United States Environmental Protection Agency

Technical Roundtables on EPA's Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources

WELL INJECTION

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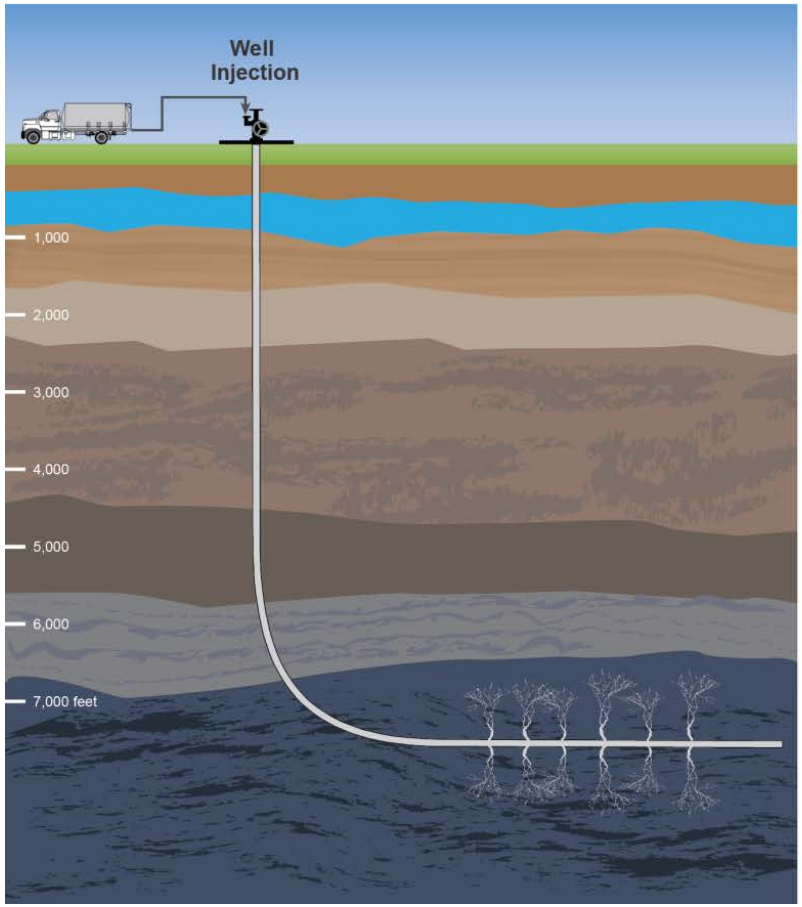
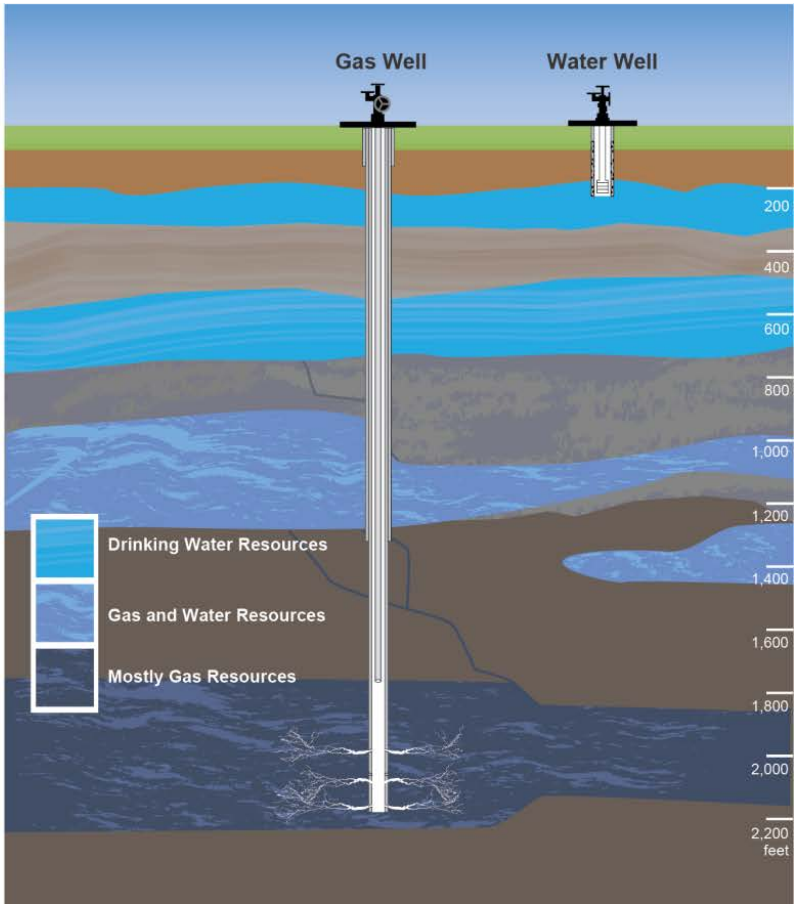
November 15, 2012



Well Injection





What are the possible impacts of the injection and fracturing process on drinking water resources?

Well Injection Research Projects

Secondary Research Questions	Applicable Research Projects
1. How effective are current well construction practices at containing gases and fluids before, during, and after fracturing?	Literature Review Service Company Analysis Well File Review Subsurface Migration Modeling Dunn County, ND Bradford County, PA
2. Can subsurface migration of fluids or gases to drinking water resources occur, and what local geologic or man-made features might allow this?	Literature Review Service Company Analysis Well File Review Subsurface Migration Modeling Las Animas County, CO

Analysis of Existing Data: Literature Review

Data Sources:

- Existing papers and reports, focusing on peer-reviewed literature.

Anticipated Data:

- Information on well construction practices related to hydraulic fracturing and possible subsurface fluid migration.

Research Progress:

- Identifying, reviewing, and evaluating existing literature following procedures in the study plan.

Next Steps:

- Continue to review and assess literature related to well injection according to research questions in the study plan.

Analysis of Existing Data: Service Company Data

Data Sources:

- Data and information provided by nine hydraulic fracturing service companies.

Anticipated Data:

- Information on practices related to establishing mechanical integrity of wells and the procedures used during hydraulic fracturing.

Research Progress:

- Requested information on standard operating procedures (SOPs) for drilling, response plans to address unexpected circumstances, determinations of material choices for wells and appropriate pressures, and which wells they hydraulically fractured the year prior.
- Seven companies reported 231 protocols.
  - EPA is assessing the extent to which companies use SOPs and is seeking to understand well construction practices and maintenance
- Performed spatial analysis of the ~25,000 reported wells using GIS.

Next Steps:

- Describe the range of operations conducted by the nine service providers. Include information on the role of the service companies during each stage of the hydraulic fracturing water cycle.

Retrospective Case Studies

Purpose

To determine whether drinking water contamination has occurred at the case study locations and if so, identify the cause of contamination.

Retrospective Case Studies

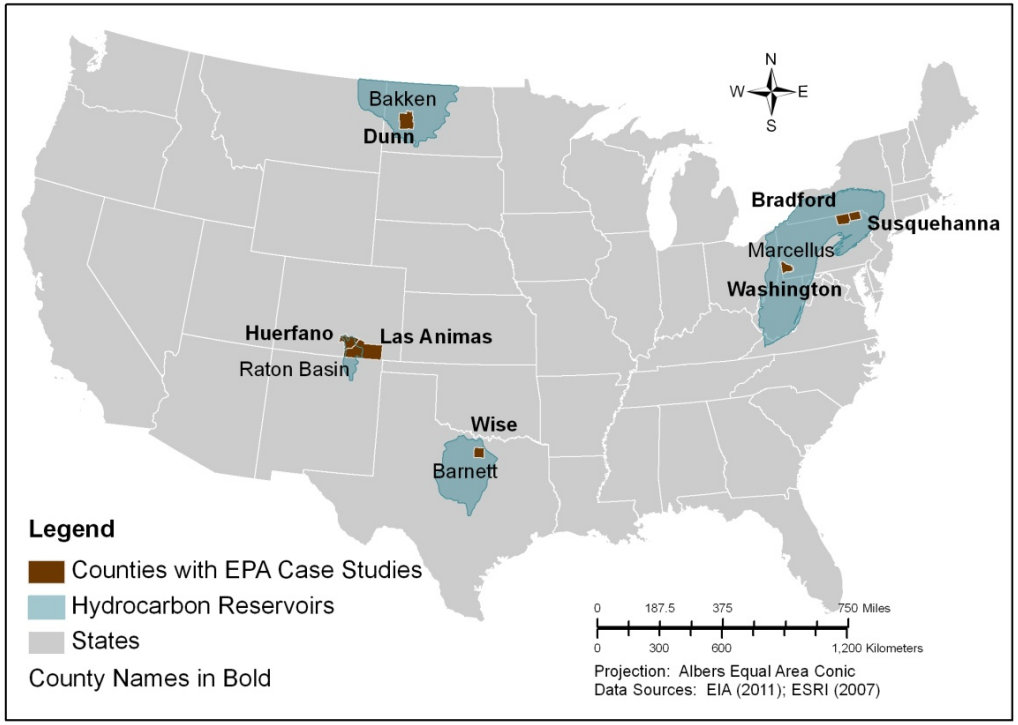
Approach

- Solicited potential case studies from stakeholders during public meetings and through the public comment process.
- Identified and narrowed case study candidates based on rigorous criteria.
- Prioritized case studies based on additional criteria.
- Selected five case studies to investigate reported drinking water impacts from shale gas development in the area.

Retrospective Case Studies

Approach (cont.)

- Case study locations
  - Bradford County, PA
  - Las Animas/Huerfano Counties, CO
  - Dunn County, ND
  - Washington County, PA
  - Wise County, TX



Retrospective Case Studies

General Analyte List

- Gasoline Range Organics and Diesel Range Organics
- Volatile and Semi-Volatile Organic Compounds
- Major and Trace Cations (Metals) and Anions
- Dissolved Organic and Inorganic Carbon
- Dissolved Gases (such as methane)
- Stable Isotopes
- Glycols and Alcohols
- Low Molecular Weight Acids
- General Water Quality Parameters (e.g., pH, temperature, specific conductance)

Retrospective Case Studies

Bradford County, PA

- Areas for research
  - Reported ground water and drinking water well contamination
  - Suspected surface water contamination from a spill of fracturing fluids
  - Reported methane contamination of multiple drinking water wells
- Sampling rounds: October/November 2011, April/May 2012
- Sampling locations: domestic wells, springs, stream, pond
- Analytical results for first two rounds will be released concurrently with the 2012 progress report
- Working with partners to determine focus and extent of future sampling events

Retrospective Case Studies

Dunn County (Killdeer), ND

- Areas for research
  - Production well failure during hydraulic fracturing
  - Suspected drinking water aquifer contamination
  - Possible soil contamination
- Sampling rounds: July 2011, October 2011, October 2012
- Sampling locations: monitoring wells, drilling supply wells, domestic wells, municipal well
- Analytical results for first two rounds will be released concurrently with the 2012 progress report
- Working with partners to determine focus and extent of future sampling events

Retrospective Case Studies

Las Animas/Huerfano Counties (Raton Basin), CO

- Areas for research
  - Potential drinking water well contamination (methane and other contaminants) in an area where hydraulic fracturing is occurring within an aquifer
- Sampling rounds: October 2011, May 2012, November 2012
- Sampling locations: domestic wells, production wells, monitoring wells, stream
- Analytical results for first two rounds will be released concurrently with the 2012 progress report
- Working with partners to determine focus and extent of future sampling events

Retrospective Case Studies

Washington County, PA

- Areas for research
  - Changes in water quality in drinking water, suspected contamination
  - Stray gas in wells
  - Leaky surface pits
- Sampling rounds: July 2011, March 2012
- Sampling locations: domestic wells, springs, stream
- Analytical results for first two rounds will be released concurrently with the 2012 progress report
- Working with partners to determine focus and extent of future sampling events

Retrospective Case Studies

Wise County, TX

- Areas for research
  - Spills and runoff leading to suspected drinking water well contamination
- Sampling rounds: September 2011, March 2012, September 2012 (limited sampling), December 2012 (anticipated)
- Sampling locations: domestic wells, industrial well, production well, ponds
- Analytical results for first two rounds will be released concurrently with the 2012 progress report
- Working with partners to determine focus and extent of future sampling events

Subsurface Migration Modeling

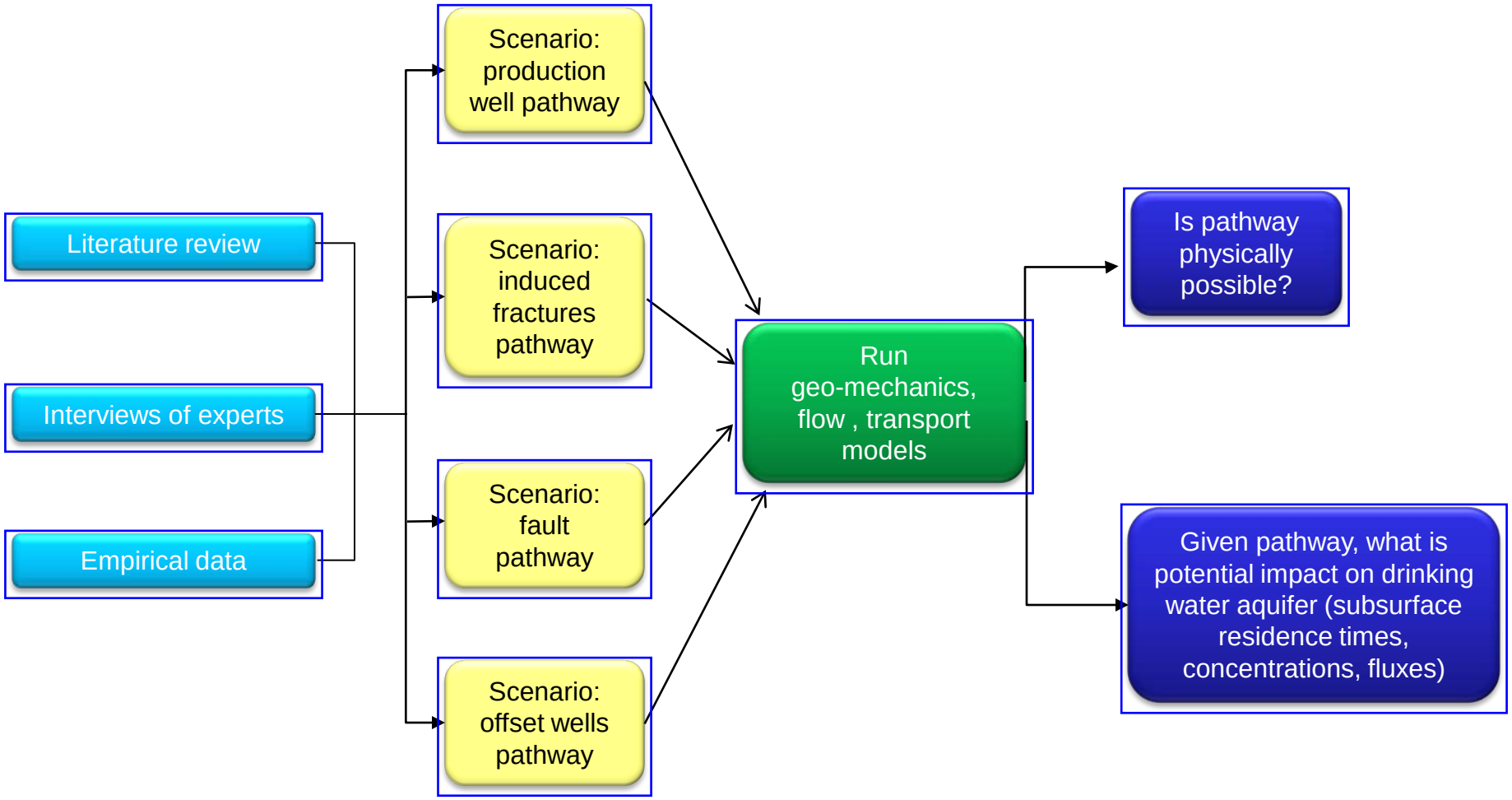
OBJECTIVE:

To evaluate the potential for fluids (e.g., natural gas, introduced chemicals, native brines) to move from the fracturing zone to drinking water aquifers using numerical modeling of subsurface fluid migration scenarios.

APPROACH:

- Collaboration with Lawrence Berkeley National Lab (LBNL).
- Design representative scenarios of potential pathways using literature review and expert judgment.
- Upgrade the LBNL model to simulate flow and transport of gas, water, and dissolved contaminants concurrently in fractures and porous low permeability rock matrix.
- Create numerical grids to solve linked geomechanics (fracture dynamics) and fluid flow.
- Is pathway creation physically possible?
- What are potential impacts?

Critical Path for Subsurface Migration Modeling



LBNL TOUGH: Transport of Unsaturated Groundwater and Heat

FLOW

TOUGH+Rgas
real gas mixtures

TOUGH+RGasH2O
real gas mixtures plus water

TOUGH+RGasH2OCont
real gas mixtures plus water
plus dissolved contaminants

coupling

GEOMECHANICS

ROCMECH
fracture creation and
propagation

FLAC3D
fault reactivation

Subsurface Migration Modeling

Scenario A:

Pathway provided by the production well

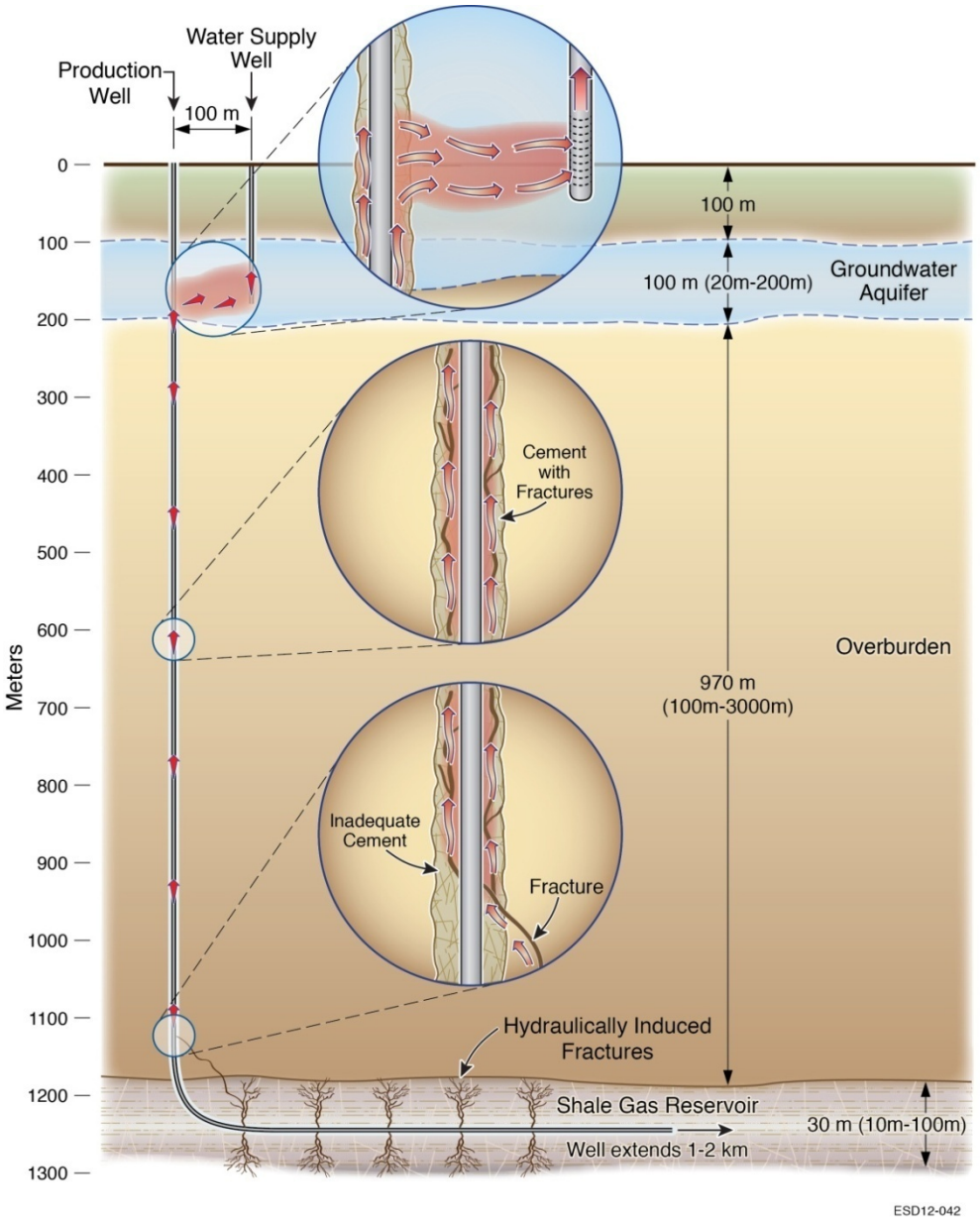
Well design ✓

Well construction?

Hydraulic fracturing operation?

Physically possible?

If present, nature of impact?



Subsurface Migration Modeling

Scenario B:

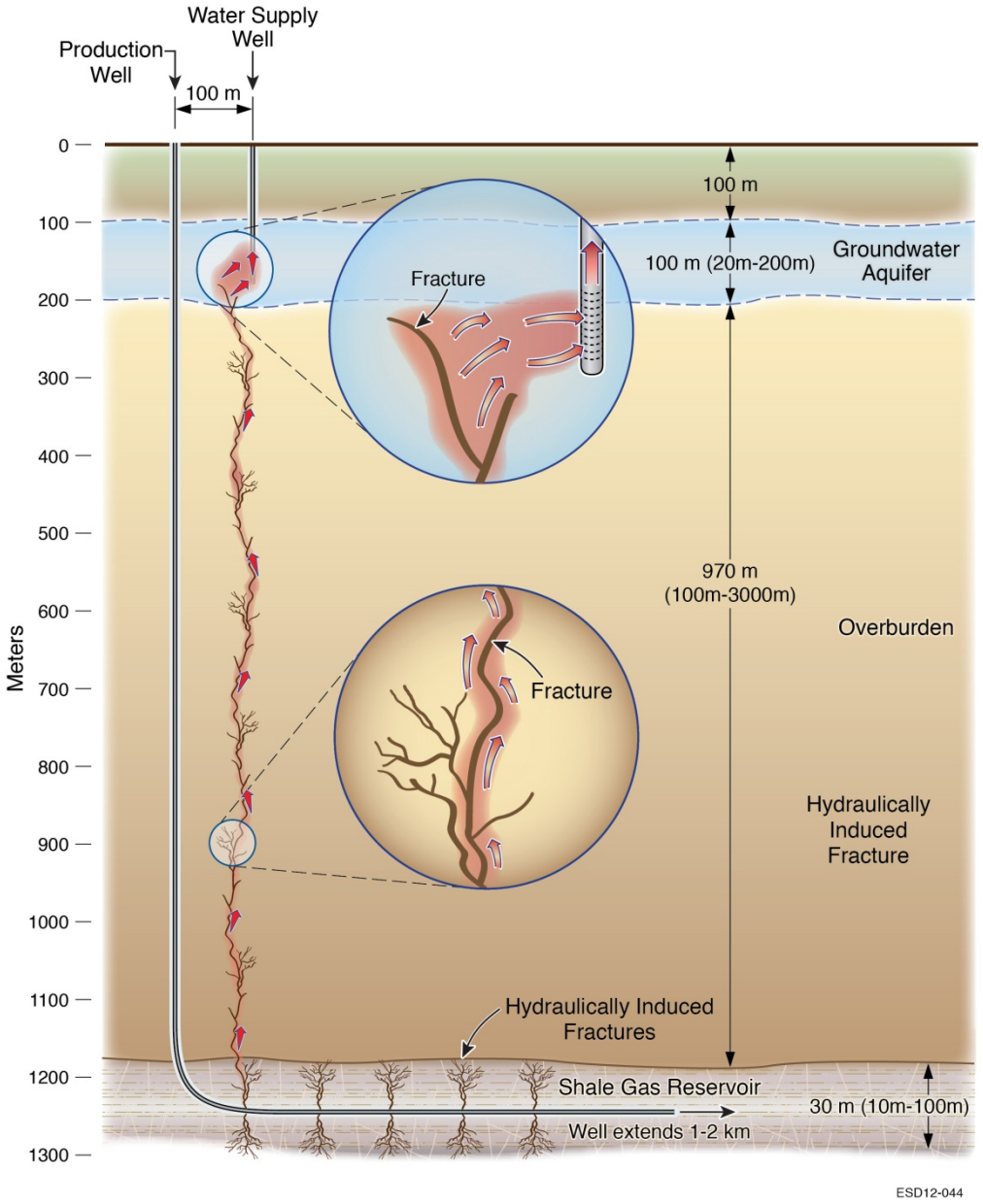
Pathway provided by **fractures** in the overburden

Well design ✓

Well construction ✓

Hydraulic fracturing operation?

Physically possible?
If present, nature of impact?



Subsurface Migration Modeling

Scenario C:

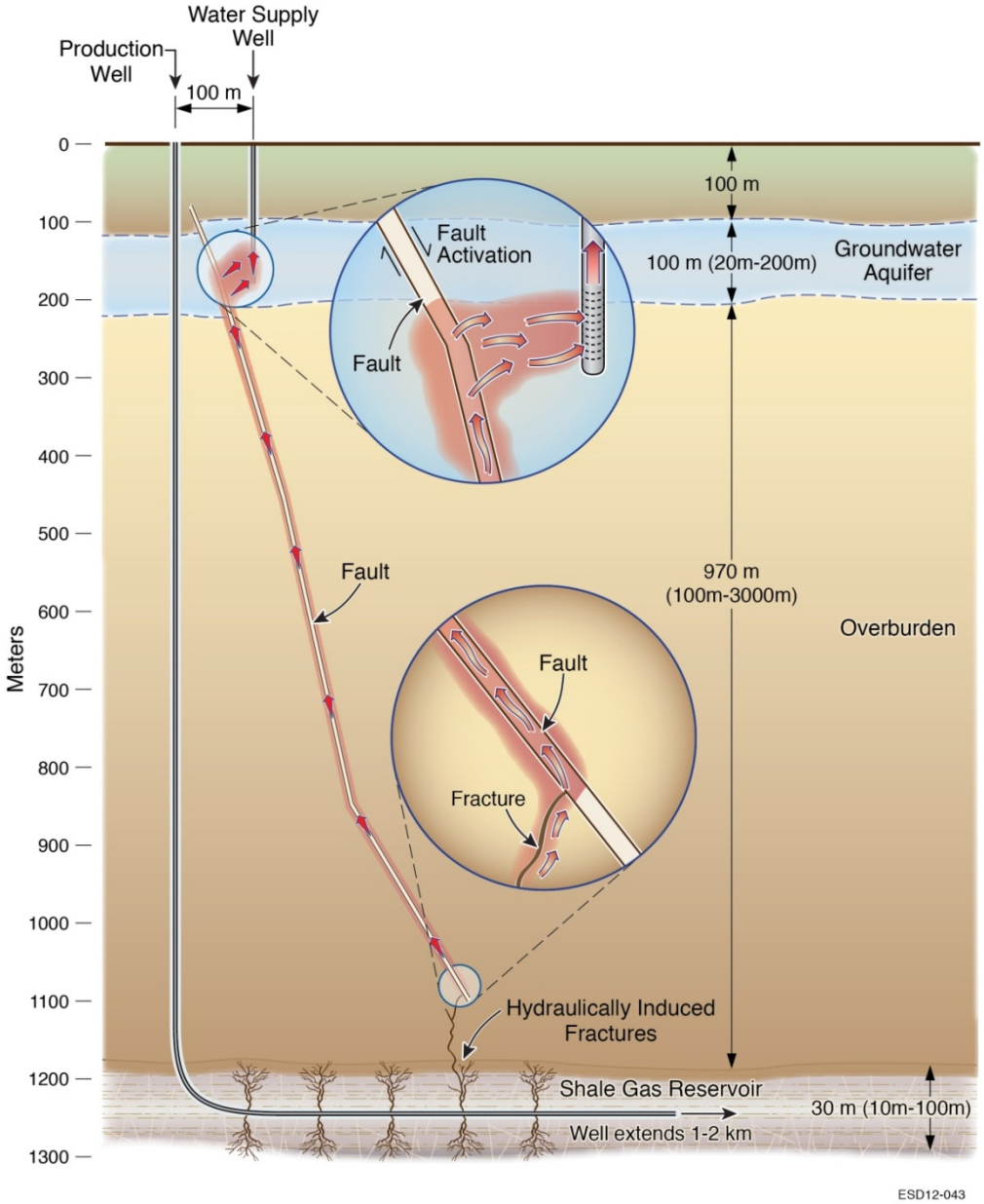
Pathway provided by an activated **fault**

Well design?

Well construction ✓

Hydraulic fracturing operation?

Physically possible?
If present, nature of impact?



Subsurface Migration Modeling

Scenario D:

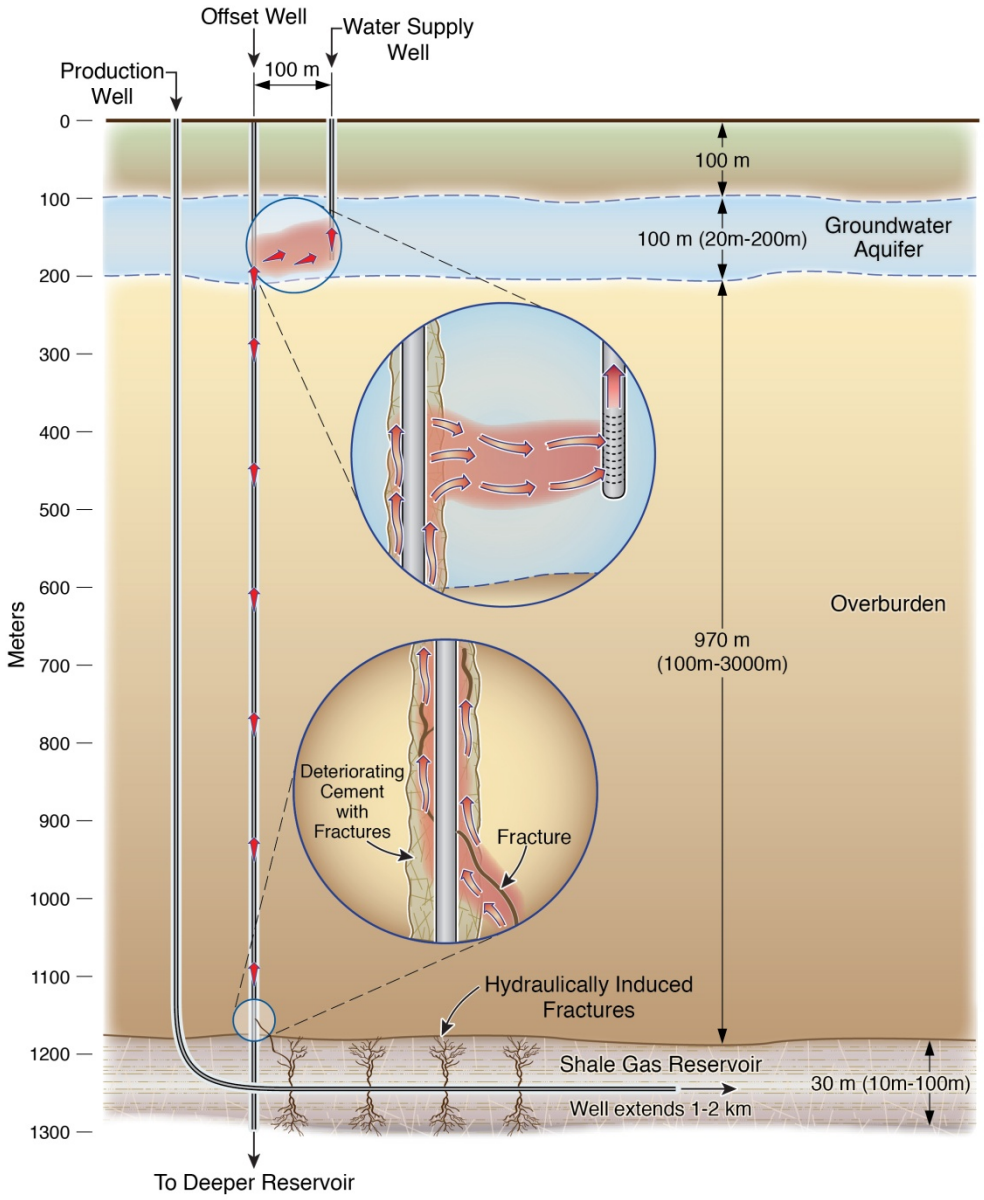
Pathway provided by **offset wells**

Well design?

Well construction ✓

Hydraulic fracturing operation?

Physically possible?
If present, nature of impact?



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Subsurface Migration Modeling

United States Environmental Protection Agency

Research Progress by LBNL:

- Identified the processes that need to be included in the computational code.
- Updated the flow and the linked geomechanics simulators.
- Identified failure scenarios.
- Designed numerical grids.
- Selected parameter ranges.
- Simulation on high performance supercomputers continues as LBNL explores dynamic fracture geomechanics and fluid and contaminant movement.

Next Steps:

- Manuscripts for peer-review journals expected:
  - Numerical solvers for coupled flow and geomechanics.
  - Physical possibility of creating a pathway (not the probability of impact).
  - Fluid and contaminant breakthroughs and fluxes assuming a pathway (again, not the probability of the pathway).

Well File Review

OBJECTIVE:

Review files from hydraulically fractured wells in different geographic areas, from different types of wells, and operated by various size companies to identify practices that may have the potential to impact drinking water.

APPROACH:

Selected 9 operators to receive a request for well file information

- Compile list of wells hydraulically fractured between September 2009 and September 2010 from list provided to EPA by hydraulic fracturing service companies
- Use groupings to randomly select 350 wells from nine operators across geographic regions and size groups

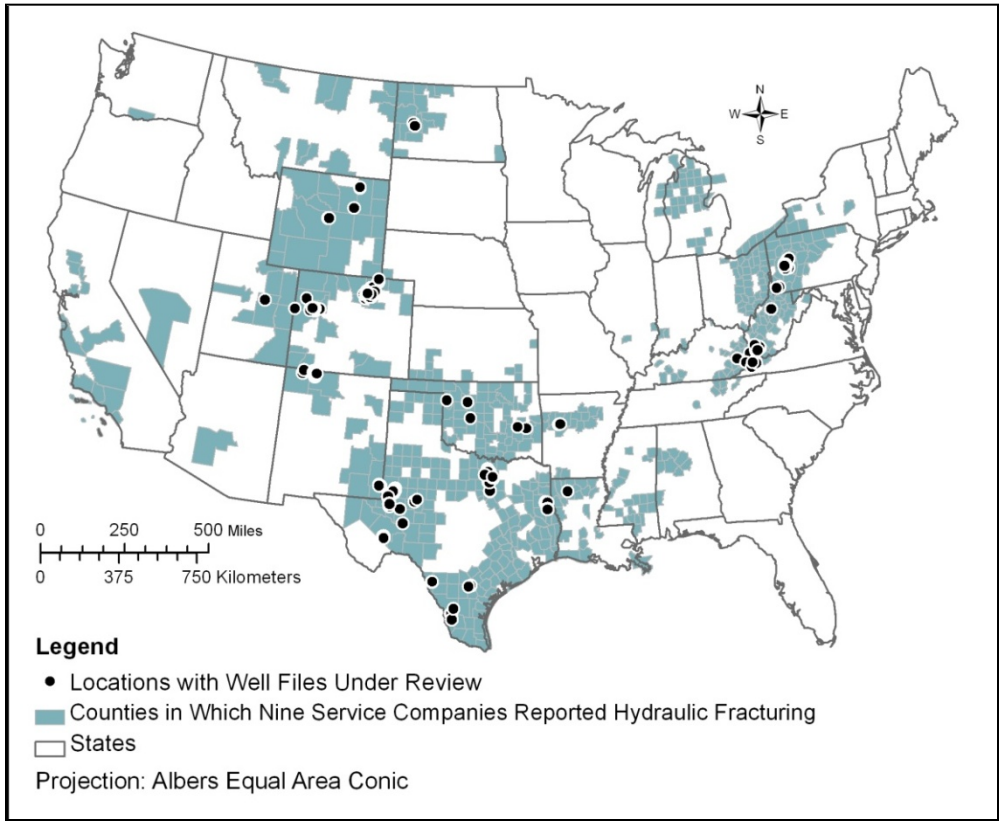
Requested information for the 350 wells on five topic areas

- Geologic maps and cross sections
- Drilling and completion information
- Water quality, volume, and disposition
- Hydraulic fracturing
- Environmental releases

Well File Review

Research Progress:

- Received well files for 333 wells.
- Some data were claimed as confidential business information under the Toxic Substances Control Act (TSCA).
- Currently extracting data from the well files and evaluating it to assess the potential impact on drinking water resources.

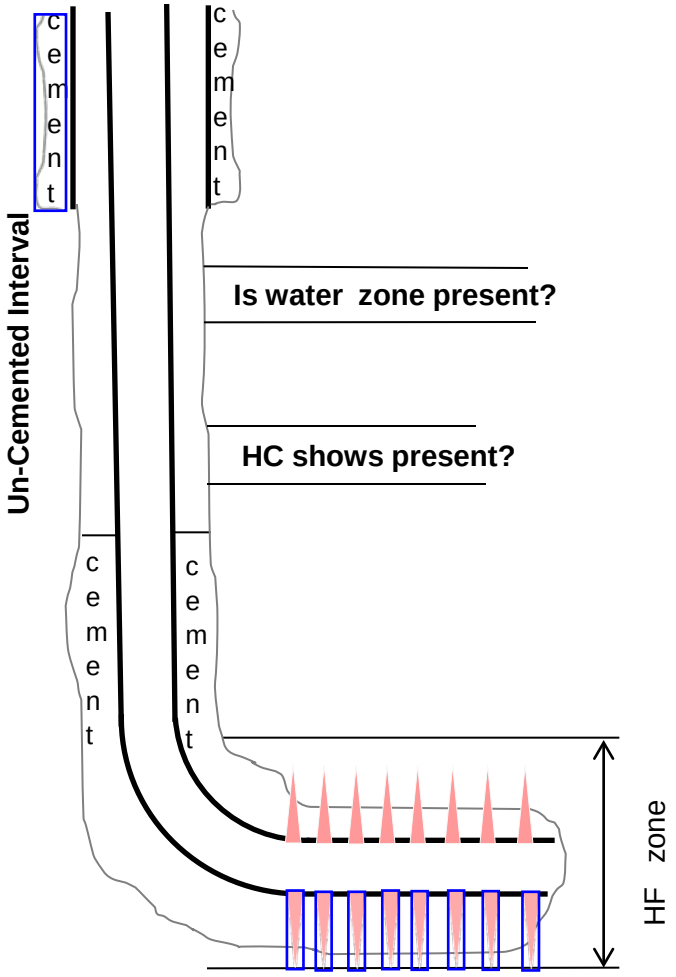


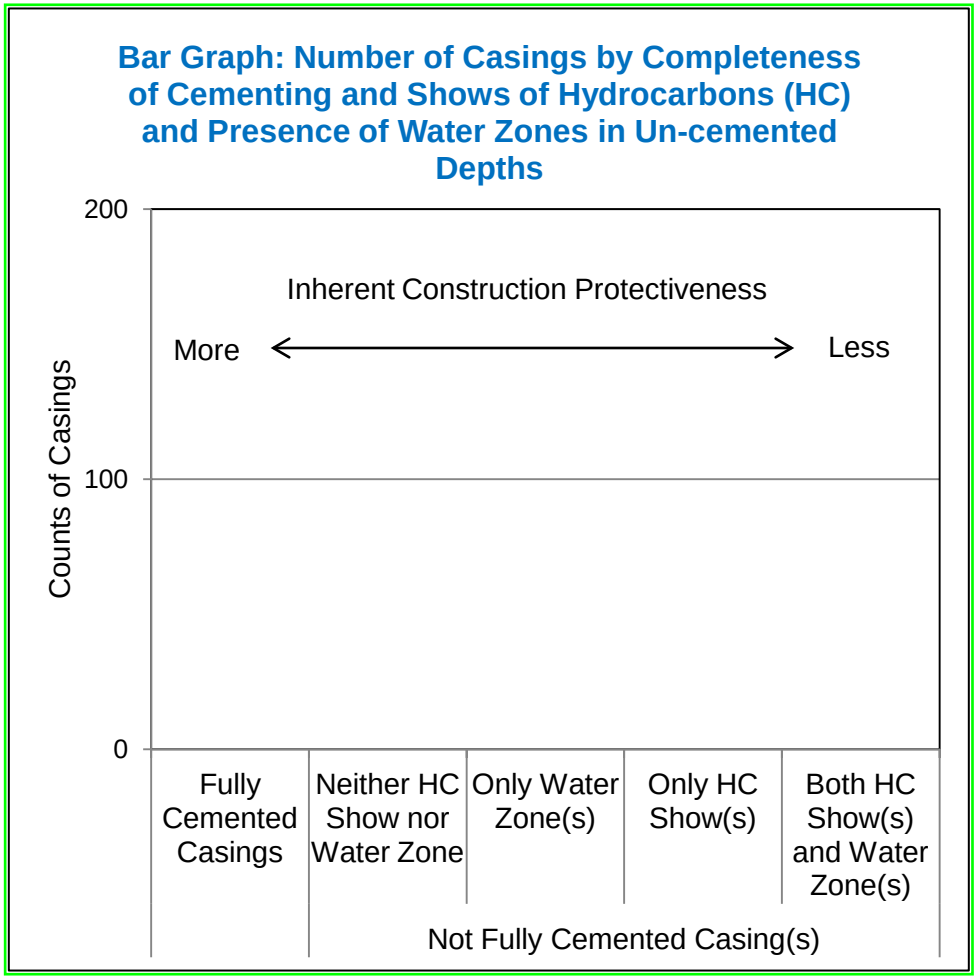
Well File Review

- Characterize diversity of wells, such as
  - Well production type (oil, gas, combined) and completion (horizontal, vertical, other)
  - Lithology stimulated (e.g., shale, sandstone, coal, chalk, carbonate)
  - Arrays of casings used
  - Fracture fluid additives used
- Factors of interest, such as
  - Depth of uppermost hydraulic fracturing relative to drinking water resource (if available)
  - Length and quality of cement sheath behind casing above uppermost depth hydraulically fractured
  - Un-cemented intervals in casing strings and potential for cross flow into drinking water resources
  - Fracture growth length and distance to nearest fault, if any
  - Is there monitoring and other data available in file to assure the operator that conducting hydraulic fracturing is protective of drinking water resources?
    - Examples :
      - *Frequency of cement evaluation*
      - *Formation water sampling to confirm presence/absence of underground source(s) of drinking water*
      - *Annular monitoring during hydraulic fracturing*
      - *Offset well monitoring during/after hydraulic fracturing*

Well File Review

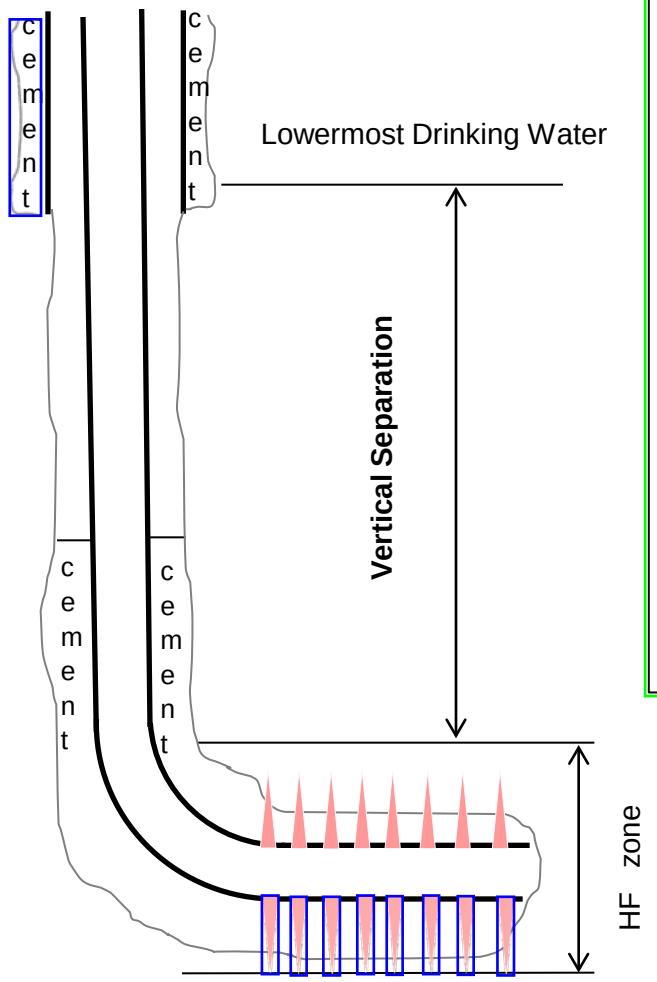
Generic Well Diagram



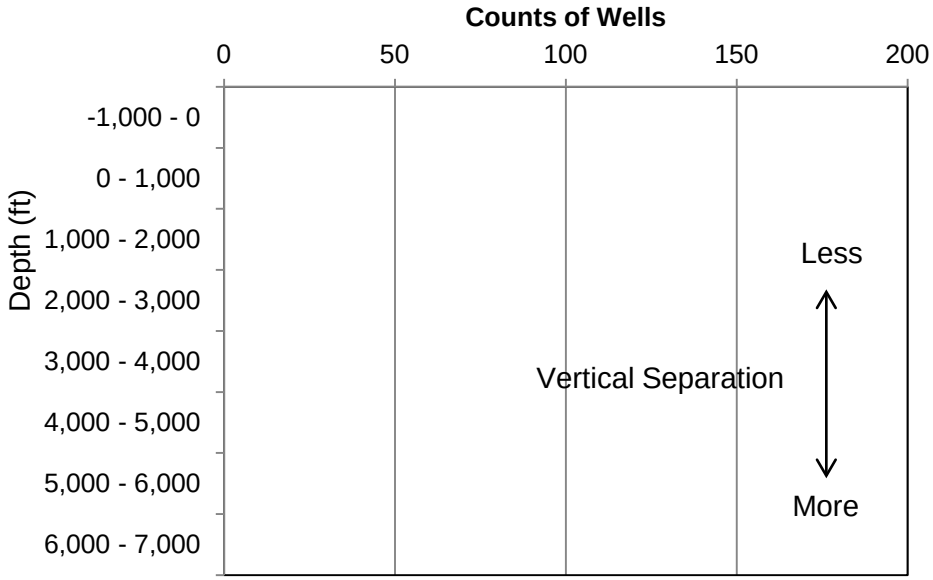


Well File Review

Generic Well Diagram



Bar Graph: Counts of Wells by Depth Differential Between Uppermost Hydraulically Fractured Zone and Lowermost Drinking Water



Well File Review

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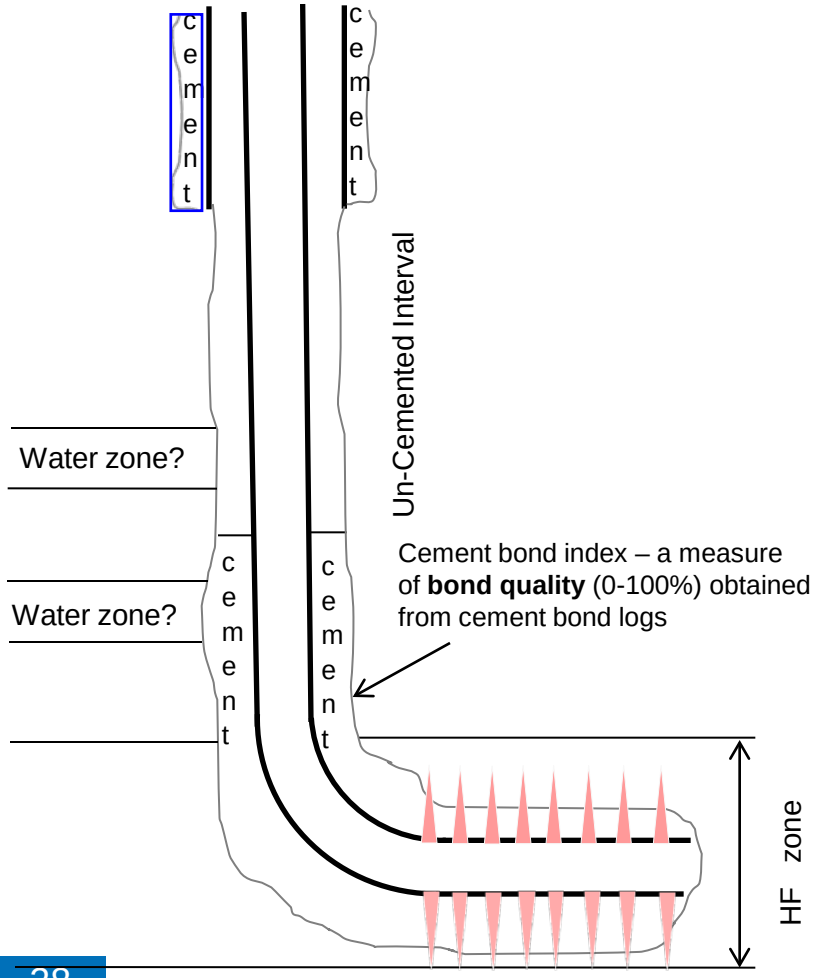
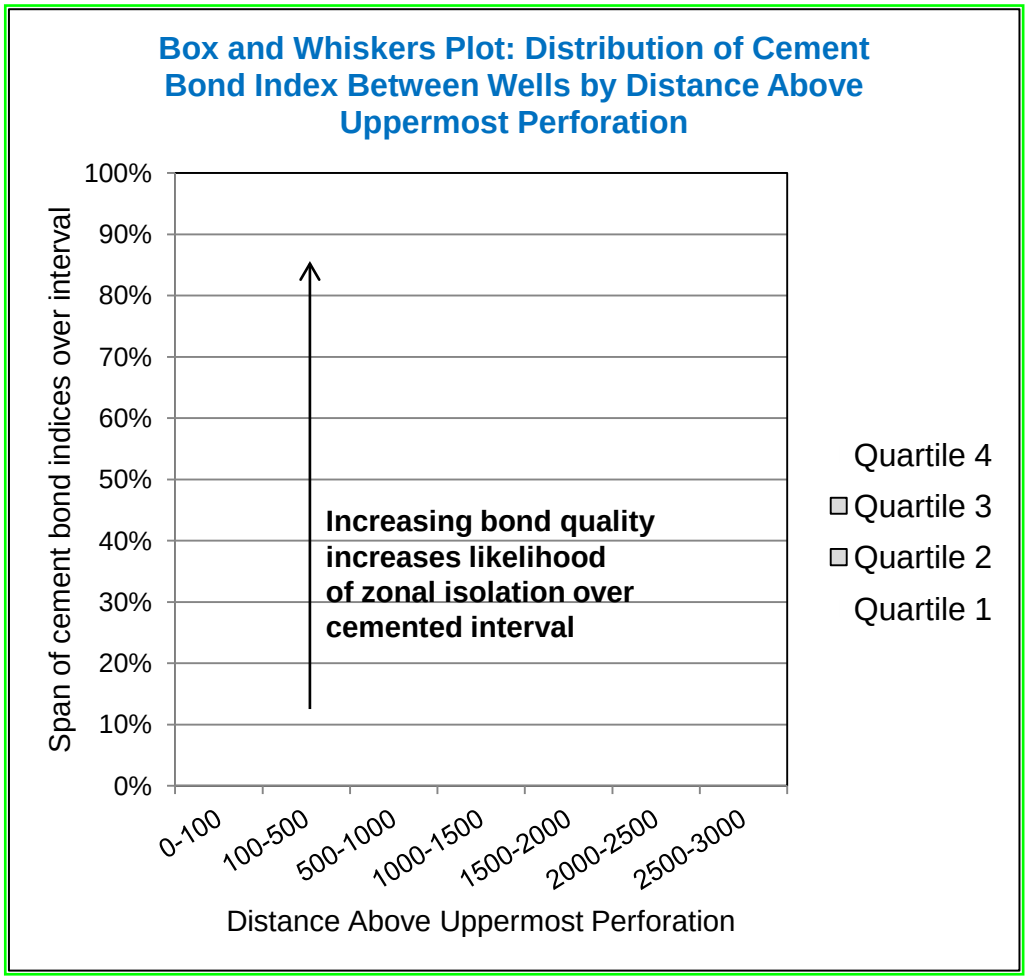
Generic Well Diagram





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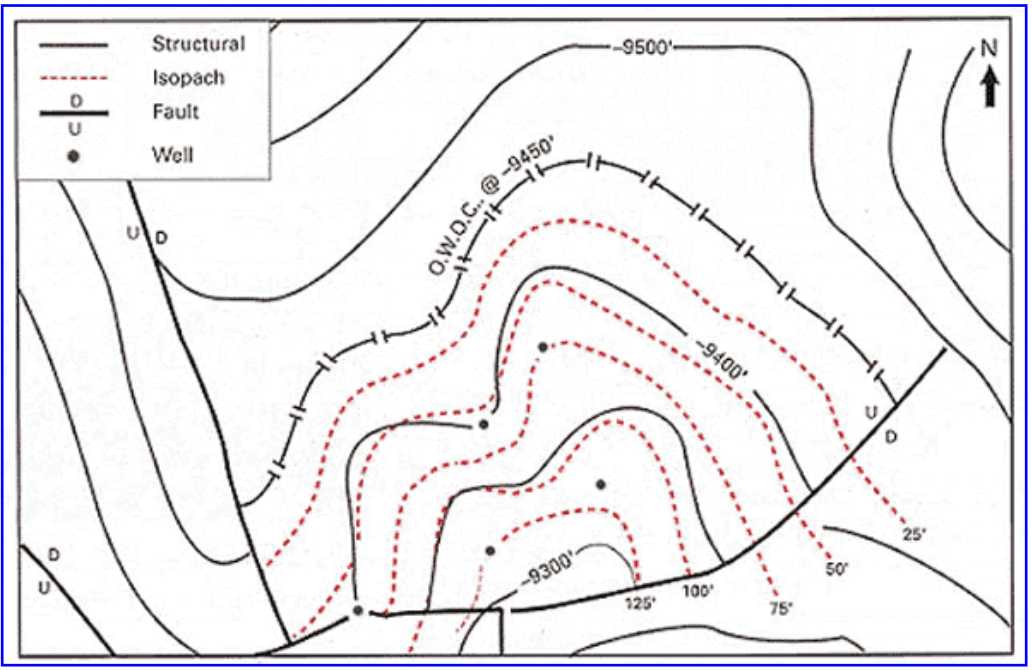

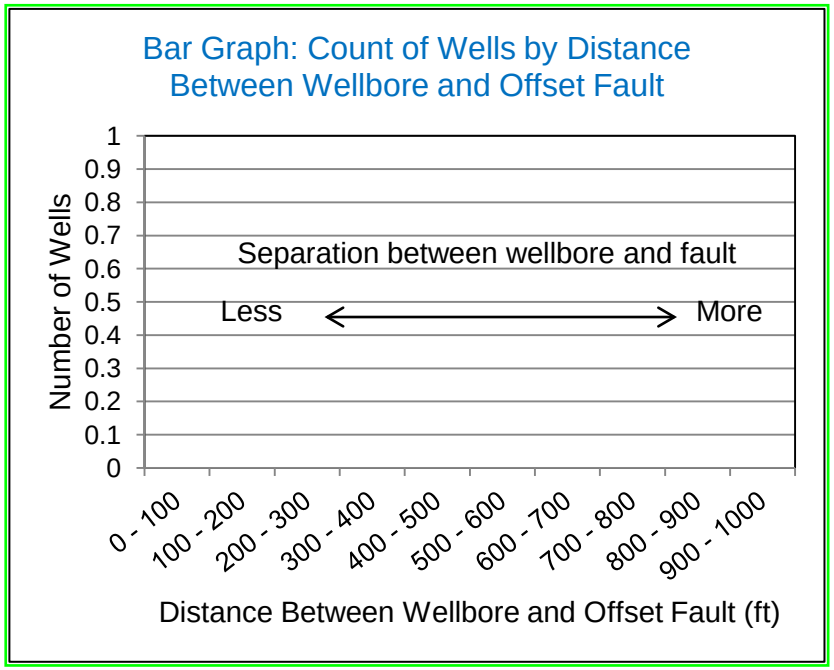

Source: Schlumberger On-Line Glossary
http://www.glossary.oilfield.slb.com/

Well File Review

NEXT STEPS

- Continue evaluating data
  - Review well files
  - Create summaries of data
  - Discuss data with well file owners
  - Ensure CBI claims are protected
  - Assess the data to answer research questions
- Prepare research findings
- Peer review findings and issue paper/report

Questions for Discussion

- Are there additional datasets available to help evaluate the parameterization and performance of the simulations?
- Are there opportunities to compare the simulations to other modeling systems, public or proprietary?