

Zero Discharge Water Management for Horizontal Shale Gas Well Development*

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Abstract

Shale gas production depends on the creation of permeability within an otherwise nearly impermeable rock formation. Two technologies have been applied to produce natural gas – directional/horizontal drilling and massive hydraulic fracturing. Fracturing uses large volumes of water to create several, long fractures in the shale formation. Sand is pumped with the water and left to prop open the fractures, thus providing multiple, permeable flow paths for the natural gas. The use of the large volumes of water often stresses local fresh water supplies, and the water flowing back from the well after fracturing is a briny mixture, creating a water disposal problem. A West Virginia University (WVU) research team is looking at methods for managing frac water withdrawals and returns from large gas wells in the Marcellus Formation by converting the briny waste into a suitable, partial replacement of the fresh water that is currently used as the fracturing fluid of choice. The objective of this two-year, two-phase project is to develop and demonstrate a process for treating return frac water (RFW) from Marcellus horizontal well development that will allow an increased recycle rate while decreasing make-up water and disposal requirements.

Industry standards for acceptable recycle water quality standards continue to evolve with current primary needs of high-rate filtration operations achieving solids removal well below 20 microns and a reduction in sulfates and heavy metals. Industry also requires a treatment system with minimal operation and maintenance, occupies a small footprint, and can easily be taken from site to site. Phase I testing and review of treatment technologies identified a unique multi-media filter unit that met current industry needs.

This project is now well into Phase II, the design, fabrication and field deployment of a mobile treatment unit (MTU) to an active field site. The anticipated mobilization date is July 2011 with testing to run for 3 months. The successful development of a technology for treatment and reuse of RFW will advance shale gas development through improved economics and resolution of environmental impacts. Improved economics will be achieved by reducing the amount of trucking and disposal of RFW and costs associated with these activities. By reusing the RFW for subsequent fractures, the need for fresh water will be reduced. The better you treat the RFW, the higher the blend ratio with fresh water, the less dependence and strain on local water resources, and the less impact on local infrastructure and surrounding environment.

Zero Discharge Water Management for Horizontal Shale Gas Well Development

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Transition From Laboratory To Field Operation

AAPG Eastern Section Meeting

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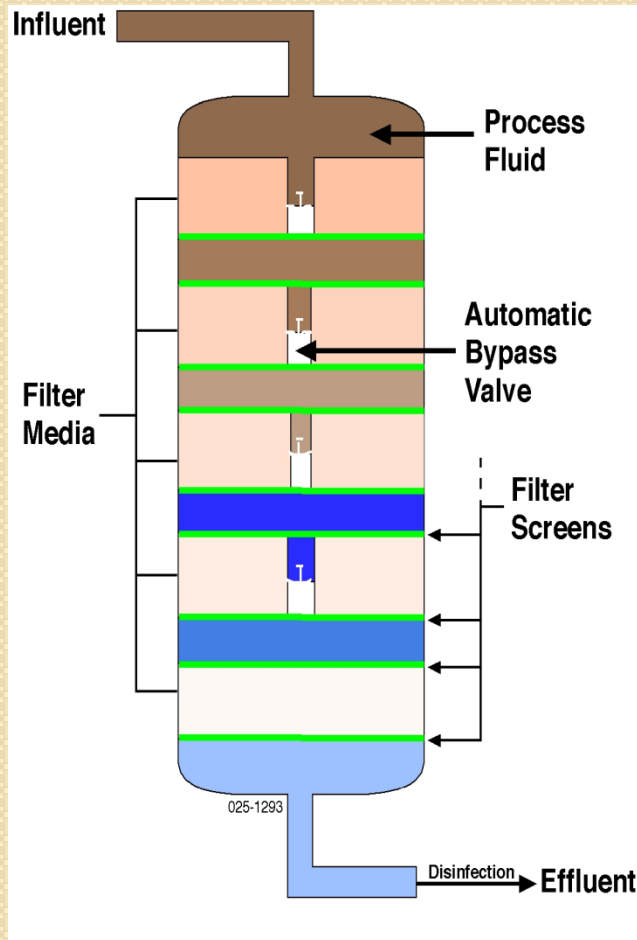
Background

- Department of Energy, in 2009, selected West Virginia University and FilterSure, Inc. to develop:

“Zero Discharge Water Management for Horizontal Shale Gas Well Development”

- Phase I Evaluated Treatment Options
- Phase II Implements Phase I Results

FilterSure Technology Approach



- Five chambers hold media that increase filter efficiency, operating flexibility, and time online compared to conventional filter
- Proprietary media carefully selected for Marcellus Shale testing program
- Automated mobile unit
 - Automatic bypass valve
 - Automatic backwash
 - Low backwash volume
 - Low pressure ops (70 psig)
- Field unit constructed, ready for operations

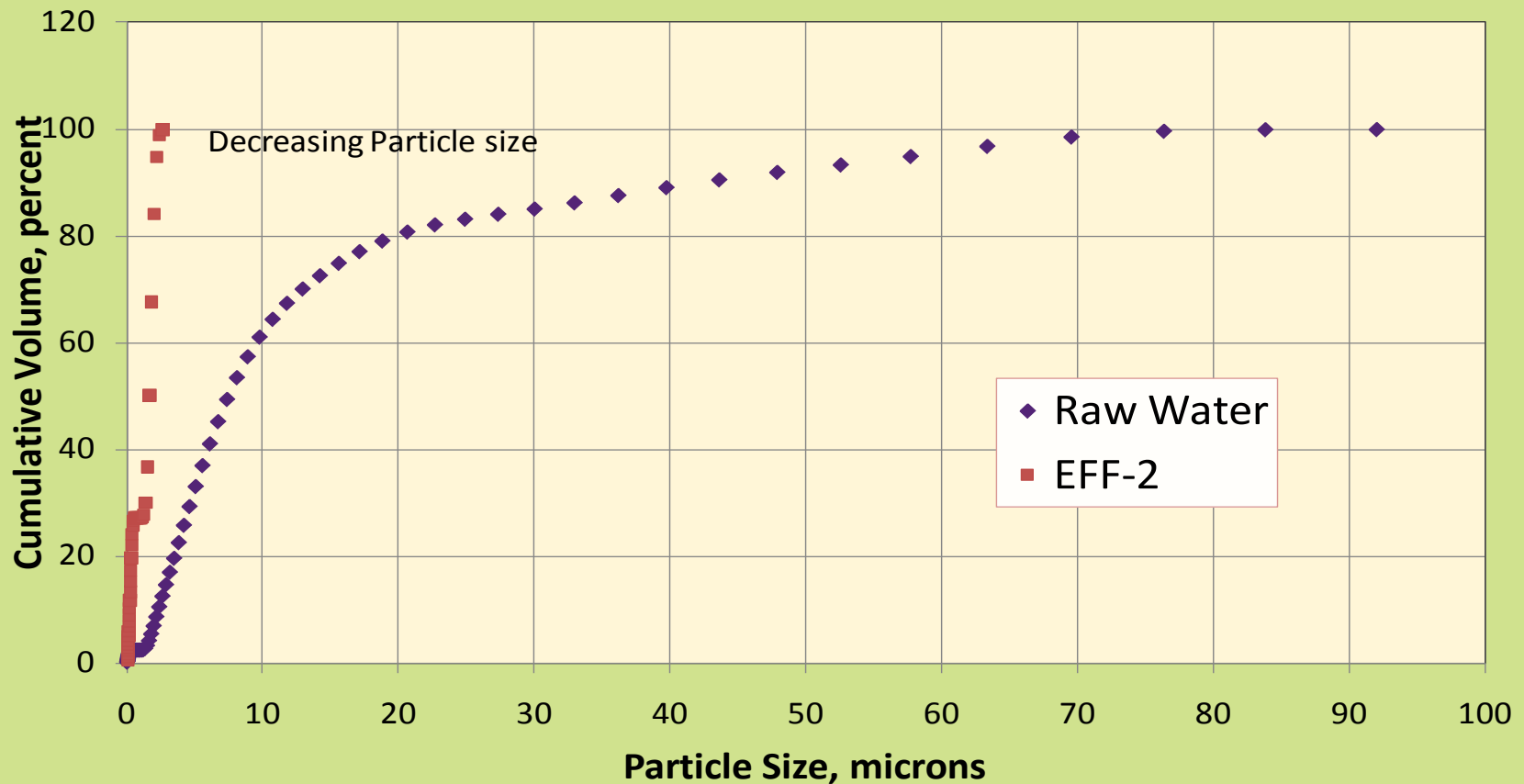
Phase I Laboratory Testing

- FilterSure 2-GPM Process Development Unit Installed At West Virginia University



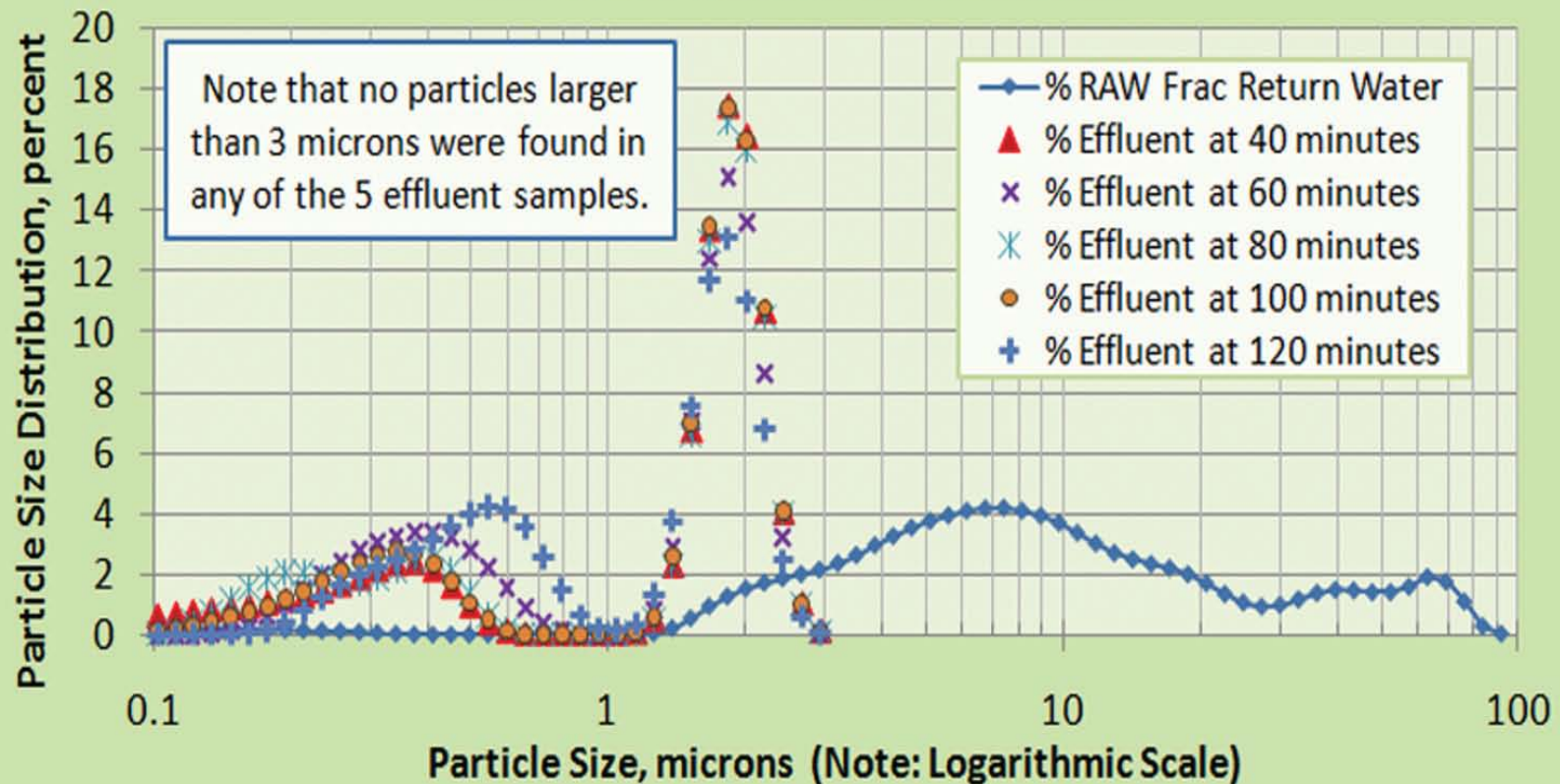
80% Of Solids In Raw Frac Water Are Under 20 Microns In Size

Extended Rate Test, Cumulative Particle Size Distribution
Raw Water & Run #1, Effluent #2



Effective Solids Removal Using FilterSure Technology

Particle Size Distribution (PSD) of Filtered and Unfiltered Frac Fluids
Filter Effluent at 20-minute Time Intervals



Suspended and Dissolved Solids Reduced

I.D.	Sample A		Sample B		Sample C			Average	
	Raw	F'Sure Only	Raw	F'Sure Only	Raw	F'Sure Only	Raw	F'Sure Only	Change, %
Date 3.5.4	4/22/10	4/22/10	8/12/10	8/19/10	8/5/10	8/5/10			
pH	7.4	7.7	5.3	6.3	5.5	5.0	6.1	6.3	4%
Cndctvty	66,300	51,000	183,000	148,000	194,000	195,000	147,767	131,333	-11%
SO4	28	11	414	101	73	-	221	56	-75%
Fe	32	15	6	8	40	45	26	23	-13%
Ca	1,610	1,540	10,600	7,830	21,000	19,300	11,070	9,557	-14%
Mg	188	175	1,200	786	2,220	2,270	1,203	1,077	-10%
Na	8,530	7,260	32,800	19,500	45,400	34,400	28,910	20,387	-29%
K	243	297	444	996	701	601	463	631	36%
Sr	280	249	1,340	1,090	2,980	3,120	1,533	1,486	-3%
Ba	172	165	201	93	1,440	1,520	604	593	-2%
Cl	17,100	13,000	65,000	51,000	80,400	95,400	54,167	53,133	-2%
TSS	99	81	570	187	882	681	517	316	-39%
TDS	38,700	28,200	112,000	81,400	188,000	187,000	112,900	98,867	-12%
Hardness	4,890	4,650	38,000	22,000	63,400	74,100	35,430	33,583	-5%
O&G	nd	nd	nd	nd	13	nd			

Tests conducted at West Virginia University, Morgantown, WV under Department of Energy Contract DE-FE0000833

Total Suspended Solids reduced 39%
Total Dissolved Solids reduced 12%

Water Chemistry Stable After Three Recycles

RFW dilution model: all ions								
recycle								
rate	initial		Frac Water	cycle				
20%	RFW	makeup	Target	1	2	3	4	5
TDS	98,867	0	50,000	19,933	23,920	24,717	24,877	24,909
Hardness	33,583	50	26,000	6,757	8,108	8,378	8,432	8,443
HCO3	100	20	300	43	45	45	45	45
SO4	56	40	50	43	52	54	54	54
Cl	53,133	10	45,000	10,635	12,762	13,187	13,272	13,289
Na	20,387	10	36,000	4,085	5,066	5,099	5,105	5,106
Ca	9,557	20	8,000	1,927	2,313	2,390	2,405	2,408
Mg	1,077	10	1,200	223	268	277	279	279
K	631	15	1,000	138	166	171	172	173
Fe	23	1	10	5	6	7	7	7
Ba	593	-	10	119	142	147	148	148
Sr	1,486	-	10	297	357	369	371	371
Mn	6	1	10	2	2	2	2	2

Filtered water can be recycled without limits.

Clear Effluent

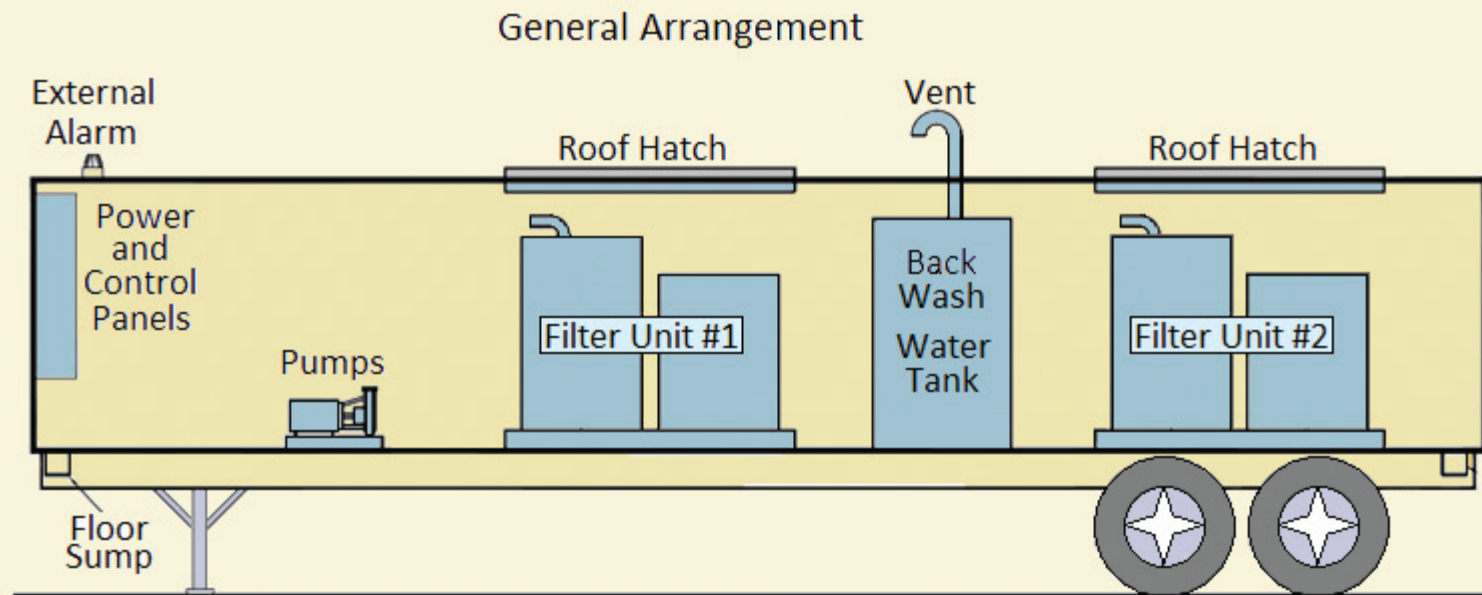


All solids > 3 microns were removed by filtration.

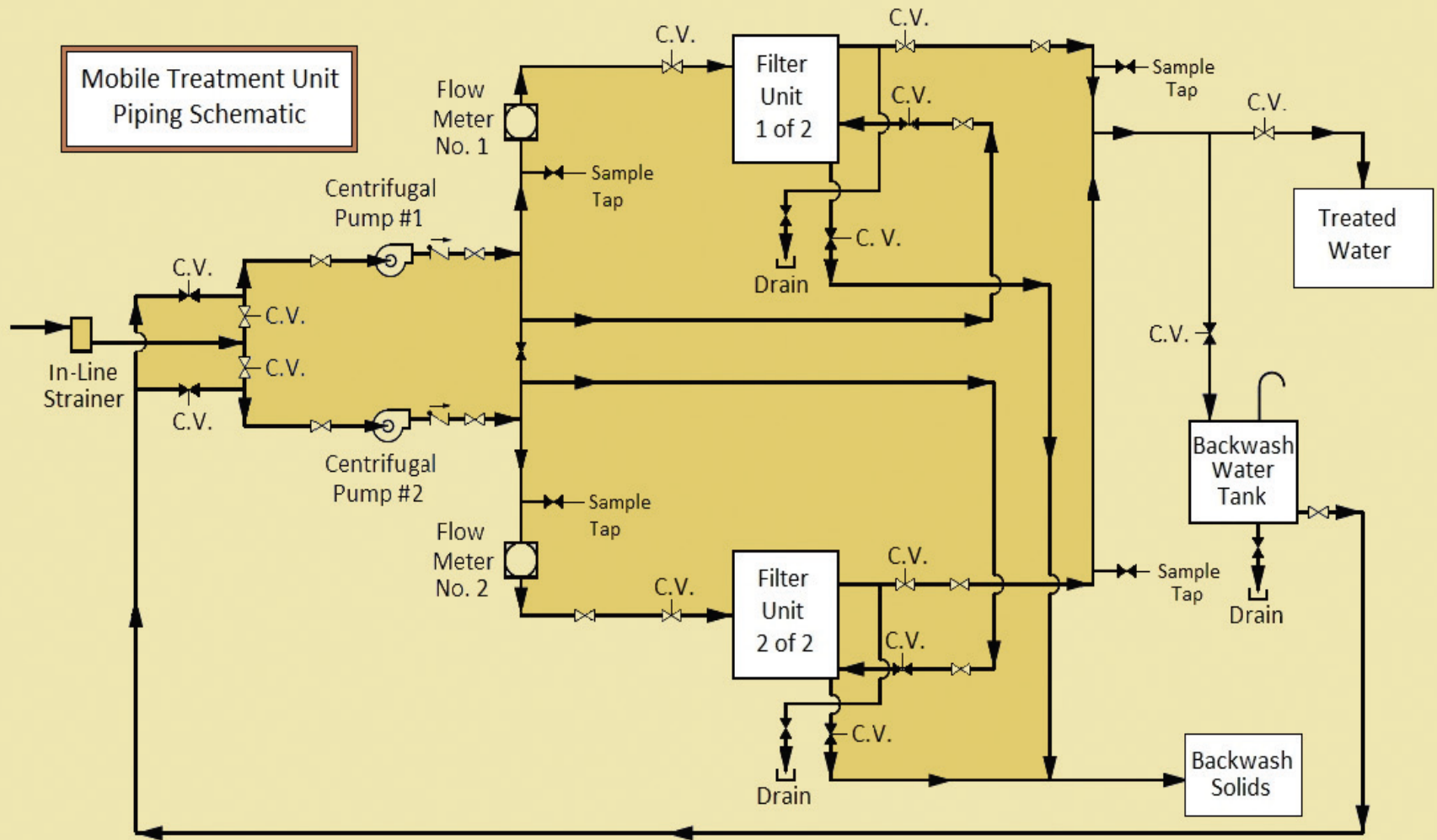
Phase II Implementation

- Goal: Construct and Test High Volume Mobile Treatment Unit (MTU)
 - 150 GPM +/- 30 GPM
 - 4,000 to 6,000 Bbl/day
- Verify That FilterSure Water Will Meet Producer Needs And That:
 - Pre-treatment is not needed
 - Post-treatment is not needed

MTU General Arrangement



MTU Piping Schematic



Mobile Unit Under Construction



Non Metallic Centrifuge Pumps



Finished Interior 40 Feet Long



Automatic Valves And Control Panel



Built-In Safety Features



Raw, Filtered, Backwash Connections



Field Testing Underway

- Mobile Treatment Unit Leased To Chesapeake Energy
 - FilterSure selected as “APPROVED VENDOR”
 - Chesapeake selected Ohio site to start
- Mobile unit will sit on well pad during fracture operations
 - Filtered frac water will be blended with fresh water
 - Staying one day ahead of next day requirements

Commercial Operations

- Treatment Services Will be offered Two Ways:
 - Per barrel treated
 - Under lease

Per Barrel Treatment Costs

- Current Mobile Unit
 - Operates 24/7
 - Expected to process up to 180 GPM
 - Expected to operate 50% of time
- Current Unit Per Barrel Treatment Costs
 - Offered at \$0.75 per bbl +/- \$0.25 per barrel
- Per Barrel Price Depends on Volume Treated

Leasing Mobile Treatment Unit

- Pricing Considerations
 - Volume to be treated
 - Producer support offered, e.g., unit movement to next site, power provided, on-site services
 - Lease term in months
- Lease Agreements will be Negotiated

Summary

- Filtration Alone
 - Reduces both total and suspended solids
 - All solids larger than 3 microns removed
- Effluent Water Chemistry
 - Suitable for blending and recycle
 - Filtered water can be recycled without limit

Summary (continued)

- Mobile Treatment Unit Constructed and Leased to Chesapeake Energy
 - Ohio site selected
 - Expected rate up to 180 GPM (6,000 Bbl/day)
- Commercial Services will be Offered
 - On per barrel basis
 - On lease basis