

## TPHENHANCED™ Project Highlights

- Order of Magnitude Reduction Benzene Concentrations to below Site MCL's at Injection Well Locations
- **>92%** Decrease Chlorobenzene without emissions generating, energy-consuming equipment
- Order of Magnitude Reduction 1,2-Dichlorobenzene Concentrations in 7-months
- Elevate Additive Availability Reduced to Baseline by Evaluation Completion
- **TPHENHANCED™** proven to expedite contaminant bioavailability via enhanced 'surfactant effect'
- **TPHENHANCED™** proven **Green** and **sustainable**, minimizing environmental impact - costs.
- **TPHENHANCED™** **cost-effective** site compliance **eliminating** long-term Site operations and maintenance needs - costs.
- **TPHENHANCED™** leverages existing Site conditions to realize enhanced in-situ contaminant biodegradation.
- **TPHENHANCED™** eliminates above-ground support equipment costs/needs; ideal for remote site locations with limited access and energy.



## BioStryke® TPHENHANCED™ Pilot Study Former Ne England Landfill – Dichlorobenzene Contamination On-Site Evaluation – Additive and Deployment Methodologies

BioStryke® Remediation Products, LLC, provide innovative and cost-effective amendment formulations designed to biostimulate treatment zone conditions and enhance in-situ anaerobic destruction of Site contaminants. **BioStryke® TPHENHANCED™** leverages existing site conditions, passive-aggressively destroys dissolved, sorbed, and residual source mass hydrocarbons while eliminating above-ground, energy-consuming emissions-generating equipment. **TPHENHANCED™** is proven effective in terms of cost and performance, allowing Site compliance with less environmental impact, working with Mother Nature, not against.

A Pilot Study was implemented to evaluate the efficacy of **TPHENHANCED™** under actual Site conditions against aromatic hydrocarbons and chlorinated-benzene contaminants. The Site is a former landfill with smear zone and dissolved phase contaminants and over the 7-month evaluation, on average, **> 90%** decrease in Site contaminants (benzene, chlorobenzene, and dichlorobenzene) was realized without costly aboveground, energy consuming, emissions generating equipment proving **BioStryke® TPHENHANCED™** a cost-effective additive for the in-situ destruction of recalcitrant source zone contaminants.

Pilot Study groundwater was amended using two 8-inch injection wells and Passive Release Sock (PRS) deployment units suspended within 2-inch monitoring well. Additive was blended with water in 300-gallon batches for an injection of approximately 3,400 and 5,700 gallons of a 525 mg/L solution in the two respective injection wells. PRS units contain 2-pounds of dry additive; remaining suspended and undisturbed within the screened interval of the test well, passive-aggressively amending a vertical column with an area-of-influence (AOI) of < 3-ft. Injection wells attained an approximate 18-ft AOI.

From December 2011 to July 2012 eleven rounds of post-injection groundwater monitoring and analytical testing events were performed and **BioStryke® TPHENHANCED™** facilitated the following overall reductions in Site contaminants at the two injection wells:

*AN ORDER-OF-MAGNITUDE (OM) DECREASE IN BENZENE TO BELOW SITE MCL (5 µg/L)*

*AN AVERAGE GROSS DECREASE IN CHLOROGENZENE ≈90% WITH UP TO 92% DECREASE AT SINGLE LOCATION*

*CONSISTENT DECREASES IN DICHLOROGENZENE APPROACHING ≈93%*

Based on the primary evidence **BioStryke® TPHENHANCED™** facilitated significant %reductions in benzene, chlorobenzene, and the dichlorobenzenes; with secondary evidence (increased additive availability, decreased COD, increased pH) consistent with non-assimilatory anaerobic contaminant degradation. Downgradient performance wells realized an order-of-magnitude decrease in DCB and benzene, and a >92% decrease in CB.

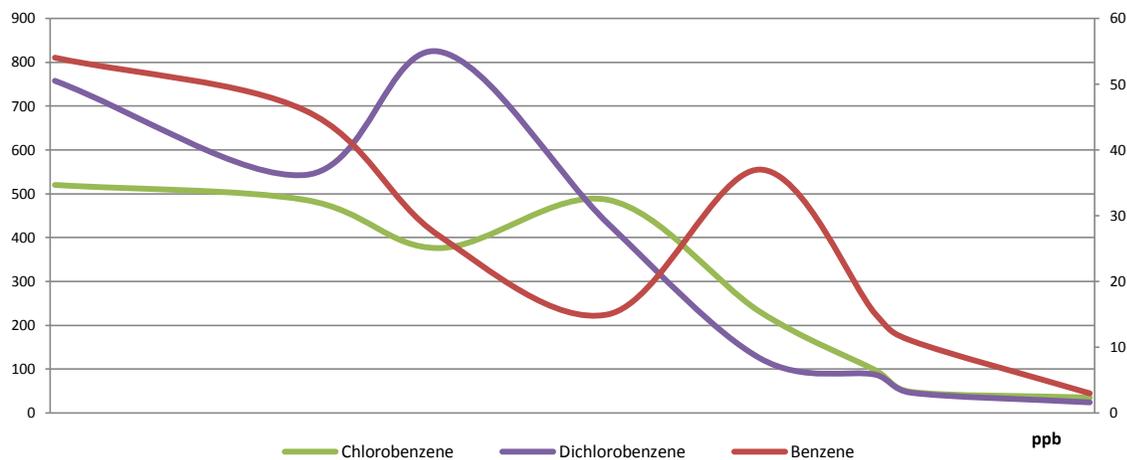
BioStryke® amendments with enhanced solubility are suitable for multiple deployment strategies including Direct Push Technology (DPT), infiltration gallery, injection well, direct solution application, etc.

BioStryke® amendments provide ease of handling, requiring less water, pore space displacement, site time, overall remedial costs.

BioStryke® amendments maximize project margins while minimizing project impacts.

Monitoring wells amended using PRS deployment units demonstrated lower performance with little to no reduction in concentrations of benzene; however, a four-time increase in the bioavailability of Chlorobenzene was observed followed by a decrease to baseline concentrations, and dichlorobenzene concentrations decreased a maximum 59% during the 7-month period. Secondary data included an increase in additive availability of up to four orders-of-magnitude; significant increases in COD levels indicative of the 'surfactant' effect observed in association with chlorobenzene concentrations, and a slight increase in pH. It is possible the lower performance observed in PRS amended wells is due to the elevated additive concentrations within a limited AOI; as compared to solution deployed additive amended at lower concentrations over a greater AOI into larger volumes of groundwater. Increased additive levels may produce a recalcitrant effect on motile state native heterotrophic soil bacteria. Chart One below diagrams anticipated results of a 7-month evaluation of groundwater located downgradient from additive amended injection wells.

CHART ONE



The Site is typical of many former landfills where an abundant volume of carbon is available, present in the soils and groundwater. The area is sparsely populated with limited energy availability. The contaminants of concern are present as residual smear zone and dissolved phase contaminants, recalcitrant in terms of cost and performance against traditional physical and/or O<sub>2</sub> based remedial strategies. TPHENHANCED™ was chosen for evaluation due to our strategy of leveraging the momentum Mother Nature provides to passive-aggressively enhance residual source mass contaminant bioavailability and realize cost-effective contaminant degradation.

BioStryke® Remediation Products LLC estimates full-scale amendment costs to address both saturated soil and groundwater adversely impacted with benzene, chlorobenzene, and dichlorobenzene contaminants at the Site to approximate **less than \$10.00 per treated ton**; with no off-site transportation, no off-site disposal, and/or associated on-site soil import needs. TPHENHANCED™ achieved anaerobic in-situ contaminant destruction while, eliminating long-term on-site operational and maintenance costs.