

## Surfactant Enhanced Aquifer Remediation The Basics

Non-aqueous phase liquids (NAPLs) are organic liquids, such as gasoline and diesel that are sparingly soluble in water. NAPL contamination commonly exists as blobs that become trapped within the formation. As they do not readily dissolve or mix with water, these compounds can remain as separate phase liquids for decades.

Because of the interfacial forces between NAPLs and groundwater, they are difficult to remove from the subsurface. NAPLs can be lighter than water (LNAPL), such as the aforementioned compounds, or denser than water (DNAPL), such as chlorinated ethenes. Surfactant Enhanced Aquifer Remediation involves the injection of specialty compounds with a molecular structure that has an affinity for the NAPL and groundwater. These compounds, called surfactants, can enhance the mobility and recovery of the trapped separate phase liquids. Surfactants can also facilitate the desorption of contaminant mass on matrix solids.

Surfactants are most appropriate for the removal of LNAPLs. For example, if you get grease on your clothing, you do not attempt to clean them by just adding water. You also use a detergent. Soaps and detergents are examples of surfactants.

Please note that the removal of NAPL will enhance the effectiveness of bioremediation and chemical oxidation processes.

### Choosing the Right Surfactant

The subsurface environment is notoriously difficult to remediate. Contact of the surfactant with the LNAPL and maintaining hydraulic control are exceedingly important. Also, choosing the right surfactant is critical. Factors to consider are the LNAPL itself, the groundwater chemistry and matrix mineralogy.

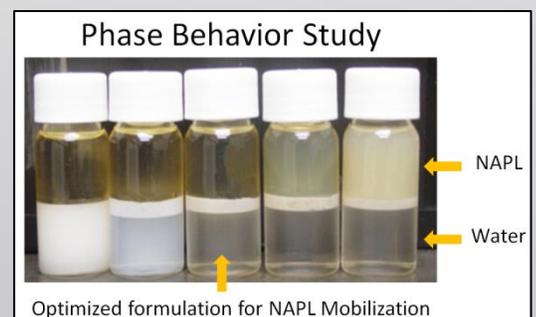
Currently, the conventional wisdom is to inject nonionic surfactants, as their chemistries will work in a wide variety of applications. Unfortunately, they easily adsorb to soil particles. Thus, when applying nonionic surfactants, you end up wasting a significant amount of money just dealing with the matrix demand. Furthermore, soils remove nonionic surfactants from water just like activated carbon removes organic contaminants from water. The manufacturers of nonionic surfactants typically recommend using 4 to 8% surfactant in the injectate.

Tersus' approach is quite different, as we use anionic (negatively charged) surfactants. Our core expertise lies in the understanding of surfactant chemistry, which yields significant benefits to our customers; namely, you can reduce the amount of surfactants by almost an order of magnitude.

### Benefits

Our anionic biodegradable surfactants provide considerable advantages.

- Dramatic reduction in cost
- You will need a minimal amount of surfactant – usually < 1% wt.
- 1 to 1.4 pore volumes for up to 95% mass removal
- No creation of a stable-emulsion, which dramatically reduces treatment costs – the oil separates from the water in a holding tank in less than 30 minutes
- Easy to handle waste stream
- Any surfactants remaining in the subsurface are easily biodegradable



## Surfactant Floods by Tersus Environmental

A key efficacy metric for surfactants is the reduction of the interfacial force, which is the force that keeps the oil trapped within pores. Most nonionic surfactants (conventional surfactants) reduce this trapping force by about an order of magnitude.

The Tersus approach is to use anionic surfactants, reducing the interfacial force by three to four orders of magnitude. Thus, you can save an enormous amount of money.

Surfactant	Initial Interfacial Force (oil and water)	Injection Vol.	Interfacial Force with Surfactant
Nonionic	30 to 50 mNewtons/meter	4 to 8%	5 mNewtons/meter
Tersus Surfactant (Anionic)	30 to 50 mNewtons/meter	0.5 to 0.9%	$10^{-2}$ to $10^{-3}$ mNewtons/meter

Applying the correct anionic surfactant (e.g., Tersus-Surfactant for Gasoline Range or for Diesel Range) reduces the amount of surfactant required and improves the effectiveness of the remedy.

### Why Tersus Surfactants

Tersus has formed a strategic alliance with Surbec Environmental. Founded in 1997 at the University of Oklahoma, Surbec has nearly two decades of experience advancing the science of surfactant molecular design and NAPL recovery. Surbec's attention to the science of surfactant chemistry has made it the industry leader.

- Tersus offers off-the-shelf surfactants for specific NAPLs, such as jet fuel, diesel and gasoline.
- For larger, more complex problems, Surbec, in conjunction with the University of Oklahoma, optimizes the anionic surfactant formulation for the site specific geochemistry and NAPL.
- By removing NAPLs, surfactants can enhance the effectiveness of bioremediation and chemical oxidation technologies.
- Tersus has teamed with Hasegawa Engineering to provide design and engineering services for complex problems.

### Packaging Options

- 55-gallon poly drums
- IBC Totes
- Bulk Tankers

### Our Philosophy

Our team continues to develop and commercialize surfactant technologies that improve performance, lower costs and speed remediation.



### TASK™ Injection Systems Available for Short Term Lease

