

The Economics of using AMD, is it feasible?

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What gives mine water value to shale gas company?

- Proximity to operations
- Volume
- Reliable availability
- Chemical suitability for fracking or use in flowback treatment operations
- Cost

Proximity Math

- 4000 gallon tanker truck
 - Average speed, 30 mph
 - roundtrip
 - Cost, \$70/hr
- \$1.17 per mile per 1000 gallons
- 4.5 million gallons from 15 miles = \$80,000
- (5,000 fracks X \$80,000 = \$400 million)

Volume Considerations: 4.5 Million Gallons

- Mine Drainage Discharges
 - Most surface mine discharges are less than 100 gpm
 - 100 gpm = 144,000 gallons per day
 - 31 days to produce 4.5 million gallons
 - Dozens of deep mine discharges that are > 1,000 gpm
 - 1,000 gpm = 1.4 million gallons per day
 - 3 days to produce 4.5 million gallons
- Mine Pools
 - One acre of flooded deep mine complex holds about 450,000 gallons of water (5 ft seam, 70% recovery 40% porosity)

Reliable Availability

- Flow rate of most surface mine discharges decreases greatly during drought
- Deep mines discharges can be more reliable during droughts
- Deep mine pools can be huge resource in droughts

Mine Drainage Chemistry and Fracking

- Sulfate Concerns
 - $\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4 (s)$
- Uncertainty about critical sulfate concentration for fracking
- Sulfate concentrations are variable

Site	Flow	Sulfate	Site	Flow	Sulfate
Markel	300	900	Colver	2,400	400
McIntyre	400	110	Canterbury	3,000	1,400
Big Run	150	1,200	Irwin	6,000	550
Philips	3,500	850	Crabtree	3,000	650
Wilson	1,000	400	Shaft #1	1,000	170
SVC W3	500	800	Markel	300	900
SVC W1	1,500	600	Gladden	1,100	750
Brubaker	300	1,300	Hope	600	600
Brinkerton	2,500	500	Coal Run	1,000	700
Anna S Mine	500	400	Presto	500	600
Marchand	1,800	1,100	Wingfield	1,500	300
Lancashire	5,000	450	ER MD1	3,200	150

Sulfate Concerns

- How much sulfate is too much?
- Sulfate removal
 - Very limited with standard AMD treatment technologies
 - Wetlands that promote sulfate reduction: limited
 - Bioreactors: unproven and expensive
 - Non-AMD treatment technologies: RO, crystallization

Sulfate Solutions?

- Dilute to acceptable concentrations
- React with Ba^{2+} in flowback water
- Direct treatment
- Determine impact of sulfate on well productivity

Water Sales by AMD Treatment Plants: Expectations

- Existing Plants that were justified without expectation of income from water sales
 - Unexpected occasional income
 - Water sales commitments that cover defined periods of plant operation
 - Commitments to take over operation responsibilities
- New Plants whose financing and/or operation is dependent on income from water sales
 - Completely finance construction and all long-term operations
 - Partially finance construction and all long-term operations

Water Sales by AMD Treatment Plants: Expectations

- Existing Plants that were justified without expectation of income from water sales
 - Expect very loose sales agreements
- New Plants whose financing and/or operation is dependent on income from water sales
 - Expect tight sales agreements

Costs of AMD Treatment

	Scootac	Wingfield	Marchand	Anna S
Flow, gpm	50	1,500	1,800	550
Mgal/day	0.1	2.2	2.6	0.8
Chemistry	pH 4, 100 acid	pH 7, 15 Fe	pH 6, 75 Fe	pH 3, 250 acid
Sulfate	1,000	300	1,100	400
Construction, \$	\$65,000	\$700,000	\$1,250,000	\$2,200,000
Annual, \$/yr	\$2,000	\$2,000	\$5,000	\$5,000
Major Maintenance	\$7,000/3	\$50,000/10	\$150,000/6	\$250,000/8
PV (total)	\$276,000	\$1,200,000	\$2,800,000	\$3,900,000

Levels of Involvement

- Full responsibility for system's installation and operation
- Option to purchase water structured to cover annual O&M
- Sale of water so that major maintenance is covered

Conflicts between AMD Treatment and AMD use

- Effective stream restoration requires continuous treatment over long time periods.
- Cost-effective utilization of AMD would use a limited amount of water over short time periods.