Application of NRAP risk assessment tools in the context of bowtie risk management framework

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National Risk Assessment Partnership

Overview

Objective:

- Demonstrate how NRAP tools can complement common risk assessment approaches used by the capture and storage (CCS) community

Approach:

- Apply NRAP tools to sites with an existing Risk Assessment to determine site risk

Case Study:

- Shell's Quest CCS Facility

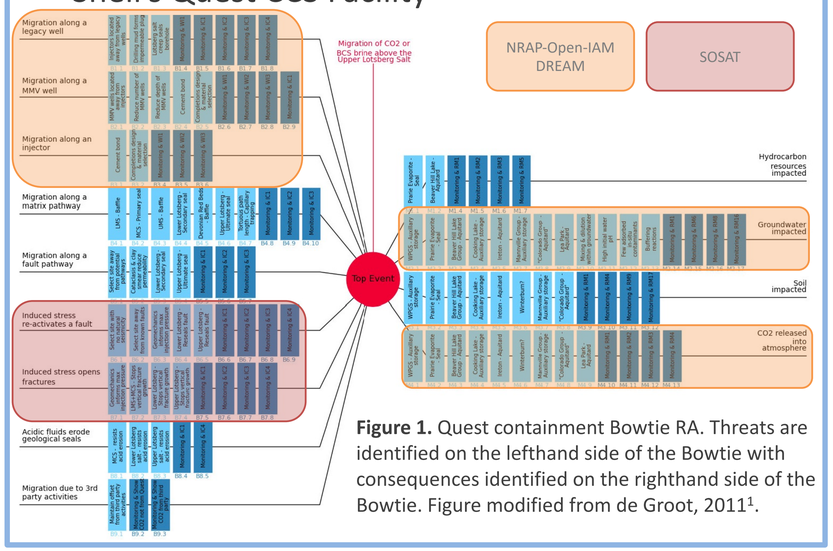

Figure 1. Quest containment Bowtie RA. Threats are identified on the lefthand side of the Bowtie with consequences identified on the righthand side of the Bowtie. Figure modified from de Groot, 2011[1].

Methods

Reservoir Model:

- Recreated Quest Petrel model using Gen-4 Modeling Report.[2]
- 1.08 Mtpa injection in 2 wells for 25 years

Open-IAM[3] Model:

- Built system model representative of Quest site
- Utilized the new generic aquifer ROM as a receptor
- Performed risk-based Area of Review (AoR) analysis[4]
- Considered both open and multisegmented wellbores (using low, high, and stochastic wellbore permeabilities)

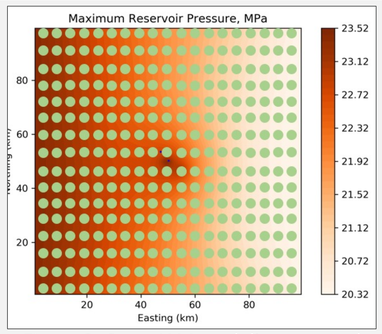

Figure 2. Open-IAM modeling approach

Results

Open Wellbore Simulations

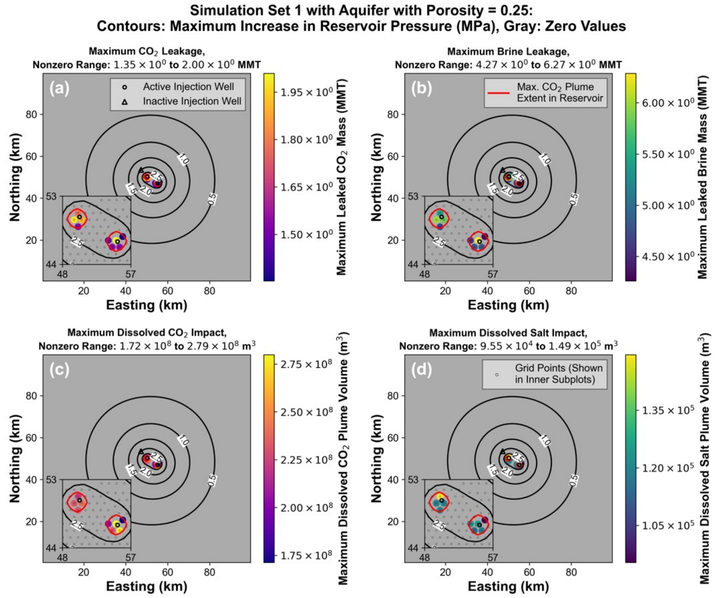

Figure 3. Subplots (a) and (b) show the CO_2 and brine leakage in million metric tons (MMT) from the hypothetical wellbores and to the BGWP. Subplots (c) and (d) show the dissolved CO_2 plume volumes and dissolved salt volumes resulting from this leakage.

Multisegmented Wellbore Simulations – high perm

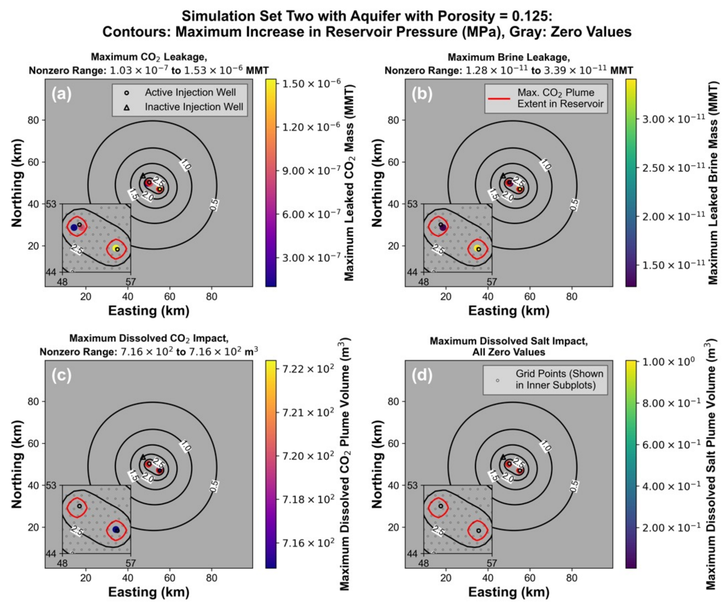

Figure 4. Results for fixed wellbore permeability of 10^{-14} m^2 with an aquifer porosity of 0.125. Subplots (a) and (b) show the CO_2 and brine leakage in MMT from the hypothetical wellbores and to the BGWP. Subplots (c) and (d) show the dissolved CO_2 plume volumes and dissolved salt volumes resulting from this leakage.

Risk-based AoR Comparison

AoR Determination

- Risk-based approach justifies AoR based on 2.5 MPa contour

AoR Comparison

Original AoR :

- 3,780 km^2

Revised AoR:

- 461 km^2 (12.2%)

Risk-based AoR:

- 102 km^2 (2.7%)

TDS & CO_2 Plume :

- 28.5 km^2 (0.8%)

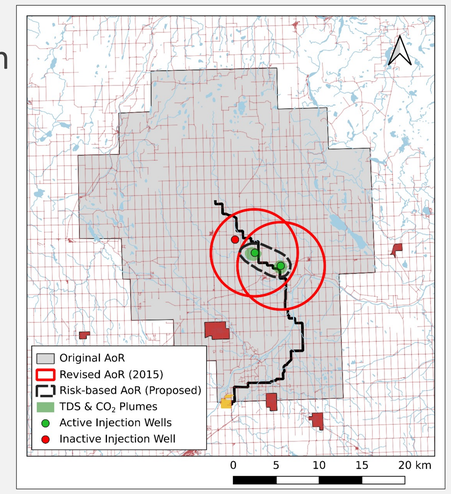

Figure 5. Comparison of AoRs used at the Quest site and the NRAP risk-based AoR calculated with the Open-IAM.

Conclusions & Next Steps

- Results from this effort support the revised AoR established by Shell during the operational period of the project
- Our results indicate the AoR could be further reduced due to the low impact risk to the groundwater if CO_2 and/or brine were to leak from the storage reservoir
- IJGGC paper documenting the full study is forthcoming
- Next steps involve developing a risk-based monitoring network for the site using the Design for Risk Evaluation and Management (DREAM) tool for comparison against the Shell monitoring, verification, and accounting (MVA) plan

References & Disclaimer

[1]de Groot, H., Containment Risk and Uncertainty Review, in Quest CCS Project. 2011, Shell.
[2]Winkler, M., *Generation-4 Integrated Reservoir Modeling Report* in *Quest CCS Project*. 2011, Shell.
[3]Vasylkivska, V., et al., *NRAP-Open-IAM: A Flexible Open-Source Integrated-Assessment-Model for Geologic Carbon Storage Risk Assessment and Management.* Environmental Modelling & Software, 2021. **143**
[4]Bacon, D.H., D.I. Demirkanli, and S.K. White, Probabilistic Risk-Based Area of Review (AoR) Determination for a Deep-Saline Carbon Storage Site. International Journal of Greenhouse Gas Control, 2020. 102.

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