Groundwater Remediation 2013 Action Plan

Chester River Hospital Center

DMW Project No. 13402.00

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CHESTER RIVER HEALTH
UNIVERSITY OF MARYLAND MEDICAL SYSTEM

Prepared for:

Chester River Hospital Center
100 Brown Street
Chestertown, Maryland 21620

DMW
DAFT McCUNE WALKER INC

Prepared by:

Daft McCune Walker, Inc.
11200 Racetrack Road, Suite 101
Berlin, Maryland 21811

CHESTER RIVER HOSPITAL CENTER
GROUNDWATER REMEDIATION
2013 ACTION PLAN

BACKGROUND:

Since the discovery of a fuel oil release from a supply line in May, 1991, a groundwater remediation and containment system has been in operation to recover liquid phase fuel oil. After twenty (20) years of managing the remediation system which consisted of seven (7) recovery wells and a filtration system with ultimate discharge to a storm sewer, 83,452 gallons of fuel oil had been recovered. In 2012 Chester River Hospital Center (CRHC) submitted the required regulatory documents requesting a close out of the case based on the success of the recovery operations and results of intensive groundwater monitoring.

In May, 2012 the Maryland Department of the Environment (MDE) agreed with the initiation of the closeout process and to a comprehensive post remediation monitoring action plan. This plan was initiated in July, 2012 and through April, 2013 all monitoring results indicated that the site remediation was successful. Pending results from May and June groundwater monitoring CRHC was prepared to perform a detailed assessment using the seven (7) risk factors and to provide other necessary documentation that would allow MDE to close out the case.

In June, 2013 very low levels of Total Petroleum Hydrocarbons – Diesel Range Organics (TPH-DRO) was found in eight (8) of seventeen (17) down gradient monitoring wells. CRHC immediately instructed Earth Data to start up the pump and treat system in order to minimize movement of these dissolved organics. Repeat samples were performed in June and results were substantially below normal quantitative analytical levels. TPH-DRO was found in trace concentrations only. Please refer to ***Appendix I*** – Post Corrective Action Quarterly Monitoring Report for June, 2013 as prepared by Earth Data for more details and discussion of the 2012/2013 remediation efforts.

GROUNDWATER REMEDIATION ASSESSMENT AND ENHANCED REMEDIATION PLAN:

Earth Data has been overseeing the remediation efforts onsite over the referenced twenty (20) year period. As mentioned in the Background above, Earth Data did a remarkable job in recovering 83,452 gallons of free product. However, the sample results and presence of trace amounts of TPH-DRO is an indication that dissolved and/or sorbed hydrophobic organic chemicals are still present in the groundwater. Upon learning that trace levels of TPH-DRO were persisting even at low detection levels, CRHC was able to determine that this situation is not uncommon amongst fuel oil groundwater remediation cases. In fact, we have learned that it is a very common place occurrence and is associated with the high molecular weight of TPH contaminants which exhibit limited solubility in water as the contaminants tend to partition and sorb (ie – adsorb and absorb) onto the soil and/or fractured bedrock matrix surfaces.

Sorption effects limit the 'Availability' of contaminants for physical, chemical, and biological remediation and can account for ninety percent (90%) or more of the total contaminant mass at a site. As such, sorbed contaminants are less 'Physically Availability' for pump and treatment methods; less 'Biologically Available' for bioremediation, and less 'Chemically Available' for chemical REDOX type chemical treatment. Hence Hydrophobic Organic Chemicals (HOC's) (free phase, dissolved, and/or sorbed) can persist in soils, sediments, and fractured bedrock for extended periods of time. This explains why some remediation projects are slow, costly and/or fail to achieve their remediation objectives.

Generally, if we can overcome contaminant sorption, we can improve all forms of in-situ and ex-situ physical (P&T), chemical (REDOX) and biological (Bioremediation) remediation of air, soil, and groundwater remediation.

Having learned about the "smear zone" and how contaminants can be bound up in soils which continue to reintroduce themselves into the water column, CRHC contacted Ivey International, Inc. This firm specializes in groundwater remediation during the final phases of case closure. They use a patented process and surfactants to remove hydrophobic organic chemicals like TPH-DRO which have been sorbed onto soil particles. With the knowledge, case histories, and successful outcomes associated with Ivey Internationals patented process, CRHC has engaged Ivey to be part of the existing Consulting Team on the Chester River Hospital Center Remediation Project. We have accepted Ivey International's proposal to apply their process and patented surfactants to remove these dissolved materials and to facilitate project cleanup and case closure. ***Appendix II*** includes a copy of Ivey International proposal to Chester River Hospital Center for MDE's review and use in approving CRHC's proposed action plan.

Implementation and Quality Control:

Since CRHC is entering the last phase of its groundwater remediation plan leading to ultimate case closure, we deemed it prudent and advisable to provide a level of independent technical oversight and assessment by hiring one of the most reputable geotechnical/hydrogeologic firms in the area; EBA Engineering, Inc. EBA is a certified MBE of considerable reputation for its high quality technical level of competency and ability to make an important difference on many high profile projects. Chester River Hospital Center has engaged EBA to provide local experience, knowledge of the State Closeout Process, and to provide important and necessary consultation to Ivey International, Inc. during the implementation of their Patented "Push-Pull" application.

EBA will work in concert with Mr. Dane Bauer from DMW in assisting the continued efficient and effective implementation of these final cleanup actions and providing MDE with the necessary documentation relative to groundwater monitoring assessments, application of the seven (7) risk factors, and any other documentation required by MDE as part of the cleanup and closure process. The existing laboratory, Phase Separation Science, Inc. (PSS), which has been onsite for many years along with Earth Data will continue to provide laboratory testing services. EBA will coordinate the tasks to be provided by Ivey International, Earth Data, and PSS.

A copy of EBA's on-call services contract has also been provided as ***Appendix III*** for MDE's further information and use.

Amended Post Corrective Action Monitoring Plan:

1. Following the second shut down of the pump and treat operation, and continuing for approximately six (6) weeks during the months of July and August, perform monthly gauging amd sampling at the eleven (11) down gradient monitoring wells (MW15, MW16, MW19, MW20, MW24, MW33, MW34, MW35, MW48, MW49, and MW50) for TPH-DRO only using EPA Method 8015. We will submit monthly progress reports that include gauging summary tables and the results of the targeted supplemental wells samples. CRHC will notify MDE five (5) working days prior to the system being shut down.

2. If measurable amounts of liquid phase hydrocarbons (LPH) are detected, corrective action must be completed on an individual well basis to the maximum extent practicable. The Department approves LPH recovery as described in the *Draft Post CAP Monitoring Plan*; however, the Department reserved the right to require additional recovery efforts based on the amount of LPH

detected. The specific requirements to be implemented is LPH is detected at a thickness greater than 0.01 foot (ie – "sheen" or "film"), the Department requires the following:

a. Notify the Department within two (2) hours;
b. Immediately complete corrective action in the form of LPH recovery via absorbent wicks or other appropriate method(s);
c. Complete LPH recovery to the maximum extent practicable during the gauging event; and
d. Re-gauge the well following recovery.

3. Prior to implementation of the Ivey-sol "Push-Pull" application, it is estimated two (2) to three (3) new recovery wells (RWs) will be installed within the limits of the existing plume. After installation of the RWs, samples will be collected and analyzed for TPH-DRO.

4. During the Ivey International application of Ivey-sol and the "Push-Pull" application it is anticipated that three (3) to five (5) applications will be required. The initial three (3) events will occur within one (1) week. It is anticipated that following the third event, groundwater samples will be collected from the new RWs and submitted for laboratory analysis for the presence of TPH-DRO using EPA Method 8015. Based upon the results of these samples, consultants of CRHC will recommend if additional Ivey-sol "Push-Pull" applications are warranted.

   If warranted, they would commence the following week. Groundwater samples from the RWs would again be collected and analyzed following the completion of the additional Ivey-sol "Push-Pull" applications. Monitoring of the groundwater will consist of the laboratory analysis and monitoring protocols both to measure the efficiency and effectiveness of the Ivey-sol application and to continue the groundwater reporting as part of the MDE reporting requirements for the groundwater remediation effort.

   For monitoring the effectiveness and efficiency of the "Push-Pull" operation and to evaluate overall performance of same, it is also recommended that a surface tension and agitation field test be conducted as necessary by the operator. These are visual field tests which will aid the operators in determining the number of applications and duration of the "Push-Pull" application to achieve desired outcomes. A detailed description of the Surface Tension & Agitation Field Tests as approved by EPA as an acceptable testing method for Ivey-sol are included in ***Appendix IV***.

5. Following the completion of the Ivey-sol "Push-Pull" applications, the consultants of CRHC will wait approximately one (1) week to allow the site to return to its natural state. Subsequently, the consultants will begin the monthly gauging and sampling through December 30, 2013 of eleven (11) down gradient wells (MW15, MW16, MW19, MW20, MW24, MW33, MW34, MW35, MW48, MW49, and MW50). We will continue to submit monthly progress reports that include gauging summary tables and the results of the targeted supplemental wells samples.

6. Quarterly sampling of the eleven (11) down gradient wells and recovery wells will be performed in September and December 2013 for the presence of TPH-DRO/GRO using EPA Method 8015B. Quarterly reports will be prepared by EBA Engineering and submitted to MDE on or about October 7, 2013 and January 6, 2014. It is envisioned that as part of the January 7, 2014 quarterly submittal that a six (6) month assessment of the Ivey-sol application and remediation efforts will also be included. Assuming the results to be successful, the necessary closeout documentation and final assessment using the seven (7) risk factors will also be provided.

7. If for any reason modifications of the above plan of action and monitoring program should need to be amended or revised in any way, CRHC will request approval of same by MDE through written request.

CASE CLOSURE:

The CRHC Team will meet with MDE in mid-November to review progress on the project and to discuss case closure. Based on Ivey International's process and successful application in other similar cases, we are expecting the TPH residual problem to have been satisfactorily addressed after three (3) or four (4) applications. The Team will present the results through October including all monitoring and laboratory analysis, engaging data with MDE at that time and discuss the advisability of proceeding with the final case assessment using the seven (7) risk factors and the data to be gathered through December 30, 2013.

Based on the results of these additional remediation efforts and assessments, CRHC will look forward to receiving final direction from MDE at that time regarding case closure and any additional documentation that may be required.

APPENDIX I

POST CORRECTIVE ACTION
QUARTERLY MONITORING REPORT
CHESTER RIVER HOSPITAL CENTER
100 BROWN STREET
CHESTERTOWN, MARYLAND 21620

JUNE 2013

Prepared For:

CHESTER RIVER HOSPITAL CENTER
100 Brown Street
Chestertown, Maryland 21620

To Be Submitted To:

MDE – OIL CONTROL PROGRAM
1800 Washington Boulevard
Baltimore, MD 21230

Prepared By:

Earth Data Incorporated
131 Comet Drive
Centreville, MD 21617

W.O. 2781

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1.0 EXECUTIVE SUMMARY

On behalf of the Chester River Hospital Center (CRHC), Earth Data Incorporated (Earth Data) collected gauging and groundwater quality data at the hospital property during the second quarter of 2013 as required by the Maryland Department of the Environment – Oil Control Program (MDE-OCP) (Figure 1). The data presented herein represents the fourth round of quarterly monitoring after the trial shutdown of the remediation/containment system at the CRHC.

On April 8, May 6 and June 3, 2013, Earth Data gauged all of the monitoring and recovery wells at the CRHC in Chestertown, Maryland. Gauging results showed a regional groundwater flow direction to the southeast towards the Chester River. As a result of the termination of the pumping from the remediation system's seven recovery wells in July 2012, the water-table contour at the site has returned to its natural flow pattern. On separate occasions during this quarter, product thicknesses ranging up to 0.18 feet were measured in two wells, MW-47 and RW-3b. No measurable thicknesses (>0.01 ft.) of liquid product were detected in any of the other wells gauged during this monitoring period. Petroleum sheens or films were detected on the water table or in the sample collected from nine other monitoring wells and the other six recovery wells at least once during this monitoring period. This included a sheen detected in the sample collected in June 2013 from MW-20 located on the south side of Brown Street immediately downgradient of the area impacted by liquid product.

On April 8 and May 6, 2013, samples were collected from monitoring wells located immediately downgradient of the remediation system for VOCs and TPH-DRO/GRO analysis as required by MDE-OCP. Results of the April 2013 sampling of the downgradient monitoring wells showed dissolved TPH in samples collected from two monitoring wells MW-19 and MW-20. Dissolved TPH was detected in samples collected from four downgradient monitoring wells, MW-19, MW-20, MW-33 and MW-34, during May 2013. During the June 2013 round of sampling, dissolved TPH was found in samples collected from eight downgradient monitoring wells, MW-15, MW-16, MW-19, MW-20, MW-34, MW-35, MW-49 and MW-50. These results show a significant movement of dissolved petroleum hydrocarbons downgradient of the source area during the quarter.

As required by MDE-OCP, all monitoring and recovery wells not showing a measurable thickness of liquid hydrocarbons were sampled for VOCs and TPH-DRO/GRO analysis on June 3 and 4, 2013 (Figure 2). Monitoring well MW-47 and recovery well RW-3B were not sampled due to the presence of measurable thicknesses of free product on the water-table in each well. Analytical results showed detectable concentrations of TPH-DRO in 27 of the 46 wells sampled, including the 8 downgradient wells discussed previously. Analytical results also showed that detectable concentrations of VOCs were present in 22 of the 46 wells sampled in June 2013.

To confirm the presence of dissolved TPH-DRO in the downgradient monitoring wells, all wells south of Brown Street will be resampled for TPH-DRO analysis. In the meantime, the remediation system has been reactivated in an attempt to recapture the downgradient dissolved hydrocarbon plume. Normal system operation and maintenance will resume. Earth Data recommends reducing the sampling and analysis at the CRHC to include only those previously detected compounds that are necessary to define the size and shape of the dissolved hydrocarbon plume.

2.0 INTRODUCTION

2.1 Background

In May 1991, shortly after the discovery of the release of fuel oil from a supply line in the hospital's heating system, a groundwater remediation and containment system was installed. The system was designed not only to recover liquid phase fuel oil from the subsurface, but also to contain the product plume on-site. Plume containment was deemed essential to protect Chestertown's well field, located approximately 1,200 feet down-gradient from the CRHC.

In 2001, an upgraded remediation system was installed. The product recovery and containment (pump-and-treat) portion of the system consisted of seven recovery wells (RW-1b, RW-2d, RW-3b, MW-4, MW-5, MW-6 and MW-22) that are equipped with submersible water-table suppression pumps. A filtration system, which includes a series of pre-filters and Mycelx® filters, treats the groundwater pumped from the containment-and-recovery wells before it is discharged to the on-site storm sewer. This system was typically operated to withdraw between 100 and 120 gallons per minute of groundwater to maintain a sufficient depression in the water-table in order to contain the dissolved and liquid product plume. Due to the decreasing quantity of liquid phase hydrocarbons recovered over the past two years, a trial shut down of the remediation system was initiated in July 2012. The remediation effort through July 2012 had resulted in the recovery of 83,452 gallons of fuel oil from the subsurface.

2.2 Site Description

Located at 100 Brown Street in Chestertown, Maryland, the Chester River Hospital Center (CRHC) occupies approximately 7.1 acres east of Washington Street (Rt. 213). The property was originally developed as a local general hospital around 1935. Prior to 1935, the property appears to have been farmland.

The CRHC property is bordered on the north, east and south by residential properties. To the west are lands of Washington College. The hospital and surrounding residential area including Washington College are served by public water and sewer provided by the Town of Chestertown.

2.3 Local Geology and Hydrogeology

Surface water from the CRHC property eventually drains into the Chester River through the local storm water collection system. The Chester River is a tidal tributary of the Chesapeake Bay and enters the bay approximately 15 miles southwest of Chestertown.

Chestertown is located in south central Kent County on the Eastern Shore of Maryland. The Eastern Shore of Maryland is part of the Delmarva Peninsula, which is in of the Atlantic Coastal Plain physiographic province. The coastal plain is underlain by thick layers of unconsolidated sediments (sands, silts and clays), which dip and thicken towards the southeast.

The Pennsauken Formation, of Pleistocene or Pliocene age, comprises the surface sediments over much of the northern portion of the Delmarva Peninsula. In Kent County, this formation consists of yellowish brown sands, silty sands and clayey sands to a depth of approximately 30 feet below ground surface. The total thickness of the Pennsauken

Formation ranges from 0 to 50 feet in Kent County. It appears to be very thin or absent under the CRHC property.

The Paleocene age Aquia Formation, which underlies the Pennsauken Formation in the Chestertown area, typically consists of sands to a depth of approximately 120 feet below ground surface (Drummond, 1998). The Aquia Formation is underlain by silts and clays of the Monmouth Formation (Cretaceous aged) to a depth of approximately 220 feet below ground surface. Cretaceous age silts, sands and clays of the Matawan Formation underlie the Monmouth Formation to a depth of approximately 320 feet. Beneath the Matawan Formation lie sands and clays of the Magothy Formation to a depth of approximately 430 feet. The Monmouth, Matawan and Magothy Formations comprise sediments of the Chesapeake Group. The Cretaceous-aged Potomac Formation underlies the Chesapeake Group. The Potomac Formation consists of several sand layers separated by relatively thick confining clay units. In the Chestertown area, the Potomac Formation extends from a depth of approximately 430 feet to 1,500 feet below ground surface. At 1,500 feet, crystalline bedrock would be encountered.

2.4 Aquifers and Water-Supply Wells

The CRHC property is directly underlain by the outcrop of the Aquia Formation. It extends from ground surface to a depth of approximately 120 feet and is characterized by layers of sand and silty sand. Some of the sand units are semi-cemented with iron oxide. Under non-pumping conditions, the water-table elevation typically fluctuates seasonally between 3 to 5 feet, depending on location. Natural groundwater flow is to the southwest towards the Town of Chestertown well field and the Chester River. The aquifer under the property is unconfined though individual sand layers may exhibit semiconfined characteristics.

While in operation, the containment/recovery system at the CRHC depressed the water-table around the recovery wells, causing a localized "cone of depression". This cone of influence prevented liquid phase and dissolved phase hydrocarbons from moving off-site and also enabled the capture and recovery of liquid phase product.

The primary well field for the Town of Chestertown is located at the intersection of Kent Street and Byford Drive, approximately 1,750 feet southwest of the CRHC property. Many of the municipal water supply wells are screened in the same unconfined Aquia aquifer which underlies the CRHC property. The Town also operates two wells in the same well field that are screened in the deeper, confined Magothy aquifer.

Prior to the discovery of the fuel oil release at CRHC in 1991, the Town of Chestertown operated their Well No. 8, which is located at the intersection of Campus Avenue and Philosopher's Terrace approximately 850 feet down-gradient of the location of the release. Well No. 8 was taken out of service in 1991 shortly after the fuel oil release at the CRHC was reported. At that time, it was concluded that the continued operation of the town well would exacerbate recovery operations at the CRHC and might pull dissolved hydrocarbons into the well which would then require treatment or the well's abandonment. Because Well No. 8 had a high yield and excellent water quality, it was not abandoned. The Town of Chestertown plans to put Well No. 8 back into service when the remediation effort at the CRHC is completed.

2.5 Monitoring Well Installation

To fill a physical gap in the groundwater monitoring network beneath the parking area south of Brown Street, Earth Data installed three new monitoring wells (MW-48, MW-49 and MW-50) using a Mobile B-61 H-S-A drill rig in March 2013 (see Figure 3). The borehole for each well was augered to a depth of 55 feet below ground surface (bgs). Each well was constructed with 30 feet of .020 inch slot size, 2-inch diameter, PVC machine-slotted well screen and 25 feet of 2-inch diameter., schedule 40 well casing. The annular space between the well screen and borehole was filled with No. 2 well gravel to a depth of three feet above the top of the well screen. The remaining annular space was grouted with 3/8" granular bentonite (Holeplug®). Drillers finished each well with an 8-inch diameter flush-mounted protective casing set in concrete. Upon completion, each well was developed using a pump and surge technique until clear water was produced. Development water was filtered through granular activated carbon before being discharged on-site. Screening of cores and drill cuttings from each borehole with an OVM-PID showed no detectable concentrations of organic vapors. Consequently, the drill cuttings were left on-site to be used as fill material. The three new monitoring wells were gauged and sampled during each month of this quarterly monitoring period (April to June 2013). Additionally, the location and top of casing elevations for the three new wells were surveyed relative to the existing monitoring well network in May 2013.

2.6 Scope of Work

On April 8, May 7 and June 3, 2013, each well in the monitoring and recovery well network at the CRHC was gauged with an oil/water interface probe to determine the depth of the water-table and the presence, if any, of liquid hydrocarbons on the surface of the water-table aquifer. Based on the gauging data for each date, water-table contour maps were prepared showing the groundwater flow direction (Figures 4, 5 and 6).

On April 8 and May 6, 2013, eleven monitoring wells designated by MDE-OCP and located immediately downgradient of the shutdown remediation/containment system, were sampled for laboratory analysis. These wells are located in and around the lower parking lot south of Brown Street and include the three new monitoring wells MW-48, MW-49 and MW-50. During the April 2013 site visit, samples could not be collected from monitoring well MW-15 because a vehicle was blocking access. For the purpose of comparing analyses with the previous month's monitoring results, samples were also collected from monitoring well MW-17 during the April 2013 site visit.

On June 3 and 4, 2013, Earth Data personnel collected groundwater samples from 40 on-site monitoring wells and six recovery wells for laboratory analysis. Monitoring well MW-47, located in the southeast corner of upper parking area, and recovery well RW-3B, located along Brown Street in the same parking lot, were not sampled during the June 2013 round of monitoring due to the presence of measurable thicknesses of liquid hydrocarbons in these wells.

During each site visit, prior to sampling, each well was purged of at least three standing volumes of water to ensure that the sample collected was representative of the water in the surrounding formation. The purge water was filtered through granular activated carbon before being discharged on-site. Using dedicated disposable bailers for each well, the groundwater samples were collected in pre-labeled sample containers and placed on ice in laboratory-supplied coolers. The samples were then sent via courier to an EPA-approved laboratory for analysis. Each groundwater sample was analyzed for volatile organic compounds (VOCs) plus oxygenates using EPA Method 8260 and total petroleum hydrocarbons – diesel range organics (TPH-DRO) and gasoline range organics (TPH-GRO) using EPA Method 8015.

3.0 SITE MONITORING RESULTS

3.1 Water-Table Measurements and Water-Table Contours

To document the return of natural water-table contours in the vicinity of the hospital after the trial shutdown of the remediation system, the monitoring well network was gauged on April 8, May 6 and June 3, 2013. Gauging data collected on all three dates show a groundwater flow direction towards the southeast and the Chester River. Using the June 2013 gauging data, the gradient of the water-table across the site was determined to be 0.0055 ft/ft. Similar gradients were found during the April and May site visits.

Well gauging results from May and June 2013 showed measurable thicknesses of liquid phase hydrocarbons (LPH) in MW-47 at 0.18 ft, and 0.08 ft., respectively. During the June gauging, no measurable thickness of LPH was found initially in recovery well RW-3b, however, after purging this well in preparation for sampling, 0.11 ft. of LPH was detected on the water-table. During each gauging event, absorbent wicks were placed in those wells showing measurable LPH to recover liquid product. No measurable thicknesses (>0.01 ft.) of liquid product were detected in any of the other wells gauged during this monitoring period. Petroleum sheens or films, however, were detected on the water table or in the samples collected from nine other monitoring wells and the other six recovery wells at least once during the monitoring period.

The Earth Data well gauging reports and corresponding field reports may be found in Appendix A. Hydrographs for the entire history of the remediation effort showing relative water-table elevations and product thicknesses for each well are presented in Appendix B. Historical gauging data used to prepare the hydrographs may be found in Appendix C.

3.3 Groundwater Sampling and Analysis

On April 8 and May 6, 2013, Earth Data representatives collected groundwater samples from eleven downgradient monitoring wells for laboratory analysis. Figures 7 and 8 show the benzene, BTEX, MTBE and TPH-DRO/GRO concentrations for each well sampled in April and May 2013, respectively. The figures also identify those monitoring wells where measurable thicknesses of free product were found.

On June 3 and 4, 2013, Earth Data representatives collected groundwater samples from all wells within the network, with the exception of MW-47 and RW-3D, which contained liquid product and IW-1, which was not accessible. Figure 9 shows the benzene, BTEX, MTBE and TPH-DRO/GRO concentrations for each well sampled in June 2013.

Laboratory analytical results of the samples collected from the eleven downgradient monitoring wells in April 2013 show detectable concentrations of dissolved TPH-DRO in only two wells (MW-19 and MW-20). These two wells are located along Brown Street, immediately downgradient of the source area. In May 2013, detectable concentrations of TPH-DRO were again found in MW-19 and MW-20, but were also found in MW-33 and MW-34. These two wells are located in the center of the lower parking area approximately 60 feet downgradient of Brown Street. Results of the June 2013 round of sampling showed dissolved TPH-DRO in eight downgradient monitoring wells. These wells included two of the three recently installed wells, MW-49 and MW-50. Monitoring well MW-49 is located along the southern boundary of the lower parking area approximately 100 feet downgradient of MW-34 or 160 feet downgradient of MW-20.

The concentration of TPH-DRO found in MW-20 during the April, May and June 2013 sampling was 1.0 mg/l, 1.8 mg/l and 1.6 mg/l, respectively. The concentration of TPH-DRO found in MW-19 in April, May and June 2013 was 1.3 mg/l, 0.13 mg/l and 0.36 mg/l, respectively. During May 2013, TPH-DRO was also detected in the samples collected from MW-33 and MW-34 at concentrations of 0.11 mg/l and 0.14 mg/l, respectively. TPH-DRO was not detected in any other downgradient monitoring wells during the April and May 2013 rounds of sampling. During the June 2013 sampling event, in addition to MW-19 and MW-20, TPH-DRO was detected in samples collected from MW-15, MW-16, MW-34, MW-35, MW-49 and MW-50 at concentrations of 1.5 mg/l, 0.13 mg/l, 0.25 mg/l, 0.16 mg/l, 0.32 mg/l and 0.35 mg/l, respectively. No other downgradient monitoring wells showed detectable concentrations of TPH-DRO during the June 2013 round of sampling. No detectable concentrations of TPH-GRO were found in any of the downgradient monitoring wells sampled during April, May or June 2013. Very low concentrations of isopropylbenzene were found in the samples collected from MW-34 during April (1.1 ug/l), May (1.2 ug/l) and June (1.5 ug/l) 2013. The sample collected from MW-19 in June 2013 also showed a very low concentration of isopropylbenzene (1.2 ug/l). No other VOCs tested were detected in the samples collected from the downgradient monitoring wells in April, May or June 2013.

Diesel-range organics (TPH-DRO) were detected in 27 of 46 wells sampled in June 2013. These included the eight downgradient monitoring wells discussed above. Detected concentrations of TPH-DRO ranged from 0.10 to 410 mg/L, depending on the well location. Two monitoring wells, MW-40 and MW-41 showed detectable concentration of TPH-GRO at 190 ug/l and 350 ug/l, respectively. Both of these wells are located within the source area (upper parking area).

Of the 58 VOCs tested, eight were found at detectable concentrations in some of the groundwater samples collected during June 2013. Eight monitoring wells had detectable concentrations of naphthalene. Naphthalene concentrations ranged from 1.1 ug/L to 14 ug/L. Low concentrations of the dissolved petroleum hydrocarbons associated with fuels (ethylbenzene, xylenes and isopropylbenzene) were found in samples collected from five wells (MW-19, MW-34, MW-40, MW-41 and MW-46). Detectable concentrations of dissolved acetone were found in thirteen water samples, with concentrations ranging from10 ug/L to 130 ug/L. The sample collected from MW-31R showed concentrations of 2-Butanone (also known as MEK) at 25 ug/l. Tetrachloroethene (PCE) was detected in only one sample (MW-2) at a concentration equal to the instrument detection limit (1.0 ug/l). Methyl-t-butyl ether (MTBE) was detected in four water samples (MW-17, MW-31R, MW-32 and RW-1B) at a concentrations ranging from 1.1 ug/l to 4.1 ug/l.

A summary of the laboratory analytical results for the June 2013 sampling event may be found in Table 1. A summary of water quality for selected downgradient monitoring wells with results of previous sampling events for comparison may be found in Table 2. Laboratory analytical reports for the groundwater samples collected at the site during this monitoring period may be found in Appendix D. For comparison purposes, analytical data for each monitoring well are presented in a time series format for this and all previous sampling events and may be found in Appendix E.

4.0 DISCUSSION

4.1 Water-Table Elevation and Contours

During the April through June 2013 monitoring period, two wells (RW-3B and MW-47) showed measurable thicknesses of liquid phase hydrocarbons on at least one occasion, ranging from 0.08 to 0.18 ft. Oil-absorbent wicks were used to retrieve the liquid product from the surface of the water-table in these wells. Since ending the suppression of the water-table at the site in July 2012, the groundwater flow pattern has returned to its natural state, e.g. southeast, towards the Chester River. Little variation in the water-table elevation was noted during the monitoring period.

4.2 Water Quality

Analytical results of groundwater samples collected during the April to June 2013 monitoring period indicate a downgradient movement of the dissolved hydrocarbon plume from the source area (upper parking area) across Brown Street to the lower parking area. The groundwater samples collected in April 2013 showed detectable concentrations of TPH-DRO in two downgradient monitoring wells. Samples collected in May showed detectable concentrations of TPH in four downgradient monitoring wells. The results of the June 2013 sampling event showed dissolved TPH concentrations in eight downgradient monitoring wells. Additionally, the TPH concentrations over the course of the monitoring period exhibit a horizontal progression away from the source area. The June 2013 data reveals the presence of dissolved petroleum hydrocarbons 160 feet southeast of Brown Street.

5.0 CONCLUSIONS AND RECOMMENDATIONS

In the April and May 2013 monthly sampling events, select monitoring wells located downgradient of the deactivated remediation/containment system at the CRHC were sampled for laboratory analysis as required in the September 5, 2012 MDE-OCP letter. In June 2013, all monitoring and recovery wells not containing measurable thicknesses of liquid hydrocarbons were sampled for laboratory analysis as required by MDE. Analytical results of the samples collected in April 2013 showed the presence of detectable concentrations of dissolved TPH-DRO in monitoring wells MW-19 and MW-20 located along Brown Street. Samples collected in May 2013 showed detectable concentrations of TPH-DRO in both MW-19 and MW-20 and in two wells located in the middle of the lower parking area (MW-33 and MW-34). The June 2013 sampling event revealed detectable TPH-DRO concentrations in eight downgradient monitoring wells included the recently installed wells MW-49 and MW-50. These new wells are located on the downgradient side of the lower parking area approximately 160 feet from Brown Street. The progression of dissolved TPH-DRO in the groundwater across the lower parking area during the monitoring period indicates that the dissolved hydrocarbon plume has begun to move away from the source area (upper parking area). In an attempt to contain the dissolved petroleum hydrocarbon plume, the remediation system was reactivated on June 14, 2013.

Since the shutdown of the remediation/containment system at the CRHC in July 2012, gauging data indicates that the water-table contour at the site has returned to its natural flow pattern towards the southeast. During the April to June 2013 monitoring period, gauging events showed a measurable amount (0.08 to 0.18 feet) of liquid phase hydrocarbons in two wells (MW-47 and RW-3B). No measurable thicknesses of liquid product were observed in any other wells during the quarterly monitoring period. A petroleum sheen or film, however, was observed on the surface of the water-table in nine other monitoring wells and the six other recovery wells at least once during the monitoring period. All of these wells are located in the source area north of Brown Street.

6.0 LIMITATIONS

The findings and conclusions presented in this report are the results of both fieldwork and data analysis by Earth Data Incorporated. Due to the limited scope of this study, Earth Data collected data from only a limited number of locations on the property and on limited occasions. Therefore, there may be environmental or subsurface conditions on the property not disclosed by our investigation. This report has been prepared using generally accepted environmental and hydrogeologic practices for the exclusive use of the Chester River Hospital Center and their representatives. No other warranty, expressed or implied, is made.

FIGURES

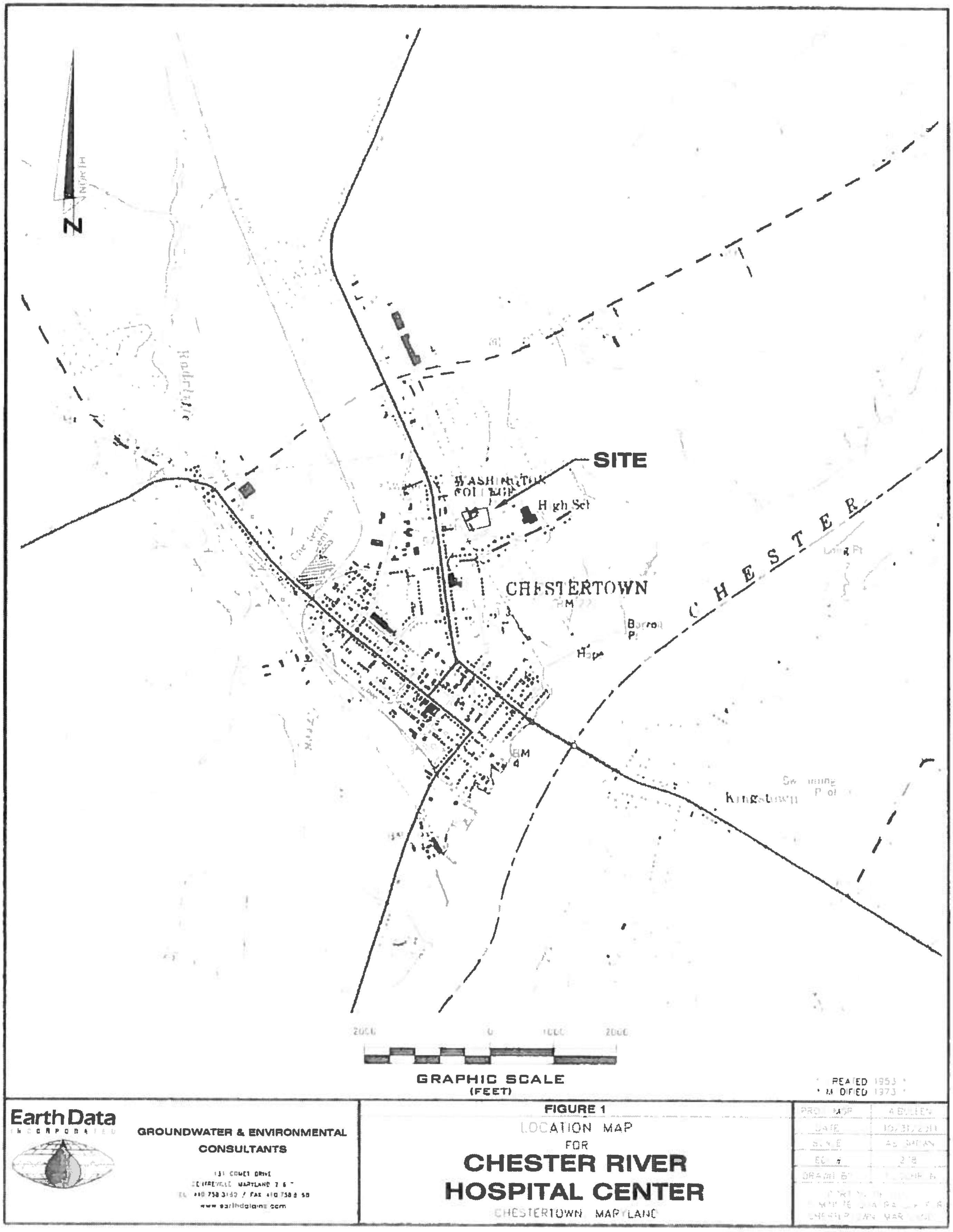


Figure 1 – Portion of USGS Quadrangle for Chestertown showing the location of Chester River Hospital Center – Chestertown, Maryland.

J:_Job_Directories\current\2781 Hospital\CAD\Quad\USGS.dwg

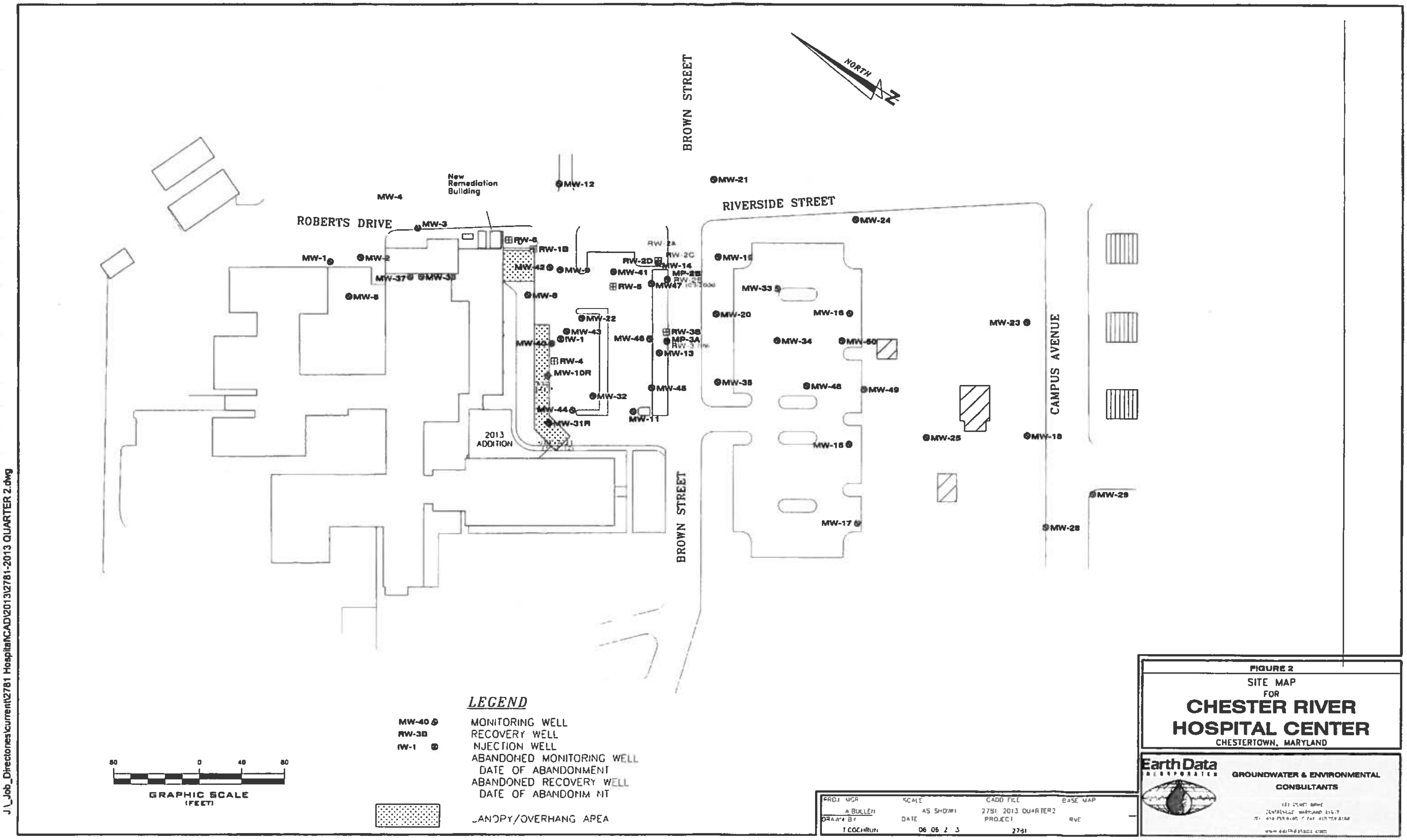


Figure 2 – Site map showing the location of monitoring wells and other pertinent features at Chester River Hospital Center, Chestertown, Maryland.

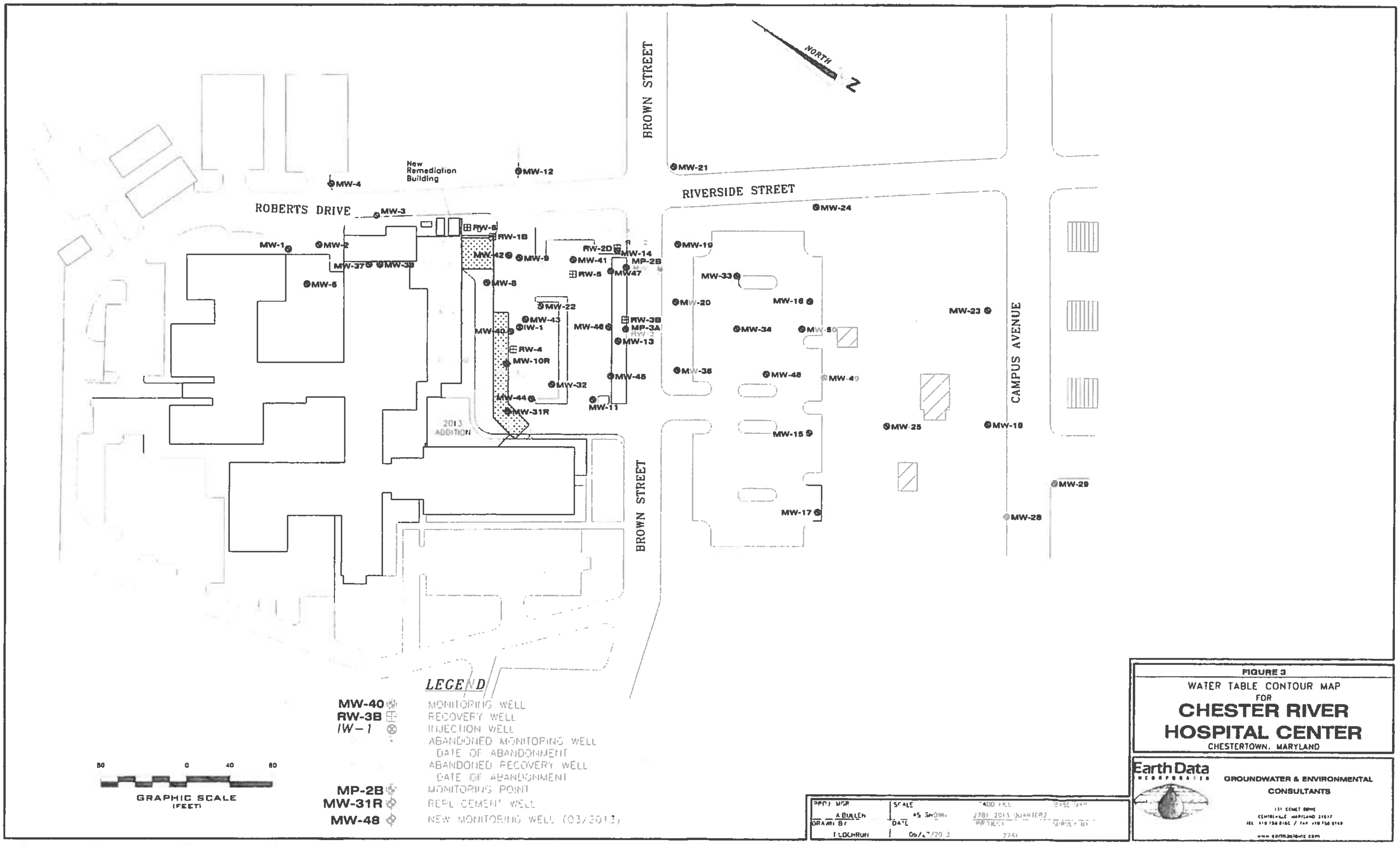


Figure 3 –Site map showing the location of new monitoring wells within the monitoring well network at the Chester River Hospital Center, Chestertown, Maryland

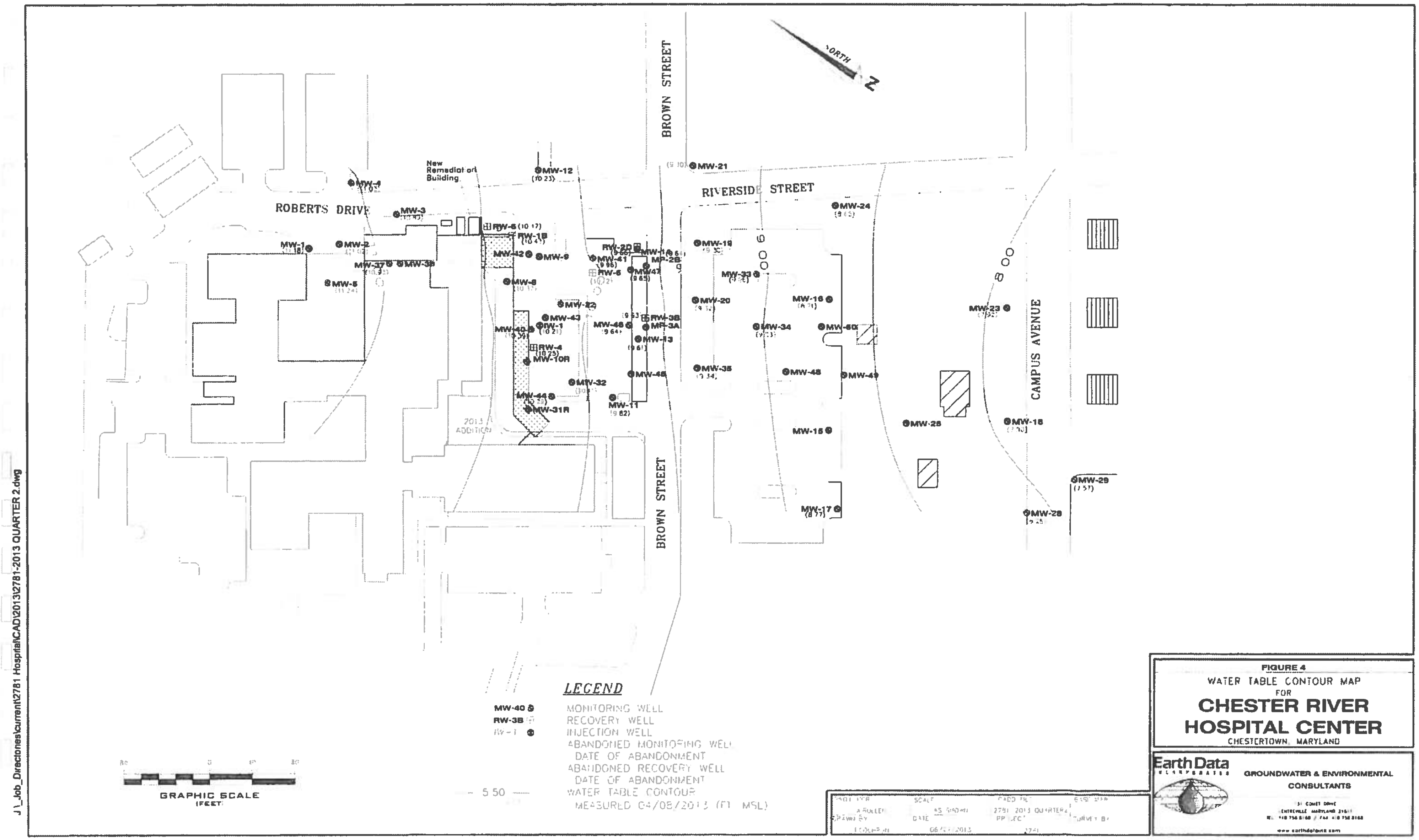


Figure 4 - Water table contour map April 8, 2013 - Chester River Hospital Center, Chestertown, Maryland.

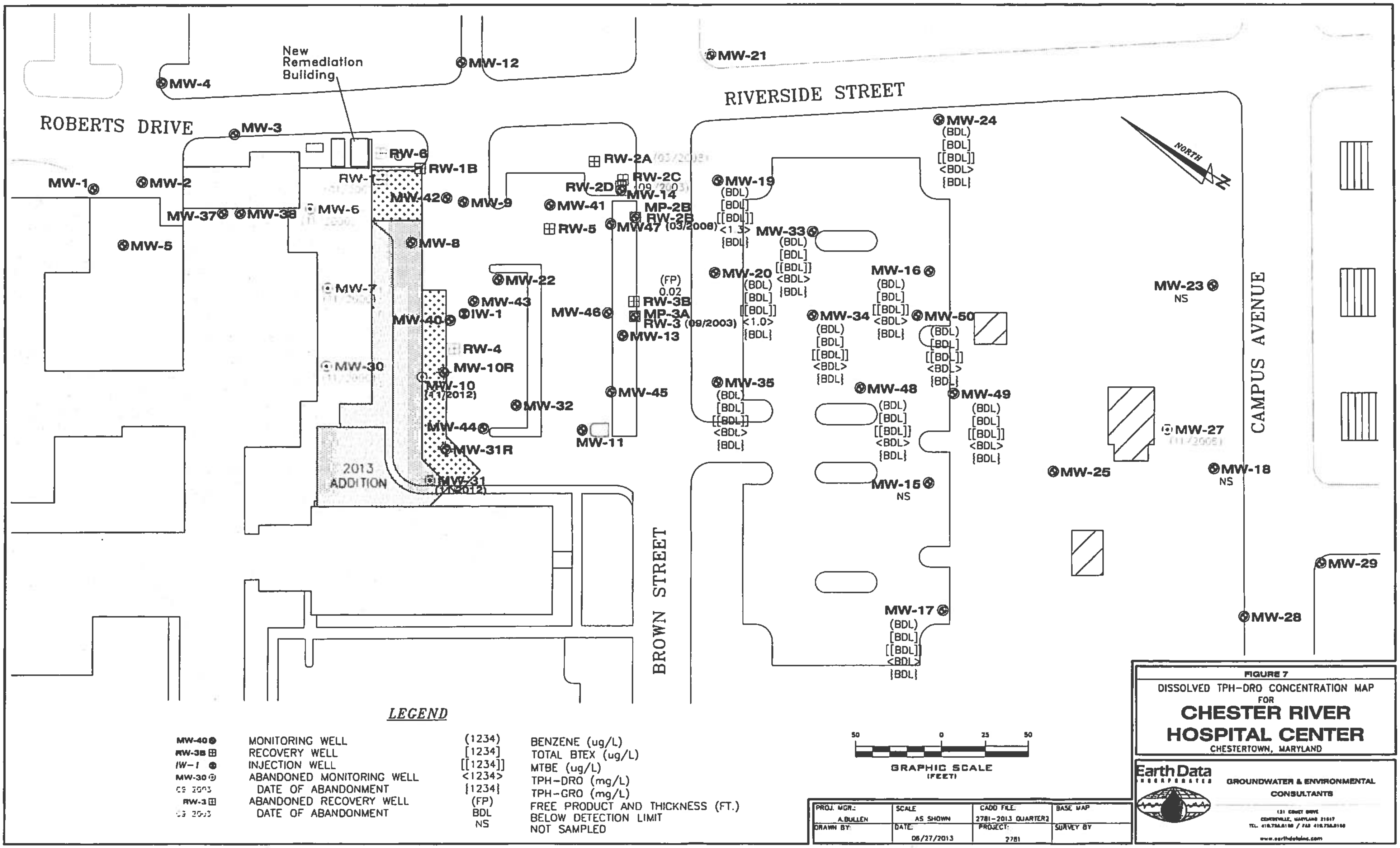


Figure 7– Water quality map showing dissolved BTEX and total petroleum hydrocarbon (TPH) concentrations, April 8, 2013 Chester River Hospital Center, Chestertown, Maryland.

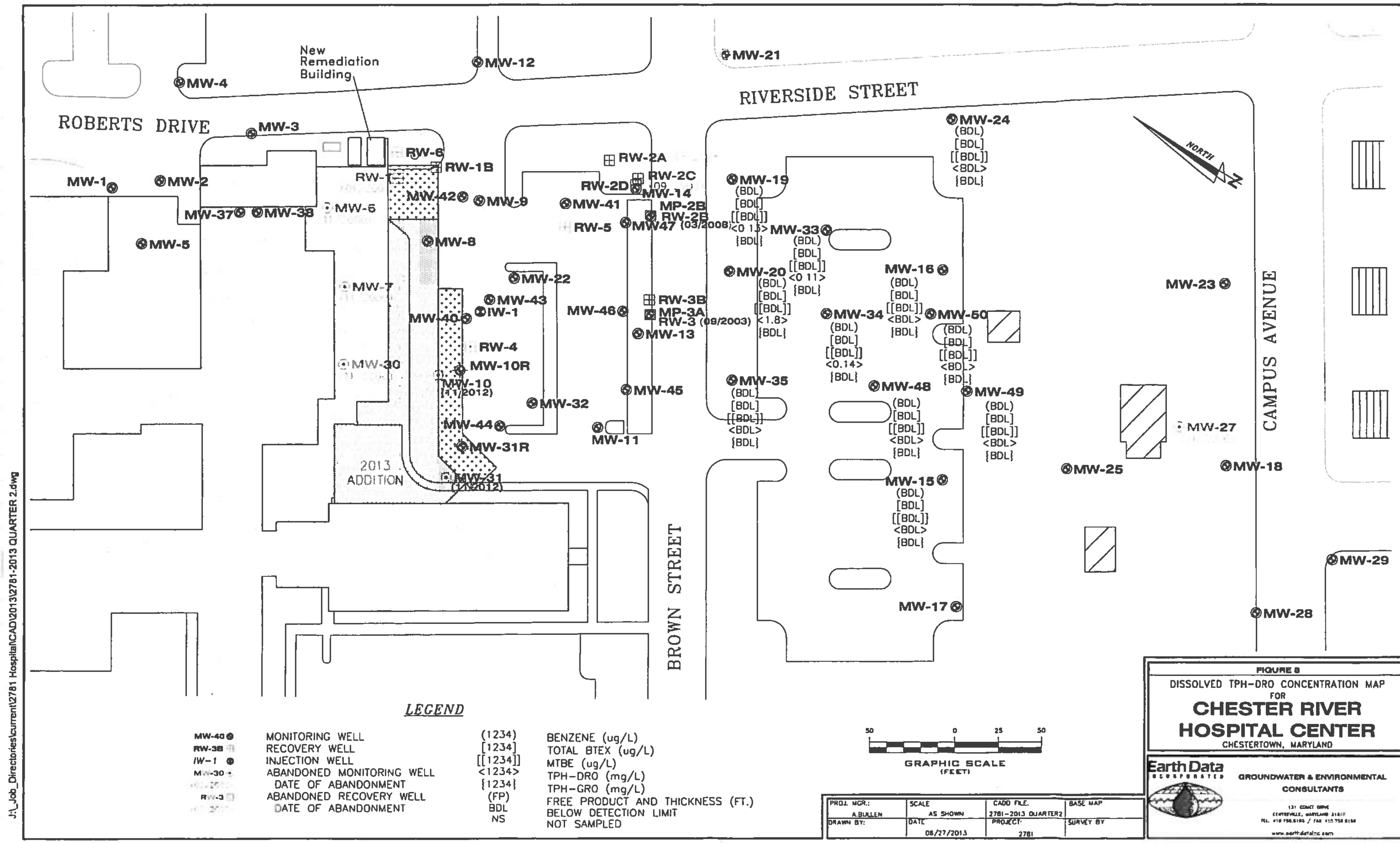


Figure 8– Water quality map showing dissolved BTEX and total petroleum hydrocarbon (TPH) concentrations, May 6, 2013 Chester River Hospital Center, Chestertown, Maryland.

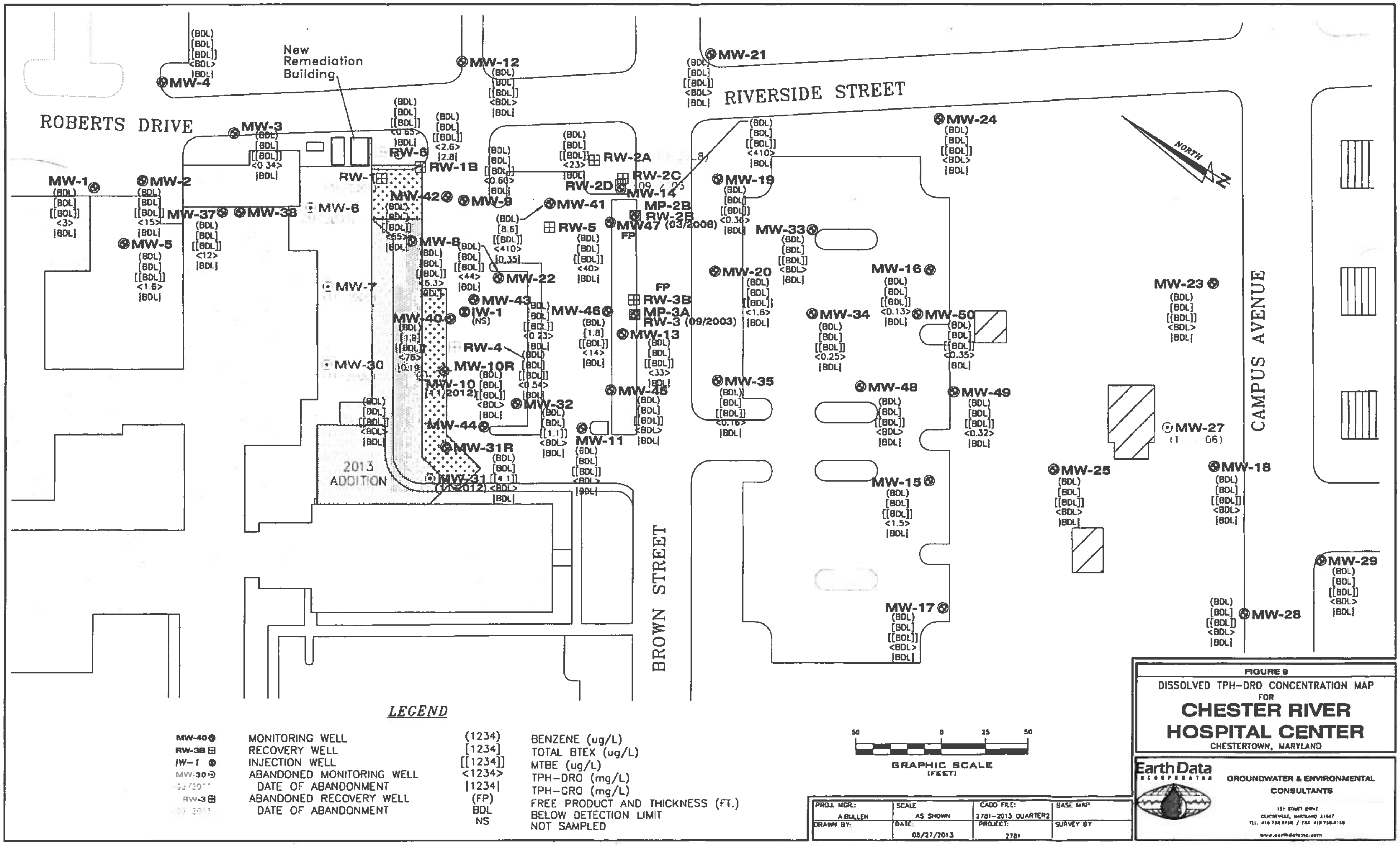


Figure 9– Water quality map showing dissolved BTEX and total petroleum hydrocarbon (TPH) concentrations, June 3 and 4, 2013 Chester River Hospital Center, Chestertown, Maryland.

TABLES

	MW-1	MW-2	MW-3	MW-4	MW-5	MW-8	MW-9	MW-10R	MW-11	MW-12	MW-13	MW-14
Benzene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
TOTAL BTEX (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Methyl-t-butyl ether (MTBE) (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Isopropylbenzene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene (ug/L)	<1	<1	<1	<1	<1	1.1	<1	<1	<1	<1	<1	3.6
Acetone (ug/L)	35	<10	16	<10	<10	43	130	12	<10	<10	48	41
Tetrachloroethene (ug/L)	<1	1.0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2-Butanone (MEK) (ug/L)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
TPH-DRO (mg/L)	3	15	0.34	<0.1	1.6	6.3	0.60	<0.1	<0.1	<0.1	33	410
TPH-GRO (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

	MW-15	MW-16	MW-17	MW-18	MW-19	MW-20	MW-21	MW-23	MW-24	MW-25	MW-28	MW-29
Benzene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
TOTAL BTEX (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Methyl-t-butyl ether (MTBE) (ug/L)	<1	<1	1.1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Isopropylbenzene (ug/L)	<1	<1	<1	<1	1.2	<1	<1	<1	<1	<1	<1	<1
Naphthalene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acetone (ug/L)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Tetrachloroethene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2-Butanone (MEK) (ug/L)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
TPH-DRO (mg/L)	1.5	0.13	<0.1	<0.1	0.36	1.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
TPH-GRO (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

	MW-31R	MW-32	MW-33	MW-34	MW-35	MW-37	MW-40	MW-41	MW-42	MW-43	MW-44	MW-45
Benzene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene (ug/L)	<1	<1	<1	<1	<1	<1	<1	1.7	<1	<1	<1	<1
Total Xylenes (ug/L)	<2	<2	<2	<2	<2	<2	1.9	6.9	<2	<2	<2	<2
TOTAL BTEX (ug/L)	<2	<2	<2	<2	<2	<2	1.9	8.6	<2	<2	<2	<2
Methyl-t-butyl ether (MTBE) (ug/L)	4.1	1.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Isopropylbenzene (ug/L)	<1	<1	<1	1.5	<1	<1	<1	2.5	<1	<1	<1	<1
Naphthalene (ug/L)	<1	<1	<1	<1	<1	3.9	3.3	14	8.1	1.4	<1	<1
Acetone (ug/L)	<10	<10	<10	<10	<10	11	120	28	<10	<10	<10	<10
Tetrachloroethene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2-Butanone (MEK) (ug/L)	25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
TPH-DRO (mg/L)	<0.1	<0.1	<0.1	0.25	0.16	12	78	410	55	0.23	<0.1	<0.1
TPH-GRO (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.19	0.35	<0.1	<0.1	<0.1	<0.1

	MW-46	MW-47	MW-48	MW-49	MW-50	IW-1	RW-1B	RW-2D	RW-3B	RW-4	RW-5	RW-6	MW-22
Benzene (ug/L)	<1	FP	<1	<1	<1	NS	<1	<1	FP	<1	<1	<1	<1
Toluene (ug/L)	<1	FP	<1	<1	<1	NS	<1	<1	FP	<1	<1	<1	<1
Ethylbenzene (ug/L)	<1	FP	<1	<1	<1	NS	<1	<1	FP	<1	<1	<1	<1
Total Xylenes (ug/L)	1.8	FP	<2	<2	<2	NS	<2	<2	FP	<2	<2	<2	<2
TOTAL BTEX (ug/L)	1.8	FP	<2	<2	<2	NS	<2	<2	FP	<2	<2	<2	<2
Methyl-t-butyl ether (MTBE) (ug/L)	<1	FP	<1	<1	<1	NS	1.3	<1	FP	<1	<1	<1	<1
Isopropylbenzene (ug/L)	1.4	FP	<1	<1	<1	NS	<1	<1	FP	<1	<1	<1	<1
Naphthalene (ug/L)	3.4	FP	<1	<1	<1	NS	<1	<1	FP	<1	<1	<1	<1
Acetone (ug/L)	<10	FP	<10	<10	<10	NS	13	18	FP	<10	<10	10	41
Tetrachloroethene (ug/L)	<1	FP	<1	<1	<1	NS	<1	<1	FP	<1	<1	<1	<1
2-Butanone (MEK) (ug/L)	<10	FP	<10	<10	<10	NS	<10	<10	FP	<10	<10	<10	<10
TPH-DRO (mg/L)	14	FP	<0.1	0.32	0.35	NS	2.6	23	FP	0.54	40	0.65	44
TPH-GRO (mg/L)	<0.1	FP	<0.1	<0.1	<0.1	NS	2.8	<0.1	FP	<0.1	<0.1	<0.1	<0.1

Table 1. Summary of water quality data for monitoring wells sampled at Chester River Hospital Center, Chestertown, Maryland, June 3-4, 2013

MW-15

Parameter	5-Jun-12	27-Jul-12	5-Sep-12	1-Oct-12	5-Nov-12	4-Dec-12	7-Jan-13	5-Feb-13	4-Mar-13	8-Apr-13	6-May-13	4-Jun-13
Benzene (ug/L)	<1	NS	<1	<1	<1	<1	NS	NS	<1	NS	<1	<1
Toluene (ug/L)	<1	NS	<1	<1	<1	<1	NS	NS	<1	NS	<1	<1
Ethylbenzene (ug/L)	<1	NS	<1	<1	<1	<1	NS	NS	<1	NS	<1	<1
Total Xylenes (ug/L)	<2	NS	<2	<2	<2	<2	NS	NS	<2	NS	<2	<2
TOTAL BTEX (ug/L)	<2	NS	<2	<2	<2	<2	NS	NS	<2	NS	<2	<2
Isopropylbenzene (ug/L)	<1	NS	<1	<1	<1	<1	NS	NS	<1	NS	<1	<1
Naphthalene (ug/L)	<1	NS	<1	<1	<1	<1	NS	NS	<1	NS	<1	<1
Acetone (ug/L)	<10	NS	<10	<10	<10	<10	NS	NS	<10	NS	<10	<10
Chloroform (ug/L)	<1	NS	<1	<1	<1	<1	NS	NS	<1	NS	<1	<1
Tetrachloroethene (ug/L)	<1	NS	<1	<1	<1	<1	NS	NS	<1	NS	<1	<1
TPH-DRO (mg/L)	<0.1	NS	<0.1	<0.1	<0.1	<0.1	NS	NS	<0.1	NS	<0.1	1.5
TPH-GRO (mg/L)	NS	NS	NS	<0.1	<0.1	<0.1	NS	NS	<0.1	NS	<0.1	<0.1

MW-16

Parameter	5-Jun-12	27-Jul-12	5-Sep-12	1-Oct-12	5-Nov-12	4-Dec-12	7-Jan-13	5-Feb-13	4-Mar-13	8-Apr-13	6-May-13	4-Jun-13
Benzene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes (ug/L)	<2	NS	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
TOTAL BTEX (ug/L)	<2	NS	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Isopropylbenzene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acetone (ug/L)	<10	NS	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chloroform (ug/L)	<1	NS	1.5	<1	<1	1.3	<1	<1	<1	<1	<1	<1
Tetrachloroethene (ug/L)	<1	NS	1.1	<1	<1	1.1	<1	<1	<1	<1	<1	<1
TPH-DRO (mg/L)	<0.1	NS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.15	<0.1	<0.1	0.18
TPH-GRO (mg/L)	NS	NS	NS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

MW-17

Parameter	5-Jun-12	27-Jul-12	5-Sep-12	1-Oct-12	5-Nov-12	4-Dec-12	7-Jan-13	5-Feb-13	4-Mar-13	8-Apr-13	6-May-13	4-Jun-13
Benzene (ug/L)	<1	NS	<1	NS	NS	<1	NS	NS	<1	<1	NS	<1
Toluene (ug/L)	<1	NS	<1	NS	NS	<1	NS	NS	<1	<1	NS	<1
Ethylbenzene (ug/L)	<1	NS	<1	NS	NS	<1	NS	NS	<1	<1	NS	<1
Total Xylenes (ug/L)	<2	NS	<2	NS	NS	<2	NS	NS	<2	<2	NS	<2
TOTAL BTEX (ug/L)	<2	NS	<2	NS	NS	<2	NS	NS	<2	<2	NS	<2
Isopropylbenzene (ug/L)	<1	NS	<1	NS	NS	<1	NS	NS	<1	<1	NS	<1
Naphthalene (ug/L)	<1	NS	<1	NS	NS	<1	NS	NS	<1	<1	NS	<1
Acetone (ug/L)	<10	NS	<10	NS	NS	<10	NS	NS	<10	<10	NS	<10
Chloroform (ug/L)	<1	NS	<1	NS	NS	<1	NS	NS	<1	<1	NS	<1
Tetrachloroethene (ug/L)	<1	NS	<1	NS	NS	<1	NS	NS	<1	<1	NS	<1
TPH-DRO (mg/L)	<0.1	NS	<0.1	NS	NS	<0.1	NS	NS	1.0	<0.1	NS	<0.1
TPH-GRO (mg/L)	NS	NS	NS	NS	NS	<0.1	NS	NS	<0.1	<0.1	NS	<0.1

MW-18

Parameter	5-Jun-12	27-Jul-12	5-Sep-12	1-Oct-12	5-Nov-12	4-Dec-12	7-Jan-13	5-Feb-13	4-Mar-13	8-Apr-13	6-May-13	4-Jun-13
Benzene (ug/L)	<1	NS	<1	NS	NS	<1	<1	NS	<1	NS	NS	<1
Toluene (ug/L)	<1	NS	<1	NS	NS	<1	<1	NS	<1	NS	NS	<1
Ethylbenzene (ug/L)	<1	NS	<1	NS	NS	<1	<1	NS	<1	NS	NS	<1
Total Xylenes (ug/L)	<2	NS	<2	NS	NS	<2	<2	NS	<2	NS	NS	<2
TOTAL BTEX (ug/L)	<2	NS	<2	NS	NS	<2	<2	NS	<2	NS	NS	<2
Isopropylbenzene (ug/L)	<1	NS	<1	NS	NS	<1	<1	NS	<1	NS	NS	<1
Naphthalene (ug/L)	<1	NS	<1	NS	NS	<1	<1	NS	<1	NS	NS	<1
Acetone (ug/L)	<10	NS	<10	NS	NS	<10	<10	NS	<10	NS	NS	<10
Chloroform (ug/L)	<1	NS	<1	NS	NS	<1	<1	NS	<1	NS	NS	<1
Tetrachloroethene (ug/L)	<1	NS	<1	NS	NS	<1	<1	NS	<1	NS	NS	<1
TPH-DRO (mg/L)	<0.1	NS	<0.1	NS	NS	0.23	<0.1	NS	<0.1	NS	NS	<0.1
TPH-GRO (mg/L)	NS	NS	NS	NS	NS	<0.1	<0.1	NS	<0.1	NS	NS	<0.1

MW-19

Parameter	5-Jun-12	27-Jul-12	5-Sep-12	1-Oct-12	5-Nov-12	4-Dec-12	7-Jan-13	5-Feb-13	4-Mar-13	8-Apr-13	6-May-13	4-Jun-13
Benzene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes (ug/L)	<2	NS	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
TOTAL BTEX (ug/L)	<2	NS	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Isopropylbenzene (ug/L)	<1	NS	<1	<1	<1	1.1	2.8	<1	1.7	<1	<1	1.2
Naphthalene (ug/L)	<1	NS	<1	<1	<1	<1	5.1	<1	1.8	<1	<1	<1
Acetone (ug/L)	<10	NS	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chloroform (ug/L)	<1	NS	<1	<1	2.8	1.8	<1	<1	<1	<1	<1	<1
Tetrachloroethene (ug/L)	<1	NS	<1	1.1	<1	<1	<1	<1	<1	<1	<1	<1
TPH-DRO (mg/L)	<0.1	NS	<0.1	<0.1	<0.1	0.30	<0.1	0.17	0.13	1.3	0.10	0.30
TPH-GRO (mg/L)	NS	NS	NS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

MW-20

Parameter	5-Jun-12	27-Jul-12	5-Sep-12	1-Oct-12	5-Nov-12	4-Dec-12	7-Jan-13	5-Feb-13	4-Mar-13	8-Apr-13	6-May-13	4-Jun-13
Benzene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
TOTAL BTEX (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Isopropylbenzene (ug/L)	<1	<1	<1	2.2	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene (ug/L)	<1	<1	<1	<1	<1	<1	2.8	<1	<1	<1	<1	<1
Acetone (ug/L)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chloroform (ug/L)	<1	<1	1.5	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tetrachloroethene (ug/L)	<1	<1	1.3	<1	<1	<1	<1	<1	<1	<1	<1	<1
TPH-DRO (mg/L)	1.3	1.8	1.9	4.0	2.5	1.8	0.88	0.88	2.2	1.9	1.8	1.5
TPH-GRO (mg/L)	NS	NS	NS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

MW-23

Parameter	5-Jun-12	27-Jul-12	5-Sep-12	1-Oct-12	5-Nov-12	4-Dec-12	7-Jan-13	5-Feb-13	4-Mar-13	8-Apr-13	6-May-13	4-Jun-13
Benzene (ug/L)	<1	NS	<1	NS	NS	<1	<1	NS	<1	NS	NS	<1
Toluene (ug/L)	<1	NS	<1	NS	NS	<1	<1	NS	<1	NS	NS	<1
Ethylbenzene (ug/L)	<1	NS	<1	NS	NS	<1	<1	NS	<1	NS	NS	<1
Total Xylenes (ug/L)	<2	NS	<2	NS	NS	<2	<2	NS	<2	NS	NS	<2
TOTAL BTEX (ug/L)	<2	NS	<2	NS	NS	<2	<2	NS	<2	NS	NS	<2
Isopropylbenzene (ug/L)	<1	NS	<1	NS	NS	<1	<1	NS	<1	NS	NS	<1
Naphthalene (ug/L)	<1	NS	<1	NS	NS	<1	<1	NS	<1	NS	NS	<1
Acetone (ug/L)	<10	NS	<10	NS	NS	<10	<10	NS	<10	NS	NS	<10
Chloroform (ug/L)	<1	NS	<1	NS	NS	<1	<1	NS	<1	NS	NS	<1
Tetrachloroethene (ug/L)	<1	NS	<1	NS	NS	<1	<1	NS	<1	NS	NS	<1
TPH-DRO (mg/L)	<0.1	NS	<0.1	NS	NS	11	<0.1	NS	<0.1	NS	NS	<0.1
TPH-GRO (mg/L)	NS	NS	NS	NS	NS	<0.1	<0.1	NS	<0.1	NS	NS	<0.1

MW-24

Parameter	5-Jun-12	27-Jul-12	5-Sep-12	1-Oct-12	5-Nov-12	4-Dec-12	7-Jan-13	5-Feb-13	4-Mar-13	8-Apr-13	6-May-13	4-Jun-13
Benzene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes (ug/L)	<2	NS	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
TOTAL BTEX (ug/L)	<2	NS	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Isopropylbenzene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acetone (ug/L)	<10	NS	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chloroform (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tetrachloroethene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	1.1	<1	<1	<1
TPH-DRO (mg/L)	<0.1	NS	<0.1	<0.1	<0.1	0.25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
TPH-GRO (mg/L)	NS	NS	NS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

MW-33

Parameter	5-Jun-12	27-Jul-12	5-Sep-12	1-Oct-12	5-Nov-12	4-Dec-12	7-Jan-13	5-Feb-13	4-Mar-13	8-Apr-13	6-May-13	4-Jun-13
Benzene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes (ug/L)	<2	NS	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
TOTAL BTEX (ug/L)	<2	NS	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Isopropylbenzene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acetone (ug/L)	<10	NS	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chloroform (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tetrachloroethene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TPH-DRO (mg/L)	<0.1	NS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.11	<0.1
TPH-GRO (mg/L)	NS	NS	NS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

MW-34

Parameter	5-Jun-12	27-Jul-12	5-Sep-12	1-Oct-12	5-Nov-12	4-Dec-12	7-Jan-13	5-Feb-13	4-Mar-13	8-Apr-13	6-May-13	4-Jun-13
Benzene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
TOTAL BTEX (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Isopropylbenzene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.1	1.3	1.5
Naphthalene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acetone (ug/L)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chloroform (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tetrachloroethene (ug/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TPH-DRO (mg/L)	0.14	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.14	0.25
TPH-GRO (mg/L)	NS	NS	NS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

MW-35

Parameter	5-Jun-12	27-Jul-12	5-Sep-12	1-Oct-12	5-Nov-12	4-Dec-12	7-Jan-13	5-Feb-13	4-Mar-13	8-Apr-13	6-May-13	4-Jun-13
Benzene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes (ug/L)	<2	NS	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
TOTAL BTEX (ug/L)	<2	NS	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Isopropylbenzene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acetone (ug/L)	<10	NS	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chloroform (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tetrachloroethene (ug/L)	<1	NS	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TPH-DRO (mg/L)	<0.1	NS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.16
TPH-GRO (mg/L)	NS	NS	NS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

MW-46

Parameter	8-Apr-13	6-May-13	3-Jun-13
Benzene (ug/L)	<1	<1	<1
Toluene (ug/L)	<1	<1	<1
Ethylbenzene (ug/L)	<1	<1	<1
Total Xylenes (ug/L)	<2	<2	<2
TOTAL BTEX (ug/L)	<2	<2	<2
Isopropylbenzene (ug/L)	<1	<1	<1
Naphthalene (ug/L)	<1	<1	<1
Acetone (ug/L)	<10	<10	<10
Chloroform (ug/L)	<1	<1	<1
Tetrachloroethene (ug/L)	<1	<1	<1
TPH-DRO (mg/L)	<0.1	<0.1	<0.1
TPH-GRO (mg/L)	<0.1	<0.1	<0.1

MW-48

Parameter	8-Apr-13	6-May-13	3-Jun-13
Benzene (ug/L)	<1	<1	<1
Toluene (ug/L)	<1	<1	<1
Ethylbenzene (ug/L)	<1	<1	<1
Total Xylenes (ug/L)	<2	<2	<2
TOTAL BTEX (ug/L)	<2	<2	<2
Isopropylbenzene (ug/L)	<1	<1	<1
Naphthalene (ug/L)	<1	<1	<1
Acetone (ug/L)	<10	<10	<10
Chloroform (ug/L)	<1	<1	<1
Tetrachloroethene (ug/L)	<1	<1	<1
TPH-DRO (mg/L)	<0.1	<0.1	0.20
TPH-GRO (mg/L)	<0.1	<0.1	<0.1

MW-50

Parameter	8-Apr-13	6-May-13	3-Jun-13
Benzene (ug/L)	<1	<1	<1
Toluene (ug/L)	<1	<1	<1
Ethylbenzene (ug/L)	<1	<1	<1
Total Xylenes (ug/L)	<2	<2	<2
TOTAL BTEX (ug/L)	<2	<2	<2
Isopropylbenzene (ug/L)	<1	<1	<1
Naphthalene (ug/L)	<1	<1	<1
Acetone (ug/L)	<10	<10	<10
Chloroform (ug/L)	<1	<1	<1
Tetrachloroethene (ug/L)	<1	<1	<1
TPH-DRO (mg/L)	<0.1	<0.1	0.26
TPH-GRO (mg/L)	<0.1	<0.1	<0.1

Table 2. Summary of water quality data for selected downgradient monitoring wells at Chester River Hospital Center Chestertown, Maryland

APPENDIX II

Chester River Hospital Center
100 Brown Street
Chestertown, MD 21620

June 25, 2013

ATTN: **Scott D. Burleson, MBA, FACHE, Executive Vice President, University of Maryland Medical System, and Dane S. Bauer, Senior Vice President, DMW**

RE: **Chestertown Hospital Fuel-Oil Spill Site Remediation**
In-situ Ivey-sol® Surfactant Enhanced Remediation
Using the Patented *'Push-Pull'* Technique To Treat Residual Fuel-oil (TPH- DRO) Contamination
MDE-OCP Case No. 1987-2534-KE

1.0 OVERVIEW

Ivey International Inc. (IVEY) is pleased to provide Chester River Hospital Center (CRHC), located at 100 Brown Street, Chestertown, MD, with the enclosed conceptual proposal for an in-situ application of the Patented Ivey-sol® Surfactant Enhanced Remediation (SER®) *'Push-Pull'* application. This process is designed to treat residual fuel-oil contamination, which is sorbed (i.e., absorbed and adsorbed) to the site soils, which recently caused contaminant rebound and impacting of the groundwater table during the Site Closure Monitoring Phase. As a result, CRHC needs to address this issue.

IVEY will provide application illustrations and an animation link to convey how a conceptual 'Push-Pull' Ivey-sol® injection and associated contaminant mass extract event works. In doing so, CRHC would better appreciate the application design approach to treat and resolve the residual sorbed fuel-oil contamination (TPH-DRO) at this site.

Client testimonials, published case studies and related technical information, will be appended to this proposal, or provided under separate cover. Animation of a typical Ivey-sol 'Push Pull' application is available as an internet link in Section 3.1.

IVEY will provide on-site supervision for the Ivey-sol injection and extraction process, with EARTH DATA providing labour, equipment and extraction system operation and maintenance over the course of the Ivey-sol 'Push-Pull' injection/extraction process.

Third-party scientific oversight for the Ivey-sol application will be provided by EBA Engineering, Inc., (EBA) of Baltimore, MD. EBA will obtain approval with MDE for the proposed the Ivey-sol application, and managing the associated groundwater sampling program, and associated laboratory analysis. EBA will also prepare the final report, with input from IVEY as required.

1.1 TERMS OF REFERENCE

The general background site information cited in this section was largely provided to IVEY by Scott D. Burleson (CRHC) and to a lesser extent from Dane S. Bauer (DMW) via email and verbal communications.

Approximately twenty-two (22) years ago, a fuel-oil spill occurred at the subject site that resulted in the contamination of the subsurface soil and shallow groundwater table. A multi-well P&T system, comprised of eight (8) recovery wells (RW) and a water treatment system, was installed and operated to affect localized containment and control of the observed soil and groundwater contaminant fuel-oil plumes. Plume containment was undertaken to guard against the risk of impacting the nearby Chestertown Well Field Water Supply located approximately 1,200 ft. down gradient of the site.

To 2010, a total of forty-one (41) monitoring wells (MW) had been installed and monitored for dissolved and free product phase fuel-oil contaminant thickness. Both, free phase fuel-oil product and associated dissolved phase fuel-oil contamination still remained on-site. As of December 2008, all eight (8) RW locations and seven (7) of the MW locations on-site had significant free product and dissolved phase contaminations.
The operation of the P&T system has reduced the product thickness significantly over the last twenty two (22), but the rate of contaminant mass removal had become asymptotic (Figure 14, Monthly Free Product Recovery 2002-2008, Earth Data Inc. January 2009). Based on the limited rate of contaminant mass recovery, over the preceding years leading up to 2009, site closure appeared to be years away.

1.1.1 CURRENT SITUATION

In 2012, CRHC was able to commence a Site Closure Monitoring Program, as approved by MDE. The program was progressing well until the June 12, 2013, groundwater sampling event completed by EARTH DATA. The laboratory results for these samples indicated a recurrence of petroleum contamination (TPH-DRO) at eight

(8) of the seventeen (17) down gradient MW they samples. Following CRHC's request, the laboratory reanalyzes the full set of samples as a verification step on June 17, 2013. The reanalyzes results determined that an additional two (2) MW locations were impacted, raising the total to ten (10) of the seventeen (17) MW's, or 59% of the MW locations samples, were contaminated.

With reference to Earth Data Figure 2 Site Map, dated June 6, 2013, a number of the original MW and RW locations installed by Earth Data were either destroyer of no longer in use. As such, some data gaps may be present in the Earth Data sampling data set.

1.2 CHALLENGE & OPPORTUNITY

Normally hydrophobic organic chemicals (HOC), including low (i.e., gasoline), medium and high molecular weight TPH contaminants, exhibit limited solubility in water as the contaminants tend to partition and sorb (i.e., absorb and/or adsorb) onto the soil and or fractured bedrock matrix surfaces. Sorption effects limit the 'Availability' of contaminants for physical, chemical, and biological remediation and can account for 90% or more of the total contaminant mass at a site. As such, sorbed contaminants are less 'Physically Availability' for pump and treatment methods; less 'Biologically Available' for bioremediation, and less 'Chemically Available' for chemical REDOX type chemical treatment. Hence HOC's (free phase, dissolved, and/or sorbed) can persist in soils, sediments, and fractured bedrock for extended periods of time. This explains why some remediation projects are slow, costly and/or fail to achieve their remediation objectives.

A concern regarding contaminant sorption, and its reduced availability for physical, chemical and biological remediation, has been well cited in literature as demonstrated by the following quotation:

"During the past decade, much discussion has centered on the unavailability of absorbed compounds to soil microorganisms; it is generally now assumed that desorption and diffusion of bound contaminants to the aqueous phase is required for microbial degradation."

(W.P. Inskeep, J.M. Wraith, C.G. Johnston, Hazardous Substance Research Center, 2005).

Generally, if we can overcome contaminant sorption, we can improve all forms of in-situ and ex-situ physical (P&T), chemical (REDOX) and biological (Bioremediation) remediation of air, soil, and groundwater LNAPL and DNAPL remediation.

The application and use of Ivey-sol® surfactant products provide a unique opportunity as has been demonstrated at several sites domestically and internationally as evidenced by conference paper and poster presentations, peer reviewed journal publications, client testimonials, and published case studies and magazine articles.

1.3 OBJECTIVE

The primary objective of this proposal is to achieve site closure with the MDE, and clean the groundwater to a sufficient extent as to adequately reduce the risk of impacting the Town's groundwater supply aquifer. IVEY in of the opinion that the in-situ Ivey-sol remediation approach, based on the patented 'Push-Pull' application method would remove residual free phase product, dissolved phase, and any associated sorbed phase within the soil and groundwater regimes, with particular focus on the smear zone associated with groundwater elevation fluctuations over time. For the residual fuel-oil (TPH–DRO) diesel range petroleum contamination, the Ivey-sol® 106 formulation would be required.

1.4 ASSUMPTIONS

Ivey assumes that the Earth Data RW locations on-site have very good hydraulic control over the rebound TPH-DRO dissolved plume area (June 12 & 17). If this is not the case, IVEY would recommend EBA design two (2) new RW locations, for hydraulic control, in the vicinity of this subject rebound plume to affect localized groundwater extraction following the recommended Ivey-sol injection events (Section 3.0). Earth Data could affect installation of these wells as they have drilling equipment.

2.0 IVEY-SOL

This section will briefly describe the Ivey-sol® surfactant technology and will include a range of in-situ and ex-situ applications, advantages and disadvantages and how it works.

Ivey-sol® Surfactant Technology is comprised of several patented non-ionic surfactant formulations that have the unique ability to selectively desorb and liberate free phase and/or sorbed (i.e., absorbed and/or adsorbed) petroleum hydrocarbons (LNAPL), chlorinated solvents (DNAPL) contaminants from fine to coarse soils, sediments and fractured bedrock surfaces.

Ivey-sol® makes the contaminants more miscible in the aqueous phase allowing for their improved physical mass recovery and/or improved treatment by other remediation techniques including chemical and biological methods. Three Ivey-sol® application processes were developed for enhancing in-situ and ex-situ site remediation. They are outlined as follows:

- **SER®** Surfactant Enhanced Remediation. In-situ and ex-situ application processes to liberate sorbed or free phase contaminants making them more miscible (soluble) and more 'Physically-Available' for mass removal via 'Push Pull' or 'Pump & Treatment' type remediation methods. SER® not only improves in-situ remediation, it is very effective for ex-situ soil washing for all types of TPH type contamination.

- **SEB®** Surfactant Enhanced Bioremediation. In-situ and ex-situ application processes to liberate contaminants making them more 'Biologically Available' for microbial (bacteria) degradation. SEB® improves both in-situ and or ex-situ bioremediation treatment methods including bio-stimulation, bio-augmentation and newer enhanced biological techniques.

- **SEC®** Surfactant Enhanced Chemicalization. In-situ and ex-situ application processes to liberate contaminants making them more 'Chemically-Available' for chemical REDOX by chemical agents. SEC® improves the availability of the contaminants to the chemical REDOX reagents, facilitating improved reaction kinetics, to enhance the in-situ and/or ex-situ chemical reagent degradation. This process may also be modified for application with chemical REDOX reagents for ex-situ applications for all types of TPH contamination.

2.1 IVEY-SOL WATER CLUSTER REDUCTION

Ivey-sol® surfactants, when introduced into contaminated soil and groundwater regimes, can reduce the surface tension of water from 73 dynes to as low as <30 dynes. Thus temporarily improving the wetting ability of the water phase and its 'Effective Hydraulic Conductivity' (K) allowing for reagent penetration and movement with finer texture geology. This is accomplished as the Ivey-sol® surfactants reduce the size and formation of larger water clusters to smaller water clusters (See Figure 2-1) allowing the water to penetrate into less permeable soils such as: clays, silty-clay, silts, silty-sand and fractured bedrock.

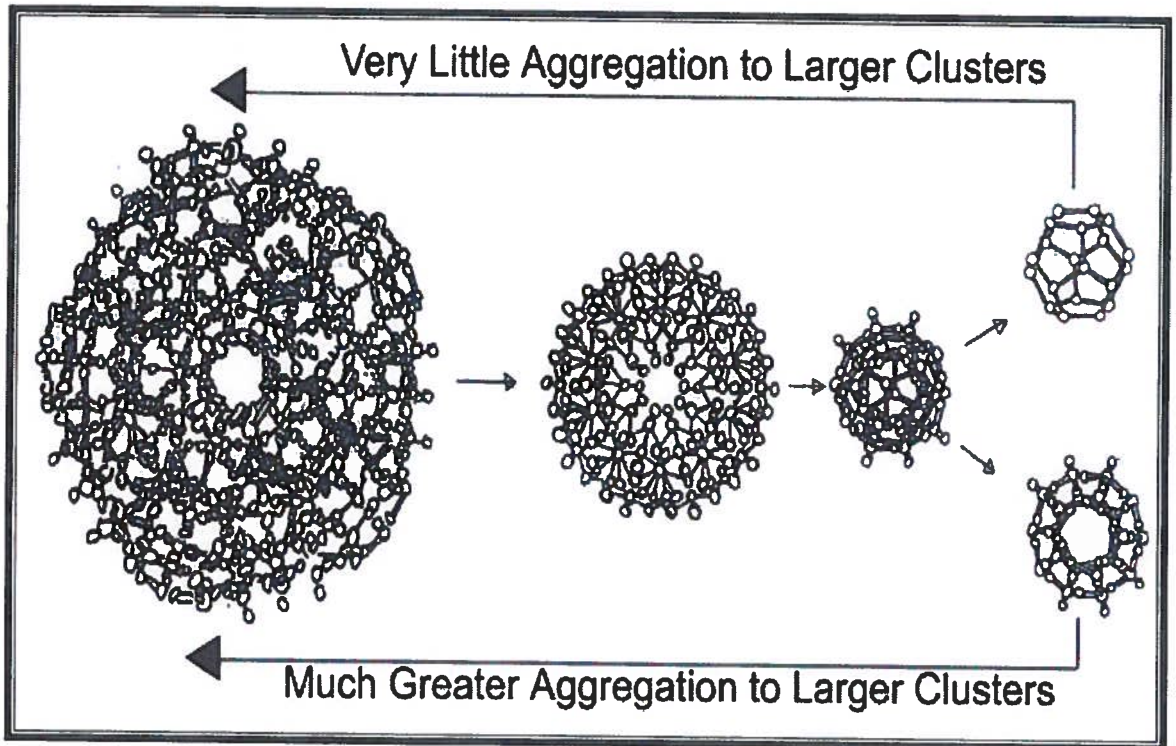


Figure 2-1: Ivey-sol reducing water cluster size (Lower water's surface tension)

2.2 ADVANTAGES AND DISADVANTAGES

Ivey-sol® makes the desorbed contaminants more 'hydraulically-available' for extraction by Push-Pull, Pump and Treatment or Soil Washing; more 'bio-available' for Bioremediation (in-situ and/or ex-situ); and by increasing the dissolved aqueous-phase contaminant concentrations it can improve their 'chemical-availability' for Reductive-Oxidative (REDOX) chemical treatment (In-situ & Ex-situ).

Increasing the 'Physical Availability' of the residual TPH-DRO will be the aim of the in-situ Ivey-sol 'Push-Pull' process.

Ivey-sol® has inherent application flexibility not common to most remediation technologies. CRHC could commence a physical 'Push-Pull' mass recovery approach, and if site conditions permitted, then flexibly modify the remediation strategy to SEB® or SEC® or MNA (Monitored Natural Attenuation), and/or close the site by completing a risk assessment once contaminant levels has decreased sufficiently. The following table lists several advantages and disadvantages associated with the Ivey-sol® technology.

Advantages:

i) The Ivey-sol® products are non-toxic and biodegradable, so they do not persist in environment after application;
ii) Improves contaminant mass recovery for in-situ P&T or 'Push-Pull' by > 400 to 800%, for LNAPL and DNAPL contamination;
iii) Improves in-situ and ex-situ soil and water bioremediation by 40-60% or more;
iv) Improves chemicalization (REDOX) so 25% to 75% less chemical reagents are required, saving time and treatment costs;
v) Does not negatively affect water treatments stems (i.e., O/W Separators, GAC, Zeolite, Air Stripping, Membrane Separation, Bio-reactors, etc.).
vi) Not toxic to bacteria, so can aid and/or improve natural attenuation;
vii) Reduces required treatment times when used in conjunction with other remediation technologies (i.e., P&T, Push-Pull, in-situ/ex-situ bioremediation, REDOX chemical treatment, etc.);
viii) Works well with duel phase extraction, vacuum extraction, and conventional P&T;
ix) Works well in fine grain soils (i.e., silty sand, silt, silty clay, clay and fractured bedrock);
x) Does not generate additional O&M issues;
xi) Applicable for the full range of LNAPLs; has been demonstrated to be very effective on most DNAPL contaminants, and several heavy organo-metals;
xii) Can be applied to saturated and/or unsaturated zones

Disadvantages:

i) Extraction and treatment equipment can be expensive when used with P&T;
ii) If the mixture freezes during storage and/or handling, it's effectiveness may be reduced;
iii) Not intended for free product recovery greater than 10 to 12 inches in thickness (25 to 30 cm), as other primary free product recovery methods are initially more appropriate to implement;
iv) With improved contaminant liberation, the site may go through more GAC than originally planned;
v) If monitoring VOCs during remediation, Ivey-sol® may suppress VOCs, making them less detectable by standard handheld vapor meters.
vi) When used for SEC®, the Ivey-sol® will consume some of the REDOX reagents being introduced (Although limited as present below CMC);
vii) During SER®, and effective improvement in mass recovery, bacterial pluming in the soil and groundwater has been observed. When not anticipated it can result in the clogging of well screens, and or bacterial slime buildup in the GAC units lowering the treatment flow rates. This can be resolved using surge block or chemical disinfection, if required.

2.3 IVEY-SOL® MECHANISM

The Ivey-sol® surfactant products are non-ionic surfactants comprised of several patented and proprietary formulations which can selectively desorb and dissolve (make miscible) HOC contaminants as microscopic 'surfactant-hydrocarbon-water' partial non-encapsulations, called partial micelles, well below the critical micelle concentration (CMC). In addition, Ivey-sol® can lower the surface tension of water from 73 dynes to less than 30 dynes (See Figure 2-1) increase the wetting and permeability properties of the groundwater in associated fine grain soil and in fractured bedrock matrix enhancing related remediation measures.

The Ivey-sol® contaminant desorption mechanism is illustrated below. The non-soluble contaminants are present on-site in a sorbed (i.e., absorbed or adsorbed) to the soil matrix or free phase floating product, both of which exhibit reduced physical, chemical and biological availability for remediation. Ivey-sol® through selective desorption below the CMC (Critical Micelle Concentration) significantly increase the availability of the contaminants for all forms of in-situ or ex-situ remediation.

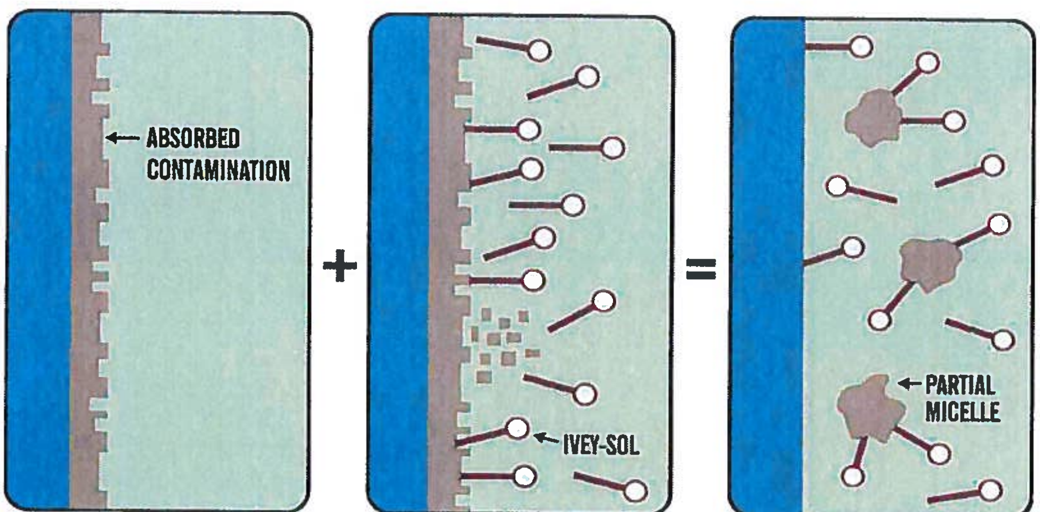


Figure 2-2: Ivey-sol® desorbing contamination off the soil surfaces making it more 'Available' for in-situ or ex-situ remediation.

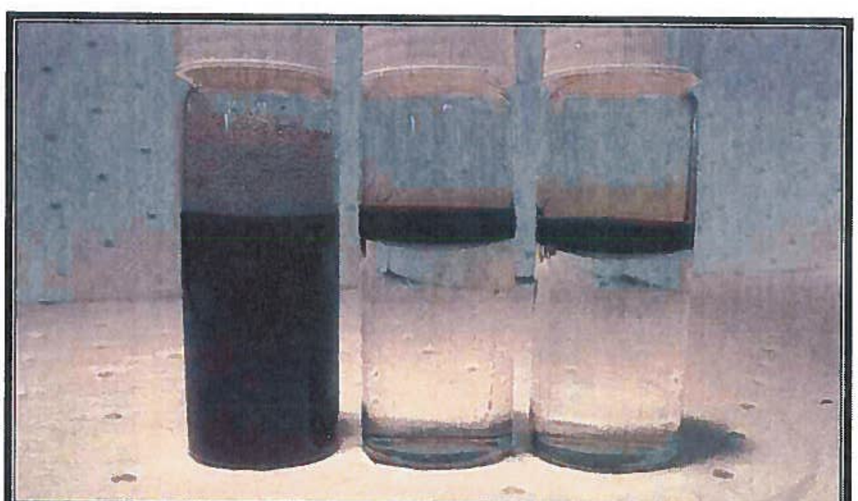
The Ivey-sol® molecules desorb the sorbed contaminants at a molecular level making them miscible in the aqueous phase where they are more 'Available' for improved physical, chemical and/or biological treatment. The Ivey-sol® surfactant products affect the sorption of HOC at the solid-liquid interface (i.e., the surface–H2O–NAPL interface). As a result, they increase the solubility and availability of the petroleum contaminants in the water-phase.

2.4 IVEY-SOL APPLICATION (SOIL, FREE PRODUCT, DNAPL)

This section provides a high level indication of Ivey-sol® effectiveness for treating TPH contaminated soil and free product, and on DNAPL contamination. Photograph 2-1 below shows contaminated soil from a refinery site that was treated using Ivey-sol® in an ex-situ soil washing remediation process. The baseline soil concentrations ranged from 30,000 to 40,000 ppm while the post treated soils TPH (C6 to C50) concentration was <500 ppm.

Photograph 2-1: Pre-post Ivey-sol® Remediation of Refinery Soils

Photograph 2-2 shows free phase product that was treated using Ivey-sol® in an in-situ soil washing 'Push-Pull' remediation process. The baseline dissolved concentrations was increased by >1000% following the Ivey-sol® application.



Photograph 2-2: Pre-post Ivey-sol® Free Product Remediation

Photograph 2-3 below show Ivey-sol® increasing the miscibility of DNAPL contamination, with a greater than 600% increase in DNAPL mass recovery being observed at the subject site. This realization may allow CRHC to treat the gasoline and the DNAPL, if present, at the same time. Within a DNAPL plume a similar Ivey-sol® 'Push-Pull' application would achieve similar mass extraction remediation results.

Photograph 2-3: **Pre-post Ivey-sol® DNAPL Remediation. Increasing the miscibility of the DNAPLs for enhanced extraction.**

In brief, Ivey-sol® applications accomplishes two (2) feats; first they overcome the 'Limitation' challenges associated with contaminant sorption; and secondly they lower the relative surface tension of water improving both its wetting and associated hydraulic conductivity (K) properties (only while the Ivey-sol® is present) broadening the range of soil types, and enhancing in-situ and ex-situ contaminant (LNAPL and DNAPL) remediation methodologies.

2.5 IVEY-SOL® 'PUSH-PULL' APPLICATION APPROACH

This section will detail the application of the Ivey-sol® non-ionic surfactant products, that would be employed in an in-situ 'Push-Pull' SER® strategy to eliminate the observed gasoline free phase, and significantly reduce observed dissolved TPH concentrations at the subject site in an economical and timely manner.

The following image (Figure 3-1) illustrates the 'Push-Pull' in-situ approach using Injection Wells (IW) designed and installed to target the Ivey-sol® injections into the subsurface zone(s) of contamination (i.e., free phase, dissolved phase and/or sorbed

phase) to make said phase contaminants more miscible in groundwater, whereby they are more 'Available' for physical mass extraction at the same IW locations, or at nearby EW locations. The process is generally easy to apply, and often a very effective method to remove contaminant mass of concern within in-situ environments.

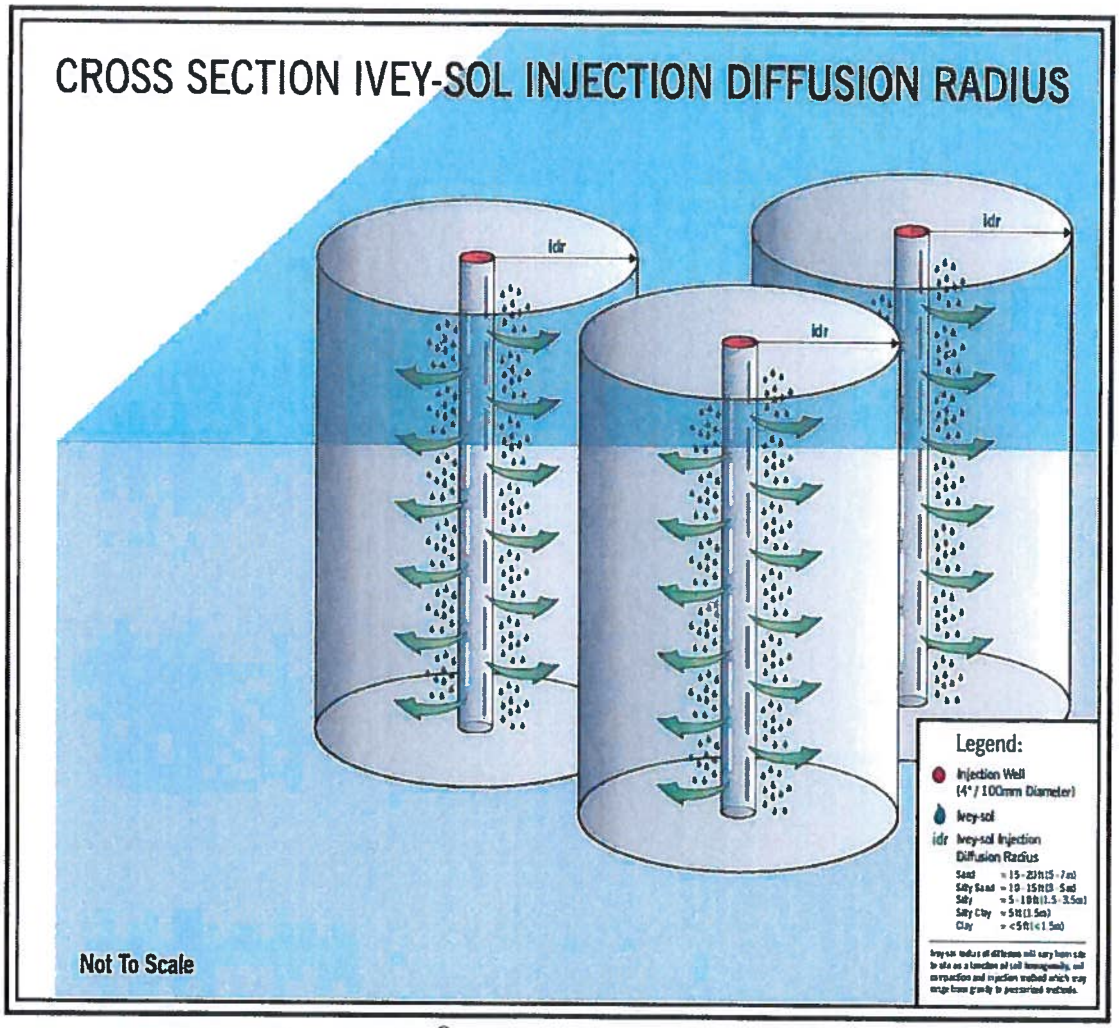


Figure 3-1: Ivey-sol® 'Push-Pull' injection event at IW locations

Figure 3-2 illustrates a typical field scale application with anticipated idr (injection diffusion radius) for the injected Ivey-sol® associated with each injection 'Push', which after allowing a prescribed 'Contact Time' is extracted - 'Pull' - from the IW locations.

The injection diffusion radius (idr) values shown in the legend are based on 2 inch (50 mm) diameter wells, so should be viewed as conservative, as several site specific variables would (soil texture, compaction, groundwater elevation, K, contaminant type, etc.) would affect the actual idr achieved at the IW locations for different sites.

If the IW's are 4 inch (100 mm) in diameter, they have a Triple-Value use at the site. In addition to making a very good IW, which can be more broadly spaced apart than 2 inch (50 mm) diameter IW's, they can serve as temporary EW locations as small diameter submersible pumps will easily fit inside the well casing as will a standard 2.5 inch (50-75 mm) vacuum truck intake hose. Once remediation is concluded, or nearing conclusion, the IW can be used as temporary or permanent MW locations to aid in the final site evaluation and closure monitoring.

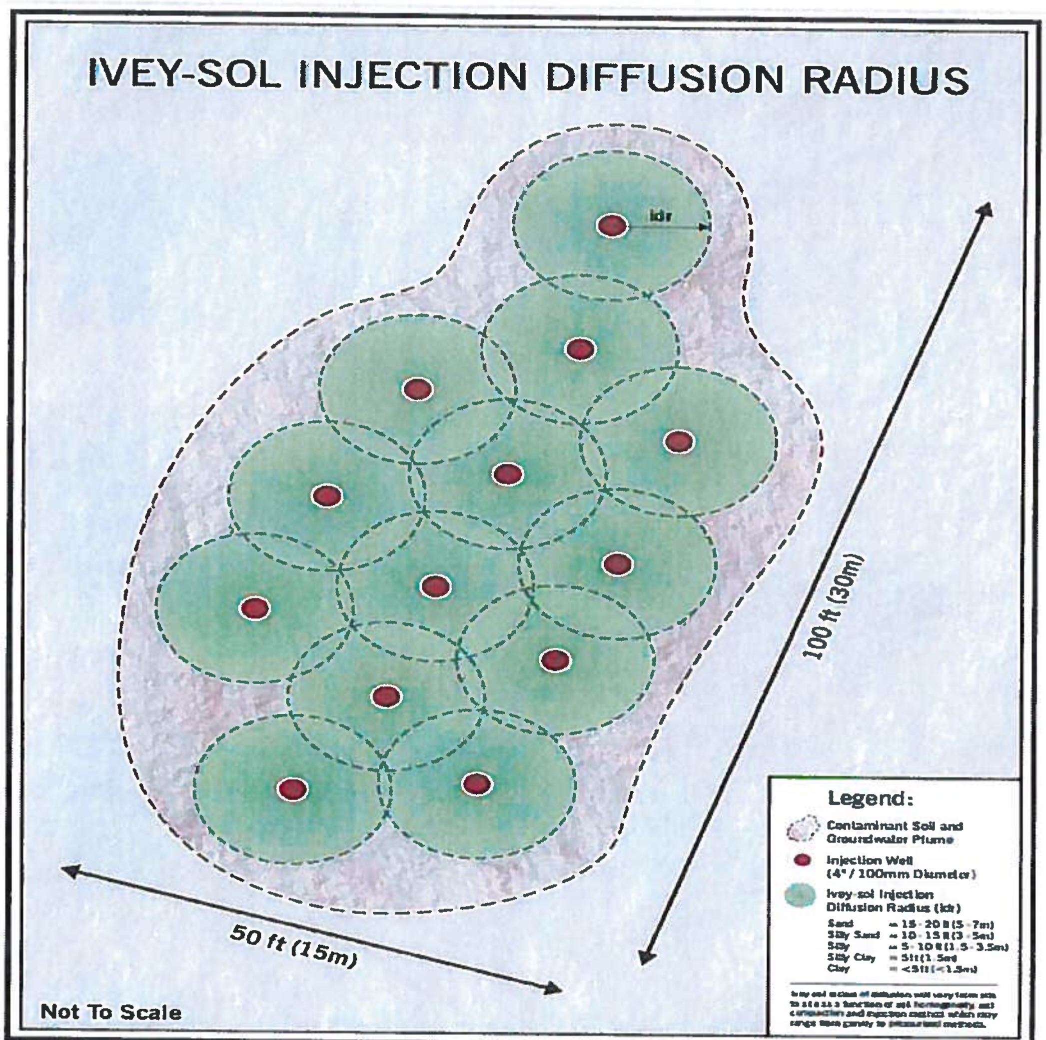


Figure 3-2: Ivey-sol® 'Push-Pull' injection event at IW locations

2.6 IVEY-SOL® PUSH-PULL ANIMATION

An animation showing an idealized in-situ Ivey-sol® 'Push-Pull' application to liberate free phase and or sorbed contaminants into the groundwater, in the vicinity of IW locations, following a 'Push' injection, and after a brief contact time (hours to days), the liberated contaminants are extracted at each IW 'Pull' to reduce the in-situ mass of said contaminants. For most sites, only a limited number of 'Push-Pull' events are required to achieve site remediation. The web based animation link is as follows:

http://www.youtube.com/watch_popup?v=B5OsW6ceM4U&vq=hd1080

CRHC could also view the 'Push Pull' as a modified Ivey-sol® surfactant enhanced pump and treatment application.

3.0 CHESTER RIVER HOSPITAL CENTER IVEY-SOL® APPLICATON

Based on the site conditions detailed in Section 1.0; this section will detail conceptual in-situ Ivey-sol® 'Push-Pull' site applications based on a series of Ivey-sol® injection extraction events within the identified groundwater impacted MW locations 'Proposed Treatment Area'. CRHC can complete the Ivey-sol® 'Push-Pull' application at the site in the following way:

With the eight (8) RW wells (Or minimum number required) to affect localized hydraulic control, within the target treatment area (Ten [10] impacted MW locations), Ivey-sol® is injected into the existing MW locations. (Note: It is also possible to inject into the RW locations, if TPH-DRO is suspected in the unsaturated zone above the depressed water table at each of the RW locations, we may want to turn these off in isolation and complete a single well 'Push-Pull' at these locations.

If the existing RW locations cannot affect localized hydraulic control of the groundwater table in the vicinity of the recently re-impacted 10 MW locations, two (2) to three (3) new Recovery Wells (RW) will need to be installed along the north-south central axis of the ten (10) impacted wells.
EBA should have Earth Data verify this as soon as possible.

IVEY recommends injecting 5 gallons of Ivey-sol® followed by 50 to 100 gallons of clean water at each well per injection event. Evaluation of the Ivey-sol® injection and mass recovery can be evaluated at one or more RW location by collecting and analyzed time based water samples. The results can be plotted to determine the increase in contaminant mass recovery, and to optimize the injection extraction 'Push Pull' process.

Volume of Ivey-sol® for 10 MW 3 to 5 injection events:
(10 Wells x 5 Gal/Event) x (3 to 5 Events) = 150 to 250 Gallons
Note: Three 55 Gallon Drums or One IBC Tote (275 Gal) Ivey-sol® 106

If any localized Ivey-sol 'Push-Pull' applications to RW or MW locations are added, that were not included in the Earth Data June 12, 2013 sampling event, additional Ivey-sol would need (5 Gal. x Wells x events) to be purchased to permit localized treatments round these .

The use of existing MW and RW locations as Injection Wells (IW) can be an acceptable approach, subject to the well screen intervals at each well relative to the observed contaminant depth interval within the treatment area.

IVEY is prepared to assist CRHC with supervision of the applied Ivey-sol 'Push-Pull' application, with Earth Data undertaking the work, for a rate of $1200.00/Day (plus applicable expenses to cover time, travel, hotel and meals) for attending the first three (3) applications (In a 5-6 working day period), and provide off-site technical should support if additional Ivey-sol injections be required (Earth Data could manage these additional Ivey-sol injections with IVEY's off-site technical support).

IVEY's involvement is anticipated to be on the order of 9 to 11 day equivalents in time. This would include travel to from the site (1-1.5 days), on-site supervision of the Ivey-sol inject process by Earth Data (5-6 days), and off-site data review and application optimization support (1-1.5 Days), and evaluation of % mass recovery calculations, and associated data interpretation for EBA reporting as required (1-1.5 days). If IVEY is required for a duration exceeding 10 days, a rate of $175.00/hours would apply.

Field evaluation techniques have been developed by IVEY so CRHC can monitor and evaluate Ivey-sol® injection-extraction 'Push-Pull' events 'In Real Time' using the IVEY Surface Tension & Agitation Field Test (IVEY, Version 121016-08) method which was developed by IVEY to assist client with field application and their interpretation (Kit is provided free of cost). This test method incorporates visual surface tension and visual agitation techniques, to accurately predict the presence and behaviour of the injected Ivey-sol®, and associated TPH being liberated for recovery. A copy of the Surface Tension & Agitation Field Test document will accompany this proposal.

If CRHC and/or MDE wants EBA to have the capacity to analyze for Ivey-sol® in groundwater samples, IVEY has established two EPA approved analysis methods detailed on a technical handout that will accompany this proposal.

3.1 DETAILED IVEY-SOL® *'PUSH PULL'* APPLICATION

Based on a conceptual 'Push-Pull' application for the Chester River Hospital site, which would be similar in approach to other in-situ Ivey-sol® applications for other impacted sites, the following steps would describe the actions associated with a typical 'Push-Pull Ivey-sol® injection-extraction event. Where applicable, 'Notes' will be provided where special consideration may be applicable.

1. Baseline Monitoring – Field sampling and testing of groundwater quality and/or free-product phase thickness to establish pre Ivey-sol® application conditions '*Control Conditions*' for post application comparisons;

   Note: *For the purpose of this project application, EBA may want to utilize Earth Data's June 12, 2013 and June 17, 2013 laboratory data set as the baseline for evaluating the Ivey-sol 'Push-Pull applications. If EBA questions the validity of Earth Data's data, past and present, they may want to establish a new baseline.*

2. The Push - Inject 'X' gallons of Ivey-sol® (See Option 1 and 2, Section 3.2) at each IW and/or RW location followed by 5 to 10 'X' gallons of water (IVEY generally recommends injecting 5 to 10 times the volume of Ivey-sol®, in some cases the water flush can vary +/- 20%r) to help diffuse the injected Ivey-sol® into the target contaminant (NAPL/Soil/Groundwater) plume in the vicinity of each IW (MW), W (EW) and/or IG (Injection Gallery) to affect the desired injection diffusion radius (idr);

   Note: *The Ivey-sol® can be pre-diluted with municipal water verses injection with post water flush. Both approaches would result in similar in-situ net effective Ivey-sol® concentrations. IVEY also suggests varying the volume of Ivey-sol® injected (increase or decrease by 25% to 50%) as CRHC may find lower volume of Ivey-sol® achieves a similar effect as slightly larger volumes, resulting in 5 Ivey-sol® product costs savings to the project.*

3. Residence Time - Allow the Ivey-sol® to have a prescribed contact time with the observed free product, and/or dissolved phase, and/or sorbed phase TPH to optimize the associated miscibility (solubilization) of the TPH into the groundwater for subsequent mass removal (This step is less relevant for Injection Gallery type applications);

Note: The residence time can be hours to days depending on the site conditions. Generally, the longer you leave the Ivey-sol® in contact with the target contaminants the more TPH mass that will be liberated for mass recovery. You can easily modify the post Ivey-sol® injection residence times to evaluate the benefits for the subject site. IVEY recommends starting with 6, 12 or 24 hours.

4. The 'Pull' - Extract the groundwater from the IW location via available extraction methods (i.e., submersible pumps, vacuum truck, etc.). We suggest you extract three (3) to five (5) volumes of groundwater at each IW compared to what was injected {(Ivey-sol® + flush water) x 3-5}.

5. For site applications, where the consultant is maintaining hydraulic control and associated groundwater recovery at EW/RW locations down gradient of IW and or IG locations maintain applied pumping rates established for hydraulic control and monitor the Ivey-sol® injection and contaminant removal process using the Surface Tension & Agitation Field Test kit (Section 3.2). The collection of time based (i.e., 00:00, 15:00, 30:00, 60:00, etc. minutes.) groundwater samples at one or more of the EW/RW locations would allow CRHC to perform field surface tension and agitation tests to minimize the total volume of water extracted and treated per injection event.

   Note: The collection of time based water samples at one or more of the IW/EW/RW locations would allow CRHC to perform field surface tension and agitation tests to minimize the total volume of water extracted.

6. Monitoring - Post Ivey-sol® application field sampling and testing of groundwater quality and/or free-product phase thickness to establish post Ivey-sol® application conditions 'Application Conditions' for comparisons against previous baseline conditions.

   Note: IVEY can assist CRHC in the completion of mass recovery calculations to determine total TPH-DRO mass recovery with each injection. This can be plotted and used to develop a site prognosis relating time, effort, and Ivey-sol® to achieve the clean-up objective.

7. Repeat Steps 1-5, with an evaluation of results between each 'Push-Pull' event to make minor modifications if and as site observations support.

   Note: IVEY anticipates between 3 to 5 Ivey-sol® injection-extraction events to significantly reduce and or eliminate the observed residual TPH-DRO groundwater impacts on-site.

4.0 ESTIMATED COST

The following project costs are based on the amount of Ivey-sol® 106 that is generally anticipated for completing 3 to 5 Ivey-sol® 'Push-Pull' applications at the subject site, as outlined in Section 3.2. The frequency of injections could be increased (*subject to receiving and reviewing groundwater data from previous Ivey-sol application*) to reduce the cleanup time horizon, if the client and project clean-up requirement so demands.

Although IVEY is not fully aware of Earth Data's undertakings at the site leading to the rebound of contamination, we anticipate that CRHC would realize favorable results from the Ivey-sol application. The reason for this statement is we feel the contamination at the site is residual contamination associated with groundwater fluctuation and the creation of a smear zone. This understanding, coupled with the TPH concentrations observed for the June 17, 2013 samples support our view.

Detailed project related costs will be provided under separate cover

5.0 CLOSING

This cost proposal was generated based on the site information provided by CRHC to IVEY. Should additional information become available, and/or if the proposed application strategy should change, we are prepared to review and modify our understanding and associated project costs.

To aid CRHC's understanding of the effectiveness of the Ivey-sol® surfactant technology, several applied case studies, and client testimonials will be appended to this proposal.

If you have any questions regarding the information presented herein, please do not hesitate to contact the undersigned.

Best Regards,

Ivey International Inc.

George A. Ivey, B.Sc., CEC, CES, CESA, P.Chem., EP
President and Senior Remediation Specialist

Ref: Chester River Hospital Center/Ivey-sol Push-Pull Proposal/ 130627-12 (FINAL WITHOUT COST Proposal)

APPENDIX

IVEY-SOL® CASE STUDIES

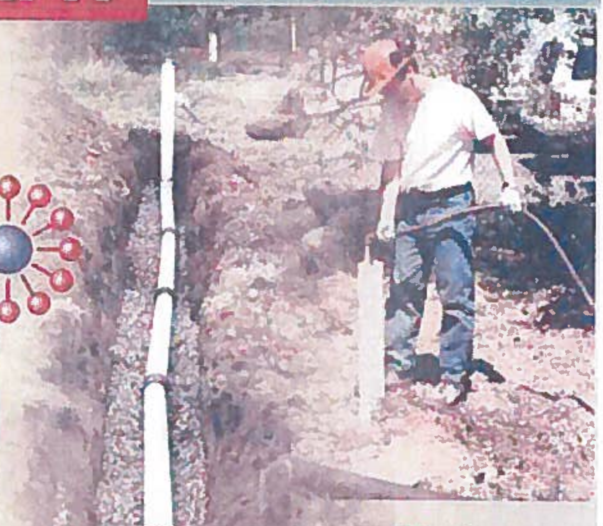
Field Surface Tension Agitation Test

EPA Ivey-sol Testing Methods

Client Testimonials

Ivey International Inc.

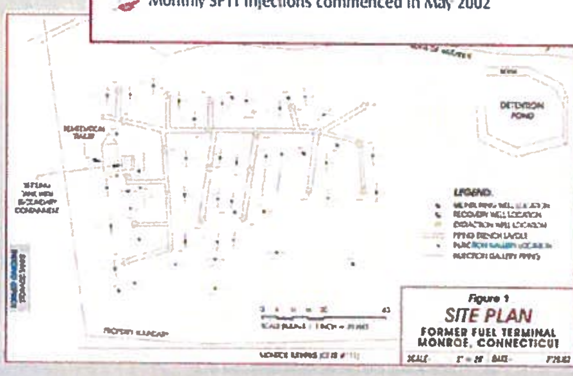
Case Study: Monroe, Connecticut, USA

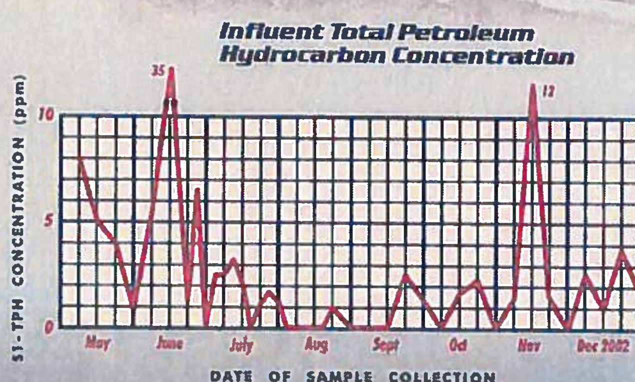


Monroe Facts:

- Former heating oil terminal from the mid-1950's to the late 1970's
- No. 2 fuel oil was stored at the site
- Multiple releases occurred over time
- Site and surrounding area are wetlands, with the former terminal area elevated with fill material for commercial use
- Irregular fill consisting of sand, silt, gravel and boulders with some timbers and metal buried throughout the site
- Sensitive receptors are adjacent stream and down-gradient potable wells
- High vacuum (dual phase) extraction system in use at the site since late 1999
- Selective Phase Transfer Technology (SPTT) system installed in May 2002
- Monthly SPTT injections commenced in May 2002

Site Images





Conclusions:

- Mass Recovery = Flow Rate x Concentration
- Mass Recovery (pounds per day) = gallons per minute (gpm) x mg/l x 0.012
- 3.785 l/gal x 1 lb/454,000 mg x 1440 minutes/day = 0.012
- Mass Recovery prior to the injection period is based on an average influent concentration of 0.75 mg/l
- 8 gpm x .075 mg/l x 0.012 = 0.072 lbs/day = 3.269 x 10^4 mg/day (prior to SPTT use)
- Mass Recovery during the injection period is based on a concentration average calculated using the post injection peak concentrations of 3.07 mg/l
- 8 gpm x 3.07 mg/l x 0.012 = 0.29472 lbs/day = 13.38 x 10^4 mg/day (during SPTT use)
- **Pre vs. post injection mass removal rates show an increase of 409.3%**

Handex Environmental, Inc.
PRACTICAL ENVIRONMENTAL SOLUTIONS

Today's Environmental Solutions For a Better Tomorrow.™

"The Ivey-sol surfactant products significantly enhanced our contaminant mass recovery by >400%, and put a rapid end to a 5 year plus remediation project in less than 9 months. We were very pleased with the results and would recommend it's use to enhancing site remediation."

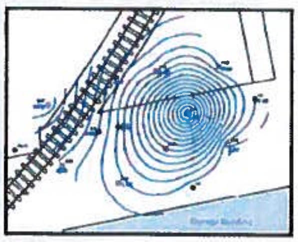
Dan Smith, Project Manager – Handex Environmental, Inc.

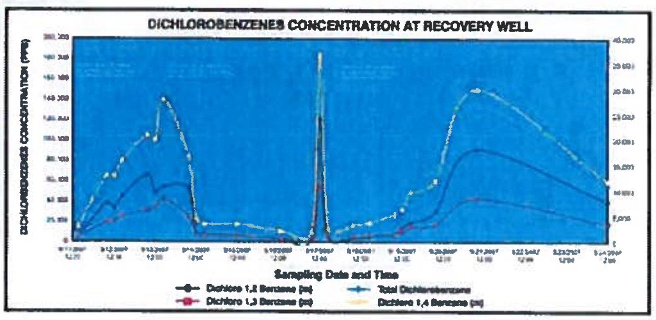
Ivey International Inc.

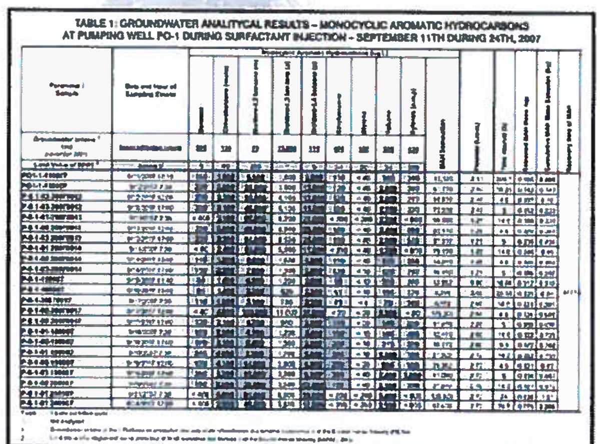
Case Study: In-situ Surfactant Enhanced DNAPL Recovery Pilot Project – Refinery Site, Montreal, Canada

PROJECT FACTS:

- Active chemical refinery (20 acre site)
- Several DNAPL (TCE chlorobenzene and dichlorobenzenes) and BTEX stored on-site
- Multiple DNAPL and BTEX spill events reported over a site history extending back to the 1950s
- DNAPL and BTEX impacts to both the local soil and groundwater covering an 8 acre (+) area
- Risk: potential risk for impacting the nearby municipal groundwater aquifer
- Soil comprised of glacial till, silt and silty sand
- Property owner tried several different in-situ remediation technologies over the past 3 years without success, at a considerable cost
- Ivey-sol® 106 pilot scale injection program between September 11 - 24, 2007
- Pump and treatment system installed and operating with 3 inch Hg vacuum
- Pilot scale results demonstrated significant ability to improve contaminant (DNAPL & LNAPL) mass recovery and potential to clean up the site in a rapid and cost effective manner







RESULTS:

"The in-situ application of the Ivey-sol® surfactant technology significantly increased the DNAPL (>500%) and BTEX (>300%) mass recovery from the impacted soil and groundwater on-site. We were very pleased by these results leading to our recommending a full scale site application as a potentially rapid and cost effective method to achieve site clean up."

– Martin Beaudoin, Project Engineer with Sanexen Environmental Services Inc.

"Today's Environmental Solutions For A Better Tomorrow"

Contact: Ivey International Inc, Tel: 250-923-6326,
Fax: 250-923-0718, Email: budivey@iveyinternational.com

Surfactant Enhanced HVDPE Remediation of Petroleum Contaminated Soil, Bedrock and Groundwater

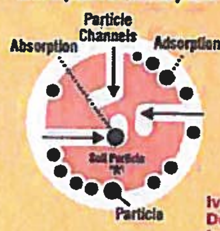
Site Conditions

Remediation Challenge

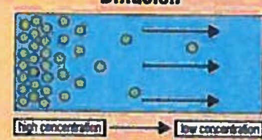
The number one limiting factor for all forms of in-situ remediation is contaminant sorption

Sorption >>>>>Desorption or Diffusion

Absorption vs Adsorption



Diffusion



solute

Solute transport is from the left to the right; movement of the solutes is due to concentration gradient (dC/dx).

Ivey-sol® Overcomes Sorption Improving Desorption & Diffusion of Contaminants Increasing Their 'Availability' for Remediation

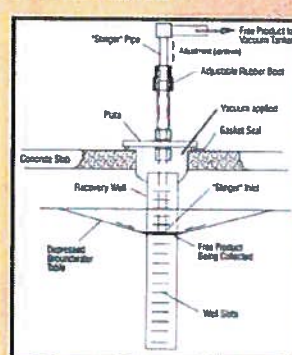
- ★ Recalcitrant petroleum product residuals sorbed in fine grain soils and fractured bedrock
- ★ Persistent concentrations in groundwater after 12 years of remediation – including pumping, HVDPE
- ★ Obtained regulatory approval for Ivey-sol® surfactant application in spring 2009

Pilot Test Approach

Focused Short-Term Surfactant Injection/Extraction to Maximize Recovery

- Ivey-sol® 106 pilot scale injection undertaken over 5 days in July 2009
- Four injection events, one injection well (MW15) and four extraction HVDEP wells (MW2, 7, 8 and 11)
- Five surrounding monitoring wells sampled during pilot
- Mobile HVDPE system capable of 28 inch Hg vacuum and 800 SCFM
- Groundwater HVDEP average recovery rate of 0.24 ppm

- Recalcitrant petroleum product residuals in fractured bedrock
- Persistent concentrations in groundwater after 12 years of remediation – including pumping, HVDPE



HVDPE Extraction Well
Diagram shows radius of influence and potential LNAPL collection

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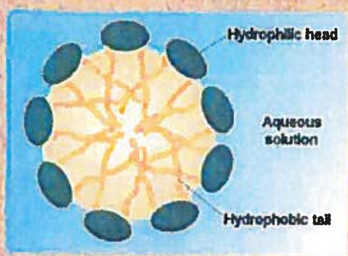
www.iveyinternational.com

RMT
Galen Kenoyer | Tel. 1-213-700-8704 | E: galen.kenoyer@rmtinc.com
Chris D'Sa | Tel. 1:310.570.7069 | E: Chris.dSa@rmtinc.com

Surfactant Chemistry

Surfactant Structure



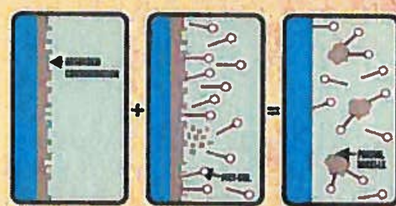
Hydrophilic (water loving) and Hydrophobic (water hating oil-liking) Groupings allow for Mobilization of many Organic Contaminants

Classes of Surfactants

- Anionic: Have one or more negatively (-) charged groupings; commonly used in laundry detergent
- Cationic: Have one or more positively (+) charged groupings, typically poor detergents but well suited for use as germicides, fabric softeners and emulsifiers.
- Amphoteric: Contains both anionic and cationic groupings; prefer neutral pH and found in products such as hair shampoo, skin cleaners and carpet shampoo.
  - *Ionic Surfactants make up >95% of the surfactant used around the world.*
- Non-ionic: Have no ionic constituents or groupings; largest single group of SAA (Surface Active Agent) and have a correspondingly wide range of chemical characteristics. Ivey-sol® surfactant mixtures are non-ionic and have the unique ability to selectively desorb contamination (LNAPL, DNAPL's, PAH, PCB, DCE, TCE, PCE), etc.

Why Ivey-sol® Surfactants?

- Improves desorption of target contaminants in soil and groundwater
- Lowers the surface tension of water improving both its wetting and associated permeability (K) properties
- Effective as a stand alone technology for soil and groundwater remediation
- Effective to improve other remediation techniques (i.e., P&T, Soil Washing, Bioremediation, Chemical Oxidation/Reduction)

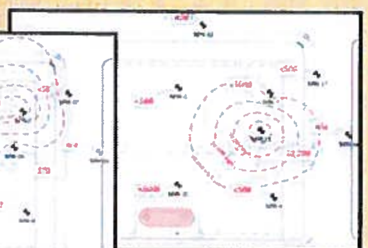


Ivey-sol® desorbing NAPL mass for increased 'availability' for remediation

Results

Before and During Test

TPH-d Isocon Map
before Pilot Test

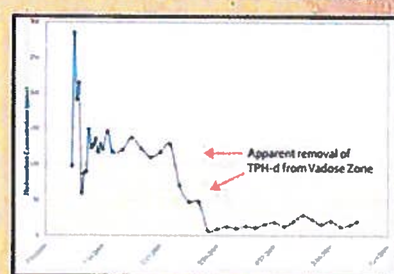


TPH-d Isocon Map
2 hrs after Pilot Test

Post Pilot Test Results

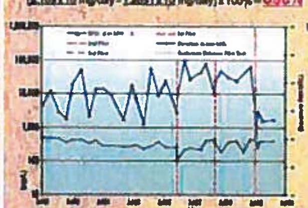
TPH-d Isocon Map
7 months after Pilot Test

HVDPE Vapor Concentrations



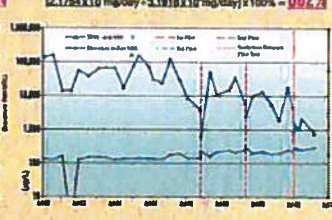
MW-2

[illegible] mg/day - [illegible] mg/day] x 100% = 590%



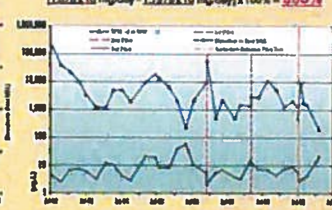
MW-7

[illegible] mg/day - [illegible] mg/day] x 100% = 682%



MW-11

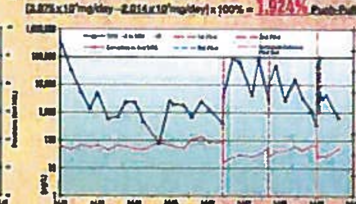
[illegible] mg/day - [illegible] mg/day] x 100% = 955%



MW-15

[illegible] mg/day - [illegible] mg/day] x 100% = 1,598% Standard Pilot

[illegible] mg/day - [illegible] mg/day] x 100% = 1,924% Push-Pull



Conclusions: We increased the TPH_d Mass Recovery Rate by 10X !!!

- Removed TPH-d from vadose zone
- Lowered groundwater concentrations
- Regulatory Agency agree to risk-based closure if concentrations continue to decrease
- Pilot Application was a Success!

Ivey International Inc.
"Today's Environmental Solutions For A Better Tomorrow"™
www.iveyinternational.com

RMT
Galen Kenoyer | Tel. 1-213-700-8704 | E: galen.kenoyer@rmtinc.com
Chris D'Sa | Tel. 1.310.570.7069 | E: Chris.dSa@rmtinc.com

Ivey-Sol® 103 Successfully Treats Free-Phase Impacted Shale Via On-Site Washing

CASE SUMMARY

Undisclosed Site, Ontario, 2008

Environmental investigation of a grass-covered area uncovered free phase petroleum (F3-F4 fraction heavy oils) in fractured, weathered shale. A pilot project was undertaken by **Terratechnik Ltd.** to excavate the shale and treat it by washing with a non-ionic surfactant, Ivey-Sol® 103.

Ivey-Sol® Benefits

- Operates below the critical micelle concentration facilitating low application rates
- Strongly enhances the solubility of hydrophobic compounds
- Does not cause emulsification of oils
- Does not foul traditional wastewater treatment systems (i.e. organoclays, GAC, etc.)
- Unlike ionic surfactants Ivey-Sol® does not disperse in the aqueous phase
- There are various formulations (103, 106, 108) designed for specific types of contaminants

Pilot Study

Washing was first conducted using just water, as a baseline for washing efficiency. Washing time was the only variable. Results are reported qualitatively.

Wash Solution	Total Time	Ratio Material: Wash-Solution (V:V)	Visual Observations of Treated Shale
H_2O	< 1 min	0.05	Free Product, Sheen and Strong Odour
H_20	2 min	0.10	Free Product, Sheen and Strong Odour
H_20	3 min	0.15	Sheen and Strong Odour
H_20	5 min	0.25	Sheen and Strong Odour
H_20	8 min	0.40	Sheen and Strong Odour

Based on the results of washing with only water, it appeared that the addition of a surfactant to facilitate the desorption of the contaminant was necessary. The shale was subsequently washed using various concentrations of Ivey-sol® 103 to determine the most efficient combination of washing time and surfactant concentration.

The results are reported below:

Wash Solution	Conc. (ml/L)	Total Time	Ratio Material: Wash-Solution (V:V)	Visual Observations of Treated Shale
Ivey-Sol® 103	1	1 min	0.05	Free Product, Sheen and Strong Odour
Ivey-Sol® 103	1	3 min	0.15	Sheen and Strong Odour
Ivey-Sol® 103	1	5 min	0.25	Sheen and Moderate Odour
Ivey-Sol® 103	4	1 min	0.05	Sheen and Strong Odour
Ivey-Sol® 103	4	3 min	0.15	No Sheen, Slight Odour
Ivey-Sol® 103	4	5 min	0.25	No Sheen, No Odour
Ivey-Sol® 103	8	1 min	0.05	Sheen and Strong Odour
Ivey-Sol® 103	8	3 min	0.15	No Sheen, No Odour
Ivey-Sol® 103	8	5 min	0.25	No Sheen, No Odour

After several iterations, it was found that the most efficient combination was a surfactant concentration of between 0.4% to 0.8% and washing for 3-5 minutes per cubic metre of shale.

Conclusions

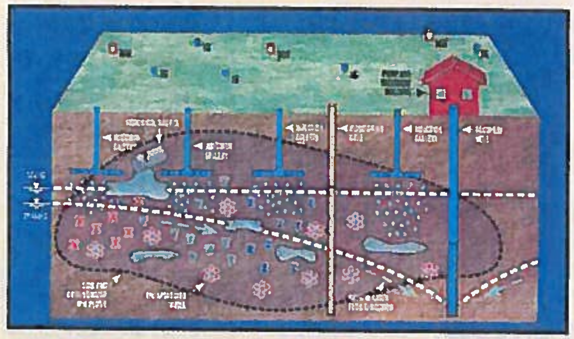
Using low concentrations of Ivey-Sol® solution, free product was successfully removed from shale. Soil/shale washing with Ivey-Sol® is a cost-effective technology for on-site treatment of impacted soils.

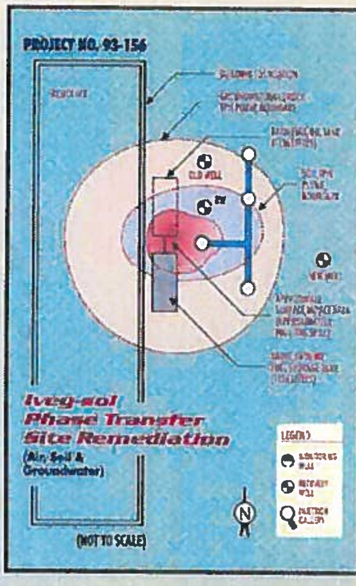
Based on the parameters above, projected treatment price for a small scale project (< 2,000 tonnes) would be $35 per tonne, which is currently less expensive than disposing of the impacted material at a landfill and replacement with clean fill. Obviously, with larger projects, the economies of scale will drive the price down even lower.

Canada Colors & Chemicals (CCC) is the exclusive distributor of Ivey-Sol® products in Canada as well as many other remediation products. ***Terratechnik Environmental Ltd*** holds MOE issued Certificates of Approval for the application of Ivey-Sol® products along with a wealth of remediation experience. Please call Leonard Chan of CCC at 416-346-5130 to discuss specific approaches and products suitable to your needs.

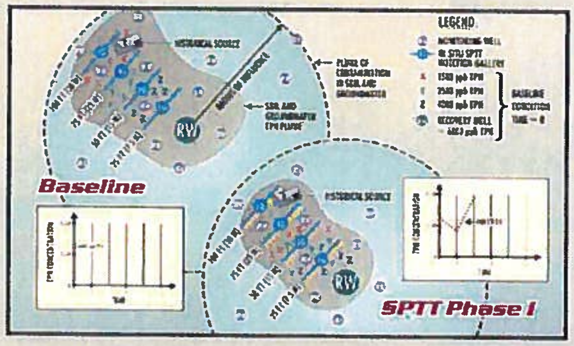
Ivey International Inc.
In-Situ Case Study #2

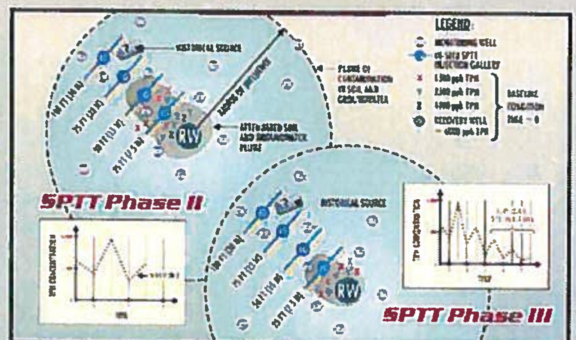
LNAPL Remediation



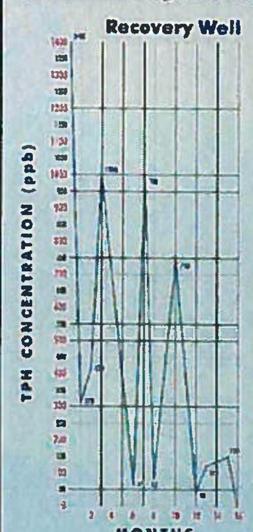


- Approx. 900 L (200 gal) fuel oil spill at the above ground storage tank
- Drinking water well and bedrock-aquifer were contaminated at 1400 ppb TPH
- Classified as a Sensitive Site by the Department of Environment with a 10 ppb TPH groundwater clean-up objective





Groundwater Hydrocarbon Analysis



- Ivey International Inc. installed a pump & treat system at the recovery well
- Several Ivey-sol injection galleries were designed and installed
- The site was successfully cleaned up to under 10 ppb in less than 18 months
- The client estimates the savings at > $50,000
- The Department of the Environment decommissioned the site

IVEY-SOL FACT:

90-95%

of Ivey International Inc. clients have their site cleaned up in under 18 months on average, and can claim cost savings of at least 20%–40% compared to alternative technologies.

Today's Environmental Solutions For a Better Tomorrow.™

Ivey International Inc. www.iveyinternational.com
PO Box 706, Campbell River, BC V9W 6J3 Canada
Tel: 250-923-6326 Fax: 1-888-640-3622

Ivey-sol® Surfactant Technology
"TODAY'S ENVIRONMENTAL SOLUTIONS FOR A BETTER TOMORROW"®
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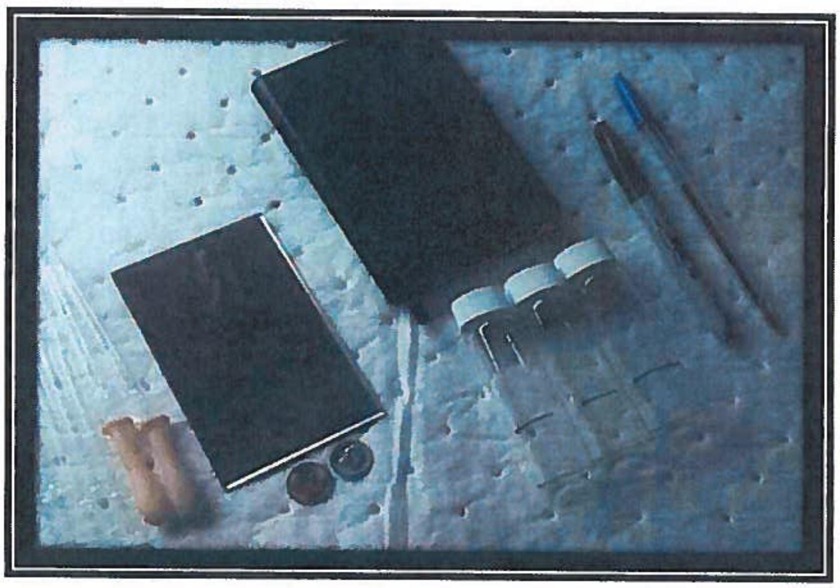
Surface Tension & Agitation Field Tests

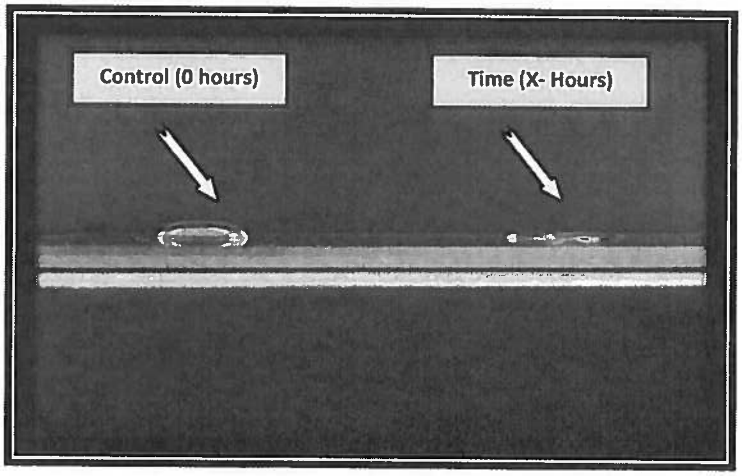
During in-situ Ivey-sol® surfactant enhanced contaminant remediation injection events, it is possible for field staff to evaluate *'in real time'* if and when the Ivey-sol surfactants, and their associated desorbed contaminant mass, are being recovered at the extraction/recovery wells on-site. In response to client requests, Ivey International Inc. developed two simple, economical, and easy to use field test procedures to aid environmental consultants and contractors, during their Ivey-sol applications, to make better decisions regarding which time based water samples collected at the extraction/recovery wells should be submitted for laboratory analysis, and to evaluate the effectiveness of their Ivey-sol site applications, and determine status of each injection if performing multiple injection extraction events over a period of a few days. These visual field test methods are as follows:

- Surface Tension Test; and
- Agitation Test



The components of the basic field test kits are shown in the above photograph. For the Surface Tension Test you require a small glass plate or mirror, glass droppers, and a penny and dime that can be used as size references for the surface tension test. The Agitation Test kit requires 40 ml clear vials, a small ruler (cm) and black marker. A field note book and pen to record observations completes the basic kits. With the exception of the glass plate, most environmental laboratories will provide the 40 ml vials and glass droppers to their clients for free, thus making this test kit easy and inexpensive to prepare. You can use one or both of these field tests to identify when the desorbed contaminants were being recovered at extraction/recovery wells. Each test is described with photographs below.

Surface Tension Test:
The physical interaction between water molecules, known as hydrogen bonding, gives rise to surface tension and explains why water beads. In the presence of the Ivey-sol surfactant, the surface tension of water can be reduced from 73 dynes to < 30 dynes. The photograph below shows water (Left) taken from an extraction/recovery well before performing an Ivey-sol injection, while the drop on the right shows the water extracted from the extraction/recovery well(s) several hours (Time 'X') after the Ivey-sol injection.

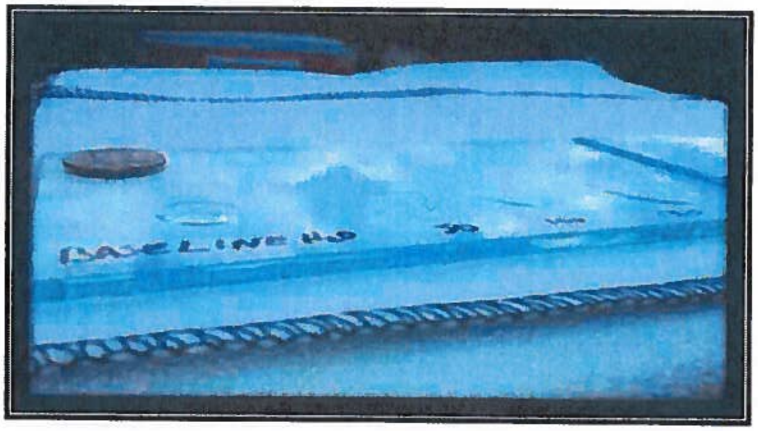


To undertake the Surface Tension Test at a site, you collect a water sample from each of the extraction/recovery wells you will be pumping from before the Ivey-sol injection. These samples serve as '*Control*' reference baseline samples for the evaluation of the Ivey-sol application process. After the Ivey-sol injection, you collect '*Time*' based (1 hour, 2 hours, 3 hours, etc.) groundwater samples at each of the extraction/recovery wells to permit a time based evaluation of the Ivey-sol application and help determine when the desorbed contaminants are being liberated and their associated mass is recovered at the designated extraction/recovery wells on-site.

Once the control and time based samples are collected, you put 20 droplets of the Control (baseline) sample on the clean glass surface to form a single reference droplet (about the size of a dime or penny) Then 20 drops of the time based (Time 'X') sample, as shown in above photograph. As the Ivey-sol surfactant lowers the surface tension of the water, the angle of incidence of the droplet to the glass decreases (become more flat) over time. This reduction in angle of incidence is a good visual indicator of the presence of Ivey-sol surfactant and associated contaminant mass liberated for recovery at the extraction/recovery wells.

You can also visualize the general shape of the droplet. The control is usually quite round, while the time based samples become increasingly more irregular in shape. The photograph below shows the side by side comparison of a baseline reference (control) droplet to the 50, 100, 150 time unit based (i.e., minutes or hours) water samples. At 50, the surface tension is lower (droplet is flatter) than the baseline, and the shape is just a little less circular. At 150, the droplet is very flat and very thin and very irregular in shape. The interpretation would generally be that at 50, the Ivey-sol and associated desorbed contaminants were just arriving at the extraction well(s), while at 150, they were at their highest concentration before decaying back to baseline conditions over the next 150 to 180 time units.

Water samples collected before 50 may not be as indicative for evaluating the efficacy (performance) of the Ivey-sol as would the samples collected after 50 time units. The client would likely submit a sample at time 0, 50, 150, 200, 300, and potentially 350 or 400, based on this field test.



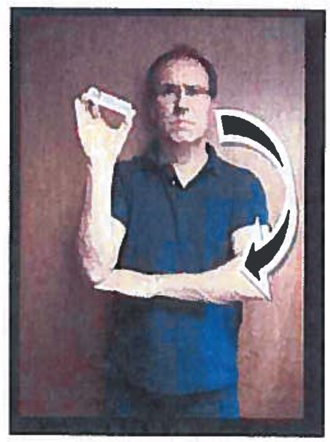
Agitation Test:

This test, like the surface tension test, involves the collection of a control (baseline) Time '0' baseline reference sample, and several time based water samples from each extraction/recovery well(s) on site. An example of such is shown in the photograph below.

To undertake the Agitation Test, you take 40 ml clear vials and mark them all at 3 cm from bottom with a black marker. This line indicates the *'fill to'* level for the water samples to keep all consistent. The cap is placed on the sample. These time based samples are then placed between the index finger tip and thumb of right hand (left if left handed), with the left forearm horizontal to the ground at stomach level (See photographs below). The right forearm is placed on top of the left and rotated up through 90 degrees vertically over 1 second period and repeated 5 times (See photographs below). The vials are *NOT* vigarously shaken as too inconsistent a procedure.

The samples are then visually inspected and the thickness of any bubbles are measured and recorded. Each time based sample can be visually compared to the control baseline reference sample, and each other, over a designated time period. The basline will generally have no bubbles, while the time based samples will start to have a few bubbles over time that go from < 0.5 mm, to 1 mm, to 2 mm, etc. then reach a maximum mm thickness before slowly reducing in thickness until no persistance of bubbles is observed and the baseline (pre Ivey-sol injection) conditions have returned.

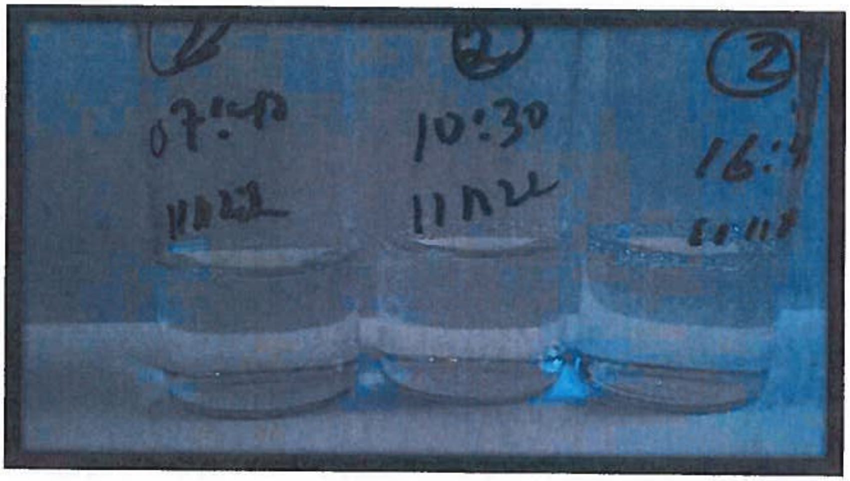
The appearance of persistant bubbles is a visual indicactor that the Ivey-sol surfactant and associated contamination have arrived at the extraction/recovery wells. As the thickness of bubbles increases, so does the associated concentration of Ivey-sol and desorbed contaminants being extracted/recovered. As the concentration of Ivey-sol decreases with groundwater extraction, the observed bubbles will subside over time until original baseline groundwater conditions (pre Ivey-sol injection) are re-established.



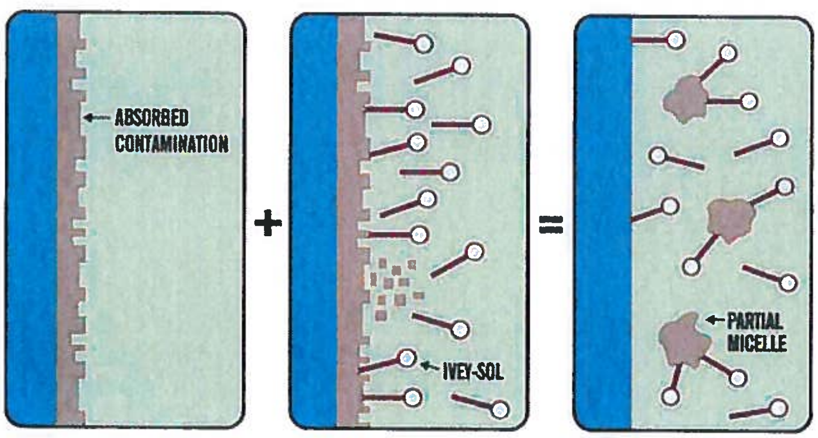
The photograph below shows three water samples collected at a site during a multi-day Ivey-sol injection extraction pilot event. These samples were taken on day two. You will note just a few minor bubbles in the 07:40 sample (Day 2 Baseline), which increases to 1 mm by 10:30, then 2 mm by 16:40. The 07:40 sample indicated that the Ivey-sol injection from day 1 was essentially concluded with only residual concentrations present allowing them to complete the second injection moments later.

The 10:30 and 16:40 samples showed the presence of Ivey-sol and associated contaminant mass recovery at the extraction/recovery wells. These samples allowed the field technician, and/or project manager to make 'informed' decisions regarding which samples should be submitted to the laboratory for analysis and the real-time status of the Ivey-sol injection event for tracking mass recovery and the planning of a third injection on day three of the subject application.

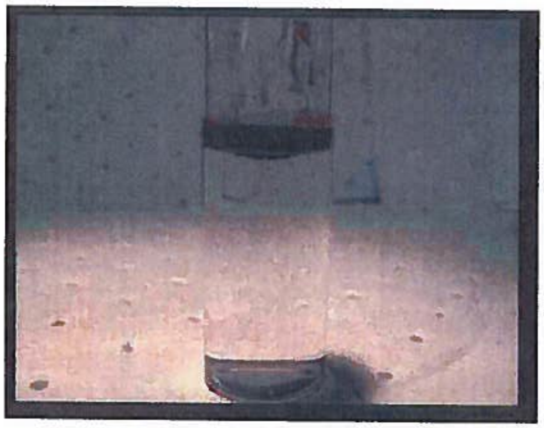
A sample field observation table, to log surface tension and aggitation tests results, is provided (Modify to your needs) below on Page 7.

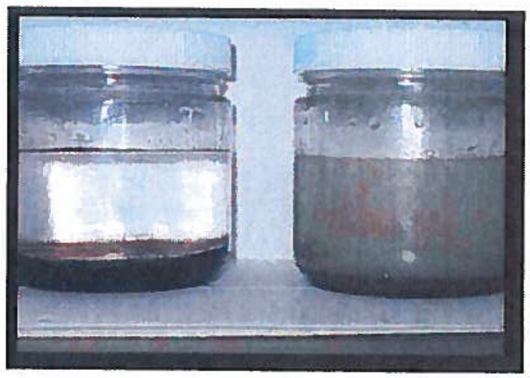


The Ivey-sol surfactants can selectively desorb sorbed contamination off the soil into the groundwater for enhanced contaminant mass recovery within the aqueous phase. This ability makes the contaminants more *'Physically Available'* for in-situ pump and treatment or push-pull applications and ex-situ soil washing. It makes the sorbed contaminants more *'Bio-Available'* for in-situ and ex-situ bioremediation. It can also make the contaminants more 'Chemically Available' for REDOX chemicalization. The mechanism of how the Ivey-sol desorbed the contaminants without forming a micelle (i.e., below the CMC) is illustrated below.



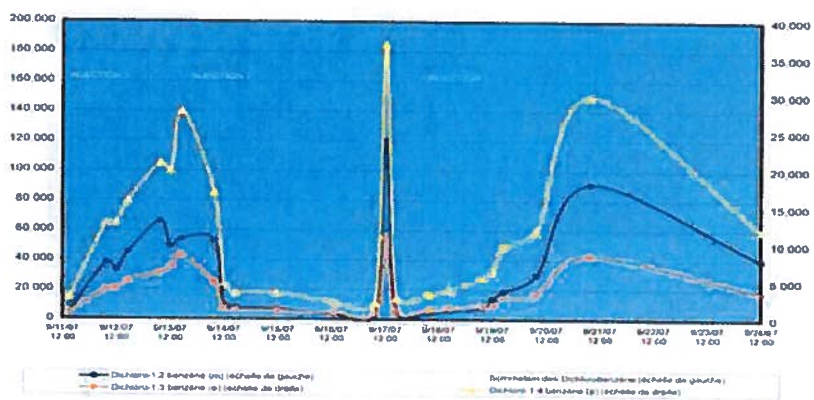
These two photographs show a pre and post Ivey-sol effect on heavy oil contamination and chlorinated solvent contamination during in-situ applications to enhance the associated contaminant mass removal for the Ivey-sol site applications.





These photographs below show petroleum contaminated soil before and after Ivey-sol applications from an ex-situ soil washing treatment process.

The following is an example of a graphs of groundwater laboratory analysis results generated from a site that employed the above Surface Tension and Agitation Field Test methods to aid improved decision making for sample selection for analysis and to determine when the effect of a series of Ivey-sol injections have been resolved between Ivey-sol injection events over a multi-day period.



Sample Field Observation Table

TIME (min)	RW/EW 1		RW/EW 2		Etc...	
	Surf.Tension	Aggitation	Surf.Tension	Aggitation	Surf.Tension	Aggitation
00						
15						
30						
60						
90						
120						
180						
240						
300						
360						
Etc.						

For more information contact:

Ivey International Inc.

Tel: 1-604-538-1168 Toll Free: 1-800-246-2744

info@iveyinternational.com

www.iveyinternational.com

Ref:Ivey-sol/SurfaceTensionAgitationTest/120904-07

Ivey International Inc.

"Today's Environmental Solutions For A Better Tomorrow"

EPA Approved
Testing Methods For
Ivey-sol® • Decon-It® • Surf Clean®
Non-Ionic Surfactant Products

CTAS: **Cobalt thiocyanate active substances (CTAS)/non-ionic surfactants using EPA Method SM5540D**

MBAS: **Methylene blue active substances (MBAS)/anionic surfactants using EPA Method SM5540C**

Most environmental laboratories have the ability to conduct these tests.
If you have any difficulty in locating a laboratory who conducts these EPA standard method tests, please contact our office at 1.800.246.2744 or E-mail: info@iveyinternationa.com

Client Testimonials

"We used Ivey-sol surfactant technology and experienced a greater than 400% enhancement of contaminant mass recovery! This innovative technology significantly sped up remediation saving my clients time and money! We were very pleased with the results and would recommend others to try it"
Dan Smith, Principle Hydrogeologist
Metric Earth Services, LLC

"Using low concentrations of Ivey-sol solution, free product was successfully removed from shale. Soil shale washing with Ivey-sol is a cost-effective technology for on-site treatment of impacted soils. Based on the parameters above, projected treatment price for a small scale project (< 2,000 tones) would be $35 per ton, which is currently less expensive than disposing of the impacted material at a landfill and replacement with clean fill. Obviously, with larger projects, the economies of scale will drive the price down even lower"
Kyle Dacey, Manager of Technical Services
Terratechnik Environmental Ltd.

"The in-situ application of the Ivey-sol surfactant technology significantly increased the DNAPL and BTEX mass recovery from the impacted soil and groundwater on-site. We were very pleased by these results leading to our recommending a full scale site application as a rapid and cost effective method to achieve site clean-up"
Martin Beaudoin, Project Engineer
Sanexen Environmental Services Inc.

"Ivey-sol has been proven highly effective at remediating both oil-based contamination and chlorinated solvents in a variety of different soil types, ranging from sands to clays. Given the current need for innovative and cost-effective cleanup technologies, usage of Ivey-sol will significantly increase in the upcoming years."
Bruce Tunnicliffe, President
Vertex Environmental Inc.

"I credit this technology with saving my company tens of thousands of dollars after using it to treat a fuel-oil spill. Drinking water was contaminated and I looked at a number of technologies. They wanted to put recovery towers in and stripper systems costing more than $100,000, and I was told remediation would take five to seven years. But Ivey-sol did it in less than 18 months saving some $60,000, while meeting stringent environmental standards."
Peter Clark, President
Clark Oil Co. Ltd. (Ultramar)

"After excavation and bio-piling of the soil, the surfactant enhanced bioremediation (SEB) treatment was applied and the bio-pile was covered. Daily aeration was done during the treatment period. After only 12 weeks samples were taken from the bio-pile showing that the remediation of the fuel-oil and PAH contamination was completed to the BC Environmental Standards and safe for reuse on-site"
Tony Robson, Director Mining & Equipment
Quinsam Coal Corporation

"This process is very cost effective and will save between $40,000 to $60,000 compared to the closest available technology that we are aware of. Our division has been working closely with Ivey International for over a year and is convinced this is the future for in-situ remediation."
Steve Wasson, P. Eng., Coordinator of Environmental Services
Key Safety Services Inc.

"We increased the TPH Mass Recovery Rate by 10x, removed TPH-d from vadose zone and lowered groundwater concentrations. Regulatory Agency agrees to a risk based closure in contamination levels continue to decrease"
Galen Kenoyer, Senior Hydrogeologist
Chris D'Sa, Senior Project Manager
TRC

"I think the future for the Ivey-sol surfactant technology is bright. It's based on sound science and Ivey International Inc. has lots of field application experience"
Lisa Rear, P.Bio.
Environmental Consultant

"We observed a noticeable drop in the level of contaminants within a two-month period"
Brad Shybunka, Senior Project Manager Operations.
Bio-Synergy Inc.

"We used a combination of Ivey-sol technology and soil excavation. It certainly saved us the headache of having to do more by way of foundation excavation. The result was the important thing. Ivey-sol was a good add-on to the original excavation and we got the results we wanted"
Mike Roy, Senior Claims Adjuster
Plant Hope Adjusters Ltd.

"The project we are now working on is in tight clay soil, 6 meters deep, 35 meters by 20 meters in area. The projected clean up will be nine to 12 months. This is very fast compared to any other in-situ process that we are aware of. The only thing faster is digging up the site and hauling away the soil."
Terry Timothy, Manager of Environmental Services
Key Safety Services Inc.

"Our research has confirmed that the Ivey-sol surfactant technology increases the controlled solubility and rate of MTBE recovery from impacted soil and groundwater by >740%"
Dr. Davis Craft
University of Alberta

"Our research has shown that the Ivey-sol surfactant technology can increases the controlled solubility rate of PCB into groundwater by >900%"
Dr. Davis Craft
University of Alberta

"The name of the game is satisfactory results and closing the file as quickly as possible. Ivey-sol technology is a big help when excavation isn't an attractive option"
Bill McCann, Senior Claims Adjuster
Halifax Insurance

"We accomplished more with $50,000 of Ivey-sol than we did with the first $500,000 we spent on the site over the previous 4 years. Ivey-sol Increased our rate of contaminant recovery by >400%"
Dan Smith, Hydrogeologist
HANDEX of Connecticut

"We had to evacuate the building after the oil spill, it was a mess. Ivey-sol cleaned up the site up rapidly. It improved the air, soil and groundwater quality"
John Vidditto
Developer/ Property Owner

For more information about the Ivey-sol surfactant technology, learn about our other innovative remediation technologies, to find a local distributor, or obtain free technical support, visit www.iveyinternationa.com

APPENDIX III

EBA Engineering Inc.
4813 Seton Drive
Baltimore, MD 21215

o 410.358.7171
f 410.358.7213
w www.ebaengineering.com

July 18, 2013

Mr. Scott D. Burleson, MBA, FACHE,
Executive Vice President
Chester River Hospital Center
100 Brown Street
Chestertown, MD 21620

Subject: On-Call Environmental Consulting Services for Chester River Hospital Center

Reference: DMW Project No. 13402.00
EBA Engineering Inc. Proposal G13-139

Dear Mr. Burleson:

EBA Engineering Inc. (EBA) is pleased to submit this proposal to Chester River Hospital Center (CRHC) for providing on-call environmental consulting services. It is our understanding the site is listed with the Maryland Department of the Environment - Oil Control Program (MDE-OCP) under Case No. 1987-2534-KE. We also understand that on behalf of CRHC, Daft-McCune-Walker, Inc. (DMW) is pursuing final remediation efforts and ultimately case closure with the MDE.

Scope of Work

EBA is experienced in working with the MDE-OCP and will provide technical assistance to the CRHC team. It is our understanding the CRHC team consists of the following:

- DMW – Providing oversight on behalf of CRHC for pursuing final remediation efforts and case closure.
- Earth Data – Responsible for continued operation/maintenance of the existing pump and treat system, providing labor and equipment as needed during the Ivey-Sol "Push-Pull" application.
- Ivey International – Responsible for implementation of Ivey-Sol® "Push-Pull" application.
- EBA will be responsible for:
  - Provide support in preparation of CRHC Groundwater Remediation 2013 Action Plan to be submitted to MDE for approval and implementation.
  - Provide correspondence updates including phone calls, emails, and letters.
  - Provide a determination for need of new recovery wells.
  - Performing monthly gauging and sampling of the eleven (11) down gradient monitoring wells (MW15, MW16, MW19, MW20, MW24, MW33, MW34, MW35,

MW48, MW49, and MW50) for TPH-DRO only as referenced in the 2013 Action Plan.
- Review and interpretation and discussion of laboratory analytical data.
- Prepare monthly progress reports for submission to DMW.
- Prepare quarterly monitoring reports for submission to DMW.
- Overseeing of third party contractors (i.e. Phase Separation Science, Ivey International, and Earth Data).
- Compilation of case closure documentation.

Additional work activities will be based upon the direction of DMW. A potential list of work activities include:

- Additional site visits.
- Locate and design of new recovery wells.
- Oversight of recovery well installation.
- Oversight of Ivey-Sol follow-up application.

Assumptions/Exclusions/Limitations

The following assumptions, exclusions, and limitations apply to this proposal:

- EBA's services do not include advice, opinions, or recommendations associated with the Ivey-sol® Surfactant Enhanced Remediation "Push-Pull" application.
- All labor, material, and equipment required to implement the Ivey-sol® Surfactant Enhanced Remediation "Push-Pull" application is excluded.
- Installations of new monitoring wells are excluded.
- CRHC will provide a copy of all site data in a usable electronic format. These include, but not limited to, CADD files for site plans and excel files for monitoring data.
- CRHC will provide complete site access including onsite parking, keys to monitoring wells, and access to all monitoring wells.
- Storage and disposal of free product, if encountered, is not included.

Terms & Conditions

The above rates will be billed in accordance with the Time & Material Units presented above. Each invoice will be accompanied by a progress report detailing the activities performed for the invoice period.

Invoices will be due and payable within 60 days after issuance. For invoices not paid within 90 days, interest at the rate of 1.5% per month shall accrue starting with the date of the invoice. For invoices not paid within 90 days, CRHC agrees to reimburse EBA Engineering for reasonable costs associated with collecting overdue amounts.

AUTHORIZATION

This proposal will be honored for a period of 60 days from the date of this quotation. Acceptance of this proposal can be accomplished by the return of your organization's Purchase Order or a signed copy of this proposal.

PROJECT SCHEDULE

A formal schedule remains to be determined. Upon receipt of Notice to Proceed, EBA and DMW will jointly determine a schedule for execution of assigned tasks.

EBA appreciates this opportunity for preparing this proposal. Should you have any questions regarding this cost proposal, do not hesitate to call upon m e at 410-504-6062.

Sincerely,

EBA Engineering, Inc.

Amar Sokhey, P.E., F.ASCE
Vice President

Kunal Gangopadhyay, P.E.
First Executive Vice President

Proposal Accepted for Chester River Hospital Center by:

Signature ______________________ Title: ______________

Printed Name ______________________ Date: ______________

APPENDIX IV

Ivey-sol® Surfactant Technology
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Surface Tension & Agitation Field Tests

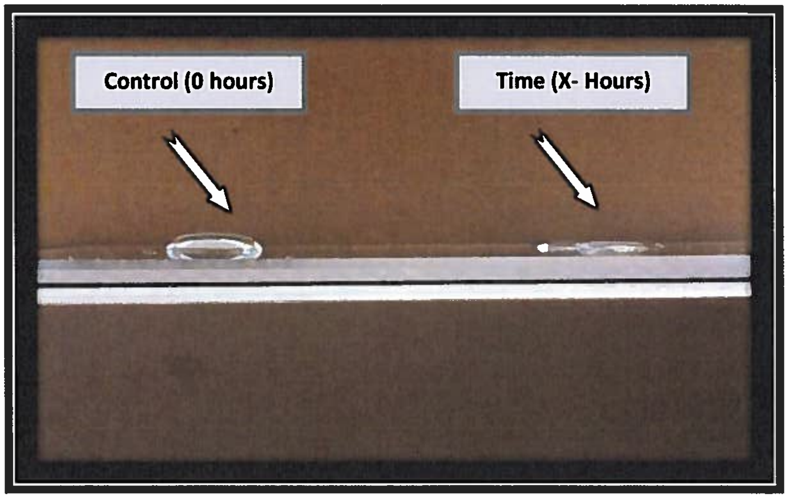
During in-situ Ivey-sol® surfactant enhanced contaminant remediation injection events, it is possible for field staff to evaluate *'in real time'* if and when the Ivey-sol surfactants, and their associated desorbed contaminant mass, are being recovered at the extraction/recovery wells on-site. In response to client requests, Ivey International Inc. developed two simple, economical, and easy to use field test procedures to aid environmental consultants and contractors, during their Ivey-sol applications, to make better decisions regarding which time based water samples collected at the extraction/recovery wells should be submitted for laboratory analysis, and to evaluate the effectiveness of their Ivey-sol site applications, and determine status of each injection if performing multiple injection extraction events over a period of a few days. These visual field test methods are as follows:

- Surface Tension Test; and
- Agitation Test

The components of the basic field test kits are shown in the above photograph. For the Surface Tension Test you require a small glass plate or mirror, glass droppers, and a penny and dime that can be used as size references for the surface tension test. The Agitation Test kit requires 40 ml clear vials, a small ruler (cm) and black marker. A field note book and pen to record observations completes the basic kits. With the exception of the glass plate, most environmental laboratories will provide the 40 ml vials and glass droppers to their clients for free, thus making this test kit easy and inexpensive to prepare. You can use one or both of these field tests to identify when the desorbed contaminants were being recovered at extraction/recovery wells. Each test is described with photographs below.

Surface Tension Test:

The physical interaction between water molecules, known as hydrogen bonding, gives rise to surface tension and explains why water beads. In the presence of the Ivey-sol surfactant, the surface tension of water can be reduced from 73 dynes to < 30 dynes. The photograph below shows water (Left) taken from an extraction/recovery well before performing an Ivey-sol injection, while the drop on the right shows the water extracted from the extraction/recovery well(s) several hours (Time 'X') after the Ivey-sol injection.



To undertake the Surface Tension Test at a site, you collect a water sample from each of the extraction/recovery wells you will be pumping from before the Ivey-sol injection. These samples serve as '*Control*' reference baseline samples for the evaluation of the Ivey-sol application process. After the Ivey-sol injection, you collect '*Time*' based (1 hour, 2 hours, 3 hours, etc.) groundwater samples at each of the extraction/recovery wells to permit a time based evaluation of the Ivey-sol application and help determine when the desorbed contaminants are being liberated and their associated mass is recovered at the designated extraction/recovery wells on-site.

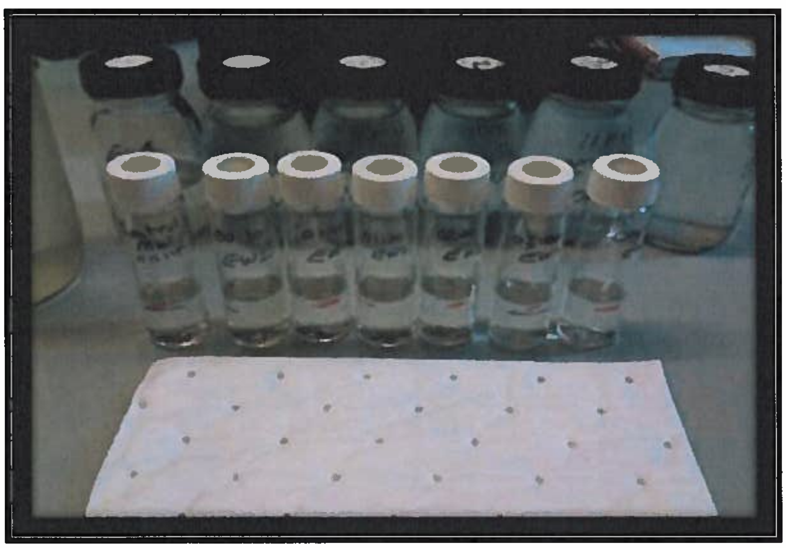
Once the control and time based samples are collected, you put 20 droplets of the Control (baseline) sample on the clean glass surface to form a single reference droplet (about the size of a dime or penny). Then 20 drops of the time based (Time 'X') sample, as shown in above photograph. As the Ivey-sol surfactant lowers the surface tension of the water, the angle of incidence of the droplet to the glass decreases (become more flat) over time. This reduction in angle of incidence is a good visual indicator of the presence of Ivey-sol surfactant and associated contaminant mass liberated for recovery at the extraction/recovery wells.

You can also visualize the general shape of the droplet. The control is usually quite round, while the time based samples become increasingly more irregular in shape. The photograph below shows the side by side comparison of a baseline reference (control) droplet to the 50, 100, 150 time unit based (i.e., minutes or hours) water samples. At 50, the surface tension is lower (droplet is flatter) than the baseline, and the shape is just a little less circular. At 150, the droplet is very flat and very thin and very irregular in shape. The interpretation would generally be that at 50, the Ivey-sol and associated desorbed contaminants were just arriving at the extraction well(s), while at 150, they were at their highest concentration before decaying back to baseline conditions over the next 150 to 180 time units.

Water samples collected before 50 may not be as indicative for evaluating the efficacy (performance) of the Ivey-sol as would the samples collected after 50 time units. The client would likely submit a sample at time 0, 50, 150, 200, 300, and potentially 350 or 400, based on this field test.

Agitation Test:

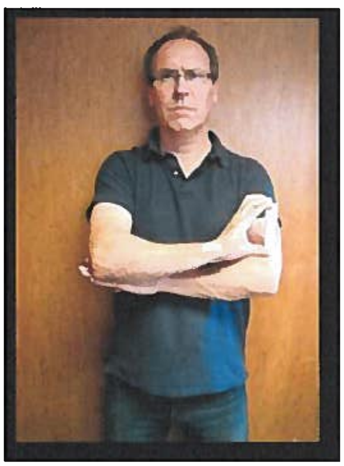
This test, like the surface tension test, involves the collection of a control (baseline) Time '0' baseline reference sample, and several time based water samples from each extraction/recovery well(s) on site. An example of such is shown in the photograph below.



To undertake the Agitation Test, you take 40 ml clear vials and mark them all at 3 cm from bottom with a black marker. This line indicates the *'fill to'* level for the water samples to keep all consistent. The cap is placed on the sample. These time based samples are then placed between the index finger tip and thumb of right hand (left if left handed), with the left forearm horizontal to the ground at stomach level (See photographs below). The right forearm is placed on top of the left and rotated up through 90 degrees vertically over 1 second period and repeated 5 times (See photographs below). The vials are *NOT* vigarously shaken as too inconsistent a procedure.

The samples are then visually inspected and the thickness of any bubbles are measured and recorded. Each time based sample can be visually compared to the control baseline reference sample, and each other, over a designated time period. The basline will generally have no bubbles, while the time based samples will start to have a few bubbles over time that go from < 0.5 mm, to 1 mm, to 2 mm, etc. then reach a maximum mm thickness before slowly reducing in thickness until no persistance of bubbles is observed and the baseline (pre Ivey-sol injection) conditions have returned.

The appearance of persistant bubbles is a visual indicactor that the Ivey-sol surfactant and associated contamination have arrived at the extraction/recovery wells. As the thickness of bubbles increases, so does the associated concentration of Ivey-sol and desorbed contaminants being extracted/recovered. As the concentration of Ivey-sol decreases with groundwater extraction, the observed bubbles will subside over time until original baseline groundwater conditions (pre Ivey-sol injection) are re-established.

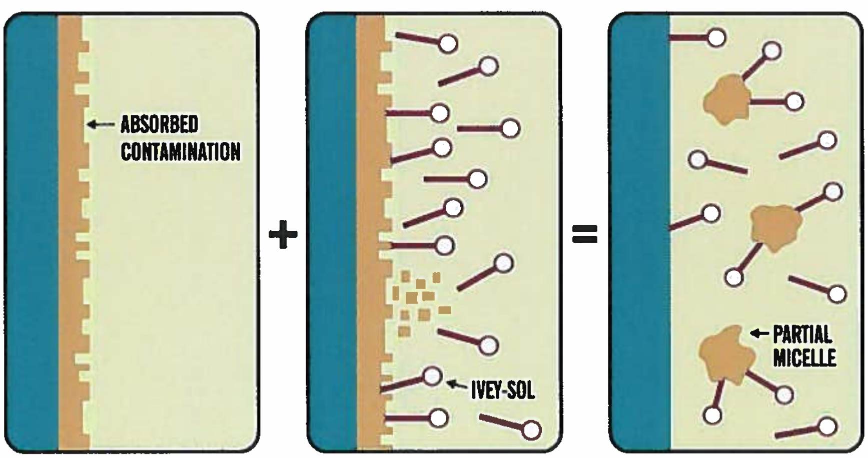


The photograph below shows three water samples collected at a site during a multi-day Ivey-sol injection extraction pilot event. These samples were taken on day two. You will note just a few minor bubbles in the 07:40 sample (Day 2 Baseline), which increases to 1 mm by 10:30, then 2 mm by 16:40. The 07:40 sample indicated that the Ivey-sol injection from day 1 was essentially concluded with only residual concentrations present allowing them to complete the second injection moments later.

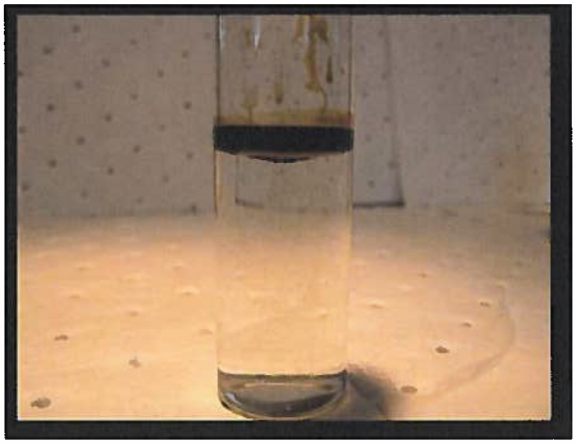
The 10:30 and 16:40 samples showed the presence of Ivey-sol and associated contaminant mass recovery at the extraction/recovery wells. These samples allowed the field technician, and/or project manager to make 'informed' decisions regarding which samples should be submitted to the laboratory for analysis and the real-time status of the Ivey-sol injection event for tracking mass recovery and the planning of a third injection on day three of the subject application.

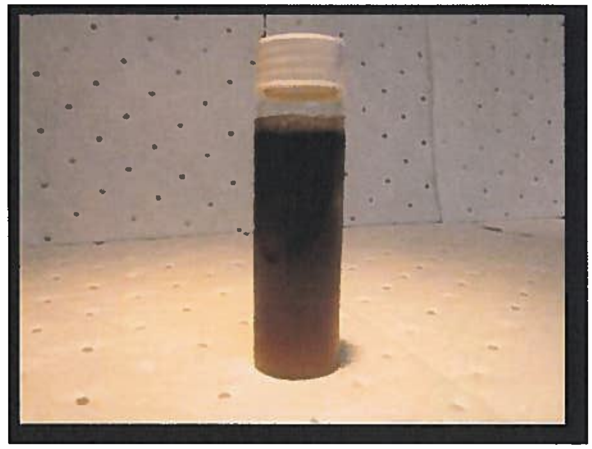
A sample field observation table, to log surface tension and aggitation tests results, is provided (Modify to your needs) below on Page 7.

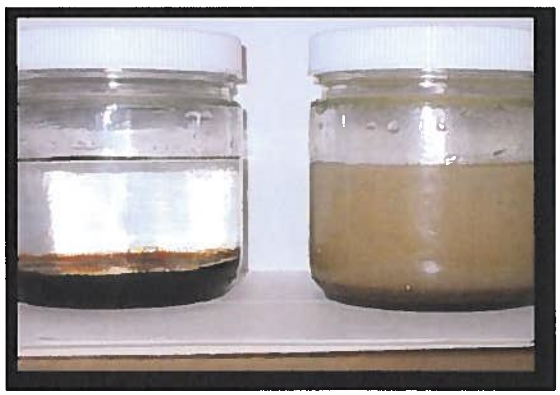
The Ivey-sol surfactants can selectively desorb sorbed contamination off the soil into the groundwater for enhanced contaminant mass recovery within the aqueous phase. This ability makes the contaminants more *'Physically Available'* for in-situ pump and treatment or push-pull applications and ex-situ soil washing. It makes the sorbed contaminants more *'Bio-Available'* for in-situ and ex-situ bioremediation. It can also make the contaminants more 'Chemically Available' for REDOX chemicalization. The mechanism of how the Ivey-sol desorbed the contaminants without forming a micelle (i.e., below the CMC) is illustrated below.



These two photographs show a pre and post Ivey-sol effect on heavy oil contamination and chlorinated solvent contamination during in-situ applications to enhance the associated contaminant mass removal for the Ivey-sol site applications.

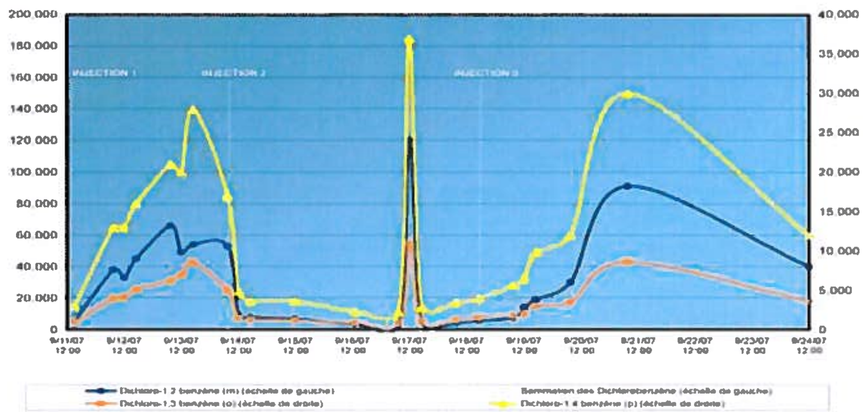






These photographs below show petroleum contaminated soil before and after Ivey-sol applications from an ex-situ soil washing treatment process.

The following is an example of a graphs of groundwater laboratory analysis results generated from a site that employed the above Surface Tension and Agitation Field Test methods to aid improved decision making for sample selection for analysis and to determine when the effect of a series of Ivey-sol injections have been resolved between Ivey-sol injection events over a multi-day period.



Sample Field Observation Table

TIME (min)	RW/EW 1		RW/EW 2		Etc...	
	Surf.Tension	Aggitation	Surf.Tension	Aggitation	Surf.Tension	Aggitation
00						
15						
30						
60						
90						
120						
180						
240						
300						
360						
Etc.						

For more information contact:

Ivey International Inc.

Tel: 1-604-538-1168 Toll Free: 1-800-246-2744

info@iveyinternational.com

www.iveyinternational.com

Ref:Ivey-sol/SurfaceTensionAgitationTest/120904-07

Ivey International Inc.
"Today's Environmental Solutions For A Better Tomorrow"

EPA Approved
Testing Methods For
Ivey-sol® • Decon-It® • Surf Clean®
Non-Ionic Surfactant Products

CTAS: **Cobalt thiocyanate active substances (CTAS)/non-ionic surfactants using EPA Method SM5540D**

MBAS: **Methylene blue active substances (MBAS)/anionic surfactants using EPA Method SM5540C**

Most environmental laboratories have the ability to conduct these tests. If you have any difficulty in locating a laboratory who conducts these EPA standard method tests, please contact our office at 1.800.246.2744 or E-mail: info@iveyinternationa.com