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Clean, Green, and Sustainable Solutions

Treatability Study Recommendations for the Implementation of an In Situ Remedy

Barangaroo – Block 5 and Hickson Rd Site
Lend Lease (LL)
Sydney, Australia

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Executive Summary

VeruTEK® Technologies, Inc. (VeruTEK®) was engaged by AECOM Australia Pty Ltd. (AECOM) to undertake a Laboratory Treatability/Dosage Study at their laboratory located in Bloomfield, Connecticut, USA. The central objective of this laboratory dosing test is to evaluate the extent of Contaminants of Potential Concern (CoPC) destruction in soil and groundwater using chemical-based reaction mechanisms. A dosage study is the first step to evaluate the use of Surfactant-Enhanced In-Situ Chemical Oxidation (S-ISCO®) and Surfactant-Enhanced Ex-Situ Chemical Oxidation (S-ESCO™) Treatment at portions of the NSW Department of Environment Climate Change and Water (DECCW) Remediation Site Declaration 21122 at Millers Point, NSW, which includes part of Hickson Road and the Barangaroo site (here in referred to as the DECCW Declaration Area or the Site). This Treatability Study addresses selected remediation alternatives being considered in parts of Block 4, Block 5 and Hickson Road within the DECCW Declaration Area.

The S-ISCO® process and possibly the Surfactant Enhanced Product Recovery Process (SEPR™), as a pretreatment step, are being proposed for treatment of Hickson Road within the DECCW Declaration Area. The S-ISCO® process is also proposed for use within the Barangaroo site; specifically (but not necessarily limited to) Block 5 within the DECCW Declaration Area. The S-ESCO™ process is also an option being considered for excavated soils from Block 4, within (but not necessarily limited to) the DECCW Declaration Area.

Test Pit soil samples from Block 4 and Block 5 were obtained for these treatability tests to be representative of soils to be treated within the DECCW Declaration Area. A soil boring sample was obtained from Hickson Road, instead of a backhoe dug Test Pit, to minimize traffic flow disruption to residents and businesses. The Hickson Road sample was obtained to determine if the Block 4 samples that did undergo treatability testing were also representative of the Hickson Road sample. Additionally a sample of Non Aqueous Phase Liquid (NAPL) from Block 5 was used in these tests. In comparison to soil sample results historically measured for soils in Block 4, Total Petroleum Hydrocarbons (TPH) Diesel Range Organics (DRO) (i.e., C_9 – C_{36}), Total PAHs and benzo(a)pyrene concentrations measured in the samples used for these Block 4 treatability tests were measured in the upper 10% to 15% of the historical soil concentrations. In comparison to soil sample results historically measured for soils in Block 5, TPH (DRO), Total PAHs and benzo(a)pyrene concentrations measured in the samples used for these Block 5 treatability tests were at least twice that of the historical soil concentrations.

Results from the study demonstrated that up to 84% of the CoPCs in the Block 5 Site soils can be destroyed in 21 days of S-ISCO® treatment, and 89% of CoPCs in Block 4 Site soil can be destroyed in 8 days of S-ESCO™ treatment. During Pilot and Full Scale treatment the duration of treatment will be in the order of many months. Because chemical oxidation reactions are rate limited (meaning the longer the period of treatment the greater the extent of treatment), these short term treatability test results are extremely conservative with respect to the Full Scale treatment potential of the S-ISCO® and S-ESCO™ processes.

The purpose of this Laboratory Treatability Study was to optimize conditions for VeruTEK®'s innovative S-ISCO®, S-ESCO™ and SEPR™ technology platforms, and to support the design and cost estimate for the implementation of the S-SICO® remedy at this Site. Both of these processes utilize enhanced desorption and solubilisation of the gas works organic chemicals from soils and simultaneous chemical oxidation of the solubilised chemicals.

A series of tests were conducted in order to optimize conditions for both in situ and ex situ treatment of the site-specific contamination located within the DECCW Declaration Area. Contamination consisted of former gas works related chemicals, including several volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and TPH caused by the nineteenth and twentieth century gas manufacturing processes at the Site.

The sequence of tests began with a supplemental solubilisation screening, where several United States (US) Food and Drug Administration (FDA) Generally Recognized as Safe (GRAS) plant-based surfactants were tested in order to determine the optimal choice for solubilisation of the gas works-related contaminants. VeruSOL-3® proved to be the most effective, enhancing the TPH (DRO) (using the SiteLAB fluorescence method) solubilisation to 1,510 times greater than water.

Several batch tests were designed where VeruSOL-3®, chemical oxidants, and activators were added directly to the Block 4 soil in order to better simulate the S-ESCO™ process as it would occur in the field. Generally, the best performing S-ESCO™ treatment was with Fe-TAML catalysed hydrogen peroxide. S-ESCO™ treatment after 14 days in these tests indicated reduction up to 89% for Total VOCs and SVOCs, 88% for Total PAHs, 84% for benzo(a)pyrene, 98% for naphthalene, >99% for benzene, and 73% for TPH (DRO) using USEPA Method 8105B. Since typical gas works residuals require at least 30 days to show more complete treatment, these are excellent results. Additional batch tests on Block 4 soils were conducted to simulate the combined SEPR™/S-ISCO® process and a S-ESCO™ ex situ treatment. S-ESCO™ treatment after only 8 days indicated a reduction of up to 86% for Total VOCs and SVOCs, 85% for Total PAHs, 84% for benzo(a)pyrene, 90% for naphthalene, >99% for benzene 85% for TPH (DRO) using USEPA Method 8105B. These are excellent results for only an 8 day treatment period.

Additional jar tests were conducted on Block 4 soils for the analysis of in situ treatment at Hickson Road. Again, these were conducted because it was impractical to disrupt Hickson Road with a Test Pit. Tests were conducted to compare a rapid sequence of in situ treatment of Surfactant Enhanced Product Recovery (SEPR™) for a 1 hour period followed by a 24 hour S-ISCO® treatment with Fe-TAML hydrogen peroxide treatment for Hickson Road Treatment. Results demonstrated that up to 51% of VOCs and SVOCs, 49% of PAHs, 37% of benzo(a)pyrene, 61% naphthalene, >99% of benzene and 66% of TPH were removed in a 1 day combined SEPR™/ S-SICO® process. Following receipt of the treatability samples from Block 4 and Block 5, VeruTEK received a small sample from the Hickson Road soil boring BH53, taken from within the Tar Tank. This soil sample was characterised for CoPCs and it was found to be similar in composition to the soil from Block 4. The Tar Tank soil was also treated with

VeruSOL-3 to generate an emulsion phase for subsequent chemical oxidation tests. The best performing chemical oxidation method was with Fe-TAML hydrogen peroxide treatment. Results demonstrated that up to 92% of VOCs and SVOCs, 62% of PAHs, >99% of benzo(a)pyrene, 62%% naphthalene, >99% of benzene and 98% of TPH were destroyed during this 7 day treatment of the CoPCs desorbed and solubilised from the Tar Tank soil.

Soil column tests were performed using contaminated Site soil, both from Block 4 and Block 5, to simulate implementation of the SEPR™ and S-ISCO® treatments. It was found that the soil from both Block 4 and Block 5 was highly reactive with hydrogen peroxide, likely the result of high concentrations of reduced iron associated with the soil and iron particles that were observed in the Site soils. The reducing conditions present in these heavily contaminated zones where the treatability soil samples were obtained enabled excellent activation of both hydrogen peroxide and sodium persulfate.

Several columns were packed with Site soil and various SEPR™/S-SICO® influents were pumped through the columns. For Block 4 soils, column tests resulted in CoPC removal from the soil up to 83%, with 83% for Total PAHs, 93% for benzo(a)pyrene, 87% for naphthalene, >99% for benzene and >99% for TPH(DRO) using the SiteLAB fluorescence method with only 14 days of treatment. These tests consisted of using hydrogen peroxide at only 4% and VeruSOL-3® at 10 g/L. Typically, in situ treatment would last months at this Site—therefore these 14 day treatment tests are conservative with respect to treatment potential that can be achieved at Full Scale on site.

Block 5 soil column tests were run for varying treatment periods from 7 to 28 days, depending on the type of tests conducted. In general, S-SICO® with hydrogen peroxide (with or without Fe-TAML as a catalyst) performed better than S-SICO® with activated persulfate. The improved treatment with peroxide is likely due to peroxide being a faster acting oxidant than sodium persulfate. For S-SICO® with Fe-EDTA activated persulfate, destruction levels were observed up to 72% for Total VOCs and SVOCs, 72% for Total PAHs, up to 87% for benzo(a)pyrene, up to 67% for naphthalene, up to >99% for benzene, and up to >99% for TPH(DRO) using the SiteLAB fluorescence method. Treatment using S-ISCO® with hydrogen peroxide was observed to have removal efficiencies of up to 84% for Total VOCs and SVOCs, 84% for Total PAHs, 95% for benzo(a)pyrene, 82% for naphthalene, >99% for benzene, and >99% TPH(DRO) using the SiteLAB fluorescence method. S-ISCO® with hydrogen peroxide tests were only run for 8 days, which illustrates its potential for treatment at Full Scale.

These Laboratory Treatability Tests clearly indicate excellent treatment potential for both in situ and ex situ treatment applications at the Block 4, Block 5 and Hickson Road Areas. The soil samples received from the Site for Block 5 were at least twice as contaminated with CoPCs than any previously reported soil results from Block 5. Despite the short term, laboratory tests indicate excellent results with respect to removal of key CoPCs from the Site soils at Block 5. During Pilot and Full Scale treatment the duration of treatment will be in the order of many months. Because chemical oxidation reactions are rate limited (meaning the longer the period of treatment the greater the extent of treatment), these short term treatability test results are extremely conservative with respect to the Full Scale treatment potential S-ISCO® and S-ESCO™ processes. Therefore, the shorter laboratory periods are an acceptable protocol for simulations of longer term Pilot and Full Scale treatment.

It is recommended that S-ISCO® with catalysed hydrogen peroxide followed by S-ISCO® with activated persulfate be the preferred method to be tested during the Pilot Trials to be conducted at Block 5. In some locations where heavy gas works NAPLs are present, S-ISCO® pretreatment with the SEPR™ process followed by short-term liquid extraction could be a successful method to effectively remove NAPLs prior to the S-ISCO® treatment. These results are also transferable to treatment at Hickson Road, both inside and outside of the historic gas works structures, particularly the former Tar Tank.

For Block 4, these results indicate that in situ S-ISCO® treatment prior to soil excavation for basement construction or ex situ S-ESCO™ treatment following excavation, are both effective alternatives. The soils used in the Block 4 treatability tests were in upper 10 to 15 percentile of detectable soil CoPC concentrations historically measured from Block 4. Ex situ treatment following excavation at Block 4, S-ESCO™ with catalysed hydrogen peroxide is recommended. Jar Tests conducted on the Block 4 soils were also conducted to simulate rapid in situ treatment at Hickson Road. Based these excellent short-term 1-day combined SEPR™/ S-ISCO® results it is recommended to use the combined SEPR™ pretreatment followed by S-ISCO® with Fe-TAML catalysed hydrogen peroxide for in situ treatment at Hickson Road.

Prior to Full Scale treatment, it is recommended to conduct a Pilot Test at Block 5 to demonstrate the effectiveness of the recommended treatment process consisting of S-ISCO® with catalysed hydrogen peroxide followed by S-ISCO® with activated persulfate as the preferred method to be tested. The Pilot Test will enable optimization of treatment for Full Scale application, as well as the refinement of the engineering design, monitoring program and system operations control measures.

It is additionally recommended to conduct a Pilot Test at Hickson Road in the location of the former Tar Tank. This feature is unique at the Barangaroo site as it is excavated into bedrock and is either a confined or semi-confined vessel containing high concentrations of gasworks residuals. Given the close proximity of the former Tar Tank to 38 Hickson Road and associated sub-grade parking facilities and utilities, careful monitoring during the Pilot Test will ensure an effective and safe application of the S-ISCO® process at Full Scale.

1.0 Introduction

VeruTEK® Technologies, Inc. (VeruTEK®) was engaged by AECOM Australia Pty. Limited (AECOM) to undertake a Laboratory Treatability/Dosage Study at their laboratory in Bloomfield, Connecticut, USA. The central objective of this laboratory dosing test is to evaluate the extent of Chemicals of Potential Concern (CoPCs) destruction in the Site soil and groundwater using chemical-based reaction mechanisms. A dosage study is the first step to evaluate the use of Surfactant-Enhanced In-Situ Chemical Oxidation (S-ISCO®) and Surfactant-Enhanced Ex-Situ Chemical Oxidation (S-ESCO™) Treatment at portions of the DECCW Remediation Site Declaration Area 21122 at Millers Point, NSW (here in referred to as the DECCW Declaration Area or the Site). This Treatability Study addresses selected remediation alternatives being considered in portions of Block 4, Block 5 and Hickson Road within the DECCW Declaration Area.

The S-ISCO® process and possibly the Surfactant Enhanced Product Recovery Process (SEPR™), as a pretreatment step, are being proposed for treatment of Hickson Road within the DECCW Declaration Area. The S-ISCO® process is also proposed for use within the Barangaroo site, specifically (but not necessarily limited to) Block 5 within the DECCW Declaration Area. The S-ESCO™ process is also an option being considered for excavated soils from Block 4, within (but not necessarily limited to) the DECCW Declaration Area.

Using soils obtained from the Site by AECOM and delivered to VeruTEK® in the USA, the laboratory dosage study was conducted to determine the optimization for degrading CoPCs in Site soils and contaminated groundwater with the S-ISCO® technology (i.e., free radical-based oxidant systems with a cosolvent-surfactant VeruSOL®). As part of the S-ISCO® technology, Surfactant Enhanced Product Recovery (SEPR™) (i.e., hydrogen peroxide with a cosolvent-surfactant VeruSOL®) has also been evaluated to determine its use as a pretreatment step to application of S-ISCO®. Additionally, the Surfactant Enhanced Ex-Situ Chemical Oxidation (S-ESCO™) was evaluated for possible ex situ treatment of soil using a free radical based oxidant system with VeruSOL®. The S-ESCO™ (ex situ) process is very similar to the S-ISCO® (in situ) process, but was developed to treat excavated soils.

A series of laboratory-scale tests were conducted to investigate the effectiveness of the remediation processes and acquire important engineering data for field application. Specific objectives of this report include:

- Partial characterization of NAPL, soil, and groundwater provided from the contaminated Site;
- Evaluation of contamination solubilisation using plant-based US FDA GRAS surfactants;
- Evaluation of contaminant oxidation with various oxidants and activators for S-ISCO® and S-ESCO™ applications;
- Performance of column tests with optimal SEPR™/S-ISCO® treatments to more accurately simulate the treatment process under virtual field conditions; and
- Preparation of a Treatability Study Report.

1.1 S-ISCO® Background

S-ISCO® is a new field verified Coelution Technology™ capable of reducing the amount of source NAPL present in soils and reducing the flux of groundwater constituents associated with these sites. The patent-pending S-ISCO® technology uses biodegradable, food-grade surfactants. VeruSOL® is one of VeruTEK®'s premier products that the company has been using for several years in the in situ and ex situ remediation market. VeruSOL® is an entirely bio-based mixture composed of citrus-based compounds and plant oil-based non-ionic surfactants. These components are either Generally Recognized as Safe (GRAS) by the United States Food and Drug Administration (USFDA) or are approved as indirect food additives and for dermal contact, such as cosmetics. VeruSOL® has a tremendous ability when dissolved in water to bring most hydrocarbons and oils into oil-in-water microemulsions which creates its significant capabilities as a component to simultaneous in situ chemical oxidation. VeruSOL® solubilises immiscible organic compounds into groundwater and free radical-based chemical oxidants such as sodium persulfate and hydrogen peroxide, are used to simultaneously destroy the contaminants.

Common contaminants successfully treated with the SEPR™ and S-ISCO® technologies are dense non-aqueous phase liquids (DNAPLs), light non-aqueous phase liquid (LNAPLs), volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs), including chloro- and bromo-ethanes and methanes, polycyclic aromatic hydrocarbons (PAHs), chlorinated solvents, pesticides, polychlorinated biphenyls (PCBs) and various organic chemicals such as petroleum products. Contaminants can be associated with several processes such as manufactured gas plant residuals, creosote wood treating liquids, and other residuals or byproducts of industrial processes and commercial activities. Contaminants may be found in liquid phase, sorbed into the soil matrix, or in the solid phase.

1.1.1 Surfactant-enhanced In Situ/Ex Situ Chemical Oxidation (S-ISCO®/S-ESCO™)

S-ISCO® is a new Coelution Technology™, capable of reducing the amount of NAPL in soils, and reducing the levels of residual contaminants present in the groundwater. VeruTEK®'s innovative S-ISCO® technology uses biodegradable, plant-based surfactants that solubilise immiscible organic compounds into the aqueous phase and subsequently destroy them in place. Environmentally friendly oxidants and activators are used to create free radicals, which are capable of degrading organic contaminants with no risk of harmful byproducts. When applied in a ex situ manner using a chemical dosing and mixing system such as a pug mill, S-ESCO™ is useful for rapid and effective treatment.

1.1.2 Surfactant Enhanced Product Recovery (SEPR™)

SEPR™ is a Coelution Technology™ capable of reducing the amount of source NAPLs in the subsurface. SEPR™ uses biodegradable, food grade surfactants and cosolvents in combination with hydrogen peroxide to solubilise immiscible organic compounds. Facilitated extraction is then used to remove the contaminants from the subsurface in an effective, efficient, and environmentally friendly manner. This process can be used to remove a significant mass fraction of the NAPLs in the subsurface prior to using S-ISCO® as a final polishing step.

2.0 Experimental Section

2.1 Receipt of Site Soil and Groundwater

On March 15, 2010 two 208 liter poly drums were received at the VeruTEK® R&D laboratory via TNT and Conway Freight, after clearing United States Customs. The drums contained soil samples collected from the Site, obtained by AECOM on February 27, 2010. Samples consisted of six sets of three 5-liter buckets, labeled "TP02 3.9-4.3", "TP04 0.5-0.7", "TP04 4.5-4.9", "TP05 1.8-2.0", "TP05 3.1-3.3", and "TP06 2.8-3.0". Sample ID's were checked against the chain of custody and two discrepancies were found: 1) sample buckets labeled as "TP04 4.5-4.9" were labeled as "TP04 4.5-4.8" on the chain of custody, and 2) the sample locations listed on the chain of custody indicated that TP01, TP02, and TP04 are in Block 4, and TP05, TP06, and TP07 are in Block 5. However, according to the Site map provided by AECOM, these locations should be switched, so that TP01, TP02, and TP04 are in Block 5, and TP05, TP06, and TP07 in Block 4. VeruTEK® subsequently confirmed the correct sample identification and locations with AECOM. The discrepancies in the Chain of Custody documentation did not negatively impact the integrity of the treatability study. Locations of the two test pits excavated to generate samples for this treatability study are found in Plate 1.

A second set of samples were received on March 23, 2010. Samples included groundwater samples in 500 mL amber glass jars, NAPL samples in 40 mL vials, and a 20 L bucket with a sample of Site soil. Groundwater samples included one sample labeled "MW54", eight samples labeled "MW74", eight samples labeled "MW52", one sample labeled "MW53", and one sample labeled "MW205". Two 40 mL NAPL samples were received; however the labels were covered with NAPL. Based on the chain of custody, the NAPL samples were deduced to be labeled "MW205". VeruTEK® subsequently confirmed the correct sample identifications with AECOM. The 20 L plastic bucket was labeled "BH53 Geologic Sample" and contained a bag with Site soil from the tar tank. Groundwater and NAPL samples were placed in a refrigerator at 4 °C until further use.

Sample pictures and log in procedures are presented in Appendix A-1.

2.2 Homogenization and Characterization of Site Soil (Task 1)

Soil samples were homogenized through a 1 cm sieve in order to remove any large particles and to ensure more uniform sample for further tests. Sieving was a critical step in generating representative homogenized soils for comparative testing, as there were numerous shells, coral, rocks and pieces of metal in the test pit soils received from the Site. Specific buckets of soil received from the test pits were selected for homogenization based on the criteria of selecting the most contaminated soils, using visual and odor as the primary selection factors. The sieving process was conducted in a manner to minimize exposure to air in order to minimize volatile compound losses from the samples. All work was conducted in protective fume hoods. One bucket of soil from TP05 3.1-3.3 was homogenized with one bucket from TP06 2.8-3.0, and was internally labeled at VeruTEK® as "BAUS B4HS-1", and "BAUS B4HS-2". Three buckets, all from TP02 3.9-4.3, were homogenized and relabeled as "BAUS B5HS-1", and "BAUS B5HS-2". The soil was sandy and clay-like, grey in color, and had a very strong petroleum odor. Homogenized soil samples were sent to Mitkem Laboratory for VOC, SVOC, and TPH (GRO) and TPH (DRO) analysis (a National Environmental Laboratory Accreditation Conference (NELAC) certified analytical laboratory). It should be noted that Total Petroleum Hydrocarbons (TPH) Diesel Range Organics (DRO) used in this report refers to $C_9 – C_{36}$ and TPH Gasoline Range Hydrocarbons (GRO) used in this report refers to $C_5 – C_{10}$), where C_5 includes methyl-tertiary-butyl ether (MTBE) through naphthalene C_{10}. It is possible that there may be some overlap between the TPH (GRO) and TPH (DRO) results with respect to naphthalene. Throughout the report reference will be made to TPH (GRO) and TPH (DRO).

Additional soil from TP05 3.1-3.3 was homogenized on 4/7/10 for use in additional tests. Soil was sampled, after homogenization, and sent to Mitkem Laboratory for VOC, SVOC, and TPH analyses.

The analytical instruments and method used during this study are summarized in Appendix A-2. It should be noted that the standard TPH (DRO) gas chromatography method used in USEPA Method 8015B is subject to interference from VeruTEK®'s VeruSOL-3® cosolvent surfactant system. Frequently, false positive results are reported when TPH analyses are conducted with the USEPA Method 8015B when VeruSOL-3® is present in soil or groundwater samples. However, VeruTEK®'s experience is that occasionally USEPA Method 8015B will result in false negative results. It is possible that occasional false negative results are due to inference of the solvent extraction step , but more typically the detection of the citrus terpenes in the C_{10}+ range and plant oils ($C_5 – C_{18}$) result in false positive results. Citrus terpenes and plant oils are major ingredients in VeruSOL-3®. As a result, VeruTEK® additionally conducts TPH (GRO) and (DRO) analyses with a SiteLAB Model UVF-3100D instrument that utilizes fluorescence detection, and which is equivalent to EPA Method 8015 (This is documented at the following location: http://www.site-lab.com/epa_performance.htm). All of the chemicals in VeruSOL-3® have been documented by VeruTEK® to have no response in the fluorescence range. Therefore, in this report TPH-(DRO) are reported using both the USEPA Method 8015B and the SiteLab fluorescence method. During characterization of samples that do not have VeruSOL-3® present, TPH using USEPA Method 8015B is typically reported.

2.3 Supplemental Solubilisation (Task SS)

A supplemental solubilisation screening was designed to test various US FDA GRAS plant-based surfactants and cosolvents to determine which would be the most effective for solubilizing contamination from the Site soil. Block 5 homogenized soil labeled "BAUS B5HS-2" was used for this set of tests. Block 5 soil was selected for these tests as a generally representative Site soil from the Site, to screen a series of surfactants and cosolvent/surfactant formulations and to select the best performing one for subsequent use in the treatability tests. Seven vials were prepared, where SS-1 contained soil and Deionized Water (DI water) (a control), and SS-2 through SS-7 contained soil and one of six surfactants/cosolvents treatments. Reactions took place in 60 mL vials, where 10 g of soil was added to each vial, followed by 50 mL of DI water and 0.5 g of the respective surfactant/cosolvent. This provides a 5:1 water to soil ratio on a mass basis. The surfactants tests consisted of VeruSOL-3®, VeruSOL-10®, VeruSOL-11®, VeruSOL-12®, X1, and X2. Reactors were shaken at 120 rpm, at ambient temperature, for 24 hours. Upon completion, vials were left to settle for six hour, after which, the aqueous phase was sampled and analysed for interfacial tension (IFT), and TPH using the SiteLab fluorescence method.

Details of the experimental conditions for Task SS are presented in Table 1.

2.4 Solubilisation Enhancement Tests (Task 2)

Following the Task 1 Supplemental Solubilisation tests, detailed solubilisation enhancement tests were designed using VeruSOL-3®—the best performing surfactant system. The solubilisation tests were set up to determine the optimal dose of VeruSOL-3® needed for effective solubilisation of the COPCs. Block 5 homogenized soil was selected for these tests, as a generally representative Site soil from the Barangaroo site, to characterise the ability of VeruSOL-3® to solubilise and desorb CoPCs from soils at the Site. Because these solubility enhancement tests are preliminary tests, it was not necessary to repeat these tests for each soil from Block 4 and Block 5. Tests were conducted using various doses of VeruSOL-3® with first with Site soil from Block 5 labeled "BAUS B5HS-2". All tests were conducted at ambient temperature, and shaken at 120 rpm for seven days. After the 7 day shaking period, samples were left to settle for 24 hours. The 7 day mixing period was selected to ensure that desorption of CoPCs from the soil would be complete to assume an equilibrium had been reached. The aqueous phase was then sampled and sent to Mitkem Laboratory for VOC, SVOC, and TPH analysis.

2.4.1 Solubilisation of COPCs from Site Soil

Contaminated soil solubilisation tests took place in 500 mL glass jars, with 100 g of Site soil. Five reactors were set up and labeled T2-A, T2-B, T2-C, T2-D, and T2-E. Reactor T2-A acted as a control and contained only soil and deionized (DI) water. Reactor T2-B, -C, -D, and -E contained

Site soil, with 2.5, 5.0, 10, and 25 g/L VeruSOL-3®, respectively. Reactors were then filled to volume with DI water, and initial photographs were taken.

Details of the experimental conditions of Task 2_Soil are presented in Table 2 and Appendix A-3

2.5 S-ESCO™ and SEPR™/S-ISCO® Batch Tests (Task 5)

Batch tests were designed to simulate the S-ESCO™ process on the Site soil, with simultaneous additions of the cosolvent/surfactant mixture and the selected oxidant/activator systems. Several tests were designed to test various oxidants, activators, concentrations, and durations in order to determine the most effective method for treatment of the Site soil.

2.5.1 Block 4 Soil Batch Tests

Six batch tests were conducted using Block 4 Site soil, "BAUS B4HS-1" and "BAUS B4HS-2", from TP05 3.1-3.3 and TP06 2.8-3.0. Reactors were labeled T5-A through T5-F, where reactors T5-A through T5-D contained 500 g of Site soil, 500 mL of total solution, and ran for a period of 14 days. Three S-ESCO™ processes were tested. Reactor T5-A acted as the control and only contained soil with DI water. Reactor T5-B was S-ESCO™ with alkaline persulfate and was treated with 10 g/L VeruSOL-3®, 100 g/L sodium persulfate, and was alkaline activated with NaOH (pH>12). Reactor T5-C was S-ESCO™ with persulfate and Fe-EDTA and was treated with 10 g/L VeruSOL-3®, 100 g/L sodium persulfate, and 350 mg/L as Fe, Fe-EDTA. Reactor T5-D was S-ESCO™ with Fe-TAML catalysed hydrogen peroxide and was treated with 10 g/L VeruSOL-3®, 4% hydrogen peroxide, and 0.1 uM Fe-TAML. Each reactor was prepared, capped and shaken. Reactor T5-D was left uncapped due to the production of oxygen gas associated with hydrogen peroxide decomposition.

Reactors T5-E and T5–F contained 250 g of Site soil, and ran for a total period of 8 days. Reactor T5-E acted as a second control and only contained soil and DI water. One in situ process, a combined SEPR™/S-ISCO® and one S-ESCO™ process were tested in these reactors: Reactor T5-F simulated a sequenced SEPR™ extraction for a 1 day period followed by a S-ISCO® process for 7 additional days; and Reactor T5-G simulated an 8-day S-ESCO™ alone treatment. The selection of the 8 day total reactor period for these tests was based using a shorter reaction period compared to the 14 day tests. The purpose of examining the role of SEPR™ on the combined SEPR™/S-ISCO® reactions was to compare to the 14-day treatment with Fe-TAML catalysed peroxide reaction and to examine the incremental S-ESCO™ reaction effectiveness in the 14 day versus 8 day test. The SEPR™ phase tested in Reactor T5-F consisted of mixing 20 g/L VeruSOL-3® with 4% hydrogen peroxide with the Site soil, and leaving it to react for 24 hours. The aqueous phase was then decanted and sent to Mitkem for VOC, SVOC, and TPH analysis. The S-ISCO® chemicals were then added and mixed with the pretreated soil, which consisted of 10 g/L VeruSOL-3®, 4% hydrogen peroxide, and 0.1 uM Fe-TAML. The S-ESCO™ phase ran for a period of 7 days. Upon completion of the batch tests, all aqueous phases were decanted and sent to Mitkem for VOC, SVOC, and TPH analysis, along with the treated Site soil.

Reactor T5-G was treated using S-ESCO™ with 10 g/L VeruSOL-3®, and 0.1 uM Fe-TAML catalysed hydrogen peroxide (8%). Following an 8 day reaction period, aqueous and soil samples were sent to Mitkem Laboratory for VOC, SVOC, and TPH analysis.

Details of the experimental conditions for Task 5_Block 4 are presented in Table 3.

2.6 Block 4 Combined SEPR™/S-ISCO® Jar Tests

Three tests were designed to test the rapid in situ treatment of the Block 4 Site soil for 25 hour treatment period. These additional jar tests were conducted on Block 4 soils for the analysis of in situ treatment at Hickson Road. Again, these were conducted because it was impractical to disrupt Hickson Road with a Test Pit. The short 25 hour reaction period for these tests was selected to determine how a very rapid reaction period using a peroxide-based in situ treatment process would perform. Reactors were labeled as B-1, B-2, and B-3, where B-1 contained Block 4 Site soil and DI water only. Both reactors B-2 and B-3 were treated for one hour using SEPR™ followed by 24 hours with S-ISCO®. Reactor B-2 was treated using 20 g/L VeruSOL-3® with 15% peroxide during the SEPR™ treatment, followed by 10 g/L VeruSOL-3® with 8% hydrogen peroxide activated with 0.1 uM Fe-TAML during the S-ISCO® treatment. Reactor B-3 was treated using 10 g/L VeruSOL-3® with 8% peroxide during the SEPR™ phase, followed by 10 g/L VeruSOL-3® with 8% peroxide activated with 0.1 uM Fe-TAML, during the S-ISCO® treatment. Upon completion of the 1 hour SEPR™ phase, the liquid was decanted off of B-2 and B3, prior to adding the S-ESCO™ chemicals, and sent to Mitkem Laboratory for VOC, SVOC, and TPH analysis. Following the 24 hour S-ISCO® phase, the liquid was decanted, the soil was homogenized, and both samples were sent to Mitkem Laboratory for VOC, SVOC, and TPH analysis.

Details of the experimental conditions for S-ISCO® Jar Tests are presented in Table 4.

2.7 Tar Tank Soil Emulsion Oxidation Tests

A small quantity of soil from a soil boring in Hickson Road was sent by AECOM to VeruTEK after the initial Block 4 and Block 5 test pit samples were received. The Hickson Road soil sampled was generated from BH53, which is located in the former Tar Tank. 800 g of soil from the Tar Tank was mixed with 25 g/L of VeruSOL-3 to form 4 L of an emulsion phase. The emulsion phase was then subject to 3 chemical oxidation treatments. In addition, there was a control reactor with the emulsion present and no oxidant. Oxidation tests took place over a 7 day period. Reactor 3-J was the control, reactor 3-K received an alkaline persulfate treatment, reactor 3-L received an Fe-EDTA activated persulfate treatment and reactor 3-M received an Fe-TAML catalysed hydrogen peroxide treatment.

Details of the experimental conditions for the solubilisation/desorption/chemical oxidation tests are presented in Table 5.

2.8 Sodium Persulfate Soil Oxidant Demand (SOD) Tests

Tests were conducted in order to determine the soil oxidant demand for sodium persulfate in Block 4 soil and Block 5 soils. Tests consisted of adding 150 mL of sodium persulfate solutions at various concentrations to 75 g of Site soil, and monitoring the persulfate concentration over time.

Seven reactors were set up using Block 4 soil, A-0 through A-6, where A-0 was a sodium persulfate control alone at 25 g/L, without soil. Reactor A-2 acted as a second control and contained soil and DI water without sodium persulfate. Reactors A-2, -3, -4, -5, and -6, contained sodium persulfate at concentrations of 0, 2.5, 10, 25, 50, and 100 g/L, respectively, along with. Six reactors were set up using Block 5 soil, B-1, -2, -3, -4, -5, and -6, and contained sodium persulfate concentrations of 2.5, 10, 25, 50, and 100 g/L, respectively. Parameters such as pH and persulfate concentrations were measured at time 0 and after 3, 5, and 7 days.

Details of the experimental conditions for SOD tests are presented in Table 6a and 6b.

2.8 Soil Column Tests with SEPR™ and S-SISCO® (Task 4)

Soil column tests were conducted to simulate field implementation of the SEPR® and S-ISCO® technologies. Two sets of columns were prepared, one set contained Site soil from Block 4, and the second set contained Site soil from Block 5. Columns were packed with the homogenized Site soils in order to ensure reproducibility between respective columns. All columns were packed in the same manner. Column caps were Teflon tapped, and contained plastic filters, and o-rings. A layer of glass wool was placed at the bottom of the column, followed by a layer of glass beads, to help prevent the migration of soil out of the column. Homogenized soil was then packed into the column using a metal rod to pack firmly and eliminate large air pockets. Since the provided soil was wet, there was no additional DI water added during the packing process. A second layer of glass beads was placed on top of the soil, followed by a layer of glass wool. The column was capped, and tubing was attached. Column influents were pumped through 1.14 mm ID Tygon tubing into the bottom of each column. Column effluents were collected from the top of the column through 6.35 mm ID Tygon tubing. Columns with multiple influents had two separate influents which joined at the bottom of the column prior to injection.

2.8.1 Block 4 Soil Columns

Three columns were designed using Block 4 soil from “BAUS B4HS-1” and “BAUS B4HS-2”, which consisted of soil from TP05 3.1-3.3 and TP06 2.8-3.0. Column T4B4-A acted as the control and was pumped with DI water alone. Column T4B4-B was treated using SEPR™, with 20 g/L VeruSOL-3® and 4% hydrogen peroxide. Due to the stability of hydrogen peroxide and VeruSOL-3®, only one influent was needed for this column which consisted of a mix of both chemicals. Column T4B4-C was treated using S-ISCO® with 10 g/L VeruSOL-3®, and 4% hydrogen peroxide catalysed with 0.1 uM Fe-TAML. Two influents were required for this column: 1) hydrogen peroxide with VeruSOL-3® mix, and 2) Fe-TAML solution. Columns were treated for a period of

14 days, 24 hours/day. Typically VeruTEK® runs S-ISCO® soil columns when gasworks contamination is present because PAH compounds require approximately one month of treatment to obtain results fully representative of field conditions. During Full-Scale treatment using S-ISCO® at gasworks contaminated site, a 2 to 6 month period is typically needed to achieve maximum soil treatment effectiveness. Due to the time constraints on the Treatability Test project schedule, these soil column tests were only run for 14 days during column test operations. VeruTEK's experience with respect to reaction time of soil column tests for gasworks coal tar residuals is that the longer the column the greater the treatment in the soil column. This is particularly true for PAH compounds which have longer reaction rates and are the longest lived species during the S-ISCO® process. During Pilot and Full Scale treatment the duration of treatment will be in the order of many months. Because chemical oxidation reactions are rate limited (meaning the longer the period of treatment the greater the extent of treatment), these shorter term soil column treatability test results are extremely conservative with respect to the Full Scale treatment potential S-ISCO® process. Therefore, the shorter laboratory periods are an acceptable protocol for simulations of longer term Pilot and Full Scale treatment.

Liquid effluents were monitored closely for oxidants, activators, and interfacial tension in order to ensure proper influx of chemicals throughout the column. Adjustments such as influent flow rate and concentrations were adjusted as needed based on daily effluent results.

Details of the experimental conditions for Task 4_Block 4 are presented in Table 7a.

2.8.2 Block 5 Soil Columns

Five columns were designed using Block 5 Site soil "BAUS B5HS-1", and "BAUS B5HS-2", which consisted of soil from TP02 3.9-4.3. Column T4B5-C1 acted as the control and was pumped with DI water alone. Columns T4B5-C2, T4B5-C3, and T4B5-C4 were all treated using S-ISCO®, while column T4B5-C5 was treated using SEPR™. Column -C2 was treated with 10 g/L VeruSOL-3®, and 100 g/L sodium persulfate activated with NaOH (pH>12) and used the S-ISCO® alkaline activated persulfate process. Two influent solutions were pumped into column –C2: 1) sodium persulfate, and 2) alkaline VeruSOL-3®. Column –C3 was treated with 10 g/L VeruOL-3®, and 100 g/L sodium persulfate activated with 350 mg/L as Fe, Fe-EDTA and used the S-ISCO® chelated iron activated persulfate process. Two influent solutions were used: 1) Fe-EDTA and VeruSOL-3®, and 2) sodium persulfate. The S-ISCO® with activated persulfate Block 5 soil column tests were run for 28 days.

The S-ISCO® Fe-TAML catalysed hydrogen peroxide process was tested in Column –C4. This column was treated with 10 g/L VeruSOL-3®, and 4% hydrogen peroxide catalysed with 0.1 uM Fe-TAML. Two influent solutions were used for this column: 1) VeruSOL-3® and peroxide, and 2) Fe-TAML. The S-ISCO® with Fe-TAML catalysed hydrogen peroxide was run for 21 days.

The SEPR™ process was evaluated in Column –C5 and was treated with 10 g/L VeruSOL-3® and 4% hydrogen peroxide. Only one influent was required for this column, which carried a solution of both chemicals. The SEPR™ column was run for 7 days.

Details of the experimental conditions for Task 4_Block 5 are presented in Table 7b.

3.0 Results and Discussion

3.1 Characterization of Site Material (Task 1)

Site soil, groundwater, and DNAPL were sent to Mitkem Laboratory for VOC, SVOC, and TPH GRO and DRO analysis; soil from Block 4 was also analysed for total iron (Fe). Duplicate samples were taken from of the Block 4 homogenized soil and the Block 5 homogenized soil to allow for an average concentration to be determined. The homogenized soils from Block 4 and Block 5 were subsequently used in all Tasks of the Treatability Tests. Results indicated that the Site soil and NAPL was highly impacted with TPH, and a large number of VOCs and SVOCs. Results from the initial characterization of Block 4 and Block 5 soils are presented in Table 8.

3.1.1 Block 4 Soil Characterisation

The homogenized soil from Block 4 (BAUS-B4HS1 and –B4HS2) had an average VOC concentration of 205 mg/kg, an average SVOC concentration of 7,078 mg/kg, an average TPH DRO concentration of 21,500 mg/kg, and an iron concentration of 8,800 mg/kg. The compound detected with the highest concentration in the Block 4 soil homogenate was naphthalene at an average concentration of 2,100 mg/kg. The average concentrations of selected CoPCs in the Block 4 homogenized soils are as follows:

- benzene - 19 mg/kg
- naphthalene – 2,100 mg/kg
- benzo (a) pyrene – 190 mg/kg
- Total PAHs – 6,207 mg/kg
- TPH (DRO) USEPA Method 8015B – 21,500 mg/kg
- TPH (DRO) SiteLAB fluorescence method – 3,940 mg/kg

A comparison was made between the historically detected soil concentrations of the selected CoPCs reported in the Draft Data Gap Investigation VMP and PDA Remediation Works Area, Hickson Road, Millers Point, NSW (AECOM 16 April 2010) and those compounds detected in the Block 4 homogenized soils. This comparison enables a comparative evaluation to determine the concentration of CoPCs in the Block 4 soils used in the Treatability Tests. The historic detected soil concentrations for each of the above listed CoPCs were rank ordered from the lowest detected to the highest detected concentrations. The concentration detected in the Block 4 homogenized soil used in the Treatability Tests was then plotted on a figure with the rank order historic detected soil concentrations to enable comparisons.

In Figure 1a, a comparison was made between the historic detected TPH (DRO) concentrations from Block 4 and the average concentration of the two duplicate soil samples taken from the Block 4 homogenized soils used in the treatability tests. It can be seen that there were 8 soil samples with TPH (DRO) concentrations greater than the average Block 4 homogenized soil TPH

(DRO) soil concentration and 74 soil samples with less than the average Block 4 homogenized soil TPH (DRO) concentration. It should be noted that the in house VeruTEK SiteLAB fluorescence TPH (DRO) analysis was not conducted on the homogenized soil until the end of the treatability tests and there was little soil remaining for these tests. The large variation in the initial TPH (DRO) analysis results using USEPA Method 8015B and the SiteLAB results could be the result of degraded or different soil conditions between the two samples used in the analyses. Because the homogenized soil did not contain the VeruSOL® mixture, the TPH (DRO) results conducted using the USEPA Method 8015B are considered more representative of Site conditions. In Figure 1b, a comparison was made between the historically detected Total PAH concentrations from Block 4 and the average concentration of the two duplicate soil samples taken from the Block 4 homogenized soils used in the treatability tests. It can be seen that there were 8 soil samples with Total PAH concentrations greater than the average Block 4 homogenized soil Total PAH soil concentration and 81 soil samples with less than the average Block 4 homogenized soil Total PAH concentration. In Figure 1c, a comparison was made between the historic detected benzene concentrations from Block 4 and the average concentration of the two duplicate soil samples taken from the Block 4 homogenized soils used in the treatability tests. It can be seen that there were 10 soil samples with benzene concentrations greater than the average Block 4 homogenized soil benzene soil concentration and 26 soil samples with less than the average Block 4 homogenized soil benzene concentration. In Figure 1d, a comparison was made between the historic detected benzo(a)pyrene concentrations from Block 4 and the average concentration of the two duplicate soil samples taken from the Block 4 homogenized soils used in the treatability tests. It can be seen that there were 6 soil samples with benzo(a)pyrene concentrations greater than the average Block 4 homogenized soil benzo(a)pyrene soil concentration and 73 soil samples with less than the average Block 4 homogenized soil benzo(a)pyrene concentration.

In summary, the Block 4 soils used in this Treatability Study are significantly on the high concentration side, with respect to selected CoPC concentrations historically detected in Block 4 at the Site.

3.1.2 Block 5 Soil Characterisation

Homogenized soil from Block 5 (BAUS-B5HS1 and –B4HS2) had an average VOC concentration of 4.1 mg/kg, an average SVOC concentration of 2,341 mg/kg, and an average TPH DRO concentration of 40,000 mg/kg. The compound detected with the highest concentration in the Block 5 soil homogenate was pyrene at an average concentration of 530 mg/kg. The average concentrations of selected CoPCs in the Block 5 homogenized soils are as follows:

- benzene - 0.575 mg/kg
- naphthalene – 70 mg/kg
- benzo (a) pyrene – 135 mg/kg
- Total PAHs – 2,305 mg/kg
- TPH (DRO) – 40,000 mg/kg

- TPH (DRO) SiteLAB fluorescence method – 6,012 mg/kg

A comparison was made between the historically detected soil concentrations of the selected CoPCs reported in the Draft Data Gap Investigation VMP and PDA Remediation Works Area, Hickson Road, Millers Point, NSW (AECOM 16 April 2010) and those compounds detected in the Block 5 homogenized soils. A rank order concentration analysis was used to compare the historic Block 5 to the homogenized soil CoPC concentrations. In Figure 2a, a comparison was made between the historic detected TPH (DRO) concentrations from Block 5 and the average concentration of the two duplicate soil samples taken from the Block 5 homogenized soils used in the treatability tests. It can be seen that there were no soil samples with TPH (DRO) concentrations greater than the average Block 5 homogenized soil TPH (DRO) soil concentration. The TPH (DRO) soil concentration in the Block 5 homogenized soils used in these Treatability Tests was approximately a factor of 3 times greater than the highest detect TPH (DRO) concentration historically measured at Block 5. It should be noted that the in house VeruTEK SiteLAB fluorescence TPH (DRO) analysis was not conducted on the homogenized soil until the end of the treatability tests and there was little soil remaining for these tests. The large variation in the initial TPH (DRO) analysis results using USEPA Method 8015B and the SiteLAB results could be the result of degraded or different soil conditions between the two samples used in the analyses. Because the homogenized soil did not contain the VeruSOL® mixture, the TPH (DRO) results conducted using the USEPA Method 8015B are considered more representative of Site conditions. In Figure 2b, a comparison was made between the historic detected Total PAH concentrations from Block 5 and the average concentration of the two duplicate soil samples taken from the Block 5 homogenized soils used in the treatability tests. It can be seen that there were no soil samples with Total PAH concentrations greater than the average Block 4 homogenized soil Total PAH soil concentration. Historically, there were only 3 soil samples from Block 5 with detected benzene concentrations, of these 2 were greater and 1 was lower than the Block 5 soil homogenate. In Figure 2c, a comparison was made between the historic detected benzo(a)pyrene concentrations from Block 5 and the average concentration of the two duplicate soil samples taken from the Block 5 homogenized soils used in the treatability tests. It can be seen that there were no soil samples with benzo(a)pyrene concentrations greater than the average Block 5 homogenized soil benzo(a)pyrene soil concentration and 29 soil samples with less than the average Block 5 homogenized soil benzo(a)pyrene concentration. The benzo(a)pyrene concentration in the Block 5 soil homogenate was approximately 2 times greater than the highest observed concentration historically detected in soils from Block 5.

In summary, the Block 5 soils used in this Treatability Test are significantly greater, by nearly at least a factor of 2, than any historic TPH (DRO), Total PAH and benzo(a)pyrene concentrations historically reported from soil samples taken at Block 5. Benzene concentrations in the Block 5 soils are significantly lower than in the Block 4 soils and this is also reflected in the Block 5 soil homogenate used in the Treatability Tests.

3.1.3 DNAPL Characterization

Results from the DNAPL characterization showed a total VOC concentration of 42,970 mg/kg, a total SVOC concentration of 221,380 mg/kg, and a total TPH concentration of 903,000 mg/kg. The most abundant compound present in the DNAPL was naphthalene at a concentration of 100,000 mg/kg.

3.2 Supplemental TPH Desorption and Solubilisation Results (Task SS)

The intention of the supplemental desorption and solubilisation test was to determine the most effective surfactant for desorption and solubilisation of target contaminants present in the soil at this Site. The Block 5 soil homogenate was used in these tests. One control reactor was prepared along with 6 experimental reactors which contained one of six US FDA GRAS plant-based surfactants. Solubilisation enhancement factors were determined by calculating the fraction of TPH (DRO) (using the SiteLAB fluorescence method) desorbed and solubilised in the experimental reactors, relative to the control (water alone). Results showed that water alone (SS-1) solubilised 3.4 mg/L TPH, VeruSOL-3® (SS-2) solubilised 5,060 mg/L TPH, VeruSOL-10® (SS-3) solubilised 2,915 mg/L TPH, VeruSOL-11® (SS-4) solubilised 2,599 mg/L TPH, VeruSOL-12® (SS-5) solubilised 1,566 mg/L TPH, surfactant X1 (SS-6) solubilised 2,660 mg/L TPH, and surfactant X2 (SS-7) solubilised 2,487 mg/L TPH. Therefore, enhancement factors for SS-2 through SS-7 were 1,510x, 870x, 776x, 467x, 794x, and 742x, relative to the control. Based on these results, VeruSOL-3® was chosen as the optimal surfactant cosolvent system for the subsequent tests. The tests demonstrate that each of the surfactant systems performed well, with respect to enhancing desorption and solubilisation of TPH (DRO) fractions from the Block 5 soils.

Results from supplemental solubilisation tests are presented in Table 9, and Figure 3.

3.3 Solubilisation Enhancement Results (Task 2)

3.3.1 Desorption and Solubilisation of CoPCs from Block 5 Site Soil

Task 2 was conducted in order to observe the relationship between the dose of VeruSOL-3® and the concentration of desorbed and solubilised CoPCs from the Block 5 homogenized soils. Results from Task 2_solubilisation and desorption tests are shown in Table 10.

Reactors T2-A, B, C, D, and E contained VeruSOL-3® at concentrations of 0, 2.5, 5.0, 10, and 25 g/L, respectively.

- In the control reactor (T2-A), only water and Site soil from Block 5 were added, and the desorbed and solubilised constituents were as follows: 0.13 mg/L VOCs, 0.09 mg/L SVOCs, and non-detectable TPH (DRO) (<2.8 mg/L) using USEPA Method 8015B and 2.5 mg/L using the SiteLab fluorescence method.

- Reactor T2-B with 2.5 g/L of VeruSOL-3®, the desorbed and solubilised constituents were: 0.152 mg/L VOCs, 1.8 mg/L SVOCs, and 104 mg/L TPH (DRO) using USEPA Method 8015B and 117 mg/L using the SiteLab fluorescence method.
- Reactor T2-C with 5.0 g/L of VeruSOL-3®, the desorbed and solubilised constituents were:0.11 mg/L VOCs, 25 mg/L SVOCs, and 815 mg/L TPH (DRO) using USEPA Method 8015B and 1,397 mg/L using the SiteLab fluorescence method.
- Reactor T2-D with 10.0 g/L VeruSOL-3®, the desorbed and solubilised constituents were: 0.926 mg/L VOCs, 28 mg/L SVOCs, and 459 mg/L TPH (DRO) using USEPA Method 8015B and 3,155 mg/L using the SiteLab fluorescence method.
- Reactor T2-E with 25.0 g/L of VeruSOL-3®, the desorbed and solubilised constituents were: 2.6 mg/L VOCs, 36 mg/L SVOCs, and 760 mg/L TPH (DRO) using USEPA Method 8015B and 4,617 mg/L using the SiteLab fluorescence method.

Overall, there was a maximum enhancement of 175 for VOCs + SVOCs, and 1,857 for TPH (DRO) using the SiteLab fluorescence method, relative to the control, indicating excellent desorption and solubilisation of CoPCs from the Block 5 soil.

Figures were developed to assist in the interpretation of the desorption/solubilisation of select CoPCs from the Block 5 soil homogenate. When considering Total VOC and SVOC desorption and solubilisation from the Block 5 soils, the increased solubilisation is evident when examining the data presented in Figure 4a. As the dose of the VeruSOL-3® used in the tests increase there was an increase in the desorption and solubility of VOCs and SVOCs into the overlying emulsion phase. When using VeruSOL-3® doses of 5 g/L and higher, the solubility enhancement of VOCs and SVOCs was greater than 100. Similar Figures depicting results from varying VeruSOL-3® doses with corresponding increases in TPH (DRO) USEPA Method 8015B, TPH (DRO) SiteLAB fluorescence method, Total PAH, and benzo(a)pyrene are presented in Figures 4b, 4c, 4d, and 4e, respectively.

The increases in total PAH solubility with respect to VeruSOL-3® dose are significant—with desorption and solubility enhancement up to a factor of 400. The difference in the magnitude and desorption and solubility enhancement when comparing TPH (DRO) USEPA Method and TPH (DRO) SiteLAB data are significant. The TPH (DRO) SiteLAB Method 8015B desorption and solubility enhancement, shown in Figure 4c, clearly indicates a normally increasing trend in solubilised TPH (DRO) with increasing VeruSOL-3® dose. A polynomial fits these data with a R^2=0.9995. Review of the photographs of the reactors used in this test and the interfacial tension-VeruSOL-3® dose relationship also shown in Figure 4c clearly indicates a predictable trend. For a typical dose range of VeruSOL-3® from 5 g/L to 10 g/L the solubility enhancement for the Block 5 Site soils varied from 559 to 1,847. Data from the TPH (DRO) USEPA Method 8015B clearly indicates interferences are present in these data, as the data do not follow a normally observed trend and the magnitude of the TPH (DRO) concentrations are quite lower than expected, particularly in comparison to the TPH (DRO) SiteLAB fluorescence method.

3.4 Block 4 SEPR™/S-ESCO™ Batch Test Results (Task 5)

These batch tests were designed to simulate both S-ISCO® and S-ESCO™ on the Site soil, with simultaneous additions of the cosolvent/surfactant mixture and the selected oxidant/activator systems. One set of reactors was set up to test S-ISCO® reactions for either in situ or ex situ applications (Reactors T5-A, -B, -C, and –D) and were run for a period of 14 days. A second set of reactors (Reactors T5-E, -F, and –G) was set up with one reactor testing SEPR followed by S-ISCO® for in situ applications and a second reactor to simulate the ex situ S-ESCO process. The second set of reactors was only run for 8 days. . Results from Task 5_Block 4 Batch tests are presented in Table 11, and Figures 5a, 5b, 5c, 5d, 5e and 5f. The results are summarized below:

- Reactor T5-A, (soil and DI water alone) had final soil CoPC concentrations of 182 mg/kg VOCs, 2,062 mg/kg SVOCs, and 7,100 mg/kg TPH DRO. The second control, T5-E, had final soil CoPC concentrations of 136 mg/kg VOCs, 3,271 mg/kg SVOCs, and 11,000 mg/kg TPH DRO.

- Reactor T5-B was treated with alkaline activated sodium persulfate and VeruSOL-3® for 14 days and had final soil CoPC concentrations of 120 mg/kg VOCs, 1,274 mg/kg SVOCs, and 4,500 mg/kg TPH DRO. Therefore, relative to the initial Block 4 homogenized soil used in these tests there was a 81% reduction of VOCs and SVOCs, a 81% reduction of Total PAHs, a 79% reduction of Benzo(a) pyrene, an 84% reduction of naphthalene, >99% reduction of benzene and a 79% reduction of TPH (DRO) using EPA Method 8015B in the treated soil.

- Reactor T5-C was treated with Fe-EDTA activated persulfate and VeruSOL-3® for 14 days and had final soil CoPC concentrations of 283 mg/kg VOCs, 1,867 mg/kg SVOCs, and 7,500 mg/kg TPH DRO. Therefore, relative to the initial Block 4 homogenized soil used in these tests there was a 70% reduction of VOCs and SVOCs, a 73% reduction of Total PAHs, a 68% reduction of Benzo(a) pyrene, an 76% reduction of naphthalene, >99% reduction of benzene and a 65% reduction of TPH (DRO) using EPA Method 8015B in the treated soil.

- Reactor T5-D was treated with Fe-TAML catalysed peroxide with VeruSOL-3® for 14 days and had final soil COPC concentrations of 7.8 mg/kg VOCs, 801 mg/kg SVOCs, and 5,800 mg/kg TPH DRO. Therefore, relative to the initial Block 4 homogenized soil used in these tests there was a 89% reduction of VOCs and SVOCs, a 88% reduction of Total PAHs, a 84% reduction of Benzo(a) pyrene, a 98% reduction of naphthalene, >99% reduction of benzene and a 73% reduction of TPH (DRO) using EPA Method 8015B in the treated soil.

- Reactor T5-F was treated using SEPR™ for 1 day with VeruSOL-3® and peroxide, sequenced with S-ISCO®, with VeruSOL-3® and Fe-TAML catalysed peroxide for an additional 7 days. It should be noted that the SEPR™ liquid was not removed, as would typically be extracted prior to the S-SICO® treatment. Following the eight day treatment period, there were final soil CoPC concentrations of Non Detected <50 mg/kg VOCs, 798 mg/kg SVOCs, and 11,000 mg/kg TPH DRO. Therefore, relative initial Block 4 homogenized soil used in these tests there was a 89% reduction of VOCs and SVOCs , a 89% reduction of Total PAHs, a 92% reduction of Benzo(a) pyrene, a 90% reduction of naphthalene, >99% reduction of benzene and a 49% reduction of TPH (DRO) using EPA Method 8015B in the treated soil. Clearly, the TPH (DRO) analysis using the EPA Method 8015B was interfered with from the presence of VeruSOL-3®.

- T5-G was treated to test an ex situ S-ESCO™ process using VeruSOL-3® and Fe-TAML catalysed peroxide. Following the 8 day treatment, the final soil CoPC concentrations were 12 mg/kg VOCs, 999 mg/kg SVOCs, and 3,200 mg/kg TPH DRO. Therefore, relative to the initial Block 4 homogenized soil used in these tests there was a 86% greater reduction of VOCs and SVOCs, a 85% reduction of Total PAHs, a 84% reduction of Benzo(a) pyrene, a 90% reduction of naphthalene, >99% reduction of benzene and a 85% reduction of TPH (DRO) using EPA Method 8015B in the treated soil.

Overall, results suggest that the S-ESCO™ technology is highly effective in the treatment of gasworks residuals present in the Block 4 Site soil. These results indicate that both S-ISCO® with alkaline persulfate and S-ESCO™ with hydrogen peroxide and Fe-TAML were effective during the 14 day treatment period. Typically, these tests are run for 28 days to achieve more complete treatment, but because of the time constraints on the Treatability Test project schedule, this was not possible. It is fully expected given a normal lab treatment test period that the treatment effectiveness would be considerably greater. Field application at Full-Scale would take place over many months with in situ treatment and for up to 1 to 2 months for ex situ treatment using S-ISCO® with alkaline persulfate and up to 1 month for S-ISCO® with Fe-TAML catalysed hydrogen peroxide. Therefore, the added time for treatment reaction is fully expected to achieve even greater reductions than observed with these 14 day tests.

A comparison of the 8 day S-ESCO™ (T5-D) and 14 day S-ESCO™ (T5-G) results reveal that there was a greater reduction of VOCs and SVOCs, Total PAH and naphthalene in the 14 day versus 8 day treatment period, even though the 8 day test used 8% hydrogen peroxide versus 4% hydrogen peroxide used in the 14 day test. The difference between naphthalene reduction is 90% in the 8 day test versus 98% in the 14 day test. Additionally, the combined SEPR™/S-ISCO® test generally performed better than the S-ESCO™ alone treatment. It is clear that the Block 4 ex-situ soil treatment would be effective at treating the gasworks contaminated soils at this Site using a VeruSOL-3, FeTAML catalysed hydrogen peroxide treatment. This treatment was very effective at treating the CoPCs present at this Site, even though the soil samples from Block 4 used during these tests were in the upper 10% to 15% concentration range in comparison to historically detected CoPCs from soils sampled at the Block 4 Area.
VeruTEK's experience with respect to reaction time of treatability tests for gasworks coal tar residuals is that the longer the treatment period, the greater the treatment in the reactors tested. This is particularly true for PAH compounds which have longer reaction rates and are the longest lived species during the S-ISCO® and S-ESCO™ process. During Pilot and Full Scale

treatment the duration of treatment will be in the order of many months. Because chemical oxidation reactions are rate limited (meaning the longer the period of treatment the greater the extent of treatment), these shorter term soil column treatability test results are extremely conservative with respect to the Full Scale treatment potential S-ISCO® process. Therefore, the shorter laboratory periods are an acceptable protocol for simulations of longer term Pilot and Full Scale treatment.

Photographs and additional data are presented in Appendix A-4.

3.5 Short Term S-ISCO® Jar Tests for Block 4 Soils

Short term batch tests were conducted to simulate very rapid ex situ S-ISCO® treatment over a 1 day period for the Block 4 soils to simulate treatment at Hickson Road. These Block 4 soils were used in these tests for the analysis of in situ treatment at Hickson Road because it was impractical to disrupt Hickson Road with a Test Pit. These tests consisted of a 1 hour SEPR™ treatment and extracting the added liquid, followed by a 24 hour S-ISCO® oxidation period with Fe-TAML catalysed hydrogen peroxide with VeruSOL-3®. Results from the Short Term Batch Tests are presented in Table 12, and Figures 6a, 6b, 6c, 6d, 6e and 6f.

Reactor B-1, which was a control for the tests without any liquid extraction which contained only soil and DI water, had final soil CoPC concentrations of 112 mg/kg VOCs, 6,870 mg/kg SVOCs, and 28,000 mg/kg TPH DRO. The overlying water phase in the control reactor at the end of the 25 hour period had 2.2 mg/L VOCs, 4.6 mg/L SVOCs, and 42 mg/L TPH DRO using EPA Method 8015B.

Both SEPR™/ S-ISCO® reactors were treated using the same Phase II S-ISCO® treatment (8% hydrogen peroxide, 10 g/L VeruSOL-3® and 0.1 µM Fe-TAML) but were treated with different doses of Phase I treatment SEPR™ chemicals.

Reactor B-2 was treated with 20 g/L VeruSOL-3® and 15% peroxide during the SEPR™ phase, and had final soil CoPC concentrations of 46 mg/kg VOCs, 4,170 mg/kg SVOCs, and 19,000 mg/kg TPH DRO. Therefore, there was a 42% reduction of VOCs and SVOCs, and an 80% reduction of TPH, relative initial Block 4 homogenized soil. The extracted SEPR™ chemicals in the overlying water phase this reactor at the end of the 1 hour reaction period had non-detected VOCs, 390.8 mg/L SVOCs, and 6,400 mg/L TPH DRO using EPA Method 8015B. After the 24 hour S-ISCO® treatment period the overlying water had 2.7 mg/L VOCs, 317.9 mg/L SVOCs, and 2,067 mg/L TPH DRO using EPA Method 8015B.

Reactor B-3 was treated with 10 g/L VeruSOL-3® and 8% peroxide during the SEPR™ phase, and had final soil COPC concentrations of 28 mg/kg VOCs, 3,540 mg/kg SVOCs, and 25,000 mg/kg TPH DRO. Therefore, there was 51% reduction of VOCs and SVOCS, and a 82% reduction of TPH, relative to the control. The extracted SEPR™ chemicals in the overlying water phase this reactor at the end of the 1 hour reaction period had non-detected mg/L VOCs, 88.8 mg/L SVOCs, and

433 mg/L TPH DRO using EPA Method 8015B. After the 24 hour S-ISCO® treatment period the overlying water had 3.1 mg/L VOCs, 26.6 mg/L SVOCs, and 1,133 mg/L TPH DRO using EPA Method 8015B.

It can be seen that the extracted liquid phase following SEPR™ treatment in both reactors after 1 hour was significantly greater than in the control reactor liquid phase after 24 hours. VOCs in the control, B-2 and B-3 reactors were; 2.3 mg/L, ND, and ND, respectively. SVOCs in the control, B-2 and B-3 reactors were; 4.6 mg/L, 390.8 mg/L and 88.8 mg/L, respectively. TPH in the control, B-2 and B-3 reactors were; 42 mg/L, 6,400 mg/L and 433 mg/L, respectively. It can be seen that the reactor with the highest SEPR™ chemical dose, B-2 also had the highest concentrations of CoPCs in the extracted phase.

These results demonstrate the efficiency of the SEPR™ and S-ISCO® processes in reducing the level of CoPCs in the Site soil in only 25 hours. There was no significant advantage to using a higher dose of SEPR™ chemicals with respect to soil treatment. It is evident that the higher SEPR™ dose did result in a greater concentration of CoPCs in the extracted liquid. Based these excellent short-term 1-day combined SEPR™/ S-ISCO® results it is recommended to use the combined SEPR™ pretreatment followed by S-ISCO® with Fe-TAML catalysed hydrogen peroxide for in situ treatment at Hickson Road.

Results from the Block 4 Jar Tests are presented in Table 12, and Figures 6a, 6b, 6c, 6d, 6e and 6f. Photographs and additional data are presented in Appendix A-5.

3.5.1 Tar Tank Soil Emulsion Oxidation Tests

A small quantity of soil from a soil boring in Hickson Road was sent by AECOM to VeruTEK after the initial Block 4 and Block 5 test pit samples were received. The Hickson Road soil sampled was generated from BH53, which is located in the former Tar Tank. 800 g of soil from the Tar Tank was mixed with 25 g/L of VeruSOL-3 to form 4 L of an emulsion phase. The emulsion phase was then subject to 3 chemical oxidation treatments. In addition, there was a control reactor with the emulsion present and no oxidant. Oxidation tests took place over a 7 day period. Reactor 3-J was the control, reactor 3-K was an alkaline persulfate treatment, reactor 3-L was a Fe-EDTA activated persulfate treatment and reactor 3-M was a Fe-TAML catalysed hydrogen peroxide treatment.

Results of the effectiveness of the three oxidation processes used to treat the desorbed/dissolved gasworks CoPCs from the Tar Tank soils are presented in Figures 7a, 7b, 7c, 7c, 7d, 7e and 7f, as well as in Table 13. Benzene and benzo(a)pyrene reductions were greater than 99% for each of the 3 chemical oxidation processes tested. Benzene concentrations were reduced from2,400 µg/L to non-detected in each case. Benzo(a)pyrene concentrations were reduced 105 to µg/L to non-detected in each case. Overall reduction of VOCs and SVOCs was greatest for the FeTAML catalysed hydrogen peroxide process, with a 92% reduction from 47,472 µg/L to 3,656 µg/L in only 7 days of treatment. Total TPH reduction was 97 percent using the USEPA method 8015B test with the greatest reduction in the TPH (GRO) fraction. AS expected given the short reaction period PAH reduction lagged behind the lighter end compounds with only a 62% reduction in the 7 day period.

3.6 Sodium Persulfate Soil Oxidant Demand (SOD) Results

After the seven day reaction period the sodium persulfate Soil Oxidant Demand (SOD) was calculated for all reactors, in terms of grams of sodium persulfate consumed per kilogram of soil. It should be noted that this SOD test used the homogenized soils from Block 4 and Block 5. Therefore the SOD values represent oxidant use from both the soil matrix and the gasworks contamination present in the samples.

For the Block 4 homogenized SOD test, 6 sodium persulfate concentrations were used varying from 0.0 g/L up to 100 g/L. Reactor A-0, sodium persulfate control without any soil, maintained a concentration of 25 g/L over the span of seven days. Reactor A-1, soil alone, maintained a sodium persulfate reading of 0 g/L after seven days. Reactor A-2 decreased from 2.5 g/L to 0.54 g/L, giving an SOD of 13.9 g/kg. Reactor A-3 decreased from 10 g/L to 9.17 g/L giving an SOD of 21.7 g/kg. Reactor A-4 decreased from 25 g/L to 11.3 g/L, giving an SOD of 27.5 g/kg. Reactor A-5 decreased from 50 g/L to 28.1 g/L, giving an SOD of 43.7 g/kg. Finally, reactor A-6 decreased from 100 g/L to 70.9 g/L, giving an SOD of 58.2 g/kg.

Reactor B-1, the Block 5 soil control, maintained a persulfate reading of 0 g/L over the seven day period. Reactor B-2 decreased from 2.5 g/L to 0.13 g/L, giving an SOD of 14.7 g/kg. Reactor B-3 decreased from 10 g/L to 2.09 g/L, giving an SOD of 55.8 g/kg. Reactor B-4 decreased from 25 g/L to 11.2 g/L giving an SOD of 77.7 g/kg. Reactor B-5 decreased from 50 g/L to 48.5 g/L giving an SOD of 102.9 g/kg. Finally, reactor B-6 decreased from 100 g/L to 41 g/L giving an SOD of 116.1 g/kg.

As expected these results demonstrate that the measured SOD increased with an increase in sodium persulfate concentration. The highest SOD measured for Block 4 soil was 58 g/kg, at a sodium persulfate concentration of 100 g/L. In other words, 58 g of sodium persulfate was consumed per kilogram of Block 4 soil. The highest SOD measured for Block 5 soil was 116 g/kg, at 100 g/L sodium persulfate concentration. Therefore, there was 116 g of sodium persulfate consumed per kilogram of Block 5 soil.

Results from the SOD tests are presented in Table 14a and 14b, and Figure 8.

3.7 Soil Column Test Results (Task 4)

3.7.1 Block 4 Soil Columns

Block 4 soil column tests ran for a period of 14 days, where Column A was pumped with DI water, Column B was treated with SEPR (hydrogen peroxide at 4% and at VeruSOL-3® at 20 g/L), and Column C was treated with S-ISCO (hydrogen peroxide at 4% and at VeruSOL-3® at 10 g/L, with Fe-TAML Catalyst at 0.1 µM and sodium hydroxide at 0.1 N). Results from Block 4 column tests are presented in Table 15a, and Figures 9a, 9b, 9c, 9d, 9e and 9f. Total CoPC results for the three soil column tests are as follows:

- The control, Column A had final soil CoPC concentrations after 14 days of flushing with DI water of 155 mg/kg VOCs, 2,592 mg/kg SVOCs and 36,000 mg/kg of TPH DRO using USEPA Method 8015B and 7,650 mg/kg TPH DRO using the SiteLAB fluorescence method.

- The SEPR™ column with 4% hydrogen peroxide and 20 g/L, Column B, had final soil CoPC concentrations following treatment of 47 mg/kg VOCs, 1,187 mg/kg SVOCs, and 12,000 mg/kg of TPH DRO using USEPA Method 8015B and 62 mg/kg TPH DRO using the SiteLAB fluorescence method. There clearly is a discrepancy between the two TPH DRO analyses and this being a SEPR™ column with little degradation of the VeruSOL-3® could easily result in the false positive number using the USEPA method. Compared to the Block 4 homogenized soils, treatment in the SEPR™ column resulted in a VOC and SVOC removal of 83%, PAH removal of 83%, Benzo(a)pyrene removal of 93%, naphthalene removal of 87% and benzene removal of greater than 99%. TPH DRO removal was dramatically different depending on the method of analysis with greater than 99% removal using the SiteLab method and 44% using the USEPA Method 8015B, which also measures the presence of VeruSOL-3®.

- The S-ISCO® column with 4% hydrogen peroxide and 10 g/L VeruSOL-3® with 0.1 µM FeTAML was Column C and following had final soil concentrations of 134 mg/kg VOCs and 2,139 mg/kg SVOCs and 20,000 mg/kg of TPH DRO using USEPA Method 8015B and 23 mg/kg TPH DRO using the SiteLAB fluorescence method. Similar to the SEPR™ column, there clearly is a discrepancy between the two TPH DRO analyses. Compared to the Block 4 homogenized soils treatment in the S-ISCO® column resulted in a VOC and SVOC removal of 69%, PAH removal of 69%, Benzo(a)pyrene removal of 77%, naphthalene removal of 78% and benzene removal of greater than 99%. TPH (DRO) removal was dramatically different depending on the method of analysis with greater than 99% removal using the SiteLab method and 69% using the USEPA Method 8015B, which also measures the presence of VeruSOL-3®.

Overall there was excellent treatment of the of Block 4 soils in these soil column tests. It should be noted that only 4% hydrogen peroxide was used in these tests while at the field scale up to 12% hydrogen peroxide concentrations can be used. In these columns, only 4% hydrogen peroxide was used because of the type of peristaltic chemical feed pumps used to inject the treatment liquids and their inability to pump against any significant back pressure caused by oxygen gas generation associated with the use of hydrogen peroxide. While these columns were run for only 14 days, the treatment effectiveness was very good. During Pilot and Full Scale treatment to duration of treatment will be in the order of several months for possible in situ treatment application. One reason that the SEPR™ column had a greater treatment effectiveness in these soil column tests compared to the S-ISCO® column is that significantly less influent was applied to the S-ISCO® column due to the gas generation associated with Fe-TAML activation of hydrogen peroxide in the S-ISCO® column. During short term tests such as these, such effects do result in decreased performance in the lab, however at Pilot and Full Scale the longer treatment duration enables more than adequate time to apply a greater mass of chemical and for a longer duration. Given that the hydraulic residence time in the columns is only 6 to 10 hours, there is little time, in comparison to Pilot and Full Scale application, for complete treatment to take place.

3.7.2 Block 5 Soil Columns

Block 5 soil columns 1, 2, and 3 ran for a period of 28 days, while column 4 ran for 21 days, and column 5 ran for 7 days. After the 28 day period the control column had a soil concentrations of <6.2 mg/kg VOCs, 913 mg/kg SVOCs, 37,000 mg/kg TPH using USEPA Method 8015B, and 12,813 mg/kg using SiteLab fluorescence method. Results from Block 5 column tests are presented in Table 15b, and Figures 10a, 10b, 10c, 10d, 10e and 10f.

- The S-ISCO® with alkaline persulfate treatment used with Column 2, resulted in final soil CoPC concentrations after treatment of <60 mg/kg VOCs, and 761 mg/kg SVOCs. Treatment removal effectiveness in comparison to Block 5 homogenized soil concentrations were as follows: VOCs and SVOCs 68%, Total PAH 68%, benzo(a)pyrene 87%, naphthalene 67%, and benzene >99%. This column ran for 28 days.

- The S-ISCO® with Fe-EDTA activated persulfate treatment used with Column 3, resulted in final soil CoPC concentrations of <59 mg/kg VOCs, and 656 mg/kg SVOCs. Treatment removal effectiveness in comparison to Block 5 homogenized soil concentrations were as follows: VOCs and SVOCs 72%, Total PAH 72%, benzo(a)pyrene 87%, naphthalene 67% and benzene >99%. This column ran for 28 days.

- The S-ISCO® with Fe-TAML catalysed hydrogen peroxide treatment used with Column 4 results in final soil concentrations of <54 mg/kg, and an SVOC concentration of 382 mg/kg. Treatment removal effectiveness in comparison to Block 5 homogenized soil concentrations were as follows: VOCs and SVOCs 84%, Total PAH 84%, benzo(a)pyrene 95%, naphthalene 46% and benzene >99%. This column ran for 21 days.

- The SEPR™ column with 4% hydrogen peroxide and 10 g/L VeruSOL-3® treatment used with Column 5 , resulted in final soil concentrations after treatment of soil <51 mg/kg VOCs, and 468 mg/kg SVOCs. Treatment removal effectiveness in comparison to Block 5 homogenized soil concentrations were as follows: VOCs and SVOCs 80%, Total PAH 80%, benzo(a)pyrene 95%, naphthalene 82%, and benzene >99%. This column ran for only 7 days.

The most effective method of treatment proved to be SEPR, which reduced 80% of the COPCs in a period of only 7 days.

Photographs and additional data are presented in Appendix A-6.

4.0 Conclusions

Overall, VeruTEK's SEPR™, S-ESCO™, and S-ISCO® technologies all proved to be effective in reducing the levels of contamination present in Site soils. Supplemental solubilisation tests indicated that VeruSOL-3® was the optimal choice for desorption and solubilisation of the CoPCs present in the Site soil, solubilizing up to 1,510 times the amount of TPH than water alone with Site soil.

Solubilisation enhancement tests with VeruSOL-3® subsequently demonstrated the direct relationship between VeruSOL-3® dose and CoPC solubilisation. Due to the interference of the VeruSOL-3® components in the TPH analyses from Mitkem Laboratory, the trend is most clearly seen in the data gathered using the SiteLab fluorescence method. A maximum enhancement of 1,847 was achieved using a VeruSOL-3® dose of 25 g/L. Photographs presented in Appendix A-3 clearly demonstrate the increased CoPC desorption into the aqueous layer, with the increase concentrations of VeruSOL-3®.

S-ESCO™ Batch Tests with Block 4 soil proved to be highly effective with alkaline activated persulfate, as well as Fe-TAML catalysed peroxide. Up to an 81% reduction of CoPCs was achieved with alkaline persulfate, and an 89% reduction of CoPCs was achieved with Fe-TAML peroxide. Given these tests ran for only 14 days, the results demonstrated the efficiency of the S-ESCO™ process. S-ESCO™ field implementation would last about 1 month, after which complete or near complete reduction is fully expected. It is expected that once the soils from Block 4 are excavated and treated using the S-ESCO™ process that treated soil would be stockpiled on site during which time treatment would be completed. VeruTEK will provide additional analyses during the Work Plan development for the Block 4 S-ESCO™ Full Scale treatment to reduce the stockpiling time required for the soil by considering a higher hydrogen peroxide dose in the 8% to 15% range. An increased peroxide dose in the Block 4 treatability tests did result in more rapid treatment using the S-ESCO™ process.

The additional batch test results treating the Block 4 soils as a model of the Hickson Road in situ S-ISCO® application demonstrate the efficiency of the SEPR™ and S-ISCO® processes in reducing the level of CoPCs in the Site soil in only 25 hours. It was shown that there was no significant advantage to using a higher dose of SEPR™ extraction chemicals with respect to soil treatment. In a matter of 25 hours, the soil CoPCs were reduced by 51% using 10 g/L VeruSOL-3® and 8% hydrogen peroxide, for the SEPR™ phase, followed by 10 g/L VeruSOL-3®with 0.1 uM Fe-TAML catalysed 8% peroxide, for the S-ISCO® phase. Extraction of the SEPR™ chemicals prior to the S-ISCO® process at Hickson Road could additionally be considered to expedite soil treatment. The SEPR™ chemicals for reactor B-2, 20 g/L VeruSOL-3® and 15% peroxide, removed 7% by mass of initial CoPCs in the Site soil, in only 1 hour. The SEPR™ chemicals for reactor B-3, 10 g/L VeruSOL-3® and 8% hydrogen peroxide, removed 2% by mass of initial CoPCs in the soil, in only 1 hour. During Full-Scale treatment in Hickson Road SEPR™ application will take place over an estimated 2 week period. It is anticipated that significantly greater CoPC mass will extracted at

Full Scale in comparison to that observed during the 1 hour laboratory SEPR™ treatment period, in addition to the oxidation processes operative during the SEPR™ phase.

Soil column tests were designed to simulate the implementation of S-ISCO® on a small scale. Overall, it was observed that the SEPR® treatment preformed the best for Block 4 soil and Block 5 soil, which reduced CoPCs by 83% and 80% in a period of only 7 and 14 days, respectively. Due to the small scale of the tests, several issues arose in regards to efficient inflow of the chemicals through the entire column. Specifically with hydrogen peroxide and Fe-TAML, which are usually known to be highly effective, there was a large amount of gas formation at the base of the column, causing clogging, and restricting S-ISCO® chemicals from proper flow through. It was also evident that the levels of iron in the soil aided in the activation of the hydrogen peroxide, causing additional pressure build up throughout the column. During short term tests such as these, such effects do result in decreased performance in the lab, however at Pilot and Full Scale the longer treatment duration enables more than adequate time to apply a greater mass of chemical and for a longer duration.

The S-ISCO® process is proposed for use across Block 5, as required based on the HHERA and will not necessarily be limited to the DECCW Declaration Area. The S-ISCO® process and possibly the Surfactant Enhanced Product Recovery Process (SEPR™), as a pretreatment step, are being proposed for treatment of Hickson Road within the DECCW Declaration Area. The S-ESCO™ process is also an option being considered for excavated soils from Block 4.

Prior to Full Scale treatment, it is recommended to conduct a Pilot Test in Block 5 to demonstrate the effectiveness of the recommended treatment process consisting of S-ISCO® with catalysed hydrogen peroxide followed by S-ISCO® with activated persulfate as the preferred method to be tested. The Pilot Test will enable optimization of treatment for Full Scale application, as well as the refinement of the engineering design, monitoring program and system operations control measures.

It is additionally recommended to conduct a Pilot Test in Hickson Road at the location of the former Tar Tank. This feature is unique at the Site as it is excavated into bedrock and is either a confined or semi-confined vessel containing high concentrations of gasworks residuals. Given the close proximity of the former Tar Tank to 38 Hickson Road and associated sub-grade parking facilities and utilities, careful monitoring during the Pilot Test will ensure an effective and safe application of the S-ISCO® process at Full Scale.

During Pilot Scale and Full Scale in situ S-ISCO® treatment at Block 5 and Hickson Road when hydrogen peroxide is incorporated into the formulation being used, a soil vapor extraction system with Granular Activated Carbon (GAC) gas phase treatment will be utilized to collect the oxygen gas generated from the hydrogen peroxide decomposition and any associated VOCs that may be desorbed into the soil gas phase during treatment.

The decomposition products of the oxidants proposed for use at this Site include oxygen gas and water for hydrogen peroxide, and sodium and sulfate ions for sodium persulfate . None of these decomposition products will have any adverse impacts on the soil, groundwater or surface water in Darling Harbor. It is expected that significant increases in the dissolved oxygen concentration in groundwater will be observed, associated with the decomposition of hydrogen peroxide. This will likely have a positive effect and increase aerobic degradation of organic chemicals in the groundwater beyond the actual S-ISCO® treatment zones. There are no known stable degradation products associated with the degradation of gasworks residuals. Acetone is frequently an unstable intermediary compound associated with the degradation of gasworks residuals, however it readily undergoes chemical oxidation to carbon dioxide and water. Similarly, there are no known degradation products associated with the chemical oxidation of the VeruSOL-3™ mixture. HPLC/MS analysis of the decomposition or VeruSOL-3 solubilised gasworks residuals previously conducted by VeruTEK reveals no intermediary products and complete oxidation.

Tables

Table 1

Task SS Protocol: Supplemental Soil Solubilization Surfactant Screening - Barangaroo Block 5 Soil										
Task	Test Conditions	Reaction Media	Surfactant	Total Volume (mL)	Soil Added (g)	Water : Soil Ratio	Surfactant Added (g)	Surfactant (g/L)	Cosolvent/ Surfactant Parameters (CSPs)	Contaminants of Potential Concern (CoPCs)
SS-1	Aqueous Control	Deionized water	None	50	10	5 to 1	0	0	IFT	TPH
SS-2	Solubilization	Surfactant dosed water	VeruSOL-3	50	10	5 to 1	0.5	10	IFT	TPH
SS-3	Solubilization	Surfactant dosed water	VeruSOL-10	50	10	5 to 1	0.5	10	IFT	TPH
SS-4	Solubilization	Surfactant dosed water	VeruSOL-11	50	10	5 to 1	0.5	10	IFT	TPH
SS-5	Solubilization	Surfactant dosed water	VeruSOL-12	50	10	5 to 1	0.5	10	IFT	TPH
SS-6	Solubilization	Surfactant dosed water	X1	50	10	5 to 1	0.5	10	IFT	TPH
SS-7	Solubilization	Surfactant dosed water	X2	50	10	5 to 1	0.5	10	IFT	TPH

Notes:

1. Reactions take place under isothermal conditions at 120rpm and 25^{0}C for 24h.
2. Reactions settle ~6h, photographed, sampled for TPH.

Table 2

Task 2 Protocol: Solubilization Enhancement - Barangaroo Block 5 Soil									
Task	**Test Conditions**	**Cosolvent/ Surfactant**	**Total Solution Volume (mL)**	**Mass Soil Added (g)**	**Water : Soil Ratio**	**Cosolvent/ Surfactant (g/L)**	**Contaminants of Potential Concern (CoPCs)**	**Cosolvent/ Surfactant Parameters (CSPs)**	**Water Quality Parameters (WQPs)**
2-A	Aqueous Control	None	500	100	4 to 1	0	VOCs, SVOCs, TPH	IFT	pH, ORP, Temp, Turb
2-B	Solubilization	VeruSOL-3	500	100	4 to 1	2.5	VOCs, SVOCs, TPH	IFT	pH, ORP, Temp, Turb
2-C	Solubilization	VeruSOL-3	500	100	4 to 1	5	VOCs, SVOCs, TPH	IFT	pH, ORP, Temp, Turb
2-D	Solubilization	VeruSOL-3	500	100	4 to 1	10	VOCs, SVOCs, TPH	IFT	pH, ORP, Temp, Turb
2-E	Solubilization	VeruSOL-3	500	100	4 to 1	25	VOCs, SVOCs, TPH	IFT	pH, ORP, Temp, Turb

Notes:
1. Reactions take place under isothermal conditions at 120rpm and 25°C for 7 days. Following this will be a 24 hour settling period.
2. Photgraphs taken immediately after 7 day shaking and also after 24 hour settling periods.
3. After 24 hour settling, supernatant samples sent to Mitkem Laboratories and also analyzed by VeruTEK.
4. Mitkem laboratories does TPH, VOC and SVOC. VeruTEK additionally performs GRO/DRO TPH.

Table 3

Task 5 Protocol: SEPR/S-ISCO Batch Tests - Barangaroo Block 4 Soil													
Task	**Test Conditions**	**Soil Added (g)**	**Total Liquid Volume (mL)**	**Reaction Container**	**SEPR Treatment**	**S-ISCO Treatment**	**Duration**	**CoPCs**	**Cosolvent/ Surfactant Parameters (CSPs)**	**Water Quality Parameters (WQPs)**	**Oxidant/ Activator Parameters (OAPs)**	**Monitoring Frequencies (days)**	**CoPC Sampling**
5-A	Control	500	500	Glass Jar	None	none	14 Days	VOCs, SVOCs, TPH	IFT	pH, ORP, Cond, Temp, Turb	None	WQPs = Every 2 days	**Day 14:** Aqueous phase, and Soil
5-B	S-ESCO	500	500	Glass Jar	None	VeruSOL-3 (10 g/L); Sodium Persulfate (100 g/L); pH>12 (NaOH)	14 Days	VOCs, SVOCs, TPH	IFT	ORP, Cond, Temp, Turb	SP, pH	WQPs = Every 2 days, OAPs = Daily	**Day 14:** Aqueous phase, and Soil
5-C	S-ESCO	500	500	Glass Jar	None	VeruSOL-3 (10 g/L); Sodium Persulfate (100 g/L); Fe-EDTA (350 mg/L as Fe)	14 Days	VOCs, SVOCs, TPH	IFT	pH, ORP, Cond, Temp, Turb	SP, Fe-EDTA	WQPs = Every 2 days, OAPs = Daily	**Day 14:** Aqueous phase, and Soil
5-D	S-ESCO	500	500	Glass Jar	None	VeruSOL-3 (10 g/L); Hydrogen Peroxide (4%); FeTAML (0.1 uM); pH=8	14 Days	VOCs, SVOCs, TPH	IFT	ORP, Cond, Temp, Turb	HP, pH	WQPs = Every 2 days, OAPs = Daily	**Day 14:** Aqueous phase, and Soil
5-E	Control	250	500	Glass Jar	None	None	**8 Days**	VOCs, SVOCs, TPH	IFT	pH, ORP, Cond, Temp, Turb	None	WQPs = Every 2 days	**Day 8:** Aqueous phase, and Soil
5-F	SEPR / S-ESCO	250	SEPR: 500 mL S-ISCO: 500 mL	Glass Jar	VeruSOL-3 (**20 g/L**), Hydrogen Peroxide (4%)	VeruSOL-3 (**10 g/L**), Hydrogen Peroxide (4%), 0.1 uM Fe-TAML, [OH-]=0.01M	**SEPR:** 24 hours **S-ISCO:** 7 days	VOCs, SVOCs, TPH	IFT	ORP, Cond, Temp, Turb	HP, pH	WQPs = Every 2 days, OAPs = Daily	**24 Hours (SEPR)**: Aqueous phase **Day 8:** S-ESCO: Aqueous phase, and Soil
5-G	S-ESCO	250	500	Glass Jar	None	VeruSOL-3 (10 g/L), Hydrogen Peroxide (8%), 0.1 uM Fe-TAML, [OH-]=0.01M	**8 Days**	VOCs, SVOCs, TPH	IFT	ORP, Cond, Temp, Turb	HP, pH	WQPs = Every 2 days, OAPs = Daily	**Day 8:** Aqueous phase, and Soil

Notes:
1. Reactions take place under isothermal conditions at 60rpm.

Table 4

SEPR/S-ESCO Jar Test Protocol: Barangaroo Block 4 Soil											
Task	**Test Conditions**	**Reaction Media**	**Contaminated Soil Added (g)**	**Total Liquid Volume (mL)**	**Reaction Container**	**Phase I. Treatment SEPR Treatment**	**Phase II. Treatment S-ISCO Treatment**	**Parameters**	**Sequence of Treatment**	**Duration**	**Analysis**
B-1	Control	Contaminated Homogenized Soil	250	500	1 L Glass Jar	None	None	IFT	DI Water Only	24 hours	Decant Water Phase, Send Water Phase and Soil Phase to Mitkem for VOC, SVOC and TPH
B-2	SEPR / S-ISCO	Contaminated Homogenized Soil	250	500	1 L Glass Jar	VeruSOL-3 (**20 g/L**), Hydrogen Peroxide **(15%)**	VeruSOL-3 (10 g/L), Hydrogen Peroxide (8%), 0.1 uM Fe-TAML	IFT, HP	**Phase I.** Add VeruSOL-3 and HP, Mix Vigorously and then let sit for 60 minutes (loosen cap so no gas pressure builds up) **Decant Liquid Phase (~500 mL)** **Phase II.** Add S-ISCO: VeruSOL-3/HP, Fe-TAML in an Additional 500 mL, Mix Vigorously (loosen cap so no gas pressure builds up)and allow to react for 24 hours	**SEPR:** 60 minutes **S-ISCO:** 24 hours	**Phase I.** Decant Water Phase, Send Water Phase to Mitkem for VOC, SVOC and TPH **Phase II.** Decant Water Phase, Send Water Phase and Soil Phases to Mitkem for VOC, SVOC and TPH analysis
B-3	SEPR / S-ISCO	Contaminated Homogenized Soil	250	500	1 L Glass Jar	VeruSOL-3 (**10 g/L**), Hydrogen Peroxide **(8%)**	VeruSOL-3 (10 g/L), Hydrogen Peroxide (8%), 0.1 uM Fe-TAML	IFT, HP	**Phase I.** Add VeruSOL-3 and HP, Mix Vigorously and then let sit for 60 minutes (loosen cap so no gas pressure builds up) **Decant Liquid Phase (~500 mL)** **Phase II.** Add S-ISCO: VeruSOL-3/HP, Fe-TAML in an Additional 500 mL, Mix Vigorously (loosen cap so no gas pressure builds up)and allow to react for 24 hours	**SEPR:** 60 minutes **S-ISCO:** 24 hours	**Phase I.** Decant Water Phase, Send Water Phase to Mitkem for VOC, SVOC and TPH **Phase II.** Decant Water Phase, Send Water Phase and Soil Phases to Mitkem for VOC, SVOC and TPH analysis

Table 5

Task 3 Protocol: Oxidation of Solubilized COCs with S-ISCO - Barangaroo Tar Tank Emulsion										
Task ID	**Test Conditions**	**Total Volume (mL)**	**Reaction Media**	**Oxidant Dose**	**Activator Dose**	**CoPCs**	**Cosolvent/ Surfactant Parameters (CSPs)**	**Water Quality Parameters (WQPs)**	**Oxidant/ Activator Parameters (OAPs)**	**Sampling Frequency**
3-J	Control	500	Supernatant of Emulsion[4]	None	None	VOCs, SVOCs, TPH	IFT	pH, ORP, Cond, Temp, Turb	None	CoPCs = Day 7 WQPs = Day 0, 7
3-K	Oxidation	500	Supernatant of Emulsion[4]	Sodium Persulfate (100 g/L)	10N NaOH (pH > 12)	VOCs, SVOCs, TPH	IFT	ORP, Cond, Temp, Turb	SP, pH	CoPCs = Day 7 WQPs = Day 0,7 OAP = Daily
3-L	Oxidation	500	Supernatant of Emulsion[4]	Sodium Persulfate (100 g/L)	Fe-EDTA = 350 mg/L as Fe	VOCs, SVOCs, TPH	IFT	pH, ORP, Cond, Temp, Turb	SP, FeEDTA	CoPCs = Day 7 WQPs = Day 0,7 OAP = Daily
3-M	Oxidation	500	Supernatant of Emulsion[4]	Hydrogen Peroxide (4%)	Fe-TAML = 0.1 uM as Fe (pH ~ 8)	VOCs, SVOCs, TPH	IFT	ORP, Cond, Temp, Turb	HP, pH	CoPCs = Day 7 WQPs = Day 0,7 OAP = Daily

Notes:

1. Reactions take place under isothermal conditions at 60rpm and 25°C for 14 days.
2. Photgraphs taken immediately before and after 14-day reaction period.
3. Upon conclusion of the experiment, aqueous samples will be sent to Mitkem for analysis of VOCs, SVOCs, and TPH. Additionally, VeruTEK measures TPH.
4. Prepare 4 L of emulsion with 25 g/L VeruSOL 3 and 800 g of Tar Pit Sample, shake for 4 days at 120 rpm, at 25 °C followed by 24 hour settling.
5. Calculations of Oxidants remaining and used will be made and results tabulated.

Table 6a

Soil Oxidant Demand Protocol: Barangaroo Block 4 Soil							
Batch Number	Treatment Condition	Soil (g)	Sodium Persulfate (g/L)	Total Oxidant Solution (mL)	D.I.water / Soil Ratio	WQT	WQT Time (Day)
A0	Control I	0	25.00	150	No soil	pH, SP	0, 3, 5, and 7 days
A1	Control II	75	0.00	150	2:1	pH, SP	0, 3, 5, and 7 days
A2	Treatment-SP SOD	75	2.50	150	2:1	pH, SP	0, 3, 5, and 7 days
A3	Treatment-SP SOD	75	10.00	150	2:1	pH, SP	0, 3, 5, and 7 days
A4	Treatment-SP SOD	75	25.00	150	2:1	pH, SP	0, 3, 5, and 7 days
A5	Treatment-SP SOD	75	50.00	150	2:1	pH, SP	0, 3, 5, and 7 days
A6	Treatment-SP SOD	75	100.00	150	2:1	pH, SP	0, 3, 5, and 7 days

Table 6a

Soil Oxidant Demand Protocol: Barangaroo Block 4 Soil							
Batch Number	Treatment Condition	Soil (g)	Sodium Persulfate (g/L)	Total Oxidant Solution (mL)	D.I.water / Soil Ratio	WQT	WQT Time (Day)
A0	Control I	0	25.00	150	No soil	pH, SP	0, 3, 5, and 7 days
A1	Control II	75	0.00	150	2:1	pH, SP	0, 3, 5, and 7 days
A2	Treatment-SP SOD	75	2.50	150	2:1	pH, SP	0, 3, 5, and 7 days
A3	Treatment-SP SOD	75	10.00	150	2:1	pH, SP	0, 3, 5, and 7 days
A4	Treatment-SP SOD	75	25.00	150	2:1	pH, SP	0, 3, 5, and 7 days
A5	Treatment-SP SOD	75	50.00	150	2:1	pH, SP	0, 3, 5, and 7 days
A6	Treatment-SP SOD	75	100.00	150	2:1	pH, SP	0, 3, 5, and 7 days

Table 6b

Soil Oxidant Demand Results: Barangaroo Block 5 Soil							
Batch Number	Reaction Time (Day) Sodium Persuflate (g/L)				C_{D7}/C_o	SOD (g/kg)	Total SP* (C_o) (g/L)
	0	3	5	7			
B1	0.00	0.00	0.00	0.00	--	0.00	0.0
B2	2.50	0.06	0.00	0.13	0.02	14.7	7.5
B3	10.00	0.00	0.83	2.09	0.07	55.8	30
B4	25.00	2.79	0.88	11.15	0.22	77.7	50
B5	50.00	13.29	7.39	48.53	0.49	102.9	100
B6	100.00	53.55	46.59	41.96	0.42	116.1	100

Notes:
*Total SP is calculated based on the total amount of SP that was redosed throughout the tests

Table 7a

Task 4 Protocol: Soil Column S-ISCO Field Simulation - Barangaroo Block 4 Soil												
Task	**Test Conditions**	**Reaction Media**	**Cosolvent/ Surfactant (g/L)**	**Contaminated Soil Added**	**Oxidant Dose**	**Activator Dose**	**CoPCs**	**Cosolvent/ Surfactant Parameters (CSPs)**	**Water Quality Parameters (WQPs)**	**Oxidant/ Activator Parameters (OAPs)**	**Effluent Sampling Frequencies (days)**	**Soil Analyses**
4-A	Control	Contaminated Homogenized Soil from Block 4	none	Full (~1kg)	none	None	VOCs, SVOCs, TPH	IFT	pH, Temp, Turb	None	**CoPCs** = PV1, D7, D14 **WQPs** = Daily **CSPs** = Daily	Composite after 14 days for VOCs, SVOCs, TPH
4-B	SEPR	Contaminated Homogenized Soil from Block 4	VeruSOL-3 (20g/L)	Full (~1kg)	Hydrogen Peroxide (4%)	None	VOCs, SVOCs, TPH	IFT	pH, Temp, Turb	HP	**CoPCs** = PV1, D7, D14 **WQPs** = Daily **CSPs** = Daily **OAPs** = Daily	Composite after 14 days for VOCs, SVOCs, TPH
4-C	S-ISCO	Contaminated Homogenized Soil from Block 4	VeruSOL-3 (10 g/L)	Full (~1kg)	Hydrogen Peroxide (4%)	Fe-TAML (0.1 uM), [OH-]=0.01N	VOCs, SVOCs, TPH	IFT	Temp, Turb	HP, pH	**CoPCs** = PV1, D7, D14 **WQPs** = Daily **CSPs** = Daily **OAPs = Daily**	Composite after 14 days for VOCs, SVOCs, TPH

Table 7b

Task 4 Protocol: Soil Column Tests - Barangaroo Block 5 Soil											
Task	**Test Conditions**	**Cosolvent/ Surfactant (g/L)**	**Contaminated Soil Added**	**Oxidant Dose**	**Activator Dose**	**CoPCs**	**Cosolvent/ Surfactant Parameters (CSPs)**	**Water Quality Parameters (WQPs)**	**Oxidant/ Activator Parameters (OAPs)**	**Effluent Sampling Frequencies (days)**	**Soil Analyses**
4-1	Control	none	Full (~1kg)	none	none	VOCs, SVOCs, TPH	IFT	pH, Temp	None	**COCs** =D1, D7, D14, D28 **WQPs** = Daily **CSPs** = Daily **OAPs** = Daily	Composite after 28 days for VOCs, SVOCs, TPH
4-2	S-ISCO	VeruSOL-3 (10 g/L)	Full (~1kg)	Sodium Persulfate (100 g/L)	10N NaOH (pH > 12)	VOCs, SVOCs, TPH	IFT	pH, Cond, Temp	SP, pH	**COCs** =D1, D7, D14, D28 **WQPs** = Daily **CSPs** = Daily **OAPs** = Daily	Composite after 28 days for VOCs, SVOCs, TPH
4-3	S-ISCO	VeruSOL-3 (10 g/L)	Full (~1kg)	Hydrogen Peroxide (4%)	Fe-EDTA = 350 mg/L as Fe	VOCs, SVOCs, TPH	IFT	pH, Cond, Temp	SP, Fe-EDTA	**COCs** =D1, D7, D14, D28 **WQPs** = Daily **CSPs** = Daily **OAPs** = Daily	Composite after 28 days for VOCs, SVOCs, TPH
4-4	S-ISCO	VeruSOL-3 (10 g/L)	Full (~1kg)	Hydrogen Peroxide (4%)	Fe-TAML = 0.1 uM as Fe (pH ~ 8)	VOCs, SVOCs, TPH	IFT	pH, Temp	HP, FeTAML	**COCs** =D1, D7, D14, D21 **WQPs** = Daily **CSPs** = Daily **OAPs** = Daily	Composite after 21 days for VOCs, SVOCs, TPH
4-5	SEPR	VeruSOL-3 (10 g/L)	Full (~1kg)	Hydrogen Peroxide (4%)	None	VOCs, SVOCs, TPH	IFT	pH, Temp	HP	**COCs** =D1, D7 **WQPs** = Daily **CSPs** = Daily **OAPs** = Daily	Composite after 7 days for VOCs, SVOCs, TPH

Notes:
1. Soil Columns will be packed with composited site soil.
2. At the end of the column tests, influent will be terminated and the soil columns sacrificed, homogenized and sent for VOCs, SVOCs and TPH by Mitkem and additional in-house TPH by VeruTEK.

Table 8

Task 1: Initial Characterization - Barangaroo																				
Sample Type	Soil		Soil		Soil	Soil		Soil		Soil		Soil		Soil	NAPL		Liquid		Liquid	
Mitkem ID	J0473-01		J0473-02		Average of BAUS-B4HS1 and BAUS-B4HS2	J0700-01		J0719-01		J0473-03		J0473-04		Average of BAUS-B5HS1 and BAUS-B5HS2	J0622-03		J0622-01		J0622-02	
VeruTEK ID	BAUS-B4HS1		BAUS-B4HS2			0407-BAUS-B4HS3		0412-BAUS-BH53-HS		BAUS-B5HS1		BAUS-B5HS2			BAUS-MW205		BAUS-MW52		BAUS-MW74	
VOCs (SW846 8260)	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	(mg/kg)	Q	(ug/L)	Q	(ug/L)	Q
1,2,4-Trimethylbenzene	41		38		40	55		0.7	J	0.31	J	0.31	J	0.31	4300		BRL (<20)		BRL (<20)	
1,2,3-Trichlorobenzene	BRL (<4.6)		BRL (<3.8)		BRL (<4.2)	BRL (<51)		BRL (<3.5)		BRL (<0.57)		BRL (<0.58)		BRL (<0.575)	BRL (<630)		BRL (<20)		BRL (<20)	
1,3,5-Trimethylbenzene	19		17		18	25	J	BRL (<3.5)		0.12		BRL (<0.58)	J	0.06	1300		BRL (<20)		BRL (<20)	
1,4-Dichlorobenzene	BRL (<4.6)		BRL (<3.8)		BRL (<4.2)	BRL (<51)		BRL (<3.5)		BRL (<0.57)		BRL (<0.58)		BRL (<0.575)	BRL (<630)		BRL (<20)		BRL (<20)	
2-Butanone	BRL (<4.6)		BRL (<3.8)		BRL (<4.2)	BRL (<51)		BRL (<3.5)		0.13		BRL (<0.58)	J	0.07	BRL (<630)		BRL (<20)		BRL (<20)	
4-Isopropyltoluene	BRL (<4.6)		BRL (<3.8)		BRL (<4.2)	BRL (<51)		BRL (<3.5)		BRL (<0.57)		BRL (<0.58)		BRL (<0.575)	BRL (<630)		BRL (<20)		BRL (<20)	
Acetone	BRL (<4.6)		BRL (<3.8)		BRL (<4.2)	BRL (<51)		BRL (<3.5)		BRL (<0.57)		BRL (<0.58)		BRL (<0.575)	BRL (<630)		BRL (<20)		BRL (<20)	
Benzene	19		19		19	46	J	26		0.51		0.64	J	0.58	5700		BRL (<20)		BRL (<20)	
Chloroform	BRL (<4.6)		BRL (<3.8)		BRL (<4.2)	10	J	BRL (<3.5)		BRL (<0.57)		BRL (<0.58)		BRL (<0.575)	BRL (<630)		BRL (<20)		BRL (<20)	
cis-1,2-Dichloroethene	BRL (<4.6)		BRL (<3.8)		BRL (<4.2)	BRL (<51)		BRL (<3.5)		BRL (<0.57)		BRL (<0.58)		BRL (<0.575)	BRL (<630)		BRL (<20)		BRL (<20)	
Ethylbenzene	24		23		24	36	J	BRL (<3.5)		0.5		0.52	J	0.51	1700		BRL (<20)		BRL (<20)	
Isopropylbenzene	BRL (<4.6)		BRL (<3.8)		BRL (<4.2)	BRL (<51)		BRL (<3.5)		BRL (<0.57)		BRL (<0.58)		BRL (<0.575)	BRL (<630)		BRL (<20)		BRL (<20)	
m&p-Xylene	65		58		62	94		2.9	J	0.7	J	0.81		0.76	8900		BRL (<20)		BRL (<20)	
Naphthalene	1600		1,600		1,600	1400		38		5		5.1		5.05	28000	E	62		BRL (<20)	
n-Butylbenzene	1.6	J	1	J	1	BRL (<51)		BRL (<3.5)		0.19		BRL (<0.58)	J	0.1	160	J	BRL (<20)		BRL (<20)	
n-Propylbenzene	1.2	J	1	J	1	BRL (<51)		BRL (<3.5)		0.17		BRL (<0.58)	J	0.09	210	J	BRL (<20)		BRL (<20)	
o-Xylene	31		29		30	44	J	1.4	J	0.43	J	0.46	J	0.45	4300		BRL (<20)		BRL (<20)	
p-Isopropyltoluene	BRL (<4.6)		BRL (<3.8)		BRL (<4.2)	BRL (<51)		BRL (<3.5)		BRL (<0.57)		BRL (<0.58)		BRL (<0.575)	BRL (<630)		BRL (<20)		BRL (<20)	
sec-Butylbenzene	BRL (<4.6)		BRL (<3.8)		BRL (<4.2)	BRL (<51)		BRL (<3.5)		BRL (<0.57)		BRL (<0.58)		BRL (<0.575)	BRL (<630)		BRL (<20)		BRL (<20)	
Styrene	4.5	J	5		5	BRL (<51)		1.8	J	BRL (<0.57)	J	BRL (<0.58)		BRL (<0.575)	5400		BRL (<20)		BRL (<20)	
Toluene	7.1		6		6	11	J	11		1.1		1.3		1.2	11000		BRL (<20)		BRL (<20)	
total-xylenes	96		87		92	140		4.3		1.1		1.3		1.2	13000		BRL (<20)		BRL (<20)	
trans-1,2-Dichloroethene	BRL (<4.6)		BRL (<3.8)		BRL (<4.2)	BRL (<51)		BRL (<3.5)		BRL (<0.57)		BRL (<0.58)		BRL (<0.575)	BRL (<630)		BRL (<20)		BRL (<20)	
Trichloroethene	BRL (<4.6)		BRL (<3.8)		BRL (<4.2)	BRL (<51)		BRL (<3.5)		BRL (<0.57)		BRL (<0.58)		BRL (<0.575)	BRL (<630)		56		BRL (<20)	
Total VOCs	213.4		197		205	321.00		43.8		4.16		4.04		4.10	42970		56		0	
SVOCs (SW846 8270)	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	(mg/kg)	Q	(ug/L)	Q	(ug/L)	Q
1,2-Dichlorobenzene	BRL (<200)		BRL (<200)		BRL (<200)	BRL (<42)		BRL (<4.6)		BRL (<260)		BRL (<270)		BRL (<265)	BRL (<990)		BRL (<44)		BRL (<44)	
2-Chlorophenol	BRL (<200)		BRL (<200)		BRL (<200)	BRL (<42)		BRL (<4.6)		BRL (<260)		BRL (<270)		BRL (<265)	BRL (<990)		BRL (<44)		BRL (<44)	
2-Methylnaphthalene	490		450		470	210		110		39	J	32	J	36	29000.00		5	J	BRL (<44)	
2-Methylphenol	BRL (<200)		BRL (<200)		BRL (<200)	1.3	J	57		BRL (<260)		BRL (<270)		BRL (<265)	BRL (<990)		BRL (<44)		BRL (<44)	
4-Methylphenol	BRL (<200)		BRL (<200)		BRL (<200)	0.73	J	83		BRL (<260)		BRL (<270)		BRL (<265)	BRL (<990)		8.9	J	BRL (<44)	
2,4-Dimethylphenol	BRL (<200)		BRL (<200)		BRL (<200)	6.3		64		BRL (<260)		BRL (<270)		BRL (<265)	960	J	BRL (<44)		BRL (<44)	
Acenaphthene	88	J	100	J	94	44		22		36	J	43	J	40	1900		8	J	BRL (<44)	
Acenaphthylene	300		240		270	110		81		180	J	180	J	180	8500		16	J	BRL (<44)	
Anthracene	270		260		265	140		74		73	J	83	J	78	6100		16	J	BRL (<44)	
Benzo(a)anthracene	240		220		230	130		58		220	J	220	J	220	4200		28	J	BRL (<44)	
Benzo(a)pyrene	190	J	190	J	190	96		41		140	J	130	J	135	3100		26	J	BRL (<44)	
Benzo(b)fluoranthene	130	J	110	J	120	85		39		80	J	68	J	74	2600		35	J	BRL (<44)	
Benzo(g,h,i)perylene	90	J	87	J	89	77	E	27		48	J	48	J	48	1300		10	J	BRL (<44)	
Benzo(k)fluoranthene	160	J	160	J	160	88	E	20		74	J	88	J	81	2500		22	J	BRL (<44)	
Bis(2-ethylhexyl)phthalate	BRL (<200)		BRL (<200)		BRL (<200)	BRL (<42)		BRL (<4.6)		BRL (<260)		BRL (<270)		BRL (<265)	BRL (<990)		BRL (<44)		BRL (<44)	
Carbazole	150	J	130	J	140	61		31		BRL (<260)		BRL (<270)		BRL (<265)	1500		12	J	BRL (<44)	
Chrysene	210		200		205	110		51		190	J	180	J	185	4000		29	J	BRL (<44)	
Dibenzo(a,h)anthracene	21	J	22	J	22	17		5		BRL (<260)		BRL (<270)		BRL (<265)	620	J	BRL (<44)		BRL (<44)	
Dibenzofuran	270		250		260	120		59		BRL (<260)		BRL (<270)		BRL (<265)	4300		11	J	BRL (<44)	
Diethylphthalate	BRL (<200)		BRL (<200)		BRL (<200)	BRL (<42)		BRL (<4.6)		BRL (<260)		BRL (<270)		BRL (<265)	BRL (<990)		BRL (<44)		BRL (<44)	
Fluoranthene	660		610		635	430		150		360		350		355	8100		84		BRL (<44)	
Fluorene	330		300		315	170		71		38	J	31	J	35	7400		16	J	BRL (<44)	
Ideno(1,2,3-cd)pyrene	83	J	84	J	84	72	E	23		46	J	43	J	45	1300		9	J	BRL (<44)	
Naphthalene	2100		2,100		2,100	1200		660	B	73	J	68	J	71	100000		26	J	BRL (<44)	
Phenanthrene	940		890		915	590		260		230	J	230	J	230	19000		53		8.0	J
Phenol	BRL (<200)		BRL (<200)		BRL (<200)	0.5	J	59		BRL (<260)		BRL (<270)		BRL (<265)	BRL (<990)		11	J	BRL (<44)	
Pyrene	530		500		515	220		110		540		520		530	15000		80		10	J
Total SVOCs	7252		6,903		7,078	3979		2155		2367		2314		2340.5	221380		507		18	
Total PAHs	6342		6073		6207.5	0		1692.2		2328		2282		2305	185620		460		17.8	
TPH - GRO (SW846 8015)	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	(mg/kg)	Q	(mg/L)	Q	(mg/L)	Q
Gasoline Range Organics	530		410		470	780		1,700		BRL (<7.4)		BRL (<7.5)		(BRL (<7.5)	63,000		BRL (<0.1)		BRL (<0.1)	
TPH - DRO (SW846 8015B)	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	(mg/kg)	Q	(mg/kg)		(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	(mg/kg)		(mg/L)	Q	(mg/L)	Q
Extractable Total Petroleum Hydrocarbon	21000		22000		21,500	17,000		13,000		38,000		42,000		40,000	840,000		1.6		BRL (<0.35)	
Total TPH	21,530		22,410		21,970	17,780		14,700		38,000		42,000		40,000	903,000		1.6		0	
VeruTEK TPH DRO	3,020		4,860		3,940	2,753		23,290		8,240		3,783		6,012	655,000		--		--	
Metals (SW846 6010)	(mg/kg)									(mg/kg)										
Mitkem ID	J0622-04		--		--	--		--		J0622-05		--		--	--		--		--	
VeruTEK ID	BAUS-B4-HS-1		--		--	--		--		BAUS-B5-HS-1		--		--	--		--		--	
Iron	8,800		--		--	--		--		8,800		--		--	--		--		--	

Note:
1) Total VOC values do not include: total xylenes, napthalene
2) Average values were calculated for Block 4 and Block 5 soil.
3) For compounds detected in one sample, but not the duplicate, zero was used to determine the average.
4) Componds highlighted orange represent PAH compounds defined by EPA

Table 9

Task SS: Supplemental Solubilization Results					
Sample	IFT	TPH-DRO	TPH-GRO	Total TPH	Enhancement Factors
SS-1	71.6	3	BRL (<25)	3.35	--
SS-2	35.4	5060	BRL (<25)	5060	1510
SS-3	39.2	2915	BRL (<25)	2915	870
SS-4	48.7	2599	BRL (<25)	2599	776
SS-5	34.2	1566	BRL (<25)	1566	467
SS-6	41.4	2660	BRL (<25)	2660	794
SS-7	37.2	2487	BRL (<25)	2487	742

Table 10

Task 2: Solubilization Enhancement (Block 5 Soil)										
Sample Type	Liquid		Liquid		Liquid		Liquid		Liquid	
Mitkem ID	J0577-01		J0577-02		J0577-03		J0577-04		J0577-05	
VeruTEK ID	032510-BAUS-T2A		032510-BAUS-T2B		032510-BAUS-T2C		032510-BAUS-T2D		032510-BAUS-T2E	
Conditions	DI_Soil		2.5 g/L VeruSOL_Soil		5 g/L VeruSOL_Soil		10 g/L VeruSOL_Soil		25 g/L VeruSOL_Soil	
VOCs (SW846 8260)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q
1,2,4-Trimethylbenzene	46		80	J	110	J	106		BRL (<1,000)	
1,2,3-Trichlorobenzene	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
1,3,5-Trimethylbenzene	17.4	J	BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
1,4-Dichlorobenzene	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
2-Butanone	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
4-Isopropyltoluene	12.6	J	BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
Acetone	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
Benzene	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
Chloroform	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
cis-1,2-Dichloroethene	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
Ethylbenzene	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
Iodomethane	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		1,900	
Isopropylbenzene	BRL (<20)		BRL (<100)		BRL (<200)		200		680	J
m&p-Xylene	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
Naphthalene	34		BRL (<100)		BRL (<200)		168		BRL (<1,000)	
n-Butylbenzene	36	J	72	J	BRL (<200)		BRL (<100)		BRL (<1,000)	
n-Propylbenzene	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
o-Xylene	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
p-Isopropyltoluene	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
sec-Butylbenzene	BRL (<20)		BRL (<100)		BRL (<200)		620		BRL (<1,000)	
Styrene	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
Tetrachloroethene	18.8	2	BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
Toluene	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
total-xylenes	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
trans-1,2-Dichloroethene	BRL (<20)		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
Trichloroethene	2,400		BRL (<100)		BRL (<200)		BRL (<100)		BRL (<1,000)	
Total VOCs	131		152		110		926		2,580	
SVOCs (SW846 8270)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q
1,2-Dichlorobenzene	BRL (<80)		BRL (<800)		BRL (<741)		BRL (<741)		BRL (<4,000)	
2-Chlorophenol	BRL (<80)		BRL (<800)		BRL (<741)		BRL (<741)		BRL (<4,000)	
2-Methylnaphthalene	BRL (<80)		BRL (<800)		BRL (<741)		BRL (<741)		BRL (<4,000)	
2-Methylphenol	BRL (<80)		BRL (<800)		BRL (<741)		BRL (<741)		BRL (<4,000)	

4-Methylphenol	BRL (<80)		BRL (<800)		BRL (<741)		BRL (<741)		BRL (<4,000)	
VeruTEK ID	032510-BAUS-T2A		032510-BAUS-T2B		032510-BAUS-T2C		032510-BAUS-T2D		032510-BAUS-T2E	
Conditions	DI_Soil		2.5 g/L VeruSOL_Soil		5 g/L VeruSOL_Soil		10 g/L VeruSOL_Soil		25 g/L VeruSOL_Soil	
SVOCs (SW846 8270)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q
2,4-Dimethylphenol	BRL (<80)		BRL (<800)		BRL (<741)		BRL (<741)		BRL (<4,000)	
Acenaphthene	10.4	J	BRL (<800)		319	J	363	J	BRL (<4,000)	
Acenaphthylene	15.2	J	104	J	741		815		720	J
Anthracene	BRL (<80)		BRL (<800)		622	J	726	J	960	J
Benzo(a)anthracene	BRL (<80)		168	J	2,000		2,593		3,200	J
Benzo(a)pyrene	BRL (<80)		BRL (<800)		1,333		1,630		2,000	J
Benzo(b)fluoranthene	BRL (<80)		96	J	963		1,111		1,200	J
Benzo(g,h,i)perylene	BRL (<80)		BRL (<800)		533	J	519	J	776	J
Benzo(k)fluoranthene	BRL (<80)		BRL (<800)		815		585	J	1,120	J
Bis(2-ethylhexyl)phthalate	BRL (<80)		BRL (<800)		BRL (<741)		BRL (<741)		BRL (<4,000)	
Carbazole	BRL (<80)		BRL (<800)		BRL (<741)		BRL (<741)		BRL (<4,000)	
Chrysene	BRL (<80)		216	J	2,519		2,444		2,800	J
Dibenzo(a,h)anthracene	BRL (<80)		BRL (<800)		170	J	178	J	BRL (<4,000)	
Dibenzofuran	BRL (<80)		BRL (<800)		141	J	133	J	BRL (<4,000)	
Diethylphthalate	BRL (<80)		BRL (<800)		BRL (<741)		BRL (<741)		BRL (<4,000)	
Fluoranthene	BRL (<80)		264	J	2,889		3,259		4,720	
Fluorene	8.0	J	BRL (<800)		BRL (<741)		BRL (<741)		BRL (<4,000)	
Ideno(1,2,3-cd)pyrene	BRL (<80)		BRL (<800)		467	J	511	J	696	J
Naphthalene	BRL (<80)		BRL (<800)		BRL (<741)		BRL (<741)		BRL (<4,000)	
Phenanthrene	28.8	J	312	J	3,630		3,704		4,960	
Phenol	BRL (<80)		BRL (<800)		BRL (<741)		BRL (<741)		BRL (<4,000)	
Pyrene	27.2	J	720	J	8,148		8,889		12,800	
Total SVOCs	90		1,880		25,289		27,459		35,952	
Total PAHs	90		1,880		25,148		27,326		35,952	
TPH - GRO (SW846 8015)	(mg/L)	Q	(mg/L)	Q	(mg/L)	Q	(mg/L)	Q	(mg/L)	Q
Gasoline Range Organics	BRL (<0.1)		0.11		194		620		1,580	
TPH - DRO (SW846 8015B)	(mg/L)	Q	(mg/L)	Q	(mg/L)	Q	(mg/L)	Q	(mg/L)	Q
Extractable Total Petroleum Hydrocarbon	BRL (<2.8)		104		815		459		760	
Total TPH	BRL (<2.9)		104		1,009		1,079		2,340	
VeruTEK TPH	2.5		117		1,397		3,155		4,617	

Notes:
1) Total VOC values do not include: total xylenes, naphthalene, trichloroethylene
2) Compounds highlighted orange represent PAH compounds defined by EPA

Qualifiers:
J - Analyte detected below quantitation limits
B - Analyte detected in the associated Method Blank
E - Value above quantitation range
BRL - Below Report Limit

Table 11

Task 5 Block 4: SEPR/S-ISCO Batch Test Results: Barangaroo															
Sample Type	Soil	Soil		Soil		Soil		Soil		Soil		Soil		Soil	
Mitkem ID	Average of BAUS-B4HS1 and BAUS-B4HS2	J0701-04		J0701-05		J0701-06		J0701-07		J0720-02		J0720-04		J0720-06	
VeruTEK ID		040710-BAUS-T5A-S		040710-BAUS-T5B-S		040710-BAUS-T5C-S		040710-BAUS-T5D-S		0408-BAUS-T5B4ES-D7		0408-BAUS-T5B4FS-D7		0408-BAUS-T5B4GS-D7	
Conditions	Initial Soil	14 Day Control		Alkaline SP		Fe-EDTA, SP		Fe-TAML, HP		8 Day Control		SEPR/S-ESCO		S-ESCO	
VOCs (SW846 8260)	(ug/kg)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q
1,2,4-Trimethylbenzene	39,500	64,000	J	56,000	J	72,000	J	BRL (<18,800)		34,000	J	BRL (<50,000)		BRL (<53,000)	
1,2,3-Trichlorobenzene	BRL (<4,200)	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
1,3,5-Trimethylbenzene	18,000	BRL (<188,000)		BRL (<188,000)		31,600	J	BRL (<18,800)		15,000	J	BRL (<50,000)		BRL (<53,000)	
1,4-Dichlorobenzene	BRL (<4,200)	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
2-Butanone	BRL (<4,200)	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
4-Isopropyltoluene	BRL (<4,200)	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
Acetone	BRL (<4,200)	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
Benzene	19,000	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		4,000	J	BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
Chloroform	BRL (<4,200)	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
cis-1,2-Dichloroethene	BRL (<4,200)	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
Ethylbenzene	23,500	BRL (<188,000)		BRL (<188,000)		31,200	J	BRL (<18,800)		14,000	J	BRL (<50,000)		BRL (<53,000)	

Isopropylbenzene	BRL (<4,200)	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	

Conditions	Initial Soil	14 Day Control		Alkaline SP		Fe-EDTA, SP		Fe-TAML, HP		8 Day Control		SEPR/S-ESCO		S-ESCO	
VOCs (8260) (cont.)	(ug/kg)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q
m&p-Xylene	61,500	80,000	J	64,000	J	104,000	J	3,800	J	49,000	J	BRL (<50,000)		12,000	J
Naphthalene	1,600,000	390,000	J	1,840,000		2,600,000		160,000		1,100,000		490000		480,000	
n-Butylbenzene	1,450	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
n-Propylbenzene	1,150	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
o-Xylene	30,000	37,600	J	BRL (<188,000)		44,000	J	BRL (<18,800)		24,000	J	BRL (<50,000)		BRL (<53,000)	
p-Isopropyltoluene	BRL (<4,200)	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
sec-Butylbenzene	BRL (<4,200)	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
Styrene	4,550	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
Toluene	6,300	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
total-xylenes	91,500	116,000	J	64,000	J	148,000		3,800		73,000	J	BRL (<50,000)		12,000	J
trans-1,2-Dichloroethene	BRL (<4,200)	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
Trichloroethene	BRL (<4,200)	BRL (<188,000)		BRL (<188,000)		BRL (<148,000)		BRL (<18,800)		BRL (<63,000)		BRL (<50,000)		BRL (<53,000)	
Total VOCs	204,950	181,600		120,000		282,800		7,800		136,000		0		12,000	
SVOCs (SW846 8270)	(ug/kg)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/L)	Q	(ug/L)	Q		
1,2-Dichlorobenzene	BRL (<200,000)	BRL (<4,100)		BRL (<4,200)		BRL (<4,000)		BRL (<3,900)		BRL (<4,800)		BRL (<4,200)		BRL (<4,300)	
2-Chlorophenol	BRL	BRL		BRL		BRL		BRL		BRL		BRL		BRL	

	(<200,000)	(<4,100)		(<4,200)		(<4,000)		(<3,900)		(<4,800)		(<4,200)		(<4,300)	
2-Methylnaphthalene	470,000	110,000		71,000		100,000		19,000		180,000		45,000		45,000	
2-Methylphenol	BRL (<200,000)	430	J	BRL (<4,200)		BRL (<4,000)		BRL (<3,900)		640	J	BRL (<4,200)		BRL (<4,300)	

Conditions	Initial Soil	14 Day Control		Alkaline SP		Fe-EDTA, SP		Fe-TAML, HP		8 Day Control		SEPR/S-ESCO		S-ESCO	
SVOCs (8270) (cont.)	(ug/kg)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q
2,4-Dimethylphenol	BRL (<200,000)	1,500	J	BRL (<4,200)		790	J	BRL (<3,900)		2,200	J	BRL (<4,200)		BRL (<4,300)	
4-Methylphenol	BRL (<200,000)	BRL (<4,100)		470	J	BRL (<4,000)		BRL (<3,900)		BRL (<4,800)		BRL (<4,200)		BRL (<4,300)	
Acenaphthene	94,000	40,000		17,000		33,000		12,000		68,000		15,000		18,000	J
Acenaphthylene	270,000	54,000		15,000		25,000		13,000		74,000		11,000		15,000	J
Anthracene	265,000	74,000		43,000		60,000		21,000		130,000		17,000		31,000	
Benzo(a)anthracene	230,000	74,000		48,000		72,000		42,000		130,000		32,000		46,000	
Benzo(a)pyrene	190,000	63,000		40,000		60,000		30,000		97,000	E	16,000		31,000	
Benzo(b)fluoranthene	120,000	54,000		29,000		56,000		33,000		74,000		23,000		34,000	
Benzo(g,h,i)perylene	88,500	45,000		29,000		37,000		23,000		62,000		17,000		22,000	
Benzo(k)fluoranthene	160,000	54,000		45,000		53,000		34,000		82,000	E	17,000		22,000	
Bis(2-ethylhexyl)phthalate	BRL (<200,000)	BRL (<4,100)		BRL (<4,200)		BRL (<4,000)		BRL (<3,900)		BRL (<4,800)		BRL (<4,200)		BRL (<4,300)	
Butylbenzylphthalate	BRL (<200,000)	BRL (<4,100)		BRL (<4,200)		BRL (<4,000)		BRL (<3,900)		BRL (<4,800)		BRL (<4,200)		BRL (<4,300)	
Carbazole	140,000	28,000		6,000		13,000		13,000		43,000		14,000		16,000	
Chrysene	205,000	74,000		45,000		69,000		47,000		98,000		30,000		41,000	
Dibenzo(a,h)anthracene	21,500	13,000		6,800		9,200		4,900		18,000		3,200	J	5,300	
Dibenzofuran	260,000	70,000		45,000		63,000		31,000		120,000		33,000		36,000	
Diethylphthalate	BRL (<200,000)	BRL (<4,100)		BRL (<4,200)		BRL (<4,000)		BRL (<3,900)		BRL (<4,800)		BRL (<4,200)		BRL (<4,300)	
Fluoranthene	635,000	200,000		150,000		200,000		130,000		330,000		88,000		120,000	
Fluorene	315,000	92,000		44,000		62,000		44,000		150,000		38,000		44,000	
Ideno(1,2,3-cd)pyrene	83,500	45,000		22,000		34,000		22,000		52,000		13,000		20,000	

Naphthalene	2,100,000	550,000		340,000		510,000		40,000		890,000	B	200,000	B	220,000	B
Phenanthrene	915,000	270,000		190,000		260,000		160,000		440,000		120,000		150,000	
Phenol	BRL (<200,000)	BRL (<4,100)		BRL (<4,200)		BRL (<4,000)		BRL (<3,900)		BRL (<4,800)		BRL (<4,200)		BRL (<4,300)	
Pyrene	515,000	150,000		88,000		150,000		82,000		230,000		66,000		83,000	
Total SVOCs	7,077,500	2,061,930		1,274,270		1,866,990		800,900		3,270,840		798,200		999,300	
Total PAHs	6,207,500	1,852,000		1,151,800		1,690,200		737,900		2,925,000		706,200		902,300	
Conditions	Initial Soil	14 Day Control		Alkaline SP		Fe-EDTA, SP		Fe-TAML, HP		8 Day Control		SEPR/S-ESCO		S-ESCO	
TPH - GRO (SW846 8015)	(mg/kg)	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q
Gasoline Range Organics	470	110		440		480		21		320		690		210	
TPH - DRO (SW846 8015B)	(mg/kg)	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q
Extractable Total Petroleum Hydrocarbon	21500	7100		4,500		7,500		5,800		11,000		11000		3,200	
Total TPH	21,970	7,210		4,940		7,980		5,821		11,320		11,690		3,410	
VeruTEK TPH	3,940	1,947		790		1,253		985		--		--		--	

Notes:
1) Total VOC values do not include: total xylenes, naphthalene
2) Compounds highlighted orange represent PAH compounds defined by EPA

Qualifiers:
J - Analyte detected below quantitation limits
B - Analyte detected in the associated Method Blank
E - Value above quantitation range
BRL - Below Report Limit

Table 12

Jar Tests Block 4 Soil - Barangaroo							
Sample Type	Soil	Soil		Soil		Soil	
Mitkem ID	Average of BAUS-B4HS1 and BAUS-B4HS2	J0584-06		J0584-07		J0584-08	
VeruTEK ID		032510-BAUS-JTB1P2-S		032510-BAUS-JTB2P2-S		032510-BAUS-JTB3P2-S	
Description	Initial Soil	Control Soil		B2 Soil		B3 Soil	
VOCs (SW846 8260)	(ug/kg)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q
1,2,4-Trimethylbenzene	39,500	33,000	J	17,000	J	13,000	J
1,2,3-Trichlorobenzene	BRL (<4,200)	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
1,3,5-Trimethylbenzene	18,000	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
1,4-Dichlorobenzene	BRL (<4,200)	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
2-Butanone	BRL (<4,200)	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
4-Isopropyltoluene	BRL (<4,200)	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
Acetone	BRL (<4,200)	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
Benzene	19,000	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
Carbon disulfide	BRL (<4,200)	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
Chloroform	BRL (<4,200)	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
cis-1,2-Dichloroethene	BRL (<4,200)	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
Ethylbenzene	23,500	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
Isopropylbenzene	BRL (<4,200)	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
m&p-Xylene	61,500	53,000	J	18,000	J	15,000	J
Naphthalene	1,600,000	1,100,000	B	470,000		390,000	J
n-Butylbenzene	1,450	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
n-Propylbenzene	1,150	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
o-Xylene	30,000	26,000	J	11,000	J	BRL (<52,000)	
p-Isopropyltoluene	BRL (<4,200)	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
sec-Butylbenzene	BRL (<4,200)	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
Styrene	4,550	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
Toluene	6,300	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
total-xylenes	91,500	79,000	J	29,000	J	15,000	J
trans-1,2-Dichloroethene	BRL (<4,200)	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
Trichloroethene	BRL (<4,200)	BRL (<100,000)		BRL (<50,000)		BRL (<52,000)	
Total VOCs	204,950	112,000		46,000		28,000	
SVOCs (SW846 8270)	(ug/kg)	(ug/kg)		(ug/kg)		(ug/kg)	
1,2-Dichlorobenzene	BRL (<200,000)	BRL (<210,000)		BRL (<190,000)		BRL (<200,000)	
2-Chlorophenol	BRL (<200,000)	BRL (<210,000)		BRL (<190,000)		BRL (<200,000)	
2-Methylnaphthalene	470000	430,000		190,000		190,000	J
2-Methylphenol	BRL (<200,000)	BRL (<210,000)		BRL (<190,000)		BRL (<200,000)	
4-Methylphenol	BRL (<200,000)	BRL (<210,000)		BRL (<190,000)		BRL (<200,000)	
2,4-Dimethylphenol	BRL (<200,000)	BRL (<210,000)		BRL (<190,000)		BRL (<200,000)	

Acenaphthene	94000	94,000	J	52,000	J	48,000	J
Acenaphthylene	270000	260,000		170,000	J	120,000	J
Anthracene	265000	260,000		160,000	J	130,000	J
Description	Initial Soil	Control Soil		B2 Soil		B3 Soil	
SVOCs (8270) (cont.)	(ug/kg)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q
Benzo(a)anthracene	230000	250,000		220,000		150,000	J
Benzo(a)pyrene	190000	200,000	J	170,000	J	120,000	J
Benzo(b)fluoranthene	120000	170,000	J	130,000	J	100,000	J
Benzo(g,h,i)perylene	88500	94,000	J	83,000	J	55,000	J
Benzo(k)fluoranthene	160000	110,000	J	110,000	J	71,000	J
Bis(2-ethylhexyl)phthalate	BRL (<200,000)	BRL (<210,000)		BRL (<190,000)		BRL (<200,000)	
Carbazole	140000	130,000	J	58,000	J	64,000	J
Chrysene	205000	210,000	J	170,000	J	140,000	J
Dibenzo(a,h)anthracene	21500	22,000	J	24,000	J	BRL (<200,000)	
Dibenzofuran	260000	250,000		130,000	J	120,000	J
Diethylphthalate	BRL (<200,000)	BRL (<210,000)		BRL (<190,000)		BRL (<200,000)	
Fluoranthene	635000	670,000		510,000		400,000	
Fluorene	315000	310,000		150,000	J	150,000	J
Ideno(1,2,3-cd)pyrene	83500	90,000	J	73,000	J	52,000	J
Naphthalene	2100000	1,900,000		900,000		820,000	
Phenanthrene	915000	900,000		450,000		500,000	
Phenol	BRL (<200,000)	BRL (<210,000)		BRL (<190,000)		BRL (<200,000)	
Pyrene	515000	520,000		420,000		310,000	
Total SVOCs	7,077,500	6,870,000		4,170,000		3,540,000	
Total PAHs	6,207,500	6,060,000		3,792,000		3,166,000	
TPH - GRO (SW846 8015)	(mg/kg)	(mg/kg)		(mg/kg)		(mg/kg)	
Gasoline Range Organics	470	110		390		160	
TPH - DRO (SW846 8015B)	(mg/kg)	(mg/kg)		(mg/kg)		(mg/kg)	
Extractable Total Petroleum Hydrocarbon	21500	28,000		19,000		25,000	
Total TPH	21,970	28,110		19,390		25,160	
VeruTEK TPH	21,970	6,126		7,890		7,214	

Notes:

1) Total VOC values do not include: total xylenes, naphthalene

2) Compounds highlighted orange represent PAH compounds defined by EPA

Qualifiers:

J - Analyte detected below quantitation limits

B - Analyte detected in the associated Method Blank

E - Value above quantitation range

BRL - Below Report Limit

Task 3 Results: Emulsion Oxidation: Tar Tank Soil (BH53)								
Sample Type	Liquid		Liquid		Liquid		Liquid	
Mitkem ID	J0854-05		J0854-06		J0854-07		J0854-08	
VeruTEK ID	0421-BAUS-T3J		0421-BAUS-T3K		0421-BAUS-T3L		0421-BAUS-T3M	
Conditions	Control		Alkaline SP		FeEDTA SP		HP FeTAML	
VOCs (SW846 8260)	(ug/L)	Q	(ug/L)	Q	(ug/L)	Q	(ug/L)	Q
1,2,4-Trimethylbenzene	4800		3600		3,600		160	J
1,2,3-Trichlorobenzene	BRL (<200ug/L)		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
1,3,5-Trimethylbenzene	1980		1560	J	1,380		BRL (<200ug/L)	
1,4-Dichlorobenzene	BRL (<200ug/L)		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
2-Butanone	BRL (<200ug/L)		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
4-Isopropyltoluene	BRL (<200ug/L)		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
Acetone	BRL (<200ug/L)		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
Benzene	2400		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
Chloroform	168	BJ	2600		1,240		188	BJ
cis-1,2-Dichloroethene	BRL (<200ug/L)		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
Ethylbenzene	1000		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
Isopropylbenzene	980		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
m&p-Xylene	9000		4400		4,400		BRL (<200ug/L)	
Naphthalene	58000	BE	158000		124,000		10,400	B
n-Butylbenzene	280		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
n-Propylbenzene	200		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
o-Xylene	4200		2200		2,200		BRL (<200ug/L)	
p-Isopropyltoluene	BRL (<200ug/L)		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
sec-Butylbenzene	BRL (<200ug/L)		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
Styrene	4200		BRL (<2000 ug/L)		840	J	BRL (<200ug/L)	
Tetrachloroethene	BRL (<200ug/L)		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
Toluene	7200		BRL (<2000 ug/L)		1,660		BRL (<200ug/L)	
total-xylenes	13200		6400		6,600		BRL (<200ug/L)	
trans-1,2-Dichloroethene	BRL (<200ug/L)		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
Trichloroethene	BRL (<200ug/L)		BRL (<2000 ug/L)		BRL (<1000ug/L)		BRL (<200ug/L)	
Total VOCs	36,408		14,360		15,320		348	
SVOCs (SW846 8270)								
1,2-Dichlorobenzene	BRL(<250ug/L)		BRL (<256 ug/L)		BRL (<278 ug/L)		BRL (<160 ug/L)	
2-Chlorophenol	BRL(<250ug/L)		BRL (<256 ug/L)		BRL (<278 ug/L)		BRL (<160 ug/L)	
2-Methylnaphthalene	650		303		483		272	
2-Methylphenol	600		BRL (<256 ug/L)		BRL (<278 ug/L)		BRL (<160 ug/L)	
4-Methylphenol	1050		BRL (<256 ug/L)		172	J	BRL (<160 ug/L)	
2,4-Dimethylphenol	700		BRL (<256 ug/L)		BRL (<278 ug/L)		BRL (<160 ug/L)	
Acenaphthene	80	J	26	J	49	J	33	J
Acenaphthylene	435		BRL (<256 ug/L)		178	J	108	J
Anthracene	255	J	BRL (<256 ug/L)		78	J	BRL (<160 ug/L)	
Benzo(a)anthracene	175	J	67	J	128	J	72	J
Benzo(a)pyrene	105	J	BRL (<256 ug/L)		BRL (<278 ug/L)		BRL (<160 ug/L)	
Benzo(b)fluoranthene	95	J	44	J	72	J	44	J
Benzo(g,h,i)perylene	39	J	18	J	29	J	17	J
Benzo(k)fluoranthene	60	J	BRL (<256 ug/L)		46	J	17	J
Bis(2-ethylhexyl)phthalate	BRL(<250ug/L)		BRL (<256 ug/L)		BRL (<278 ug/L)		BRL (<160 ug/L)	
Carbazole	180	J	BRL (<256 ug/L)		BRL (<278 ug/L)		68	J
Chrysene	165	J	72	J	111	J	72	J
Dibenzo(a,h)anthracene	BRL(<250ug/L)		BRL (<256 ug/L)		BRL (<278 ug/L)		BRL (<160 ug/L)	
Dibenzofuran	250	J	118	J	189	J	116	J
Diethylphthalate	BRL(<250ug/L)		BRL (<256 ug/L)		BRL (<278 ug/L)		BRL (<160 ug/L)	
Fluoranthene	550		221	J	406		236	
Fluorene	320		72	J	211	J	136	J
Ideno(1,2,3-cd)pyrene	55	J	BRL (<256 ug/L)		48	J	BRL (<160 ug/L)	
Naphthalene	3750		1744		2,778	E	1,440	
Phenanthrene	1,050		513		833		440	
Phenol	BRL(<250ug/L)		BRL (<256 ug/L)		BRL (<278 ug/L)		BRL (<160 ug/L)	
Pyrene	500		256		422		236	
Total SVOCs	11,064		3,452		6,233		3,308	
Total PAHs								
TPH - GRO (SW846 8015)								
Gasoline Range Organics	3000		1040.0		620.0		7	
TPH - DRO (SW846 8015B)								
Extractable Total Petroleum Hydrocarbon	105		179		67		80	
Total TPH	3,105		1,219		687		87	
Notes:			Qualifiers:					
1) Total VOC values do not include: total xylenes, napthalene			J - Analyte detected below quantitation limits					
2) Componds highlighted orange represent PAH compoun	B - Analyte detected in th eassociated Method Blank							

Table 14a

Soil Oxidant Demand Results: Barangaroo Block 4 Soil							
Batch Number	Reaction Time (Day) Sodium Persulfate (g/L)				C_{D7}/C_o	SOD (g/kg)	Total SP* (C_o) (g/L)
	0	3	5	7			
A0	25	25.50	24.48	25.30	1.01	--	25
A1	0.0	0.00	0.00	0.00	--	0.0	0.0
A2	2.5	0.14	0.02	0.54	0.07	13.9	7.5
A3	10	3.36	2.01	9.17	0.46	21.7	20
A4	25	15.92	11.87	11.25	0.45	27.5	25
A5	50	37.02	30.80	28.13	0.56	43.7	50
A6	100	79.10	74.69	70.91	0.71	58.2	100

Notes:
*Total SP is calculated based on the total amount of SP that was redosed throughout the tests

Table 14b

Soil Oxidant Demand Results: Barangaroo Block 5 Soil							
Batch Number	Reaction Time (Day) Sodium Persulfate (g/L)				C_{D7}/C_o	SOD (g/kg)	Total SP* (C_o) (g/L)
	0	3	5	7			
B1	0.00	0.00	0.00	0.00	--	0.00	0.0
B2	2.50	0.06	0.00	0.13	0.02	14.7	7.5
B3	10.00	0.00	0.83	2.09	0.07	55.8	30
B4	25.00	2.79	0.88	11.15	0.22	77.7	50
B5	50.00	13.29	7.39	48.53	0.49	102.9	100
B6	100.00	53.55	46.59	41.96	0.42	116.1	100

Notes:
*Total SP is calculated based on the total amount of SP that was redosed throughout the tests

Table 15a

Task 4 Soil Columns - Barangaroo Block 4 Soil							
Sample Type	Initial Soil	Soil		Soil		Soil	
Mitkem ID	Average of BAUS-B4HS1 and BAUS-B4HS2	J0768-01		J0768-02		J0768-03	
VeruTEK ID		041510-BAUS-T4B4A-S		041510-BAUS-T4B4B-S		041510-BAUS-T4B4C-S	
VOCs (SW846 8260)	(ug/kg)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q
1,2,3-Trichlorobenzene	39,500	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
1,2,4-Trimethylbenzene	BRL (<4,200)	41,000	J	21,000	J	44,000	J
1,3,5-Trimethylbenzene	18,000	18,000	J	9,400	J	20,000	J
1,4-Dichlorobenzene	BRL (<4,200)	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
2-Butanone	BRL (<4,200)	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
4-Isopropyltoluene	BRL (<4,200)	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
Acetone	BRL (<4,200)	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
Benzene	19,000	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
Chloroform	BRL (<4,200)	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
Chloromethane	BRL (<4,200)	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
cis-1,2-Dichloroethene	BRL (<4,200)	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
Ethylbenzene	23,500	18,000	J	BRL (47,000)		11,000	J
Iodomethane	BRL (<4,200)	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
Isopropylbenzene	BRL (<4,200)	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
m&p-Xylene	61,500	53,000		17,000	J	39,000	J
Naphthalene	1,600,000	1,400,000		870,000		1,500,000	
n-Butylbenzene	1,450	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
n-Propylbenzene	1,150	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
o-Xylene	30,000	25,000	J	BRL (47,000)		20,000	J
p-Isopropyltoluene	BRL (<4,200)	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
sec-Butylbenzene	BRL (<4,200)	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
Styrene	4,550	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
Toluene	6,300	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
total-xylenes	91,500	77,000		17,000	J	60,000	
trans-1,2-Dichloroethene	BRL (<4,200)	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
Trichloroethene	BRL (<4,200)	BRL (<51,000)		BRL (47,000)		BRL (<49,000)	
Total VOCs	204,950	155,000		47,400		134,000	
SVOCs (SW846 8270)	(ug/kg)	(ug/L)	Q	(ug/kg)	Q	(ug/kg)	Q
1,2-Dichlorobenzene	BRL (<200,000)	BRL (<2,100)		BRL (<2,000)		BRL (<2,000)	
2-Chlorophenol	BRL (<200,000)	BRL (<2,100)		BRL (<2,000)		BRL (<2,000)	
2-Methylnaphthalene	470,000	130,000	E	72,000	E	110,000	E
2-Methylphenol	BRL (<200,000)	BRL (<2,100)		BRL (<2,000)		BRL (<2,000)	
4-Methylphenol	BRL (<200,000)	BRL (<2,100)		200	J	BRL (<2,000)	
2,4-Dimethylphenol	BRL (<200,000)	730	J	BRL (<2,000)		BRL (<2,000)	

Acenaphthene	94,000	60,000	E	18,000		46,000	E
Acenaphthylene	270,000	72,000	E	20,000		47,000	E
Anthracene	265,000	95,000	E	23,000		70,000	E
VeruTEK ID	Average of BAUS-B4HS1 and BAUS-B4HS2	041510-BAUS-T4B4A-S		041510-BAUS-T4B4B-S		041510-BAUS-T4B4C-S	
SVOCs (SW846 8270) (cont.)	(ug/kg)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q
Benzo(a)anthracene	230,000	120,000	E	53,000	E	100,000	E
Benzo(a)pyrene	190,000	59,000	E	14,000		43,000	E
Benzo(b)fluoranthene	120,000	73,000	E	41,000	E	60,000	E
Benzo(g,h,i)perylene	88,500	56,000	E	27,000		40,000	E
Benzo(k)fluoranthene	160,000	51,000	E	25,000		37,000	E
Bis(2-ethylhexyl)phthalate	BRL (<200,000)	BRL (<2,100)		690,000	E	400,000	E
Carbazole	140,000	44,000	E	16,000		36,000	E
Chrysene	205,000	90,000	E	42,000	E	70,000	E
Dibenzo(a,h)anthracene	21,500	15,000		5,600		13,000	
Dibenzofuran	260,000	130,000	E	59,000	E	89,000	E
Diethylphthalate	BRL (<200,000)	BRL (<2,100)		BRL (<2,000)		BRL (<2,000)	
Fluoranthene	635,000	220,000	E	130,000	E	210,000	E
Fluorene	315,000	150,000	E	50,000	E	120,000	E
Ideno(1,2,3-cd)pyrene	83,500	46,000	E	23,000		38,000	E
Naphthalene	2,100,000	550,000	E	270,000	E	460,000	E
Phenanthrene	915,000	410,000	E	200,000	E	370,000	E
Phenol	BRL (<200,000)	BRL (<2,100)		BRL (<2,000)		BRL (<2,000)	
Pyrene	515,000	220,000	E	98,000	E	180,000	E
Total SVOCs	7,077,500	2,591,730		1,186,800		2,139,000	
Total PAHs	6,207,500	2,287,000		1,039,600		1,904,000	
TPH - GRO (SW846 8015)	(mg/kg)	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q
Gasoline Range Organics	470	310		530		810	
TPH - DRO (SW846 8015B)	(mg/kg)	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q
Extractable Total Petroleum Hydrocarbon	21,500	36,000		12,000		20,000	
Total TPH	21,970	36,310		12,530		20,810	
VeruTEK TPH DRO	3,940	7,650		62		23	

Notes:
1) Total VOC values do not include: total xylenes, naphthalene
2) Compounds highlighted orange represent PAH compounds defined by EPA
3) SVOCs do not include Bis(2-ethylhexyl)phthalate, as it results from the plastic used in the columns

Qualifiers:
J - Analyte detected below quantitation limits
B - Analyte detected in the associated Method Blank
E - Value above quantitation range
BRL - Below Report Limit

Table 15b

Task 4 Soil Columns: Barangaroo Block 5 Soil											
Sample Type	Initial Soil	Soil		Soil		Soil		Soil		Soil	
Mitkem ID	Average of BAUS-B5HS1 and BAUS- B5HS2	J0769-01		J0769-02		J0769-03		J0769-04		J0769-05	
VeruTEK ID		0415-BAUS-T4B5-C1S-D28		0415-BAUS-T4B5-C2S-D28		0415-BAUS-T4B5-C3S-D28		0415-BAUS-T4B5-C4S-D28		0415-BAUS-T4B5-C5S-D7	
Description		Control - Day 28		Alkaline SP - Day 28		FeEDTA SP - Day 28		FeTAML HP - Day 21		SEPR - Day 7	
VOCs (SW846 8260)	(ug/kg)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q
1,2,3-Trichlorobenzene	310	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
1,2,4-Trimethylbenzene	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
1,3,5-Trimethylbenzene	60	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
1,4-Dichlorobenzene	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
1,2-Dichloroethane	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
2-Butanone	65	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
2-Hexanone	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
4-Isopropyltoluene	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
Acetone	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
Benzene	575	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
Carbon disulfide	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
Chloroform	BRL (<575)	1,400	BJ	BRL (<60,000)		13,000	J	11,000	J	12,000	J
Chloroethane	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
Chloromethane	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
cis-1,2-Dichloroethene	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
Ethylbenzene	510	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
Iodomethane	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
Isopropylbenzene	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
m&p-Xylene	755	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
Methylene chloride	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	

Naphthalene	5,050	4,300	J	84,000		20,000	J	23,000	J	29,000	J
n-Butylbenzene	95	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
n-Propylbenzene	85	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
Description	Average of BAUS-B5HS1 and BAUS- B5HS2	Control - Day 28		Alkaline SP - Day 28		FeEDTA SP - Day 28		FeTAML HP - Day 21		SEPR - Day 7	
VOCs (8260) (cont.)	(ug/kg)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q
o-Xylene	445	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
p-Isopropyltoluene	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
sec-Butylbenzene	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
Styrene	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
Toluene	1,200	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
total-xylenes	1,200	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
trans-1,2-Dichloroethene	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
Trichloroethene	BRL (<575)	BRL (<6,200)		BRL (<60,000)		BRL (<59,000)		BRL (<54,000)		BRL (<51,000)	
Total VOCs	4,100	0		0		0		0		0	
SVOCs (SW846 8270)	(ug/kg)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q
1,2-Dichlorobenzene	(BRL (<265,000)	BRL (<2,400)		BRL (<2,300)		BRL (<2,300)		BRL (<2,100)		BRL (<2,000)	
2-Chlorophenol	(BRL (<265,000)	BRL (<2,400)		BRL (<2,300)		BRL (<2,300)		BRL (<2,100)		BRL (<2,000)	
2-Methylnaphthalene	35,500	6,300		12,000		9,300		16,000		6,400	
2-Methylphenol	(BRL (<265,000)	BRL (<2,400)		BRL (<2,300)		BRL (<2,300)		BRL (<2,100)		BRL (<2,000)	
4-Methylphenol	(BRL (<265,000)	BRL (<2,400)		BRL (<2,300)		BRL (<2,300)		BRL (<2,100)		BRL (<2,000)	
Acenaphthene	39,500	9,100		5,900		4,900		3,000		3,400	
Acenaphthylene	180,000	20,000		38,000	E	30,000		27,000		34,000	E
Anthracene	78,000	28,000		27,000		21,000		20,000		24,000	
Benzo(a)anthracene	220,000	110,000	E	88,000	E	66,000	E	21,000		47,000	E
Benzo(a)pyrene	135,000	44,000	E	17,000		18,000		6,900		7,300	
Benzo(b)fluoranthene	74,000	36,000		29,000		26,000		17,000		17,000	
Benzo(g,h,i)perylene	48,000	22,000		17,000		17,000		9,400		14,000	
Benzo(k)fluoranthene	81,000	20,000		23,000		26,000		13,000		23,000	

Bis(2-ethylhexyl)phthalate	(BRL (<265,000)	BRL (<2,400)		150,000	E	530,000	E	1,500,000	E	410,000	E
Carbazole	(BRL (<265,000)	BRL (<2,400)		BRL (<2,300)		BRL (<2,300)		BRL (<2,100)		BRL (<2,000)	
Chrysene	185,000	86,000	E	66,000	E	70,000	E	37,000	E	60,000	E
Dibenzo(a,h)anthracene	(BRL (<265,000)	10,000		6,400		7,900		4,000		6,700	
Dibenzofuran	(BRL (<265,000)	2,100	J	2,400		2,600		1,700	J	1,500	J
Description	Average of BAUS-B5HS1 and BAUS- B5HS2	Control - Day 28		Alkaline SP - Day 28		FeEDTA SP - Day 28		FeTAML HP - Day 21		SEPR - Day 7	
SVOCs (8270) (cont.)	(ug/kg)	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q	(ug/kg)	Q
Diethylphthalate	(BRL (<265,000)	BRL (<2,400)		BRL (<2,300)		BRL (<2,300)		BRL (<2,100)		BRL (<2,000)	
Fluoranthene	355,000	160,000	E	140,000	E	110,000	E	68,000	E	79,000	E
Fluorene	34,500	12,000		8,000		8,200		5,900		8,600	
Ideno(1,2,3-cd)pyrene	44,500	20,000		20,000		18,000		8,900		13,000	
Naphthalene	70,500	12,000		23,000		23,000		38,000	E	13,000	
Phenanthrene	230,000	95,000	E	88,000	E	78,000	E	36,000	E	39,000	E
Phenol	(BRL (<265,000)	BRL (<2,400)		BRL (<2,300)		BRL (<2,300)		BRL (<2,100)		BRL (<2,000)	
Pyrene	530,000	220,000	E	150,000	E	120,000	E	49,000	E	71,000	E
Total SVOCs	2,340,500	912,500		760,700		655,900		381,800		467,900	
Total PAHs	2,305,000	904,100		746,300		644,000		364,100		460,000	
TPH - GRO (SW846 8015)	(mg/kg)	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q
Gasoline Range Organics	(BRL (<7.5)	23		1,200		570		820		2,200	
TPH - DRO (SW846 8015B)	(mg/kg)	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q	(mg/kg)	Q
Extractable Total Petroleum Hydrocarbon	40,000	37,000		43,000		13,000		29,000		55,000	
Total TPH	40,000	37,023		44,200		13,570		29,820		57,200	
VeruTEK TPH	5,143	12,813		39,310		290		35,300		74	

Notes:

1) Total VOC values do not include: total xylenes, Napthalene

Qualifiers:

J - Analyte detected below quantitation limits

2) Componds highlighted orange represent PAH compounds defined by EPA
3) SVOCs do not include Bis(2-ethylhexyl)phthalate, as it results from the plastic used in the columns

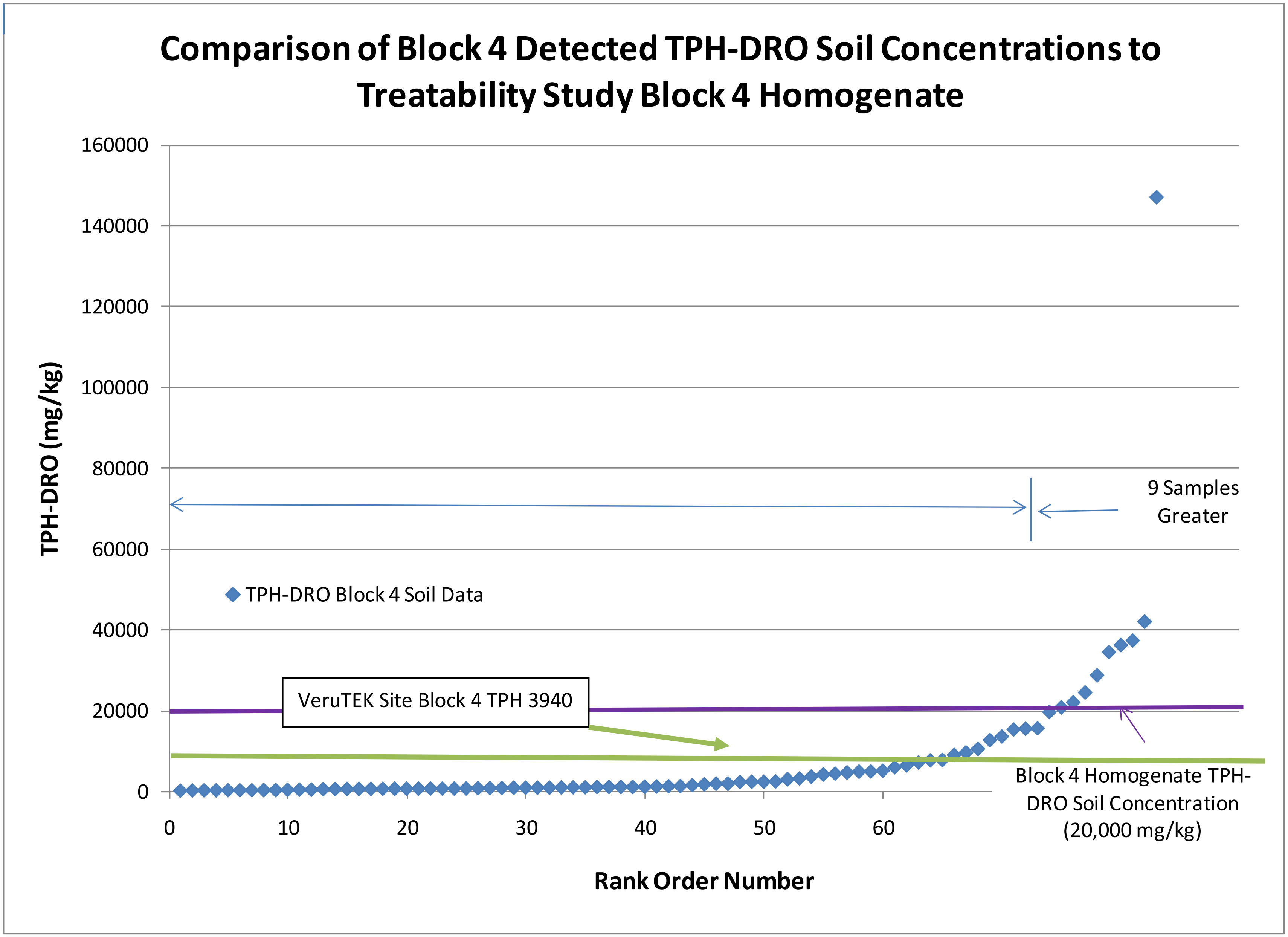
B - Analyte detected in the associated Method Blank
E - Value above quantitation range
BRL - Below Report Limit

Figures

b. Total TPH vs. Treatment
c. Total PAHs vs. Treatment
d. Benzo(a)pyrene Concentration vs. Treatment
e. Naphthalene Concentration vs. Treatment
f. Benzene Concentration vs. Treatment

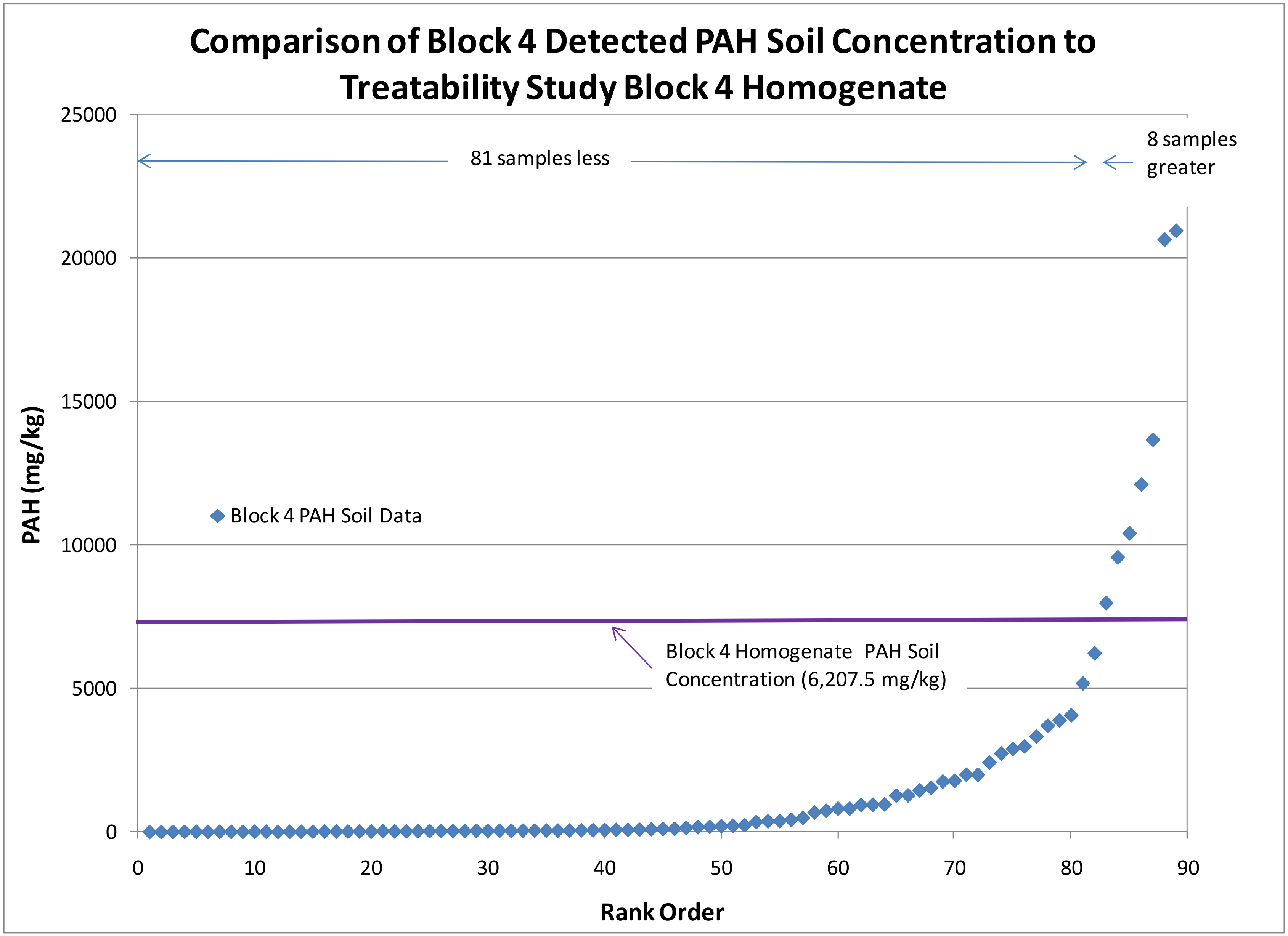
8. Soil Oxidant Demand - SOD vs. Persulfate Concentration
9. Column Tests Block 4
    a. VOCs/SVOCs vs. Treatment
    b. TPH DRO vs. Treatment
    c. Total PAHs vs. Treatment
    d. Benzo(a)pyrene Concentration vs. Treatment
    e. Naphthalene Concentration vs. Treatment
    f. Benzene Concentration vs. Treatment
10. Column Tests Block 5
    a. VOCs/SVOCs vs. Treatment
    b. TPH DRO vs. Treatment
    c. Total PAHs vs. Treatment
    d. Benzo(a)pyrene vs. Treatment
    e. Naphthalene Concentration vs. Treatment
    f. Benzene Concentration vs. Treatment

Figure 1a



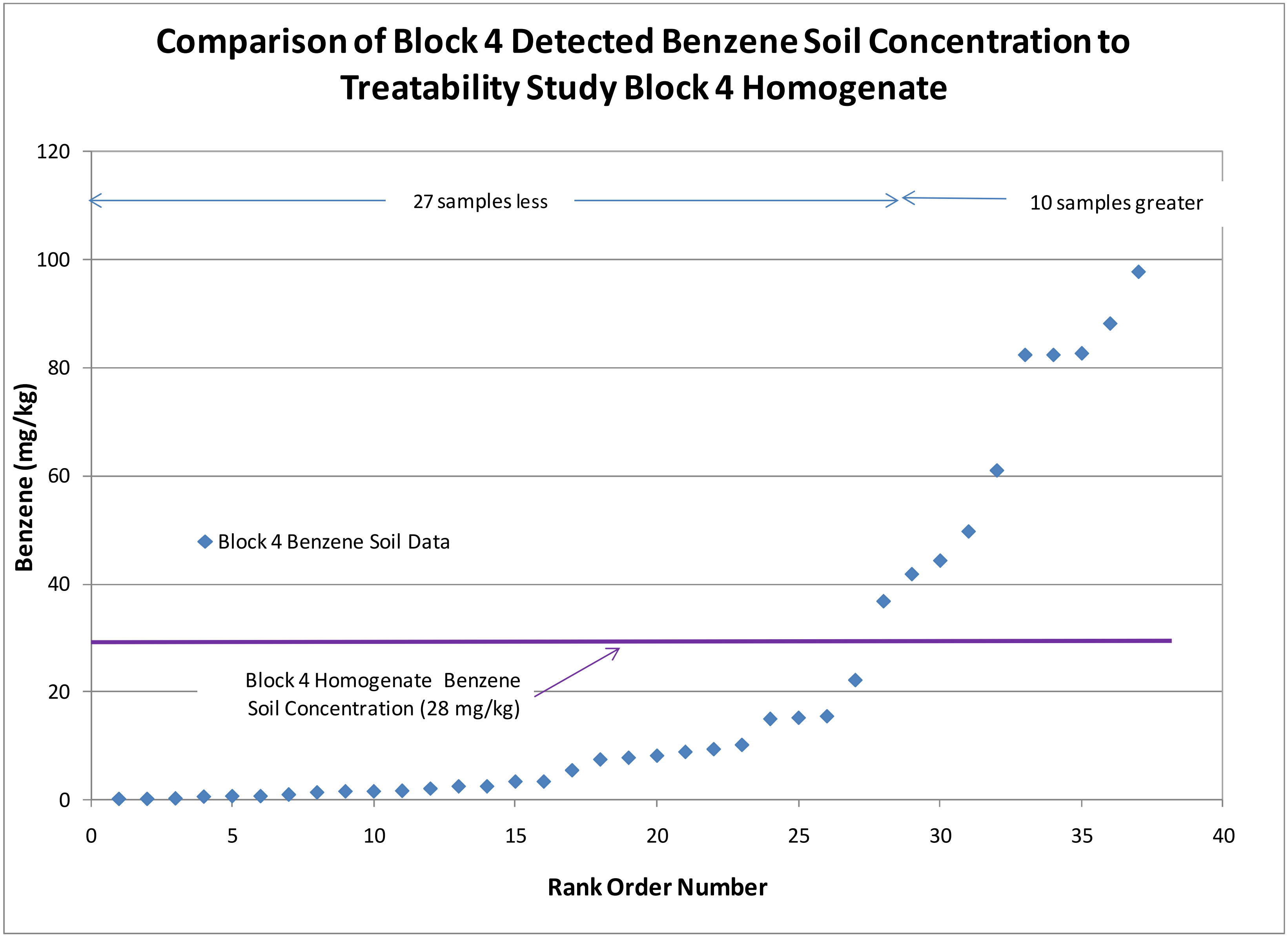
Comparison of Block 4 Detected TPH-DRO Soil Concentrations to Treatability Study Block 4 Homogenate
TPH-DRO (mg/kg)
160000
140000
120000
100000
80000
60000
40000
20000
0
0
10
20
30
40
50
60
Rank Order Number
9 Samples Greater
TPH-DRO Block 4 Soil Data
VeruTEK Site Block 4 TPH 3940
Block 4 Homogenate TPH-DRO Soil Concentration (20,000 mg/kg)

Figure 1b



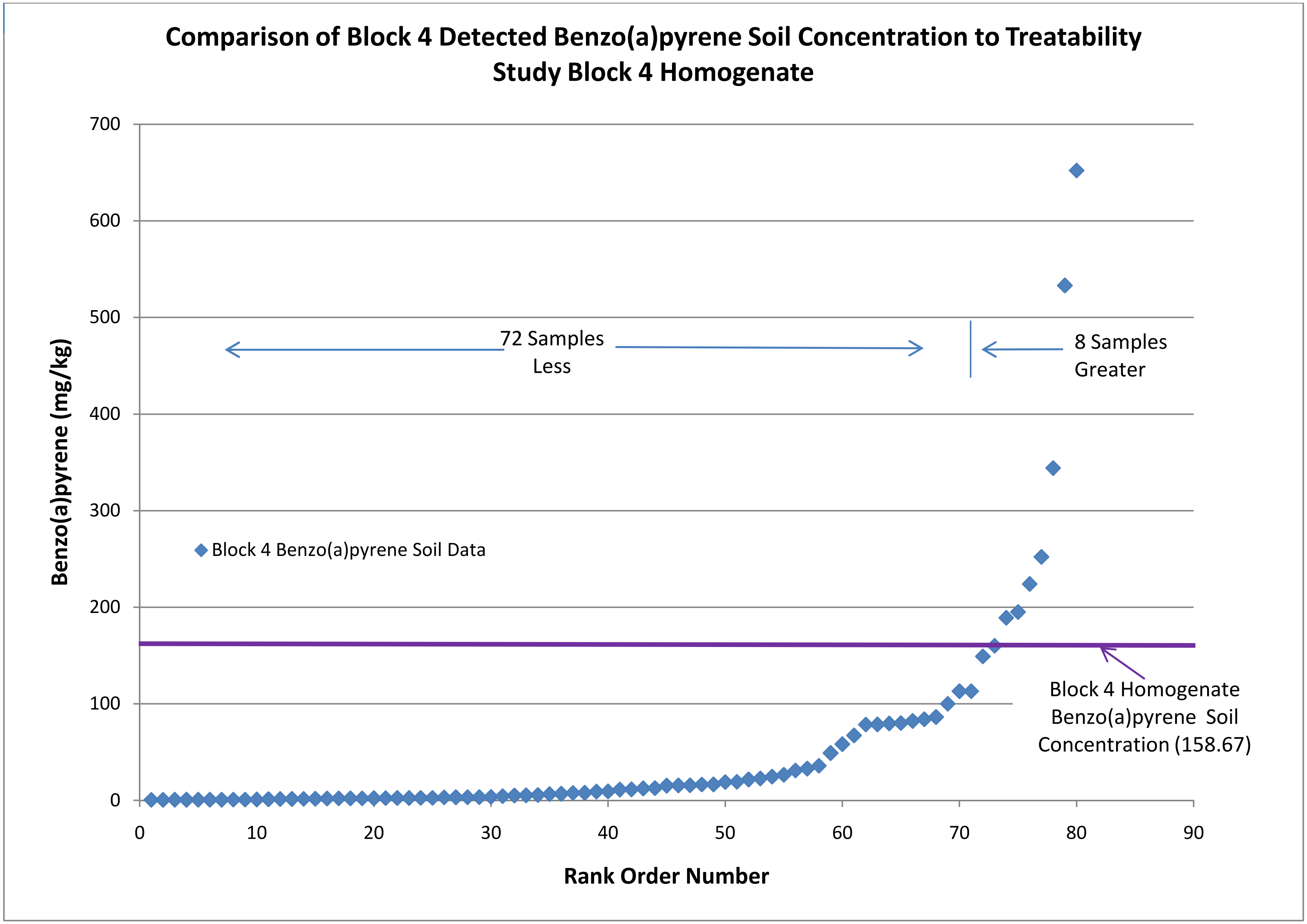
Comparison of Block 4 Detected PAH Soil Concentration to Treatability Study Block 4 Homogenate
PAH (mg/kg)
25000
20000
15000
10000
5000
0
81 samples less
8 samples greater
Block 4 PAH Soil Data
Block 4 Homogenate PAH Soil Concentration (6,207.5 mg/kg)
0
10
20
30
40
50
60
70
80
90
Rank Order

Figure 1c



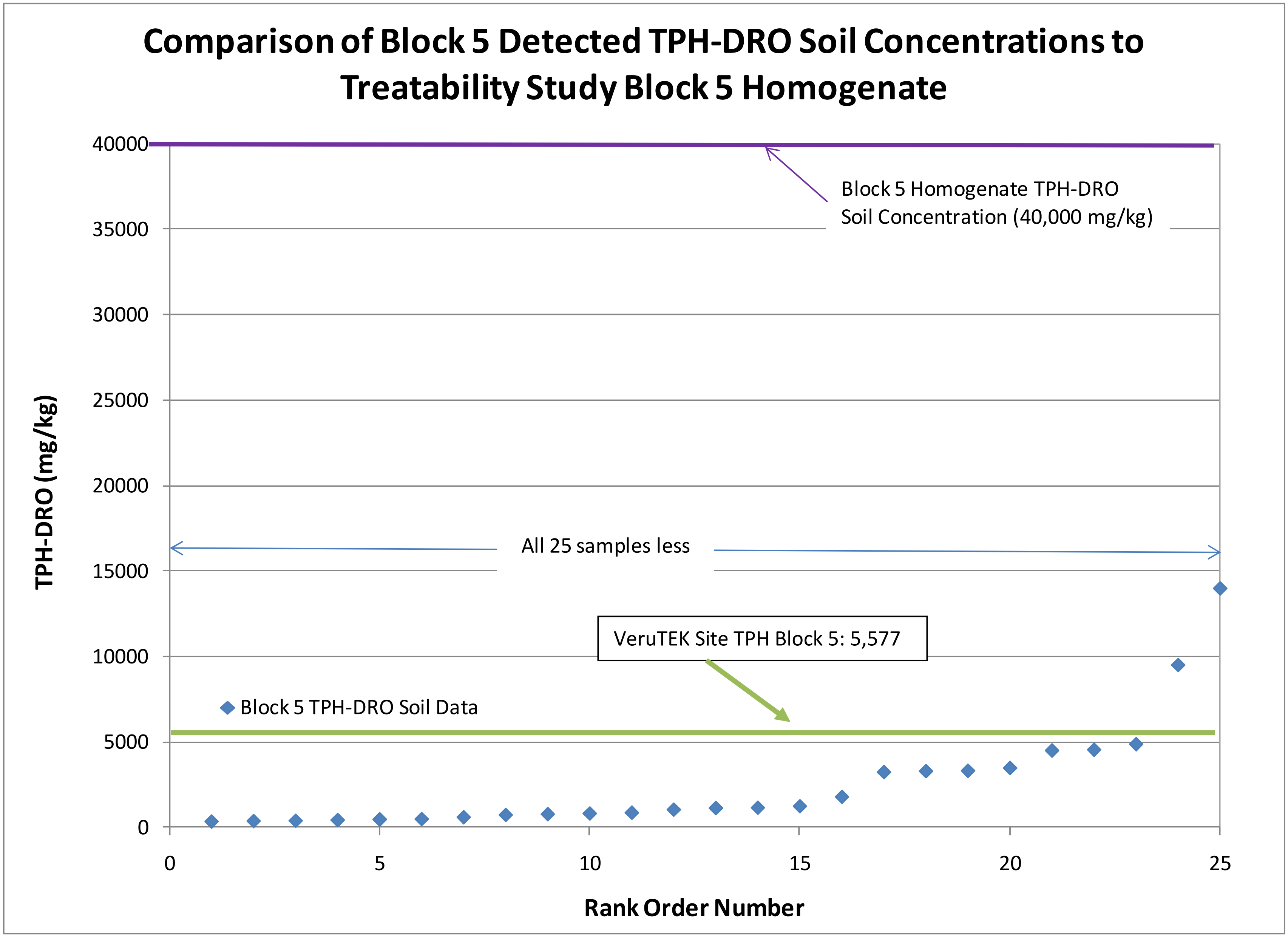
Comparison of Block 4 Detected Benzene Soil Concentration to Treatability Study Block 4 Homogenate
120
100
80
60
40
20
0
Benzene (mg/kg)
27 samples less
10 samples greater
Block 4 Benzene Soil Data
Block 4 Homogenate Benzene Soil Concentration (28 mg/kg)
0
5
10
15
20
25
30
35
40
Rank Order Number

Figure 1d



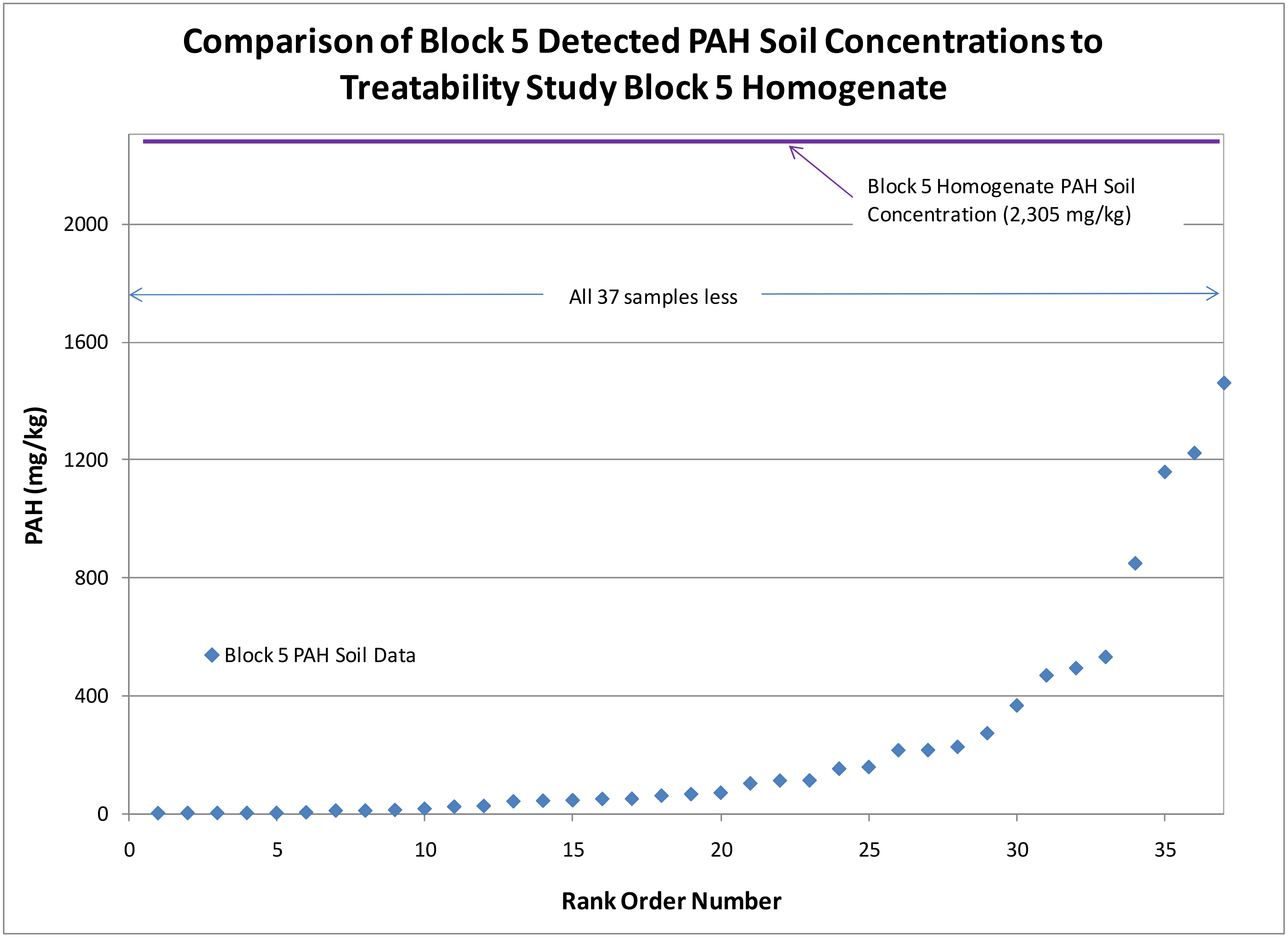
Comparison of Block 4 Detected Benzo(a)pyrene Soil Concentration to Treatability Study Block 4 Homogenate
Benzo(a)pyrene (mg/kg)
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
Rank Order Number
72 Samples Less
8 Samples Greater
Block 4 Benzo(a)pyrene Soil Data
Block 4 Homogenate Benzo(a)pyrene Soil Concentration (158.67)

Figure 2a



Comparison of Block 5 Detected TPH-DRO Soil Concentrations to Treatability Study Block 5 Homogenate
TPH-DRO (mg/kg)
40000
35000
30000
25000
20000
15000
10000
5000
0
0
5
10
15
20
25
Rank Order Number
Block 5 Homogenate TPH-DRO Soil Concentration (40,000 mg/kg)
All 25 samples less
VeruTEK Site TPH Block 5: 5,577
Block 5 TPH-DRO Soil Data

Figure 2b



Comparison of Block 5 Detected PAH Soil Concentrations to Treatability Study Block 5 Homogenate
Block 5 Homogenate PAH Soil Concentration (2,305 mg/kg)
All 37 samples less
Block 5 PAH Soil Data
PAH (mg/kg)
0
400
800
1200
1600
2000
0
5
10
15
20
25
30
35
Rank Order Number

Figure 2c

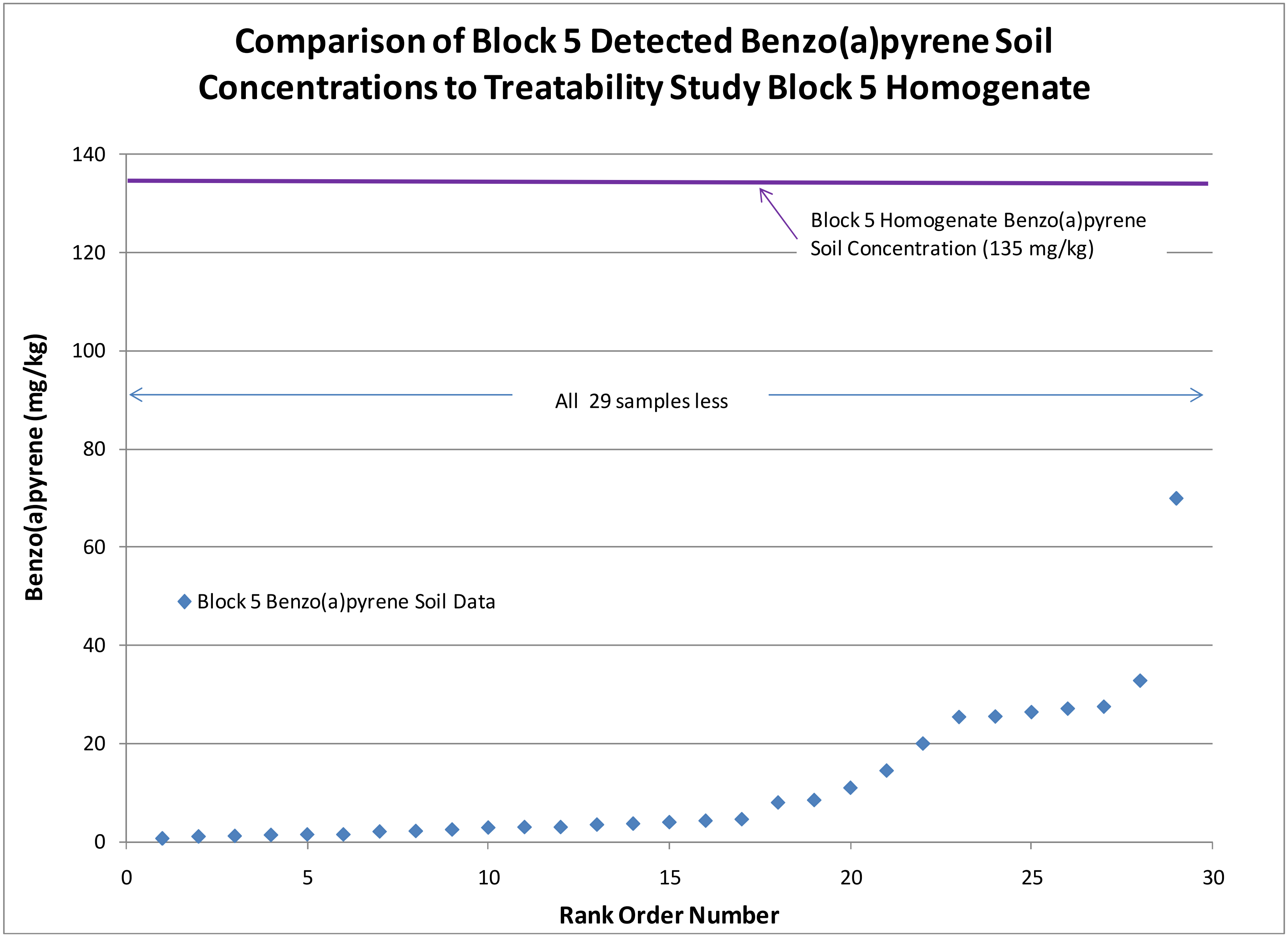
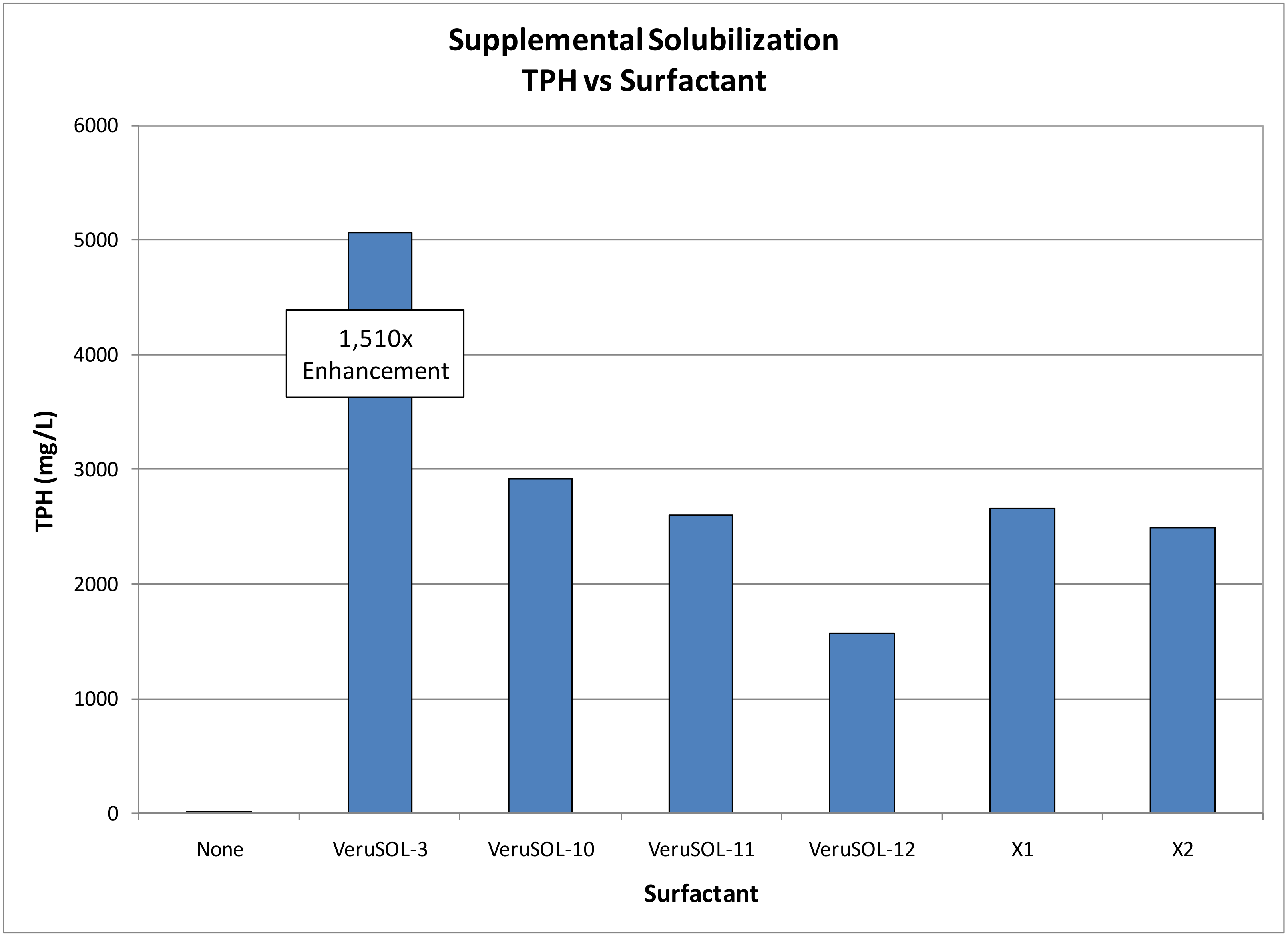
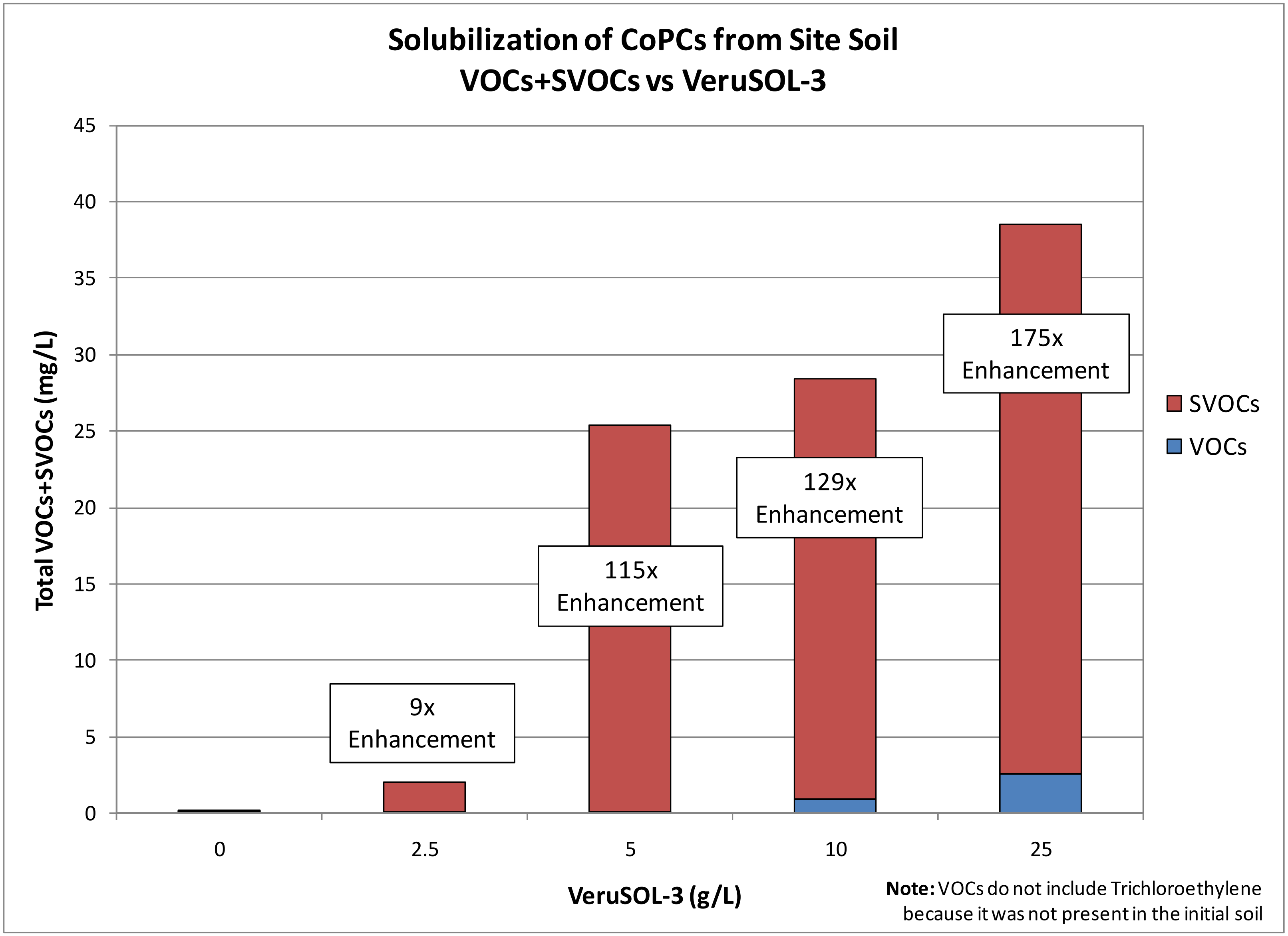

Comparison of Block 5 Detected Benzo(a)pyrene Soil Concentrations to Treatability Study Block 5 Homogenate
140
120
100
80
60
40
20
0
0
5
10
15
20
25
30
Benzo(a)pyrene (mg/kg)
Rank Order Number
Block 5 Homogenate Benzo(a)pyrene Soil Concentration (135 mg/kg)
All 29 samples less
Block 5 Benzo(a)pyrene Soil Data

Figure 3



Supplemental Solubilization
TPH vs Surfactant
TPH (mg/L)
6000
5000
4000
3000
2000
1000
0
1,510x
Enhancement
None
VeruSOL-3
VeruSOL-10
VeruSOL-11
VeruSOL-12
X1
X2
Surfactant

Figure 4a



Solubilization of CoPCs from Site Soil
VOCs+SVOCs vs VeruSOL-3
Total VOCs+SVOCs (mg/L)
45
40
35
30
25
20
15
10
5
0
9x Enhancement
115x Enhancement
129x Enhancement
175x Enhancement
SVOCs
VOCs
0
2.5
5
10
25
VeruSOL-3 (g/L)
Note: VOCs do not include Trichloroethylene because it was not present in the initial soil

Figure 4b

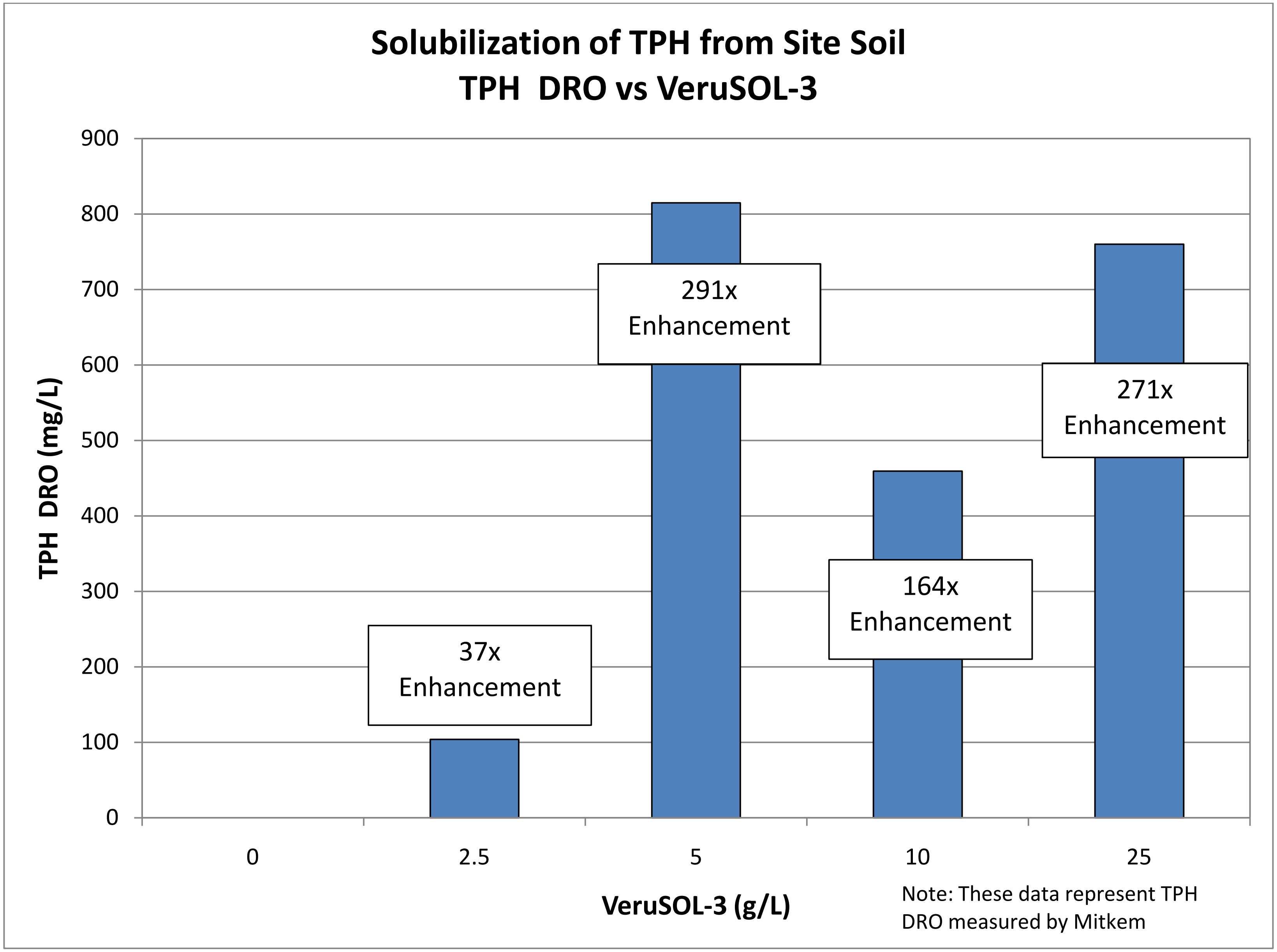
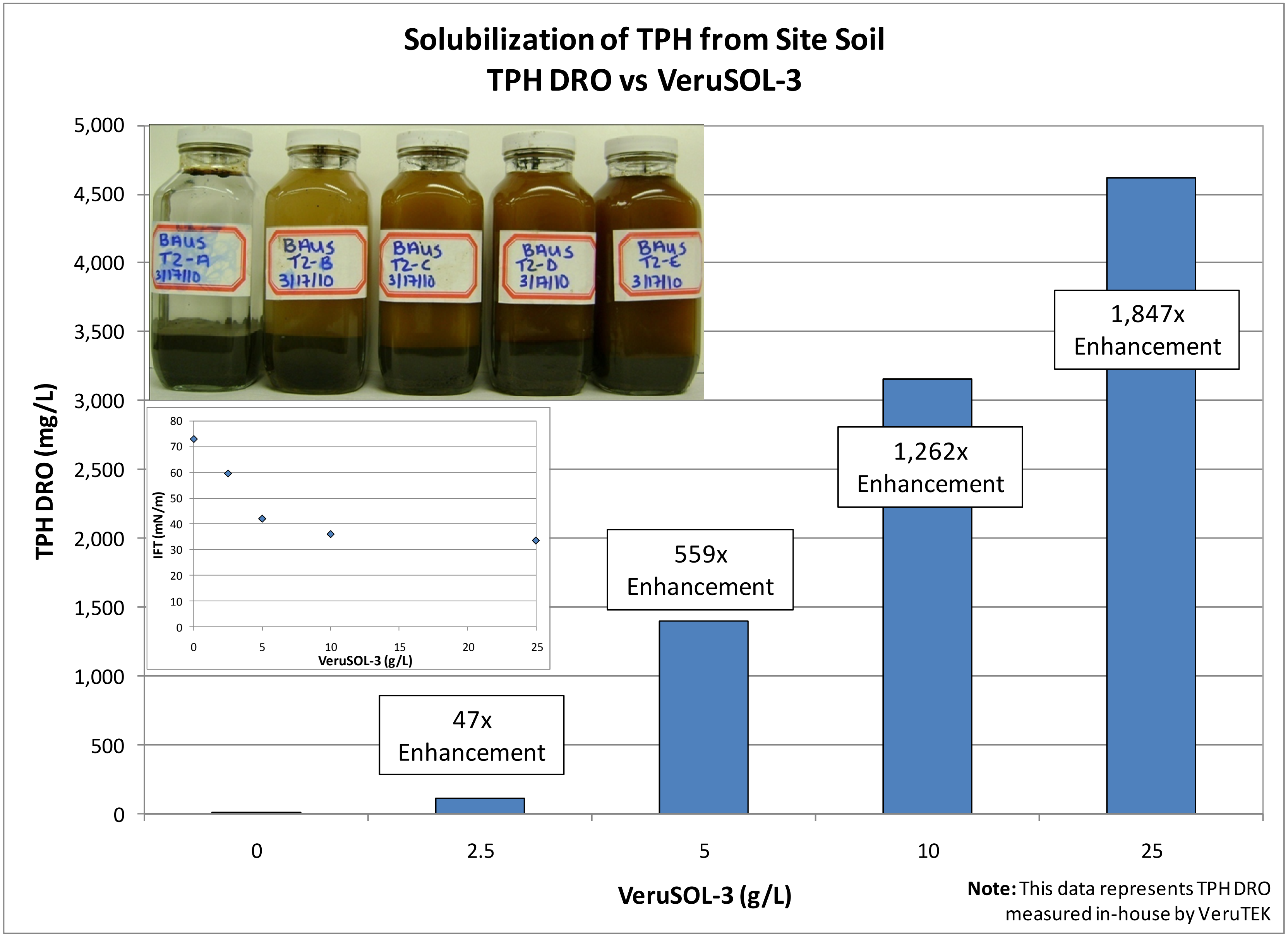
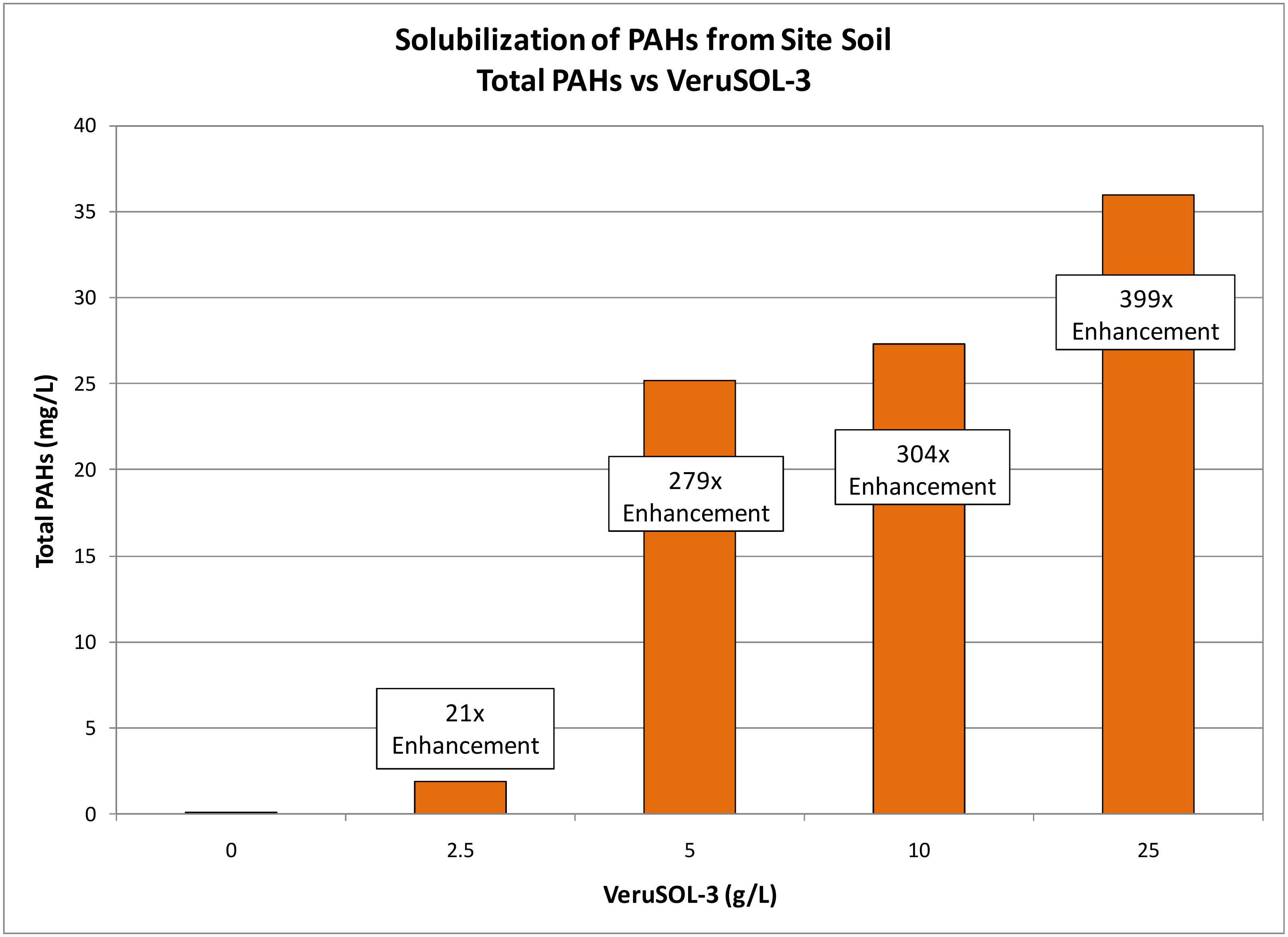

Solubilization of TPH from Site Soil
TPH DRO vs VeruSOL-3
TPH DRO (mg/L)
900
800
700
600
500
400
300
200
100
0
0
2.5
5
10
25
VeruSOL-3 (g/L)
37x Enhancement
291x Enhancement
164x Enhancement
271x Enhancement
Note: These data represent TPH DRO measured by Mitkem

Figure 4c



Solubilization of TPH from Site Soil
TPH DRO vs VeruSOL-3
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
TPH DRO (mg/L)
BAUS T2-A 3/17/10
BAUS T2-B 3/17/10
BAUS T2-C 3/17/10
BAUS T2-D 3/17/10
BAUS T2-E 3/17/10
80
70
60
50
40
30
20
10
0
IFT (mN/m)
0
5
10
15
20
25
VeruSOL-3 (g/L)
47x Enhancement
559x Enhancement
1,262x Enhancement
1,847x Enhancement
0
2.5
5
10
25
VeruSOL-3 (g/L)
Note: This data represents TPH DRO measured in-house by VeruTEK

Figure 4d



Solubilization of PAHs from Site Soil
Total PAHs vs VeruSOL-3
Total PAHs (mg/L)
40
35
30
25
20
15
10
5
0
21x Enhancement
279x Enhancement
304x Enhancement
399x Enhancement
0
2.5
5
10
25
VeruSOL-3 (g/L)

Figure 4e

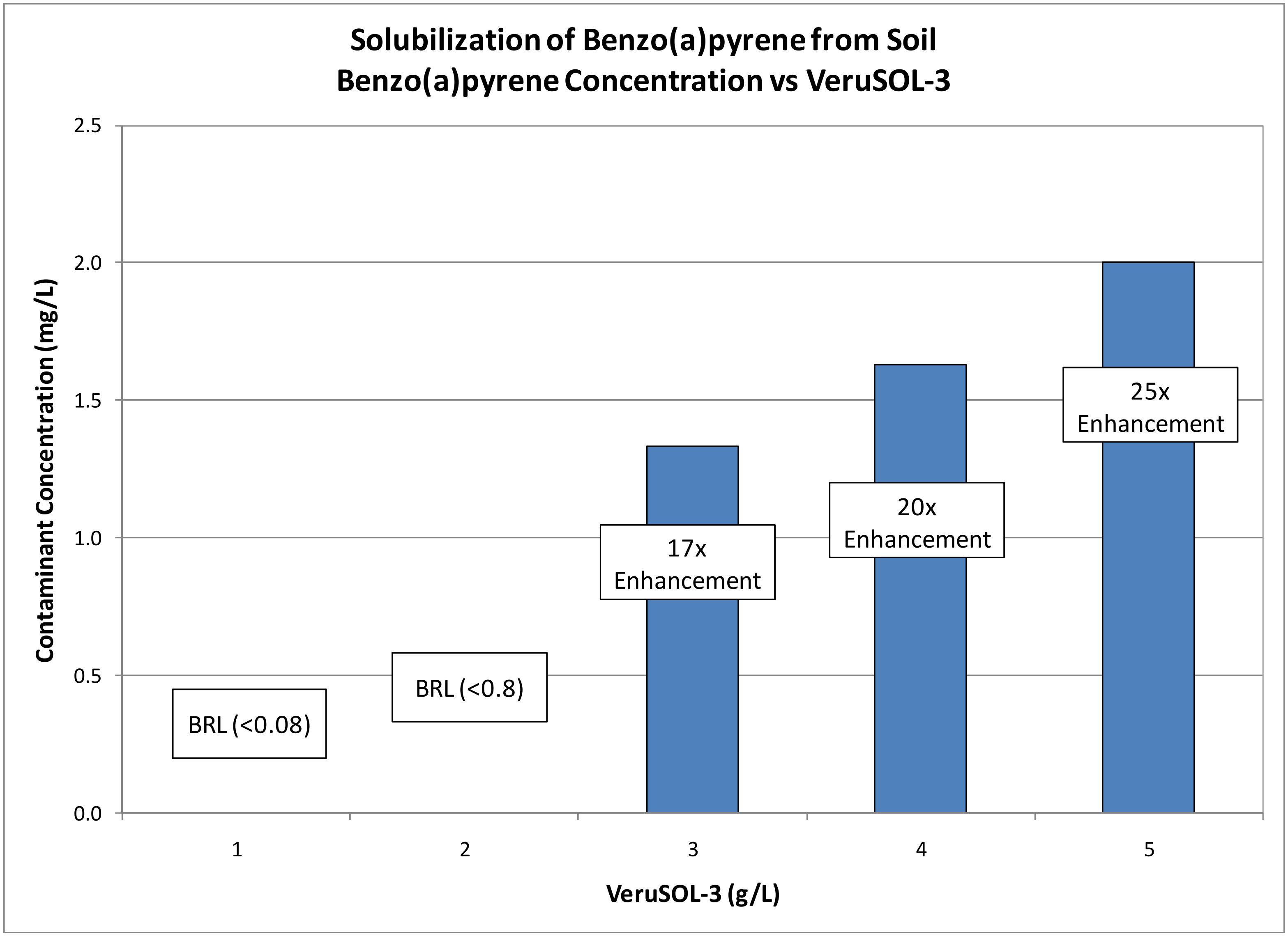

Solubilization of Benzo(a)pyrene from Soil
Benzo(a)pyrene Concentration vs VeruSOL-3
Contaminant Concentration (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
BRL (<0.08)
BRL (<0.8)
17x Enhancement
20x Enhancement
25x Enhancement
1
2
3
4
5
VeruSOL-3 (g/L)

Figure 5a

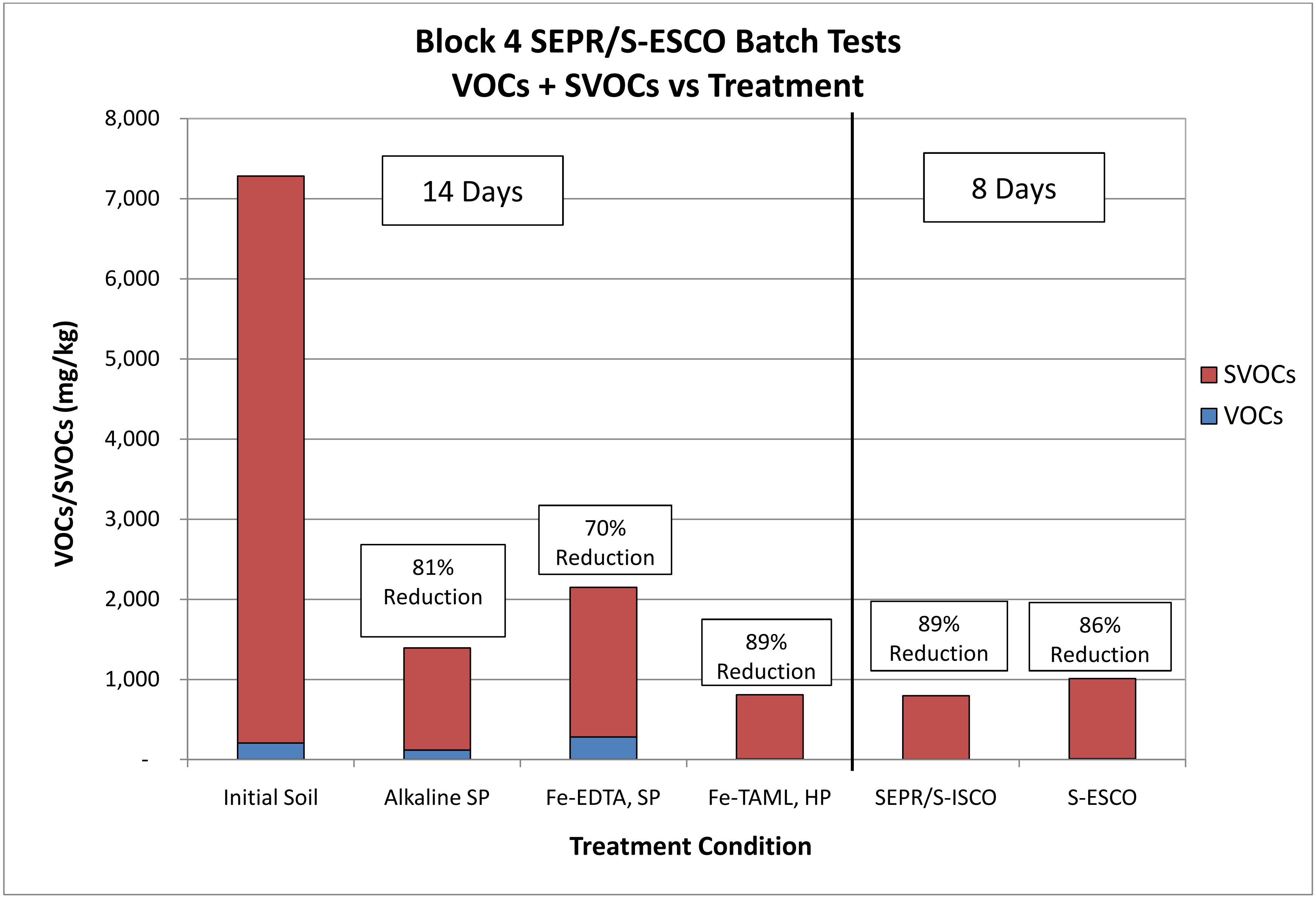

Block 4 SEPR/S-ESCO Batch Tests
VOCs + SVOCs vs Treatment
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
VOCs/SVOCs (mg/kg)
14 Days
8 Days
81%
Reduction
70%
Reduction
89%
Reduction
89%
Reduction
86%
Reduction
SVOCs
VOCs
Initial Soil
Alkaline SP
Fe-EDTA, SP
Fe-TAML, HP
SEPR/S-ISCO
S-ESCO
Treatment Condition

Figure 5b

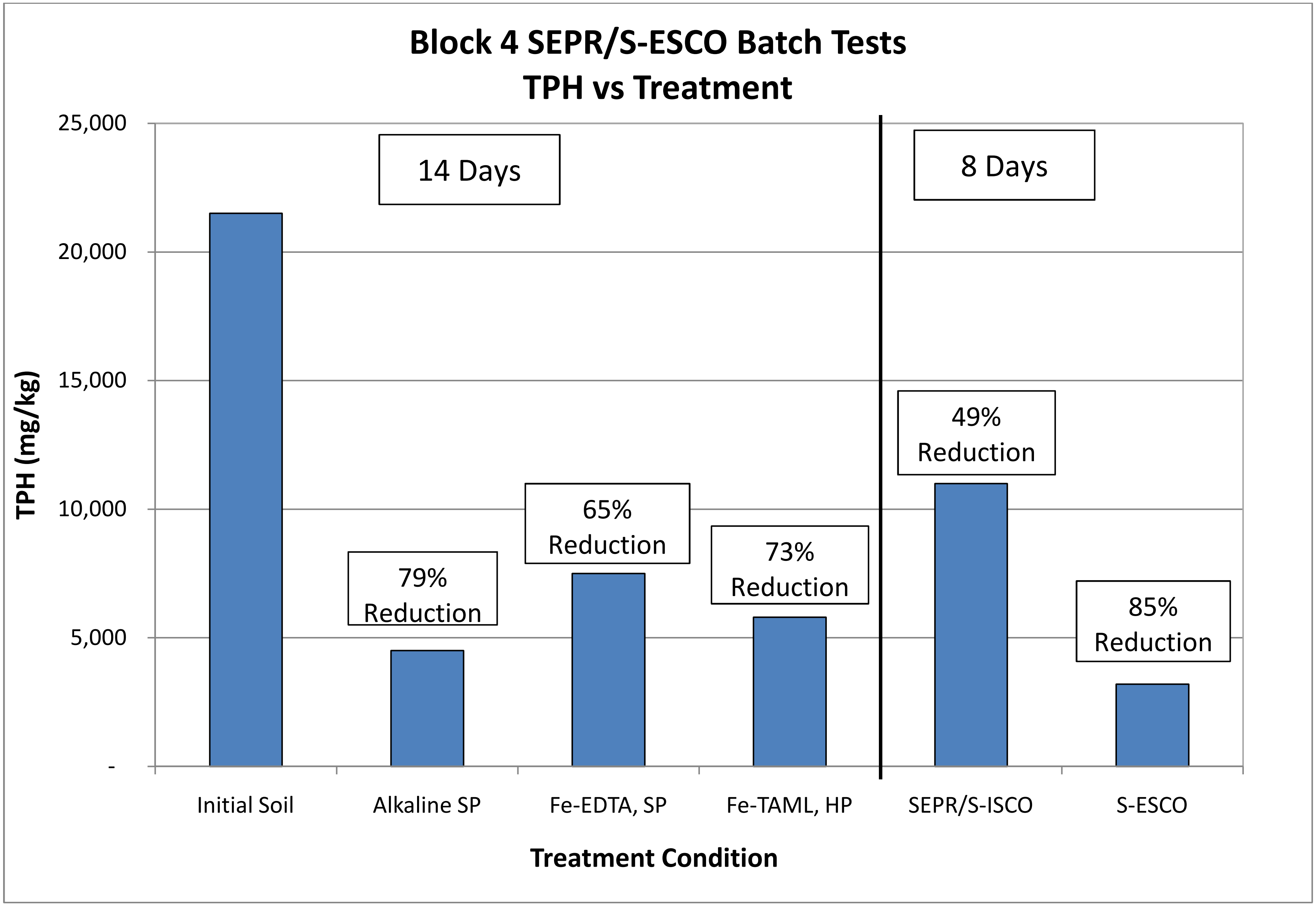
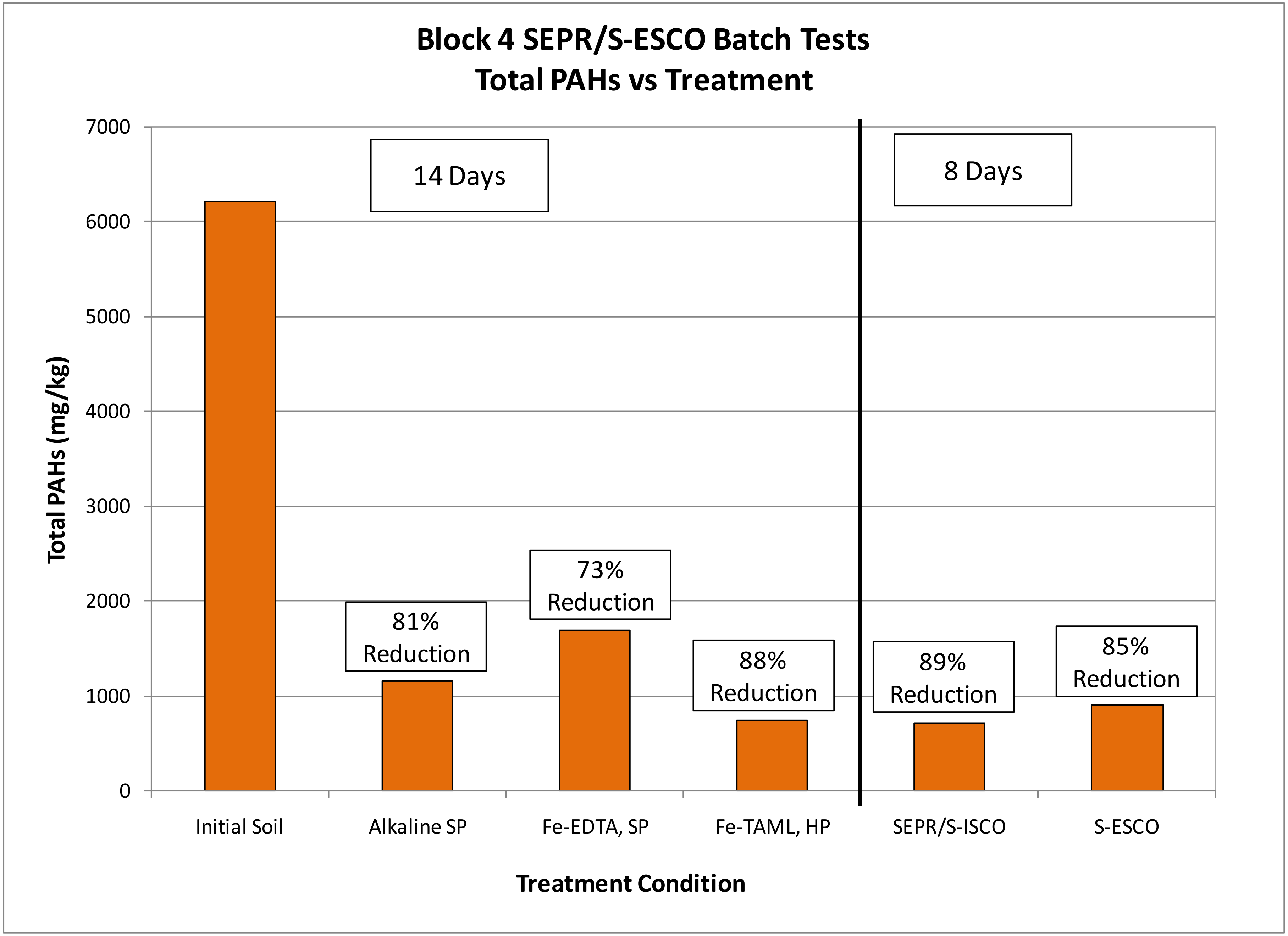
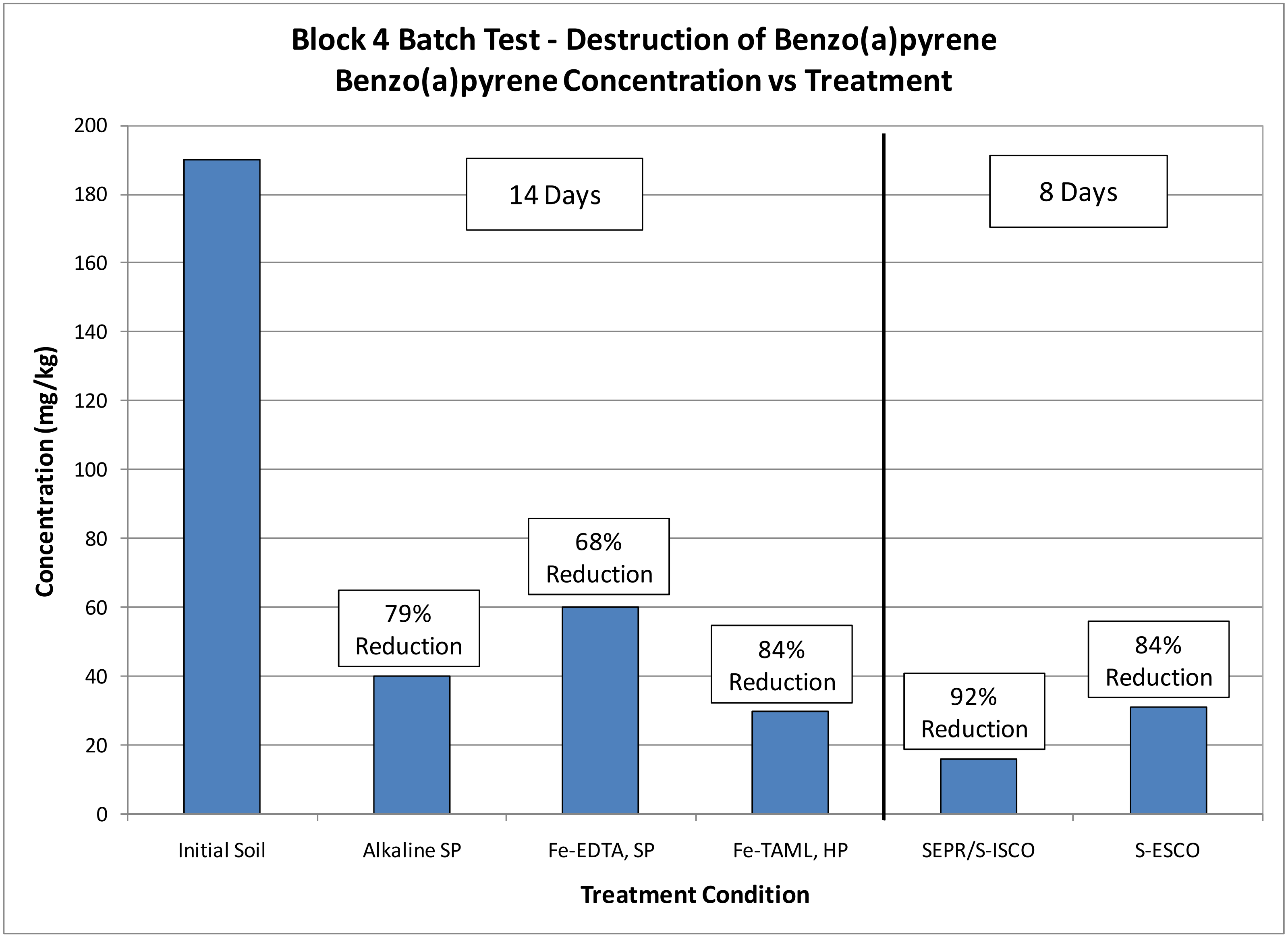

Block 4 SEPR/S-ESCO Batch Tests
TPH vs Treatment
TPH (mg/kg)
25,000
20,000
15,000
10,000
5,000
-
14 Days
8 Days
79% Reduction
65% Reduction
73% Reduction
49% Reduction
85% Reduction
Initial Soil
Alkaline SP
Fe-EDTA, SP
Fe-TAML, HP
SEPR/S-ISCO
S-ESCO
Treatment Condition

Figure 5c



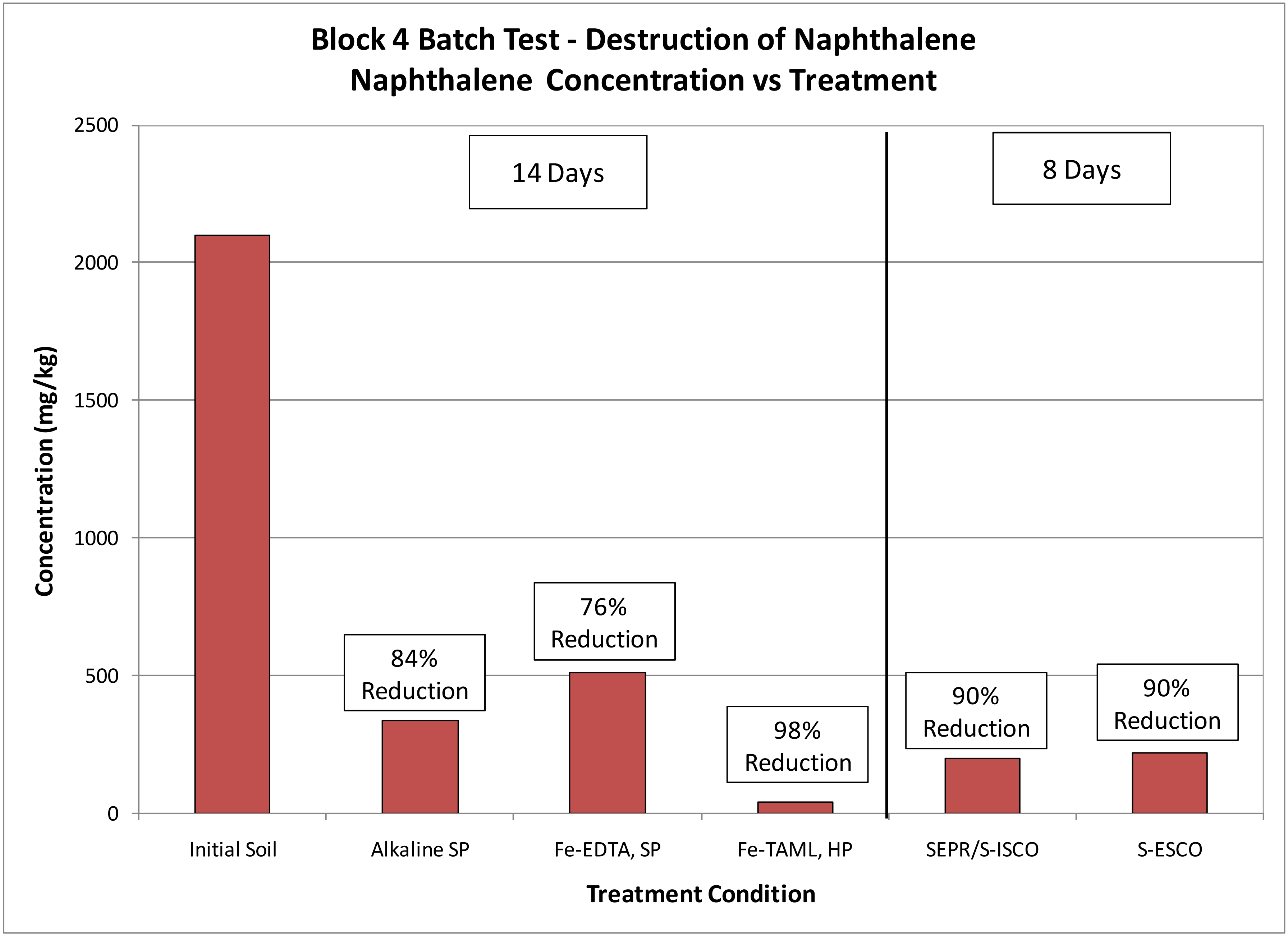
Block 4 SEPR/S-ESCO Batch Tests
Total PAHs vs Treatment
Total PAHs (mg/kg)
7000
6000
5000
4000
3000
2000
1000
0
14 Days
8 Days
81% Reduction
73% Reduction
88% Reduction
89% Reduction
85% Reduction
Initial Soil
Alkaline SP
Fe-EDTA, SP
Fe-TAML, HP
SEPR/S-ISCO
S-ESCO
Treatment Condition

Figure 5d



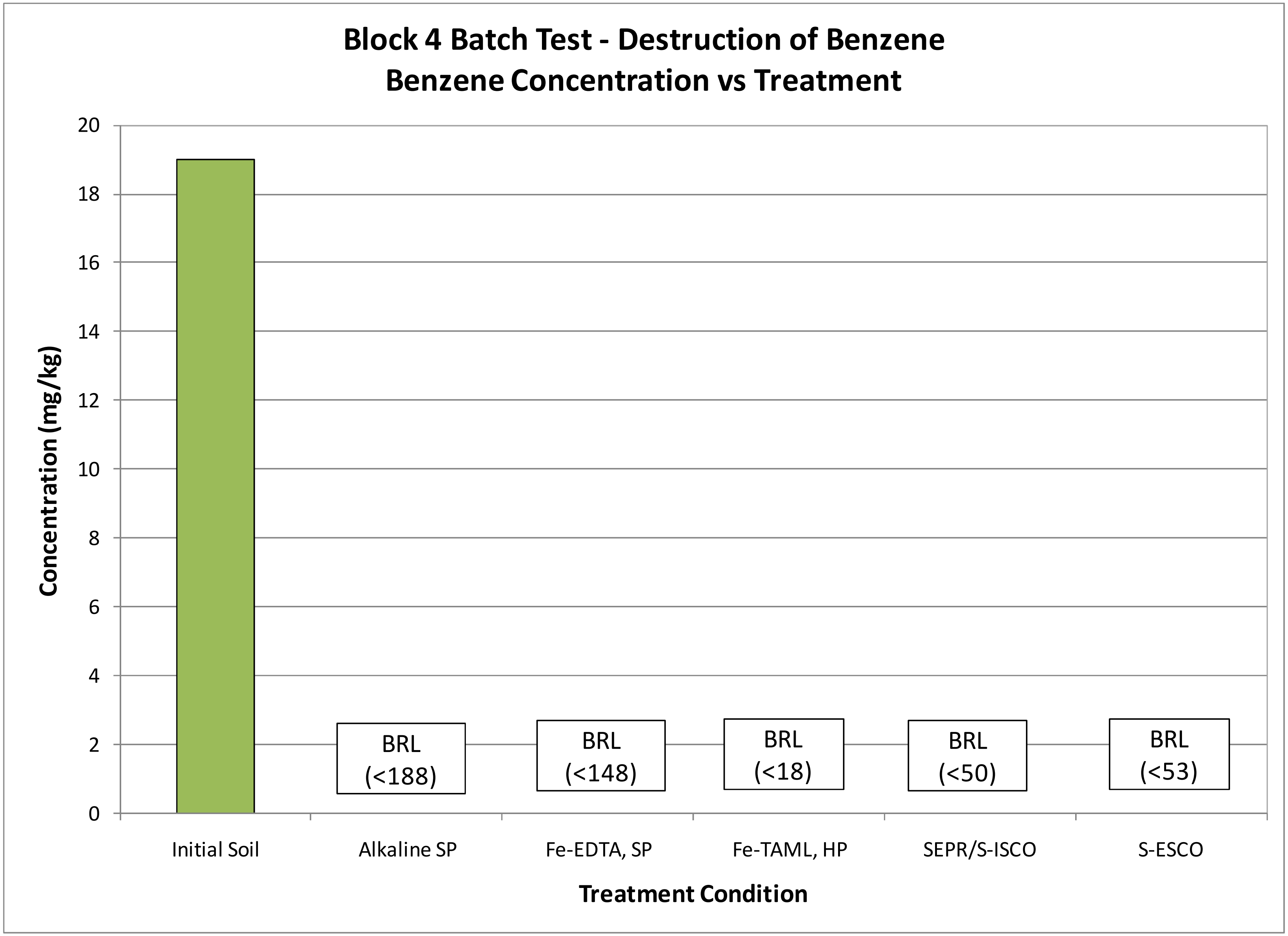
Block 4 Batch Test - Destruction of Benzo(a)pyrene
Benzo(a)pyrene Concentration vs Treatment
Concentration (mg/kg)
200
180
160
140
120
100
80
60
40
20
0
14 Days
8 Days
79% Reduction
68% Reduction
84% Reduction
92% Reduction
84% Reduction
Initial Soil
Alkaline SP
Fe-EDTA, SP
Fe-TAML, HP
SEPR/S-ISCO
S-ESCO
Treatment Condition

Figure 5e



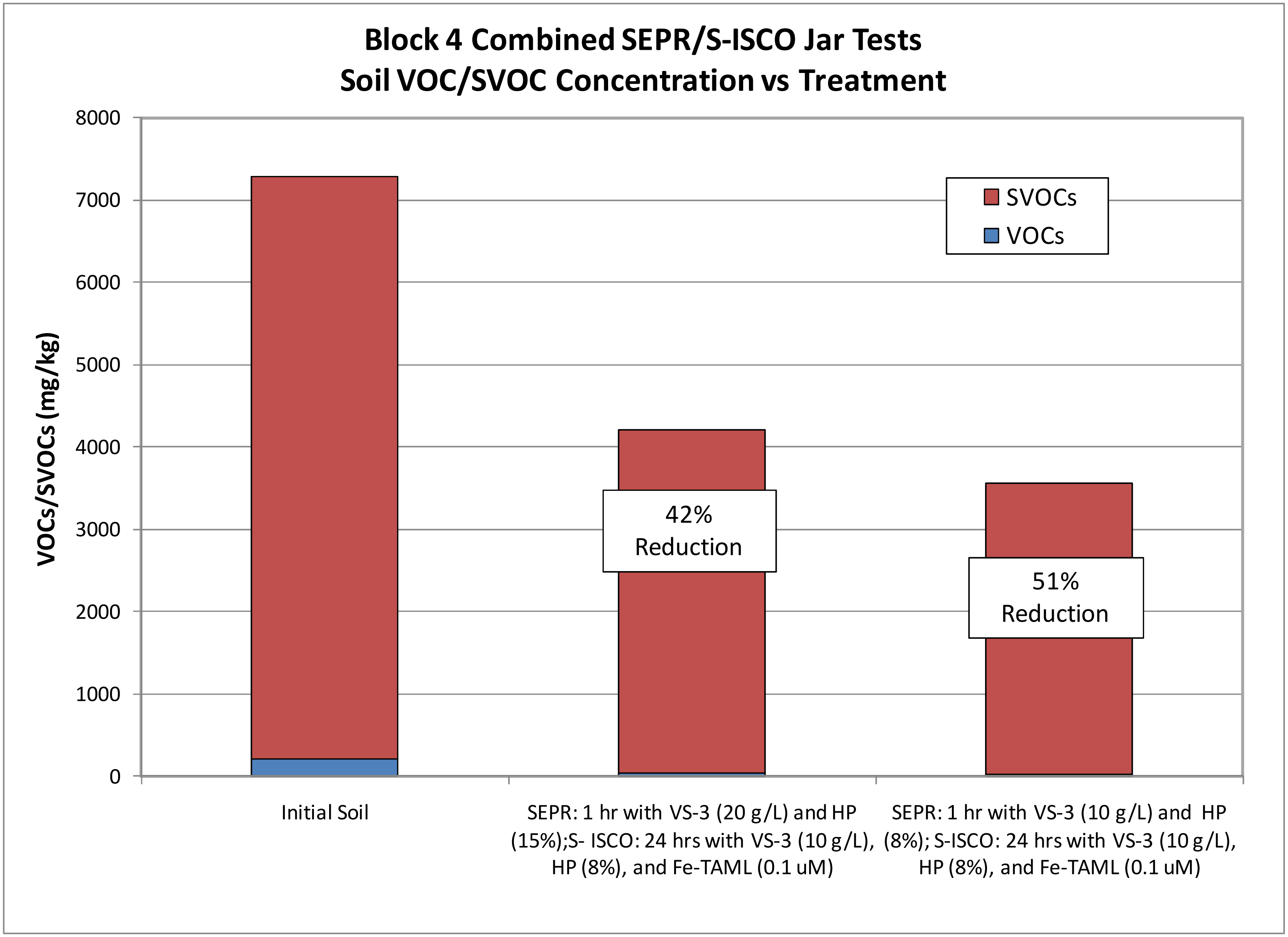
Block 4 Batch Test - Destruction of Naphthalene
Naphthalene Concentration vs Treatment
Concentration (mg/kg)
2500
2000
1500
1000
500
0
14 Days
8 Days
84% Reduction
76% Reduction
98% Reduction
90% Reduction
90% Reduction
Initial Soil
Alkaline SP
Fe-EDTA, SP
Fe-TAML, HP
SEPR/S-ISCO
S-ESCO
Treatment Condition

Figure 5f



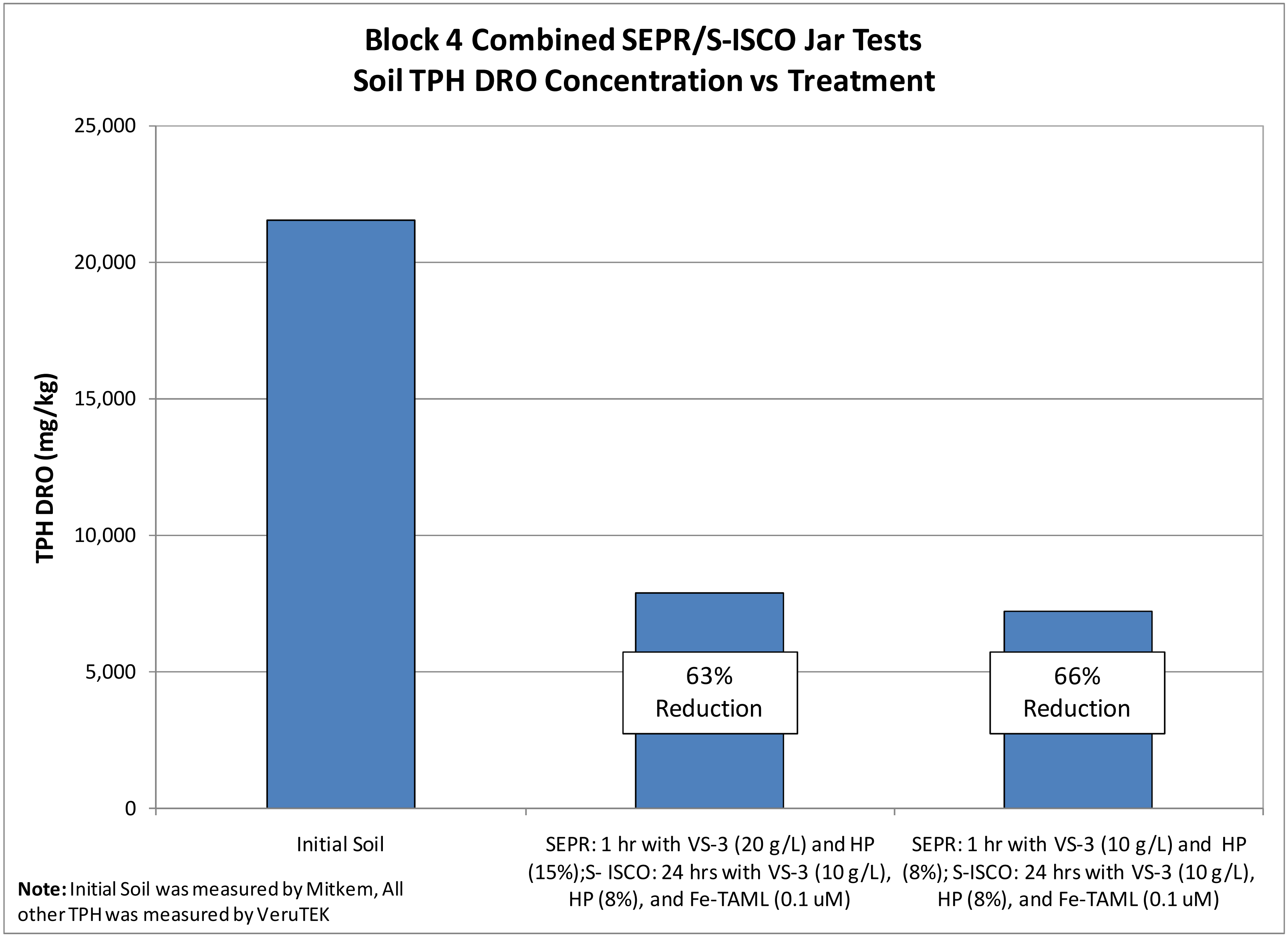
Block 4 Batch Test - Destruction of Benzene
Benzene Concentration vs Treatment
Concentration (mg/kg)
20
18
16
14
12
10
8
6
4
2
0
BRL (<188)
BRL (<148)
BRL (<18)
BRL (<50)
BRL (<53)
Initial Soil
Alkaline SP
Fe-EDTA, SP
Fe-TAML, HP
SEPR/S-ISCO
S-ESCO
Treatment Condition

Figure 6a



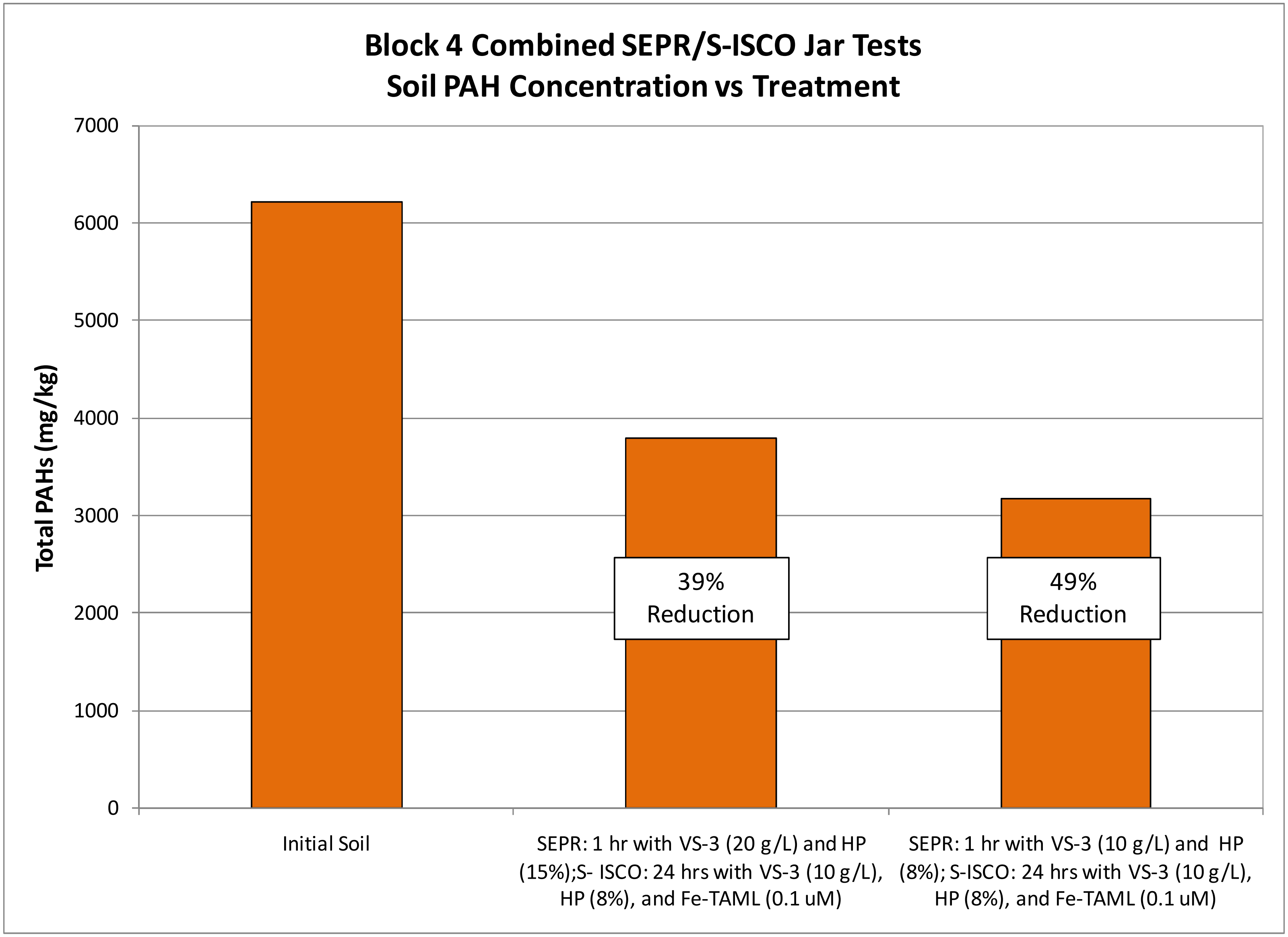
Block 4 Combined SEPR/S-ISCO Jar Tests
Soil VOC/SVOC Concentration vs Treatment
VOCs/SVOCs (mg/kg)
8000
7000
6000
5000
4000
3000
2000
1000
0
SVOCs
VOCs
42% Reduction
51% Reduction
Initial Soil
SEPR: 1 hr with VS-3 (20 g/L) and HP (15%);S- ISCO: 24 hrs with VS-3 (10 g/L), HP (8%), and Fe-TAML (0.1 uM)
SEPR: 1 hr with VS-3 (10 g/L) and HP (8%); S-ISCO: 24 hrs with VS-3 (10 g/L), HP (8%), and Fe-TAML (0.1 uM)

Figure 6b



Block 4 Combined SEPR/S-ISCO Jar Tests
Soil TPH DRO Concentration vs Treatment
TPH DRO (mg/kg)
25,000
20,000
15,000
10,000
5,000
0
63% Reduction
66% Reduction
Initial Soil
SEPR: 1 hr with VS-3 (20 g/L) and HP (15%);S- ISCO: 24 hrs with VS-3 (10 g/L), HP (8%), and Fe-TAML (0.1 uM)
SEPR: 1 hr with VS-3 (10 g/L) and HP (8%); S-ISCO: 24 hrs with VS-3 (10 g/L), HP (8%), and Fe-TAML (0.1 uM)
Note: Initial Soil was measured by Mitkem, All other TPH was measured by VeruTEK

Figure 6c



Block 4 Combined SEPR/S-ISCO Jar Tests
Soil PAH Concentration vs Treatment
Total PAHs (mg/kg)
7000
6000
5000
4000
3000
2000
1000
0
39% Reduction
49% Reduction
Initial Soil
SEPR: 1 hr with VS-3 (20 g/L) and HP (15%);S- ISCO: 24 hrs with VS-3 (10 g/L), HP (8%), and Fe-TAML (0.1 uM)
SEPR: 1 hr with VS-3 (10 g/L) and HP (8%); S-ISCO: 24 hrs with VS-3 (10 g/L), HP (8%), and Fe-TAML (0.1 uM)

Figure 6d

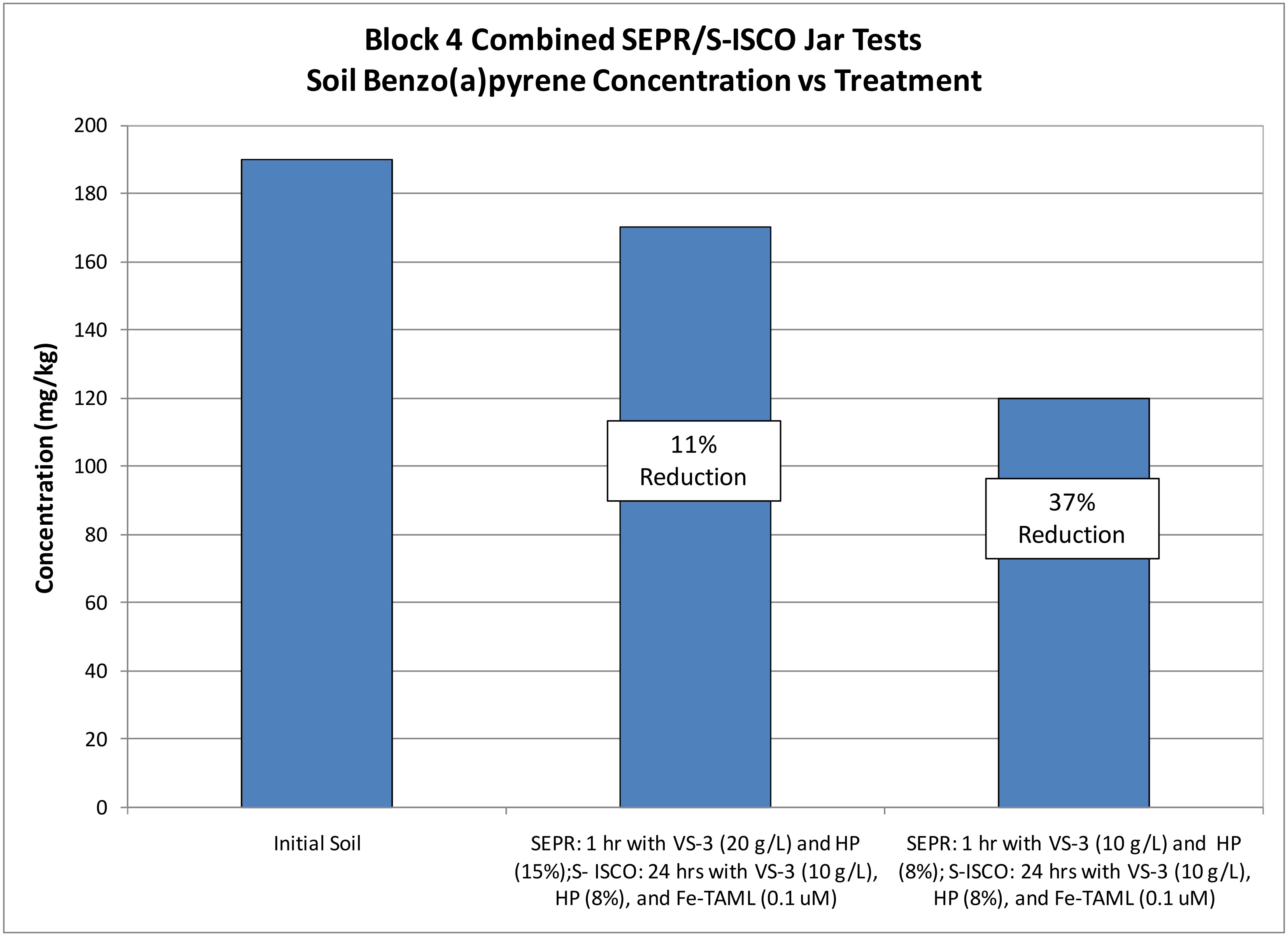
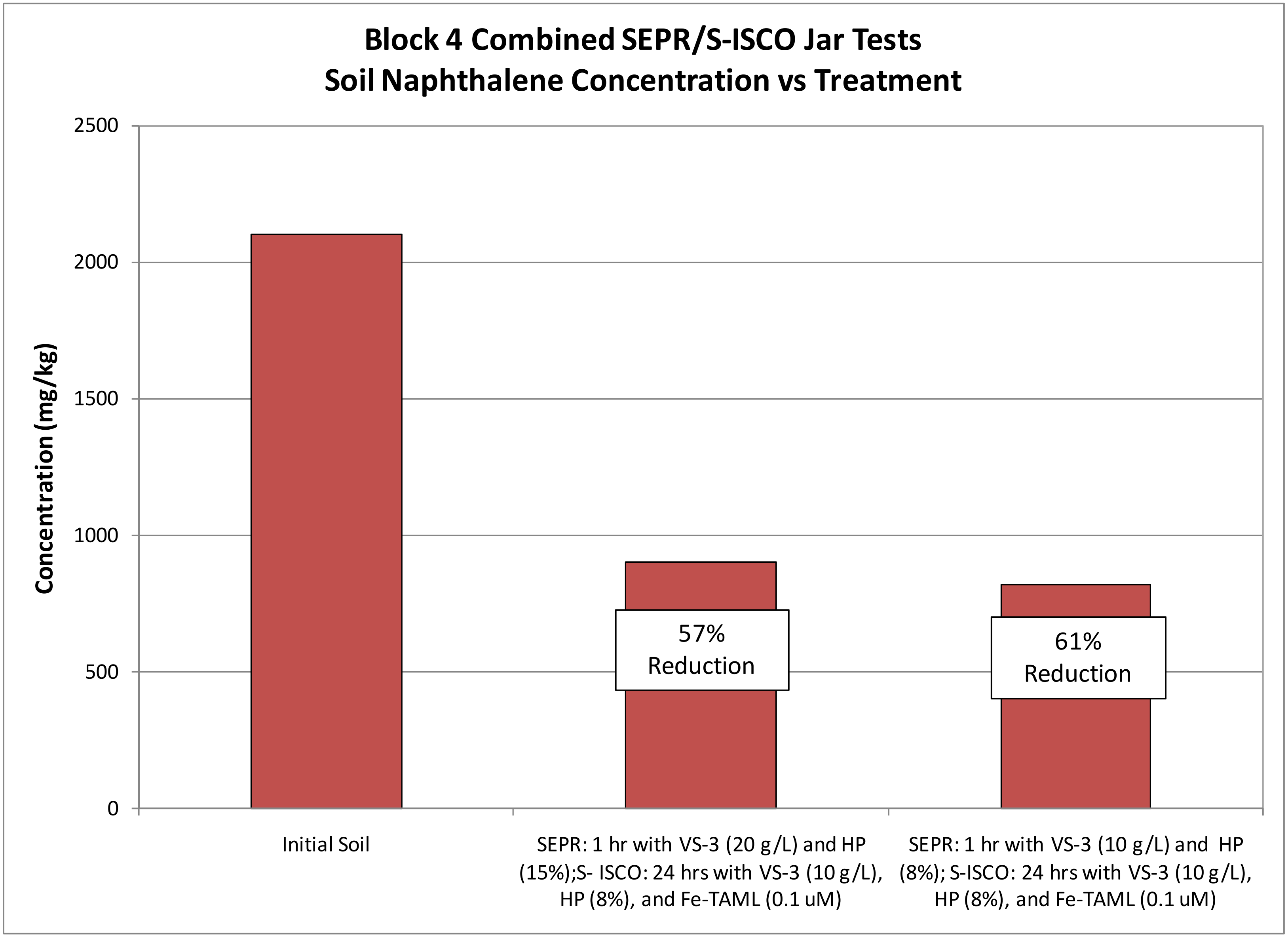

Block 4 Combined SEPR/S-ISCO Jar Tests
Soil Benzo(a)pyrene Concentration vs Treatment
Concentration (mg/kg)
200
180
160
140
120
100
80
60
40
20
0
11% Reduction
37% Reduction
Initial Soil
SEPR: 1 hr with VS-3 (20 g/L) and HP (15%);S- ISCO: 24 hrs with VS-3 (10 g/L), HP (8%), and Fe-TAML (0.1 uM)
SEPR: 1 hr with VS-3 (10 g/L) and HP (8%); S-ISCO: 24 hrs with VS-3 (10 g/L), HP (8%), and Fe-TAML (0.1 uM)

Figure 6e



Block 4 Combined SEPR/S-ISCO Jar Tests
Soil Naphthalene Concentration vs Treatment
Concentration (mg/kg)
2500
2000
1500
1000
500
0
57%
Reduction
61%
Reduction
Initial Soil
SEPR: 1 hr with VS-3 (20 g/L) and HP (15%);S- ISCO: 24 hrs with VS-3 (10 g/L), HP (8%), and Fe-TAML (0.1 uM)
SEPR: 1 hr with VS-3 (10 g/L) and HP (8%); S-ISCO: 24 hrs with VS-3 (10 g/L), HP (8%), and Fe-TAML (0.1 uM)

Figure 6f

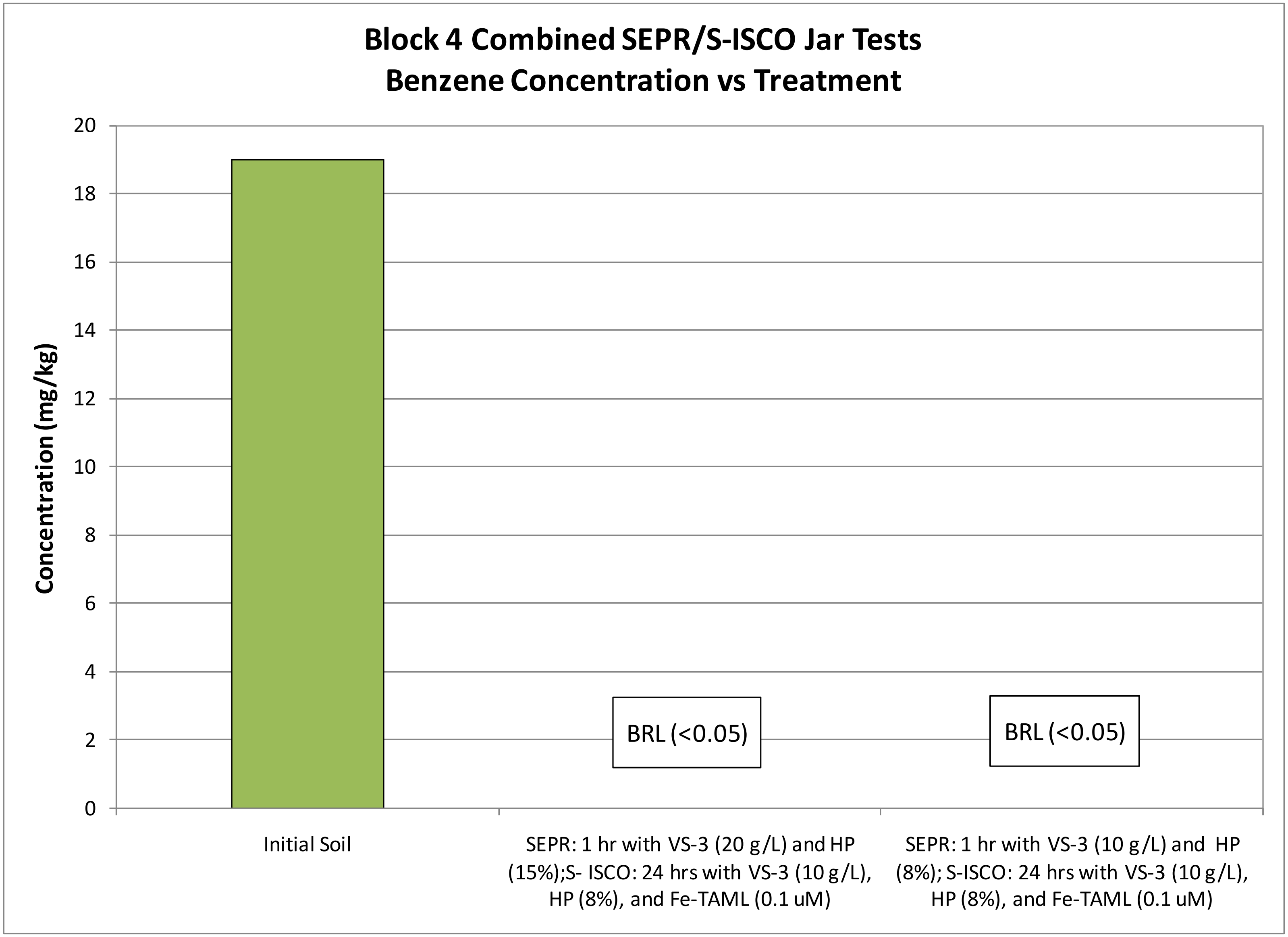
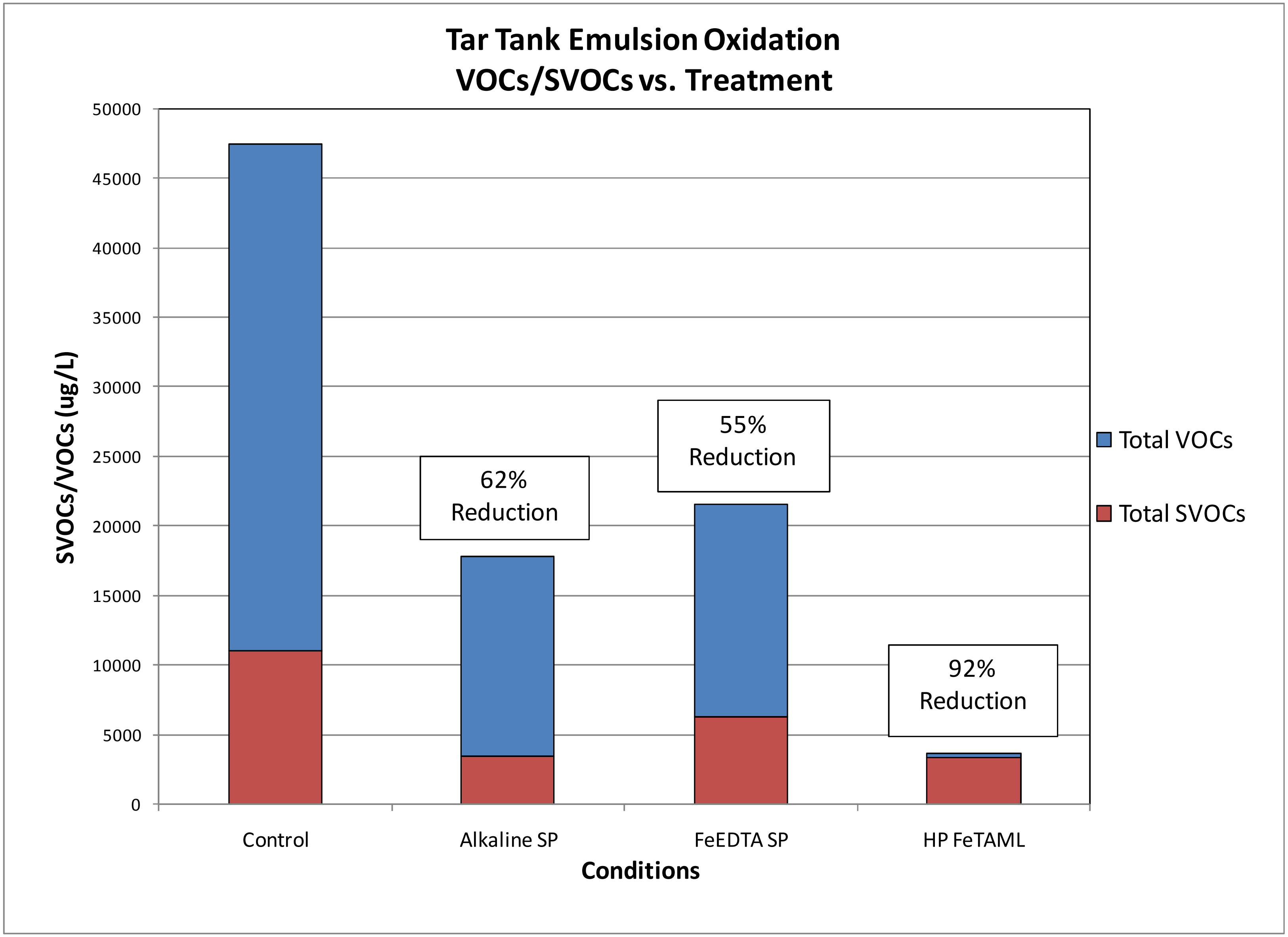

Block 4 Combined SEPR/S-ISCO Jar Tests
Benzene Concentration vs Treatment
Concentration (mg/kg)
20
18
16
14
12
10
8
6
4
2
0
BRL (<0.05)
BRL (<0.05)
Initial Soil
SEPR: 1 hr with VS-3 (20 g/L) and HP (15%);S- ISCO: 24 hrs with VS-3 (10 g/L), HP (8%), and Fe-TAML (0.1 uM)
SEPR: 1 hr with VS-3 (10 g/L) and HP (8%); S-ISCO: 24 hrs with VS-3 (10 g/L), HP (8%), and Fe-TAML (0.1 uM)

Figure 7a



Tar Tank Emulsion Oxidation
VOCs/SVOCs vs. Treatment
SVOCs/VOCs (ug/L)
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
62%
Reduction
55%
Reduction
92%
Reduction
Total VOCs
Total SVOCs
Control
Alkaline SP
FeEDTA SP
HP FeTAML
Conditions

Figure 7b

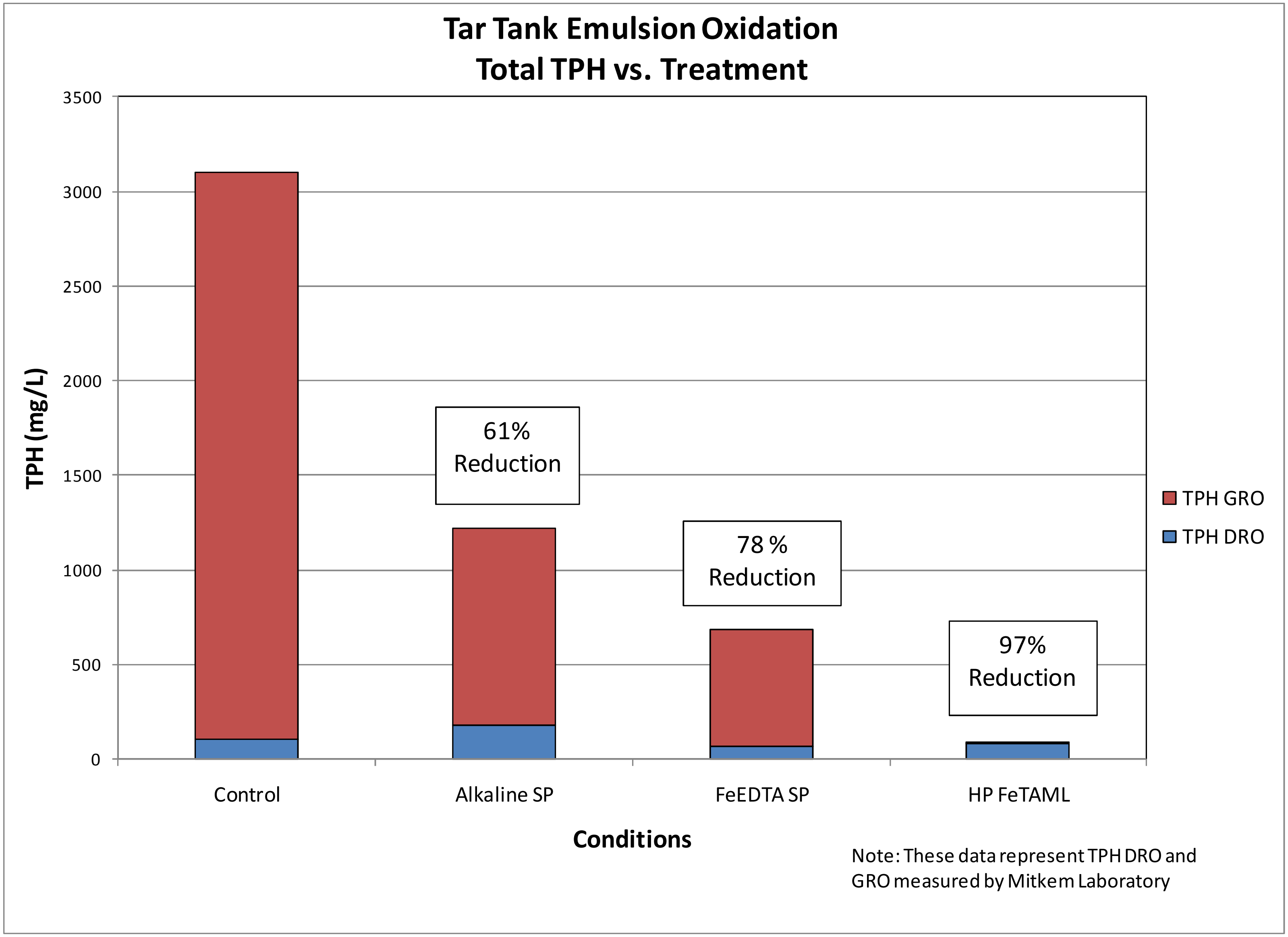

Tar Tank Emulsion Oxidation
Total TPH vs. Treatment
3500
3000
2500
2000
1500
1000
500
0
TPH (mg/L)
61%
Reduction
78 %
Reduction
97%
Reduction
Control
Alkaline SP
FeEDTA SP
HP FeTAML
Conditions
TPH GRO
TPH DRO
Note: These data represent TPH DRO and
GRO measured by Mitkem Laboratory

Figure 7c

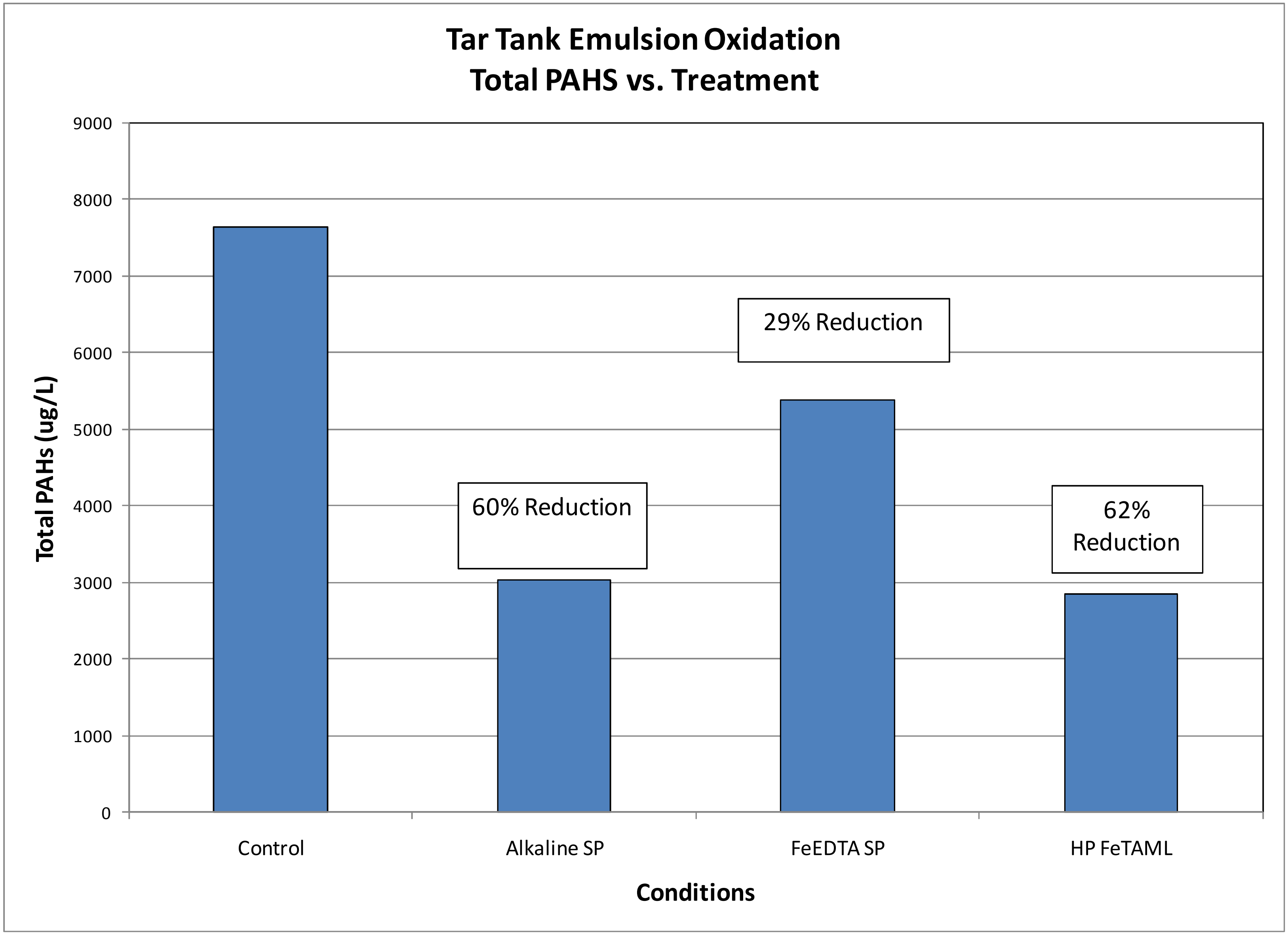

Tar Tank Emulsion Oxidation
Total PAHS vs. Treatment
Total PAHs (ug/L)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
29% Reduction
60% Reduction
62% Reduction
Control
Alkaline SP
FeEDTA SP
HP FeTAML
Conditions

Figure 7d

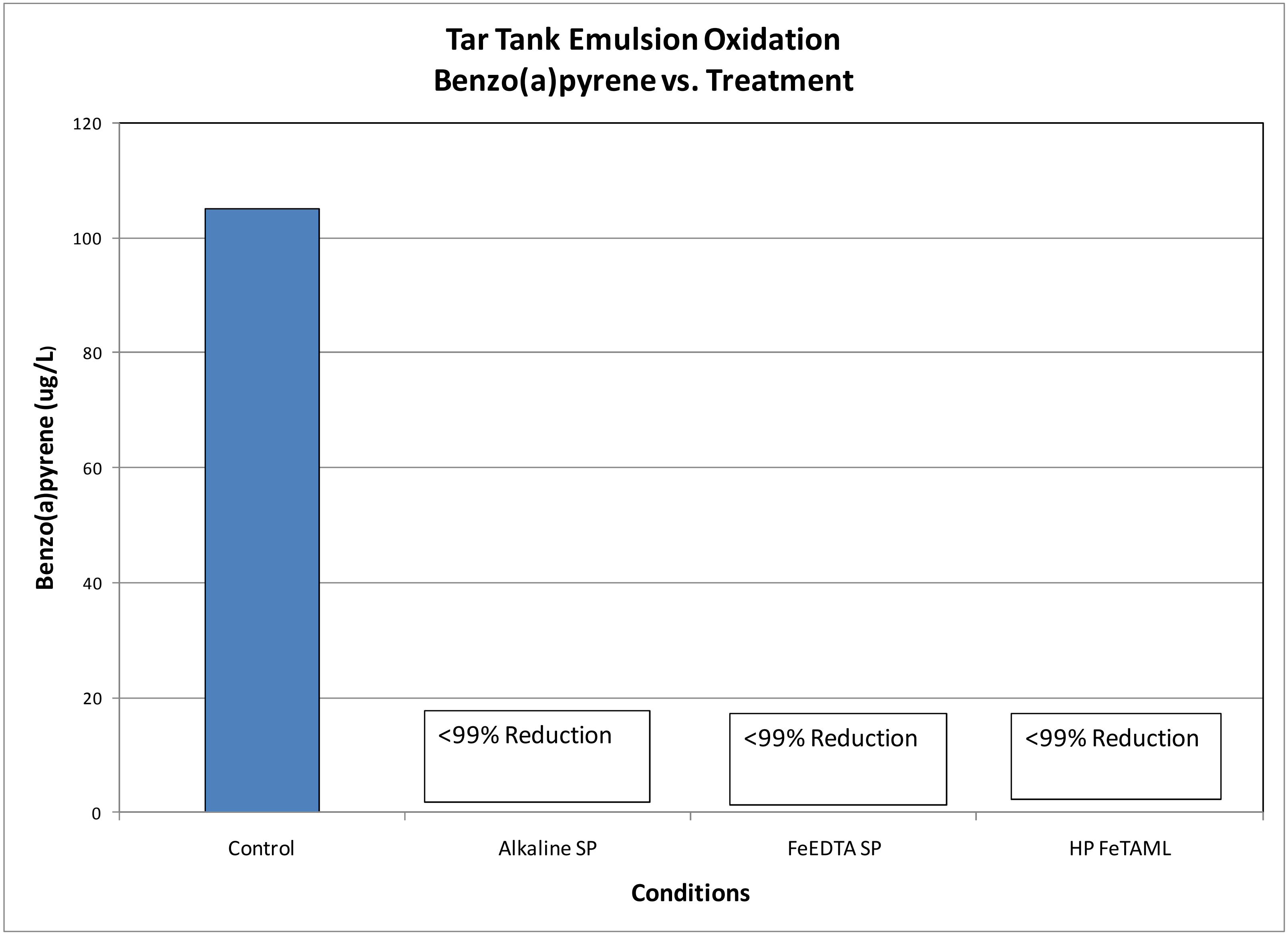
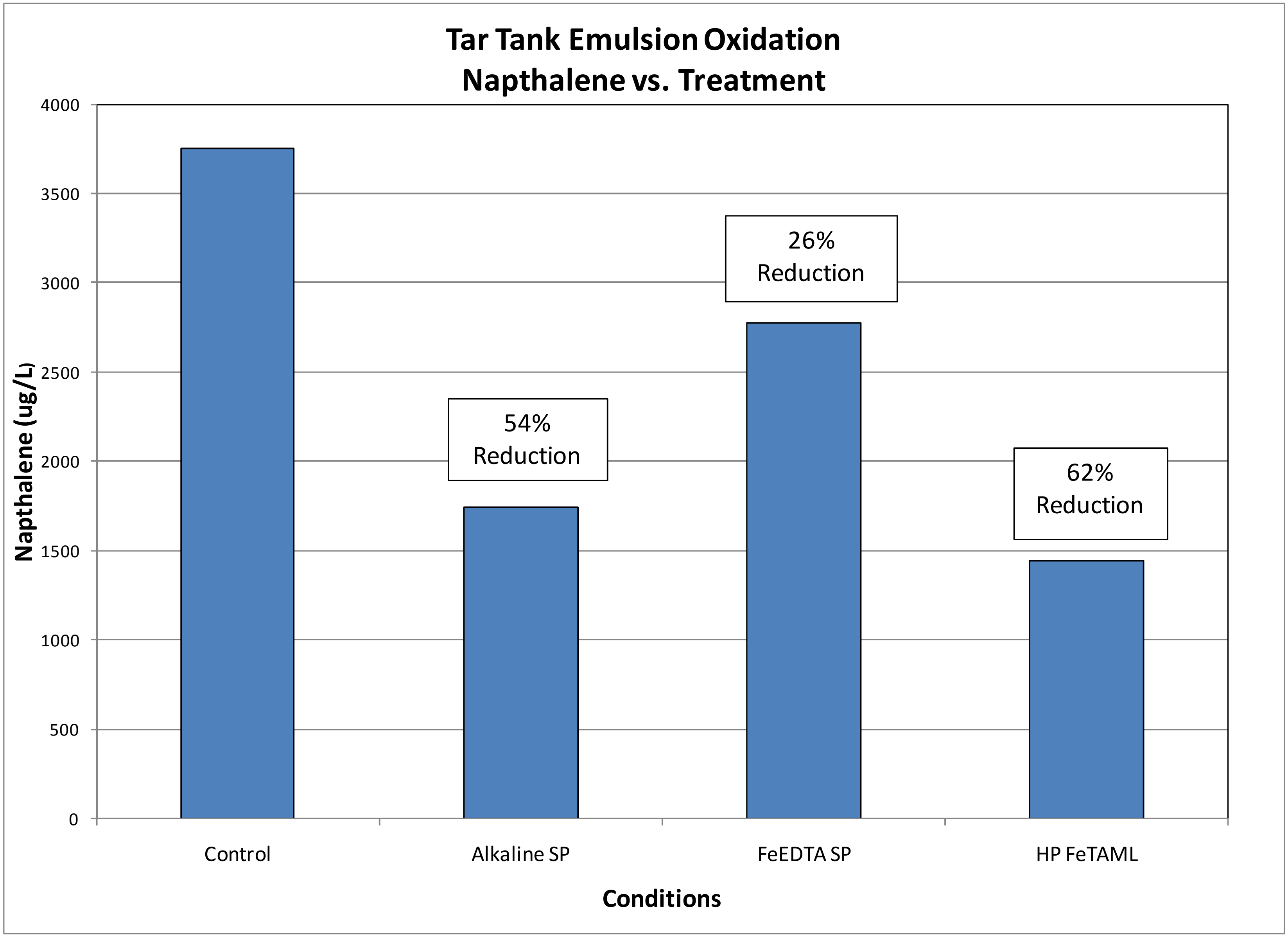

Tar Tank Emulsion Oxidation
Benzo(a)pyrene vs. Treatment
Benzo(a)pyrene (ug/L)
120
100
80
60
40
20
0
<99% Reduction
<99% Reduction
<99% Reduction
Control
Alkaline SP
FeEDTA SP
HP FeTAML
Conditions

Figure 7e



Tar Tank Emulsion Oxidation
Napthalene vs. Treatment
Napthalene (ug/L)
4000
3500
3000
2500
2000
1500
1000
500
0
54% Reduction
26% Reduction
62% Reduction
Control
Alkaline SP
FeEDTA SP
HP FeTAML
Conditions

Figure 7f

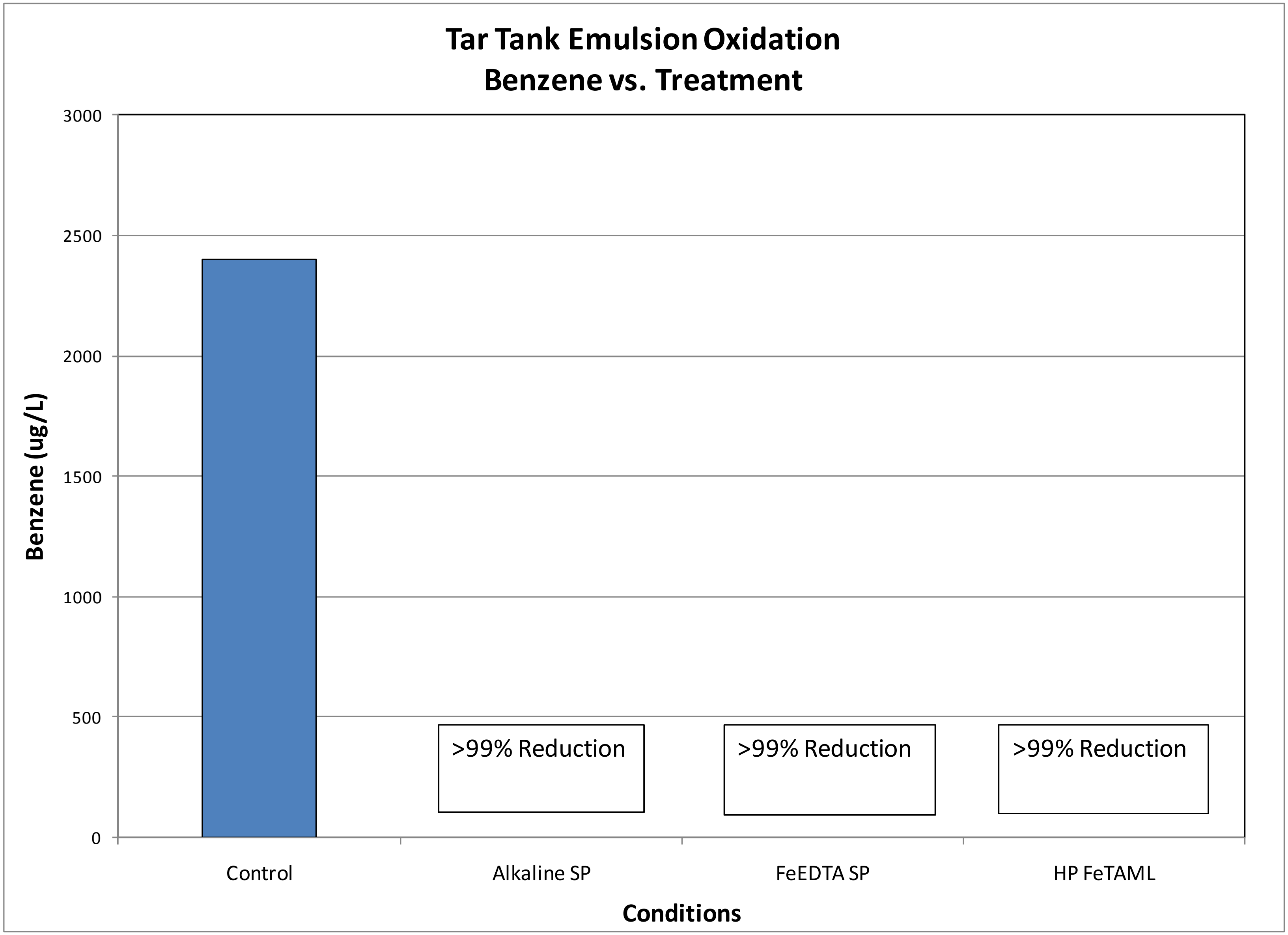
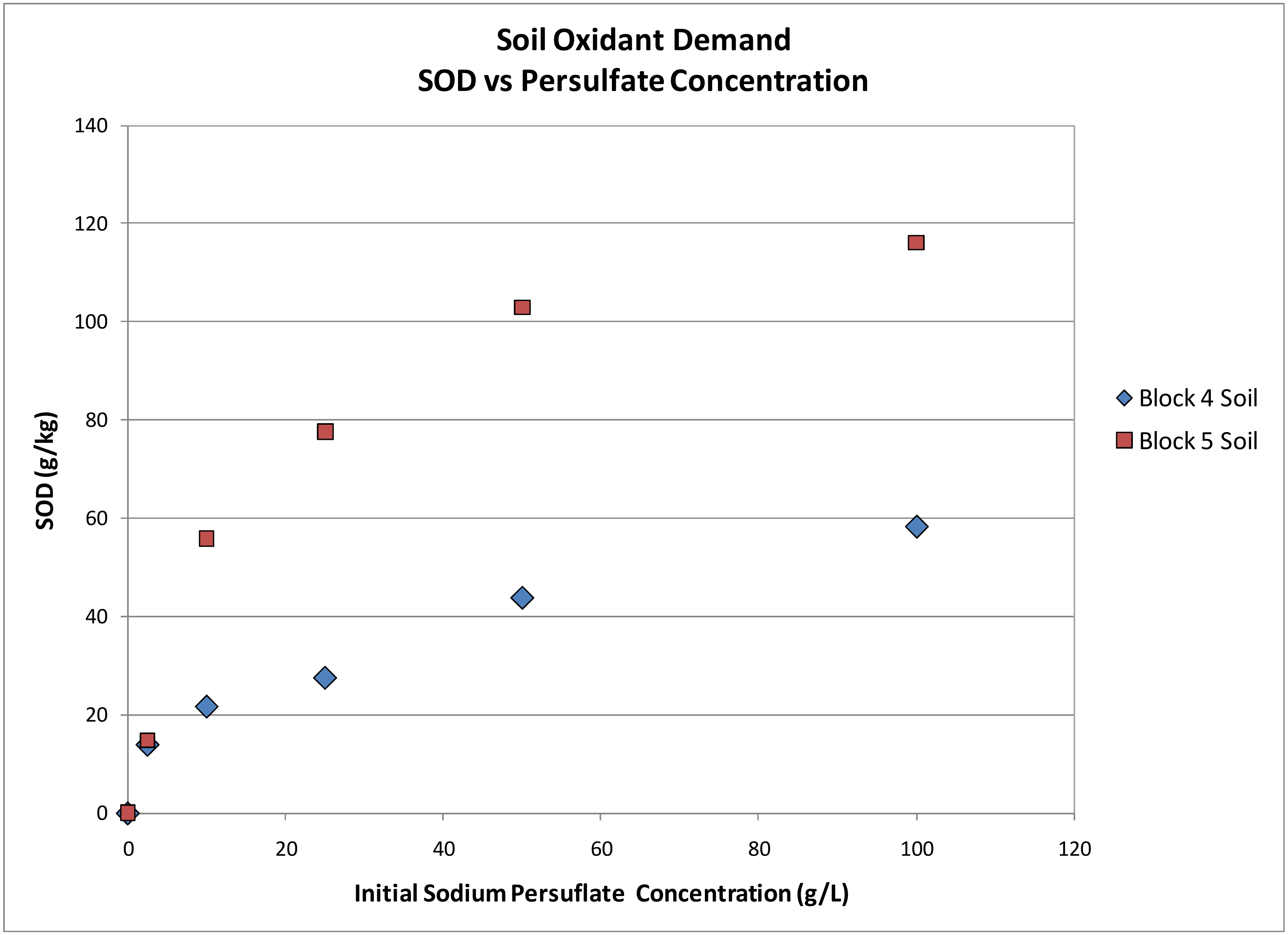
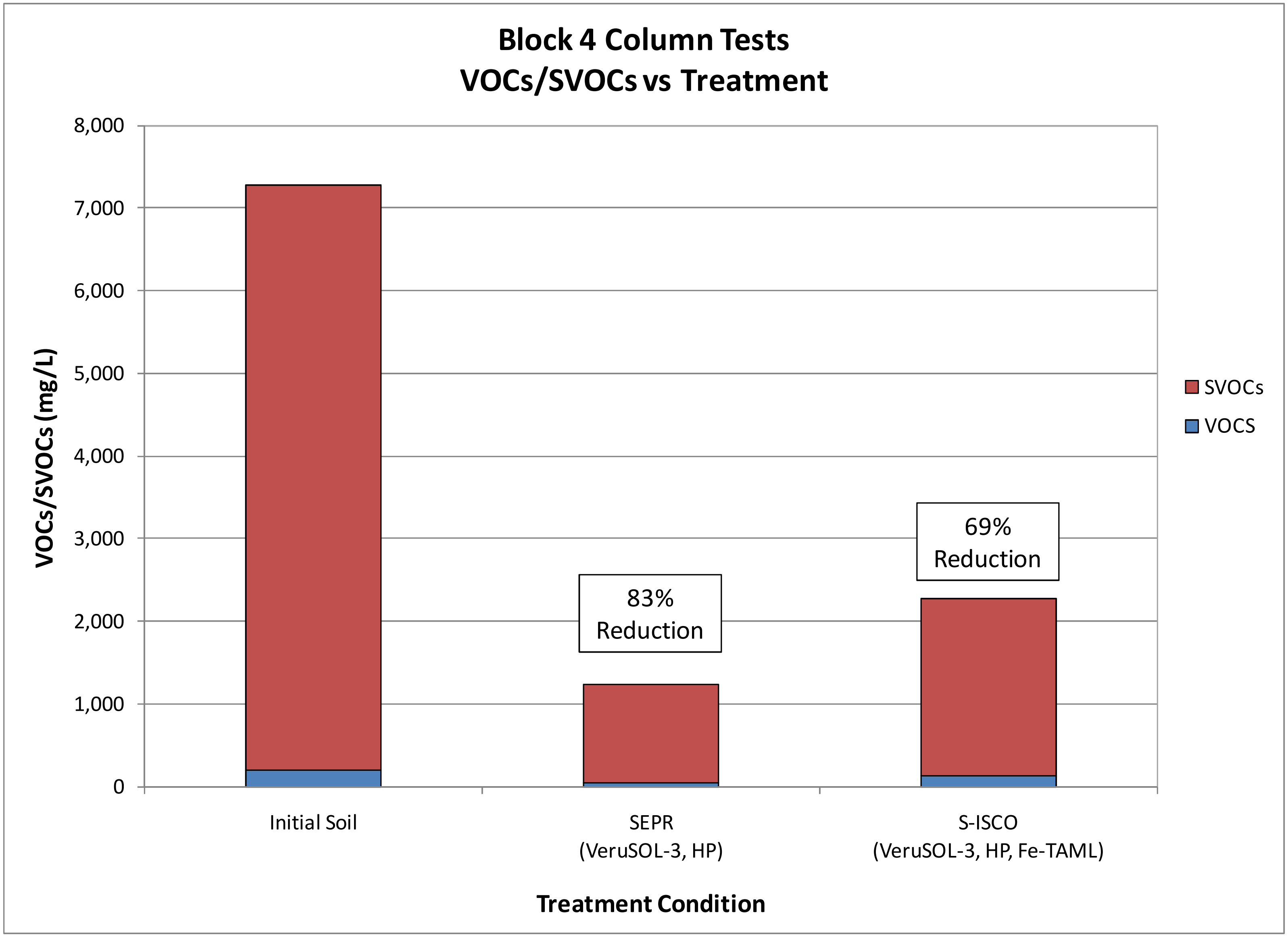

Tar Tank Emulsion Oxidation
Benzene vs. Treatment
Benzene (ug/L)
3000
2500
2000
1500
1000
500
0
>99% Reduction
>99% Reduction
>99% Reduction
Control
Alkaline SP
FeEDTA SP
HP FeTAML
Conditions

Figure 8



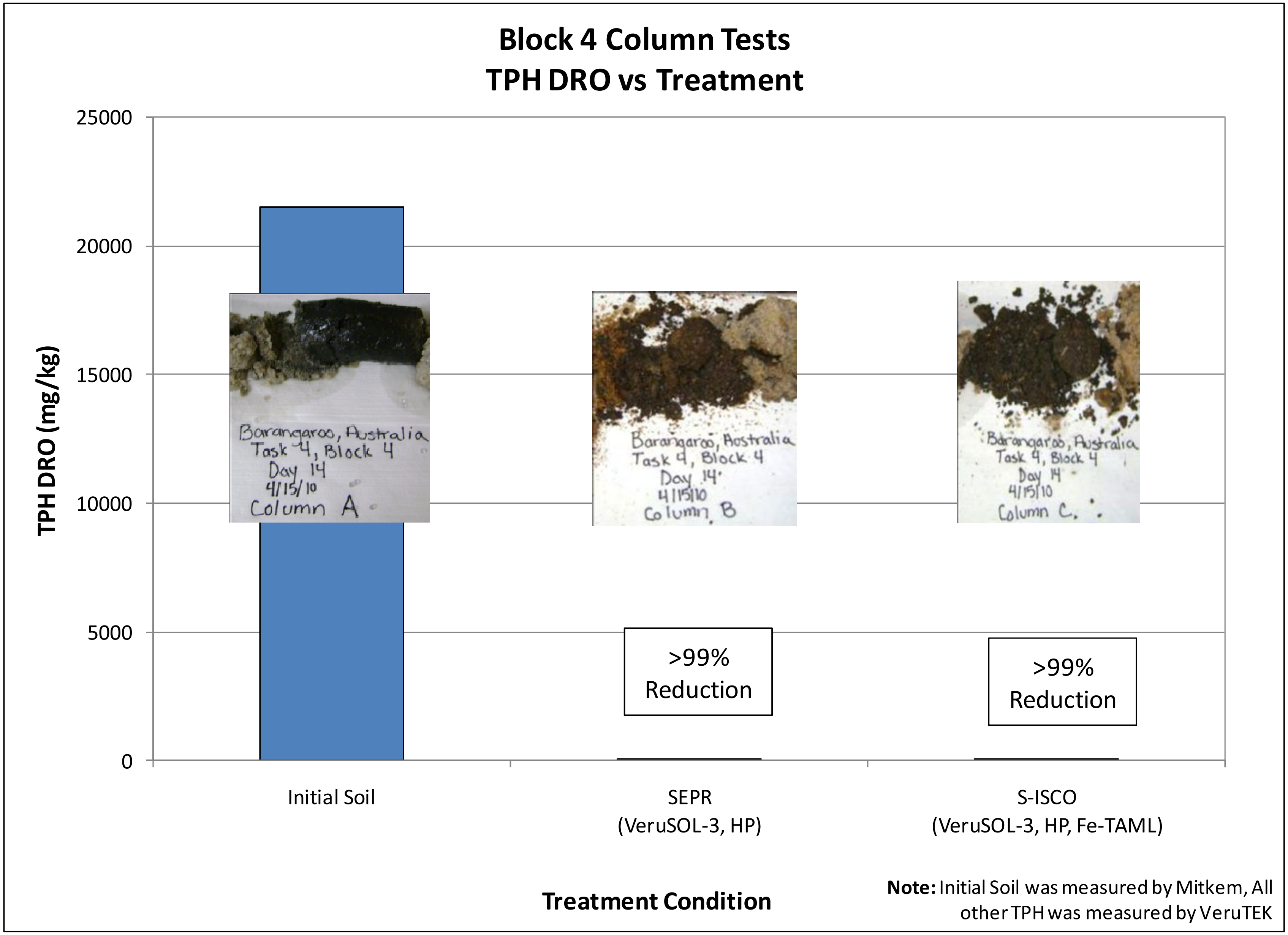
Soil Oxidant Demand
SOD vs Persulfate Concentration
140
120
100
80
60
40
20
0
SOD (g/kg)
0
20
40
60
80
100
120
Initial Sodium Persuflate Concentration (g/L)
Block 4 Soil
Block 5 Soil

Figure 9a



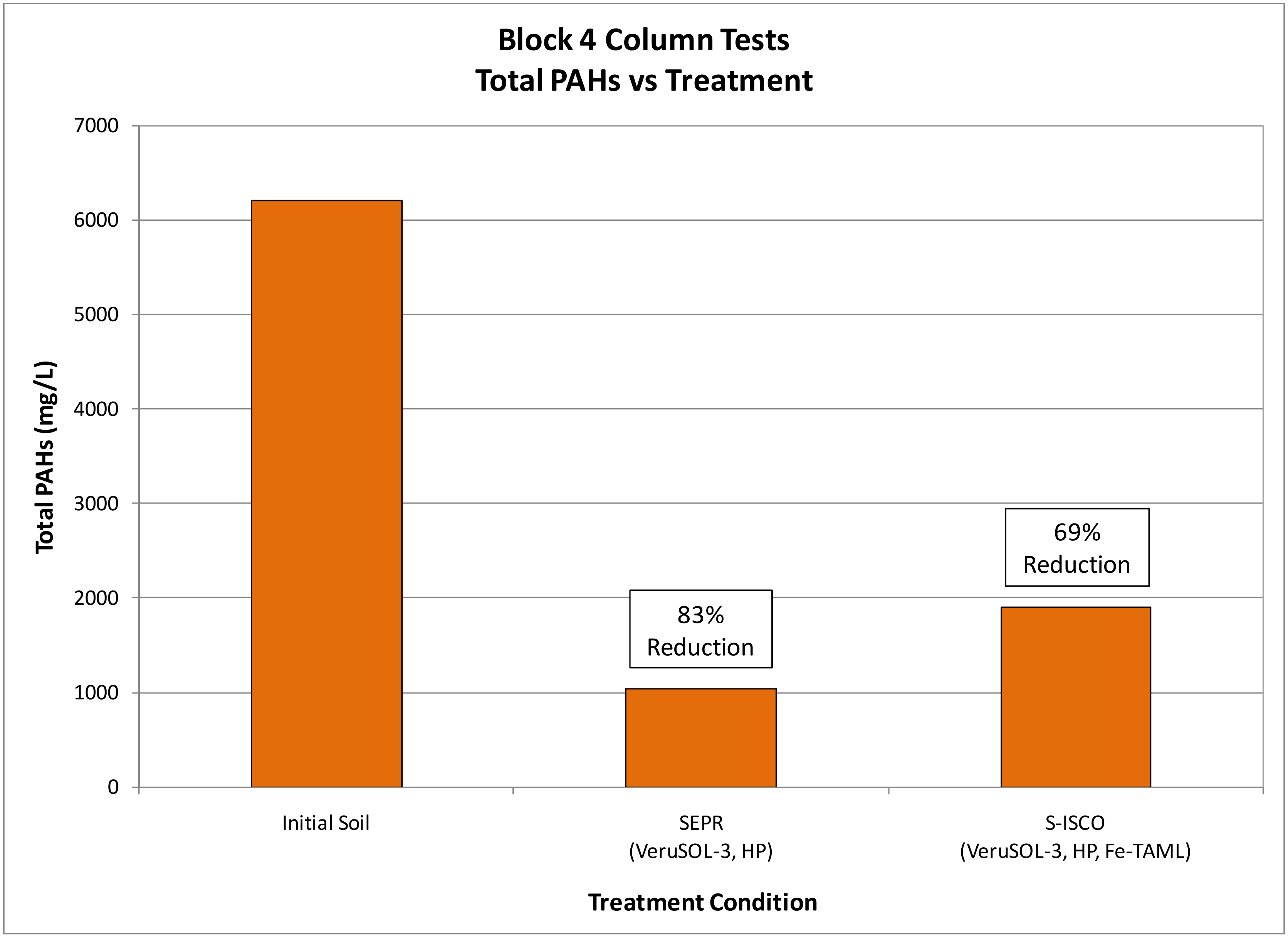
Block 4 Column Tests
VOCs/SVOCs vs Treatment
VOCs/SVOCs (mg/L)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
83%
Reduction
69%
Reduction
Initial Soil
SEPR
(VeruSOL-3, HP)
S-ISCO
(VeruSOL-3, HP, Fe-TAML)
Treatment Condition
SVOCs
VOCS

Figure 9b



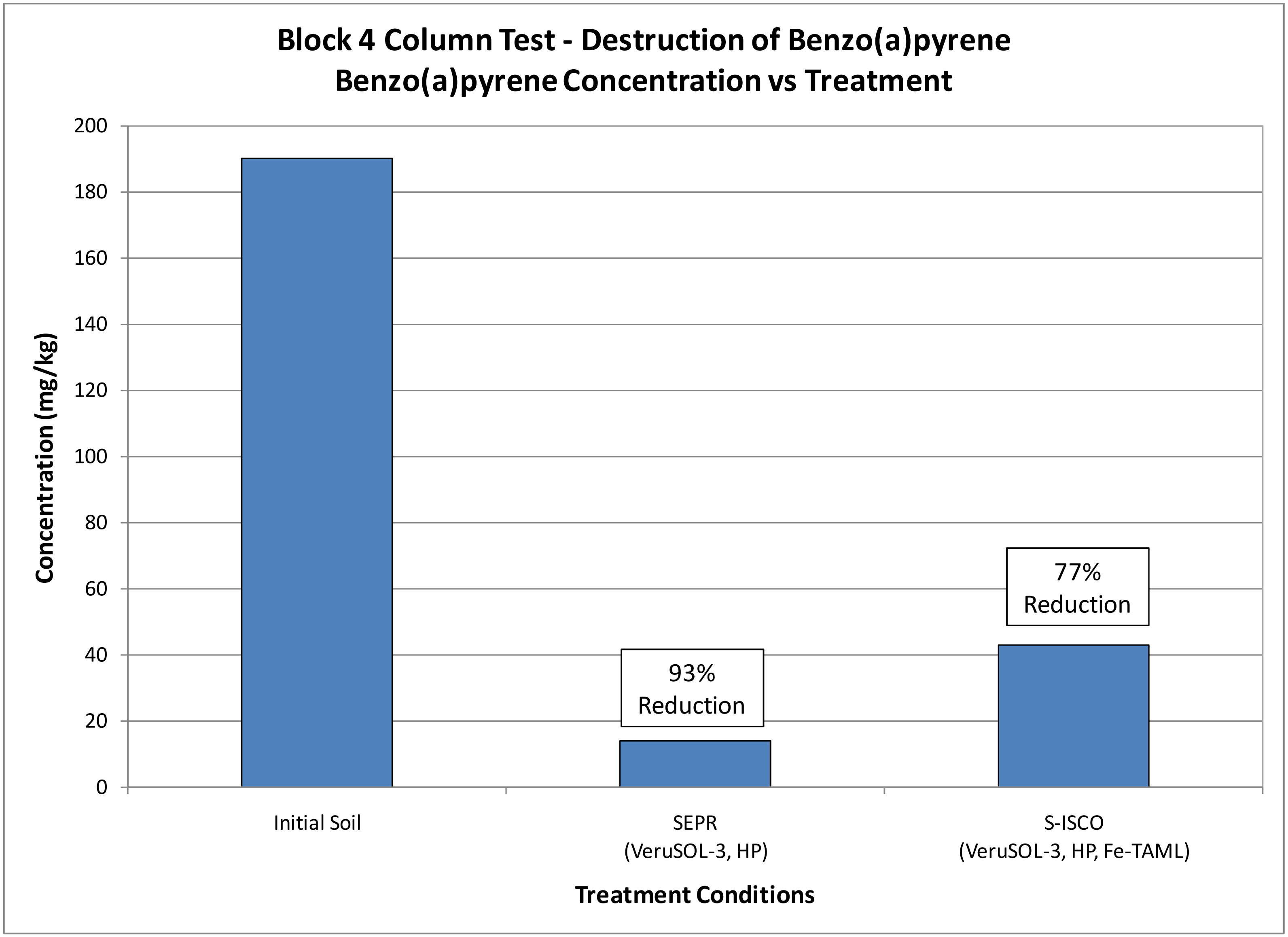
Block 4 Column Tests
TPH DRO vs Treatment
TPH DRO (mg/kg)
25000
20000
15000
10000
5000
0
Barangaroo, Australia
Task 4, Block 4
Day 14
4/15/10
Column A
Barangaroo, Australia
Task 4, Block 4
Day 14
4/15/10
Column B
Barangaroo, Australia
Task 4, Block 4
Day 14
4/15/10
Column C
>99% Reduction
>99% Reduction
Initial Soil
SEPR (VeruSOL-3, HP)
S-ISCO (VeruSOL-3, HP, Fe-TAML)
Treatment Condition
Note: Initial Soil was measured by Mitkem, All other TPH was measured by VeruTEK

Figure 9c



Block 4 Column Tests
Total PAHs vs Treatment
Total PAHs (mg/L)
7000
6000
5000
4000
3000
2000
1000
0
83% Reduction
69% Reduction
Initial Soil
SEPR (VeruSOL-3, HP)
S-ISCO (VeruSOL-3, HP, Fe-TAML)
Treatment Condition

Figure 9d



Block 4 Column Test - Destruction of Benzo(a)pyrene
Benzo(a)pyrene Concentration vs Treatment
Concentration (mg/kg)
200
180
160
140
120
100
80
60
40
20
0
93% Reduction
77% Reduction
Initial Soil
SEPR (VeruSOL-3, HP)
S-ISCO (VeruSOL-3, HP, Fe-TAML)
Treatment Conditions

Figure 9e

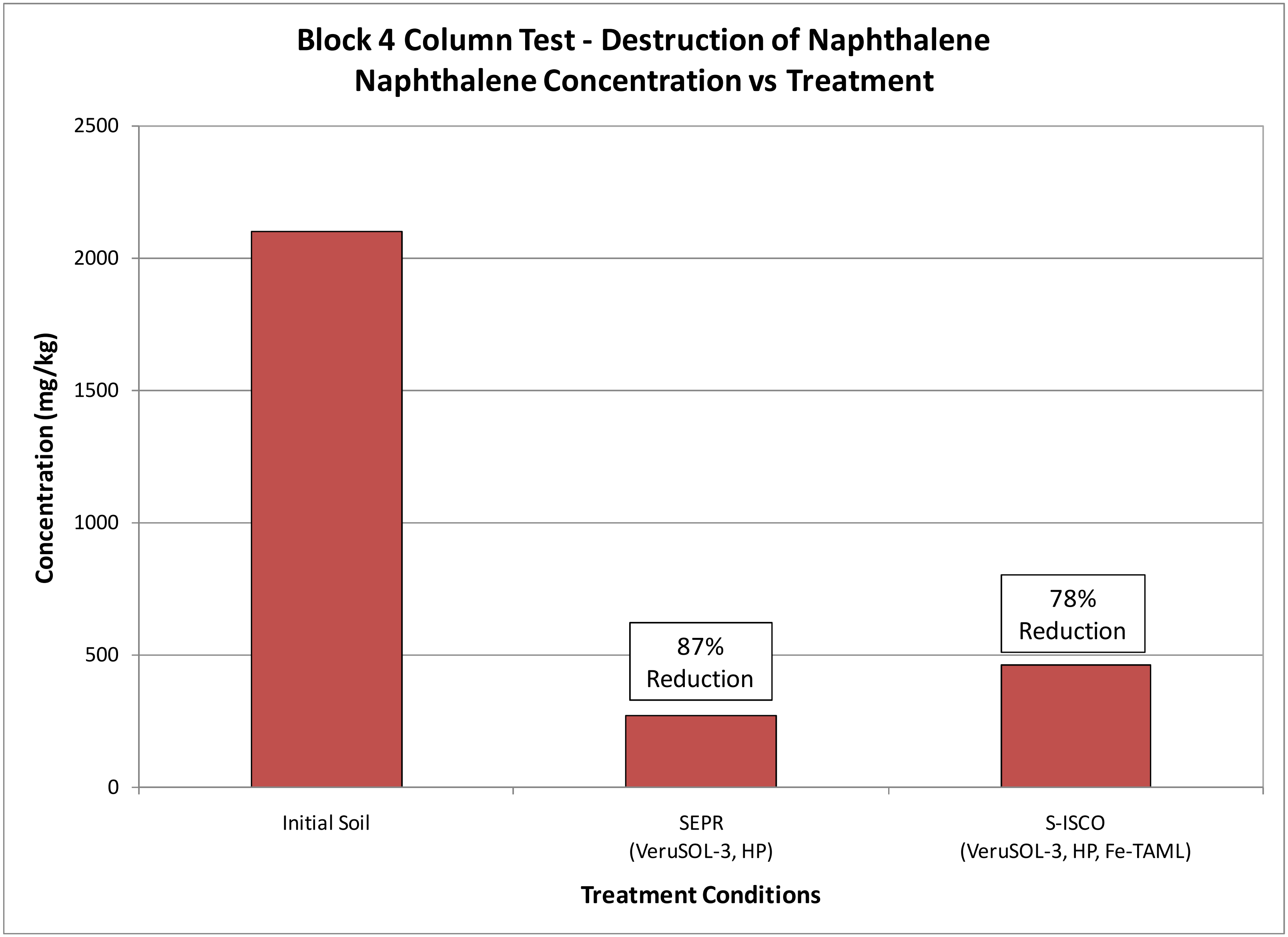
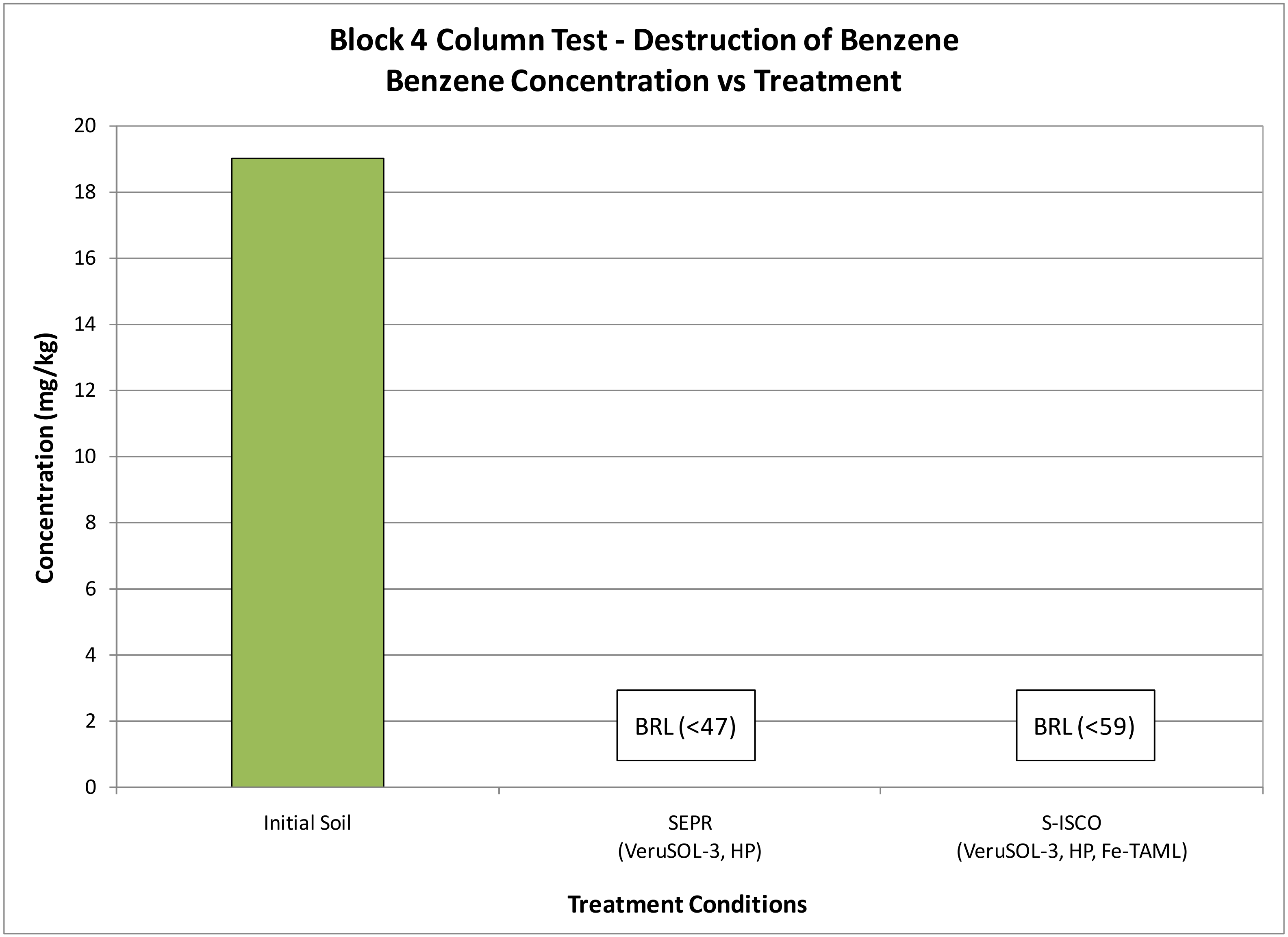

Block 4 Column Test - Destruction of Naphthalene
Naphthalene Concentration vs Treatment
Concentration (mg/kg)
2500
2000
1500
1000
500
0
87%
Reduction
78%
Reduction
Initial Soil
SEPR
(VeruSOL-3, HP)
S-ISCO
(VeruSOL-3, HP, Fe-TAML)
Treatment Conditions

Figure 9f



Block 4 Column Test - Destruction of Benzene
Benzene Concentration vs Treatment
Concentration (mg/kg)
20
18
16
14
12
10
8
6
4
2
0
BRL (<47)
BRL (<59)
Initial Soil
SEPR
(VeruSOL-3, HP)
S-ISCO
(VeruSOL-3, HP, Fe-TAML)
Treatment Conditions

Figure 10a

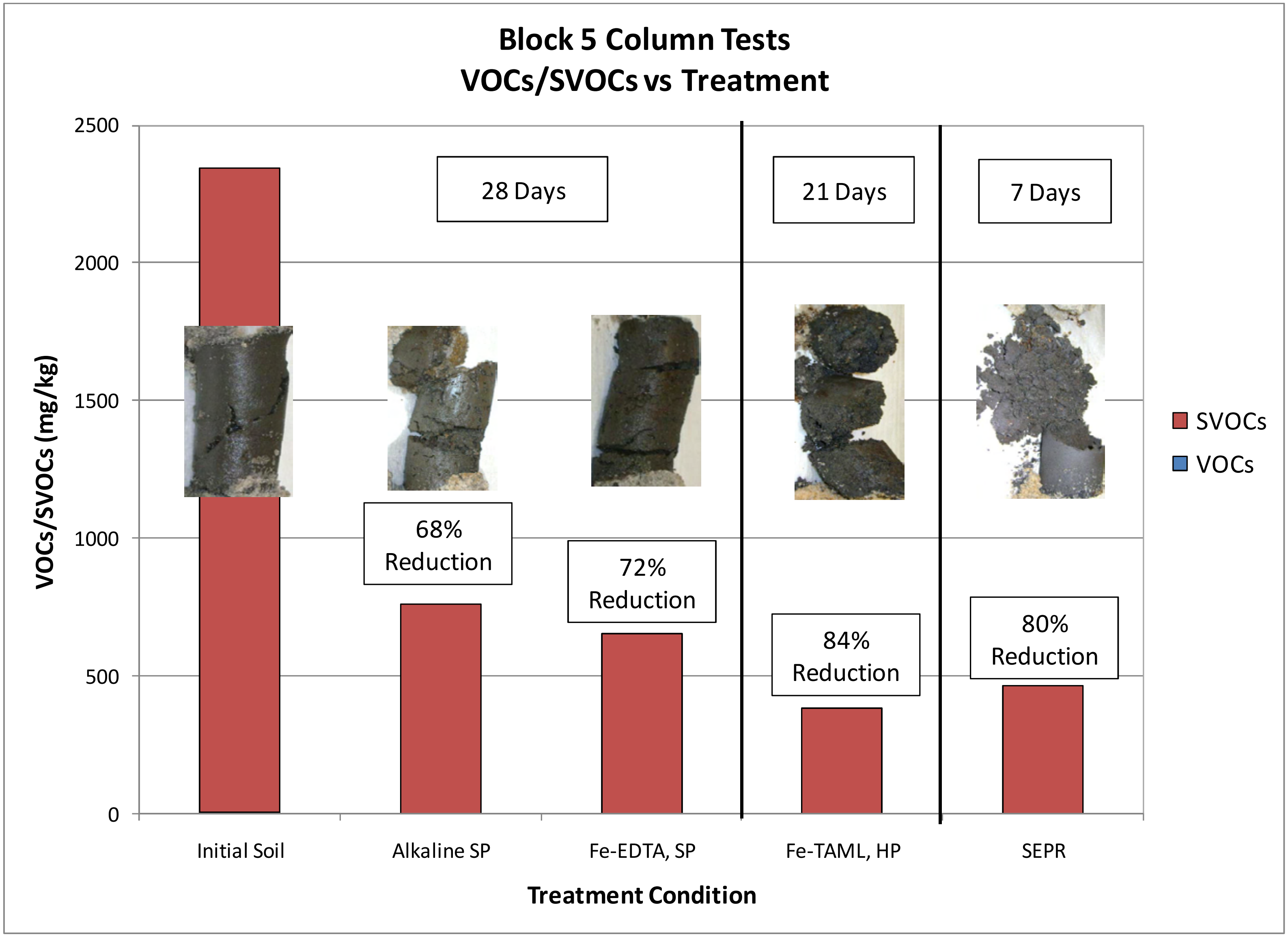
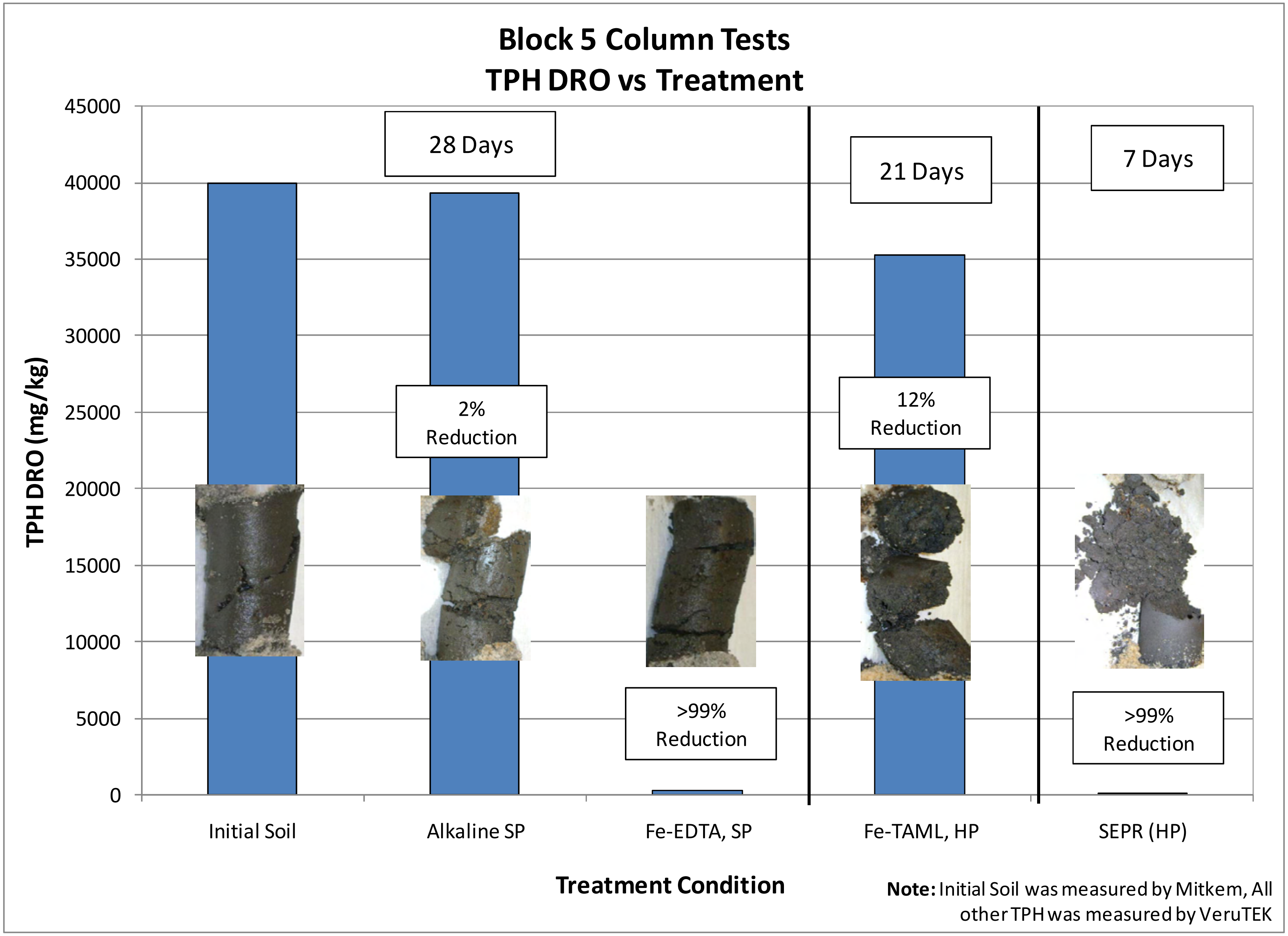
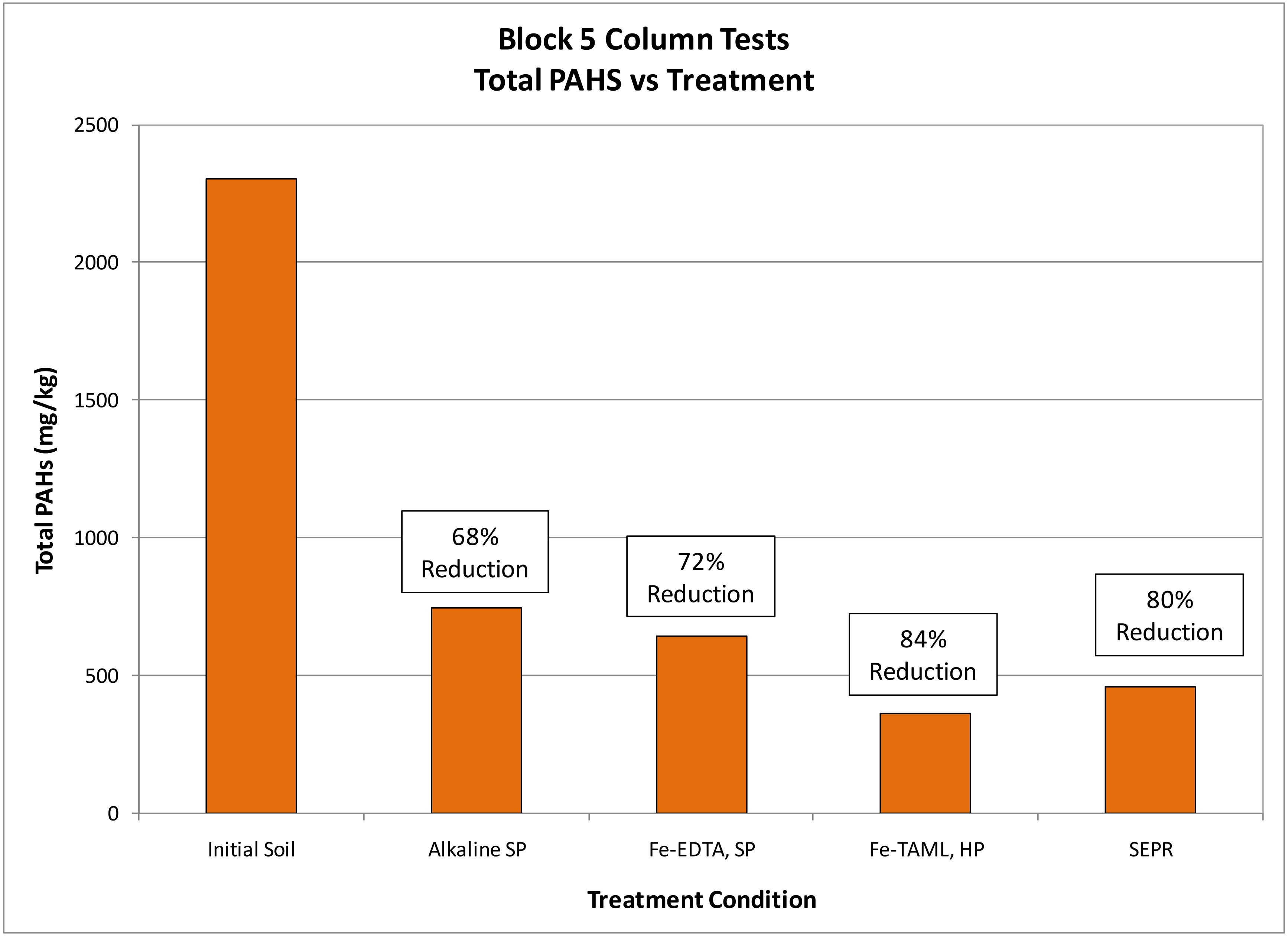

Block 5 Column Tests
VOCs/SVOCs vs Treatment
VOCs/SVOCs (mg/kg)
2500
2000
1500
1000
500
0
28 Days
21 Days
7 Days
68% Reduction
72% Reduction
84% Reduction
80% Reduction
SVOCs
VOCs
Initial Soil
Alkaline SP
Fe-EDTA, SP
Fe-TAML, HP
SEPR
Treatment Condition

Figure 10b



Block 5 Column Tests
TPH DRO vs Treatment
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
TPH DRO (mg/kg)
28 Days
21 Days
7 Days
2% Reduction
12% Reduction
>99% Reduction
>99% Reduction
Initial Soil
Alkaline SP
Fe-EDTA, SP
Fe-TAML, HP
SEPR (HP)
Treatment Condition
Note: Initial Soil was measured by Mitkem, All other TPH was measured by VeruTEK

Figure 10c



Privileged and Confidential: Prepared for the purpose of legal advice

Figure 10d

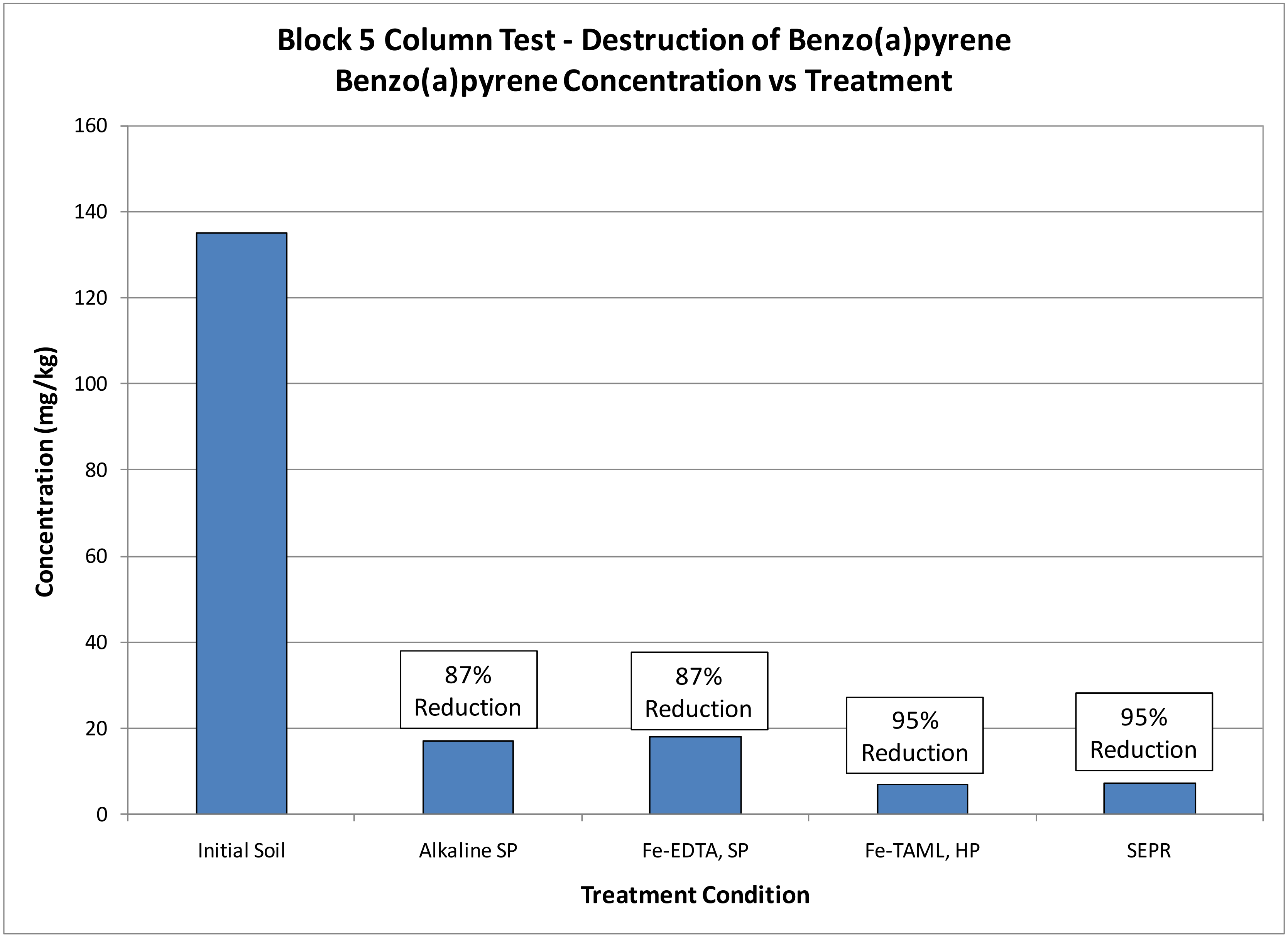
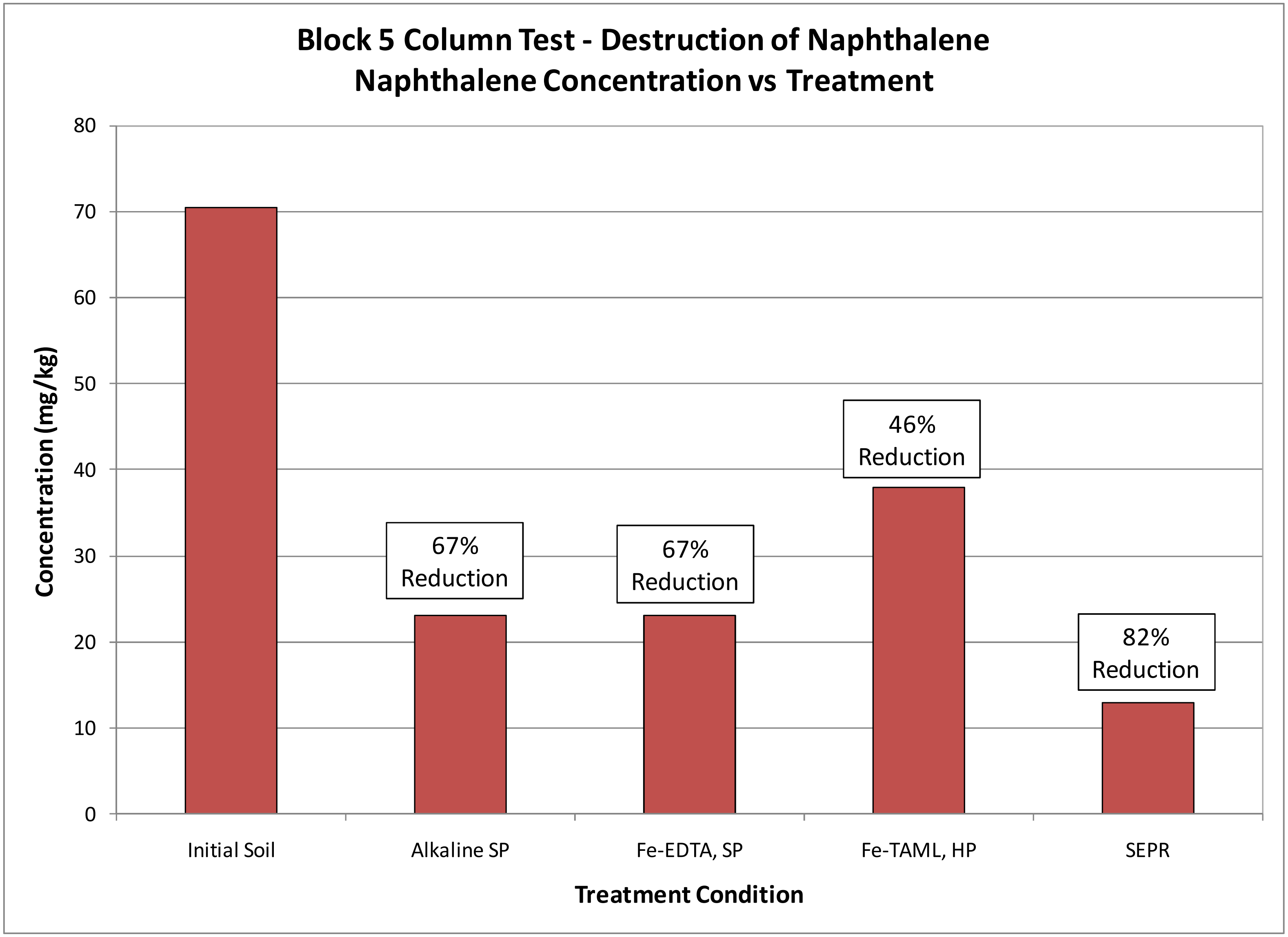
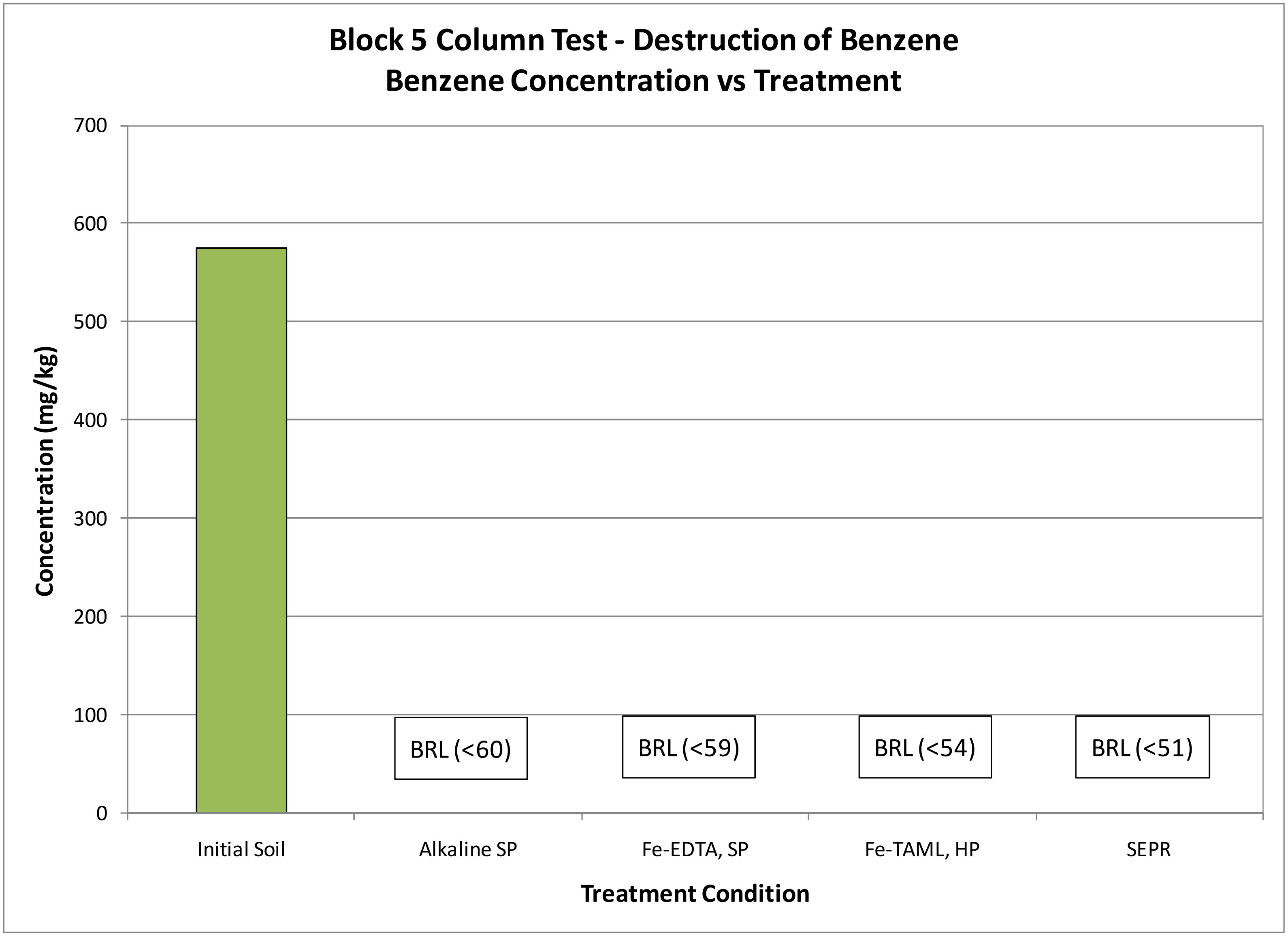

Block 5 Column Test - Destruction of Benzo(a)pyrene
Benzo(a)pyrene Concentration vs Treatment
Concentration (mg/kg)
160
140
120
100
80
60
40
20
0
87% Reduction
87% Reduction
95% Reduction
95% Reduction
Initial Soil
Alkaline SP
Fe-EDTA, SP
Fe-TAML, HP
SEPR
Treatment Condition

Figure 10e

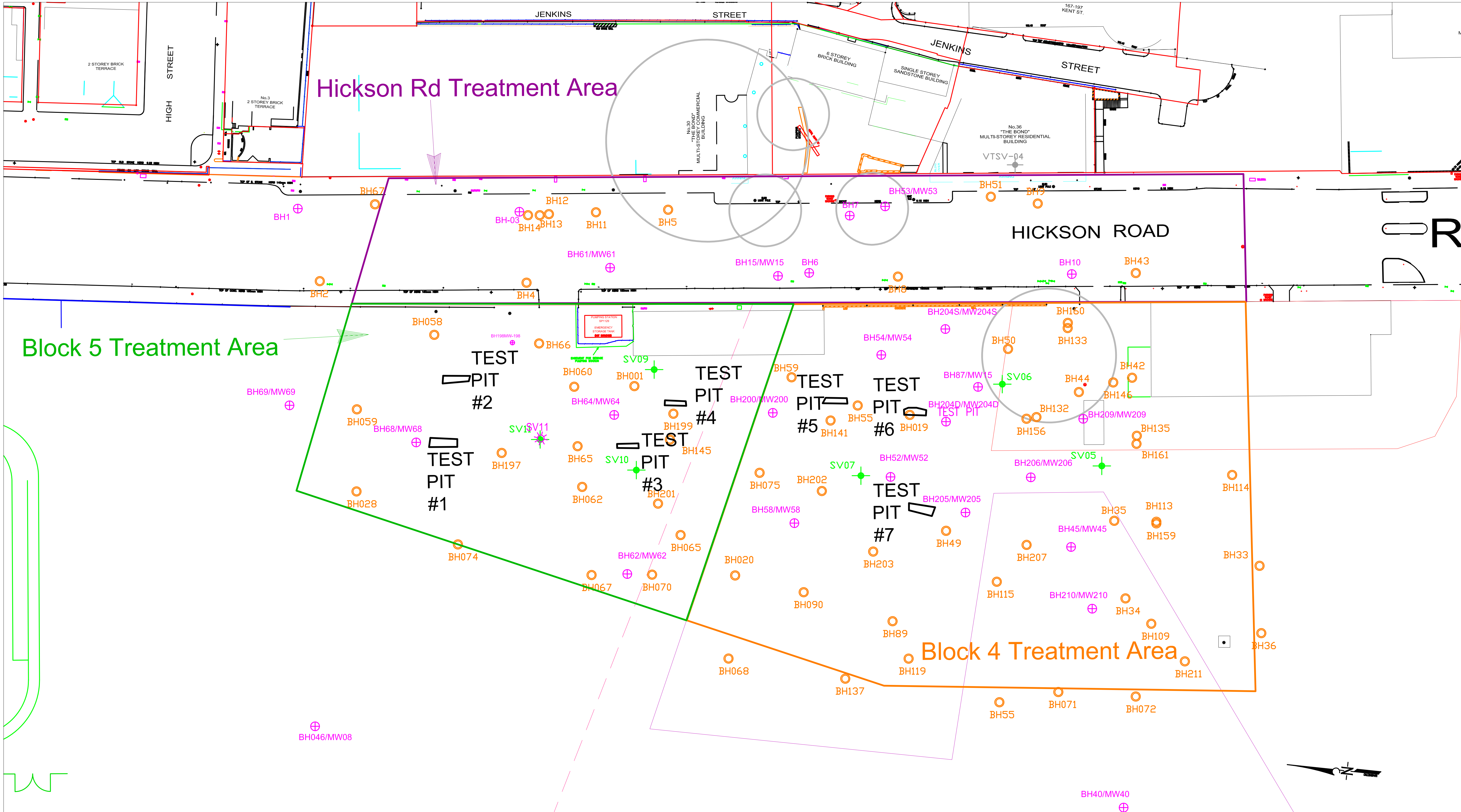


Block 5 Column Test - Destruction of Naphthalene
Naphthalene Concentration vs Treatment
Concentration (mg/kg)
80
70
60
50
40
30
20
10
0
67% Reduction
67% Reduction
46% Reduction
82% Reduction
Initial Soil
Alkaline SP
Fe-EDTA, SP
Fe-TAML, HP
SEPR
Treatment Condition

Figure 10f



Block 5 Column Test - Destruction of Benzene
Benzene Concentration vs Treatment
Concentration (mg/kg)
700
600
500
400
300
200
100
0
BRL (<60)
BRL (<59)
BRL (<54)
BRL (<51)
Initial Soil
Alkaline SP
Fe-EDTA, SP
Fe-TAML, HP
SEPR
Treatment Condition



0 20 40

SCALE, METERS

Note: Exact location of wells is estimated based on previous maps

Lend Lease	VeruTEK TECHNOLOGIES	Test Pit Location Map	
Barangaroo Hickson Rd Miller Point		May 2010	Plate 1

Appendix

Appendix A

1. Sample Login
2. Methods and Instruments
3. Task 2: Solubilization Enhancement
4. Task 5: SEPR/S-ISCO Batch Tests – Block 4 Soil
5. Jar Tests
6. Task 4: Soil Column Tests
    - -Block 4
    - -Block 5

Appendix B

1. Mitkem Data

Appendix A-1

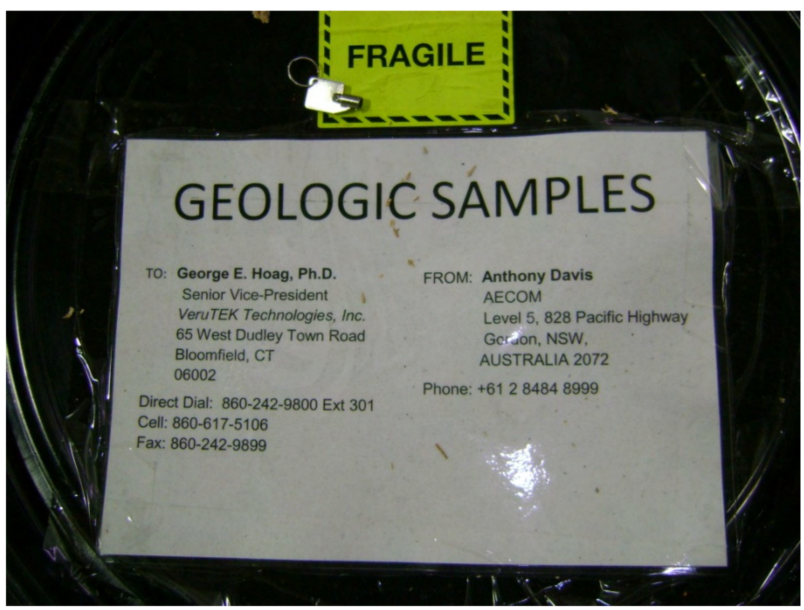
Sample Login Record
VeruTEK Technologies, Inc.
65 West Dudley Town Road, Suite 100
Bloomfield, CT 06002

Project Name:	Barangaroo S-ISCO	**Project Number (Client):**	S4150014
Sent by:	Anthony Davis AECOM	**Project Number (VeruTEK):**	10-201-56-6501
Received by:	Jessica Hoag VeruTEK	**Date and time of receipt:**	15.03.10 11:00
Sample Type:	Geologic Samples	**Sample Quantity :**	18x 3L Buckets; 2x 20L Buckets

Sample Inspection Record:

Two 208 liter poly drums containing geologic sample were delivered to the VeruTEK R&D Laboratory via TNT and Conway Freight Delivery on March 15, 2010. Samples were collected from the Site on 27.02.2010 and consisted of six sets of 3 x 5L buckets labeled [TP02_3.9-4.3], [TP04_0.5-0.7], [TP04_4.5-4.9], [TP05_1.8-2.0], [TP05_3.1-3.3], [TP06_2.8-3.0], respectively. In addtion, 2 x 20L buckets were delivered labeled: [TP01_4.5-4.8] and [TP07_4.1-4.3], respectively.

Upon arrival to the VeruTEK R&D Laboratory, the two 55-gal poly drums were unpacked and sample buckets unloaded. One drum had a large pressure dent in its side, but this did not affect the sample containers. Sample IDs were checked against the accompanying Chain of Custody and two minor discrepencies were found: 1) The sample buckets containing [TP04_4.5-4.9] were labeled as [TP04_4.5-4.8] on the Chain of Custody. 2) The location of each sample indicated on the Chain of Custody puts TP01, TP02, and TP04 in Block 4 and TP05, TP06, and TP07 in Block 5. According to the AECOM Site map, however, these locations should be switched, placing TP01, TP02, and TP04 in Block 5, and TP05, TP06, and TP07 in Block 4.

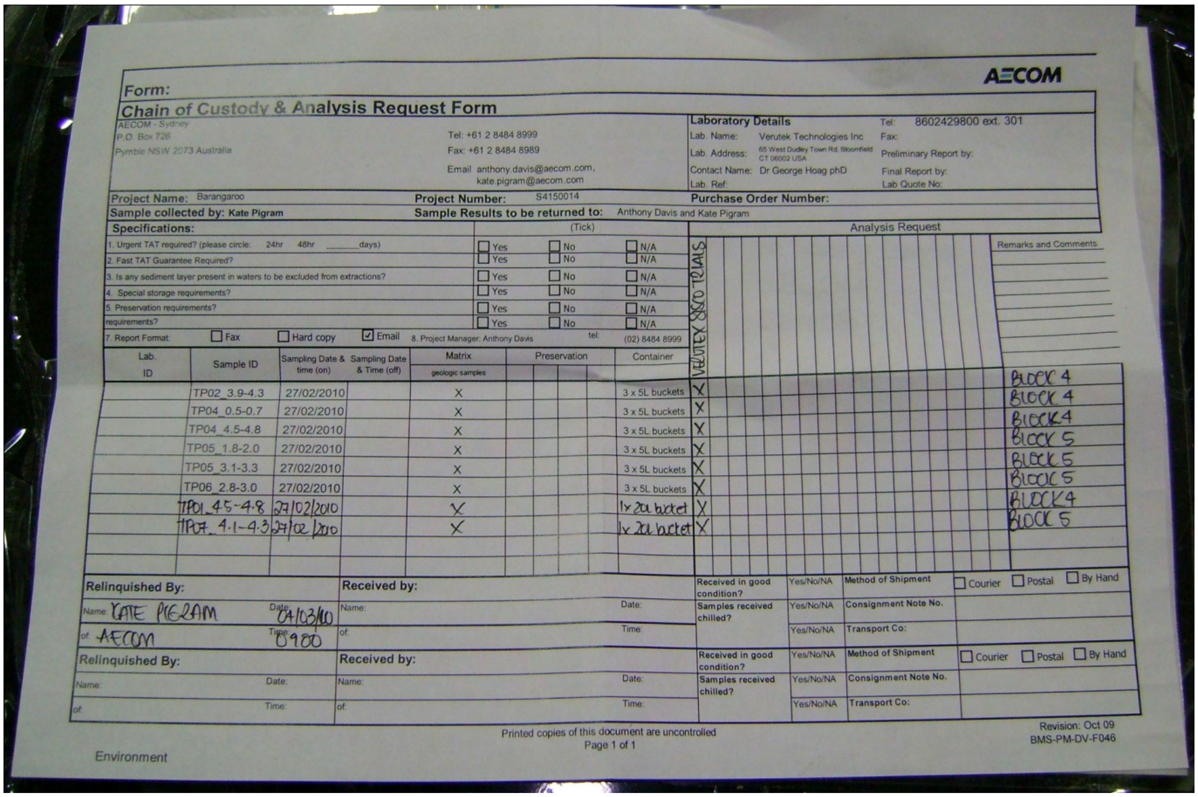


Sample Login Record
VeruTEK Technologies, Inc.
65 West Dudley Town Road, Suite 100
Bloomfield, CT 06002

Project Name:	Barangaroo S-ISCO	**Project Number (Client):**	S4150014
Sent by:	Anthony Davis AECOM	**Project Number (VeruTEK):**	10-201-56-6501
Received by:	Jen Holcomb VeruTEK	**Date and time of receipt:**	March 23, 2010
Sample Type:	Geologic Samples	**Sample Quantity :**	2x 40 mL NAPL; 19x 500 mL Groundwater; 1x 20 L Bucket of Soil Sample

Sample Inspection Record:

One cooler along with one 20L bucket were received at VeruTEK on March 23, 2010. The cooler contained a total of 19 500mL amber glass jars, filled with Site groundwater, collected from Barangaroo on March 10, 2010. Samples consited of 1) Groundwater in : 1 jar labeled MW54, 8 jars labeled MW74, 8 jars labeled MW52, 1 jar labeled MW53, and 1 jar labeled MW205; 2) NAPL in: 2 40mL VOA vials labeled MW205; 3) Soil in a plastic bag in 20L bucket labeled BH53 Geologic Sample. The bucket also contained liquid which covered about half of the bag of soil from a tar tank. All samples arrived in good condition, with exception to the NAPL vials, which were covered on the outside with NAPL (making it hard/impossible to see the sample IDs). All other sample ID's were checked against the chain of custody, and only one small discrepancy was found. The bucket labeled "BH53 Geologic Sample" was listed on a chain of custody.



AECOM

Form:

Chain of Custody & Analysis Request Form

AECOM - Sydney
P.O. Box 726
Pymble NSW 2073 Australia

Tel: +61 2 8484 8999
Fax: +61 2 8484 8989
Email anthony.davis@aecom.com, kate.pigram@aecom.com

Laboratory Details
Lab. Name: Verutek Technologies Inc
Lab. Address: 65 West Dudley Town Rd, Bloomfield CT 06002 USA
Contact Name: Dr George Hoag phD
Lab. Ref:
Tel: 8602429800 ext. 301
Fax:
Preliminary Report by:
Final Report by:
Lab Quote No:

Project Name: Barangaroo
Project Number: S4150014
Purchase Order Number:
Sample collected by: Kate Pigram
Sample Results to be returned to: Anthony Davis and Kate Pigram

Specifications:	(Tick)		
1. Urgent TAT required? (please circle: 24hr 48hr ______days)	☐ Yes	☐ No	☐ N/A
2. Fast TAT Guarantee Required?	☐ Yes	☐ No	☐ N/A
3. Is any sediment layer present in waters to be excluded from extractions?	☐ Yes	☐ No	☐ N/A
4. Special storage requirements?	☐ Yes	☐ No	☐ N/A
5. Preservation requirements?	☐ Yes	☐ No	☐ N/A
requirements?	☐ Yes	☐ No	☐ N/A
7. Report Format: ☐ Fax ☐ Hard copy ☑ Email	8. Project Manager: Anthony Davis	tel:	(02) 8484 8999

Analysis Request: VERUTEX 8800 TRIALS

Lab. ID	Sample ID	Sampling Date & time (on)	Sampling Date & Time (off)	Matrix (geologic samples)	Preservation	Container	VERUTEX 8800 TRIALS	Remarks and Comments
	TP02_3.9-4.3	27/02/2010		X		3 x 5L buckets	X	BLOCK 4
	TP04_0.5-0.7	27/02/2010		X		3 x 5L buckets	X	BLOCK 4
	TP04_4.5-4.8	27/02/2010		X		3 x 5L buckets	X	BLOCK 4
	TP05_1.8-2.0	27/02/2010		X		3 x 5L buckets	X	BLOCK 5
	TP05_3.1-3.3	27/02/2010		X		3 x 5L buckets	X	BLOCK 5
	TP06_2.8-3.0	27/02/2010		X		3 x 5L buckets	X	BLOCK 5
	TP01_4.5-4.8	27/02/2010		X		1x 20L bucket	X	BLOCK 4
	TP07_4.1-4.3	27/02/2010		X		1x 20L bucket	X	BLOCK 5

Relinquished By:
Name: KATE PIGRAM Date: 04/03/10
of: AECOM Time: 0900

Received by:
Name: Date:
of: Time:

Received in good condition? Yes/No/NA — Method of Shipment ☐ Courier ☐ Postal ☐ By Hand
Samples received chilled? Yes/No/NA — Consignment Note No.
Yes/No/NA — Transport Co:

Relinquished By:
Name: Date:
of: Time:

Received by:
Name: Date:
of: Time:

Received in good condition? Yes/No/NA — Method of Shipment ☐ Courier ☐ Postal ☐ By Hand
Samples received chilled? Yes/No/NA — Consignment Note No.
Yes/No/NA — Transport Co:

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Page 1 of 1

Revision: Oct 09
BMS-PM-DV-F046

Environment


FRAGILE
Con-way
CONSIGNEE COPY
INVOICE NUMBER
TO: George E. Hoag, Ph.D.
Senior Vice-President
VeruTEK Technologies, Inc
65 West Dudley Town Road
Bloomfield, CT
FROM: Anthony Davis
AECOM
Gordon, NSW,
AUSTRALIA 2072
Phone: +61 2 8484 8999

Appendix A-2

Analytical Methods and Instruments			
Parameters	**Instruments**	**Analysis methods**	**Conducted By**
pH, Conductivity	Accumet Model 25 pH/ORP meter and Denver Instrument AP 50 pH/Ion/Conductivity Meter	Solution pH (4500-H+in Standard Methods for the Examination of Water and Wastewater (1995); Soil pH (SW 846 Method 9045C)	VeruTEK®
Oxidation Reduction Potential (ORP)	Orion Model 810 ORP meter/platinum combination electrode	Standard methods for water and soil	VeruTEK®
Interfacial Tension (IFT)	SITA Dynotester/bubble pressure tensiometer	Standard methods for water and soil	VeruTEK®
Sodium Persulfate	Spectronic Genesys 5 Spectrophotometer	Colorimetric method	VeruTEK®
Hydrogen Peroxide	None	Titration	VeruTEK®
VOCs and SVOCs	Gas Chromatography/Mass Spectrometry	SW-846 Method 8260B and Method 8270C/8270Sim for soil; Methods 624 and 625 for liquid	Mitkem Laboratories
TPH	Sitelab Spectrophotometer / Gas Chromotography	Sitelab colormetric method / GC Extractable Products Method 8100	VeruTEK™ / Mitkem Laboratories

Appendix A-3

Task 2: Solubilization Enhancement (Block 5 Soil) - Parameter Log									
	pH	**ORP (mV)**	**Conductivity (mS/cm)**	**IFT (mN/m)**	**Temp. (°C)**	**Turb. (NTU)**	**TPH-GRO (ppm)**	**TPH-DRO (ppm)**	**TPH-Total (ppm)**
T2-A	6.5	201	4.801	72.9	18.5	3.2	BRL (<25)	3	2.5
T2-B	6.61	182	4.457	59.5	18.5	618.1	BRL (<25)	117	117
T2-C	6.51	234	4.388	41.9	18.6	> 1100	BRL (<25)	1,397	1,397
T2-D	6.46	247	4.384	35.9	18.4	> 1100	BRL (<25)	3,155	3,155
T2-E	6.67	256	4.148	33.4	18.6	> 1100	BRL (<25)	4,617	4,617

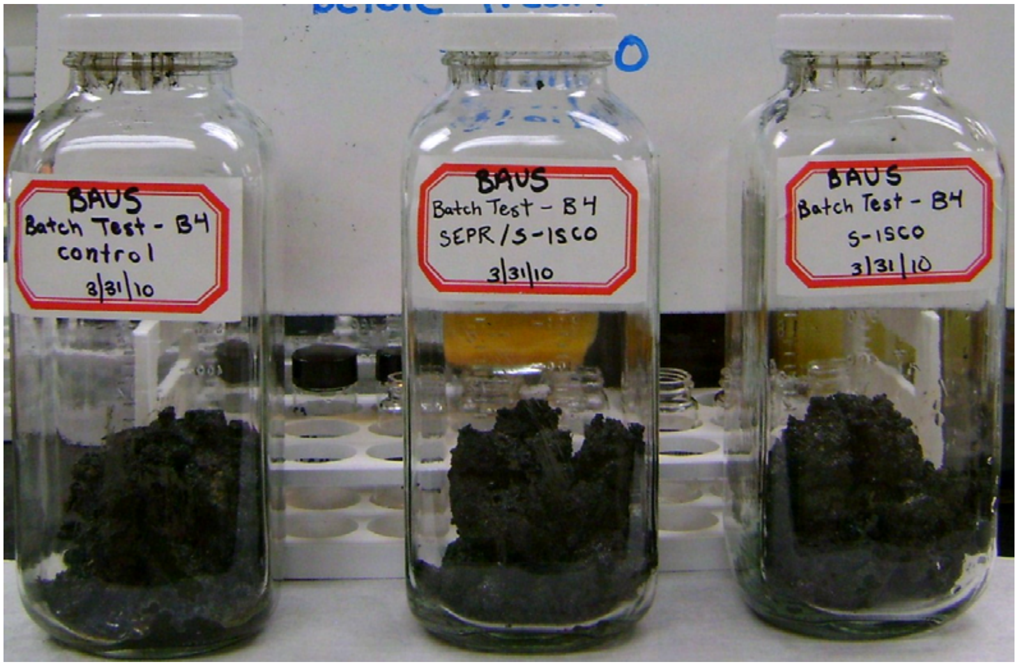
Task 2: Solubilization Enhancement – **Block 5 Soil** – Day 0

Task 2: Solubilization Enhancement – **Block 5 Soil** – Day 7 (settled)

Appendix A-4

Task 5: SEPR/S-ISCO Batch Tests- Block 4 Soil

Contaminated soil before treatment



Time: 5 minutes

Time: 24 hrs End SEPR Phase

Time: Day 8 End S-ISCO Phase

Task 5 Block 4 Daily Parameters

	SEPR/S-ISCO		S-ISCO		Notes
Date	pH	HP %	pH	HP %	
4/1/2010	6.5	0.71	6.5	0.45	+ .1 mL NaOH to S-ISCO
4/2/2010	7	0.37	6.5	0.2	.5 mL NaOH to both
4/5/2010	7	0.14	7	0.05	Added .5 mL NaOH to both Added 65mL H2O2 to both
4/6/2010	8	0.27	7	0.28	Added .5 mL NaOH to both Added 60mL H2O2 to both
4/7/2010	7.5	0.325	7.5	0.31	Added .5 mL NaOH to both Added 60mL H2O2 to both
4/8/2010	7.5	0.2	7.5	0.37	Added .5 mL NaOH to both Added 70 mL H2O2 to both

Appendix A-6

Jar Tests Phase I: Time 0 before activation

Jar Tests Phase I: Time 0 Activated

Jar Tests Phase I: Time 60 minutes

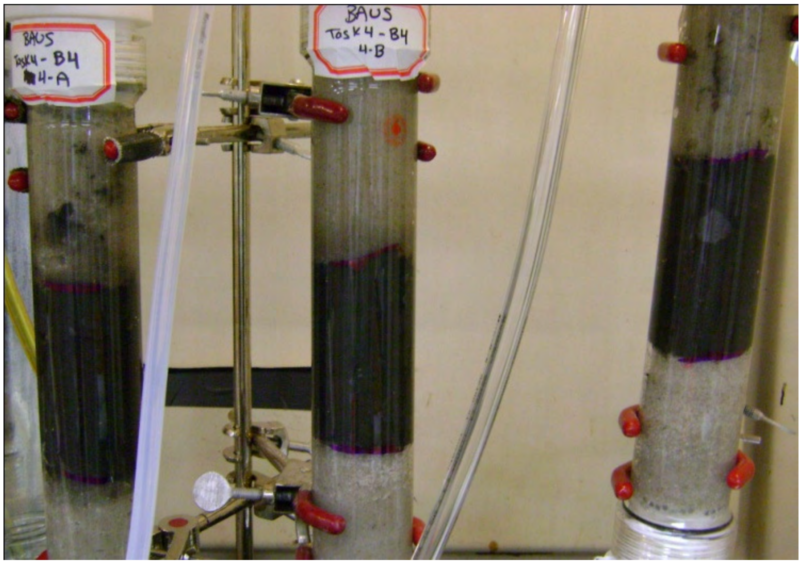
Jar Tests Phase II: Time 0

Jar Tests Phase II: Time 24 Hours

Appendix A-4

Task 4: Soil Column Tests - Block 4

Time: 0



Time: 40 mins

Time: Final Day

Task 4 Soil Column Tests –Block 4- Daily Parameters

Barangaroo - Block 4 - COLUMN A											
Control Column - DI H20											
Effluent	Date	Run Vol	pH	ORP	IFT	Temp	Cond.	Turb.	TPH-DRO	TPH-GRO	**Total TPH**
		mL		mV	mN/m	°C	mS/cm	NTU	ppm	ppm	**ppm**
1	4/2/2010	500	6.00		72.1	23.3		2.23	6.5	<25	
2	4/2/2010	**500**	6.00		70.7	23.3		1.00	<5.0	<25	
3	4/2/2010	500	6.00		72.2	23.2		1.64	<5.0	<25	
4	4/3/2010	1000	6.00		72.1	23.3		1.79	<5.0	<25	
5	4/4/2010	1000	6.00		72.1	23.4		1.63	<5.0	<25	
6	4/5/2010	1000	6.00		71.6	23.3		1.29	<5.0	<25	
7	4/5/2010	500	6.00		72.0	23.6		1.79	<5.0	<25	
8	4/5/2010	1000	6.00		72.6	21.8		0.27	19.7		
9	4/6/2010	1000	6.00		72.7	21.8		0.49	<5.0		
10	4/8/2010	1000	6.00		72.7	21.8		0.8	<5.0		
11	4/8/2010	450	6.00		72.6	21.8		1.22	<5.0		
12	4/9/2010	1000	6.00	333	72.5	22.1	0.124	1.56	<5.0		
13	4/10/2010	1000	6.00		72.2	22.0		5.11	14		
14	4/12/2010	3000	6.00		72.2	22.0		2.01	7.2		
15	4/13/2010	1000	6.00		72.5	22.1		1.26	<5.0		
16	4/14/2010	1000	6.00	325	71.6	22.3		1.06	<5.0		

Barangaroo - Block 4 - COLUMN B												
SEPR/S-ISCO												
Effluent	Date	Run Vol	pH	ORP	IFT	Temp	Cond.	Turb.	HP	TPH-DRO	TPH-GRO	**Total TPH**
		mL		mV	mN/m	°C	mS/cm	NTU	%	ppm	ppm	**ppm**
1	4/2/2010	264	7.00		69.5	23.3		56.9	0.03	28.9	<25	
2	40271	**368**	6		40	23		626	0	1177	<25	
3	40272	232	6		46	23		103	0	292	<25	
4	40273	293	6		45	23		167	0	524	<25	
5	40274	318	6		41	22		496	0	2375	<25	
6	40277	354	6	331	42	22	2	232	0	1075	<25	
7	40282	345	6	407	37	22	2	844	0	3965	<25	

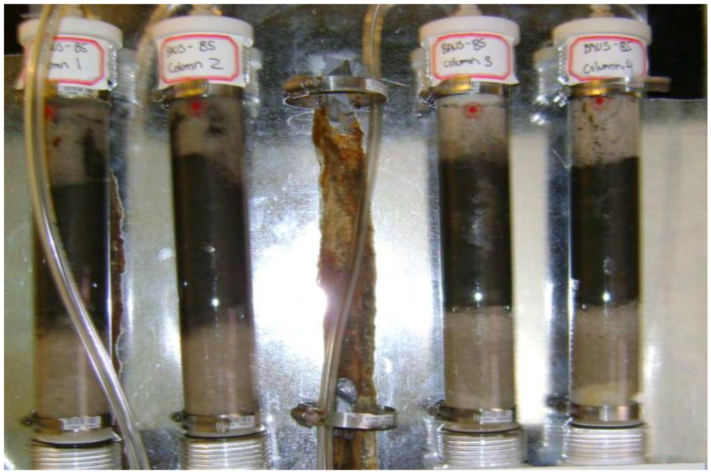
Barangaroo - COLUMN C												
S-ISCO												
Effluent	Date	Run Vol	pH	ORP	IFT	Temp	Cond.	Turb.	HP	TPH-DRO	TPH-GRO	**Total TPH**
		mL		mV	mN/m	°C	mS/cm	NTU	%	ppm	ppm	**ppm**
1	4/2/2010	500	7.5		71.1	23.6		4.7	<0.1	<5.0	<25	
2	4/3/2010	368	7.0		40.6	23.5		587.2	<0.1	633.5	<25	
3	4/4/2010	383	7.0		45.7	23.6		88.9	0.2	163.8	<25	
4	4/5/2010	430	6.0		49.9	23.6		104.3	0.4	103.6	<25	
5	4/6/2010	322	6.0		43.6	22.3		249.2	0.0	263.5	<25	
6	4/8/2010	431	7.0		49.5	22.4	11.0	220.9	<0.1	177.9	<25	
7	4/10/2010	296	7.0	245.0	42.5	22.4		555.2	<0.1	1246.0	<25	
8	4/14/2010	500	6.0	250.0	43.7	22.5	0.9	174.6	<0.1	390.5	<25	

Influent Usage Log										
Day	Date	Influent								Notes/Additions
		DI Water (C1)		SEPR (4%HP + 20 g/L VeruSOL) C2		8% HP + 20 g/L VeruSOL (C3)		0.2 uM Fe-TAML (C3)		
		Morning	Night	Morning	Night	Morning	Night	Morning	Night	
Initial	4/1/2010	2000	1600	2000	1950	1000	890	1000	890	Columns started at 2pm
1	4/2/2010	210	2000	1800	1460	670	530	655	500	DI refilled to 2000
2	4/3/2010	500		**1340**		**220**		**160**		HP/VS + FeTAML refilled, DI refilled
3	4/4/2010			820	2000	560	755	520	650	
4	4/5/2010			1700	2000	290	1000	185	1000	C3 refilled to 1000, topped off to 1000
5	4/6/2010			1120	745	710	530 / 1000	695	525 / 1000	
6	4/7/2010			1940	1420	670	490 / 1000	715	555 / 1000	
7	4/8/2010			1300	180 / 1560	675	600	740	580	
8	4/9/2010			520	1560	300	825	280	805	
9	4/10/2010			1560	2000	340	1000	340	1000	
10	4/11/2010			160	1900	670	510	630	440	
11	4/12/2010			1140	920 / 1920	120	830	0	820	
12	4/13/2010			1560		475		485		
13	4/14/2010									

Barangaroo - Block 4 Columns					
		Column 2		Column 3	
Date	Time	pH	HP	pH	HP
4/1/2010	4:55	7.0	0	7.0	0
4/2/2010	10:45	Restarted		7.5	<0.1
4/2/2010	2:00	7.0	0.02	7.5	<0.1
4/2/2010	4:00	7.0	0.11	7.5	<0.1
4/3/2010	9:00	7.0	0.3	7.5	<0.1
4/4/2010	9:30	7.0	0.38	7.0	0.4
4/5/2010	8:30	6.0	0.44	6.0	0.41
4/5/2010	10:45	6.0	0.62	6.0	0.37
4/5/2010	12:10	6.0	0.81	6.0	0.31
4/5/2010	2:10	6.0	0.51	6.5	0.17
4/5/2010	4:30	6.0	0.31	7.0	0.03
4/6/2010	8:45	6.0	0.27	7.0	<0.1
4/6/2010	10:25	6.0	0.28	6.5	<0.1
4/6/2010	2:10	6.0	0.52	7.0	<0.1
4/6/2010	4:00	6.0	0.57	7.0	<0.1
4/7/2010	10:00	6.0	0.17	7.0	<0.1
4/7/2010	4:30	6.0	0.11	7.0	<0.1
4/8/2010	8:40	6.0	0.1	7.0	<0.1
4/8/2010	10:45	6.0	0.06	7.0	<0.1
4/8/2010	1:15	6.0	0.1	7.0	<0.1
4/8/2010	4:30	6.0	0.1	7.0	<0.1
4/9/2010	9:15	6.0	0.09	7.0	0.02
4/9/2010	1:15	6.0	0.12	7.0	0.03
4/10/2010	9:30	6.0	0.12	7.0	<0.1
4/12/2010	9:00	6.0	0.05	7.0	<0.1
4/12/2010	4:00	7.0	0.1	7.0	<0.1
4/13/2010	10:00	6.5	0.1	7.0	<0.1
4/13/2010	2:00	6.0	0.07	7.0	<0.1

Task 4: Column Tests – Block 5

Time 0



Time: Day 4

Column 2 – Alkaline, SP

Column 4 – Fe-TAML, HP

Time: Final Day: Day 28 Columns 1-3, Day 21 Column 4, Day 7 Column 5

Barangaroo - COLUMN 1											
Control Column - DI H20											
Effluent	Date	Run Vol	pH	ORP	IFT	Temp	Cond.	Turb.	TPH-DRO	TPH-GRO	**Total TPH**
		mL		mV	mN/m	°C	mS/cm	NTU	ppm	ppm	**ppm**
1	18/10-3/19/10		6.00								
2	0 PM- 3/22/	650	6.6		74.4	21.1			2.2	9	
3									2.1	4.5	
4	3/22/10 Day	275	6.0		75.3	19.2					
5	3/23/2010	290	6.0		73.0	20.0					
6	3/24/2010	170	6.5		74.1	19.9			4	5	
7	3/25/2010	495	6.5						2.8	3.5	
8	/25/2010 Da	825	6.0		72.6	19.4					
9	26/2010 D	450	6.0		72.6	20.0			2.65	3.5	
10	/-3/28 Week	1100	6.5		72.6	19.9			2.25	4	
11	3/29/2010	825	6		73.4	18.9			3.6	4.5	
12	3/30/2010	550	6.5		72.9	19.8			3.05		
13	4/1/2010	850	6.5		73.2	21.9			2.9		
14	4/2/2010	400	6.5		74.1	21.3			4.6	9.5	
15	4/3-4/4	3500	6.5		74.3	21.6			0.8	6.5	
16	4/5/2010	100	6.0		73.8	20.9			0.65	5.5	
17	4/6/2010	550	6.5		72.9	19.9			1.35	6	
18	4/7/2010	500	6.0		72.6	24.0			1.25	35	
19	4/8/2010	1250	6.0		72.7	21.9			0.7	21	
20	4/9/2010	500	6.0		71.8	20.4			0.5	10.5	
21	4/10/2010	825	6.0		72.7	20.4			0.45	4.5	
22	4/11/2010	0	-		-	-					
23	4/12/2010	890	6.0		72.8	18.3				8	
Totals											
Soil									12812.5	0	
Soil-D											

Barangaroo - COLUMN 2												
S-ISCO: 10 g/L VS-3, 100 g/L SP, pH>12												
Effluent	Date	Run Vol	pH	ORP	IFT	Temp	Cond.	Turb.	SP	TPH-DRO	TPH-GRO	**Total TPH**
		mL		mV	mN/m	°C	mS/cm	NTU	g/L	ppm	ppm	**ppm**
1	18/10-3/19/10		1.00						48.63			
2	0 PM- 3/22/	1300	1.4		44.1	21.3			136.805	240	1	
3									145.88	625	1	
4	3/22/10 Day	690	3.0		42.5	19.1			375.4			
5	3/23/2010	700	3.0						208.8			
6	3/24/2010	350	2.5						175.1	118.8	1.5	
7	3/25/2010	835	6.0									
8	/25/2010 Da	875	1.0		39.3	19.4			161.44	37	3	
9	26/2010 D	450	1.0		40.5	20.0			147.825	46	3	
10	-3/28 Weel	3250	3.5		38.0	20.1			130.95	159.5	1.5	
11	3/29/2010	375	11		35.2	18.9	55.250		99.5	657.5	-1.5	
12	3/30/2010	1250	8.5		34.8	20.0	59.080		79.5	239.1		
13	4/1/2010		10.5		37.9	22.4	52.130			172.25		
14	4/2/2010	450	2.0		39.7	21.3	45.340		78.775	19.8	3.0	
15	4/3-4/4	3200	3.0		39.6	21.5	23.110		59.75	499.25	-4	
16	4/5/2010	1200	7.0		36.1	21.0	38.590		91.4	22.25	5.5	
17	4/6/2010	1250	5.5		41.2	20.1	35.320		48.5	8.1	5	
18	4/7/2010	500	3.0		42.9	23.9	39.320		85.9	39.35	16	
19	4/8/2010	1300	8.0		33.4	22.1	31.600		74.885	37.65	5.5	
20	4/9/2010	400	1.0		40.9	20.4	37.500		93.025	2.7	6.5	
21	4/10/2010	725	2.0		39.0	20.6	43.670		82.99	2.8	8.5	
22	4/11/2010	2000	7.0		36.8	20.2	27.590		30.15	112.85	1	
23	4/12/2010	1100	8.5		35.3	18.8	60.790				0	
Totals												
Soil										39310	0	
Soil-D												

Barangaroo - COLUMN 3											
S-ISCO: 10 g/L VS-3, 100 g/L SP, 350 mg/L as Fe Fe-EDTA											
Effluent	Date	Run Vol	pH	IFT	Temp	Cond.	Fe	SP	TPH-DRO	TPH-GRO	**Total TPH**
		mL		mN/m	°C	mS/cm	ppm	g/L	ppm	ppm	**ppm**
1	18/10-3/19/10		1.50					51.225			
2	0 PM- 3/22/	1650	1.3	45.5	21.5			122.5	62.5	3	
3								132.25	145	2.5	
4	3/22/10 Day	600	1.0	39.5	19.1			138.1			
5	3/23/2010	625	1.0				275.00	109.5			
6	3/24/2010	150	1.0						22.4	3	
7	3/25/2010	700	1.0				253.00	214.6			
8	/25/2010 Da	795	1.0				102.00		48.7	2	
9	26/2010 D	700	1.0	48.70	20.00		356.00	199.695	2.3	4.5	
10	7-3/28 Week	1400	1.0	45.20	20.00		470.00	123.84	251	0	
11	3/29/2010	925	1.0	38.70	19.00	118.70	214.2	134.86	182	2	
12	3/30/2010	500	1.0	41.00	19.90	115.70	191.10	134.5	121.35		
13	4/1/2010	560	1.0	42.30	22.10	85.62	207.20	130.95	77.5		
14	4/2/2010	350	1.0	40.40	21.30	98.46	219.80	146.2	228	-2.5	
15	4/3-4/4	2000	1.0	40.10	21.50	82.20	213.50	109.895	170	-1.5	
16	4/5/2010	900	1.0	39.60	21.00	59.43	225.05	122.8625	162.9	1	
17	4/6/2010	800	1.0	39.10	20.20	54.30	238.70	91	231.1	-1	
18	4/7/2010	500	1.0	43.20	24.10	72.69	252.35	107.3025	1337.75	15	
19	4/8/2010	825	1.0	43.30	22.30	51.81	239.40	110.22	192	-4.5	
20	4/9/2010	250	1.0	42.70	20.10	55.49	298.55	80.3975	180.2	-5.5	
21	4/10/2010	990	1.0	41.80	20.70	59.81	250.25	153.9	107.4	-2.5	
22	4/11/2010	610	1.0	36.80	20.00	60.95	340.90	129.325	111.5	0.5	
23	4/12/2010	650	1.0	37.10	18.20	65.14	352.80			0	
Totals											
Soil									290	0	
Soil-D											

Barangaroo - COLUMN 4												
S-ISCO: 10 g/L VS-3, 4% HP, 0.1 uM Fe-TAML (Note: Only 2% HP was used for first 4 PVs)												
Effluent	Date	Run Vol	pH	ORP	IFT	Temp	Cond.	Turb.	HP	TPH-DRO	TPH-GRO	**Total TPH**
		mL		mV	mN/m	°C	mS/cm	NTU	%	ppm	ppm	**ppm**
1	18/10-3/19/10		3.00									
2	0 PM- 3/22/	**2300**	2.2		72.60	21.6				11	5	
3										245	0	
4	3/22/10 Day	170	5.0		39.10	18.9						
5	3/23/2010	175	6.0									
6	3/24/2010	300	5.0							2.7	5	
7	3/25/2010	260	3.5						0.0161			
8	/25/2010 Day								0.0204	560	-1	
9	/26/2010 D	55	6.0		37.00	20.10			0.07	995	-7.5	
10	/-3/28 Week	350	4.0		43.80	19.80			0.08	448	-0.5	
11	3/29/2010	490	5		55.7	18.8			0.16	400	0	
12	3/30/2010	200	12.0		38.10	19.90			0.08	1582.5		
13	4/1/2010	150	11.0		49.00	22.70			0.03	210		
14	4/2/2010								0.04	354		
15	4/3-4/4											
16	4/5/2010	52	8.0		55.60	20.60			0.03			
17	4/6/2010	50	8.5		58.20	20.00			0.01	17.25	20	
18	4/7/2010	58	8.0		58.30	23.30			0.01	128	-2	
19	4/8/2010	200	4.0		64.30	22.00			0.04	6.3	3	
20	4/9/2010	88	1.0		69.40	20.50				0.75	8	
21	4/10/2010	550	1.0		69.60	21.00			0.99	0.45	6.5	
22	4/11/2010	250	1.0		63.20	20.10			1.49	0.35	6.5	
23	4/12/2010	210	1.0		59.80	17.80			1.57			
Totals												
Soil										35300	0	
Soil-D												

Barangaroo - COLUMN 5												
SEPR- %4 H2O2, 20g/L Verusol 3												
Effluent	Date	Run Vol	pH	ORP	IFT	Temp	Cond.	Turb.	HP	TPH-DRO	TPH-GRO	**Total TPH**
		mL		mV	mN/m	°C	mS/cm	NTU	%	ppm	ppm	**ppm**
1	4/8/2010	400	4		73.00	22.4			0	1	8	
2	4/8/10 Nigh	**550**	1.5		73.10	22.3			0.07	0	5	
3	4/9/2010	400	1.0		71.80	20.4				0	5	
4	4/10/2010	1000	1.0		70.20	21.0			1.28	1	4	
5	4/11/2010	750	1.0		60.40	20.3			1.35	5	3.5	
6	4/12/2010	580	1.0		57.50	18.3			1.28		4.5	
7	4/13/2010	450	1.0									
Totals												
Soil										74	0	
Soil-D												