Assessing Risk from Oil and Gas wells in Preparation for Geologic Storage of Carbon Dioxide: A case study of the Powder River Basin of Wyoming

Thomas Moore[a]*, Charles Nye[a], Scott Quillinan[a], Nick Bosshart[b], and Sitian Xiong[a&c]

[a] *Carbon Management Institute-School of Energy Resources, University of Wyoming*

[b] *Energy and Environmental Research, University of North Dakota*

[c] *Geographic Information Science for Development and Environment, Clark University*

Contact: Thomas Moore
TMoore24@UWYO.edu

Problem Statement

The Powder River Basin (PRB) is being studied for geologic storage of commercial quantities (50+ million tonnes) of carbon dioxide (CO_2). **Oil and Gas wells that penetrate confining lithologies introduce risk to CO_2 geologic storage projects. This study attempts to define this risk, to inform a Carbon Capture and Storage (CCS) project.** Factors of risk considered independently in this study include: well density, permanent plug and abandonment (PA) date (Table 1), and topography.

Dates Abandoned	Wyoming Regulatory Body	Written rule?	Cement used?	Leakage Risk
1883-1933	No regulatory oversight	No	Unknown	6
1933-1951	State Mineral Supervisor	Yes	Most state agencies require cement plugs	5
1951-1962	WOGCC	No	Probably, not required	5
1962-1976	WOGCC	Yes	Likely, loosely required	4
1976-1982	WOGCC	Yes	Yes	3
1982-1998	WOGCC	Yes	Yes	2
1998-Present	WOGCC	Yes	Yes	1

Table 1. Standards and regulations for plugging and abandoning wells. The regulations have generally improved over time and are associated in reducing risk, in this case, a smaller chance to act as a pathway for a CO_2 leak.

Methods

Well data was downloaded from the Wyoming Oil and Gas Commission database. This data was cropped within a 10 mile radius from the CO_2 source, Dry Fork Station (DFS). An additional six mile radius was included as a spatial reference. Wells were vertically selected based on the confining layer(s) they penetrate, so risk could be investigated per confining layer. The metadata of each well was examined to define risk based on a pre-existing methodology (Nelson, 2013). Risk is defined here by increases in well density, less PA regulations "regulatory risk", and by topographic confinement "topographic risk".

Well In Depression		Wells Near Depression	
Area in buffer (%)	**Risk**	**Area in buffer (%)**	**Risk**
>75%	6	>75%	5
50-75%	5	50-75%	4
25-50%	4	25-50%	3
0-25%	2	0-25%	2
unconfined	1	unconfined	1

Table 3. Number of wells in each "topographic risk" (Nelson, 2013) on the basis of local topography causing confinement.

Results and Conclusions

Well Density

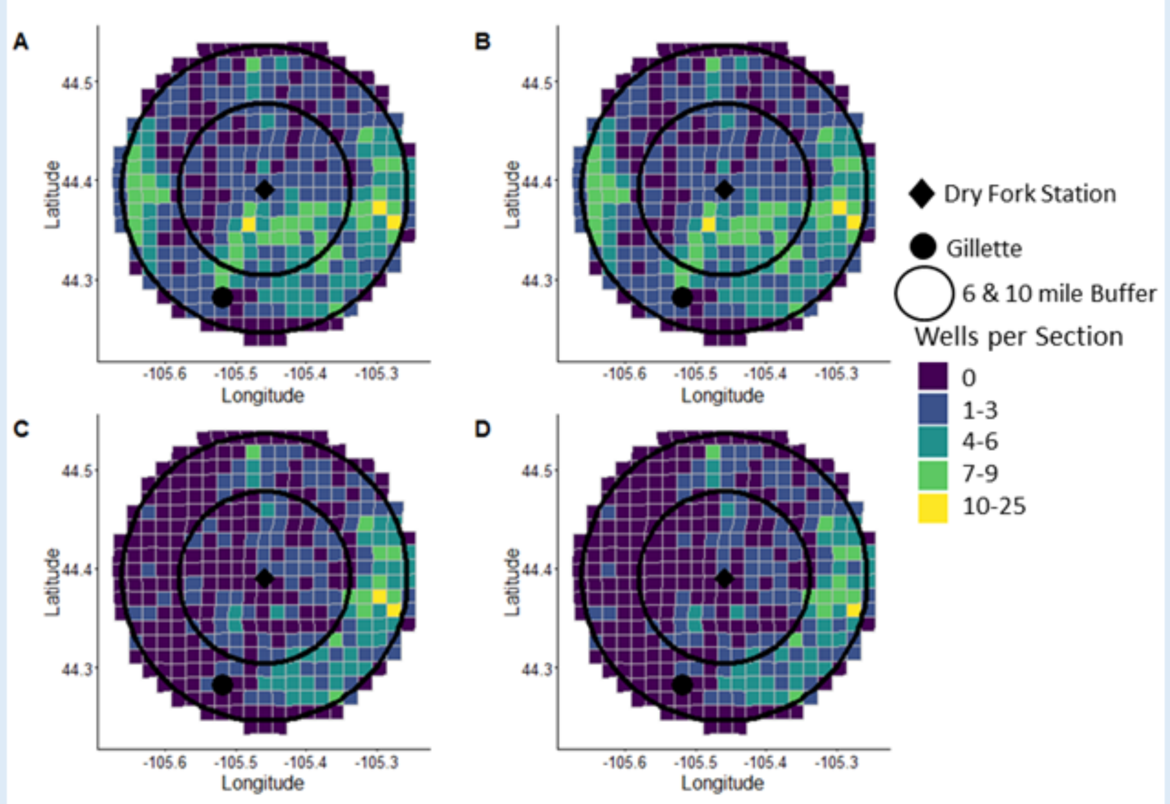

Figure 1. The density of wells per township section (1 mile x 1 mile) that penetrate the A) Lewis, B) Mowry, C) Morrison, and D) Opeche confining layers surrounding Dry Fork Station near Gillette, WY.

Density analysis is critical for comparing CCS scenarios, the risk wells may pose in a given scenario, and scenario selection. Avoiding areas with high well density is a simple way to mitigate risk.

- Density of wells decreases with the depth of the formations
- The highest density of wells is located east of DFS and is more than 6 miles away
- Density is lowest to the west of DFS
- Density is also low in the up-dip direction NE of DFS

Plug and Abandonment Date & Topographic Depressions

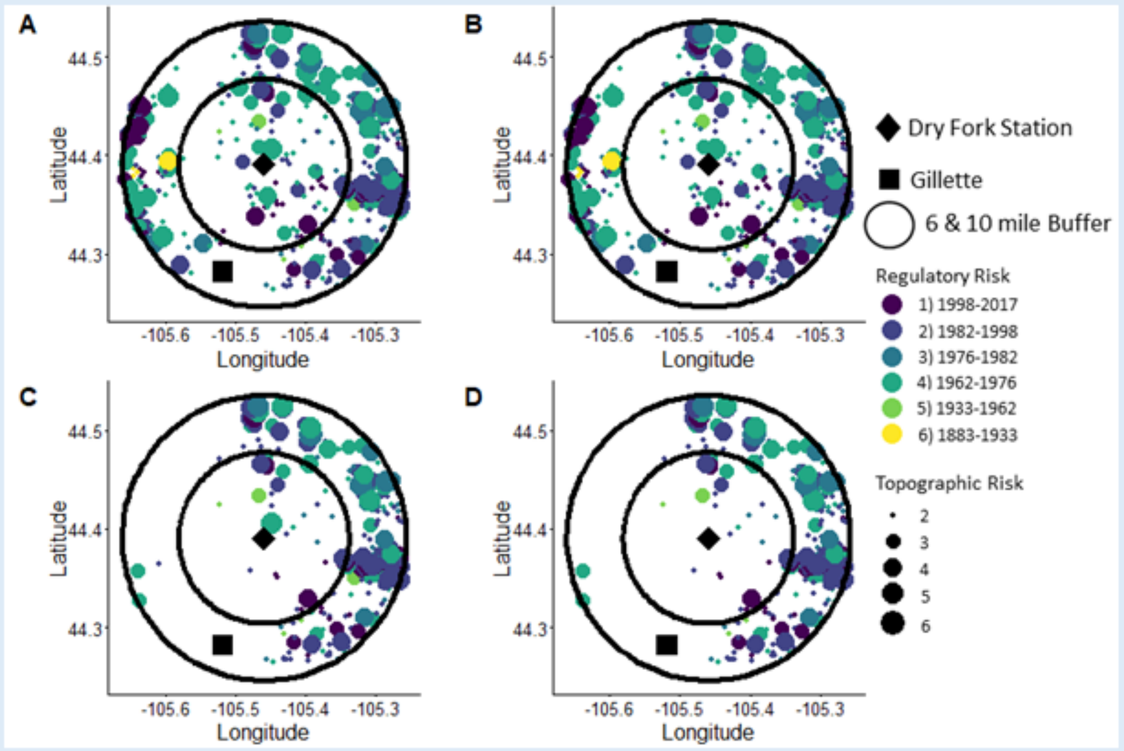

Figure 2. The risk associated with each plugged and abandoned well within ten miles of Dry Fork Station. The size of the point indicates the risk associated with topographic depressions, "6" being the riskiest. The color indicates the PA regulations of the time period, with yellow having the highest risk. (**Table 1**).

Risk is further defined by looking at abandoned wells which are not actively monitored, the regulatory period they were PA and the local topography surrounding the well. This can point to areas to avoid, and specific wells for further testing or monitoring as part of MVA planning

- The majority of "riskier" wells are in the two shallower formations
- PA wells to the west do not penetrate the two deeper formations
- The highest risk wells considering regulations and topography are outside the 6 mile buffer to the west and north.
- Two wells close to DFS (north) have a high regulatory risk (5).

Application to CCS Scenario

Based of this analysis, we are able to compare CCS scenarios for different storage formations being investigated, underlying the confining layers. Figure 3 shows a CCS scenario (50 Million tonnes) of CO_2 stored in the Minnelusa formation. We can look at each of the four injection wells, the CO_2 plume (red), and the total pressure extent (green) (Figure 3).

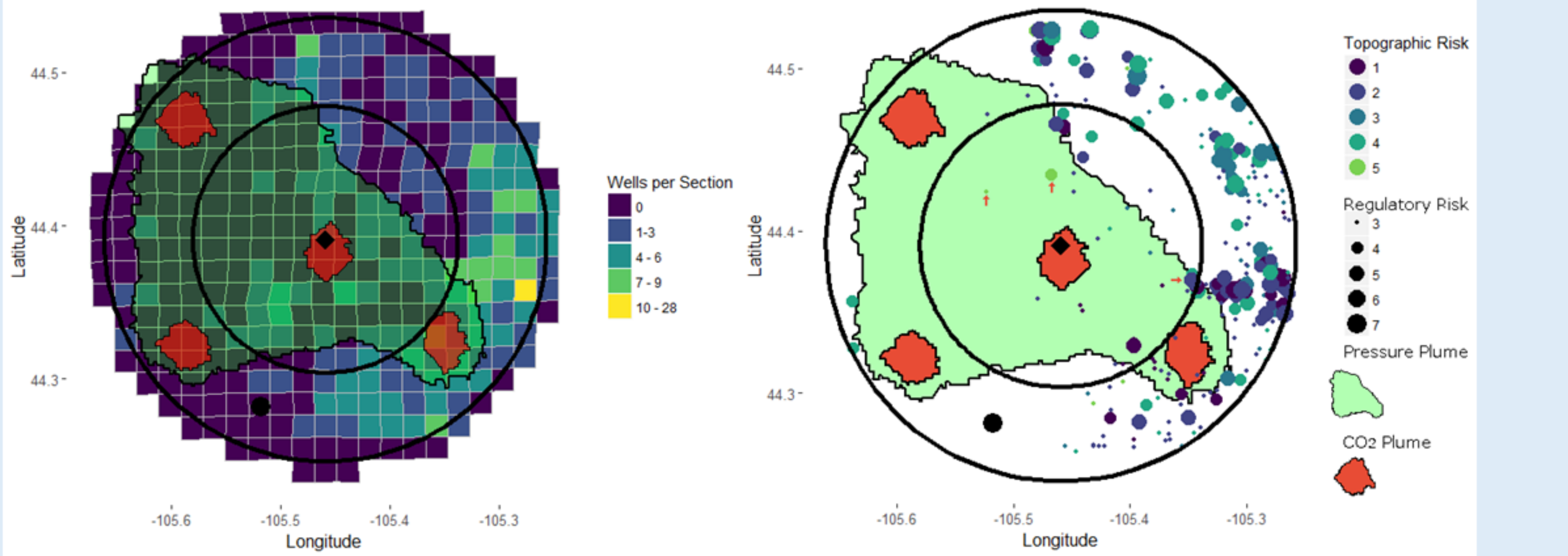

Figure 3. Risk as shown in Figure 1 and 2 from wells penetrating the Opeche confining layer and the CO_2/pressure plume extent of a simulation storing 50 million tonnes of CO_2 in the Minnelusa formation , underlying the Opeche.

- The two western plumes have the least risk and cover sections with no wells
- The central plume encompasses a section with low density (1-3 wells)
- The eastern plume cover 1 high density section (7-9 wells), 2, medium density wells (4-6) and 3 low density (1-3) sections
- The eastern injection well can be moved to minimize this risk.
- The one central and two western wells are ideal and encompass no PA wells in the CO_2 plume.
- The eastern well encompasses 2 wells with minimal PA risk (3) and low topographic risk (2).
- The pressure extent from all simulating injection wells misses the majority of existing wells
- However, some wells should be prioritized for further monitoring due to higher risk (red arrows).

Future Work

- Ground truth PA well locations with a magnetic survey.
- Develop a monitoring, verification, and accounting (MVA) plan with clear goals and objectives for data collection.
- Collect a robust baseline dataset.
- Monitor PA wells near current injection wells for potential leaks from increased pressure.
- Remotely sense vegetation stress surrounding PA wells indicating a leak.

Citation

Nelson, J. D. 2013., Assessment Tools for Assigning Leakage Risk to Individual Wells at a Geologic Sequestration Site in Wyoming. University of Wyoming.

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