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Shallow Subsurface Water Storage Schemes in Alluvial Sediments Utilizing the Multi-Azimuth Sand Plane Technology

Executive Summary

GeoSierra has adapted its multi-azimuth highly permeable vertical sand plane technology[1] to be an effective method for developing shallow subsurface water storage reservoirs that will have minimal disruption to any surface activities such as agricultural farming and ranch operations. With a vertical height of approximately 80 feet, each sand-filled highly permeable plane extends from 20' below surface down to a depth of 100 feet. The multi-azimuth planes propagate out away from a 9-5/8" cased wellbore on a 60-degree wellbore azimuth and have a wing length of roughly 90 feet. The storage capacity of each multi-azimuth well on a one (1) acre spacing is approximately 25 acre-feet, i.e. eight (8) million gallons. The multi-azimuth shallow water storage scheme is an ideal application of the technology for watershed storage along creeks and rivers, and municipal storage in the close proximity of population demand; since it is subsurface, it has zero evaporation losses, with minimal site disturbance and disruption of surface activities.

GeoSierra is proposing five (5) pilot projects constructed at five (5) different sites, and to collect operational and performance data on each pilot over one (1) year of operation, to enable an informed decision on whether to proceed with the large scale implementation of the multi-azimuth technology at that site. To cap the costs of the full scale pilot, each pilot consists of twenty (20) multi-azimuth wells, nineteen (19) wells in a cluster array on an acre spacing, consisting of seven (7) interior wells and twelve (12) perimeter wells, and a single isolated multi-azimuth well, to provide temporary water storage and supply for operational testing of the main array. The perimeter wells are configured differently than the interior wells, to ensure perimeter water losses are a minimum. Following construction, each pilot will be filled and operated for one (1) year, during which it will be subjected to extensive performance monitoring and testing, including water quality testing.

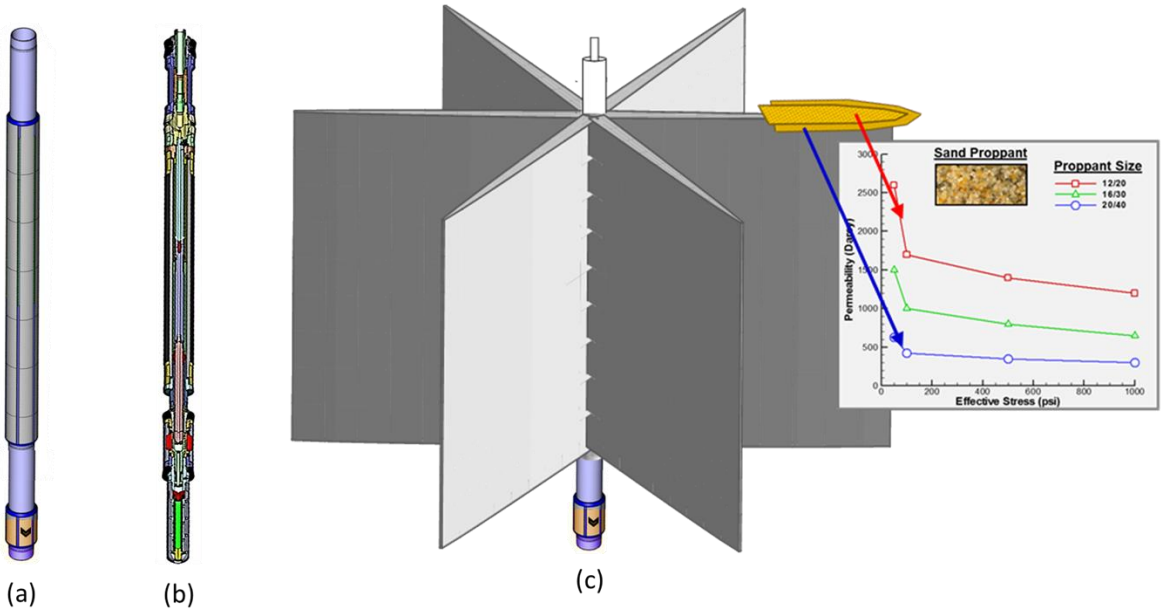

Figure 1. Multi-Azimuth Sand Plane Technology: (a) Casing System, b) Expansion & Treatment Tool, c) Multi-Azimuth Vertical Sand Planes of High Permeability Constructed from the Expansion Casing.

1. Hocking, G., T. W. Cavender, J. Person and T. Hunter. 2012. "Single-Well SAGD Field Installation and Functionality Trials", Paper presented at the SPE Heavy Oil Conference Canada, Calgary, Alberta, Canada, June 2012. doi: https://doi.org/10.2118/157739-MS.

The multi-azimuth sand plane technology is a mature, U.S.-patented method for creating engineered subsurface water reservoirs at depths down to 100 feet, with no evaporation losses and zero impact on surface usage. Unlike conventional Aquifer Storage and Recovery (ASR), which depends on favorable natural aquifer geology, the multi-azimuth system creates its own high-permeability pathways, of approximately 2,300 Darcy, enabling virtually instantaneous gravity water injection and pumped withdrawal in a wide range of sediments common across the Texas Gulf Coast and South Texas. These multiple vertical, high-permeability sand planes radiate outward from a single vertical cemented cased wellbore. Each plane is initiated by the expansion of a specially designed split casing system and then self-propagates outwards as a fluidized inclusion in the surrounding formation. The propagation is driven by a highly viscous, food-grade starch carrier fluid that transports the sand proppant into the inclusion. The starch subsequently biodegrades into drinking-water-quality end products (sugars and water), thus creating engineered highly permeable vertical sand planes.

The patented multi-azimuth sand plane technology was jointly developed by GeoSierra and Halliburton, with GeoSierra having the exclusive rights to the technology outside hydrocarbon recovery field of use. Each multi-azimuth well consists of six (6) multi-azimuth highly permeable propped sand planes installed at varying azimuths, minimizing the impact of low vertical permeability and geological heterogeneities on the multi-azimuth water storage scheme's performance. Note, that the sand planes are constructed with the finer 20/40 proppant injected first, which thus forms the skin of these planes; while the interior of the sand planes is composed of 12/20 sand proppant. Field hydraulic pulse interference testing[1] of the installed multi-azimuth sand planes determined both their hydraulic continuity, vertically and horizontally, and their in-situ hydraulic transmissivity as 570ft^2/day, being a combined sand proppant permeability of 2,300 Darcy.

The multi-azimuth wells are positioned on one (1) acre spacing throughout the shallow subsurface water storage leased area, see Figure 2. The multi-azimuth wells are gravity fed during a storm event, and due to their significant permeability and continuity, both horizontally and vertically, do not experience any air lock or back pressure issues, during either rapid filling or extraction. In Figure 2, only the pilot interior multi-azimuth wells on an acre spacing are shown; with total water storage of each individual multi-azimuth well of 25 acre-feet for an 80 foot well completion, installed to 100' depth. Only the seven (7) interior wells of the pilot are shown in Figure 2, which are contained by twelve (12) perimeter wells. A single multi-azimuth well removed from the main well array is utilized for temporary water storage during operational testing of the pilot water storage scheme.

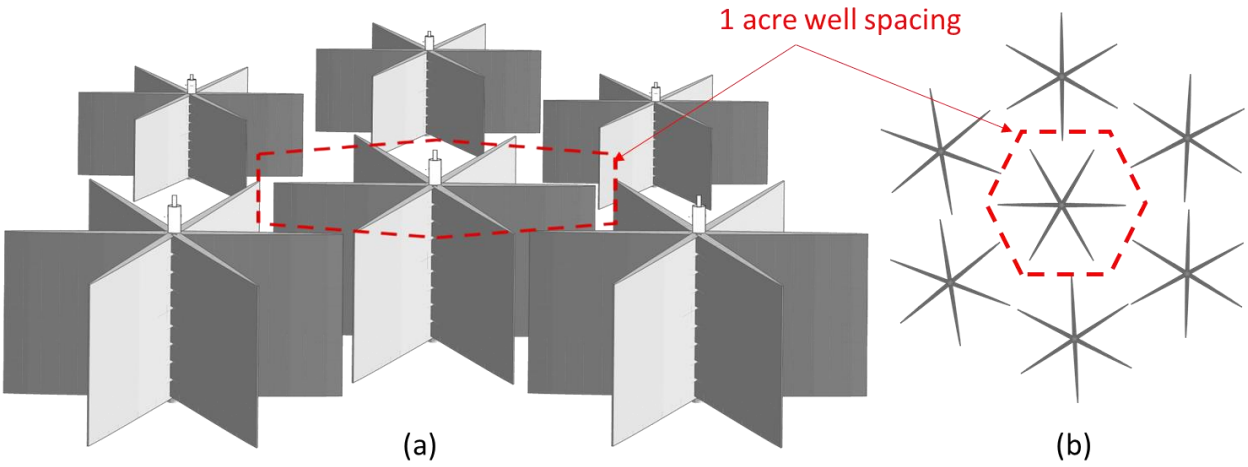

Figure 2. Shallow Subsurface Water Storage Scheme utilizing the Multi-Azimuth Sand Plane Technology: a) Cutaway Isometric View of Pilot Interior Wells, b) Plan View of Pilot Interior Wells.

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