Marcellus Summit 2011

The Penn Stater – State College, Pennsylvania

Water Management: Opportunities and Challenges in Recycling Marcellus Wastewater

November 17, 2011

Balancing Today's Water Needs & Tomorrow's Water Vision

How to Progress from A to B…

Brent Halldorson,
Fountain Quail Water Management

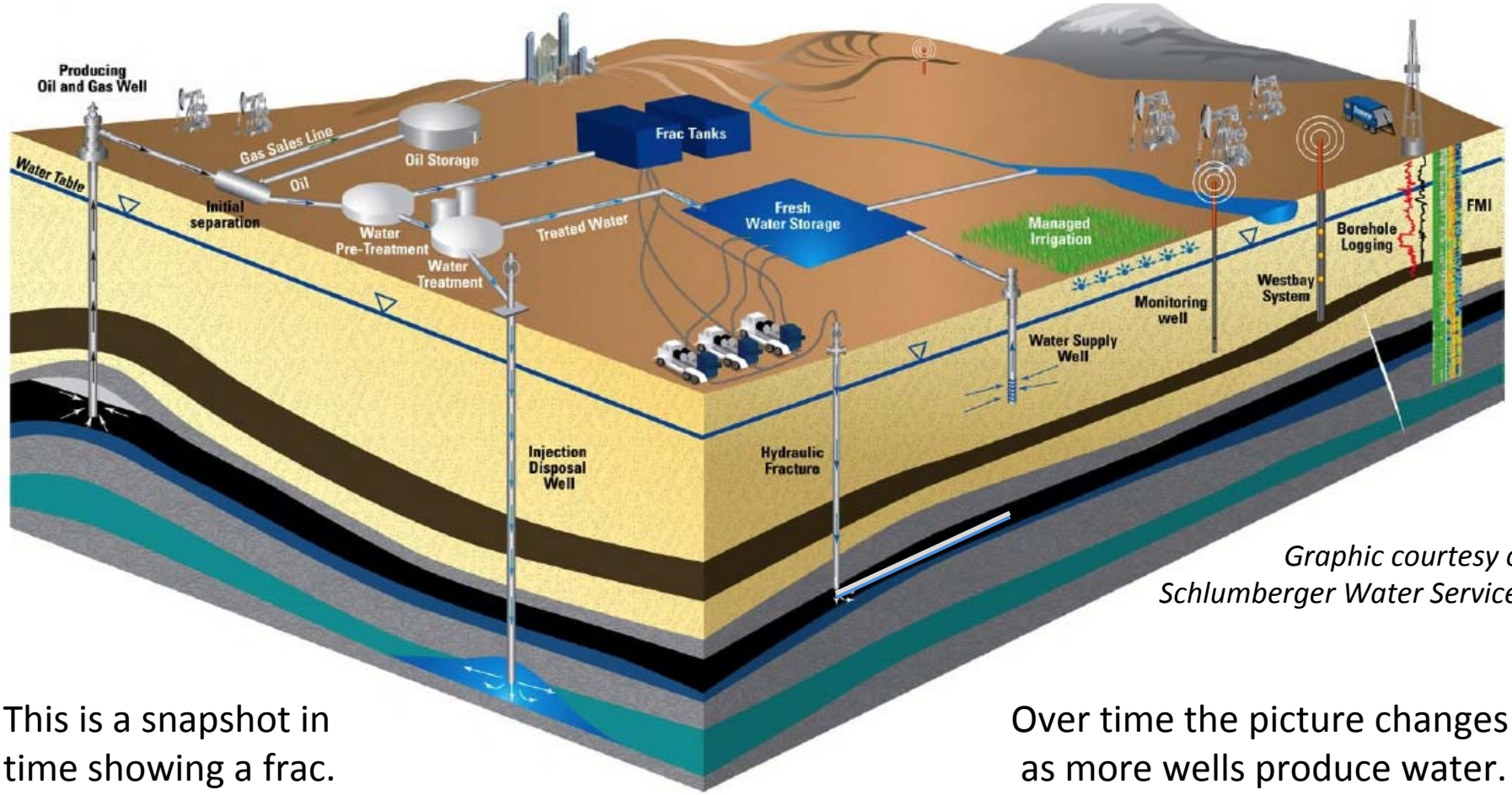
Shale Development Water Use

Short term issues tend to obscure the big picture costs of water management.

Needs are constantly changing over time (moving target).

- Early stage development tends to favor re-use of flowback.
- More mature plays generally require desalination (possibly ZLD).

Shale Development Water Use

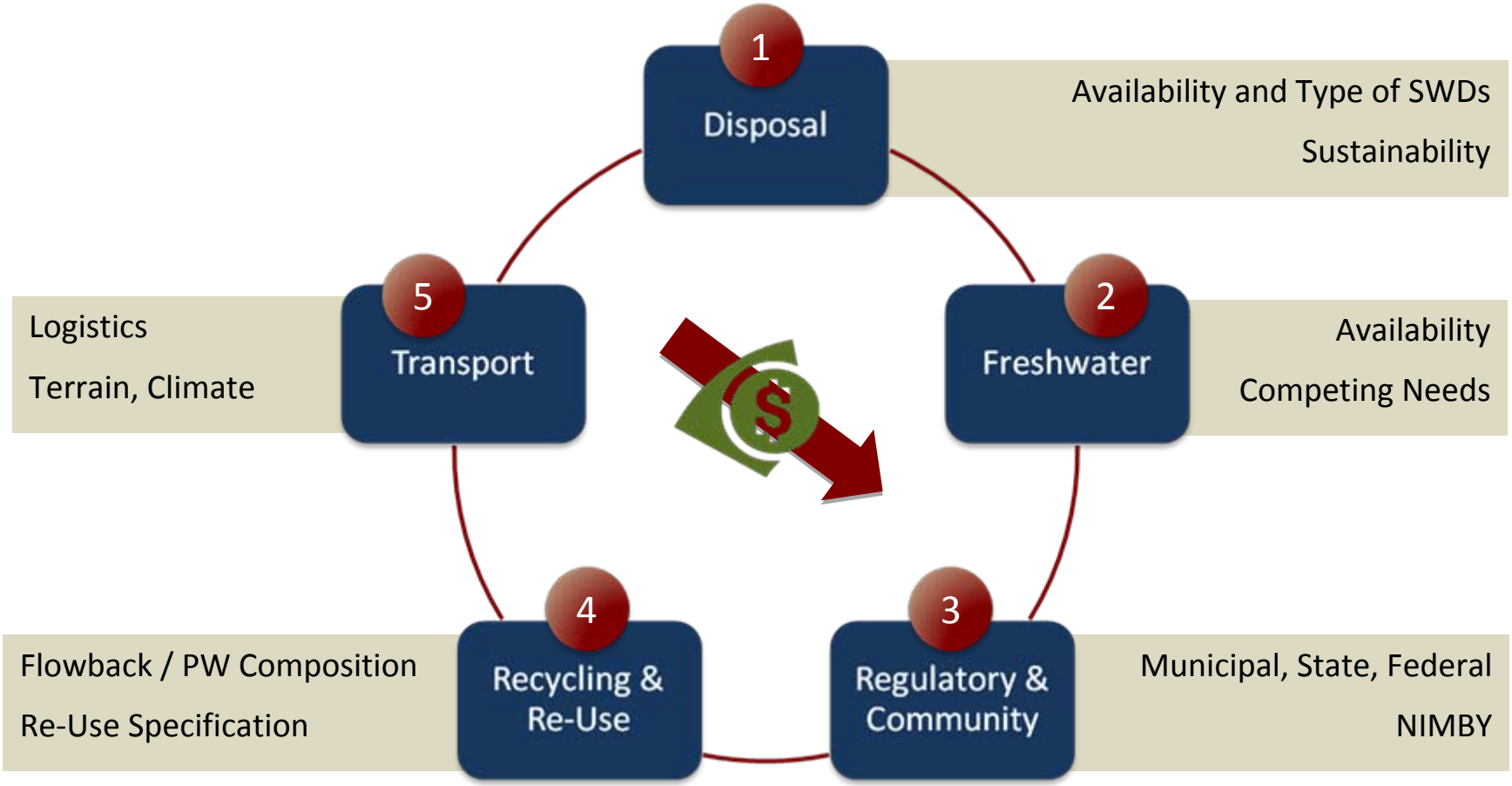


Graphic courtesy of Schlumberger Water Services

This is a snapshot in time showing a frac.

Over time the picture changes as more wells produce water.

Key Water Issues



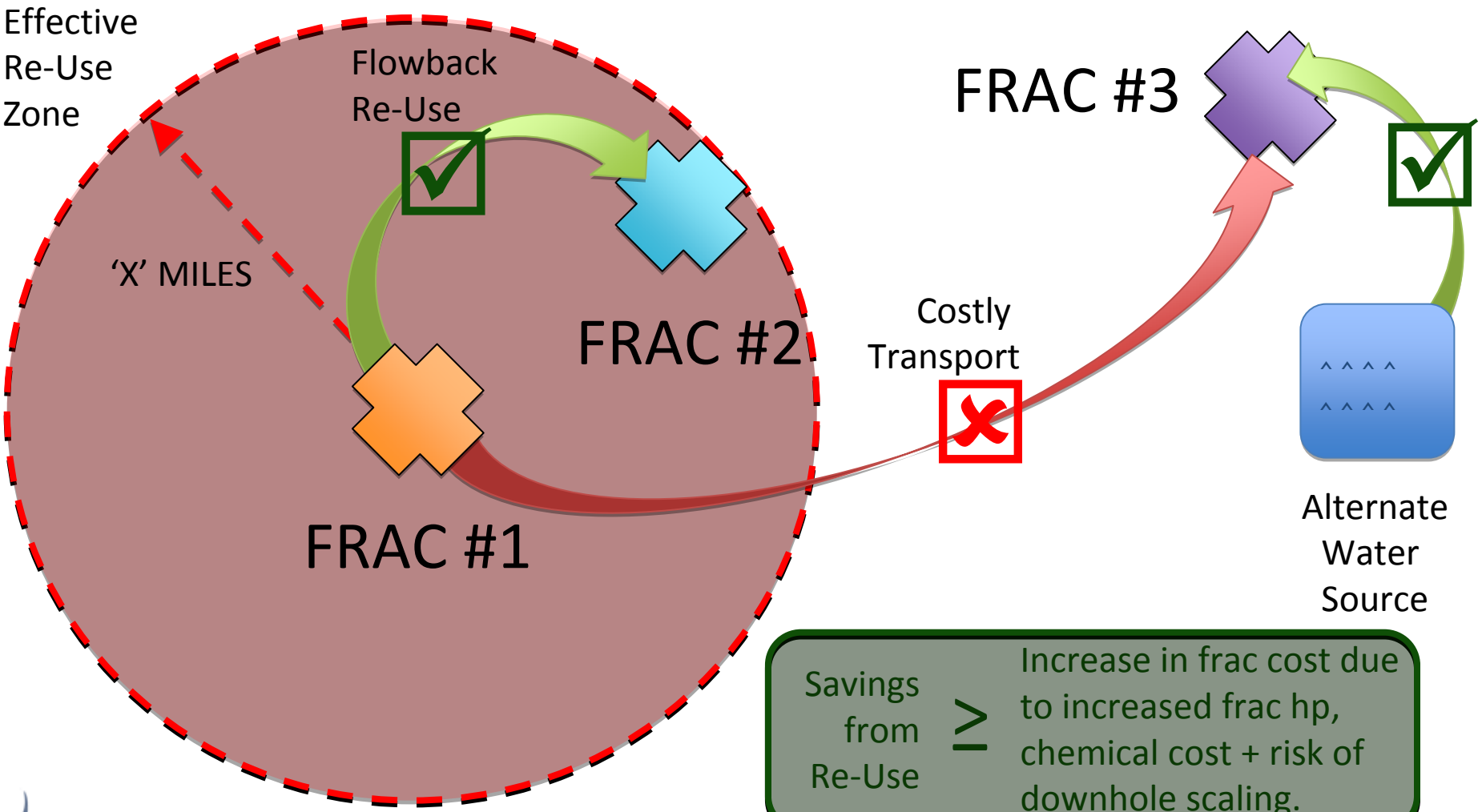
Shale	Water Management Drivers	Possible Solutions
Barnett (TX)	- Urban drilling. - Abundant disposal wells. - Dry climate.	- Utilize low cost disposal. - Pipeline water to reduce trucking costs.
Marcellus (PA)	- Very limited disposal capacity. - Difficult terrain and climate.	- Re-use of salt brine preferred for initial development of field.
Fayetteville (AR)	- Fresh water has minimal value. - Disposal is problematic (recent earthquakes near shallow sandstone SWDs).	- Treat for environmental discharge. - FQWM has first ever NPDES discharge permit for treatment of Fayetteville shale wastewater.
Haynesville (LA)	- Limited freshwater supply. - Disposal marginal.	- Pipeline distribution and on-site treatment being used.
Eagle Ford (TX)	- Very limited freshwater. - Heavy (concentrated) brine used for drilling.	- FQWM is setting up sites to provide (1) freshwater and (2) concentrated brine – has value for drilling.

Individual states are "laboratories" with unique drivers and regulations. Comparisons and competition often help develop better solutions.

A – Short Term Needs

- Where do I get the water for my next frac?
- Is a minimum quality required? (i.e.: for cross-linking, etc.).
- Do I need to “hold acreage” by drilling/fraccing in areas where I do not have adequate infrastructure?
- Even if I can re-use flowback, what are the storage & transportation issues?

Logistical Challenge Example



Savings from Re-Use ≥ Increase in frac cost due to increased frac hp, chemical cost + risk of downhole scaling.

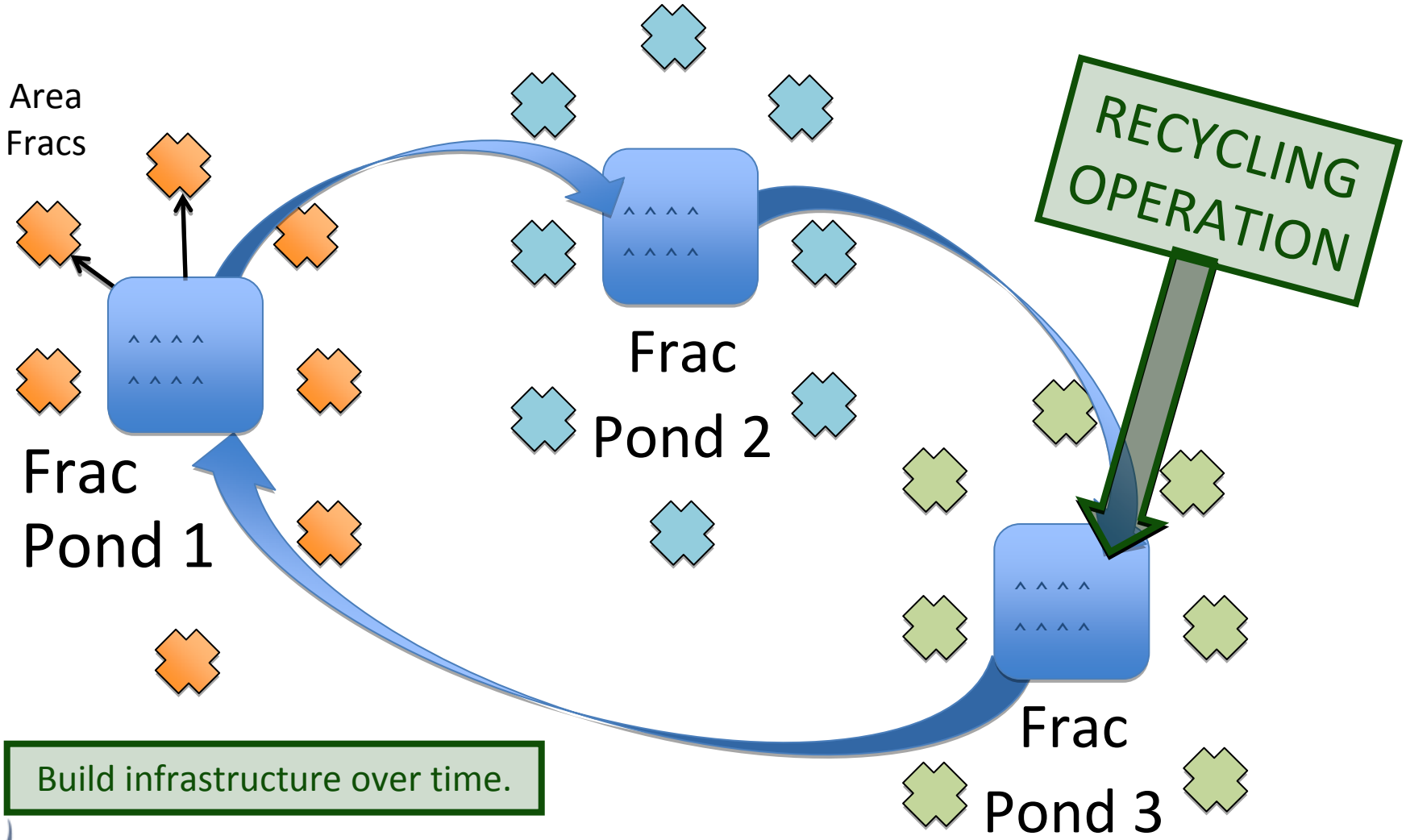
B – Long Term Vision

- Grandiose Goals:
  a) *100% re-use.*
  b) *Limit freshwater withdrawals.*
  c) *Frac with water that has minimal downhole "scaling index".*
- Structured drilling/fraccing becomes more practical after the "land rush" is over.
- Large contiguous lease blocks help manage water effectively.

Intermediate Thoughts (A to B)

- I know what works today for fracs.
  a) *What might work tomorrow?*
  b) *Can I use more saltwater?*
  c) *Do I risk downhole scaling with improper (or lack of) treatment?*
- Can I drill with different fluid to re-use water management by-products?
- How do I move water without taking on too much liability?

Spoke and Wheel Example



Build infrastructure over time.

Central vs. On-Site Treatment

On-Site Treatment
TSS Removal
Limit Downhole Scaling

Central Treatment
TDS Removal
Alternate to Disposal

Filtration
DAF
Oil Separation – *walnut shell filters, hydrocyclones*
Clarifiers
Softeners
Electro-Coag

Precipitation

Simple
High Capacity
Low Cost

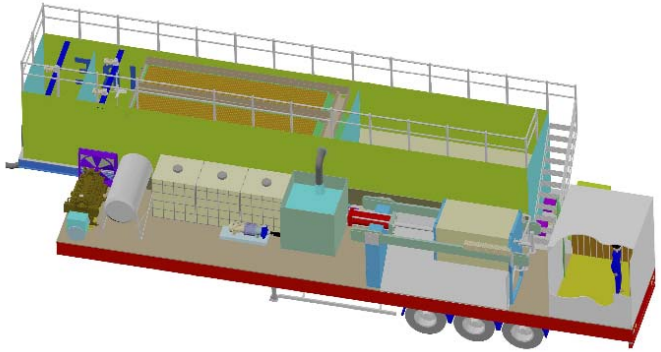
Membranes –
UF, RO, EDR, etc.

Evaporators
Crystallizers
Waste Heat Systems -
use pipeline compressor heat.

TIME

On-Site Treatment

- ROVER Mobile TSS Removal.
- 10,000bbl/d capacity.
- Perform basic on-site water treatment & deliver clean brine.
- Ability to remove Ba, Sr, Fe, etc.



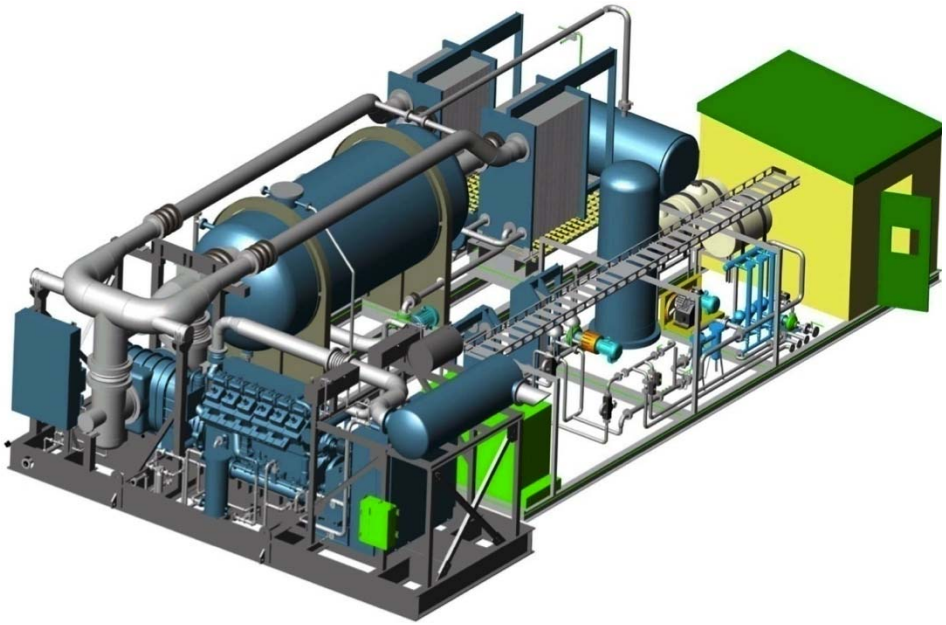
ROVER Example

Perform on-site brine re-use.

High capacity (10,000bbl/d), low-cost.

Mobile Treatment

- NOMAD Mobile Evaporator - 2,000bbl/d (320m^3/d) distillate (pure fresh water, < 100mg/L).
- Complete TDS removal, delivers fresh water.

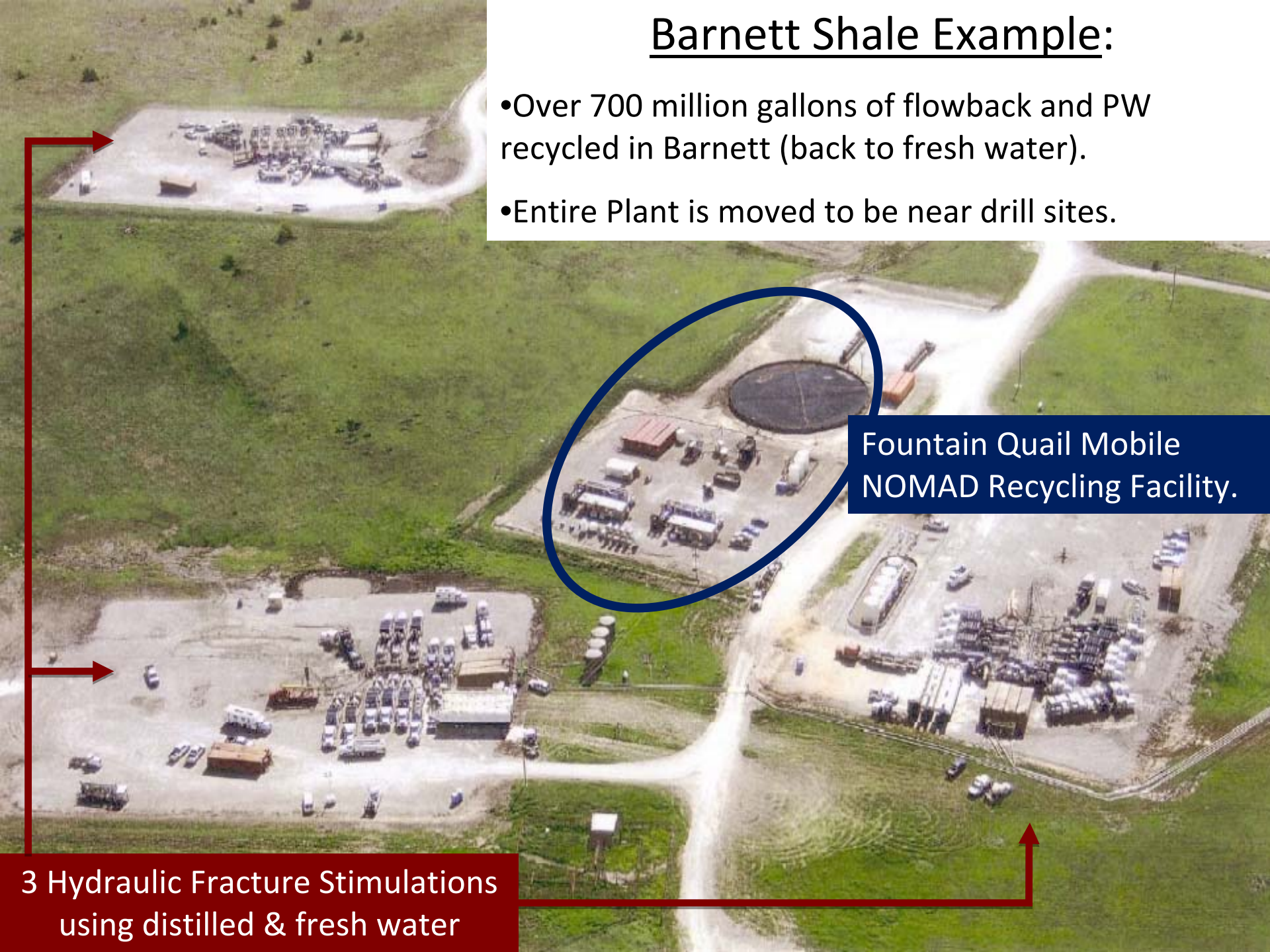


NOMAD Example

Move water recycling equipment near drilling activity to reduce transport costs.

Barnett Shale Example:

- Over 700 million gallons of flowback and PW recycled in Barnett (back to fresh water).
- Entire Plant is moved to be near drill sites.



Eagle Ford Example

- New Facility at Kenedy, TX.
- Converts waste into (1) clean water, and (2) clean concentrated salt brine for re-use.

Eagle Ford Example

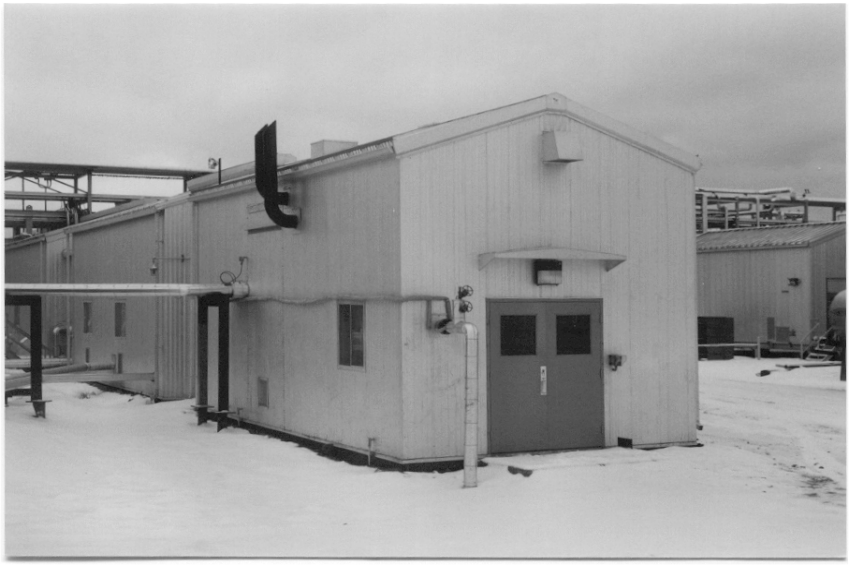
Marcellus Shale Example

- Indoor facility in Williamsport, Pennsylvania - 7,500bbl/d treatment.
- Discharge fresh water or return to customer.

2011 IOGCC Award

Fountain Quail was awarded the IOGCC Chairman's Stewardship Award last month.

Central Plant Examples



EnCana SAGD Oilfield Evaporator – Foster Creek, Alberta (Canada)

Feed: Oilfield Produced Water (direct from skim tank)

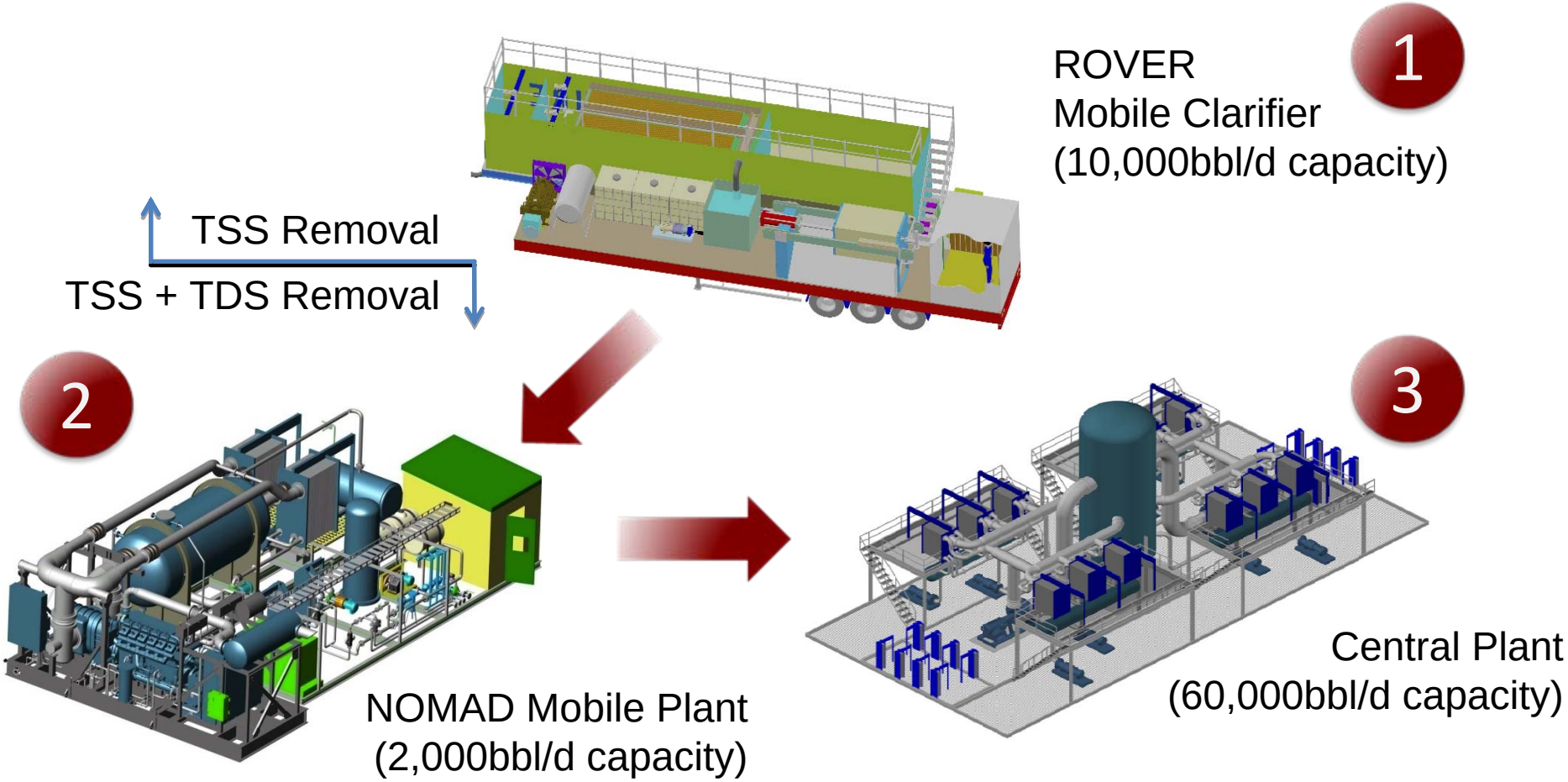
Product: Distilled Water (60usgpm) for boiler feed water

BP Brine Concentrator - Sarnia, Ontario (Canada)

Feed: 12-22wt% dilute salt brine (100 to 220 usgpm)

Product: 26wt% concentrated brine & distilled water (42usgpm)

Flexibility Required



What is Needed?

1. Common Sense Approach.
   - Economics and regulation will determine how water is managed.
   - Consider the big picture of overall water management.
2. Range of Solutions.
   - Look for a proven track record. Talk to the customers.
   - Nobody has "the magic cure".
   - Technology must be based on real science backed up with real results.
3. Flexibility.
   - Solution must be adaptable to the changing needs of the industry.
   - Example: Start with mobile NOMAD, build fixed plant as need increases.
4. Cooperation.
   - Share results and experiences (good and bad). We can learn as much, or more, from what has not worked.

Summary

1. **Shale gas/oil is a blessing.**
   - Energy independence.
   - Economic growth – local jobs.

2. **Water is a blessing.**
   - Water management can be challenging – balance is needed.
   - One time use of fresh water for stimulation.
   - Water vapor is a by-product of natural gas combustion (returns water to environment).
   - Given the proper tools, industry can innovate.

Contact

Brent Halldorson

- Aqua-Pure / Fountain Quail
- brent.halldorson@fountainquail.com
- Office: 817-491-8650 x223
- Cell: 817-825-6805