Shale Gas: A Game-changer in Energy
May 17, 2013

EXPERIENCES IN SHALE WASTE WATER MANAGEMENT

An Update on the Issues Associated with Water in the United States Shale Gas Sector

Devesh Sharma - Managing Director

Discussion Points

I – Shale and Water

II – Processes and Technology

III – Commercial Aspects / Business Model

IV – Thoughts on Indian Sector

About Aquatech

Dedicated to bringing the ***most valuable solutions*** and providing the ***best customer experience*** in meeting water and environmental needs through our ***innovative technology*** solutions, products and services.

Background

- **Founded 1981 in Pittsburgh, PA. USA**
- **Global Footprint-Canada, China, India, Europe, GCC & USA**
- **Over 1000 Major Projects in 60 Countries**
- **In India since 1993, Major Clients – RIL, TATA Power, ONGC, GVK**

Technology

- **Industrial Process Water**
- **Desalination**
- **Wastewater Treatment, Recycle, and Reuse**
- **Advanced Reuse & Zero Liquid Discharge**

Markets

- **Energy**
- **Natural Resources**
- **Infrastructure**
- **Heavy Industry**

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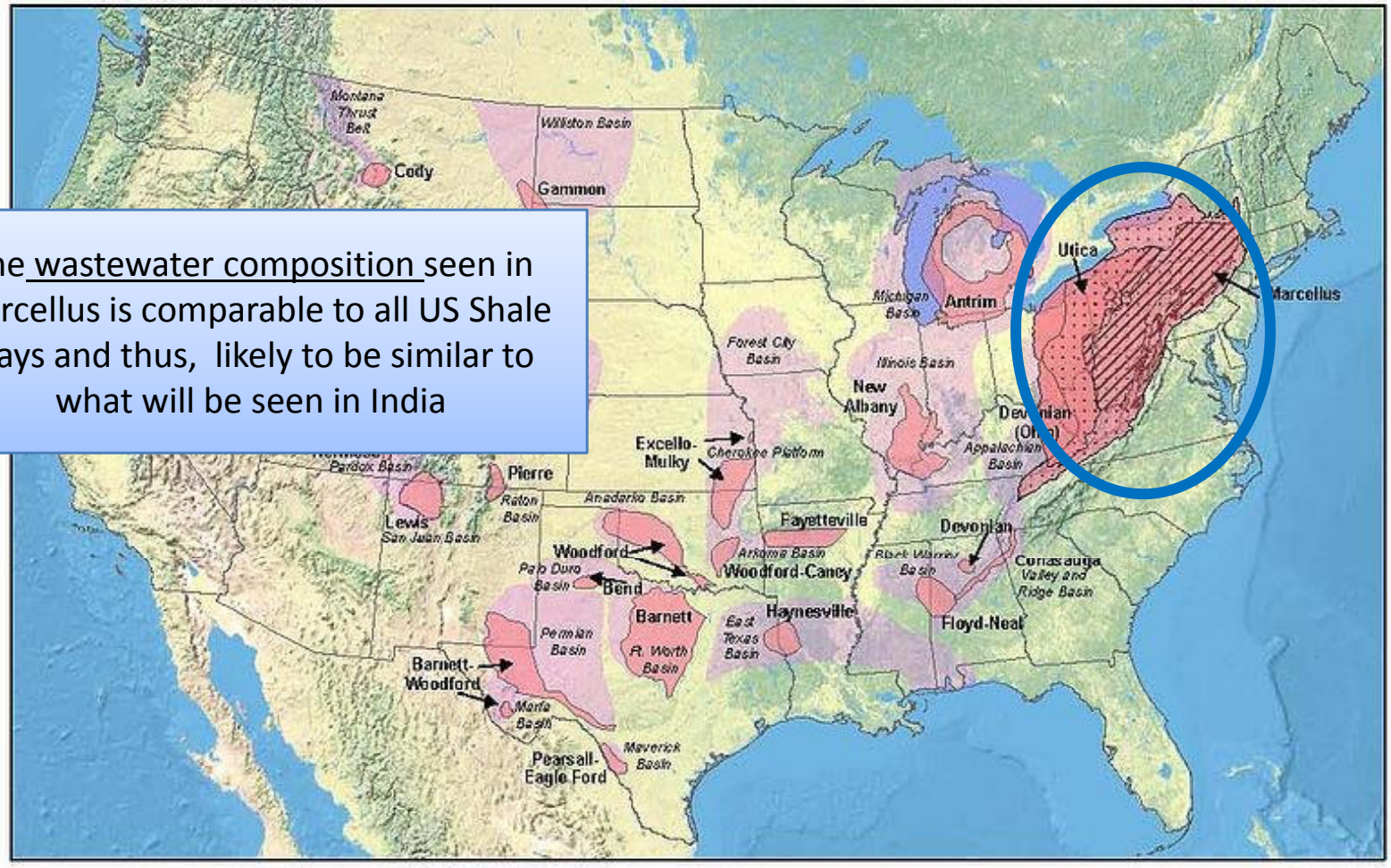
BACKGROUND OF SHALE AND WATER

FOCUS OF THIS PRESENTATION

The wastewater composition seen in Marcellus is comparable to all US Shale Plays and thus, likely to be similar to what will be seen in India



United States Shale Gas Plays

www.eia.doe.gov
Energy Information Administration
Office of Oil and Gas

Shale Gas Plays
Basins

Stacked Appalachian Plays
Marcellus
Utica
Devonian (OH shale)

November 2008
Miles
0 150 300 600

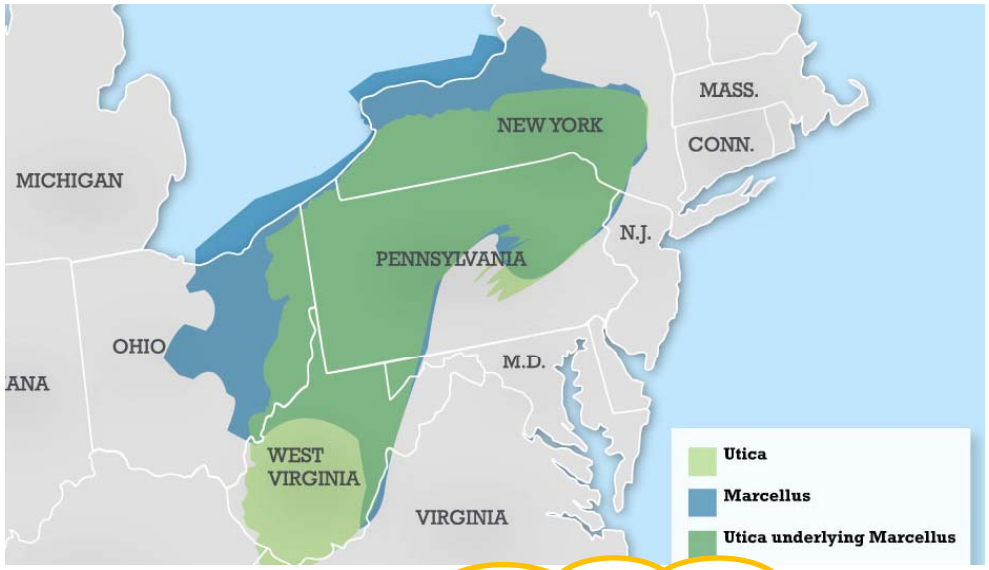
N

MARCELLUS SHALE

Field History	
Start of production	1859 by Colonel Drake in Titusville
Wells drilled since then…	45,000 ++

Impact Facts

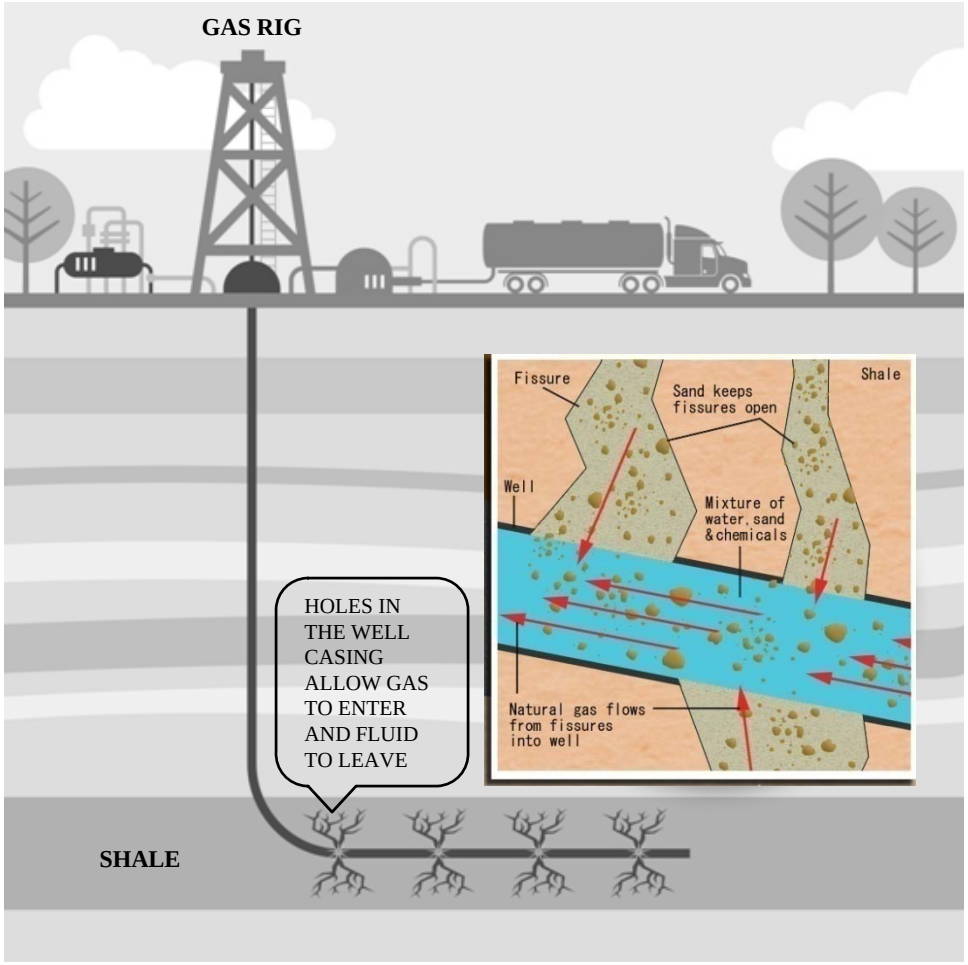
By 2020 the industry will provide:
- A total economic impact of $18.8 billion
- 211,000 jobs for the Commonwealth
- $1.8 billion in state and local tax revenues
- Make Pennsylvania a natural gas exporter instead of a gas importer in the next few years



In 2011: USA consumed 24.3 TCF and India 2.3TCF of Natural Gas

Production	
Reserve Estimate and Depth	Reserves: 489 TCF (Trillion Cubic Feet) Depth: 4500-8000 feet
Operators	Chesapeake Energy; Chief; Range Resources; Rex Energy; Chevron; Shell

WATER AND SHALE GAS



A typical Marcellus Shale Well requires

- 100,000 gallons/3,175 Barrels/ 450 $m^3$of water for Drilling
- Water consumed
- **3-8 million gallons**
- **95 - 255 K Barrels**
- **13,500 – 36,500m^3**

….per well for Hydraulic fracturing

- The Flowback is on average 10 - 25%
- The initial surge of Flowback (first 3-4 weeks) is as high as 200 GPM (45 m^3/hr) with a TDS of 80,000
- Then Produced Water is 1-2 GPM for years
- *Water quality more challenging as time goes on*

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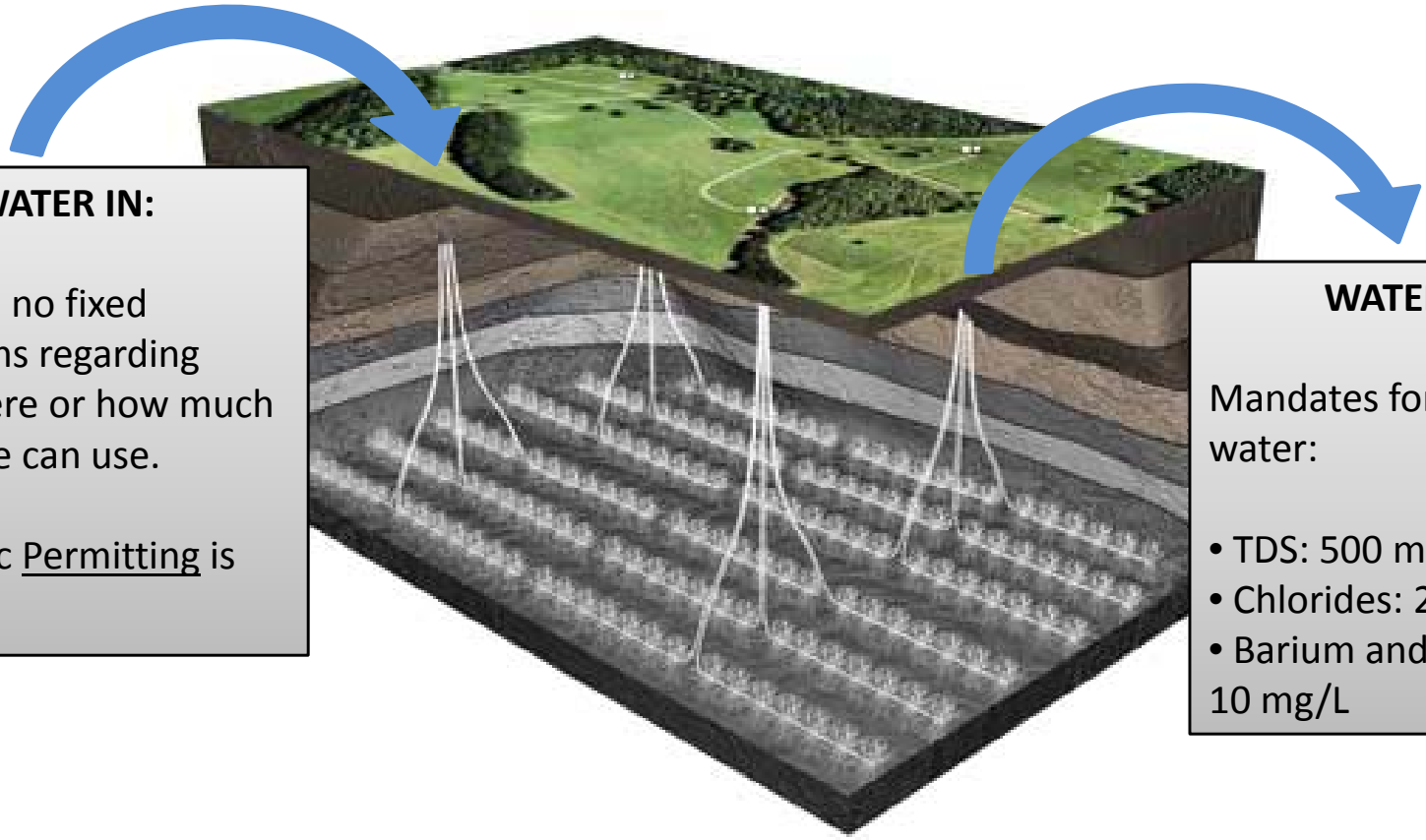
ENVIRONMENTAL REGULATION

WATER IN:

There are no fixed regulations regarding from where or how much water one can use.

Only basic Permitting is required.



WATER OUT:

Mandates for disposal of water:

- TDS: 500 mg/L
- Chlorides: 250mg/L
- Barium and Strontium: 10 mg/L

PROCESS AND TECHNOLOGY

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WATER QUALITY FACTS

WATER OUT:

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- **TDS: 500 mg/L**
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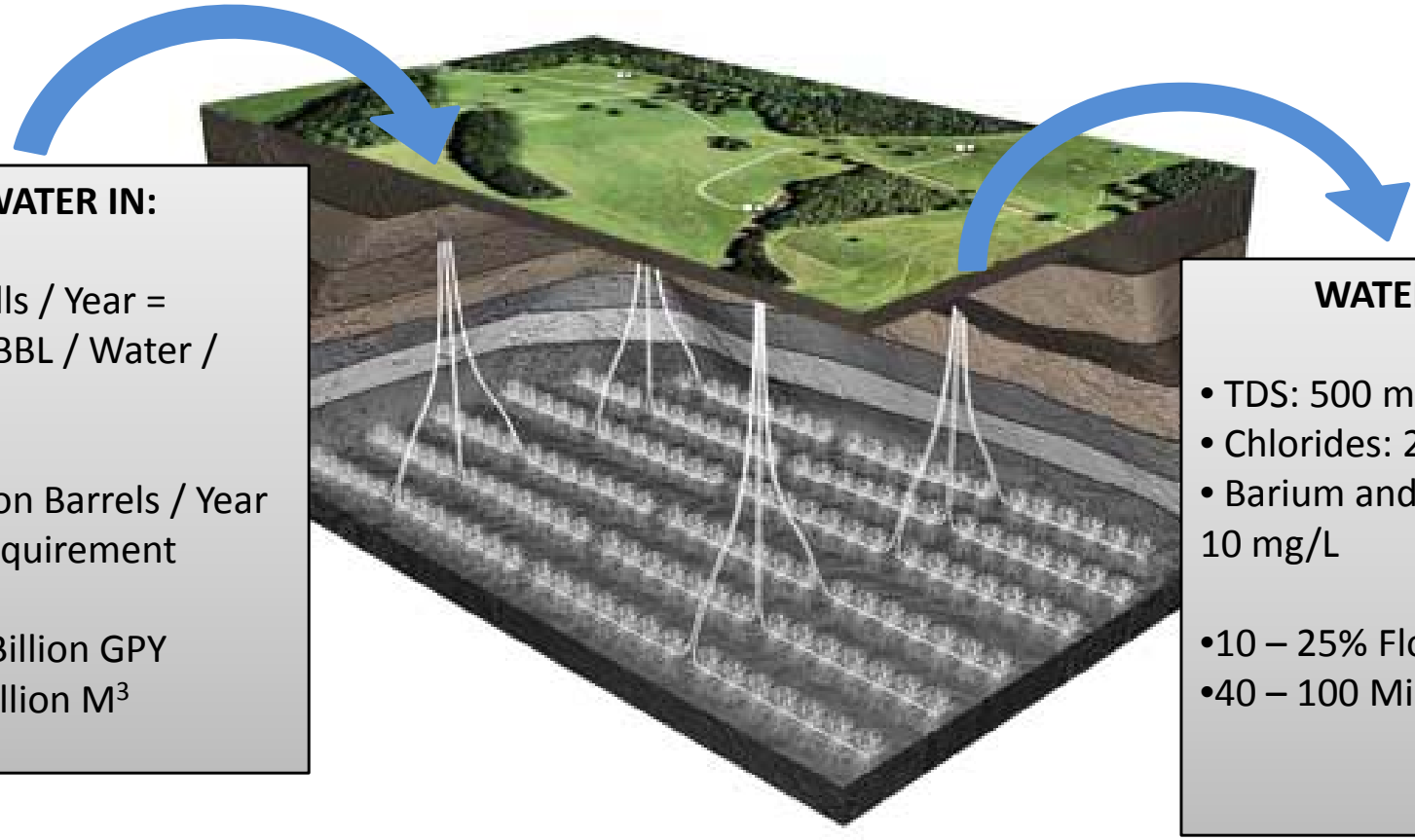
Flowback Water

Parameter	Range	Median	Units
Total alkalinity	48.8 – 327	138	mg/L*
Hardness as $CaCO_3$	5,100 - 55,000	17,700	mg/L
Total suspended solids	10.8 - 3,220	99	mg/L
Turbidity	2.3 – 1540	80	NTU†
Chloride	26,400 - 148,000	41,850	mg/L
Total dissolved solids	38,500 – 238,000	67,300	mg/L
Specific conductance	79,500 – 470,000	167,500	umhos/cm‡
Total Kjeldahl nitrogen	38 – 204	86.1	mg/L
Ammonia nitrogen	29.4 –199	71.2	mg/L
Biochemical oxygen demand	37.1 - 1,950	144	mg/L
Chemical oxygen demand	195 - 17,700	4,870	mg/L
Total organic carbon	3.7 – 388	62.8	mg/L
Dissolved organic carbon	30.7 – 501	114	mg/L
Bromide	185 - 1,190	445	mg/L

WATER BALANCE OF THE PLAY



WATER IN:

2000 Wells / Year = 200,000 BBL / Water / Well

400 Million Barrels / Year Water Requirement

- 12.6 Billion GPY
- 57 Million M^3

WATER OUT:

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•10 – 25% Flowback
•40 – 100 Million Barrels

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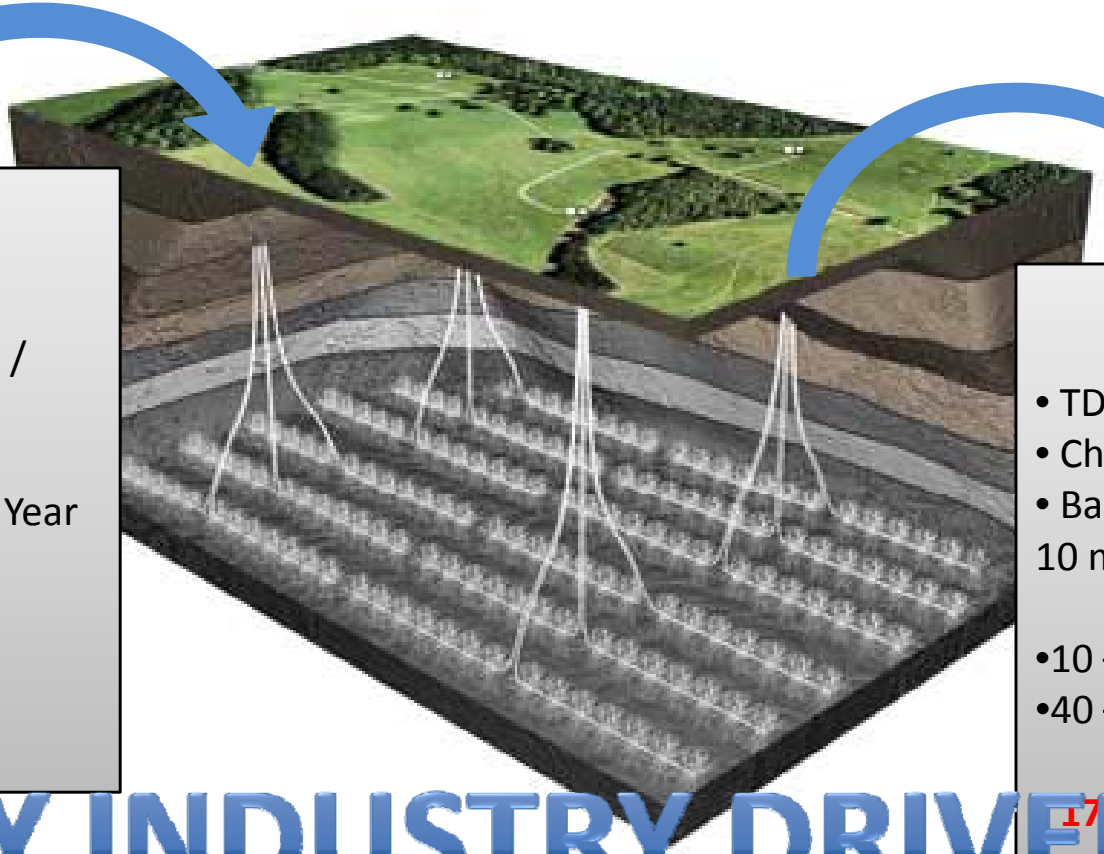

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17 [illegible] BBL in 2011

KEY INDUSTRY DRIVER

MAXIMIZE REUSE

WATER QUALITY FACTS

- The Flowback Water is **reused** a number of times in Fracking until it contains approx. 50,000–100,000 mg/LTDS, at which point it is treated .

- Produced water is water from the reservoir that flows to the surface with gas during the life of the well.
- Typical composition of Produced water is:
  - pH = 6.5 to 8
  - Oil & Grease = 9,500 mg/L
  - TSS = 10,000
  - TDS = 5% (500,000 mg/L)
  - COD = 20,000 mg/L

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TECHNOLOGY

- **Pretreatment**
  - Reduction of suspended solids
  - Reduction of hardness compounds
  - Disinfection against bacteria
  - Reduction of scaling compounds
- **Dissolved Solids Removal**
  - Membrane Treatment
  - Evaporation
  - Waste minimization; reduced trucking
  - Integration with disposal wells
- **Crystallization**
  - Production of reusable salts

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PRETREATMENT

Total Suspended Solids (TSS) TREATMENT

- **Chlorine dioxide oxidation:** Breaks oil/grease emulsions; destroys friction reducers and other chemical additives; and kills bacteria
- **Dissolved air flotation:** Floats oil, grease and TSS to the top of the chamber
- **Liquid-phase activated carbon:** Removes most hydrocarbons and other organics
- **Chemical precipitation:** Removes scale-forming compounds
- **Conventional sand filter:** Removes the TSS

Dissolved Solids Removal

Total Dissolved Solids (TDS) TREATMENT

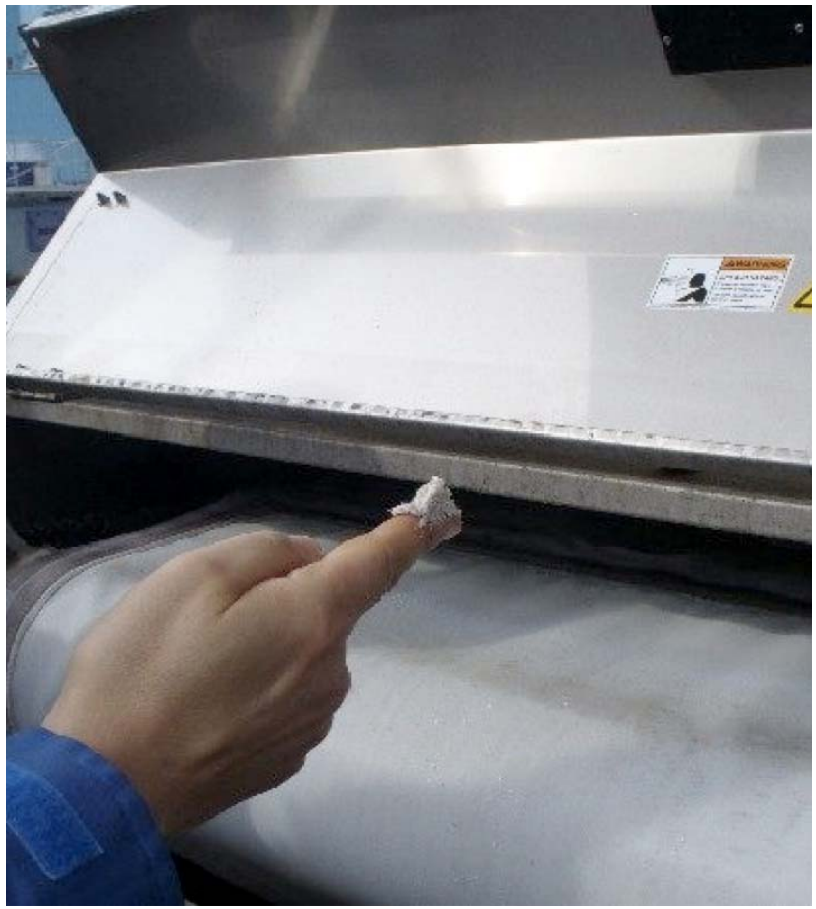
- **Ultrafiltration (UF):** Does not handle TDS, but is common Pretreatment for removal of TSS effectively
- **Reverse Osmosis (RO):** Limited efficiency at the TDS of Shale Waste Water (50,000 TDS)
- **Brine Concentration:** Efficient form of Evaporation / Concentration

EMERGING TECHNOLOGIES

- **Forward Osmosis**
- **Membrane DIstillation**

CRYSTALIZATION

- Highly concentrated waste (greater than 2.5%) is usually treated through an off-site crystallizer.
- A 1 million gallon a day crystallization plant will generate approximately 400 tons a day of salt waste.
- This Salt has many applications and can be re-used:
    - Product for Industrial ion exchange
    - Product for de-icing (road)
    - Feedstock for cal-hypo etc.



A COMMERCIAL MODEL

NATURE OF THE INDUSTRY

Aquatech's Approach

- Provide Technology /Equipment Solutions

Industry Reality

- Constantly Evolving
- Unknowns driving the desire to not have capital equipment

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MoSuite

MoTreat™

MoVap™

Modular Crystallizer

Salt Products Recovery

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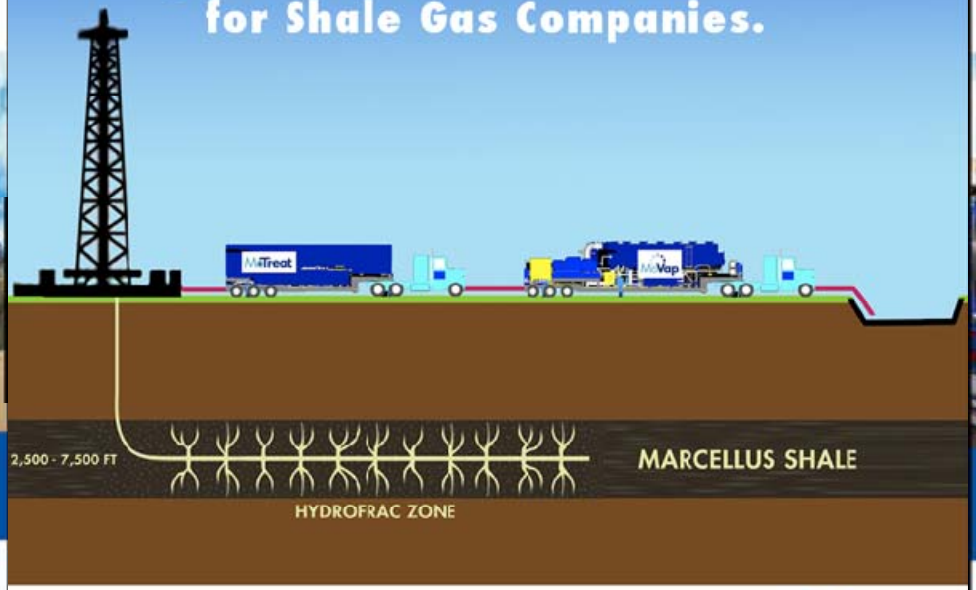
MoTreat Mobile Water Pre-treatment System

Pre-treatment for removal of suspended solids (TSS), manage hardness, bacteria, and select precipitation of metals.

- Reduced suspended solids.
- Reduced hardness compounds.
- Disinfection against bacteria.
- Precipitation of select metals.

Integrated water treatment solutions for Shale Gas Companies.



Aquatech is your single source provider of multi-tier, sustainable and cost effective treatment solutions for flowback and produced water at the well pad.

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MoVap Mobile Water Distillation System

Industrial scale distillation system for removal of dissolved solids (TDS) to produce water for recycling or reuse.

- Ultra-clean water < 500ppm TDS.
- Reduced waste water volumes.
- Water meets PA DEP regulations.
- Minimizes down-hole scaling.

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NATURE OF THE INDUSTRY

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- **Provide Technology /Equipment Solutions**
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Industry Reality

- Constantly Evolving
- Unknowns driving the desire to not have capital equipment
- Wildcatting mentality
  - "Just Truck it Off"
  - Disposal Wells
  - Cost not the primary issue

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- Driver to recycle as much as possible
  - Cost and Regulatory Pressure

Contact: Ann Seamonds
+1 978 887 9959; mobile +1 978 761 5528
scamonds@scamonds.com

**AQUATECH ACQUIRES FLUID RECOVERY SERVICES,
CREATES LEADING WATER MANAGEMENT SERVICES NETWORK FOR
OIL & GAS PRODUCERS IN THE MARCELLUS AND UTICA SHALE REGION**

CANONSBURG, PA, USA, May 13, 2013 – Aquatech, a global leader in water treatment technology and service solutions, announces the acquisition of Fluid Recovery Services (FRS). Based in Creekside, PA, FRS operates a network of central, satellite and mobile facilities that deliver a menu of environmentally compliant and economically viable water management services. In addition to treatment, FRS offers numerous water management service options such as storage, transport services (rail and truck), and disposal (non-return) across the state.

FRS was formed through the merger of Pennsylvania Brine Treatment (PBT) and Hart Resource Technologies (HRT). PBT and HRT have a 25+year history of providing water management services to the oil & gas industry in the Commonwealth of Pennsylvania and have treated more water than any other service provider in the Marcellus and Utica Shale region.

The Aquatech acquisition will immediately expand the network from three to five central water management facilities located in Franklin, Josephine, Creekside, Rouseville and Tioga, establishing an "end-to-end" network for producers in the Marcellus and Utica Shale region. Aquatech's strategy includes investments of capital, technology, expertise and experience.

Venkee Sharma, President and CEO of Aquatech, said, "Aquatech's goal is to be the leader in oil & gas water management. The acquisition of FRS represents significant progress towards achieving our vision. We will continue to aggressively develop facilities with innovative technology and service solutions to meet the growing needs of our customers."

NATURE OF THE INDUSTRY

Aquatech's Approach

- **Provide Technology /Equipment Solutions**
- **Mobile Equipment**
- Integrated On Site Services + Central Facilities
  - Treat and Manage Flowback on Site with MoSuite
  - Establish Central Facilities to take water that customer doesn't want
  - Utilize technology to create Fracking Fluid and Reusable Salts

Industry Reality

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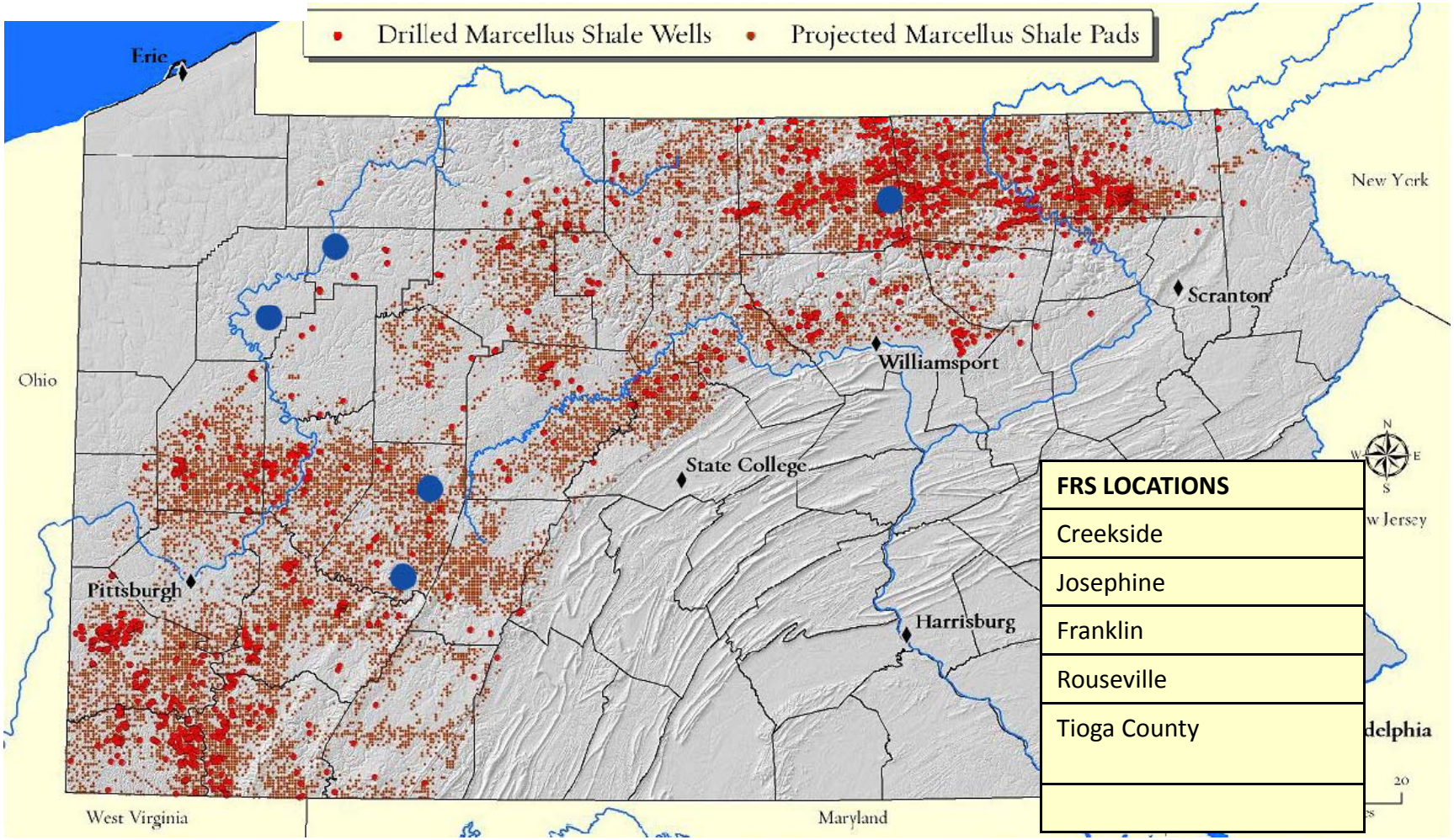
TREATMENT LOCATIONS



FRS LOCATIONS
Creekside
Josephine
Franklin
Rouseville
Tioga County

From Innovation **Flows Leadership**

NATURE OF THE INDUSTRY

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- **Mobile Equipment**
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SUMMARY OF KEY POINTS

- Water issues are central to Shale Gas Development
- The technology exists to support this industry cost effectively, reliably, and sustainably without harm to the environment
- Support service **may not already exist** in order to optimally solve the issues
- It is likely a ***new and innovative approach*** is needed to support the water issues effectively

INDIA SCENARIO

- Policies to promote gas development are important, seeing the change in Pittsburgh is example of how this can rejuvenate a region.
- India will have a different driver – ***water scarcity***
- Producers, government, and water companies need to work in a partnership mode to evolve
  - Business model
  - Water quality standards for fracking, treatment and disposal
  - Optimal Hydraulic Fracking Fluid

Thank You….