

October 2019

WHITE PAPER



THE SECRET IS IN THE WATER

Unlocking Oil with Wettability Alteration

After years of research, ESaI, LLC (ESaI) has developed a breakthrough method to increase oil recoveries by optimizing reservoir wettability via altering the inorganic chemistry of injected water.

The ESaI solution can be applied in all three phases of oil field production at a cost significantly lower than alternatives and without using chemicals.

Whether you are looking to rejuvenate your old field or drill a new well, ESaI can help you increase your production and oil recoveries.

You are already using water, now use the RIGHT water!

EXECUTIVE SUMMARY



While improvements in technology have led to the development of new petroleum resources such as deep offshore and unconventional reservoirs, the expense of finding and producing new petroleum reservoirs is rapidly increasing.

Meanwhile, less expensive onshore conventional discoveries are declining. Current oil production recovers 32% (world average) of the original oil in place (OOIP) in the ground. The recovery factor in unconventional shale reservoirs is even lower, only 5-12%. With oil consumption predicted to increase through 2040, the need to unlock and bring to market the remaining portion of a viable and, most importantly, known resource is paramount.

After years of research, ESaI™ has developed a revolutionary method to improve reservoir wettability by altering the inorganic chemistry of injected water. This unique method mobilizes an additional 5-15% of OOIP during subsequent production at much lower costs than all other currently available techniques and without using chemicals. The methodology can work alone or in conjunction with other methods such as chemical, thermal and CO₂ to further enhance recovery.

Wettability describes the preference of a solid surface to be in contact with one of two or more fluid phases. Wettability in the petroleum reservoir

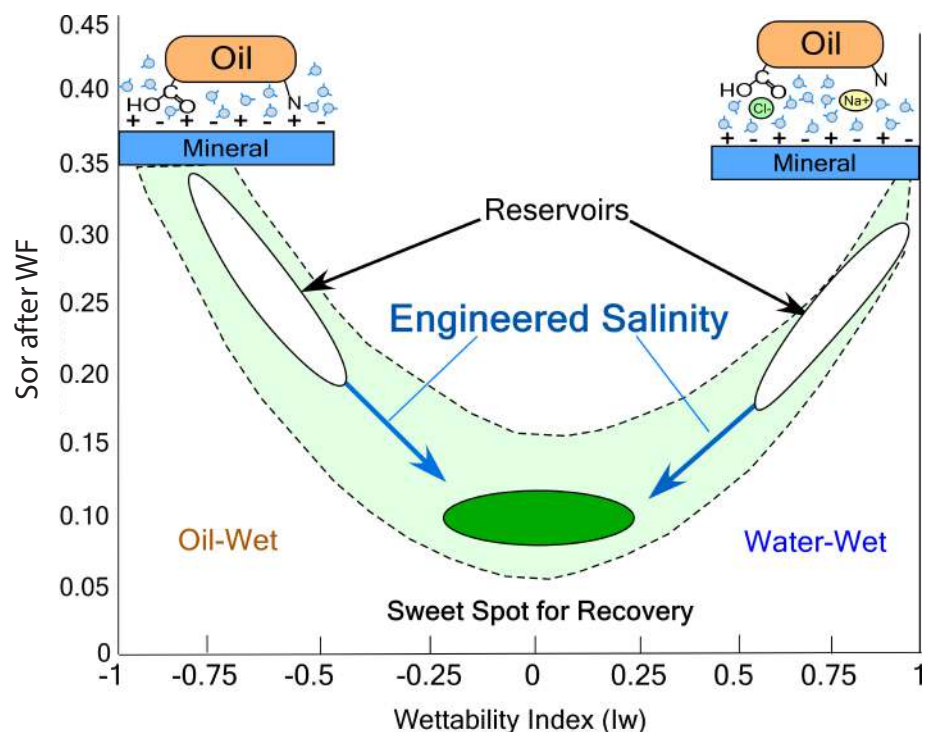
refers to the preferential adhesion of crude oil or reservoir brine to the rock surfaces.

Reservoirs have an optimum wettability that maximizes oil production, but few reservoirs start in this optimal condition. Reservoirs can be oil wet to the point that oil is not mobile even under waterflood. When the rock is water wet, pore throats shrink the effective diameter as the capillary force of water clinging to the rock resists oil movement through the throat and snaps off the oil phase, stranding mobile oil. Neutral wettability is the

optimum condition, where oil and water move equally well through the porous medium. The illustration below captures this concept. Under neutral conditions, water can easily displace the non-miscible oil. Current techniques to improve wettability involve expensive surfactants.

The Engineered Salinity™ solution shifts the reservoir's wettability to achieve this optimal state by changing the salinity of the injected water.

In simple terms, ESaI engineers the salinity to increase oil recovery.



Engineered Salinity™ Process

An additional 5-15% OOIP can be recovered by improving wettability with designed salinity.

SCREENING

The ESal process begins with our proprietary screening tool that evaluates the rock, water, field and oil characteristics to produce a numerical score indicating the likelihood of successful wettability modification. The fact that wettability modification does not work in every reservoir makes it necessary to be able to inform our customers, early in a project, whether Engineered Salinity is right for them. By doing this, we reduce project risk and improve technical confidence in the outcome.

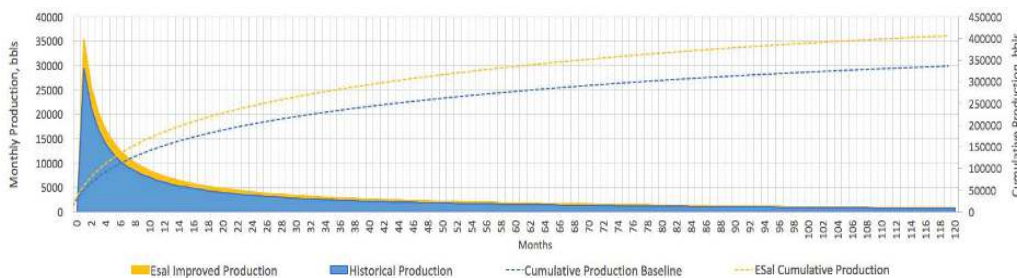
The charts below illustrate the increased recovery generated by using the Engineered Salinity solution during drilling, waterflood or tertiary recovery. In many cases, the benefit can be greater.

LAB TESTING

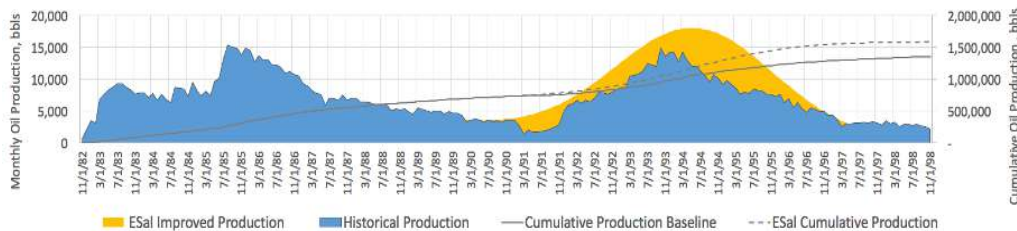
If the screening results are positive, the next step is laboratory testing to determine the in-situ wettability and the correct salinity level for optimizing wettability during fluid injection (visit www.esalinity.com/publications/ for more information). This methodology allows fast and accurate measurement of reservoir wettability using oil and rock samples (core or cuttings), gives our customers confidence that we can improve the wettability and provides the basis for field design and cost-benefit evaluations.

At each positive step of the screening process, the results provide a basis to move forward with confidence and an understanding of the benefits and costs. We can also provide economic evaluations of cost versus benefit at each step to help make the business case.

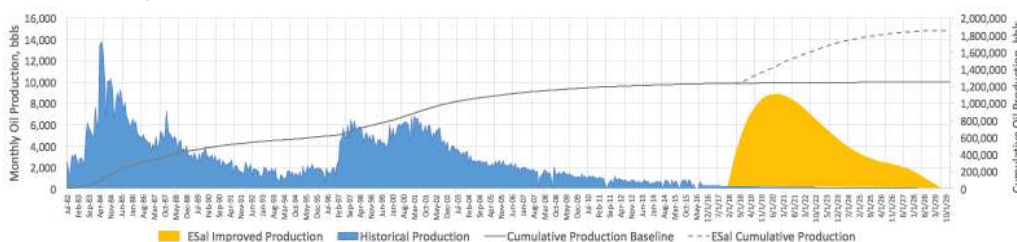
Unconventional Benefit Forecast



Waterflood Benefit Forecast



Tertiary Benefit Forecast



DEPLOYMENT

Finally, full deployment includes water resources evaluation, computer modeling, specifications for the injected water chemistry, as well as field deployment and operational support.

Extensive laboratory and field data show an additional 5-15% OOIP can be recovered by improving wettability with designed salinity. Improving your reservoirs' wettability with engineered water chemistry is the least expensive method for increasing oil recovery. Surfactant application costs \$8-12 per incremental barrel, as compared to an average of \$3 per incremental barrel for the ESal solution.

Engineered Salinity can be employed during completion, waterflooding or in EOR mode.

After the laboratory work, ESaI can design the injection water chemistry for your vetted projects. This step includes formulation of the right water chemistry, identification of potential water sources to mix with produced water and/or water treatment options to achieve optimal salinity. The right water chemistry also ensures compatibility with reservoir rocks and fluids to ensure suitability with field operations.

ESaI continues our support into the deployment stage with expert analysis of results and identification of refinements to further improve recovery. ESaI has taken the industry standard process of 4 to 6 years and \$10M - \$15M cost to screen one field and reduced the time and money required exponentially.

We are your partners in improving oil recovery through wettability alteration.

ESaI's Solutions

Screening

Evaluate your property's potential for wettability alteration by salinity changes using the ESaI screening algorithm.

Scoping

Analyze costs and economic benefits to implementing the ESaI process in the candidate property.

Lab Testing

Measure field wettability and determine the optimal fluid chemistry to promote oil recovery.

Water Sources

Evaluate available water source(s) (produced, surface and/or subsurface) for mixing and/or treatment options to create injection fluid.

Modeling

Design of injection water chemistry and specifications for field operation to improve wettability while avoiding formation damage.

Deployment

Specify optimal injection water chemistry and water treatment or mixing requirements, coordinate field/pilot operations and continual analysis and refinement of injection formulations.

Why ESal is right for you

High Return:

An additional 5-15% more of the original oil in place (OOIP) from your field

Quick Results:

Increased production in as little as 6 months after deployment

Seamless:

No change in normal operations

Versatile:

Works in carbonate or clastic reservoirs

Increase Reserves:

Successful pilot test can be used to increase reserves

Improve Well Performance:


Reduce Plugging, Scaling and Corrosion



Contact Information

 (432) 250-5612

 SThyne@ESalinity.com

 1938 Harney Street
Laramie, WY 82072

 www.esalinity.com