

TerraStryke® TPHENHANCED™

Product Highlights

TPHENHANCED™ passive aggressively reduced BTEX constituents **95.7%** from peak bioavailability in <4-months

TPHENHANCED™ represents a quantum leap forward in bioremediation practices

TPHENHANCED™ enhances native microbial populations and expedites natural attenuation

TPHENHANCED™ keeps the treatment area *anaerobic*

TPHENHANCED™ expedites residual mass solubilization by enhancing entire degrading community behavior

TPHENHANCED™ is sustainable, eliminating energy-consuming, emissions generating aboveground equipment

TPHENHANCED™ leverages existing Site conditions to realize low-cost, low-risk, cost-effective contaminant destruction.

TPHENHANCED™ is ideal for remote site locations with limited access and energy availability.



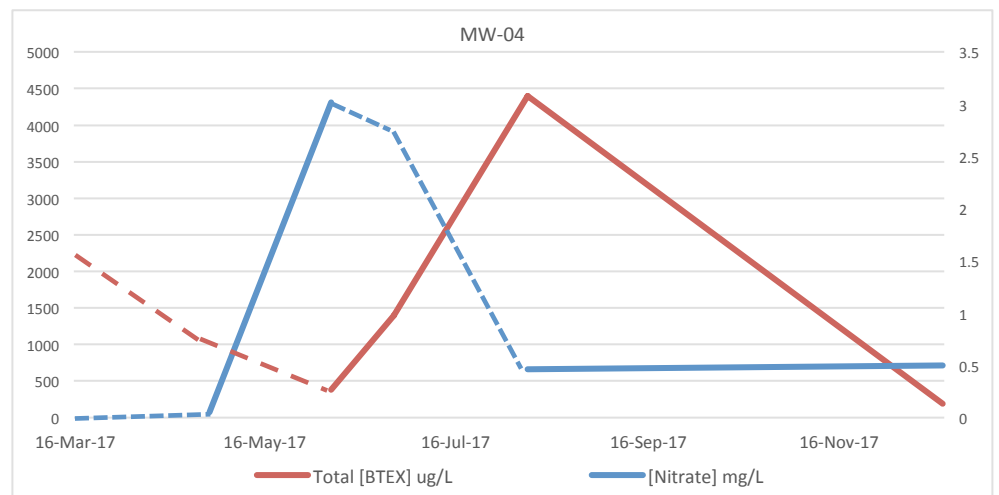
TerraStryke® TPHENHANCED™ Residual Source Mass Remediation Abandoned Oil-Gas Production Facility – Petroleum Hydrocarbons, BTEX Legacy Production Water Retention Pond, Colorado

TerraStryke® Products LLC (*TerraStryke®*) develop and distribute biostimulation additives enhance native microbial performance; proven to enhance natural attenuation by expediting solubilization of residual source mass *and* the destruction of dissolved phase contaminants. Our additives represent a new era in biostimulation leveraging Mother Nature’s experience.

PROCEDURES: Treatment area approximately 80x80ft (6,400 ft²) with estimated 5-foot vertical impact. 26 injection nodes, constructed of 2-inch OD PVC, previously installed using 10-foot centers within the treatment area. Using existing infrastructure, groundwater was amended with TPHENHANCED™ using Passive Release Sock (PRS) deployment units at each node. PRS units are 5-ft long, contains ≈2-pounds of additive, and were deployed twice during 9-month evaluation, March 2017 then May 2017. Two monitoring wells, MW-7 within the treatment area and MW-4 downgradient the treatment area, were periodically monitored/sampled to evaluate product efficacy. Post TPHENHANCED™ deployment observations included solubilization of residual mass and destruction of newly bioavailable dissolved contaminant:

From peak bioavailability, the following reductions were observed at MW-4:

- >98% decrease in Benzene after >1,000% increase
- >83% decrease in Ethylbenzene, after initial 768% increase, and
- >97% decrease in Xylenes after initial 2,500%+ increase
- Toluene was BDL throughout the evaluation



During the solubilization period (June-August 2017) rapid additive utilization was observed however; continued reductions in [BEX] were observed after additive availability ‘appeared’ exhausted. TerraStryke® products organically enrich groundwater biogeochemistry to cost-effectively enhance contaminant destruction; eliminating rebound. minimizing Site impacts

while maximizing your remediation dollar.



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This case study summarizes the superior ability of **TPHENHANCED™** to enhance the destruction of bioavailable dissolved-phase contaminants but more important to long-term compliance, solubilize, 'release to the hounds', residual source mass. **First**, with increased additive availability we see increases in the Oxidation-Reduction Potential (ORP). **Second**, we observe expedited destruction of the *already* available dissolved-phase contaminants. **Third**, expedited solubilization of previously unavailable residual source mass. **Fourth**, the enhanced destruction of the Site contaminants, organically, efficiently, cost-effectively.

We propose that microbial populations enhanced with **TPHENHANCED™** collectively secrete natural surfactants to increase contaminant bioavailability. Additionally, the microbial efficiencies associated with nutrient and food source (PHC) utilization are optimized using **TPHENHANCED™** maximizing PHC degradation rates; sustainably, cost-effectively realizing site compliance. These results are consistently observed and demonstrate **TPHENHANCED™** may represent the start of a new understanding of biostimulation and microbial processes. Most important, cost-effective destruction of LNAPL and dissolved-phase contaminants.

THEORY: Additive enhanced bacterial populations utilized the **TPHENHANCED™** as an alternative electron acceptor to O₂ during respiration, and the dissolved-phase contaminant (BTEX) as electron donor; or food, an energy and carbon source providing cellular energy and building-block material to grow the PHC degrader community. PHC degradation continued as additive availability was exhausted, indicating the duality of the additive itself. The proprietary, patent pending additive formulation stimulates native heterotrophic microbial respiration; and in turn, PHC destruction. As the formulation is utilized the enhanced native microbial community, via endogenous decay, naturally 'recycle' supplied inorganics to maintain robust microbial communities which support continued PHC destruction even *after* the additive has been 'exhausted'.

In summary, data suggest that the unique combination of **TPHENHANCED™** components enhances the ability of unicellular organisms to combine their metabolic capabilities and degrade substrate(s) that neither could degrade alone. **TPHENHANCED™** stimulates microbial respiration (without O₂) and PHC destruction, organically, leveraging existing site biogeochemical conditions.

To determine if our additive is appropriate for an environmental management concern at your site, please consider our low-cost, low-risk PRS based pilot evaluation process described below

PRODUCT EVALUATION PROCESS: TerraStryke® established our Pilot program to provide practitioners a low-cost low-impact method to evaluate our additives under actual Site biogeochemical conditions. The process provides potential end-users a representative, yet conservative, 'Go-No-Go' evaluation that will confirm amendment efficacy and facilitate a more accurate determination of full-scale additive loading requirements, thereby allowing all Stakeholders a level of assurance prior to committing to full-scale deployment.

TerraStryke® evaluations are performed *in-situ*, using existing 2-inch diameter groundwater monitoring well(s) located proximate to source zone contaminants. Additive-filled deployment units are suspended in the screened interval of the test well and remain undisturbed for approximately 10-14 days. PRS units are replaced with performance groundwater monitoring/sampling performed each event. Typical evaluations require up to 6-8 deployment/replacement events, requiring a total of 6-9 weeks to complete. Additive efficacy is determined by comparing baseline results to performance data with a minimum 50% Performance Goal established to consider the evaluation a success and justify discussions regarding future full-scale additive deployment strategies. A Technical Memorandum presenting pertinent results relative to established Performance Goal(s), estimated costs, and remediation time-lines will be provided at the evaluation end.