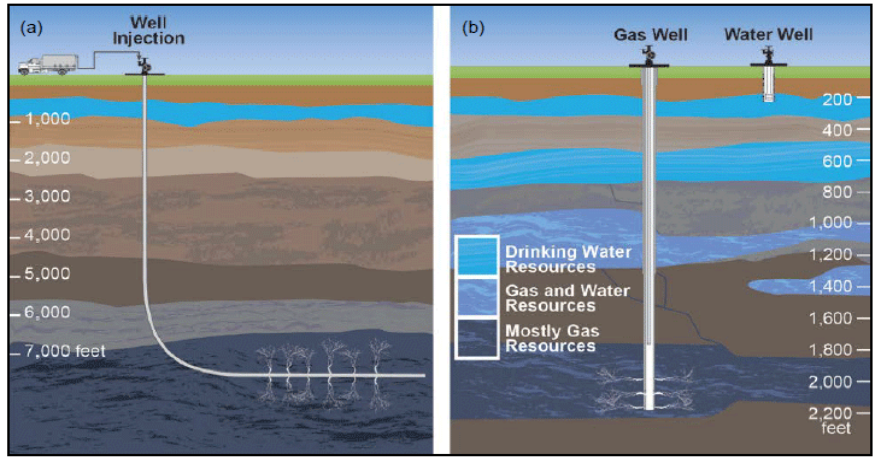
United States
Environmental Protection
Agency

Evaluating Scenarios of Potential Subsurface Impact using Computational Models

Technical Workshop Series:
Well Construction/Operation and Subsurface Modeling



Office of Research and Development
National Exposure Research Laboratory

Stephen Kraemer

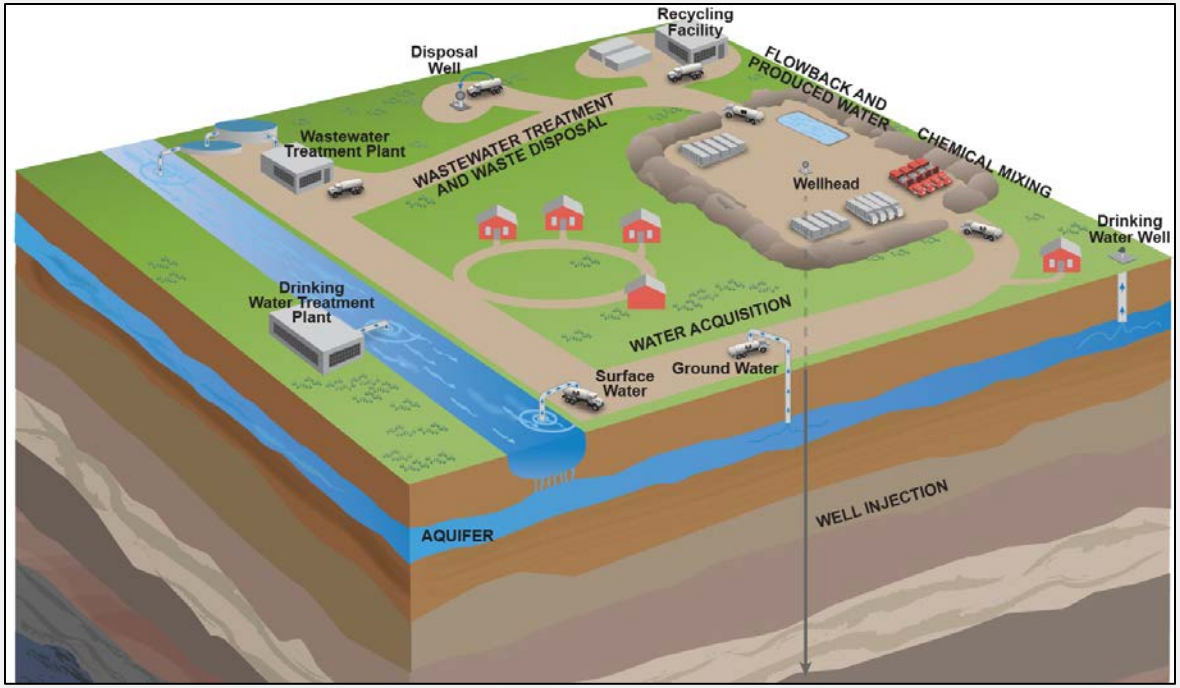
EPA-Research Triangle Park • April 17, 2013

EPA HF Study – research questions

Water Acquisition | Chemical Mixing | Produced Water | Waste and Wastewater

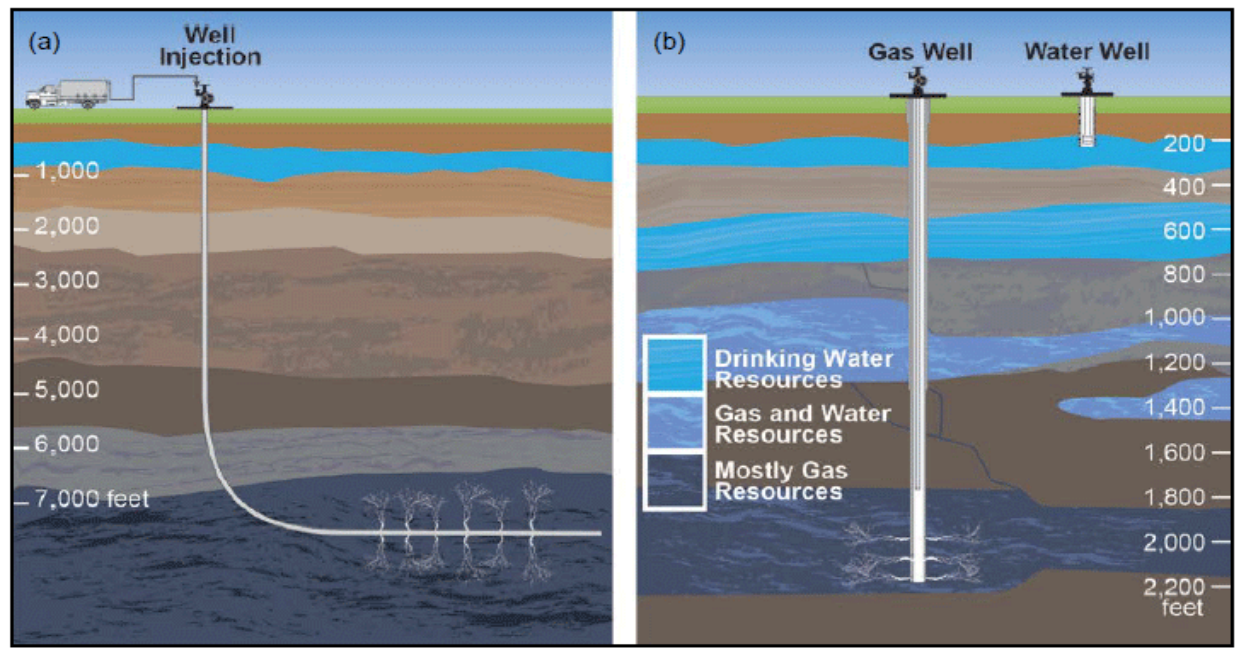
Well Injection

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



How effective are current well construction practices at containing fluids (gases, liquids) before, during, and after fracturing?

Can subsurface migration of fluids (gases, liquids) to drinking water resources occur, and what local geologic or man-made features might allow this?



- Well File Review (yesterday)
- Subsurface Migration Modeling (today)

Session Presentations

- **EPA Subsurface Scenario Modeling Project** *Steve Kraemer, US EPA*
- **Analysis of Feasibility of Extensive Fracture Development and Fault Activation Induced by Hydraulic Fracturing** *George Moridis, LBNL*
- **Modeling of Leakage in Potential Failure Scenarios in Shale Gas Systems** *Matt Freeman,* LBNL
- **Emergence of Delamination Fractures around the Casing during Wellbore Stimulation** *Arash Dahi-Taleghani, Louisiana State University*
- **Abandoned Wells as Potential Leakage Pathways: Lessons Learned from CO_2 Geological Sequestration** *Mike Celia, Princeton University*

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Session Discussion Questions

- What additional potential failure scenarios not covered in the EPA HF study progress report should be investigated?
- What are the most important parameters and appropriate level of complexity for a model that studies the severity of the potential impact of HF on drinking water resources?
- Water are the advantages and disadvantages of different modeling approaches?
- What well performance data (e.g., microseismic testing, pressure, tracer or other) are available to EPA that we be useful to build and evaluate models?

Collaborative Research

HF Project: scenario modeling subsurface

EPA ORD – DOE LNBL
Interagency Agreement

EPA Team

Stephen Kraemer (NERL-ERD-Athens GA), EPA project officer
Jim Kitchens, QA Manager

Jim Weaver (NRMRL-Ada OK)
Junqi Huang (NRMRL-Ada OK)
Nathan Wiser (EPA-R8-Denver, CO)
Chip Hillenbrand (EPA-R2-New York, NY)

Technical Monitors

LBNL Team

George Moridis, Lead
Peter Pershoff, QA
Matt Freeman
Matthew Reagan
Jonny Rutzvist
Jihoon Kim

TOUGH+ Scenario Modeling

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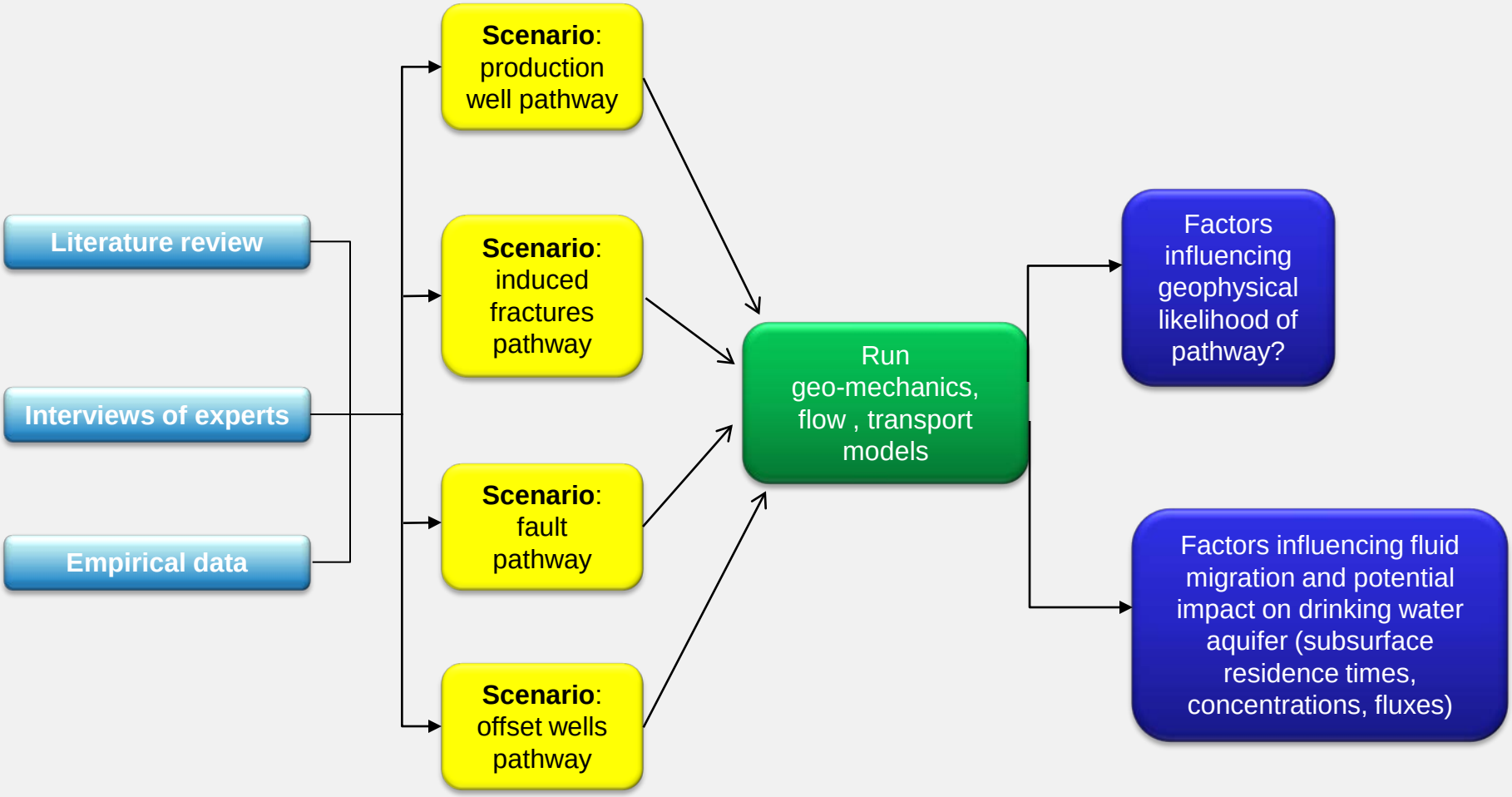
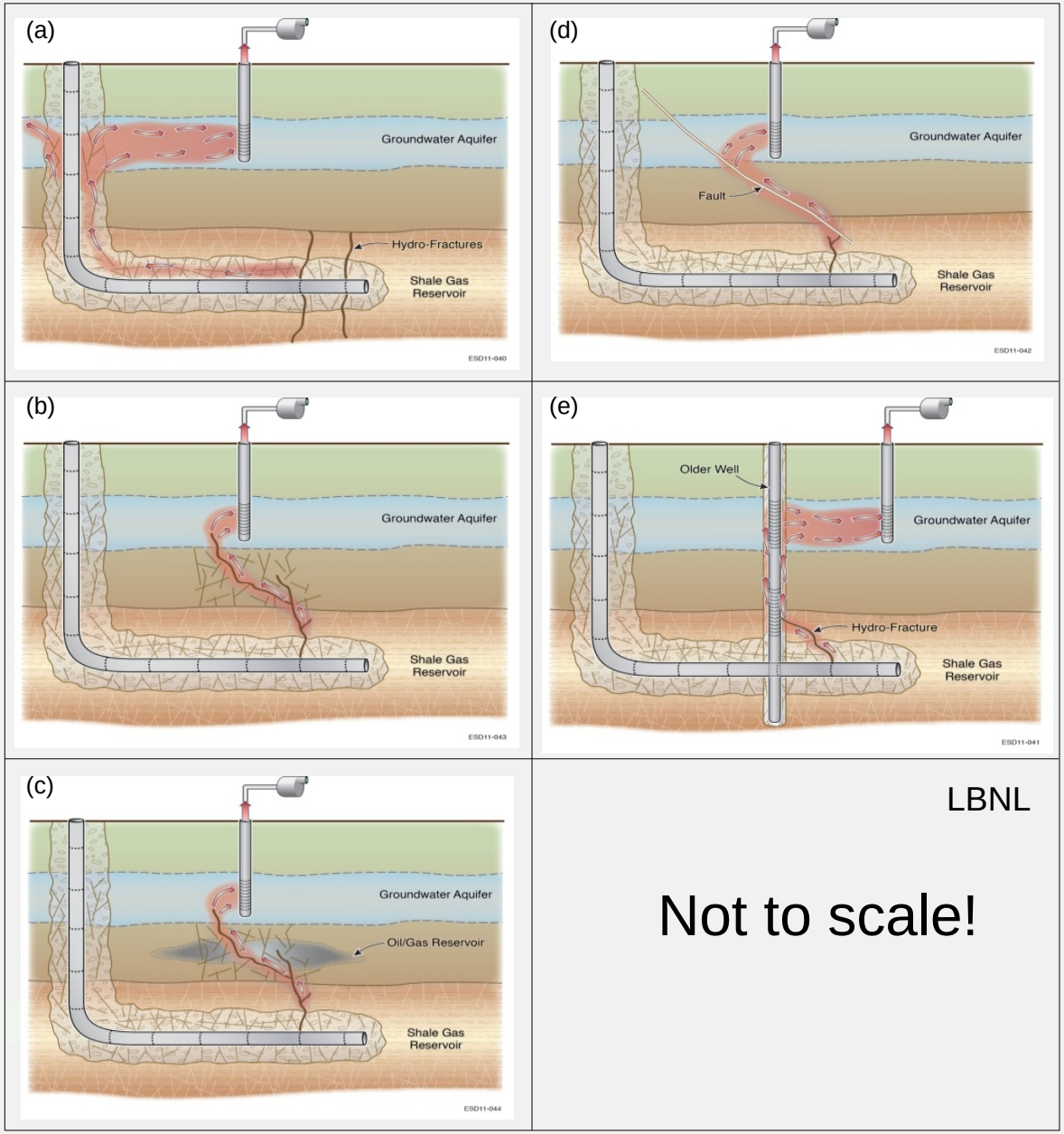
Critical Path for Subsurface Migration Modeling

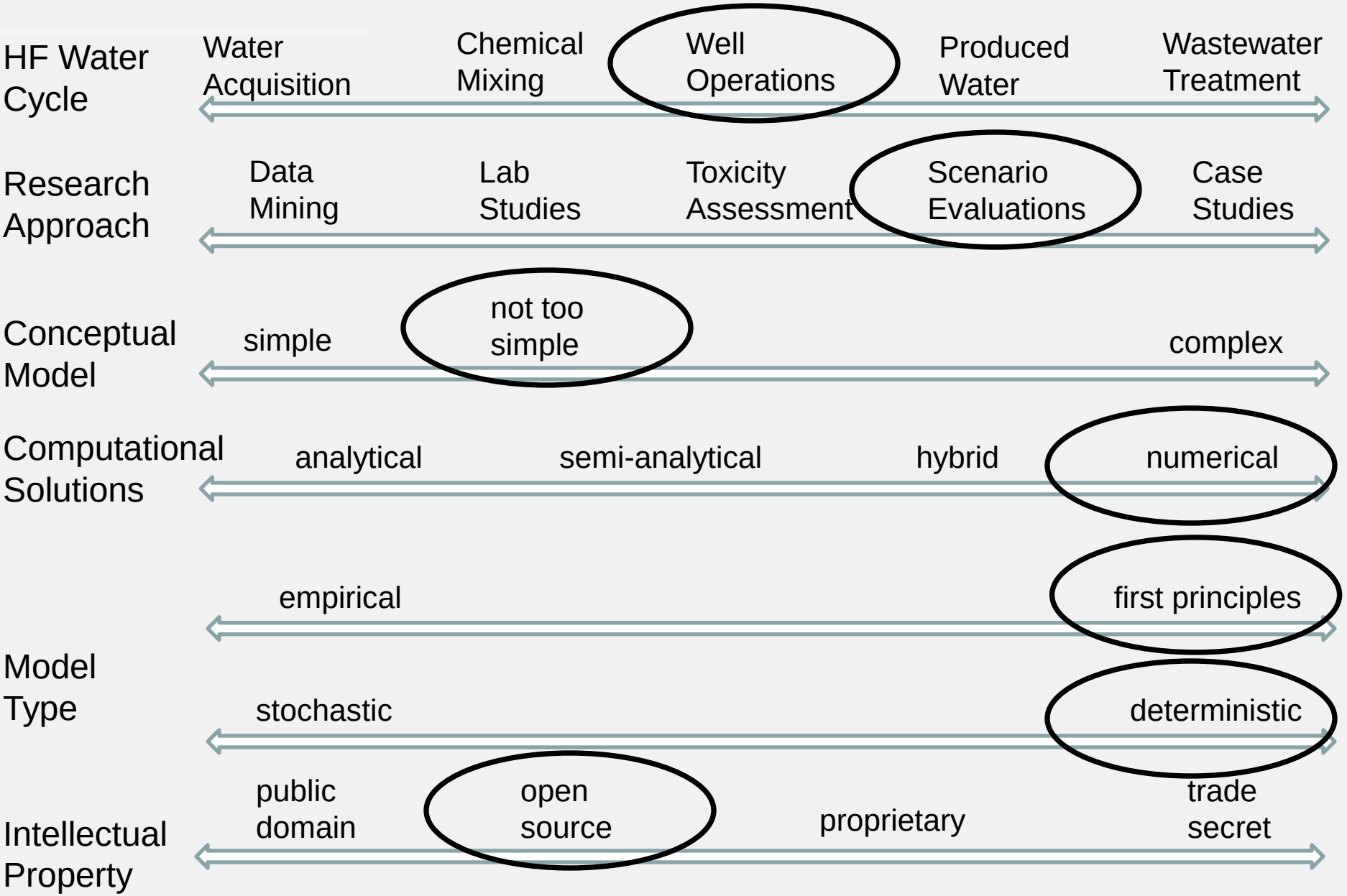


Conceptual Models --- Scenarios

- Geophysical likelihood of pathways?
- Potential for fluid migration?



Computational Model Selection (1)



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Computational Model Selection (2)

Property	Attributes
multidimensional	2D, 3D
multiphase	liquid, gas
multicomponent	water, brine, introduced chemicals
non-isothermal	heat
fractured-media	equivalent continuum, dual porosity, multiple interacting continua, dual permeability
coupling	fully coupled (mass and energy), fully implicit

LBNL TOUGH: Transport of Unsaturated Groundwater and Heat

FLOW & TRANSPORT

TOUGH+Rgas
real gas mixtures

TOUGH+RGasH2O
real gas mixtures plus water

TOUGH+RGasH2OCont
real gas mixtures plus water plus dissolved contaminants

EOS
equations of state

coupling

GEOMECHANICS

ROCMECH
fracture creation and propagation

FLAC3D™
fault reactivation

Handoff to next presentations

- geophysical factors influencing the likelihood of the pathways?
  - » *George Moridis, LBNL*
- implications of pathways for fluid migration?
  - » *Matt Freeman, LBNL*

Information presented is part of the EPA's ongoing study (www.epa.gov/hfsudy). EPA intends to use this, combined with other information, to inform its assessment of the potential impacts to drinking water resources from hydraulic fracturing. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.