WATER WORKING GROUP WEB SITE CONTENT UPDATE

Plains CO_2 Reduction (PCOR) Partnership Phase III
Task 14 – Deliverable D101

Prepared for:

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WATER WORKING GROUP WEB SITE CONTENT UPDATE

EXECUTIVE SUMMARY

Members of the U.S. Department of Energy Regional Carbon Sequestration Partnerships (RCSPs) have formed the Water Working Group (WWG), a team of experts from government, academia, and industry whose goal is to address stakeholder concerns regarding emerging carbon capture and storage (CCS) technology and its potential interactions with local and regional water resources. The mission of the WWG is to address stakeholder concerns regarding emerging CCS technology and potential interactions with local and regional water resources. In order to more effectively engage stakeholder groups and address stakeholder concerns, the WWG has prepared the content for a Web site that will be hosted on the National Energy Technology Laboratory's (NETL's) existing Web site as one of the programs described within the set of Web pages which describe the Carbon Dioxide Storage Program. NETL's current Web page will dictate specific content formatting, but the content itself has been generated by the WWG. This content will be periodically updated and formally reported as part of the scheduled update to Deliverable 101 (D101) due the end of May 2016.

WATER WORKING GROUP WEB SITE CONTENT UPDATE

INTRODUCTION

The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) has been developing the technology, infrastructure, and regulations to implement large-scale carbon capture and storage (CCS) from a regional perspective through the resources of its Regional Carbon Sequestration Partnership (RCSP) Program, which consists of seven regional partnerships. Members of these partnerships have formed the Water Working Group (WWG), whose goals are to address the concerns of the public and industry regarding CCS technology and its potential relationships with water resources. Members of the WWG represent different regions of North America, each with its own unique set of challenges and opportunities surrounding water resources and CCS. The opportunities and challenges at the nexus of carbon storage and water are being evaluated by the RCSP WWG as various carbon dioxide (CO_2) capture and storage strategies are assessed.

WWG Web Site Content Development

The mission of the WWG is to address stakeholder concerns regarding emerging CCS technology and potential interactions with local and regional water resources. In order to more effectively engage stakeholder groups and address stakeholder concerns, the WWG has prepared the content for a Web site that will be hosted on NETL's existing Web site as one of the programs described within the set of Web pages which describe the Carbon Dioxide Storage Program. The final location of the WWG-related content is being determined by DOE. Furthermore, specific formatting requirements are also dictated by the existing DOE Web site template. Therefore, the WWG has elected to provide only Web site content, presented in a layout approximating NETL's Web site layout and allowing NETL to formalize the necessary formatting requirements.

WWG Web Site Content

The Web site content is broken into six individual "pages" which outline the WWG program and goals, provide links to WWG produced content and other related sources of information, as well as providing contact information for Web site users to request additional information from the group. These six pages consist of:

- An introduction page.
- A page describing the basic principles of CCS.

- A page highlighting the interrelationships, the nexus, of water and CCS.
- A page highlighting the challenges and opportunities provided by CCS.
- A page of WWG products.
- A page of relevant program links.
- A page formally describes the goals of the WWG and appropriate contact information.

The Web site content is designed to be self-contained and informative but also succinct and streamlined. Users are given brief topical discussions and encouraged to explore additional linked resources. The content and associated links will also be updated as new products become available. A full summary of updates will be provided in the deliverable update report due May 2016. All figures represent individual pages of the proposed Web site, and can be found in Appendix A. Layout and fonts have been approximated for this report. Final layout and fonts will be determined by NETL.

WEB PAGE DESCRIPTIONS

Site Map

A site map is provided for internal use to help developers and programmers see the organization of the page. It is not intended for this page to be displayed publically. The site map can be found on page A-1 of Appendix A.

Home Page/Introduction

This page provides a brief introduction to the Web site and describes why water is an important component of CCS. Please refer to page A-2 of Appendix A.

Carbon Capture and Storage

The page provides an overview of CCS and introduces some of the concepts necessary to understand the information on the nexus of water and CCS. It also provides definitions of CCS and illustrates what a CCS project may look like and how water resources are protected. Please refer to pages A-3–A4 of Appendix A.

Water and CCS

This page provides information on the "nexus" of water and CCS (pages A-5–A-7 of Appendix A), which is central to the mission of the WWG. The page illustrates how water is an important component of all major CCS steps as well as defines the major processes involved.

Challenges and Opportunities

This page describes "challenges and opportunities" related to water and CCS (pages A-8–A-9 of Appendix A), which are areas of research that members of the WWG are either pursuing or have identified as areas of needed research. This page describe the focus of the WWG's

efforts and highlights the major focus areas, such as the need for additional water resources, the need to ensure and demonstrate water protection, and the opportunities to use extracted water as a new water resource.

Products

A products page was created to house all WWG-produced material and RCSP- and DOE-related material (pages A-10–A-11 of Appendix A). New material will be linked as it becomes available.

Links

A links page was created to house all related RCSP links as well as links to other related CCS programs (pages A-12–A-13 of Appendix A). New material will be linked as it becomes available.

About Us

Finally, an "About Us" page was created to provide the mission statement of the WWG, reiterate the composition of its membership, and disseminate further contact information (pages A-14–A-16 of Appendix A). A description of the RCSP and map are also included here.

FUTURE WORK

The next Web site content update deliverable is in May of 2016. Additional and updated content will be provided to NETL to update the Web site content as it is produced and fully reported in the update deliverable. In the near term, the WWG will work with NETL with respect to any challenges which arise with respect to implementation of the Web site content. Any required modifications will be noted and included in the May 2016 update. As NETL will be hosting the Web site content, the authors cannot say when the site will go live as of the writing of this deliverable.

APPENDIX A

WWG WEB SITE CONTENT

Site Map – FOR INTERNAL USE

Home Page

CCS

Water and CCS

Challenges and Opportunities

Products

Links

About the WWG

Clean water is critical to the survival of all living things, but it also plays an important role in economics, manufacturing, and energy production. Access to clean water will be needed to implement many of the strategies proposed to reduce our carbon footprint. We explore how water is used and what researchers, regulators, and industry representatives are doing to identify and address concerns.

Carbon Capture and Storage

A majority of the carbon dioxide (CO_2) generated by human activities comes from the use of fossil fuels as reliable sources of energy, helping us to maintain our current economy and quality of life. Many actions will be needed to reduce CO_2 emissions. Options include conserving energy; improving the energy efficiency of our cars, appliances, and power plants; generating more electricity from nuclear and renewable energy sources; and implementing carbon capture and storage, or **CCS** *[add a hover box definition]*, at power plants that burn fossil fuel.

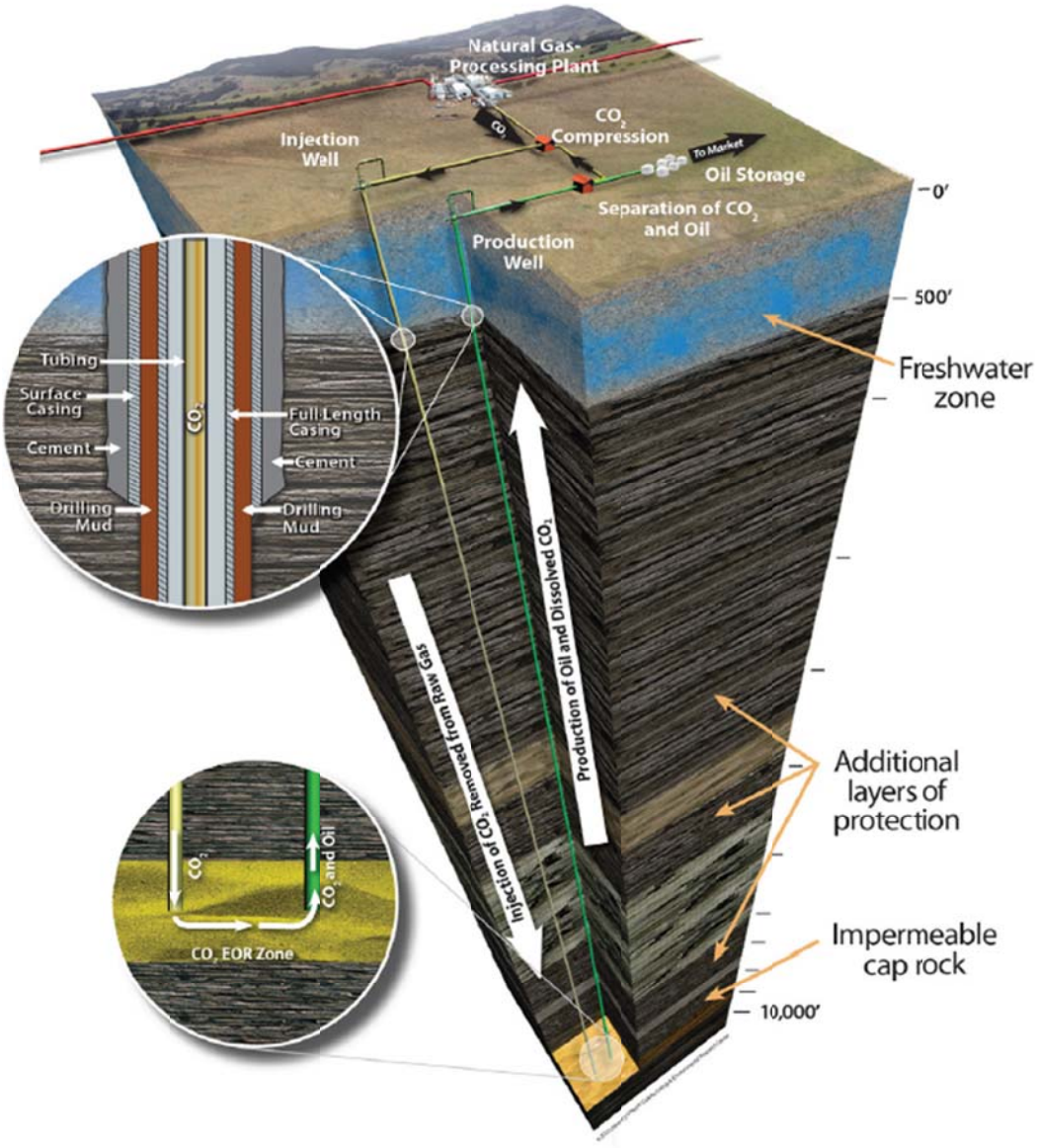
*[**Hover box CCS definition**: Carbon capture and storage, or CCS, is the process of capturing CO_2 from large industrial sources, compressing it for transportation, and then injecting it into a carefully selected, deep underground rock formation for permanent storage. This process prevents CO_2 from being emitted into the atmosphere.]*

CCS could substantially reduce CO_2 emissions to the atmosphere. It would be most efficient when applied to large power plants and industrial facilities that produce large volumes of CO_2. Using specialized processes and equipment, CO_2 is captured, compressed, and transported to sites appropriate for safe, long-term geologic storage.

Underground storage entails injecting compressed CO_2 into deep rock formations that are both physically and chemically stable; have an adequate storage space within the rock (porosity); and are covered by thick, impermeable rock formations (seals or cap rocks) that confine the CO_2 at depths typically greater than 1 mile.

[Interactive boxes for the geologic column figure below]

Section of Figure	Associated Text
Casing Insert	Freshwater aquifers must be protected from all drilling activities. To accomplish this, existing regulations require a series of steel pipes, tubes, and cement be used to separate and seal the well from the surrounding environment. This also ensures that any fluids transferred through the well are kept separate and do not interact with the surrounding environment until they are allowed to exit or enter at the bottom of the well.
EOR in the Storage Zone	In an enhanced oil recovery (EOR) operation, injected CO_2 helps to free some of the oil trapped in the reservoir. In turn, it becomes trapped and ultimately stored.
Cap Rock	Rock layers above the injection layer must prevent the flow of CO_2 beyond the storage zone. These cap rocks or seals will usually comprise shale, mudstone, or salts that do not have connected pores (low permeability) and thus do not allow injected fluids or existing formation fluids to exit the storage formation.
Additional Layers of Protection	Sites carefully selected for CCS will typically have many layers of low-permeability rock, in addition to the cap rock, which will provide additional barriers to prevent injected fluids or existing formation fluids from exiting the storage formation.
Freshwater Zone	The freshwater zone is the layer or layers of groundwater near the surface which is likely to exist above nearly every CO_2 storage site. Aquifers contained within this zone are protected by rules and regulations established by multiple local, state, and federal regulating bodies, as well as engineering design and site selection choices illustrated by this figure.

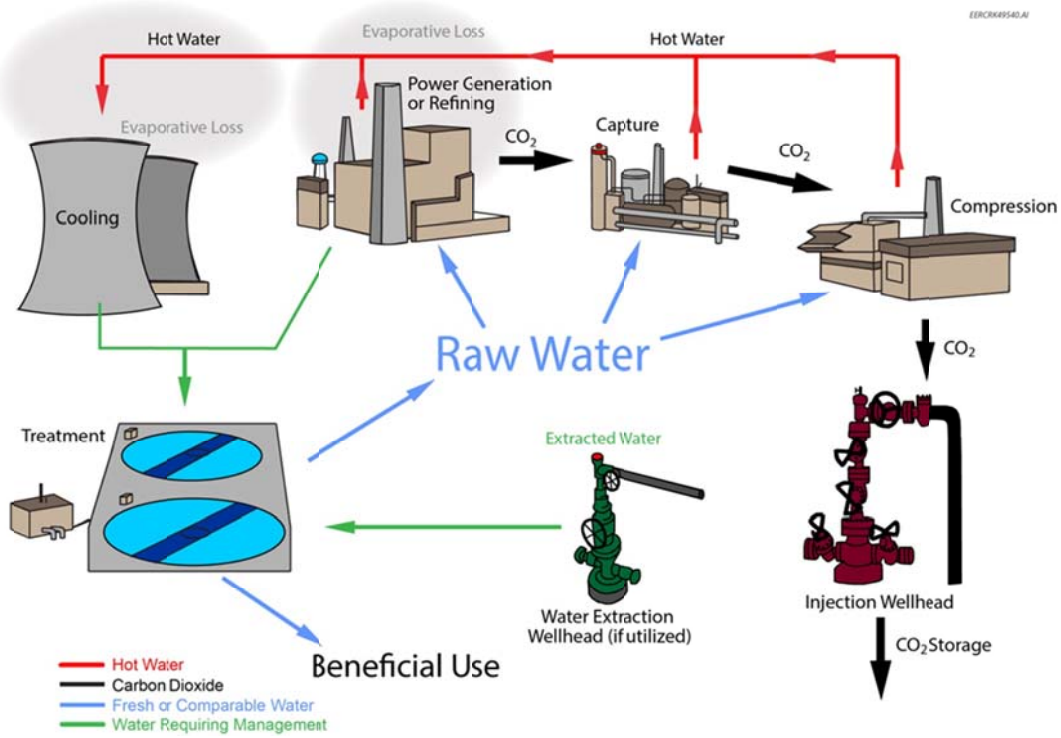


Long-term CO_2 storage can be achieved as part of an enhanced oil recovery, or EOR, operation (image not to scale, taken from Klapperich and others, 2013a).

RCSP Water Working Group

Water and CCS

Water is involved in most steps of the **CCS** *[hover box definition; same as above]* process. Current capture technologies require additional water supplies at the site of CO_2 generation, either as a direct result of the capture process or indirectly by making the electricity needed to power the capture facility. Click on the images in the diagram to learn more about water use.



Caption: Water is used in many ways during the CCS process (image from Klapperich and others, 2011).

Within the CO_2 storage zone itself, the impact of storage activities on appropriately targeted rock formations has been shown to be minimal. CCS activities require great depth, and in most cases, the carefully selected formations will be separated from potable water by hundreds to thousands of feet of rock, consisting of multiple low-permeability rock layers (or formations). Extracting water (removing formation water from the carbon storage zone) is not necessary for carbon storage, although it may be beneficial in individual circumstances. The National Energy Technology Laboratory's (NETL's) Regional Carbon Sequestration Partnerships *[hyperlink to the RCSP program page]* are actively testing the various phases of CCS to identify safe, efficient, stable, and cost-effective methods to minimize impacts to the surrounding environment, both aboveground and belowground. State and federal regulations currently exist or are being developed to further ensure that CCS activities will be conducted in a responsible manner.

[Popup boxes]

Section of Figure	Associated Text
Power Generation	In this graphic, CO_2 emissions are generated by a fossil fuel-burning power plant. Power plants, and other large industrial facilities, often produce CO_2 as part of their normal operations. In this case, the power plant burns fossil fuel

	to generate heat, which is used to convert water into steam. The steam is then used to generate power via a steam turbine. Typically, the generated CO_2 emissions are vented to the atmosphere; however, in a CCS scenario, these emissions are diverted to a CO_2 capture facility.
Cooling	Cooling is necessary to convert steam back into water after it has been used to generate power. Cool water is passed over a heat exchanger containing the steam. This removes the heat from the steam and, in turn, warms the water used for cooling. This is typically the dominant water used at a power plant. Other processes may also require cooling, and this may be done with separate cooling facilities or a shared facility.
Capture	The capture facility is where CO_2 gas is separated from the other gases (mostly nitrogen and oxygen) and diverted to the compression facility. A variety of CO_2 capture technologies exist, and individual processes are best suited for specific types of power generation processes. Water is necessary for the majority of these capture processes, as it typically is a component of the CO_2 separation media.
Compression	The compression facility is where CO_2 is compressed into a very dense state of matter for ease of transportation. This process generates a large amount of heat, which requires cooling, which may be accomplished using water.
Injected Wellhead	The injection wellhead is where CO_2 is injected into the carefully selected, deep underground rock formation. Once the CO_2 reaches the bottom of the well, it is released into the rock formation where it becomes trapped and permanently stored.
Water Extraction Wellhead	The water extraction wellhead is an optional well which may be installed by some storage site operators to help manage injection activities. Formation fluids, typically water, can be removed to influence the movement of CO_2 injected into the rock formation or create room for additional CO_2. If formation fluids are extracted, they would be injected into an appropriate disposal well (a common and regulated practice) or treated and used in some way.
Treatment	Water treatment may be required to manage wastewater generated by the power plant and, if used, water extracted from the storage formation. A wide variety of standard water treatment processes can be appropriately applied to manage these wastewater streams.
Raw Water	Raw water refers to the source water used by an industrial source. It may be freshwater, such as a river, lake, or groundwater, or some other source, such as treated municipal wastewater.
Beneficial Use	Beneficial use refers to any number of processes that extracted water could be used for. These processes include cooling water for power plants, source water for other industrial processes, or crop irrigation. Virtually any process that requires large volumes of water could be a potential beneficial use of extracted water.
Legend	Blue arrows represent freshwater or a treated equivalent. Red arrows represent hot water requiring cooling facilities. Green arrows represent water requiring some treatment strategy. Black arrows represent the flow of CO_2 through the system.


RCSP
Water Working Group

Water demand for **CCS** *[hover box definition; same as above]* represents a series of challenges and opportunities related to water to achieve the widespread application of CO_2 capture and storage technology. Maintaining the integrity of current water supplies, meeting new water demands, developing and managing new water resources, developing appropriate regulations, meeting expectations of other public and private users, and controlling costs pose many challenges. In response, opportunities arise in the form of technological advances in water treatment, use, and minimization; subsurface monitoring and modeling; capture technology development; and public education. With careful development of CCS, the challenges can be met and many of the opportunities realized.

The CCS Challenge

Additional Water Resources

CCS needs water at the point of capture, with additional water resources required for the capture process, makeup water, cooling, and generation of replacement power. Evaluating the water supply as part of the CCS planning process and implementing efficient, cost-effective treatment of capture-related wastewater are critical steps to ensure that water is available for the CCS process sustainably.

Water is an integral component of any large-scale CCS project.

Opportunities

Treating and Using Extracted Water

Water that may be removed from a target CO_2 storage formation during CCS operations is called extracted water. Extracted water can potentially be used to manage geologic storage formation pressure and/or increase storage volume. In some situations, it may also be treatable for use in an industrial or utility process or could serve as the source of a usable product (e.g., dissolved salts and minerals that are used as road salt).

Water Protection

A number of regulations are in place to ensure water resources are actively protected and that storage activities are performing up to expectations. The monitoring, verification, and accounting programs of NETL's Regional Carbon Sequestration Partnerships *[hyperlink to the RCSP program page]* are focused primarily on the collection of data from both the near-surface and deep subsurface environments to demonstrate the safety and effectiveness of geologic storage of CO_2. This affords the opportunity for industry and research personnel to develop new monitoring techniques and further improve existing techniques.

The WWG is among the many groups working to ensure that all of the challenges and opportunities related to CCS and water are recognized and addressed.

(images from Klapperich and others, 2013b)

RCSP Water Working Group

WWG Products

WWG Fact Sheet 1: Regional Carbon Sequestration Partnership Water Working Group Fact Sheet [image is link to pdf]

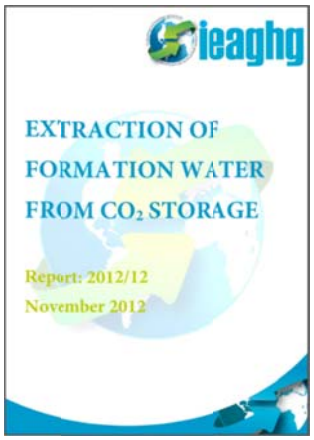
WWG Fact Sheet 2: Carbon Capture and Storage: Protecting Freshwater Resources [image is link to pdf]

WWG Fact Sheet 3: Monitoring, Verification, and Accounting Plans for Protection of Water Resources During the Geologic Storage of Carbon Dioxide [image is link to pdf]

WWG Fact Sheet 4: *Coming Winter 2015*

WWG Presentation: Regional Carbon Sequestration Partnership Water Working Group [image is link to pdf]

Related RCSP and DOE Products



IEAGHG Report on the Extraction of Formation Water from CO_2 Storage (contact the WWG to request a copy)

RCSP Water Working Group

Links

NETL Regional Carbon Sequestration Partnership (RCSP) Program Links

NETL RCSP Program – Home Page

Big Sky Carbon Sequestration Partnership (BSCSP)

Midwest Geological Sequestration Consortium (MGSC)

Midwest Regional Carbon Sequestration Partnership (MRCSP)

Plains CO_2 Reduction (PCOR) Partnership

Southeast Regional Carbon Sequestration Partnership (SECARB)

Southwest Regional Carbon Sequestration Partnership (SWP)

West Coast Regional Carbon Sequestration (WESTCARB)

Related CCS Links

DOE Carbon Capture and Storage Research Page

EPA Carbon Capture and Sequestration

EPA Underground Injection Control (UIC) Program

USGS Geological CO_2 Sequestration

National Carbon Sequestration Database and Geographic Information System (NATCARB)/Atlas

Water, Energy and Carbon Sequestration Model (WECSsim)

[List of Hyperlinks]

Web Site	Hyperlink
NETL RCSP Program	http://www.netl.doe.gov/research/coal/carbon-storage/carbon-storage-infrastructure/rcsp
Big Sky Carbon Sequestration Partnership	http://www.bigskyco2.org/
Midwest Geological Sequestration Consortium	http://sequestration.org/

Midwest Regional Carbon Sequestration Partnership	http://www.mrcsp.org/
Plains CO_2 Reduction (PCOR) Partnership	http://www.undeerc.org/pcor/
Southeast Regional Carbon Sequestration Partnership (SECARB)	http://www.secarbon.org/
Southwest Regional Carbon Sequestration Partnership (SWP)	http://www.southwestcarbonpartnership.org/
West Coast Regional Carbon Sequestration (WESTCARB)	http://www.westcarb.org/
DOE Carbon Capture and Storage Research Page	http://www.netl.doe.gov/research/coal/carbon-storage/
EPA Carbon Capture and Sequestration	http://www.epa.gov/climatechange/ccs/
EPA Underground Injection Control (UIC) Program	http://water.epa.gov/type/groundwater/uic/
USGS Geological CO_2 Sequestration	http://energy.usgs.gov/EnvironmentalAspects/EnvironmentalAspectsofEnergyProductionandUse/GeologicCO2Sequestration.aspx#3776287-overview
National Carbon Sequestration Database and Geographic Information System (NATCARB)/Atlas	http://www.netl.doe.gov/research/coal/carbon-storage/natcarb-atlas
Water, Energy and Carbon Sequestration Model (WECSsim)	http://carbonmanagement.sandia.gov

About Us

The Water Working Group (WWG) is a team of experts from government, academia, and industry comprising members of NETL's **Regional Carbon Sequestration Partnerships** *[hyperlink to the RCSP program page]* (RCSPs). Our mission is to address stakeholder concerns regarding emerging carbon capture and storage (CCS) technology and potential interactions with local and regional water resources.

Members of the WWG represent different regions of North America, each with its own unique set of challenges surrounding water resources and CCS. We are evaluating the opportunities and challenges as various CO_2 capture and storage strategies are assessed. The RCSP WWG is working to find technically and economically feasible answers to questions such as:

- What additional water resources does CCS technology require?
- Will water be extracted during CO_2 storage?
- What are the characteristics of water in deep underground rock?
- How are sources of drinking water protected?
- What are the potential methods to manage extracted waters?
- Can there be beneficial uses for extracted waters?

The WWG strives to provide valuable information and quality outreach materials for all interested stakeholders. To learn more, contact:

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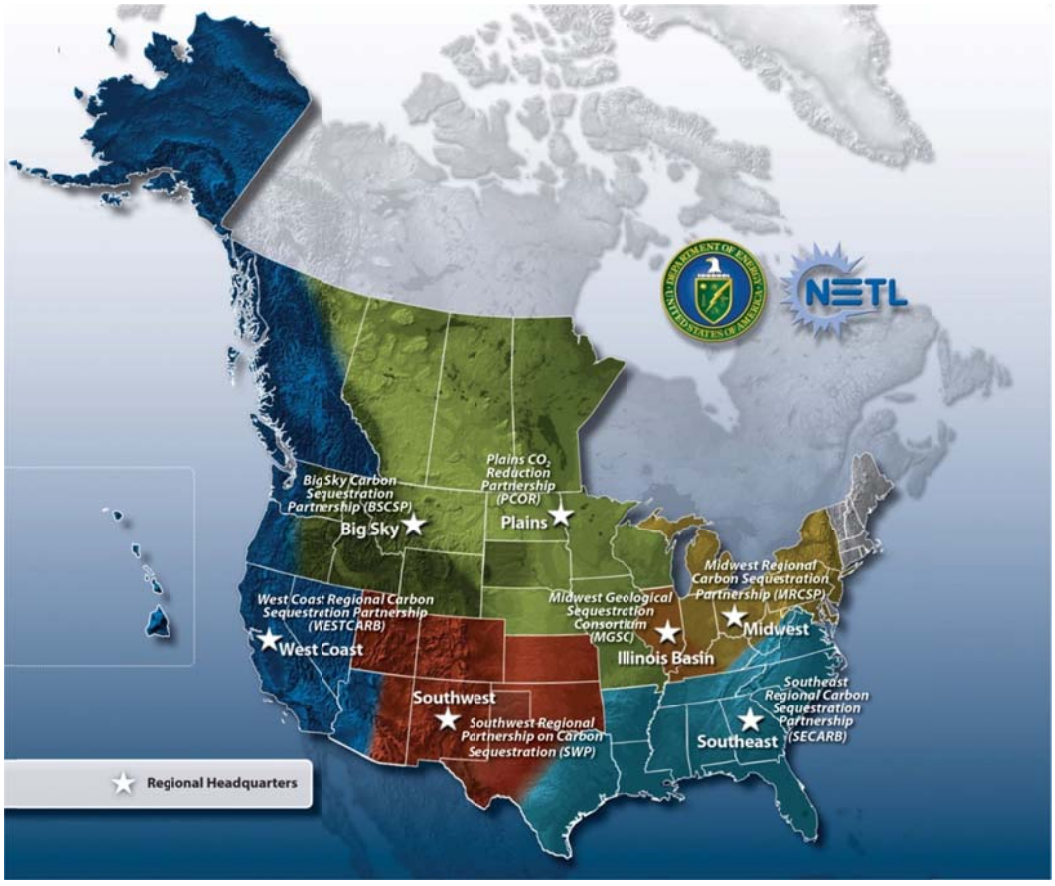
The WWG is organized by the Plains CO_2 Reduction (PCOR) Partnership led by the Energy & Environmental Research Center at the University of North Dakota. The PCOR Partnership is one of seven regional partnerships under the U.S. Department of Energy National Energy Technology Laboratory's RCSP Initiative.



DOE has seven regional partnerships tasked with evaluating a variety of CO_2 storage strategies to determine which is best suited for specific regions of the country. The WWG is organized by the Plains CO_2 Reduction (PCOR) Partnership led by the Energy & Environmental Research Center at the University of North Dakota (image from Peck and others, 2012).

Figure References:

Peck, W., Buckley, T., Battle, E., Grove, M., compilers and creators, 2012, Plains CO_2 Reduction (PCOR) Partnership atlas (4th ed.): Prepared for the U.S. Department of Energy National Energy Technology Laboratory and the PCOR Partnership, Grand Forks, North Dakota, Energy & Environmental Research Center, 124 p.

Klapperich, R.J., Nakles, D.V., Peck, W.D., Gorecki, C.D., Steadman, E.N., Harju, J.A., and McNemar, A.T., 2013a, Carbon capture and storage—protecting freshwater resources: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 14 Deliverable D99 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

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