



Midwest Geological  
Sequestration Consortium

# Midwest Geological Sequestration Consortium Update

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University of Illinois - Illinois State Geological Survey  
Addressing the Nation's Energy Needs through Technology Innovation  
28 August 2019 – Pittsburgh, PA





Research and Capacity Building in Capture, Utilization, and Storage

Biphasic Solvents

Large-scale post-combustion testing

Utilizing CO<sub>2</sub> from Coal-Fired  
Power Plants (algae)

Water Conservation at Power Plants

Reducing Amine-Based Aerosol Formation

Illinois Basin - Decatur Project

Illinois Industrial Sources Project

CarbonSAFE Illinois - East Basin

CarbonSAFE Illinois - Macon/Christian

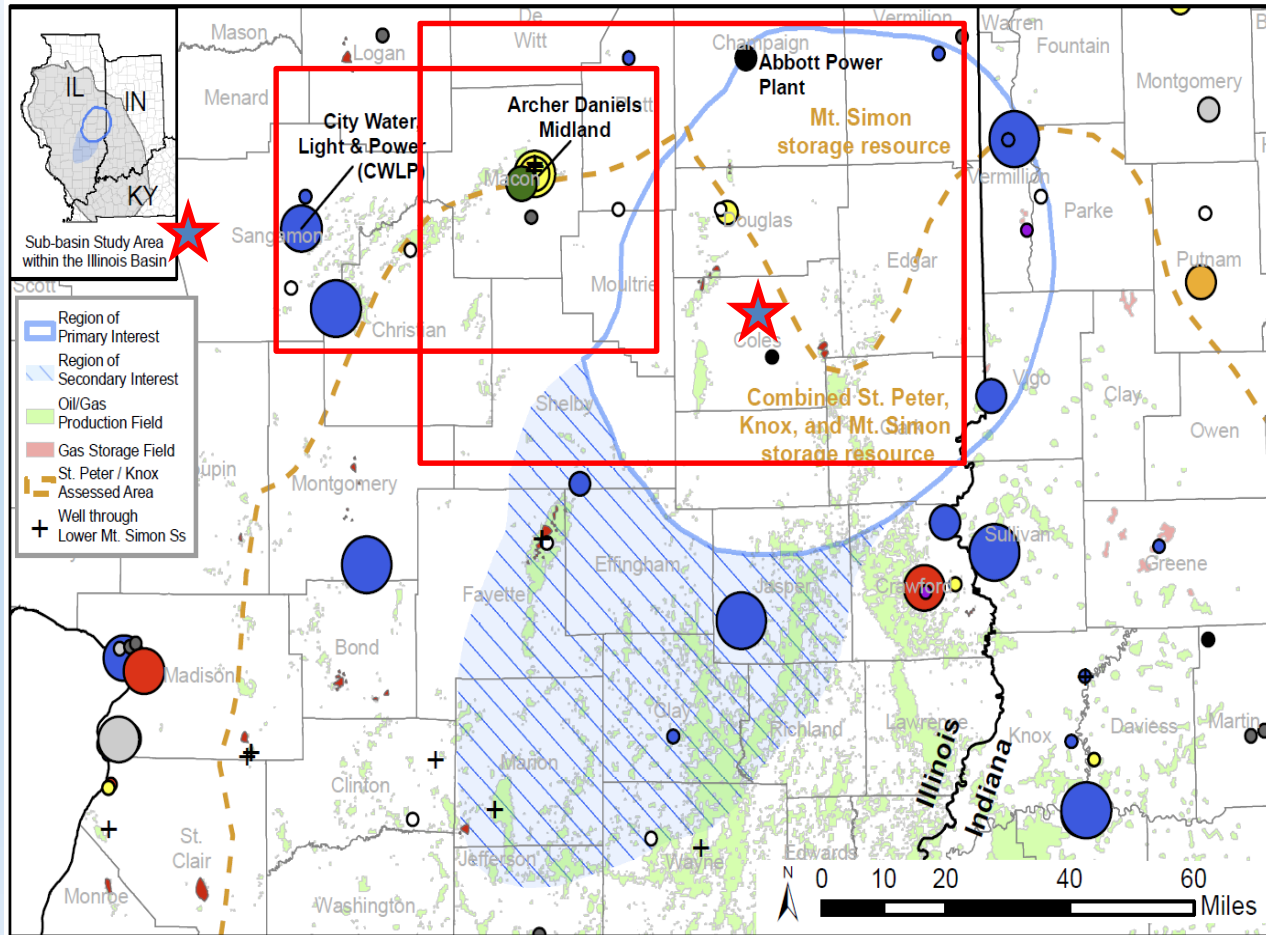
CarbonSAFE - Wabash

Cypress - ROZ

GSCO2 - EFRC

State of Stress/Induced Seismicity

# Carbon Capture and Storage Projects in the Illinois Basin



# Current CCUS Projects in Decatur, IL USA



## Illinois Basin – Decatur Project

- Large-scale demonstration
- Volume: 1 million tonnes
- Injection period: 3 years
- Injection rate: 1,000 tonnes/d
- Compression capacity: 1,100 tonnes/day

### Contribution:

- Geologic and Social Site Characterization
- Reservoir Modeling and Risk Assessment
- MVA Development and Engineering Design
- Stakeholder Engagement

### Status:

- Post-injection monitoring ends April 2020
- Conceptual site model and history matching

## Illinois Industrial CCS Project



- Industrial-scale demonstration
- Volume: up to 5 million tonnes
- Injection period: 3 years (or longer)
- Injection rate: 3,000 tons/d
- Compression capacity: 2,200 tonnes/day

### Contribution:

- Commercial-scale up surface and subsurface
- Intelligent Monitoring
- Class VI permitting

### Status:

- Injection Began April 7, 2017
- Optimization of capture process
- 1,312,583 (as of August 22, 2019)



Establishing  
Injectivity,  
Containment, and  
Capacity

Illinois Basin -  
Decatur Project

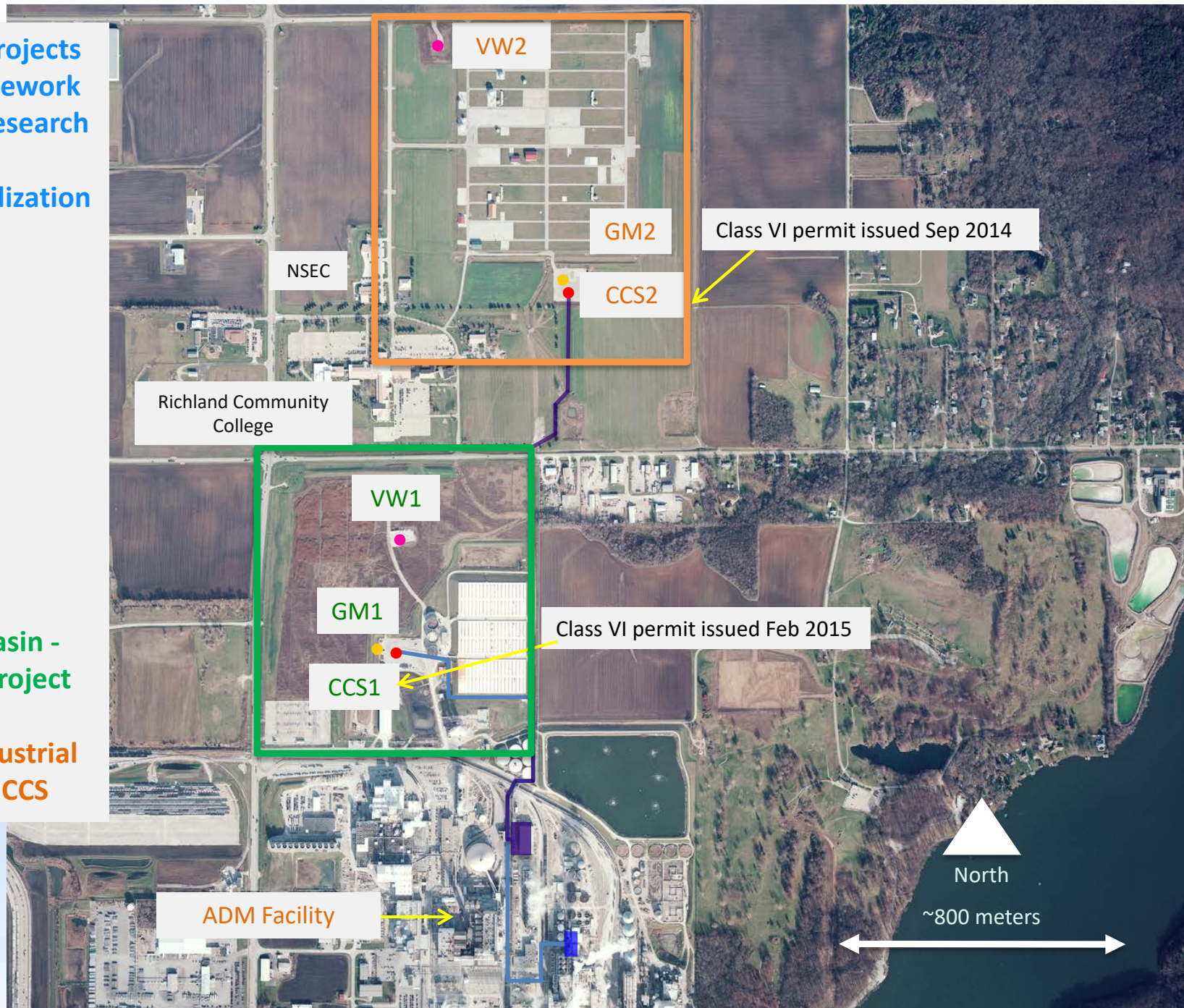




**Multiple Projects  
Build Framework  
for CCUS Research  
and  
Commercialization**

**Illinois Basin -  
Decatur Project**

**Illinois Industrial  
Sources CCS**



# Major Tasks Remaining

- Regional Characterization
- Site assessment
- Outreach and public engagement
- Permitting and building the IBDP test site
- Collect and analyze key monitoring baseline data
- Injection, monitoring, and modeling
- Post-injection monitoring, modeling, and analysis
- Research collaborations, knowledge sharing

Completed

Current activities

# MGSC Teacher Kit

## Exploring Energy and the Environment

**NEXT GENERATION SCIENCE STANDARDS ALIGNMENT**

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**STEP Energy Activity Set**



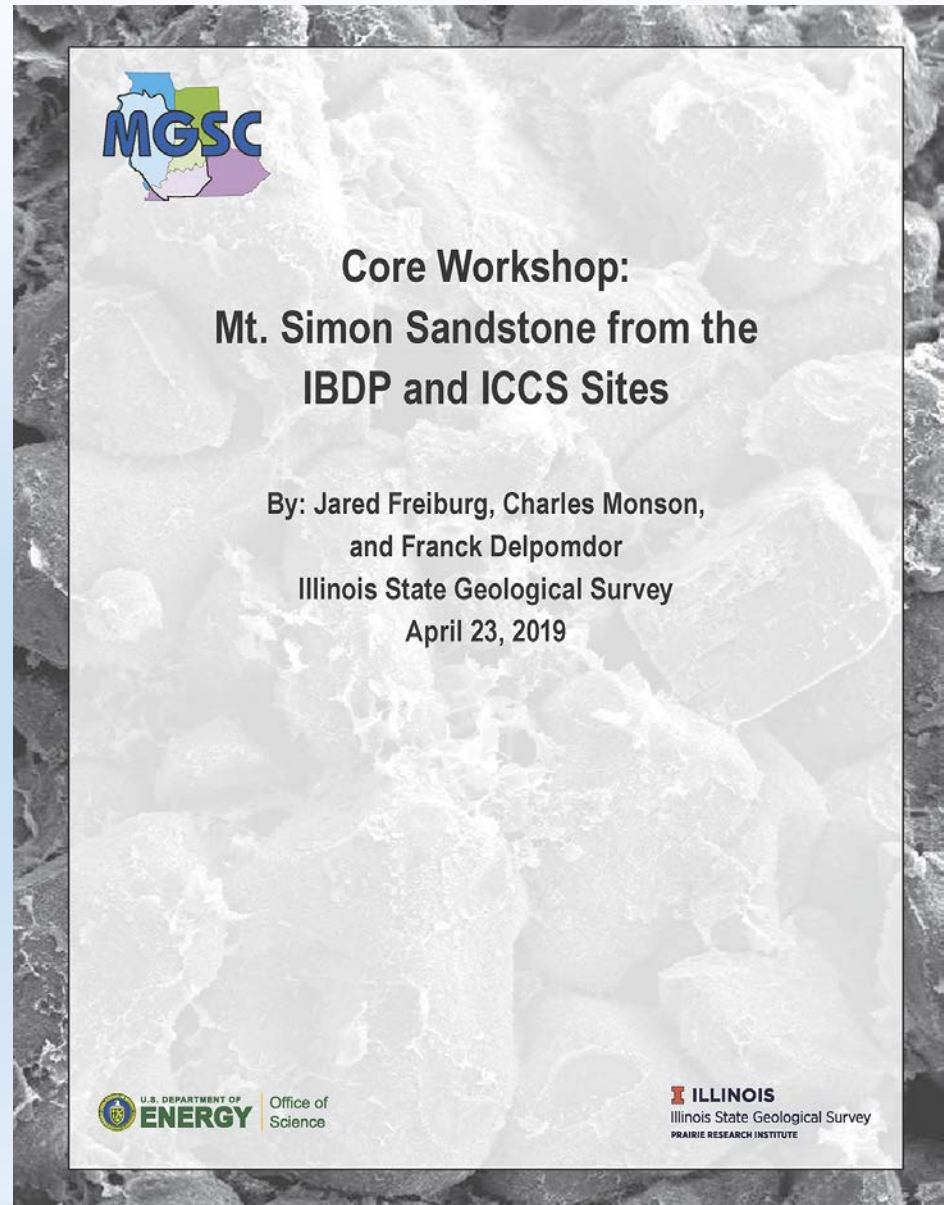
A Supplemental Curriculum  
for Middle School Learners





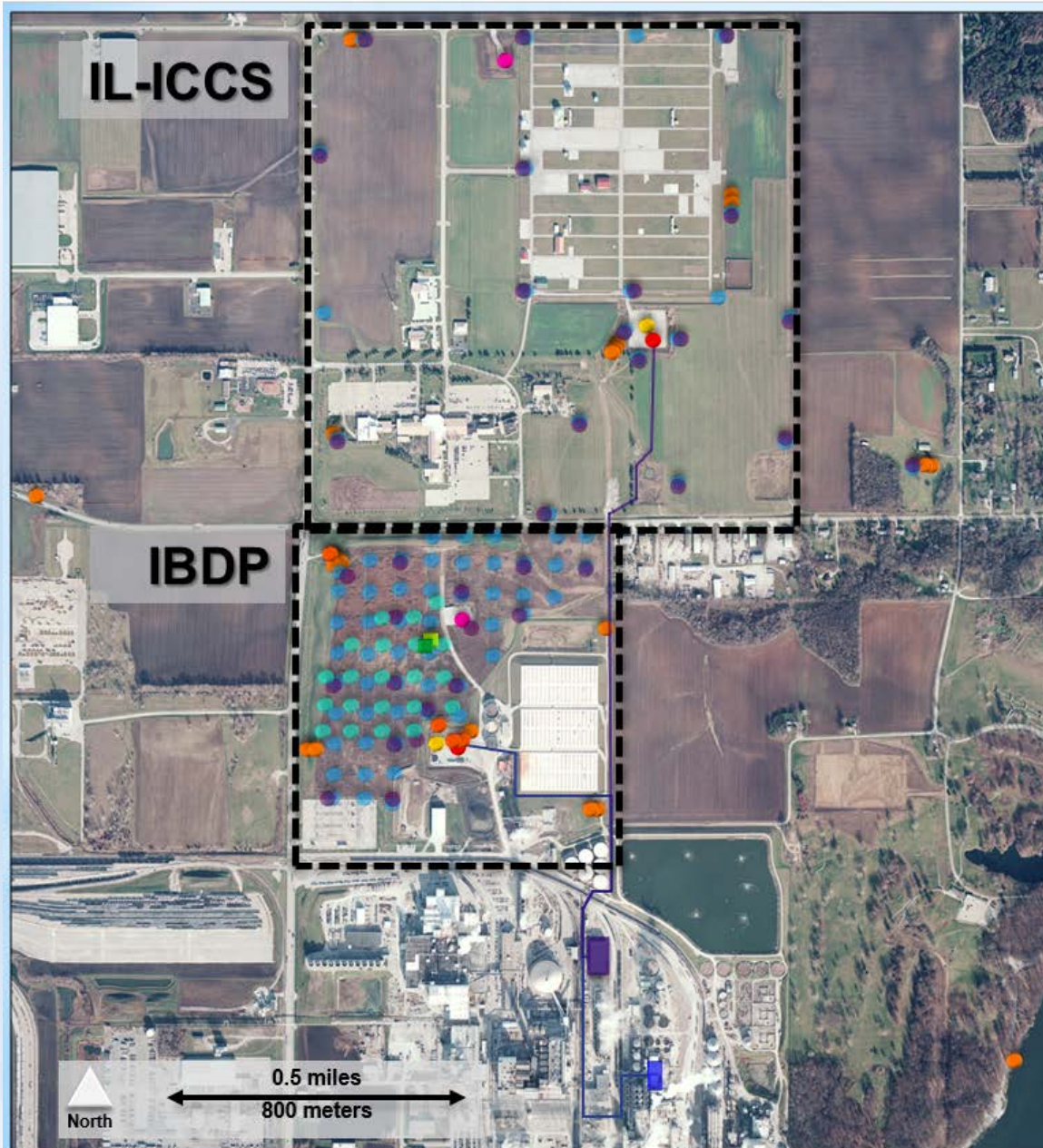
# Core Workshop

- 30 participants
- Definitive source for information about Mt. Simon Sandstone



# Monitoring Summary

- Injection wells (2)
- Verification wells (2)
- Geophysical wells (2)
- Compliance wells (4)
- Research wells (24)
- Soil gas points (35)
- Soil flux points (145)
- Eddy covariance station (1)
- Continuous GPS station (1)
- InSAR artificial reflectors (21)



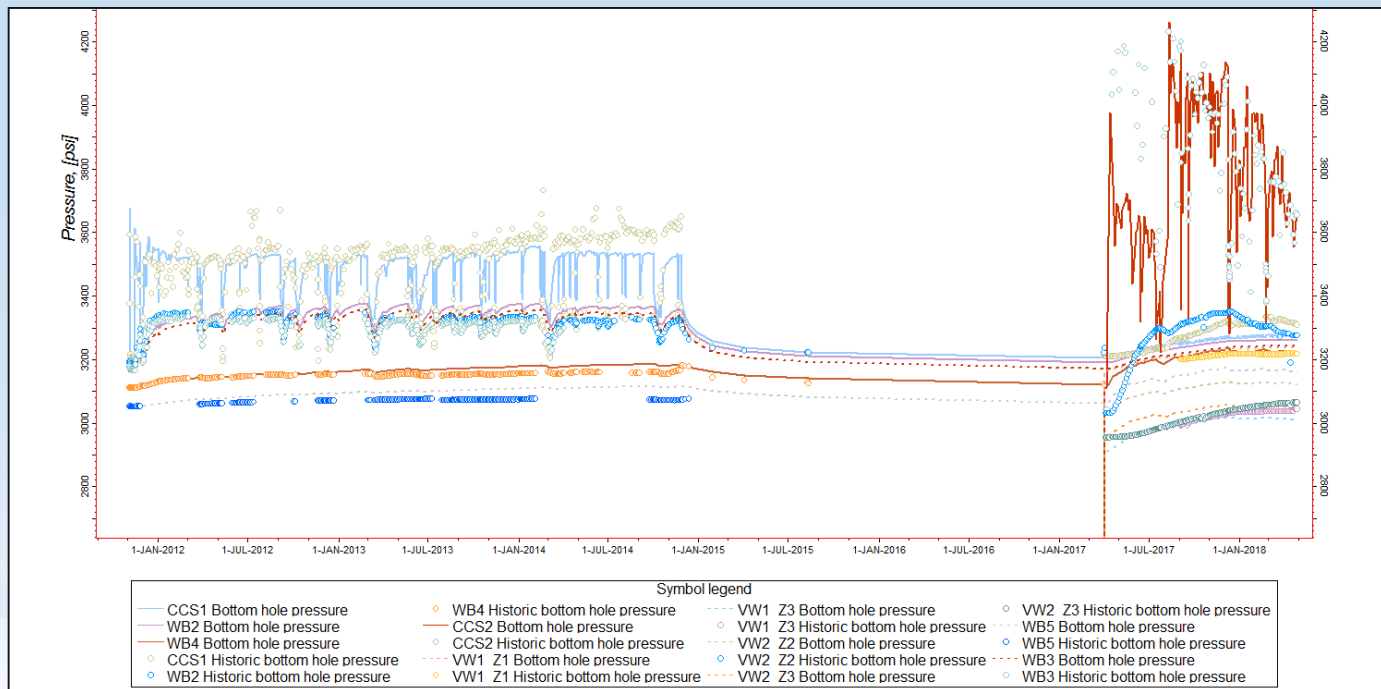
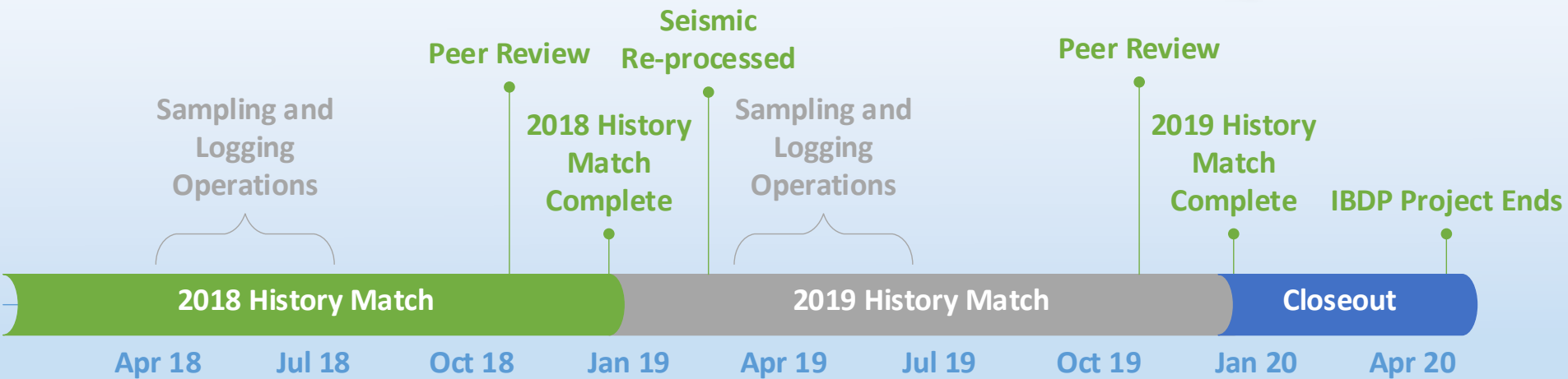
# IBDP Monitoring Summary

	Monitoring Activity	Freq.	Pre-injection			Injection				Post-Injection					
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Surface	Aerial imagery	SA		x	x	x	x	x	x	x	x	x	x	x	x
	Eddy covariance	C					x	x	x						
	Soil flux - network *	W-Q		x	x	x	x	x	x	x					
	Soil flux - multiplexer	C			x	x	x	x	x	x					
	Tunable diode laser- single path	C					x	x							
	Tunable diode laser- multi path *	C								x					
	InSAR *	BW				x	x								
	Continuous GPS *	C					x	x	x						
Near-Surface	Soil gas sampling	Q-A				x	x	x	x	x	x				
	Shallow groundwater sampling	M-Q-SA		x	x	x	x	x	x	x	x	x	x	x	x→
	Shallow electrical earth resistivity *	A	x	x	x										
Subsurface	Pressure/temp. - VW1 and CCS1	C				x	x	x	x	x	x	x	x	x	x→
	Pulsed neutron (CCS1, VW1, GM1)	Q-A		x		x	x	x	x	x			x		x→
	Deep fluid sampling (VW1)	SA				x	x	x	x	x		x	x	x	
	Passive seismic monitoring (GM1)	C			x	x	x	x	x	x	x	x	x	x	x→
	Seismic/3D VSP imaging	SA-A			x	x	x	x	x	x					x→
	Mechanical integrity (CCS1, VW1)	A			x	x	x	x	x	x					x

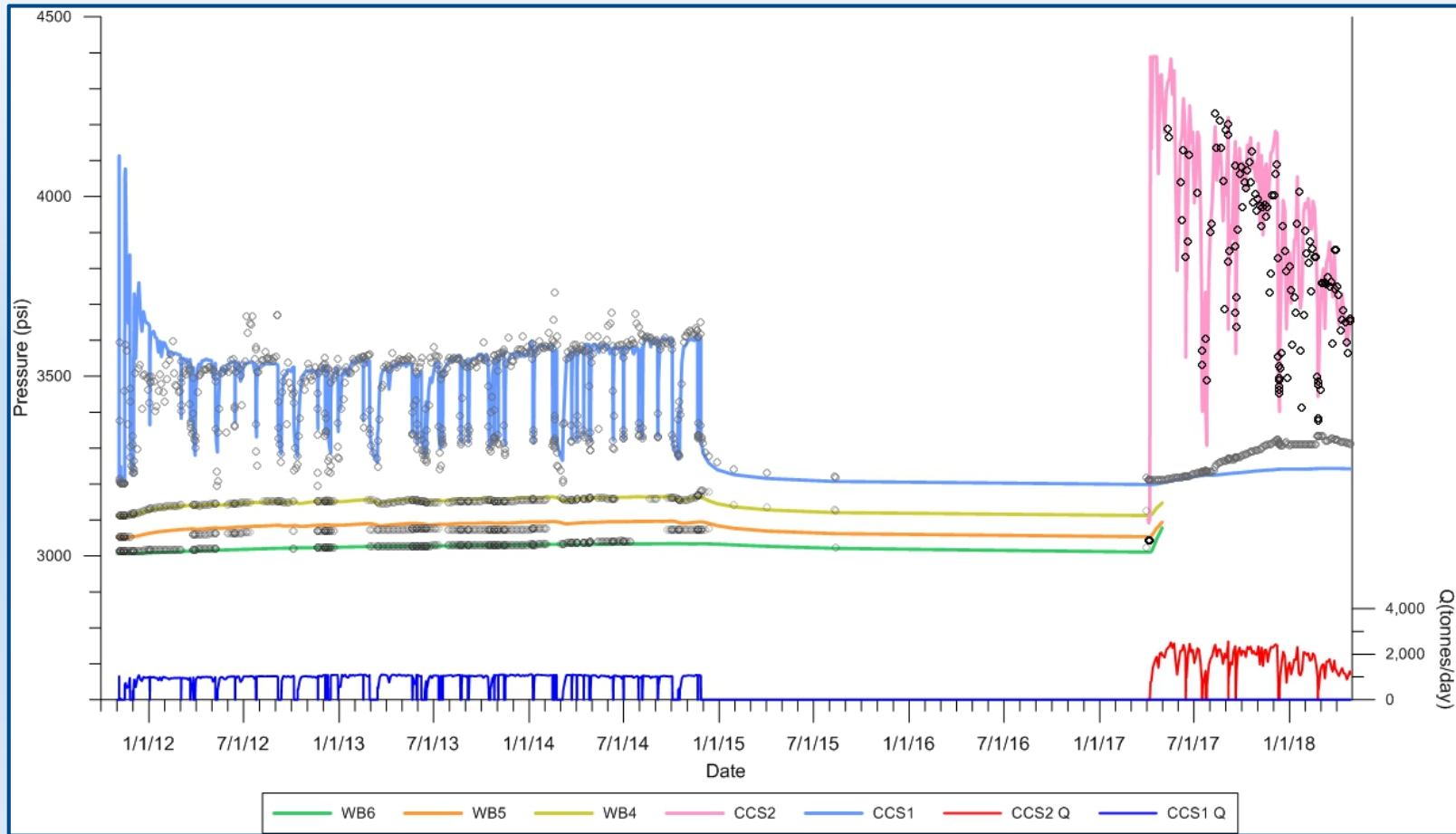
Abbreviations: C = Continuous, W = Weekly, BW = Biweekly, M = Monthly, Q = Quarterly, SA = Semi-Annually, A = Annually,  
 x = planned, not permit required; \* = experimental technique or deployment; x = planned, permit required;  
 x→ = permit activity required beyond 2020; yellow box highlights decrease in monitoring activity during PISC phase



# Modeling and History Matching Update

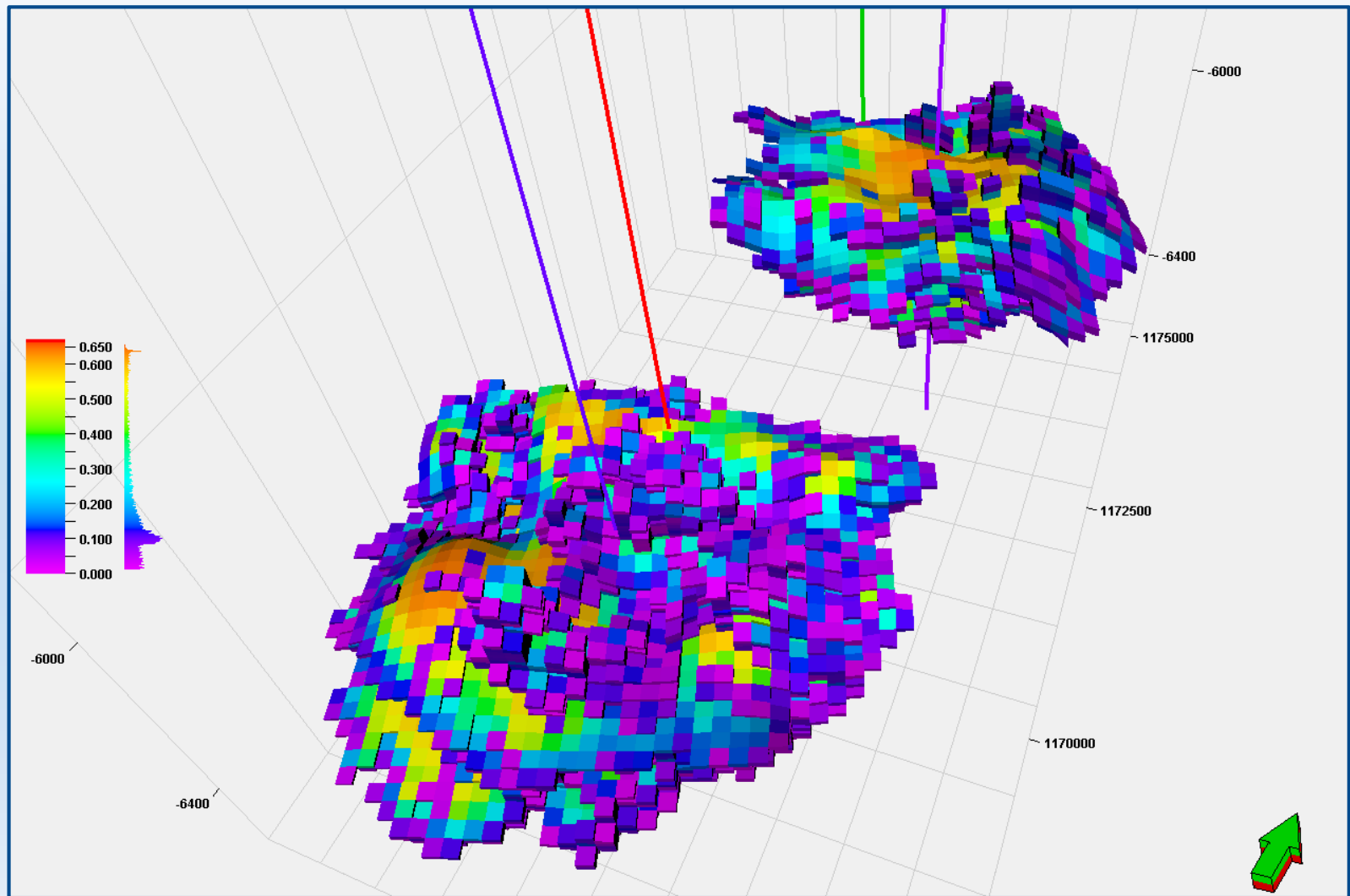


# 2018 Updated Model History Match



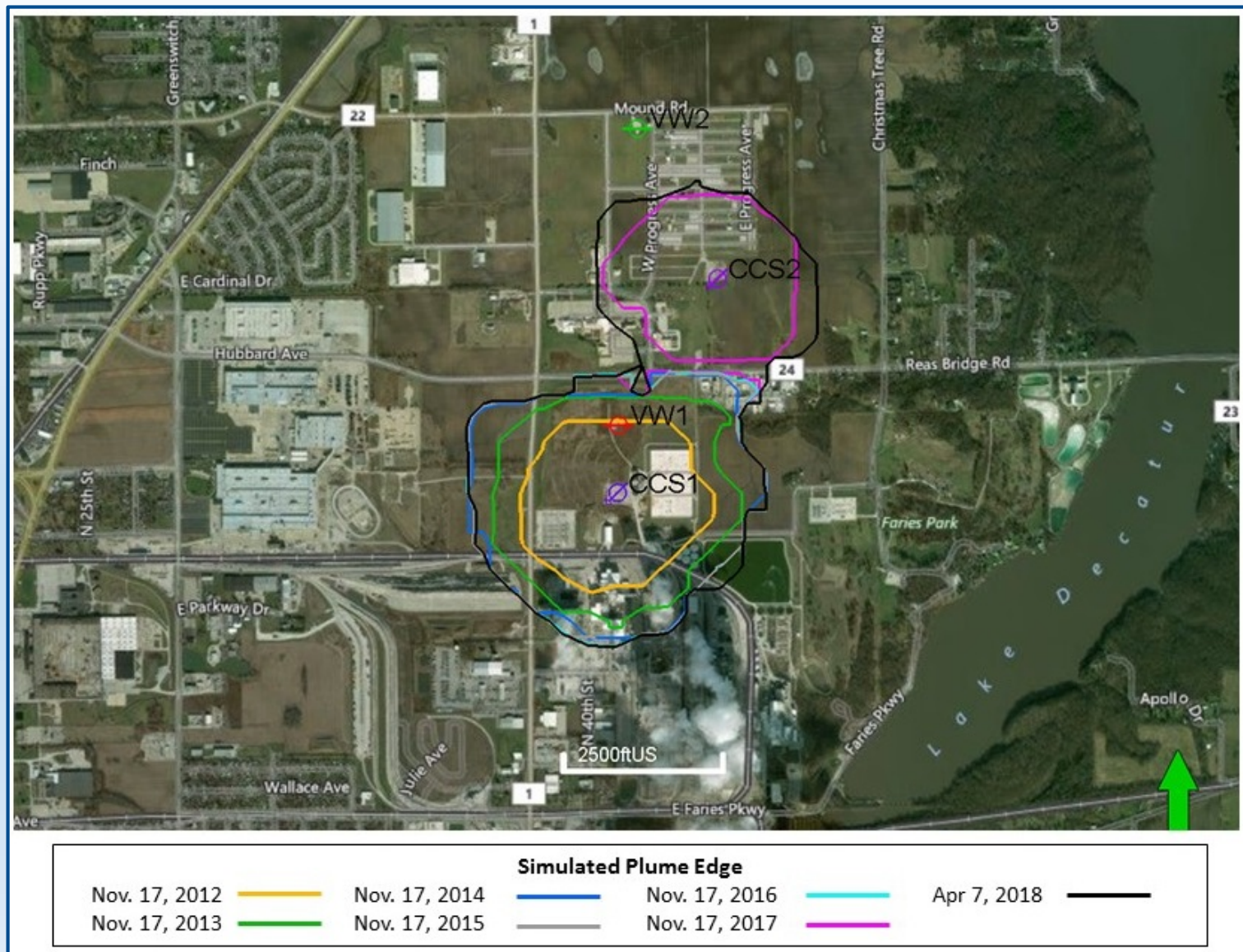
Simulation results and observed data of CCS1, CCS2, WB4, WB5, and WB6 until April 7, 2018.

# Plume Distribution of IBDP and ICCS



3D simulated CO<sub>2</sub> plume distribution on Apr. 7, 2018. Vertical exaggeration is 5x.





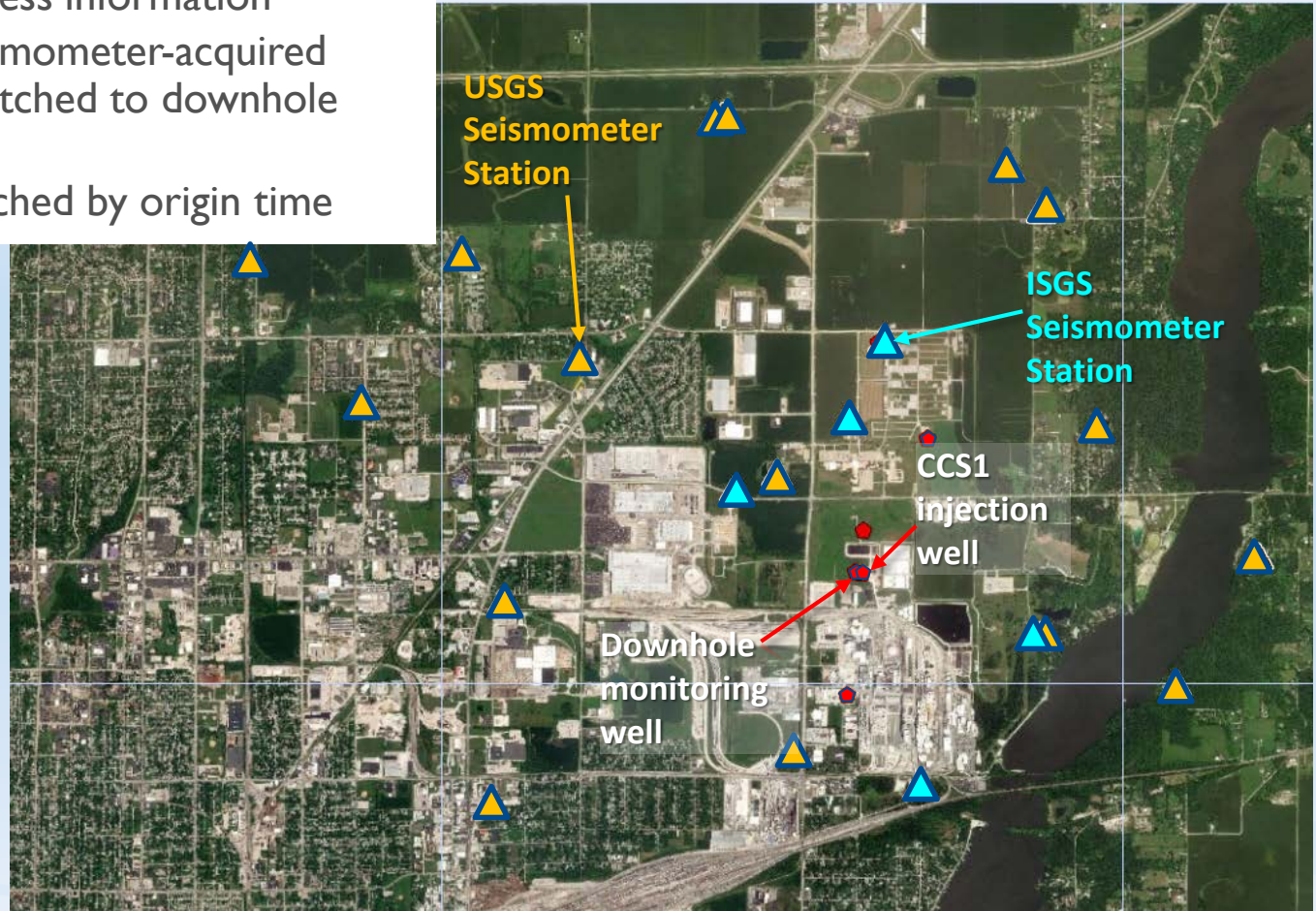
Simulated plume edge (CO<sub>2</sub> concentration >1%)

# Seismic Data at IBDP

- Microseismic Data (passive seismic)
  - Integrating data acquired by ISGS seismometers with data acquired by USGS – data interpretation is underway
- Reflection Seismic Imaging Data (active seismic)
  - Reprocessing of 3D volume is complete, better resolution for fault ID, inversion volumes strongly illuminate rock properties
- 3D VSP Reprocessing (active seismic)
  - Currently underway, with preliminary results showing improved imaging

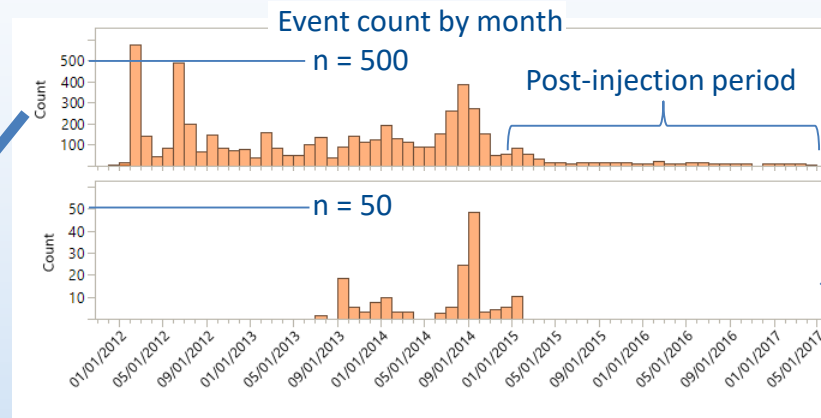
# Microseismic Event Data Integration

- Source mechanisms of seismometer events constrain fault geometry and size, provide stress information
- A subset of seismometer-acquired events were matched to downhole events
- 110 events matched by origin time





# Microseismic Event Data Integration

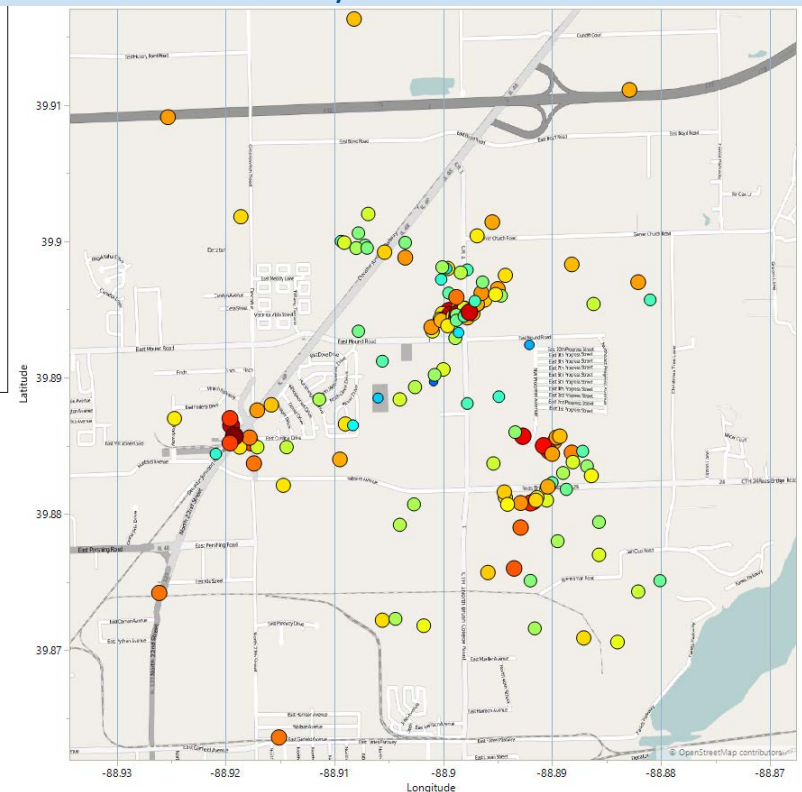
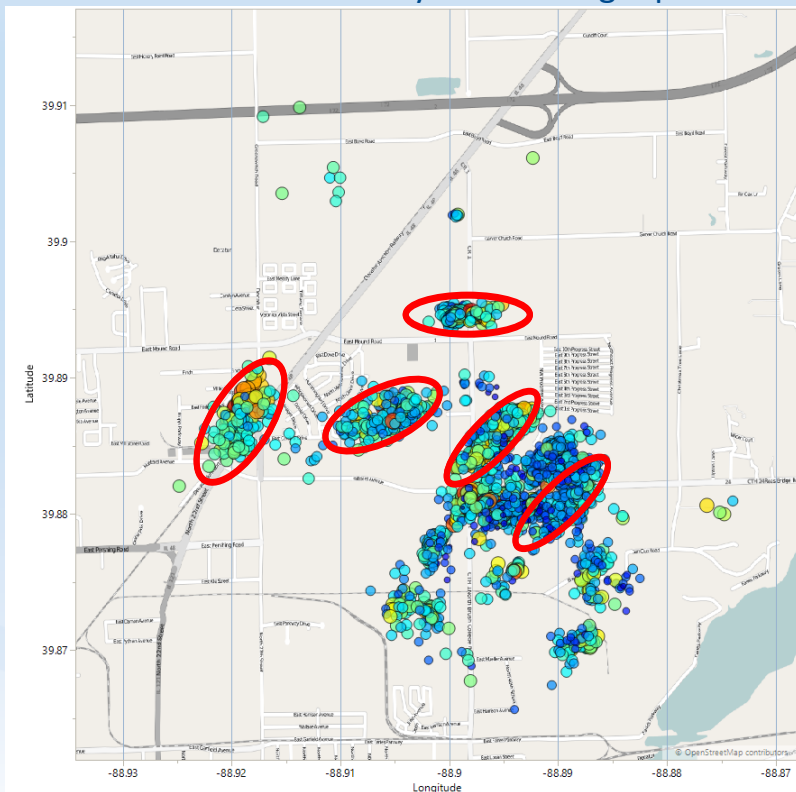


Bigger location error for surface seismometer events.

Additional data from ISGS seismometers can reduce the error.

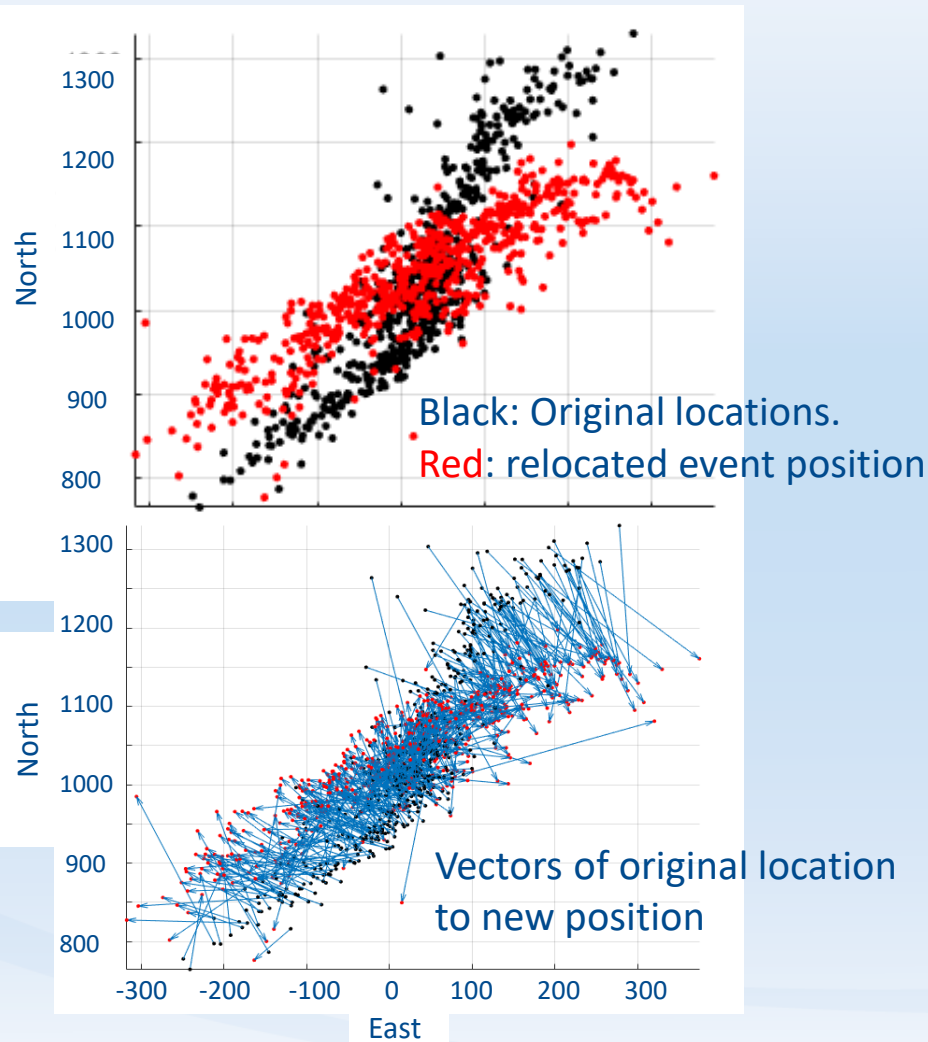
5600 events located by downhole geophones

150 events located by USGS Surface seismometer array

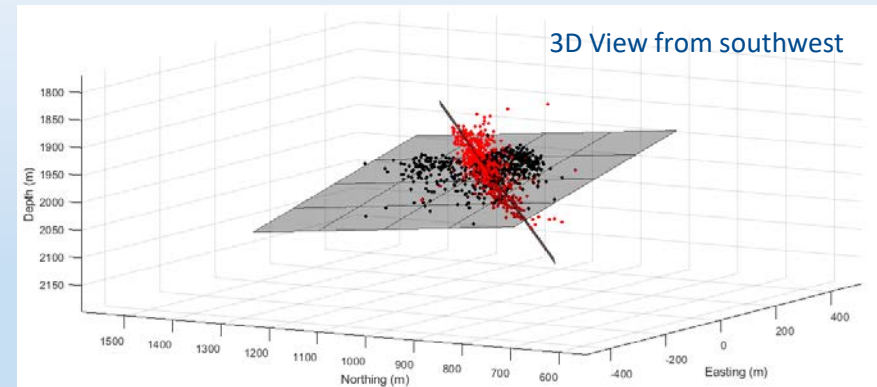


# Collaboration with NORSAR – CO2CAP

Detailed analysis of microseismic event clusters. One cluster example.



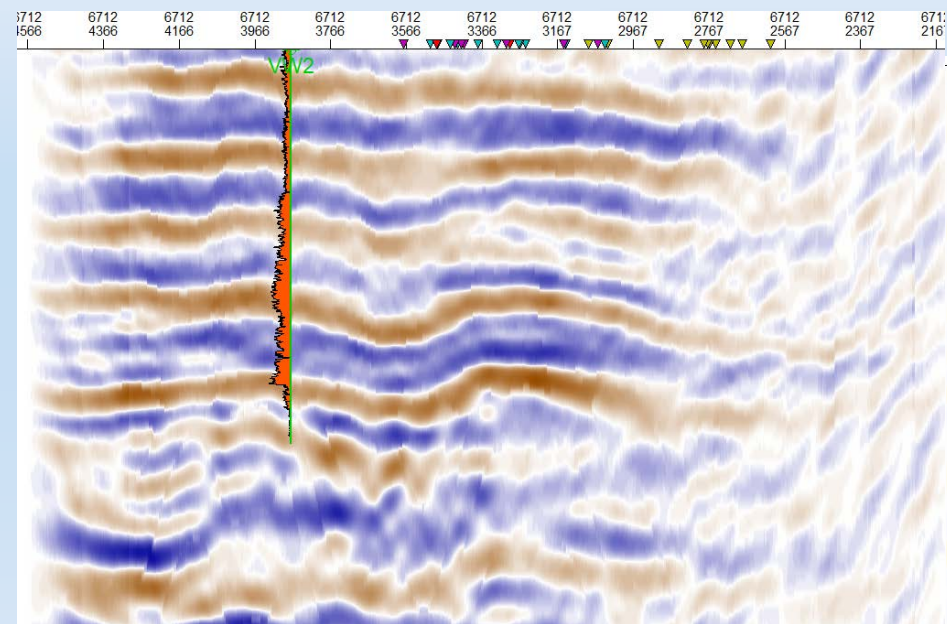
- Shape and orientation of cluster gets rotated in 3D



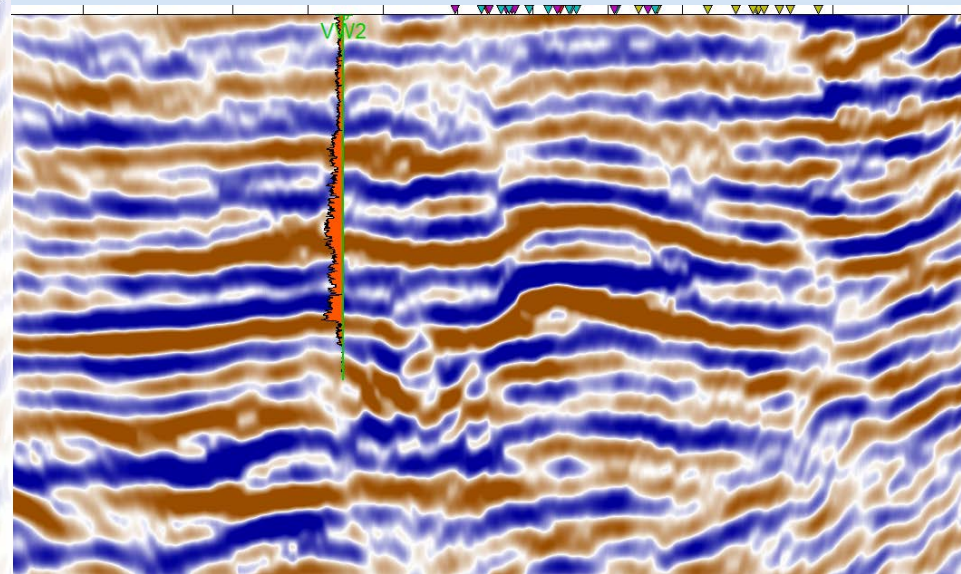
- A plane fit to the cluster dips to the south-east, consistent with stress orientation
- Improved geometry from event relocation enables better understanding of reservoir dynamics

# 3D Seismic Reprocessing

## 20 | I seismic

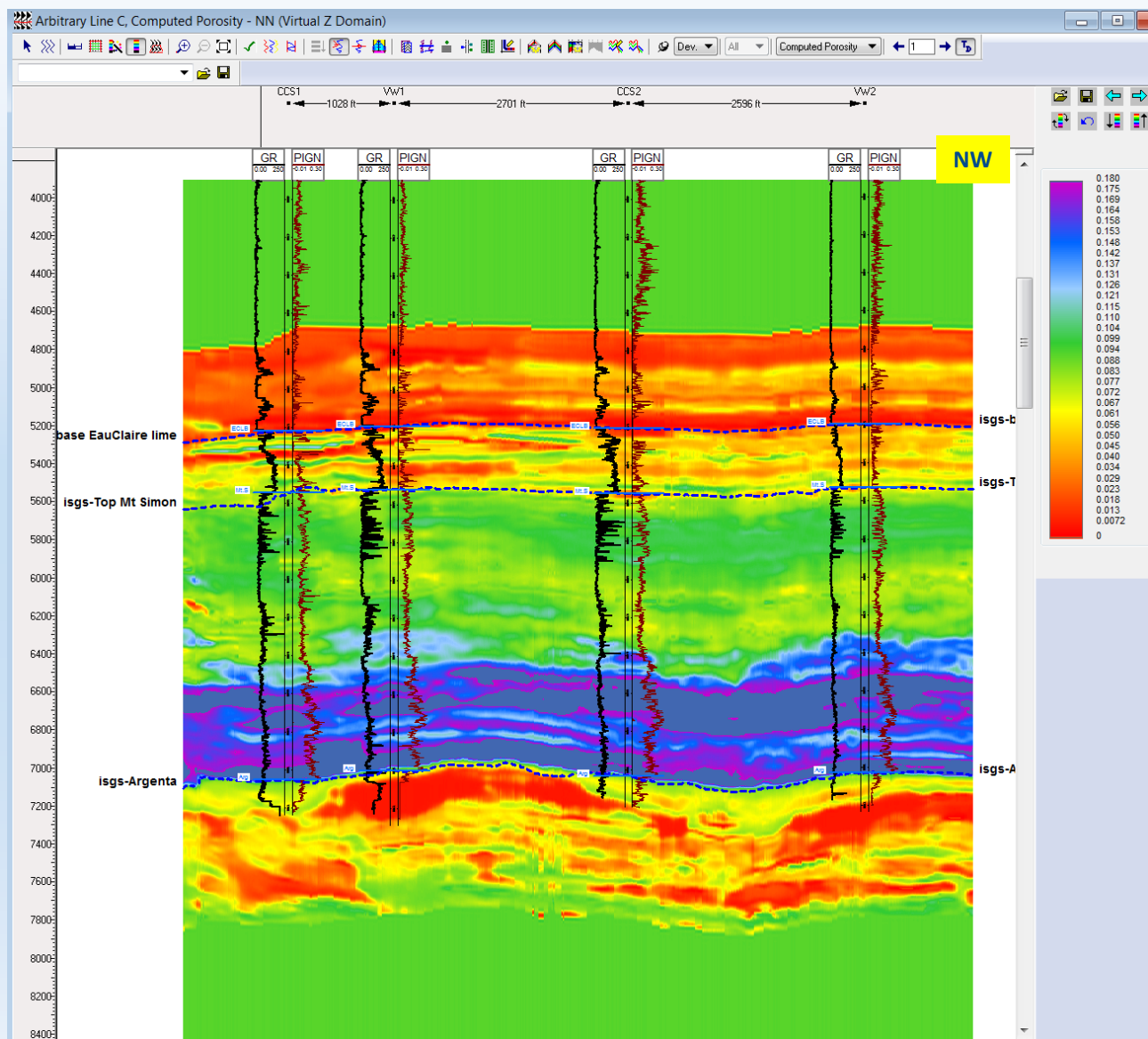


## 2019 seismic





# Porosity Inversion

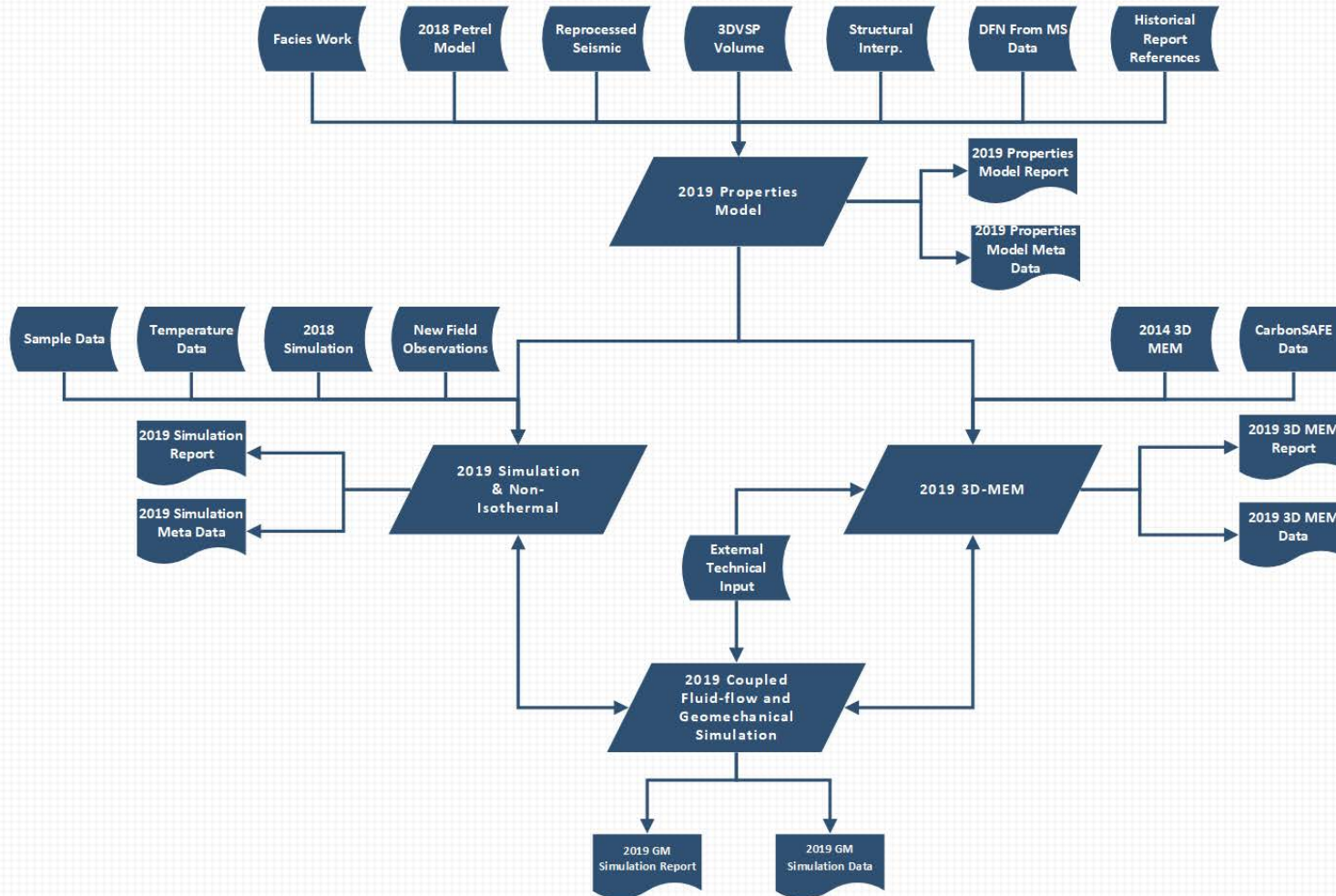


# Model Updates using seismic

Active and passive seismic interpretations feed into:

- Structural framework model refinement
- coupled geomechanical simulation model update
- Final microseismic site model

# 2019 IBDP Modeling and Simulation Plan Flow Chart





# Additional Information from Logs

- CSIRO soon to be engaged
  - Improved interpretation of pulsed neutron logs to quantify trapped CO<sub>2</sub>
  - Application of machine learning for log interpretation



# IBDP Cost Analysis

- Infrastructure (capture and transport) conduct by Trimeric, report available. <http://library.isgs.illinois.edu/Pubs/pdfs/circulars/c597.pdf>
- Subsurface and monitoring - in progress
  - Developed methodology for analysis
  - Costs analyzed from invoices for federal share of funding
  - Cost/benefit for MVA
  - Presented at GHGT

# American Geosciences Institute Publication Database

- Working with AGI to create a publication database that houses 700+ publications from MGSC
- Similar to GeoRef
- Searchable, preserved metadata
- Publication focus, linked with EDX data
- Preserves and makes publications accessible





# The Future



# MGSC and IBDP Future Steps

- Compliance phase of post-injection monitoring – April 2020 (tied to start of ADM Industrial CCS Sources project)
  - Finalize integrated conceptual site model and history match
  - Generate final data integration and completion of geologic and reservoir models
  - Knowledge sharing and capacity building
  - Publication of IBDP technical papers and final report
  - AGI publication database
- 
- Active interest from partners within region to pursue CCUS

# Final Thoughts

- Critical Features:
  - Partners
  - Geology
  - Monitoring
  - Communication
  - Risk mitigation
- Critical qualities:
  - Knowledge
  - Experience
  - Flexibility
  - Patience



# Acknowledgements



- The Midwest Geological Sequestration Consortium is funded by the U.S. Department of Energy through the National Energy Technology Laboratory via the Regional Carbon Sequestration Partnership Program (contract number DE-FC26-05NT42588)
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- CarbonSAFE Illinois projects are funded by the U.S. Department of Energy through the National Energy Technology Laboratory





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