BELL CREEK TEST SITE – 2 YEARS OF NEAR-SURFACE ASSURANCE MONITORING COMPLETED

Plains CO_2 Reduction (PCOR) Partnership Phase III
Task 9 – Milestone M50

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

BELL CREEK TEST SITE – 2 YEARS OF NEAR-SURFACE ASSURANCE MONITORING COMPLETED

INTRODUCTION

The Plains CO_2 Reduction Partnership (PCOR) Partnership, led by the Energy & Environmental Research Center (EERC), is working with Denbury Onshore LLC (Denbury) to study associated carbon dioxide (CO_2) storage with regard to a commercial enhanced oil recovery (EOR) project at the Denbury-operated Bell Creek oil field located in southeastern Montana. Denbury is managing all injection, production, and recycle activities as part of its commercial CO_2 EOR operation. The EERC, through the PCOR Partnership, is studying the behavior of reservoir fluids and injected CO_2 to demonstrate safe and effective associated CO_2 storage with a commercial EOR project. The PCOR Partnership is developing practices and technologies that will allow future commercial-scale CO_2 storage projects to make informed decisions regarding site selection, injection programs, operations, and monitoring strategies that maximize storage efficiency and effective storage capacity in clastic geologic formations.

Denbury is developing the Bell Creek oil field in a phased approach with each development phase corresponding to approximately 12 months of injection before the next development phase is brought online. Continuous CO_2 injection has been occurring at the Bell Creek oil field since May of 2013, primarily in the Phase 1 development area. Currently, active injection has expanded into the Phase 2, 3, and 4 development areas.

The purpose of the near-subsurface monitoring program is to establish baseline conditions and variability of surface water, soil, and shallow groundwater aquifer chemistries in the vicinity of geologic CO_2 injection that can be used in conjunction with continued assurance monitoring to 1) provide a scientifically defensible source of data to show that near-surface environments remain unaffected by fluid or gas migration and 2) identify and evaluate anomalies that could be indicative of an out-of-zone migration event should they occur during assurance monitoring. The baseline near-subsurface water- and soil gas-monitoring program, which comprised six full-field quarterly events and several targeted monthly events, was carried out by the PCOR Partnership between November 2011 and April 2013. This milestone marks the completion of 2 years of continued near-surface assurance monitoring following the start of CO_2 injection in May 2013 through April 2015.

BELL CREEK TEST SITE – 2 YEARS OF NEAR-SURFACE ASSURANCE MONITORING COMPLETED

Surface and shallow-subsurface water and soil gas chemistries, as well as the naturally occurring chemical variability within these systems, were evaluated via collection and analysis of water and soil gas samples throughout the Bell Creek Field (Figure 1). As of June 2015, the assurance monitoring program (detailed in Table 1) has consisted of three full-field events and a series of 13 phase-focused events. The phase-focused events provide a higher assurance monitoring frequency in the development phases of the Bell Creek Field undergoing active CO_2 injection at the time of monitoring.

The acquired data sets have provided key insight regarding how near-surface research monitoring programs could be transitioned toward a more commercially viable long-term assurance-monitoring strategy. For example, workflows were developed to semiautomate the analysis and characterization process that could be adapted into site-specific intelligent monitoring approaches. Baseline data spanning an 18-month period prior to injection, supplemented by 2 years of assurance monitoring data, have generated a defensible data set characterizing the natural variability of near-surface environments. The monitoring program has overall been sufficient to detect, characterize, and attribute multiple anomalies to naturally occurring processes and has successfully demonstrated no impact to near-surface environments. The methodology and lessons learned developed at Bell Creek will allow future carbon capture utilization and storage operators to make informed decisions regarding site-specific monitoring programs at other commercial-scale injection sites throughout the region.

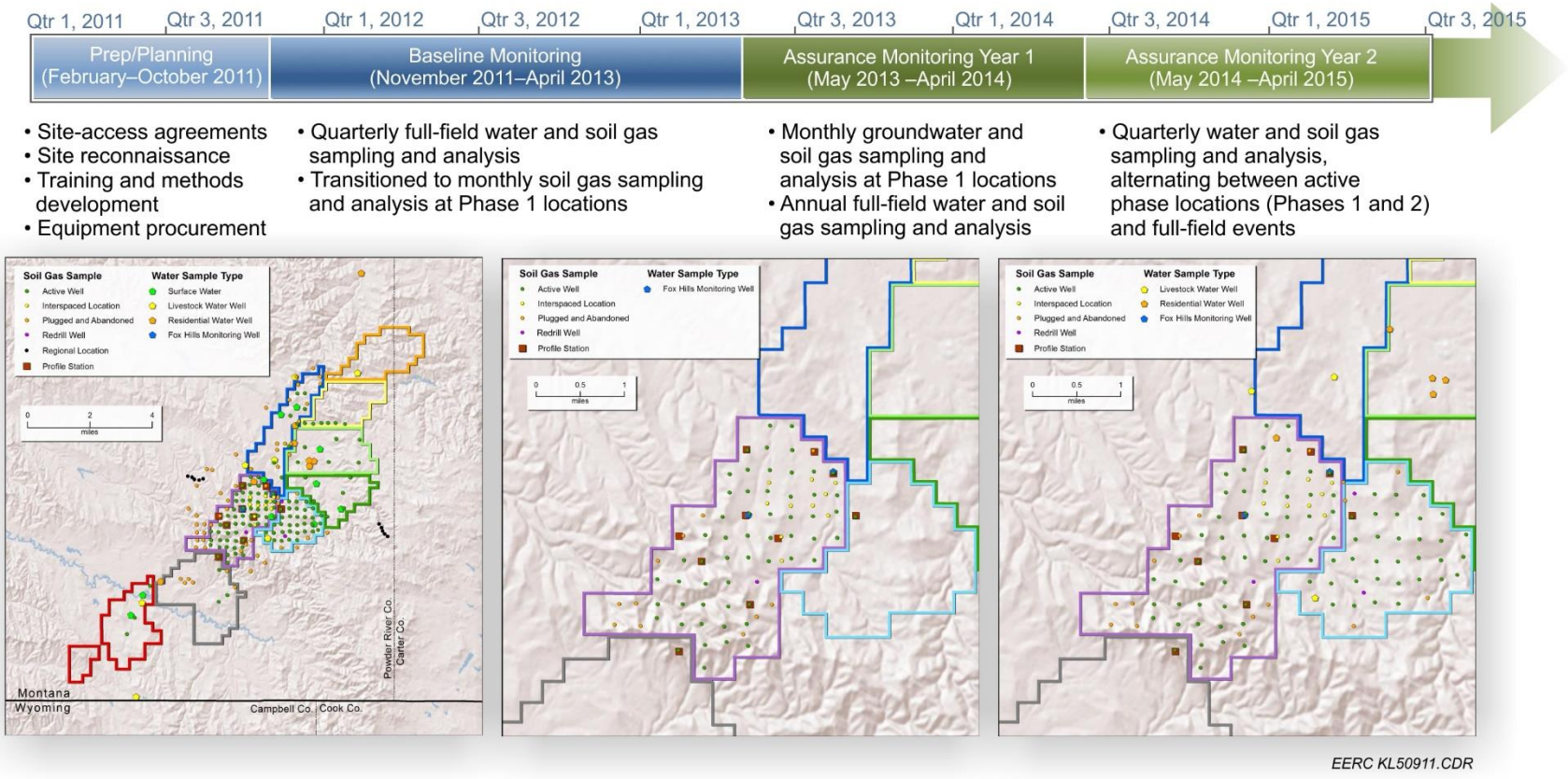

Figure 1. Near-surface monitoring program time line and water- and soil gas-sampling locations collected for various sampling events between November 2011 and April 2015.

Table 1. Water- and Soil Gas-Sampling and Analysis Categories Collected During Assurance Monitoring Period Between May 2013 and April 2015

Sample Type	Sampling Event: Full Field (Nov-13, Sep-14, Apr-15)	Sampling Event: Phase 1 Monthly (May-13 to Apr-14)	Sampling Event: Phases 1 and 2 Quarterly (Jun-14, Dec-14)	Description
Water Samples				
Surface Waters	10			Ponds, streams, etc.
Livestock Water Wells	7		3	Shallow groundwater wells
Residential Water Wells	8		5	Shallow groundwater wells
Fox Hills Monitoring Wells	2	2	2	Two purpose-built groundwater-monitoring wells screened in the Fox Hills Formation (the deepest regional underground source of drinking water)
Total Water-Sampling Locations	27	2	10	
Soil Gas Samples				
Active Wells	121	57	89	Injection/production well locations
Interspaced Locations	10	10	10	Between active well locations
Plugged and Abandoned Wells	56	11	16	P&A well locations (sampled in a three-directional spot pattern at each location)
Redrilled Wells	3	1	3	Previously P&A well locations during baseline sampling (sampled in a three-directional spot pattern)
Regional Locations	10			Provides background soil gas concentrations for QA/QC
Profile Stations	10	10	10	Ten purpose-built fixed-location soil gas profile stations (sampled at depths of 3.5, 9, and 14 feet)
Total Soil Gas-Sampling Locations	210	89	128	
Total Sampling Locations	**237**	**91**	**138**	