



Project Highlights

- **TPHENHANCED™** enhances the nutritive capacity of the treatment zone to support indigenous microbial degraders.
- **TPHENHANCED™** amended wells realized **>97% REDUCTION** in diesel range organics, **>99% REDUCTION** in oil range hydrocarbons in 30-days.
- **TPHENHANCED™** expedited the flux of bound residual source mass to get the rebound out *up-front*.
- **TPHENHANCED™** supports Quorum Sensing and Signaling (QSS) and the development of biofilm to realize maximum contaminant destruction.
- **TPHENHANCED™** enhances smear-zone and low-perm contaminant bioavailability/destruction.
- Minimize site liabilities and realize low-impact, cost-effective site compliance letting Nature have it!

TPHENHANCED™
Cost-Effective
Long-Term
Low-Impact

TerraStryke® TPHENHANCED™

Residual Diesel and Oil Range Organics LNAPL Source Zone Remediation

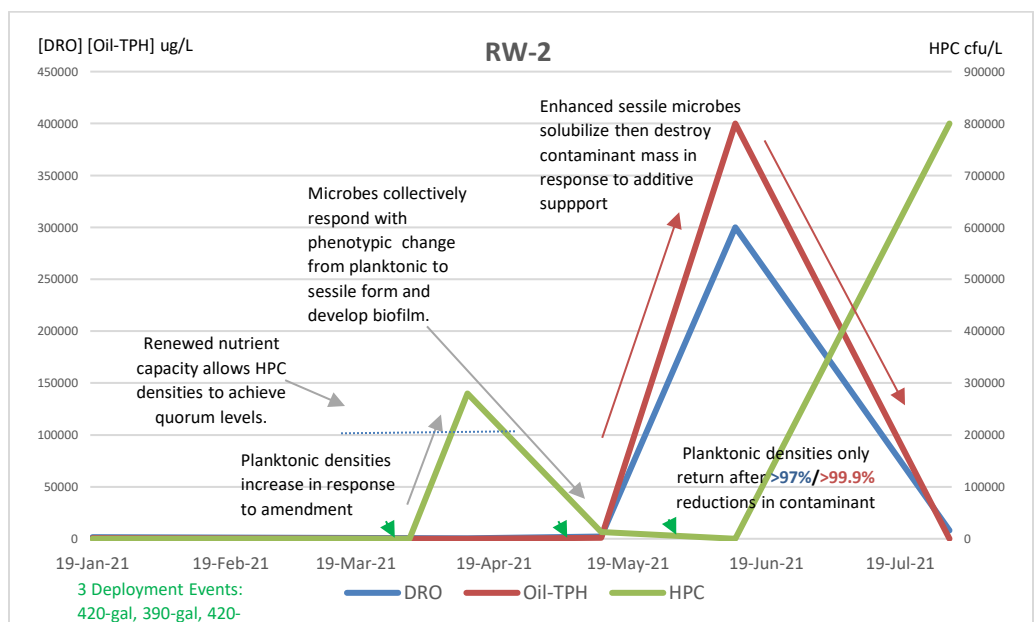
Simple Additive Delivery Approach; Future Retail Development, Seattle WA

TerraStryke® Products LLC develop and distribute biostimulation additives proven to cost-effectively maximize performance at any site using bioremediation or other remedial processes. Our biostimulation additives revive the nutritive capacity of the treatment zone to support the indigenous microbial population ability to expedite contaminant destruction, eliminate rebound, and realize long-term compliance with minimal impact and **less cost**. **TPHENHANCED**, our proprietary biostimulation additive, provides respiratory pathways and nutritive compounds that allow indigenous microbes to achieve quorum densities, support biofilm development, and realize sustainable contaminant destruction.

SITE: Future condominium development site contaminated with Diesel Range and Oil Range Organics (DRO/ORO) in saturated soils and groundwater at dissolved-phase concentrations indicative of residual Light Non-Aqueous Phase Liquid (LNAPL).

PROCESS: Six-month evaluation passively deployed solution of **TPHENHANCED** with minimal amounts of a fully encapsulating surfactant blended 1:2 with water. Total volumes used 615-pounds additive, 16-gallons surfactant, with water, gravity fed into RW-2 over three separate deployment events. Specifically, 420-gallons TPHenhanced solution only March 27, 2021, 390-gallons additive solution with 8-gallons surfactant May 2021, and 420-gallons additive solution with 8-gallons surfactant June 2021. The Area-of-Influence was assumed to extend approximately 15-20ft about RW-2. Additive performance monitored from groundwater samples collected monthly from RW-2 and a network of 6 monitoring wells to include one upgradient well.

RESULTS: **TPHENHANCED** amended RW-2 realized no change in [DRO]/[ORO] after the first deployment; however, Heterotrophic Plate Counts (HPC) increased from 40 colonies per Litre to 2.8×10^5 to attain assumed quorum densities. See the graph below.





RESULTS (continued): Less than one month later the planktonic densities *plummeted* to BDL. Concurrently, [DRO] and [Oil-TPH] increase three-fold to 300 mg/L and 400 mg/L; an assumed 'rebound' of sorbed contaminant mass to the groundwater as microbial densities and associated performance rates apparently fail. What then happens demonstrates the behaviour *expected* because of Bioremediation 4.0. Shortly after the second deployment of additive-solution is performed in May, as planktonic densities remain BDL, concentrations of [DRO] *decrease* 97.3% to 8.1 mg/L and [Oil-TPH] *decreases* >99.99% to BDL. Only after dissolved-phase concentrations of site contaminants (available protons) decrease to 1-2% baseline levels, densities of planktonic bacteria return to levels 3 orders-of-magnitude greater than reported when assumed quorum densities were achieved immediately prior to peak contaminant (proton) destruction/utilization levels or, 8.0×10^4 colonies per Litre.

Secondary geochemical parameters including dissolved-phase Manganese and Iron, Sulphate and Oxygen reduction Potential (ORP) data supports changes due to enhanced biological activity stimulated by the additive-solution cocktail.

CONCLUSIONS: Introduction of the biostimulation additive **TPHENHANCED** restored the nutritive capacity of the treatment zone/microbial ecosystem. Microbial densities in response were able to achieve quorum densities and signaling levels which initiated phenotypic changes in the population as a whole changing from swimming (planktonic) to sessile populations. The community of sessile microbes then collectively secreted biosurfactant-like compounds, polysaccharides and peptides to enhance solubilization of bound residual mass. Additionally, the community established a biofilm in which cell to cell communications and genetic sharing occur 100-1000x greater than the same populations can achieve in the bulk water. Important to site remediation objectives, energy/contaminant utilization by the enhanced microbial community also is maximized due to coordinated nutrient recycling, water movement, waste management and, through endogenous decay sustainable contaminant degradation is achieved. In summary, within the biofilm the additive enhanced microbial populations were able to share information, evolve and adapt to existing site conditions in real time to maximize the available organic compounds (DRO/ORO) present.

SUMMARY: this case study, field observations and laboratory data continue to demonstrate the biostimulation additive **TPHENHANCED** removes the environmental stresses in the treatment zone (microbial habitat) that limit growth to support the establishment of syntrophic relationships between various bacteria. This allows unicellular organisms to combine and unify their metabolic capabilities and collectively degrade substrate(s) neither could degrade alone. Specifically, many bacteria can ferment numerous organic compounds, yet most can't 'touch' Hydrogen (H_2). Furthermore, while many Archeae (methanogens) ferment H_2 and Carbon Dioxide (CO_2), most can't 'touch' organics. **TPHENHANCED**, supports the nutritive capacity of the microbial habitat, the development of biofilm, and cell-to-cell communication. Within biofilm amended indigenous bacteria/microbes are provided levels of protection from predation and bulk water conditions that allow the collective development of 'internal' systems to develop nutrient sinks, expedite the transfer of water and the removal of wastes, expedite electron transmissivity and utilization of available energy (PHC/protons) all by establishing syntrophic relationships between fermenters and Archeae to realize the sustainable and compete destruction of petroleum hydrocarbon (PHC) contaminants with less-impacts and at greatly reduced costs.

Call **TerraStryke®** now to develop a solution that minimizes your environmental liabilities by leveraging Nature alone.