Eighth Annual Conference on Carbon Capture & Sequestration

Steps to Accelerate Deployment of CCS … Storage

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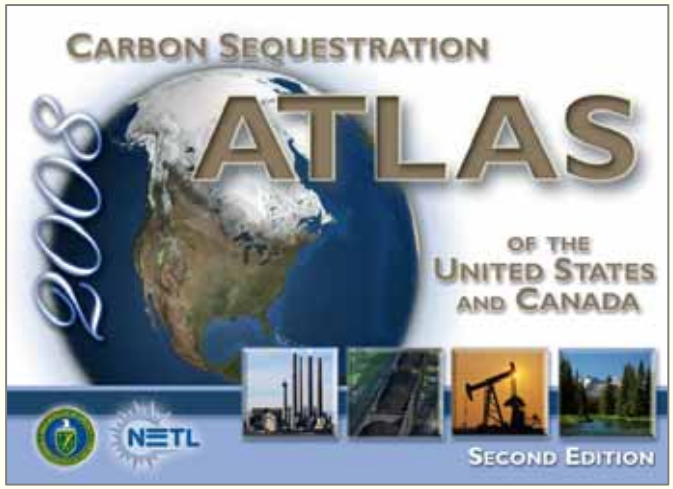
Three Concrete Steps to Accelerate Deployment of CCS

1. Beyond capacity assessment
   … *initiate a nation-wide effort to pre-qualify promising storage sites in saline aquifers.*
2. Beyond identification of institutional issues
   … *form multi-agency teams to expedite resolution of permitting and legal issues.*
3. Beyond CCS validation
   … *provide financial incentives and institutional support for 5 -7 commercial scale projects with greater than 4 Mt/yr CO_2 storage by 2014.*

Capacity Assessment

- Capacity assessments provide
  - global, national and regional estimates of the mass of CO_2 that could potentially be stored underground
  - identification of prospective areas for CO_2 storage



- U. S. capacity is very large
- Broadly distributed
  - but not everywhere
- Saline aquifers have the largest storage capacity

But…

Capacity Assessment ≠ Site Characterization

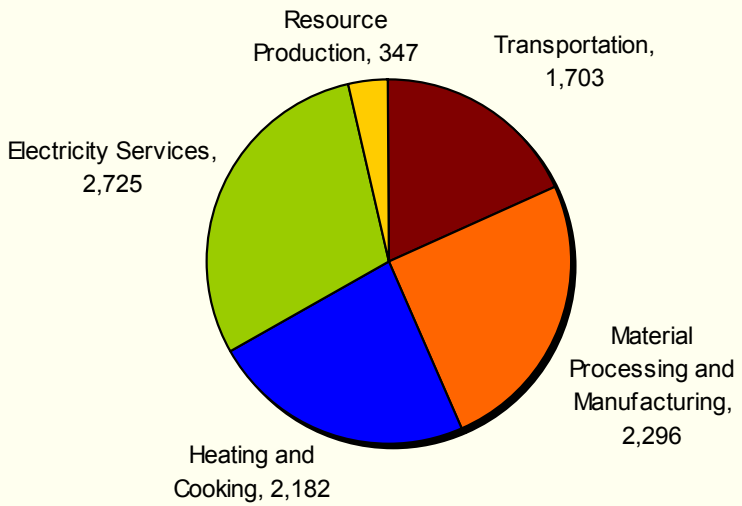
> *Site characterization is the collection, analysis and interpretation of data and the application of knowledge to judge, with a degree of confidence, if an identified site will store a specific quantity of CO_2 for a defined period of time and meet all health, safety, environmental requirements."*

From Peter Cook, CO2SC 2006

To accelerate deployment of CCS we need to initiate a nation-wide effort to characterize and pre-qualify promising storage sites in saline aquifers.

Current Worldwide Sources and Emissions (~7,500 total > 0.1 MT/yr)

2004 Global CO_2 Emissions (Mt C)



Electricity Sector

Fuel	# of Sources	Average Emissions per Source (MT/source)
Coal	2025	3.9
Nat. Gas	1728	0.8 – 1.0
Fuel Oil	1108	0.6 – 1.3

IPCC Special Report, 2005

Material Processing & Manufacturing

Source	# of Sources	Average Emissions per Source (MT/source)
Cement	1175	0.8
Refining	638	1.35
Other	736	0.15 – 3.5

IPCC Special Report, 2005

Transportation Sector

Little today.
Future Potential?

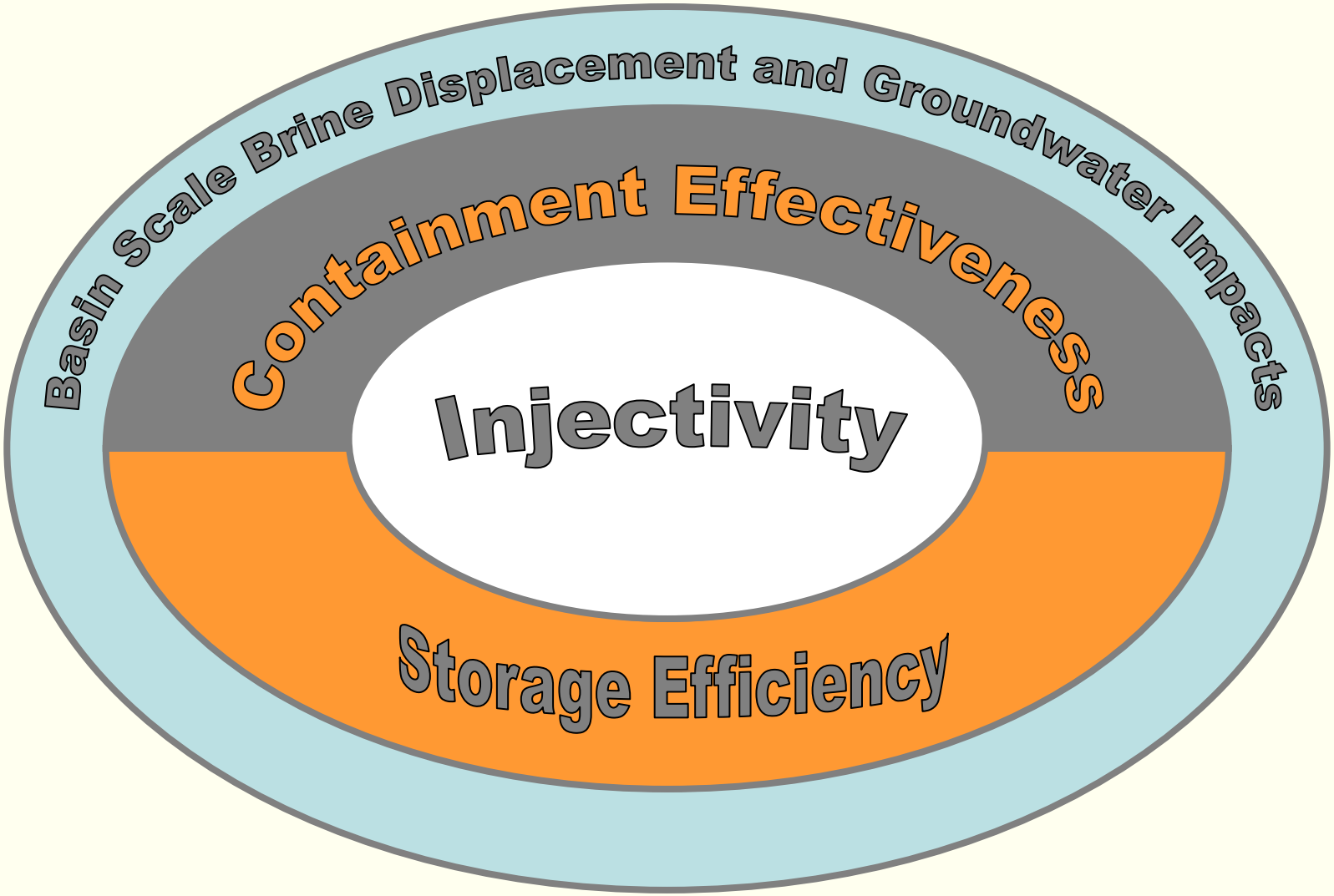
73% of U.S. light duty transport could be powered with existing fleet of power plants, Kintner-Meyer, PNNL, 2007

Lifetime Emissions from Typical CO_2 Sources

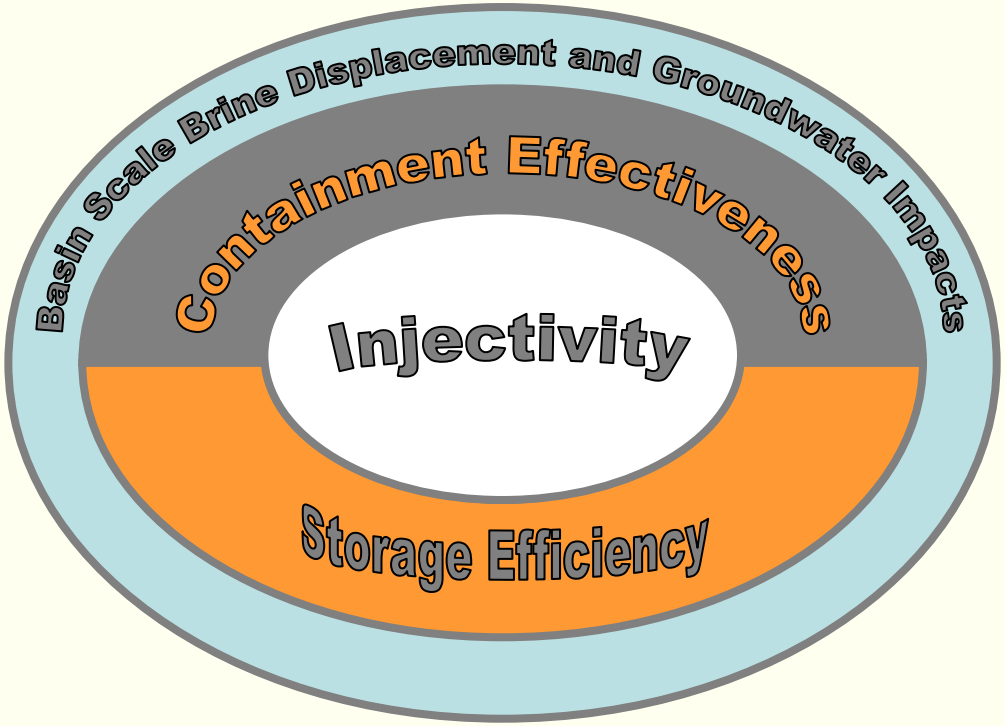
Source	Emissions
Coal-Fired Power Plants	200 MT over 50 years
Natural Gas Fired Power Plants	50 MT over 50 years
Refinery	65 MT over 50 years
Cement Plants	40 MT over 50 years

Need sites with from 40 to over 200 MT capacity. At typical densities, this mass of CO_2 will occupy from 60 to 300 M m^3.

Site Characterization



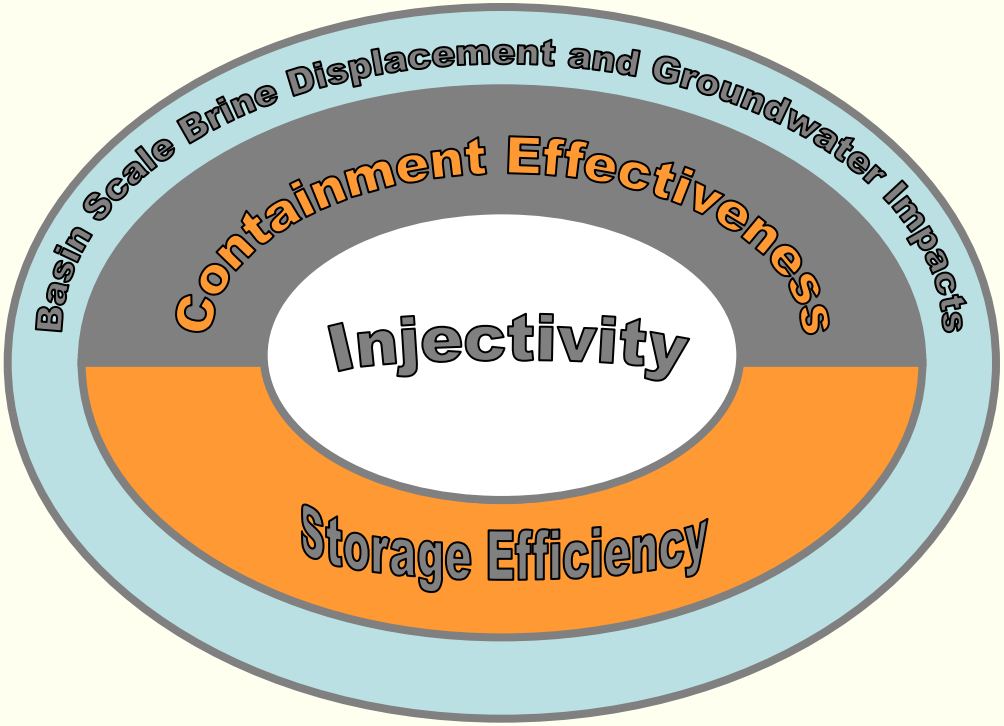
Injectivity



- Characterize the rate at which CO_2 can be injected underground
- Requires adequate permeability x thickness
- Storage formation volume >> injection volume to assure long term injectivity

Storage Efficiency

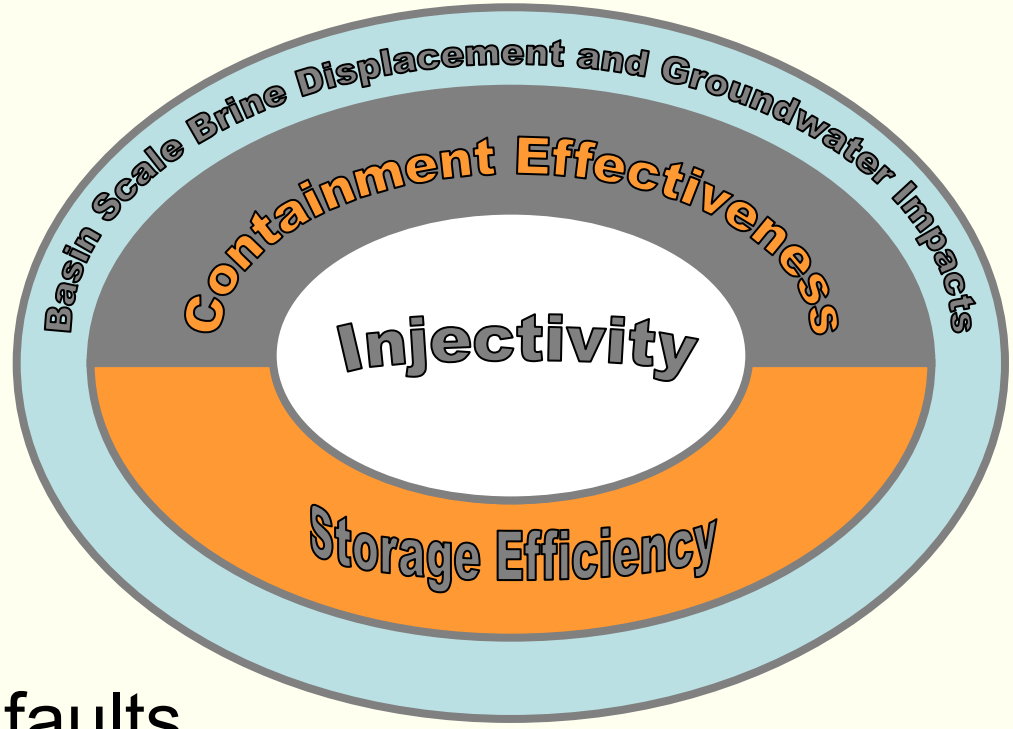
- Short term
  - Average CO_2 saturation in the plume
  - 5%, 10%, 20%?
- Longer term
  - Dissolution
  - Capillary trapping
  - Adsorbed
  - Mineralized
- Footprint of the CO_2 plume



Note: The storage efficiency for individual projects is likely to be far greater than the 1-4% used in regional capacity estimation.

CO_2 Containment Effectiveness

- Seal Characteristics
  - Capillary barrier
  - Permeability barrier
- Continuous and thick
- Geographically extensive
  - More extensive than CO_2 plume
- Absence of conductive faults
- Stable during pressure buildup
  - Avoid hydrofracture, fault reactivation
- Multiple barriers
- Manageable pre-existing wells

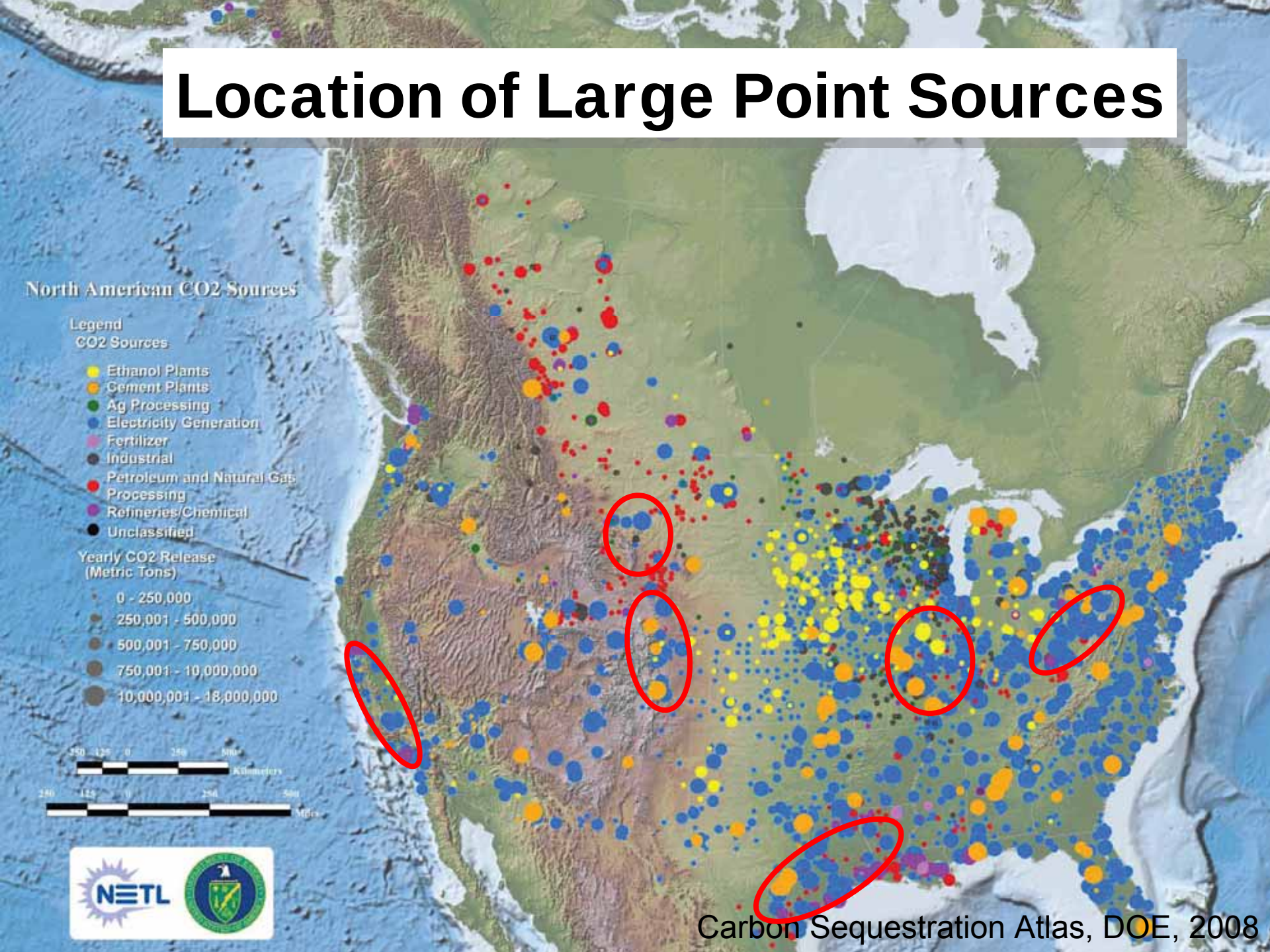


Basin Scale Brine Displacement

- Seal Characteristics
  - Permeability barrier
- Continuous and thick
- Geographically extensive over extent of the pressure buildup
- Absence of conductive faults
- Manageable existing wells

The Challenge: Pressure buildup extends over an area >> CO_2 plume.

Location of Large Point Sources



Carbon Sequestration Atlas, DOE, 2008

Saline Aquifers

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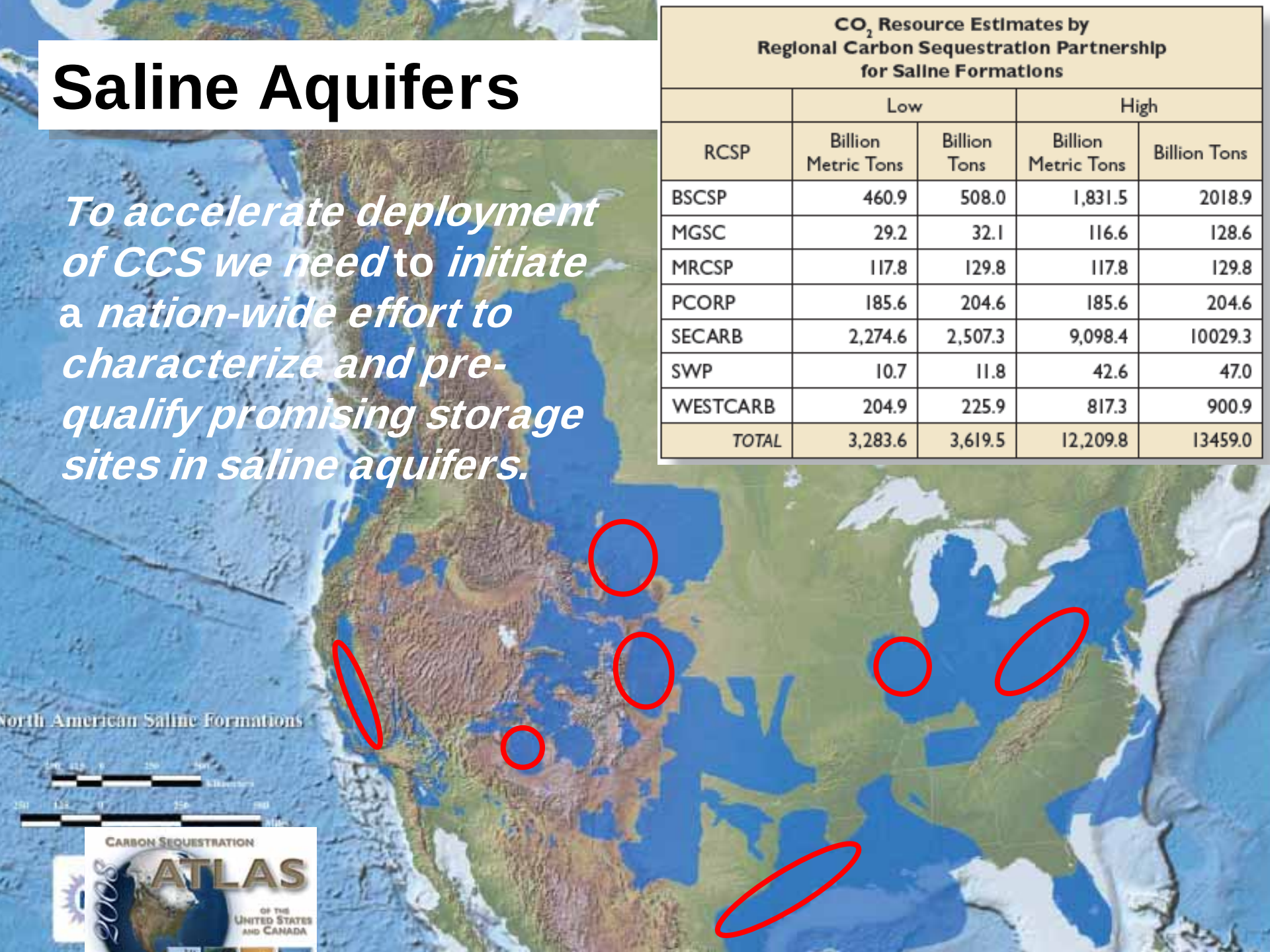
CO_2 Resource Estimates by Regional Carbon Sequestration Partnership for Saline Formations				
	Low		High	
RCSP	Billion Metric Tons	Billion Tons	Billion Metric Tons	Billion Tons
BSCSP	460.9	508.0	1,831.5	2018.9
MGSC	29.2	32.1	116.6	128.6
MRCSP	117.8	129.8	117.8	129.8
PCORP	185.6	204.6	185.6	204.6
SECARB	2,274.6	2,507.3	9,098.4	10029.3
SWP	10.7	11.8	42.6	47.0
WESTCARB	204.9	225.9	817.3	900.9
TOTAL	3,283.6	3,619.5	12,209.8	13459.0



Unresolved Permitting and Legal Issues Slow Deployment of CCS

- Access to pore space
  - Clarity on pore space ownership
  - Unitization of storage reservoirs
- Permitting
  - Injection, pipelines, emissions, water rights
  - etc…
- Basin-wide pressure management
- Accounting protocols
- Credits for carbon emission reductions
- Long term liability
  - Financial responsibility
  - Governance

To accelerate deployment of CCS we need to form multi-agency teams to expedite resolution of permitting and legal issues.

Lack of Experience and Business Models for CCS Slow Deployment

- Deployment of CCS challenges existing competencies and business models
  - Power generation
  - Capture
  - Transport
  - Storage
- Need to gain experience with integrated capture and storage systems
  - Cost - Performance - Reliability
- Engage the private sector innovation engine to drive down costs and improve performance
  - Begin moving down the learning curve
- One size does not fit all
  - Pre-combustion, post-combustion, oxy-fuel, co-production
  - Regional differences in storage options, costs and drivers

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