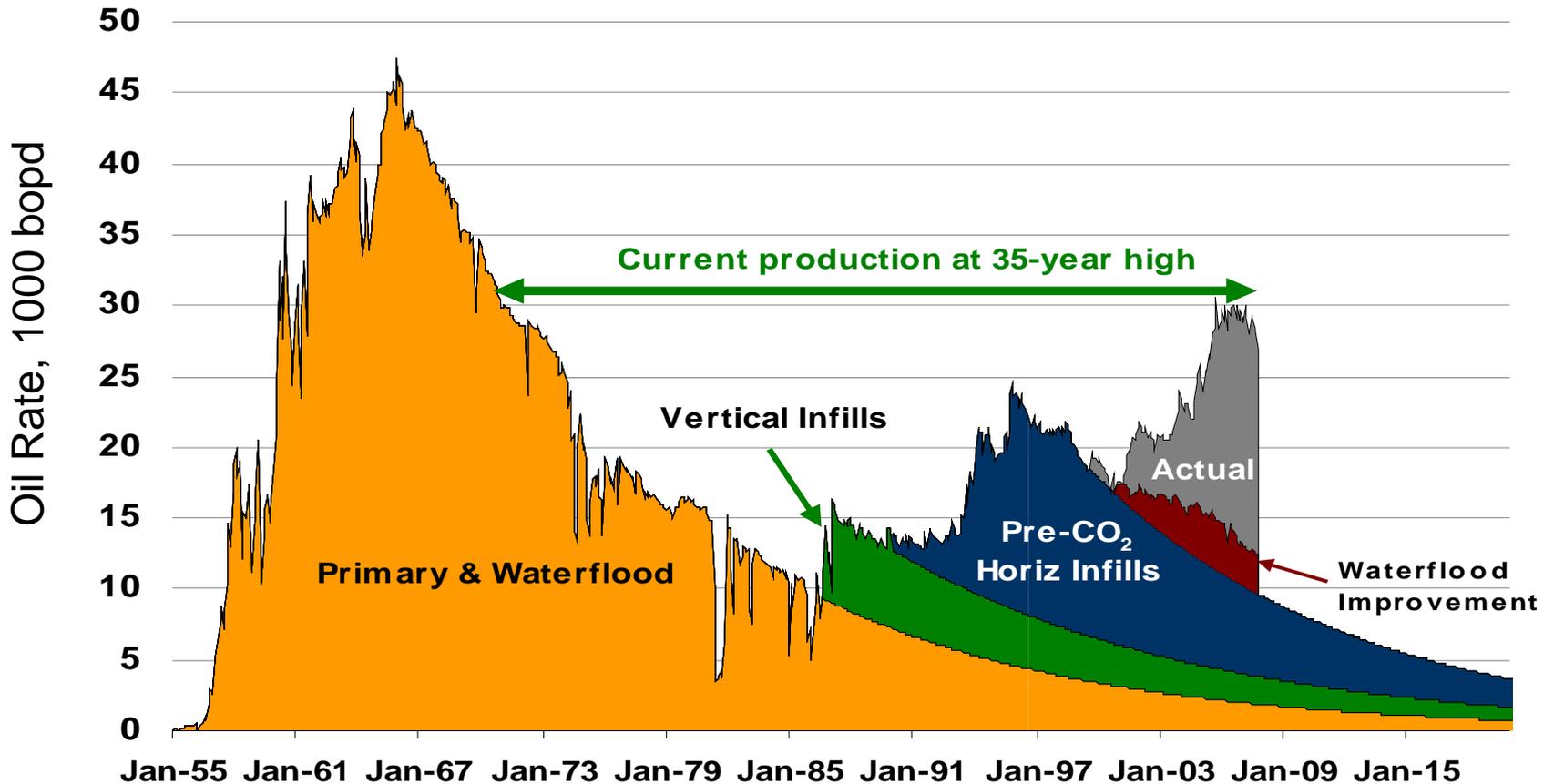
# Gulf Coast (MS) CO<sub>2</sub> EOR Production



# Wyoming Crude Oil Production 1998 - 2007

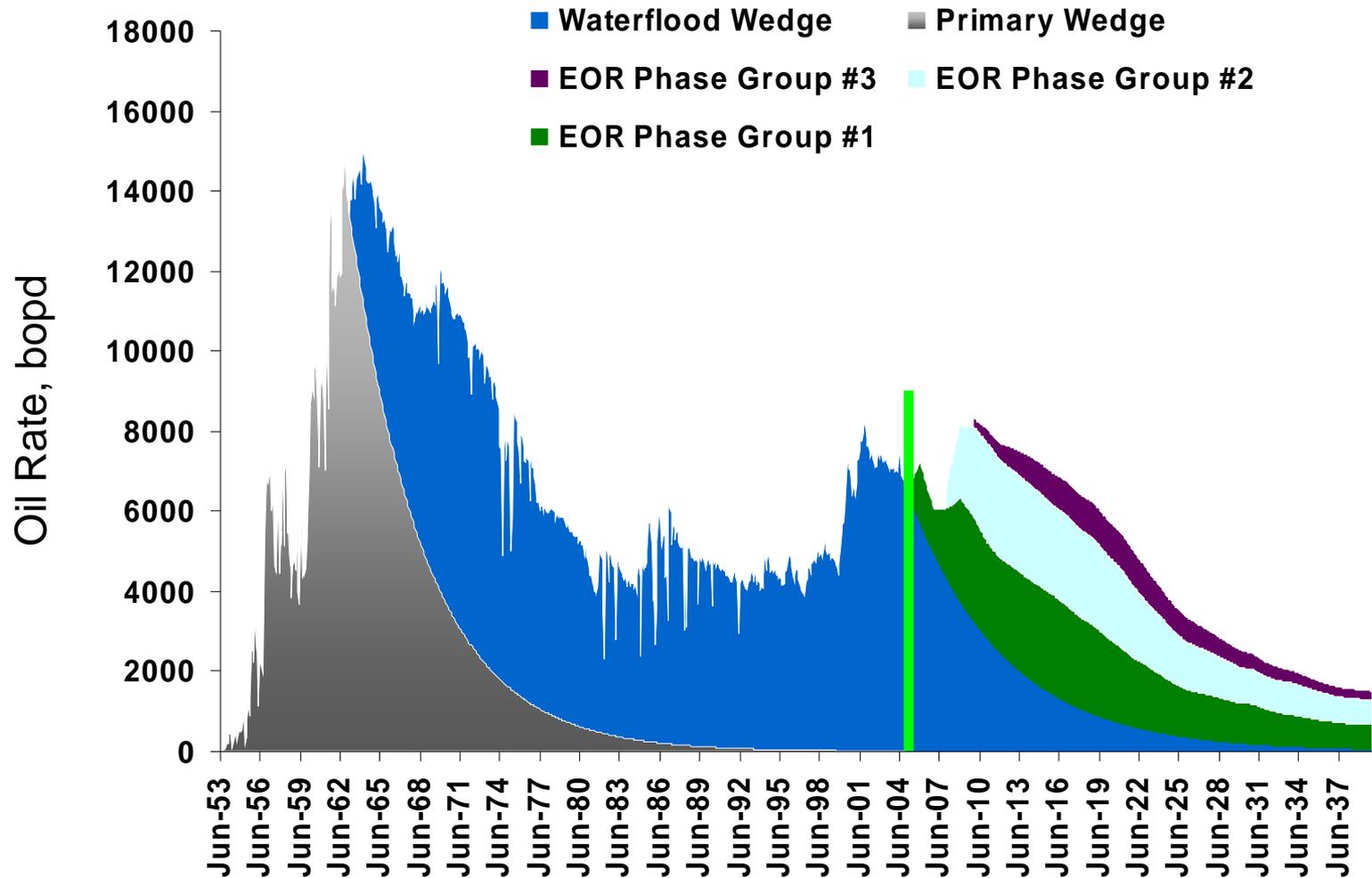


# Production History at EnCana's Weyburn Unit Saskatchewan, Canada



Source: Bachu, 2008 CO<sub>2</sub> Conference and EnCana Corporation

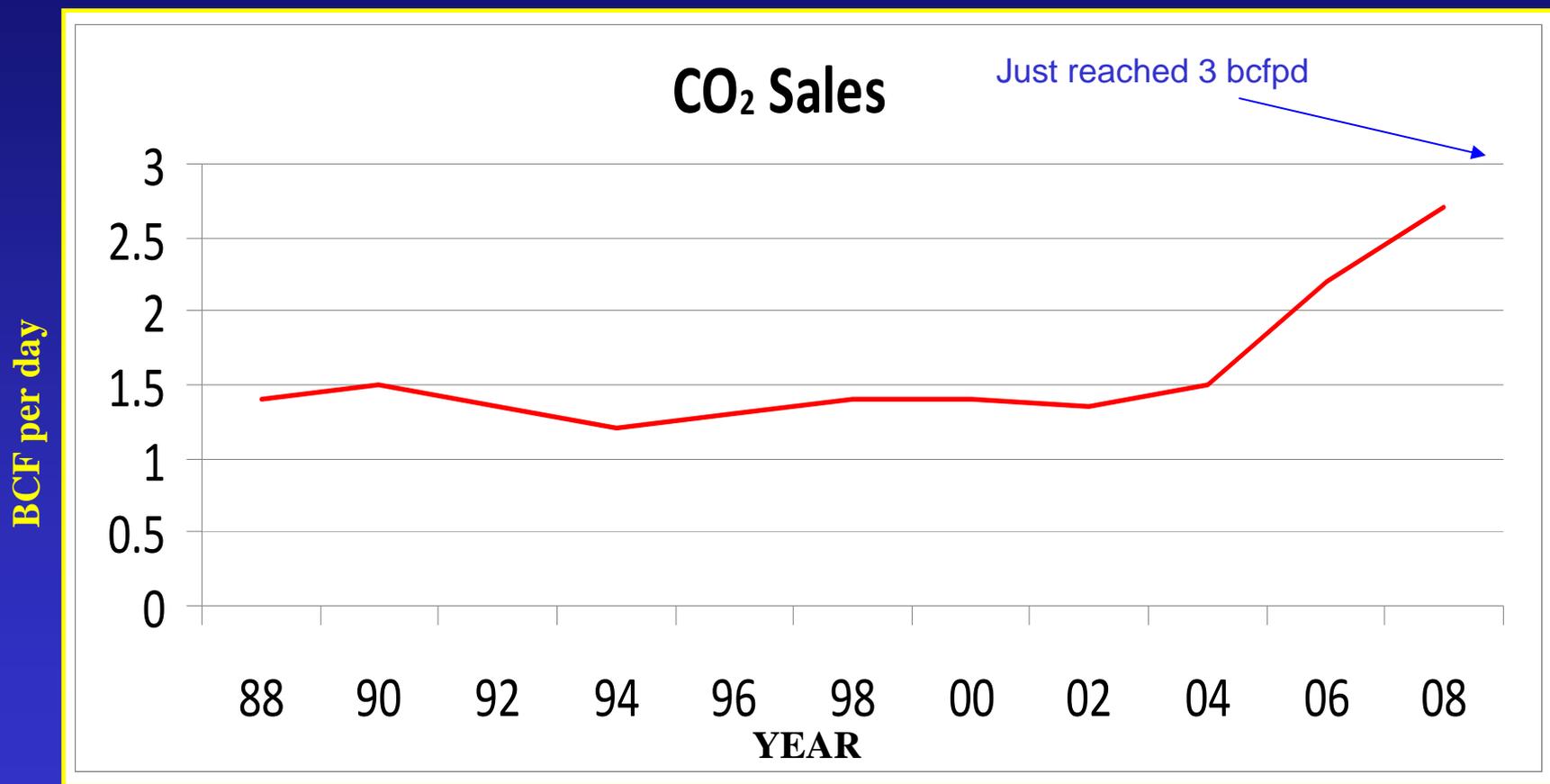
# Production History & Forecasts at Apache Canada's Midale Unit



Source: Bachu, 2008 CO<sub>2</sub> Conference and Apache Canada

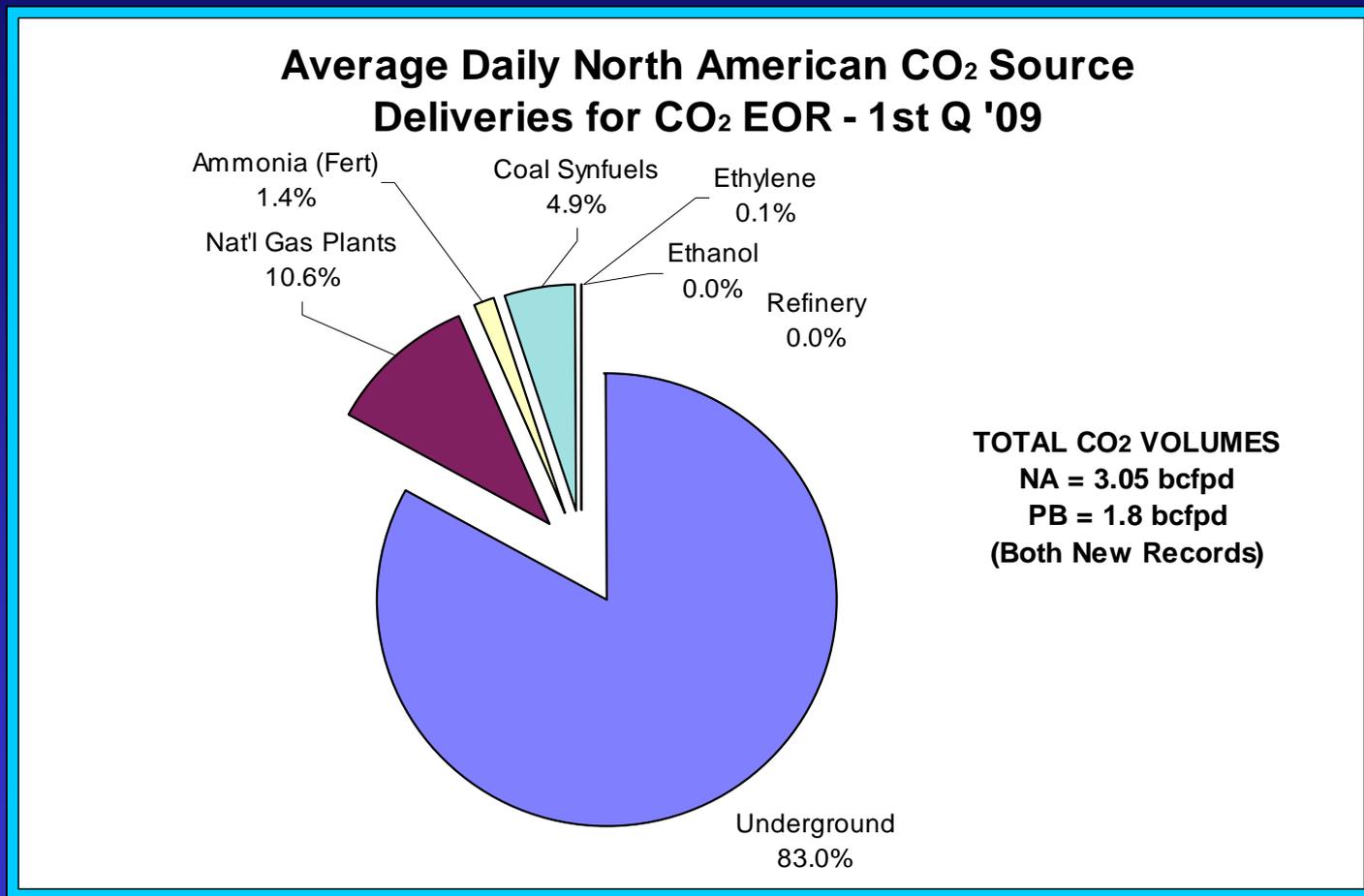
# STATUS OF THE SUPPLY OF CO<sub>2</sub>

# U.S. CO<sub>2</sub> SALES FOR EOR



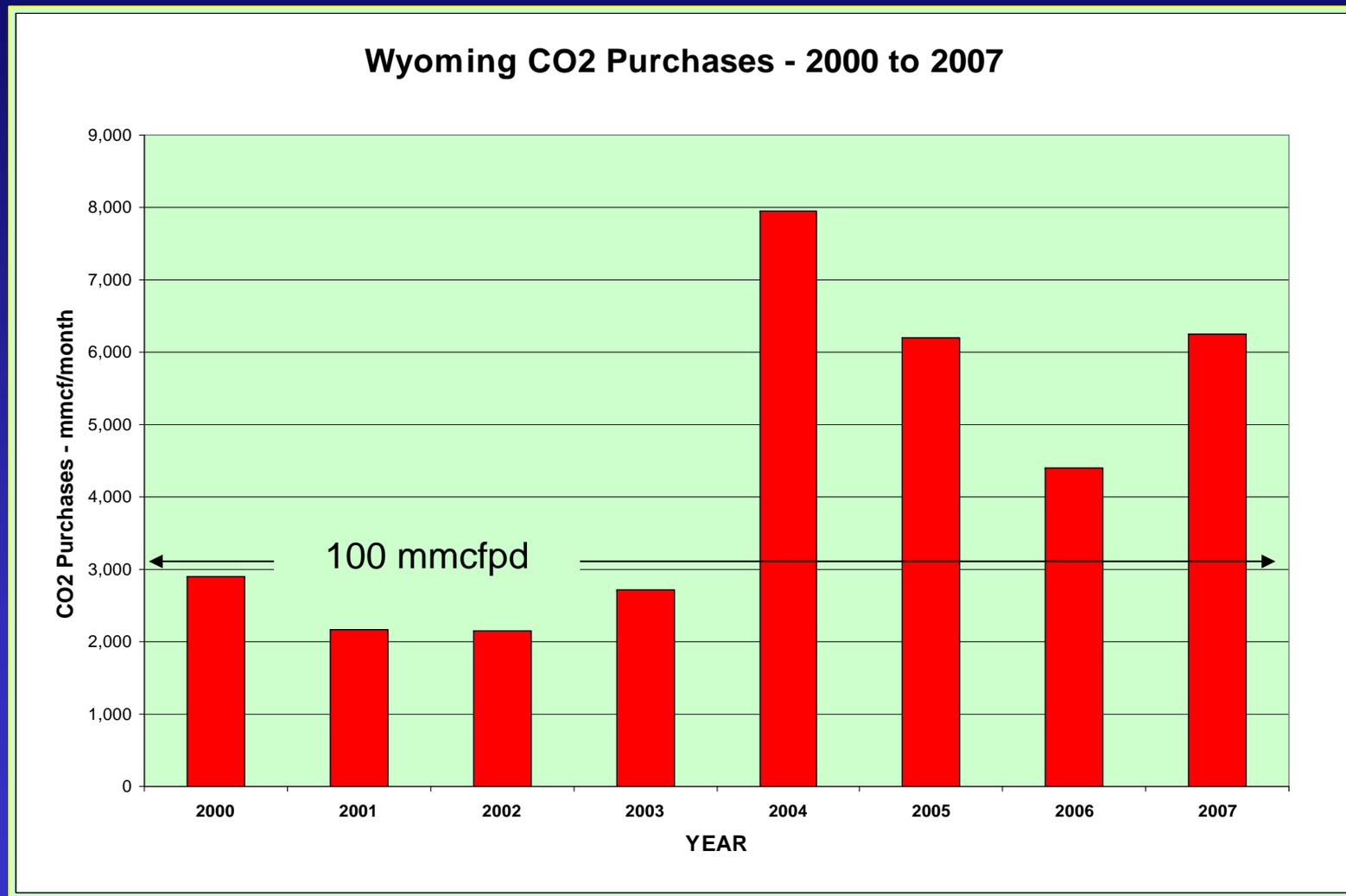
\* Source: 2008, Hargrove, Melzer and Whitman, CO<sub>2</sub> Flooding Conference (Dec '08)

# NORTH AMERICAN CO<sub>2</sub> SOURCE DELIVERIES FOR ENHANCED OIL RECOVERY (1<sup>st</sup> Q '09)

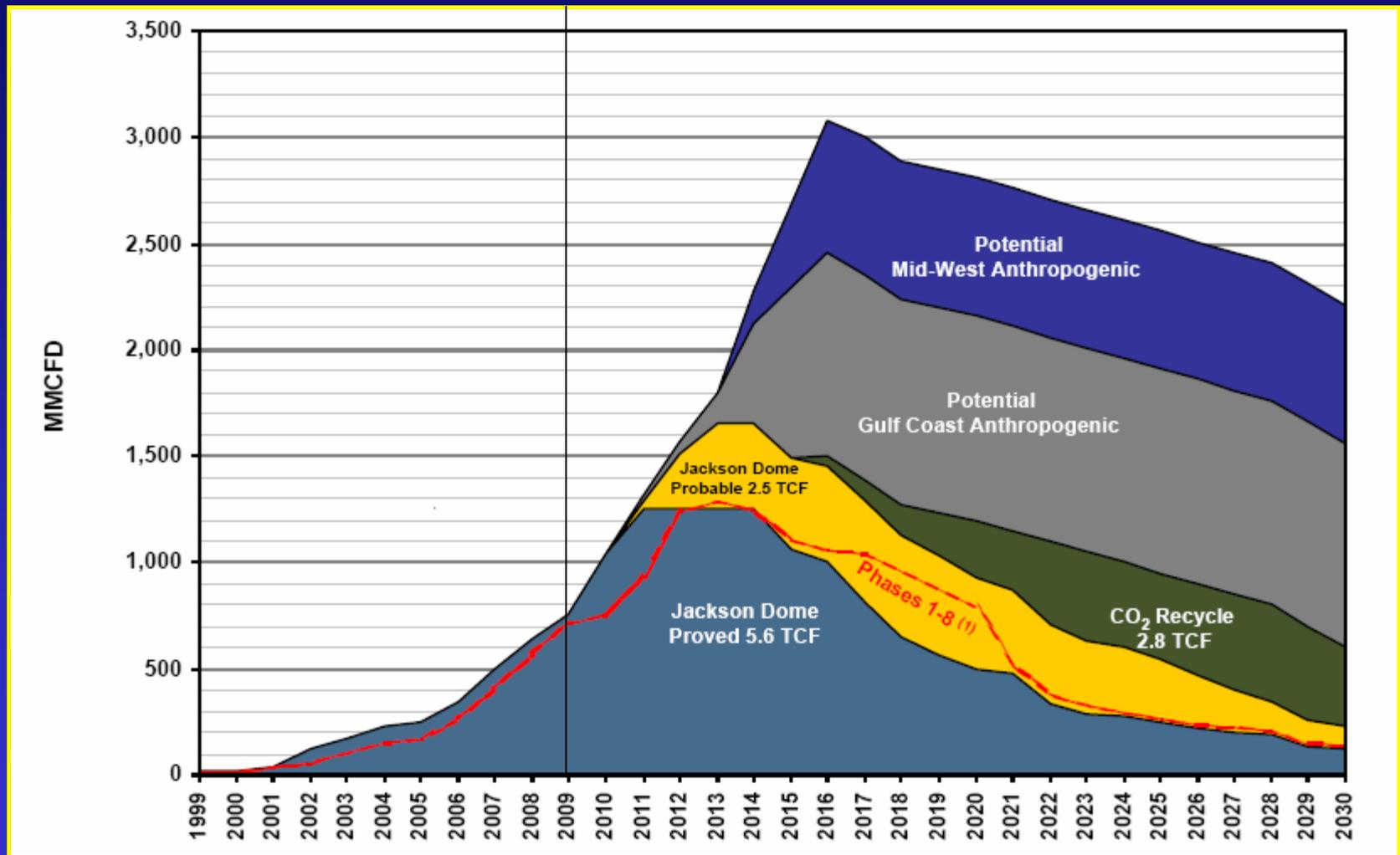


\* Source: APTA CO<sub>2</sub> School (Jan '09) and Melzer Consulting

# Wyoming CO<sub>2</sub> Supply



# Gulf Coast CO<sub>2</sub> Supply



Ref: Denbury Resources, Inc. June 2009 Corporate Presentation

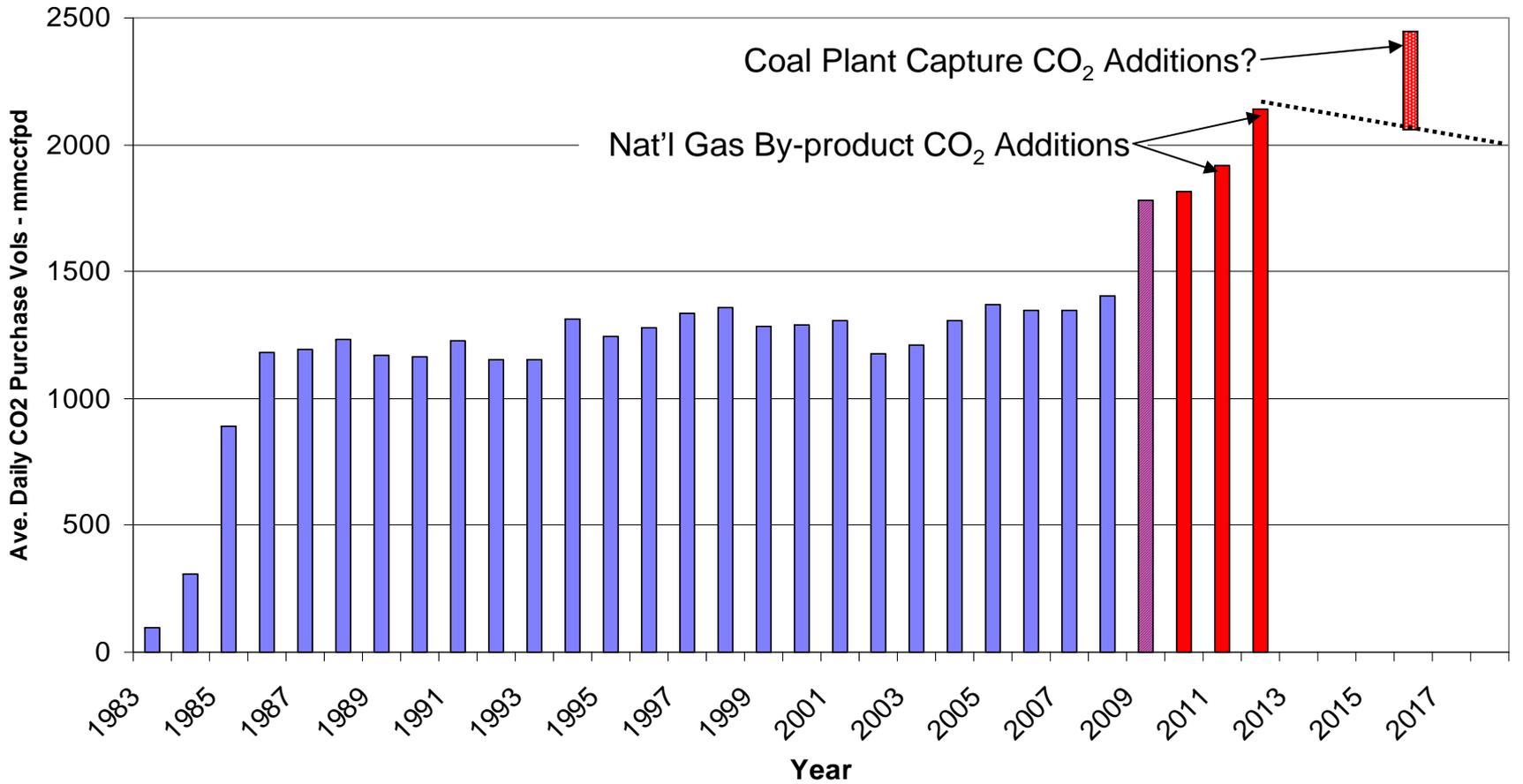
[www.denburyresources.com](http://www.denburyresources.com)

# Permian Basin CO<sub>2</sub> Supply Suppliers At Maximum Capacity

- McElmo Dome/Doe Canyon Source Fields Limited by Cortez Line Capacity (but a recent upgrade incremented throughput by 200 mmcfpd) **1.1-1.3 bcfpd**  
*REACHED 1.3 BCFPD IN JAN & FEB)*
  - Sheep Mountain on Decline (~2-4 years life left?) **40 mmcfpd**
  - Bravo Work Underway but Expansions are Challenging **250 mmcfpd**
  - West Bravo Now On-line **110 mmcfpd**
  - South Permian by-product CO<sub>2</sub> is Currently Compression Limited\* **80 mmcfpd**
- \* But about to change **1.6-1.8 bcfpd**

# Permian Basin CO<sub>2</sub> Supply

## Average Daily CO<sub>2</sub> Purchases w/ Projections- Permian Basin



# Proposed CO<sub>2</sub> Backbone Pipelines in Alberta

## ICON Project Proponents:

- Suncor, Husky, Nexen, Shell and Air Products
- CNRL, ConocoPhillips, Syncrude, Imperial Oil, Transalta, Sherritt and Agrium

Currently in negotiations with the federal and Alberta governments

Note: Weyburn pipeline: 328 km (204 mi), capacity of 5 Mt/yr

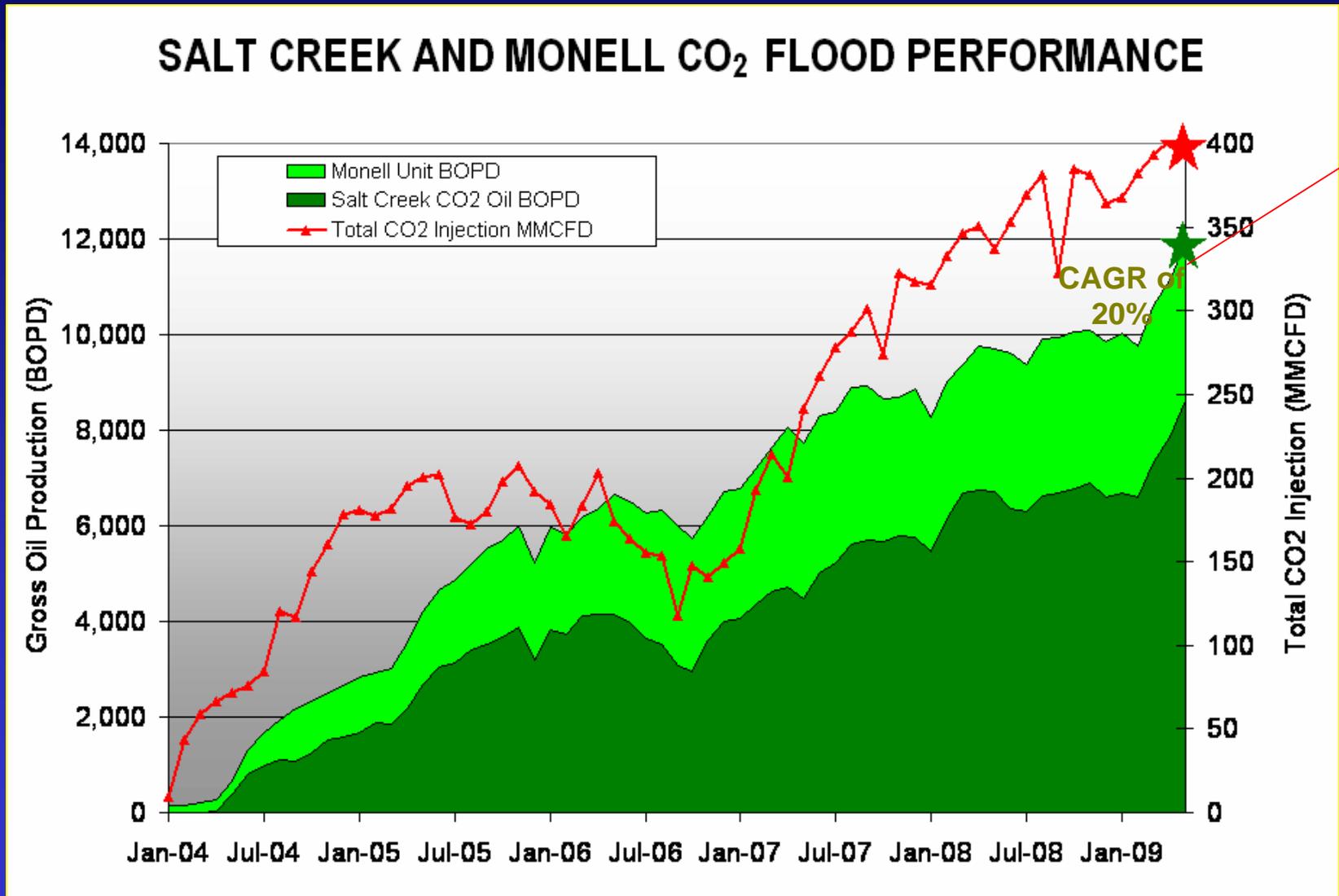
Source: Bachu, 2008 CO<sub>2</sub> Conference



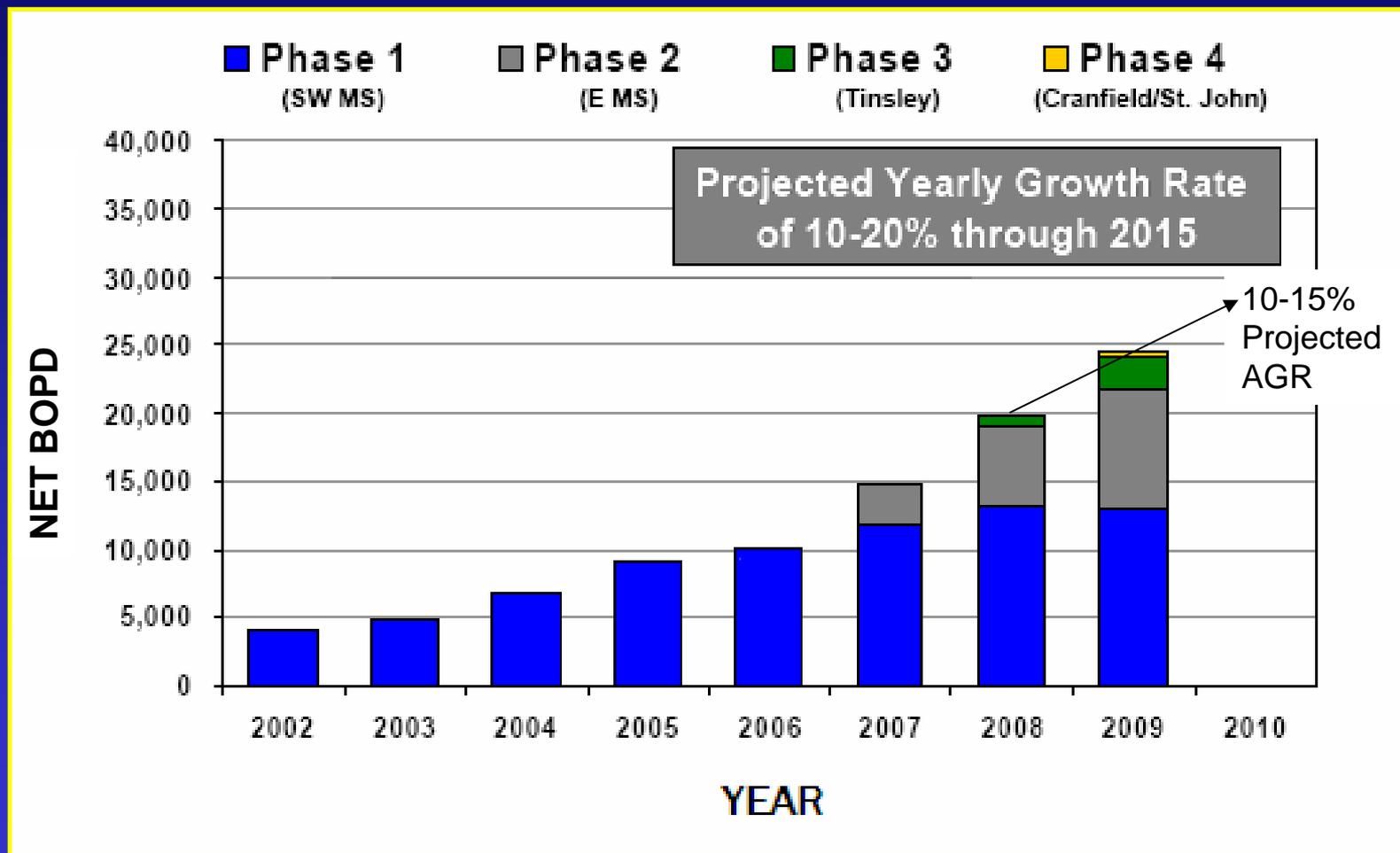
**But What About EOR Growth Potential?  
...and then, Where Would the CO<sub>2</sub> Come From?**

# SALT CREEK AND MONELL FLOOD PERFORMANCE

## 12,000 BOPD (@ 40% Development)



# Gulf Coast CO<sub>2</sub> EOR Growth Record\*



Ref: Denbury Resources, Inc. June 2009 Corporate Presentation

[www.denburyresources.com](http://www.denburyresources.com)

# U.S. Growth Potential

# So How Much U.S. CO<sub>2</sub> EOR Potential is Out There?

**Table 4: Technically Recoverable Resources from Applying State-of-the-Art CO<sub>2</sub> EOR Technology \***

*Data Base and National Totals*

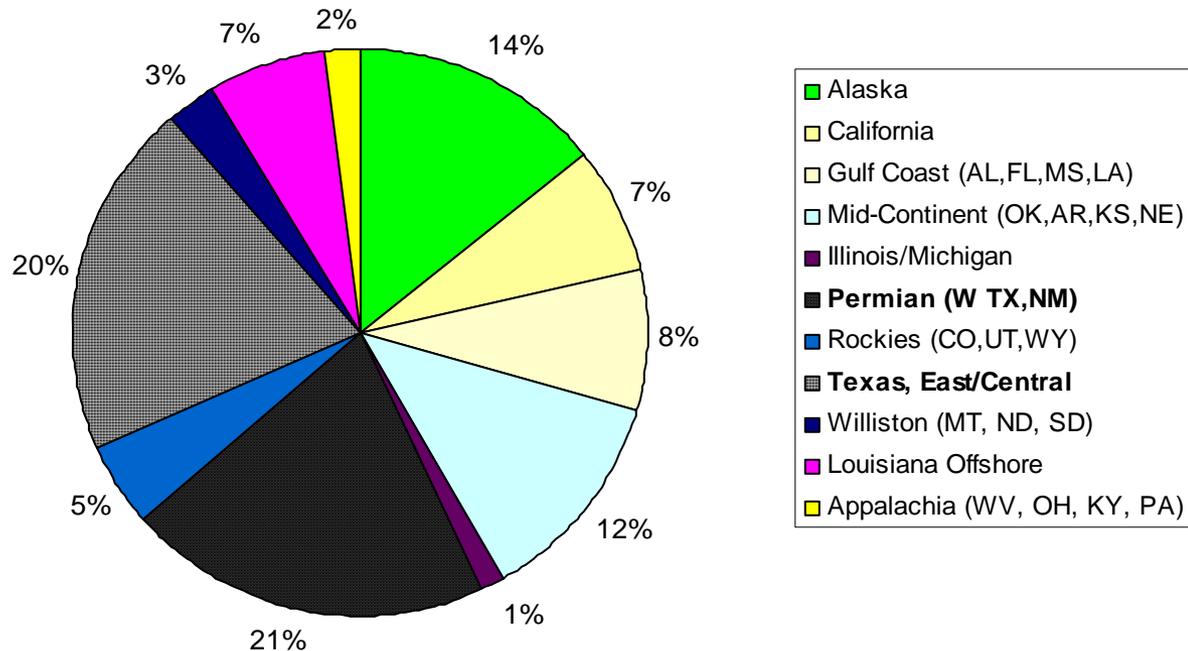
Basin/Area	DATA BASE			NATIONAL	
	OOIP (B Bbls)	OOIP Favorable for CO <sub>2</sub> -EOR (B Bbls)	Technically Recoverable (B Bbls)	OOIP (B Bbls)	Technically Recoverable (B Bbls)
1 Alaska	65.4	64.5	12.0	67.3	12.4
2 California	75.2	31.6	5.7	83.3	6.3
3 Gulf Coast (AL,FL,MS,LA)	26.4	20.2	4.2	44.4	7.0
4 Mid-Continent (OK,AR,KS,NE)	53.1	28	6.4	89.6	10.7
5 Illinois/Michigan	12.0	4.6	0.8	17.8	1.2
6 Permian (W TX,NM)	72.4	63.1	13.5	95.4	17.8
7 Rockies (CO,UT,WY)	23.7	18	2.9	33.6	4.2
8 Texas, East/Central	67.4	52.4	10.9	109	17.6
9 Williston (MT, ND, SD)	9.4	7.2	1.8	13.2	2.5
10 Louisiana Offshore	22.2	22.1	4.6	28.1	5.8
11 Appalachia (WV, OH, KY, PA)	10.6	7.4	1.2	14.0	1.6
<b>Total</b>	<b>437.8</b>	<b>319.1</b>	<b>64.0</b>	<b>595.7</b>	<b>87.1</b>

\* "Storing CO<sub>2</sub> with Enhanced Oil Recovery," DOE/NETL-402/1312/02-07-08 dtd Feb 7, 2008, Advanced Resources International

# Regional CO<sub>2</sub> EOR Growth Potential

**Distribution of Technically Recoverable CO<sub>2</sub> Reserves\***  
in billions of barrels

Total Recoverable: 87.1 billion bbls



\* "Storing CO<sub>2</sub> with Enhanced Oil Recovery," DOE/NETL-402/1312/02-07-08 dtd Feb 7, 2008, Advanced Resources International

# WHAT ARE THE LIMITING FACTORS FOR FURTHER GROWTH OF CO<sub>2</sub> EOR?

- LACK OF AFFORDABLE CO<sub>2</sub>
- LOCAL AVAILABILITY / TRANSPORTATION NETWORKS
- CONVERGENCE OF CARBON CAPTURE AND STORAGE GOALS WITH CO<sub>2</sub> EOR
- NEXT GENERATION TECHNOLOGIES

# One Large Next Generation Technology is Already Here !

*(if Time Permits)*



## Seminole Sentinel

12 Pages, 1 Insert Sunday, May 20, 2007

Volume 98, Number 064

# Hess to Expand

## CORP. ANNOUNCES \$300 MILLION PROJECT PLANS

By Dustin Wright Special Managing Editor

The Hess Corp.'s green and yellow ~~expansion~~ have been a long time staple of Seminole and Gaines County.

They can be seen spread throughout the county's landscape and in various locations within the Seminole city limits.

And to assure that the oil industry in Gaines County remains strong, Seminole's largest employer will begin work ~~in~~ July on the first stage of a project that is ~~planned~~ to extend the recovery of long-life oil reserves of the famed Seminole Sea Ancho Unit (SSAU) for another 20-plus years.

~~The~~ ~~expansion~~ ~~planned~~ ~~by~~ ~~Hess~~ ~~Corp.~~ ~~Seminole~~ ~~office~~ ~~Monday~~, the ~~company~~, along with major partners British Petroleum (BP), Exxon Mobil, Occidental Petroleum (OXY), Marathon, Chevron and ~~Conoco~~ ~~Phillips~~, have agreed to an approximate \$300 million investment to expand production in the Residual

Oil Zone (ROZ).

"We have operated a pilot program on this production since 1994 and a second program since 2004, and they have proved to be successful, so the partners have agreed to move ahead with a larger scale development in this zone," said Patrick O'Connell, Director of Production Operations for Hess. Floyd Peterson, Manager of Production Operations for Hess Corp.



According to Peterson, the ROZ lies directly underneath the ~~SSAU~~ ~~unit~~ ~~and~~ ~~contains~~ ~~about~~ ~~one~~ ~~billion~~ ~~barrels~~ ~~of~~ ~~unconventional~~ ~~oil~~ ~~that~~ ~~can~~ ~~be~~ ~~recovered~~ ~~with~~ ~~carbon~~ ~~dioxide~~ ~~injection~~.

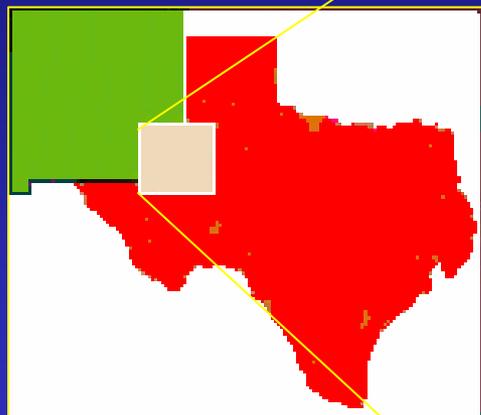
The first stage of the development will include the deepening of 47 ~~existing~~ ~~production~~ ~~wells~~.

~~in~~ ~~the~~ ~~ROZ~~, ~~and~~ ~~the~~ ~~conversion~~ ~~of~~ ~~29~~ ~~existing~~ ~~production~~ ~~wells~~ ~~that~~ ~~can~~ ~~be~~ ~~converted~~ ~~from~~ ~~production~~ ~~of~~ ~~oil~~ ~~to~~ ~~carbon~~ ~~dioxide~~ ~~injection~~ ~~for~~ ~~the~~ ~~future~~ ~~production~~ ~~in~~ ~~the~~ ~~ROZ~~.

In addition to the field ~~development~~, the capacity of ~~the~~ ~~SSAU~~ ~~unit~~ ~~will~~ ~~be~~ ~~increased~~ ~~to~~ ~~1.5~~ ~~million~~ ~~barrels~~ ~~per~~ ~~day~~.

See HESS Page 3

# GEOGRAPHICAL AND GEOLOGICAL SETTING OF THE WASSON AND SEMINOLE FIELDS

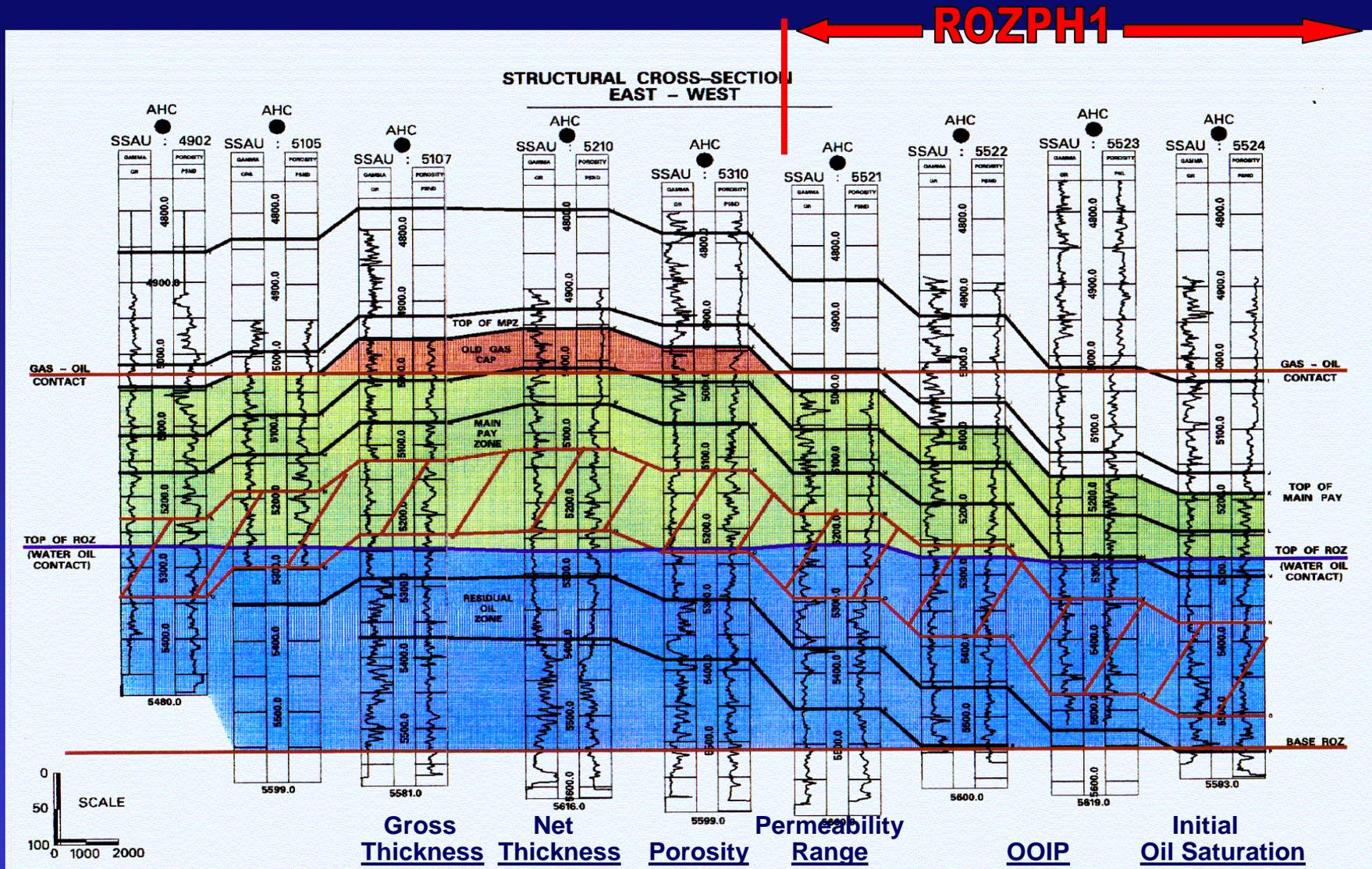


San Andres Producing Fields and Approximate mid-San Andres Paleogeography



\* Adapted from Brown, A., (2001), "Effects of Hydrodynamics on Cenozoic Oil Migration, Wasson Field Area, NW Shelf PB," W. Tx Geol Soc Fall Symp, Pub 01-110, Oct 2001, pp 133-142.

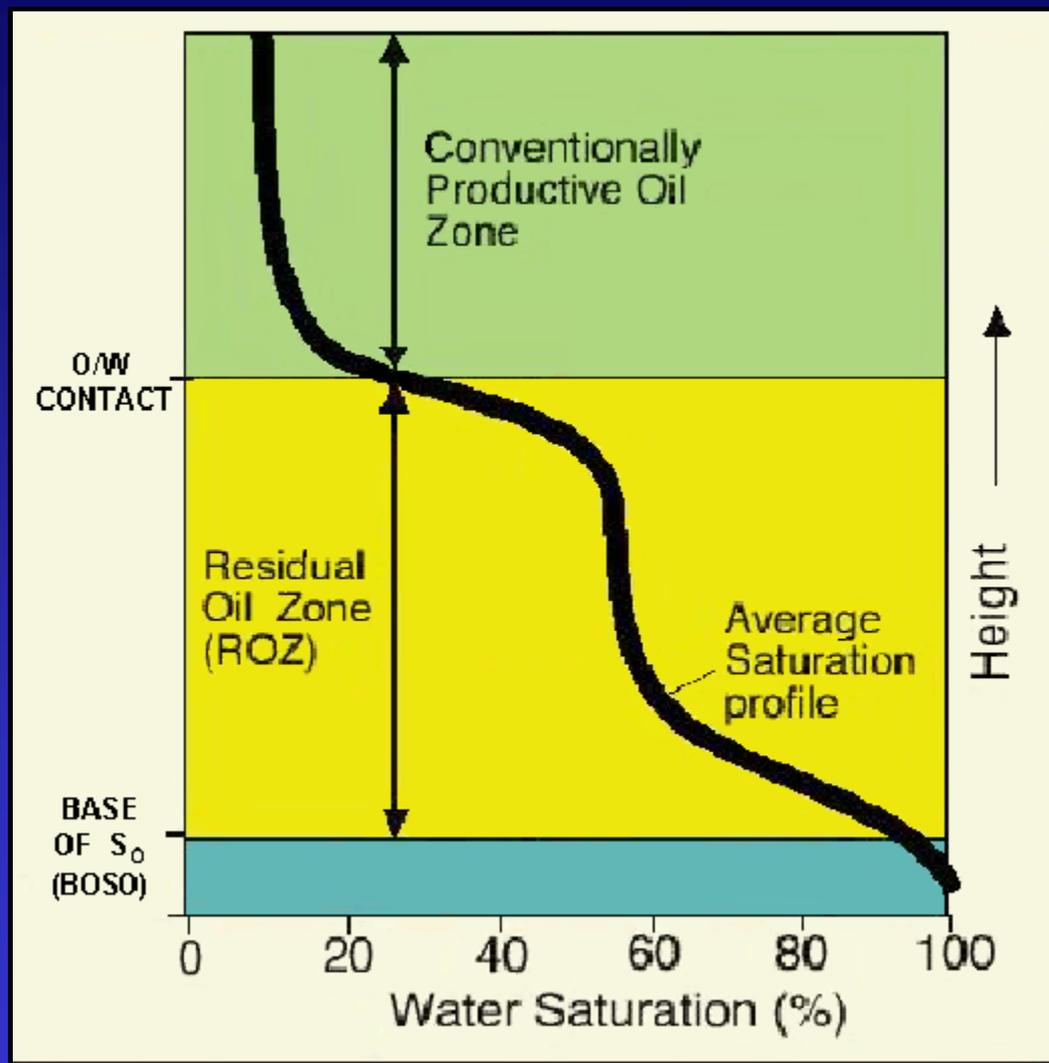
# SSAU MPZ & ROZ Crosssection and Zonal Attributes



**Main Pay Zone (MPZ):** 160' Gross Thickness, 126' Net Thickness, 12% Porosity, 0.8-120 md Permeability Range, 1 billion stbo OOP, 0.84 Initial Oil Saturation

**Residual Oil Zone (ROZ):** 246' Gross Thickness, 197' Net Thickness, 12.6% Porosity, 0.5-270 md Permeability Range, 0.4-1.1 billion stbo OOP, 0.32 Initial Oil Saturation

# Seminole Field Water Saturation Profile\*

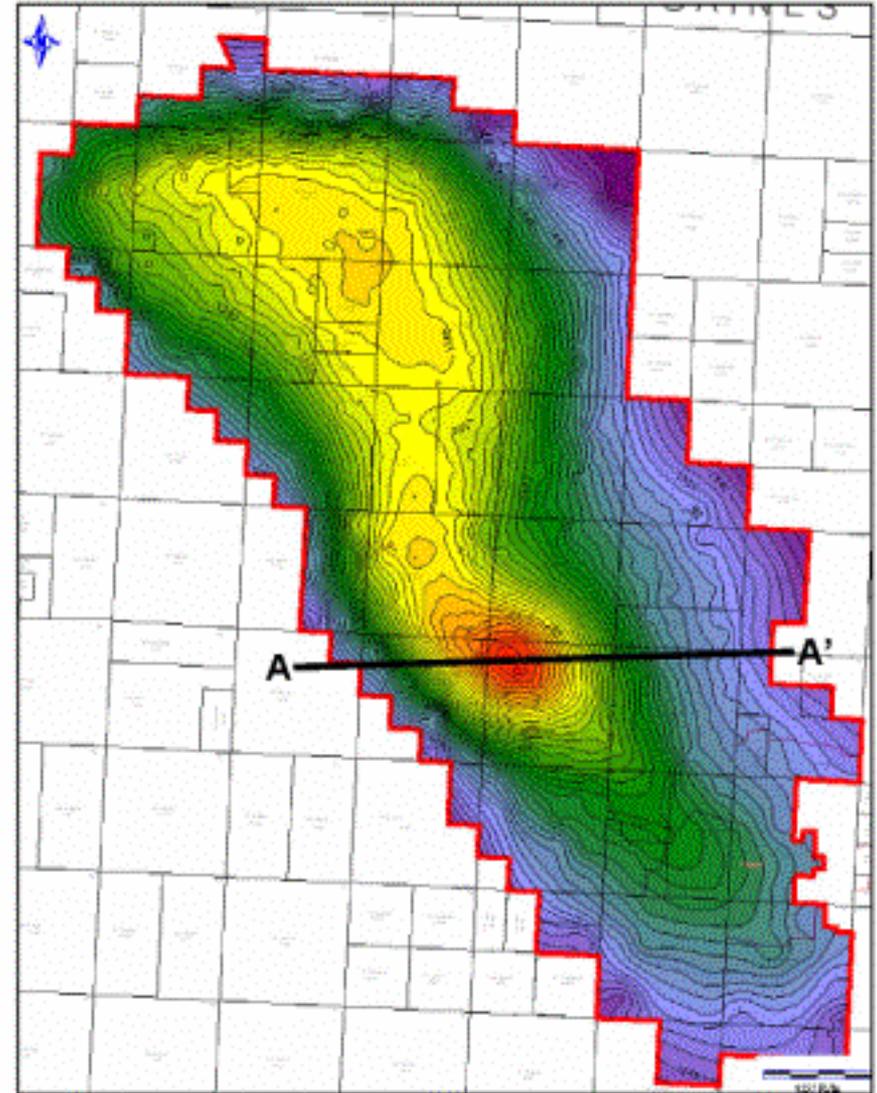
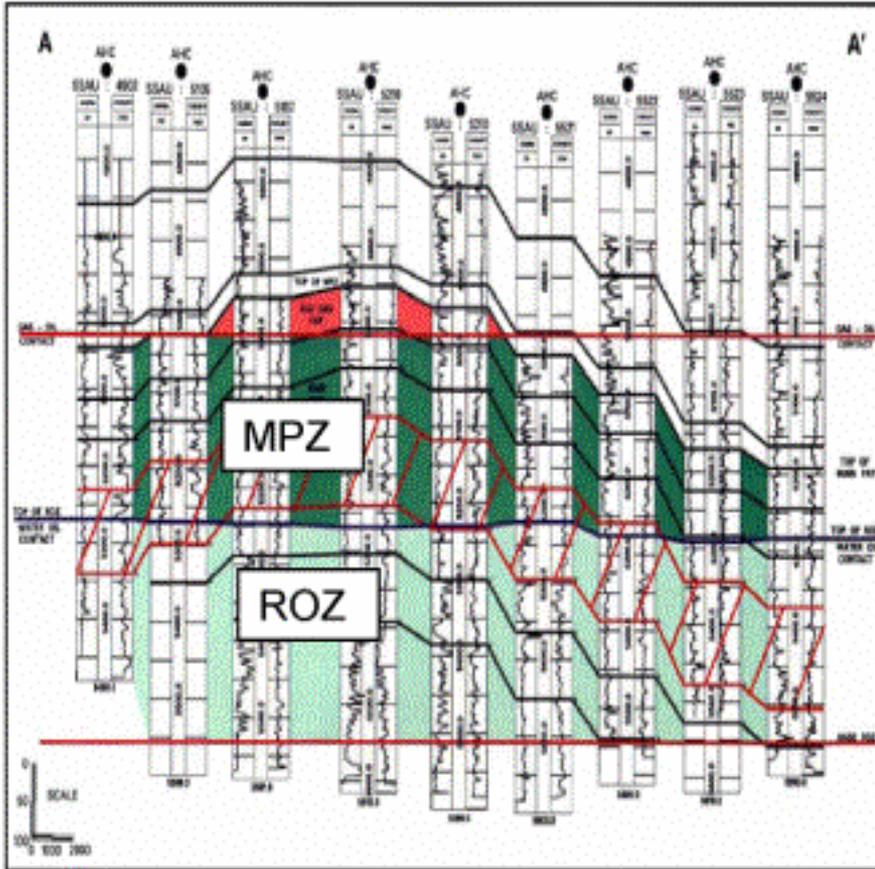


\* Brown, A., (2001), "Effects of Hydrodynamics on Cenozoic Oil Migration, Wasson Field Area, NW Shelf PB," W. Tx Geol Soc Fall Symp, Pub 01-110, Oct 2001, pp 133-142.

# Seminole San Andres Unit SSAU Structure Map & Cross Section



	<u>Net Thickness</u>	<u>Average Permeability</u>	<u>Initial Oil Saturation</u>
Main Pay Zone (MPZ):	126'	9 md	84%
Residual Oil Zone (ROZ):	213'	12 md	32%



# But Not All the Policy for this Growth is in Place

*(CO<sub>2</sub> Sourcing is Still Challenging)*

# A QUICK LEAD-IN FOR TOMORROW

- STATE POLICY ACTIONS
  - Wyoming
  - Texas
  - Louisiana
  - Others
- FEDERAL ACTIVITY
  - Draft EPA Rules on Sequestration
  - Draft GhG Source Reporting Rules
  - Senate Energy Bill
  - Waxman-Markey Climate Change Bill
  - Stimulus (ARRA) Funding

# SUMMARY (1)

- CO<sub>2</sub> EOR Growth has been Steady for Two Decades and Rapidly Accelerating in the Past Few Years
- For 2007-8, CO<sub>2</sub> Supplies Were at Full Utilization in the Permian Basin, Wyoming, and Canada (and Mississippi Supplies were Rapidly Expanding)
- Until the Very Recent Months, EOR Production Growth was Reflective of Lack of Supply Growth (New Projects were also Limited as a Result)

## SUMMARY (2)

- Mississippi Supplies Were Not Similarly Constrained and Showed Dramatic Growth: EOR Production Rising Quickly as a Result
- Wyoming CO<sub>2</sub> Production Continuing to Grow as Salt Creek and Monell Mature
- Sudden Collapse of Oil Prices in Last Half of '08 Curtailed Demand Somewhat but Lingering, Pent-up Project Demand is Filling Gaps; New Projects are Being Announced and Implemented

## SUMMARY (3)

- Further CO<sub>2</sub> EOR Production Growth Expected, Both Within the Three Regions and Canada plus Louisiana and Texas Gulf Coast, Michigan, Montana, Oklahoma, and Possibly California and Kansas
- Next Generation Technologies are Coming ('Quaternary' Oil)
- Policy Actions are Everywhere (Driven by Storage Considerations)

# QUESTIONS?