Fresh, Brackish or Saline Water for Hydraulic Fracs: What are the Options?

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Introduction

As part of the process for evaluating the type of water used in hydraulic fracturing, lets ask a few questions:

-Who is concerned about fresh, brackish and saline water?

- Why should anyone be concerned?

-What is important to understand?

-Where is it located?

-When do we need to know about it?

Purpose

The purpose of this presentation is to:

- visit the terms fresh, brackish and saline
- locate the major fresh and saline aquifers
- evaluate various aquifer water qualities
- summarize frac water quality parameters
- discuss groundwater usage
- cover spent frac water management

(in less than 15 minutes !)

Information Sources

- Records Research
- Well Log Review
- Published Reports
- Economic Data
- Public Records
- State Geologists
- Universities/Colleges
- GIS Mapping
- Private Data Bases
- Regulatory Agency
- Surface Geology
- Groundwater/Soil
- Appraisal/Real Est.
- USGS
- Federal Agencies

What is Salinity?

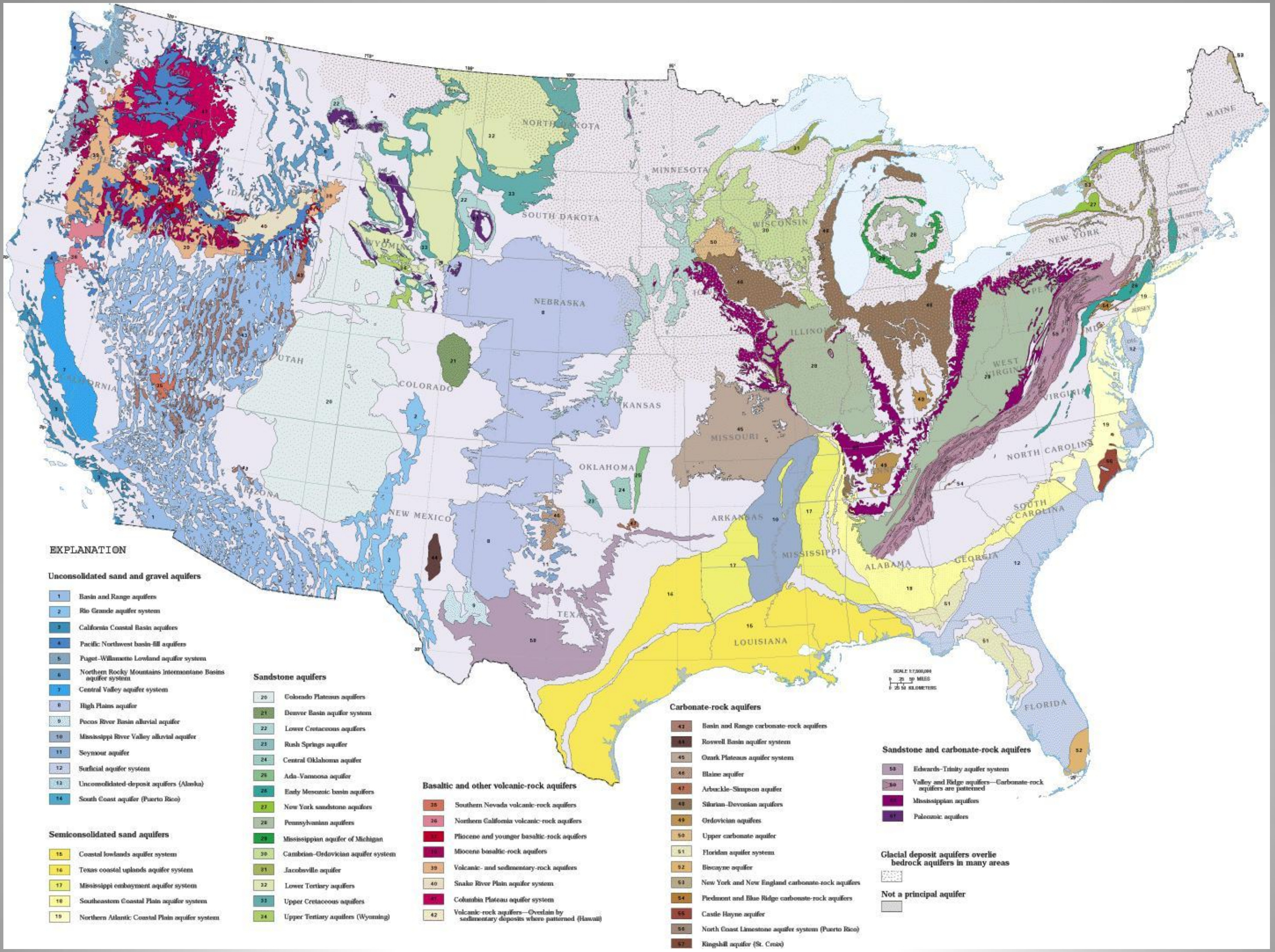
- Salinity refers to the amount of total dissolved solids (TDS) in the water and is frequently measured by electrical conductivity (EC), as ions dissolved in water conduct electricity and actual TDS analyses are expensive to conduct.

- Waters with higher TDS concentrations will be relatively conductive. TDS is measured in parts per million or mg/L and EC is measured in micro-Siemens per centimeter (µS/cm).

Water Terms for This Presentation

- A TDS concentration of 1,000 mg/L is a somewhat arbitrary upper limit of freshwater based on the suitability of water for human consumption. Although water with TDS greater than 1,000 mg/L is used for domestic supply in areas where water of lower TDS content is not available, water containing more than 3,000 mg/L is generally too objectionable to drink. Water with a TDS concentration less than 3,000 mg/L can be considered **fresh water.**
- Water from 3,000-10,000 Mg/L TDS will be considered **brackish**
- Water in excess of 10,000 Mg/L will be considered **saline.**
- Ground water with salinity greater than seawater (about 35,000 mg/L) is typically referred to as **brine.**

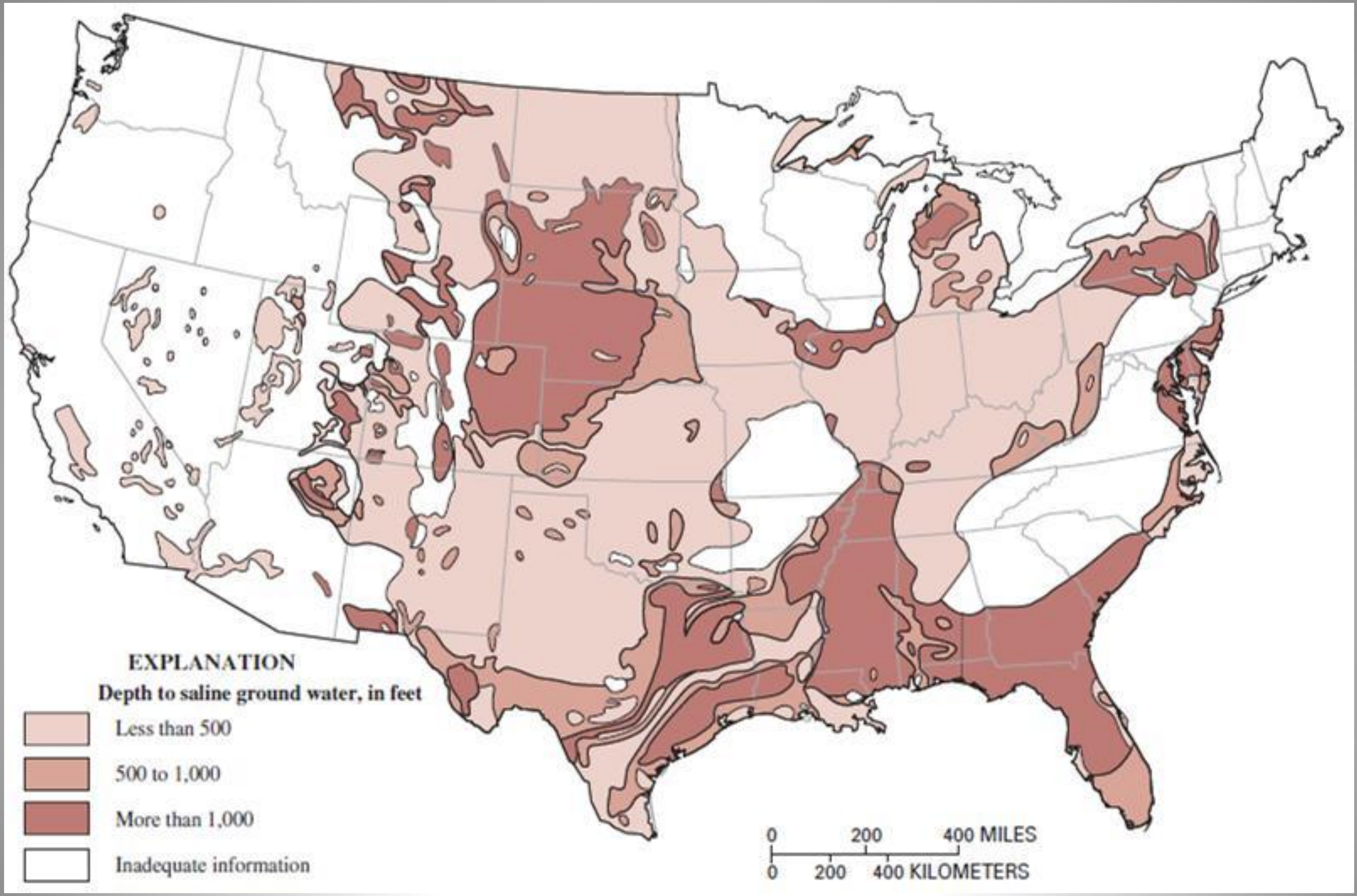
US Fresh Water Aquifers



Food (Water) for Thought

- The volume of water being used for hydraulic fracturing is relatively small when compared to all other uses for fresh water (golf courses, thermoelectric cooling, residential, agriculture, industrial) versus the benefit to out nation from natural gas production.
- These are one-time or limited uses.
- There is not a shortage of groundwater. Sometimes population demand exceeds the ability of an aquifer to deliver the volume of water needed instantaneously.

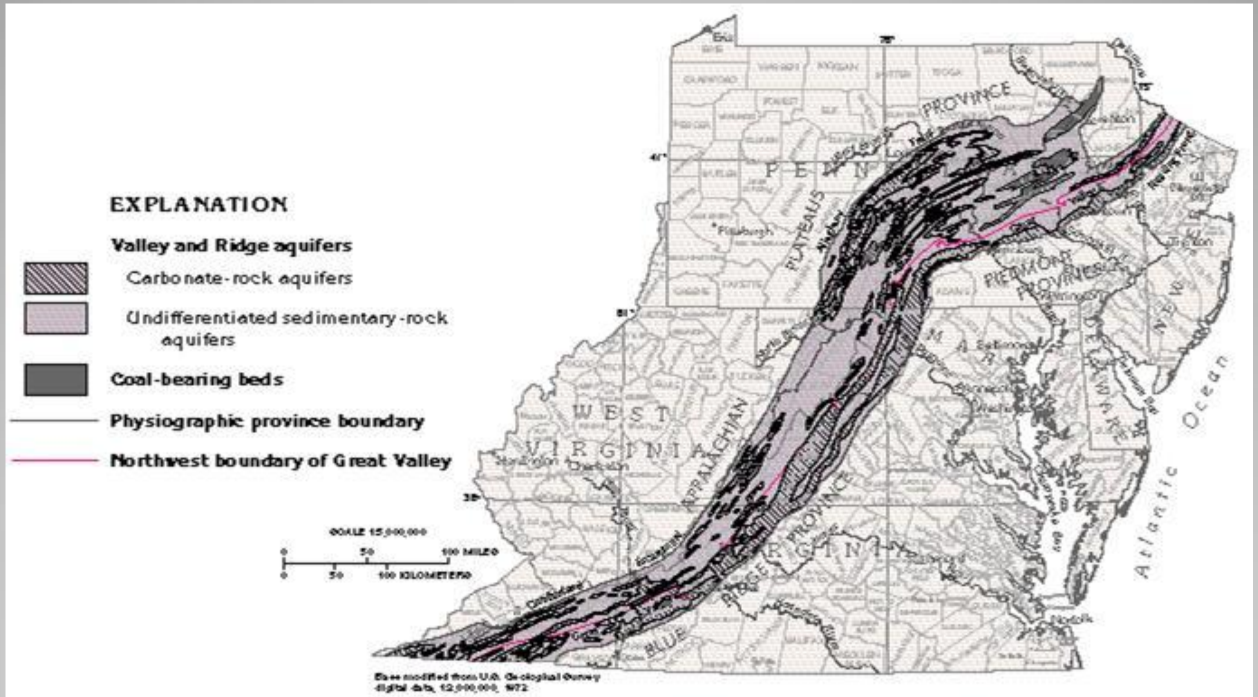
US Saline Aquifers



A View of the Various Aquifers of the Northeast

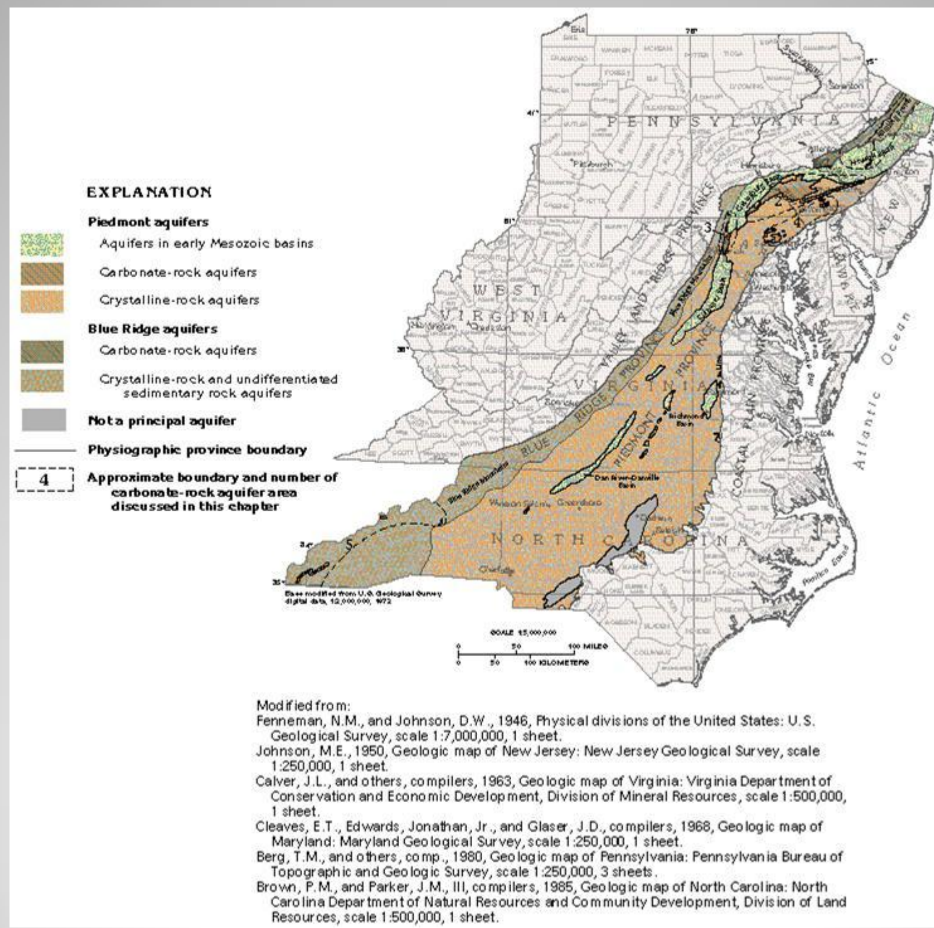
A Focus on the Marcellus Shale Area

Valley and Ridge Sandstone Aquifer With Coal Beds

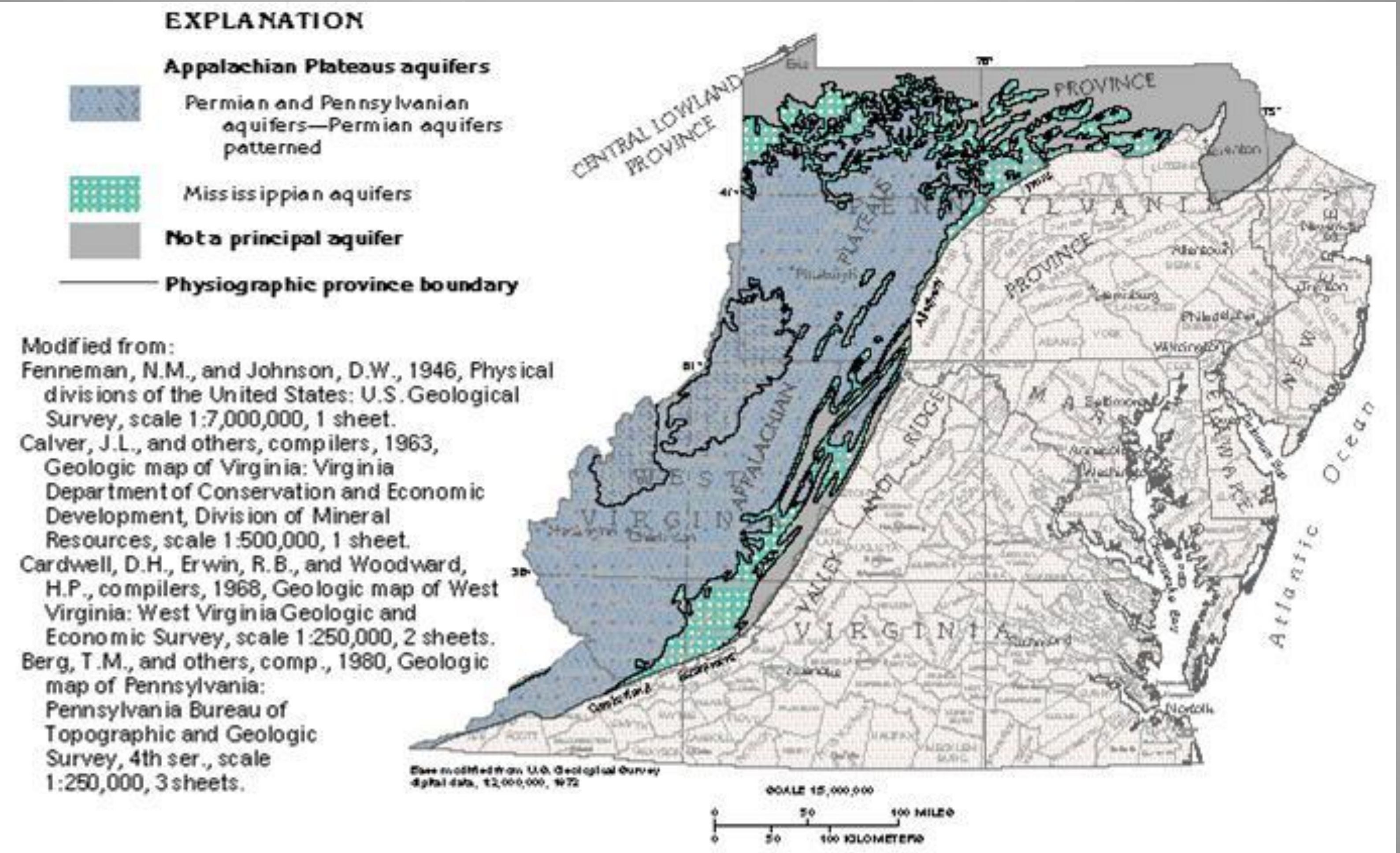


Modified from:
Fenneman, N.M., and Johnson, D.W., 1946, Physical divisions of the United States: U.S. Geological Survey, scale 1:7,000,000, 1 sheet.
Calver, J.L., and others, compilers, 1963, Geologic map of Virginia: Virginia Department of Conservation and Economic Development, Division of Mineral Resources, scale 1:500,000, 1 sheet.
Cardwell, D.H., Erwin, R.B., and Woodward, H.P., compilers, 1968, Geologic map of West Virginia: West Virginia Geologic and Economic Survey, scale 1:250,000, 2 sheets.
Cleaves, E.T., Edwards, Jonathan, Jr., and Glaser, J.D., compilers, 1968, Geologic map of Maryland: Maryland Geological Survey, scale 1:250,000, 1 sheet.
Berg, T.M., and others, comp., 1980, Geologic map of Pennsylvania: Pennsylvania Bureau of Topographic and Geologic Survey, scale 1:250,000, 3 sheets.

Piedmont Aquifer: Carbonate and Fractured Crystalline Rock



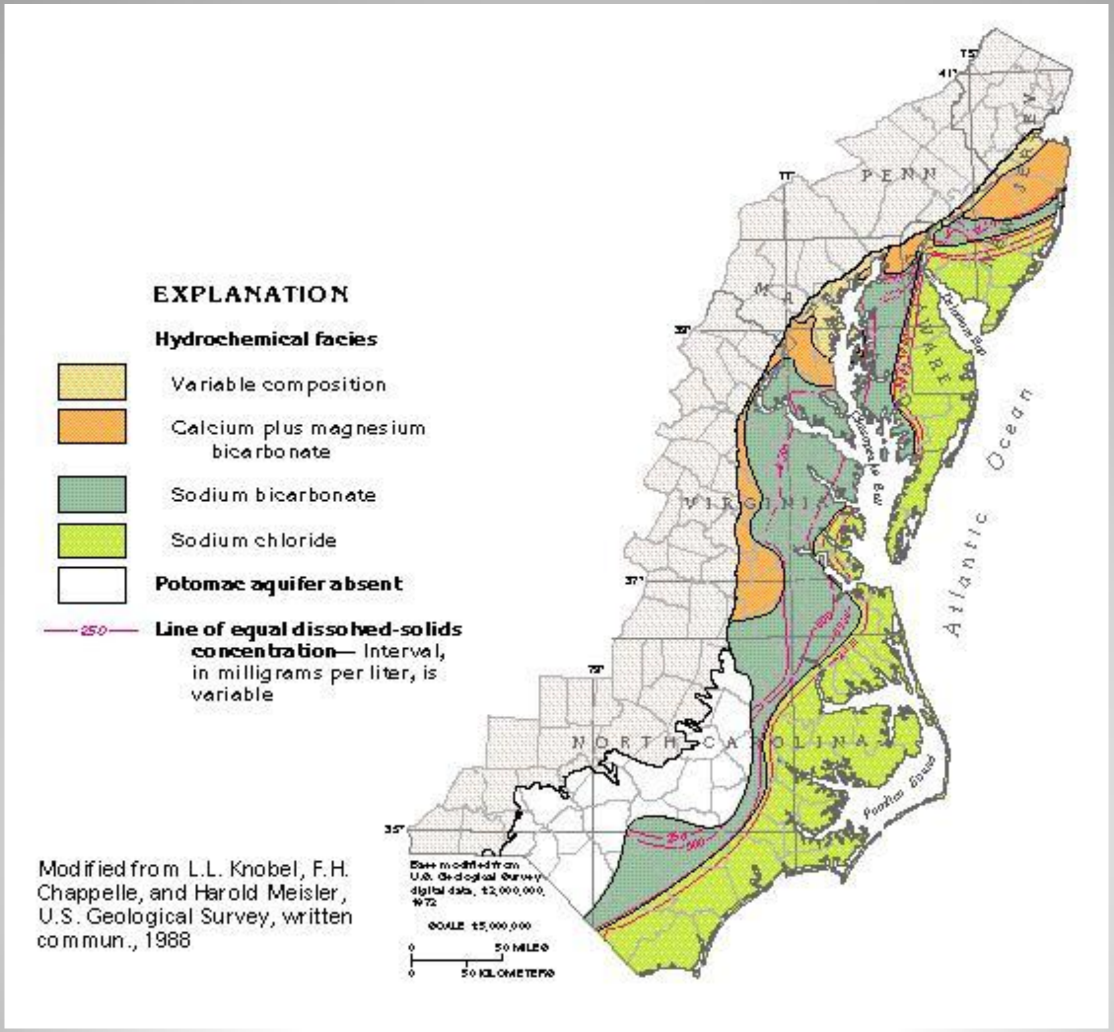
Consolidated Sandstone Aquifers of the Appalachian Plateau Province



How Water Quality Changes in an Aquifer Based on Depth and Extent

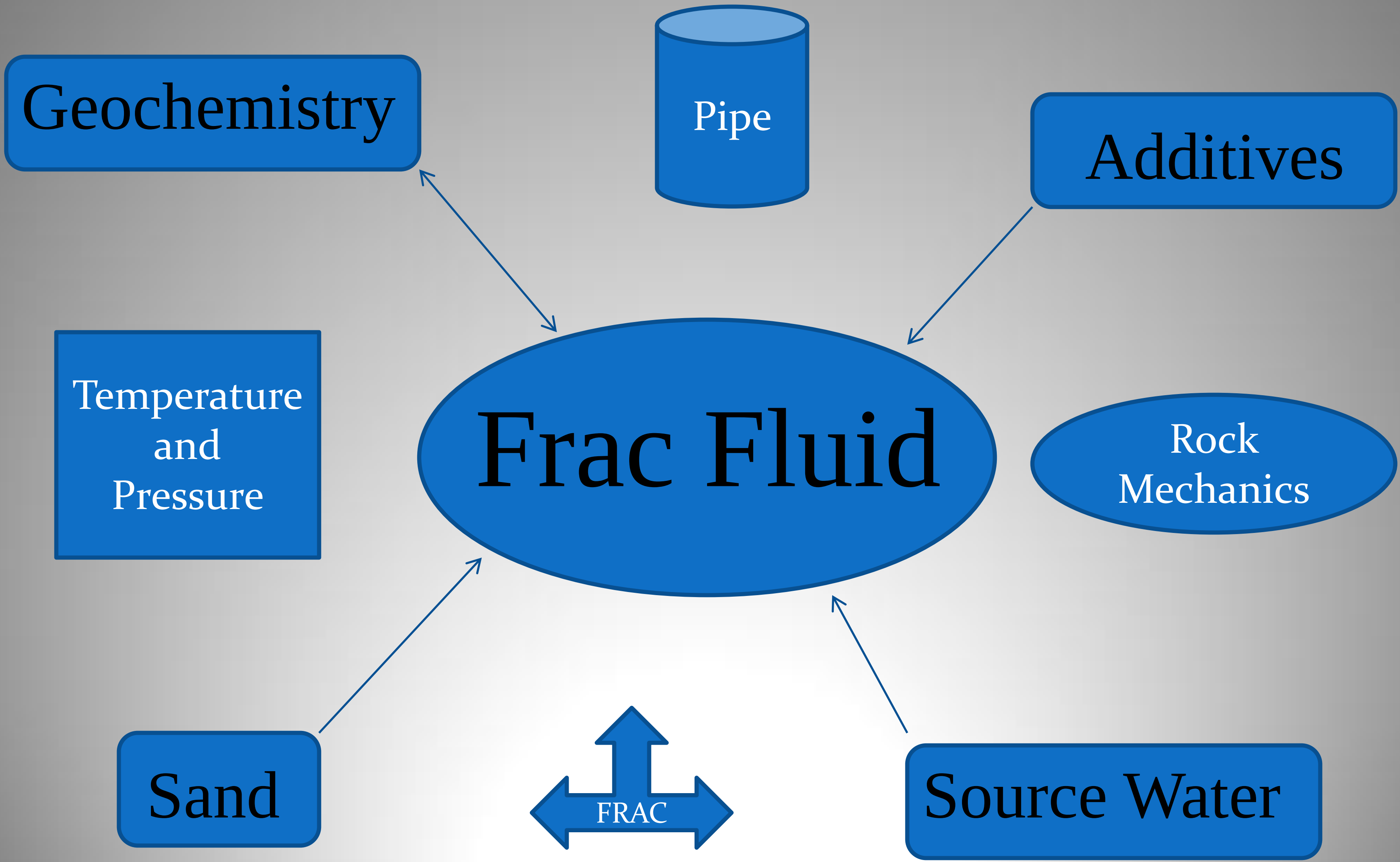
A View of the Potomac Aquifer in the Region of Virginia & Maryland

Variable Water Quality in an Aquifer Based on Depth and Areal Extent Across a Basin



How Water Quality and Frac Fluids Relate

Cations- Anions , hydration, crosslinks, polymers, breakers, oxidation, interference, delay …. and more fun than you ever thought you were going to have outside of a chemisty lab, football game or airport!


Geochemistry
Pipe
Additives
Temperature and Pressure
Frac Fluid
Rock Mechanics
Sand
FRAC
Source Water

Parameter or Compound	**Range for Parameter or Compound**	**Comments on Impact of Parameter or Compound on Frac Fluid Performance**
pH	6-8.5 units	Interferes with hydration of polymer, scale
Ca & Mg	<2000 ppm	Scale, interferes with breakers
Fe	<10 ppm	Catalyst for polymer oxidation, scale
Ba & Sr	<5 ppm	Reducing agents, interferes with breakers
Chlorides	<40,000 ppm	Interferes w/hydration of polymers and breakers
Bicarbonates	<300 ppm	With Ca/Mg & heat will scale, delay crosslink
Phosphates	<5 ppm	Interferes with metal crosslinkers
Sulfates	<500 ppm	Scales, crosslinker precipitation

Concerns for Use of Saline Water as a Frac Fluid

Saline ground water has a tendency to precipitate sulfate (example rock or mineral precipitate: gypsum), carbonate (rock or mineral example: calcite), and silicate scales. The tendency of saline ground water to form scale is important to its suitability for use in frac water due to the extreme temperature and pressure differentials the water will encounter during use. Knowledge of the compounds present in the water prior to use is an important factor.

Concerns for Use of Saline Water as a Frac Fluid (continued)

Use of saline water as a frac fluid present operating issue which must be addressed:

- Transport
- Storage
- Treatment/Management
- Equipment damage
- Spillage

Aquifer Storage of Frac Fluids

Fresh water storage in saline aquifers has been developed for many decades as a method of storing fresh water for later use in arid areas. Fresh water will perch atop of the brine water. Perhaps consideration should be given to this concept for frac fluids as well. Where multiple wells are being drilled on a single pad, a saline aquifer could be used to store fresh or brackish frac fluids for use at a later date. The frac fluids could be stored and withdrawn as needed from a brine aquifer. Provided the brine aquifer is suitable, the aquifer could serve as a source water reservoir as well as a storage reservoir.

Advantages of Fresh Water Utilization

- Recycling and reuse of fluid is possible
- Treatment & release to publically owned treatment works (POTW) or by NPDES possible
- Evaporation and reuse of salts
- Subsurface injection in permitted wells
- Surface water and groundwater sources available
- Source of revenue to landowners

Advantages of Saline or Brackish Water

- Recycling and reuse is possible
- Treatment and release to POTW or NPDES possible but more restricted than fresh water
- Evaporation and reuse of salts
- Subsurface injection in permitted wells
- Potential use for brine aquifer storage and reuse

Summary and Conclusions

- The type and concentration of TDS in the water used for frac work is important for a successful completion.
- Ba, Sr, Fe and phosphates (not chlorides) appear to be the major limitations to using non-potable water for hydraulic fracturing operations.
- Water quality in aquifers across the country is variable and combined use of waters from multiple sources may be required in some areas.
- Volume of fresh water used is small in comparison.
- Recycling, reuse and subsurface aquifer storage of frac fluids may provide workable methods for fracs.

Summary and Conclusions

- Groundwater of all types is plentiful
- Treatment and utilization of non-potable sources of water may be a viable options
- Management of waters while being utilized and spent waters must be taken into consideration
- We must all be cooperative and creative with our natural resources if we are to continue to develop clean, dependable energy resources for our nation.