



Carbon Capture and Storage (CCS) Project Development Workshop

Tuesday, October 19, 2010

Final Report

This is the final report of the 2010 PCOR Partnership Annual Meeting Carbon Capture and Storage (CCS) Project Development Workshop. Workshop participants leveraged their collective knowledge using the Implications Wheel™ to identify the potential ramifications of conducting an enhanced oil recovery project or a saline formation geologic sequestration project. These implications were then assessed, and the results were discussed by the group. Although the specific scenarios were hypothetical, they were built on real-world settings and issues. This report contains the following:

- General Background
- Map
- Saline Reservoir Center (background and assumptions)
- Saline Reservoir Center Implication Wheel Results
- Enhanced Oil Recovery Center (background and assumptions)
- Enhanced Oil Recovery Center Implication Wheel Results
- Key to Interpreting Implication Wheel Results

To view the workshop results on the Web, please visit the PCOR Partnership Partners-Only Web site:
<http://www2.undeerc.org/website/PCORP/>.

For more information about this workshop or the PCOR Partnership, please contact:

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General Background

- NGPU is an investor-owned utility that operates several coal-fired power plants in North America and wants to expand its electricity-generating capacity.
- Federal legislators are expressing interest in developing and implementing some type of CO₂ emission control strategy within the next 5 to 10 years. It has been announced that CO₂ will be priced at \$30/ton.
- NGPU is considering expansion of the Sunflower Station, a coal-fired facility located along the Sapphire River in farming and ranching country 40 miles south of Bigtown, the regional commercial hub. Following the planned expansion, the Sunflower Station will produce 4.9 million tons of CO₂ annually. Because of the likelihood of CO₂ emission control regulations, NGPU plans to install equipment needed to capture at least 20% of the CO₂ generated at the expanded Sunflower Station.
- The Sapphire River separates North State from South State. Each of these is a separate jurisdiction. Indian lands straddle the Sapphire River in the vicinity of Bigtown and the Belle Plain Federal Wildlife Preserve is located in North State about 80 miles from the Sunflower Station.
- There are three other power plants in the region. One of them, the Pintail Station, is also owned by NGPU, while the other two (i.e., the Polaris Station and the Blue Mountain Station) are owned by Mountainside Utilities. The Pintail Station produces 4.5 million tons of CO₂ per year. The Polaris Station and the Blue Mountain Station both produce 3.0 million tons of CO₂ each year.
- NGPU hired the PCOR Partnership to develop a carbon management plan. The plan indicates that either enhanced oil recovery or storage in a saline formation could be viable techniques for sequestering the potential 20% CO₂ emission reduction at the Sunflower Station following its expansion.
- Blackhawk Oil Company owns oil fields that are roughly 175 miles from Sunflower Station and have enough capacity to store the 20-year volume of CO₂ captured at the expanded Sunflower Station.
- A preliminary assessment, based on limited data, indicates that there may be sufficient capacity within the deep saline formation underlying the Sunflower Station to not only store the CO₂ captured at the expanded Sunflower Station but also a significant volume of additional CO₂.
- NGPU engineers have chosen a scrubbing technology for the Sunflower Station that has been applied commercially at large gas-processing facilities and can capture at least 85% of the CO₂ from a mixed-gas stream.
- Recent NGPU plans for construction of a coal-fired facility in a neighboring jurisdiction were scuttled because of adverse public response.
- NGPU personnel do not have storage reservoir engineering, pipeline, or injection expertise.

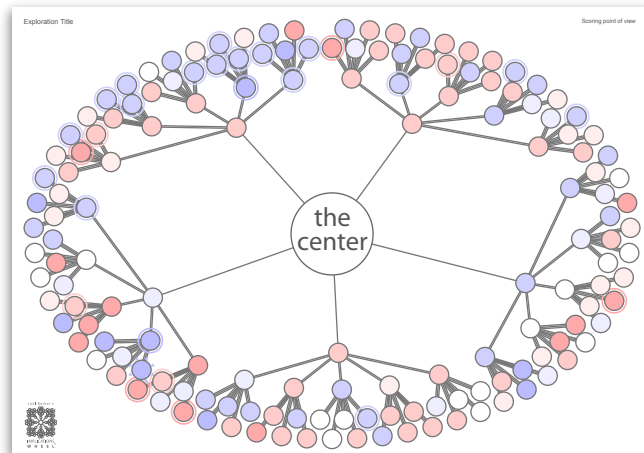


Reference Map for the Plains CO₂ Reduction (PCOR) Partnership Carbon Capture and Storage (CCS) Project Development Workshop



The Implications Wheel®

Reading an Exploration



Start by assuming that **the center** happens. The circles connected to the center are possible consequences of the center. These are called **1st order implications**.

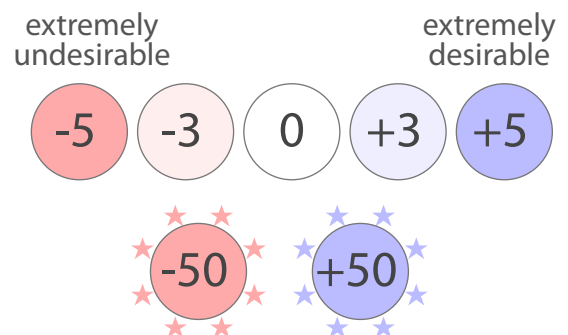
Then assume that the 1st order implications happen. The **2nd order implications** are possible implications of the 1st orders.

Finally, the **3rd order implications** are possible implications of the 2nd orders.

Scoring for Desirability

The desirability or undesirability of an implication depends on one's point of view. The point of view from which these implications were scored is printed in the upper-right corner of the exploration.

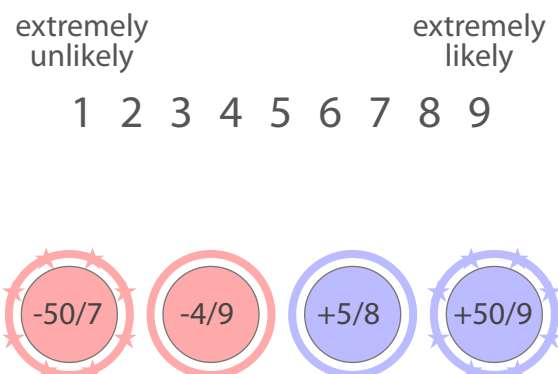
The desirability scale goes from -5 to +5, with two special scores (+/-50) for extraordinary situations.



Scoring for Likelihood

Each likelihood score assumes the occurrence of the preceding implication. The likelihood scale is from 1 to 9.

If you see a red or a blue implication that is circled, the circle indicates that the implication received a 7, 8, or 9 likelihood.



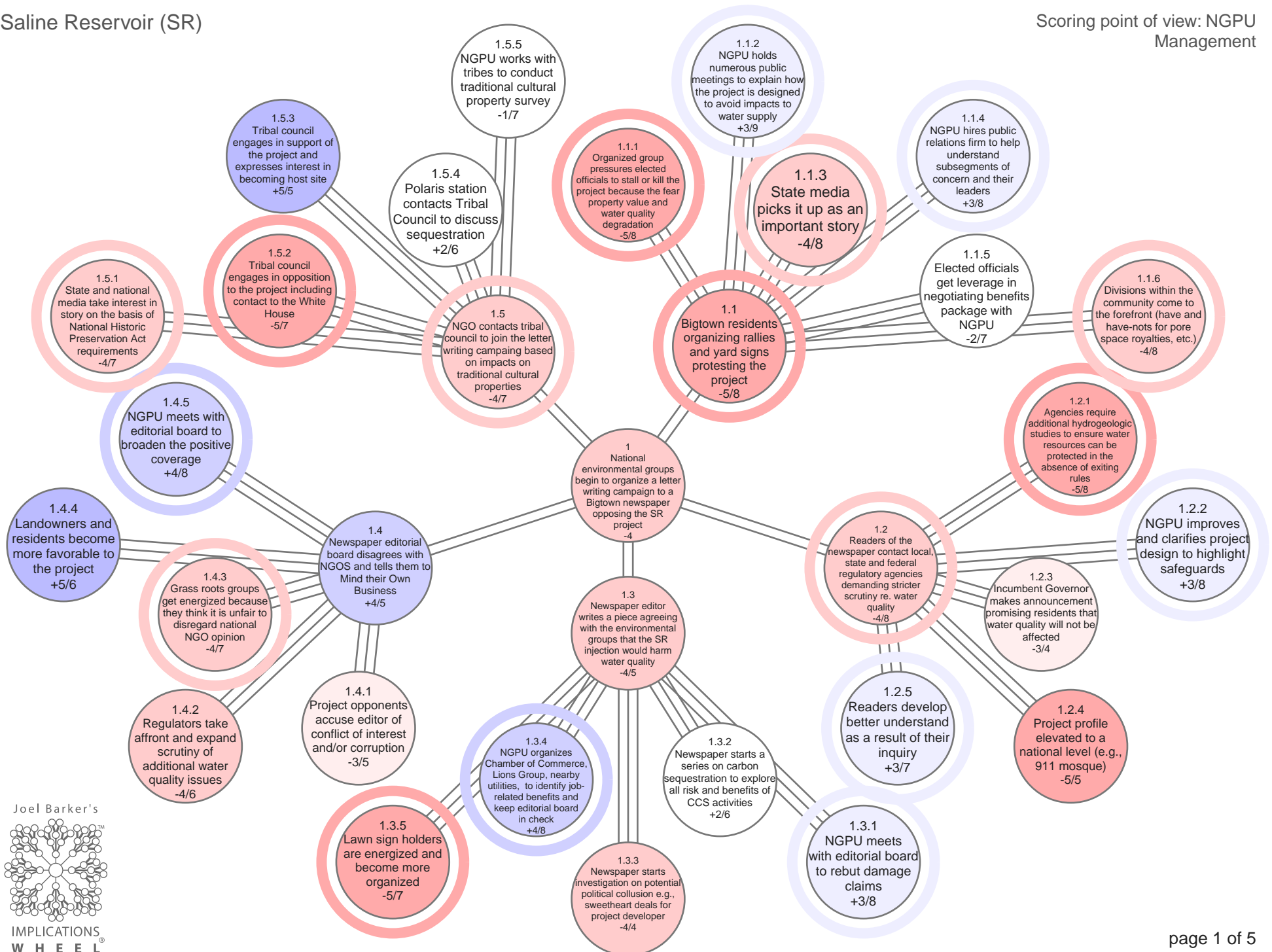
Saline Reservoir Center

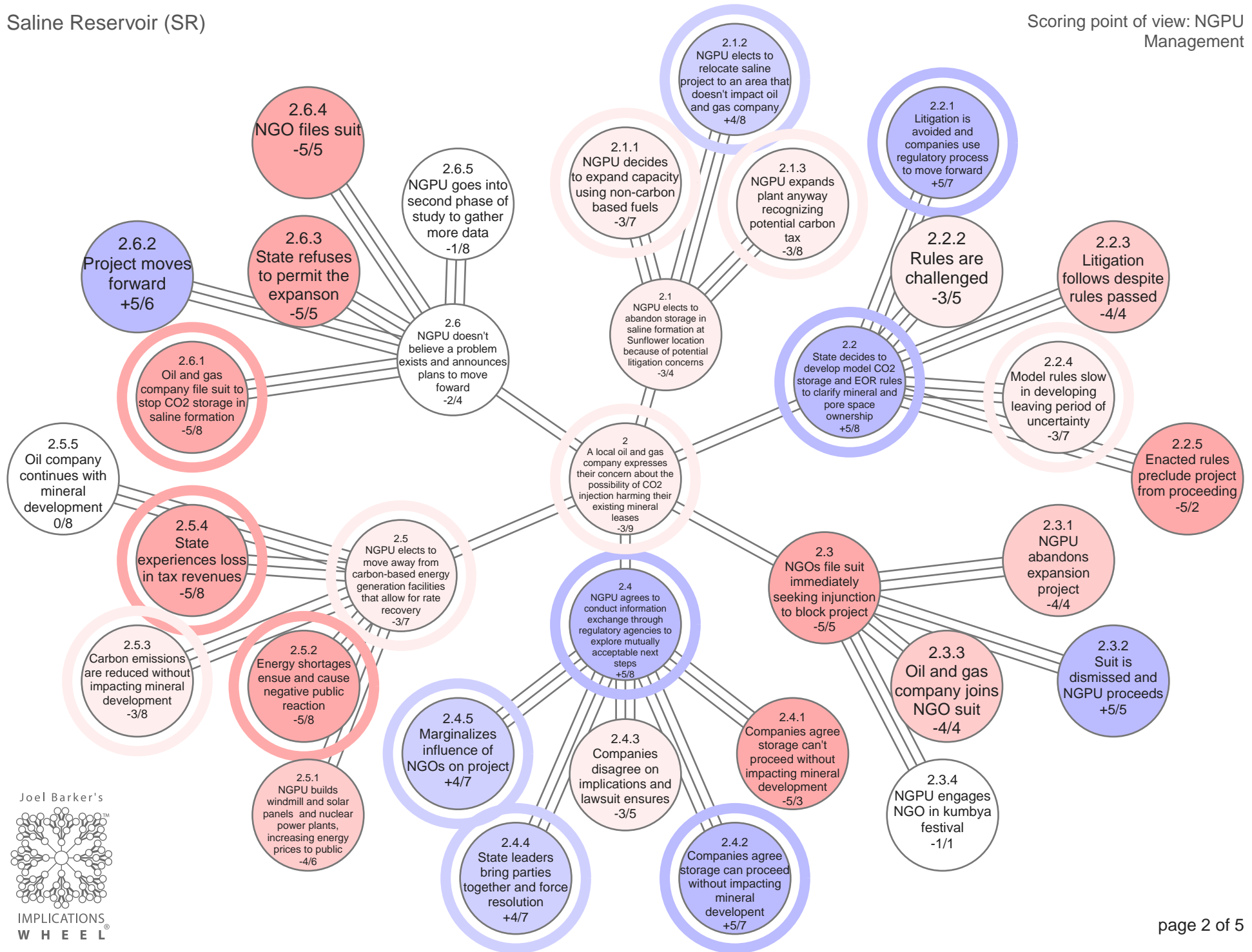
What are the implications for NGPU if it decides to develop a saline reservoir (SR) geologic storage project near the Sunflower Station?

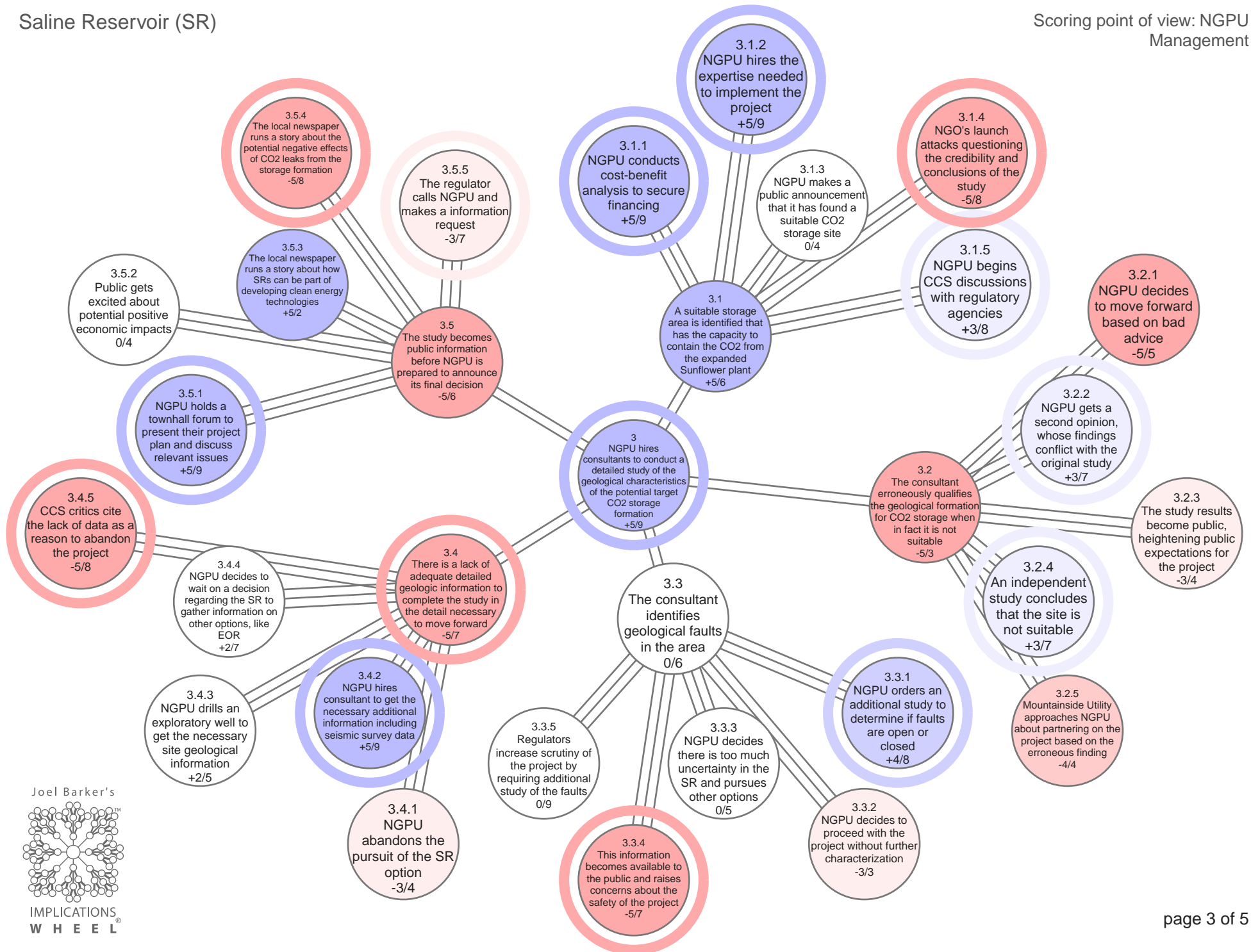
- A geologic consulting firm retained by NGPU has performed a preliminary assessment of saline reservoir storage opportunities in the area in proximity to the Sunflower Station. The results are as follows:
 - Analysis of geologic logs from a handful of deep exploratory wells drilled in the 1950s indicates that the area near the power plant may be a good candidate for CO₂ storage.
 - The primary CO₂ storage target is thick, regional, permeable sandstone at a depth of 6000 feet saturated with saline water (100,000 parts per million total dissolved solids) and overlain by 150-ft-thick shale.
 - Modeling efforts based on the limited data indicate the potential for storage of 150 million tons of CO₂ in the reservoir.
- Recent South State legislation requires that rules be promulgated to govern the injection of CO₂ into a saline formation for storage purposes and that the regional environmental agency must consult with other relevant regional agencies during the rule-making process. The regional environmental agency has begun a study to determine the protocol for developing appropriate rules.
- Pore space ownership and long-term stewardship have not been addressed by the legislature, and no legislation is pending.
- Various reports and findings have been assessed and compiled into an internal NGPU feasibility study. The technical findings are cautiously favorable for SR.

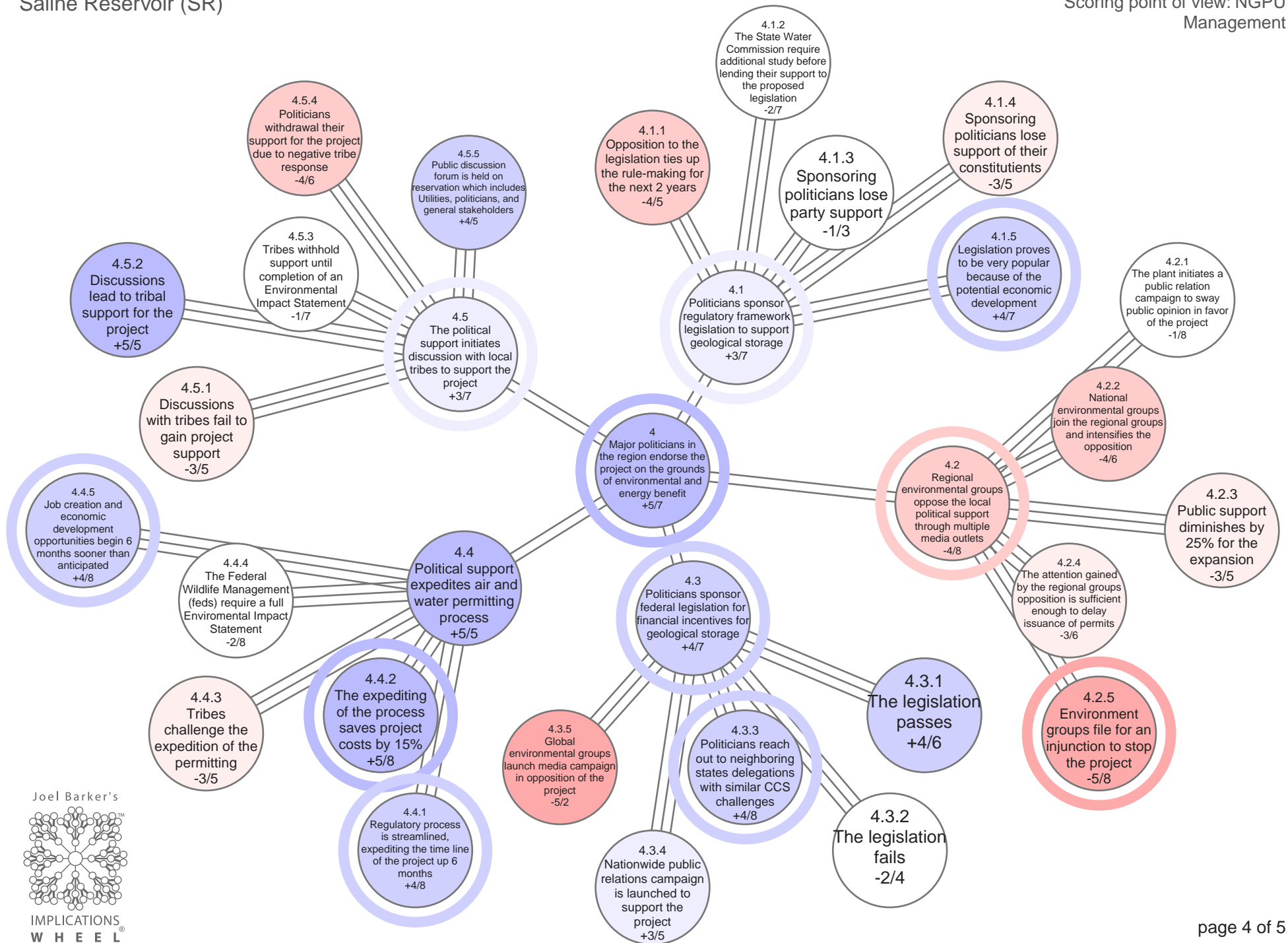
Assume that:

- NGPU can secure funding for the project but may file for a rate increase in the future, if necessary, to cover the capture costs.
- NGPU will be filing for the necessary permits.
- NGPU will build the pipeline to carry the CO₂ to the saline formation injection point.
- Other regional power companies (e.g., Mountainside Utilities) are looking at the same target formation for storage of their CO₂.
- NGPU will develop a detailed project plan.
- As an early adopter of carbon capture and storage in a saline reservoir, NGPU is eligible to apply for government funding for implementation of the technology.
- NGPU will issue press releases announcing the intention to develop an SR project.











Enhanced Oil Recovery Center

What are the implications for NGPU if it decides to supply CO₂ captured at the expanded Sunflower Station to an enhanced oil recovery (EOR) project?

- Blackhawk Oil Company is a major regional oil field operator with several fields nearing the economic limits of their water flood production. Based on Blackhawk's preliminary assessment, the Limestone oil field is a good candidate for EOR because:
 - The field has significant oil remaining.
 - The field is unitized and well-characterized.
 - The field consists of permeable carbonate reservoir rock overlain by an impermeable layer that is nearly 100 ft thick.
 - The field could use as much as 2 million tons of CO₂ annually for 20 years.
- Blackhawk Oil Company has interest in three similar fields in the proximity of Limestone Field.
- The Sunflower Station and the Limestone oil field are in different jurisdictions. Rules are in place in North State that cover CO₂ storage that takes place during EOR operations.
 - Additionally, these laws and rules allow an EOR project to be converted to a direct CO₂ storage project upon cessation of EOR operations.
 - Regulatory authority for all aspects of the project resides with the North State oil and gas commission.
 - Pore space ownership resides with the surface owner, but the mineral estate has dominance.
 - Promulgated rules allow for the project operator to transfer liability (postclosure) to the region, after a set of conditions have been met.
- Various reports and findings have been assessed and compiled into an internal NGPU feasibility study. The findings are cautiously favorable for EOR.

Assume that:

- NGPU will be filing for the necessary permits.
- NGPU will build the pipeline that crosses from South State to North State.
- NGPU will be contracting with a field operator for a threshold price of CO₂.
- NGPU will file for a rate increase to cover the cost of carbon capture and storage.
- NGPU will be developing a detailed project plan.
- NGPU's EOR agreement will include transfer of CO₂ liability to the oil company at the injection point.
- NGPU will issue press releases announcing the intention to develop EOR projects.

