An Exciting New Produced Water Concentrator Technology for Tail and Brine Waters: AltelaRain™

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Abstract

Through the use of its proprietary, patented AltelaRain™ technology, Altela, Inc. desalinates and decontaminates highly challenged water sources without the energy intensive equipment, high temperatures, or high pressures of other water desalination technologies. Altela's System provides a unique solution for the desalination/decontamination of highly concentrate tail and brine water effluents including reverse osmosis coal bed natural gas produced water treatment systems. The AltelaRain™ desalination/decontamination system requires no expensive pre-treatment or post-treatment processes – extremely clean water is simply extracted from contaminated brines in a single, elegant step. This allows the AltelaRain™ System's operational costs to be far lower than those of competing technologies, especially in the realms of highly challenged produced water treatment. Altela has developed a mobile, scalable system that can be configured to be economically feasible for operation at individual well locations to treat as little as 20 barrels per day (BPD), or as much as 250 BPD. By further scaling larger modules together, AltelaRain™ Systems can also be configured to treat large volumes (in excess of 1,000 BPD) of tail water on-site. The AltelaRain™ System has successfully completed real-world oilfield beta testing.

The Company

Altela, Inc. provides products and services to customers in need of creating pure water from highly salinated and contaminated water sources. Through the use of its proprietary, patented AltelaRain™ technology, Altela desalinates and decontaminates highly challenged water sources without the energy intensive equipment, high temperatures, or high pressures of other water desalination technologies. The AltelaRain™ desalination/decontamination system requires no expensive pre-treatment or post-treatment processes – extremely clean water is simply extracted from contaminated salt water in a single, elegant step. This allows the AltelaRain™ System's operational costs to be far lower than those of comparable reverse osmosis, multi-stage flash, ion-exchange, or vapor compression technologies in the realms of highly-brackish and/or contaminated waters.

The AltelaRain™ System is an elegant solution for the desalination/decontamination of moderate volumes of challenged water, on-site where the brackish, salty and/or contaminated water is generated or stored. Within the water desalination/decontamination market, there are numerous, sizeable market segments with characteristics ideally suited to the AltelaRain™ System. These include the purification and remediation of:

1. Produced (formation) water in the oil, natural gas, and mineral extraction industries,
2. Highly salinated concentrate "tail-water" from large-scale reverse osmosis and other brine generating desalination systems,
3. Industrial waste water treatment, particularly in the semi-conductor and electronic manufacturing industries,
4. Cooling tower "blowdown" water from electrical power generating stations, and
5. Contaminated ground water.

Water & Environmental Challenges in the CBNG Fields

As noted above, the AltelaRain™ System is well suited for the treatment of highly salinated concentrate "tail-water" from large-scale reverse osmosis systems which recently have begun to be employed in the coalbed natural gas (CBNG) industry for the treatment of produced water. CBNG, the natural gas derived from water-saturated underground coal seams, has recently become one of the most talked about energy resources in the West. CBNG is classified as an unconventional source of natural gas. It is growing dramatically as a domestic source of natural gas at a time when demand is rapidly increasing and output from some conventional sources appears to have peaked.

As of the mid-1980s, CBNG was widely regarded as a hazardous byproduct of coal mining and was not traditionally considered a resource. CBNG was initially discovered during coalmining operations when fires or explosions of methane gas threatened the safety of miners. To mitigate the risk of explosions, methane began to be vented during mining operations. Later, these same companies began to capture this methane gas as a valuable asset. Interestingly, this in turn, resulted in ownership questions centered on whether the CBNG was part of the coal estate or part of the gas estate. In Amoco Production Company v. Southern Ute Indian Tribe, 526 U.S. 865 (1999), the Supreme Court ruled that CBNG is not included in the meaning of coal. CBNG is part of the gas estate, not the coal estate. The Court held that coal companies could vent the gas while mining, but the right to vent the gas does not imply ownership of it. This ruling, coupled with federal tax credits for exploration, has contributed to the CBNG boom.

Production of CBNG often involves significant amounts of produced water. CBNG operators typically drill surface wells into coal seams. These coal seams usually contain deep bedrock aquifers and large volumes of water. CBNG operators pump this water from the seam causing a reduction in pressure, thereby releasing methane to the surface along with significant amounts of produced water. U.S. Environmental Protection Agency guidelines define produced water as "water (brine) brought up from the hydrocarbon-bearing strata during the extraction of oil and gas, and can include formation water, injection water, and any chemical added downhole or during the oil/water separation process." Recently, the Ninth Circuit Court of Appeals found that CBNG water qualified as produced water under these same guidelines.1 Generally, neither the amount of produced water nor the quality of the water can be predicted prior to bringing the water to the surface.

Due to distinct variances in water quality, CBNG produced water is dealt with differently across the basins. Water quality indicators vary across and even within basins, depending on the depth of the methane, geology, and environment of the deposition. In the San Juan Basin of New Mexico for example, produced water is typically re-injected because of poor quality. Conversely, much of the produced water in Wyoming's Powder River Basin is useable for a variety of purposes. A major CBNG challenge has been managing the tremendous increase in produced water. Over the past three years within the Powder River Basin, approximately 5,500 new CBNG wells have been drilled and more areas of the basin have been opened to exploration.2 To support this dramatic increase in exploration, considerable infrastructure has been installed which in turn, has raised numerous environmental concerns. Demand for CBNG will undoubtedly continue. The Energy Information Administration, in its Annual Energy Outlook 2004, estimates that natural gas demand in the United States could be 31.41 Tcf by the year 2025. That is an increase of 38 percent over 2002 demand levels of 22.8 Tcf.

Management of produced water, including treated concentrate brine ("tail waters"), will continue to be a central development issue. CBNG development has produced important energy and other economic benefits throughout the West. However, such dramatic growth and exploration has resulted in numerous stakeholder concerns. In many areas, concerns over adverse environmental impacts, the regulation of development by local governments, and conflicts between surface owners and gas companies have all contributed to increased uncertainty and acrimony. Counties have sued state oil and gas regulatory bodies over who has responsibility for regulating the impacts of CBNG development. Companies have fought with counties over zoning and land use plans. Local community groups have sued federal and state agencies over water quality concerns. Environmental and recreation stakeholders increasingly clash with traditional oil and gas exploration and development stakeholders over handling, treatment and disposal/re-use of produced water.

Concentrate Management – An Economic Solution

Based on the high degree of complexity of produced water chemistry, produced water treatment technologies are generally not in wide use. Those that are have historically been applied only to lesser challenged produced waters (such as certain CBNG produced water), and they have largely been developed by oil and gas operators on a case-by-case approach. In those applications where the CBNG produced water is treated, large streams of concentrate brine (tail water) are generated as reject water. Depending on the quality of the influent, cut rates can range from 90% to under 50%. The resulting tail water is highly concentrated and is unable to effectively and economically be treated by membrane based systems. Such tail water has historically been trucked and related inland concentrate brine is traditionally disposed of via underground reinjection wells. The cost of such disposal is often prohibitive to the operator. Oil and gas companies must pay for disposal trucking companies to visit the site multiple times per week, pump the

produced water concentrate out of large storage tanks or evaporative ponds and transport the waste to commercial underground reinjection sites. These disposal trucks must often travel great distances to the reinjection sites. When these trucks are unavailable or during periods of poor weather, many sites must be shut down due to the inability to store and/or dispose of the concentrated brine on-site.

Concentrate management has been identified has a key water management area of focus. In 2001, Congress directed the United States Bureau of Reclamation (BOR) to partner with Sandia National Laboratories (SNL) to develop a desalination technology research plan for the nation. BOR and SNL formed a multi-disciplinary committee made up of experts from academia and the public, private, and non-profit sectors to develop the desalination technology research plan. As a result, The Desalination and Water Purification Technology Roadmap: A Report of the Executive Committee (Roadmap) was published in January 2003. The Roadmap presents a summary of the water supply challenges facing our nation through 2020, and suggests areas of R&D that may lead to technological solutions to these challenges. The guiding vision for the Roadmap provides that "…By 2020, desalination and water purification technologies will contribute significantly to ensuring a safe, sustainable, affordable, and adequate water supply for our nation". Concentrate management technologies that address the disposal and/or beneficial use of desalination waste streams were identified as central to the roadmap.

Altela's patented AltelaRain™ technology is such a concentrate management technology. The technology uniquely cleans oil and gas industry concentrated brine. The technology removes the salts, residual oils and other contaminants from the concentrate stream in a single treatment pass - allowing the clean water to be used on-site rather than requiring disposal in costly reinjection wells or evaporation ponds. In the arid western United States, purified concentrated brine represents a new water supply and very desirable asset. Altela-cleaned water is attractive to ranch and farm landowners leasing their mineral rights to oilfield producers. In addition, drilling operators need clean water for fractionation and tertiary recovery operations. Following treatment, the purified AltelaRain water meets water quality standards acceptable for irrigation, livestock watering, power plant cooling, or dust suppression.

Technology Process Description

The basic Altela technology is a simple and elegant process based on thermal distillation, which desalinates and decontaminates salty and polluted water in a fundamentally different way than the more familiar reverse osmosis and other membrane-based desalination technologies. In simple terms, the technology mimics nature's process of making pure rain water from seawater. What positions it as the first, truly new and disruptive water desalination/decontamination technology in over 50 years, however, is a scientifically complex, but inexpensively implemented, internal heat transfer process that allows the re-use of the latent heat of condensation over and over again to greatly offset the total latent heat of evaporation required in conventional thermal distillation. This internal heat transfer technology recaptures the energy used to evaporate water, thus yielding approximately 4 times the amount of distilled water per energy input as traditional distillation/evaporation techniques. Consequently, the AltelaRain™ technology yields energy costs that are approximately only 25% of comparable distillation/evaporation processes.

The water vapor from the evaporation chamber is transferred to the condensation chamber by a carrier gas, with the ability to absorb and desorb pure water from the produced water several times over, resulting in extremely high energy efficiencies, Figure 1. Ambient air is brought into the bottom of the tower on the evaporation side of a heat transfer wall. The wall is wetted by saline feed water, which is fed into the evaporation side at the top of the tower. As the air moves from the bottom to the top of the tower, low-temperature heat is transferred into the evaporation side through the heat transfer wall, allowing the air to rise in temperature and evaporate water from the wet saline liquid which coats the heat transfer wall. Water concentrated in contaminates leaves from the bottom of the tower and warm saturated air rises to the

top of the tower. Heat is added to this hot air by an external heat source (low grade, atmospheric pressure steam). This hotter saturated air is then sent back down through the tower on the condensation side of the heat transfer wall. The evaporation side of the tower, being slightly cooler than the condensation side, allows the air to cool and transfer the latent heat condensation from the condensation side to the evaporation side. Pure distilled water condensate leaves the condensation side of the tower at the bottom of the tower.

Individual AltelaRain™ towers are approximately the size of a residential water heater and are capable of processing approximately 330 gallons per day (8 BPD) of water with salt concentration in excess of 150,000 ppm. The AltelaRain™ System can reduce effluent disposal volumes by as much as 90%. Since the treated water stream is distilled water, the quality of water from the AltelaRain™ System is extremely high. In summary, the key advantages of the AltelaRain™ technology include:

- Extremely high quality of treated water
- Relatively low cost
- High thermal efficiency
- Unattended operation
- No fouling
- No scaling
- No membranes to replace
- Near ambient temperature operation
- Operates at ambient pressure
- Uses waste heat to operate
- No pre-treatment
- No post-treatment

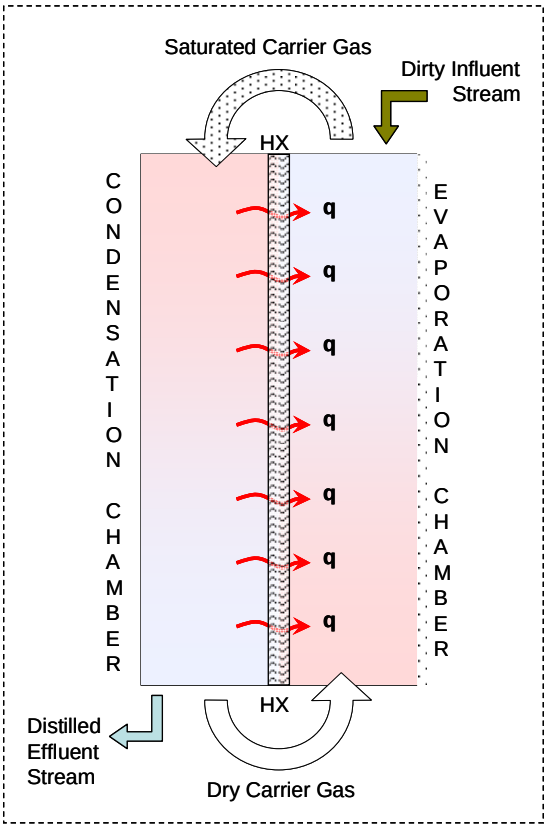

Figure 1: AltelaRain™ Process

The AltelaRain™ System is highly scalable in size and can be produced in a variety of configurations to fit individual on-site needs. A smaller capacity system can be built and installed in a single 8 by 40 foot container. For higher volume applications, larger 180 to 250 BPD systems can be joined together to double or triple production capacity. Scaling up the volume of the system in this manner yields some cost savings on a per-barrel cost basis. The AltelaRain™ System is designed to minimize maintenance and operation costs. The use of plastics minimizes or eliminates many of the maintenance issues related to scaling, fouling or corrosion of metal systems. The moving parts in the system are few, and consist of proven, robust, off-the-shelf components, such as low pressure water pumps and air blowers. The system operates at ambient pressures and modest temperatures, and as such, has few mechanical failures in plumbing and related systems. The ability to remotely monitor the system allows field operators to detect system problems early and take remedial action before major failures take place.

Summary of Field Results

A beta pilot test using real oil-field produced water was conducted by Altela, Inc. employing the AltelaRain™ System for a conventional oil well located in southeastern New Mexico in early 2006.

Coincident with this, Altela received from the New Mexico environmental regulatory authorities the first-ever permit issued for the surface discharge, on site, of clean water extracted from the highly brackish and contaminated produced water pumped from an oil or gas wellhead. The water quality test results received from an independent water quality lab demonstrate the very high quality of treated water obtained from this simple technology for the treatment of highly challenged produced water. Total dissolved solids were reduced from 41,700 mg/L to 106 mg/L. Chloride was reduced from 25,300 mg/L to 59 mg/L. Similarly, benzene levels were reduced from 450 ug/L to non-detectable following AltelaRain™ treatment. Detailed water quality data following AltelaRain™ treatment is outlined below in Table 1.

Table 1: AltelaRain™ Produced Water Pilot Test

	Water Contaminant (Analyte)	**Symbol**	**Before Altela (mg/L)** *except for Radium 226 and 228 which is in pCi/L	**After Altela (mg/L)** *except for Radium 226 and 228 which is in pCi/L
	Salts:			
1	Total Dissolved Solids	TDS	41,700	106
2	Chloride	Cl	25,300	59
3	Sulfate	SO4	81	0
	Metals:			
4	Arsenic	As	0.036	0
5	Barium	Ba	19.1	0
6	Cadmium	Cd	0	0
7	Chromium	Cr	0	0
8	Cyanide	CN	0	0
9	Fluoride	F	0.6	0
10	Lead	Pb	0	0
11	Total Mercury	Hg	0	0
12	Nitrate	NO3 as N	0	0
13	Selenium	Se	0.096	0.001
14	Silver	Ag	0	0
15	Uranium	U	0	0
16	Copper	Cu	0.02	0
17	Iron	Fe	38.1	0
18	Manganese	Mn	0.72	0
19	Zinc	Zn	0.01	0.03
20	Aluminum	A	0	0.3
21	Boron	Ba	44.8	0.2
22	Cobalt	Co	0	0
23	Molybdenum	Mo	0	0
24	Nickel	Ni	0	0
25	**BTEX:**			
26	Benzene		0.45	0

27	Toluene		0.45	0.0078
28	Ethylbenzene		0	0
29	Total Xylenes		0.76	0
	Radialogical:			
30	Radium 226		423	1.1
31	Radium 228		587	1.1
	Other:			
32	pH	pH	7.17	8.74

Upcoming Testing & Installations

Two additional well sites have been identified where the AltelaRain™ System will be employed to demonstrate its unique ability to purify highly challenged produced water, including concentrate brine "tail water. The first well site is located in the San Juan Basin of New Mexico inside the city limits of Farmington, San Juan County, NM. This State of NM sponsored project is anticipated to begin in late 2006 and finish in early 2007. Total dissolved solids at this site are 32,600 mg/L; chlorides are 20,200 mg/L, barium is 66.5 mg/L, Radium 226 is 68.3 and boron is 3.3 mg/L. The second well site is located in the Green River Basin of Wyoming. An AltelaRain™ System will be linked to a membrane treatment train to treat the concentrated "tail water" effluent from the membrane system. The tail water concentration is approximately 49,650 TDS, with the majority being sodium chloride.

Conclusion

Oil and gas companies need lower cost methods for handling and disposing of produced water concentrate, including tail water streams from CBNG production. The application of new proprietary technology to treat produced water concentrate on-site will yield major returns, both economically and environmentally.

AltelaRain™ represents a simple solution to removing all produced water contaminants, even in highly-challenged and extremely high-TDS conditions found in concentrated brine. Another major advantage of AltelaRain™ is its inherent flexibility and modularity. The low cost, scale-resistant materials used to fabricate AltelaRain™ towers enable treatment systems to be built that are modular and mobile, easily maintained, and capable of processing water with highly variable influent compositions. The modular design of an AltelaRain™ System enables installers to customize each treatment n with little or no additional cost to oil and gas companies. For example, an AltelaRain™ System can be installed to

minimize the effluent brine reject stream simply by re-configuring the physical layout of the primary system towers into differing series/parallel configurations. Like other thermal processes, AltelaRain™ is simple, easy to maintain, and can operate unattended for long periods of time. However, unlike other desalination methods the primary treatment components are fabricated entirely from plastic. This eliminates the need for costly influent pretreatment components (such as filters, flocculants, and anti-scalant additives) with respect to concentrated brine treatment.

The AltelaRainTM technology provides Altela several distinct competitive advantages in the concentrate brine treatment market. These include:

- Cost: The cost structure associated with building, installing, maintaining and servicing the system is significantly lower than the escalating costs associated with traditional concentrate brine hauling and reinjection.

- Energy Use: Altela's technology allows it to desalinate/decontaminate concentrate brine using less than 25% of the energy of competitive distillation/concentration technologies. As an essentially passive system operating at ambient pressures and comparatively low temperatures, Altela's System has little of the energy loss associated with powering high pressure electrical pumps and other machinery typical in other membrane technologies.

- On-Site Treatment: By treating directly on-site, Altela eliminates the cost and uncertainty of concentrate hauling, and assures continuous 24/7 production to the well operator.

- Universal Applicability: The AltelaRain™ technology can treat concentrate brine of varying chemistry and contaminate concentrations. Competing membrane technologies have great difficulty treating concentrate brine with TDS concentrations above 40,000, and require site specific pre- and post-treatment of brine streams. The AltelaRain™ technology is able to treat high TDS effluent streams and does not require pre- or post treatment.

- Environmental and Infrastructure Impact: Because the Altela treatment is done on-site, and the treated concentrate brine is converted into extremely pure water that can be surface discharged (or be put to use wherever clean water is needed), Altela's service significantly mitigates the damage to transportation infrastructure from water hauling and potential environmental problems from spills and improper reinjection.

- Water: The AltelaRain™ technology creates pure water from the concentrated brine stream that could be used at the well site for irrigation, stock watering, drilling "frac" water or other clean water uses. The AltelaRain™ System can easily and inexpensively be installed onsite, can treat concentrate brine, regardless of TDS concentration, and can be scaled according to treatment demand.

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[1] 40 C.F.R. §§ 435.41(bb), 435.11(bb)), in addition, s*ee generally* Northern Plains Resource Council v. Fidelity Exploration and Development Co., 325 F.3d 1155 (9th Cir.) cert. denied, 124 S. Ct. 434 (2003).

[2] Gregory C. Bank, Vello A. Kuuskraa, The Economics of Powder River Basin Coalbed Methane Development, U.S. Department of Energy, January 2006.