From: William Clogan <WClogan@regenesis.com>
Sent: Wednesday, August 18, 2021 1:20 PM
To: Grittner, Paul V - DNR
Cc: Amungwafor, Binyoti - DNR; Altenbach, Lanette; Scott Mullin; Owen Miller; Gregory Boldt
Subject: RE: Questions regarding Kenosha Engine Plant Injection Proposal
Attachments: KEP-Primary Application Inj Vol Eval.xlsx; KEP - WDNR - Design Rationale.pdf

Hello Paul,

Below are our responses to the questions you sent us earlier this month. Additionally, we provided some documents to help address the questions Binyoti had directed at Lannette Altenbach. Let us know if you need anything else.

1. Provide some additional details on the monitoring that will be conducted to ensure that injections will not impact downgradient receptors.

The injections will be carefully controlled and within the boundaries of the plumes as depicted on the figures provided in the *Groundwater Treatment Injection Plan*.
For areas 2, 3, and 4 the injection on the downgradient side of the plume will be PlumeStop which is a chemical that adsorbs contaminants of concern and provides long term contaminant reduction. Additionally, injections will generally occur from the outside of the treatment area to the interior of the treatment areas to control displacement. Groundwater monitoring will be conducted at the monitoring wells installed on the periphery of each treatment area, as well as the perimeter wells (generally outside the KEP fence). The new interior wells have been tested twice as a baseline and the perimeter monitoring wells have been monitored since 2014.

- Changes in temperature, conductivity, DO, ORP, and in some cases water level will be monitored at temporary wells during the injection process. Explain how this information will be used to make decisions in the field to determine if the amount of material being injected should be increased or decreased.

Changes in groundwater elevation is an indicator of horizontal migration of the injected fluid. Changes in field parameters demonstrate influence of the injected reagents (e.g., temperature, conductivity, DO, pH and ORP). If expected changes and indications of distribution are observed, then no changes will be made. Conversely, if no changes or unexpected changes are observed, then field adjustments will be made to ensure proper distribution of reagents.

Under what circumstances will pumping be discontinued?
If surfacing of the injected materials occurs in or near sensitive receptors, such as storm sewers, pumping will be halted to mitigate any further infiltration. If general surfacing is noticed around the annular space of the injection points and/or on the ground surface, mitigation techniques, such as applying a granular bentonite seal around the injection points, will be employed to reduce surfacing and continue the application. These are normal issues that arise during in-situ applications and are managed at the time of injection.

How will the temporary wells at treatment areas 2,3 and 4 be positioned to assess whether there is a significant increase of migration of contaminated groundwater offsite towards occupied buildings?

The PlumeStop injection is not expected to push contaminated groundwater offsite because the injections are planned from the outside inward. The purpose of the treatment in Areas 2,3,and 4 is to provide a treatment barrier that captures the contamination, so there should be no migration of contaminated groundwater. Injections in these areas will be nearest the property boundaries first. When considering the total amount of fluid injected in each treatment area, relative to the total amount of pore volume in the effective porosity, the likelihood of pushing the plume is low. For example, the design approach and volumes used only comprise filling approximately 0.5 to 3% of the total effective porosity for the treatment areas (assuming an effective porosity of 20%). Within the areas of injection, the proportionality will be higher, to establish a strong reactive zone. But, on a bigger scale, these volumes are miniscule and therefore, very unlikely to push the plume.

- Explain how AECOM will be monitoring nearby accessible sewers.

The sewers will be monitored visually.

Where are the sewers located that will be accessed, how and when will they be monitored?

A temporary storm sewer network was installed as part of soil remediation and is connected to the existing storm sewer main line that extends northward to 52nd Street or southward toward 60th Street depending upon the location within the KEP. These storm sewers are shallow and observations can be made at the storm sewer inlets depicted on the attached storm sewer map. There is no sanitary sewer network on the KEP. The sanitary sewers were capped at the property boundary at the time that the bankruptcy liquidation trust demolished the buildings.

How will a breach into the sewers be identified and what actions will be taken if one is observed?

It is unlikely that a breach into the sewer will occur. Should a breach of the sewer occur, the injections will cease until the location of the breach has been isolated and repaired.

- A stormwater pond was proposed to be constructed in the southeast corner of the site. If it was completed, is there a potential for the stormwater pond to be affected by the injection process and will how will this be monitored for?

The pond was lined with clay and the sand below the clay was stabilized with lime prior to clay placement to prevent a surface water/groundwater interaction zone. The pond should not be affected by the injection process. Additionally, the injections are only planned for the saturated zone, the zone below the clay liner of the pond. Only Area 4 is near the pond and PlumeStop barriers are the proposed treatment. The injection lines are sufficiently distant from the pond such that treated groundwater is not expected to migrate under the pond.

2. The results of pilot tests conducted at the site documented in the “Enhanced Reductive Dechlorination Pilot Test Documentation Report” (October 2, 2018) and the “In-Situ Chemical Oxidation Pilot Test Documentation Report” (March 7, 2018). Briefly explain why the proposed treatment strategy differs from what was tested in these pilot studies and why the proposed treatment strategy is expected to produce superior results.

Both pilot tests were conducted within the area currently identified as Area 1, and were applied within a source area and in an area immediately downgradient of a source. These pilot tests were intended to provide proof of concept in support of these technologies with the secondary goal of using these data to refine subsequent remedial efforts. The pilot tests were carried out to allow for an independent evaluation of the efficacy for both these treatment technologies. The ISCO pilot test utilized permanganate as the oxidant. The results of the pilot test demonstrated that the TCE concentrations can be treated at the site using chemical oxidation and therefore is an applicable technology to reduce contaminants in a source zone setting. Subsequent monitoring following the ISCO pilot test, indicated that the oxidant appear to have liberated contaminant mass that had been stored in the low permeability silts and therefore, additional treatment is necessary to provide further treatment to mitigate contaminant rebound. Results from the ERD pilot test demonstrated that this is viable treatment technology, especially in a lower concentration range. While both ISCO and ERD will be incorporated into the proposed approach, there are several key differences, including the inclusion of other treatment technologies, and these differences described below:

1. In treating the most impacted source zone in Area 1, at the Southwest Hot Spot, we will utilize a different, persulfate based oxidant, PersulfOx. In general, persulfate is a stronger oxidant than permanganate and will provide greater contaminant destruction capabilities for the primary contaminant, TCE. In addition, the proposed ISCO application uses greater volumetric loading and tighter point spacing than the previous application. In addition, the oxidant loading rate proposed here is greater than the permanganate pilot test. These design modifications will aid in further distributing the material into the aquifer, particularly in the lower permeability silts, where the majority of the contaminant concentrations are stored and provide greater constructive capabilities. This will reduce back-diffusion of the contaminants (i.e., rebound) compared to the pilot test. Following the ISCO treatment, a secondary treatment phase will be conducted using ERD and In-Situ Chemical Reduction (ISCR). The combined remedy of ERD/ISCR will provide another degradation mechanism with significant longevity to treat any residual contaminant that may rebound.

As covered in our supporting document, the approach to treating the remaining source zones identified in Area 1, uses a combination of ERD/ISCR. These remaining hot spot treatments, are markedly less contaminated than the Southwest Hot Spot and have greater daughter production, indicative of natural reductive dechlorination, use a grid based approach to ensure complete distribution and use significantly greater reagent loading rates, volumetric loading rates and point spacing than the ERD pilot test. For example, the pilot test used 20-25 foot point spacing, while the proposed hot spot treatments are slated to use 8 foot spacing. The remaining impacts in Area 1 will be addressed using ERD/ISCR in a series of treatment lines that will spread the material out over time using groundwater flow. **Further information on this approach is covered in the supporting document.**

In addition, technologies proposed for ERD/ISCR are superior. This is particularly the case in our ISCR reagent proposed, S-MZVI, which has been specifically formulated to enhance longevity and reactivity, by coating the ZVI with a layer of FeS. This feature, called sulfidation, is unique and provides better performance compared to the ZVI reagent used during the pilot test, which was not sulfidated.

2. In addition to these key differences in Area 1, further characterization of the site was undertaken using high resolution soil sampling across the site (~1 foot increments), in combination with the installation of Passive Flux Meters (PFMs) in numerous monitoring wells and piezometers. The PFMs provide direct measurements of the contaminant mass flux on 1 foot increments. These two datasets provide high resolution into where the contaminants are stored and transported within the subsurface system, allowing for surgical emplacement of the material to optimal treatment efficacy. This is in contrast to the pilot tests, which used a more uniform placement across the vertical treatment interval. Lastly, our injection approach will use lower injection pressures and low rates to mitigate surfacing and enable more uniform distribution in the subsurface compared to the pilot tests.

3. In Areas 2, 3 and 4, no pilot tests were conducted. Based on the site characterization (e.g., contaminant concentrations, soil mass and groundwater flow velocities) of these areas, size of the treatment areas, and the setting of these areas located near the property boundary, we have adopted a sorption based approach using PlumeStop. PlumeStop will deposit a thin layer of carbon onto the soils and remain there indefinitely, effectively creating a filter. In these three areas, PlumeStop will be applied in a barrier arrangement that will intersect the migrating contaminants where they will be captured and degraded by the supporting and co-applied ERD/ISCR technologies. **Further information on this approach is covered in the supporting document.**

The combined treatment strategy is proposed to meet a 90% contaminant concentration reduction within a two-year period. The reduction will be based on the concentrations detected in the monitoring well network that was installed in November 2020. Groundwater will be monitored during and after treatment. If reductions do not occur as planned or rebound (as is often seen in single treatment strategies) occur, a supplemental treatment will occur. The design for this contingency will be prepared if needed.

Thanks,

Will Clogan
Remediation Services Project Manager
724-766-1811

For leading vapor intrusion mitigation, please visit www.landsciencetech.com, a division of **REGENESIS**

REGENESIS

From: Grittner, Paul V - DNR <Paul.Grittner@wisconsin.gov>
Sent: Tuesday, August 3, 2021 8:11 AM

To: William Clogan <WClogan@regenesis.com>
Subject: Questions regarding Kenosha Engine Plant Injection Proposal

Will,

The Department of Natural Resources is requesting some additional information regarding the work that will be conducted under the injection permit requested for the Former Kenosha Engine Plant site (5555 30th Avenue, Kenosha; BRRTS # 02-30-000327).

1) Provide some additional details on the monitoring that will be conducted to ensure that injections will not impact downgradient receptors.

    - Changes in temperature, conductivity, DO, ORP, and in some cases water level will be monitored at temporary wells during the injection process. Explain how this information will be used to make decisions in the field to determine if the amount of material being injected should be increased or decreased. Under what circumstances will pumping be discontinued? How will the temporary wells at treatment areas 2,3 and 4 be positioned to assess whether there is a significant increase of migration of contaminated groundwater offsite towards occupied buildings?

    - Explain how AECOM will be monitoring nearby accessible sewers. Where are the sewers located that will be accessed, how and when will they be monitored? How will a breach into the sewers be identified and what actions will be taken if one is observed?

    - A stormwater pond was proposed to be constructed in the southeast corner of the site. If it was completed, is there a potential for the stormwater pond to be affected by the injection process and will how will this be monitored for?

2) The results of pilot tests conducted at the site documented in the "Enhanced Reductive Dechlorination Pilot Test Documentation Report" (October 2, 2018) and the "In-Situ Chemical Oxidation Pilot Test Documentation Report" (March 7, 2018). Briefly explain why the proposed treatment strategy differs from what was tested in these pilot studies and why the proposed treatment strategy is expected to produce superior results.

Finally, the fee for the injection permit is $700, not $1050. The DNR cannot provide a refund for the extra amount. We can either process the check you provided, or you can provide a check for $700 and we will return the check you provided earlier.

Please let me know if you have any questions regarding these items and how you would like us to resolve the fee issue.

We are committed to service excellence.
Visit our survey at http://dnr.wi.gov/customersurvey to evaluate how I did.

Paul Grittner
Hydrogeologist - Remediation and Redevelopment Program
Wisconsin Department of Natural Resources

Phone: (414) 405-0764
paul.grittner@wisconsin.gov

dnr.wi.gov

Kenosha Engine Plant – Design Approach and Rationale

To: Binyoti Amungwafor - Wisconsin DNR

Paul Grittner - Wisconsin DNR

From: Will Clogan – REGENESIS

Owen Miller – REGENESIS

Scott Mullin - REGENESIS

CC: Lanette Altenbach - AECOM

Date: August 18, 2021

Re: **Wisconsin DNR Permit Submittal**

Mr. Amungwafor, and Mr. Grittner,

REGENESIS appreciates your inquiry regarding the remedial design approach proposed for the Kenosha Engine Plant (KEP) project and the opportunity to provide our design approach and rationale. The intent behind this memo is to provide further clarification on the approach for the proposed remedial program. We trust this additional information will be valuable in supporting and communicating the remedial approach. It should also be noted our application program and approach is dynamic. Adjustments will be made to the application based on field observations to ensure that we are achieving the necessary distribution to achieve optimal results. Therefore, the proposed remedial design is subject to change with respect to the application volumes of mix water (not remediation product quantity) and injection point spacing. Below we provide a summary of the design approach and rationale for each treatment area.

Remedial Overview

Treatment Area 1 - 754,000 square feet

Treatment Area 1 will be treated using a multi-tiered approach to efficiently address these impacts. Within Treatment Area 1, the degree of contaminant impacts varies greatly. We have identified four primary areas (i.e., hot spots) where contaminant mass is much more elevated than the other remaining impacts. Thus, to optimize treatment efficiency, this program targets the highly contaminated areas more aggressively than the less impacted areas. By depleting the contaminant mass in these hot spots, further leaching of the contaminants into the groundwater will be minimized and the overall plume strength will be significantly diminished.

These four hot spots will all be treated using a combination of treatment technologies including Enhanced Reductive Dechlorination (ERD) and In-Situ Chemical Reduction (ISCR). ERD will provide a biological pathway to degrade the contaminants by providing an electron donor source and bioaugmentation culture using 3DME and BDI Plus. ISCR will provide an abiotic pathway via S-MICROZVI. ERD and ISCR will work in tandem and synergistically to provide potent degradation mechanisms designed to fully degrade the contaminants into non-toxic end products (e.g., ethane, ethene and CO2). In each of these four hot spots, the injections will be carried out in a large injection grid application with tight injection spacing to ensure good contact between the reagents and contaminants. Due to the varying degree of contaminant impacts across Treatment Area 1, a phased treatment approach will be adopted. The first phase (i.e., Phase I) will consist of In-Situ Chemical Oxidation (ISCO) using a persulfate-based oxidant, PersulfOx, in the Southwest Hot Spot, as denoted by PZ-2103. This ISCO application will provide an additional treatment mechanism to substantially reduce the contaminant mass. After the ISCO application, a transition to the second treatment phase of ERD/ISCR (i.e., Phase II) will commence in each of the four hot spots.

Upon completion of Phase I/II, the other remaining impacts in Treatment Area 1 will also be treated using a combination of ERD/ISCR in the third phase (i.e., Phase III). The contaminant impacts targeted during Phase III are substantially less compared to the hot spots in Phase I/II. Consequentially, Phase III will facilitate treatment using a series of treatment lines strategically placed throughout the footprint of Treatment Area 1. These treatment lines are designed to concurrently treat groundwater that is passing through these planes, while also moving with the groundwater to effectively create an expending Treatment Area. The electron donor proposed, 3DMe, has unique properties that allow for a fraction of the material to attach onto the soil, while the remaining fraction moves with groundwater flow. This unique transport feature and design approach is illustrated in the attached case study. The S-MICROZVI particles will remain relatively stationary and act as a permeable reactive barrier (PRB). In addition, a prominent byproduct of S-MICROZVI is ferrous iron, which will move with groundwater and function as a reductant to further promote ISCR degradation reactions downgradient of the treatment (e.g., increased FeS mineral formation).

In total, Phase III utilizes approximately 3,735 linear feet of treatment lines spread across Treatment Area 1. These treatment lines are positioned 135 to 250 feet apart, and, on average, are 200 feet apart from each other. The average groundwater velocity is approximately 150 ft/year. Therefore, the theoretical travel time for a molecule of water to move from one treatment line to the next treatment line (i.e., 200 feet) is ~approximately 1.33 years. These reagents (i.e., 3DMe) typically move at a rate 1/2 to 1/3 the speed of groundwater flow. Given the longevity of these reagents is on the order of several years (e.g., 5 years+), we expect our electron donor to fully spread between adjacent treatment lines and establish a continuous reactive zone. The reducing geochemistry (e.g., low oxygen and nitrate) of the aquifer will provide a low consumptive setting that will enable 3DMe to transport with minimal consumption by undesired side reactions (e.g., from aerobic and nitrate reducing bacteria). This notion is further supported by the presence of total organic carbon (TOC) and natural biological reductive dechlorination already ongoing (e.g., ethane/ethene) in many wells in treatment area 1. Further details on the application design for Phase I, II and III for Treatment Area 1 can be seen in the Attachment 1 in the KEP GW Treatment Injection Plan.

Treatment Area 2 - 40,000 square feet

The remedial program for Treatment Areas 2 uses a combined approach of ERD, ISCR and In-Situ Sorption. The treatment approach uses a two-part approach to address these impacts. The first component, within the upgradient portion of the Treatment Area, consists of installing a 3DMe, S-MICROZVI and BDI Plus treatment line to facilitate ERD and ISCR degradation reactions. Consistent with the dynamics of these reagents described in treatment area 1, a portion of the reagents will remain stationary, while the other portion will move with groundwater, effectively creating an expanding reactive zone, which is much greater than the zone during initial emplacement. This will allow for the material to "sweep" throughout this upgradient portion to treat the residual daughter products present (i.e., cis-DCE) and transform them to non-toxic products such as ethane/ethene/CO2 and effectively reduce the contaminant mass flux across the plume.

At the same time, the downgradient impacts located near the property boundary will be treated using a combination of In-Situ Sorption and ERD/ISCR in a treatment line. The technologies used here consist of PlumeStop, S-MICROZVI, Hydrogen Release Compound (HRC), and BDI Plus. HRC is an electron donor to support ERD, with optimal compatibility with PlumeStop. PlumeStop is a form of liquid activated carbon, comprised of fine scale activated carbon particles, suspended in food grade polymers. This allows for the reagent to readily distribute and uniformly cover the pore spaces, while depositing a thin layer onto the aquifer surface. Once PlumeStop has deposited, it will remain a fixture, effectively converting the aquifer into a filter. In this way, PlumeStop will create a true PRB. Once the contaminants are captured onto the surface of PlumeStop, the contaminants will be localized onto its surface and enhance the efficiency for ERD/ISCR reactions. Further details on the application design for Treatment Area 2 can be seen in the Attachment 1 in the KEP GW Treatment Injection Plan.

Treatment Area 3 - 18,000 square feet

The approach for Treatment Area 3 consists of the installation of two PRBs. The placement of these PRBs, spread throughout the plume, are designed to optimally intersect groundwater that is moving Easterly through Treatment Area 3 and prevent further off-site migration. These PRBs will be constructed with In-Situ Sorption with ERD/ISCR treatment technologies using PlumeStop, S-MICROZVI, HRC and BDI+. When groundwater passes through these PRBs, the contaminants will be captured onto PlumeStop, where they will be subsequently degraded using ERD/ISCR treatment. Further details on the application design for Treatment Area 3 can be seen in the Attachment 1 in the KEP GW Treatment Injection Plan.

Treatment Area 4 - 54,000 square feet

Treatment Area 4 will install two PRBs as a part of the proposed remedial approach. These PRBs are optimally placed to intersect groundwater flow in this area. Consistent with the PRBs installed in Treatment Areas 2 and 3, these proposed PRBs will provide In-Situ Sorption with ERD/ISCR via PlumeStop, S-MICROZVI, HRC and BDI Plus. The first PRB will be installed near the retention pond, near the railroad track. This PRB will prevent contaminant migration to the South or the North, in the event groundwater flow direction changes. Further details on the application design for Treatment Area 4 can be seen in the Attachment 1 in the KEP GW Treatment Injection Plan.

Closing

We sincerely appreciate the opportunity to present this information and hope this is provides further insight into the proposed approach. If further clarification is needed, we would be happy to set up a meeting to discuss this further.

Respectfully,

Will Clogan
Project Manager
724-766-1811

Attachments

State Led Combined Remedy Approach – Paw Paw

REGENESIS®

ADVANCED REMEDIAL TECHNOLOGIES RESTORE NEIGHBORHOOD

CASE STUDY:
Former Michigan Industrial Site Treated Using Combined Remedy Approach

Case Study Overview

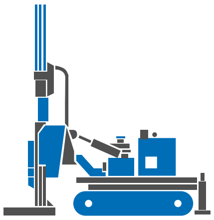
A former plating facility in southwest Michigan, released chlorinated volatile organic compounds (CVOCs) into shallow groundwater which resulted in a ¼-mile long contaminant plume. This fast-moving contaminant plume extended beneath a residential neighborhood and discharged to the nearby Paw Paw River. The contaminated groundwater infiltrated into a nearby storm water system and into several residential basement sumps.

In response, the Michigan Department of Environmental Quality (MDEQ) and the environmental firm, DLZ, implemented a combined remedy which included mitigating vapor intrusion in the residential basements and treating the groundwater plume with a novel, multi-phase Enhanced Reductive Dechlorination (ERD) approach. These efforts succeeded in eliminating the immediate vapor intrusion risk at the residences and virtually eliminating the dissolved-phase CVOC plume, negating any potential future risks to the residences and the surface water.

Project Highlights

3-D MICROEMULSION

3DME was injected with little disruption to the residential community.

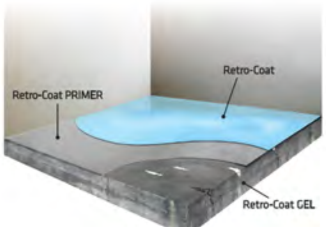


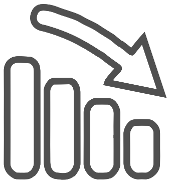
PLUME STOP Liquid Activated Carbon

PlumeStop bio barriers were installed strategically to protect against further plume migration.

Retro-Coat™ Vapor Intrusion Coating

Retro-Coat Vapor barriers were installed in residential basements to protect occupants.





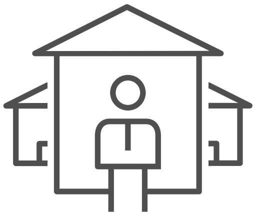
98-100%
CONTAMINANTS ELIMINATED

Treatment reduced the total cVOC plume extent by 95% and reduced mass by 99.8% to-date.

DEGRADATION
ONGOING AND PROGRESSING

Indicator parameters are showing positive results, indicating the degradation process is ongoing and processing.

LIMITED DISRUPTION
TO RESIDENTIAL NEIGHBORHOOD



About the Project

The MDEQ (Michigan Department of Environmental Quality) began state-funded activities at an industrial plating facility in southwest Michigan to determine the nature and extent of contamination emanating from an area of the facility where degreasing agents were used. The investigation identified CVOCs and impacted groundwater. The impacted groundwater was in a ¼-mile long shallow plume ranging from 2 to 5 feet in depth migrating from the site and throughout a residential area. Contaminated water was found in some of the basement sumps in the residential area. After assessing a nearby storm water system, it was clear that the contaminated groundwater was also discharging into the East Branch of the Paw Paw River.

Environmental consultant firm, DLZ, was engaged to evaluate the site and determine recommendations for clean up.

The extent of the groundwater CVOC plume circa 2010. The plume moved south to north through a residential neighborhood toward the Paw Paw River to the north.

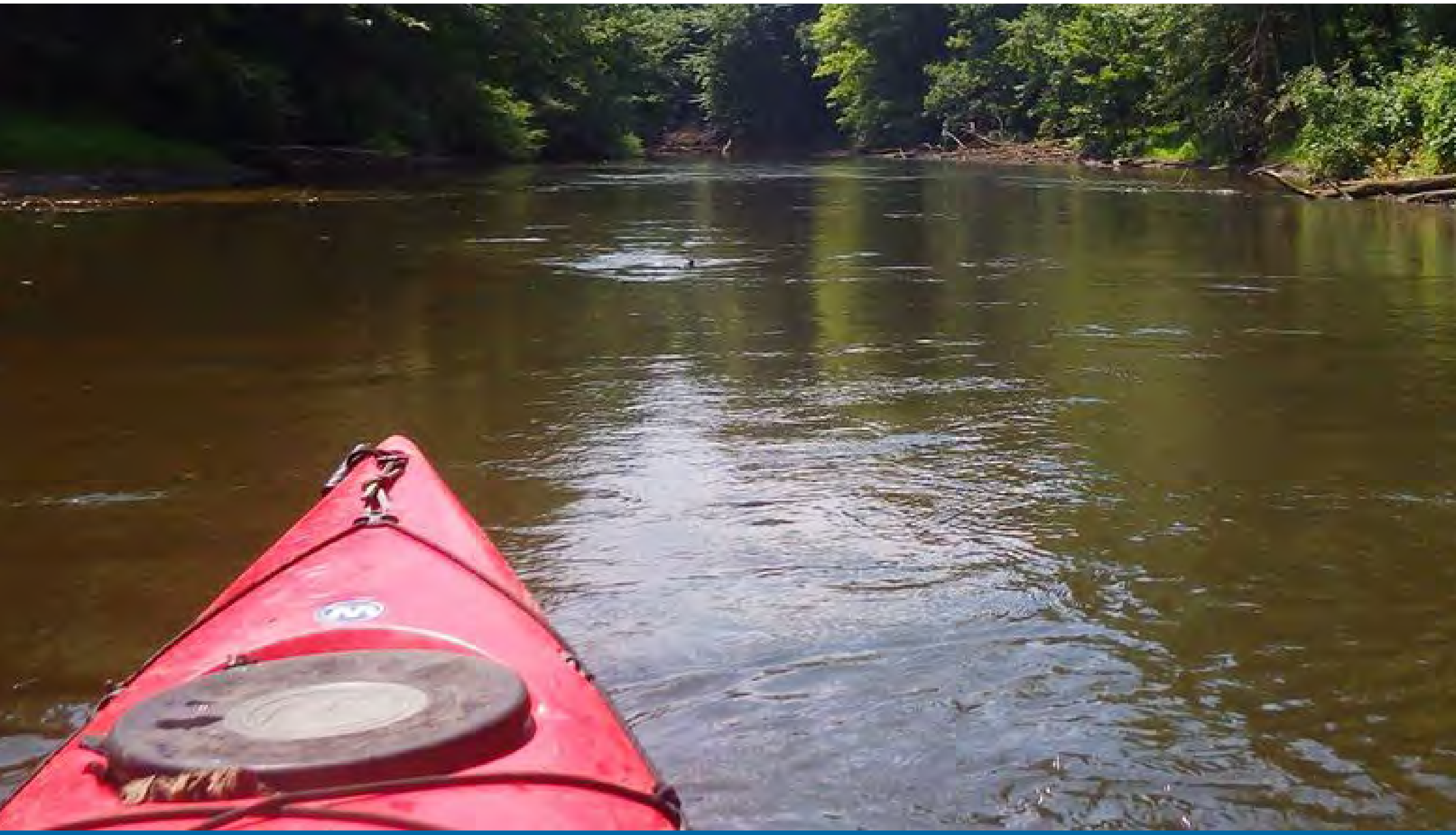
Department of Environmental Quality

David Harn, MS
Assistant District Supervisor at Michigan Department of Environmental Quality

About the Consultant

DLZ partners with clients to develop the best solutions to achieve the goals of any project. DLZ's multidisciplinary staff includes architects; civil, traffic/transportation, structural, mechanical, electrical, geotechnical, sanitary, chemical, and construction engineers; environmental specialists; land and community planners; computer applications specialists; surveyors; drillers; geologists; landscape architects; interior designers; ecologists; and specification writers. DLZ's subsurface investigation division offers a full range of drilling services for a variety of environmental projects and is capable of providing most types of rotary, coring, and auger drilling. DLZ personnel are familiar with the proper field protocols outlined by ASTM, AASHTO, USEPA, and USACE, as well as various local, state, and federal specifications and guidelines.

DLZ is one of the top consulting firms in the architectural, engineering, and surveying industry. The firm was ranked by Engineering News Record as Midwest Design Firm of the Year in 2016 and currently ranked as one of the Top 150 in the U.S. and the 8th largest in the Midwestern United States. Our multidisciplinary, collaborative approach to professional services allows us to build and lead successful project teams that are dedicated to providing solutions that save money, improve operations, and solve problems with our competency, integrity, and contributions to the people and communities we serve. Our vision is simple: Create successful partnerships with our clients that facilitate trust, commitment, and communication. DLZ is one of the top consulting firms in the architectural, engineering, and surveying industry. The firm was ranked by Engineering News Record as Midwest Design Firm of the Year in 2016 and currently ranked as one of the Top 150 in the U.S. and the 8th largest in the Midwestern United States. Our multidisciplinary, collaborative approach to professional services allows us to build and lead successful project teams that are dedicated to providing solutions that save money, improve operations, and solve problems with our competency, integrity, and contributions to the people and communities we serve. Our vision is simple: Create successful partnerships with our clients that facilitate trust, commitment, and communication.



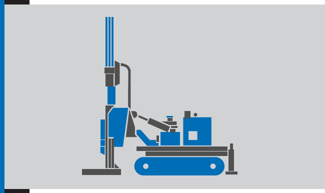
Timeline

2010

Vapor Intrusion Mitigation: To diminish vapor intrusion in several residential basements, the sumps were capped and vented, and Retro-Coat was applied to the floors and walls.

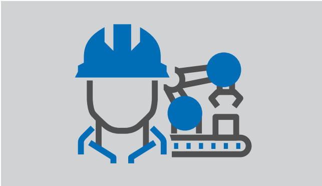
Pilot Test: The six-month pilot test demonstrated effectiveness of the 3DME technology.

2011



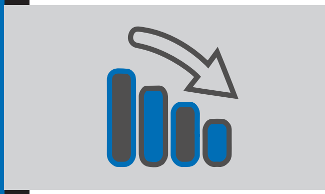
CVOC Groundwater Plume Treatment: 3DME was applied to the groundwater plume at large. The 3DME technology allowed for minimal interferences with residents and a low pore volume displacement.

2013



Industrial Building Demolition: A grid based injection point array was used to administer the 3DME treatment underneath the former Paw Paw Plating building following demolition and removal. CVOCs were drastically reduced in the source and near-source areas.

2015



Residential Area Plume Maintenance: PlumeStop biobarriers were employed within the residential plume area to provide a final polishing treatment of residual low levels of CVOCs and to protect against any future migration of residual CVOCs.

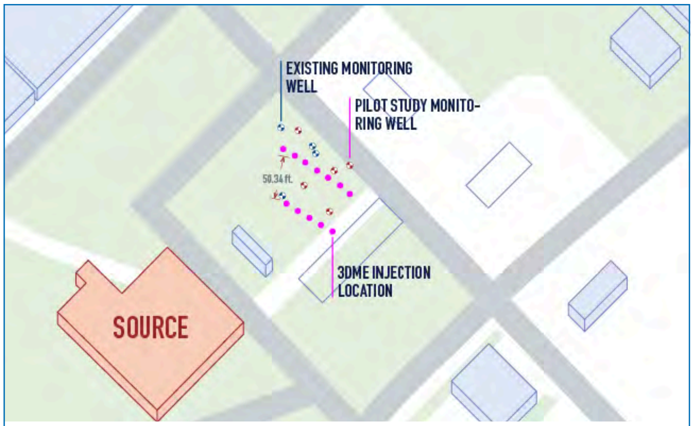
2016

Results: After treatment, the CVOC plume has been eliminated. The treatment reduced the total CVOC plume extent by 95% and reduced the cumulative mass by 99.8%, thus far.

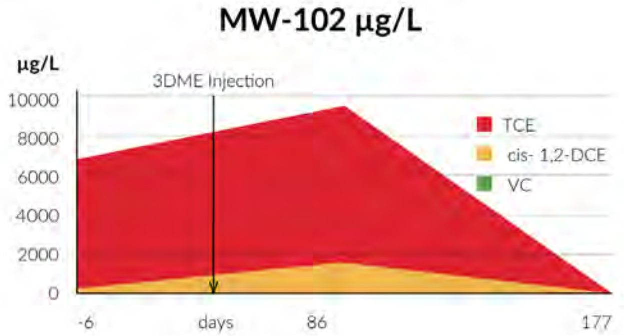
The Pilot Test Demonstrates Technology Efficacy

MDEQ and DLZ conducted a six month pilot test to demonstrate the efficacy of 3-D Microemulsion or 3DME technology. The remediation team spaced two rows of injection points approximately 50 feet apart for the test. The graph shown is from a representative well (MW-2) depicting 97% reduction in CVOCs within six months.

Based on the successful pilot test, MDEQ proceeded with the full-scale application. 3DME was the chosen technology for this project because it has unique subsurface distribution characteristics and a beneficial, sequential staged release of three unique electron-donor materials. Because of its staged release mechanism, 3DME is highly efficient, providing the optimal amount of electron donor for complete dechlorination of CVOCs. This mechanism along with its distribution characteristics allows there to be less injection sites making 3DME both time and cost-effective compared to other enhanced natural attenuation approaches.



3DME Pilot Test Layout



This graph indicates point of injection and subsequent reduction of TCE, cis 1,2 DCE and VC levels post-application.

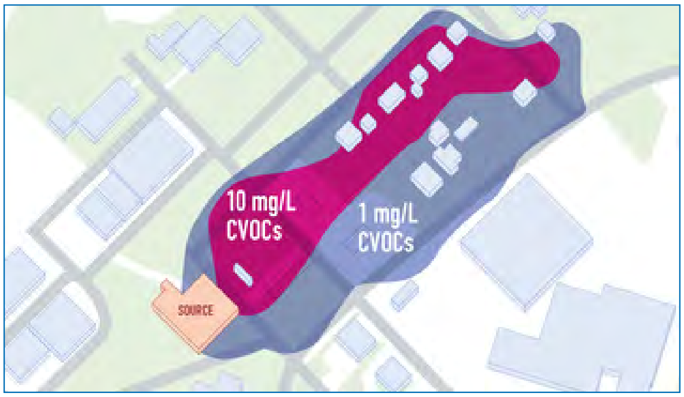
Full-Scale Application

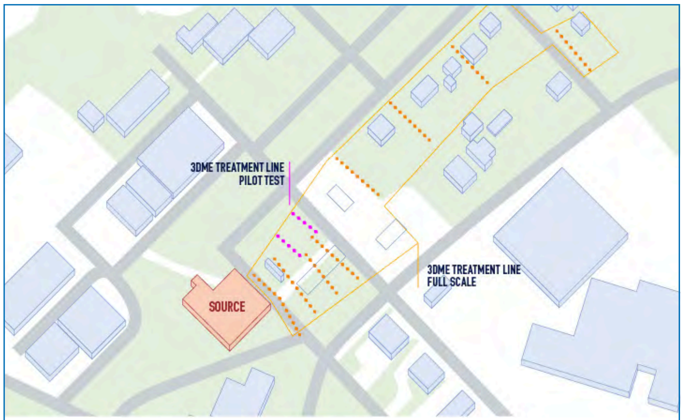
Following the successful proof-of-concept pilot test, 3DME was applied to the groundwater CVOC plume downgradient of the former Paw Paw Plating facility. The design challenges of a fast-moving aquifer (more than one foot a day) migrating through a residential neighborhood required an innovative remedial design approach consisting of treatment lines spaced approximately 200 feet apart (on average) between residential properties. In this manner the natural groundwater advection could be utilized to take advantage of 3DME's unique micellar distribution properties. Closer to the source, treatment lines were spaced approximately 50 feet apart.

The effective pore volume within the target treatment zone was estimated to be 1.3 million gallons. The injected 3DME dilution mixture was approximately 15,000 gallons, resulting in a minimal 1.7% effective pore volume displacement. This very low-volume approach is afforded by the mobile properties of 3DME which do not require it to be pushed by pumping for final displacement. Instead, natural groundwater advection may be used to distribute 3DME. This was a critical consideration because it minimized both the installation costs and onsite time, while maintaining sufficient treatment coverage to achieve the desired result: elimination of the CVOC plume.

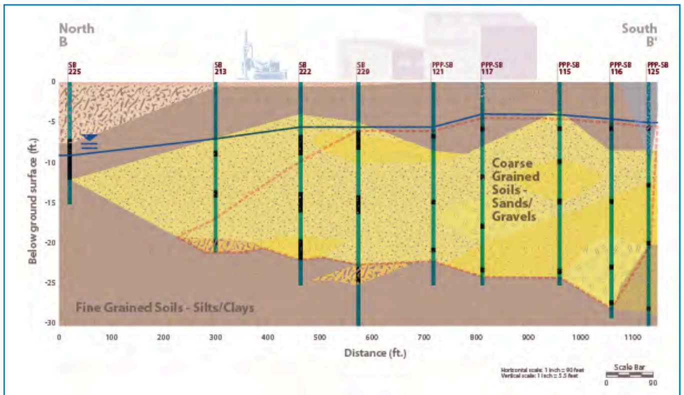
Following the full-scale application of 3DME, the industrial building was demolished so that the source area for the contaminants could be accessed for treatment using the ERD approach. A grid based injection point array was used for 3DME treatment in this area. As with the plume-wide treatment, contaminants were drastically reduced.

PlumeStop was used as a final polishing treatment to address residual low levels of CVOCs not treated with 3DME. A series of biobarriers was placed strategically within the residential plume area to protect against any future migration of residual CVOCs from untreated or not-fully treated areas. The biobarriers employed PlumeStop along with a polylactate-based electron donor (Hydrogen Release Compound [HRC]) and Bio-dechlor INOCULUMN Plus (BDI-Plus), a microbial consortium containing *Dehalococcoides sp* (DHC) to promote sorption-enhanced ERD.

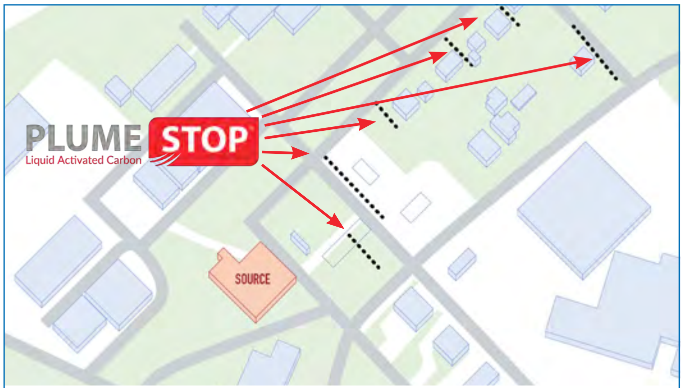




Site Plan Depicting The 3DME Full Scale Injection Layout. Neighborhood Treatment Lines Are Spaced Approximately 200Feet. Apart With Closer Spacing Near The Source.



Cross section shown depicting the shallow saturated coarse-grained outwash deposits... CVOCs moved through the outwash soils, but also diffused into the lower permeable soils underneath.



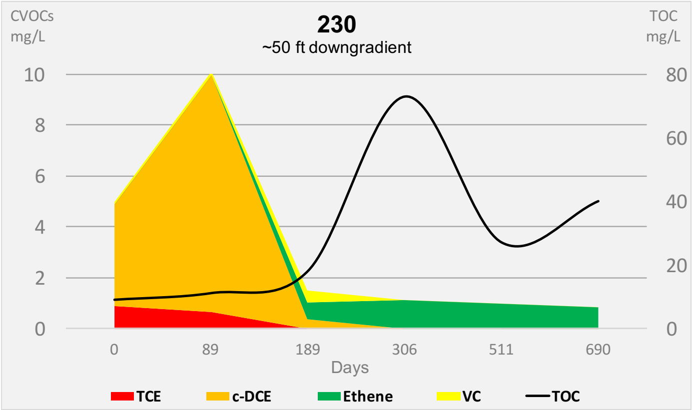
PlumeStop Biobarriers

Results

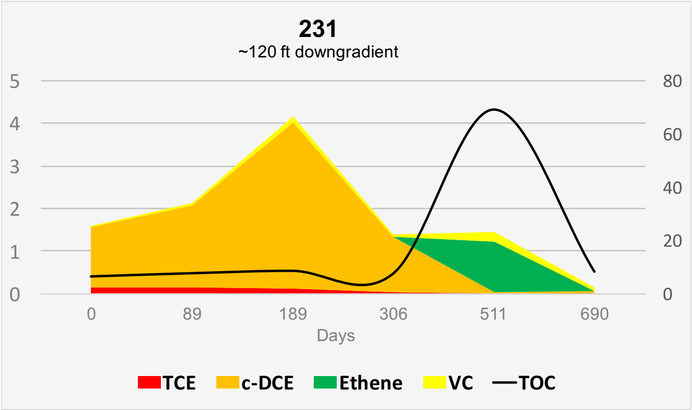
The ERD treatment used the natural groundwater gradient along with the mobile properties of 3DME to sweep the treatment from line to line throughout the residential neighborhood. The following figures and charts demonstrate how this was accomplished with a focus on two wells downgradient of a treatment line.

The mobile portion of the 3DME was observed between 3 and 6 months as indicated by the gradual rise in total organic carbon (TOC). Once the TOC was observed, total CVOC concentrations were reduced three orders of magnitude within 10 to 12 months. Additionally TOC longevity was greater than 600 days while ethene persisted above 0.5 milligrams per liter (mg/L) for 500 days.

The remediation team observed a rise in TOC at Well #231 after 300 days post-injection. When this occurred, CVOCs were reduced to ethene almost immediately. The team noted the time of the TOC rise and compared it to the time and distance of the injection line to determine that the mobile fraction of the electron donor migrated at approximately 1/3 the speed of the groundwater. This distributive behavior is consistent with observations at other project sites for 3DME in moderate to highly conductive aquifer systems (i.e., >0.5 feet/day).



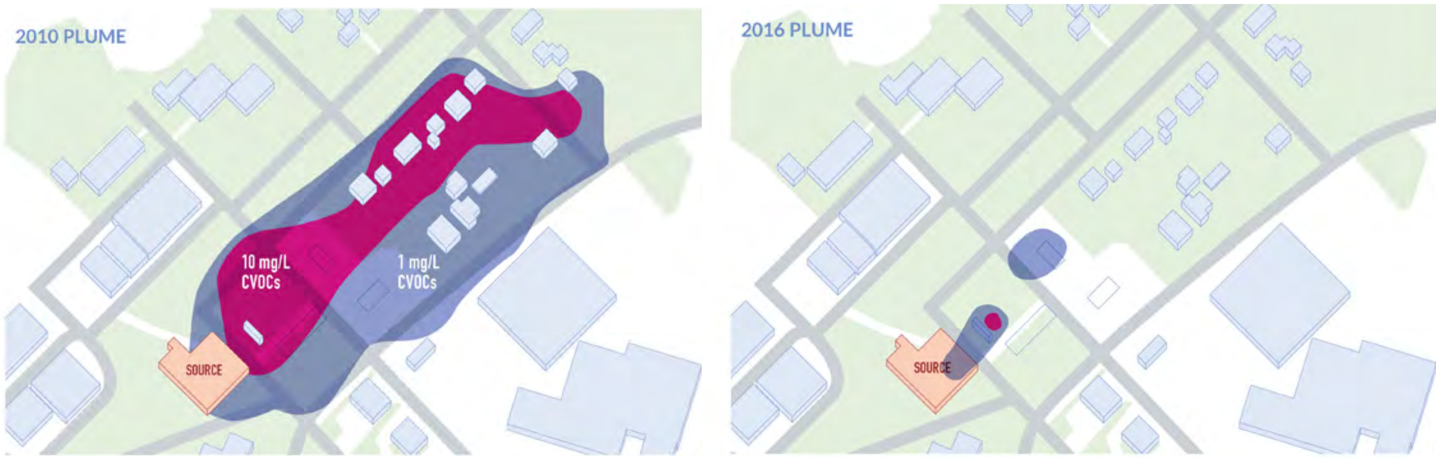
CVOCs and TOC in days following injection at Well #230



CVOCs and TOC in days following injection at Well #231

Well #230 - Approximately 50 feet away from the nearest upgradient treatment line

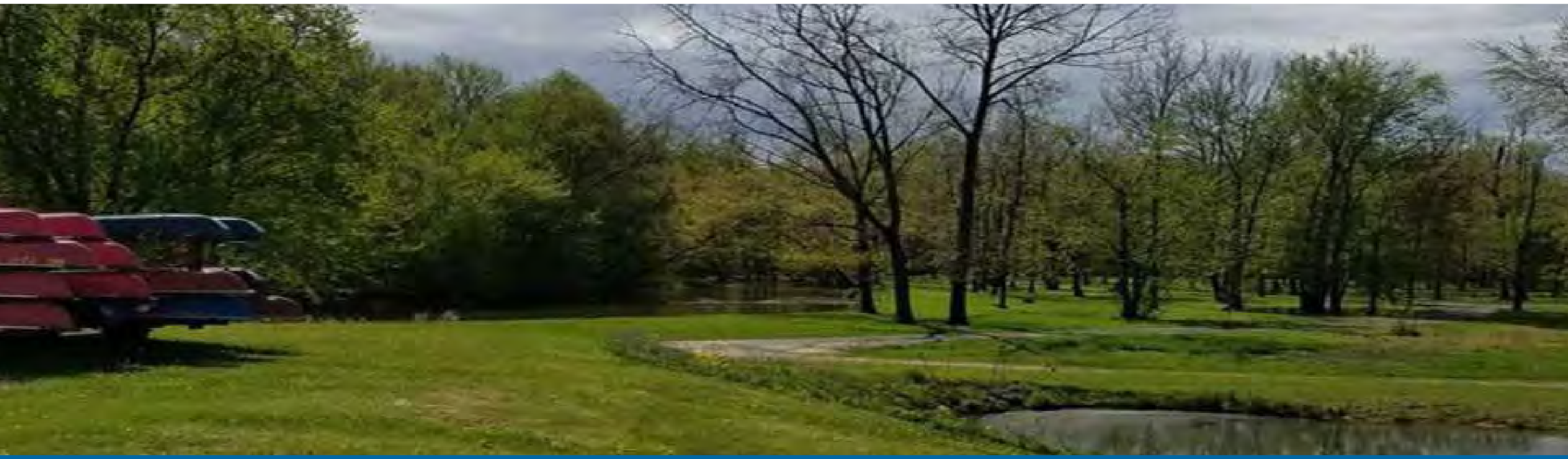
Well #231 - Approximately 120 feet away from the nearest upgradient treatment line



Pictured are two figures comparing the CVOC plume before treatment to the CVOC plume following the groundwater remediation treatment. These treatments reduced the total CVOC areal plume extent by 95% and cumulative mass by 99.8%, thus far, while ongoing biodegradation continues.

Summary Highlights

- An investigation led by MDEQ and DLZ identified contamination under a residential neighborhood and within basement sumps.
- Through the use of passive venting, crack sealing, and reconditioning of the basements with Retro-Coat, the risk of further vapor intrusion was nullified.
- With REGENESIS design support, MDEQ and DLZ implemented a multi-stage groundwater remedy to address the groundwater CVOC plume. The design allowed for the mobility and persistence of 3DME to be harnessed by utilizing the natural groundwater gradient in a fast moving aquifer system.
- The strategic design allowed sweeping of the reagent using a limited number of injection points to minimize disturbance to the residents in the neighborhood.
- The mobile properties of 3DME do not require it to be pushed by pumping for final displacement which allowed the effective pore volume displacement to be only 1.7%, greatly reducing application costs.
- Biobarriers using PlumeStop's technology were strategically placed within the residential plume area to protect against further migration of residual CVOCs over the long-term from untreated or not-fully treated areas.
- The remediation design and the use of 3DME minimized the installation costs and onsite time while maintaining sufficient treatment coverage to achieve the desired result.



Technologies Used

PLUME STOP
Liquid Activated Carbon

A Liquid Activated Carbon™ material that's designed to address the challenges of excessive time and end-point uncertainty in the in *situ* remediation of groundwater contaminants.

HYDROGEN RELEASE COMPOUND

An injectable liquid electron donor material with wide-area surface distribution properties and staged hydrogen release profile specifically designed for *in*

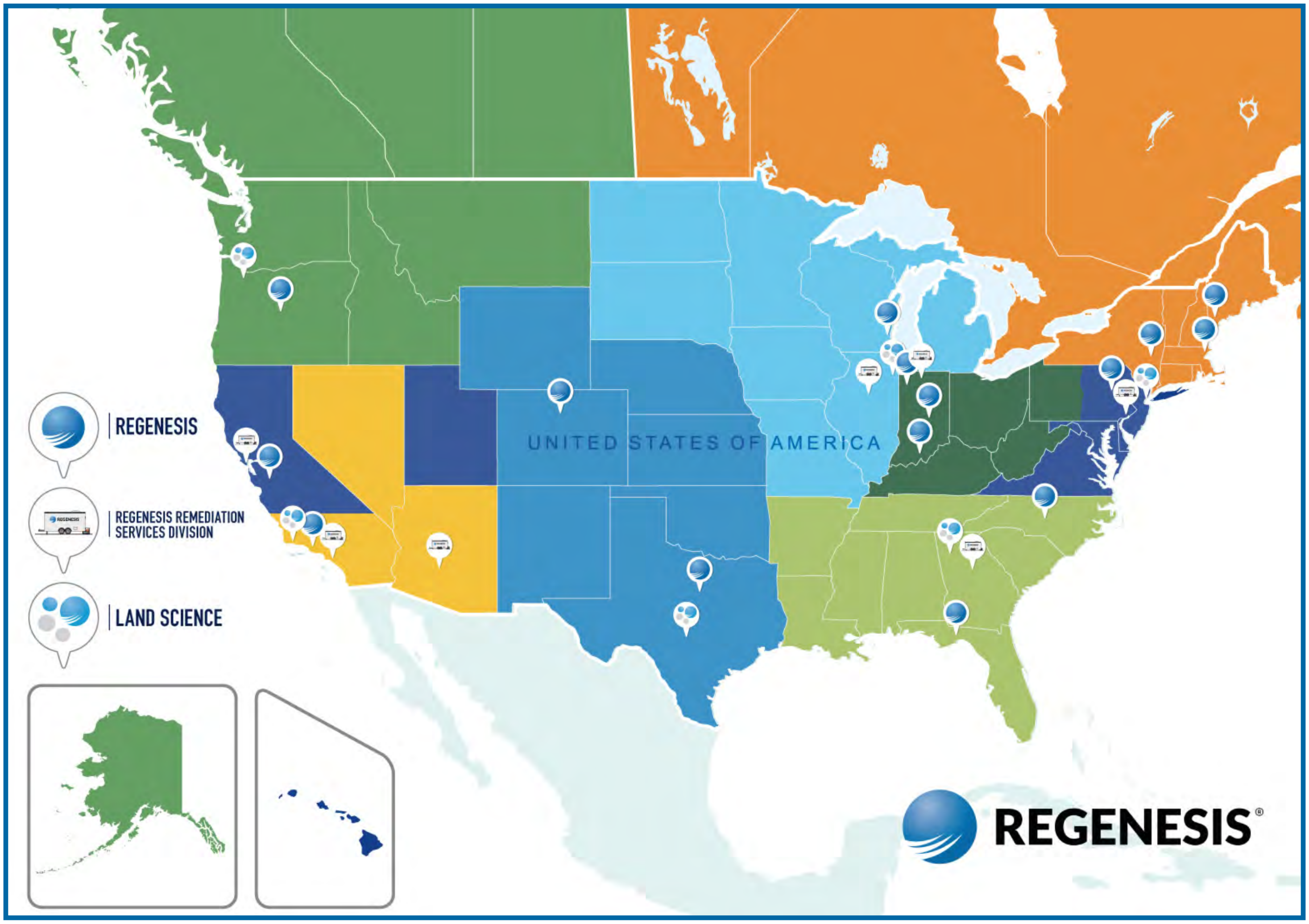
3-D MICROEMULSION

An injectable liquid electron donor material with wide-area surface distribution properties and staged hydrogen release profile specifically designed for *in situ* remediation projects where the anaerobic biodegradation of chlorinated compounds by enhanced reductive.

Retro-Coat™
Vapor Intrusion Coating

A vapor intrusion protection coating that consists of chemically resistant materials which properly eliminates the threat of contaminants.

REGENESIS Is Ready To Assist You In Determining The Right Solution For Your Site



Contact Us:

Global Headquarters
1011 Calle Sombra
San Clemente, CA 92673 USA
Ph: (949) 366-8000
Fax: (949) 366-8090

European Offices
Bath, United Kingdom
Ph: +44 (0) 1225 61 81 61
Dublin, Ireland
Ph: +353 (0) 1 9059 663
Torino, Italia
Ph: +39 (0) 11 19781549
Ieper, België
Ph: +32 (0) 57 35 97 28

www.regenesis.com

1011 Calle Sombra Suite 110, San Clemente, CA 92673 | T: 949.366.8000

Kenosha Engine Plant - Injection Volume Evaluation

total porosity	40%
effective porosity	20%

	Full Treatment Area (sq. ft)	vertical interval (ft)	total porosity		Pore volume displaced by injectate
TA1	745,000	12	26,750,340	gallons	0.48%
TA2	40,000	11.5	1,376,416	gallons	2.38%
TA3	18,000	14	754,036	gallons	2.27%
TA4	54,000	9	1,454,213	gallons	2.99%

effective porosity		Total Reagent Injection Volume	
13,375,170	gallons	129,500	gallons
688,208	gallons	32,816	gallons
377,018	gallons	17,093	gallons
727,107	gallons	43,453	gallons

0