Chemical Characteristics of Frac Flowback Water & Technologies Deployed to Recycle Water, Reduce Waste Volumes & Reduce Cost

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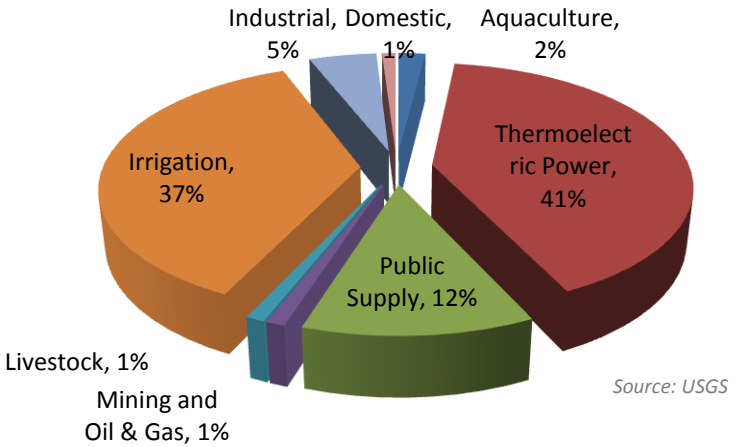
Tervita Manages Waste

Tervita Facilities

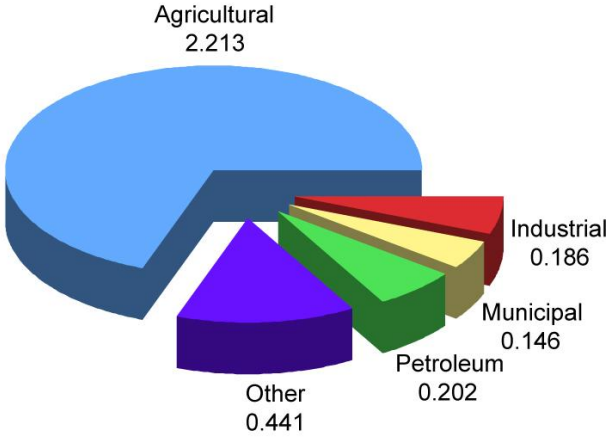
Water Supply & Use

- Oil and gas sector:
  - A small user of water relative to other segments
  - A large recipient of attention and regulatory scrutiny
- Industry's water management critical to social license
- Regulations continue to tighten on industry & limit access

Percentage of Water Used by Market Segment in the U.S.

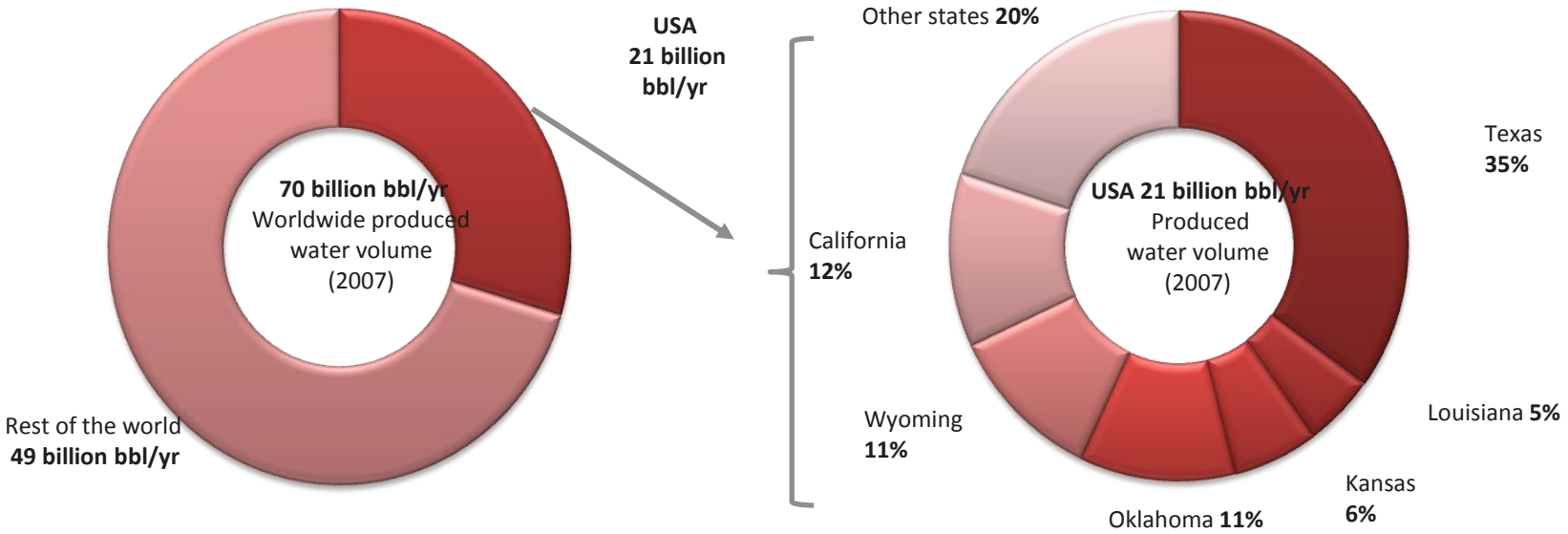


Cubic meters used in Alberta



Produced Water Volumes O & G

- Produced water volumes predicted to increase by 32% by 2025*
- Potential for water reuse exists to decrease freshwater use
- Produced water management is a major cost to industry and consumes resources otherwise slated for hydrocarbon production



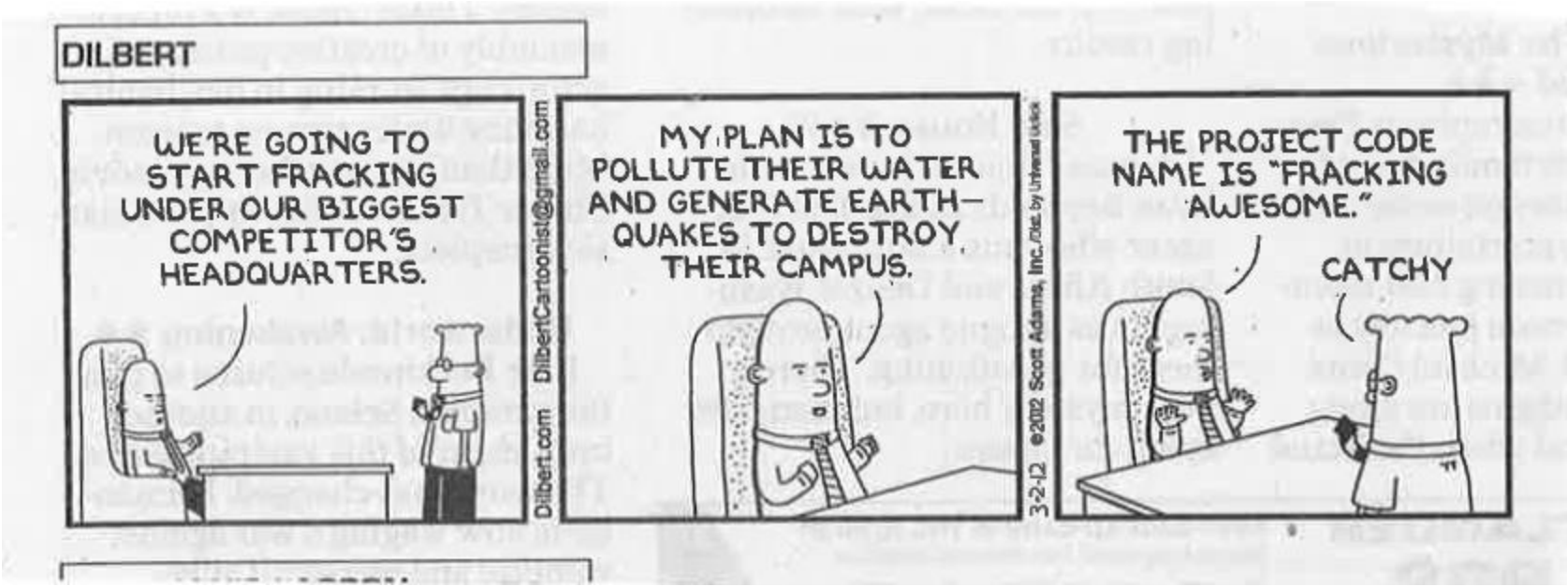
** Source: Clarke & Veil, 2009*

Addressing Environmental Concerns of Hydraulic Fracturing

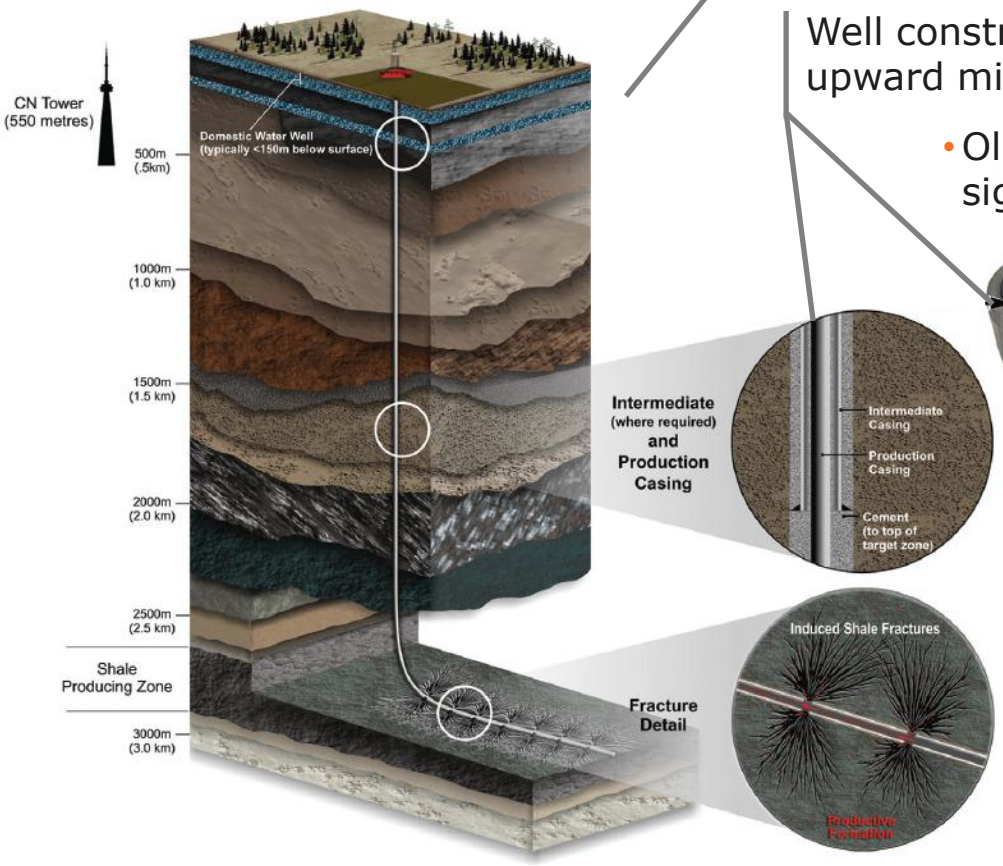
- There has been a significant increase in frac'ing:
  - Between 2004-2009 US shale gas supply increased 5 times
  - In Canada, shale gas currently accounts for nearly 30% of natural gas production

- This has led to concerns about:
  - Aquifer and soil contamination
  - Unsustainable water use
  - Seismic activity

What The Frac?



Typical Horizontal Shale Well and Frac



Aquifers are typically at much shallower depths than shale gas zones

Well constructed wellbore and casing prevent upward migration of frac fluid and produced water

- Old, poorly constructed existing wells are a significant contamination risk during frac'ing

- Pressure characteristics within the geology determine the extent to which vertical fracturing may exist

Fracs and Aquifer Contamination

- Pay zone frac typically separated from aquifers by thousands of feet and several impermeable layers, vertical frac propagation typically < 300 ft
- Contamination issues likely from surface operations and historic oil and gas wells in the area.
- Presence of methane in drinking water wells is prevalent and not associated with recent drilling.
- Disclosure and understanding of additives should be routine.
- A (federal) approach is required to deal with orphaned wells.

Table 3 Incidents Investigated and Determined Cause of Problem (Kell, 2011)											
State	Study Period	# wells producing	Num. Cases Investigated.	Site Related	D&C Related	Frac Related	Prod. Related	Orphan Well Related	Waste Disposal Related	P&A Related	Unk
Ohio	26 yrs.	65,000	185	0	74	0	39	41	26	5	0
Texas	16 yrs.	250,000	211	0	10	0	56	30	75	1	39

Source: King 2012. Estimating Frac Risk and Improving Frac Performance in Unconventional Gas and Oil Wells.

Aquifer and Soil Contamination

Risk mitigation leading practices

- Baseline aquifer data assessment allows accurate monitoring and real-time adjustment
- Comprehensive environment and geology assessment facilitates effective frac planning
- Appropriate pad development for drilling minimizes surface impact
- Improved frac and produced water storage and treatment to minimize contamination risk
- Improved isolation through cement additives

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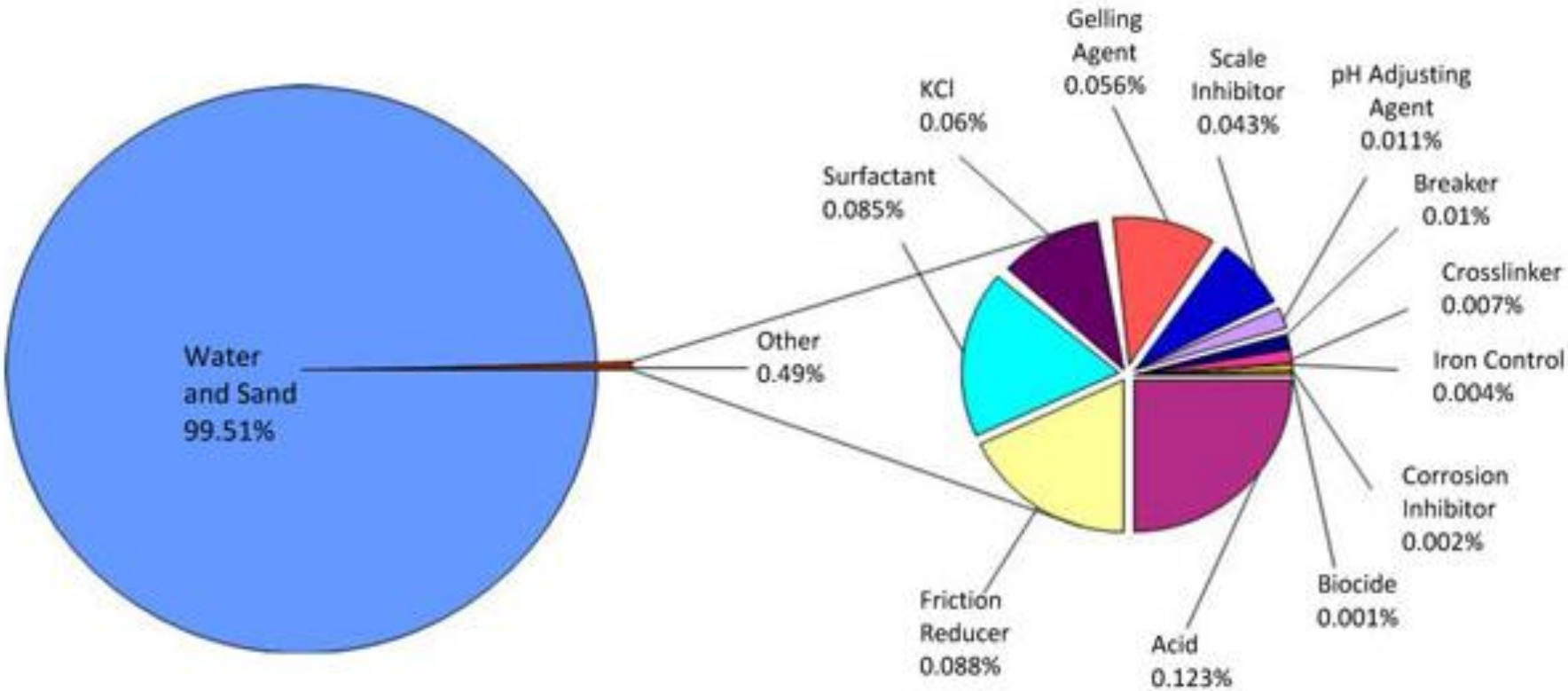
Understanding Additives



Source: http://fracfocus.org/water-protection/drilling-usage

Chemicals Commonly Used in Shale Fracturing and consequences of not using the chemical

Chemical	Use	Consequences of not using chemical
Acid	Removes near well damage	Higher treating pressure, slightly more engine emissions.
Biocides	Controls bacterial growth	Increased risk of souring the formation (H_2S gas from sulfate reducing bacteria growth) and increasing corrosion.
Corrosion Inhibitor	Used in the acid to prevent corrosion of pipe	Sharply increased risk of pipe corrosion from acid. Well integrity compromised.
Friction Reducers	Decreases pumping friction	Significantly increases surface pressure and frac pump engine emissions .
Gelling Agents	Improves proppant placement	Increased water use. Natural gas recovery may decrease in some cases by 30 to 50% where frac fluids must be gelled (conventional fracs).
Oxygen scavenger	Prevents corrosion of well tubulars by oxygen	Corrosion sharply increased and well integrity (containment) compromised.

Source: http://gekengineering.com/Downloads/Free_Downloads/A_Guide_to_Chemicals_in_Fracturing_10_Aug_2010.pdf

How Much Chemical is Used? Examples:

Chemical	Common in a Shale Frac?	Normal Concentration Ranges (actual minimum set by testing)
Acid (15% HCl)	Yes	1500 to 2500 gallons total
Bacteria Control	Yes	0.0 to 0.001%
Friction Reducer	Yes	0.01 to 0.025%
Oxygen Scavenger (ammonium bisulfite)	Yes	0.005%
Corrosion Inhibitor	Yes	0.001% in the frac to 0.2% in acid
Surfactants (multiple products – similar to products in dish washing soaps)	Common, but often over used	0.005 to 0.01%
Gelling Agent (guar gum or cellulose product)	Only in Hybrid fracs	10 to 20 lb/1000 gallons
Cross Linker (borax base is laundry detergent)	In some hybrid fracs	Varies, but very low conc.
KCl (potassium chloride is table salt substitute)	Uncommon in shale	2%
Gel Breaker (ammonium persulfate)	Only with gel	0.01%
pH adjusting agent (sodium carbonate)	Only with gel	0.01%
Scale Inhibitor (5% to 10% active phosphate ester, or polymer or 0.02 to 0.4% ethylene glycol)	Rare	1 to 2 gallons per 1000 gallons
Iron Control (Citric Acid)	Rare	0.001 to 0.004%

Source: http://gekengineering.com/Downloads/Free_Downloads/A_Guide_to_Chemicals_in_Fracturing_10_Aug_2010.pdf

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Sustainable Water Use

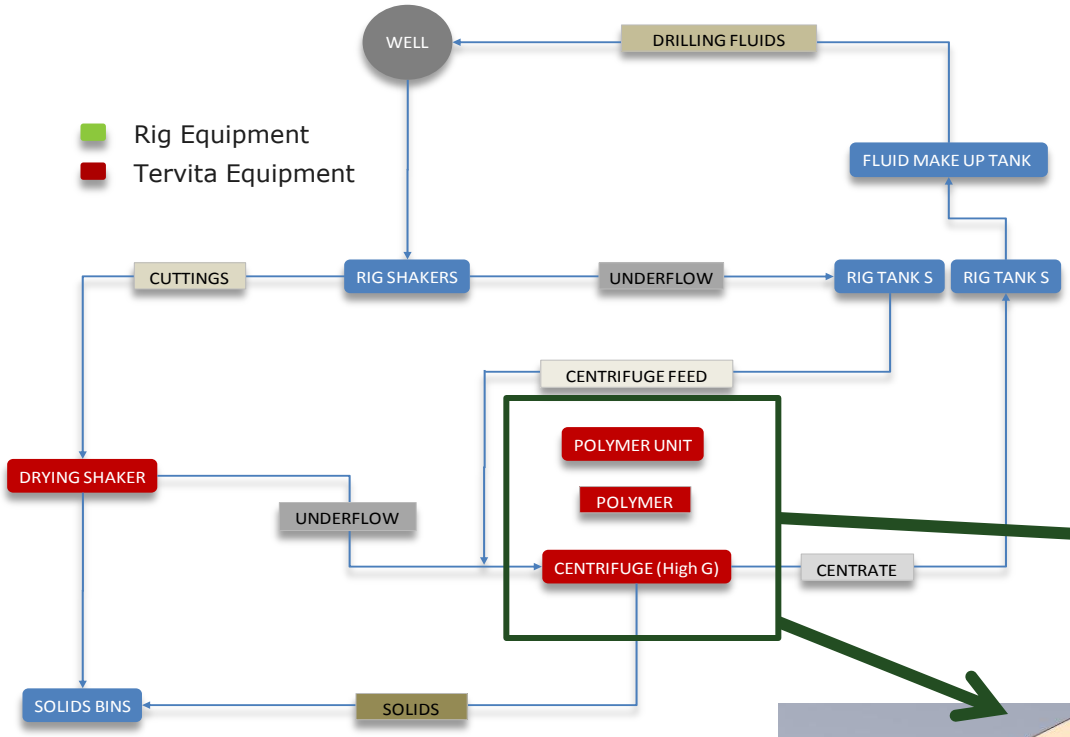
Risk mitigation leading practices

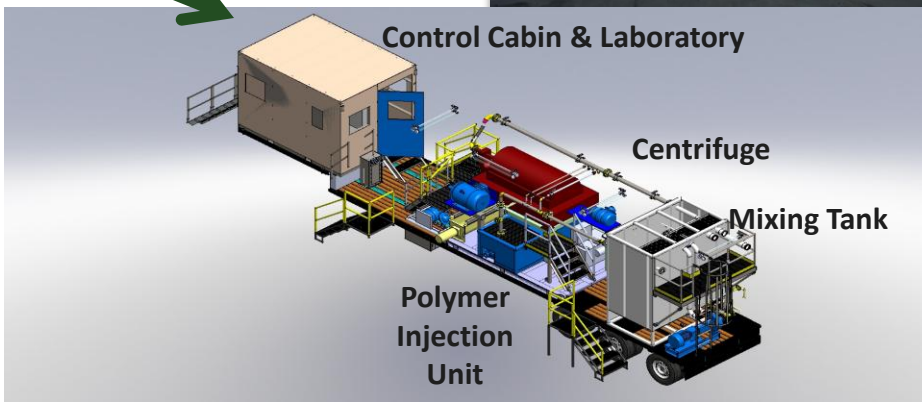
- Re-use of flowback and produced water
  - Tervita is developing "Closed Loop" systems to re-use flowback water
- Treatment of flowback and produced water
  - Tervita water treatment technologies minimize environmental impact
- Understanding resource availability
  - Brackish water can be treated for use to minimize freshwater use

Frac Water Example

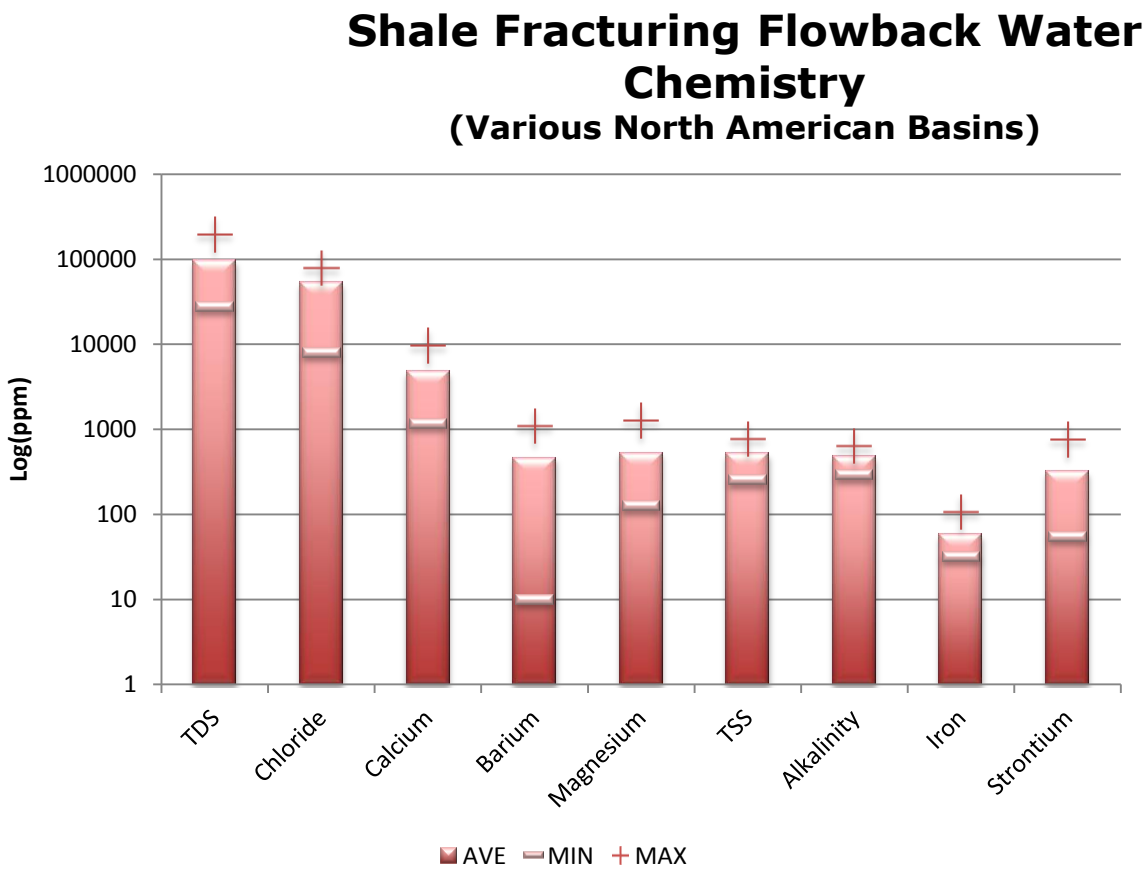
- A typical frac may require 10 to 20, 000 m^3 of water[1]
- This recovers about 11,000 person years of energy[2]
- Typical 100 000 ppm TDS with variable non-carbonate and carbonate hardness depending on region
- Cost for on site treatment and recycle breaks even at about 55 bbl/hr compared to trucking

Closed Loop Drilling



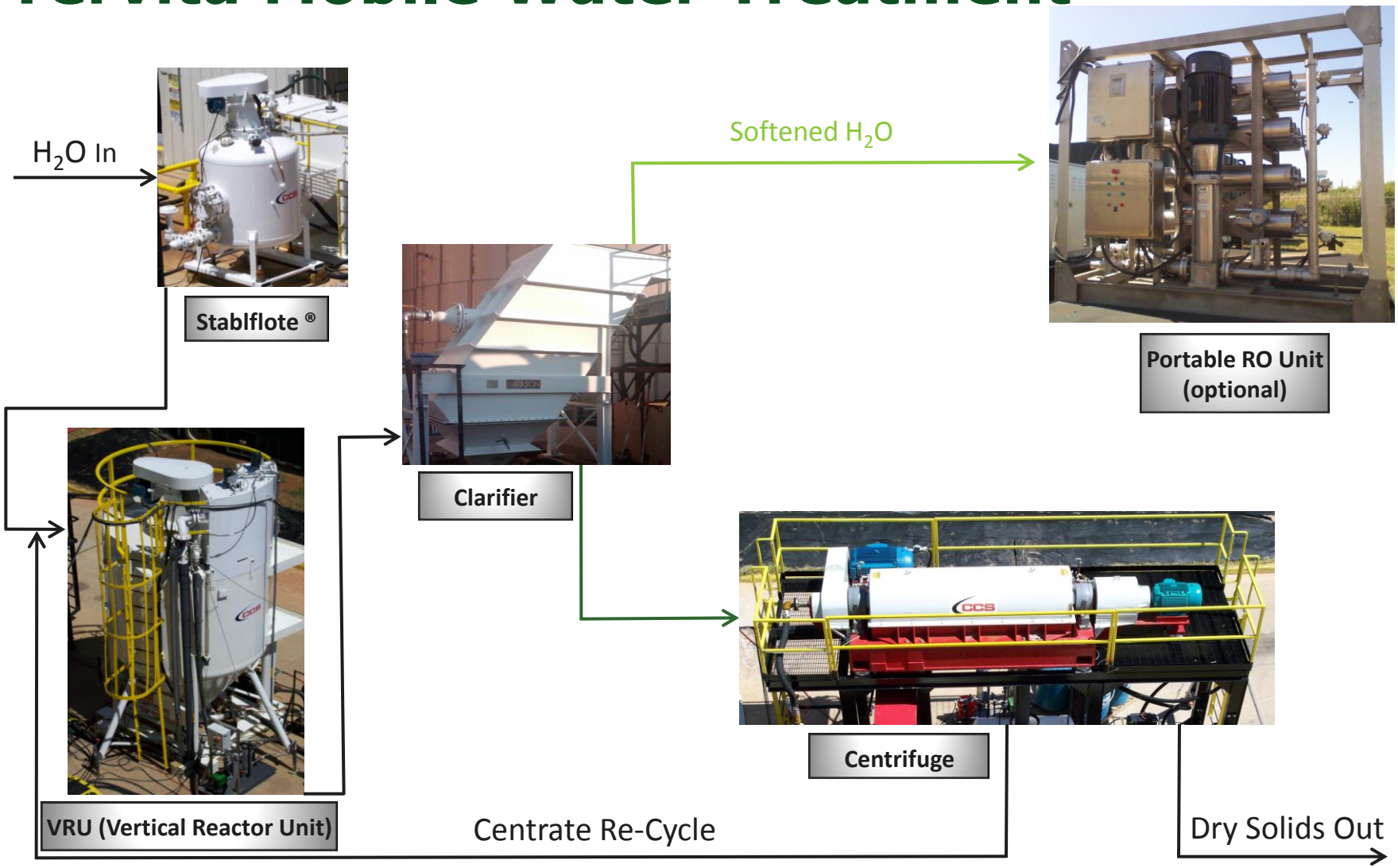


Fracturing Flowback Water



Sources: Canadian Shale Basins, Bakken, Haynesville, Marcellus, Barnet flowback water chemical analysis

Tervita Mobile Water Treatment



Haynesville Water

Flowback Water	Raw Water In	Product Water
Total Hardness (ppm)	10,200	40
Calcium (ppm)	3,780	16
Barium (ppm)	1,050	1
Strontium (ppm)	72	1
Magnesium (ppm)	178	ND
Iron (ppm)	93	0.3

Seismic Activity

Risk mitigation leading practices

- Assessment of fault location to minimize fault risk during frac planning
- Reduce frac flowback and produced water disposal to minimize seismic activity related to disposal caverns
- Careful monitoring to minimize risk
    - Pressure monitoring
    - Frac propagation monitoring

Increasing Industry Response

- The industry is responding to growing awareness around impacts and mitigating strategies

- CAPP together with industry partners established newly created *Guiding Principles and Operating Practices for Hydraulic Fracturing*

- Guidelines impact:
  - Use and disclosure of frac fluid additives, groundwater testing, wellbore construction quality, water sourcing, fluid management

Questions or Comments?

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