WESTCARB Overview

Phase I Accomplishments, Phase II Plans

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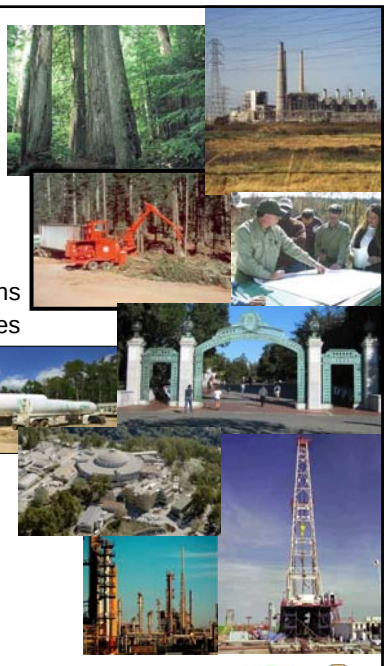
Who Is WESTCARB?



- Researchers from 70 organizations comprising:
  - Resource management and environmental protection agencies
  - National laboratories and research institutions
  - Conservation nonprofits and climate registries
  - Oil and gas companies
  - Power companies
  - Pipeline companies
  - Colleges and universities
  - Trade associations and policy coordinating bodies
  - Vendors and service firms
  - Consultants
- Led by California Energy Commission

WESTCARB Addresses Five Major Questions in a Phased Program

- Where are the sources of CO_2 and how much is there?
- Where can it be stored?
- How much will it cost (and over what time scale)?
- Will it be safe?
- Are existing regulations adequate?

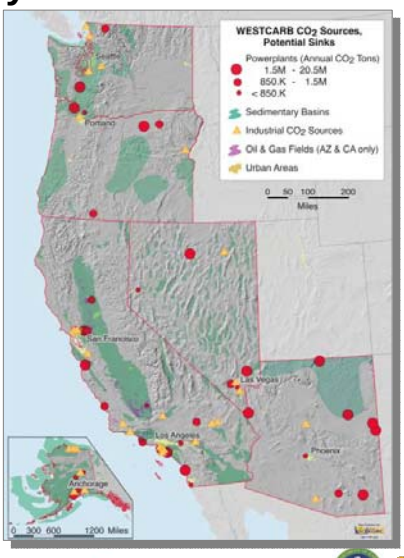
Phase I characterizes regional opportunities
Phase II tests promising storage options at pilot scale: 4-year, $25M effort
Phase III?—integrated capture and storage pilots?

Phase I Accomplishments

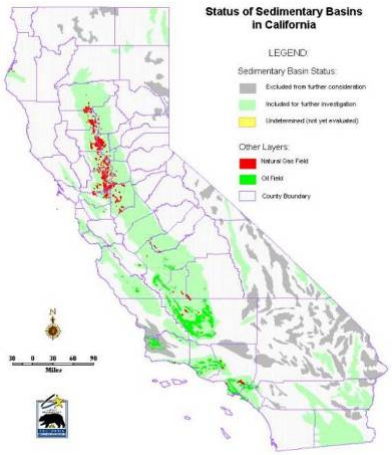
- Centralized GIS source and sink database
- Major point sources and geologic sinks identified and characterized
- Geologic and terrestrial storage estimates made for major sinks
- GIS-based method for source-sink matching implemented; marginal cost curves developed
- Terrestrial baselines and supply curves developed
- Current regulatory structure outlined
- Heightened awareness of sequestration among state, community, and industry leaders
- New approach for screening and ranking sequestration sites

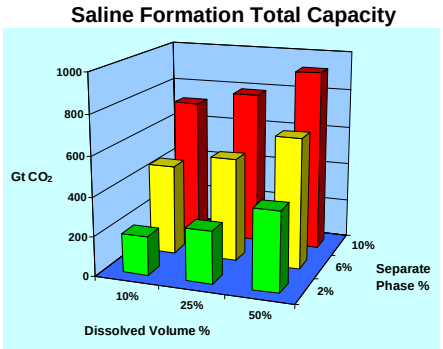
Point Sources in Proximity of Broadly Distributed Sedimentary Basins

- Characterized sources account for about 80% of total industrial and utility sector emissions
- Sedimentary basins defined; geologic and oil and gas field data assembled
- Data reside at Utah AGRC, publicly accessible, part of national database



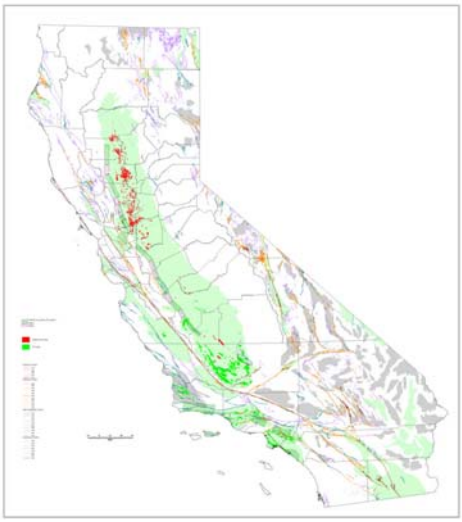
California Sedimentary Basins Are Prime West Coast Sequestration Targets





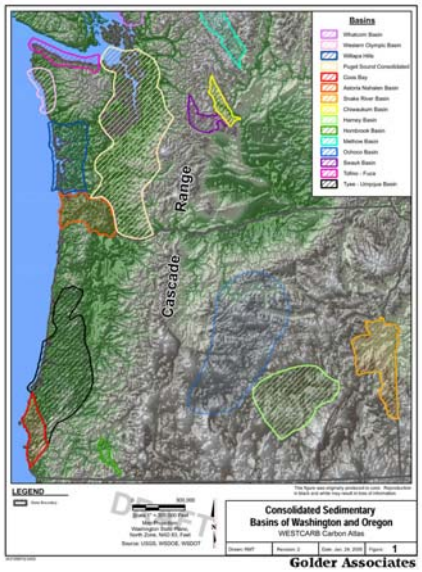
Low Occurrence of Quarternary Faulting in Many Basins

- Hydrocarbons have remained trapped in faulted basins
- In Central Valley, faulting is absent except at southern end; deep thrust faulting along western margin

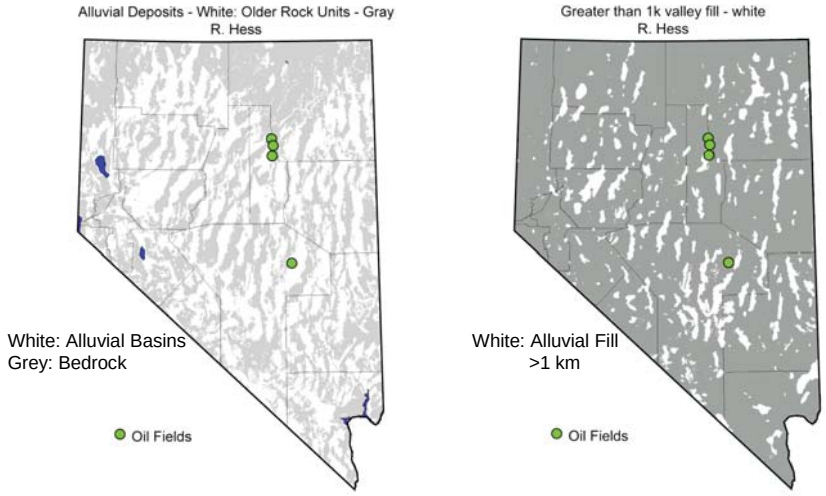


Consolidated Sedimentary Basins in Oregon and Washington

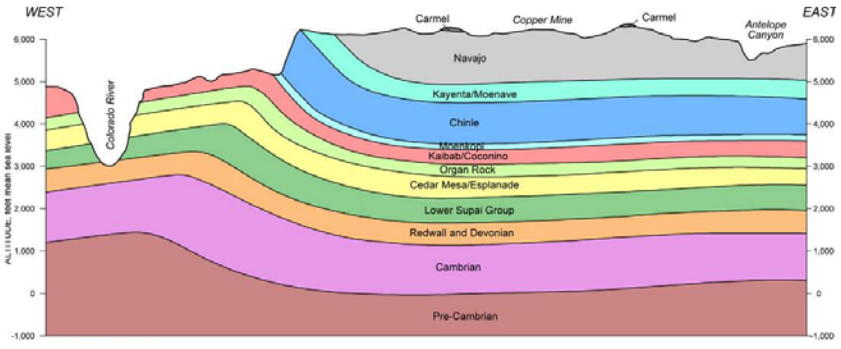
- Puget Trough and Whatcom basins are important targets
  - Sediment depths from 10,000 ft to 20,000 ft
  - Gas, coal present
  - Good porosity and permeability
- In OR, Western Tertiary Basins cover 20,000 sq miles with sediments up to 20,000 ft thick
- Basalts in eastern WA and OR underlain by sediments



Alluvial Deposits in Basin and Range Offer Suitable Depth

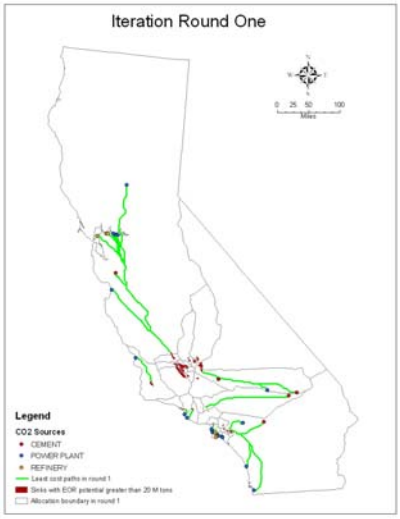


Colorado Plateau Is a Major Arizona Sink



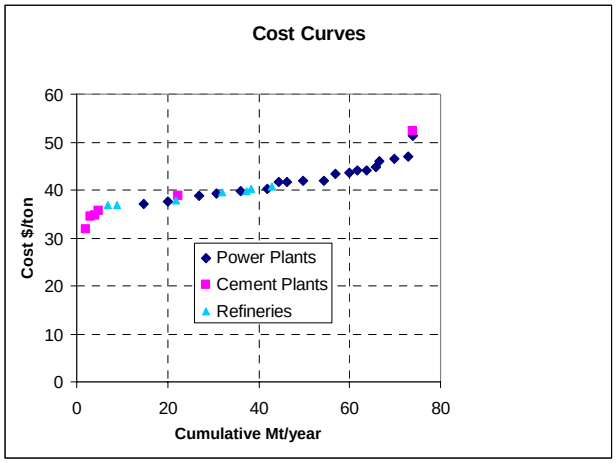
Development of Supply Curves for Geologic Storage

- CO_2 source characterization
- Capture cost estimation
- CO_2 storage capacity estimation
- Transportation cost estimation
- Source-sink matching

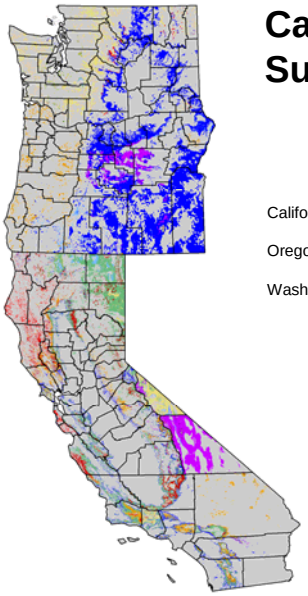


Capture is Most of the Cost of Geologic Sequestration

- Using current, amine-based technology, capture is 70-80% of total cost
- New approaches are being studied



Capture costs for retrofitting existing CA plants



Carbon Sequestration on Suitable Rangelands

	Rangelands (million acres)	Suitable Rangelands (million acres)	Total t C after 40 yrs (million metric tons)
California	59.3	23.1 (39%)	1030
Oregon	26.9	19.1 (71%)	403
Washington	11.9	9.1 (77%)	335

Tons C per Hectare after 40 years
- 0 (or non-candidate)
- < 25
- 26 - 50
- 51 - 75
- 76 - 100
- 101 - 125
- 126 - 150
- 151 - 175
- 176 - 200
- > 201

Terrestrial Storage Costs after 40 Years

	California		Oregon		Washington	
	Area	Quantity	Area	Quantity	Area	Quantity
Grazing Lands—Afforestation	million acres	MMT CO_2	million acres	MMT CO_2	million acres	MMT CO_2
< \$2.40/metric ton CO_2	**3.61**	**1138**	**1.43**	**341**	**4.34**	**897**
< \$10/metric ton CO_2	**17.1**	**3228**	**16.86**	**1395**	**9.04**	**1217**
< \$20/metric ton CO_2	**20.1**	**3347**	**19.12**	**1476**	**9.08**	**1220**
Crop Lands—Afforestation						
< \$2.40/metric ton CO_2			**0**	**0**	**0.03**	**8**
< \$10/metric ton CO_2			**2.25**	**484**	**1.76**	**159**
< \$20/metric ton CO_2			**5.18**	**693**	**5.59**	**425**
Forests—Rotation Extension 5 yr extension, 20 yr contract						
< \$2.40/metric ton CO_2		**0**		**0**		**6.08**
< \$10/metric ton CO_2		**0**		**0.37**		**7.17**
< \$20/metric ton CO_2		**7.25**		**1.80**		**13.55**

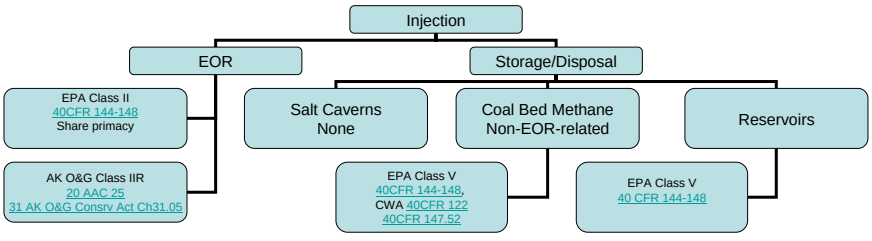
Other Opportunities Have Co-Benefits

- Conservation
  - Habitat preservation
- Improved Fire management
  - Avoid ecosystem-changing fires
  - Fuel treatments provide biomass for power generation

Source: S Sandberg

Current Regulatory Framework Has Been Reviewed

- Regulatory framework varies from state to state
- Comparative assessment of regulations for enhanced oil recovery, natural gas storage, and underground waste injection
- Comparative assessment of regulations covering land use changes required for forest sequestration



Alaska storage regulations

Outstanding Issues

- Is CO_2 injection disposal or storage,or does it matter?
- Is CO_2 a product or a waste, or does it matter?
- Is CO_2 injected as a liquid or a gas, or does it matter?
- Is CO_2 injection into a depleted oil/gas reservoir with no EOR/EGR a Class II injection?

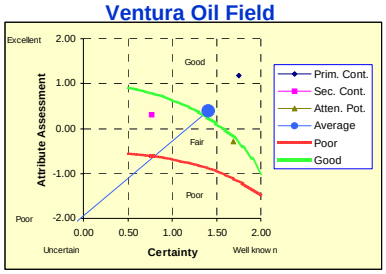
Public Awareness Increased Through Outreach

- Website
- News media interactions
- Meetings with state and local leaders
  - Ventura County
  - Portland forum
  - Lakeview, Oregon
  - Redding, California
- Norwegian CO_2 Study Tour
- Input to WGA CDEAC Clean Coal Task Force
- Input to CA Integrated Energy Policy Report

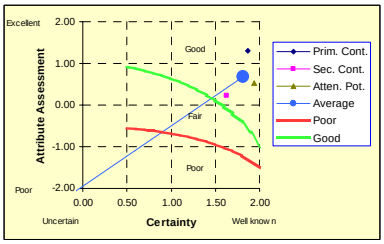
Tool Developed for Selecting Geologic Storage Sites

- Spreadsheet model for ranking/screening of sites, focused on assuring containment
- Three main controlling characteristics:
  - Primary containment potential
  - Secondary containment potential
  - Attenuation potential
- User can:
  - Evaluate and score various attributes
  - Specify the importance of various attributes through weighting factors
  - Specify uncertainty inherent at sites

Ventura Oil Field



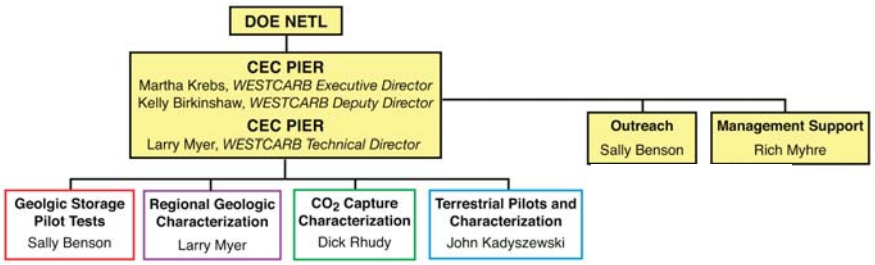
Rio Vista Gas Field



WESTCARB Phase II Participation

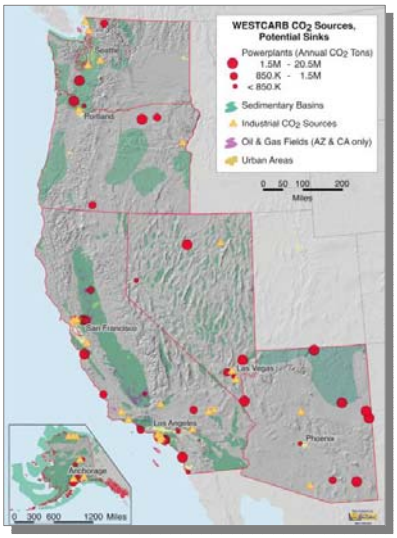
- New WESTCARB partners boost membership to 70: Air Liquide, Alaska Department of Natural Resources, Bascom Pacific LLC, California Forest Products Commission, Calpine, Collins Company, DNV Research—Det Norske Veritas, Greenwood Resources, Jeld Wen Timber and Ranch, Lake County Resources Initiative, Oregon Forest Resources Institute, Oregon State University, Pacific Gas & Electric, Portland General Electric, Rosetta Resources Inc., USDA Forest Service, US National Park Service, University. of California–Berkeley, Western Shasta Resource Conservation District, Wheelabrator Shasta Energy Company, W.M. Beaty and Associates
- 14 organizations providing cash and in-kind cost share of $10M

WESTCARB Phase II Management Team



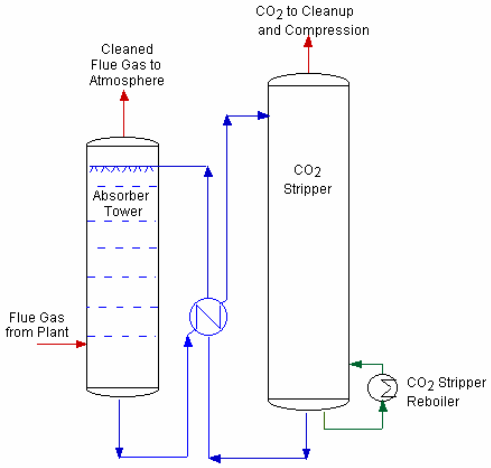
Regional Geologic Characterization Will Be Enhanced

- Additional geologic characterization
- Calculation of storage capacity
- GIS data made available through Utah AGRC and NATCARB



Linking Storage and Capture

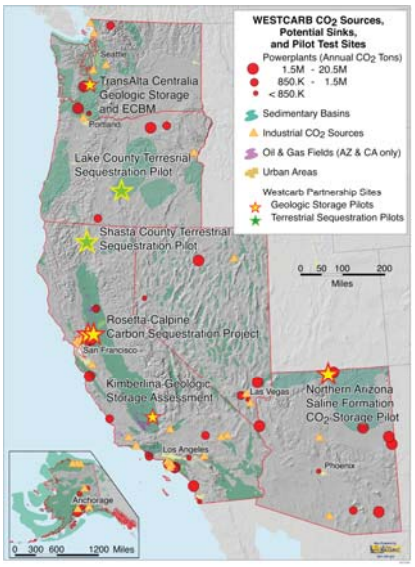
- Complete source-sink matching and capacity-cost analyses; perform plant siting study
- Updated review of capture options, integration with power plants
- Site-specific studies of capture options



Source: EPRI

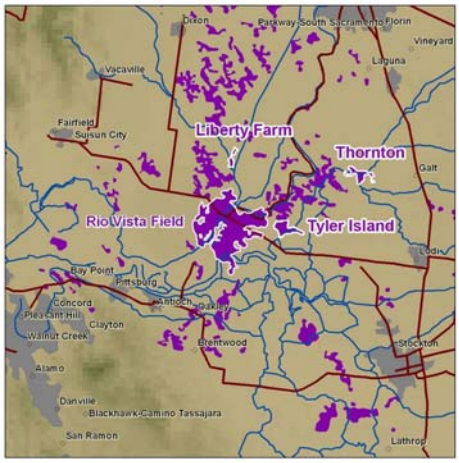
Pilots Planned in Arizona, California, Oregon, and Washington

- Pilots are representative of best sequestration options, unique technologies and approaches, in region
- Pilots involve site-specific focus for
  - Testing technologies
  - Assessing capacity
  - Defining costs
  - Assessing leakage risks
  - Gauging public acceptance
  - Testing regulatory requirements
  - Validating monitoring methods



Rosetta-Calpine Gas Reservoir and Saline Formation Pilot Test

- Lead industrial partners: Rosetta Resources and Calpine
- Validate sequestration potential of Central Valley sediments
- Test CO_2 Storage Enhanced Gas Recovery
- Focus on monitoring



Northern Arizona Saline Formation CO_2 Storage Pilot

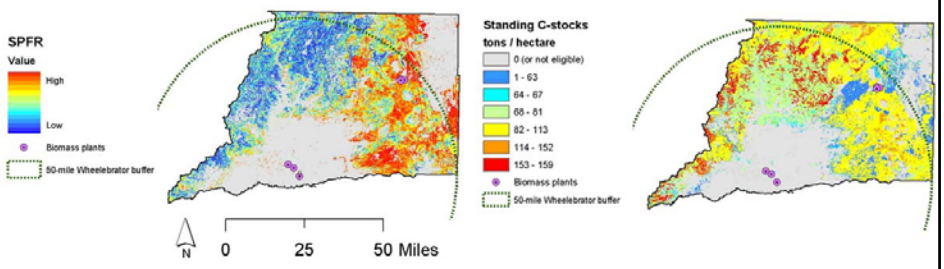
- Lead industrial partner: Salt River Project, through EPRI Tailored Collaborative program
- Test sequestration potential of Colorado Plateau sediments
- "Greenfield" saline formation injection
- Focus on monitoring

Two Site Characterization Pilots

- Lead industrial partner: TransAlta Centralia plant
- Evaluate ECBM potential of deep coals near plant; saline formation potential

- Lead industrial partner: Clean Energy Systems
- Evaluate EOR and saline sequestration potential near Kimberlina plant

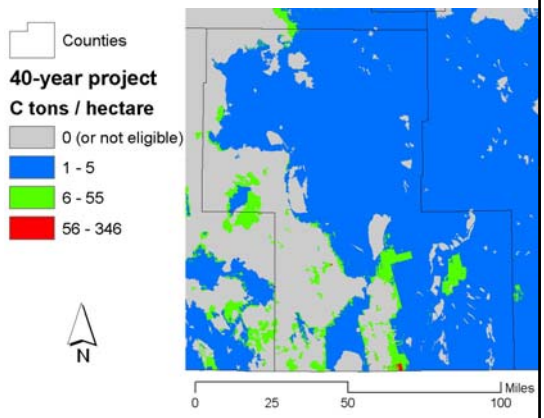
Shasta County Pilot will Involve Reforestation, Fuel Reduction and Forest Management Studies



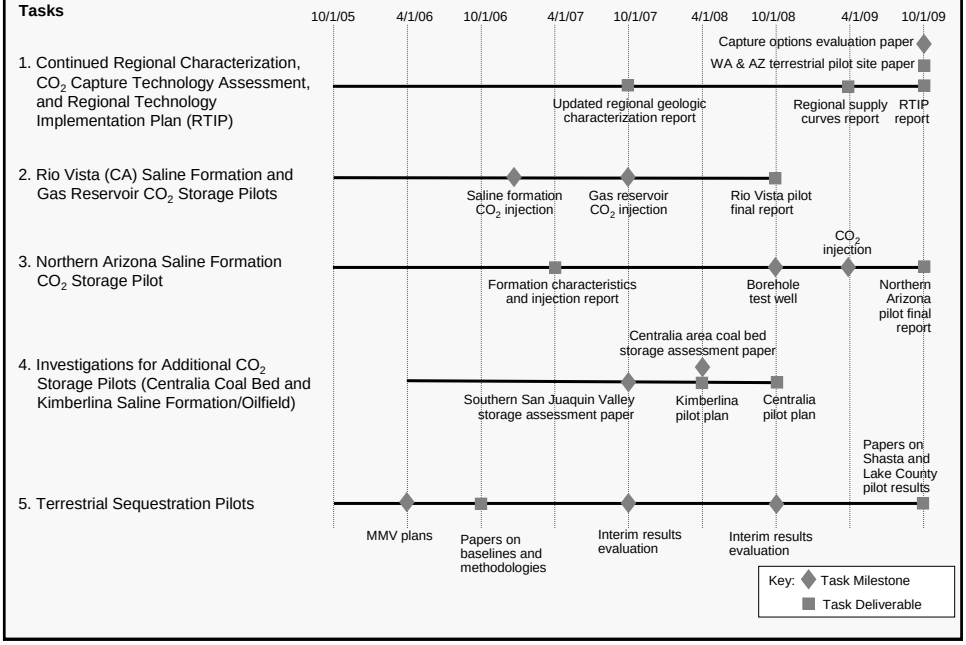
- Validation of forest growth type for rangelands
- Develop and test fuel management activities; baselines and measurement and monitoring
- Validate emissions reductions from conservation and sustainable forest management practices

Lake County, Oregon Terrestrial Pilot

- Research fire models
- Carry out fuel treatment, measurement and monitoring activities
- Assess potential of hybrid poplar “plantations”



WESTCARB PHASE II SCHEDULE



Any Questions?