Summary of WRI Workshop on
Carbon Capture and Storage Liability
29 September 2006

On 29 September 2006, a multi-stakeholder group including state and federal regulators, industry representatives, policymakers, and non-governmental organizations met to discuss the liability issues surrounding carbon dioxide capture and geological storage (CCS). The goal of the workshop was to identify liability risks and assess consensus on measures to address those risks. An agenda for the discussions is contained in Attachment 1 following this summary.

There was general consensus that if siting and monitoring are done well, the risks associated with CCS would be manageable and similar in magnitude to those of natural gas storage. Establishing a sound regulatory framework is seen as a key step towards encouraging CCS projects and commanding greater public confidence in the technology.

Areas of Potential Liability for CCS Projects

Although projects are expected to operate safely, with no seepage or unwanted movement of carbon dioxide plumes, potential risks cannot be ignored. The following potential downstream liability issues, with no implied ranking, were noted during the workshop.

1. Well leakage
    a. Groundwater pollution
        i. Geochemical reaction
        ii. Brine or gas displacement
    b. Emissions to the atmosphere
        i. Jeopardizing human life
        ii. Enhanced climate change (cost of carbon credits)
    c. Ecosystem degradation—terrestrial vegetation, aquatic plants, etc.
2. Excessive pressure buildup
    a. Damages the well seals
    b. Structural damage from induced seismicity or potential geological weakening that could result in unknown future damage
3. Resource damage—migration to oil and gas fields and to mineable coal
4. Devalued land
5. Industrial accidents - CO2 leakage and exposure, similar in frequency and magnitude as many other industrial environments.
6. All of the above may result in--Financial losses, premature closure, and litigation expenses

How do we avoid/address these problems?

I. Regulation

The main issue appeared to be deciding whether we should create new regulations before gaining more experience through large scale CCS project demonstrations. The concern is that without such demonstrations, the degree of uncertainty of performance will be

excessively high and could prove economically untenable. If the government takes over responsibility for liability, it may be such a cumbersome, gold-plated process that it costs considerably more than if the private sector carried it.

Another important issue was whether regulations should include a federal or state indemnity program. Some industry representatives noted that they would not undertake these projects without regulatory clarity and perhaps even a federal indemnity program. The Department of Energy lacks the regulatory authority to create indemnity regulations for CCS and Congress must pass enabling legislation in order to make that possible.

Some thought CCS was similar enough to current activities that no additional regulations are needed and states could permit CCS projects using regulations already in place for CO2-EOR projects and other oil and gas permitting processes. The FutureGen example was used to bolster the argument that we do not need additional federal legislation, and that states are capable of coming up with their own programs. However, others noted that it was only due to large federal subsides that states were competing over the project and willing to invest in the legislation necessary to permit the project. Not all states have such expertise in oil and gas permitting or experience with CO2-EOR activities and would be incapable of simply building off an already existing regulatory structure. There are also questions of national and international public goods related to the long-term transparency of stated carbon dioxide sequestration.

Figure 1 - Conceptual Risk Profile

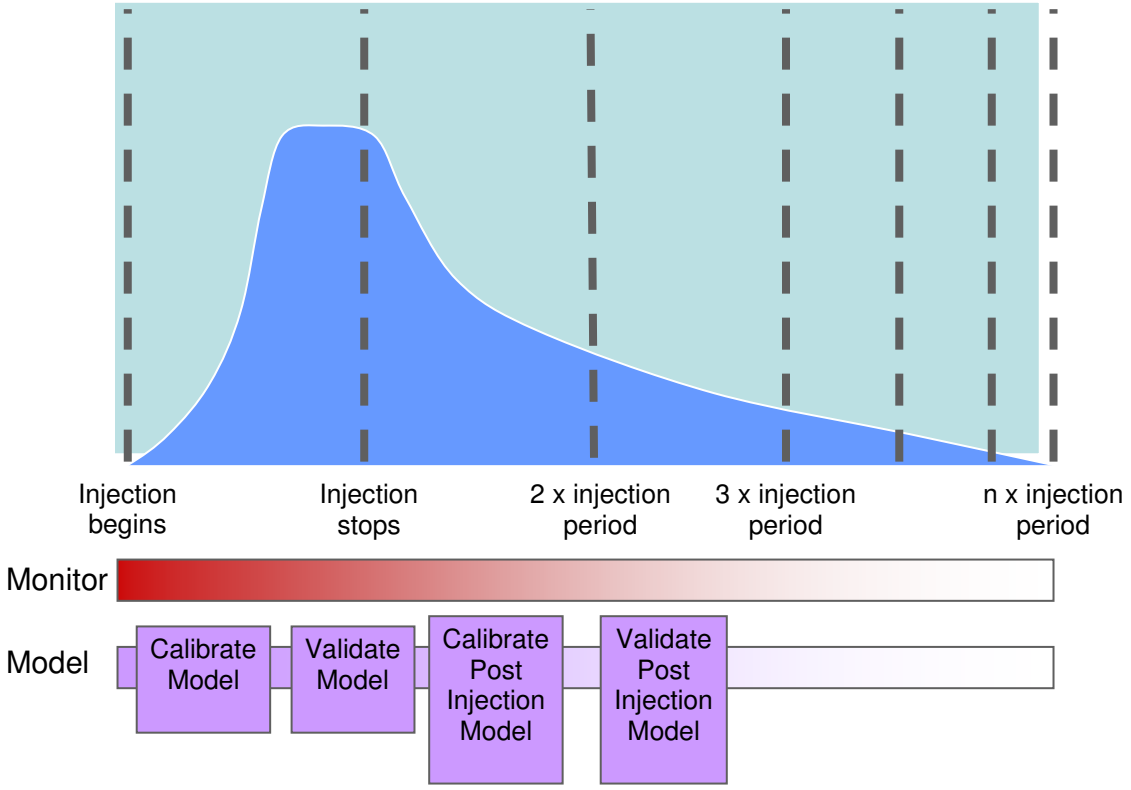

Figure 1. *Source: Sally Benson, Lawrence Berkeley National Laboratory*

It may be helpful to view management of CCS risks through a phased or hybrid approach (see Figure 1). Such a system would offer maximum flexibility for addressing issues as we learn more about CCS with practice. Participants discussed what such a phased liability system might look like. Also discussed was a potential decommissioning period of several years after which liability would be turned over to the government. It was noted that government must make regulations for decommissioning and avoiding default.

There appeared to be general consensus that CERCLA (Comprehensive Environmental Response, Compensation and Liability Act) or RCRA (Resource Conservation and Recovery Act) frameworks would not serve as useful models due to their rigidity, distortionary effects, cumbersome bureaucracy, and the inherently different risk profile between hazardous wastes and carbon dioxide. However, there could still be valuable lessons in the strengths and weaknesses of these statutes. RCRA, in particular, offers a lesson in the importance of flexibility given rapid changes in scientific understanding and technological capability.

RCRA (prospective)
Strengths: Preventative in nature, defined liabilities, offers a hedge against bankruptcy/corporate dissolution.
Weaknesses: prescriptive, old, hazardous waste, inflexible.

CERCLA (retrospective)
Strengths: Hybrid financial instruments, ability to shift with rapidly changing market environments, joint and several liability.
Weakness: Underfunded.

Several participants noted that Australia, in particular, might have useful lessons to offer in terms of developing regulatory frameworks. While such observations might be useful, U.S. law is unique enough to prevent any wholesale replication.

Questions raised in a discussion of the UIC well classification program included:

- How is the UIC program working?
- Should we continue to use this framework for CCS?
- Is the existing framework sufficient to regulate CCS?
- Where do CO2 pipelines and wells fit in?
- Do we need another UIC class or amendments to the existing classes for CCS?

Property rights
We need to consider the larger preexisting property rights regime within which CCS will operate. This includes rapidly changing state and federal rules on eminent domain based on recent Supreme Court cases and state initiatives diminishing eminent domain powers all over the country, especially in West. There are many issues to consider here in the siting of projects and in the liability to surface, subsurface, mineral, and neighboring property owners. One participant suggested that siting projects on federal lands could circumvent these private property rights issues.

II. Insurance

There was a considerable discussion on the need to improve our understanding of the actuarial risk during project operation and whether a type of federal indemnity program is warranted. It was noted that a federal indemnity or shared risk pooling system works well in cases where the risk of catastrophic events is small—assuming the program is properly funded. There was concern that such an indemnity program might appear as "another handout" to the oil and gas industry and that the public would get the message that the industry was uncertain of CCS safety. However, it was stressed that some companies may not undertake CCS projects *without* a federal indemnity program.

At least one representative noted industry is not especially concerned about reasonable liability or that some projects may require special indemnity while being operated. Conceptually, companies expect to be on the hook for site selection issues, and certainly industry majors are accustomed to being liable for a whole universe of risks while operating big projects. They expect to be liable for any mismanagement for some reasonable time frame afterward.

For early projects there is real concern that the cost of liability protection (especially in the U.S.) will prove to be excessively onerous, and this can be exacerbated by poorly constructed regulations.

There was concern that equating CO2 storage with nuclear waste would create a regulatory structure too stringent for the low non-catastrophic risk profile of CCS. However, while CCS experts believe the risks presented by CCS are low, it is uncertain whether insurance underwriters will agree. Some believe that total liability caps, similar to those in the nuclear industry, may help lower the costs of CCS insurance.

A shared risk pooling statute was also suggested as a possible solution to the problem that companies can't get reclamation of performance bonds because they require 100 percent cash backing due to the uncertainty involved for insurance companies.

It was suggested that we need to bring together technical experts and financial insurance experts to determine if there is sufficient data to create the actuary tables some thought were necessary in order to insure projects. It was noted that an actual risk profile can only be done on a site-specific basis but that it was possible and useful to create a general framework of methodologies for populating the risk profile of any given project. Some work is being done on this at Lawrence Livermore National Laboratory. Others suggested private insurance would not be necessary if there was a federal indemnity program in place but there was concern that this would encourage sloppy projects or create unneeded public concern.

Some suggested that it would be helpful to find out how EOR and CCS companies are currently obtaining insurance. Several participants noted that companies would be

unwilling to divulge their insurance structures, although others noted redacted documents, or other publicly available documents should be obtainable.

III. Monitoring

Several participants noted that we need 15 to 20 years to observe large scale CCS demonstration projects in order to verify models of carbon dioxide movement underground. There were differences of opinion as to the cost of this data gathering. The numbers ranged from $30-100 million to run a scientific monitoring study of a large CCS project. It was suggested that the government should pay for some of these costs because very few companies could afford such projects but they are a necessary part of developing a CCS policy framework. There was concern that the public might not trust monitoring results if oil and gas companies received research dollars for something in which they had a vested interest.

In the case of CO2-EOR, some industry representatives believe a lengthy monitoring period in the decommissioning phase or closure phases is unwarranted. This rationale is based on the concept that most CO2-EOR projects will last 25-50 years and will be modeled extensively during their lifetime. Therefore, an addition monitoring period longer than 2-3 years will not be of value. Industry would not likely oppose third-party monitoring, but believes the terms should be limited based on the statement above.

IV. Effective Site Selection and Characterization

The importance of proper site characterization and selection cannot be overemphasized. Done correctly, site selection will lower the importance of liability in general and monitoring/remediation in particular. Poor site selection, on the other hand, will elevate the need for more robust downstream regulations and precautionary measures. The siting process for the FutureGen project, illustrated below, was noted by some participants as a good model.

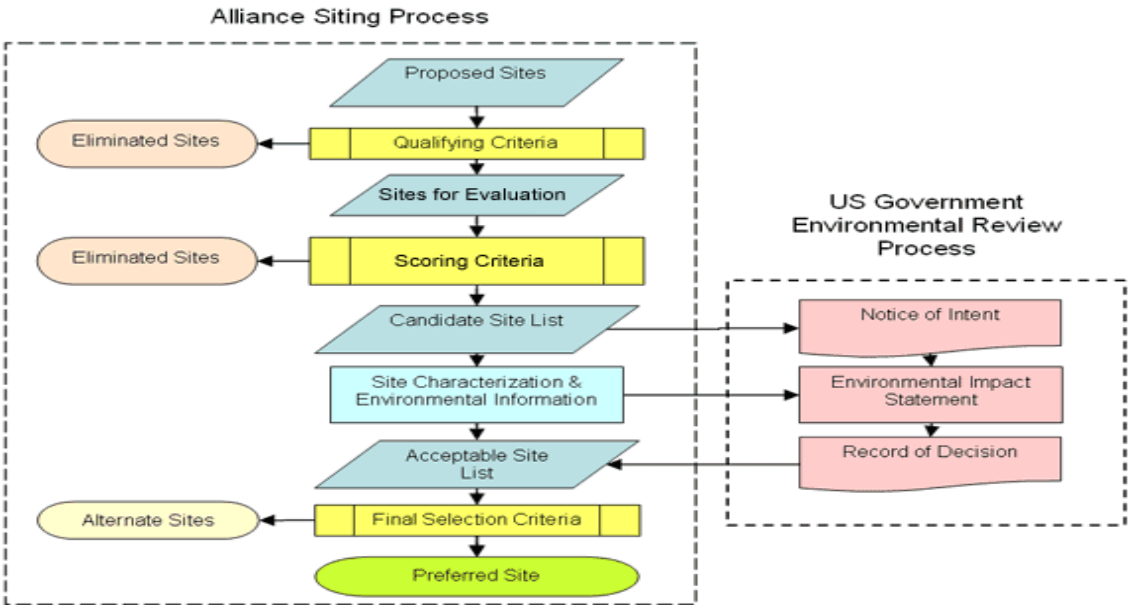

Figure 2. FutureGen Siting Process
Source: *Mike Mudd, Chief Executive Officer of the FutureGen Alliance*

V. Fundamental Scientific Knowledge

CCS projects are larger in volume than typical CO2-EOR projects to date, creating uncertainties of permanence and safety. Many participants agreed more research was needed with large scale CCS projects. Some questions concerning research on CCS projects included:

- How many test cases do we need?
- We should decide on a the basis of storage type the minimum amount of research needed. These types could consist of EOR, deep saline aquifers, depleted gas fields, etc.
- One major research priority is defining the risk profile – how fast does the risk drop-off post injection? It may prove to be very fast and fewer years of monitoring may be necessary.

In North America, where much data exists on the many wells that dot the landscape, it was suggested that mapping the depth of these wells would help us better understand if these reservoirs pose concern when siting CCS projects. In areas with many wells, there is better scientific knowledge to evaluate potential storage sites, although the issue of cap rock penetration cannot be ignored. Any wells significantly shallower that the depth of injection sites and cap rocks have little impact on the discussion of well integrity and a huge percentage of wells in North America fall into that category. Other areas of potentially useful research are natural gas storage (where reservoirs will soon reach a peak in storage capacity) and mixed stream injection, which represents a very different risk and cost/benefit profile from pure-stream CCS. Long-term storage in oil and gas reservoirs should not be allowed to exceed original reservoir pressure. Most of our

"natural analogues" become inapplicable if storage reservoirs are pressured above original pressure even if they remain below fracture pressure.

VI. Public Acceptance

Public acceptance of CCS is critical. There is a need to educate people that we're not talking about a bubble of CO2 ready to escape at any moment but to instead instill in the public a basic understanding of the forces that keep CO2 in place (viscocity and capillary forces). We discussed that the public has the right to be skeptical and we are obligated to convince them that what we want to do is safe and in everyone's best interest. Property values are a valid concern of property owners and must be considered. It was noted that those critical of CCS were not at the table for this discussion and every effort should be made to open up a dialog with such groups.

Time was spent discussing due diligence. We must find the careful balance of generating public confidence while not scaring away investors. The level of due diligence will vary by site and will likely decrease with time. Due diligence will be higher with saline aquifers, at least initially, because we don't know as much about these formations as hydrocarbon fields.

What Does a Good CCS Project Look Like?

1. CO2 stays where it's injected
2. Formation pressures remain below the fracture gradient - natural gas provides a useful example
3. Wellbore integrity is maintained
4. Monitoring is demonstrated (also over the long term)
5. Storage security increases over time with:
    a. Secondary trapping mechanisms (engineered to enhance trapping)
    b. A decline in pressure
6. Time frames are site specific

VII. Next Steps

WRI will continue to work in cooperation with other groups to develop a straw proposal for a CCS liability framework. To that end, we will convene a group of technical and insurance experts to explore the development of actuary tables for CCS projects. We will also consider developing a matrix of CCS applicable consequences, hazards, and regulations to establish where the gaps exist in the current structure. Lastly, mapping the depth of wells in North America was discussed as a useful tool for better informing CCS siting.

CCS Liability Workshop Agenda
29 September 2006
World Resources Institute

9:30-10:00 **Registration and Refreshments**

10:00-10:30 **Introduction**
The need to address CCS liability, Jonathan Pershing, WRI

10:30-11:30 **What are the liability issues that affect CCS projects?**
Subsurface and surface risks, Sally Benson, LBNL
Respondent, Julio Friedmann, LLNL
Discussion

11:30-12:30 **What are relevant analogs to CCS liability?**
Toxics, nuclear power, natural gas storage, etc., Chiara Trabucchi, Industrial Economics
Respondent: Mark DeFigueiredo, MIT
Discussion

12:30-1:45 **Lunch**

1:45-2:30 **Existing state and federal frameworks for CCS**
Summary from liability working group efforts, Elizabeth Wilson, University of Minnesota
Discussion

2:30-3:30 **Panel Presentations (10 minutes each)**
- Michael Cox, BP Carson Hydrogen Power Project
- Mike Mudd, FutureGen
- Alice LeBlanc, AIG Insurance Perspective
- Rob Finley, Illinois Geological Perspective
- David McIntosh, U.S. Senate, Legislative Outlook

Discussion

3:30-4:00 **Break**

4:00-4:45 **Discussion Questions**
What are potential approaches to address these issues?
Can we rely on experience with relevant analogs?
What type of framework can best balance risk and efficiency?
How can we best coordinate federal and state actions?

4:45-5:00 **Recommendations and Next Steps**