



**Regional Carbon Sequestration Partnerships Annual
Review Meeting**

Oct 6, 2010

**Presented by Mike Bruno, PhD, PE
Terralog Technologies USA, Inc**

- 1. Project Background and Motivation**
- 2. Project Status and Accomplishments**
- 3. Next Steps**



Characterization of Wilmington Graben, Offshore Los Angeles, for Large Scale Geologic Storage of CO₂

Project Sponsors and Participants:



DOE NETL



California Energy Commission



City of Los Angeles, Department of Public Works



Southern California Gas Company (transport infrastructure)

Cal State Long Beach, Dr. Dan Francis (seismic acquisition)

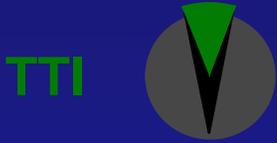
Legg Geophysics (seismic interpretation)

USGS, Dr. Dan Ponti (cores and samples repository)



Terralog Technologies USA (geology, geomechanics, reservoir eng)



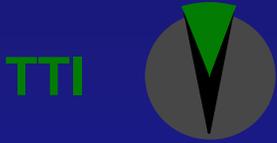


Characterization of Wilmington Graben, Offshore Los Angeles, for Large Scale Geologic Storage of CO₂

The Los Angeles Basin presents a unique combination of great need and great opportunity for large scale geologic storage of CO₂.

In part due to its significant population, and in part due to its historical and geologic setting as one of the most prolific oil and gas producing basins in the United States, the region is home to more than a dozen major power plants and oil refineries which produce more than 5 million metric tons of fossil fuel related CO₂ emissions each year.



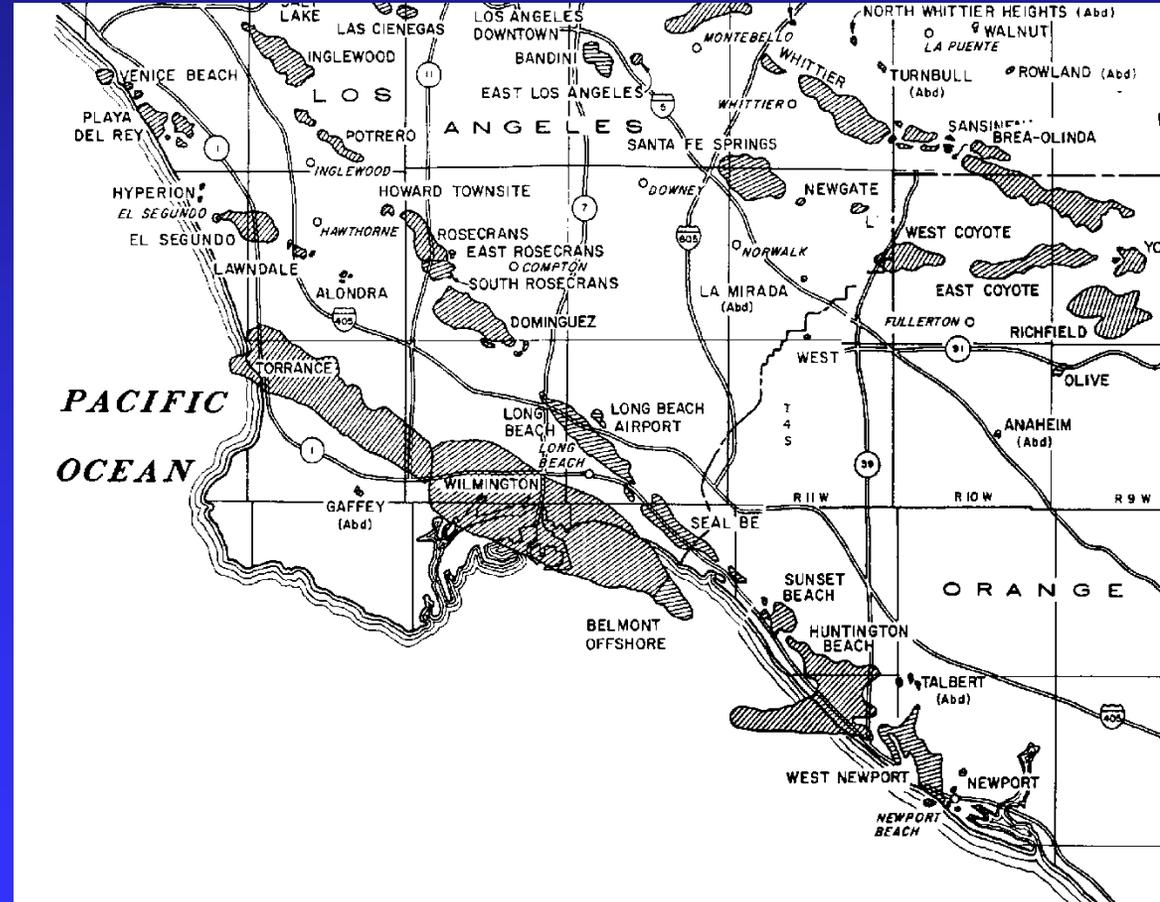


Characterization of Wilmington Graben, Offshore Los Angeles, for Large Scale Geologic Storage of CO₂

Pliocene and Miocene sediments in the Los Angeles Basin (massive interbedded sand and shale sequences) are known to provide excellent and secure traps for oil and gas.

The area contains several billion-barrel oil and gas fields, including the giant Wilmington Field in Long Beach (more than two billion barrels produced to date).

These formations have been used by Southern California Gas Company for very large scale underground storage of natural gas at half a dozen locations throughout the Los Angeles basin for more than fifty years, demonstrating both the storage potential and security of these formations for CO₂ sequestration if properly characterized and selected.



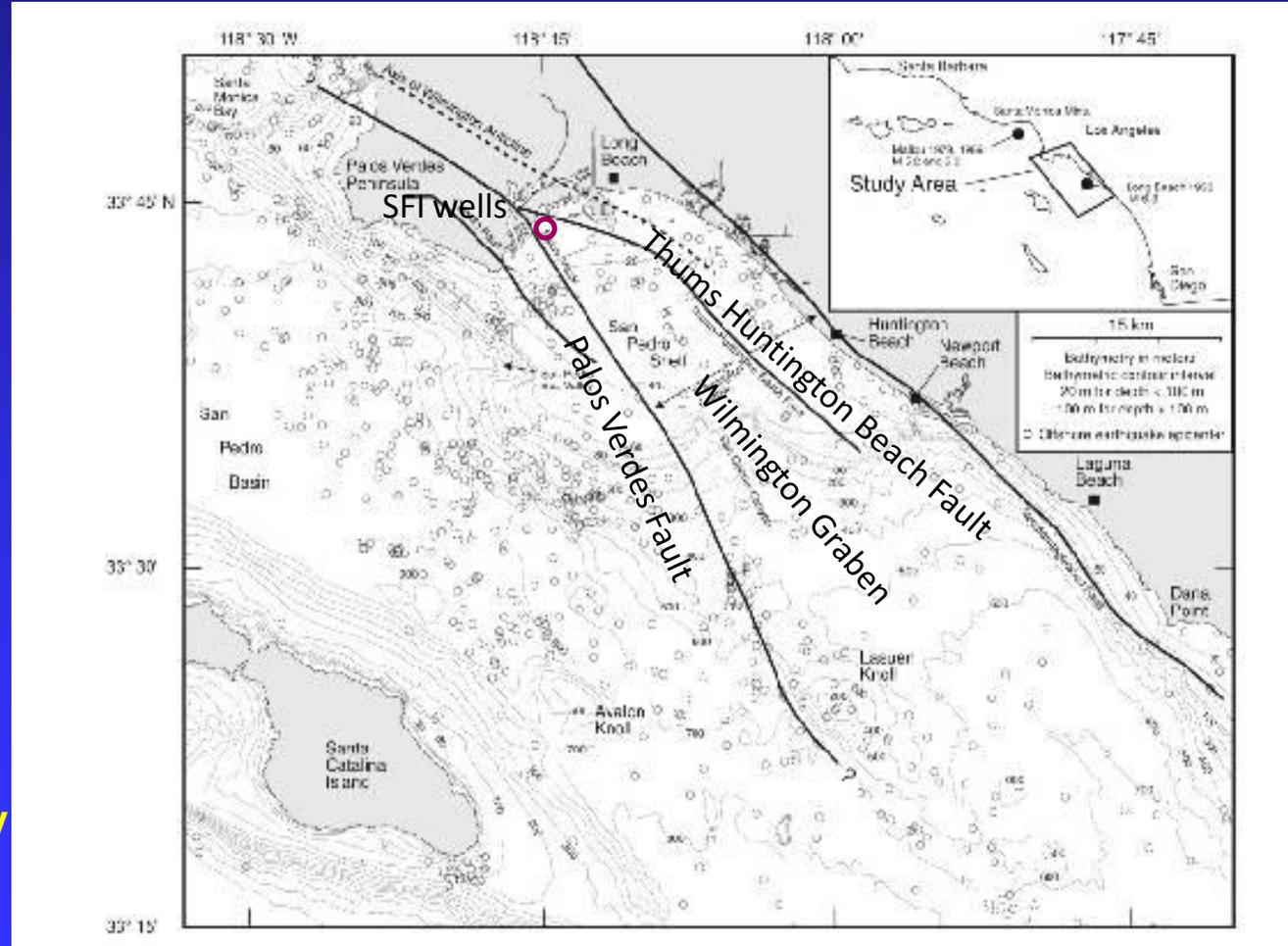


Characterization of Wilmington Graben, Offshore Los Angeles, for Large Scale Geologic Storage of CO₂

Given the current population density (and complex land ownership), it is impractical to site a large scale CO₂ storage project onshore beneath the City.

More than 3000 feet thickness of these same Pliocene and Miocene formations are present in the large Wilmington Graben directly offshore the Los Angeles and Long Beach Harbor area, at appropriate depth for CO₂ sequestration (about 3000 to 7000 ft).

This zone is easily accessible yet geologically isolated from the nearby Wilmington Oilfield and onshore area, reducing communication risk and public risk.





Characterization of Wilmington Graben, Offshore Los Angeles, for Large Scale Geologic Storage of CO₂

Comprehensive research program to better characterize Pliocene and Miocene sediments in the Wilmington Graben and surrounding areas for high volume CO₂ storage. The effort includes:

- 1) Detailed log evaluation of existing exploration wells in the area;**
- 2) Improved evaluation and interpretation of existing 2D and 3D seismic data;**
- 3) Acquisition and interpretation of additional 2D seismic lines;**
- 4) Drilling and coring two new evaluation wells into the Graben (Pliocene and Miocene) and one on the landward side of the THUMS-HB fault**
- 5) Development of 3D geologic models, geomechanical models, and CO₂ injection and migration models for the region.**
- 6) Analysis of industrial sources (top 20 in the LA Basin)**
- 7) Engineering study of existing and new pipeline systems to transport CO₂ from significant local sources to sequestration sites (transport infrastructure study)**
- 8) Risk analysis (incl well integrity, induced and natural seismicity)**



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Exploration wells in Wilmington Graben





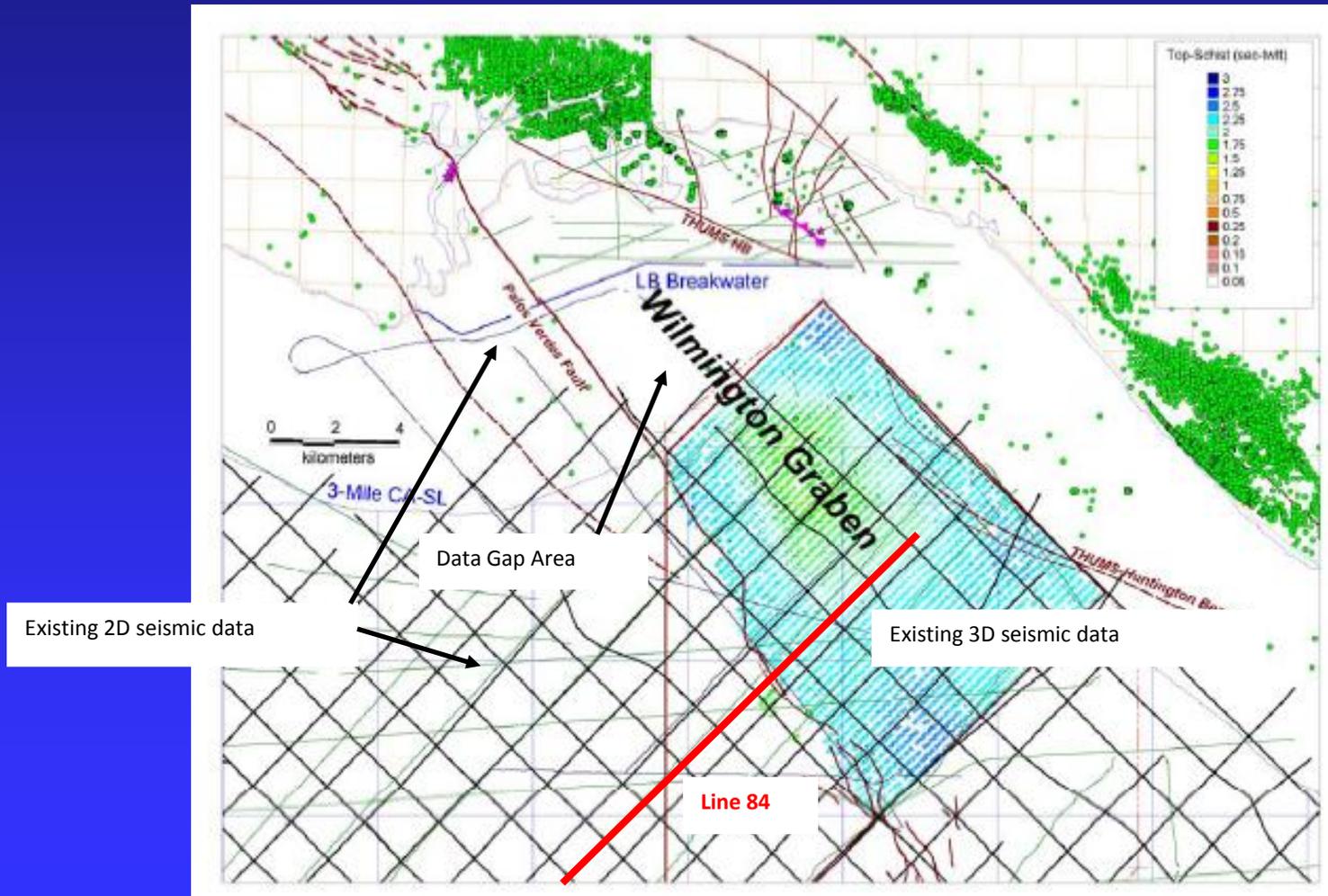
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Wells Reviewed for Lithology and Stratigraphy

API_no	Operator	Lease	Well_no	Td	Latitude	Longitude
State						
23700493	Exxon Mobil Corp		H 10 R-7	6643	33.67754	-118.16522
23720208	Conoco Inc.		SP S-4	4775	33.69454	-118.18442
23720211	Conoco Inc.		SP S-6	5025	33.70187	-118.1562
25920074	Chevron U.S.A. Inc.		10R-34	6976	33.68089	-118.15494
23705997	Chevron U.S.A. Inc.	S-P La Harbor	2	9936	33.72407	-118.24223
25900361	Mobil Oil Corp.		SP-11	8423	33.68704	-118.13692
Federal						
4312200100000	GULF OIL CORP	OCS P-0302	1	6660	33.5512	-118.0601
4312200240000	SOHIO PETROLEUM CO	OCS-P-0302	2	7100	33.5724	-118.0516
4312200110000	SHELL OIL CO	OCS-P-0298	1	7200	33.5995	-118.0345
4312200080000	SHELL OIL CO	OCS-P-0293	1	6805	33.6611	-118.1405
4312200190000	CHEVRON U S A INC	OCS-P-0296	12	10973	33.6192	-118.1603
4312200180100	CHEVRON U S A INC	OCS P-0296	9	8400	33.6018	-118.1322
4312200060200	CHEVRON U S A INC	OCS-P-0296	4	5336	33.5908	-118.1289
4312200130100	SHELL OIL CO	OCS-P-0300	2	4988	33.577	-118.1225
4312200160000	SHELL OIL CO	OCS P-0301	6	5244	33.5698	-118.1114
SFI						
n/a (EPA Permit)	City of LA		SFI#1	5499	33.74388	-118.26497
n/a (EPA Permit)	City of LA		SFI#2	5426	33.74385	-118.26502
n/a (EPA Permit)	City of LA		SFI#3	5448	33.74399	-118.26466



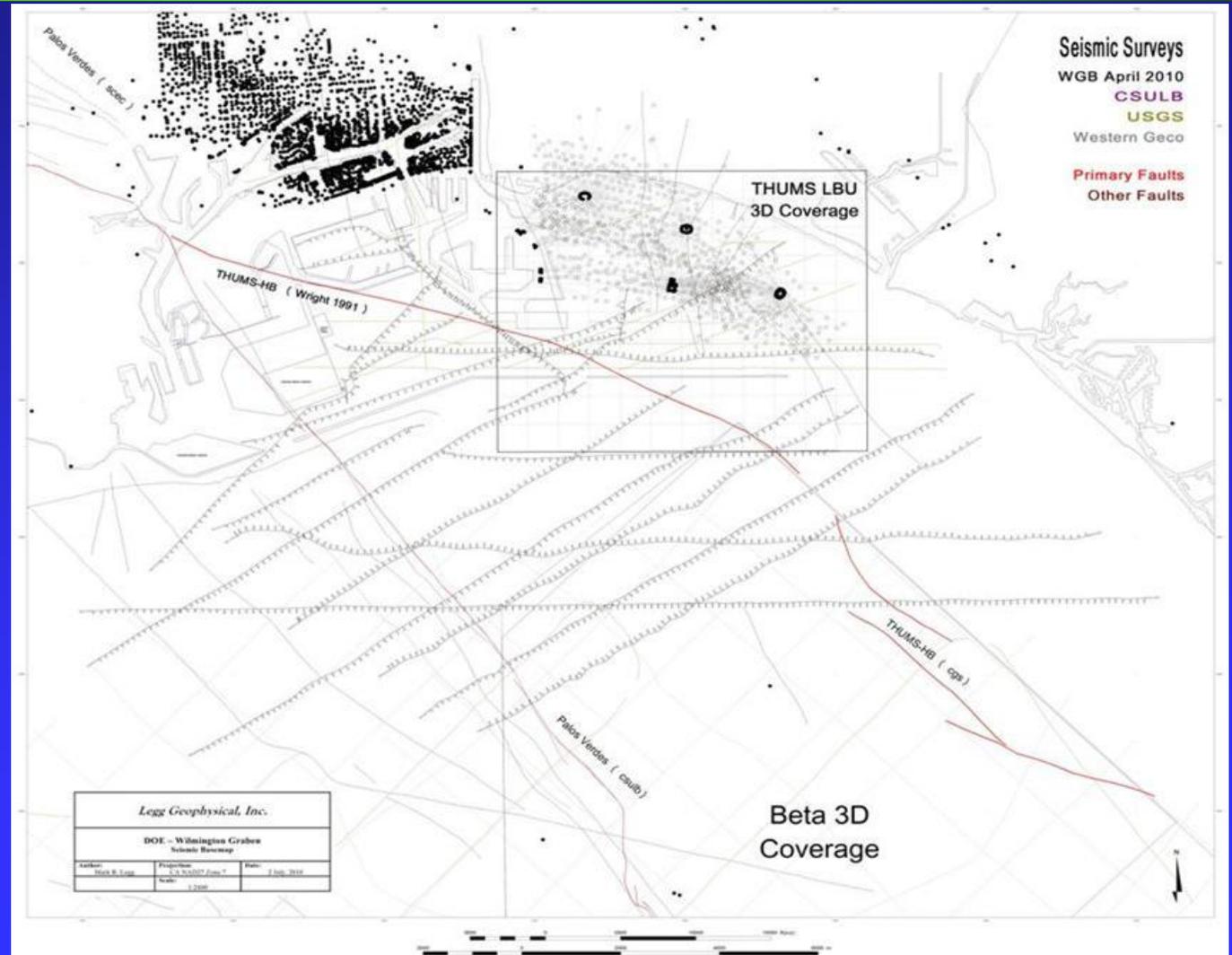
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Shot Point Map for
175km of new seismic
lines



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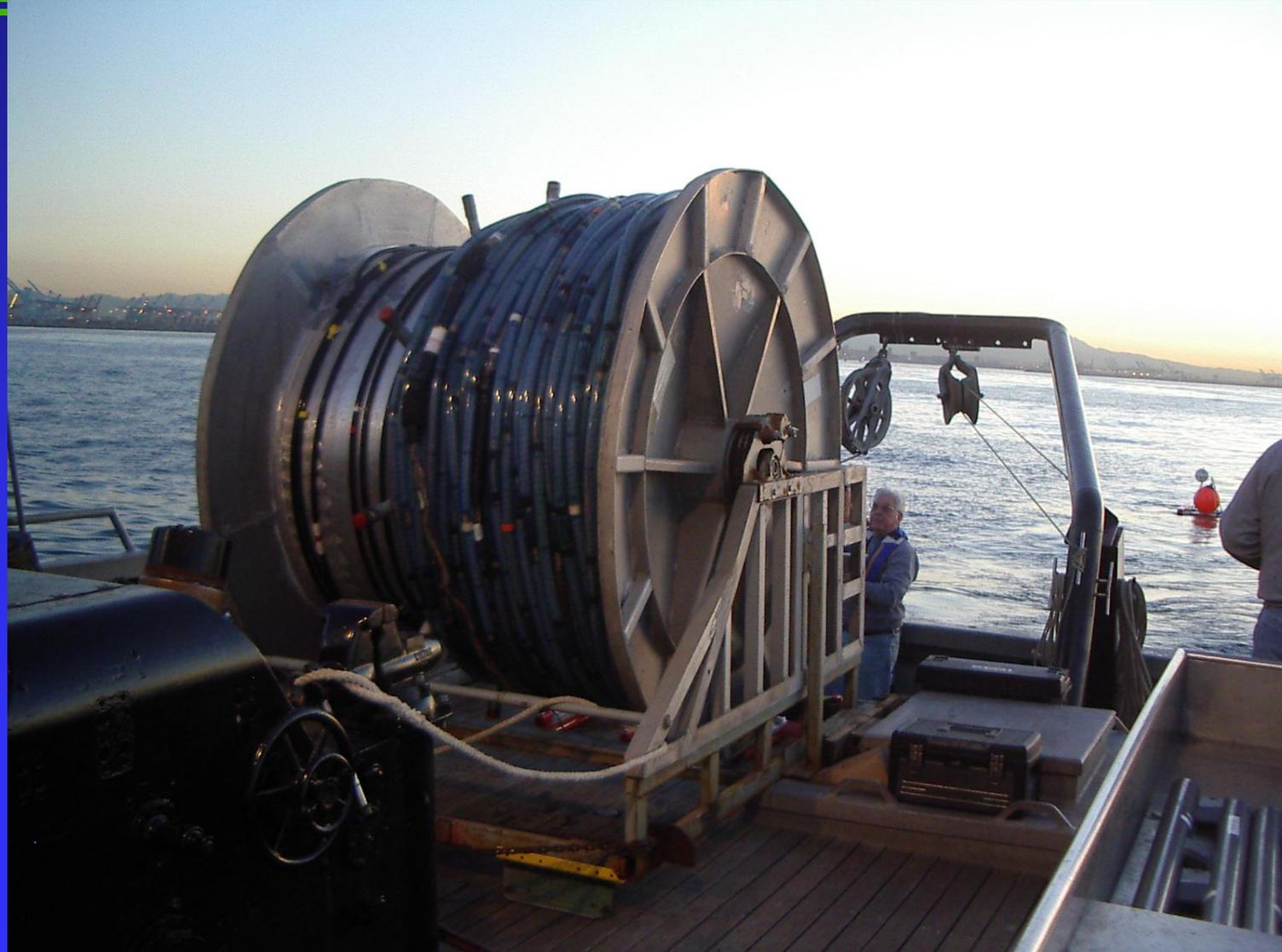


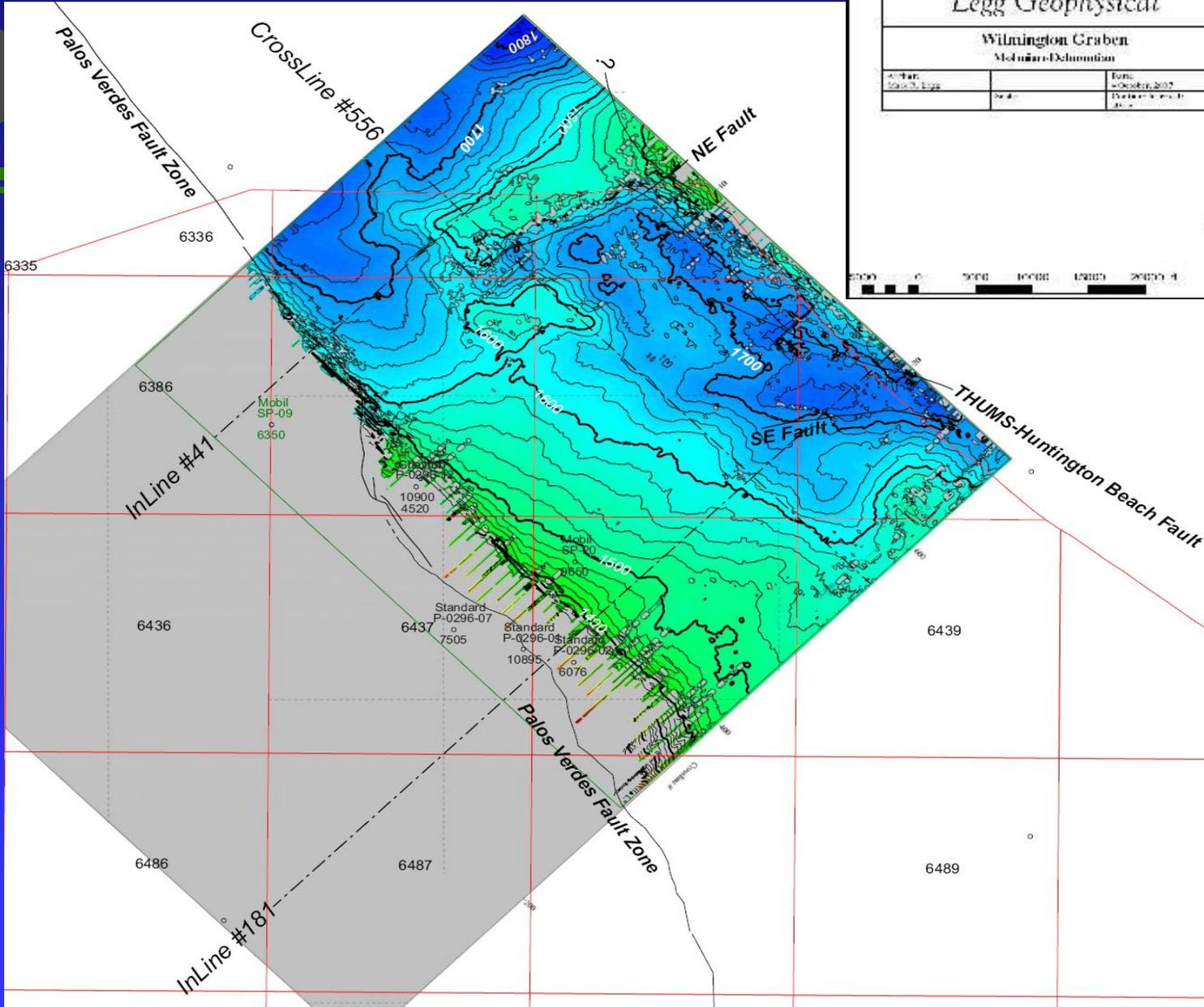
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Streamer





Legg Geophysical

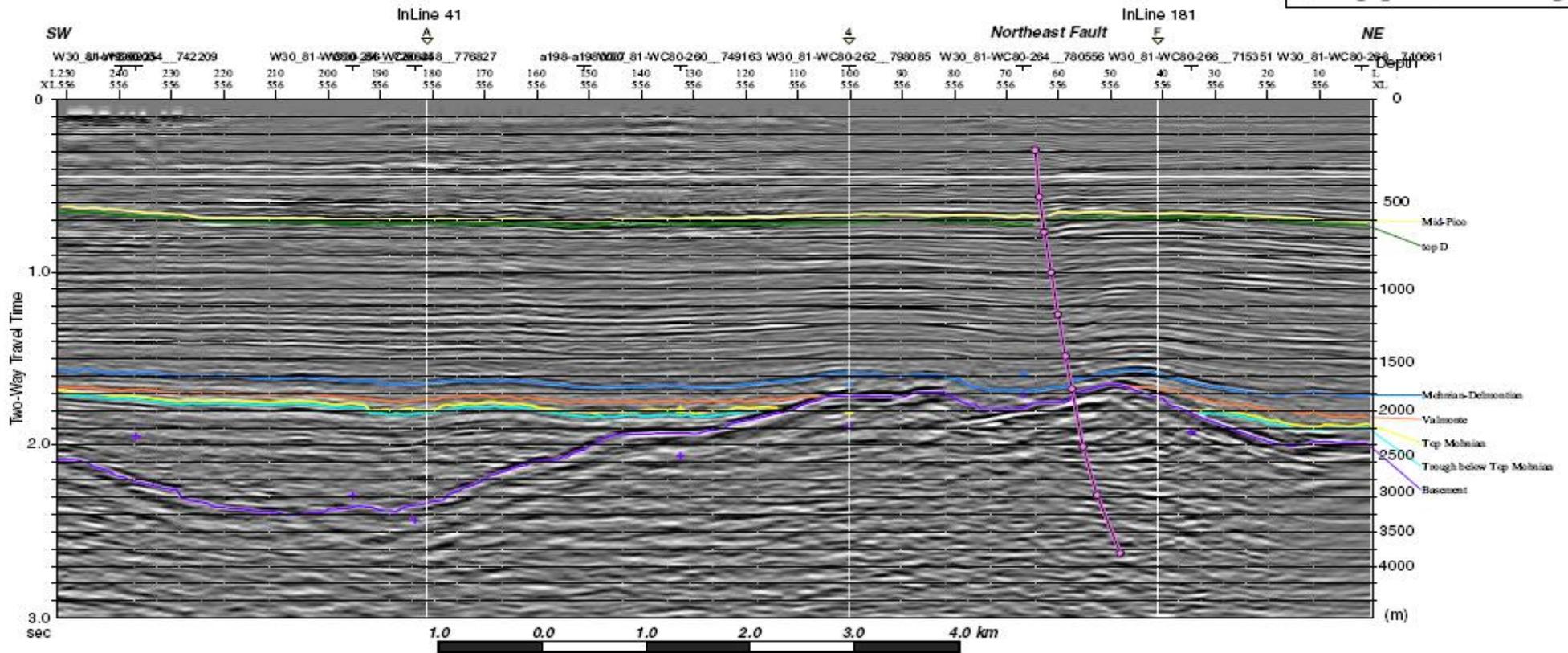
Wilmington Graben Molnia-Delimitation

Author: David N. Legg	Scale:	Date: October, 2007
Project Name: Wilmington Graben		Drawn by: David N. Legg

0 5000 10000 15000 20000 ft

N

0
500
1000
1500
1700



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Kenai Drilling Rig #38





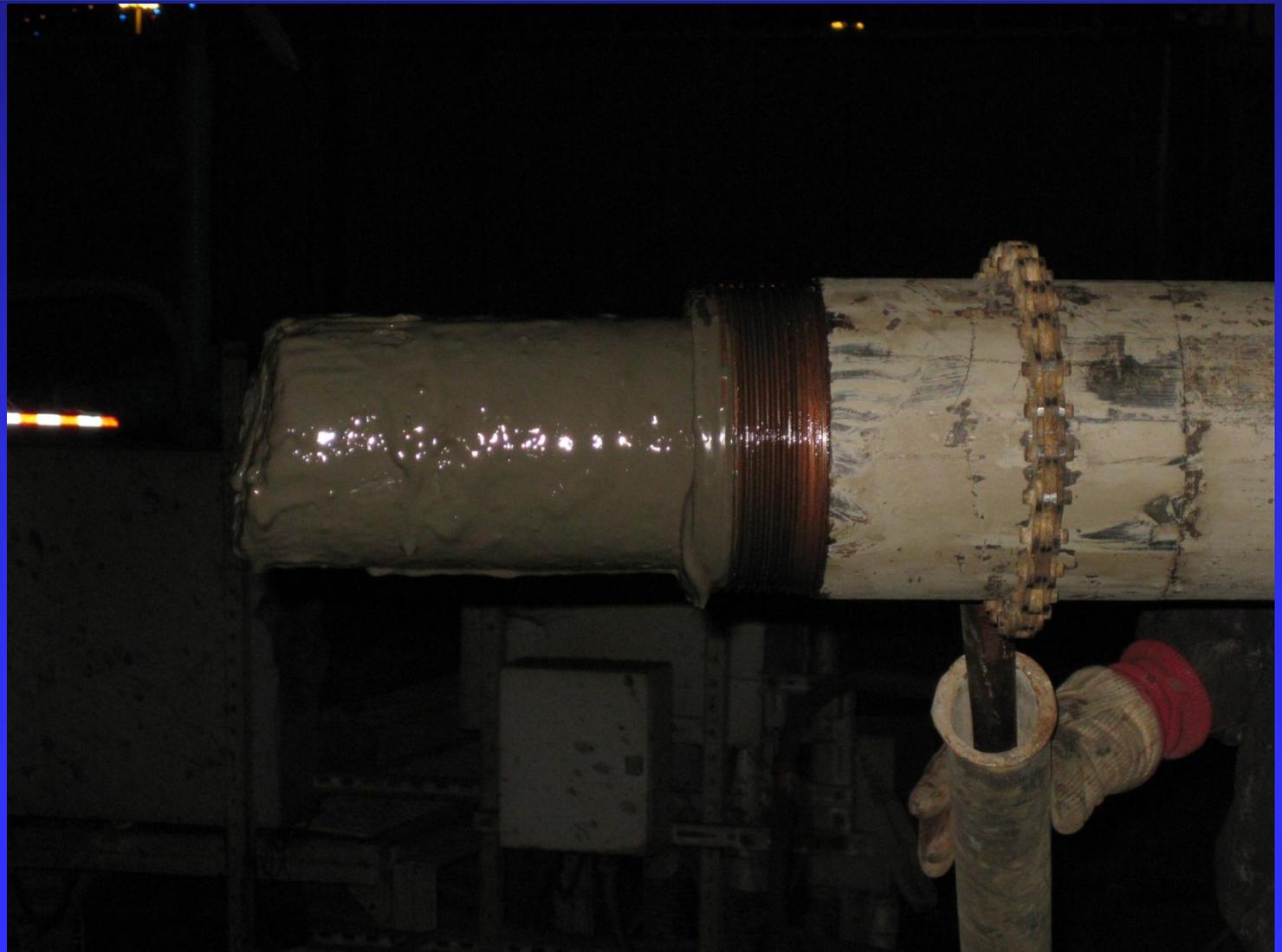
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Conventional Core
fresh out of hole





Characterization of Wilmington Graben, Offshore Los Angeles, for Large Scale Geologic Storage of CO₂



SFI#3 Sidewall Core Samples

SF#3

4,000

GR

MD (ft)

Lithology

4000

4,500

Repetto
Fm

Turn Around sub/fiber
optic @ 4822'

Equivalent SFI#2 perf zone

9 5/8" - 47lb L80 BTC
casing

3 1/2" tubing to be installed

9 5/8" x 3 1/2" Injection
Packer @ 4900'

WL Re-entry guide @4910'

5,000

Equivalent SFI#2 perf zone

Perf 5086-5116'

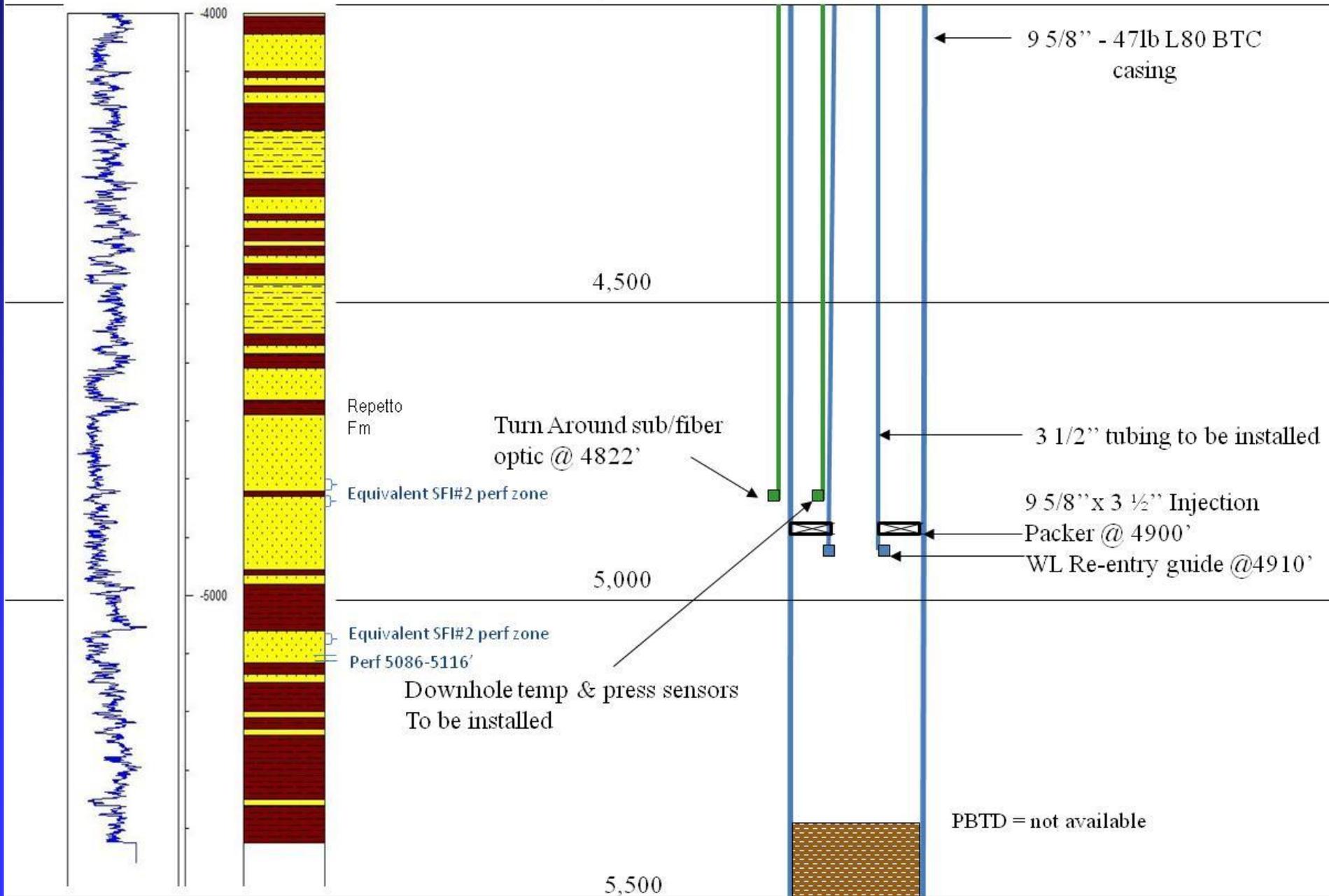
Downhole temp & press sensors
To be installed

PBTD = not available

5000

5,500

TD=5430'MD; 5382'TVD





Characterization of Wilmington Graben, Offshore Los Angeles, for Large Scale Geologic Storage of CO₂

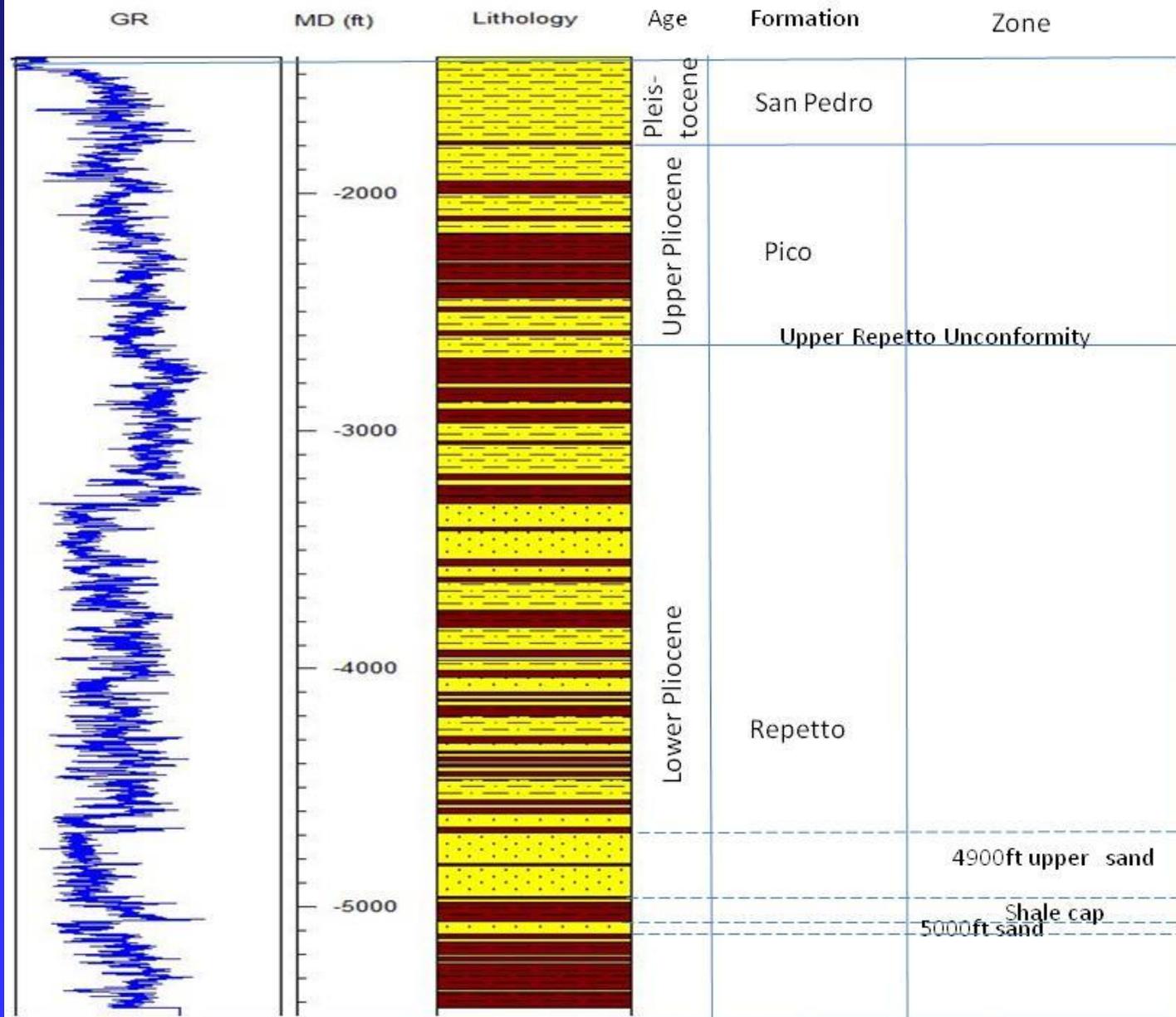
Reservoir Properties from SWC and Conventional Core

Zones	Porosity (%)	Permeability (md)
Shale between 4465-4570ft	28 to 29	2 to 4
Sand at 4640ft	32	371
Shale above 4900ft sand	27	<1
4900ft sand @ 4690-4975ft	24 to 30	51 to 187
Shale above Injection Zone	28 to 29	<1 to 2
Injection Zone (5055-5115ft)	26 to 31	50 to 353
Sand at 5351ft	29	135
Conventional Core shale (5431-5439.5ft)	23 to 24	<1



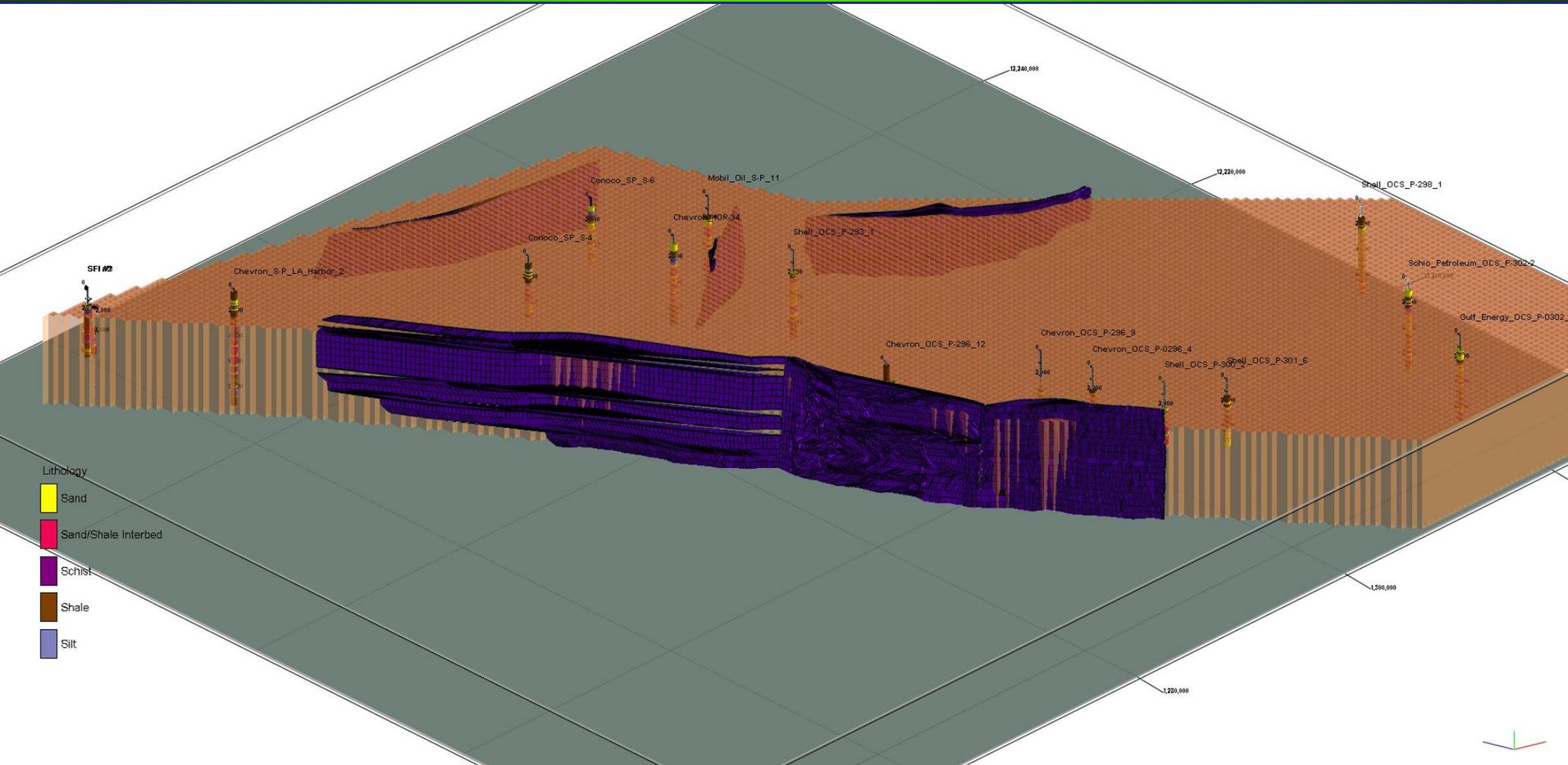
- Recovered 29 SWC and 9.5ft conventional core
- Correlated well with SFI#1 and SFI#2 wells
- Well TD in Pliocene based on micropaleontology correlation from SFI#2 well
- Sand porosities – 24-31%
- Sand permeabilities – 50-353md
- Shale porosities – 23-29%
- Shale permeabilities – <1-2md
- Pliocene sand thickness – 3000-3500ft

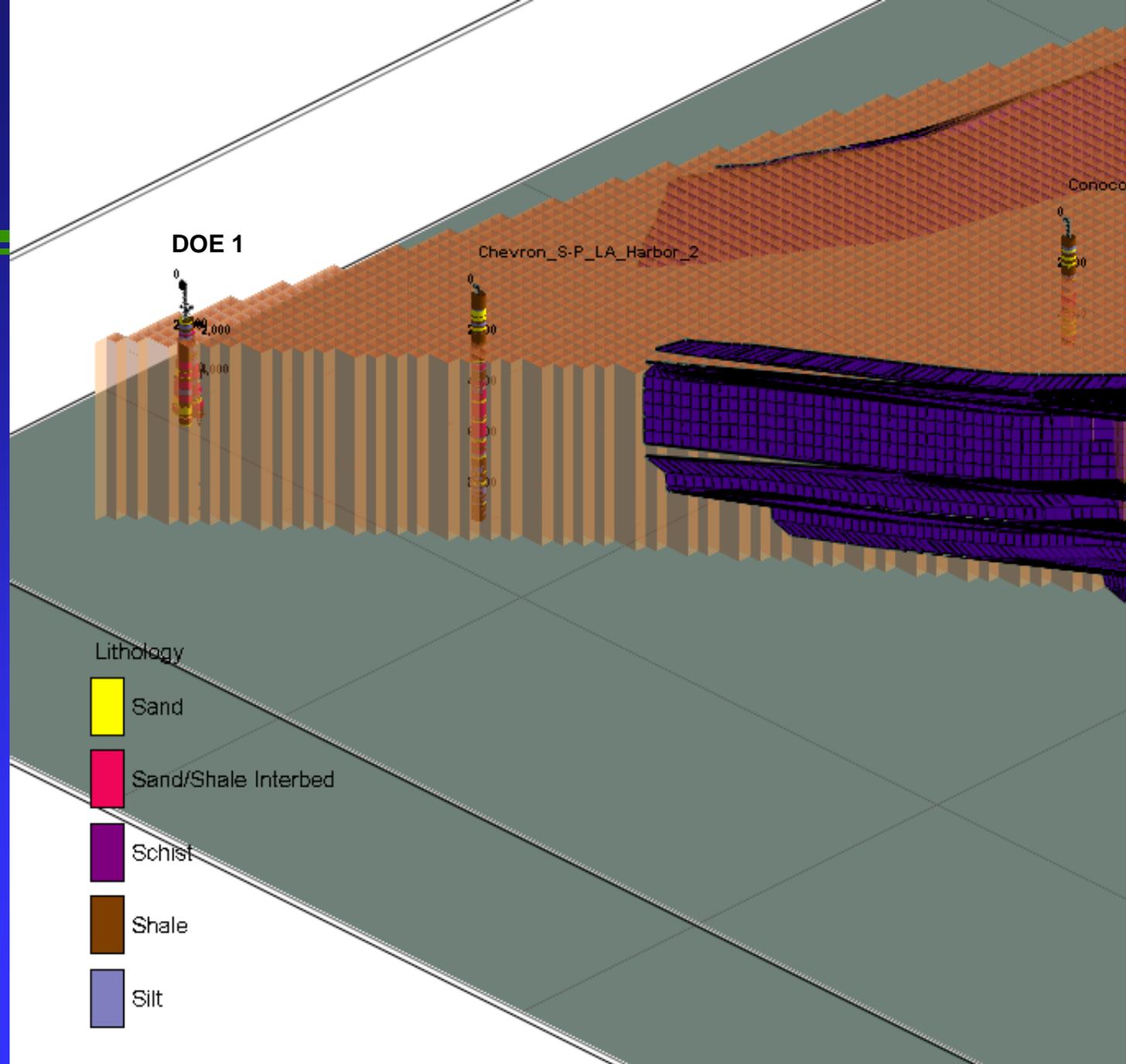
SFI#3





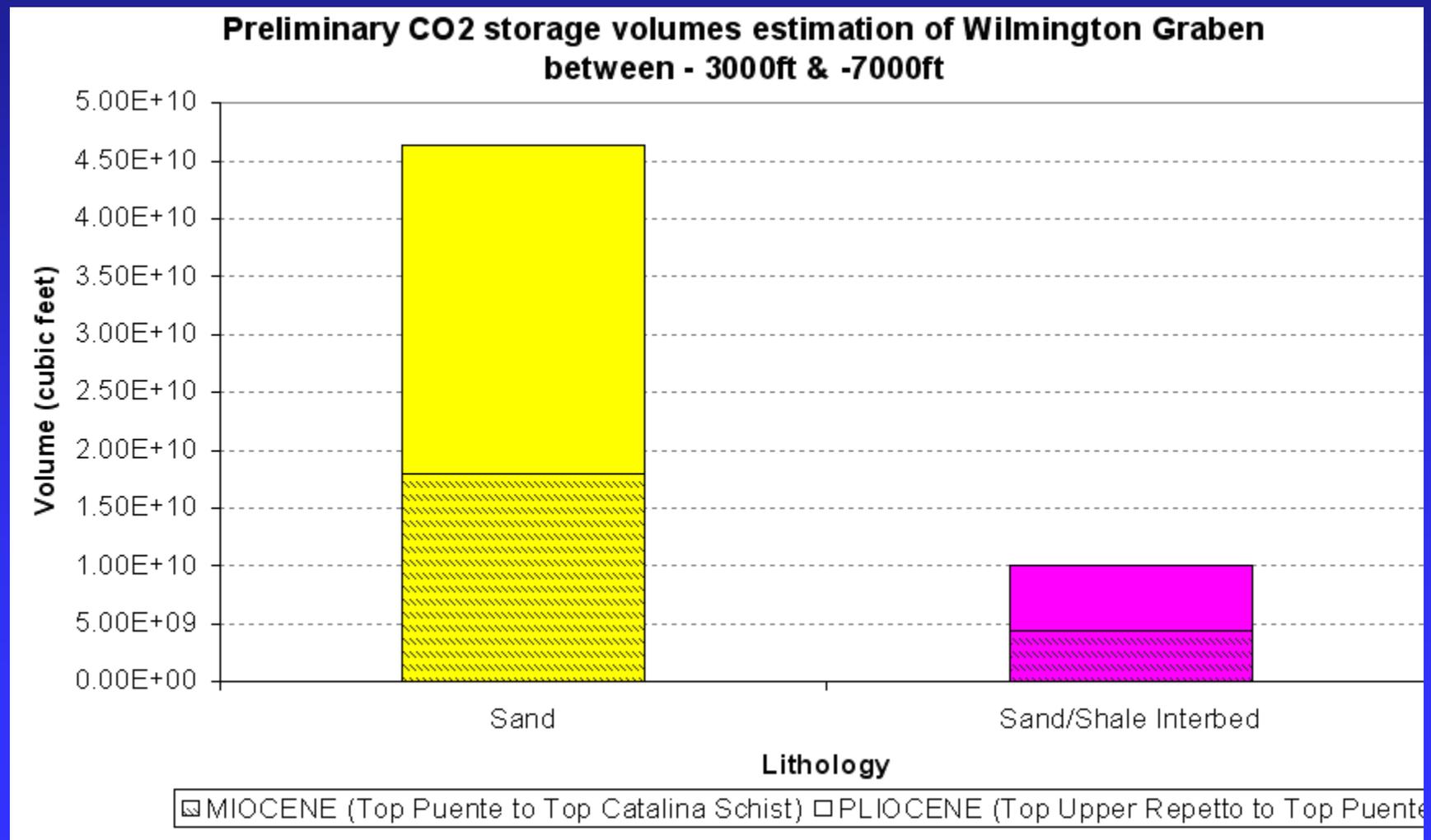
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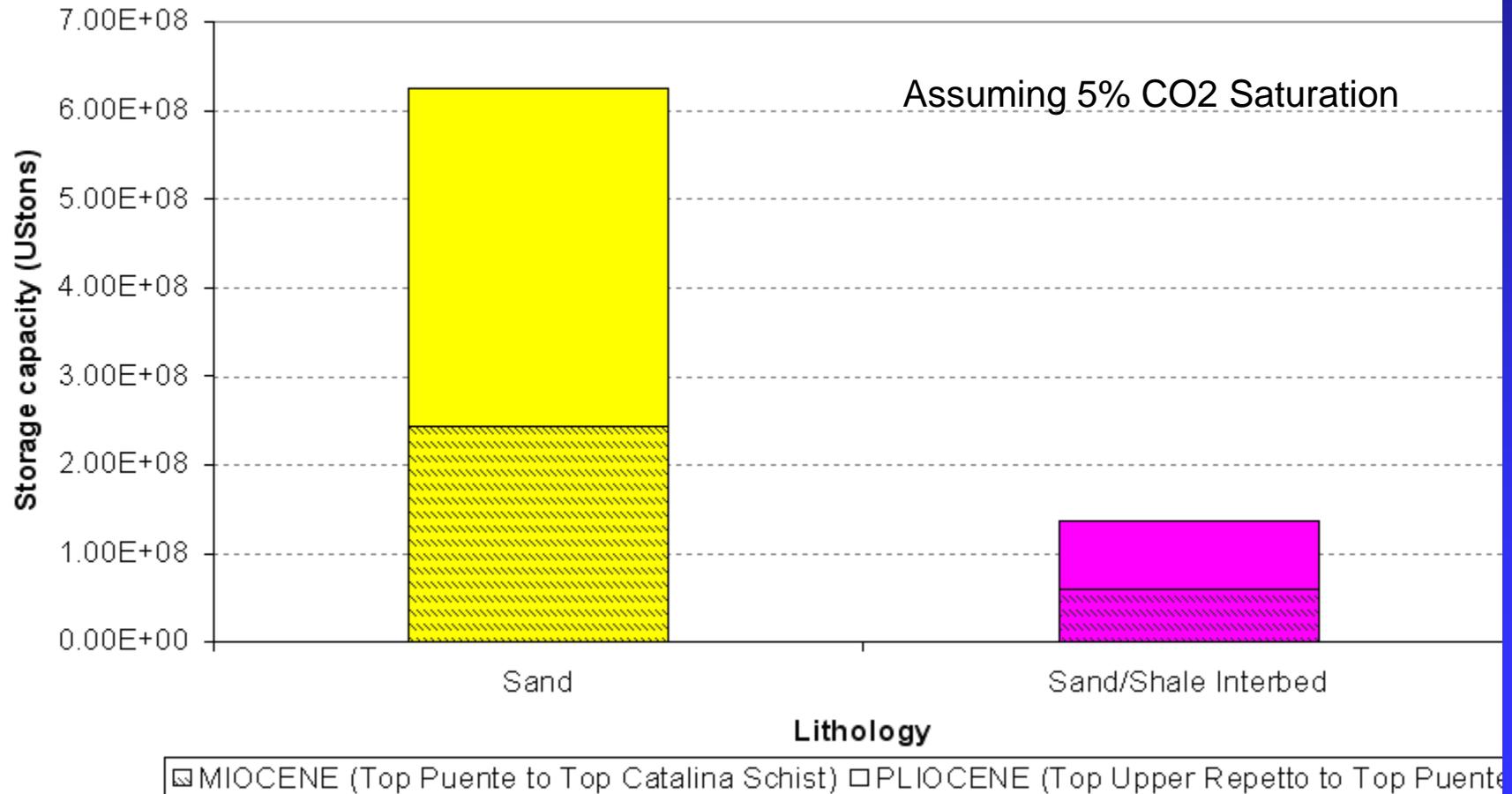
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Characterization of Wilmington Graben, Offshore Los Angeles, for Large Scale Geologic Storage of CO₂

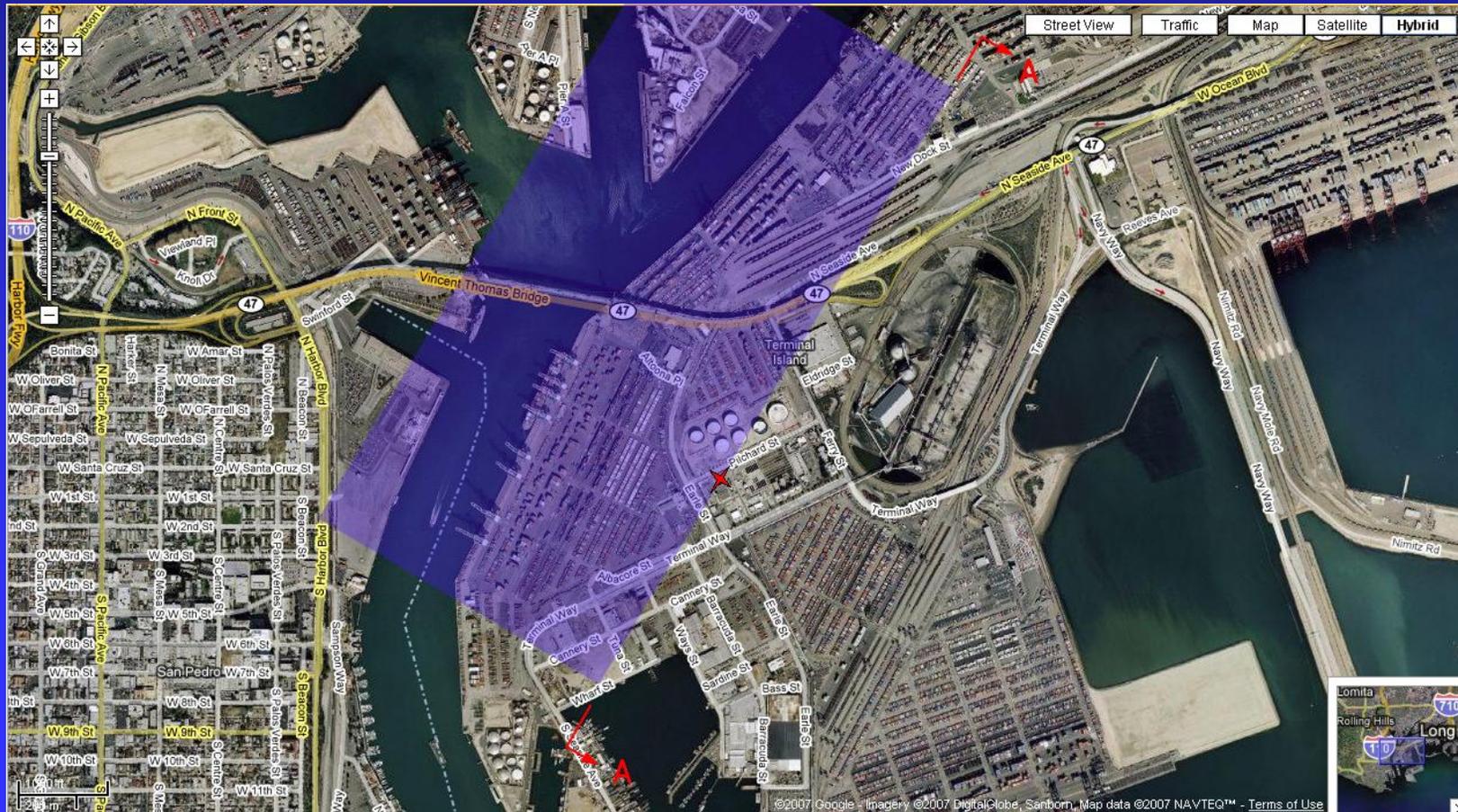
**Preliminary CO₂ storage capacity estimation of Wilmington Graben
between - 3000ft & -7000ft**





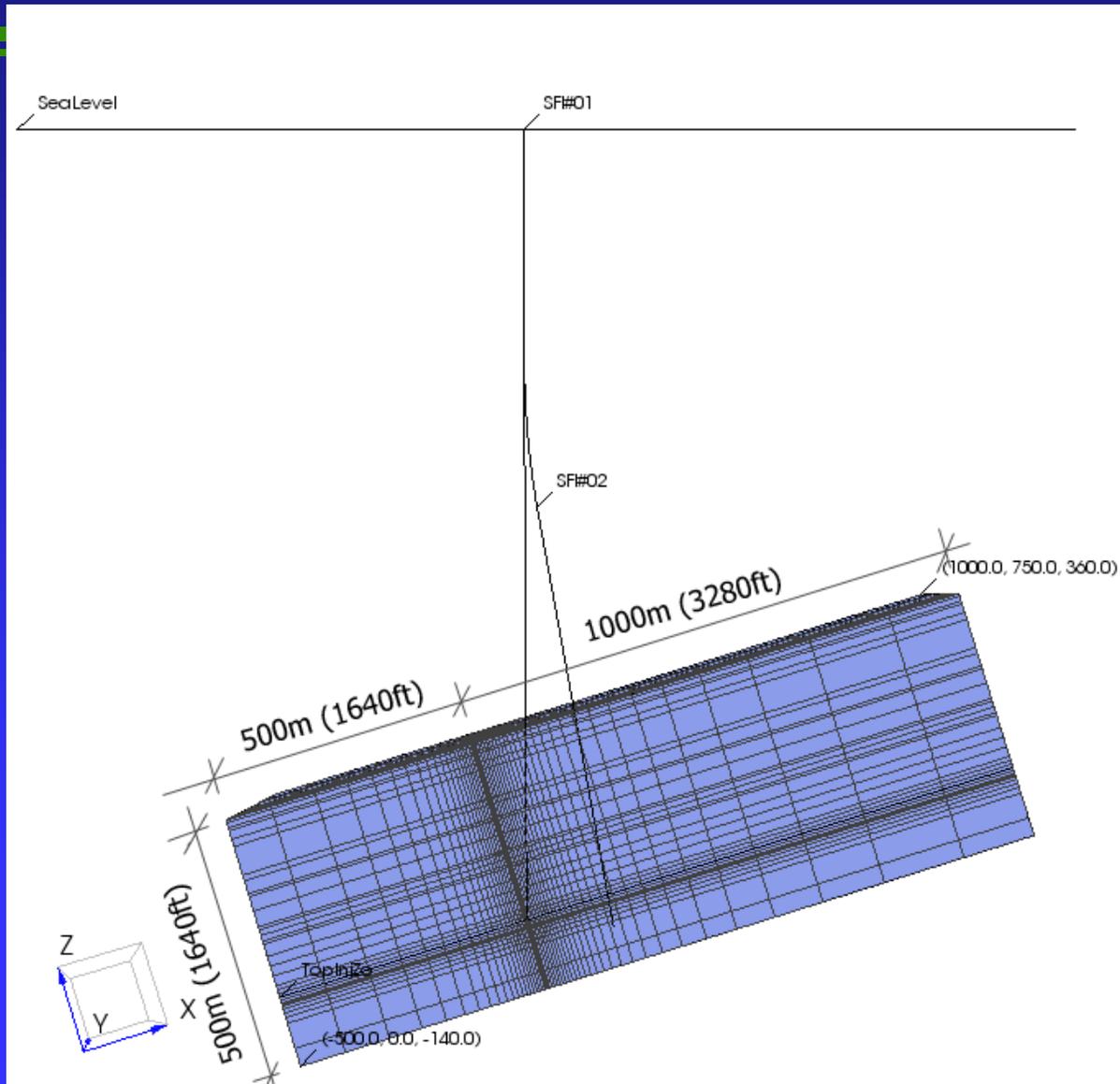
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Model Area





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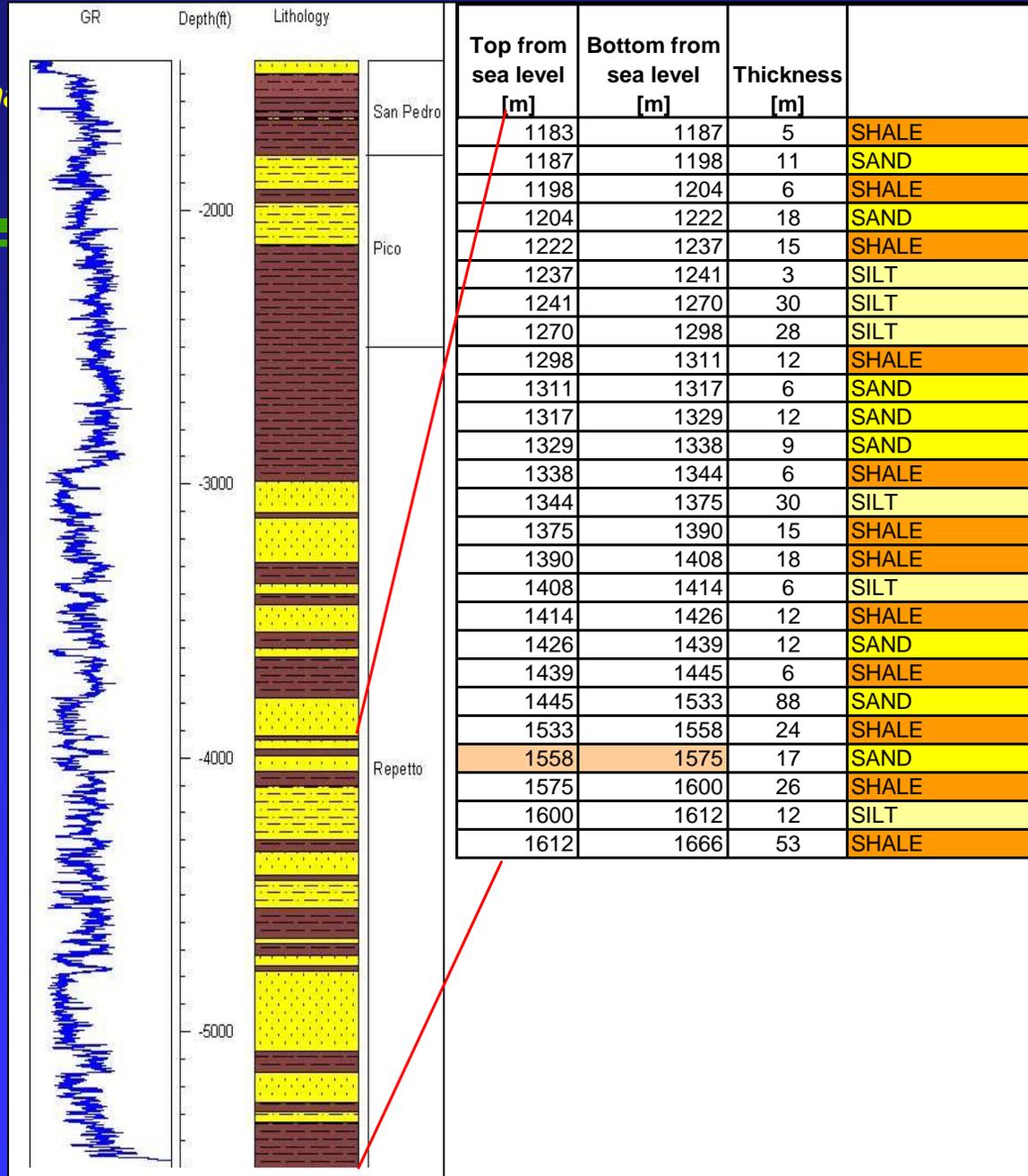


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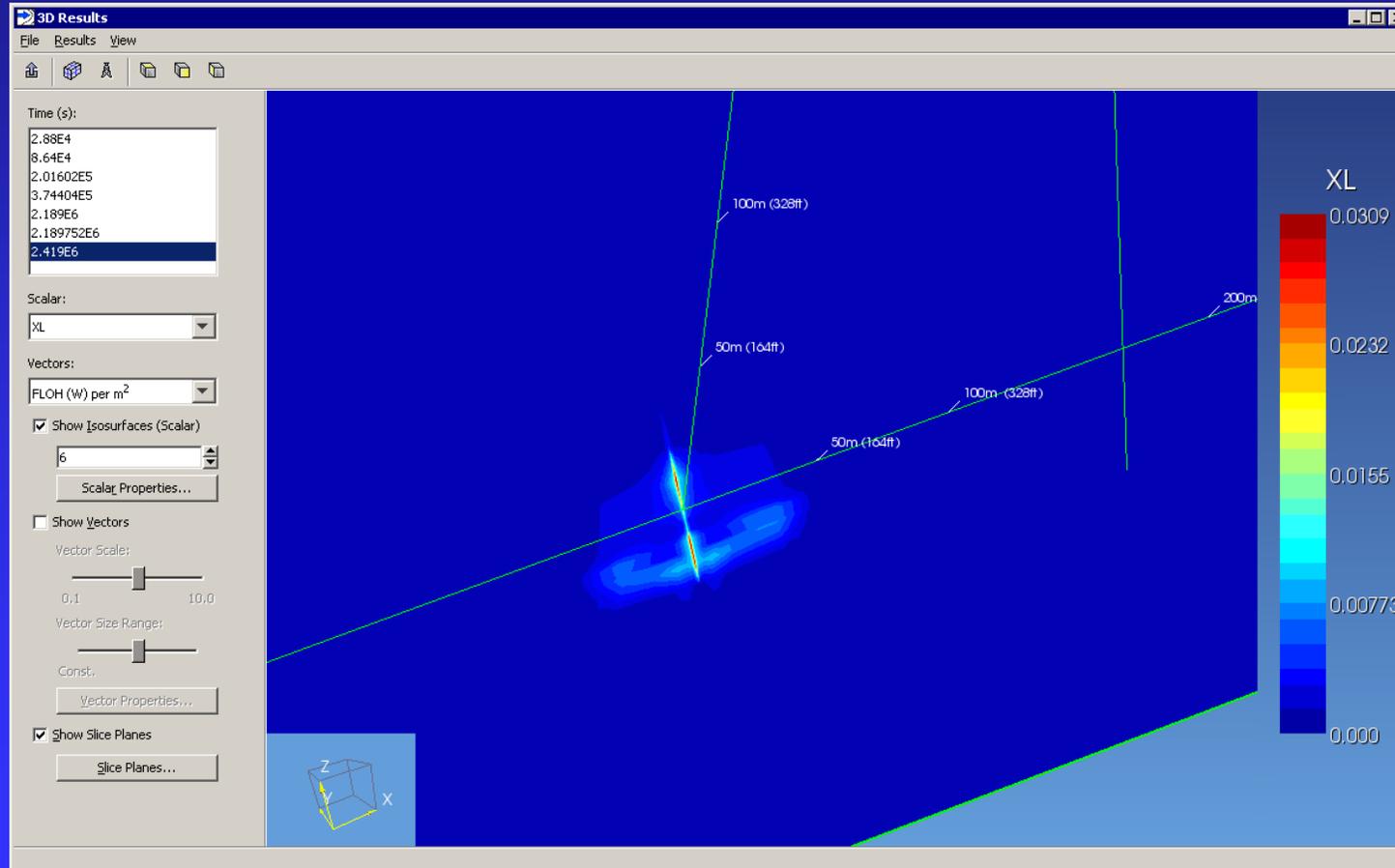


Figure 30: Mass fraction of CO₂ in liquid phase after 28 days – symmetry plane



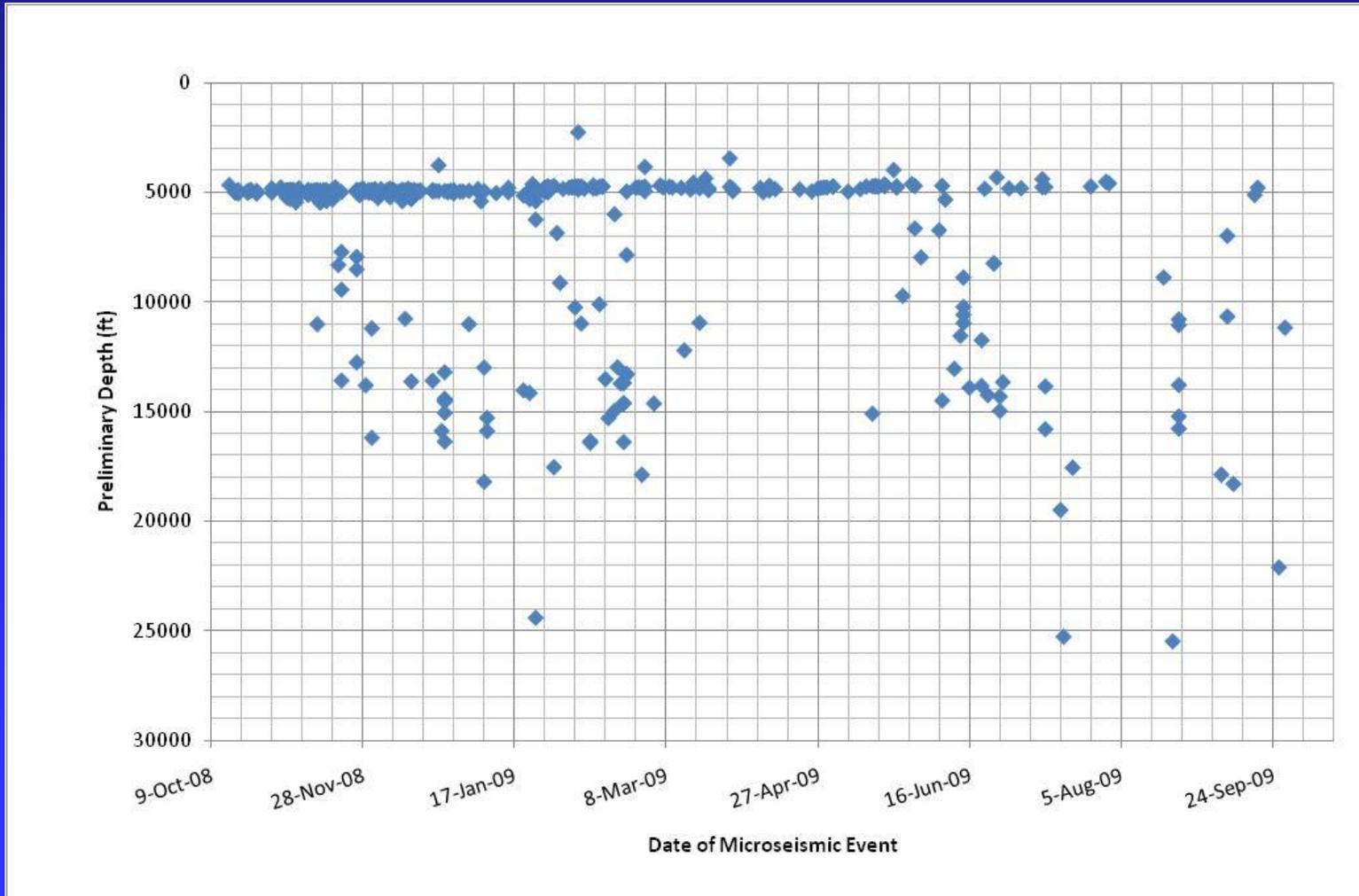
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Risk Assessment and Documentation Includes:

- Seal continuity and uncertainty;
- Existing well completion integrity (primarily cement);
- Seeps along faults;
- Natural seismicity (historical impact on O&G and gas storage operations in LA Basin);
- Induced seismicity (characterization of target sands, analog injection monitoring);
- Spill points, long-term permeation through caprock;

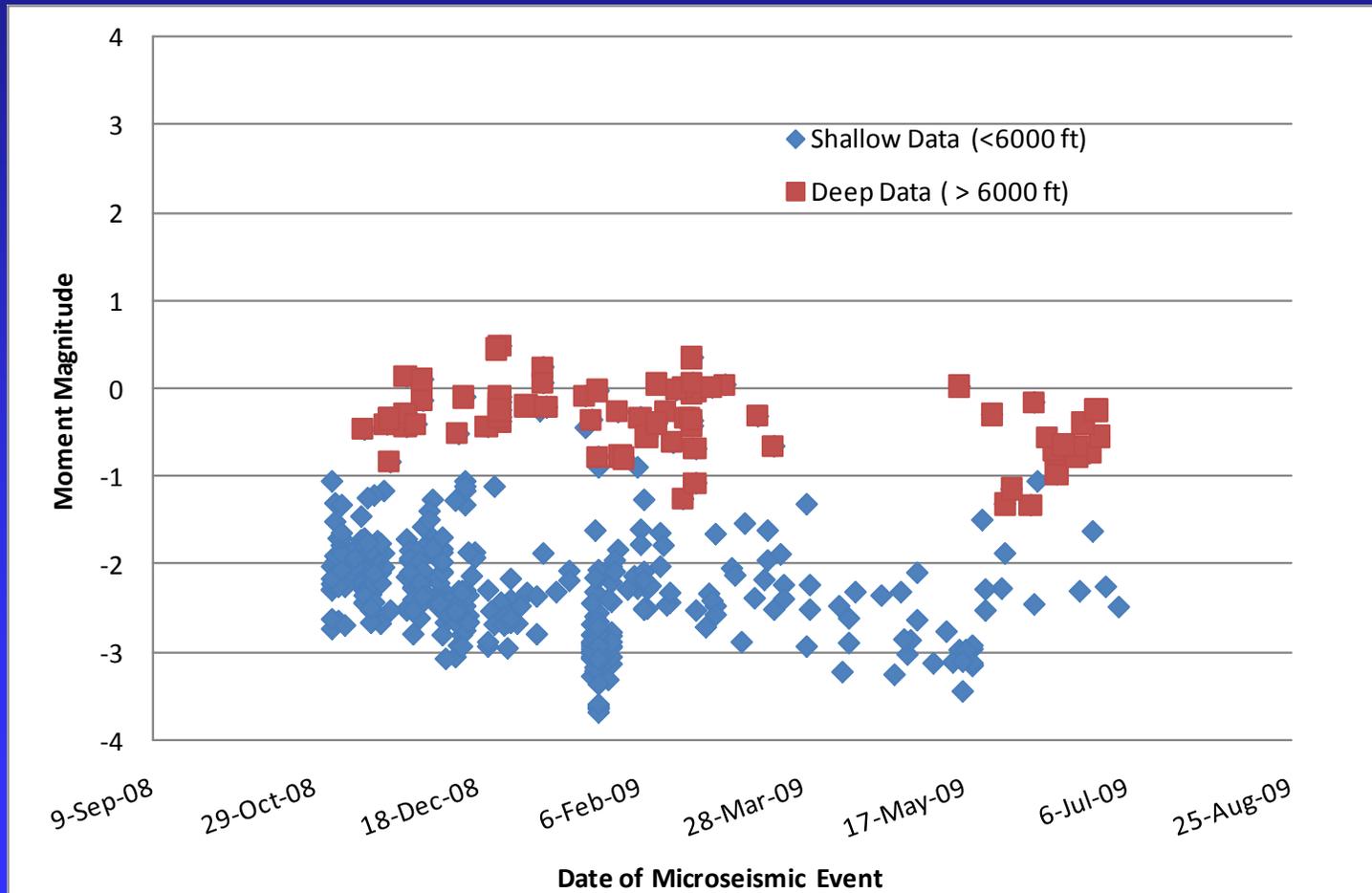


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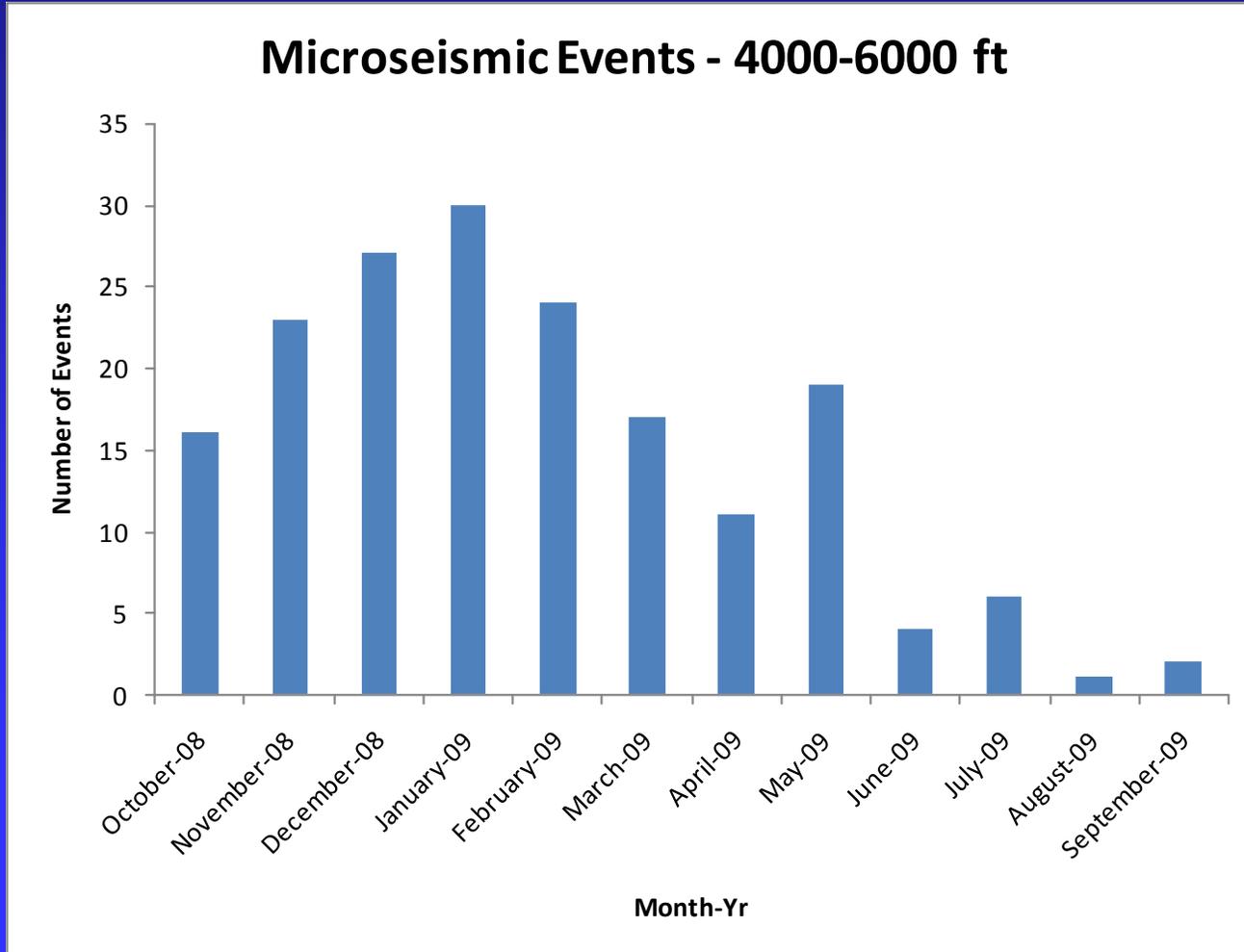


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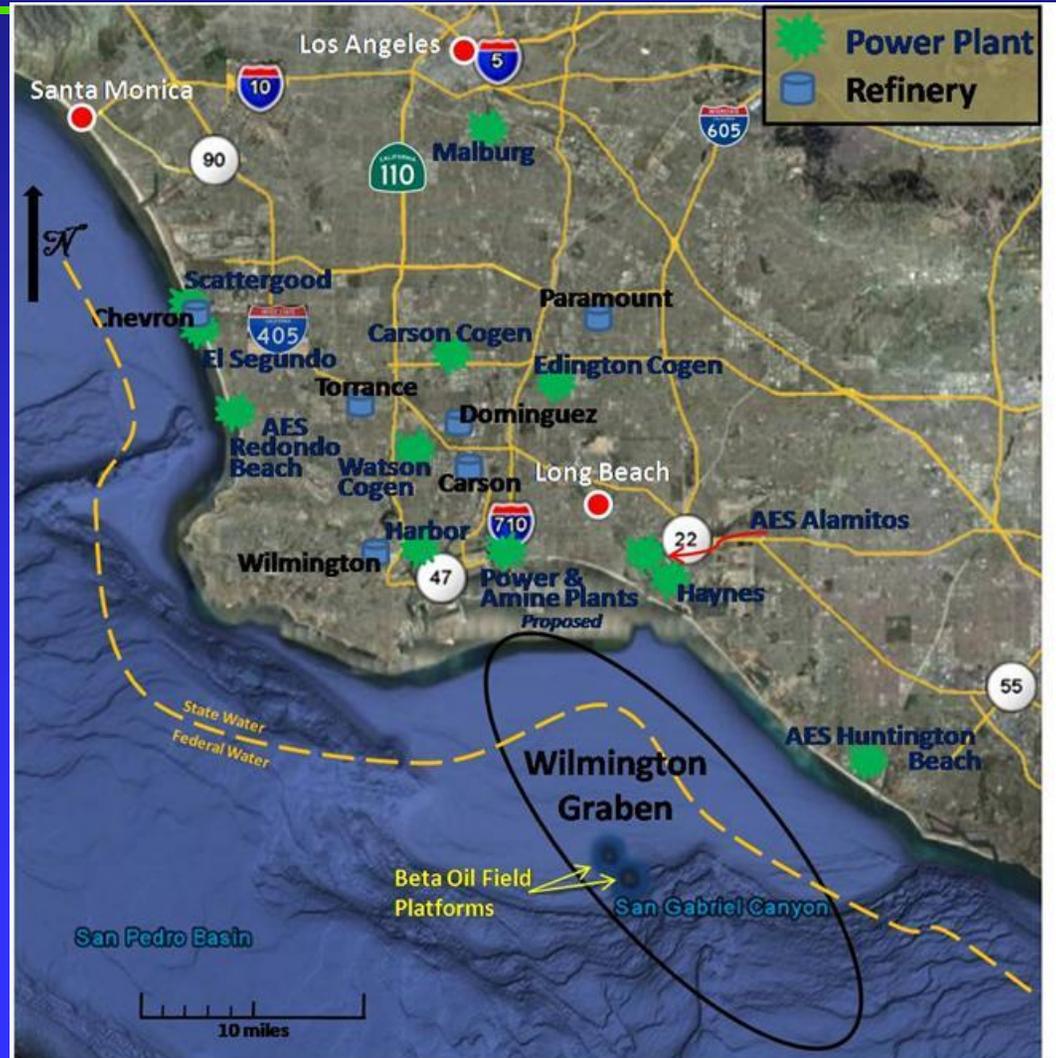
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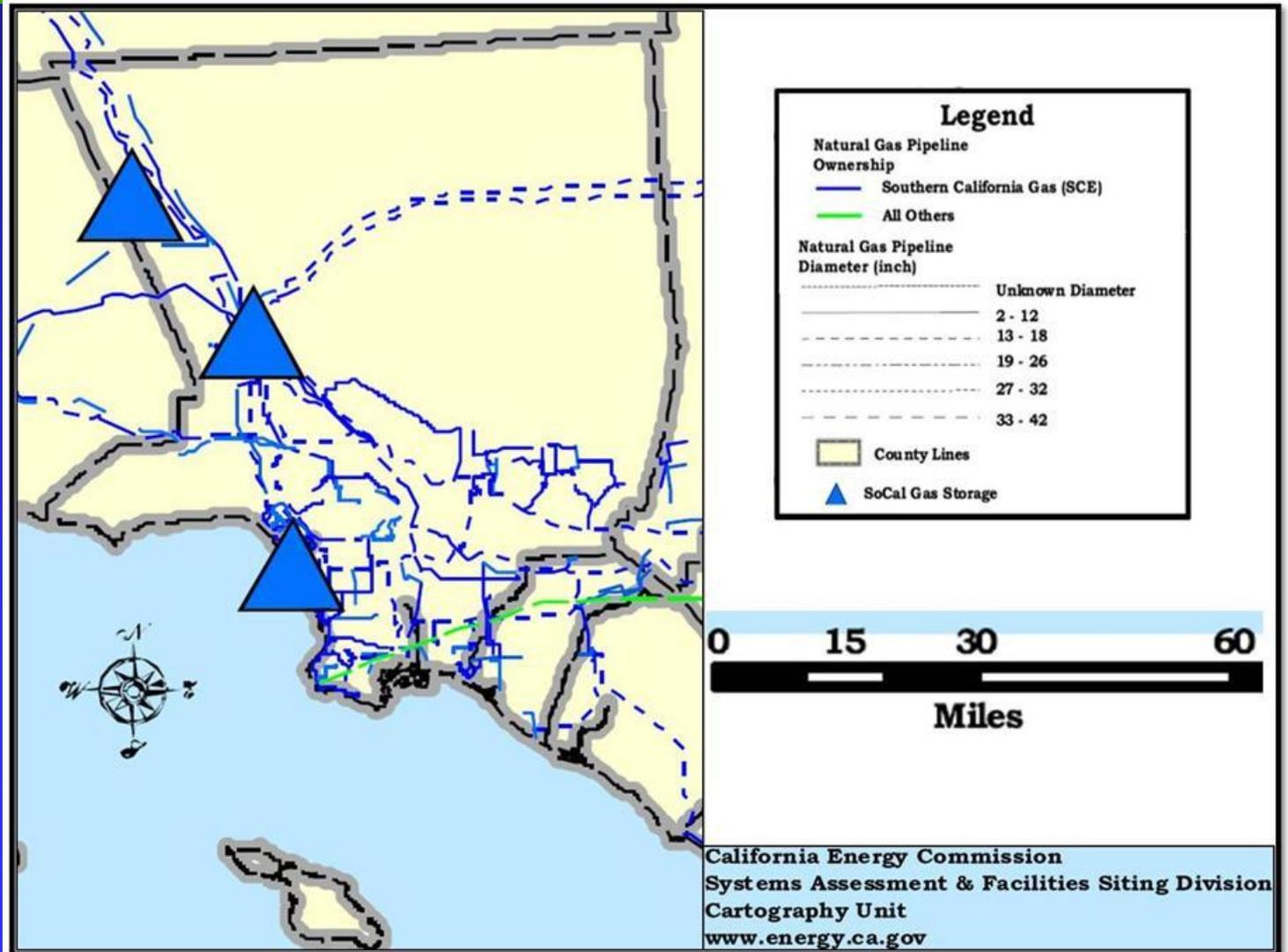
Industrial CO₂ Sources in LA Basin





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Existing Pipelines and Active Storage





Characterization of Wilmington Graben, Offshore Los Angeles, for Large Scale Geologic Storage of CO₂

- Acquired 175km of new seismic lines
- Drilled 1st characterization well into Pliocene
- Rock properties collected for Pliocene formation
- Preliminary structure maps constructed for 4 horizons
- Reviewed all exploratory wells and loaded into 3D Geologic Model (static and dynamic simulation)
- Initiated CO₂ migration modeling (TOUGH2) and geomechanical modeling (FLAC3D)
- Preliminary storage estimates >100MT



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Next Steps:

- Improve 3D geologic model, Oct-Dec 2010
- Additional seismic acquisition in 2011 to better define fault closure
- Additional characterization wells in 2011 and 2012
- Develop geomechanical model for northern and central areas
- Expand reservoir flow modeling (local and regional scale)
- Complete engineering studies of LA Basin sources and transportation systems
- Risk characterization and documentation