Environmental Assessment Framework for Shale Gas Development

Battelle

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Battelle

- **Mission:** To be a major force in scientific discoveries that benefit mankind
- **Non-profit, charitable trust**
  - Apply science and technology to complex real-world problems
  - Promote sound science, innovation, and proof-of-concept testing
  - Advance technology adoption and commercialization (xerography, UPC, more…)
  - Support STEM (science, technology, engineering, and math) education through local, regional, and national programs

- $6.5 billion annually in global R&D
- Over 22,000 employees in 130 locations worldwide; 31 scientific user facilities

20 International Locations
Four Global Businesses

Energy, Environment & Material Sciences

National Security

Health & Life Sciences

Laboratory Operations

Broad Spectrum of Interdisciplinary Research

- Sustainability
- Ecosystem services
  - Environmental assessment, permitting, monitoring, remediation
    - Advanced chemical fingerprinting, geochemistry
    - Microbiology and metagenomics
    - Toxicology, epidemiology, health & risk studies
  - Homeland security: detection, decontamination, risk assessments, risk modeling
    - Climate adaptation
    - Energy-Environment nexus
  - Advanced materials, discovery, development, performance testing
- Systems development: sensors, data transmission, process engineering
- Data analytics, signal processing, statistics, image processing, data management
Energy and Environment Nexus

• Sustainable Solutions

  – Multidisciplinary teams to solve complex challenges

  – Looking at entire life cycle of shale gas operations
    - Shale gas reserve modeling
    - Environmental assessment for shale gas development
    - Improved operations; “greener” fluids; well bore integrity; isotopic and real-time environmental monitoring tools
    - Optimal pipeline design; water reuse; water treatment; disposal via injection
Demonstrated Need for Assessment

- State Review of Oil and Natural Gas Environmental Regulations (STRONGER)
  - Comprehensive well completion reporting requirements
  - Review of potential pathways of contamination
  - Enforcement tools for compliance
  - Use of Web site to disseminate information

- Ohio
  - Notice to land owners <500 ft of lateral

- Pennsylvania Act 13
  - Notice to land owners <3,000 ft from the vertical well bore
  - Setback distances from existing buildings, water wells, water bodies, wetlands, more
  - Rebuttable presumption of damage to a water supply to 2,500 feet and 12 months of drilling completion

Source: NETL, 2011
Framework Objectives

• Leverage advanced GIS-based assessment tools, numerical modeling, and visualization capabilities

• Collect and organize site-specific environmental data into a cohesive framework

• Assist in meeting regulatory requirements for drilling, completion, and production operations

• Design and optimize the monitoring program associated with shale gas activities

• Provide accessible information to help to characterize and mitigate potential risks
Framework Concepts

• **Regional Geologic Module** – identifies geologic units of interest and relationship to near surface features

• **Geographic Information System (GIS) Module** – geospatial database of pertinent features
  - Near surface (e.g. population distribution, wetlands, land use, water supplies)
  - Deep (e.g. current and former O&G exploration, geologic structure)

• **Migration Analysis Module** – modeling for constituent migration to define potential site-specific consequences
  - Surface release (e.g., infiltration, surface water, groundwater transport)
  - Subsurface release (e.g., groundwater transport, deep to shallow fate and transport)

• **Assessment Results Mapping Module** – integration of assessment results into GIS Module
Conceptual Environmental Assessment Framework

1. Regional Geologic Model

   Near Surface Components/Inputs

   Local Geologic Model

   Several 1000’s Feet

2. GIS Module

   Population

   Surface Water (Watersheds)

   Groundwater Resources

   Sensitive Habitats

   Existing Wells

OUTPUT

Integrated GIS map and database showing assessment results for proposed locations

3. Migration Analysis Module

Water Table Aquifer

Semi-confined Aquifer

Particle Tracks

Shallow Groundwater Model Framework
Regional Geologic Model/GIS

• Created 3-D geologic model (GIS and EarthVision™)
  • Water well completions
  • Oil and gas wells
  • Geologic units including structure, formation thicknesses, and characteristics
  • Surface water characteristics
  • Groundwater/aquifer characteristics
  • Land use/population
  • Wetlands/sensitive habitats
  • Chemistry/analytical data
Migration Analysis

- Site-specific potential “consequence” of release
- Surface spills/releases
  - Soil to groundwater (column models e.g., FEHM)
  - Overland flow/runoff (watershed models e.g., SWMM, HSPF)
- Subsurface release
  - Groundwater flow and transport (e.g., MODLFLOW, MODFLOW SurFACT)
  - Gas migration e.g., TOUGH 2.0 (multiphase flow, transport, energy, multi-porosity, fracture flow)

Hypothetical release at surface and along well bore (to simulate casing failure within the aquifer zones). Shallow migration pathway evaluation identifies likely pathways, time of travel, and key potential monitoring locations.
Environmental Assessment

- Risk = Consequence x Likelihood of Failure
  - Consequence is site-specific based on GIS/migration analysis
  - Likelihood of failure is based on operational practices
    - Fracture pressure ruptures surface casing at fresh water depth (1 in 100,000 fracs)
    - Frac intersects abandoned well bore (2 in 100,000 fracs)
    - Spill of 500 bbl (21,000 gal) of stored frac water (1 in 1,000 fracs)

- Mitigation measures may include:
  - Risk avoidance in the planning and siting stage
  - What, where, and when to monitor
  - An array of potential response actions for any inadvertent release
  - A framework for public outreach/education
Utility of Framework

• Supports planning efforts
  – Baseline monitoring, monitoring design, and optimization
  – Key monitoring locations are identified for verification of numerical modeling results
  – Identify land use constraints
    - Sensitive habitats
    - Wetlands

• Input into decision-making
  – Risk prioritization, mitigation, management, and communication
  – Evaluate individual or multiple concerns within a consistent spatial environment
  – Areas where no plausible set of conditions exist for potential impact
Other Potential Uses for Framework

- Route planning, resource identification, disposal locations
- Minimize footprint in sensitive areas
- Stakeholder communication/agreement
- Prevent and/or mitigate impacts (alternatives evaluations)
- Monitoring locations and source apportionment
Other Shale Gas Research Initiatives

- GIS Framework and Database for Ohio River Valley Enhanced Oil Recovery (EOR)/Shale Gas Operations
- Improved, More Environmentally Friendly Hydraulic Fracturing Fluids
- Monitoring Air Quality for Hydraulic Fracturing Activities
Improved, More Environmentally-Friendly Hydraulic Fracturing Fluids

• Evaluate and optimize microbial control strategies to support unconventional shale gas operations

• Reduce the use of petroleum distillates and chemicals of concern to the EPA
  – friction reducer ($C_7^{-} C_{12}$)
  – gelling agent (*mineral spirits*)
  – surfactant (*2-butoxy ethanol*)
  – antifreeze/ scale inhibitor/gel breaker/ crosslinker (*ethylene glycol*)

• Factors to consider
  – affordability
  – availability
  – compatibility
  – equal or better performance
Related Air Monitoring Research

• Literature review on air emissions (toxic, reactive, or greenhouse gas) from shale gas development

• Difficult-to-characterize sources identified (e.g., flow back water treatment, flares, condensate tanks)

• Plans for field measurements of emissions
  – Identification of CH$_4$ source in air/groundwater a key issue
  – Ground level ozone issues in West
  – Potential demonstration study to apply cavity ring-down spectroscopy to simultaneously measure concentration and C isotope composition of both CH$_4$ and CO$_2$

Source: ETV, 2011
Conclusions

• Battelle has several research initiatives underway to advance the state-of-the-technology for shale gas development and operations

• Advanced GIS tools for environmental assessment, “greener” fluids, improved scale inhibitors/microbial control; air monitoring tools

Source: NETL, 2011