

***US EPA Technical Workshop on Wastewater Treatment and Related
Modeling For Hydraulic Fracturing***

**Treatment for Beneficial Use of Produced Water and Hydraulic
Fracturing Flowback Water**

Dr. David R. Stewart, PhD, PE – Chief Science Officer



April 18, 2013

Introduction

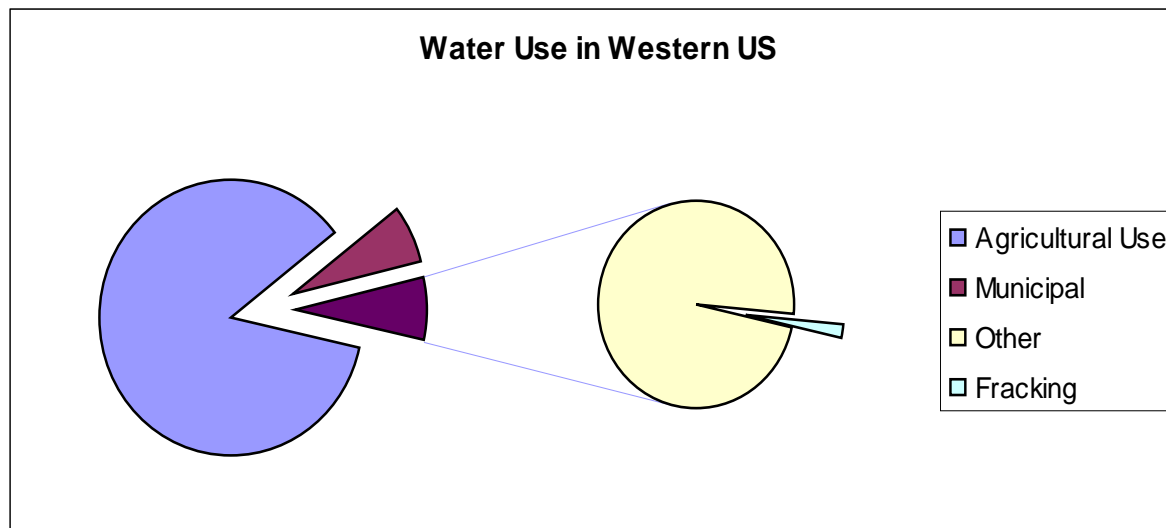
- 💧 Water reuse and recycling is a significant issue in the development of oil and gas shale plays in the United States
- 💧 Water use for E&P operations is significant in areas where the drought exists – low percentage number but total consumption
- 💧 Water reuse will be dependent on the interactions of water quality constituents as they relate to water reuse and recycling
- 💧 Beneficial reuse of produced water can be for hydraulic fracturing but also for agricultural reuse, municipal augmentation and environmental benefit

Water Quality Criteria for Reuse

- 💧 Constituents of concern for water reuse:
 - 💧 Total Dissolved Solids
 - 💧 Oil and Grease
 - 💧 Suspended solids
 - 💧 Dispersed oil
 - 💧 Dissolved and volatile organic compounds
 - 💧 Heavy metals
 - 💧 Radionuclides
 - 💧 Dissolved Gases and Bacteria
 - 💧 Chemical additives such as biocides, scale and corrosion inhibitors, guar gum and emulsion/ reverse-emulsion breakers

Water Use as a Function of Overall Water Management

- What is the percentage of total fracking and energy development = **0.14% of total** use in the US typical - (example is Colorado)
- Largest use is Agricultural at 85%
- Second highest use is Municipal and Industrial at 7%
- All others is 8%
- This 0.14% equals the amount of water used on an annual basis by the City of Denver.



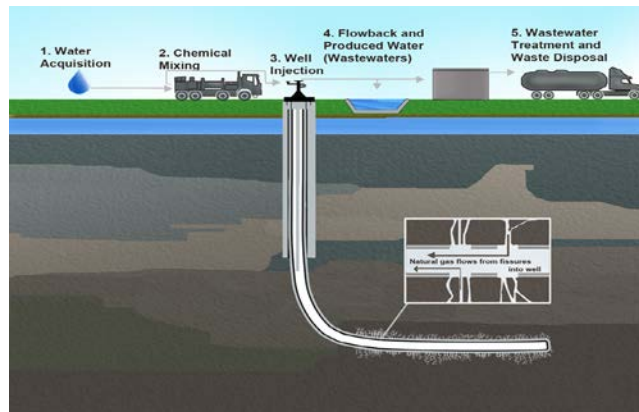
Experience in produced water treatment

- Experience in treatment of produced water for beneficial reuse
 - Wellington Colorado
 - 5,000 bbl/ day facility
 - Operational since 2006
 - Produced water uses
 - Makeup water for hydraulic fracturing
 - Agricultural irrigation
 - Municipal augmentation water for a drinking water supply
 - Utah facility of 5,000 bbl/ day
 - Texas facility of 1,500 bbl/ day
 - Wyoming facility 100,000 bbl/ day



Impacts on Water Market

- 💧 Impacts on the water market
 - 💧 Water Availability
 - 💧 Truck Traffic
 - 💧 Surface Spills and leaks
 - 💧 Air pollution



Water and Hydraulic Fracturing

A White Paper From the American Water Works Association

© Copyright 2013 American Water Works Association

www.awwa.org/fracturing

American Water Works Association

The Authoritative Resource on Safe Water®

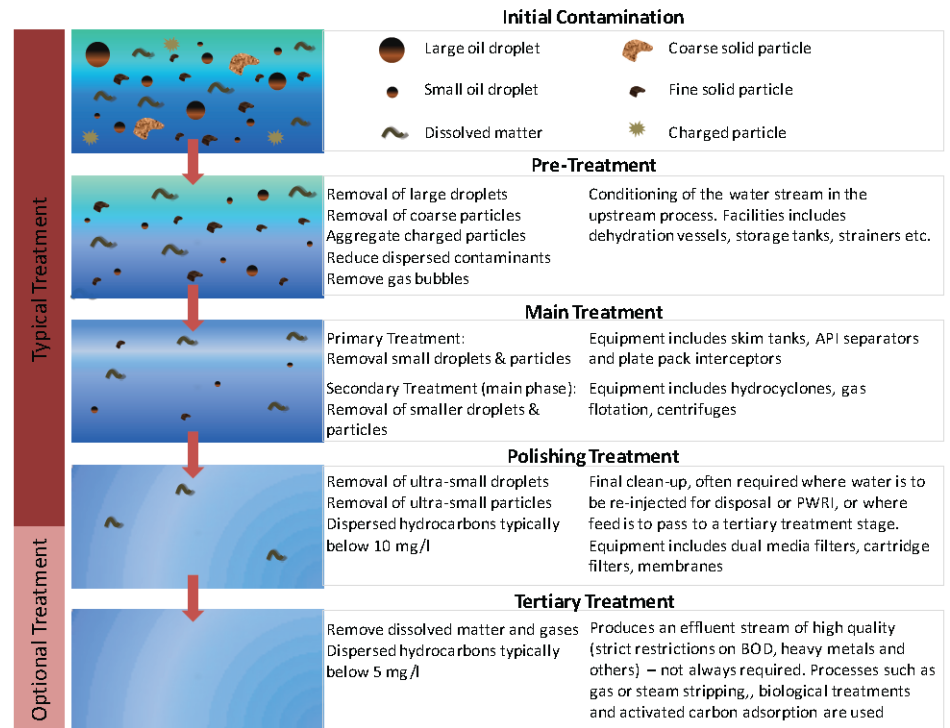
Flowback Chemistry

- 💧 Note the following
 - 💧 Barium levels
 - 💧 Iron levels
 - 💧 TOC
 - 💧 TSS
- 💧 These will be issues in treatment resulting in issues for reuse or recycling

Parameter	Feed Water	Flowback
pH	8.5	4.5 to 6.5
Calcium	22	22,200
Magnesium	6	1,940
Sodium	57	32,300
Iron	4	539
Barium	0.22	228
Strontium	0.45	4,030
Manganese	1	4
Sulfate	5	32
Chloride	20	121,000
Methanol	Neglible	2,280
TOC	Neglible	5,690
TSS	Neglible	1,211

Treatment Issues

- 💧 Treatment to what standard?
- 💧 Frack water makeup?
- 💧 Discharge to a surface water or tributary
- 💧 groundwater – 40 CFR 435
- 💧 Disposal is Class II injection well
- 💧 Disposal is surface water pond



Treatment Requirements

- Two areas of concern
 - Organic treatment
 - Inorganic treatment
- Organic
 - Heavy Oils
 - Asphaltines/ Parrafi ns
 - VOC's
 - BTEX – benzene
 - Air stripping
 - GAC
 - Guar gum
 - Micro-organisiums
- Inorganic Treatment
 - Ion exchange
 - Higgins Loop
 - Precipitation chemistry
 - Electro-coagulation
 - CMF
 - NF/ RO

Treatment Process

Treatment Steps

- Aeration - removal of VOC's
- W SF – heavy oils and asphaltines/ paraffins
- EC – precipitation of multi-valent ions
- CMF – removal of precipitants and micro-organisms
- GAC – VOC removal
- NF/ RO – control of salts

EWS Patented Technology

Modular On Site Energy Water Solution

Fresh Water & Products

11/784,569 - Purification of oilfield Water for beneficial use (1-5)
6,348,154- Methods to remove heavy metals from water - rare earth minerals harvesting (4)



energywater SOLUTIONS

32

Scale Formation & Chemical Interference Issues for Water Reuse

- ❖ Constituents of concern:
 - ❖ Barium sulfate formation
 - ❖ Hardness (Calcium and Magnesium) interactions
 - ❖ Silicate formations
 - ❖ Boron issues
 - ❖ Salt removal
 - ❖ Radionuclides

Table 3 – An Example of Water Quality Goals for Hydraulic Fracturing Fluids

Bacteria	100,000 per 100 ml
Barium (mg/l)	< 2
Bicarbonates (mg/l)	250 to 100,000
Calcium (mg/l)	300
Chlorides (mg/l)	2,000 to 40,000
Iron (mg/l)	10
Hydrogen Sulfide (mg/l)	ND
Magnesium (mg/l)	100
pH	6.5 to 8.0
Phosphates (mg/l)	10
Radionuclides (pCi/l)	<15
Reducing agents (mg/l)	ND
Silica (mg/l)	<20
Strontium (mg/l)	<10
Sulfate (mg/l)	400 to 1,000
Total Dissolved Solids (mg/l)	500 to 5,000

Brine Control and Disposal

- 💧 Control of brine is the most difficult issue in recycling/ reuse of produced water and hydraulic flowback water
 - 💧 Brine stream can be 50,000 to 300,000 mg/ l TDS
 - 💧 Potential uses
 - 💧 10 Pound Brine for drilling operations
 - 💧 Chlor-Alkali process for the manufacture of HCl or NaOCl and NaOH
 - 💧 By product capture
 - 💧 Lithium example

Conclusions

- 💧 Recycling and Reuse of produced water and flowback water will become a significant issue for the development of oil and gas shale plays in the United States
- 💧 Development of criteria for reuse and recycling needs to be developed
- 💧 Treatment technologies that fit the final reuse and recycling criteria will need to be deployed economically
- 💧 Economics is the driver for recycling and reuse
- 💧 Companies are committing to higher recycling and reuse rates but will need to implement more complicated treatment technologies
- 💧 Brine harvesting will need to be researched and perfected in the future