Sustainable Development of CBM, Coal, and Groundwater in the Raton Basin of Colorado, USA*

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Abstract

The Raton Basin, situated in southeast Colorado and northeast New Mexico, has been a profitable location for coal mining, natural gas and coalbed methane (CBM) development for many years. Coal mining in the region began in the late 1800’s, natural gas development started in the 1970’s and the first coalbed methane wells were drilled in the early 1980’s. In the Colorado portion of the basin, coalbed methane production peaked in 2008 when 131 BCF of gas and 121 MMbbls of water were produced, followed by an economically driven decline. Maximum sustained historical coal production in the early 1900s was 5.6 million tons. Thus far, in this century, coal production peaked at approximately 1.1 million tons and then ceased until recent development at the New Elk site in Las Animas County.

Agriculture, an economic mainstay since the area was first settled, may soon be competing for water resources as the extractive industries grow and if the current industry practices and climate change trends continue. Determining the sustainable rates of development among each of these important economic sectors requires policy and decision makers to address the environmental impacts resulting from resource extraction and agricultural activities within the Raton Basin boundaries. Obvious points of concern and potential conflicts are surface disturbances resulting from mining and gas development; disposal of produced water from gas wells and coal mines, runoff from agricultural land, water rights conflicts and depletion of water resources. More subtle issues revolve around greenhouse gas emissions from industry activities stemming from gas production and mining. Oil and gas development has primacy on some leaseholds while coal mining has primacy on others. This situation poses barriers to employing a comprehensive approach to optimizing economic recovery of resources where both coal and gas are being extracted. Recent investigations have shown that both coal and gas can be sustainably extracted while reducing greenhouse gas emissions and preserving water resources for future use.

This presentation will showcase the interplay between the natural gas and CBM producers and active coal mining taking place in the basin, focusing on illustrating the issues between producers and agricultural concerns; while outlining a path toward working together with policy makers to reduce conflict and environmental impact of resource extraction activities.
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Economic Development and Geologic Setting

Coal Mining History
- Most active mining period was between 1890 and 1940, in which gas explosions occurred frequently.
- Coal seams have been known to contain large amounts of CH4.
- CBM production became very active during the late 1990s.
- Along eastern flank of basin, coal strata are relatively shallow and dip gently westward, making for ideal surface mining.
- Land grants – New Elk Coal Company (NECC) area Maxwell Land Grant.
- As many as 465 coal mines.

Coal Mining in the Raton Basin

NECC Facts
- Cline owns 100% New Elk Coal Mine near Trinidad, CO.
- Measured and indicated metallurgical coal resource of 618.9 million tons.
- 29,940 acre lease.
- Coal quality:
  - low-sulphur
  - medium to high fluidity
  - high-volatile B bituminous
  - metallurgical coking coals
  - Btu/lb 13,500-14,000.

Geological and Structural History

- The Raton Basin is an asymmetric foreland basin formed in early Pennsylvanian time.
- During Late Cretaceous time, Laramide compressional tectonics deformed the Raton Basin following the framework of the existing Pennsylvanian structural elements and uplifted the Sangre de Cristo Mountains to the west.
- From Late Cretaceous through Middle Tertiary the basin downwarped and filled with a thick wedge of continental sediments.

- The Raton Basin is rich in gas, produced as CBM and some conventional natural gas.
- The Upper Cretaceous Vermejo Formation contains sandstone, shale and coal beds.
- The Upper Cretaceous and Paleocene Raton Formation contains conglomerates at the base, sandstone, siltstone, shale and minable coal.
- Both the Vermejo and Raton Formations produce economically important quantities of coal, gas and water.

Raton Formation

Photo by C. Carroll, CEN
Area of Overlapping Development of Coal and Gas Resources

- Coal resources have been mined since the area was settled.
- Over the last few decades development of CBM resources has resulted in wells penetrating minable coal seams.
- Primacy of coal or gas resource development has been determined by language in mineral leasing contracts.

- 242 wells in NECC area included for production analysis.
- 280 wells total in the NECC area – 38 wells without production.
- 2 water injection wells within NECC area.
- NECC production analyzed for years January 1999 through April 2012.
- Determinations were made relative to safety of cement bonding of casing to formation and the likelihood of excursion of CBM into nearby mining workings as coal extraction proceeded.
- EUR and value of remaining CBM production was estimated to determine cost of purchasing, plugging, and abandoning wells in proximity to mining operations that could pose safety issues.
Gas and Water Resources

Gas and Water Production of the Northern Raton Basin

- Analysis performed on gas and water produced from more than 3000 wells in the Northern Raton Basin from January 1999 through June 2013
- Produced gas is collected by operators and sold via interstate pipelines
- 85% of co-produced water is disposed via surface outfalls to streams and rivers and 15% is disposed of via underground injection into 13 water injection wells within Raton Basin

-CBM production in NECC mining area has overlapped mining in the area
- The Golden Eagle mine operated in gassy conditions and was a significant commercial source of abandoned mine methane (AMM) sold to the natural gas pipelines after its closure
- Water has been produced by mines and wells since extraction of coal and gas began
- Groundwater recharge of the basin is restricted in the Basin (Nelson, et al 2013) and makes regulation and monitoring of water production crucial
- The NECC mining area is illustrative of the interplay between coal mining, gas production and agriculture

Agriculture and CBM Produced H2O in Las Animas County, Colorado

- ~600 farms and ranches in 2.1 million acres
- 71% of surficial acreage in county
- In 2010, employed 579 people in county
- 7% of total employment
- Cattle and calf sales = $21.9 million in 2007
- 87% of total agricultural products sold
- Crop sales = $3.4 million in 2007
- Average of $113 per harvested acre
- 80-85% of total water use in county goes toward agriculture
- Irrigation requires >41K acre-feet/annum
- Annual shortage for irrigation exceeds 14K acre-feet

- Surface H2O over appropriated by 3 times
- Livestock consume >950 acre-feet/annum
- 7-8K acre-feet of CBM water discharged into tributaries of Purgatoire River/annum
- Suitable for livestock consumption
- 4K acre-feet of CBM water reaches main Purgatoire River
- Now suitable for crop irrigation
- CBM water available year round
- CBM water represents ~8% of total Purgatoire River flow
- Availability of CBM produced water helped support 40 agricultural jobs and >80 jobs in the county in 2010
**Environmental and Water Use Issues**

**Safe Drinking Water Act**
- Main federal law that ensures the quality of Americans’ drinking water.
- Under SDWA, EPA sets standards for drinking water quality and oversees the states, localities, and water suppliers who implement those standards.

**Underground Injection Control (UIC)**
- Protect underground sources of drinking water
- Six types of injection wells
- Class II wells are used for disposal of oil or gas production fluids
- Produced water, drilling fluids, spent well treatment or stimulation fluids, and gas plant wastes such as amine, cooling tower blowdown and tank bottoms

**Colorado Oil and Gas Conservation Commission (COGCC)**
- EPA regulates all wells unless they have granted primacy to a state
- Colorado received primacy of the Class II program on April 2, 1984
- COGCC manages UIC program as well as other treatment and disposal of exploration and production waste, such as drilling fluids

**US Environmental Protection Agency (EPA)**
- Stormwater Management
- Surface Water Outfall

**Colorado Department of Public Health and Environment (CDPHE)**
- Water Quality Control Division
  - Provides discharge permits that are protective of established standards
  - Provides compliance oversight, technical and financial assistance for facilities
  - Permits establish monitoring parameters, frequency, and reporting requirements

**Clean Water Act**
- Restore and maintain the chemical, physical, and biological integrity of the nation’s waters
- Preventing point and nonpoint pollution sources
- Providing assistance to publicly owned treatment works for the improvement of wastewater treatment
- Maintaining the integrity of wetlands

**National Pollutant Discharge Elimination System (NPDES)**
- Controls water pollution by regulating point sources that discharge pollutants into waters of the US
- Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters
- Discharges regulated according to Effluent Limit Guidelines (ELGs)
- Administered, in most cases, by authorized states

**CBM Discharges**
- Direct discharges from CBM extraction are not currently subject to limitations under ELGs as are other on-shore oil and gas discharges
- NPDES permits for CBM discharges are currently developed according to the best professional judgement of the permit authority

**Proposed Rule to Amend Effluent Limitations Guidelines (ELGs) for Oil and Gas**
- Scheduled for publication in 2014
- EPA has proposed to delist CBM from this process
- “May not be able to identify a wastewater treatment technology that would be economically achievable for [CBM]”

**Water Use Regulations**

**Colorado Department of Natural Resources**
- Division of Water Resources (Office of the State Engineer)
- Administers water rights
- Issues water well permits
- Represents Colorado in interstate water compact proceedings
- Monitors streamflow and water use
- Issues licenses for well drillers
- Assures the safe and proper construction of water wells
- Maintains numerous databases of Colorado water information

**Colorado Supreme Court Decision, Vance v. Wolfe**
- CBM produced water historically unregulated in Colorado
- Plaintiffs: ranchers who possessed existing water rights which they used for irrigation, stock watering, and other domestic uses, argued that the water extracted during CBM production constituted out-of-priority depletions, injurious to their vested, senior water rights and that ‘appropriation’ of groundwater during CBM production constituted a beneficial use
- Colorado Supreme Court held that the “[State Water] Engineer cannot allow out-of-priority diversions of water for CBM production without a well permit”
- CBM operators now must obtain permit from State Engineer to drill a well
- If “tributary” (hydrologically connected) to a surface stream, use of the groundwater falls under the prior appropriation system, and water rights must obtained; in nontributary aquifers the water is allocated based on the percentage of land owned on the surface above the aquifer


Colorado Oil and Gas Conservation Commission, http://cogcc.state.co.us/


