Ecological Considerations in Shale Gas Development

Workshop on Risks of Unconventional Shale Gas Development – 31 May 2013

National Academy of Sciences

Washington, DC

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Hydrologist
Supervisory Hydrologist
WQ Specialist
Hydrologist
Studies Chief
Environmental Engineer
Hydrologist - GW
Hydrologist
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Briefing Topics

• Background and issues
• Terrestrial considerations
• Aquatic considerations
• Summary and Discussion
Unconventional Gas – Key to supply

U.S. dry natural gas production
trillion cubic feet

History 2011 Projections


Shale gas
Non-associated offshore
Tight gas
Coalbed methane
Associated with oil
Non-associated onshore

Source: U.S. Energy Information Administration, Annual Energy Outlook 2013 Early Release
Areas of Unconventional Oil and Gas

Shale Gas Development - Classes of Decisions

- National policy
- Planning
- Permitting/Disposal
- Siting
- Mitigation/Treatment
- Reclamation/Restoration

Common question: *What are the effects of the proposed action or decision on other resources?*
## Terrestrial Considerations

<table>
<thead>
<tr>
<th>Direct effects</th>
<th>Indirect effects</th>
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<tbody>
<tr>
<td>• Removal of habitat</td>
<td>• Avoidance</td>
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<tr>
<td>• Mortality from collision</td>
<td>• Fragmentation of habitat</td>
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<tr>
<td>• Invasive species</td>
<td>• Physiological effects</td>
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### Cumulative effects

- Accumulated effects of an action over space and time
Direct Effect – Surface Disturbance
Indirect Effect – Surface Disturbance

Approaches to Evaluate Potential Effects

Spatial Analysis
- Mapping resources
- Estimating development patterns

Ecoregional Assessment
- Considers multiple species or communities
- Evaluates multiple drivers of change

Species-based Modeling
- Population biology
- Behavioral studies
- Habitat modeling

Vulnerability Assessment
- Examining overlap in habitat and potential development
Surface Disturbance Measurement

Multi-well Pads and Directional Drilling

Reduced density of well pads within a project area

Reduces the cumulative disturbance of development over large areas

Wind Energy – Surface Disturbance
Indirect Effects – Habitat selection studies

Indirect Effects – Migration studies

Indirect and Cumulative Effects

Habitat Connectivity Modeling

Vulnerability Assessment

Ecoregional Assessment – CO Plateau

Concentrations of species or communities

The distribution of shale gas resources and the methods used to develop the resource determine potential surface disturbance.

Habitat requirements and behavioral responses to development are species specific.

Species responses must be known or estimated to predict responses to development but population responses are difficult to predict precisely.

Vulnerability of species, communities, or ecosystems to potential development is typically assessed by examining areas of overlap and optimally considers sensitivity of the affected species.

Ecoregional assessments examine multiple natural resources and are potentially useful in identifying priority areas for development or conservation.
Water Cycle

Illustration of the five stages of the hydraulic fracturing water cycle. The cycle includes the acquisition of water needed for the hydraulic fracturing fluid, onsite mixing of chemicals with the water to create the hydraulic fracturing fluid, injection of the fluid under high pressures to fracture the oil-or gas-containing formation, recovery of flowback and produced water (hydraulic fracturing wastewater) after the injection is complete, and treatment and/or disposal of the wastewater. Taken from EPA 601/R-12/011 | December 2012 | www.epa.gov/hfstudy
Water Source

Disposal and Treatment Options

USGS

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Aquatic Considerations

**Direct effects**
- Quantity (erosion and habitat loss)
- Quality (beneficial use vs. toxicity)
- Infiltration
- Produced waters (salts) vs. flowback (trace organics)

**Indirect effects**
- Runoff (SAR and TDS)
- Alteration of flow rates and seasonal cycles
- Reduced diversity of habitat patches, increase non-natives
- Trace metals

**Cumulative effects**
- Accumulated effects of an action over space and time
Direct Effect – Surface Disturbance

Quantity (erosion and habitat loss)

Produced waters (salts) vs. flowback (trace organics)
Direct Effect – Water Quality

Potential toxicity/aquatic health

Beneficial use
Approaches to Evaluate Potential Effects

LABORATORY
- Acute (96 hrs)
- Chronic

INDIVIDUAL (Quality)
- Physiological Malfunction
- Growth

POPULATION (Quantity)
- Population Structure
- Death

FIELD
- In Situ
- Mixing Zone
Individual to Population

- Growth
- Deformaties
- Mechanisms of toxicity
  - Na/K ATPase
  - Ionoregulation
  - Histology
  - Estrogen and androgen receptors
Laboratory to Field – Study Area Broadens

- Toxicity thresholds in laboratory
- Fish kill - Kentucky
- Watershed - Brook trout Marcellus
- Structural Basin – Powder River
- Brine contamination – Prairie Pothole Region
- United States - Powell
Fish Kill – Limited Area

- pH decreased to 5.6
- Epithelial lifting, hyperplasia
- Conductivity increased to 35,900 μS/cm

In situ and streamside

Papoulas, D.M, and Velasco, J.L., 2013, "Histopathological Analysis of Fish from Acorn Creek, Kentucky, exposed to Hydraulic Fracturing Fluid Releases" (in Press)
Discharge – Basin Wide

Proximity to Water Sources

Wetland Proximity Analysis

- 33% within 1 mile buffer
- 17% within ½ mile buffer
- 7% within ¼ mile buffer
- Need information on potential biological impacts

EPA

- Study of potential infiltration into test wells
- Study ecological implications at similar locations

Summary – Aquatic

• Mitigation of surface disturbance can maintain diversity of aquatic habitat patches

• Integrated scientific approach balances beneficial use with potential toxicity

• Defining mechanisms of toxicity at the individual level provides explanations and early warning

• Establishing toxicity thresholds and field studies expands the study area focus

• Long-term water quality monitoring data are essential
Retrospective Study - Unconventional Energy and Water Quality

- Watersheds in areas with unconventional energy resources
- 11,401,883 results from over 110,000 sites
- Surface water and ground water quality data from NWIS and STORET
- Completing analyses now

Integrated Assessment

Common characteristics include:

- Collaboration between policymakers or managers and scientists
- Consideration of multiple resource values and societal needs
- Development of relevant products based on the best available information

Approaches or methods include vertical integration, decision analysis, and ecosystem services valuation.
Opportunities

• Improve our understanding of the needs of decision makers and managers – multiple resource use

• Focus effort and technical assistance on helping managers make better use of existing high-quality science (now)

• Develop better data and understanding of the basics – distribution and abundance of shale gas, water, vegetation, and fauna

• Continue improving frameworks, methods, and analytical approaches for assessing potential effects of shale gas development on other natural resources