EPA
United States
Environmental Protection
Agency

Well Injection

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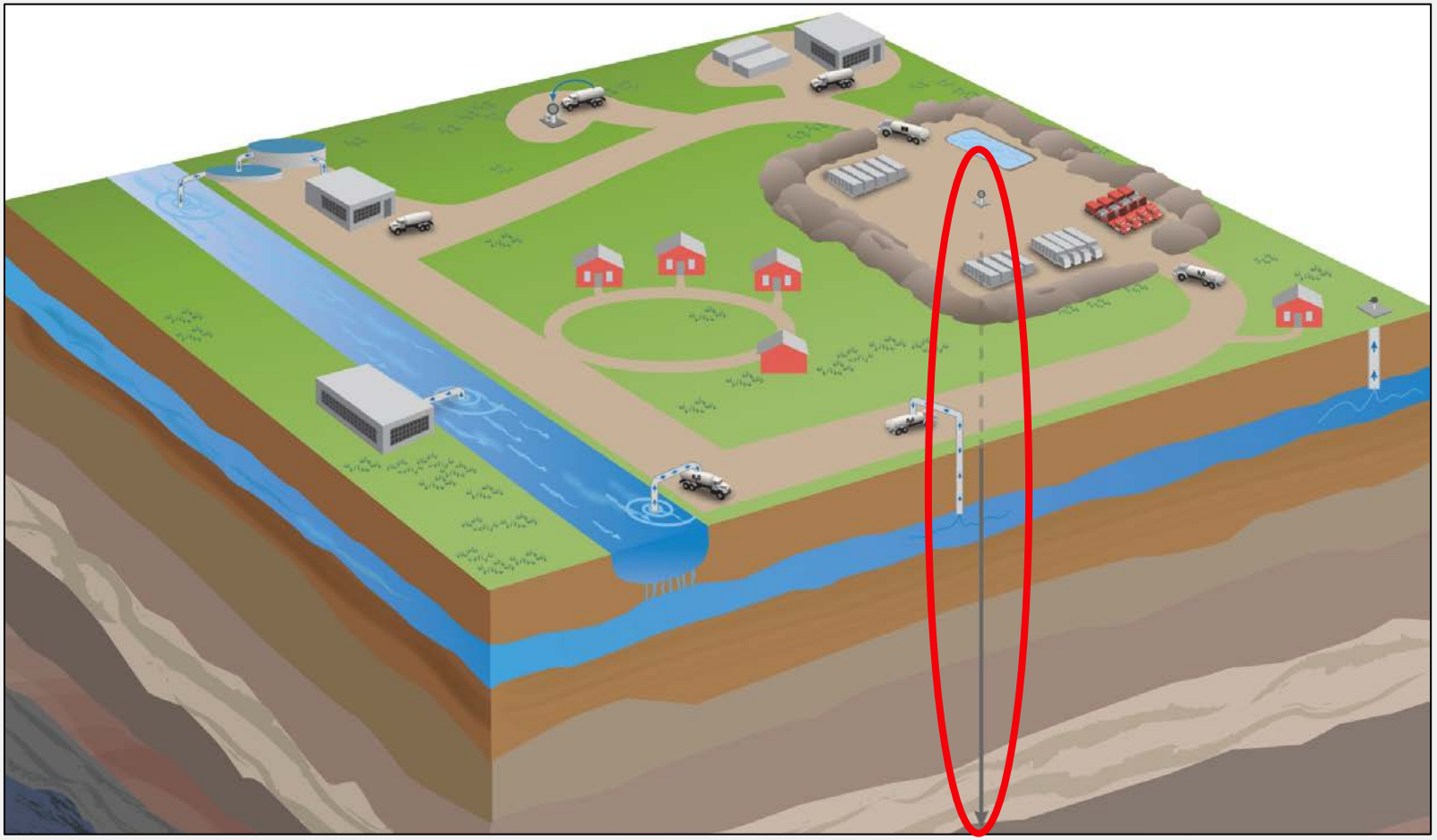
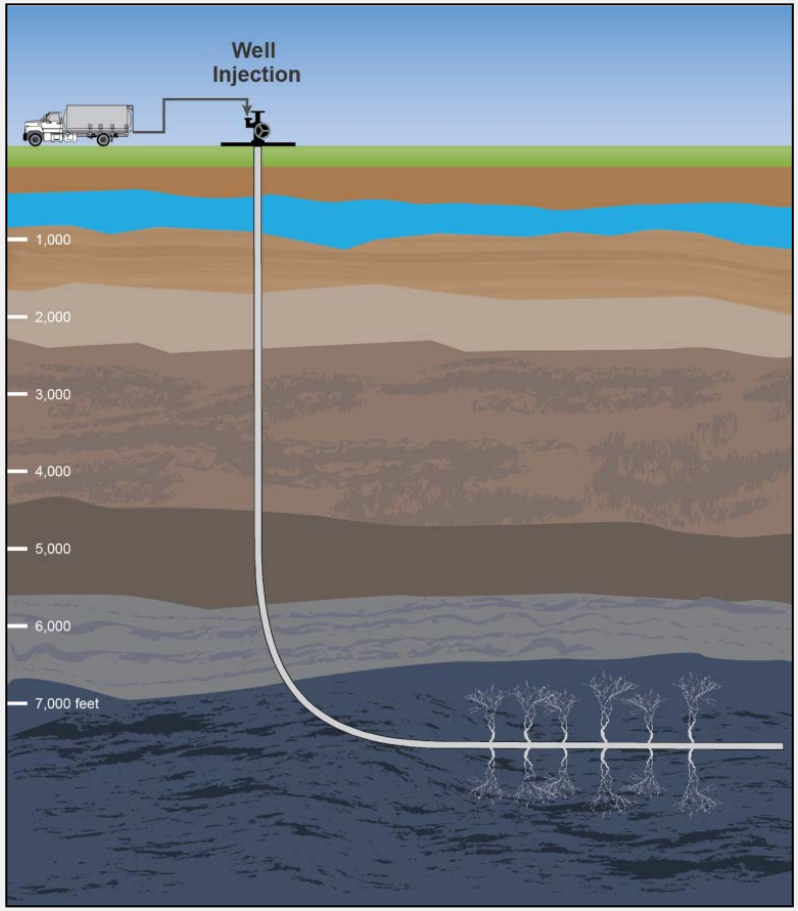
Well Injection

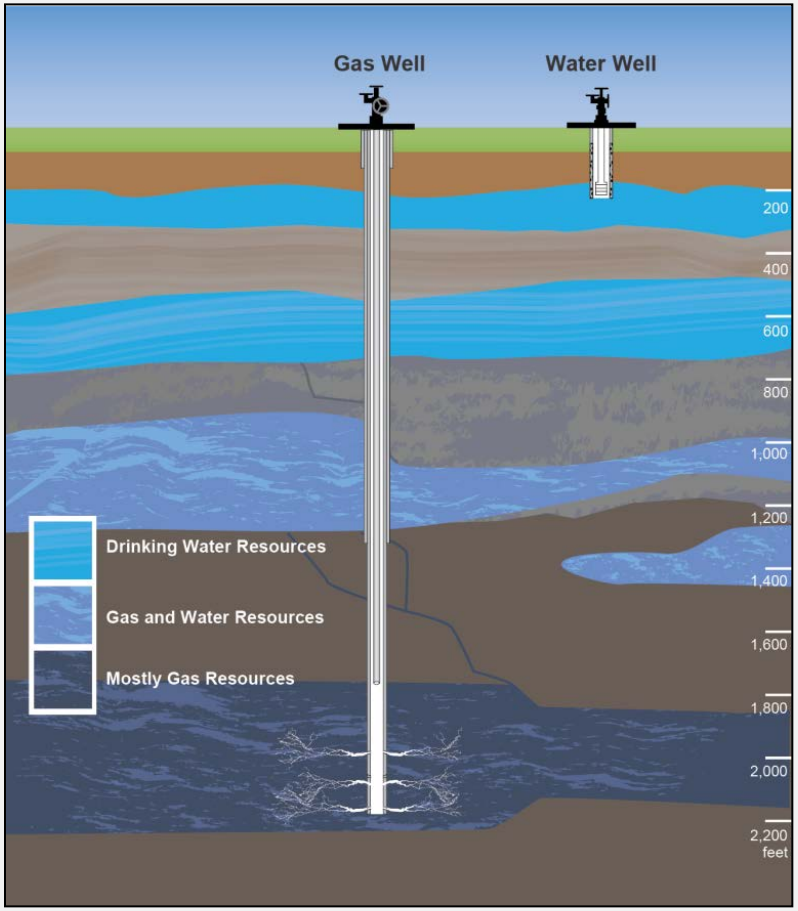


What are the possible impacts of the injection and fracturing process on drinking water resources?

Well Injection



Deep
Shale
Horizontal completion



Shallow
Coalbed
Vertical completion

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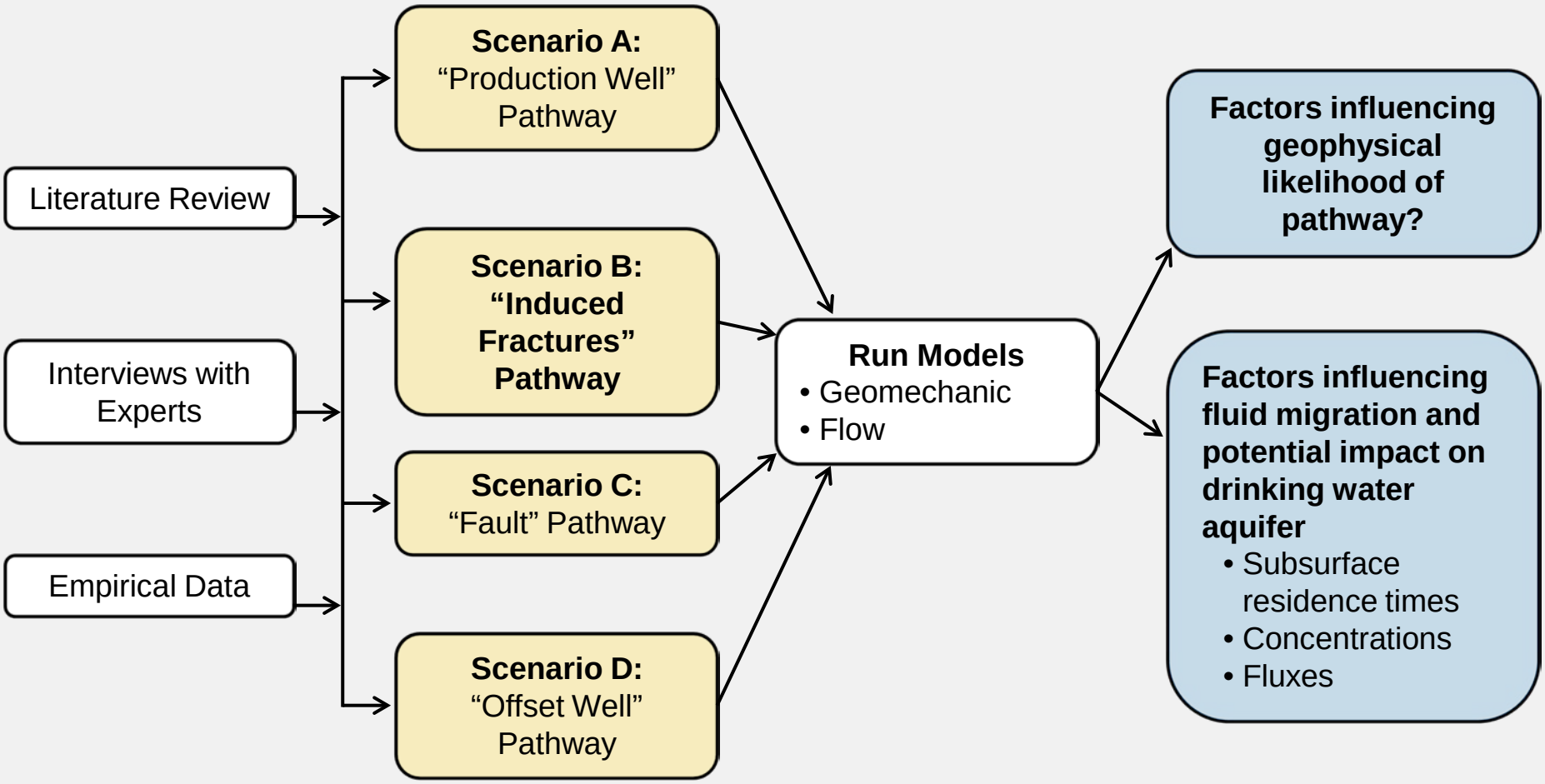
Charge Question #7

Given that hydraulic fracturing occurs at different depths and in different types of rock formations, please comment on how to best use anticipated results from the **subsurface migration modeling** simulations to answers to the research questions listed in Table 26 (page 62).

EPA is particularly interested in feedback on how generalizable the results will be to formations beyond the Marcellus Shale.

Subsurface Migration Modeling



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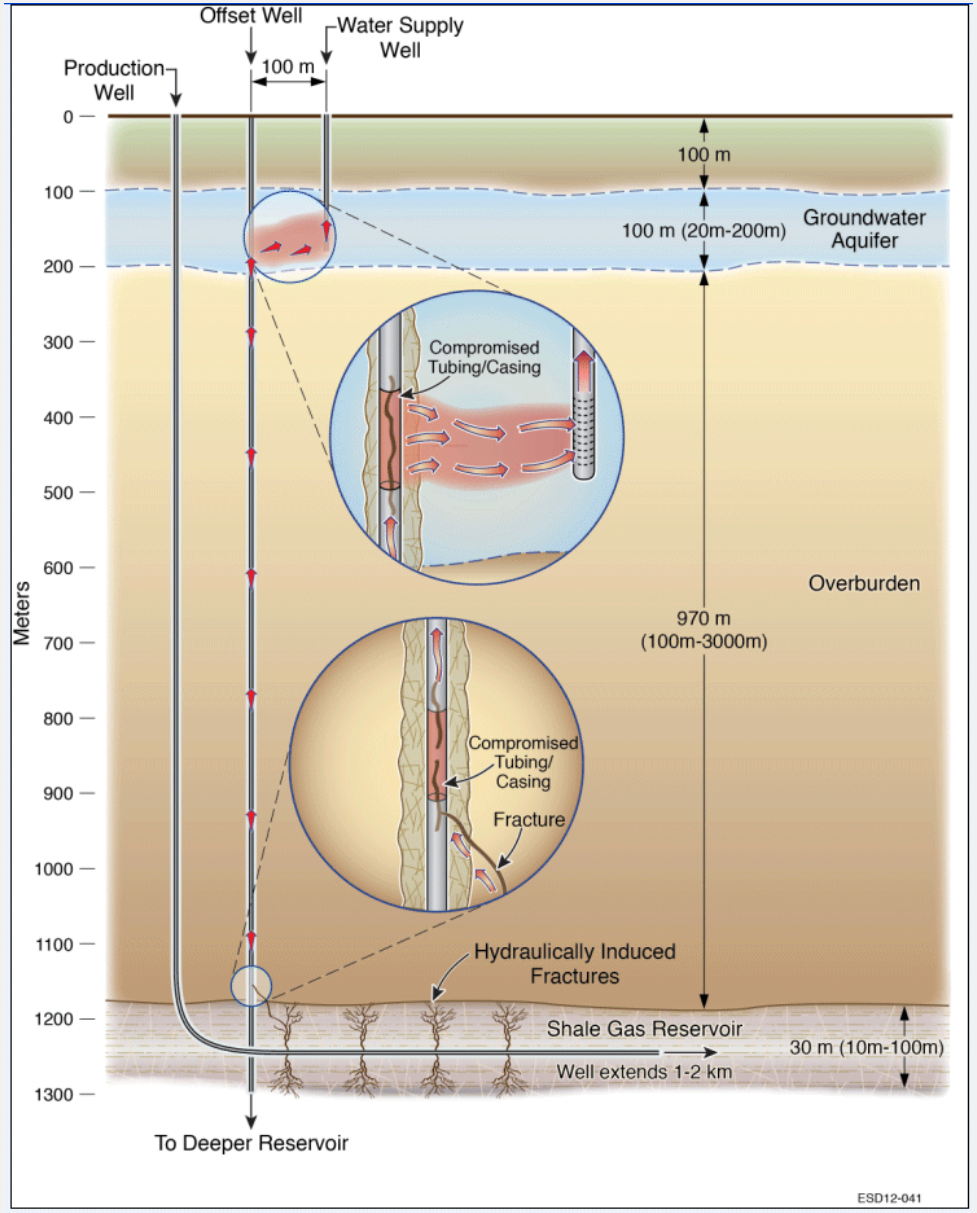
Subsurface Migration Modeling

SCENARIO	DESCRIPTION
A	Damage to cement during hydraulic fracturing resulting in compromised well integrity
B	Fracturing of the overburden resulting in either direct or indirect communication
C	Sealed/dormant fractures and faults are activated during hydraulic fracturing
D	Nearby offset wells with insufficient cementing or casing create a migration pathway

Example: Offset Well Pathway



Fracture extends to an offset well with compromised casing or cement

Key Modeling Parameters

- Vertical distance between fracture zone and aquifer
- Production well depth

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Anticipated Results

- Identification of factors influencing geophysical likelihood of potential subsurface migration pathways
- Identification of factors influencing fluid migration and potential impacts to drinking water aquifers

KEY CHALLENGE

- Hydraulic fracturing is used for oil and gas production in various rock formations at different depths
  - Coalbed methane: 300 – 7,000 ft
  - Shale gas and oil: 1,000 – 14,000 ft
  - Tight gas: 1,000 – 20,000 ft

Technical Stakeholder Input*

- Models should take into account
  - Geologic layering, natural vertical hydraulic gradients, pre-event stress states
  - Rock and fluid interactions, including fluid leakoff and influence of imbibition (capillary trapping)
  - Observed data and ranges where available, including rock and cement permeabilities, rock strength
- Model testing should consider benchmark comparisons with other models (industry) and comprehensive data sets (MPX)
- Sensitivity analyses should eventually feed into uncertainty quantification and risk assessment

*Technical Workshops 2011 and 2013, Technical Roundtable 2012

Charge Question #8

Please comment on ways information gathered as part of the **well file review** may be used to characterize the effectiveness of well construction and operation practices at protecting drinking water resources.

Well File Review

GOAL

Indentify practices or factors that may impact drinking water resources

Identify Hydraulically Fractured Wells

- Provided by nine hydraulic fracturing service companies
- Fractured between Sept. 2009 and Sept. 2010

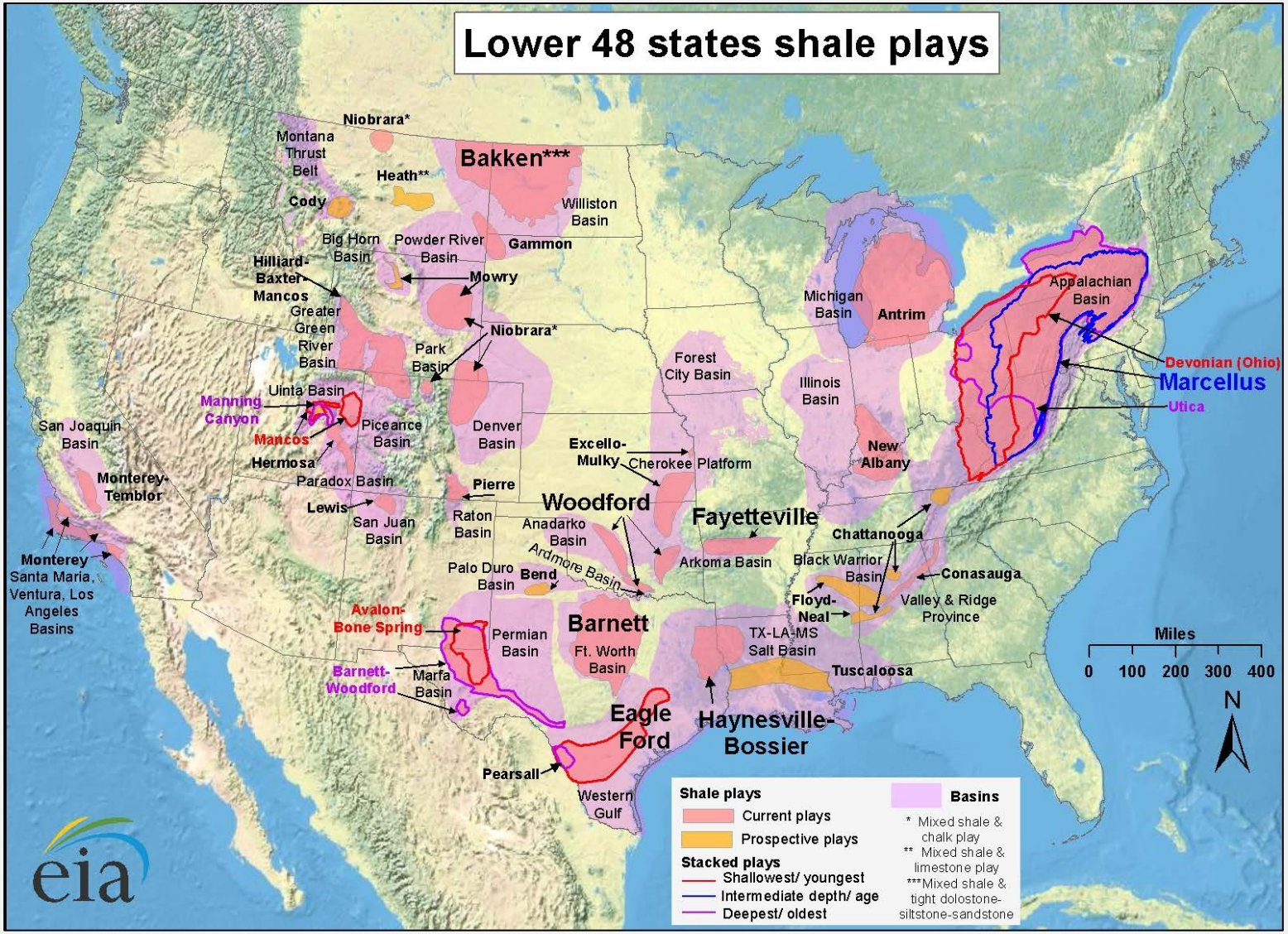
Select Wells for Well File Review

- Select hydraulically fractured wells from nine oil and gas operators of various sizes
- Wells include different geographic areas and completion types

Extract and Analyze Well File Data

- Well construction practices
- Hydraulic fracturing practices, including water acquisition and wastewater disposal

Shale Plays in the United States



Source: US Energy Information Administration based on data from various published studies
Updated: May 9, 2011

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Well Locations

Locations of Wells Selected for Review
(Wells fractured Sept. 2009 – Oct. 2010)

Information Requested

- Geologic maps and cross sections
- Daily drilling and completion records
- Mud logs
- Open hole logs, such as porosity and resistivity logs
- Description of well casings installed
- Cased hole logs, such as cement evaluation logs
- Pressure testing results of installed casing
- Up-to-date wellbore diagram
- Pre- and post-hydraulic fracturing reports, including volumes/additives used
- Source(s) of water used
- Chemical analyses of fluids (used in treatment, water zones, offset locations, flowback)
- Microseismic monitoring results
- Spill/incident reports

Example Proposed Assessments

Analyses describing the data

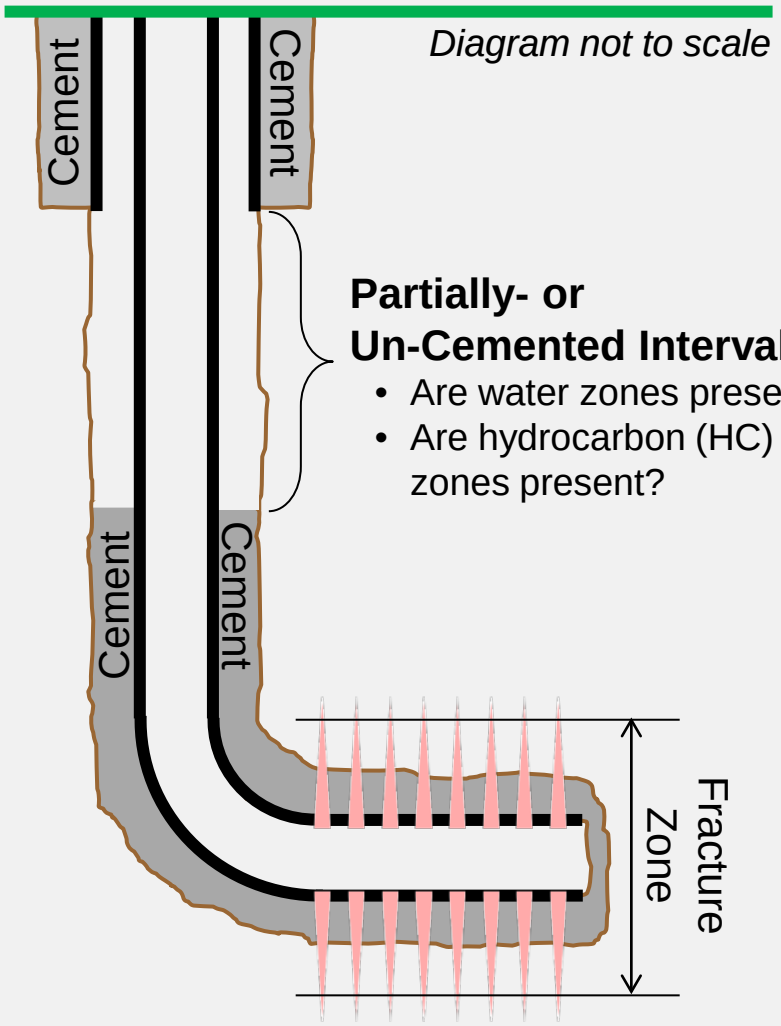
- Horizontal, vertical, deviated completions
- Well construction dates
- Production type

Analyses depicting potential driving factors

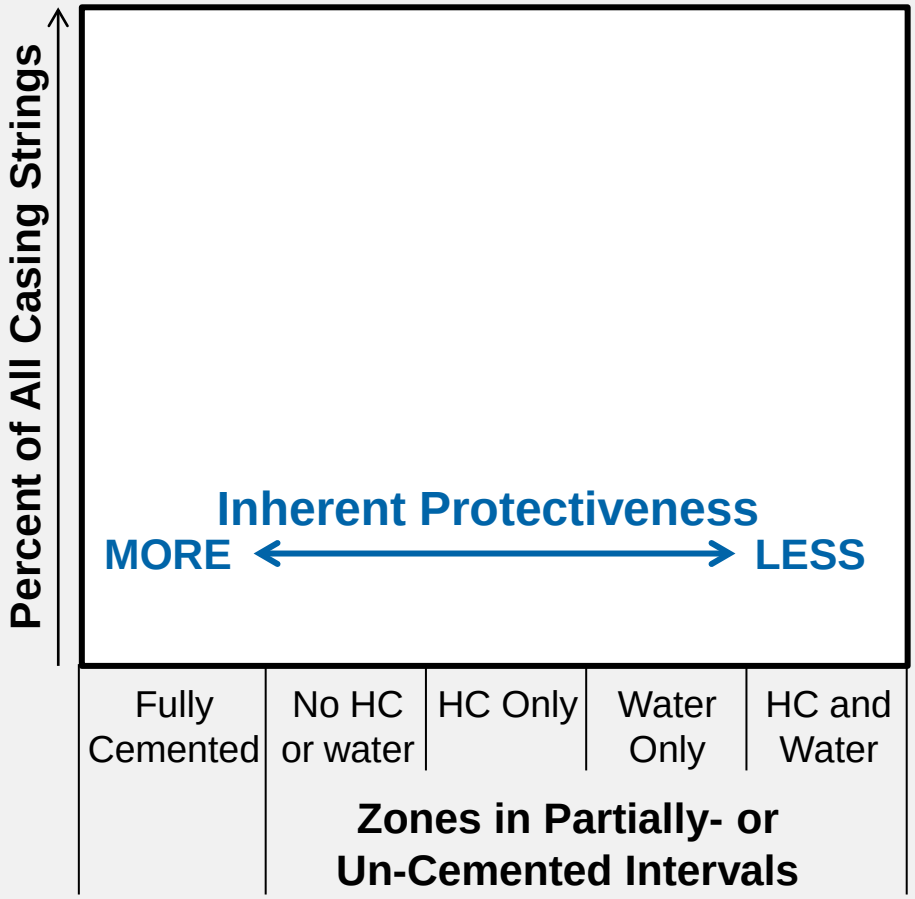
- Vertical separation between fracture zone and
  - Ground surface
  - Top of cement
- Distribution of cement bond indices
- Distance to nearby faults
- Zones and degree of cement

Example: Zones and Degree of Cement

Generic Well Diagram



Zones and Degree of Cement (Bar Graph)



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Other Potential Factors of Interest

- **Trend in water usage** – fresh vs. recycled
- **Flowback percentage** of injected volume
- **Flowback disposition**
- **Patterns of additives used** as a function of geologic lithology treated
- **Pre-stimulation casing test pressure** vs. maximum treatment pressure
- **Spills and the remedial actions** taken during and after hydraulic fracturing
- **Degree of monitoring** and other data available in file to assure the operator that conducting hydraulic fracturing is protective of drinking water resources
  - *Examples*
    - Formation water sampling to confirm presence/absence of underground source(s) of drinking water
    - Frequency of cement evaluation (i.e., cement bond logs)
    - Annular monitoring during hydraulic fracturing
    - Offset well monitoring during/after hydraulic fracturing

Technical Stakeholder Input*

- Identifying the subsurface water resource
  - Inconsistent definition, local efforts and requirements vary
- Cementing the casing to isolate subsurface zones
  - Cement job does not always isolate all zones
  - Attempting fully cemented annulus can result in poor job
  - Un-cemented annulus useful for monitoring, but since problems identified from monitoring are remediated by cementing the annulus, then should the annulus be cemented in the first place?
  - Cement bond logs subject to interpretation
- Testing casing
  - Prior to treatment and when re-fracturing

*Technical Workshops 2011 and 2013, Technical Roundtable 2012

Charge Questions

7. Given that hydraulic fracturing occurs at different depths and in different types of rock formations, please comment on how to best use anticipated results from the **subsurface migration modeling** simulations to inform answers to the research question:

- Under what circumstances can subsurface migration of fluids or gases to drinking water resources occur and what local geological or man-made features may allow this?

8. Please comment on ways information gathered as part of the **well file review** may be used to characterize the effectiveness of well construction and operation practices at protecting drinking water resources.