CO_2 Sequestration in Unmineable Coal with Enhanced Coal Bed Methane Recovery

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James E. Locke & Richard A. Winschel

CONSOL Energy Inc.

U.S. Department of Energy

National Energy Technology Laboratory
Carbon Storage R&D Project Review Meeting
Developing the Technologies and
Infrastructure for CCS

August 21, 2013

Presentation Outline

- **Benefit to the program**
- **Project overview**
- **Technical status**
- **Accomplishments**
- **Summary**
- **Appendix**

Benefit to the Program

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This project will demonstrate the effectiveness and the economics of carbon sequestration in an unmineable coal seam with enhanced coal bed methane (ECBM) production.

Project Overview:
Goals and Objectives

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- Demonstrate horizontal drilling in underground coal seams ✓
- Devise economical drilling strategies to maximize both CO_2 sequestration potential and CBM recovery, ✓
- Define effective CO_2 injection methods and procedures, ✓
- Measure the impact of CO_2 injection on CBM recovery,
- Monitor the CO_2 concentrations in the water and gas phases to determine the stability of sequestered CO_2 over an extended period of time, and
- Assess the overall economics of CO_2 sequestration ($/ton), including the co-benefit of methane production in coal seams.

Project Overview: Tasks

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20,000 short ton injection goal

- Examine effective methodology for injecting CO_2 gas into an unmineable coal seam
- Determine the impact of CO_2 injection on ECBM

Environmental Monitoring

- Deep well gas & produced water
- USDW zone monitoring well gas & water
- Residential drinking well water
- Stream water
- Soil gas, surface gas, & tracer gas monitoring

Geophysical Work

- Seismic surveys
- Cleat & fracture model development
- Reservoir modeling
- Tilt meter monitoring

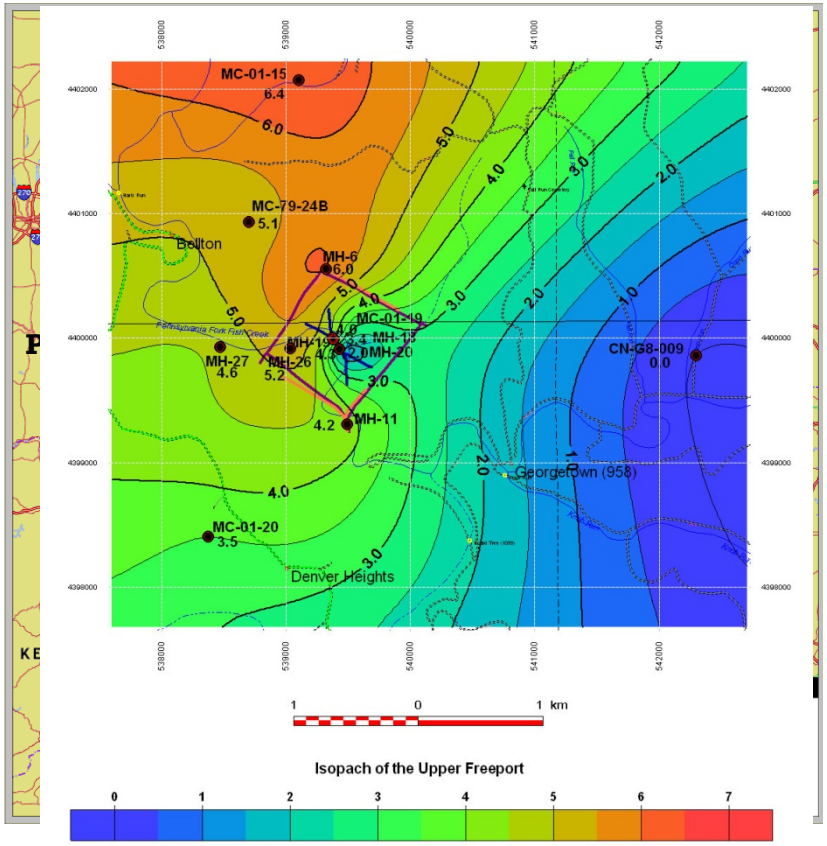
Technical Status: Background

Project Location

- Marshall County, West Virginia, USA

Target Formation

- Upper Freeport coal seam (1,200-1,800 ft deep)
  - 4-6 ft seam to the north & west
  - 1-2 ft seam to the south & east
- Pittsburgh coal seam overlying ~600 ft.



Technical Status: Timeline

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Technical Status: Site Layout

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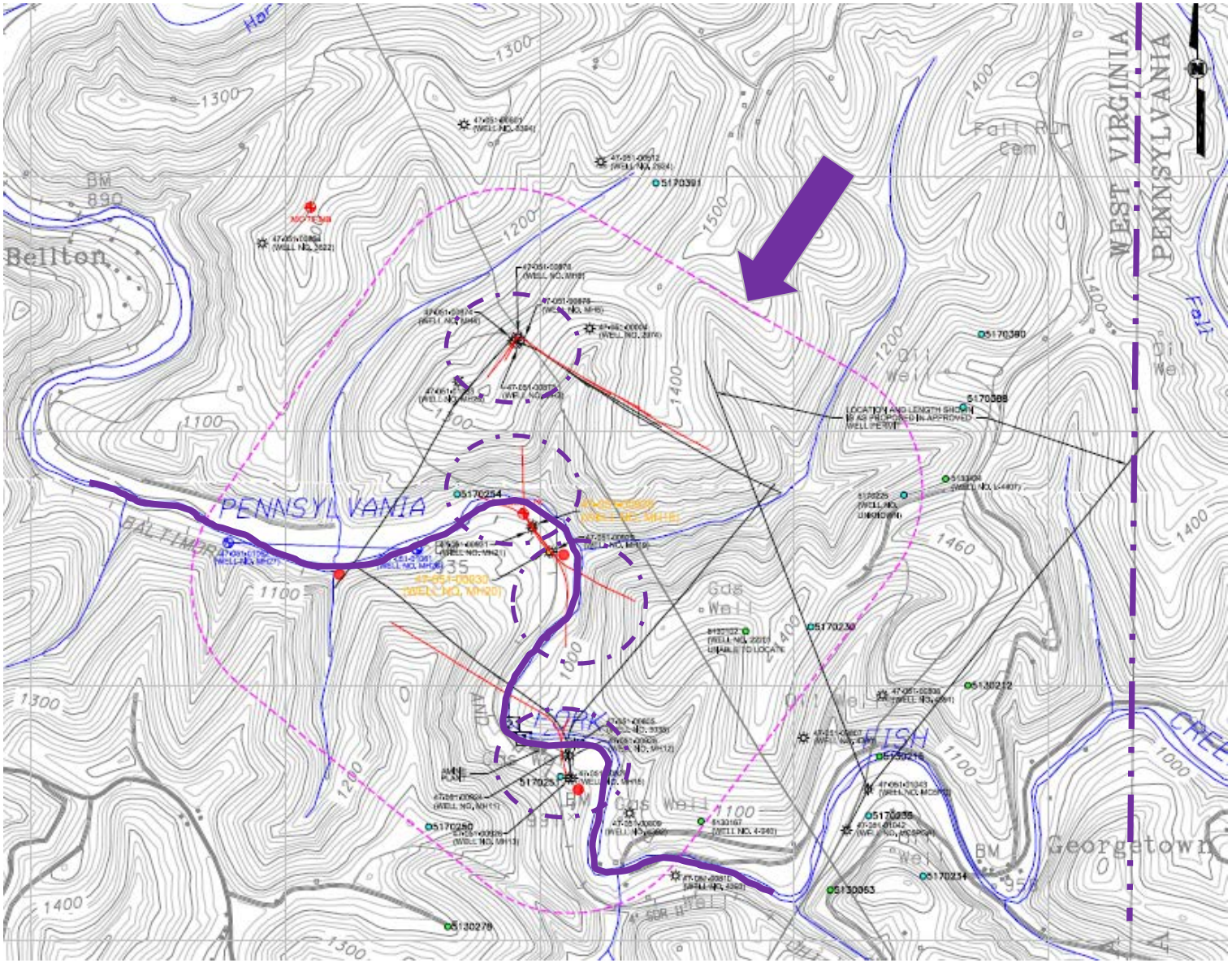

Technical Status: Injection

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Improved Pumping System Activities (2012 – Current)

- New injection pumping system installation and troubleshooting
- UIC permit modification – 1,400 psig
- UIC permit extension – Dec. 31, 2013
- Increased injection pressure operation
  - Step Rate Test: September 11, 2012 – Successful
  - Pressure limited injection (09/12/12 – 02/09/13)
    - MH-18: 1.3 tons per day @ 934 psig
    - MH-20: 4.9 tons per day @ 933 psig

Technical Status: Injection

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Improved Pumping System Activities (2012 – Current)

- Increased injection pressure operation
  - MH-20 shut-in tilt meter study
    - Started 02/09/13
    - Booster pump bearing failure on 02/12/13
      - Subsequent leak around shaft
      - Area pipeline rupture
    - Resumed tilt meter study on 06/24/13
    - MH-18 injection pressure decrease from ~1,350 psig to ~1,210 psig
    - MH-18 injection rate increase from ~13 tpd to ~16 tpd
    - Reopened MH-20 on 07/30/13: presently ~21 tpd, total at ~1,150 psig
    - Awaiting tilt meter results
- >4,300 short tons injected through July 31
- Anticipate ~7,000 short tons, project total (Dec. 31)

Technical Status: Injection

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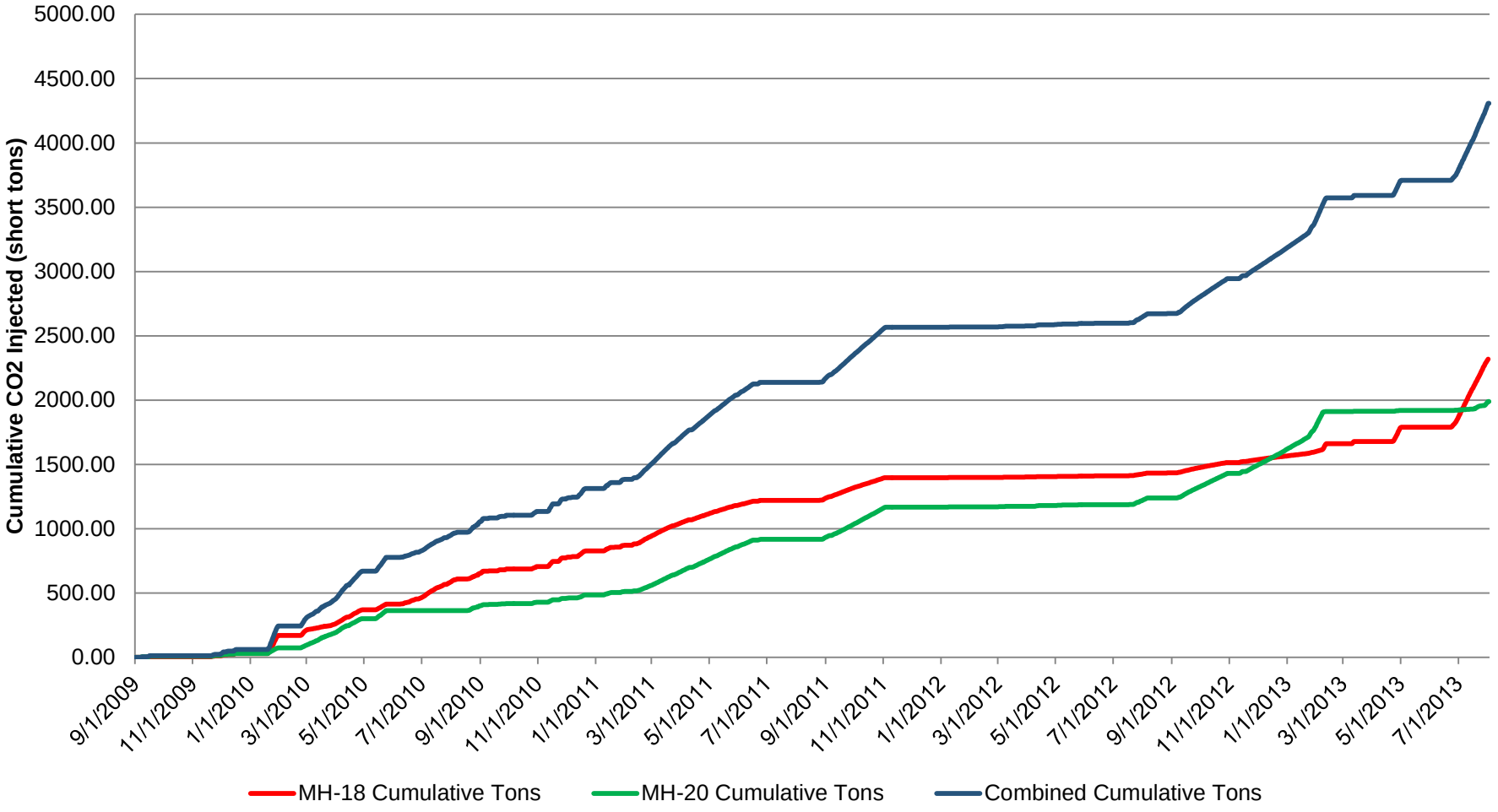
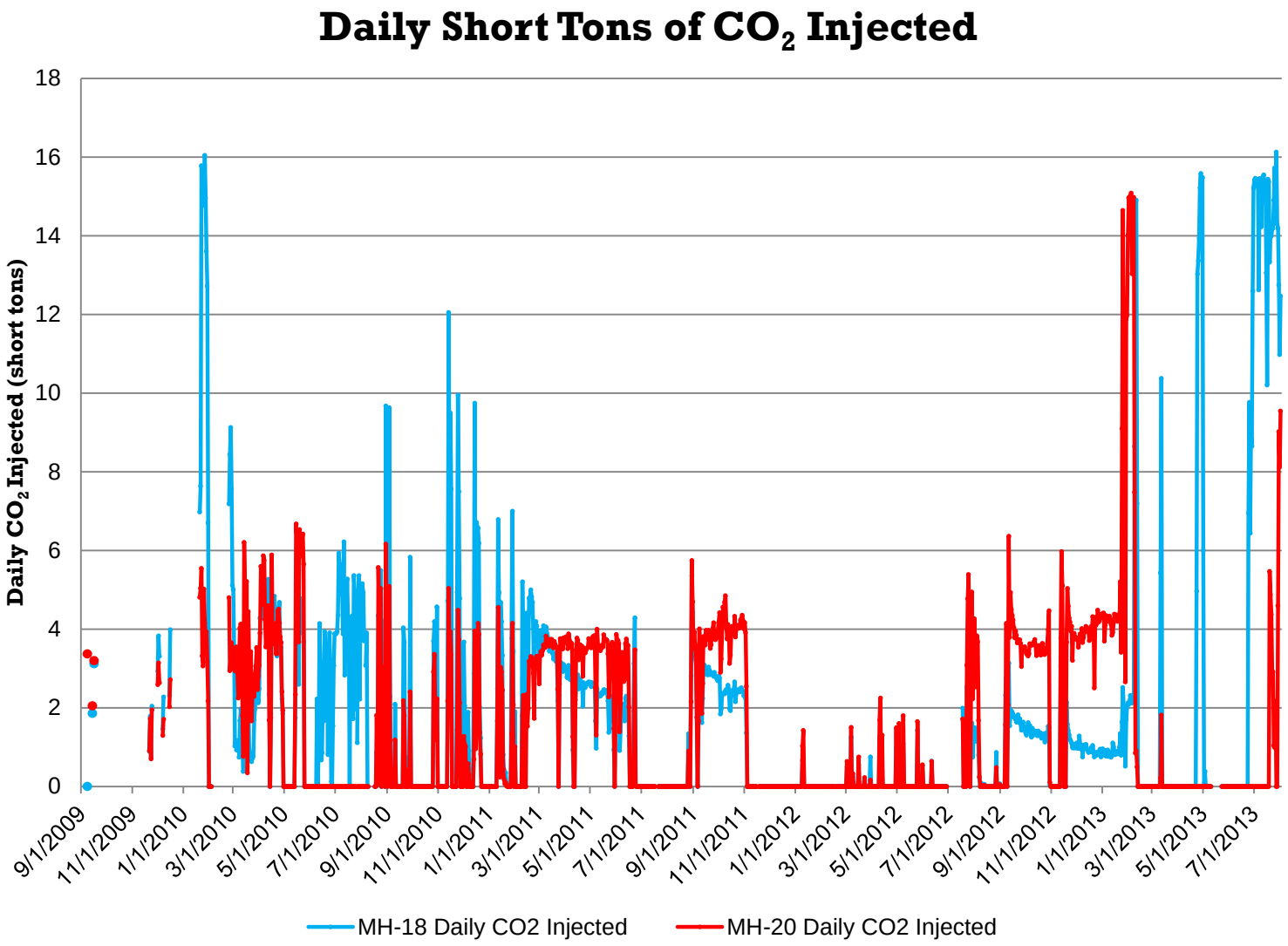
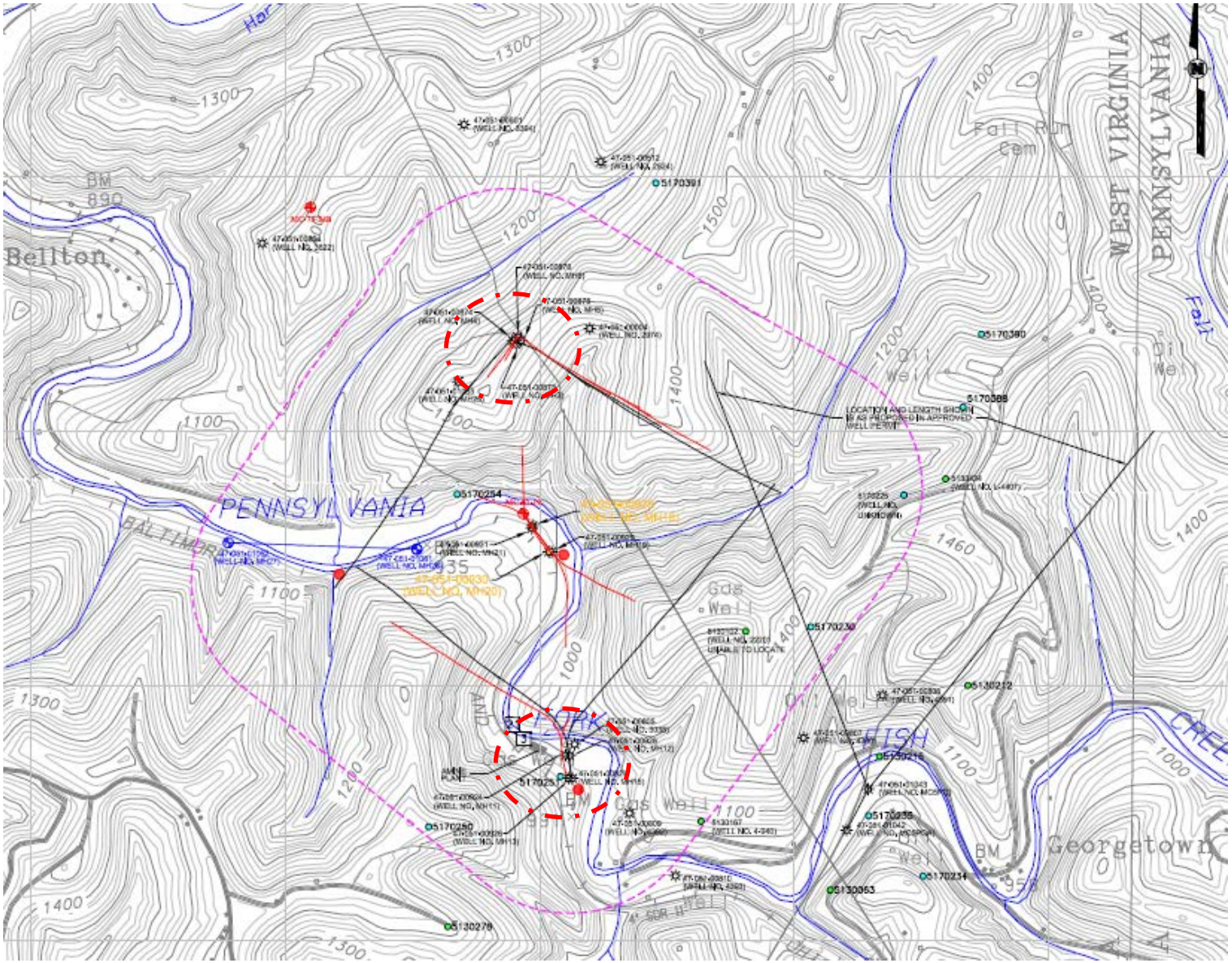
Daily Cumulative Tons of CO_2 Injected



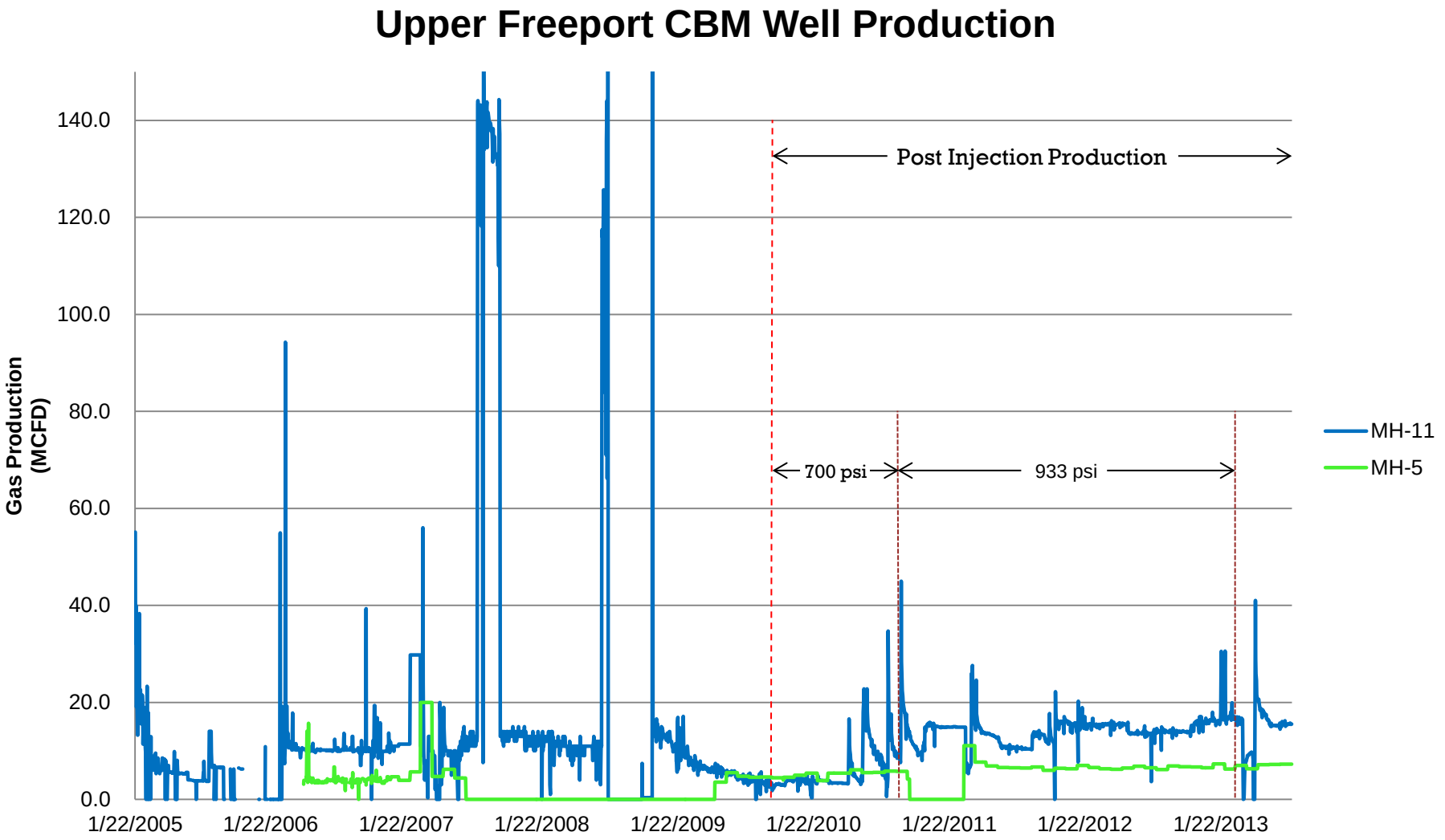
Technical Status: Injection



Technical Status: CBM Production



Technical Status: CBM Production



Technical Status: CBM Production

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Potential Gas Production Impact

New pump start-up: Sept. 12, 2012

Operation through Feb. 11, 2013:

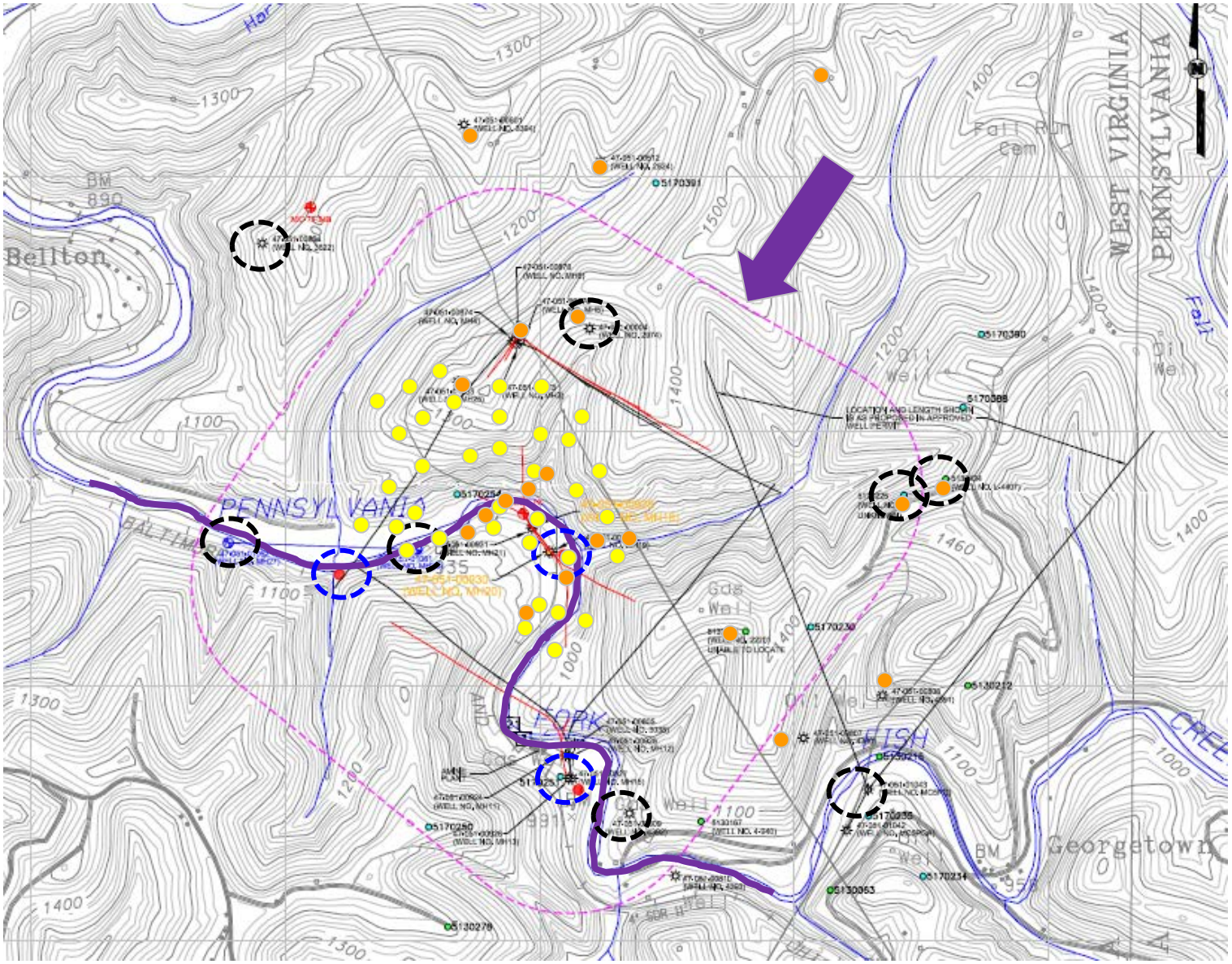
- 153 days
- 3,149 hrs
- 20.6 hr/day
- 801 tons CO2 injected

28% CBM production rate increase (Feb. vs. Sept. daily rate)

CBM Well MH-11

Month	Average Daily CBM Production (MCF)
August ('12)	13.9
September ('12)	13.9
October ('12)	13.9
November ('12)	15.4
December ('12)	16.4
January ('13)	17.5
February ('13)	17.8

Technical Status: Monitoring



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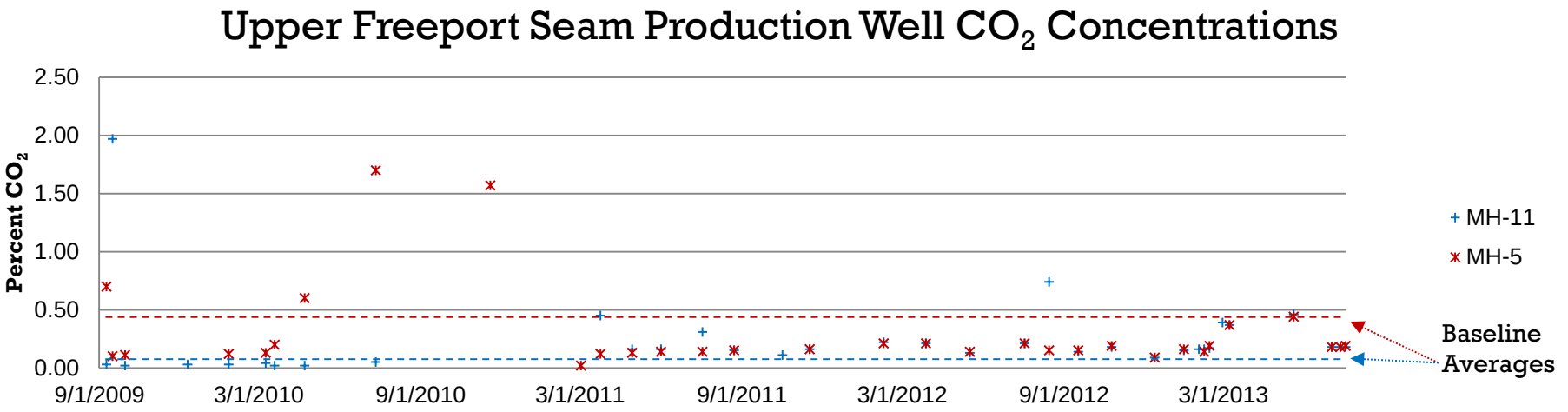

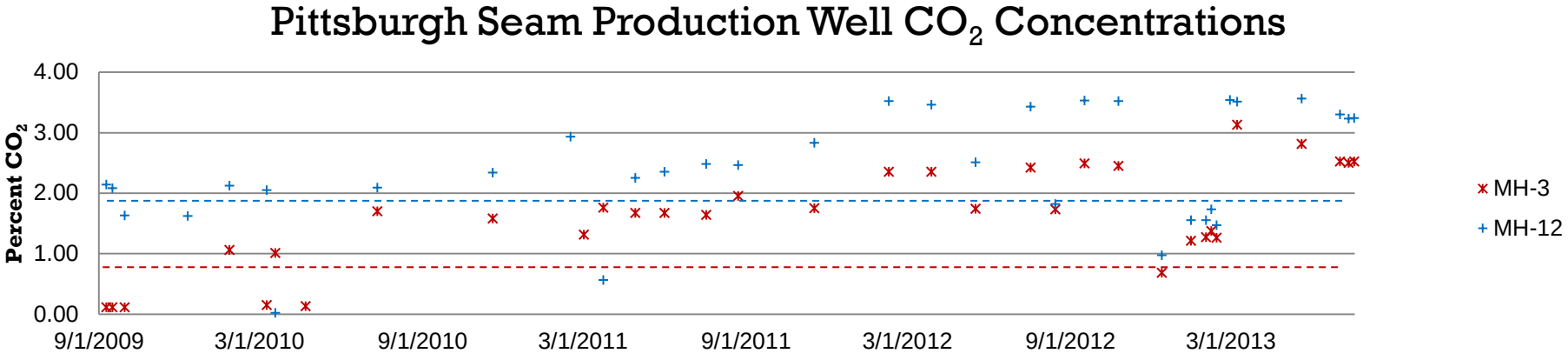

Technical Status: Monitoring

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AOR Gas Monitoring Results:

AOR Gas Wells

Well No.	% CO_2	SD
1588		
Baseline Average	0.31	0.04
Post injection average	0.41	0.14
Most recent value	0.35	
2974		
Baseline Average	0.70	0.05
Post injection average	1.22	0.50
Most recent value	1.54	
4407		
Baseline Average	0.79	0.05
Post injection average	0.54	0.27
Most recent value	0.35	
MC-5		
Baseline Average	2.82	0.38
Post injection average	3.31	0.83
Most recent value	4.36	

Aquifer-Zone Wells

Well No.	% CO_2	SD
WVU #1		
Baseline Average	0.05	0.02
Post injection average	0.09	0.06
Most recent value	0.12	
WVU #2		
Baseline Average	0.06	0.03
Post injection average	0.07	0.04
Most recent value	0.14	
WVU #3		
Baseline Average	0.05	0.01
Post injection average	0.20	0.18
Most recent value	0.44	

Upper Freeport Monitoring Wells

Well No.	% CO_2	SD
MH-26		
Baseline Average	0.20	0.27
Post injection average	0.06	0.07
Most recent value	0.02	
MH-27		
Baseline Average	0.53	0.72
Post injection average	0.09	0.04
Most recent value	0.08	

Accomplishments to Date

- > 4,300 tons CO_2 injected
- Injection studied at 700 psig, 933 psig, now at 1,400 psig limit
- Injection planned through YE2013
- No conclusive signs of plume migration
- Working closely with academia
- Provided a platform for Master's and Ph.D. research

Summary

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Key findings

- Increased "at-rest" formation pressure over time
- Injection rate consistency at higher pressure
- Evidence of ECBM production

Lessons learned

- Down-dip drilling not suitable for CBM wells
- Injection operations for vapor lock control

Future plans

- Examine CBM production impact
- NETL tracer injection evaluation
- Continue injection through December 2013
- Two years of post-injection monitoring

Acknowledgements

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Questions?

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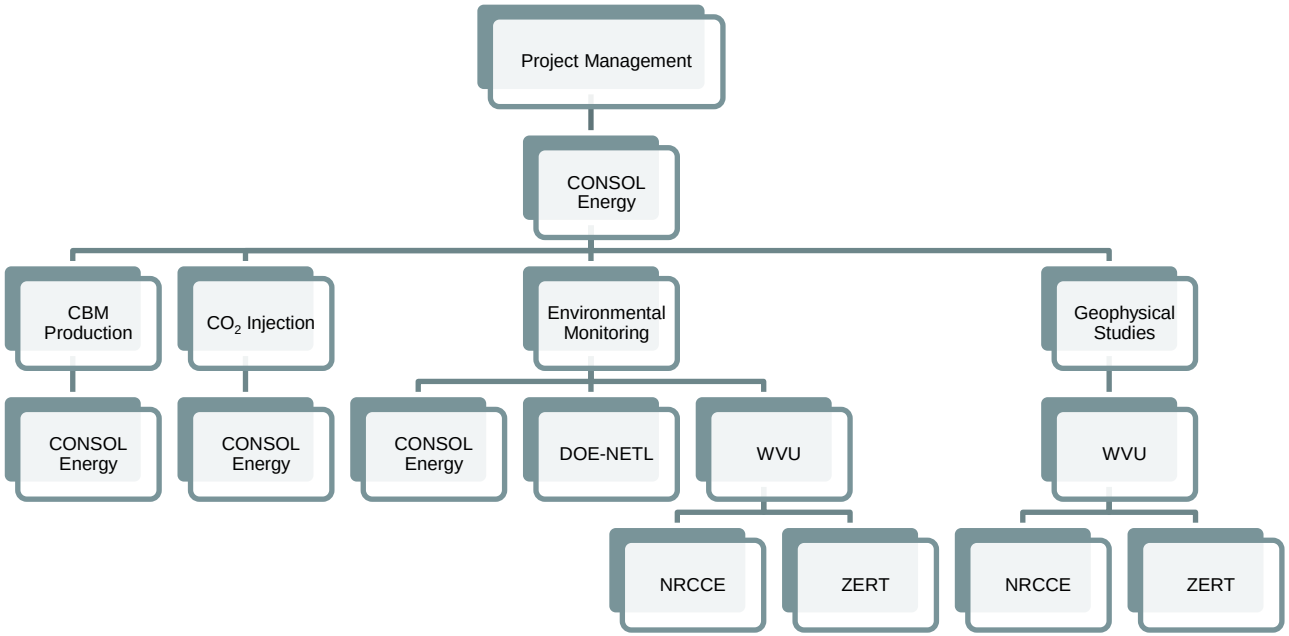
Appendix

Organization Chart



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