HIGH EFFICIENCY SOFTENING PROCESS (HESP ®)
FOR
FRACK FLOWBACK / PRODUCED WATER TREATMENT
SPONSORED BY
OGRES, IN ASSOCIATION WITH
CITY OF GRAND PRAIRIE, TEXAS

PREPARED BY
KEN PANDYA
AWTS, INC.
1817 TRIPLE CROWN LN
PLANO, TX 75093
OFFICE: 972 733 4404
EMAIL: awtsusa@aol.com

APRIL 11, 2012

BARNETT SHALE PLAY IN TEXAS, THE NATURAL GAS ECONOMY

- "According to Potter, the 5,500 wells currently pumping gas in the Barnett Shale play will ultimately generate on the order of $35 billion for their owners. As those companies pay taxes and wages, and as their employees and contractors in turn spend their money, there is an economic ripple effect, creating an overall value of about $100 billion to the Texas economy" **The Barnett Shale Gas Boom Igniting a Hunt for Unconventional Natural Gas Resources** by Marc Airhart, Jackson School of Geosciences, The University of Texas at Austin, http://geology.com/research/barnett-shale-gas.shtml

THE ART OF HYDRAULIC FRACTURING

- HYDRAULIC FRACTURING TECHNOLOGIES HAVE BEEN EMPLOYED FOR SEVERAL DECADES.
- LATEST DEVELOPMENTS ARE BASED ON HORIZONTAL FRACTURING TECHNIQUES
- DEVELOPMENT OF NATURAL GAS IS AN IMPORTANT PART OF THE US ENERGY POLICY.
- ENVIRONMENTAL CONCERNS, COUPLED WITH SHORTAGE OF WATER AND DEEPWELL INJECTION DOMINATE THE NEWS
- IT IS IMPORTANT FOR THE ENERGY COMPANIES TO SOLVE ENVIRONMENTAL PROBLEMS, AT THE SAME TIME HAVING A COST EFFECTIVE TREATMENT PROCESSES

WATER USAGE AND FLOWBACK

- FOR MOST HYDRAULIC FRACTURING OPERATIONS WATER AND SAND PORTION IS 99.5%. BALANCE OF THE COMPOSITION UTILIZES CHEMICALS
- FRESH WATER USAGE / EACH GAS WELL CAN RANGE FROM 2 -4 MILLION GALLONS
- APPROXIMATELY 20% OF THIS WATER CAN RETURN TO SURFACE AS FLOWBACK WATER.
- “PRODUCED WATER” CARRIES MUCH HIGHER LEVEL OF OIL, GREASE, ORGANICS AND SALINITY.

SOURCE WATER COMPOSITION (1)

PARAMETER, MG/L	CITY WATER (POTABLE WATER)	TYPICAL POTW EFFLUENT LIMITS	SEA WATER	FLOWBACK WATER	PRODUCED WATER
SOURCE	CITY OF GRAND PRAIRIE		TYPICAL ANALYSIS	FORT WORTH	CITY OF GRAND PRAIRIE
Calcium	27		400	3500	15,932
Magnesium	3.5		1262	470	2,170
Barium	0.02		0.02	12	<5
Strontium	NR		13	380	616
Sodium	55.4		10,556	14000	50705
Potassium	NR		380	380	629
Bicarbonate	80		140	580	-
Sulfate	67.8		2,649	200	822
Chloride	34.4		18,980	26,800	103,222
Fluoride	0.75				102
Nitrate	0.61		15.5	10	<100

SOURCE WATER COMPOSITION (2)

PARAMETER, MG/L	CITY WATER (POTABLE WATER)	TYPICAL POTW EFF LIMITS	SEA WATER	FLOWBACK WATER	PRODUCED WATER
Silica	NR		1	61	34
Iron	0.26		0.003	27	<5
Manganese	0.001		0.0004	NR	NR
Arsenic	0.0024	0.2	0.002	NR	1.36
TOC	NR		<10	30	51
O&G	NR	200	<1	21	28
pH	7.9	5.5-11.0	8.0-8.2	7.5	3.96
Conductivity	444		65,000?	94,000	314,300
TDS Calculated	261		33,000-45,000	46,400	174,300
TSS					131
Turbidity	NR				

FRACKING CHEMICALS AND AGENTS

- FOR MOST HYDRAULIC FRACTURING OPERATIONS USE CHEMICALS SUCH AS HYDROCHLORIC ACID, SURFACTANTS, SCALE INHIBITORS, CORROSION INHIBITORS, GELLING AGENTS, BIOCIDES, FRICTION REDUCING AGENTS, IRON CONTROL AGENTS, ETC.
- SINCE APPROX. 20% OF FRESHWATER MAKEUP VOLUME RETURNS TO SURFACE AS FLOWBACK WATER, THE FLOW BACK WATER IS EXPECTED TO CONTAIN SOME OR ALL OF THESE CHEMICALS.
- THE FOLLOWING LINKS PROVIDE GENERAL INFORMATION ON THE CHEMICALS AND AGENTS THAT ARE BEING USED BY THE COMPANIES THAT PERFORM HYDRAULIC FRACTURING. NOTE: CHEMICAL COMPOSITION CAN VARY FROM SITE TO SITE, DEPENDING UPON SEVERAL FACTORS SUCH AS, WATER CHEMISTRY, NATURE OF FORMATION AND SITE SPECIFIC PRACTICES
- http://fracfocus.org/water-protection/drilling-usage
- http://fracfocus.org/chemical-use/what-chemicals-are-used

NATURALLY OCCURRING CONTAMINANTS

- THE UNDERGROUND GEOLOGY PLAYS A MAJOR ROLE IN CONTAMINATION OF WATER.
- TYPICAL MINERALS FOUND IN BARNETT SHALE: QUARTZ 35-50%, CALCITE DOLOMITE, SIDERITE 0-30%, FELDSPARS 7%, PYRITE 5%.
- THESE MINERALS CAN REACT WITH FRACKING CHEMICALS SUCH AS HYDROCHLORIC ACID AND ENTER THE WATER STREAM. CALCITE AND DOLOMITE ARE THE MAJOR SOURCE OF CALCIUM AND MAGNESIUM HARDNESS . SIDERITE PROVIDES A MAJOR SOURCE OF IRON. QUARTZ PROVIDES MAJOR SOURCE OF SILICA.
- ALL OF THESE CONTAMINANTS CAN IMPACT THE DESIGN OF ANY WATER TREATMENT EQUIPMENT, AND SEVERELY LIMIT THE EFFICIENCY OF OPERATION, INCLUDING RECOVERY OF GOOD WATER WHICH COULD BE RECYCLED FOR FURTHER FRACKING OPERATIONS OR RELEASED TO ENVIRONMENT.
- CONTAMINATED SALT PRODUCTS HAVE LITTLE OR NO MARKET VALUE

SCALING

- “SCALING”, AS REFERRED BY PROFESSIONALS IN WATER TREATMENT INDUSTRY, ALLUDES TO DEPOSIT OF SPARINGLY SOLUBLE SALTS SUCH AS CALCIUM CARBONATE, ON A SURFACE OF PROCESS COMPONENT
- FORMATION OF SCALE INSIDE A PIPE CAN CAUSE PARTIAL OR COMPLETE PLUGGING. FORMATION OF SCALE ON A METAL SURFACE CAN INHIBIT HEAT TRANSFER. SCALE DEPOSITS INSIDE HIGH PRESSURE BOILERS FOR POWER PLANTS IS A MAJOR CAUSE OF REPAIRS, MAINTENANCE OR FAILURE
- SCALING IS TYPICALLY CAUSED BY SALTS OF MINERALS SUCH AS CALCIUM, MAGNESIUM, BARIUM, STRONTIUM AND SILICA. ONCE SCALING OCCURS, THE OPERATORS MAY HAVE TO SHUT DOWN THE PROCESS TO CHEMICALLY CLEAN THE PROCESS EQUIPMENT, OR REPAIR OR REPLACE SCALED COMPONENTS. IN MANY CASES CLEANING BY CHEMICALS IS PROHIBITIVE DUE TO AGGRESSIVE CHEMISTRY OF THE CLEANING AGENT SUCH AS, HYDROCHLORIC ACID.
- SCALE FORMATION INSIDE OIL AND GAS WELLS MUST BE AVOIDED, OTHERWISE FLOW OF NATURAL GAS CAN SLOW DOWN OR STOP.
- SCALE CONTROL IS A MAJOR CONCERN FOR ANY OIL OR GAS DRILLING OPERATION. MOST COMMON METHODS INCLUDE USE OF SPECIAL SCALE INHIBITORS.
- WHAT TYPE OF COST SAVINGS ARE POSSIBLE, IF THE FRAC FLUID HAS MINIMUM LEVELS OF CALCIUM, MAGNESIUM, BARIUM, STRONTIUM, FLUORIDE AND METALS?

FOULING

- FOULING, AS REFERRED BY PROFESSIONALS IN WATER TREATMENT INDUSTRY, ALLUDES TO THE DEPOSITS OF SUSPENDED SOLIDS OR BACTERIAL MATTER THAT IS FOUND IN VARIOUS BODIES OF WATER AND WASTEWATER.
- FOULING CAN CAUSE DAMAGE TO THE PROCESS PIPING, WELLS AND PROCESS COMPONENTS, SIMILAR TO SCALING.
- EXAMPLES OF FOULING AGENTS INCLUDE, OIL AND GREASE, BACTERIA, RUST PARTICLES, INORGANIC CLAY MATERIALS AND SAND PARTICLES.
- REMOVAL OF FOULING AGENTS FROM CONTAMINATED WATER IS GENERALLY EASIER THAN REMOVAL OF SCALING AGENTS.
- FOR REMOVAL OF FOULING AGENTS FROM FRACKING WATER, THE TECHNOLOGIES INCLUDE OILY WATER SEPARATORS, DISSOLVED AIR FLOATATION, ELECTRO-COAGULATION, CLARIFIERS AND FILTERS. HOWEVER, THESE TECHNOLOGIES TYPICALLY DO NOR REMOVE SCALE-CAUSING MATERIALS WHICH ARE DISSOLVED IN WATER.

CONVENTIONAL PRETREATMENT METHODS FOR WASTEWATER TREATMENT (2)

- VACUUM FILTERS/BELT FILTER/ FILTER PRESS/ PLEATED FILTER PRESS
  - EFFECTIVE REMOVAL OF HEAVY LOAD OF SUSPENDED SOLIDS. CREATE NEARLY SOLID FILTER CAKE (25-40% SOLIDS) WHICH CAN BE HAULED AWAY BY OPEN TRUCKS/DUMPSTERS
  - MODERATELY EXPENSIVE, LABOR INTENSIVE
- MEDIA FILTERS
  - EFFECTIVE REMOVAL OF LIGHT LOAD OF FINE SUSPENDED SOLIDS.
  - 0.5-1% SOLIDS IN LIQUID STREAM. SOLIDS HAVE TO BE DEWATERED BY OTHER MEANS
  - MODERATELY EXPENSIVE, SOME SUPERVISION REQUIRED
- CARTRIDGE FILTERS/BAG FILTERS
  - EFFECTIVE REMOVAL OF VERY LOW LEVELS OF SUSPENDED SOLIDS
  - TYPICALLY DEAD-END FILTERS. REPLACEMENT OF CARTRIDGE FILTERS OR BAG FILTERS CAN BE EXPENSIVE AND LABOR INTENSIVE PROCESS.
  - RELATIVELY LOW CAPITAL COST.

CONVENTIONAL PRETREATMENT METHODS FOR WASTEWATER TREATMENT (3)

- INCLINED PLATE CLARIFIERS, TUBE SETTLERS
  - EFFECTIVE FOR REMOVAL OF SUSPENDED SOLIDS INCLUDING PRECIPITATED SOLIDS.
  - MODERATELY EXPENSIVE, MODULAR. OPERATOR ATTENTION DEPENDS UPON LEVEL OF SOLIDS AND CHEMISTRY
  - CAN BE CONSIDERED ALONG WITH CHEMICAL PRECIPITATION PROCESSES
- CONVENTIONAL CHEMICAL PRECIPITATORS INCLUDING LIME SOFTENING CLARIFIERS
  - EFFECTIVE FOR LOW LEVELS OF HARDNESS (TYPICALLY LESS THAN 1250 PPM), REMOVAL OF SUSPENDED SOLIDS, DISINFECTION. INEFFECTIVE FOR TREATMENT OF EXTREMELY HIGH LEVELS OF HARDNESS WHICH IS TYPICAL FOR FLOWBACK WATER AND PRODUCED WATER FROM FRACKING OPERATIONS
  - MODERATELY EXPENSIVE, COMPETES WITH ELECTRO-COAGULATION PROCESS, CAN BE LABOR INTENSIVE

CONVENTIONAL POST-TREATMENT PROCESS EQUIPMENT (1)

- ULTRAFILTRATION, MICRO FILTRATION
  - EFFECTIVE AS POLISHING FILTERS, FOR REMOVAL OF MICROSCOPIC LEVEL OF CONTAMINANTS. WILL NOT REMOVE DISSOLVED IONIZED SALTS
  - REQUIRES EXTREMELY CAREFUL DESIGN, PROPER SELECTION OF MEMBRANE AND WATCHFUL OPERATION. MEMBRANES CAN FOUL OR PLUG QUICKLY, WILL REQUIRE CHEMICAL CLEANING, DISINFECTION
  - HIGH CAPITAL COST, HIGH OPERATING COST, LABOR INTENSIVE
- REVERSE OSMOSIS MEMBRANE SYSTEMS
  - EFFECTIVE FOR CONCENTRATION OF PRETREATED, HIGHLY FILTERED, STREAMS WITH IONIZED, DISSOLVED SALTS AND LOW LEVELS OF ORGANICS. WORKS WELL FOR TOTAL DISSOLVED SOLIDS LESS THAN 45000 PPM . CAN PROVIDE HIGH QUALITY TREATED WATER (PERMEATE)
  - REQUIRES TIGHT CONTROL/LIMITS OF INCOMING HARDNESS, SILICA, BARIUM, SILICA, IRON AND OTHER METALS. PROPER DESIGN OF PRETREATMENT IS ABSOLUTELY CRITICAL
  - IF FEEDWATER IS NOT COMPLETELY SOFTENED, RO REJECT MAY HAVE TO BE SENT TO DEEPWELL INJECTION
  - HIGH CAPITAL COST, HIGH OPERATING COST, LABOR INTENSIVE

CONVENTIONAL POST-TREATMENT PROCESS EQUIPMENT (2)

- EVAPORATORS
  - EFFECTIVE FOR CONCENTRATION OF PROPERLY PRE-TREATED, HIGHLY FILTERED STREAMS WITH DISSOLVED SALTS AND LOW LEVELS OF ORGANICS.
  - WORKS WELL FOR HIGH LEVELS OF DISSOLVED SOLIDS RANGING FROM 40,000 PPM TO 150,000 PPM.
  - HIGH LEVELS OF HARDNESS OR SUSPENDED SOLIDS OR OIL OR ORGANICS IN THE FEEDWATER CAN QUICKLY LEAD TO SCALING AND FOULING, LEADING TO COSTLY MAINTENANCE AND FREQUENT SHUTDOWNS.
  - DISTILLED WATER CAN BE RECYCLED AND REUSED. IF FEEDWATER IS NOT COMPLETELY SOFTENED, REJECT (CONCENTRATED STREAM) MAY HAVE TO BE SENT TO DEEPWELL INJECTION
  - HIGH CAPITAL COST, HIGH OPERATION AND MAINTENANCE COST
- DRYERS
  - EFFECTIVE FOR RECOVERING DRY SALT FROM SEMI-DRY FILTER CAKE
  - RELATIVELY SIMPLE TO OPERATE
  - VAPOR CAN BE CONDENSED AND RECYCLED AS PURE WATER STREAM
  - MODERATE CAPITAL COST, MODERATE OPERATING COST

HIGH EFFICIENCY SOFTENING PROCESS (HESP)®

- THIS PROCESS WAS DEVELOPED BY KEN PANDYA (OWNER, AWTS, INC.) SIX YEARS AGO, US PATENT NO. 8,147,696 (B1) WAS AWARDED ON APRIL 3, 2012. INTERNATIONAL PATENTS PENDING.
  - THIS IS HIGH EFFICIENCY SOFTENING PROCESS. PROVEN RESULTS FOR EXTREMELY HARD WATER INCLUDING PRODUCED WATERS AND FLOW BACK WATERS THAT CAN CONTAIN ANYWHERE FROM 10,000 PPM HARDNESS TO 50,000 PPM OF HARDNESS. ALSO EFFECTIVE IN REMOVAL OF SILICA, AND METALS SUCH AS IRON, COPPER, ZINC, ARSENIC
  - FIELD TRIALS HAVE DEMONSTRATED UP TO 99.9% REMOVAL OF SCALE-CAUSING MINERALS (CA, MG, BA, SR, SILICA)
  - USES CONVENTIONAL CHEMICALS SUCH AS LIME, SODA ASH AND CAUSTIC. USES PROPRIETARY CHEMICALS FOR COAGULATION OF SUSPENDED SOLIDS.
  - PROCESS ALLOWS US TO USE WASTE CAUSTIC FROM CERTAIN INDUSTRIAL OPERATIONS, WASTE ALUMINUM PRODUCTS, EVEN GREENHOUSE GAS SUCH AS CARBON DIOXIDE AND CARBON MONOXIDE (READILY AVAILABLE FROM DIESEL GENERATORS ON SITE) WHICH WILL CLEAN UP THE ENVIRONMENT

WHY HESP ® ? (1)

- HESP ® PROCESS WAS PRIMARILY DEVELOPED TO ELIMINATE THE NEED FOR DEEPWELL INJECTION
- CONVENTIONAL PRECIPITATION PROCESS ARE ABLE TO REMOVE HARDNESS AND OTHER SCALING AGENTS BY 50-70%. WHEN THE INCOMING HARDNESS LEVELS ARE IN THE RANGE OF 10,000 TO 50,000 PPM, THE TREATED EFFLUENT WILL STILL HAVE 5000 TO 25,000 PPM HARDNESS, WHICH IS TOO HIGH!
- HESP ® EFFLUENT CAN BE RECYCLED FOR FURTHER FRACKING OPERATIONS, OR SENT TO FURTHER TREATMENT BY PROCESSES SUCH AS RO OR EVAPORATORS, WHICH BECOME MUCH MORE EFFICIENT.
- IF INCOMING TDS IS IN THE RANGE OF 150,000 PPM (EXAMPLE: PRODUCED WATER TESTED AT CITY OF GRAND PRAIRIE) THEN THE HESP ® EFFLUENT COULD BE USED TO SEAL GAS WELLS AFTER COMPLETION OF GAS EXTRACTION PROCESS. ANOTHER OPTION IS TO SEND CONCENTRATE STREAM TO DRYER, TO RECOVER DRY SALTS (ROAD SALT)
- HESP ® EFFLUENT CAN BE 20-30% PORTION OF FRACK WATER COMPOSITION, WHICH WILL REDUCE THE REQUIREMENT FOR FRESH WATER.

WHY HESP® ? (2)

- HESP® ALLOWS THE CUSTOMERS TO USE WASTE CAUSTIC FROM CERTAIN INDUSTRIAL OPERATIONS AND WASTE ALUMINUM PRODUCTS. ALSO, GREEN HOUSE GASES SUCH AS CARBON DIOXIDE AND CARBON MONOXIDE (DIESEL GENERATOR OFF GAS) CAN BE USED AS SOURCE OF CARBONATE
- PRECIPITATED SOLIDS FROM HESP® PROCESS ARE MOSTLY CALCIUM AND MAGNESIUM CARBONATE , WHICH COULD BE RECYCLED AS WALL BOARD MATERIAL, OR ROAD CONSTRUCTION OR LAND FILL
- HESP® PROCESS DOES NOT REQUIRE ENERGY FOR HIGH PRESSURE PUMPS (E.G. RO PROCESS) OR BOILING WATER (E.G., EVAPORATORS). OUR PROCESS DOES NOT REQUIRE HANDLING OF CORROSIVE ACID SUCH AS HCL

- IN COMPARISON TO COSTS ASSOCIATED WITH TRUCKING, TREATMENT AND INJECTING FLOW BACK WATER OR PRODUCED WATER, WE PROJECT 30-50% REDUCTION IN OPERATING COSTS. THESE SAVINGS, ALONG WITH OBVIOUS BENEFITS OF ENVIRONMENTAL

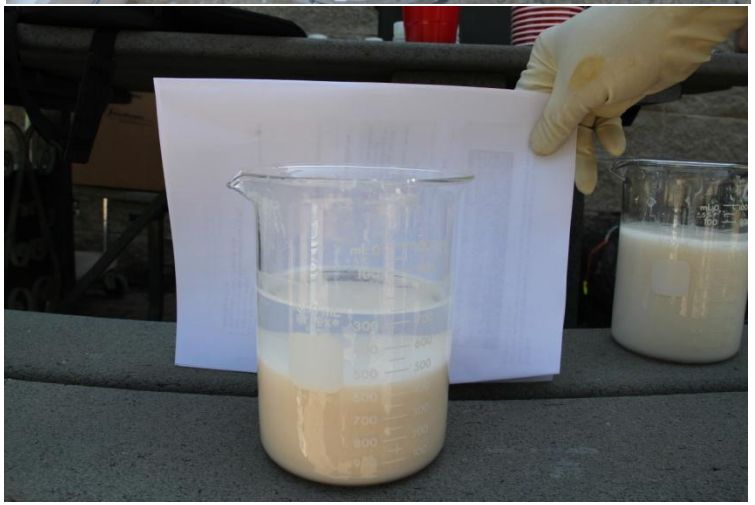
HESP ® TEST RESULTS, PRODUCED WATER FROM CITY OF GRAND PRAIRIE

PARAMETER	BEFORE	AFTER	% REDUCTION
CALCIUM, PPM CACO3	39,832	39	99.9 %
MAGNESIUM, PPM CACO3	8901	188	97.9 %
STRONTIUM	616	<5	99.2 %
SILICA, mg/l	34	11	67.6 %
FLUORIDE, mg/l	102	26.4	74.1 %
ARSENIC, mg/l	1.36	0.13	75.7 %
pH	3.96	10.28	
CONDUCTIVITY, mmho	314,300	358,100	-
TDS, mg/l	174,300	133,330	23.5 %

HESP ® PERFORMANCE TESTS, CITY OF GRAND PRAIRIE

THIS PICTURE SHOWS JAR TEST EQUIPMENT. ON THE RIGHT IS THE PRODUCED WATER SAMPLE, AND ON THE LEFT IS THE CHEMICAL REACTOR. OBSERVE WHITE COLOR PRECIPITATE, MOSTLY CALCIUM AND MAGNESIUM CARBONATE. ON TOP WE CAN SEE CLEAR WATER

HESP ® PERFORMANCE TESTS, CITY OF GRAND PRAIRIE



THE PICTURE ON TOP SHOWS RAW PRODUCED WATER. THIS SAMPLE HAD LOT OF OIL, GREASE AND PETROLEUM PRODUCTS, IN ADDITION TO NEARLY 50,000 PPM OF HARDNESS AND OVER 150,000 PPM TOTAL DISSOLVED SOLIDS

THE PICTURE ON THE BOTTOM SHOWS HESP TREATED PRODUCED WATER. THE CLARIFIED WATER (ON TOP) CONTAINED LESS THAN 35 PPM OF HARDNESS. MOST OF THE CALCIUM, MAGNESIUM AND STRONTIUM SALTS WERE PRECIPITATED, AND SETTLED ON BOTTOM.

SUMMARY

- HYDRAULIC FRACTURING PROCESS REQUIRES 2-4 MILLION GALLONS OF FRESH WATER FOR EACH DRILLING. WITH HESP PROCESS, WE CAN MINIMIZE FRESH WATER MAKEUP
- WITH HESP ® PROCESS, IT IS POSSIBLE TO ELIMINATE DEEP WELL INJECTION
- WITH HESP ® NO MORE ISSUES WITH SCALING OR FOULING OF PROCESS EQUIPMENT
- WITH HELP OF HESP PRETREATMENT, OTHER CONCENTRATION PROCESSES (E.G. RO, EVAPORATORS) BECOME MUCH MORE EFFICIENT.
- BY DROPPING OUT SOLIDS IN HESP ® PRETREATMENT, DRIED SOLIDS CAN BE RECYCLED
- HESP ® PROVIDES A COST EFFECTIVE, ENVIRONMENTALLY SOUND SOLUTION