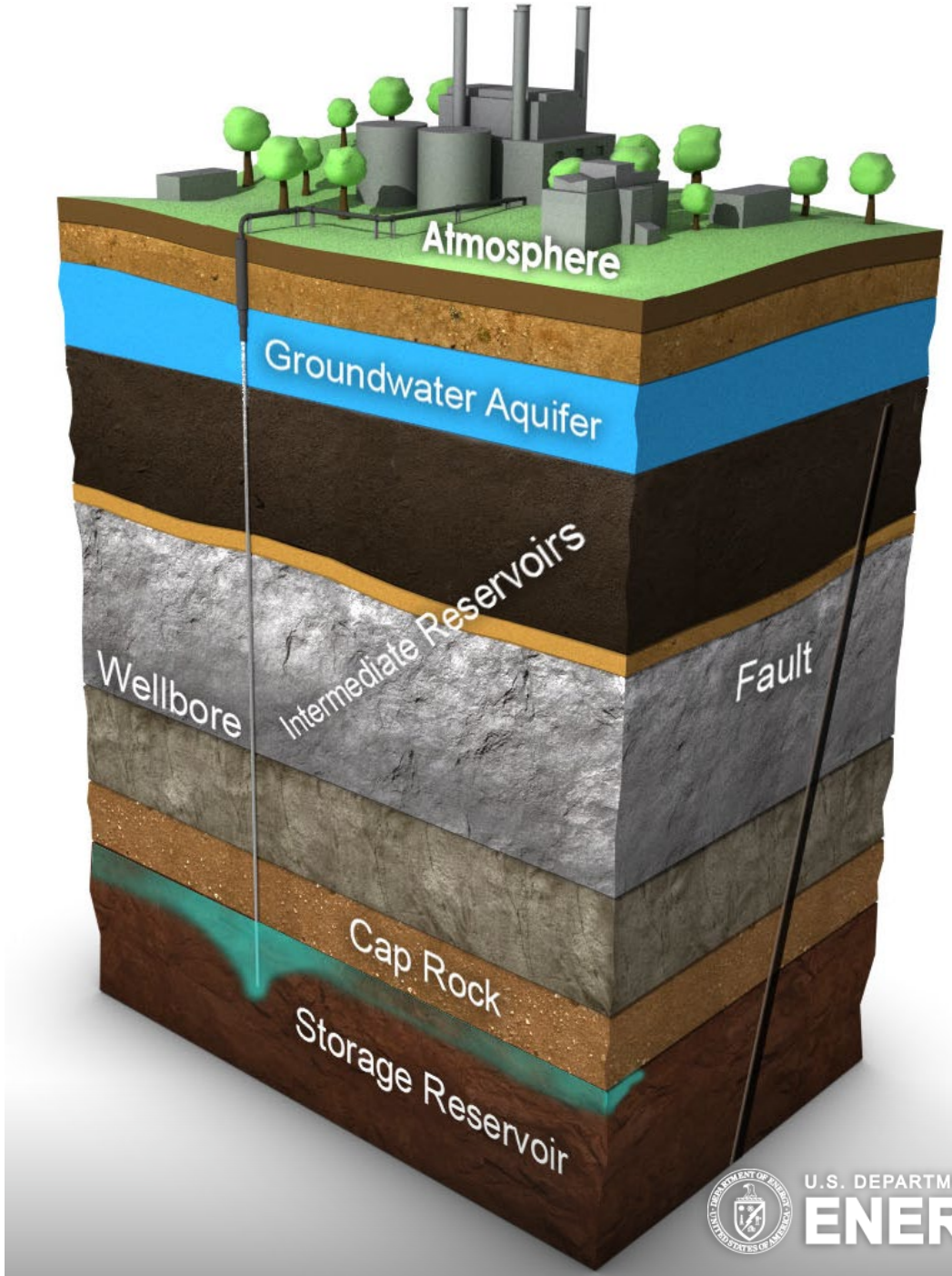
NRAP Phase III Overview: Objectives and Progress

Robert Dilmore, PhD, P.E.
National Energy Technology Laboratory

2023 Carbon Management Research Project Review Meeting
August 31, 2023



NRAP
National Risk Assessment Partnership

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BERKELEY LAB
Lawrence Livermore National Laboratory
Los Alamos NATIONAL LABORATORY
Pacific Northwest NATIONAL LABORATORY
U.S. DEPARTMENT OF ENERGY

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NRAP leverages DOE's capabilities to develop and apply computational tools to quantitative assess subsurface risks for GCS, amidst uncertainty, and inform stakeholder decision making.

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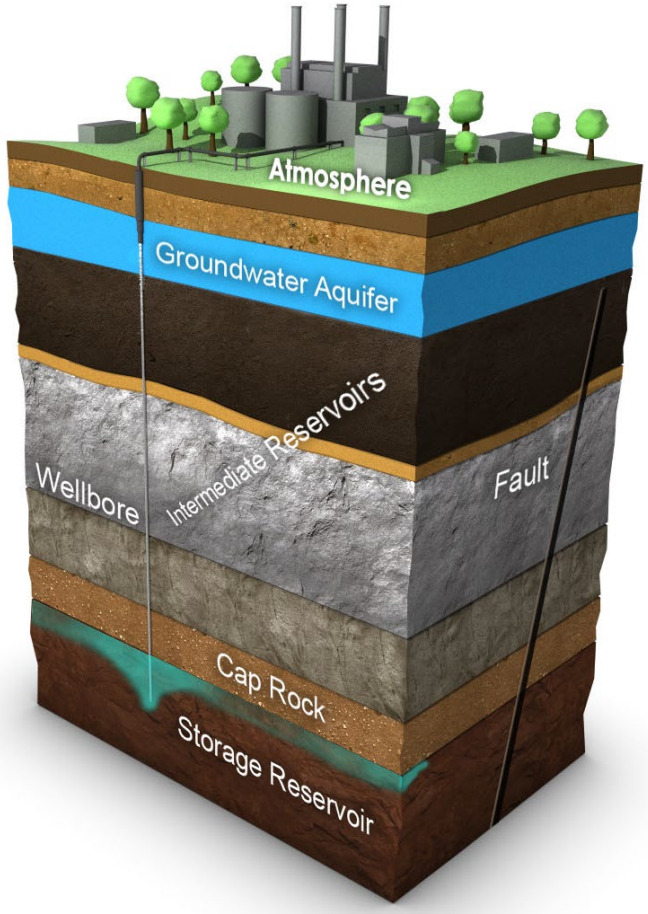
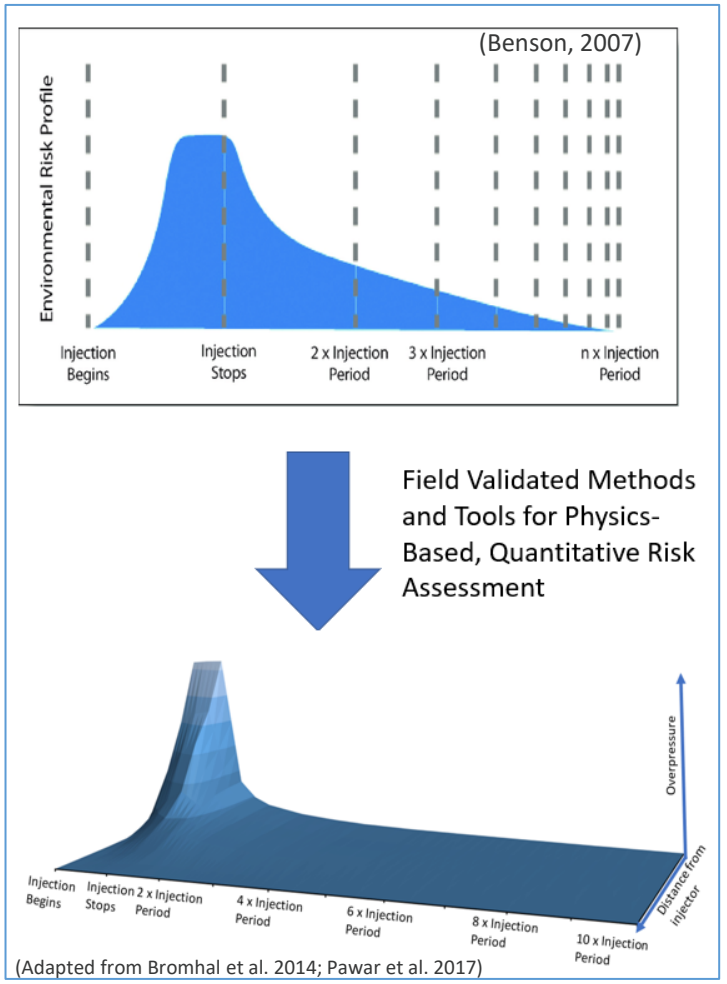
NRAP Website: https://edx.netl.doe.gov/nrap/





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NRAP leverages DOE's capabilities to develop and apply computational tools and methods to enable physics-based, quantitative, site-specific assessment of subsurface risks for GCS, amidst uncertainty, and to inform stakeholder decision making related to risk and liability.

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Presentations from Tuesday's Poster & Demo Session

Tool Demonstrations

ORION Induced Seismicity Module (Chris Sherman)
NRAP-Open-IAM: Open-Source Integrated Assessment Model (Veronika Vasylkivska)
Risk-Based Adaptive Monitoring Plan (RAMP) Tool (Xianjin Yang)
SoSAT Tool (Jeff Burghardt)

Tool Demonstrations

Mehana, Mohamed	The Transition from Class II to Class VI Operations: Assessing CO2 Storage and Risk
Chen, Bailian	Incorporating feedback between risk assessment and monitoring strategies: Optimizing detection and minimizing risk
Guglielmi, Yves	Mechanisms of permeability and friction evolution in faults affecting reservoir-caprock systems: Towards the development of an earthquake cycle ROM including fluid pressure and flow
Bhuvankar, Pramod	Estimating the CO_2 leakage rate during well blowouts in underground CO_2
Kroll, Kayla	High-Fidelity Simulation of Induced Earthquakes Inform Operational Management Strategies
Geffers, et al.	Introducing Spatial Heterogeneity in Seismic Forecasts in ORION
Warner, Travis	A Framework for Linking Quantitatively Assessed Risks and Costs for Geological Carbon Storage (GCS) to Consider Impact of Contingency Plans at a GCS Site
Lackey, Greg	Linking basin-scale geologic modeling, well integrity characterization, and dynamic storage simulation to NRAP's quantitative risk assessment framework
Liu, Gouxiang	Class II to Class VI Operations – Insights from Simulation-Based Investigation of a CO2-EOR to Dedicated Storage Scenario
Brown, Chris	Application of NRAP Risk Assessment Tools in the Context of the Bowtie Risk Management Framework
Baek, Seunghwan	A Modular Multi-Segmented Model for Wellbore Leakage Assessment and Site-Specific Risk Evaluation in Geological Carbon Sequestration
Appriou, Delphine	New Recommendations for Assessing Geomechanical Risk at GCS Sites
Rasouli, Pejman	Decision Support for Aquifer Impact Remedial Response of CO_2 and Brine Leakage

NRAP Phase III Technical Tasks (Leads)

Task 2.0: Addressing Stakeholder Needs to Accelerate Geologic Storage Projects: **Tools and Methods to Assess and Manage Subsurface Risks** in Site Development and Reuse Scenarios (**Mohamed Mehana, LANL)**

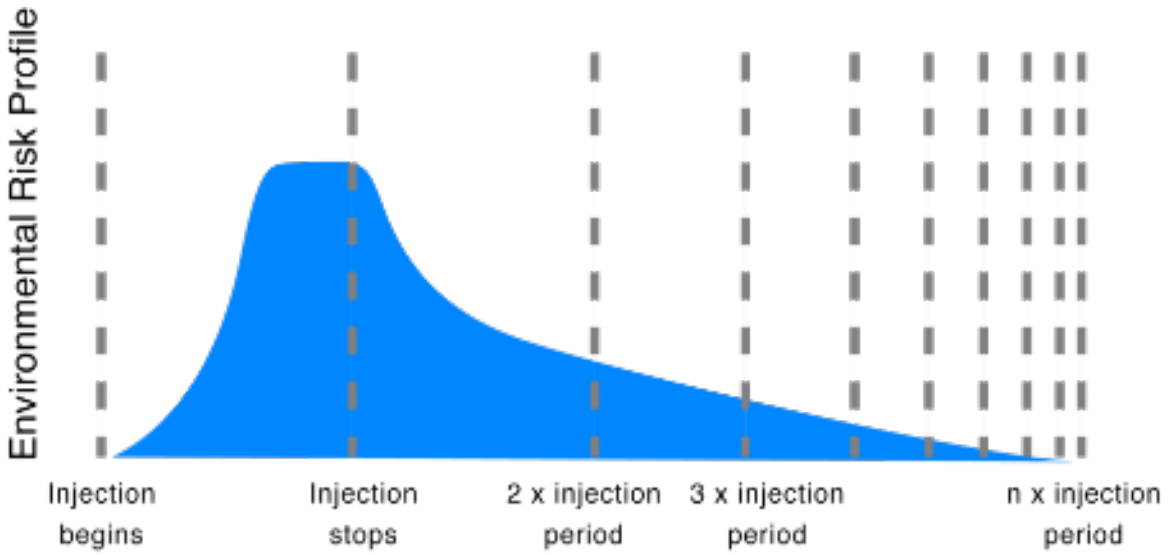
Task 3.0: Induced Seismicity Risk Management (Kayla Kroll, LLNL)

Task 4.0: Adaptive, Risk-Based Monitoring Design for Risk Management **(Erika Gasperikova, LBNL)**

Task 5.0: Quantitative Assessment of **Long-Term Liability**, and Project-Wide Financial Risk Evolution **(David Morgan, NETL)**

Task 6.0: Assessing and Managing **Risks of Basin-Scale GCS** Deployment **(Diana Bacon, PNNL)**

Can we quantify how risks evolve over time?



(Benson, 2007)

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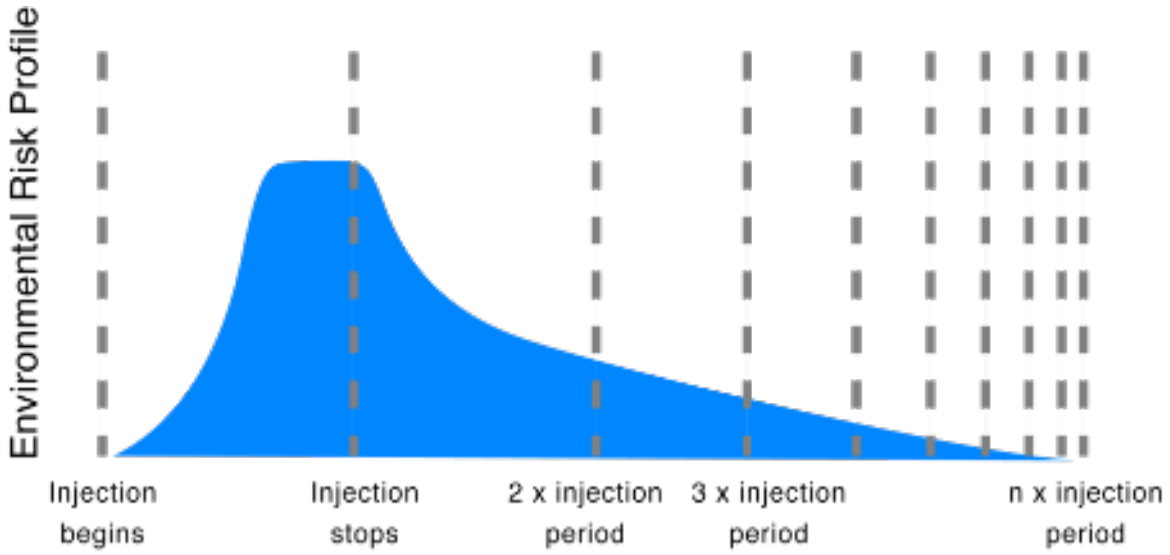

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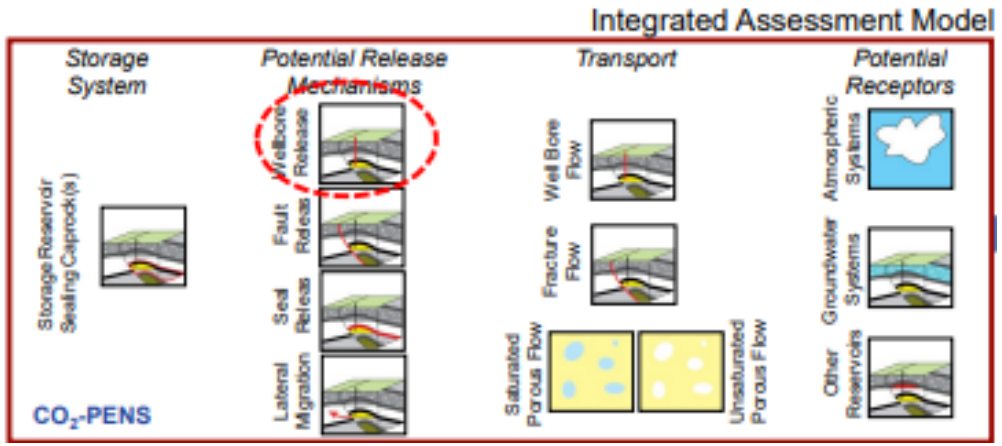
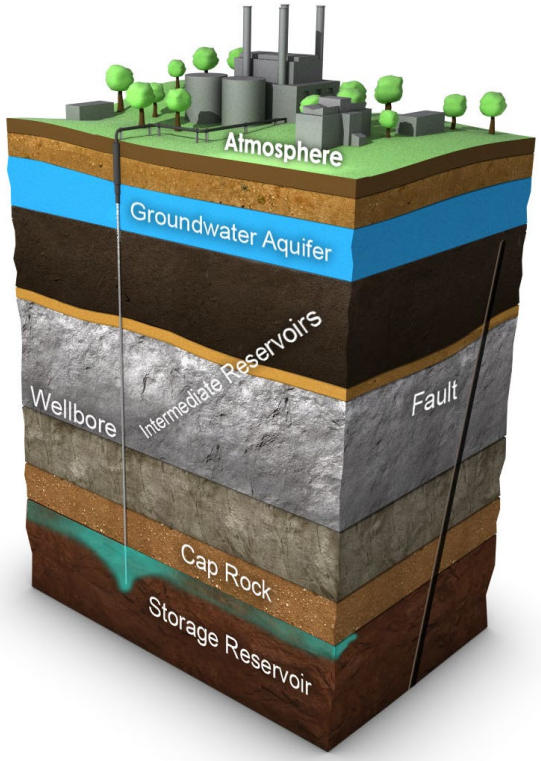


Viswanathan et al., 2008;
Stauffer et al., 2008

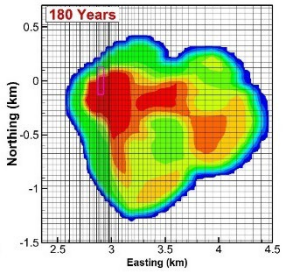
NRAP approach for rapid prediction of whole-system risk performance

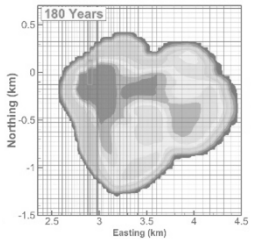
A. Divide system into discrete components

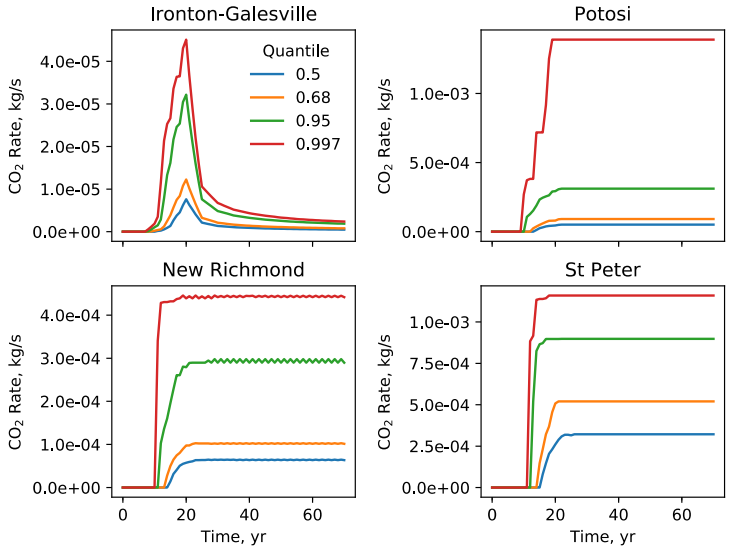


B. Develop detailed component models that are validated against lab/field data

C. Develop reduced-order models (ROMs) that rapidly reproduce component model predictions







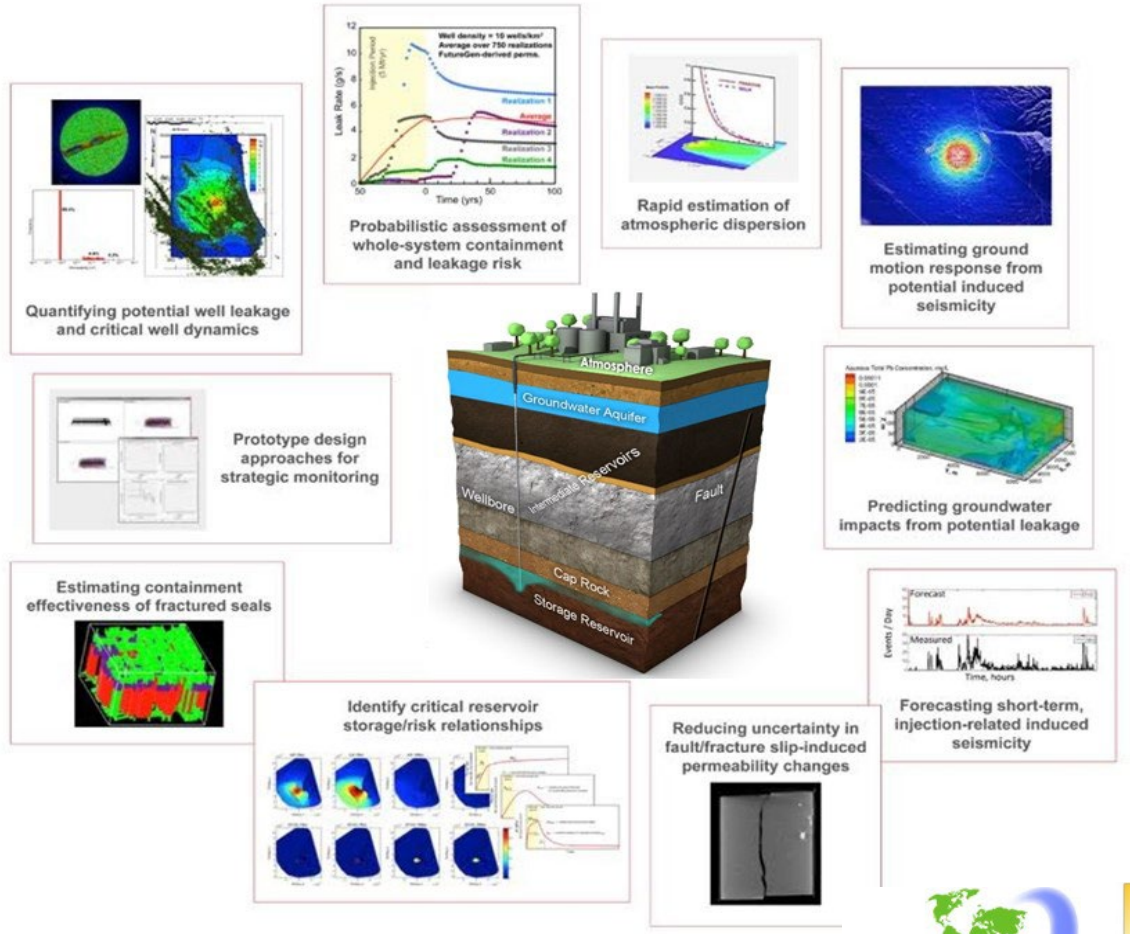
D. Link ROMs via integrated assessment models (IAMs) to predict system performance

E. Exercise whole system model to explore risk performance

Evolving Focus of NRAP

- Phase I (2010–2016) - Risk Assessment and Uncertainty Quantification
- Phase II (2017–2022) - Risk Management and Uncertainty Reduction
- Phase III (2022 – 2027) – Supporting CCS deployment.

NRAP Phase I Toolset (2016)



carbon sequestration leadership forum

R&D 100 55 Years of Invention

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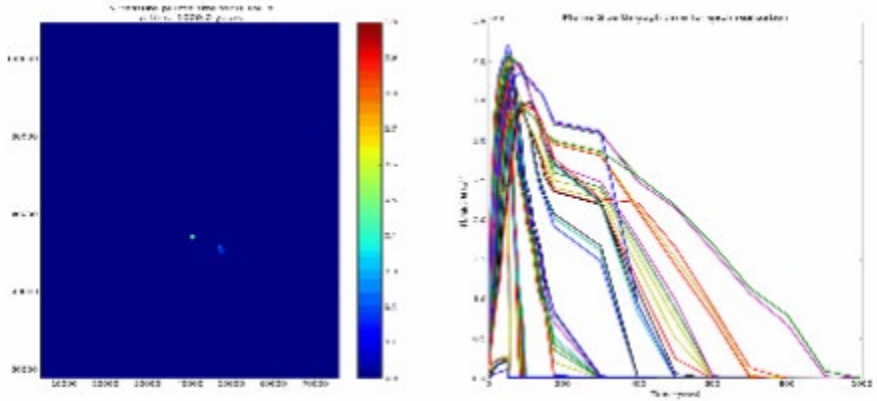
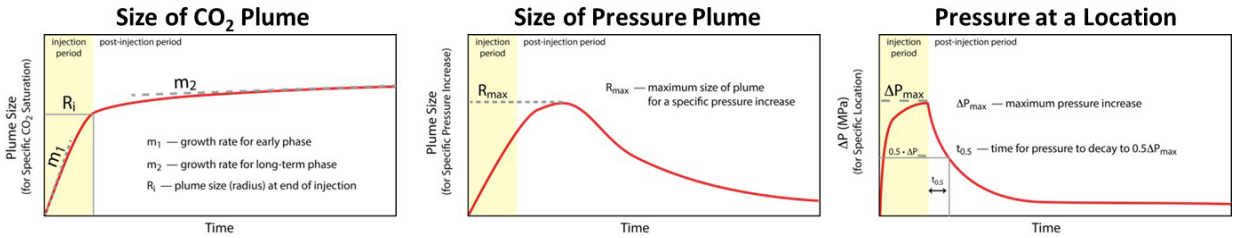
How does the storage formation respond as a function of geology and injection choices?





Bromhal et al., 2015

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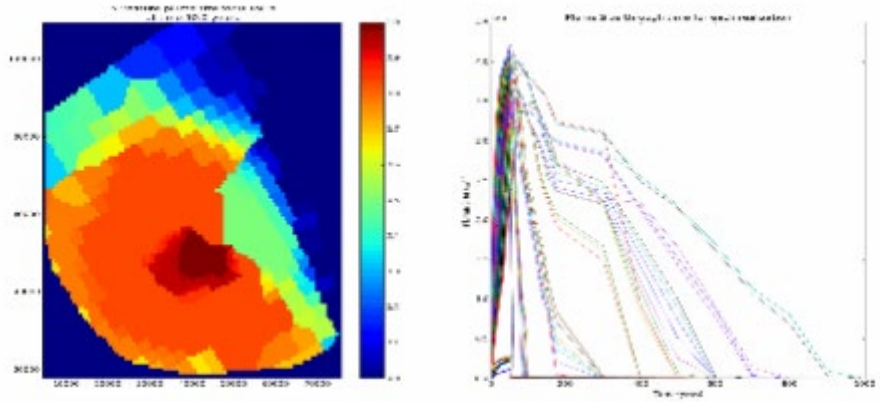

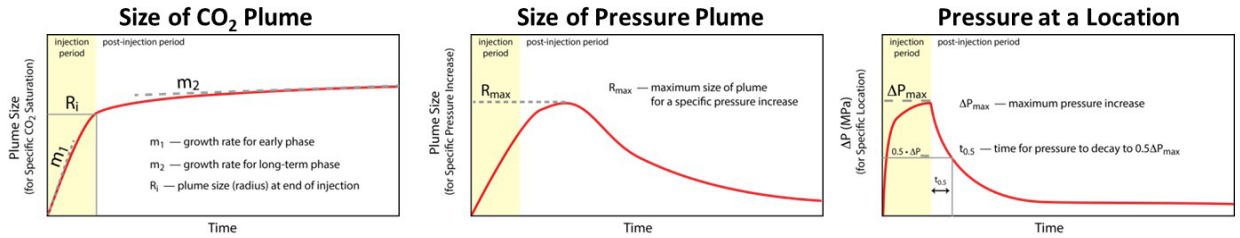

Bromhal et al., 2015

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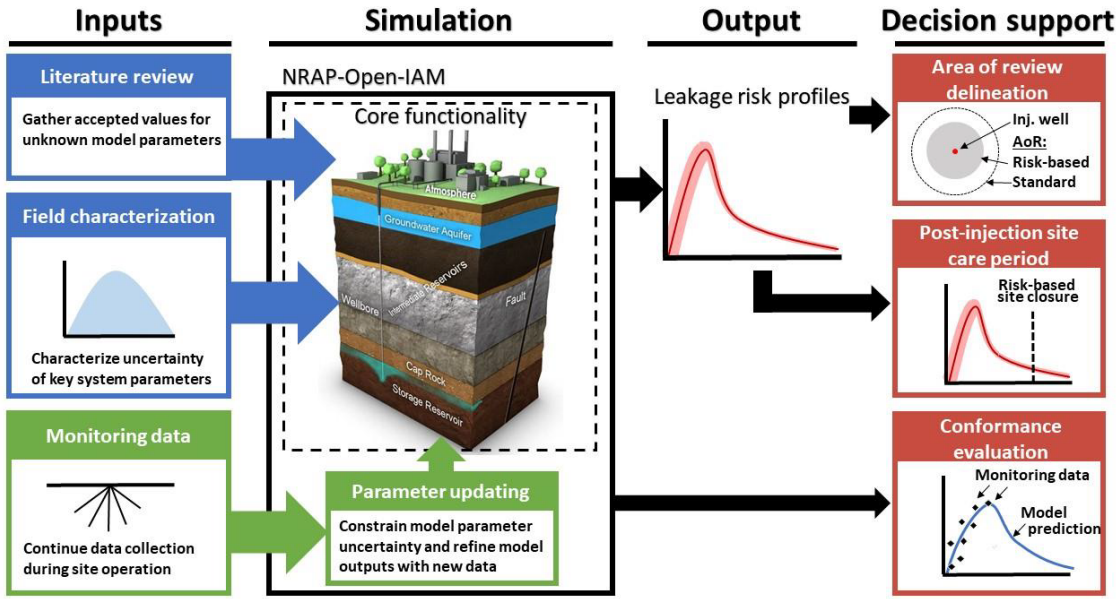
Open Source Tools



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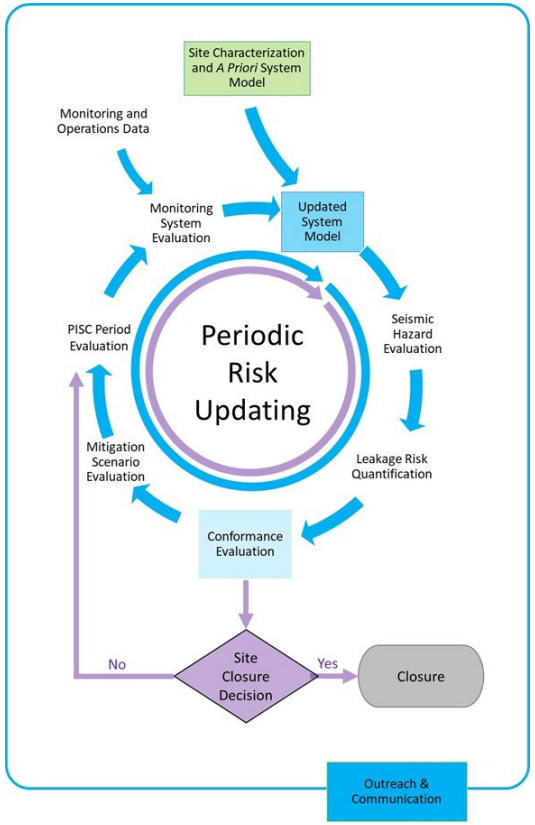
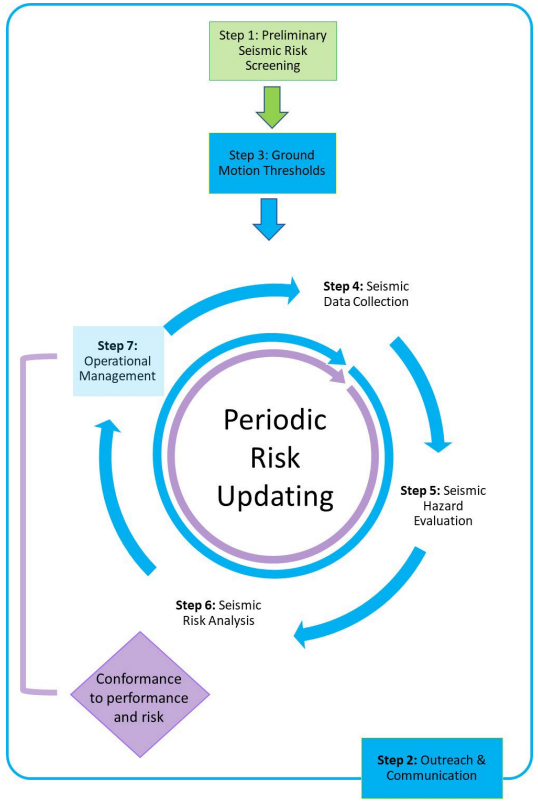
Recommended Practices

Containment Assurance & Leakage Risk Management



Induced Seismicity Risk Management



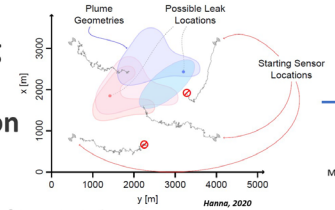
Templeton, et al. Recommended Practices for Managing Induced Seismicity Risk Associated with Geologic Carbon Storage; NRAP-TRS-I-001-2021; DOE.NETL-2021.2839; DOI: 10.2172/1834402

Thomas, et al. forthcoming. NRAP Recommended Practices for Containment Assurance and Leakage Risk Quantification. NRAP-TRS-I-001-2022

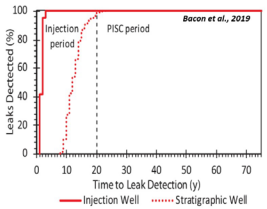
NRAP Phase II (2017 – 2022), cont.

Containment Assurance & Leakage Risk Management

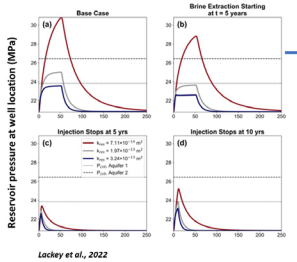
Monitoring design optimization

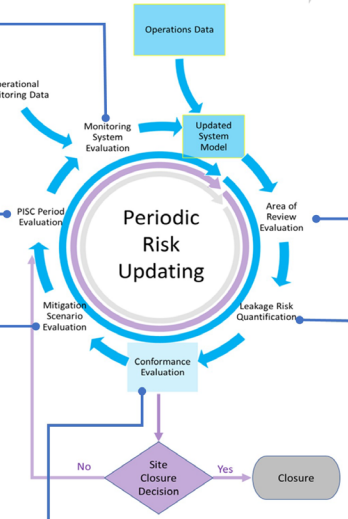


Risk-Based Post-Injection Site Care Duration

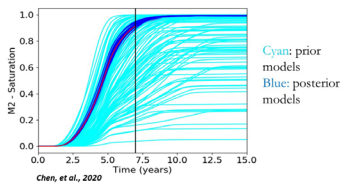


Evaluating Mitigation Alternatives



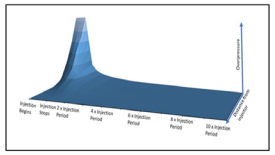


Plume Conformance

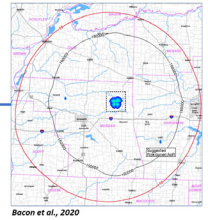


Cyan: prior models
Blue: posterior models

Leakage Risk Quantification

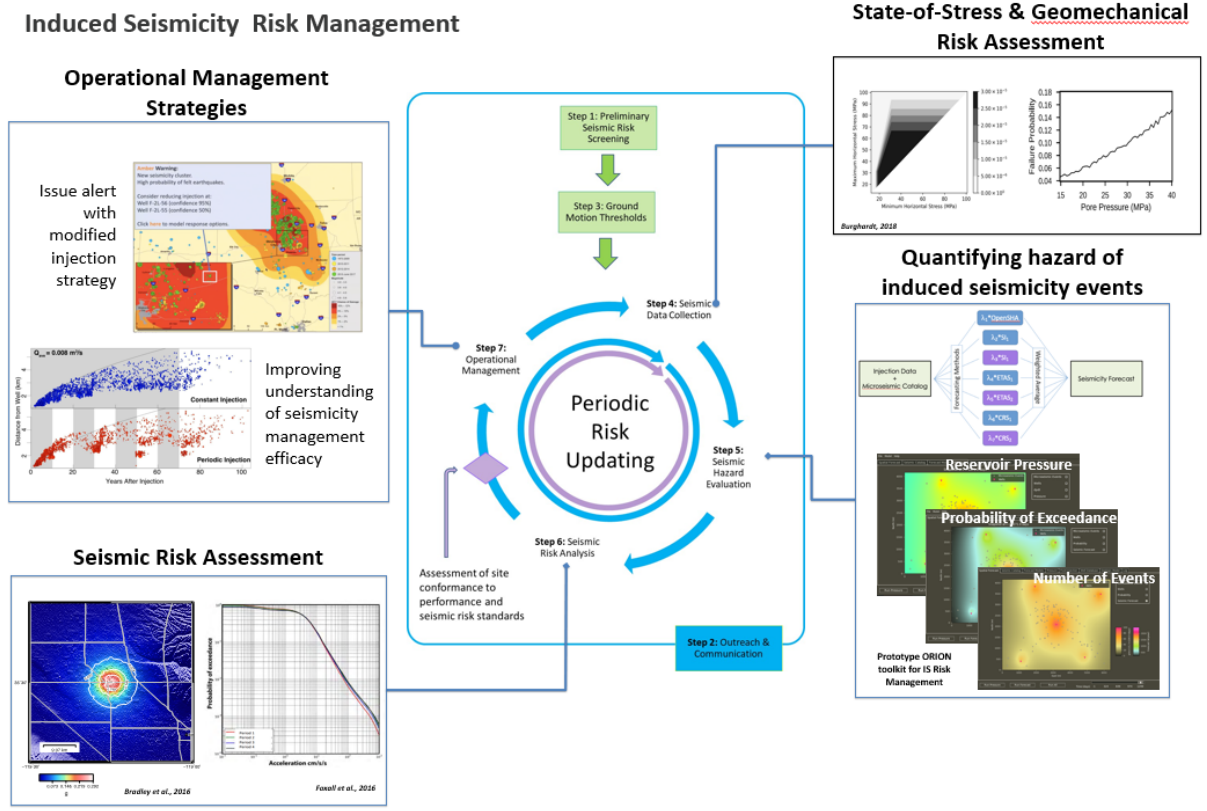


Determining Risk-based AoR



NRAP has developed recommended practices for risk-based leakage risk and containment assurance (Thomas et al., forthcoming), comprising workflows that address various aspects of geologic carbon storage site selection, permitting, and risk management. Case studies demonstrating these workflows are summarized in an application catalog (Huerta et al., 2021)

Induced Seismicity Risk Management



[NRAP Application Catalog - Groups - EDX (doe.gov)]

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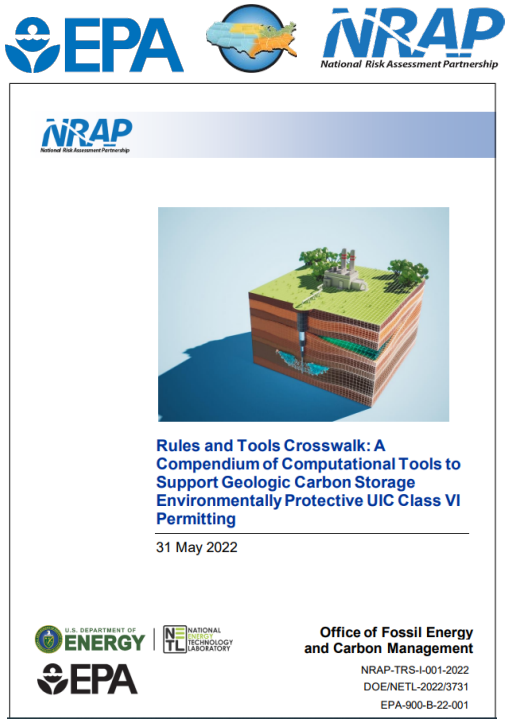
Stakeholder Engagement

NRAP Workshops at GWPC Conferences



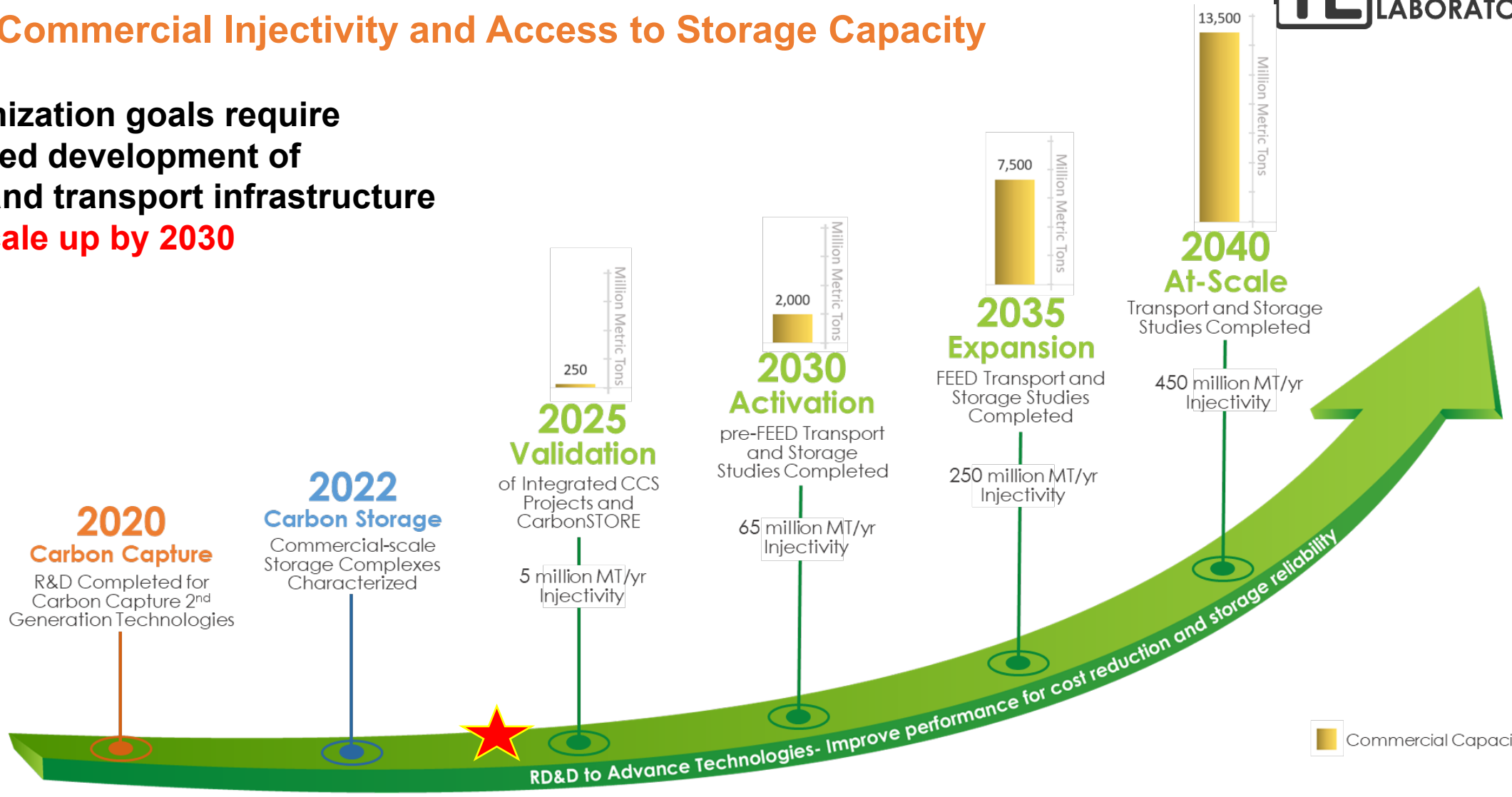
UIC Class VI Rules and Tools Crosswalk

DOE Carbon Transport and Storage Vision

NATIONAL ENERGY TECHNOLOGY LABORATORY

Scaling Commercial Injectivity and Access to Storage Capacity

Decarbonization goals require accelerated development of storage and transport infrastructure
→ 20X scale up by 2030



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2022-Strategic-Vision-The-Role-of-Fossil-Energy-and-Carbon-Management-in-Achieving-Net-Zero-Greenhouse-Gas-Emissions_Updated-4.28.22.pdf

Evolving Focus of NRAP

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Maturing practical, useable tools and methods to quantitatively assess and manage risks and liability for geologic carbon storage at site and basin scales, and promoting their application for permitting and risk-related decision support to enable GCS commercial deployment.

Delivering methods and computational tools to:

- Support permitting for environmentally protective storage (containment assurance/leakage risk)
- Assess and manage induced seismicity risk
- Design adaptive, risk-based monitoring networks
- **Inform liability assessment and investment decisions**
- **Inform risk management for basin-scale deployment**

Source: Templeton et al., (2021) Recommended Practices for Managing Induced Seismicity Risk Associated with Geologic Carbon Storgae

NRAP Toolset (As of: 8/31/2023)

Currently available
Forthcoming

Potential Leakage Risk and Containment Assurance

- NRAP-Open-Source Integrated Assessment Model (**NRAP-Open-IAM v2.7.2 α**)
- NRAP Basin-scale-Open-IAM

Induced Seismicity and State of Stress

- Operational Forecasting of Induced Seismicity toolkit (**ORION v0.5.1**) – induced seismic risk assessment
- State of Stress Analysis Tool (**SOSAT v3.1**)

Monitoring Design

- Risk-Based Adaptive Monitoring Plan (**RAMP**)
- Designs for Risk Evaluation and Management (**DREAM v3**) – monitoring design and optimization
- Passive Seismic Monitoring Tool (PSMT v1.0)

Linking Cost Modeling and Risk Assessment

- Python version of FECM/NETL CO2 Saline Storage Cost Model (CO2_S_COM_py) with remedial response

Stakeholder engagement to improve value and impact

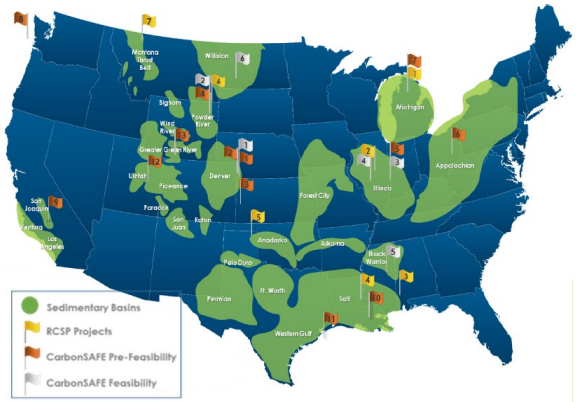
- Are we addressing the right questions?
- Is the approach credible and understandable?
- Are the tools useful and useable?

SMART NRAP National Risk Assessment Partnership EDX 4CCS Energy Data eXchange

DEV-OPS Image SOURCE: https://res.cloudinary.com/practicaldev/image/fetch/s---dbI8WY9--/c_limit%2Cf_auto%2Cfl_progressive%2Cq_auto%2Cw_880/http://aisaac.io/content/images/2018/11/DevOps.jpg

Part of an integrated strategy to enable CCS deployment

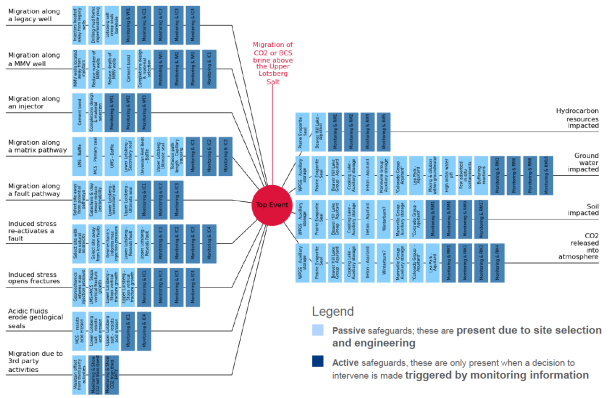
DOE CarbonSAFE



NETL Research Carbon Storage Program

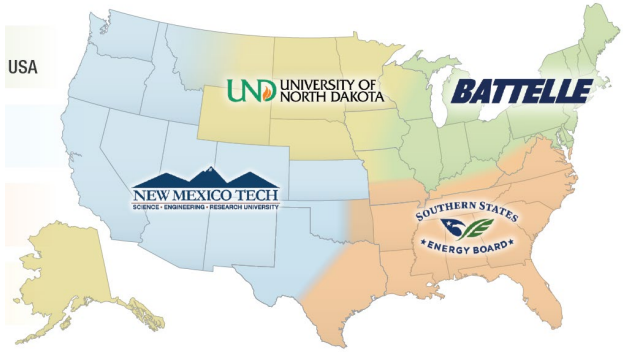
EDX 4CCS Energy Data eXchange

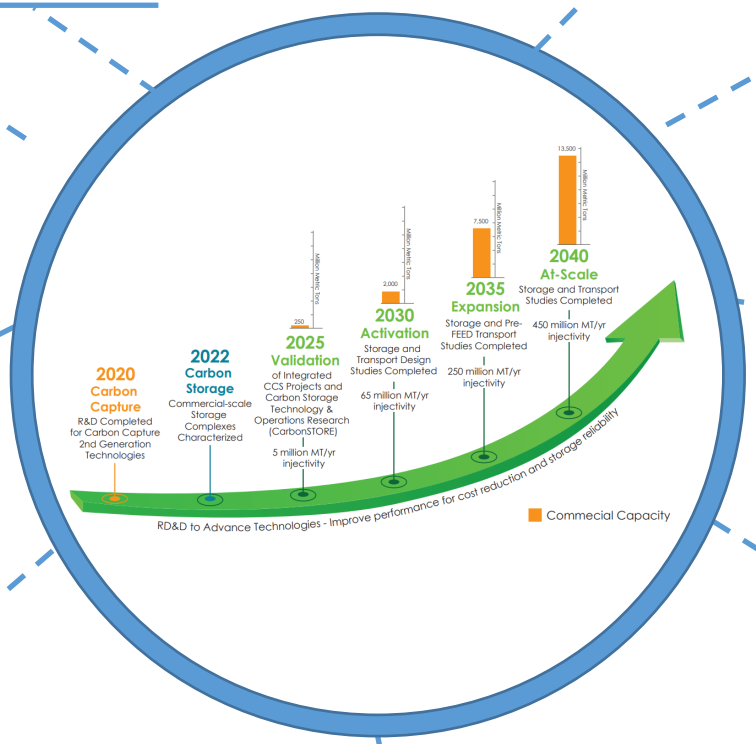
Industry Best Practices



Bourne et al., 2014

DOE-FE Regional Initiatives





International CCUS RD&D Community

ieaghg

Regulatory Context

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

NORTH DAKOTA OIL AND GAS DIVISION

DEQ

SMART

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Thank you!

Comments and Questions:

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