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SLIDES: Routes to Sustainability: Natural Gas Development and Air and Water Resources in the Rocky Mountain Region

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Routes to Sustainability: Natural Gas Development and Air and Water Resources in the Rocky Mountain Region

University of Colorado Boulder
California State Polytechnic University Pomona
Colorado School of Mines
Colorado School of Public Health
Colorado State University
National Oceanic and Atmospheric Administration
National Renewable Energy Laboratory
University Corporation for Atmospheric Research
University of Michigan
Social-Ecological Systems Framework
CSU
UC Boulder

Natural Gas Infrastructure
CSM

Data Management
UC Boulder

Social-Ecological Systems Framework
CSU
UC Boulder

Outreach Education
UC Boulder
UCAR
CSU

Health Effects
CO School of Public Health

Embedded Tech
University of Michigan
UC Boulder

Air Quality
NOAA
UC Boulder
NREL

Water Quality
UC Boulder
CSU
CA Poly Pomona
UC Boulder
CSM
Social Studies Sustainability
Protecting Drinking Water Resources

Drinking Water From Household Wells

Well Integrity Is the Key!

(James Bolander, Southwestern Energy)
Ultrasonic Image of the Cement Sheath

With a great deal of certainty, casing can be cemented, evaluated, and remediated if necessary to prevent annular fluid migration, to protect surface waters.
Natural Gas Infrastructure

- Obtain well-integrity data from industry
- Ultrasonic imagery
- Quantitative risk assessment of “black swan” events
- Quantitative assessment of fracture migration (modelled)
Water Quantity

• Alterations of groundwater flow
• Portfolios of future water supply
• Comparative assessments of regulations
• Risk assessment
• Hari Rajaram, Reagan Waskom, Kevin Doran, Mark Williams
Experience w/ Contaminant Transport

Discrete-Fracture Network and Matrix Transport Models for Nevada Test Site scale applications, with ~ 1 Billion computational nodes

Combine these cutting edge computational tools with readily accessible open-source software such as NETL’s FRACGEN/NFFLOW

Preferential high-flow channels and dead-end fractures (right figure zooms in to show particle traces in red)
Sustainable Water Use and Reuse

- Past and present industry partners:
  - Anadarko Petroleum Corporation
  - Chevron
  - Marathon Oil Company
  - Petro-Canada Resource (USA), Inc.
  - Pioneer Natural Resources
  - Pinnacle Gas Resources
  - Triangle Petroleum Corporation
  - Bear Creek Services
  - CGRS Inc.

- [http://aqwaterc.mines.edu/produced_water/](http://aqwaterc.mines.edu/produced_water/) for more information
Risk of Casing Failure
(Reliability/Statistical analysis based on well logging records from Encana and COGCC)

Risk of Induced “runaway” Fractures connecting failed casing to a drinking water aquifer
(Monte-Carlo simulations using Gopher, FracPro to generate induced fracture networks, accounting for heterogeneities in rock properties and in-situ stresses)

Risk of contamination of drinking water wells following gas/fracking chemical discharge into a groundwater aquifer
(Monte-Carlo simulations using Groundwater flow and transport codes – porous media and/or fractured rock, accounting for heterogeneous permeability fields and/or stochastic fracture network structure, and well locations)

Cumulative Risk of Groundwater Contamination
Social-Ecological System Modeling

Agent behavior

- Land owners
- Oil and gas industry
- Local governments
- State/federal regulators

Assessment and forecast

Economics/Markets

Landscape/region:
socio-economic condition & trend
water quantity & quality
wetland/stream condition

Decision maker *(game player)*
Social-Ecological System Model

• Optimal outcomes?
  • less risk ⇔ less value; more value ⇔ more risk
  • best event for a risk-value combination
Air Quality

Emissions Measurements

Air Quality & Energy Modeling

How will our energy future impact air quality?

Difference in O₃ concentration

Jana Milford (UCB) and Greg Brinkman (NREL)

Gaby Pétron (NOAA)

Ambient & Exposure Measurements

Mike Hannigan (UCB)