North Dakota Department of Mineral Resources

NDGS
Research Arm

OGD
Regulatory
Arm

https://www.dmr.nd.gov/oilgas/ ***https://www.dmr.nd.gov/ndgs/***

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(701) 328-8020 (701) 328-8000

Hydraulic Fracturing

Lifeline to Domestic Independence

- Hydraulic Fracturing
- Frack water
- State Regulation
- North Dakota results

Bruce E. Hicks
Assistant Director
NDIC-DMR-OGD
Bismarck, ND

Little Johnny was in science class and the professor conducted an experiment to show the dangers of liquor.

He stuck a worm in a glass of water and it floated and looked happy.

He stuck a worm in a glass of wine and it sunk to the bottom and died.

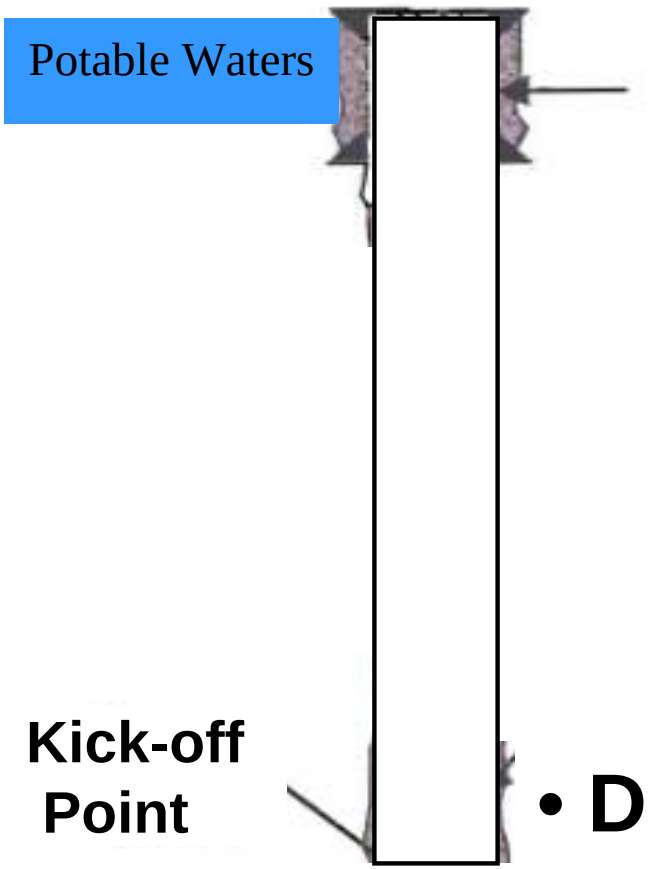
So the professor asks “What have we learned?”

Little Johnny spoke up and said, “Drink liquor and you won’t get worms!”

TYPICAL HORIZONTAL OIL WELL

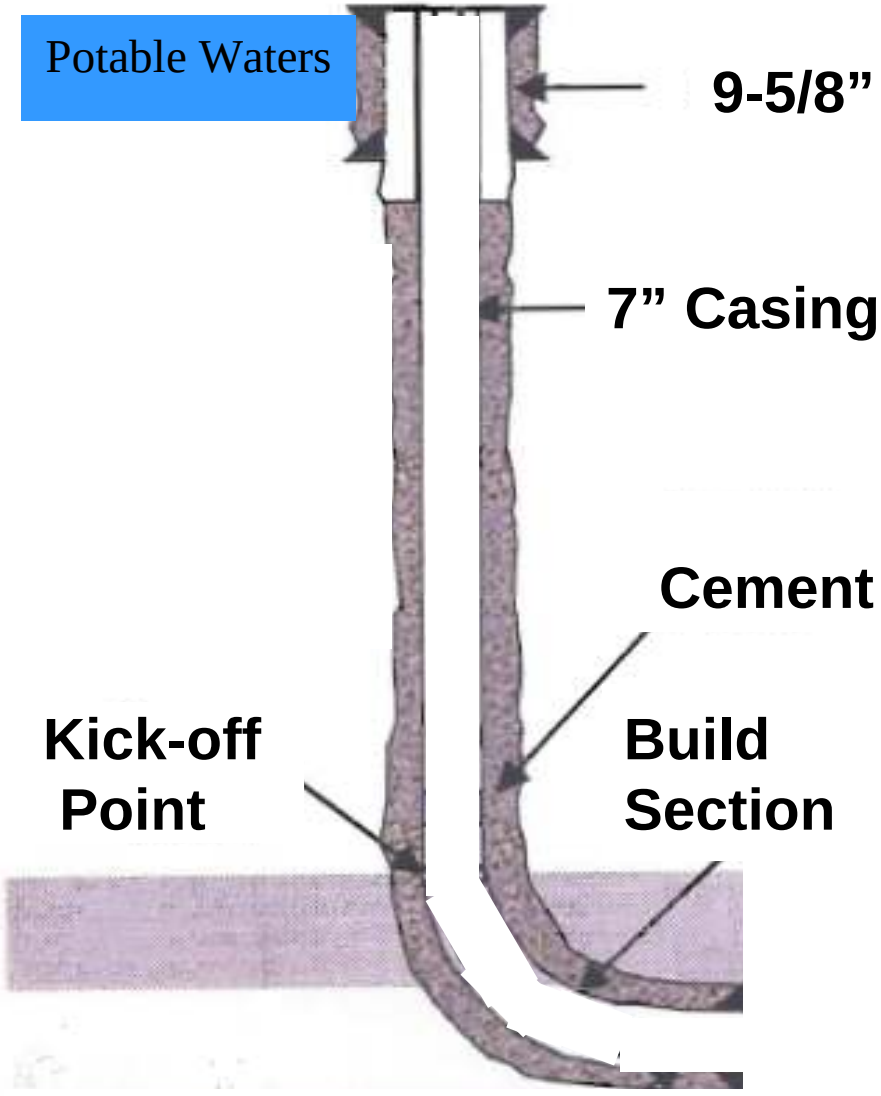
- **Drill with fresh water**
- **Total depth below lowest potable water**
- **Run in hole with surface casing**
- **Cement casing back to surface of ground**
- **1st layer of surface water protection**

TYPICAL HORIZONTAL OIL WELL



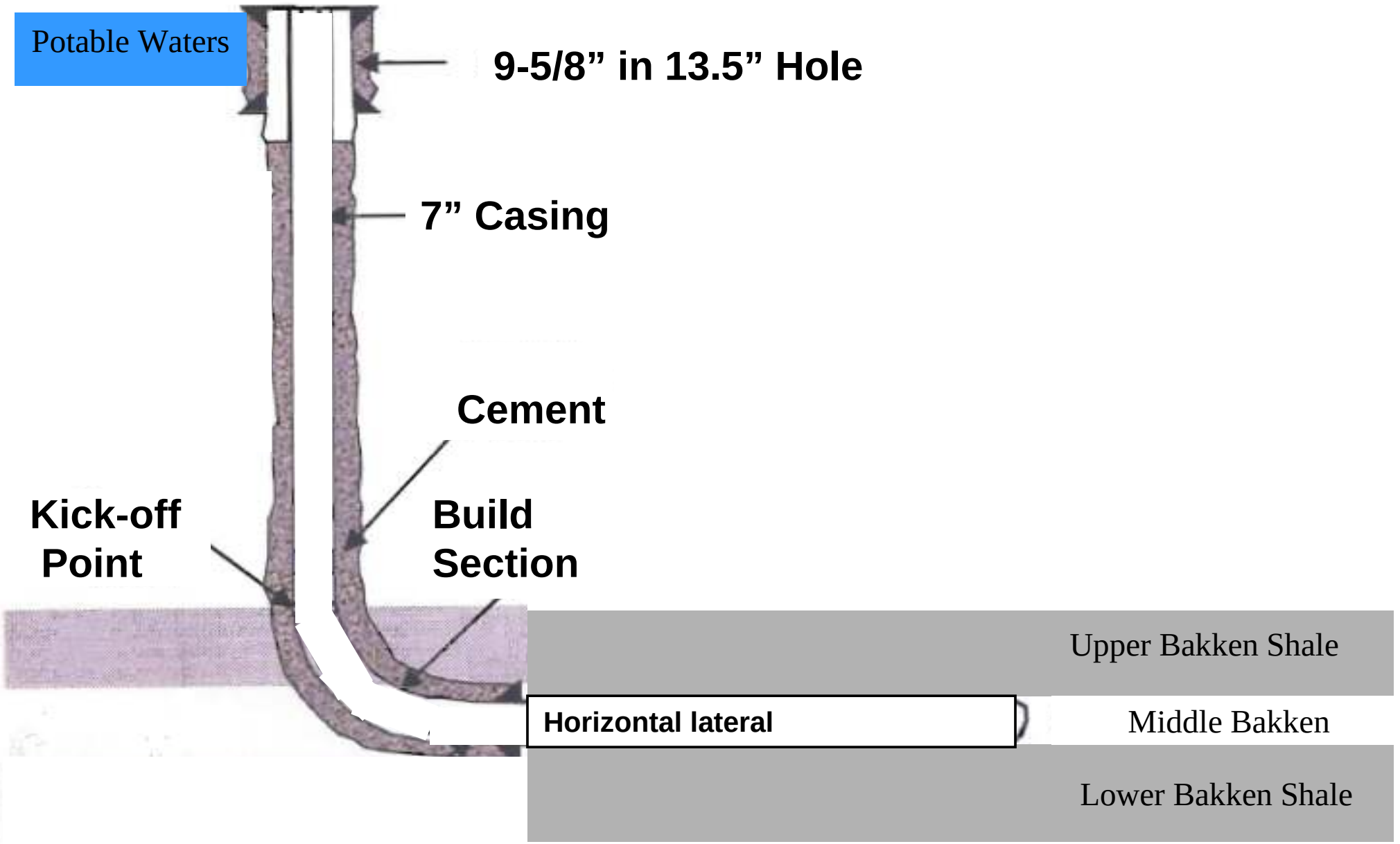
- Drill vertically to kick-off point
- Run in hole with bent assembly
- Downhole mud motor

TYPICAL HORIZONTAL OIL WELL



- Drill 8-3/4” hole to pay
- Run in hole with 7” casing
- Cement 7” casing
- 2nd layer of protection

TYPICAL HORIZONTAL OIL WELL



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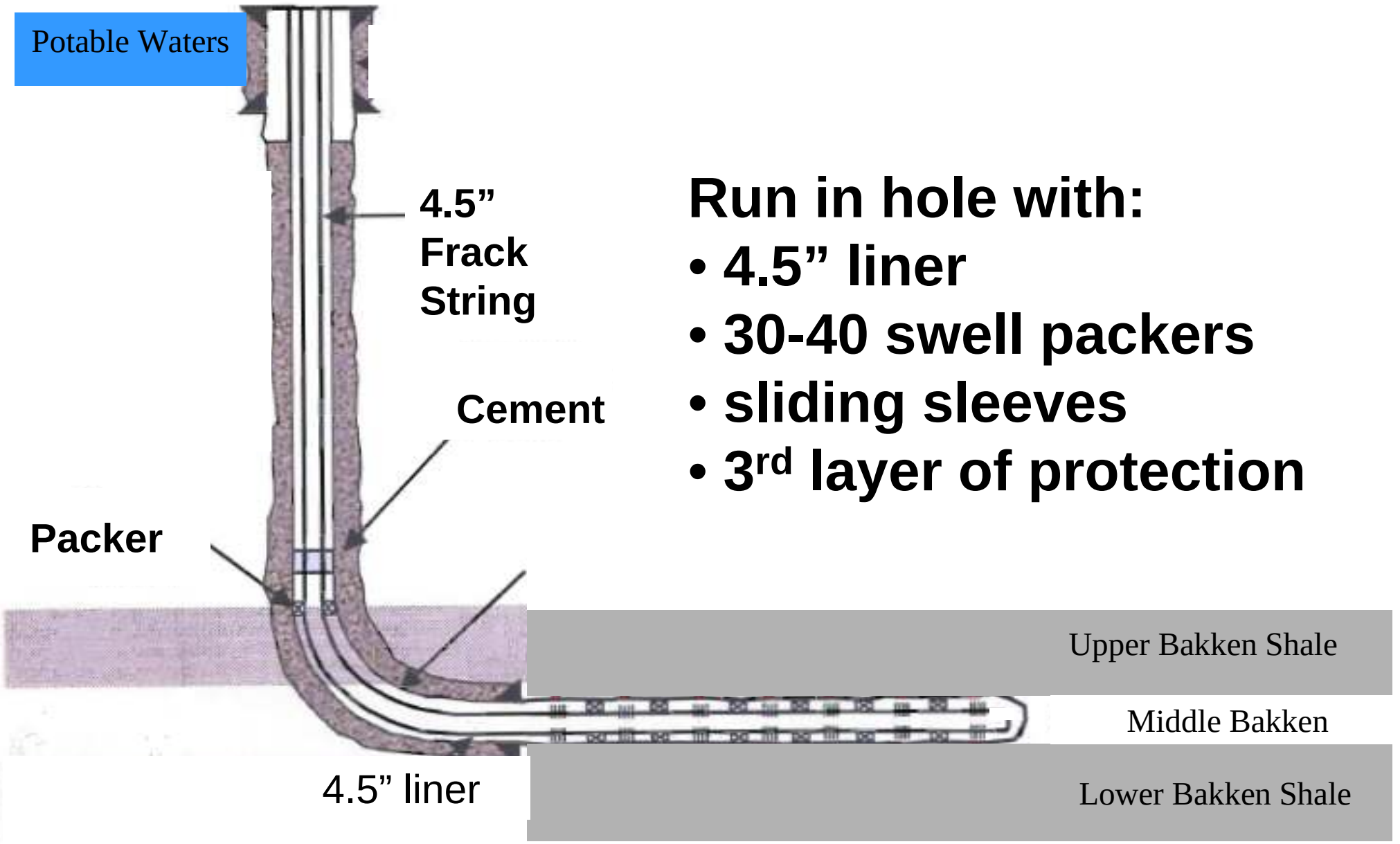
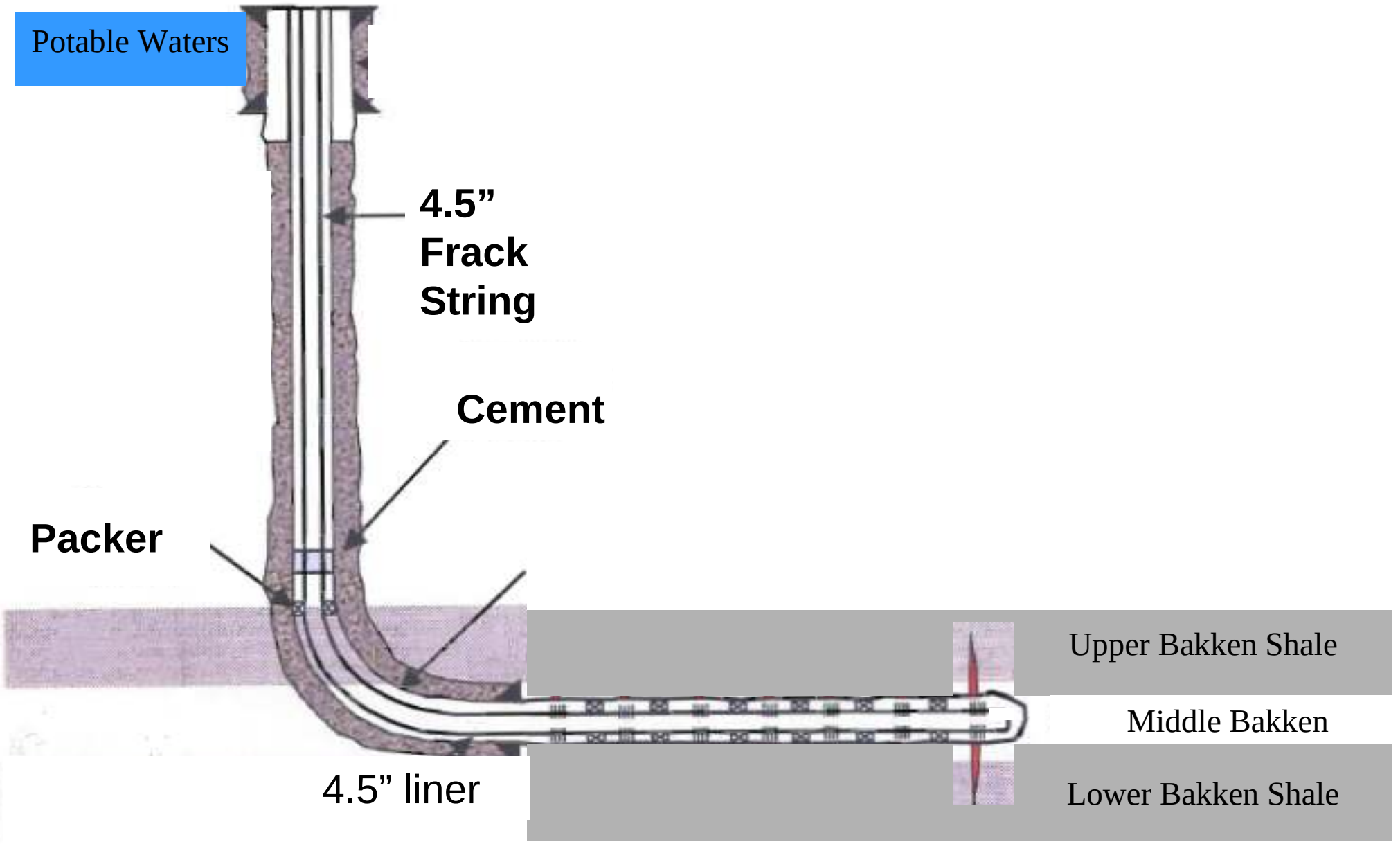


Run in hole with:

- **4.5” liner**
- **30-40 swell packers**
- **sliding sleeves**
- **3rd layer of protection**

TYPICAL HORIZONTAL OIL WELL



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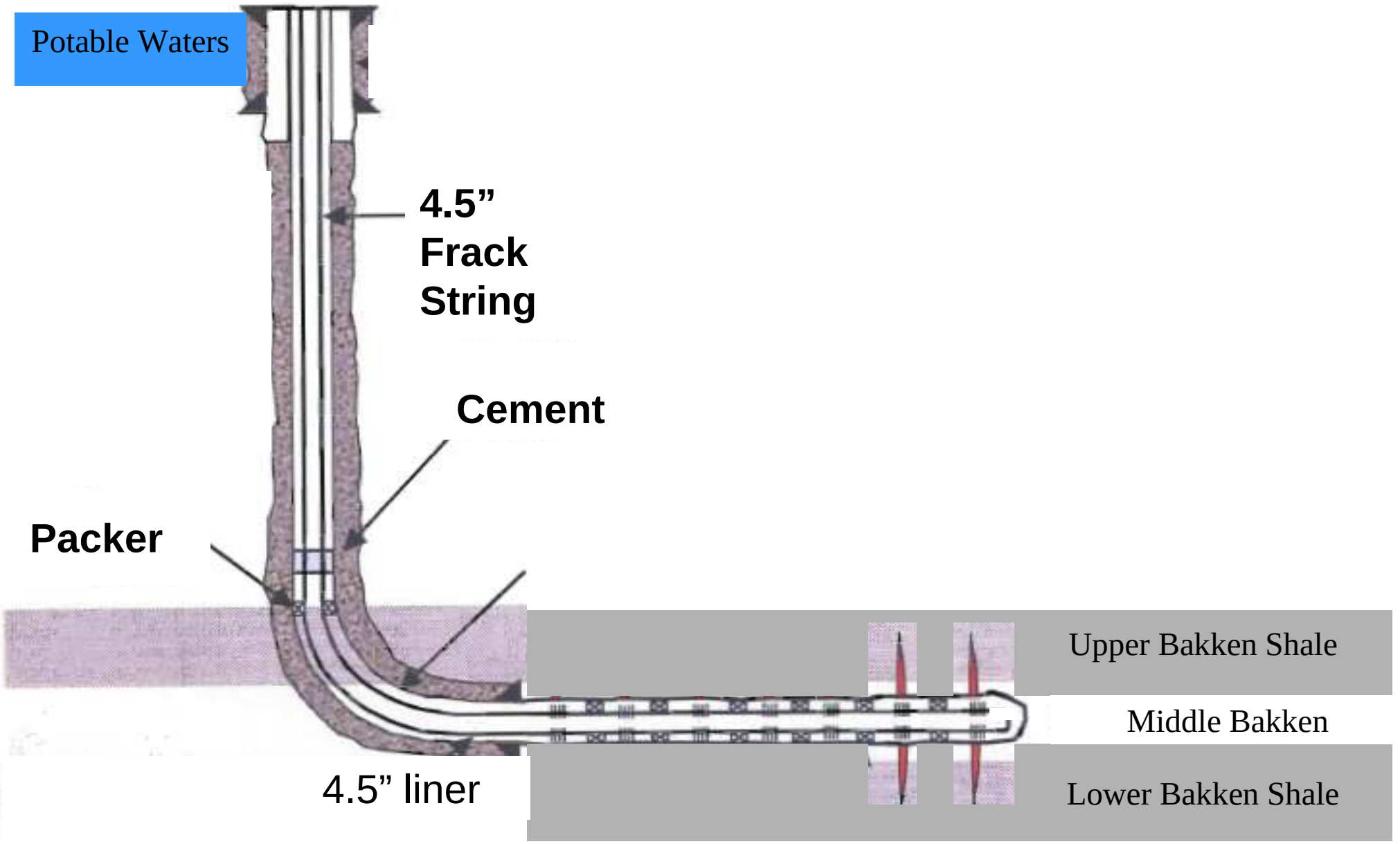

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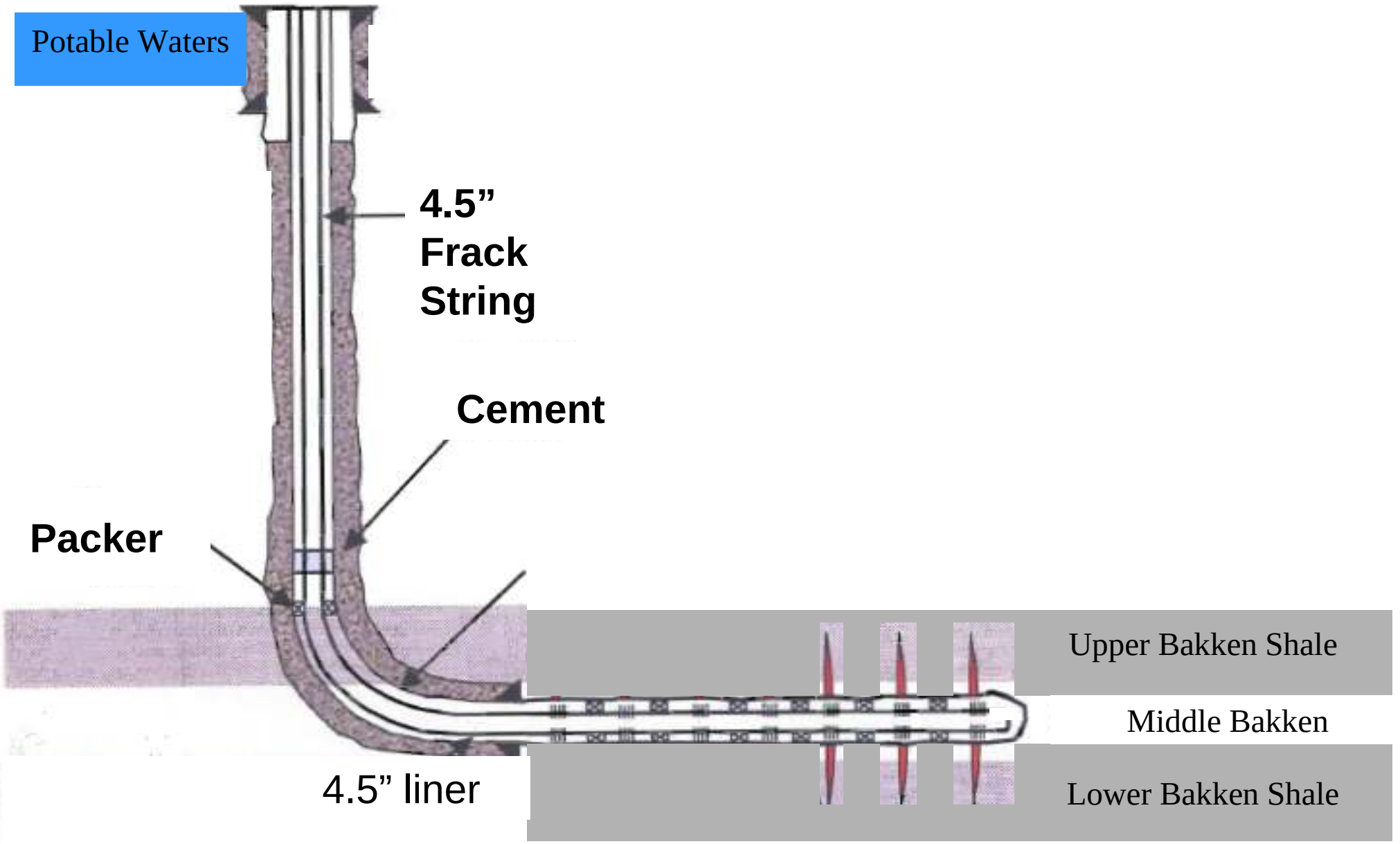

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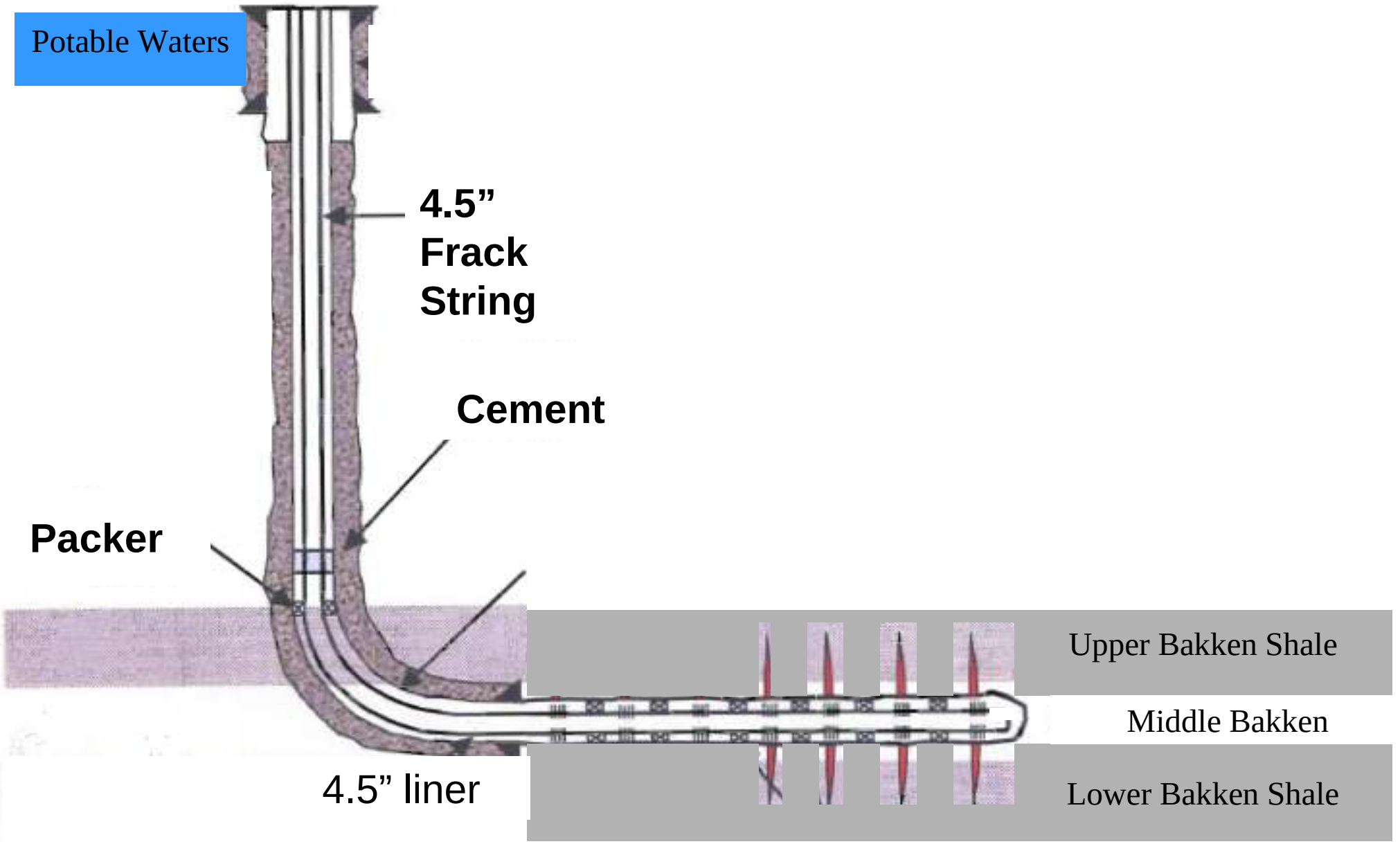

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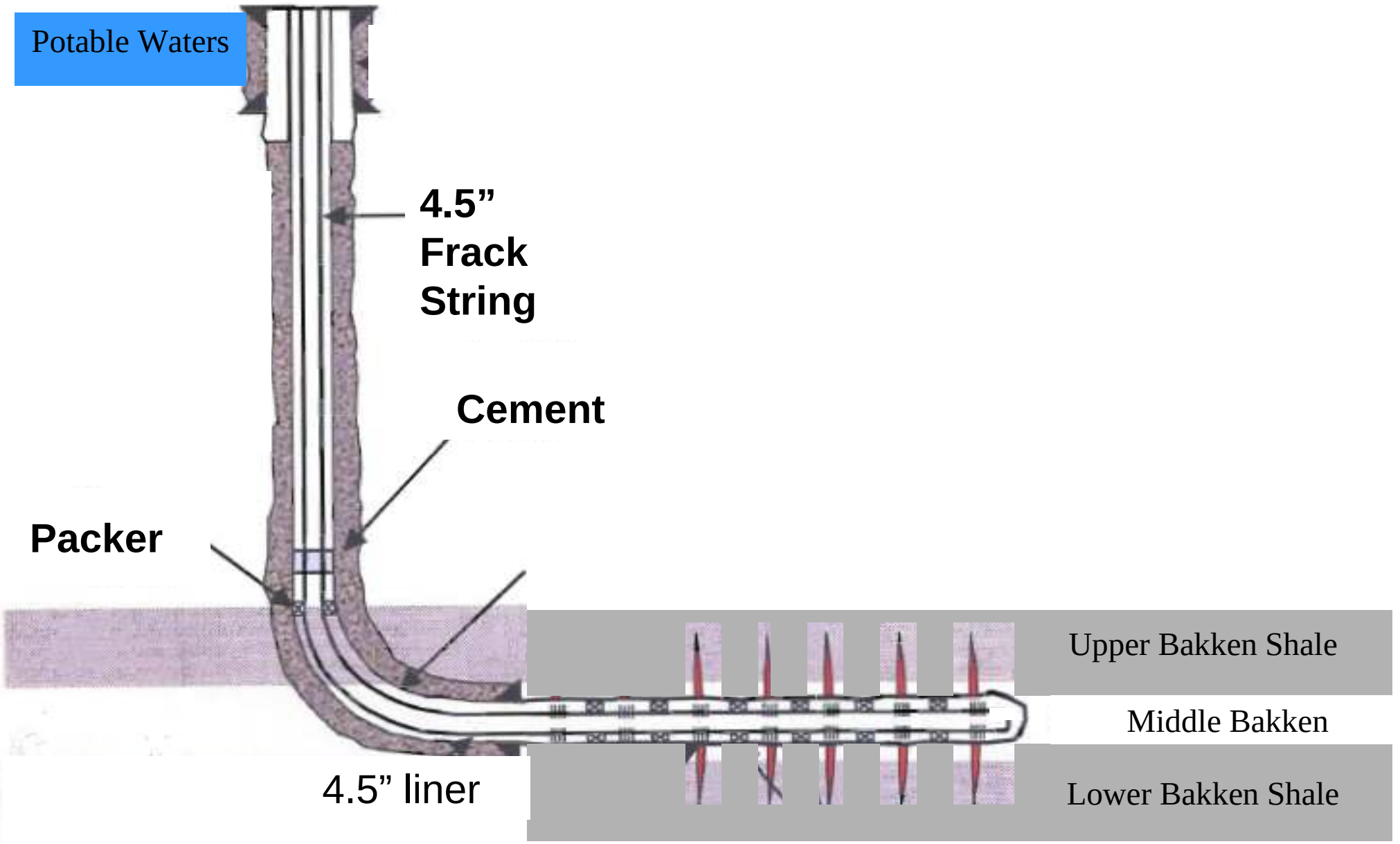

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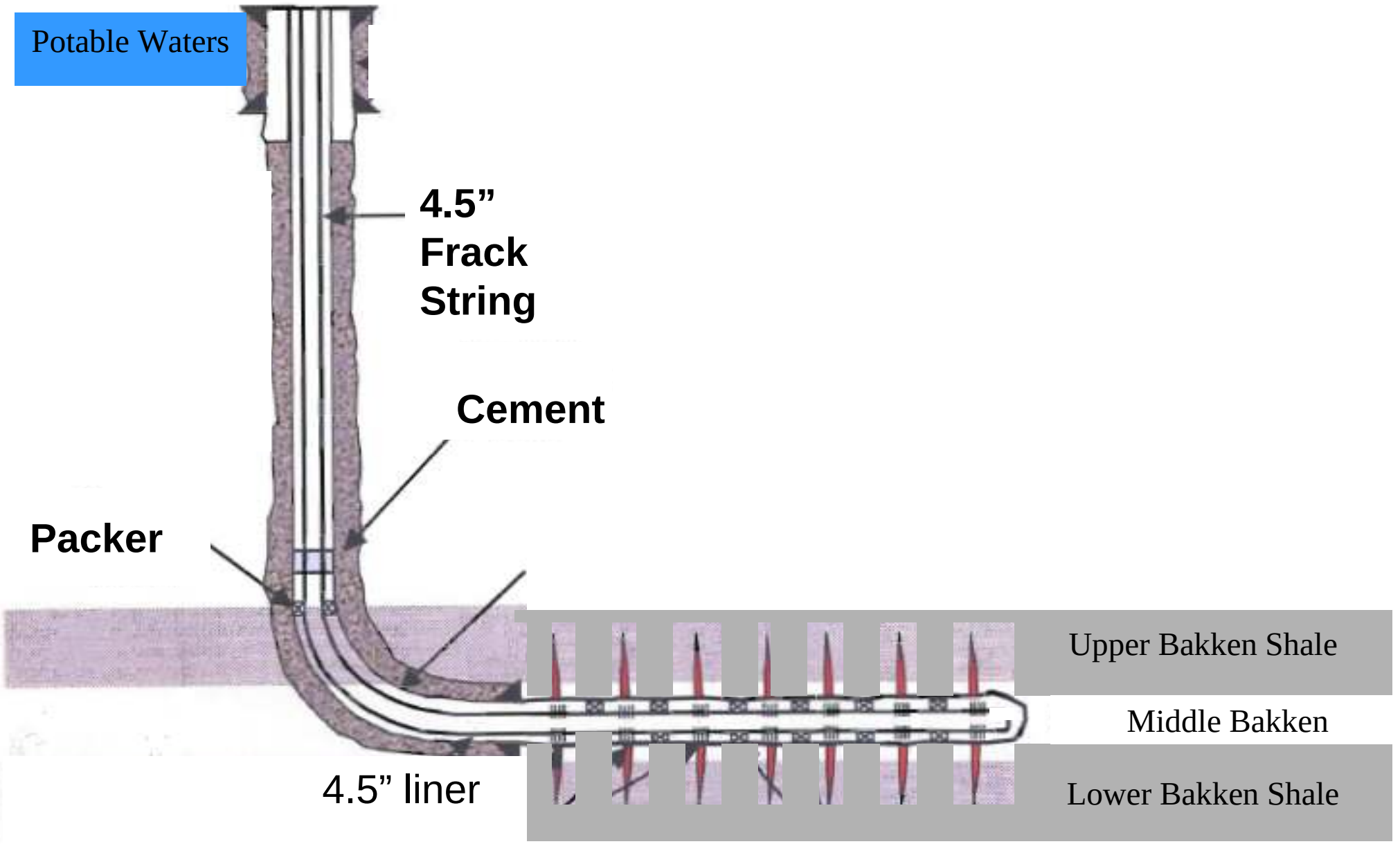
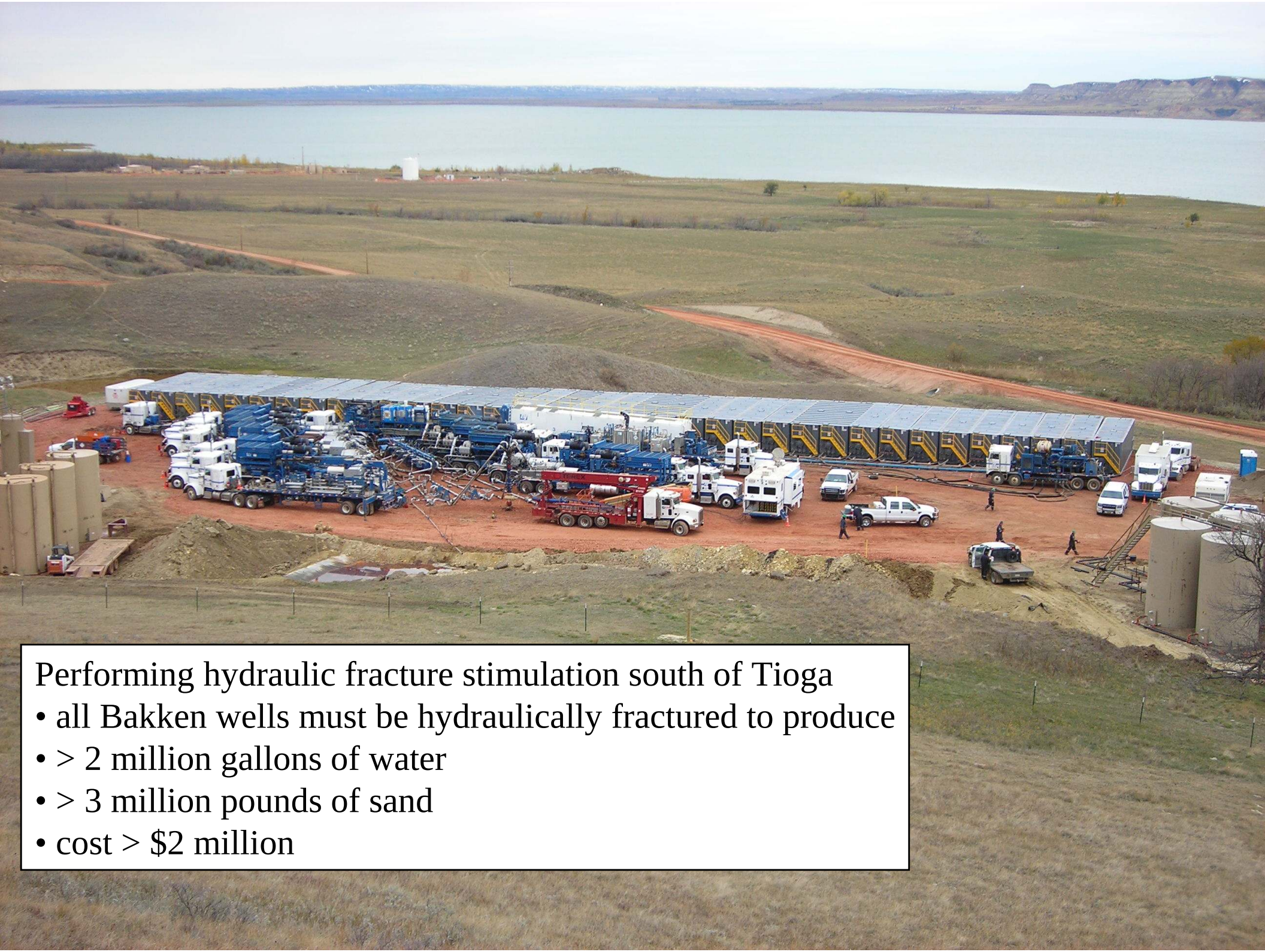




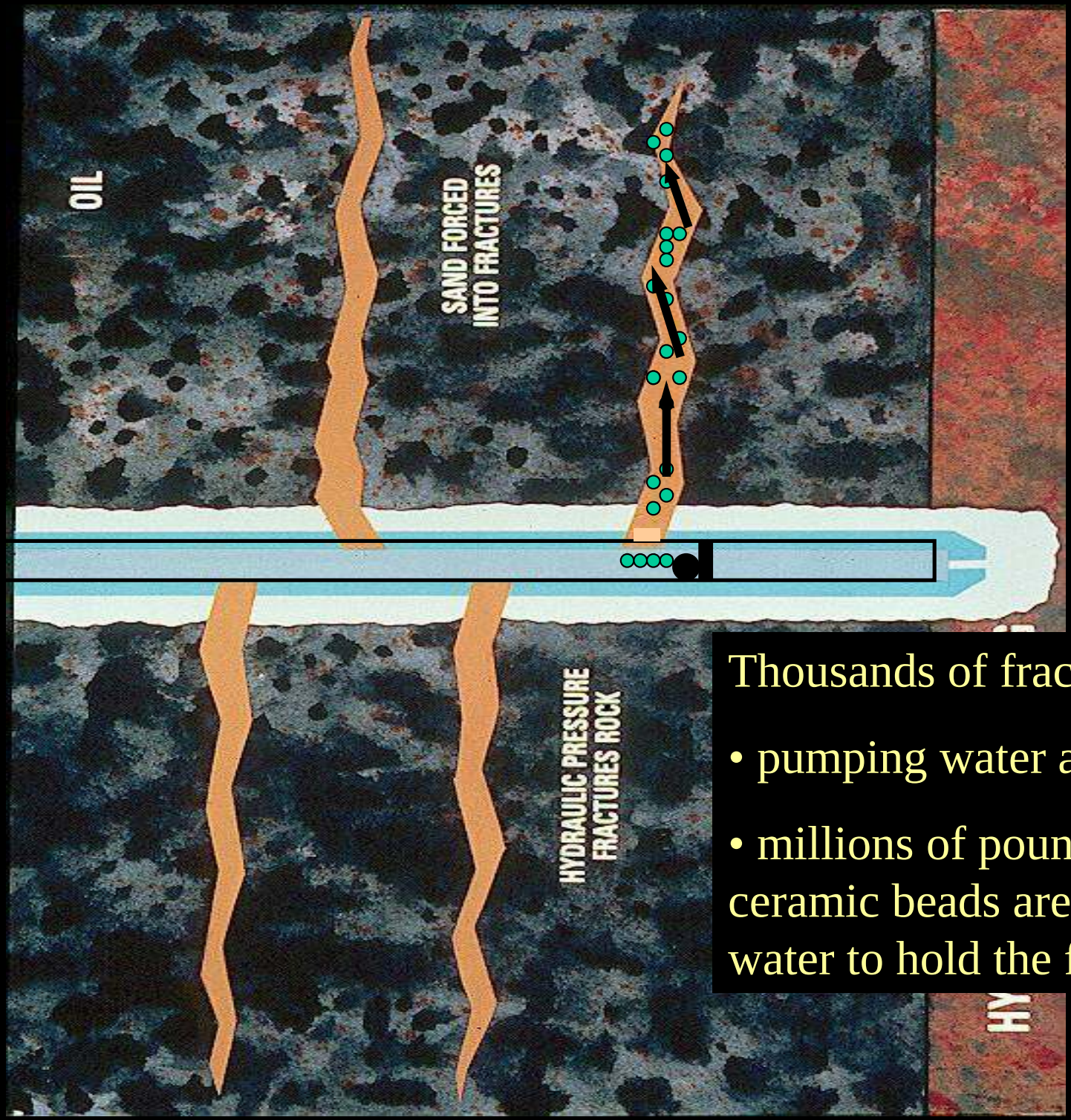
Performing hydraulic fracture stimulation south of Tioga

- all Bakken wells must be hydraulically fractured to produce
- > 2 million gallons of water
- > 3 million pounds of sand
- cost > $2 million

WHY FRACK THE ROCK?

- already developed easy oil
  - oil flows easily without fracking

- Reservoirs developed today are tight
  - look at sample
  - uneconomic to produce w/o fracking
  - must create a path for oil to flow

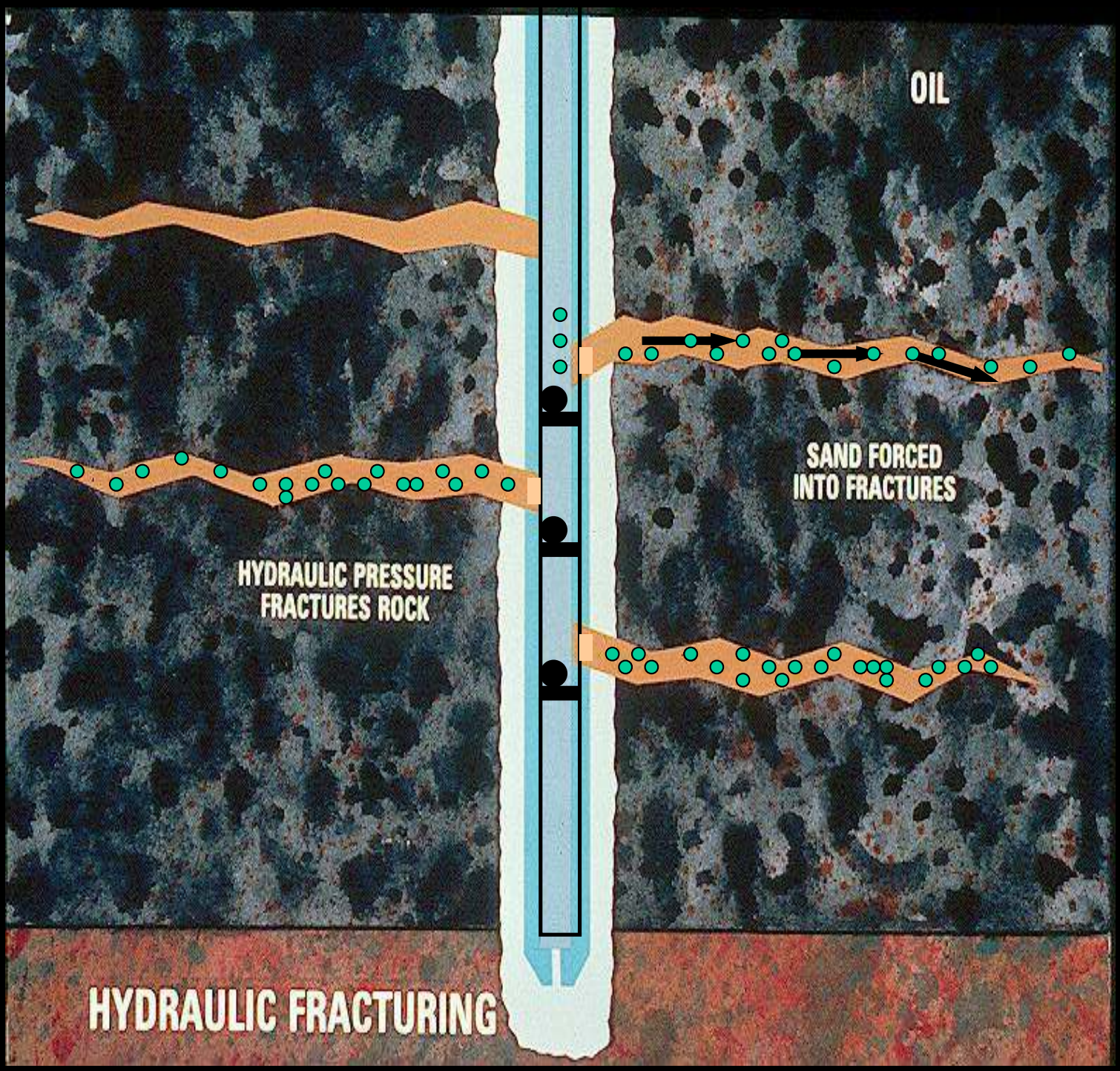


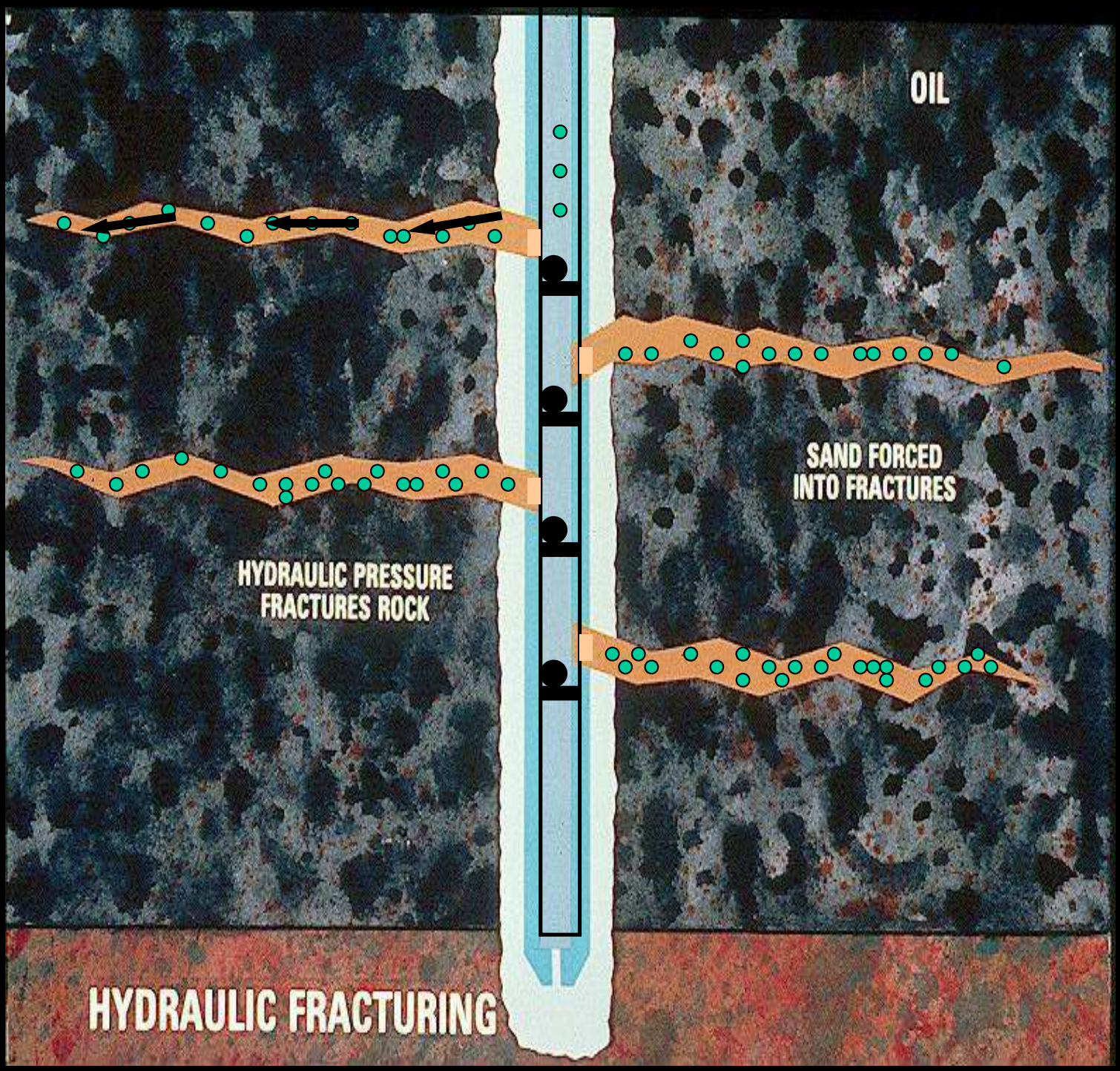
Thousands of fractures are created

- pumping water at 6,000-9,000 psi
- millions of pounds of sand and ceramic beads are pumped with the water to hold the fractures open.

Stage Fracturing

- up to 40 stages


OIL
SAND FORCED
INTO FRACTURES
HYDRAULIC PRESSURE
FRACTURES ROCK
HYDRAULIC FRACTURING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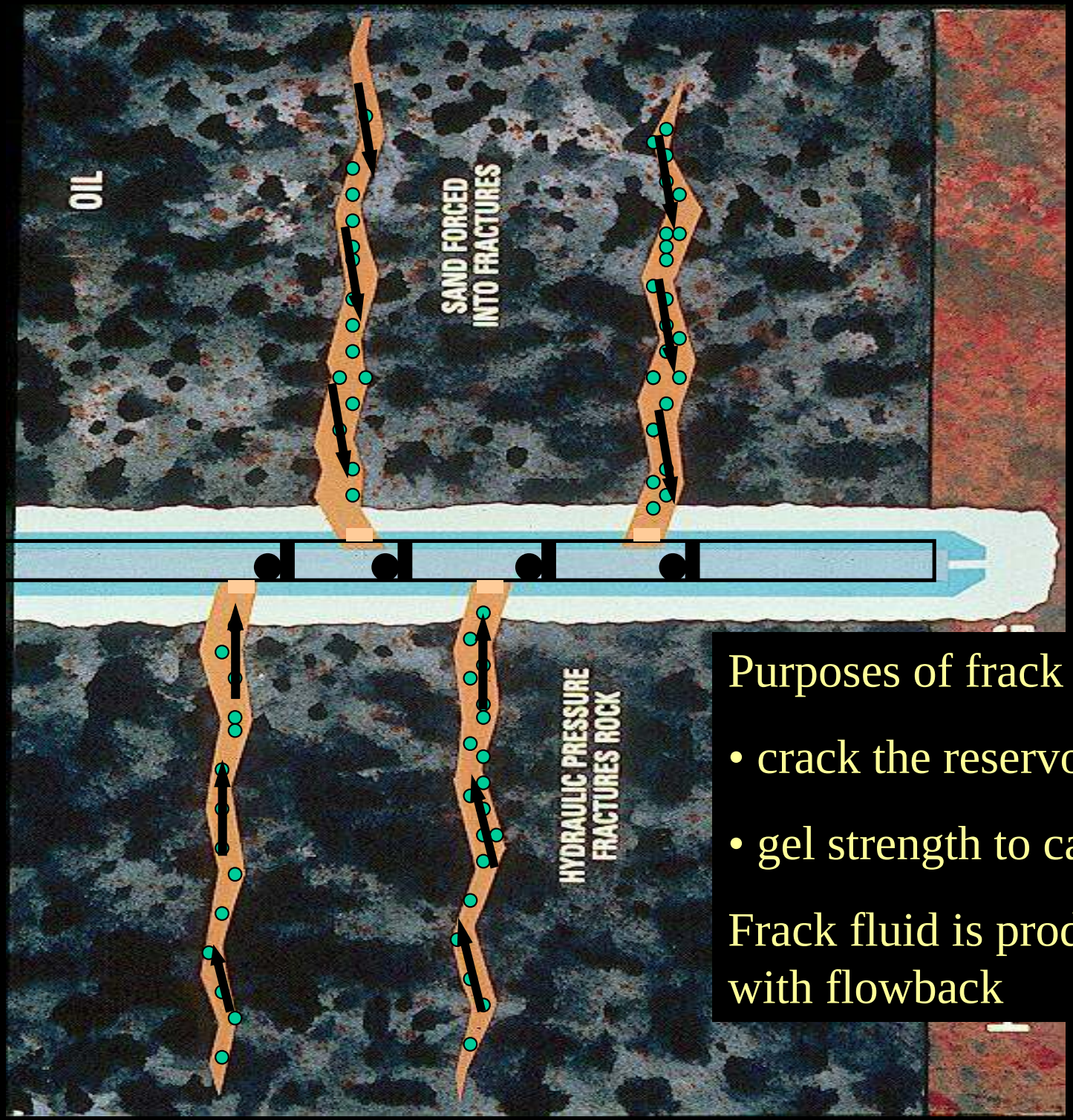
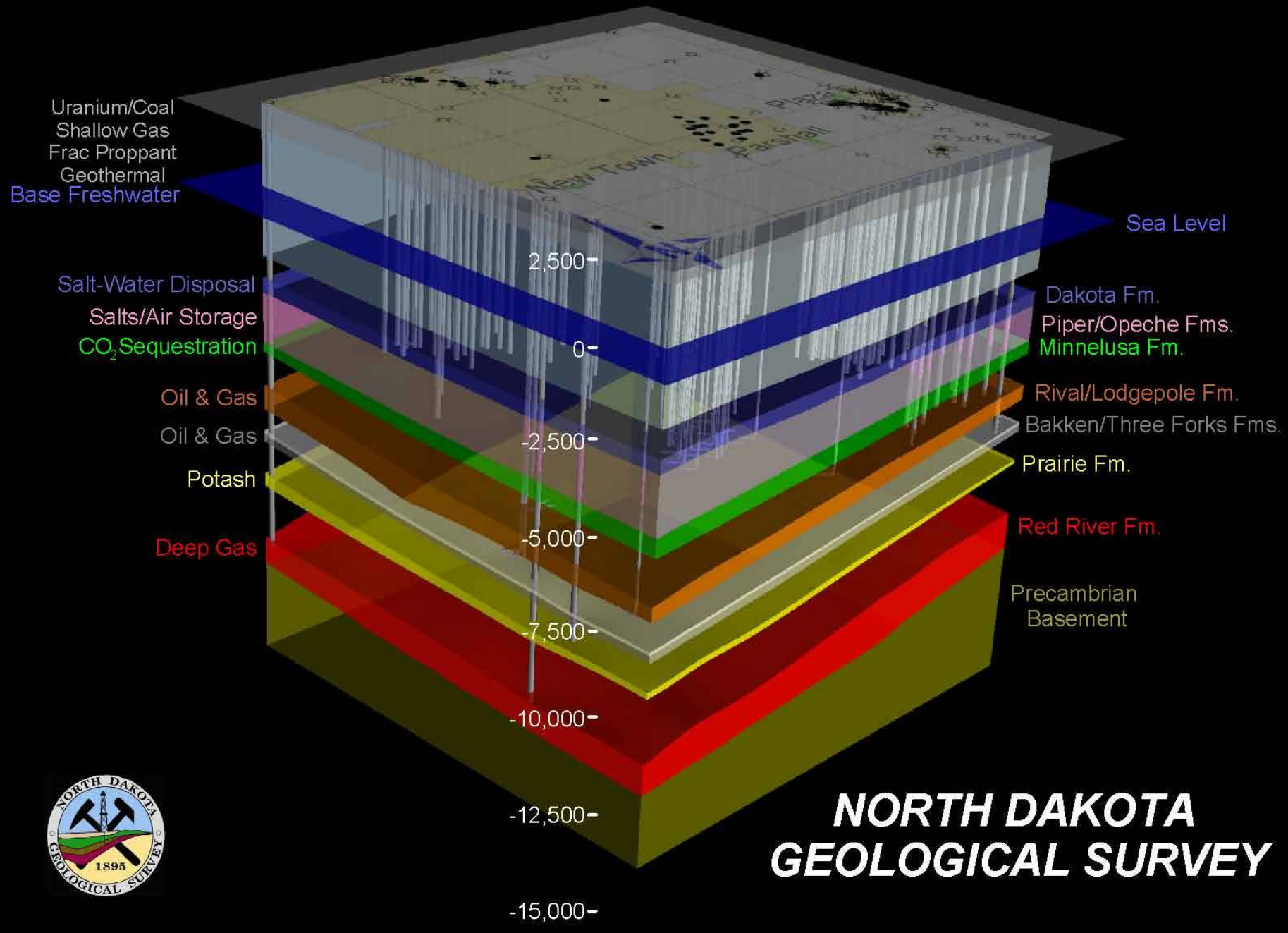


Purposes of frack fluid

- crack the reservoir
- gel strength to carry sand

Frack fluid is produced back with flowback

Three-Dimensional Geologic Model of the Parshall Area



NORTH DAKOTA GEOLOGICAL SURVEY

States have been regulating the full life cycle of hydraulic fracturing for decades

- Water Appropriation Regulation
- Oil & Gas Regulation
- Health Department Regulation
- Geologic setting in each basin different

Hydraulic Fracturing Stimulation is Safe

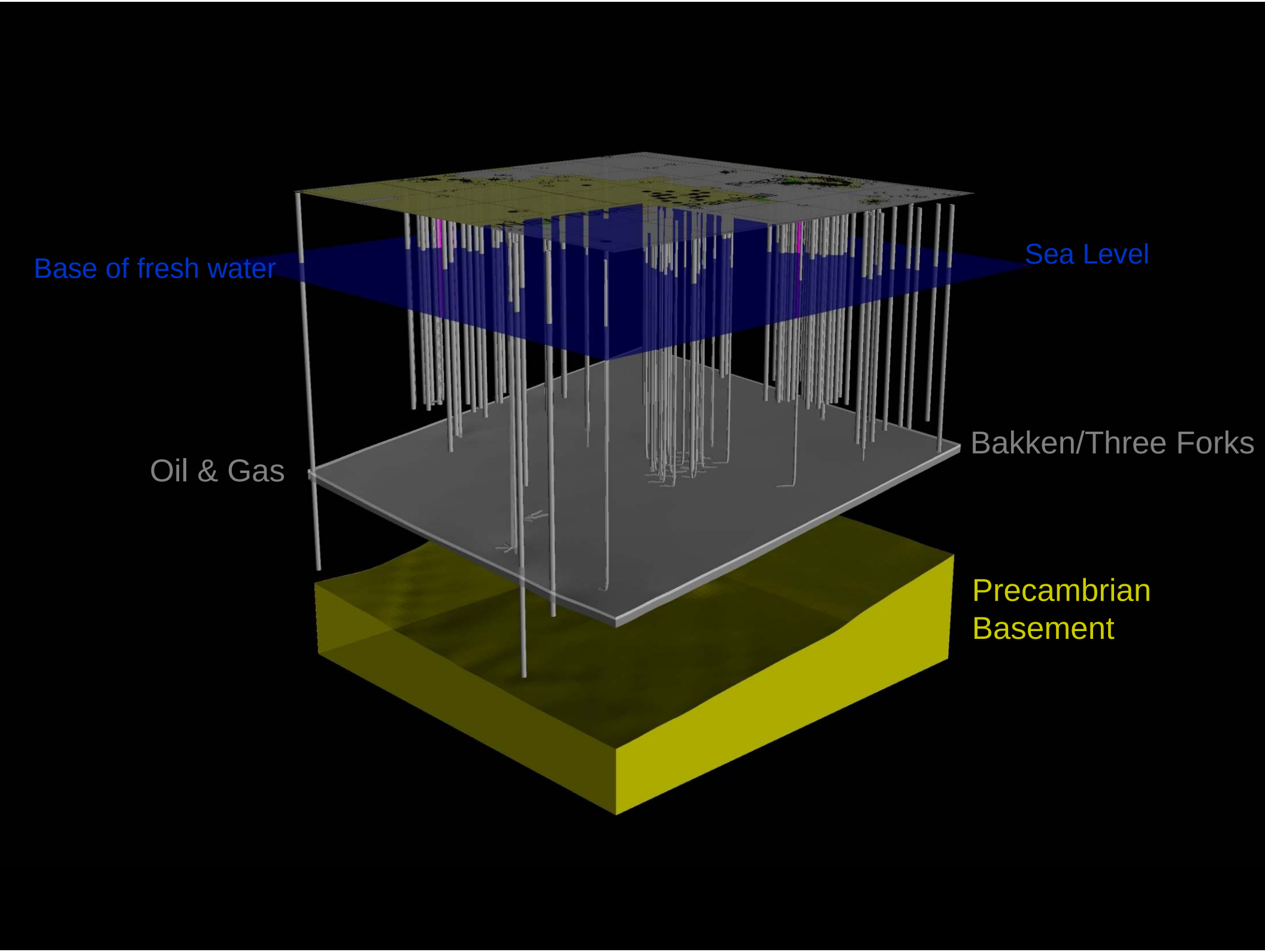
- IOGCC survey—no contamination
- GWPC study verifies State's regs
- GWPC National Registry f/chemicals

North Dakota has been regulating the full life cycle of hydraulic fracturing for decades

- Water Comm—water withdrawls
- Industrial Comm—well permitting & disposal of flowback water
- Health Dept—Spill cleanup

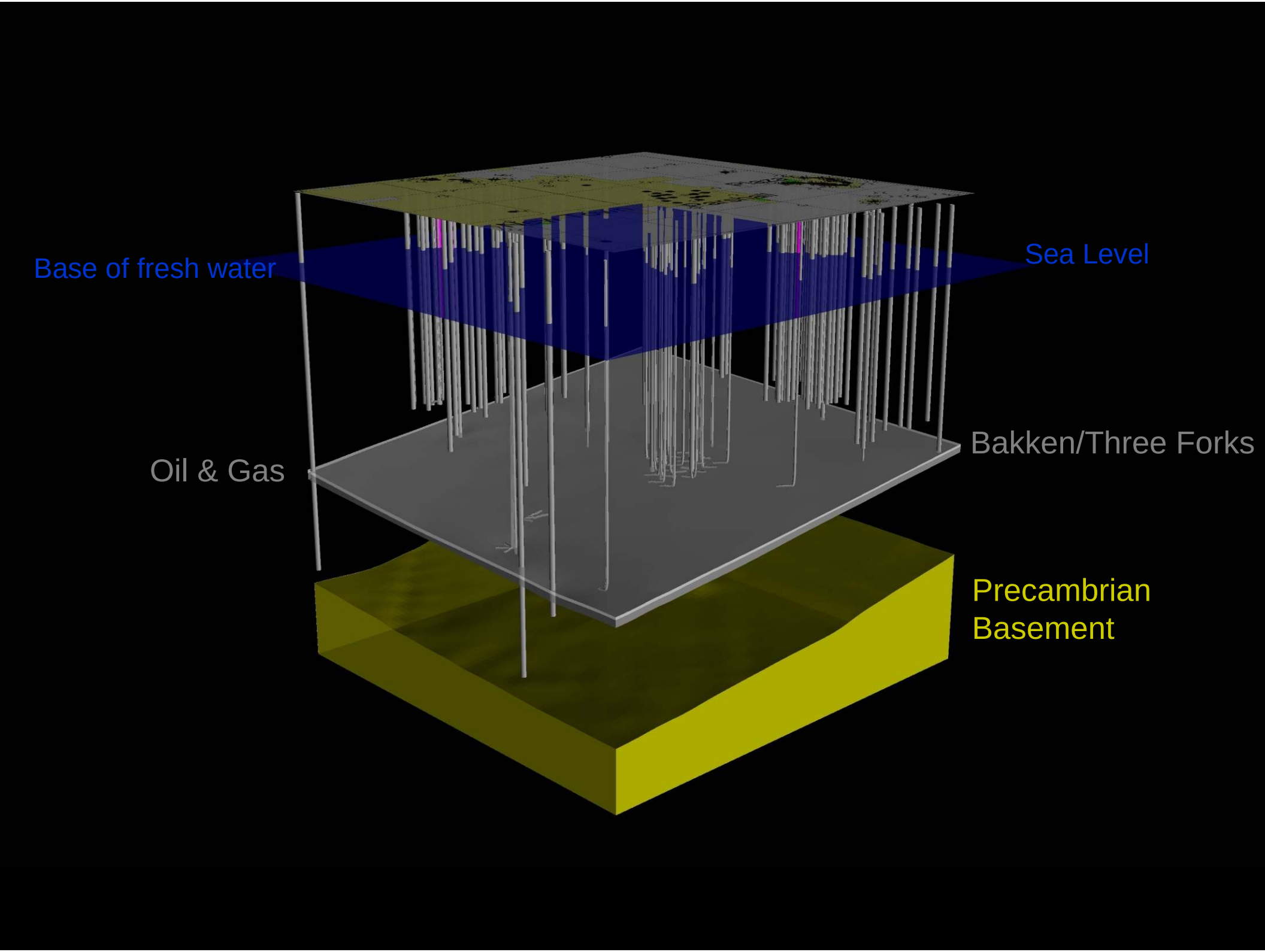
Water Commission Regulation

- **Regulate water appropriations**
- **Guard against withdrawls exceeding recharge**


Base of fresh water
Sea Level
Oil & Gas
Bakken/Three Forks
Precambrian
Basement

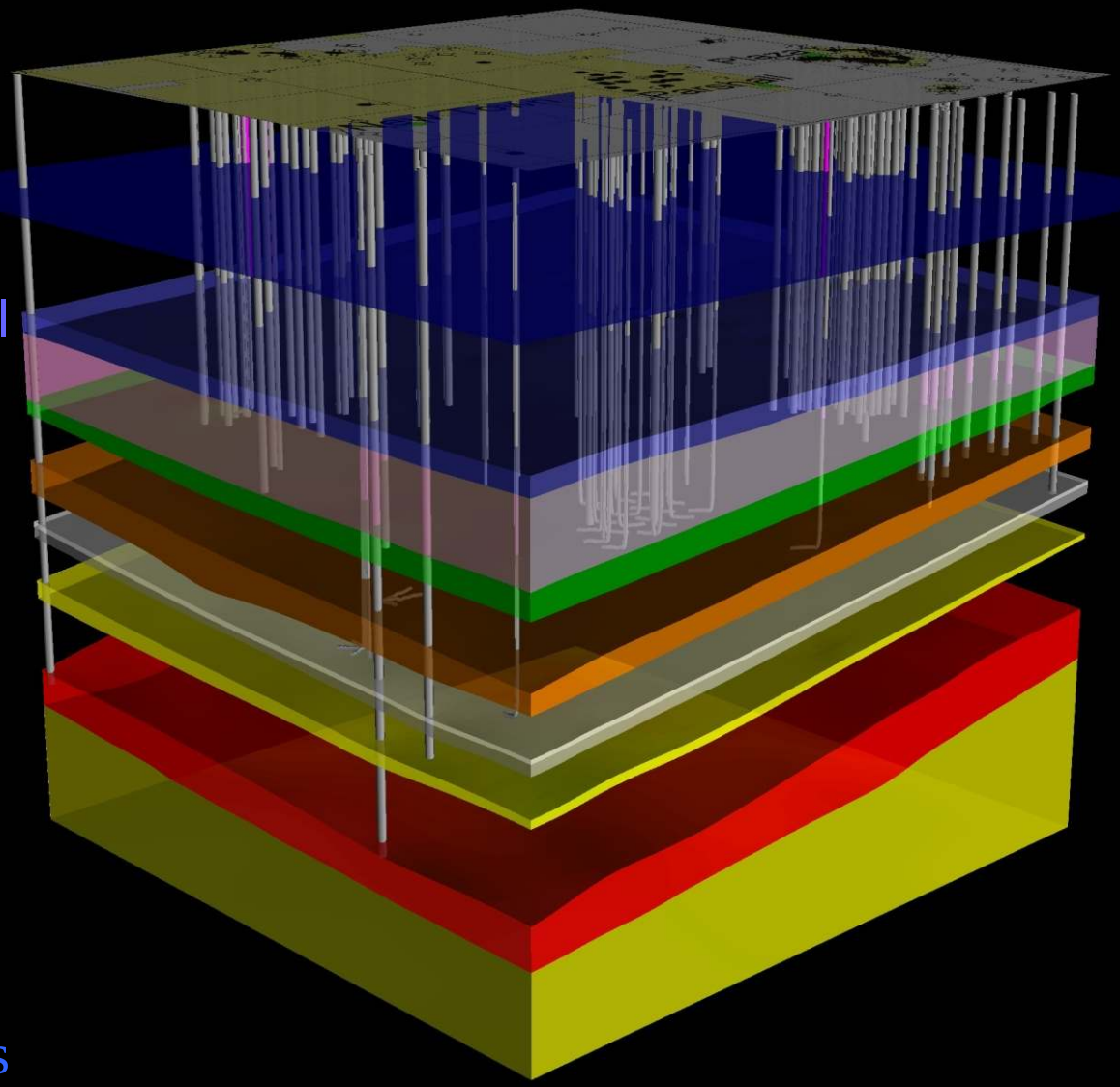
Industrial Commission Regulation

- Hydraulic fracturing
  - Two casing strings required
  - Both strings must be cemented
  - Pressure test casing required
  - Frack is > 1 mile below potable water


Base of fresh water
Sea Level
Oil & Gas
Bakken/Three Forks
Precambrian
Basement

Industrial Commission Regulation

- Water flowback after frack
  - Storage in open pits prohibited
  - Disposal wells permitted through Underground Injection Program
  - Disposal zone is 2,500 feet below potable waters



300 disposal wells

330,000 barrels per day

Health Department Regulation

- Cleanup of discharge to environment
- Coordinate w/local Emergency offices
- Emergency Planning and Community Right-to-know Act (EPCRA)
  - Congress passed to protect against storing and handling chemicals
  - Requires material safety data sheet (MSDS) for each chemical on location

Thirsty Horizontal Wells

- 2,000 wells / year
- 15-25 years duration
- 20 million gallons water / day

FRAC WATER NEEDS

- Lake Sakakawea best water resource
  - one inch contains 10 billion gal water
    - 5000 wells @ 2mil gal wtr/well
    - 2.5-year supply

FRAC WATER ADDITIVES

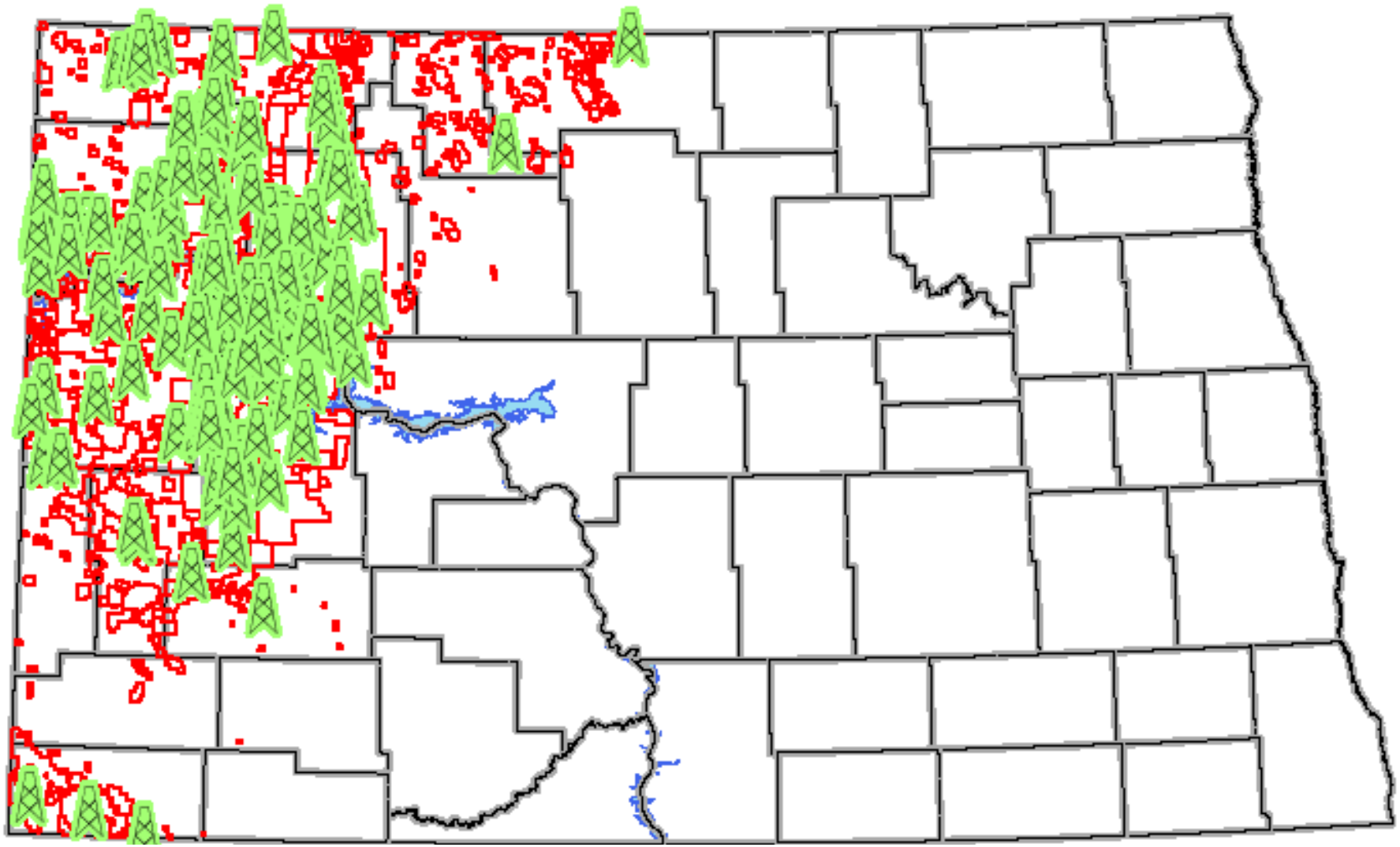
- 99.5% water and sand
  - 80.5% water
  - 19.0% proppant
  - 0.5% chemicals
    - most are found in every household

- **Compound**
  - **Purpose**
    - **Common application**

- Fresh **Water** – 80.5%
- Proppant – 19.0%
  - Allows the fractures to remain open so the oil and gas can escape
    - Drinking water filtration, **play ground sand**
- Acids - 0.12%
  - Help dissolve minerals and initiate fractures in rock (pre-fracture)
    - **Swimming pool cleaner**
- Petroleum distillates – 0.088%
  - Dissolve polymers and minimize friction
    - **Make-up remover**, laxatives, and candy
- Isopropanol – 0.081%
  - Increases the viscosity of the fracture fluid
    - **Glass cleaner**, antiperspirant, and hair color
- Potassium chloride – 0.06%
  - Creates a brine carrier fluid
    - Low-sodium **table salt substitute**
- Guar gum – 0.056%
  - Thickens the water to suspend the sand
    - **Thickener used in cosmetics**, baked goods, ice cream, toothpaste, sauces, and salad dressing
- Ethylene glycol – 0.043%
  - Prevents scale deposits in the pipe
    - Automotive **antifreeze**, household cleansers, deicing, and caulk

- Sodium or potassium carbonate – 0.011%
  - Improves the effectiveness of other components, such as cross-linkers
    - Washing soda, detergents, **soap**, water softeners, glass and ceramics
- Sodium Chloride – 0.01%
  - Delays break down of the gel polymer chains
    - **Table Salt**
- Polyacrylamide – 0.009%
  - Minimizes friction between fluid and pipe
    - **Water treatment**, soil conditioner
- Ammonium bisulfite – 0.008%
  - Removes oxygen from the water to protect the pipe from corrosion
    - Cosmetics, **food and beverage processing**, water treatment
- Borate salts – 0.007%
  - Maintain fluid viscosity as temperature increases
    - Used in laundry **detergents**, hand soaps and cosmetics
- Citric Acid – 0.004%
  - Prevents precipitation of metal oxides
    - **Food additive**; food and beverages; lemon juice
- N, n-Dimethyl formamide – 0.002%
  - Prevents the corrosion of the pipe
    - Used in **pharmaceuticals**, acrylic fibers and plastics
- Glutaraldehyde – 0.001%
  - Eliminates bacteria in the water
    - **Disinfectant**; Sterilizer for medical and dental equipment

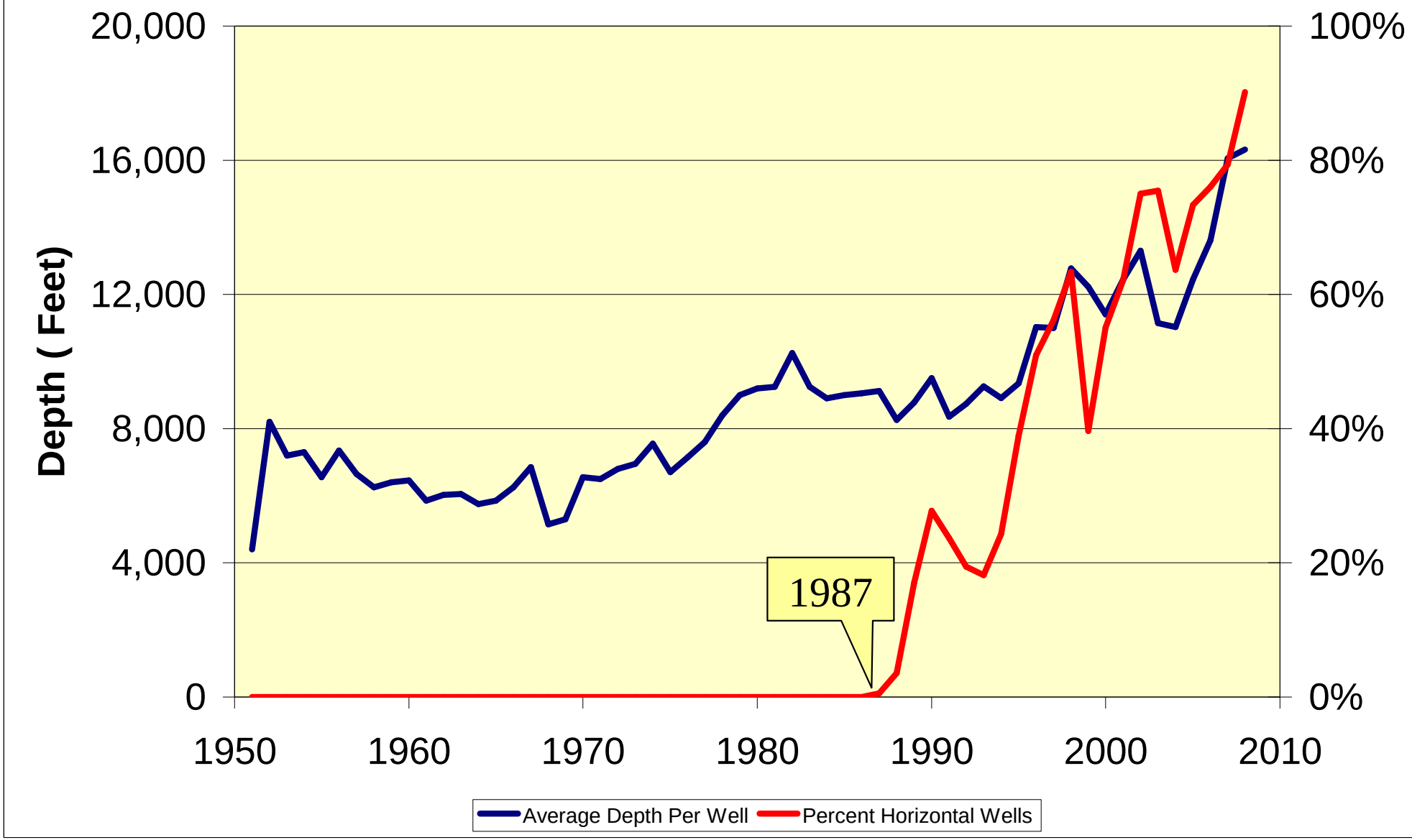
NORTH DAKOTA – 171 DRILLING RIGS – March 2011



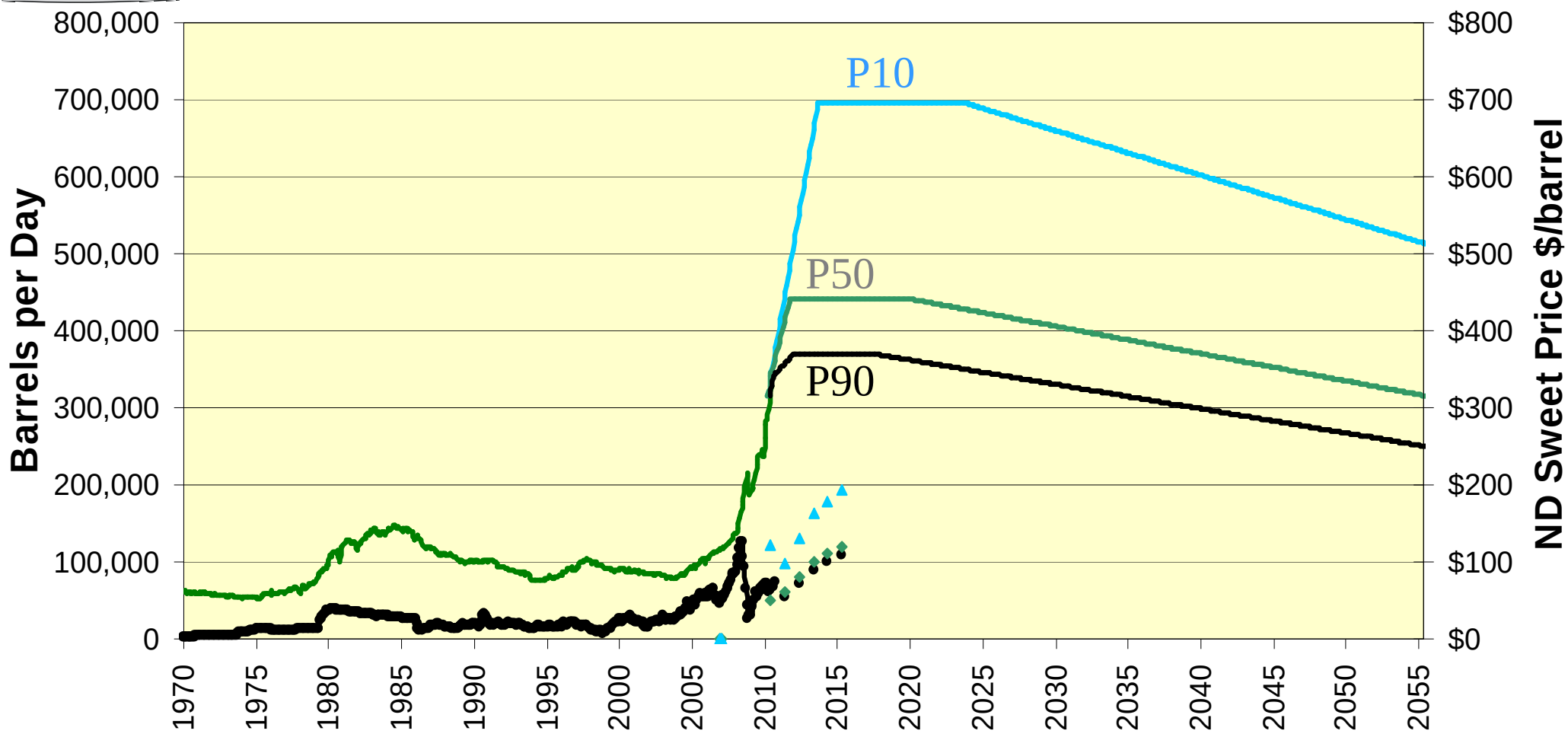
Current drilling activity is focused

in Mountrail, Dunn, McKenzie, and Williams Counties.

North Dakota Well Depth and % Horizontal



North Dakota Oil Production and Price

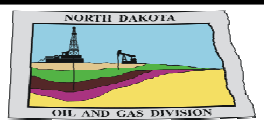


2,000 **Bakken and Three Forks wells drilled and completed**

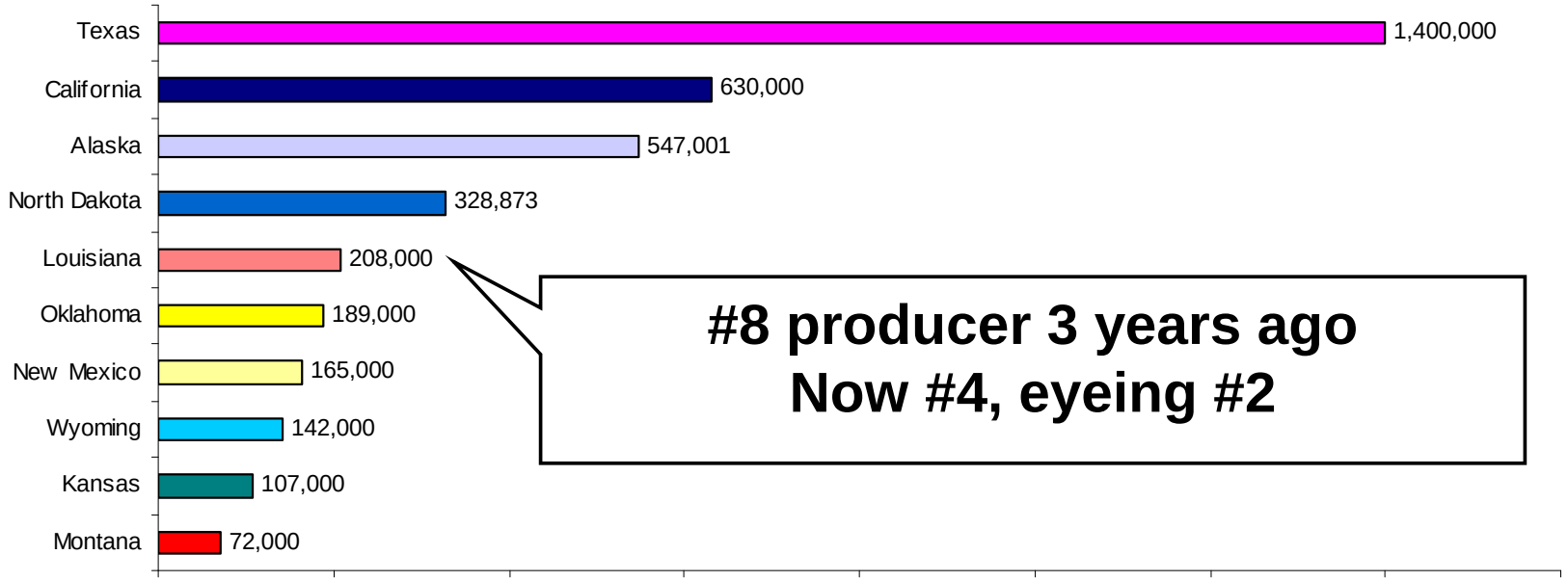
19,000 – 47,000 **more new wells possible in thermal mature area**

P90=5 BBO – P50=7 BBO – P10=11 BBO (billion barrels of oil)

History
Bakken - Three Forks P10
Bakken - Three Forks P50
Bakken - Three Forks P90
$/Barrel History & DOE-EIA Projected
$/Barrel P50
$/Barrel P10



United States Daily Oil Production -- August 2010



#8 producer 3 years ago
Now #4, eyeing #2

Job Opportunities

- 170 – 225 rigs
  - 20,000 jobs in drilling
- 15 – 25 years
  - 28,000 additional wells
  - 28,000 long term jobs

NDSU Economic Impact Study

- Calendar Year 2009 Impact Study
  - $5 billion direct impact
  - $13 billion secondary impact
  - $822 million taxes
  - 18,328 direct jobs
    - 52 rigs + $52.35/bo
- Calendar Year 2010 Impact Study
    - 126 rigs + $69.74/bo

BAKKEN FORMATION

NDIC-DMR estimated

- **appr 200-300 billion bo in place in ND**
  - **34-yr supply @ current US consumption**
    - **2.1 billion bo recovery in ND w/1well**
    - **4.2 billion bo recovery in ND w/2wells**
    - **1-7 horizontal wells / spacing unit**

USGS estimated (independent simultaneous study)

- **2.6 billion bo recovery in ND**
- **largest continuous resource they have assessed in lower 48 States**

THREE FORKS FORMATION

NDIC-DMR estimated

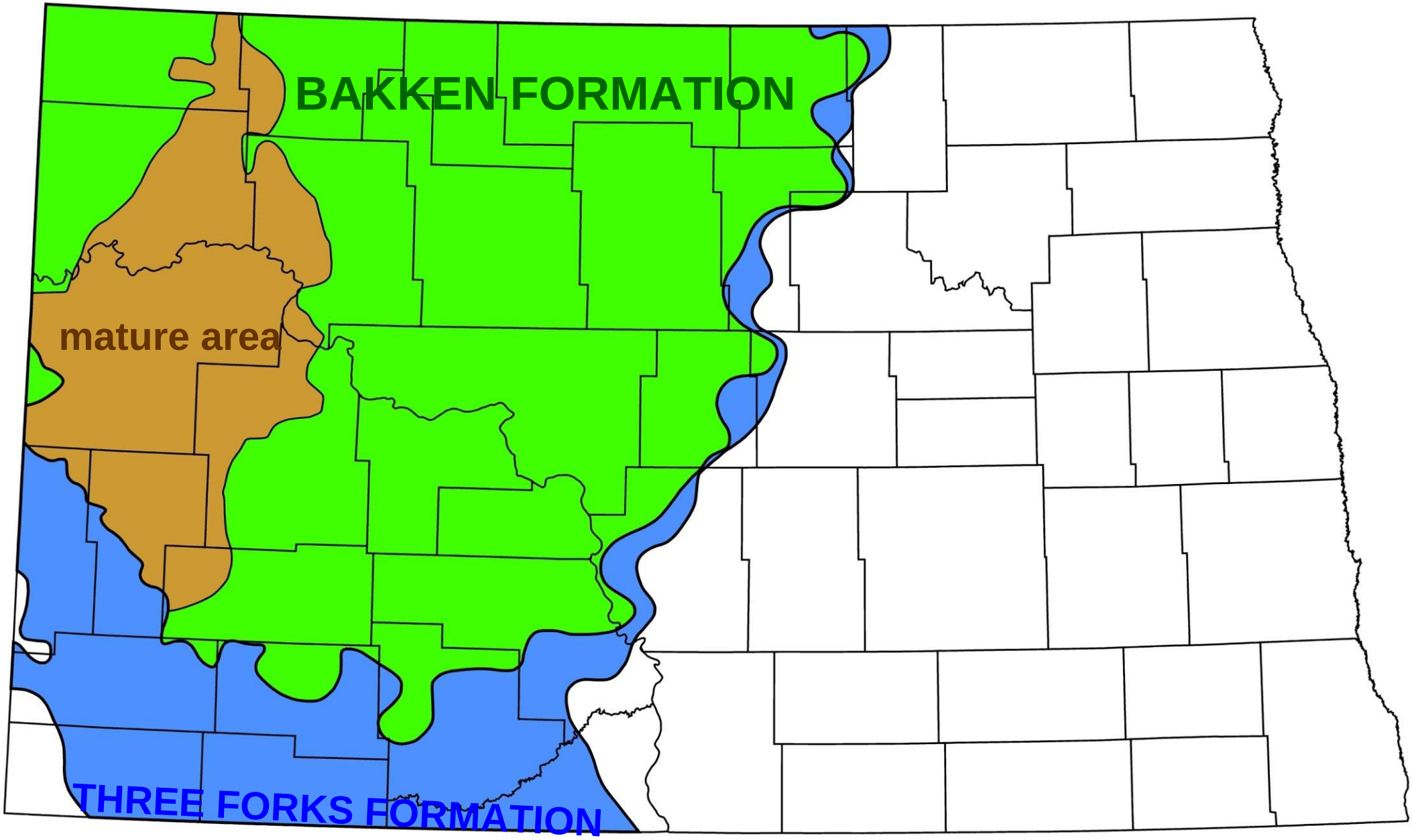
- **1.9 billion bo recovery in ND w/1well**
- **3.8 billion bo recovery in ND w/2wells**

USGS: (No study)

BAKKEN PROVIDES ENERGY/JOBS

- Over 5,000 wells in next 3 yrs
  - will double our cur wells @ cur rigs
  - all require hydraulic stimulation
  - provides significant domestic energy
  - creates numerous jobs

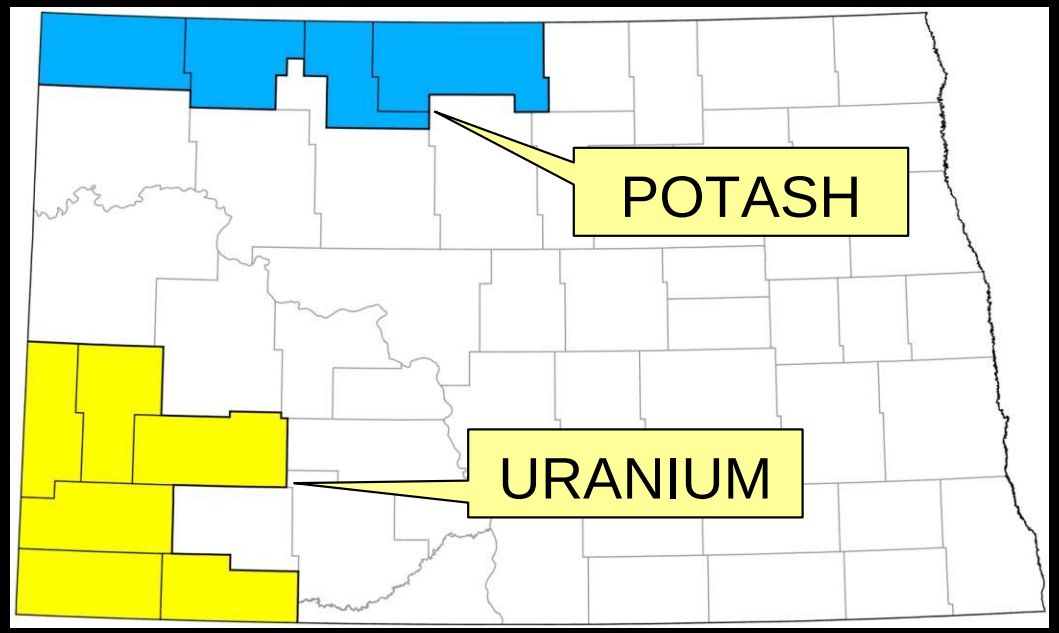
ESTIMATED MATURE AREA OF THE BAKKEN FORMATION



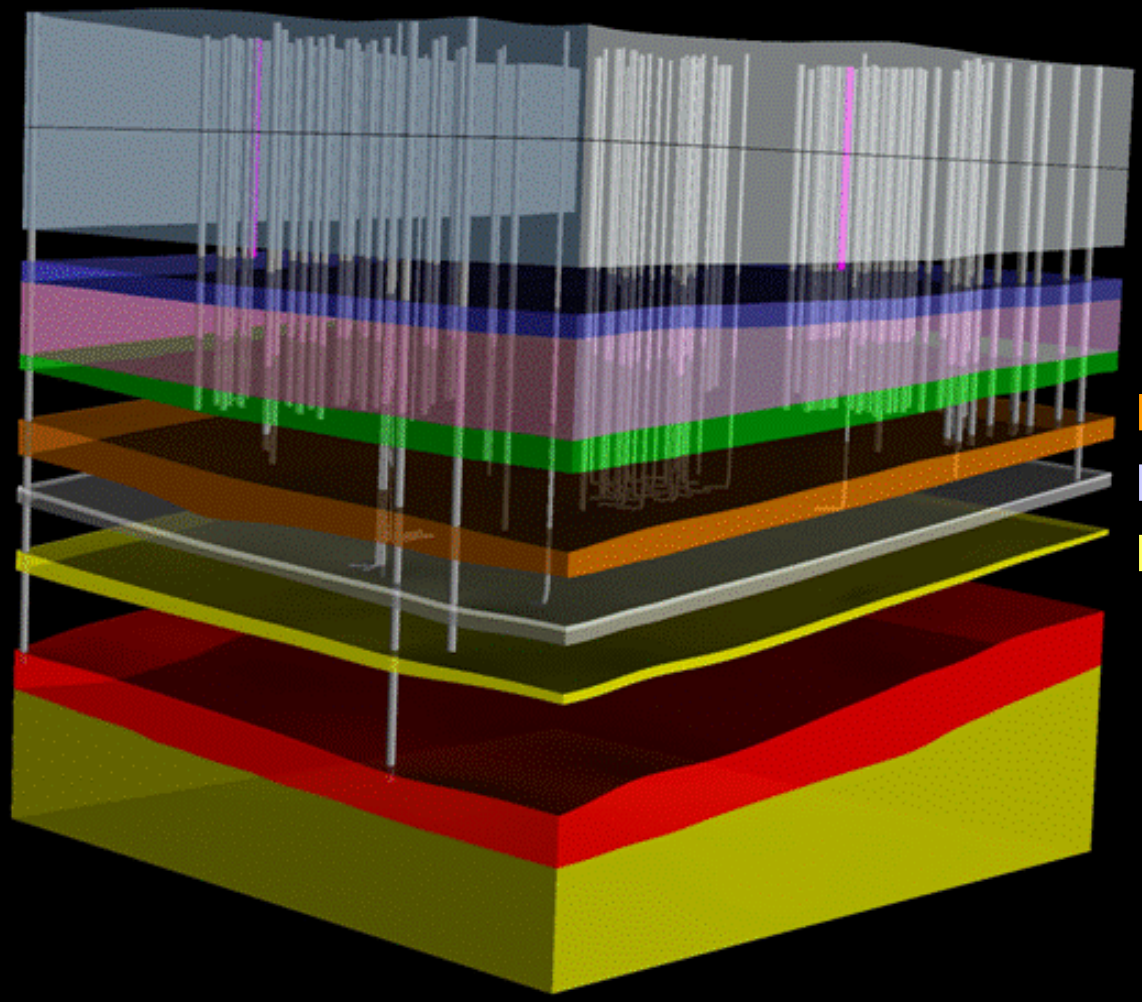
(Nordeng, 2010)

Estimate 20-50 billion tons of ND Mineable Reserves

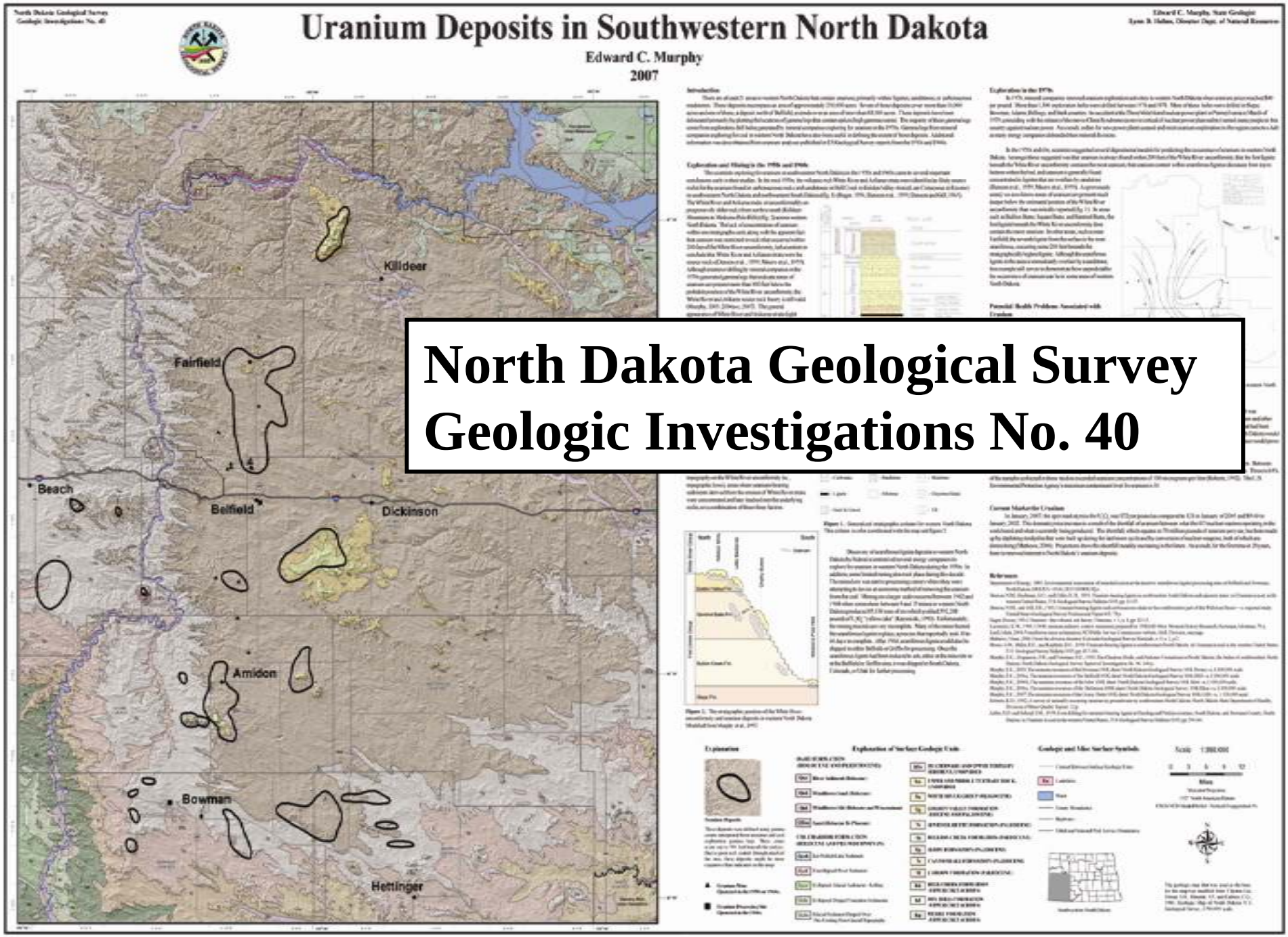
$6 trillion -15 trillion



Three-dimensional Geologic Model



North Dakota Geological Survey


North Dakota Geological Survey
Geologic Investigations No. 40
Uranium Deposits in Southwestern North Dakota
Edward C. Murphy
2007
Killdeer
Fairfield
Beach
Belfield
Dickinson
Amidon
Bowman
Hettinger
North Dakota Geological Survey
Geologic Investigations No. 40

URANIUM

- found in lignite beds as deep as 500’
- SW ND greatest potential
- molybdenum—Element Mo
  - high-temp steels (melts @ 4730 F)
- germanium—Element Ge
  - semiconductor (fiber-optics)
- future mining in-situ leaching
- shortfall for current reactors (435)

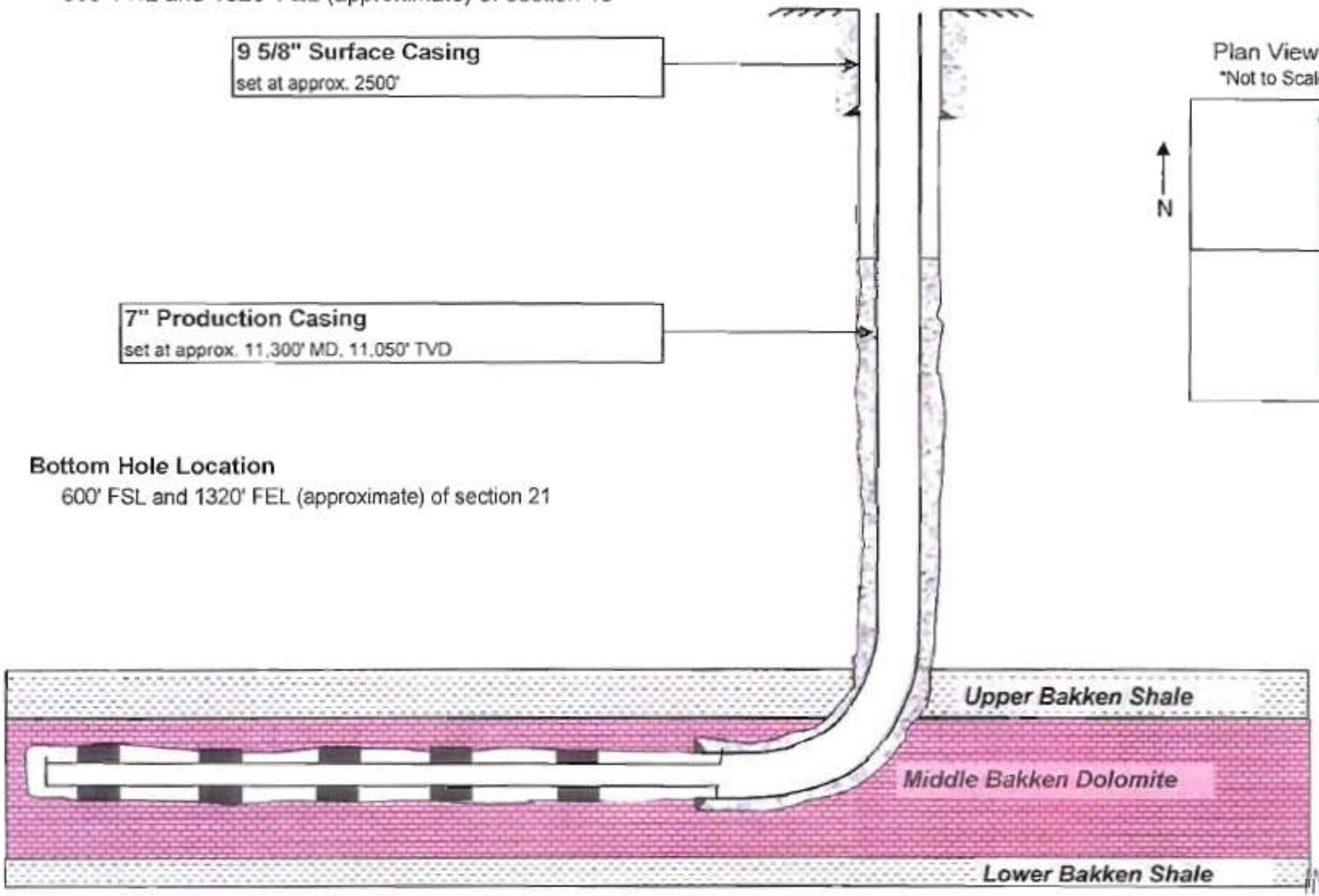
Wellbore Schematic

Surface Location
300' FNL and 1320' FEL (approximate) of section 16

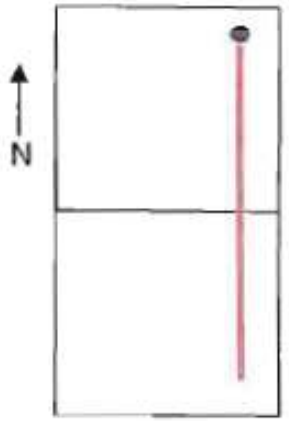
9 5/8" Surface Casing
set at approx. 2500'

7" Production Casing
set at approx. 11,300' MD, 11,050' TVD

Bottom Hole Location
600' FSL and 1320' FEL (approximate) of section 21

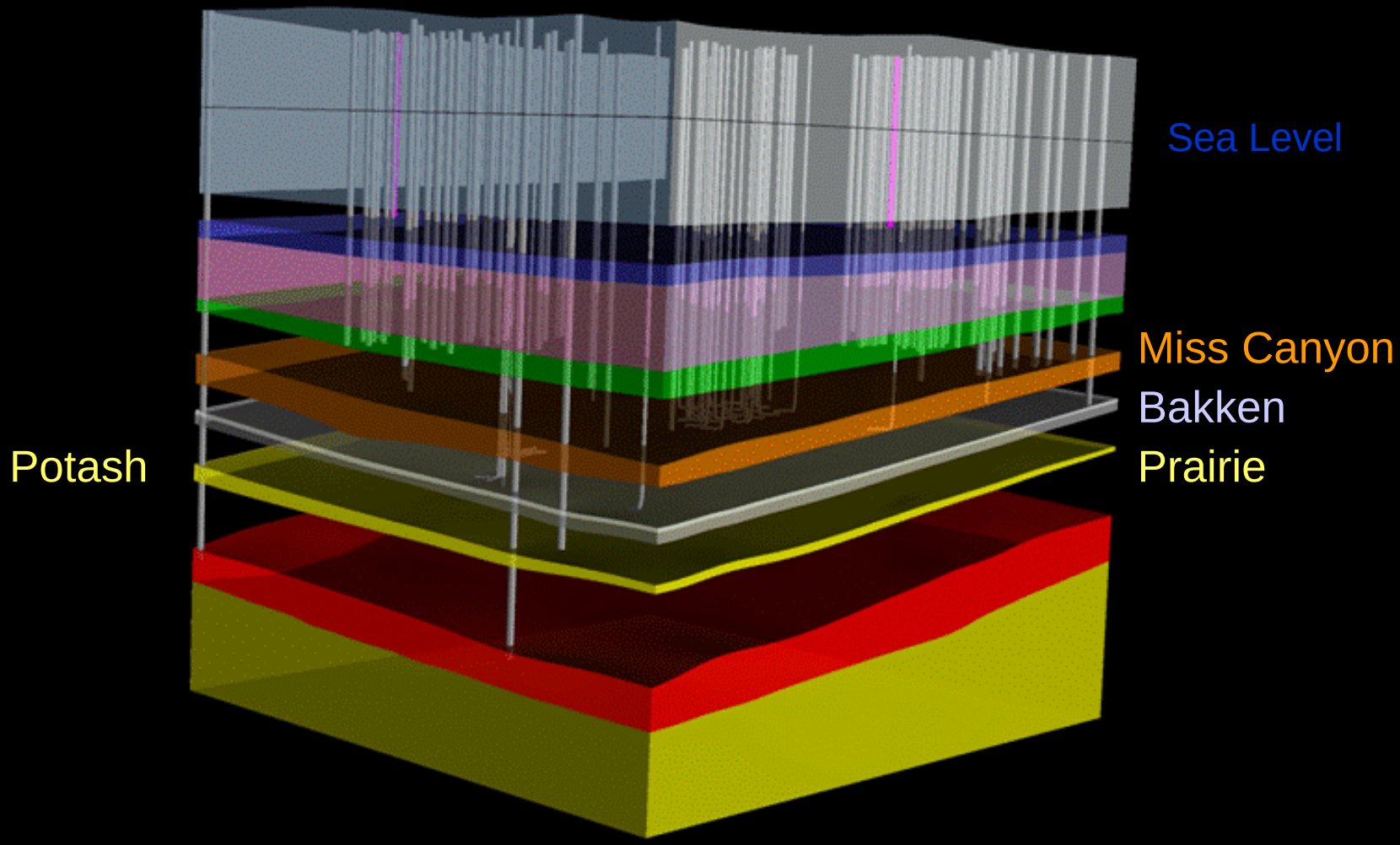


Plan View *
*Not to Scale

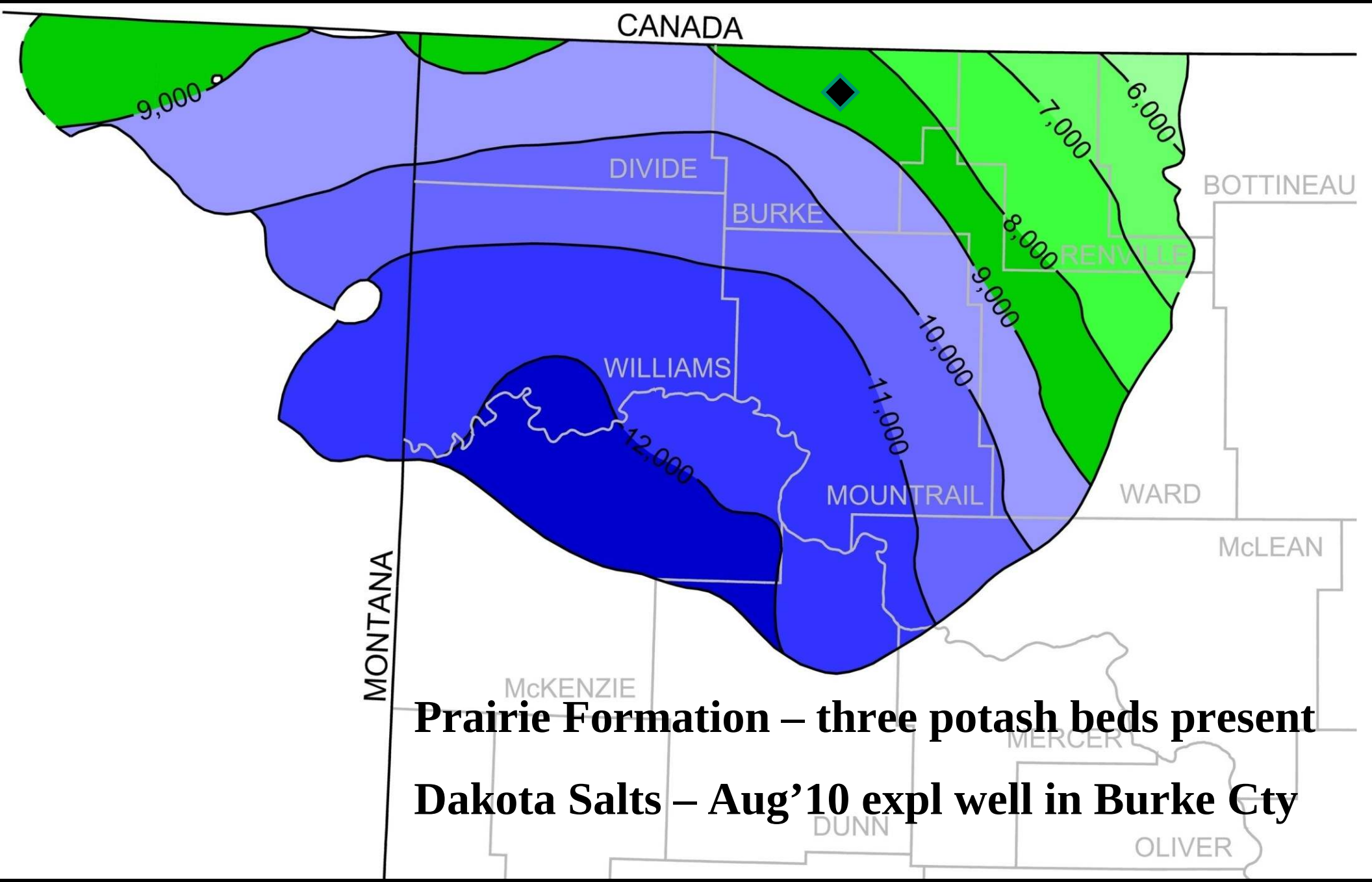


INDUSTRIAL COM

Three-dimensional Geologic Model



North Dakota Geological Survey

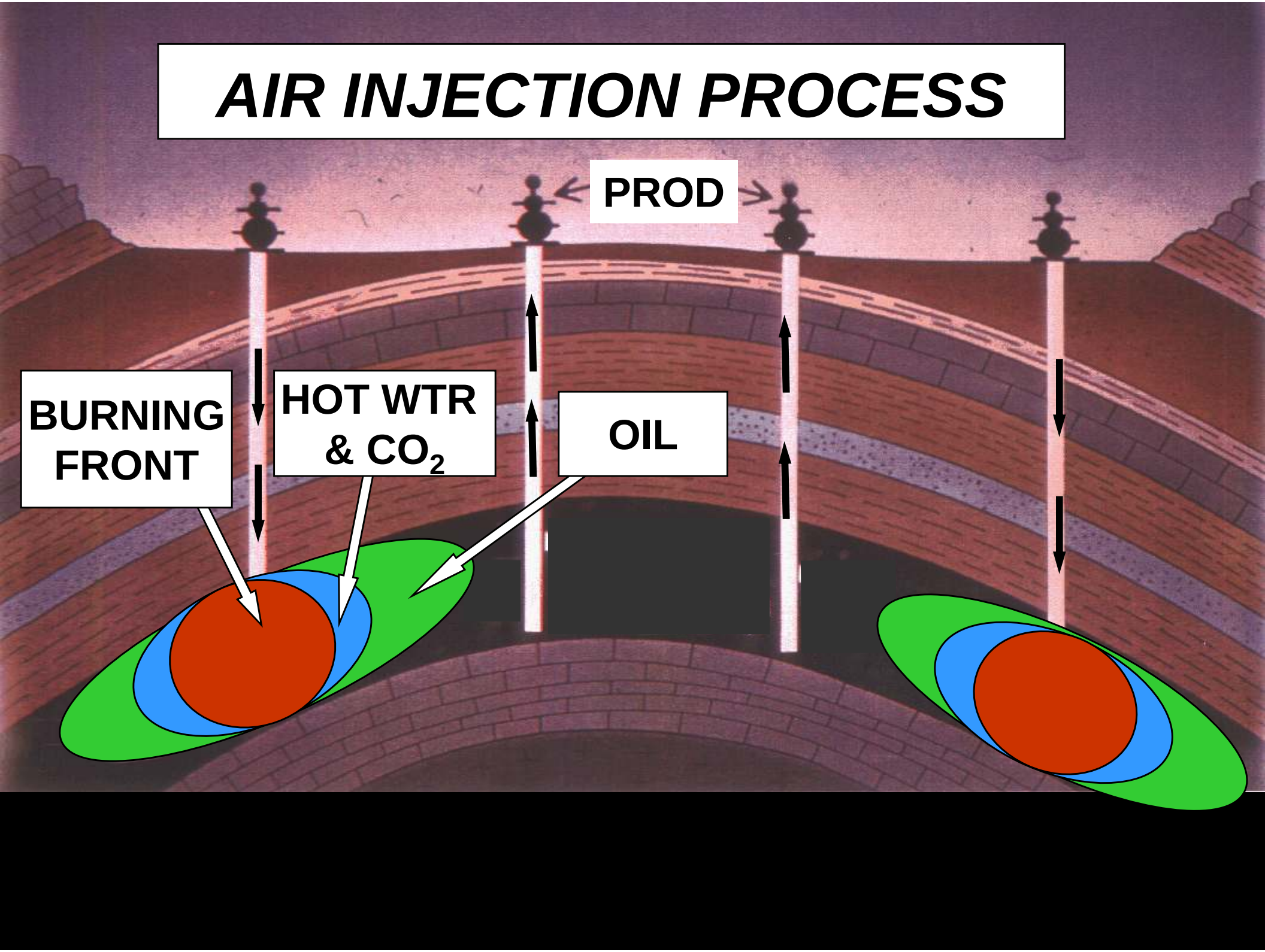


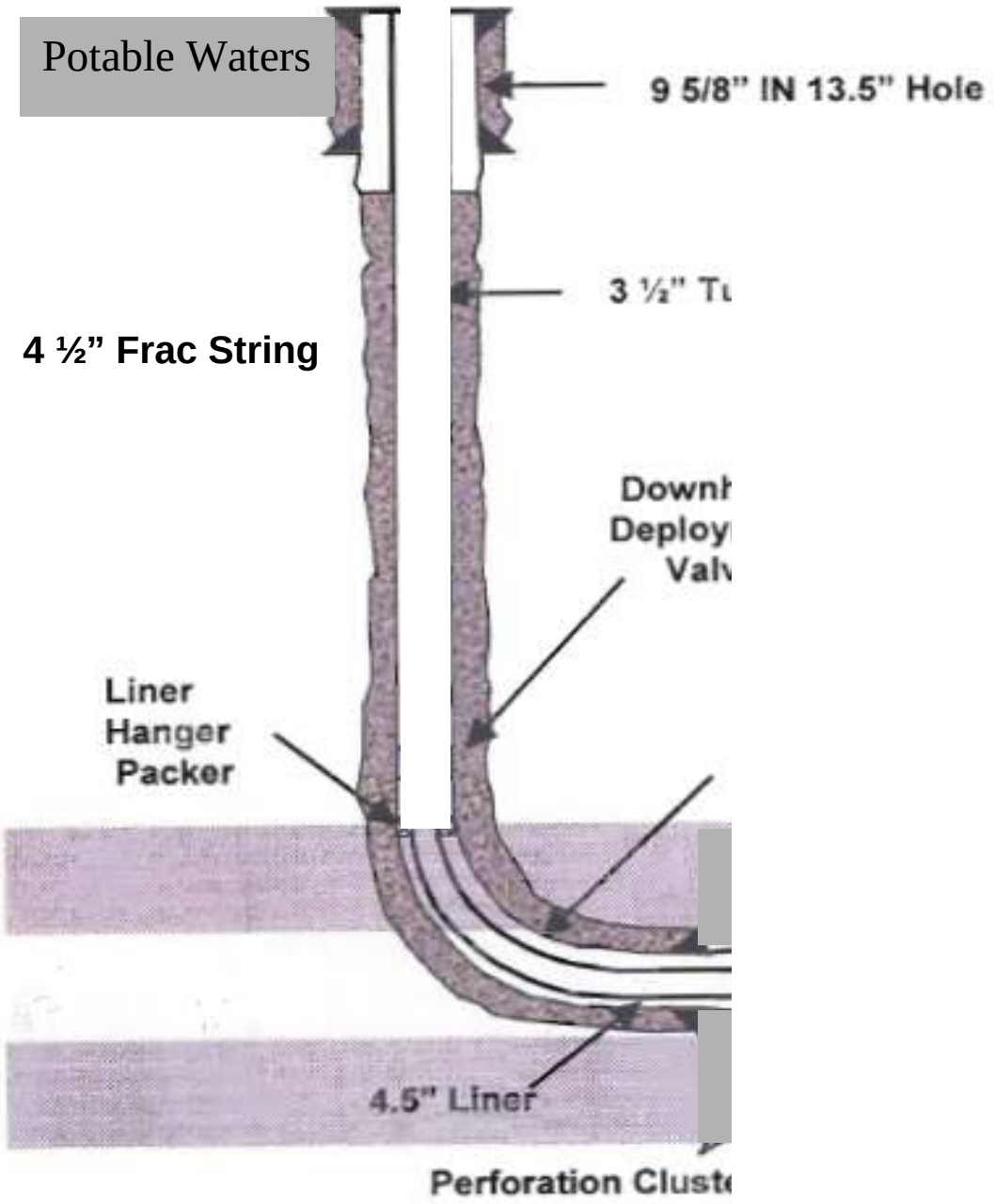
Prairie Formation – three potash beds present

Dakota Salts – Aug'10 expl well in Burke Cty

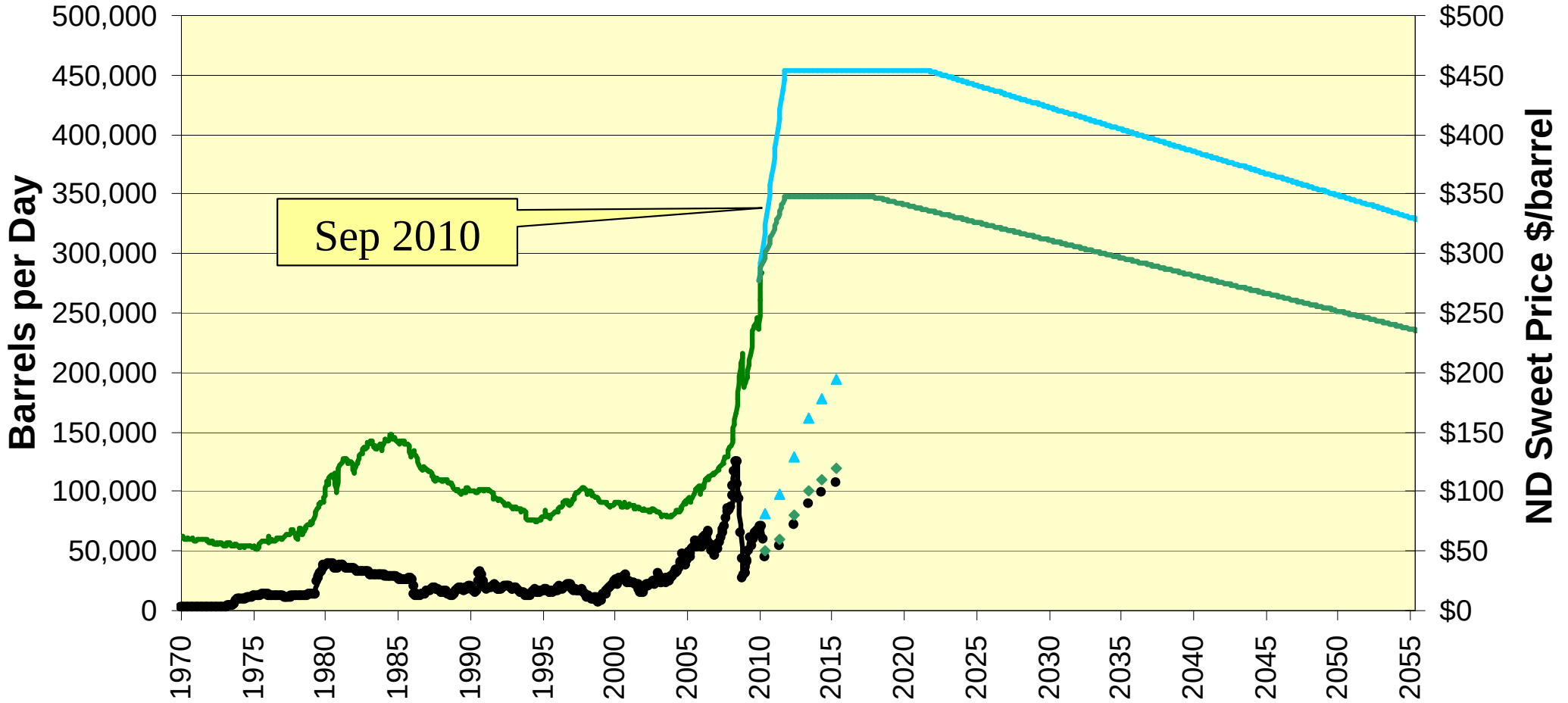
POTASH

- found in salts 9000 feet deep
- gross thickness of 83 feet
- Northern ND greatest potential
- potassium salts used in fertilizer
- solution mining in future (2013)
- increasing demand


AIR INJECTION PROCESS
PROD
BURNING FRONT
HOT WTR & CO_2
OIL


Potable Waters
9 5/8" IN 13.5" Hole
3 ½" Tu
4 ½" Frac String
Downh
Deploy
Valv
Liner
Hanger
Packer
4.5" Liner
Perforation Cluste

North Dakota Oil Production and Price

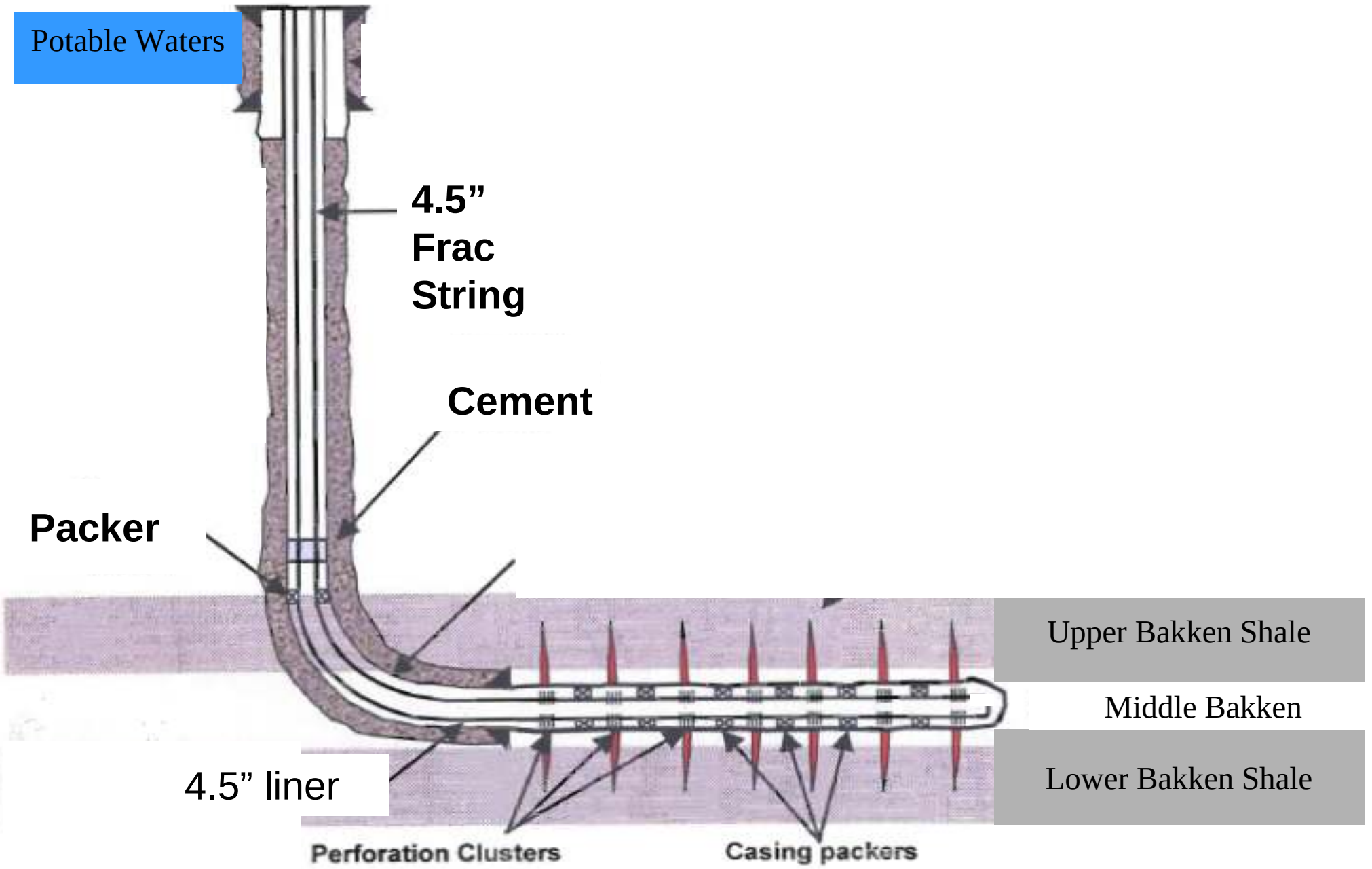


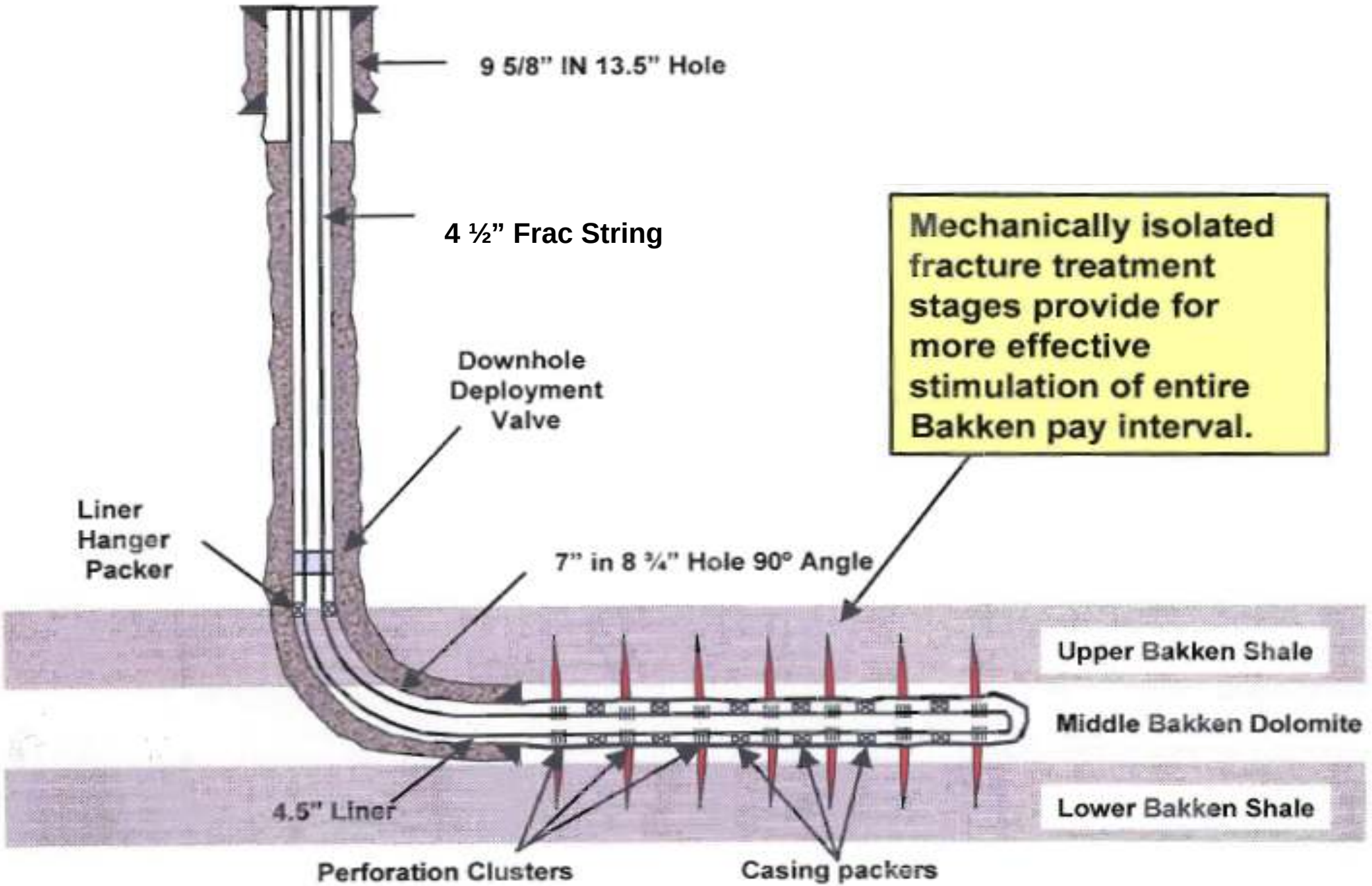
1,734 Bakken and Three Forks wells drilled and completed

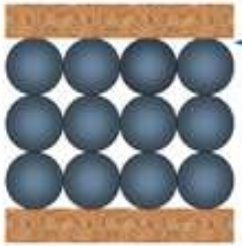
20,000 potential new wells possible in thermal mature area

4.9 to 7.2 billion barrels = $350 – 500 billion

TYPICAL HORIZONTAL OIL WELL

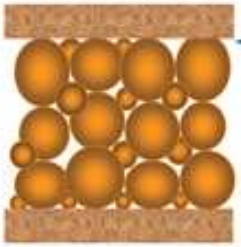



9 5/8" IN 13.5" Hole
4 ½" Frac String
Mechanically isolated fracture treatment stages provide for more effective stimulation of entire Bakken pay interval.
Downhole Deployment Valve
Liner Hanger Packer
7" in 8 ¾" Hole 90° Angle
Upper Bakken Shale
Middle Bakken Dolomite
Lower Bakken Shale
4.5" Liner
Perforation Clusters
Casing packers



Ceramic Proppant Benefits

Uniform size and shape ceramic grains provide maximum porosity and allow more oil and gas to flow through the proppant pack.



Alternative Proppant

Broadly sieved and irregularly shaped proppants such as sand and resin coated sand pack more tightly, resulting in loss of fracture width and reduced conductivity.

ND Water Commission

61-04-02. Permit for beneficial use of water required. Any person, before commencing any construction for the purpose of appropriating waters of the state or before taking waters of the state from any constructed works, shall first secure a water permit from the state engineer ….

North Dakota has been regulating the full life cycle of hydraulic fracturing for decades

- The Industrial Commission regulates well permitting and construction
  - Assure that a minimum of 2 steel casings and 2 layers of cement are installed and tested between ground water and any fluids pumped into or produced from an oil and gas well.
- The Hydraulically Fractured formations are 6,000 to 8,000 feet below our fresh water formations.
  - Most formations between are impermeable shale, salt, and limestone

North Dakota has been regulating the full life cycle of hydraulic fracturing for decades

- Water Commission regulates water appropriations
  - Guards against ground water withdrawals exceeding recharge
- The Industrial Commission regulates well permitting and construction
  - Assure that a minimum of 2 steel casings and 2 layers of cement are installed and tested between ground water and any fluids pumped into or produced from an oil and gas well.
- The Health Department and local Emergency Managers
  - Clean up of any discharge to the environment
  - EPCRA (material safety data on any released chemicals).
- The Industrial Commission regulates flow back water collection and disposal
  - SDWA UIC Class II underground injection program

ND Industrial Commission

38-08-04. JURISDICTION OF COMMISSION. The commission has continuing jurisdiction and authority over all persons and property, public and private, necessary to enforce effectively the provisions of this chapter. The commission has authority, and it is its duty, to make such investigations as it deems proper to determine whether waste exists or is imminent or whether other facts exist which justify action by the commission. The commission has the authority:

1. To require:

a. Identification of ownership of oil or gas wells, producing leases, tanks, plants, structures, and facilities for the transportation or refining of oil and gas.

b. The making and filing with the industrial commission of all resistivity, radioactivity, and mechanical well logs and the filing of directional surveys if taken, and the filing of reports on well location, drilling, and production.

c. The drilling, casing, operation, and plugging of wells in such manner as to prevent the escape of oil or gas out of one stratum into another, the intrusion of water into oil or gas strata, the pollution of freshwater supplies by oil, gas, or saltwater, and to prevent blowouts, cavings, seepages, and fires.

North Dakota has been regulating the full life cycle of hydraulic fracturing for decades

- The Health Department and local Emergency Managers regulate
  - Clean up of any discharge to the environment
  - EPCRA (material safety data on any released chemicals)
- The chemicals used are found in things we encounter daily and are in very low concentrations when mixed and pumped

ND Water Commission

61-04-02. Permit for beneficial use of water required. Any person, before commencing any construction for the purpose of appropriating waters of the state or before taking waters of the state from any constructed works, shall first secure a water permit from the state engineer unless such construction or taking from such constructed works is for domestic or livestock purposes or for fish, wildlife, and other recreational uses or unless otherwise provided by law. However, immediately upon completing any constructed works for domestic or livestock purposes or for fish, wildlife, and other recreational uses, the water user shall notify the state engineer of the location and acre-feet [1233.48 cubic meters] capacity of such constructed works, dams, or dugouts. Regardless of proposed use, however, all water users shall secure a water permit prior to constructing an impoundment capable of retaining more than twelve and one-half acre-feet [15418.52 cubic meters] of water or the construction of a well from which more than twelve and one-half acre-feet [15418.52 cubic meters] of water per year will be appropriated. If a permit is not required of a landowner or the landowner's lessee to appropriate less than twelve and one-half acre-feet [15418.52 cubic meters] of water from any source for domestic or livestock purposes or for fish, wildlife, and other recreational uses, those appropriators may apply for water permits in order to clearly establish a priority date and the state engineer may waive any fee or hearing for such applications. An applicant for a water permit to irrigate need not be the owner of the land to be irrigated.

North Dakota has been regulating the full life cycle of hydraulic fracturing for decades

- Water Commission regulates water appropriations
  - Guards against ground water withdrawals exceeding recharge

Western North Dakota

- 1,050 to 2,700 wells / year = 2,000 expected
  - 85-225 rigs = 10,000 – 27,000 jobs = 21,000 expected
- 10 - 25 million gallons frac water / day
  - Equal to 1” of water from Lake Sakakawea / yr
- 10 to 20 years
  - 28,000 new wells expected = ±28,000 long term jobs

ND Department of Health

23-33-04. Chemical use data and confidentiality requirement. The department may require chemical use data from product registrants on products that have been or may likely be found in ground water in order to conduct its ground water protection program. This information must include chemical registration data and sales information. The department shall keep this information confidential.

23-33-05. Ground water standards. The department shall establish standards for compounds in ground water as set forth by other states and the United States environmental protection agency unless new scientifically confirmed data provides justification for changing these standards.

23-33-06. Ground water quality monitoring. The department shall conduct ground water quality monitoring activities in cooperation with the state engineer and other state agencies. monitoring results, the department shall implement or require appropriate mitigation activities or remedial action to prevent future contamination of ground water. The commissioner may implement or require appropriate mitigation activities pursuant to chapter 4-35 to prevent future contamination of ground water as it relates to the use of pesticides.

Build Section

23-33-07. Notification requirement. Any person with verifiable information on the presence of contamination of ground water within the state shall notify the department regarding such contamination.

33-16-02.1-11. Discharge of wastes. Following are general requirements for all waste discharges or chemical additions:

4. Any spill or discharge of waste which causes or is likely to cause pollution of waters of the state must be reported immediately. The owner, operator, or person responsible for a spill or discharge must notify the department as soon as possible (701-328-5210) or the North Dakota hazardous materials emergency assistance and spill reporting number (1-800-472-2121) and provide all relevant information about the spill. Depending on the severity of the spill or accidental discharge, the department may require the owner or operator to:

a. Take immediate remedial measures;

b. Determine the extent of pollution to waters of the state;

c. Provide alternate water sources to water users impacted by the spill or accidental discharge; or

d. Any other actions necessary to comply with this chapter.

- EPCRA was passed in response to concerns regarding the environmental and safety hazards posed by the storage and handling of toxic chemicals. These concerns were triggered by the disaster in Bhopal, India, in which more than 2,000 people suffered death or serious injury from the accidental release of methyl isocyanate. To reduce the likelihood of such a disaster in the United States, Congress imposed requirements on both states and regulated facilities.
- **Key Provisions of the Emergency Planning and Community Right-to-Know Act**
- **Sections 301 to 303. Emergency Planning** Local governments are required to prepare chemical emergency response plans, and to review plans at least annually. State governments are required to oversee and coordinate local planning efforts. Facilities that maintain Extremely Hazardous Substances (EHSs) on-site in quantities greater than corresponding Threshold Planning Quantities (TPQs) must cooperate in emergency plan preparation.
- **Section 304. Emergency Notification** Facilities must immediately report accidental releases of EHS chemicals and "hazardous substances" in quantities greater than corresponding Reportable Quantities (RQs) defined under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to state and local officials. Information about accidental chemical releases must be available to the public.
- **Sections 311 and 312. Community Right-to-Know Requirements** Facilities manufacturing, processing, or storing designated hazardous chemicals must make Material Safety Data Sheets (MSDSs) describing the properties and health effects of these chemicals available to state and local officials and local fire departments. Facilities must also report, to state and local officials and local fire departments, inventories of all on-site chemicals for which MSDSs exist. Information about chemical inventories at facilities and MSDSs must be available to the public.
- **Section 313. Toxics Release Inventory** Facilities must complete and submit a Toxic Chemical Release Inventory Form annually for each of the more than 600 Toxic Release Inventory (TRI) chemicals that are manufactured or otherwise used above the applicable threshold quantities.
- **Section 322 Trade Secrets** Facilities are allow to withhold the specific chemical identity from the reports filed under sections 303, 311, 312 and 313 of EPCRA if the facilities submit a claim with substantiation to EPA.

North Dakota has been regulating the full life cycle of hydraulic fracturing for decades

- The Industrial Commission regulates flow back water collection and disposal
  - Storage in open pits is not allowed
  - Disposal wells are regulated under the SDWA UIC Class II underground injection program
  - The disposal formation is approximately 2,500 feet below our fresh water zones
    - The formations between are impermeable shale

43-02-03-19.2. DISPOSAL OF WASTE. All waste associated with exploration or production of oil and gas must be properly disposed of in an authorized facility in accord with all applicable local, state, and federal laws and regulations. This is not to be construed as requiring the offsite disposal of drilling mud or drill cuttings associated with the drilling of a well. However, top water remaining in the reserve pit used in the drilling and completion operations is to be removed from the reserve pit and disposed of in an authorized disposal well or used in a manner approved by the director. The disposition or use of the water must be included on the sundry notice (form 4) reporting the plan of reclamation pursuant to section 43-02-03-19.

43-02-03-19.3 EARTHEN PITS AND OPEN RECEPTACLES. Except as otherwise provided in section 43-02-03-19, no saltwater, drilling mud, crude oil, waste oil, or other waste shall be stored in earthen pits or open receptacles except in an emergency and upon approval by the director. An earthen pit or open receptacle may be temporarily used to retain oil, water, or fluids generated in well servicing or plugging operations. A pit or receptacle used for this purpose must be sufficiently impermeable to provide adequate temporary containment of the oil, water, or fluids. The contents of the pit or receptacle must be removed within seventy-two hours after operations have ceased and must be disposed of at an authorized facility in accordance with section 43-02-03-19.2. The director may permit pits or receptacles used solely for the purpose of flaring casinghead gas. A pit or receptacle used for this purpose must be sufficiently impermeable to provide adequate temporary containment of fluids. Permission for such pit or receptacle will be conditioned on keeping it free of any saltwater, crude oil, waste oil, or other waste. Saltwater, drilling mud, crude oil, waste oil, or other waste shall be removed from the pit or receptacle within twenty-four hours after being discovered and must be disposed of at an authorized facility in accordance with section 43-02-03-19.2.