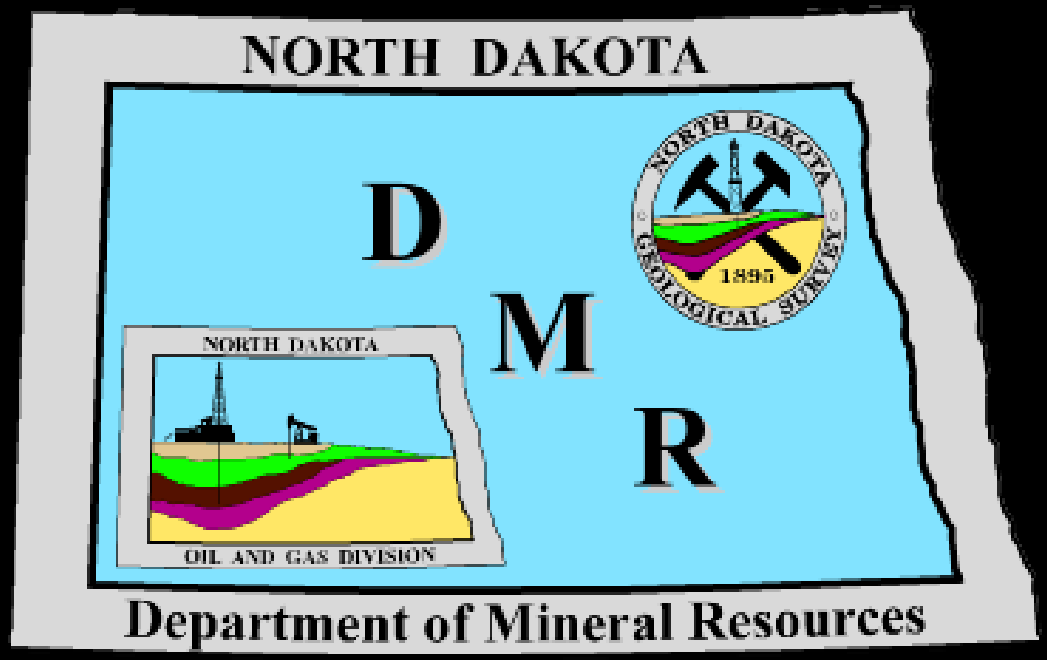
Lynn Helms

Director, Department of Mineral Resources

North Dakota Industrial Commission

UNITED STATES

North Dakota Department of Mineral Resources

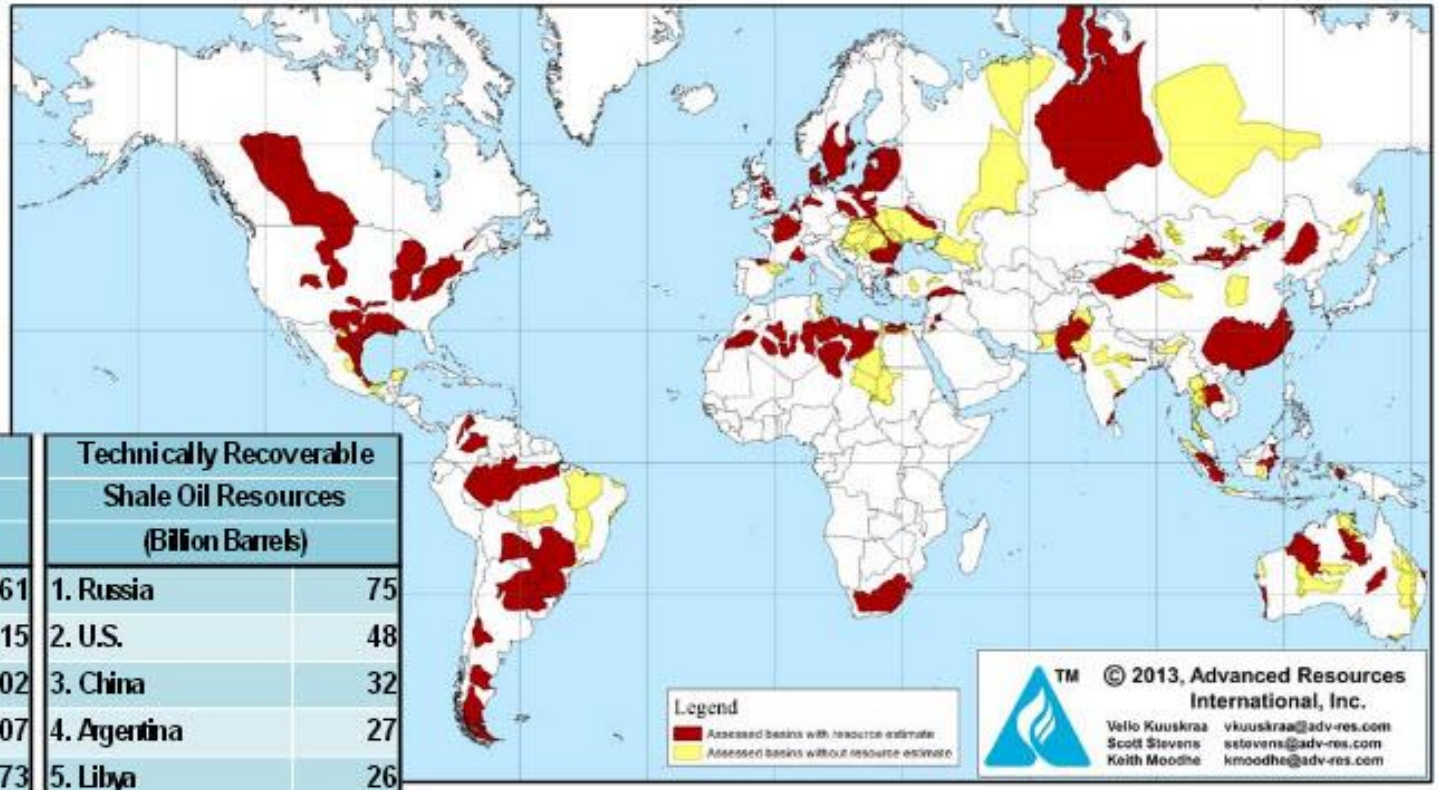


http://www.oilgas.nd.gov

http://www.state.nd.us/ndgs

600 East Boulevard Ave. - Dept 405
Bismarck, ND 58505-0840
(701) 328-8020 (701) 328-8000

Source: U.S. Energy Information Administration based on data from various published studies. Canada and Mexico plays from ARI.
Updated: May 9, 2011



Technically Recoverable Shale Gas Resources (Tcf)	
1. U.S.	1,161
2. China	1,115
3. Argentina	802
4. Algeria	707
5. Canada	573
6. Mexico	545
7. Australia	437
8. South Africa	390
9. Russia	285
10. Brazil	245
11. Others	1,535
TOTAL	7,795

Technically Recoverable Shale Oil Resources (Billion Barrels)	
1. Russia	75
2. U.S.	48
3. China	32
4. Argentina	27
5. Libya	26
6. Australia	18
7. Venezuela	13
8. Mexico	13
9. Pakistan	9
10. Canada	9
11. Others	65
TOTAL	335

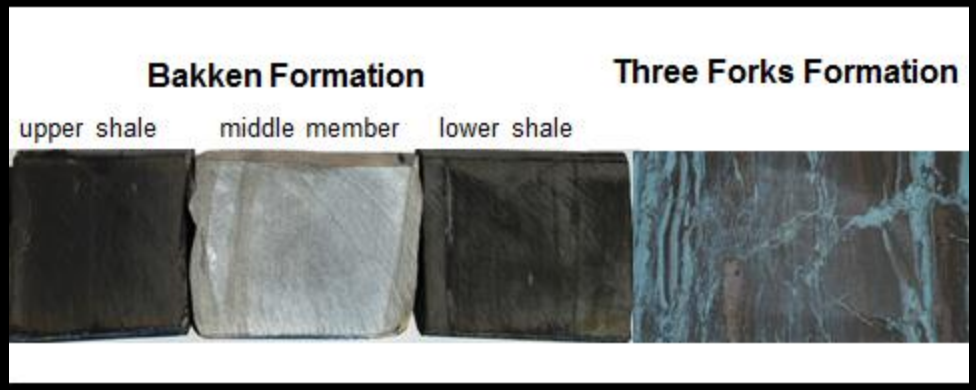
Hydraulic Fracturing
Lifeline to Shale Energy

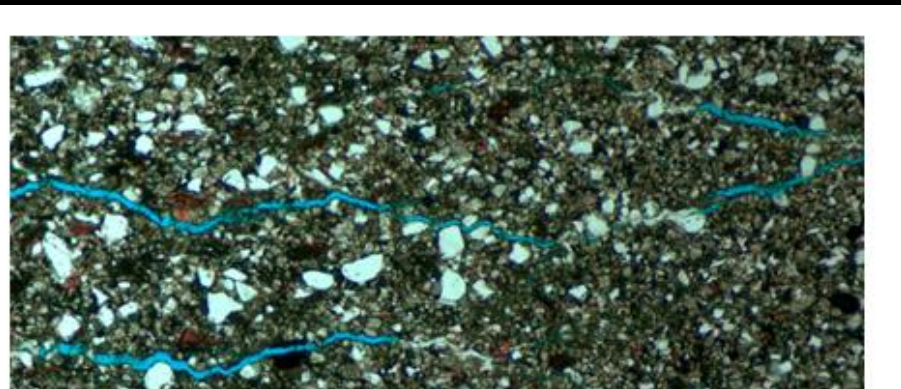
Hydraulic Fracturing

- **Why**
- **How**
- **Risks and Regulations**

Hydraulic Fracturing
Lifeline to Shale Energy

- **Why**
  - **Onshore oil and gas that flow without fracturing are already developed**
  - **Unconventional Reserves**
    reservoirs are tight (look at pictures)
    uneconomic production rate without fracing
    must create a path for oil to flow



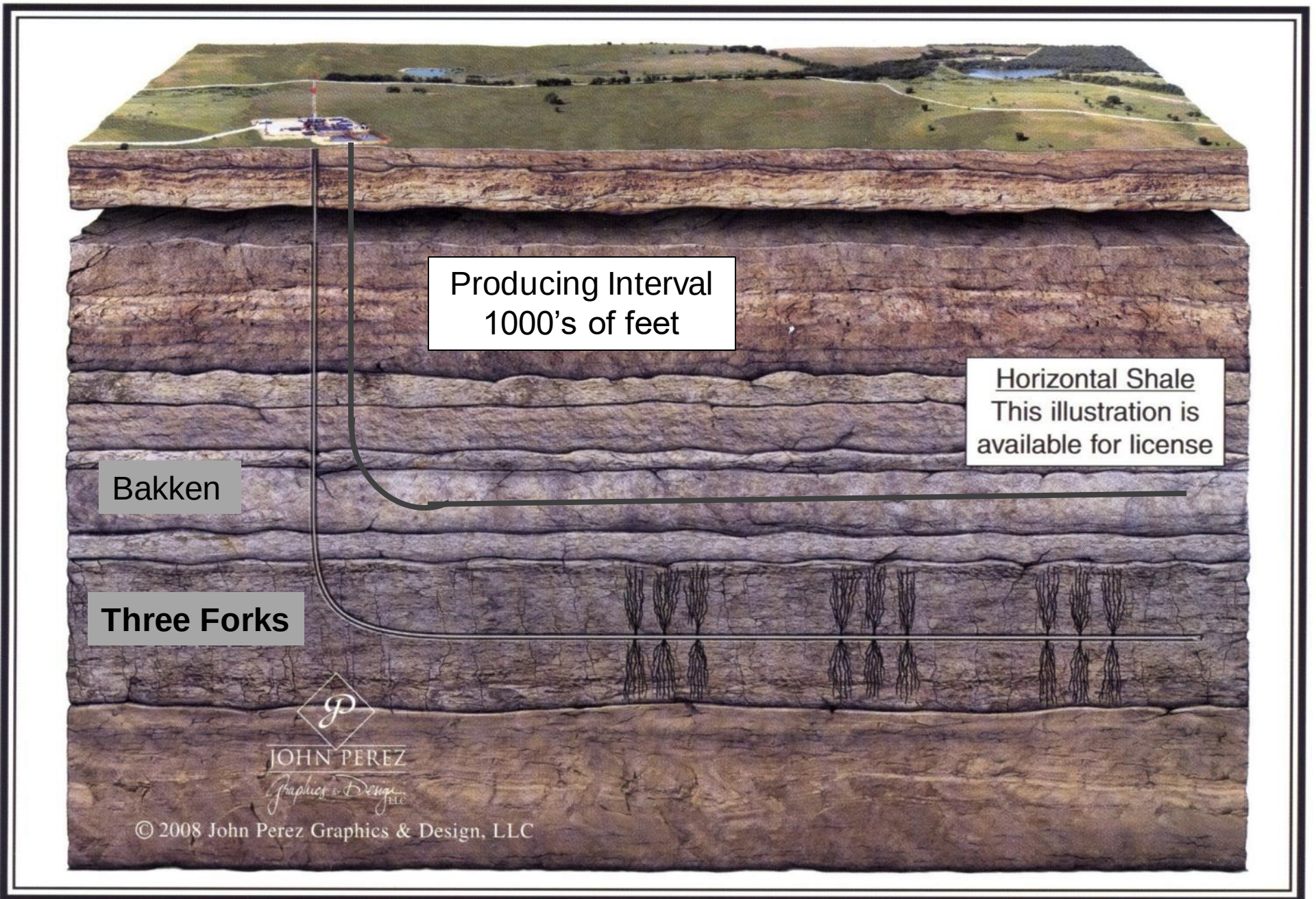


Hydraulic Fracturing
Lifeline to Domestic Energy

Hydraulic Fracturing

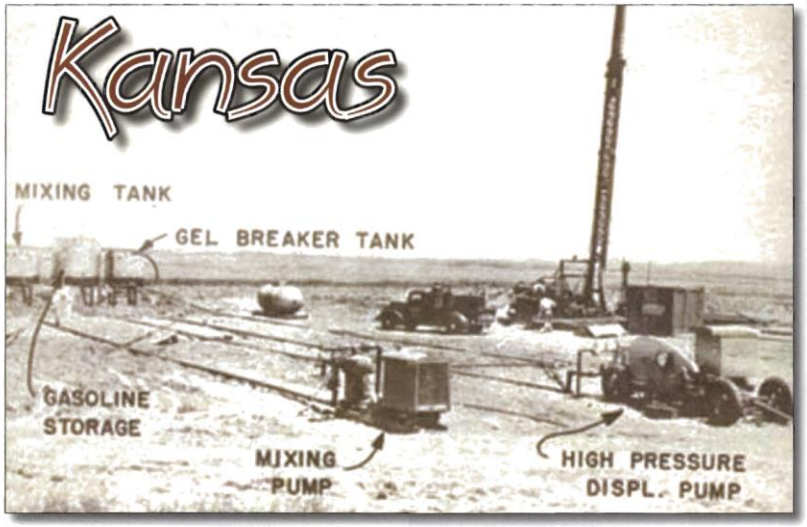
- **How**

5) Technology = horizontal well + multi stage hydraulic fracturing



Drilling Voyager Oil Gas.flv

The 6½ minute horizontal drilling/hydraulic fracturing video is available to download for free from this web site (you will need Real Player to view it).
http://www.voyageroil.com/drilling



The first hydraulic fracturing stimulation was at Hugoton Field in 1947

"1,000 gallons of thickened gasoline and sand from the Arkansas River."

As shown in this historic photograph, the first hydraulic fracture treatment was performed by Halliburton under license to Stanolind Oil Company on March 17, 1949, east of Duncan, Ok. Hydraulic fracturing has since allowed commercial hydrocarbon recovery from more than 1 million wells that could not have produced economically, and that number grows by the day, with nearly every U.S. gas well and the majority of all U.S. oil wells now being hydraulically fractured.

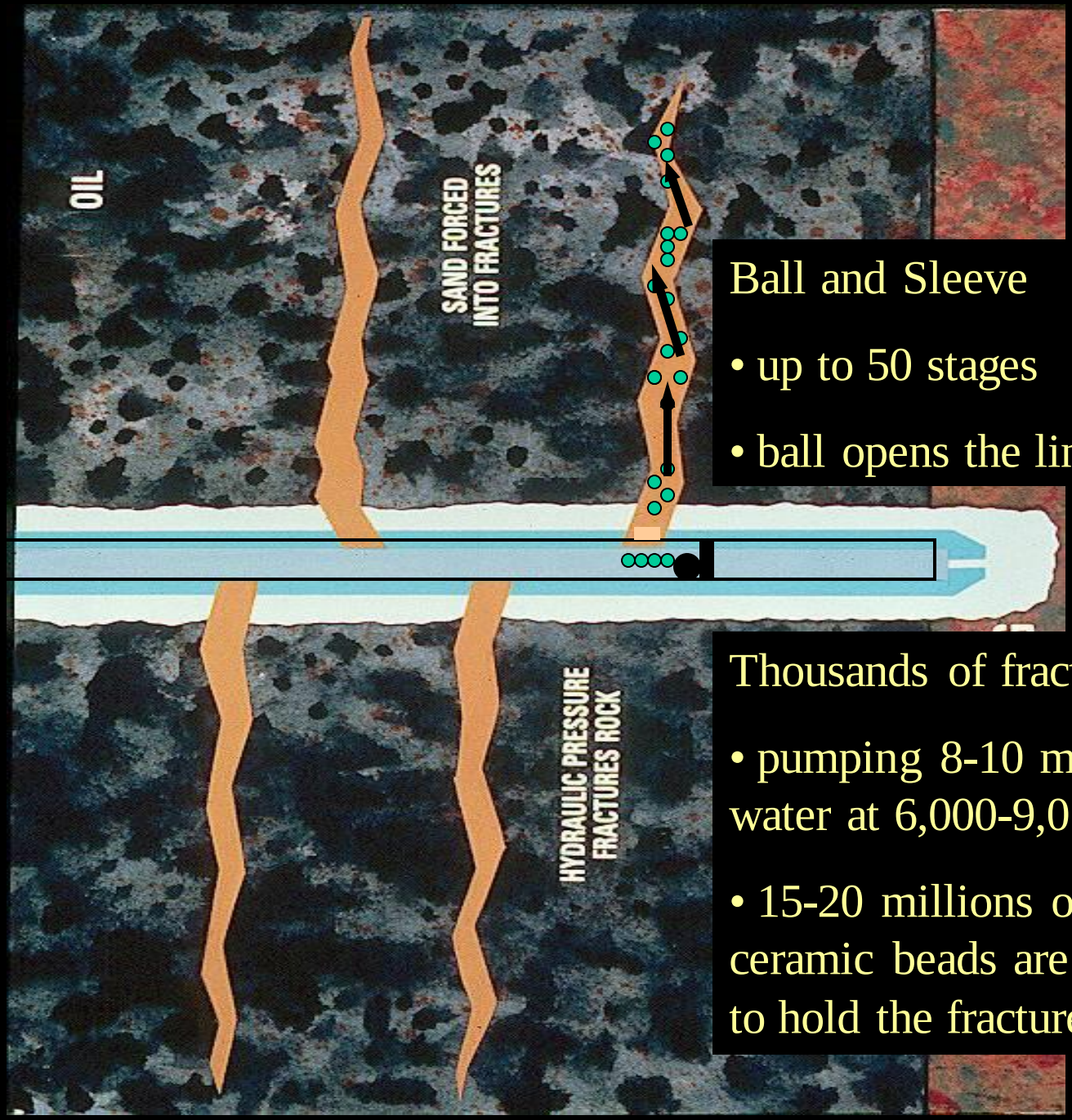
Not New

> 65 years

> 1 million wells fractured

Greatly Improved

Performing hydraulic fracture stimulation south of Tioga
- all Bakken wells must be hydraulically fractured to produce
- 2-4 million gallons of water
- 3-5 million pounds of sand and ceramic
- cost $2-5 million

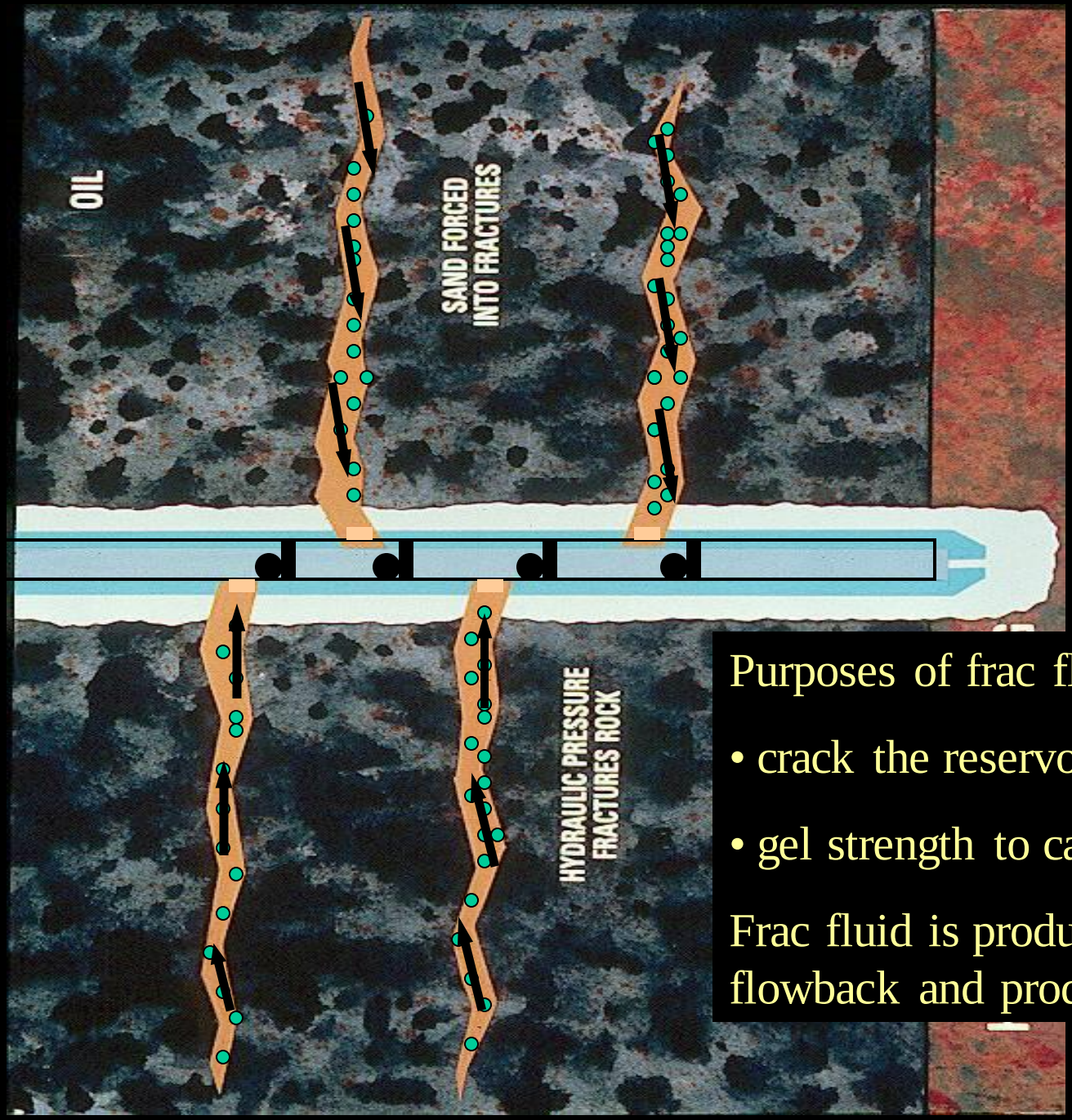


Ball and Sleeve

- up to 50 stages
- ball opens the liner sleeve

Thousands of fractures are created

- pumping 8-10 million gallons of water at 6,000-9,000 psi
- 15-20 millions of pounds of sand and ceramic beads are added to the water to hold the fractures open.



Purposes of frac fluid

- crack the reservoir
- gel strength to carry sand

Frac fluid is produced back as flowback and produced water

Hydraulic Fracturing
Lifeline to Shale Energy

Hydraulic Fracturing

- **Risks and Regulations**

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

- Geology of each sedimentary basin is different
- States Have Water Appropriation Regulations
  - North Dakota Water Commission
- States Have Oil & Gas Regulations
  - North Dakota Industrial Commission
- States Have Health and Environmental Regulations
  - North Dakota Health Department

FOUR AREAS OF RISK
&
HOW WE MANAGE THEM

- Sustainability of water supply
- Geology of confining zones
- Well bore construction
- Chemicals and flow back water handling

Unconventional Resource Wells are Thirsty

In North Dakota

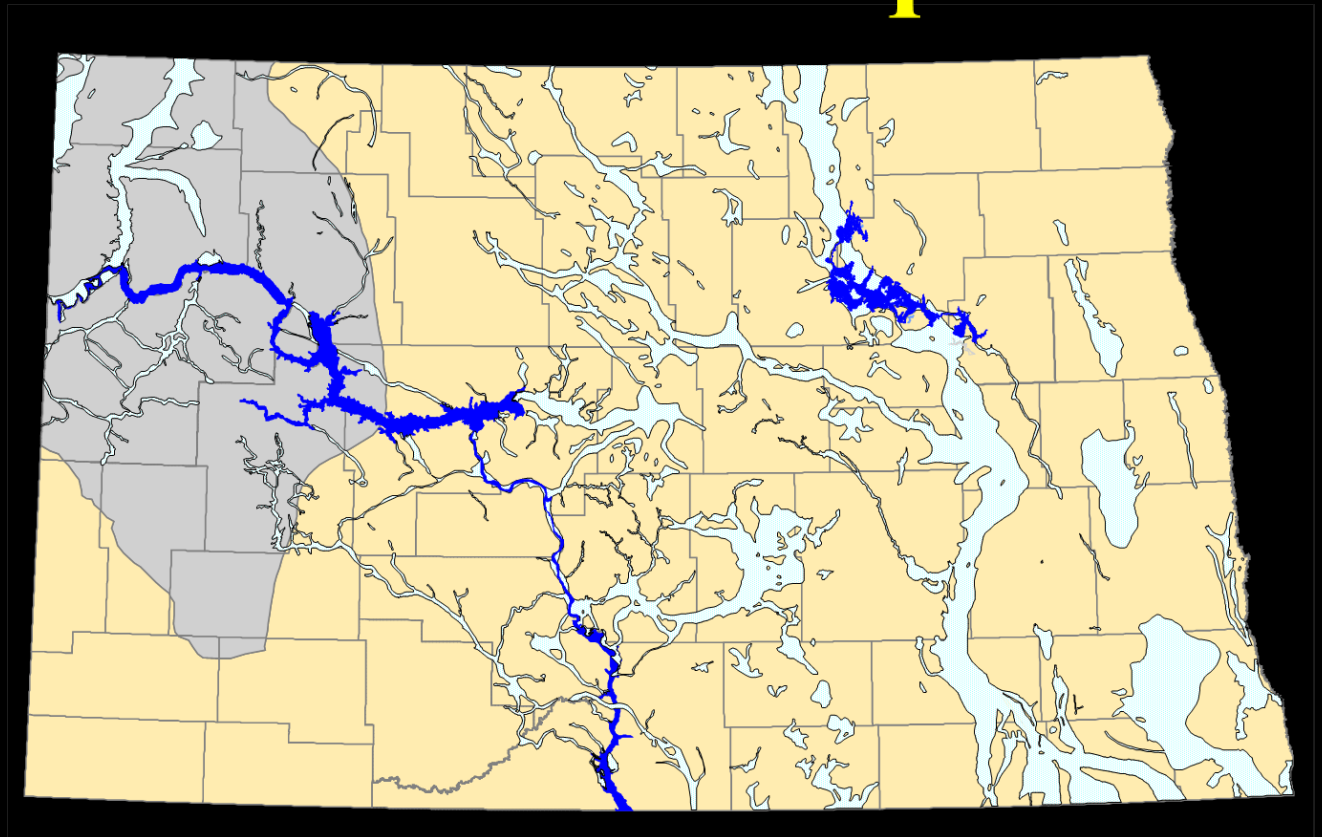
- **2,000 - 3,000 wells / year**
- **20 - 30 million gallons water / day**
- **15 - 25 years duration**

Water Commission

Regulate water appropriations

Guard against withdrawals >> recharge

Glacial Drift Aquifers



Frac Water Needs ± 20-30 million gallons per day

Ground water maximum ±7 million gallons per day

Lake Sakakawea (Missouri River) is the most sustainable water resource

- **one inch contains ±10 billion gal water**
  - **enough to fracture 2,500-5,000 wells**
  - **approximately ±10 million gallons per minute flows into and out of Lake Sakakawea**

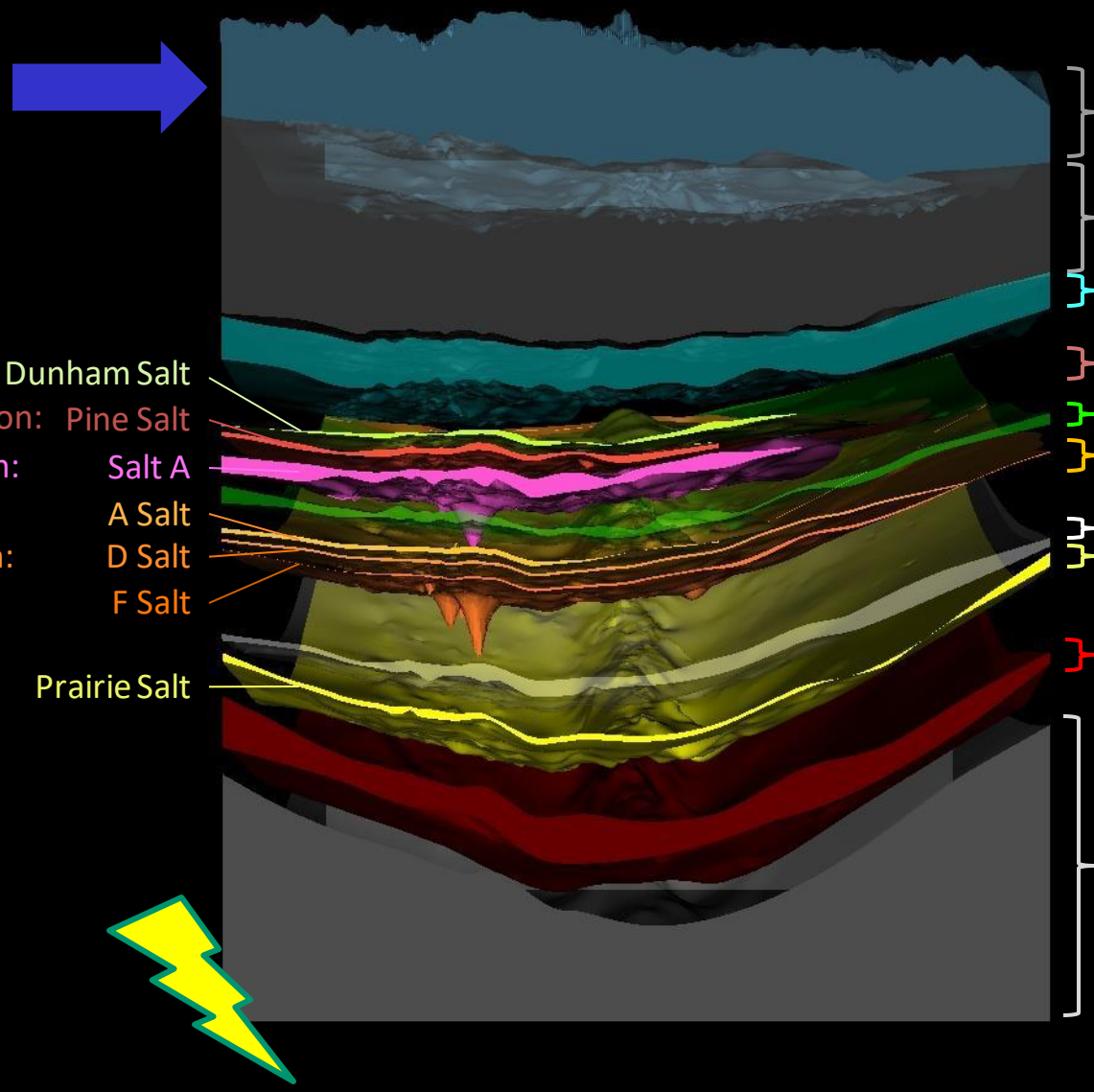
FOUR AREAS OF RISK
&
HOW WE MANAGE THEM

- Sustainability of water supply
- Geology of confining zones
- Well bore construction
- Chemicals and flow back water handling

The properties of geologic confining zone(s) can be determined by science:

- **Minimum thickness**
- **Maximum pressure**
- **Vertical fracture height**

Sedimentary Rocks of Western North Dakota

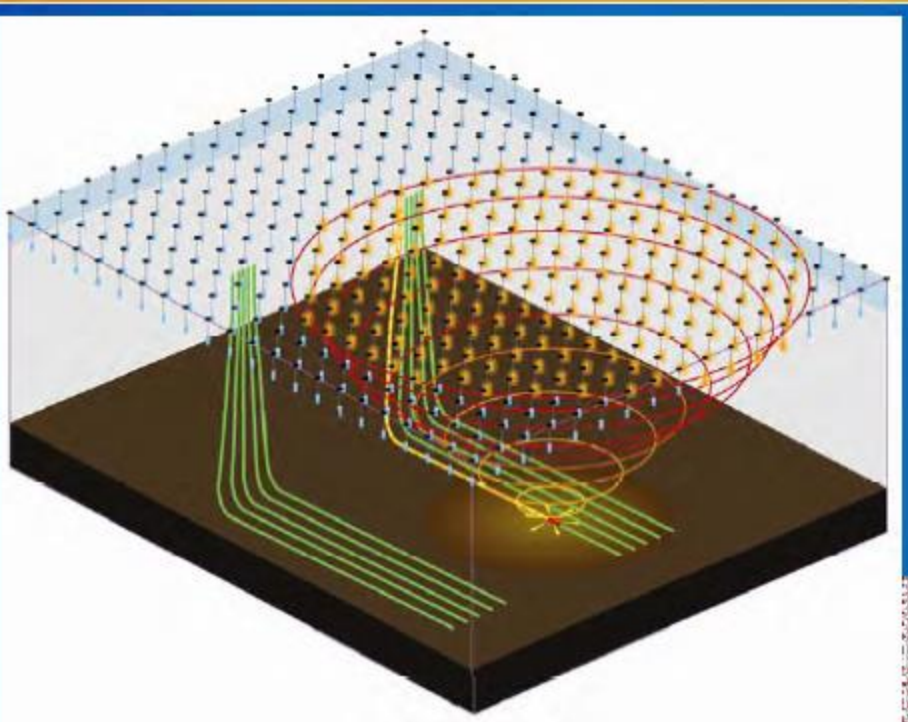


Piper Formation: Dunham Salt
Spearfish Formation: Pine Salt
Opeche Formation: Salt A
A Salt
Charles Formation: D Salt
F Salt
Prairie Formation: Prairie Salt

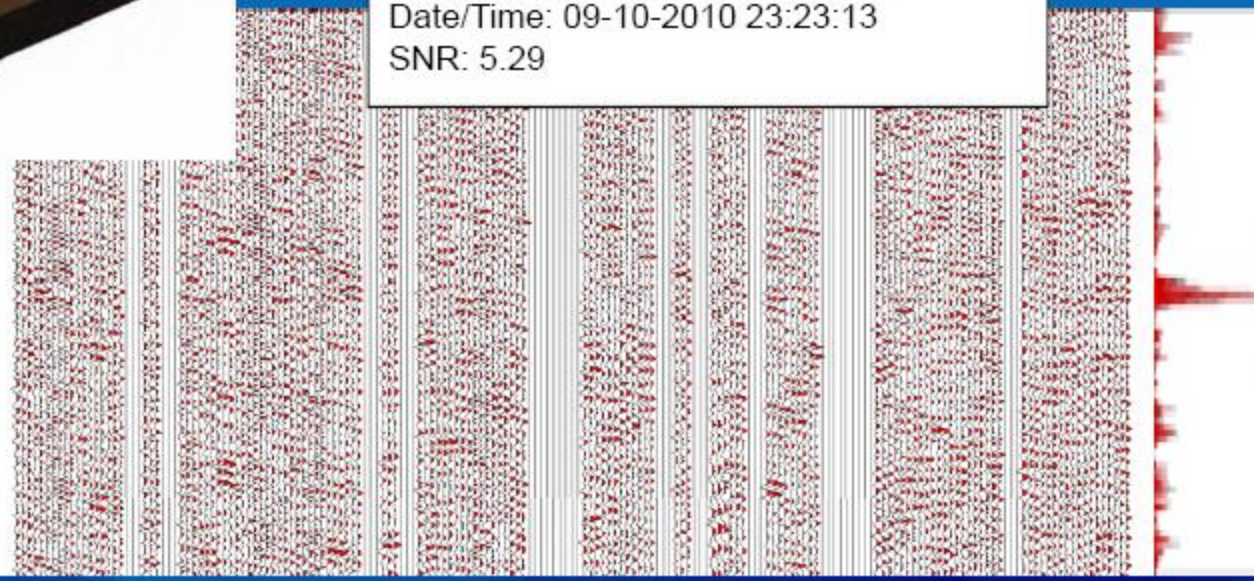
Fresh Water Zone
Shallow Gas Zone
Dakota Group
Spearfish Formation
Tyler Formation
Madison Group
Bakken-Three Forks
Prairie Formation
Red River Formation
Precambrian Basement

Fresh water
Disposal
Shale Formations
Seismic zones

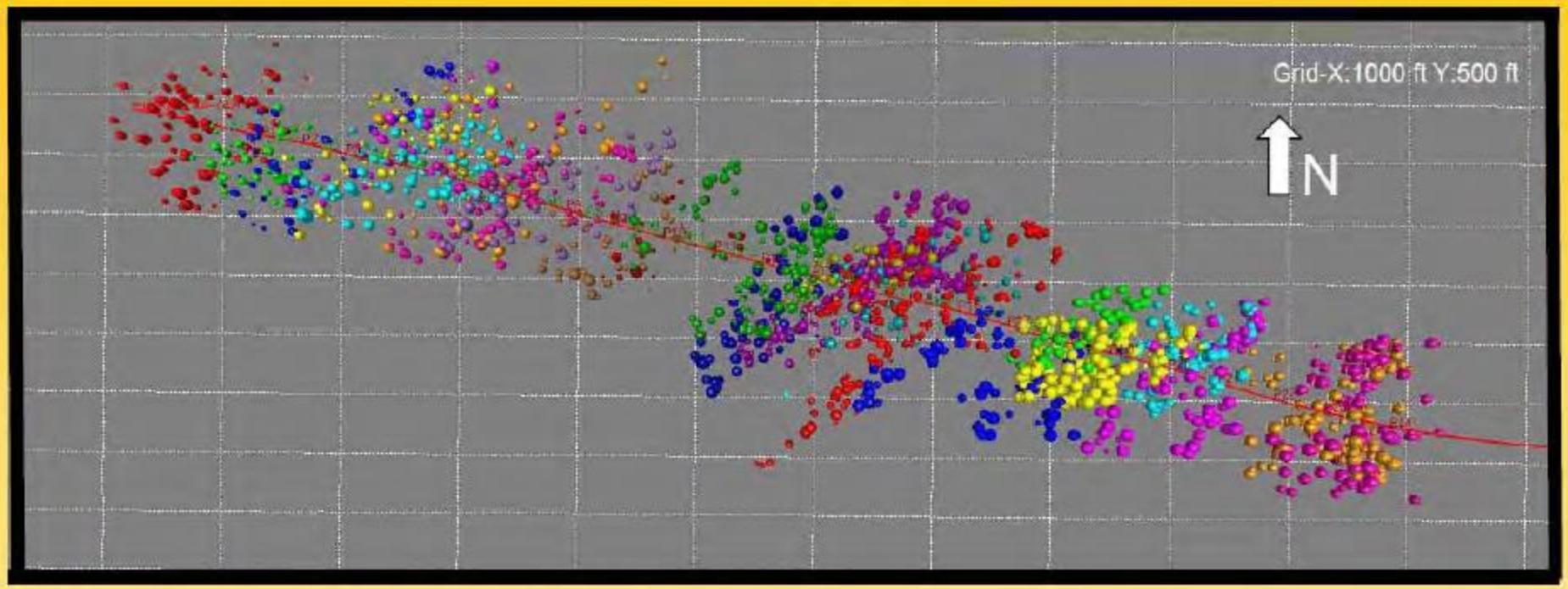
PSET Imaging



Microseismic events are imaged via PSET, a migration based imaging algorithm.



"Excellent 'frac saturation'…."

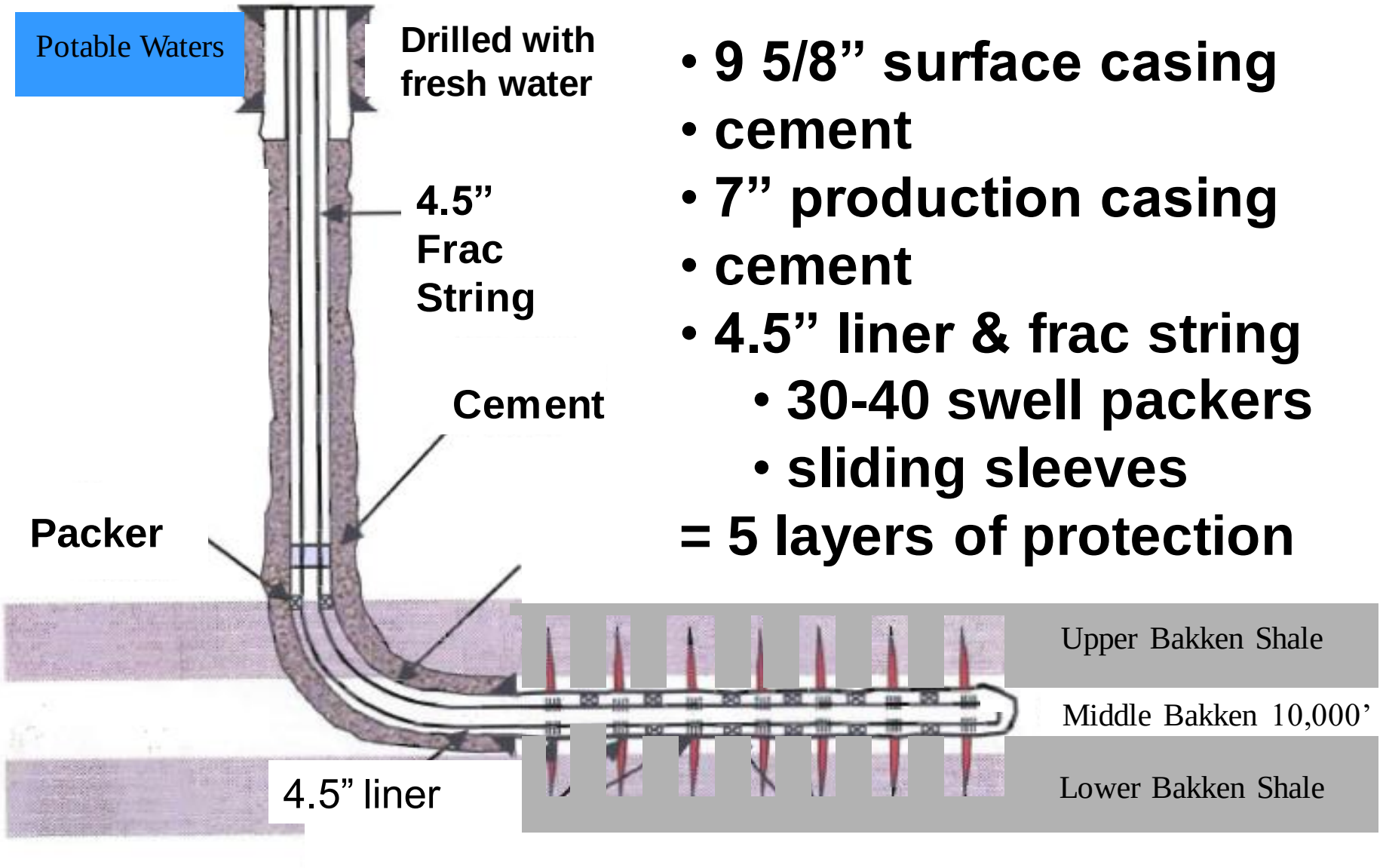


- **24-Stage Frac / IP: 2,558 BOE/D**
- **Excellent "frac saturation" evidenced by minimal gaps of unfraced rock along the wellbore with some stages impacting the same rock volume.**
- **Minimal gaps along NE trending natural fractures where the frac follows large regionally extensive fractures. These areas already have good naturally occurring fractures.**
- **Lateral frac wings that average 750' on either side of the wellbore. This is consistent with our other fracs and planned spacing pattern for full field development.**

FOUR AREAS OF RISK
HOW WE MANAGE THEM

- Sustainability of water supply
- Geology of confining zones
- Well bore construction
- Chemicals and flow back water handling

TYPICAL HORIZONTAL OIL WELL



- 9 5/8” surface casing
- cement
- 7” production casing
- cement
- 4.5” liner & frac string
  - 30-40 swell packers
  - sliding sleeves

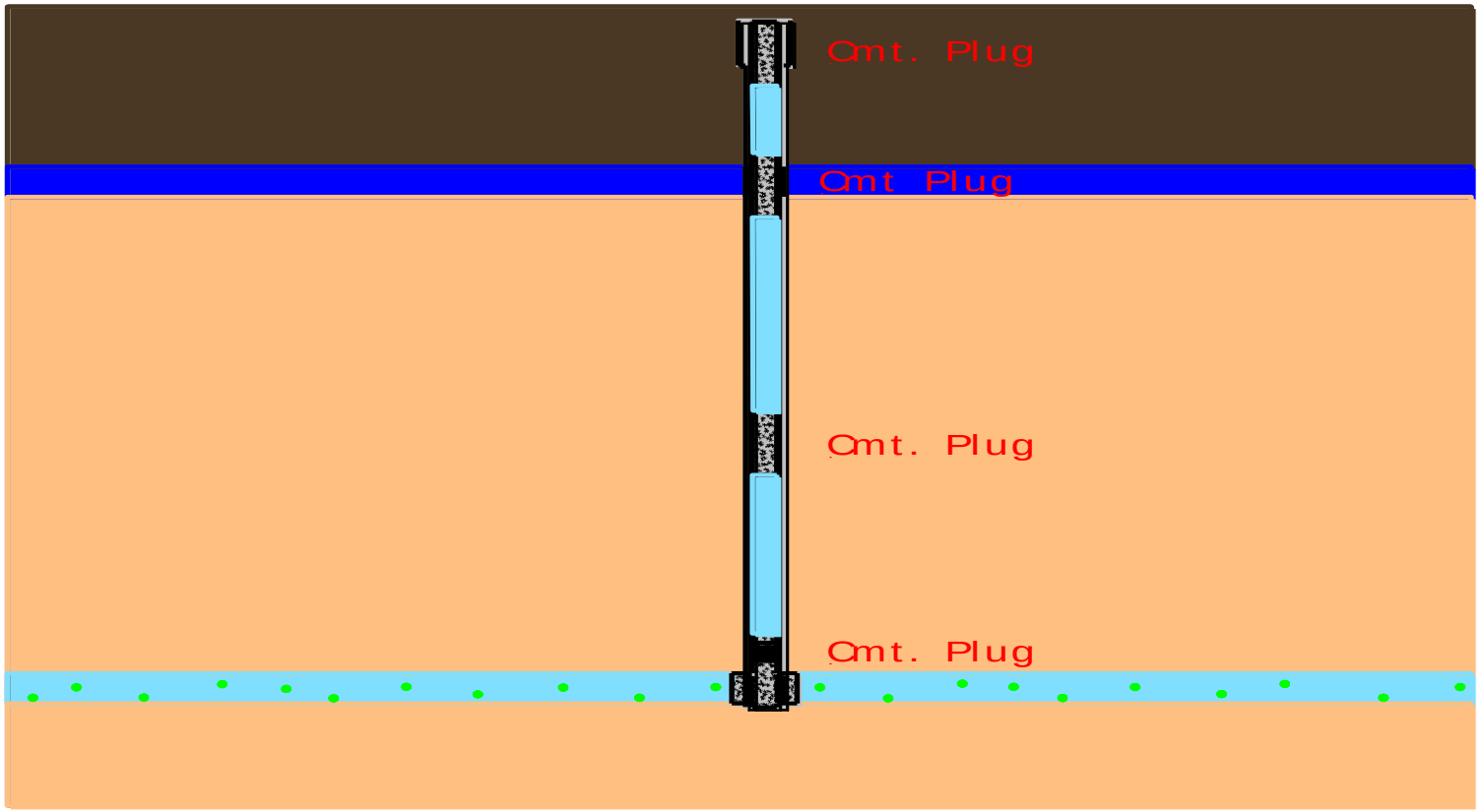
= 5 layers of protection

Industrial Commission Regulation

- Well construction for Hydraulic fracturing
  - Failure rate one well/month
- Collaborative rule making process
  - Two cemented casing strings required
    - Frac string liner considered best practice
  - Pressure testing and monitoring required
  - Casing and cement evaluation required
    - Failure rate is zero with these requirements
  - Well plugging and abandonment

PLUG AND ABANDON

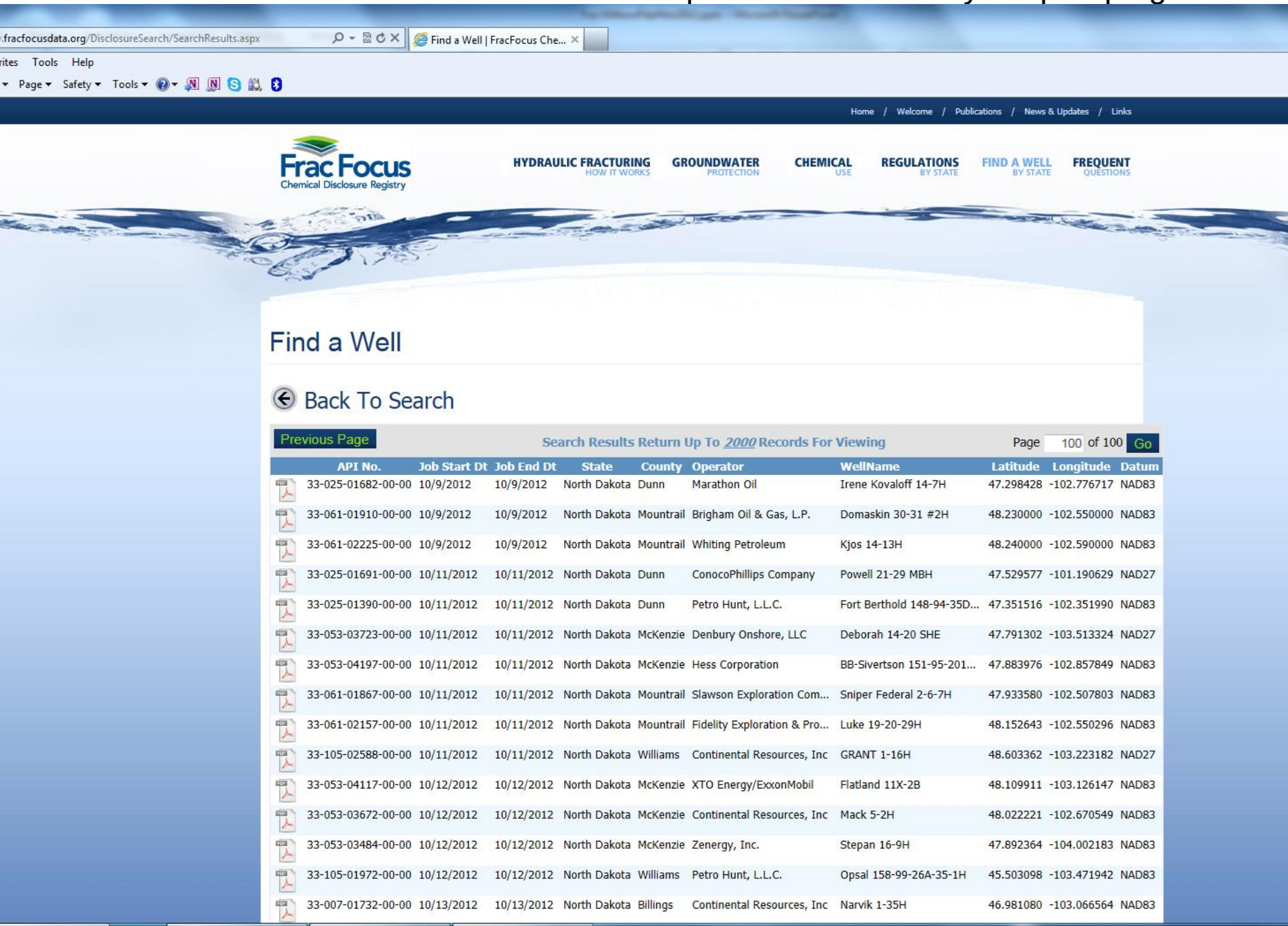
In North Dakota state inspectors witness every well plugging



FOUR AREAS OF RISK
HOW WE MANAGE THEM

- Sustainability of water supply
- Geology of confining zones
- Well bore construction
- Chemicals and flow back water handling

In North Dakota frac chemicals must be posted within 60 days of pumping



API No.	Job Start Dt	Job End Dt	State	County	Operator	WellName	Latitude	Longitude	Datum
33-025-01682-00-00	10/9/2012	10/9/2012	North Dakota	Dunn	Marathon Oil	Irene Kovaloff 14-7H	47.298428	-102.776717	NAD83
33-061-01910-00-00	10/9/2012	10/9/2012	North Dakota	Mountrail	Brigham Oil & Gas, L.P.	Domaskin 30-31 #2H	48.230000	-102.550000	NAD83
33-061-02225-00-00	10/9/2012	10/9/2012	North Dakota	Mountrail	Whiting Petroleum	Kjos 14-13H	48.240000	-102.590000	NAD83
33-025-01691-00-00	10/11/2012	10/11/2012	North Dakota	Dunn	ConocoPhillips Company	Powell 21-29 MBH	47.529577	-101.190629	NAD27
33-025-01390-00-00	10/11/2012	10/11/2012	North Dakota	Dunn	Petro Hunt, L.L.C.	Fort Berthold 148-94-35D...	47.351516	-102.351990	NAD83
33-053-03723-00-00	10/11/2012	10/11/2012	North Dakota	McKenzie	Denbury Onshore, LLC	Deborah 14-20 SHE	47.791302	-103.513324	NAD27
33-053-04197-00-00	10/11/2012	10/11/2012	North Dakota	McKenzie	Hess Corporation	BB-Sivertson 151-95-201...	47.883976	-102.857849	NAD83
33-061-01867-00-00	10/11/2012	10/11/2012	North Dakota	Mountrail	Slawson Exploration Com...	Sniper Federal 2-6-7H	47.933580	-102.507803	NAD83
33-061-02157-00-00	10/11/2012	10/11/2012	North Dakota	Mountrail	Fidelity Exploration & Pro...	Luke 19-20-29H	48.152643	-102.550296	NAD83
33-105-02588-00-00	10/11/2012	10/11/2012	North Dakota	Williams	Continental Resources, Inc	GRANT 1-16H	48.603362	-103.223182	NAD27
33-053-04117-00-00	10/12/2012	10/12/2012	North Dakota	McKenzie	XTO Energy/ExxonMobil	Flatland 11X-2B	48.109911	-103.126147	NAD83
33-053-03672-00-00	10/12/2012	10/12/2012	North Dakota	McKenzie	Continental Resources, Inc	Mack 5-2H	48.022221	-102.670549	NAD83
33-053-03484-00-00	10/12/2012	10/12/2012	North Dakota	McKenzie	Zenergy, Inc.	Stepan 16-9H	47.892364	-104.002183	NAD83
33-105-01972-00-00	10/12/2012	10/12/2012	North Dakota	Williams	Petro Hunt, L.L.C.	Opsal 158-99-26A-35-1H	45.503098	-103.471942	NAD83
33-007-01732-00-00	10/13/2012	10/13/2012	North Dakota	Billings	Continental Resources, Inc	Narvik 1-35H	46.981080	-103.066564	NAD83

In North Dakota frac chemicals must be posted within 60 days of pumping

Hydraulic Fracturing Fluid Product Component Information Disclosure

Last Fracture Date:	10/09/2012
State:	North Dakota
County:	Dunn
API Number:	33-025-01682
Operator Name:	Marathon Oil Company
Well Name and Number:	Irene Kovaloff 14-7H
Longitude:	-102.776717
Latitude:	47.298428
Long/Lat Projection:	NAD83
Production Type:	Oil
True Vertical Depth (TVD):	10,854
Total Water Volume (gal)*:	1,201,494

Hydraulic Fracturing Fluid Composition:

Trade Name	Supplier	Purpose	Ingredients	Chemical Abstract Service Number (CAS #)	Maximum Ingredient Concentration in Additive (% by mass)**	Maximum Ingredient Concentration in HF Fluid (% by mass)**	Comments
Water	Operator	Carrier	Water	7732-18-5	100.00%	77.31939%	
Alpha 452	Baker Hughes	Biocide	Tetrakis(hydroxymethyl) Phosphonium Sulfate	55566-30-8	60.00%	0.01346%	
Enzyme G-I	Baker Hughes	Breaker	Hemicellulase Enzyme Concentrate	9025-56-3	3.00%	0.00059%	SmartCare Product
			Water	7732-18-5	97.00%	0.01916%	
GBW-23L	Baker Hughes	Breaker	White Mineral Oil	8042-47-5	100.00%	0.04637%	
BF-9L, 300 gal tote	Baker Hughes	Buffer	Potassium Carbonate	584-08-7	60.00%	0.09013%	SmartCare Product
			Potassium Hydroxide	1310-58-3	30.00%	0.04507%	
XLW-30AG, tote	Baker Hughes	Crosslinker	Petroleum Distillates	64742-47-8	60.00%	0.03629%	SmartCare Product
XLW-32, 260 gal tote	Baker Hughes	Crosslinker	Boric Acid (H3BO3)	10043-35-3	30.00%	0.00292%	
			Methanol	67-56-1	60.00%	0.00584%	
			Methyl Borate	121-43-7	30.00%	0.00292%	
GW-3LDF	Baker Hughes	Gelling Agent	1-Butoxy-2-Propanol	5131-66-8	5.00%	0.02696%	SmartCare Product
			Cyrstalline Silica, Quartz (SiO2)	14808-60-7	5.00%	0.02696%	
			Guar Gum	9000-30-0	60.00%	0.32352%	
			Isotridecanol, ethoxylated	9043-30-5	5.00%	0.02696%	
			Paraffinic Petroleum Distillate	64742-55-8	30.00%	0.16176%	
			Petroleum Distillates	64742-47-8	30.00%	0.16176%	
NE-900, tote	Baker Hughes	Non-emulsifier	Methanol	67-56-1	30.00%	0.01160%	SmartCare Product
			Oxyalkylated Alkylphenol	9016-45-9	10.00%	0.00387%	
Sand, White, 20/40	Baker Hughes	Proppant	Crystalline Silica (Quartz)	14808-60-7	100.00%	18.58277%	
Sand, White, 40/70	Baker Hughes	Proppant	Crystalline Silica (Quartz)	14808-60-7	100.00%	2.81698%	
ScaleSorb 3, (50# bag)	Baker Hughes	Scale Inhibitor	Amino Alkyl Phosphonic Acid	Trade Secret	30.00%	0.00718%	SmartCare Product
			Crystalline Silica: Quartz (SiO2)	14808-60-7	1.00%	0.00024%	
			Diatomaceous Earth, Calcined	91053-39-3	100.00%	0.02393%	
			Phosphonic Acid	13598-36-2	1.00%	0.00024%	
GasFlo G2, 330 gal tote	Baker Hughes	Surfactant	Amphoteric Surfactant	Trade Secret	40.00%	0.01856%	SmartCare Product
Ingredients shown above are subject to 29 CFR 1910.1200(i) and appear on Material Safety Data Sheets (MSDS). Ingredients shown below are Non-MSDS.							
			2-Butoxy-1-Propanol	15821-83-7		0.0004313602%	
			Alkyl Benzenesulfonic Acid	68584-22-5		0.0004637457%	
			Boric Oxide	1303-86-2		0.0193521449%	
			Copolymer	Trade Secret		0.0154632947%	
			Crystalline Silica	14808-60-7		0.0004637457%	
			Formaldehyde	50-00-0		0.0000112208%	
			Magnesium Hydroxide	1309-42-8		0.0023187267%	
			Magnesium Oxide	1309-48-4		0.0009274915%	
			Magnesium Peroxide	14452-57-4		0.0013912372%	
			Methanol	67-56-1		0.0004637457%	
			Modified Amide	68442-77-3		0.0004637457%	
			Organophilic Clay	Trade Secret		0.0030237726%	
			Petroleum Distillates	64742-47-8		0.0004637457%	
			Polymeric Suspending Agent	Trade Secret		0.0030237726%	
			Propylene Carbonate	108-32-7		0.0004637457%	
			Quaternary Ammonium Compounds bis[Hydrogenated Tallow Alkyl] Dimethyl Salts With Bentonite	68953-58-2		0.0004637457%	
			Sodium Aryl Sulfonate	119345-04-9		0.0002244163%	
			Sodium Chloride	7647-14-5		0.0139303187%	
			Sodium Sulfate	7757-82-6		0.0000112208%	
			Surfactant	Trade Secret		0.0006047545%	
			Water	7732-18-5		0.1606138799%	

* Total Water Volume sources may include fresh water, produced water, and/or recycled water

** Information is based on the maximum potential for concentration and thus the total may be over 100%

Ingredient information for chemicals subject to 29 CFR 1910.1200(i) and Appendix D are obtained from suppliers Material Safety Data Sheets (MSDS)

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

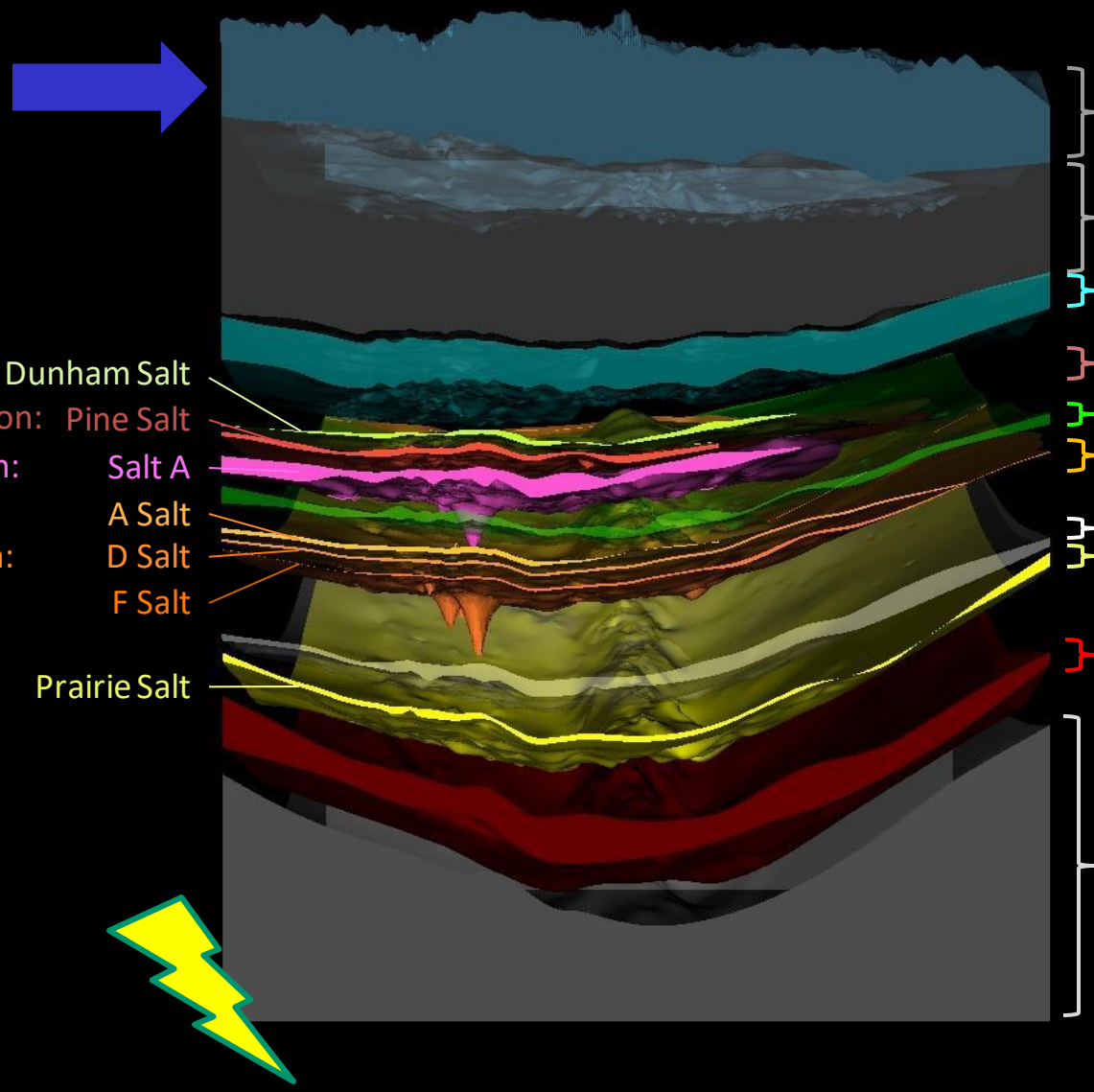
- Fresh **Water** – 80.5%
- Proppant – 19.0%
  - Allows the fractures to remain open so the oil and gas can escape
    - Drinking water filtration, **play ground sand**
- Acids - 0.12%
  - Help dissolve minerals and initiate fractures in rock (pre-fracture)
    - **Swimming pool cleaner**
- Petroleum 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

Industrial Commission Regulation

- Water flow back after frac
  - Storage in open pits prohibited
  - Disposal wells permitted through Underground Injection Program
  - Disposal zone is 1/2 mile below potable waters with impermeable shale between and >2 miles above seismic zone with many layers including salts between

Sedimentary Rocks of Western North Dakota



Piper Formation: Dunham Salt
Spearfish Formation: Pine Salt
Opeche Formation: Salt A
A Salt
Charles Formation: D Salt
F Salt
Prairie Formation: Prairie Salt

Fresh Water Zone
Shallow Gas Zone
Dakota Group
Spearfish Formation
Tyler Formation
Madison Group
Bakken-Three Forks
Prairie Formation
Red River Formation
Precambrian Basement

Fresh water
Disposal
Shale Formations
Seismic zones

The handling of flow back water can be carefully controlled:

- License truckers as waste haulers
  - Use GPS to track trucking
- Underground disposal zone(s) must be separated from drinking water and seismic zones
- Recycling of water must be encouraged

Health Department Regulation

- Cleanup of discharges to environment
- Coordinate with local Emergency Managers
- Emergency Planning and Community Right-to-know Act (EPCRA)

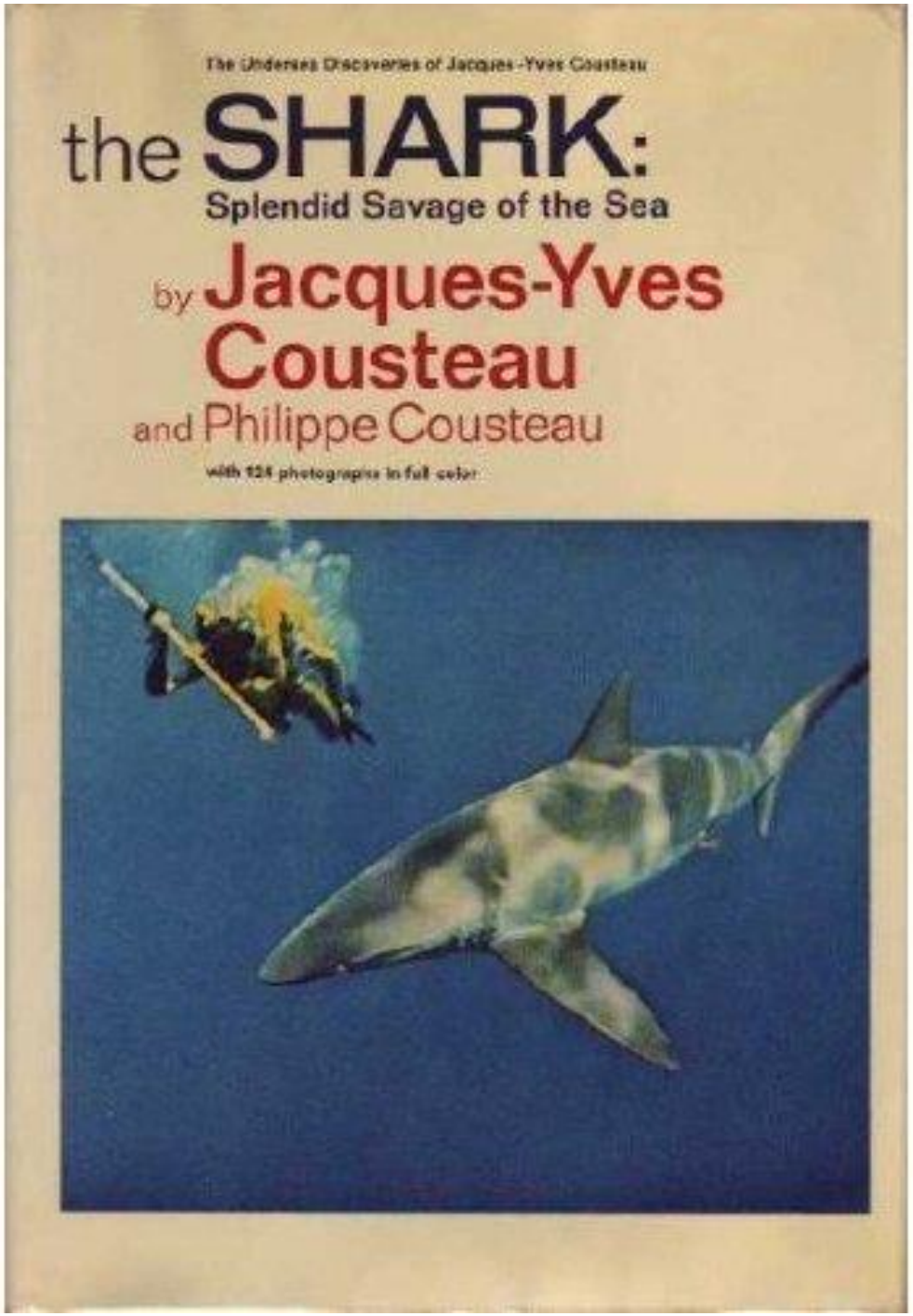
  Congress passed for storing and handling of chemicals

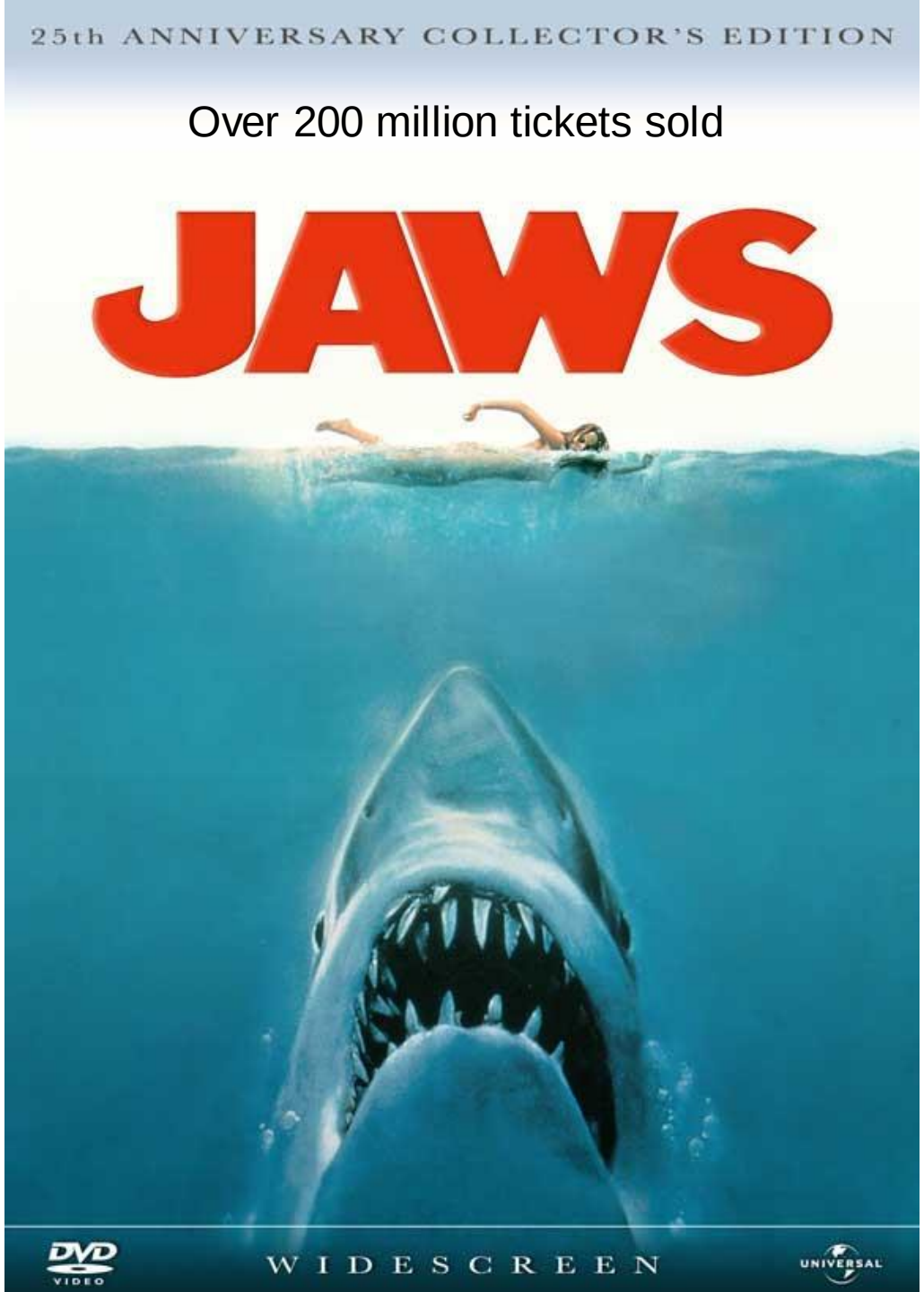
  Requires material safety data sheet (MSDS) for each chemical on location

1975

Two Movies

About 2.4 million viewers

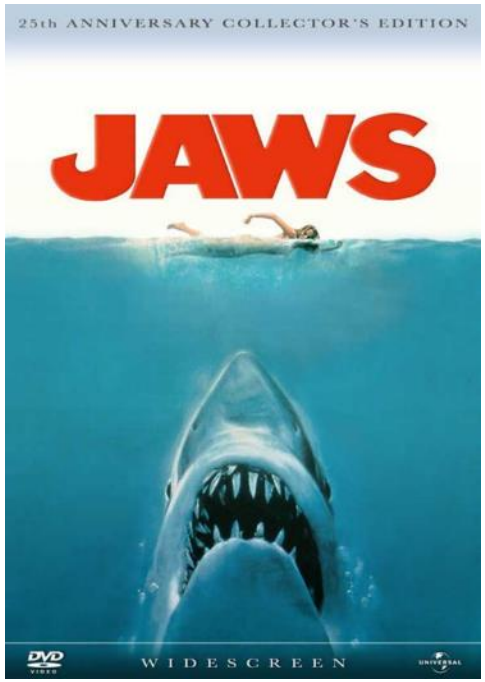


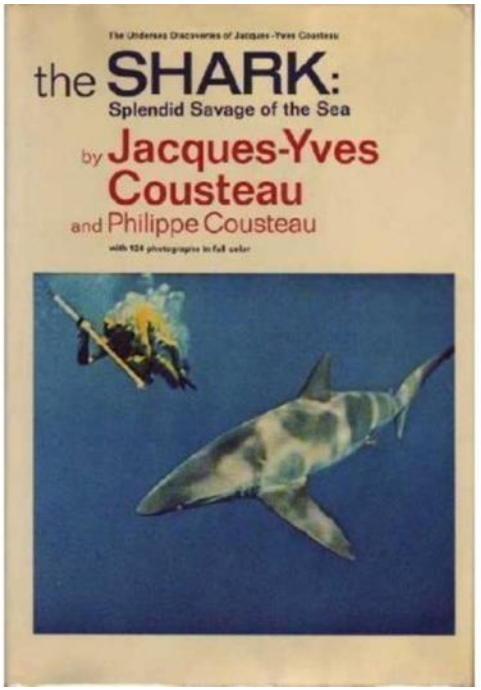


Over 200 million tickets sold

Which movie would you rather watch?

Which should guide how we manage sharks and beaches?



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