CO_2 Sequestration in Unmineable Coal with Enhanced Coal Bed Methane Recovery

DE-FC26-01NT41148

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U.S. Department of Energy

National Energy Technology Laboratory
Carbon Storage R&D Project Review Meeting
Developing the Technologies and
Infrastructure for CCS
August 12-14, 2014

August 12, 2014

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, ✓
- Define effective CO_2 injection methods and procedures, ✓
- Devise economical drilling strategies to maximize both CO_2 sequestration potential and CBM recovery, ✓
- 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 injection of CO_2 gas into an unmineable coal seam
- Determine the enhancement of CBM production from CO_2 injection

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

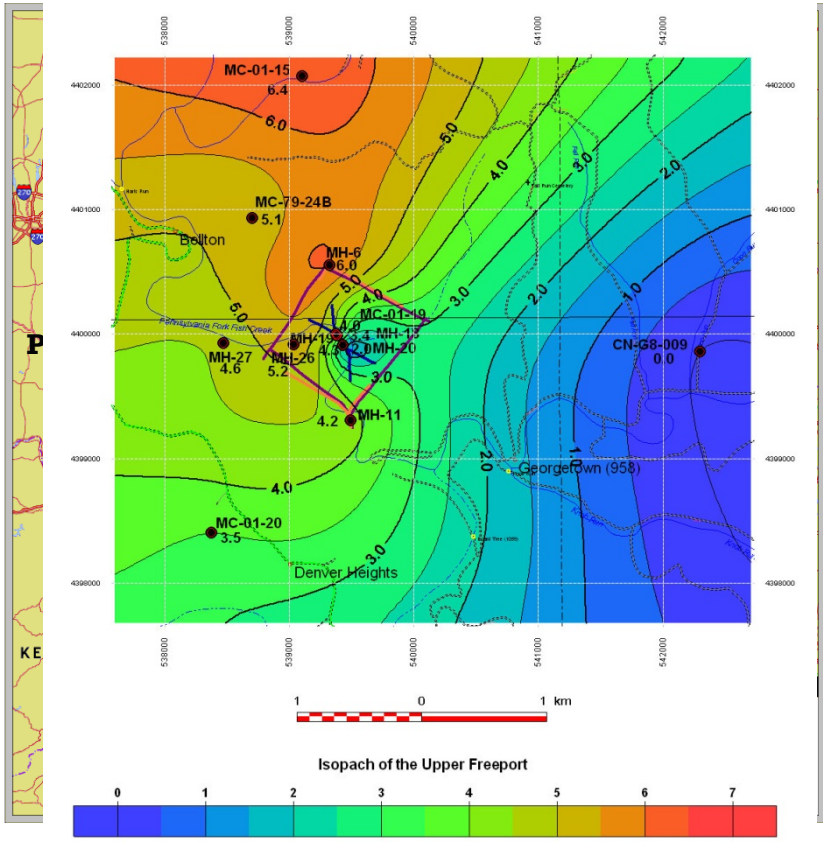
Technical Status: Background

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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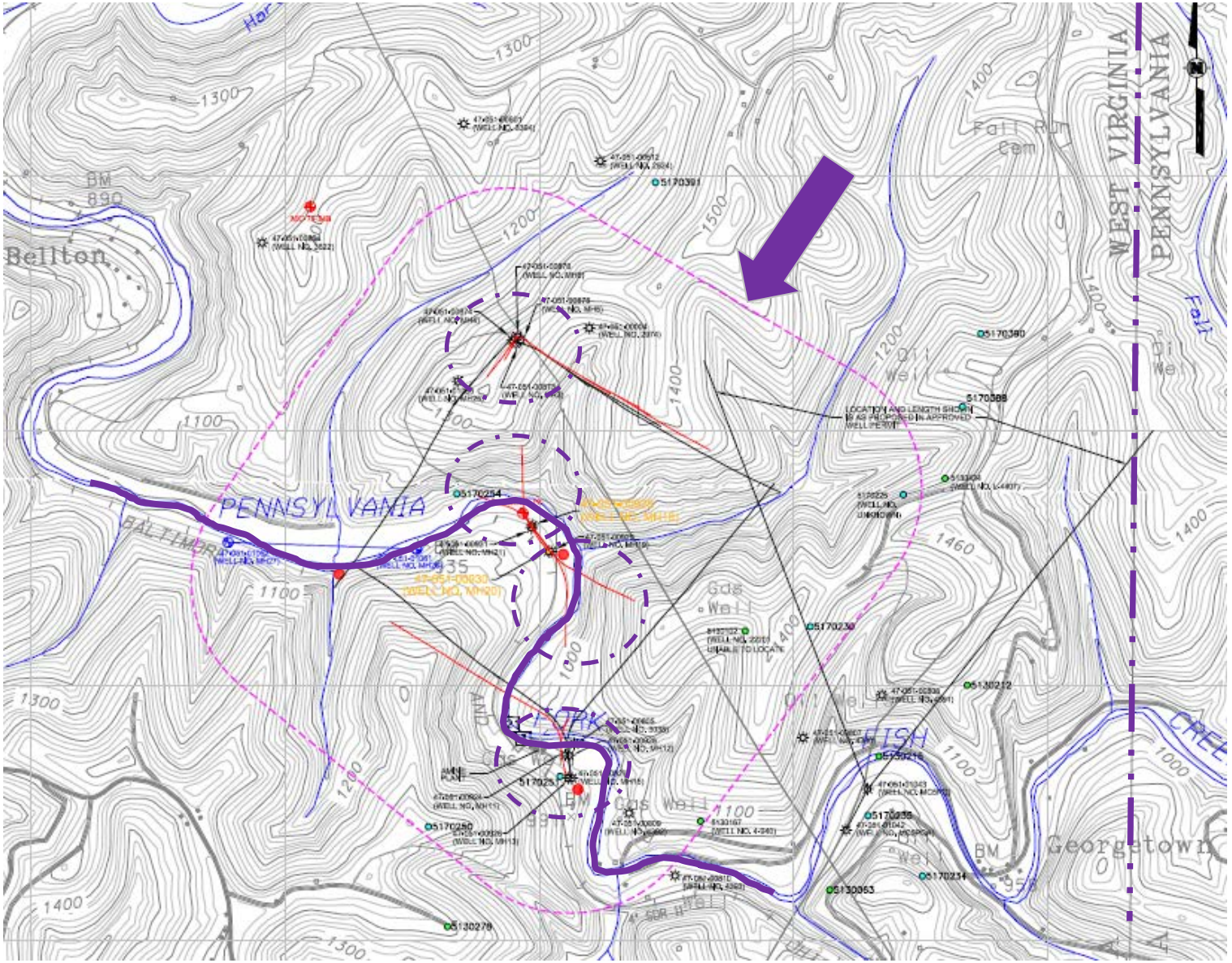

Technical Status: Injection

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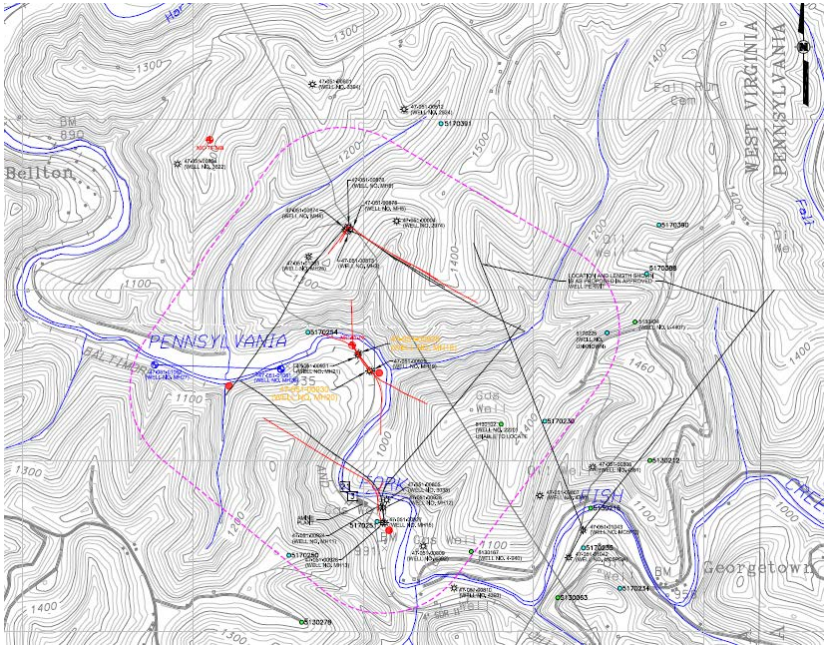
Injection Activities (2013 – Current)

- CO_2 injection (August 2013)
  - MH-18
    - 9.25 tons CO_2 per day
    - Max flow
    - 1,118 psig (avg)
  - MH-20
    - 8.41 tons CO_2 per day
    - Restricted
    - 981 psig (avg)
- MH-11 CO_2 breakthrough
  - Typical MH-11 CBM production: ~15 mcfd
  - 08/22/13 (last meeting): MH-11 CBM production increase to ~18 mcfd
  - 09/01/13
    - CBM production at ~25 mcfd
    - CO_2 concentration reported at 8.2%
  - 09/04/13: MH-11 CBM CO_2 = 21.8%
    - Immediate shutdown
    - WVDEP notification
    - Increased monitoring frequency



Technical Status: Injection

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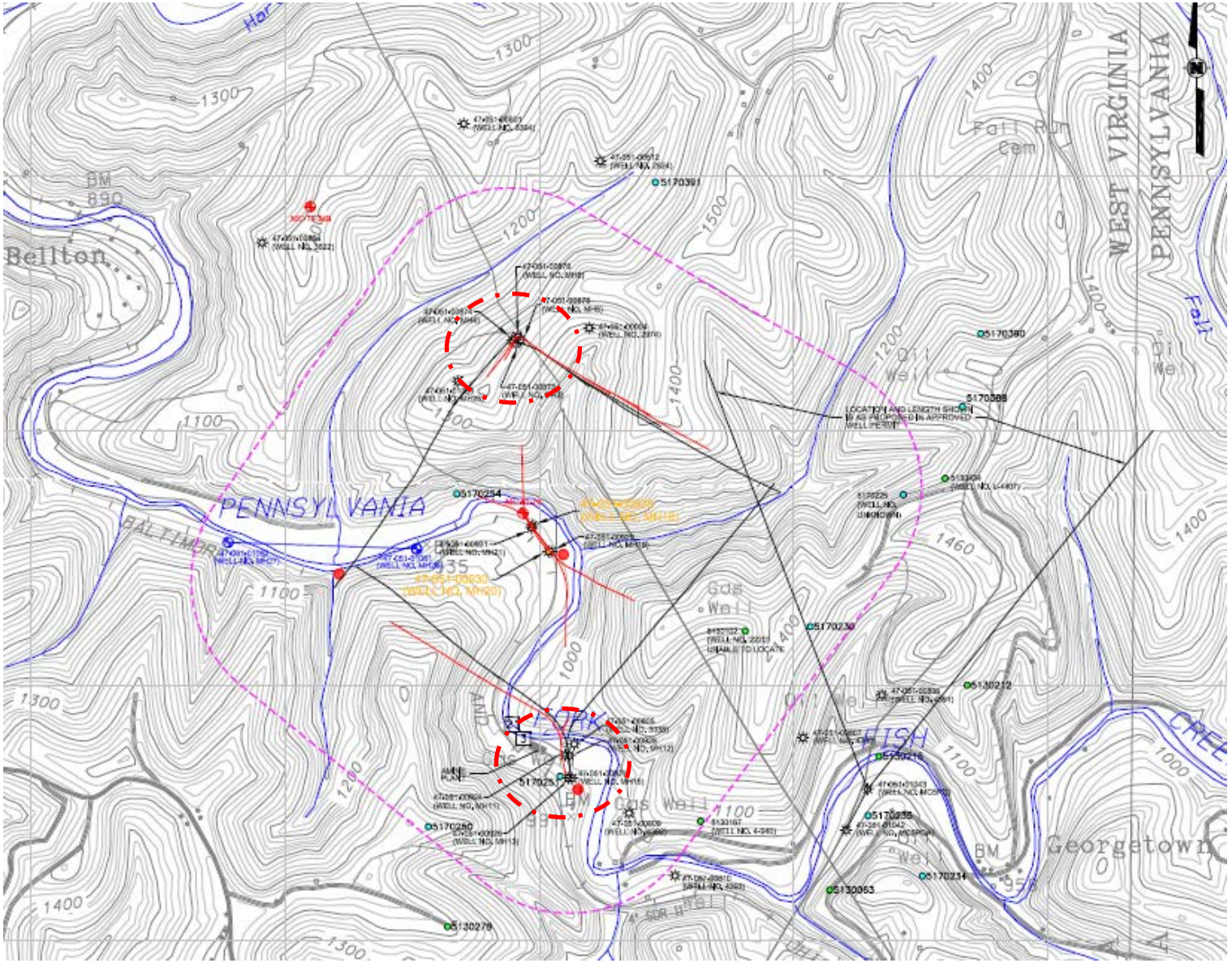
Injection Activities (2013 – Current)

- MH-11 CO_2 breakthrough cont.
  - Resumed injection to the north on 10/24/14
  - Pump failure on 11/01/14
- UIC permit expiration – Dec. 31, 2013
- 4,968 short tons CO_2 injected
- Site reclamation

Technical Status: CBM Production



Technical Status: CBM Production

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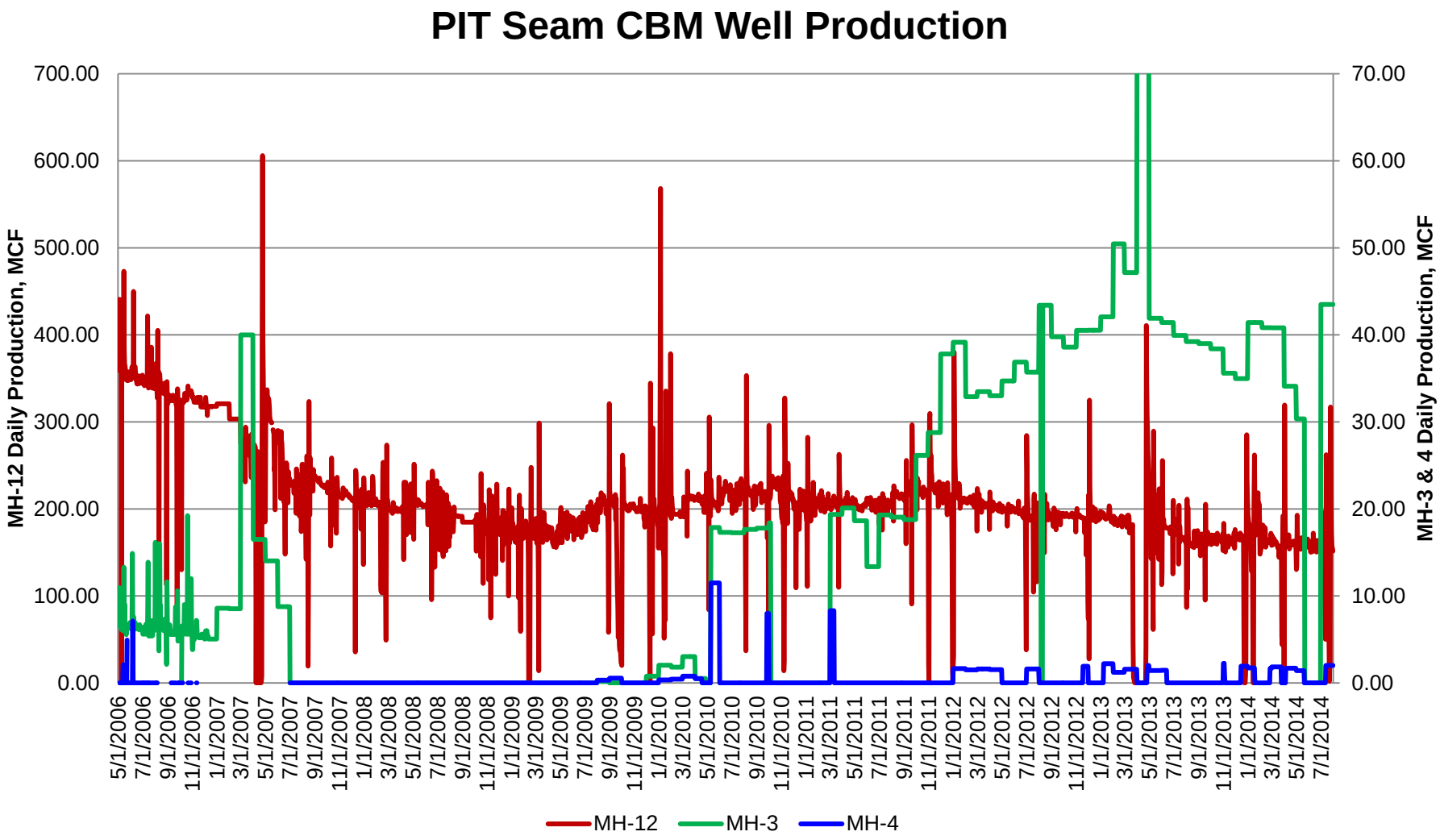
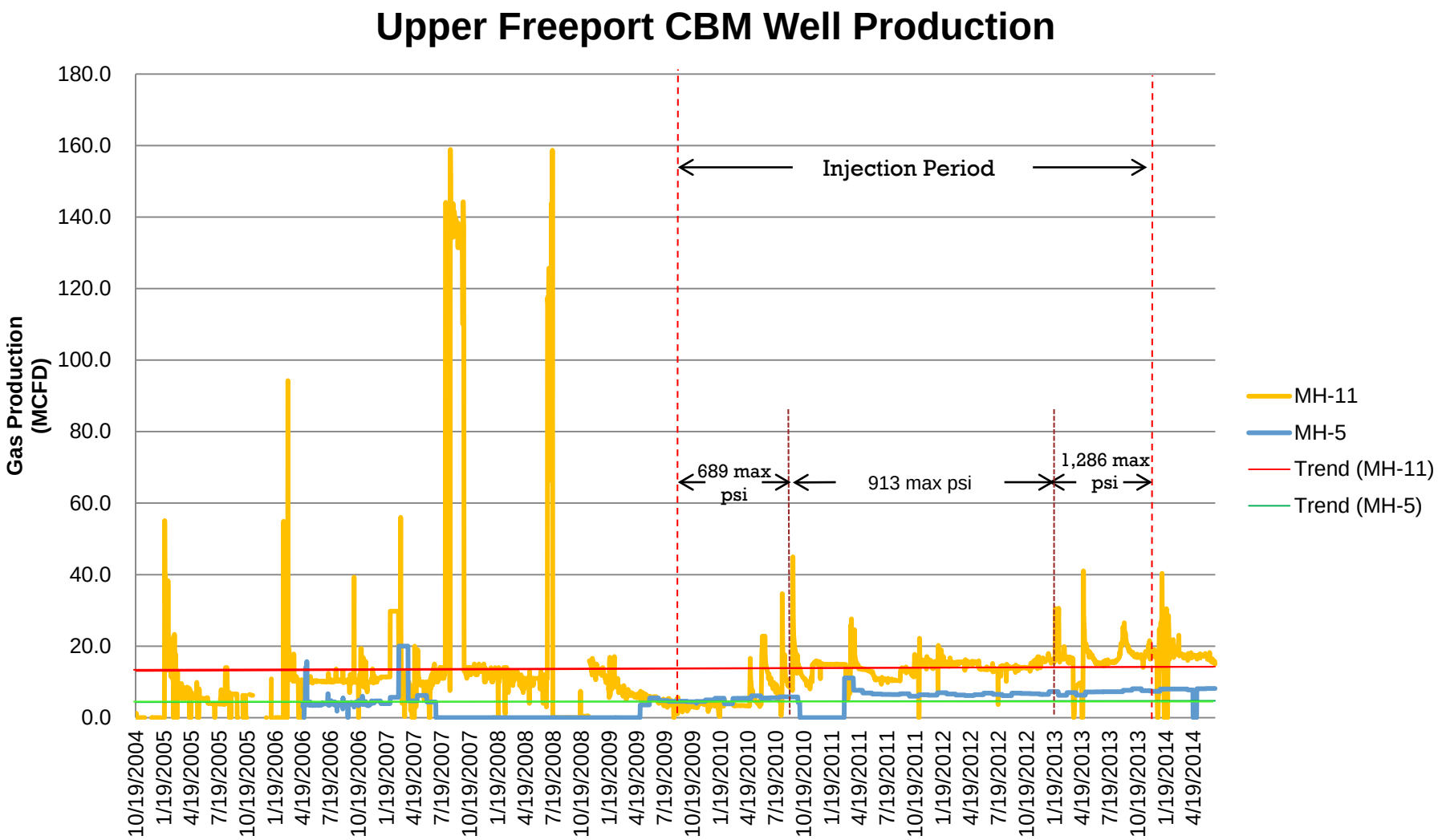


Technical Status: CBM Production



Technical Status: CBM Production

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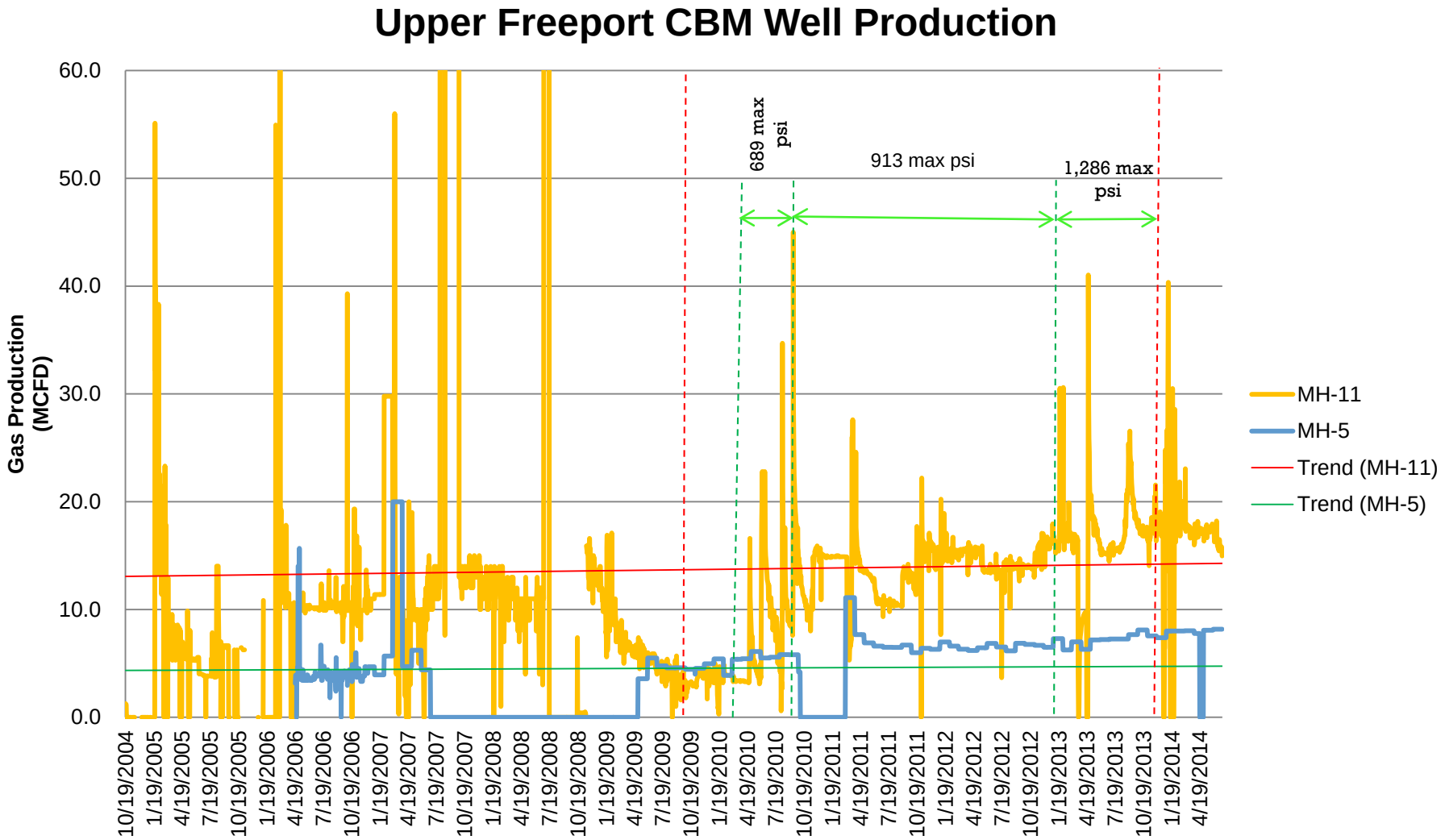
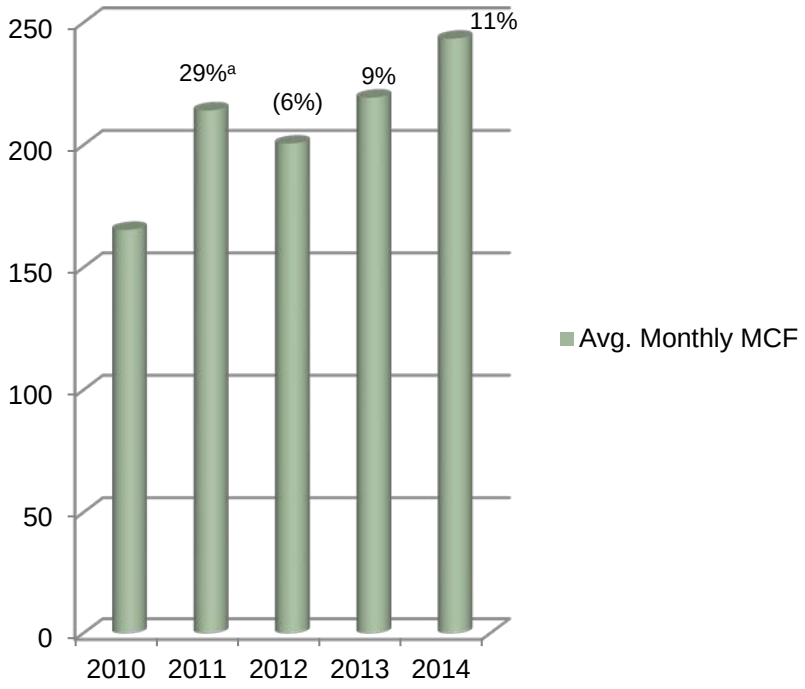
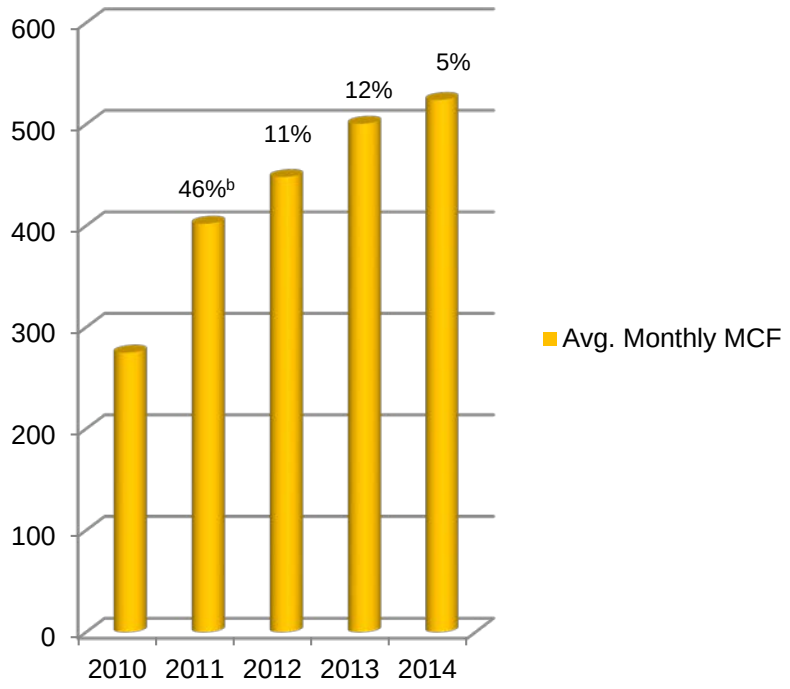


Technical Status: CBM Production

MH-5 Production

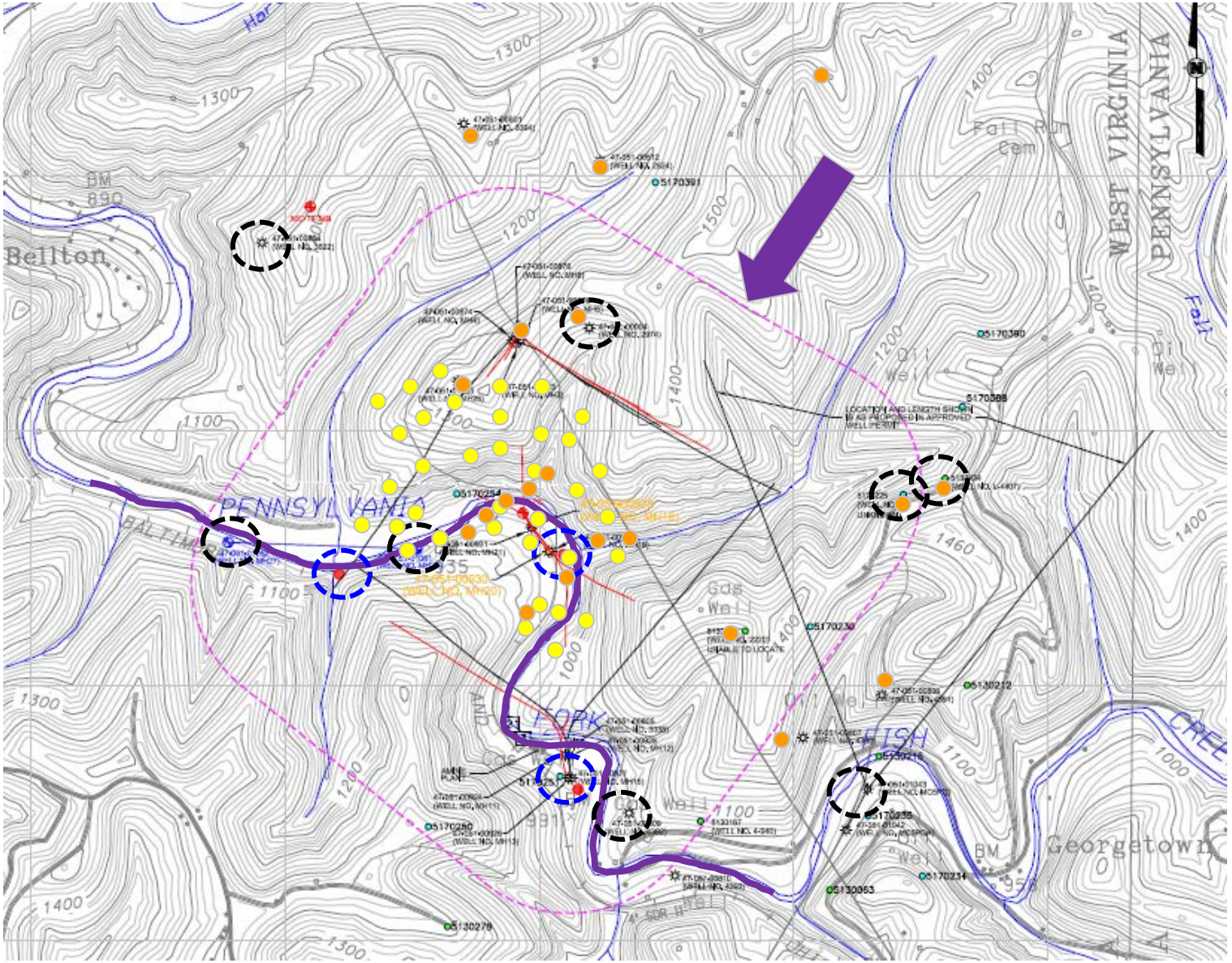


MH-11 Production



a – biased high due to 330 mcf production in March, following 5 month shut-in
b – dewatering routine improvements resulted in greater production YOY 2010/2011

Technical Status: Monitoring



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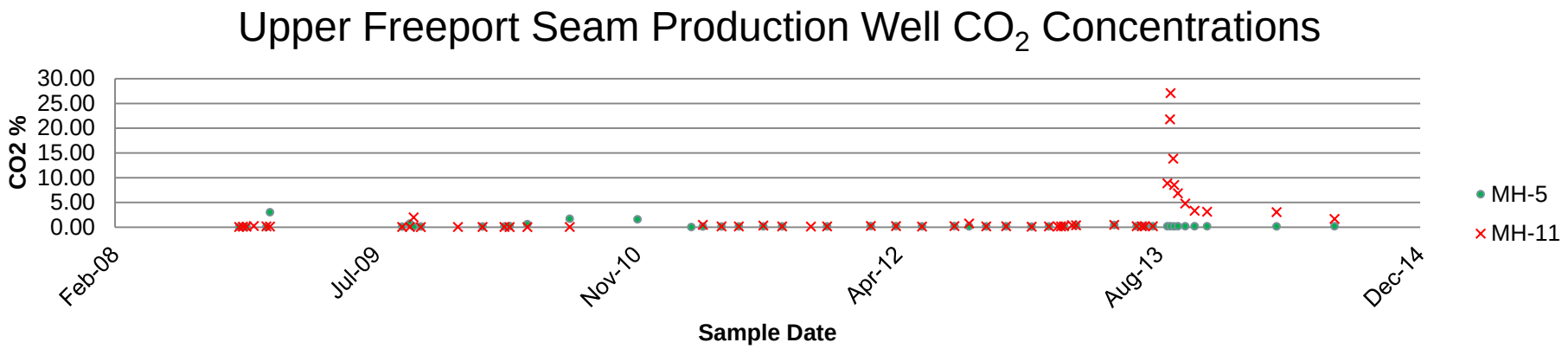

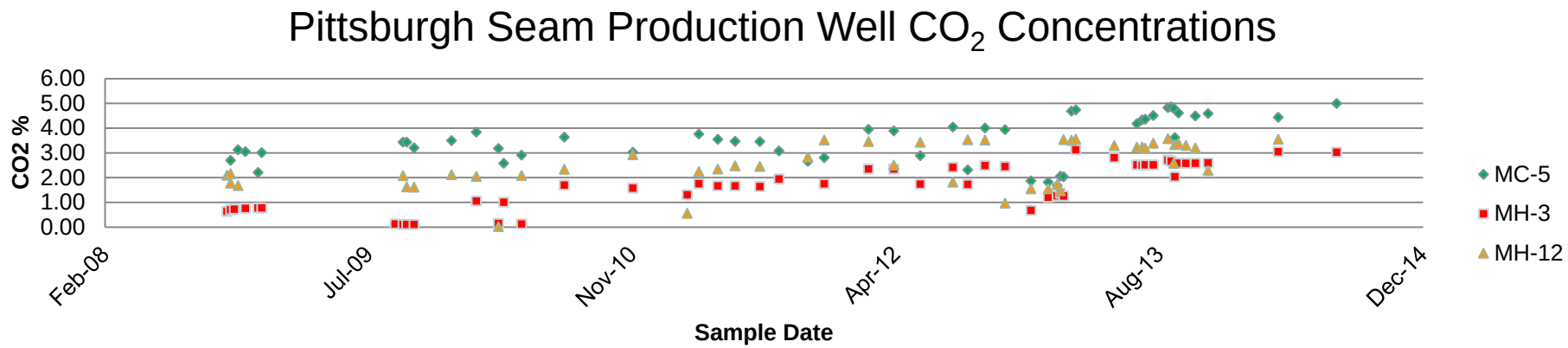

Technical Status: Monitoring

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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	0.40	0.13
Most recent value	0.28	
2974		
Baseline Average	0.70	0.05
Post injection average	1.32	0.53
Most recent value	2.21	
4407		
Baseline Average	0.79	0.05
Post injection average	0.52	0.25
Most recent value	0.32	
MC-5		
Baseline Average	2.82	0.38
Post injection average	3.59	0.92
Most recent value	5.00	

Aquifer-Zone Wells

Well No.	% CO_2	SD
WVU #1		
Baseline Average	0.05	0.02
Post injection average	0.10	0.07
Most recent value	0.00	
WVU #2		
Baseline Average	0.06	0.03
Post injection average	0.08	0.04
Most recent value	0.11	
WVU #3		
Baseline Average	0.05	0.01
Post injection average	0.21	0.17
Most recent value	0.18	

Upper Freeport Monitoring Wells

Well No.	% CO_2	SD
MH-26		
Baseline Average	0.20	0.27
Post injection average	0.05	0.06
Most recent value	0.04	
MH-27		
Baseline Average	0.53	0.72
Post injection average	0.09	0.04
Most recent value	0.09	

Accomplishments Since Previous Meeting

- 4,968 tons CO_2 injected
- Achieved 1,286 psig injection
- Completed injection YE2013
- Clear evidence of ECBM
- Established/maintained an extensive monitoring network
- Continued close work with academia
- Provided a platform for Master's and Ph.D. research

Summary

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Key findings

- Clear breakthrough episode
- No evidence of CO_2 migration through AOR
- Enhanced CBM production linked to CO_2 injection

Lessons learned

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

Future plans

- Continue observation of CBM production
- NETL tracer injection evaluation
- Post-injection monitoring (through 2015)

Acknowledgements

Environmental monitoring, geophysical work, data review, soil and tracer gas sampling and analysis.

Funding provided in part by the U. S. Dept. of Energy under Cooperative Agreements No. DE-FC26-01NT41148 and No. DE-FC26-04NT42262

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Questions?

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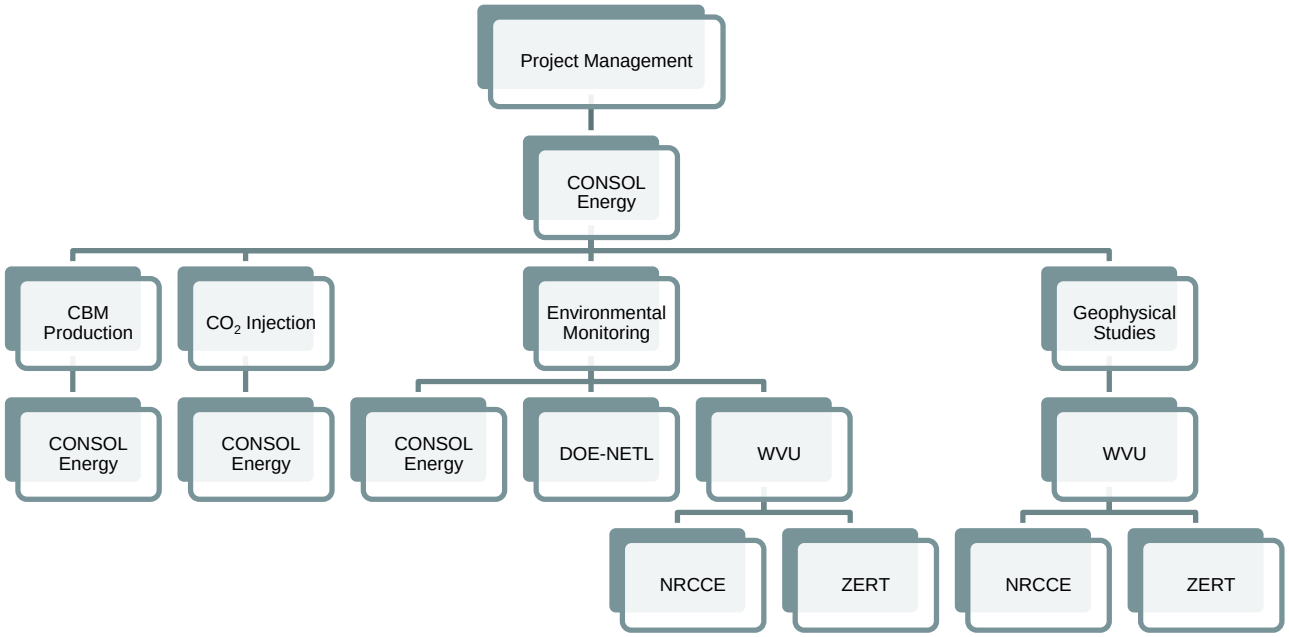
Appendix

Organization Chart



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Wilson, T. H.; Tallman, J.; Rauch, H.; Wells, A.; Smith, D.; 2003, Reconnaissance Studies of a Pilot Carbon Sequestration Site in the Central Appalachians of West Virginia, Northeastern Geology & Environmental Sciences, v. 25, no. 4, p. 330-345.