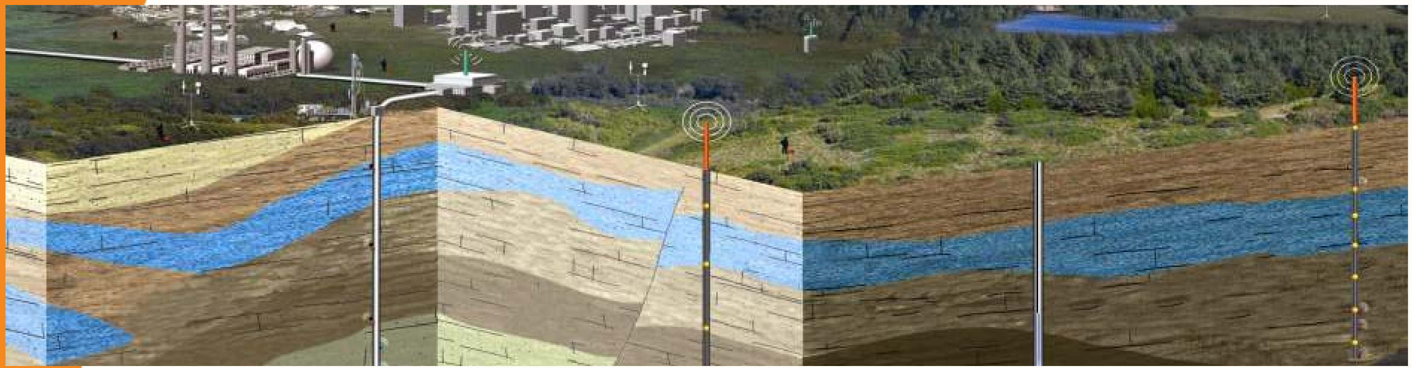
Schlumberger
Carbon Services



Commercial Sequestration

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North America Business Manager

Mar 9, 2011

Acknowledgements

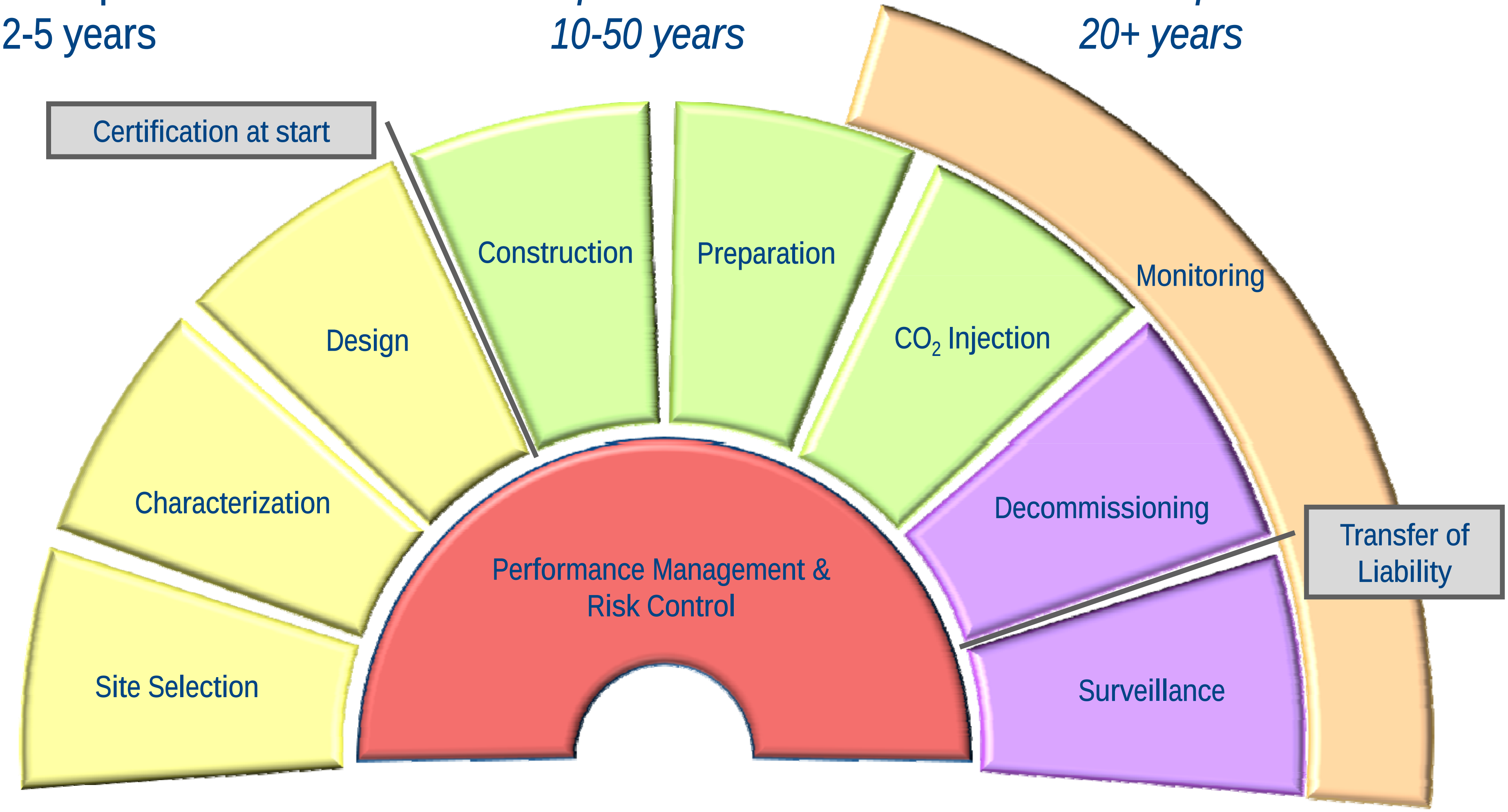
Some graphics in this material is based upon work supported by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL). This work is managed and administered by the Regional Carbon Sequestration Partnerships and funded by DOE/NETL and cost-sharing partners.

The Commercial CO2 Storage Workflow

Pre-Operation Phase
2-5 years

Operation Phase
10-50 years

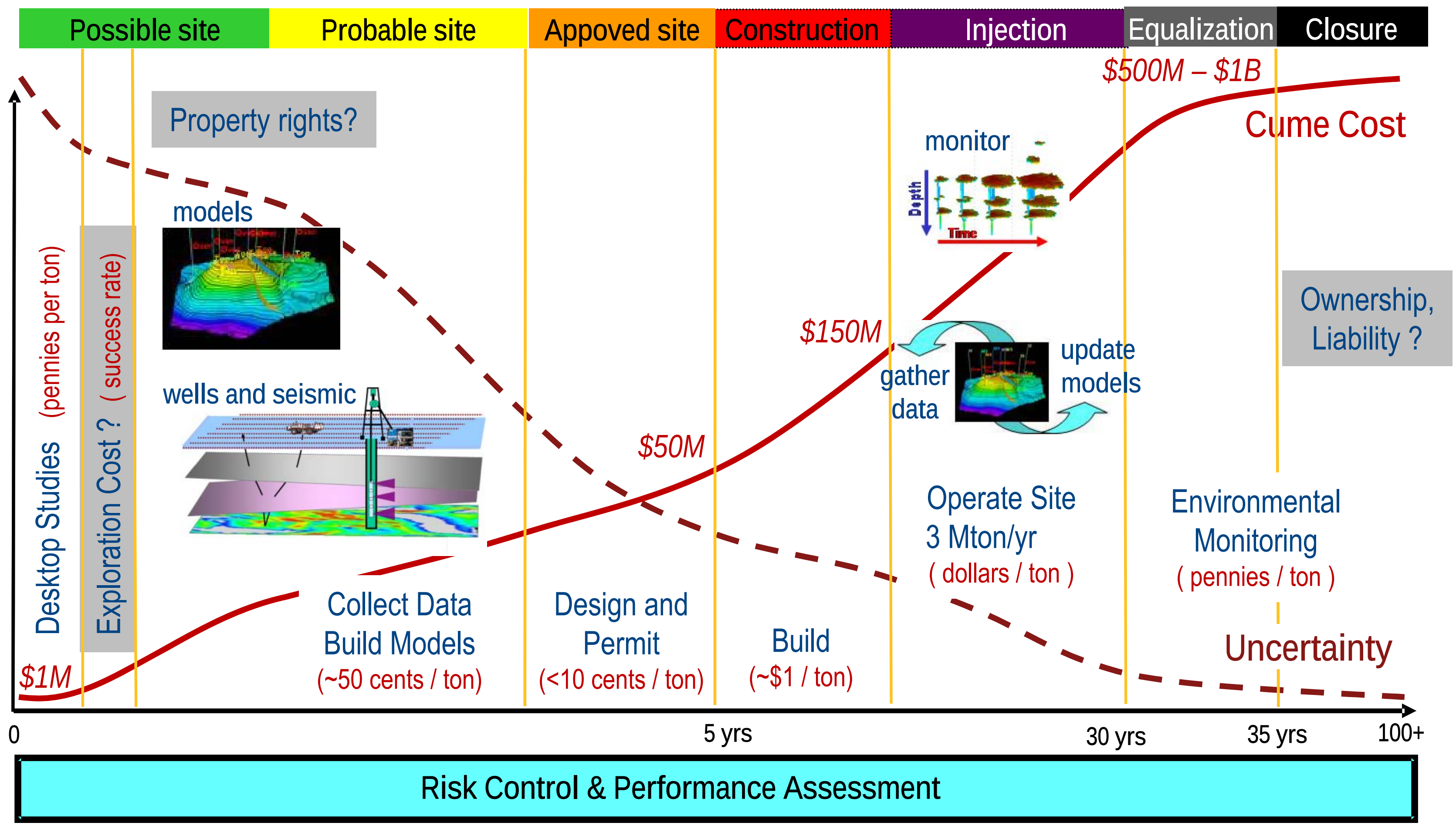
Post-Operation Phase
20+ years



Current Knowledge

- Scientific work has identified many potential storage sites in the US and rest of world
- Only some of these sites can provide low risk, low cost commercial storage
- Injection pilots build acceptance but leave many unknowns about commerciality
- Today' s best practices manuals have been derived from small scale experiences
- Many important pilot project experiences are not completely understood
- Scale-up will require commercial processes adapted from the oil and gas industry.

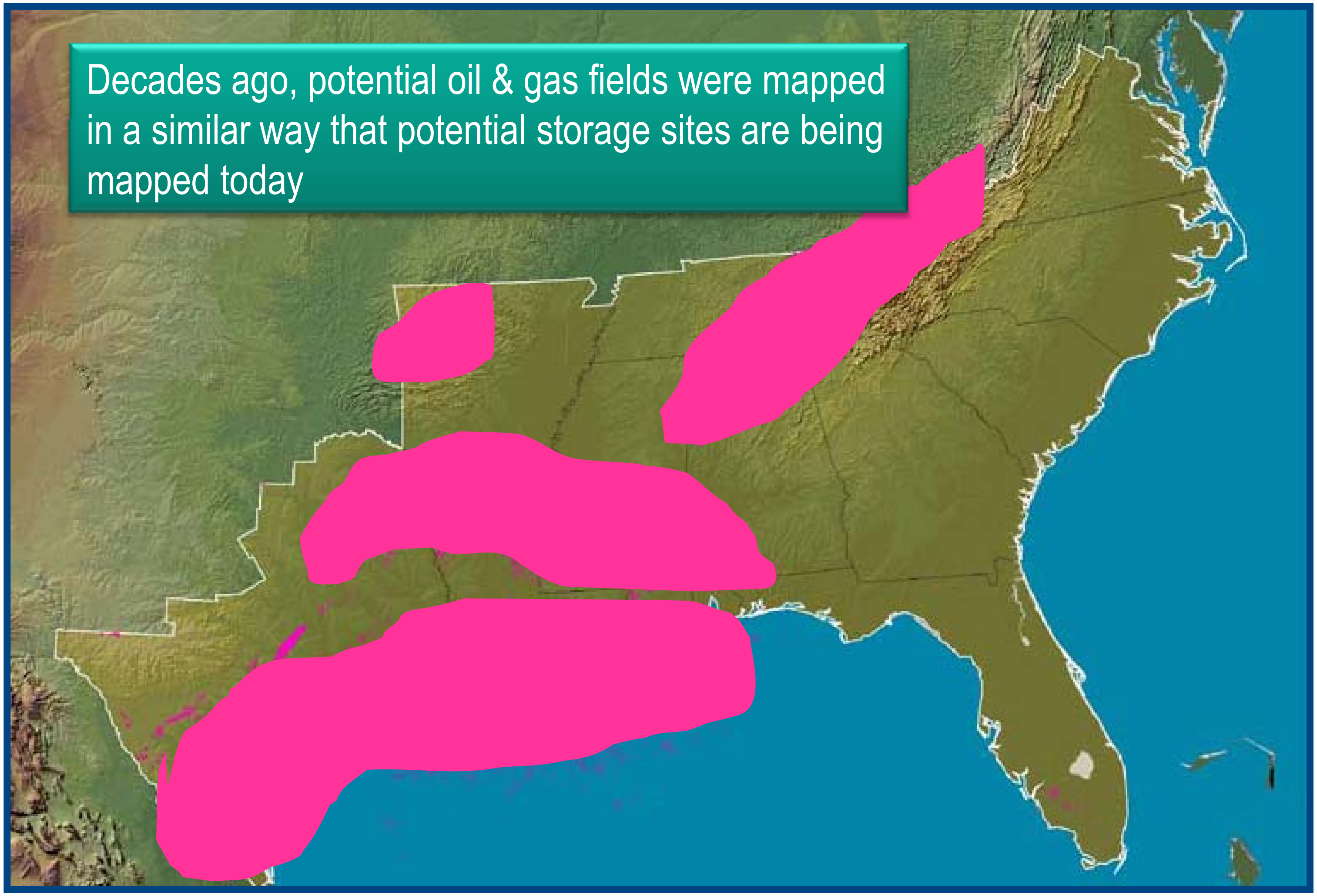
Important Variables



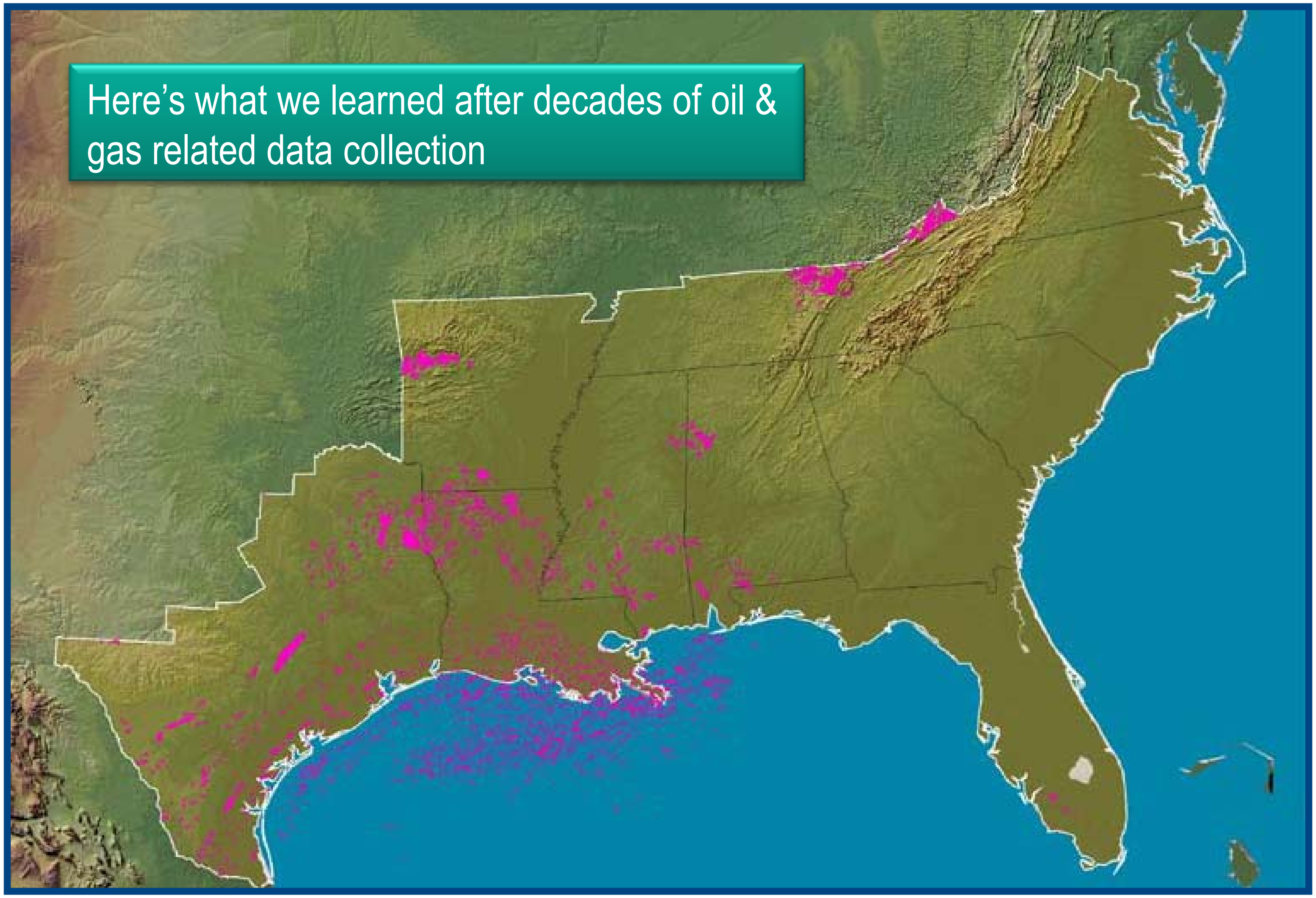
** Per ton estimates and total costs (in current day $USD) are based on 100 Mton lifetime storage volume*

NATCarb Data "Blobs"

An Oil and Gas Analogy



The Importance of Data

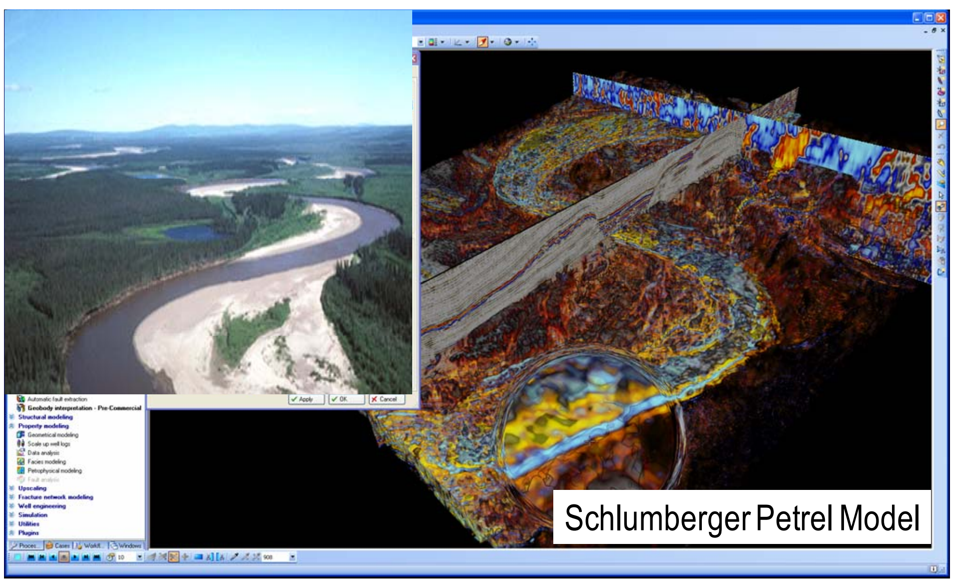


Scale Up Challenges for CO_2 Storage

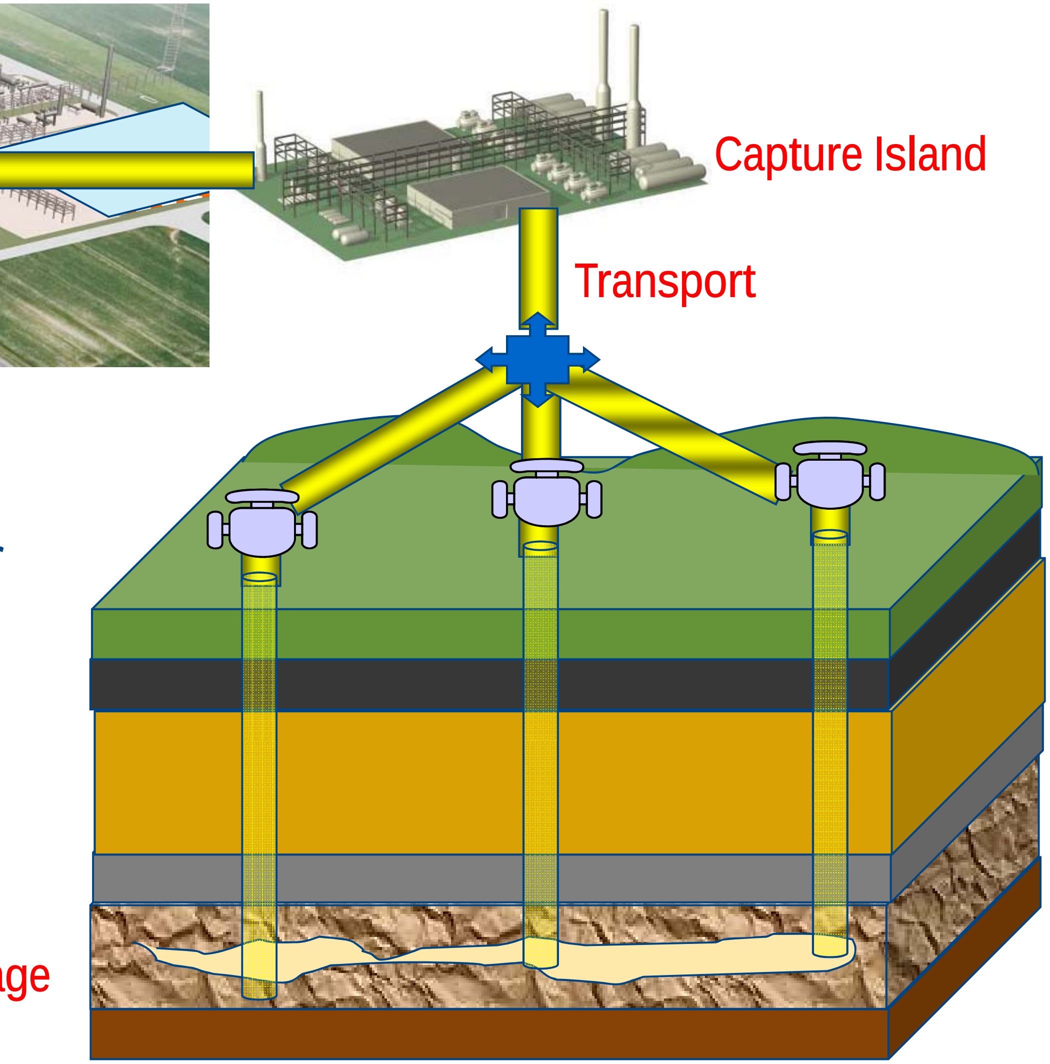
- Data integration
- Risk management
- Monitoring and validation
- Operational challenges and HSE

Data Integration

- Pilot projects have followed hypothesis driven scientific experimentation
- Subsurface models should represent a range of possibilities not a best estimate.
- Integration enables us to continually restrict possible scenarios and lessen risk
- Multiple disciplines must converge on a shared earth model
- New information must be rapidly added into the decision process

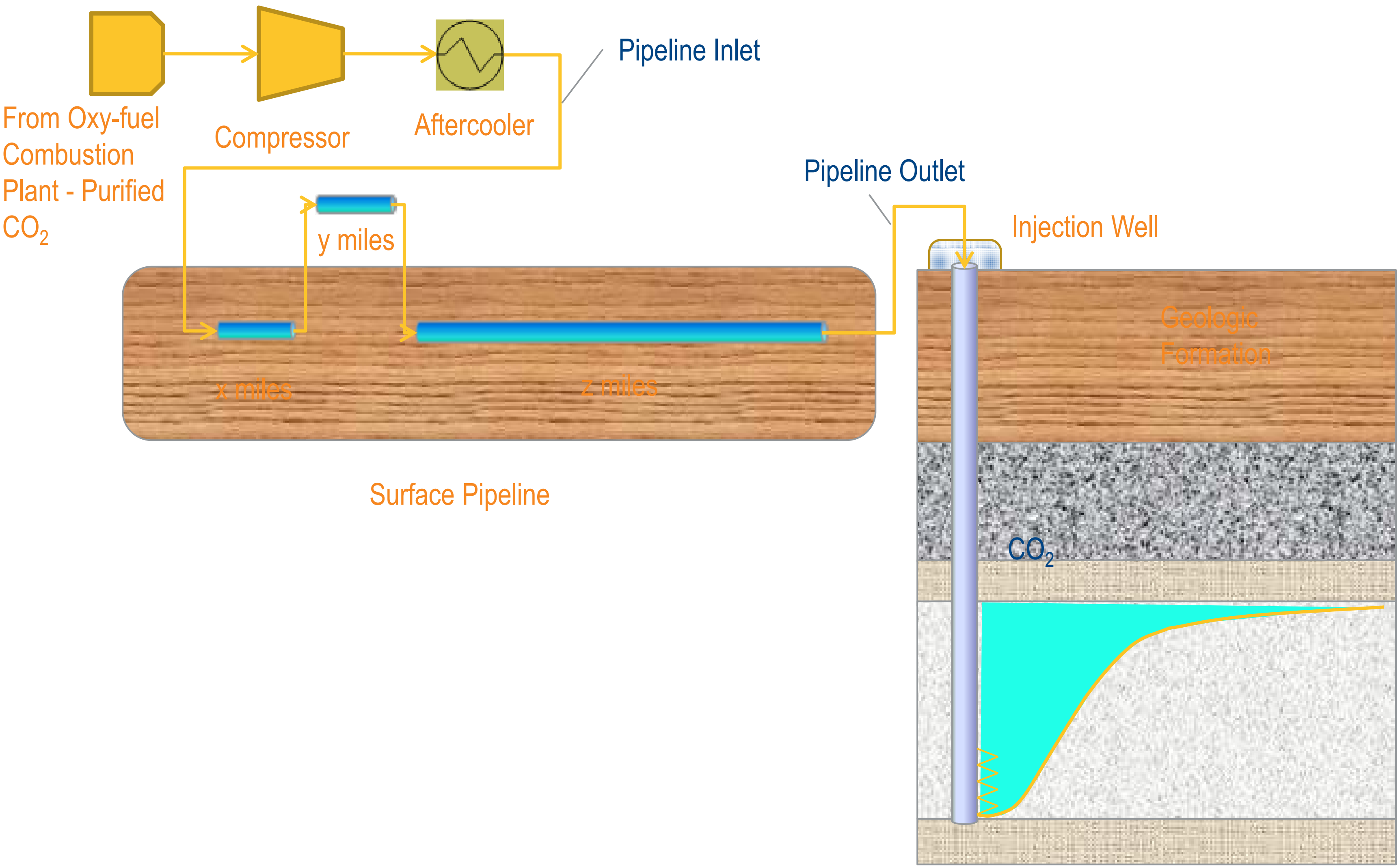


CCS Full System Integration



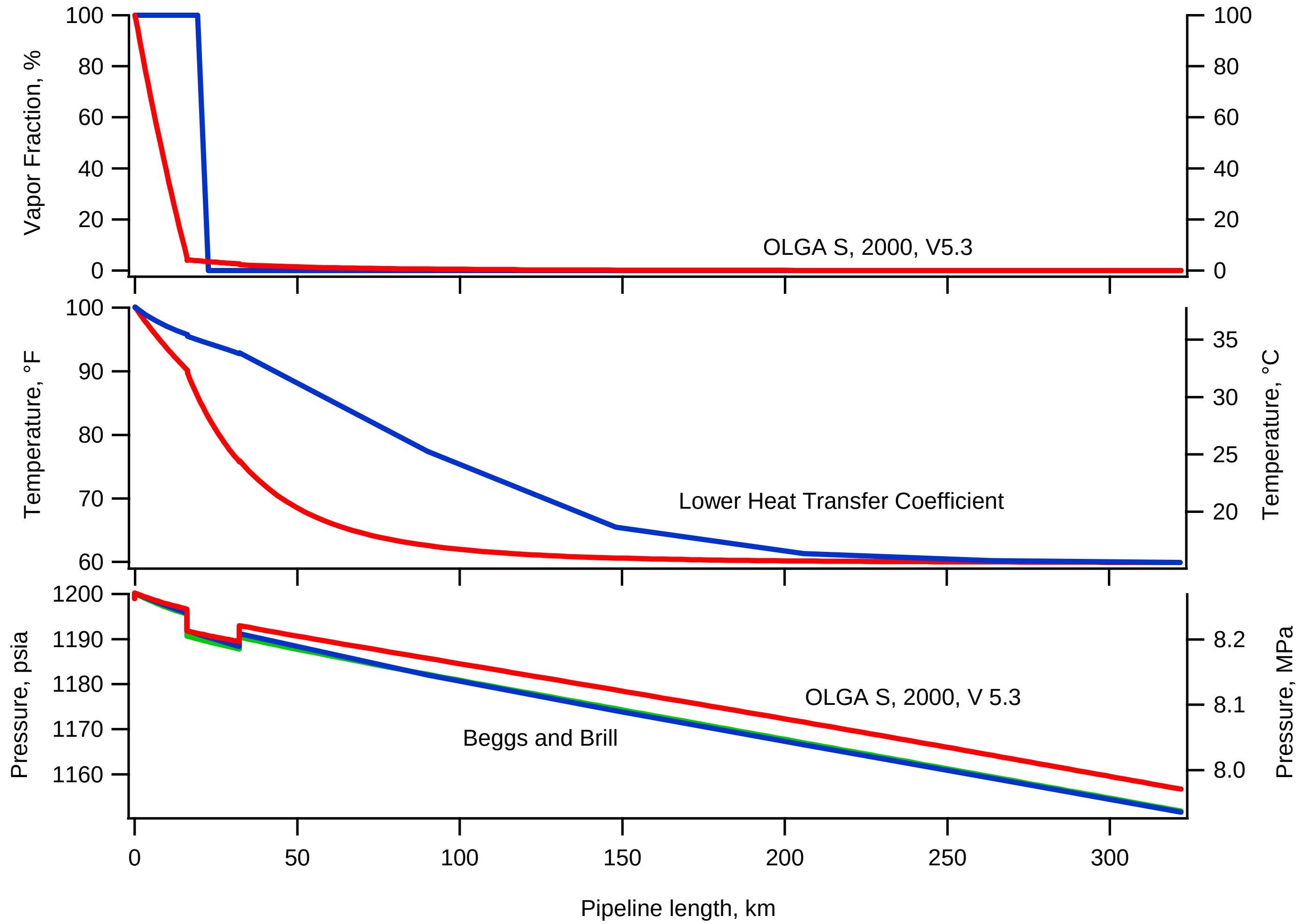
- CO_2 quality matched to reservoir
- Fluid behavior through network
- Operational integration
  - alarming
  - shut downs
  - back up

CO2 Injection – Simple Schematic



Surface Pipeline – Effect of Pipeline Diameter

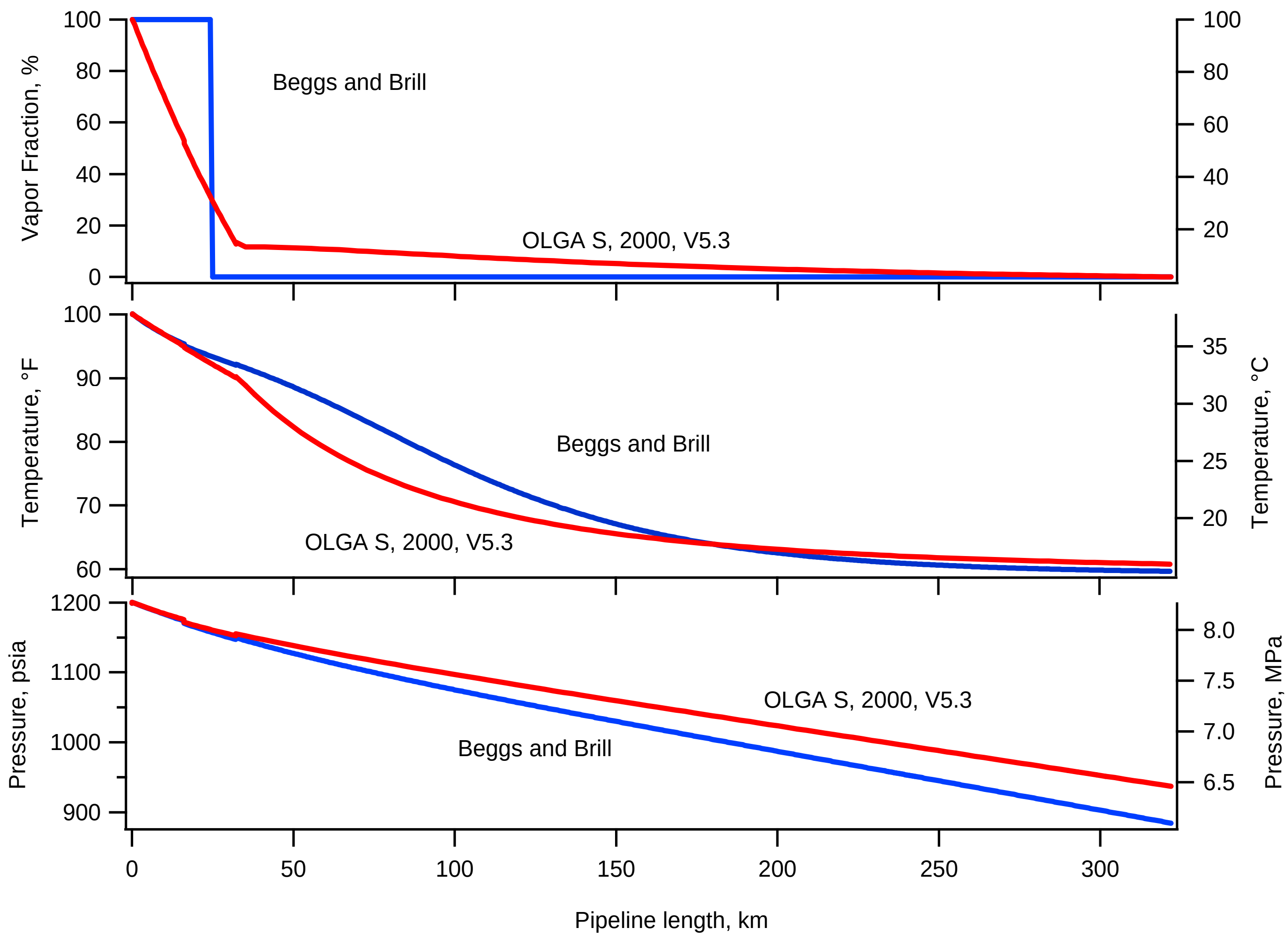
200 miles long, 10 miles elevated, 190 miles buried. Inlet temperature 100 °F, inlet pressure 1200 psia, ambient temperature 60 °F, pure carbon dioxide, one million tonnes per year, 18” pipeline



ΔP	4.1%

Surface Pipeline – Effect of Pipeline Size

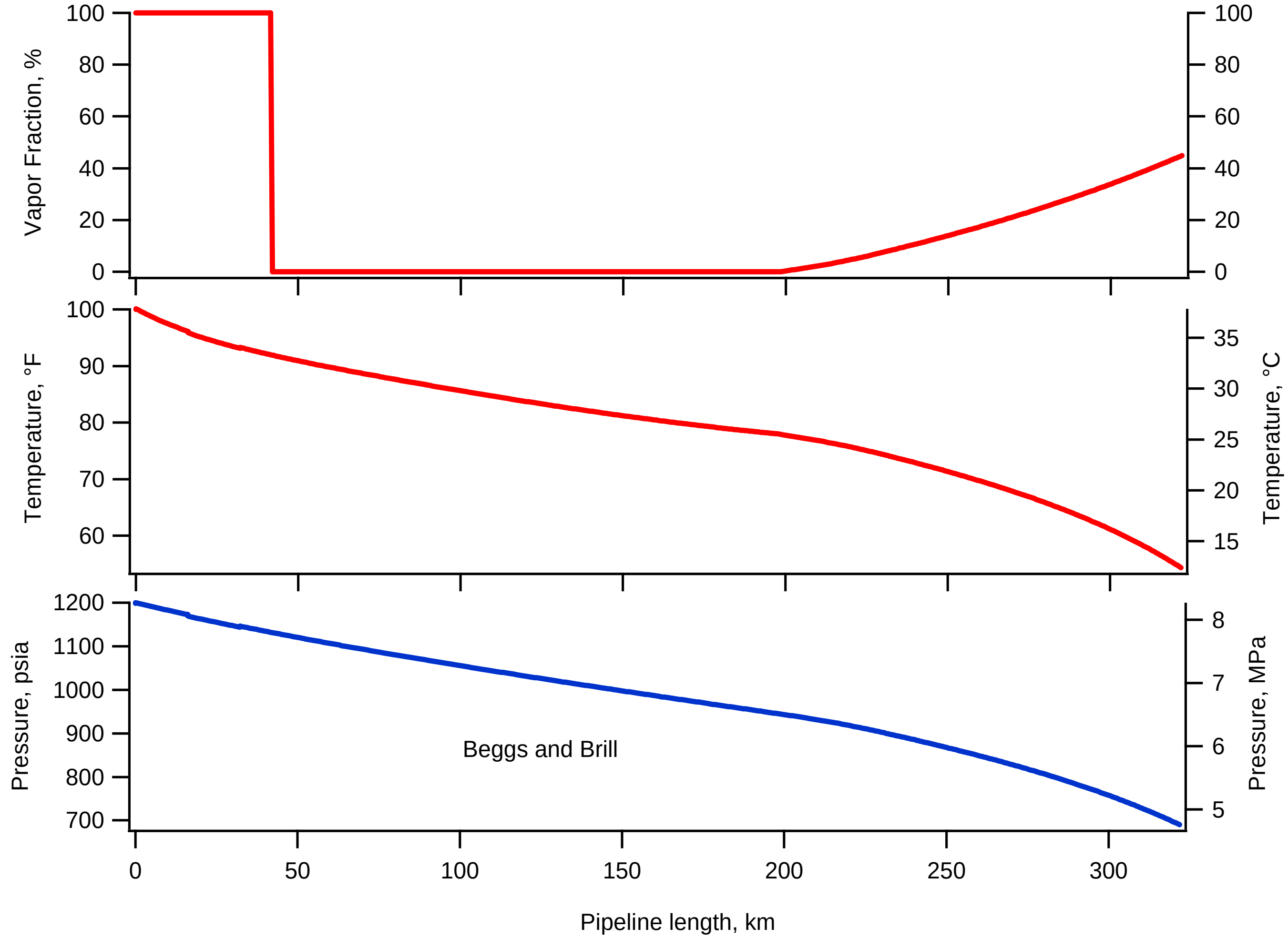
200 miles long, 10 miles elevated, 190 miles buried. Inlet temperature 100 °F, inlet pressure 1200 psia, ambient temperature 60 °F, pure carbon dioxide, one million tonnes per year, 12” pipeline



ΔP	26.3%

Surface Pipeline – Effect of Temperature

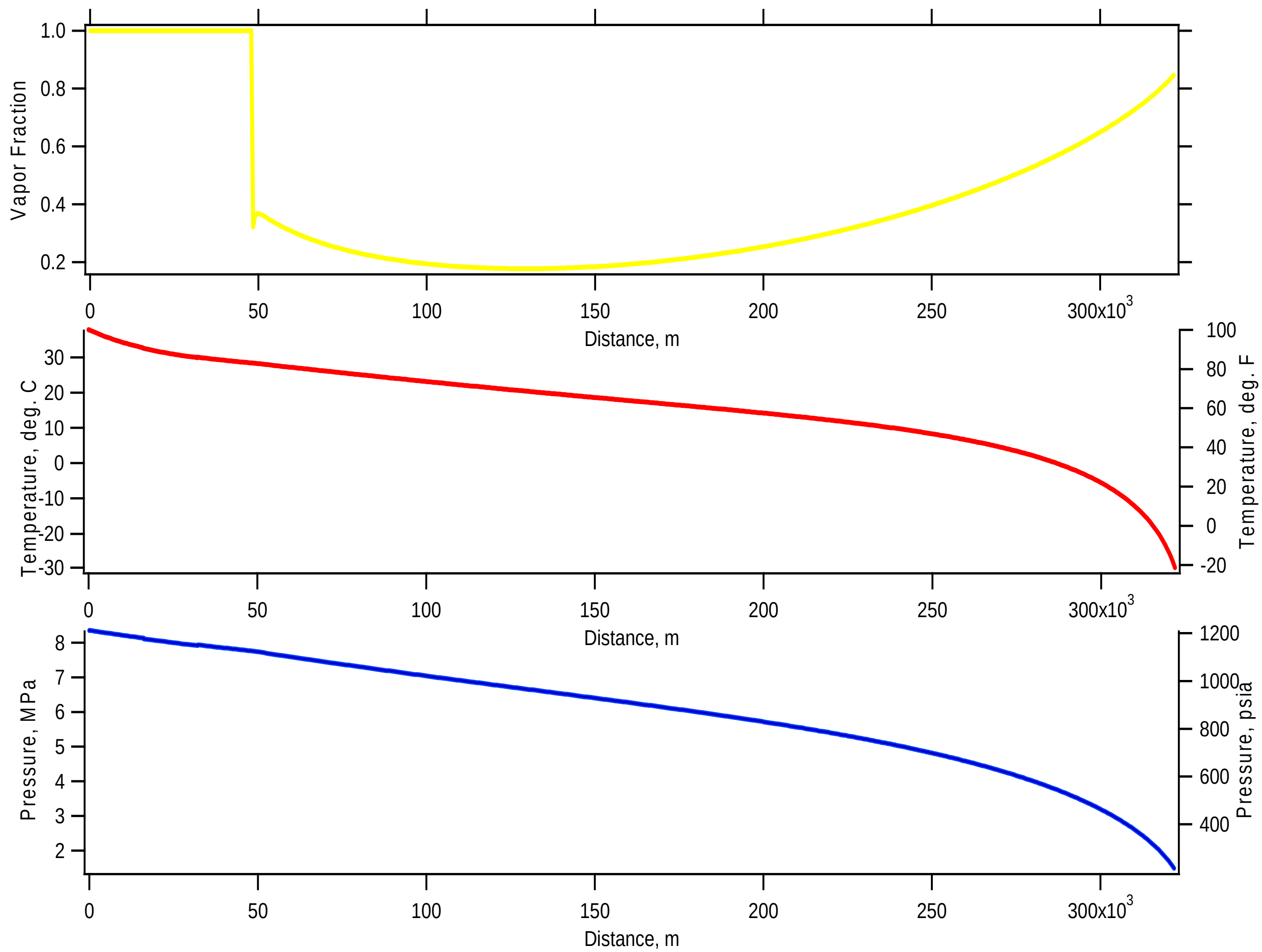
200 miles long, 10 miles elevated, 190 miles buried. Inlet temperature 100 °F, inlet pressure 1200 psia, ambient temperature 75 °F, pure carbon dioxide, one million tonnes per year, 12” pipeline



ΔP	42.5%

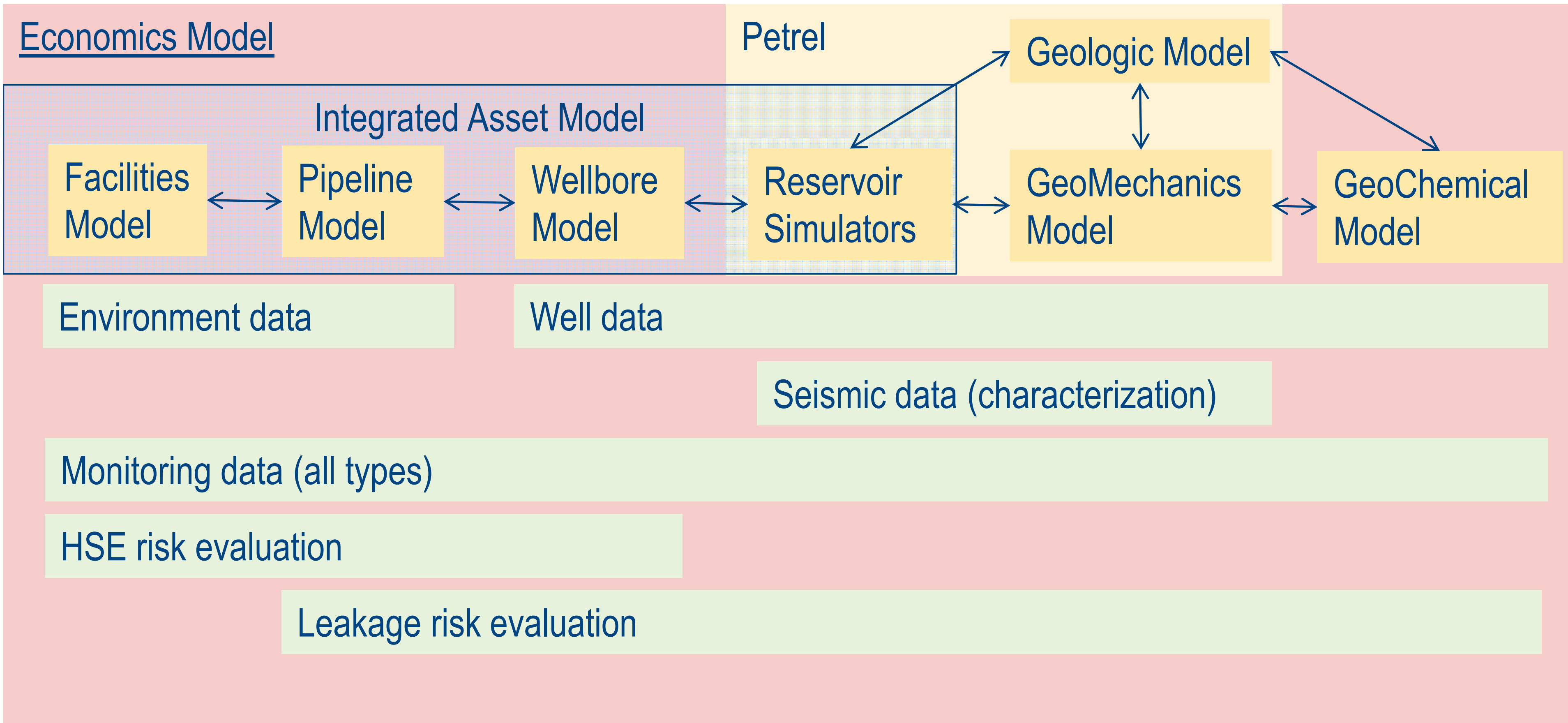
Surface Pipeline – Effect of 4 mole% Argon Addition

200 miles long, 10 miles elevated, 190 miles buried. Inlet temperature 100 °F, inlet pressure 1211 psia, ambient temperature 60 °F, one million tonnes per year, 12” pipeline



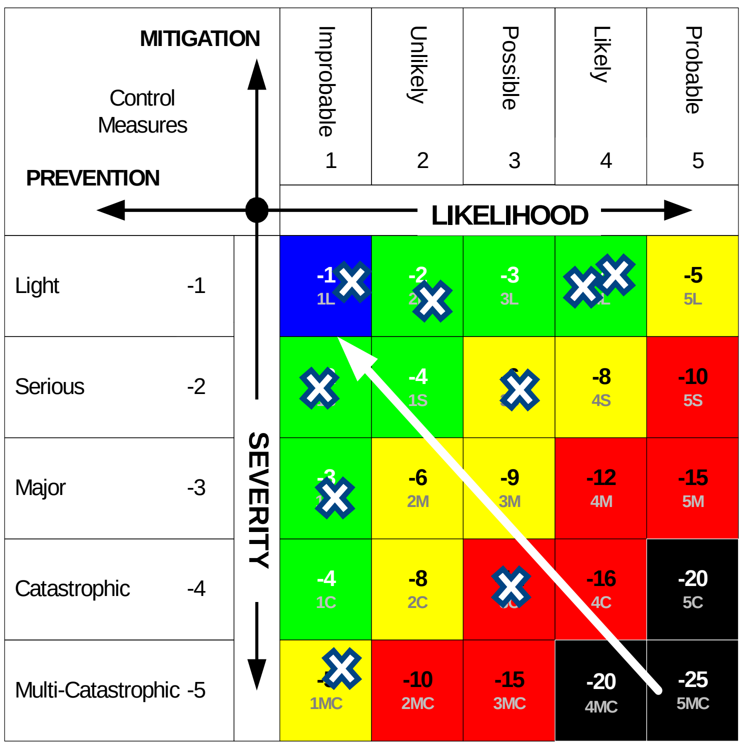
ΔP	82.2%

Full Integration



The Risk Management Matrix

-25 to -20	BLACK	NON-OPERABLE:	Evacuate the zone and or area/country
-16 to -10	RED	INTOLERABLE:	Do not take this risk
-9 to -5	YELLOW	UNDESIRABLE:	Demonstrate ALARP before proceeding
-4 to -2	GREEN	ACCEPTABLE:	Proceed carefully, with continuous improvement
-1	BLUE	NEGLIGIBLE:	Safe to proceed



White arrow indicates decreasing risk

Responses

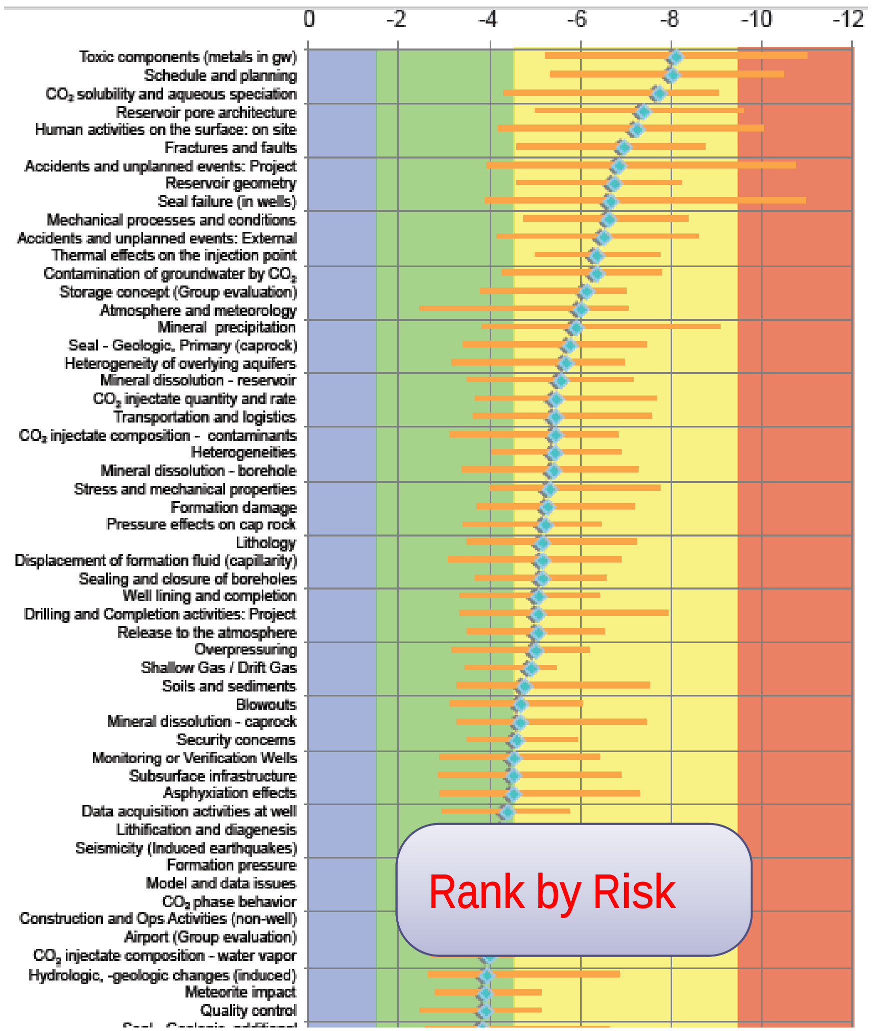
- reduce likelihood (PREVENT)
- reduce severity (MITIGATE).

Tasks:

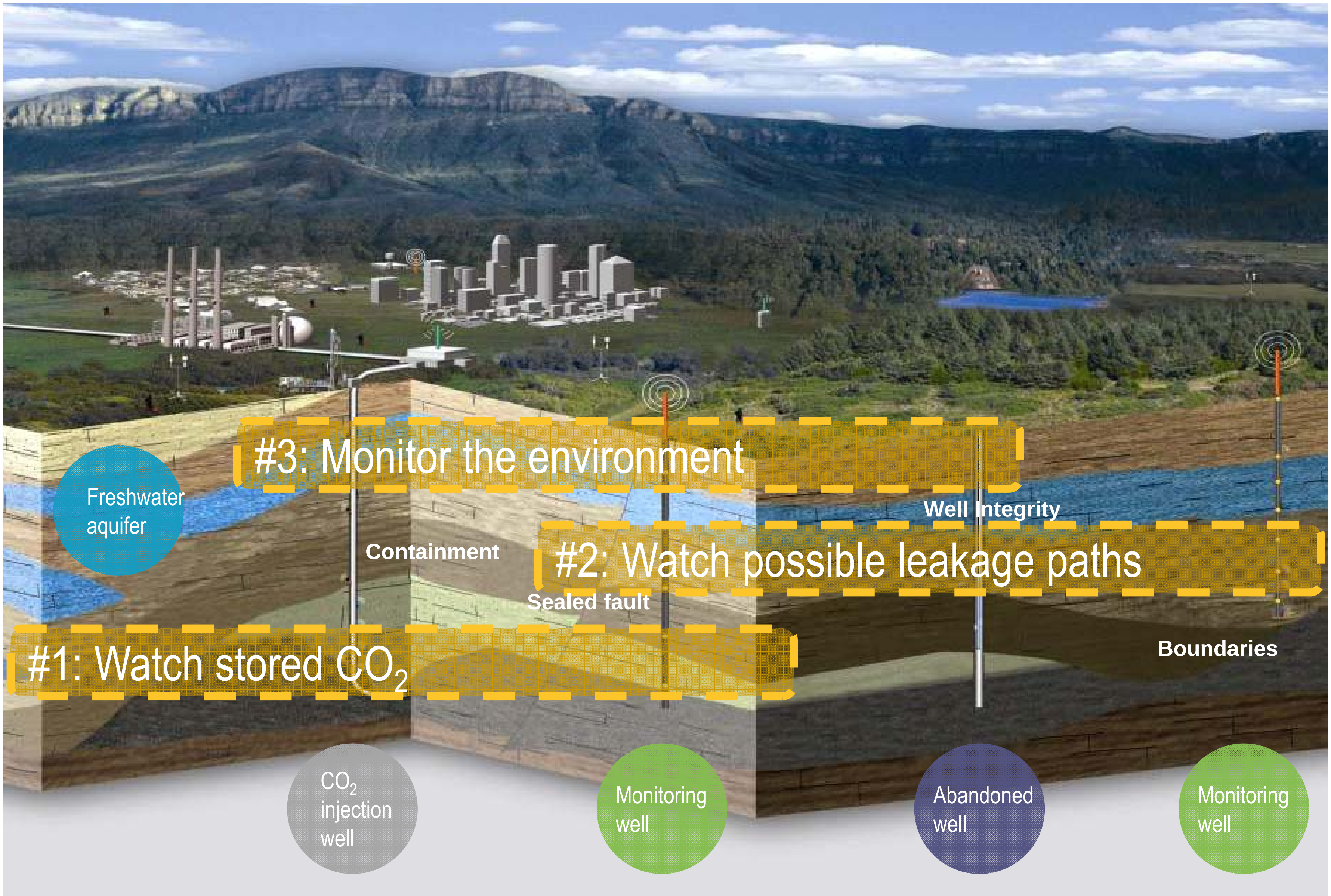
- Intelligently construct "Scenarios" that can be modeled.
- Efficiently apply simulation resources.

Hazard Analysis and Risk Control Standard SLB-QHSE-S020

Risk Management Tools



CO_2 Monitoring – 3 objectives

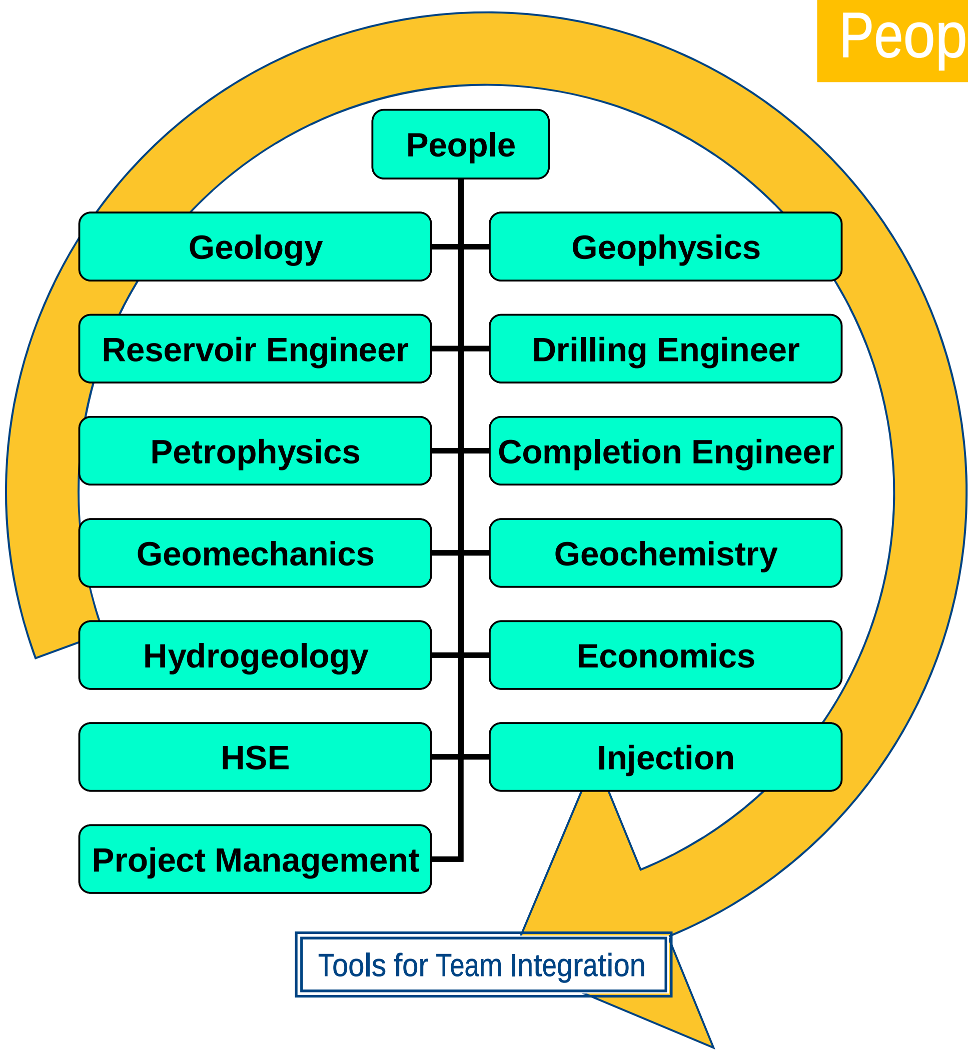


Operational Challenges and HSE

- The ability to execute a plan in real-time is as important as the plan itself
- A proven methodology for decision making, in a dynamic environment, is critical.
- When we drill and inject into the subsurface we create:
  - predictable events that we can validate
  - Indicators for unpredicted events that could lead toward negative consequences
- Our ability to anticipate scenarios and respond, prior to incident, is crucial
- Response capability is the key ingredient in overall cost minimization
- All of the above impact HSE

What is Needed for Project Success

People + Technology



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CO2 Technology

- All Seismic Services
- Wellbore Integrity Evaluation
- Drilling & Completion
- Cementing
- Logging, Testing & Sampling
- Lab Analysis
- Data Processing
- Modeling & Plume Prediction
- Data Management
- Operational Monitoring
- Verification Monitoring
- Compliance Monitoring

The Operational Team Needs:

- Significant, commercial experience with field operations and asset development
- CO_2 specific experience
- Organizational alignment and motivation – culture, training, HSE
- Understanding of and access to key technologies and tools
- Support infrastructure, HSE

Lessons Learned Through Demonstrations

- Geologic uncertainty is scary to some (esp. engineers)
- CO_2 moves farther, faster, and with fingering
- CO_2 stands out from brine on most monitoring techniques
  - No chance of 100% accounting
- Old wells will need special focus
  - Large problem in depleted oil fields
- Need to consider the entire system or suffer the consequences