

# FINAL REPORT

## Treatment of Explosives Residues from Range Activities

ESTCP Project ER-0434

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## List of Acronyms

2,4-DNT / 2,6-DNT	2,4- and 2,6-dinitrotoluene
DoD	Department of Defense
EPA	Environmental Protection Agency
EOD	explosive ordnance disposal
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
MMR	Massachusetts Military Reservation
OB/OD	open burn/open detonation
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
TNT	2,4,6-trinitrotoluene
UXO	unexploded ordnance
MNX	hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine
DNX	hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine
TNX	hexahydro-1,3,5-trinitroso-1,3,5-triazine
2ADNT	2-amino-4,6-dinitrotoluene
4ADNT	4-amino-2,6-dinitrotoluene
CIA	Central Impact Area
cu.	cubic
PMSO	peat moss plus crude soybean oil; the treatment material being evaluated
PO1	PMSO with a 1:1 ratio of peat moss:soybean oil (w:w basis)
PO2	PMSO with a 1:2 ratio of peat moss:soybean oil (w:w basis)

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## Executive Summary

*NOTE: This project was conducted as two parallel and different types of demonstrations. These two types of demonstrations were meant to address and evaluate very different aspects of the technology, and as such, they were very different in terms of scope.*

*The first demonstration, described in Part I of this report, was the Aboveground Soil Plot (SPI) Demonstration. The key focus of the SPI demonstration was to evaluate the effectiveness of immobilization of explosives by the treatment layer under real (outdoor) environmental conditions. The SPI demonstration was performed at the Massachusetts Military Reservation (MMR).*

*The second demonstration, described in Part II of this report, was the Grenade Range (GR) Demonstration. The key focus of the GR demonstration was to assess the compatibility and robustness of the technology with actual range activities (i.e., how is the treatment material redistributed and/or otherwise affected by detonations). The GR demonstration was performed at Fort Jackson, SC.*

**Background.** Ranges and other areas used by the Department of Defense (DoD) for testing new ordnance and for training personnel are common sites for environmental contamination with explosives. The munitions used by DoD contain a number of different explosive compounds including 2,4,6-trinitrotoluene (TNT), hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) in the fuse (6). Residues from munitions are dispersed over the soil surface and then serve as point source for explosive compounds, which can migrate into the soil and eventually contaminate the underlying groundwater. Technologies are needed to reduce the impact of range activities involving munitions on environmental resources.

**Objectives.** The overall objective of this project (as detailed in PART I and PART II of this Final Report) was to evaluate a surface-applied material composed of peat moss plus crude soybean oil (PMSO) as a technology to prevent and mitigate near-surface soil contamination with explosive compounds, thereby protecting the subsurface and groundwater at active DoD ranges..

PART I of this report details the evaluation of the effectiveness of the PMSO technology with respect to reducing the flux of dissolved explosive compounds in soil emanating from surface deposited munition residues. The specific objectives of the SP1 demonstration were to:

- 1) Determine the effectiveness of the PMSO material (compared to a control with no PMSO) to reduce the soil pore water concentrations of dissolved explosives (TNT, HMX, RDX and their respective breakdown products) over the duration of the demonstration.
- 2) Determine the effectiveness of PMSO (compared to a control with no PMSO) to reduce the total soil concentrations of these compounds in the soil as a result of dissolution and transport of the munition residues.
- 3) Refine the modeling of the PMSO effectiveness for reducing the flux of dissolved explosives into underlying soil.

PART II of this report details the evaluation of the compatibility of the PMSO technology with DoD training activities at ranges, with a focus on hand grenade training activities, and was designated the GR Demonstration. *Please see PART II of this report for more specific details.*

**Methods.** Nine aboveground plots containing native uncontaminated soil were established at the Massachusetts Military Reservation (MMR). Plots were instrumented for the collection of soil pore water and pore gases, as well as with soil moisture probes; a weather station was also setup to collect meteorological data. Three plots served as controls and received no PMSO, three received a 10 cm layer of PMSO (1:1 peat moss:crude soybean oil, PO1) and the remaining three received a 10 cm layer of PMSO (1:2, PO2). Composition B detonation residues of approximately 1-mm size from an 81-mm mortar round were applied uniformly over the surface of each aboveground soil plot. Soil pore water samples, as well as drainage water samples, were collected over the course of 1.5 years and analyzed for explosive compounds. At the end of the demonstration, the plots were deconstructed and the concentration profile of residual explosives in the soil was determined. Results were used to calculate the explosive compound flux, and

results from the different treatments were compared. Data was also used to refine the PMSO effectiveness model developed during the previous SERDP project.

**Performance Objectives and Performance Evaluation.** The results obtained during the SP1 demonstration compared to the performance objectives yielded the following:

Performance Objective 1: The PMSO will result in >50% reduction in explosives leaching and/or explosive compound flux into soil in treatment plots compared to control plots.

Results:

- 1) The concentrations of dissolved explosives were lower in the PMSO treated plots compared to the control plots.
- 2) 1:2 PMSO (PO2) performed better than 1:1 PMSO (PO1) with respect to reductions in dissolved explosive concentrations.
- 3) At the end of the demonstration, the flux of RDX (and MNX) was lower in the PO2 treated plots than in the control plots.

***Performance Evaluation: Objective was met and exceeded.***

Performance Objective 2: The PMSO will result in >50% reduction in total soil explosives concentrations at different depths in the treatment plots compared to control plots at the end of the demonstration.

Results:

- 1) The residual concentrations of explosives with respect to soil depth were significantly lower in the PMSO-treated plots compared to the control plots.

***Performance Evaluation: Objective was met and exceeded.***

**Overall Project Conclusions and Recommendations.** Even with the early termination of the GR Demonstration, the results from both the SP1 Demonstration (PART I) and the GR Demonstration (PART II) allow for some important conclusions and recommendations:

- The PMSO material is very effective at reducing the migration of RDX into and through the soil when it is dissolving from surface applied Composition B residues. The RDX flux reduction ranged from 25- to 100-fold in the PMSO-treated plots (10 cm depth of 1:2 peat moss:soybean oil) vs. control plots. MNX flux was also reduced 12- to 50-fold, depending on the depth. Dissolved TNT and HMX were not detected with enough frequency to allow calculation of fluxes of these compounds, but based on the previously developed model, the effectiveness for these compounds would be expected to be very high as well.
- It is expected that the PMSO would be effective at reducing the transport (flux) of other munition and propellant compounds including 2,4- and 2,6-DNT, nitroglycerin, and nitroguanidine based on the physico-chemical properties of these compounds, as well as some preliminary laboratory results.
- Surface applied PMSO would not likely be drastically affected by grenade (or other munition) detonations themselves, but it would be redistributed horizontally and mixed vertically into the soil in the treated area.
- EOD activities which employ large quantities of C4 could result in smoldering of a surface-applied layer of PMSO.
- Dry conditions and strong winds would likely result in the production of nuisance dust at a grenade range, especially in low precipitation climates.
- Based on current results and model predictions, the PMSO material would be effective as a barrier to reduced explosive compound transport (flux) if it were either i) applied and buried under a shallow depth of soil, or; ii) mixed into the top 15-30 inches of soil. This would avoid most of the issues involving smoldering and generation of excessive fugitive dust.
- The PMSO technology is most applicable for portions of the range where UXO is not of concern, such as OB/OD areas and EOD training areas, as well as grenade training areas and mortar firing points. PMSO would also be applicable for inclusion as a sustainable range management technology for use in areas that have been cleared of all past UXO.

# 1. INTRODUCTION

## 1.1 Background

Impact ranges, that are used by the Department of Defense (DoD) for testing new ordnance and for training personnel to use mortars, rockets, and other munitions are common sites for environmental contamination with explosives. The munitions that are tested at DoD impact ranges contain a number of different explosive compounds. For example, a 60-mm mortar round contains 2,4,6-trinitrotoluene (TNT) in the primer, 2,4- and 2,6-dinitrotoluene (2,4-DNT and 2,6-DNT, respectively) in the propellant charge, TNT and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) in the filler, and RDX and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) in the fuse (6).

After full- or partial- detonation of a high explosive, residues of these materials can remain in the impact area. In addition, munitions that fail to detonate during training (i.e., unexploded ordnance (UXO)) are also a potential long-term source for the release of explosive compounds into soils. In sandy soils with little organic matter or clay content, such as those present at the Massachusetts Military Reservation (MMR; Cape Cod, MA), transport of TNT, RDX, and HMX to the vadose zone and ultimately to groundwater is possible. Recent reports of groundwater contamination at MMR with RDX confirm this assumption (7). The contamination of groundwater underlying these facilities is particularly problematic because the explosive residues have the potential to adversely impact local drinking water supplies.

Explosive-related compounds have been observed to be recalcitrant in many environments, leading to the potential for long-term contamination at sites where they are released (9). However, under the proper conditions (i.e., low oxygen concentrations, presence of labile carbon sources), the ability of microorganisms to biotransform and biodegrade these compounds has been shown to be very widespread (3, 5).

The challenges to effectively addressing the pollution issues associated with live fire range activities stem from several factors, which are summarized in the Table 1-1 below. The proposed technology was developed to address and overcome all of the listed challenges.

The proposed technology is a soil amendment process designed to enhance the immobilization and biodegradation of explosives residues generated during live fire training, explosive ordnance disposal (EOD) and training activities, and open burn/open detonation (OB/OD) procedures. The basic components of the amendment are a long-lived, high-capacity sorbent (i.e., peat moss and/or sawdust) and a slow-release microbial stimulant (i.e., soybean oil and/or molasses). These are natural materials that are nontoxic and environmentally benign. The materials are generally available and inexpensive, can be easily mixed, and are easily applied to large areas using readily available landscaping/agricultural equipment (i.e., mulch/bark blowers), or can be applied from the air, if required.

**Table 1.1-1. Key factors and associated challenges that need consideration when addressing prevention of live fire range contamination with energetic compounds.**

<b>FACTOR</b>	<b>RESULTING CHALLENGE/DIFFICULTY</b>
Large Size of Impact Areas	<ul style="list-style-type: none"> <li>• Additives must be low cost</li> <li>• Additives must be effective in reasonable amounts</li> <li>• Additives should be available locally</li> </ul>
Existence of Unexploded Ordnance (UXO)	<ul style="list-style-type: none"> <li>• Surface application required (no tilling)</li> <li>• May require aerial application</li> </ul>
Existing Vegetation	<ul style="list-style-type: none"> <li>• Additives must be compatible with vegetation</li> <li>• May require aerial application</li> </ul>
Permeable Soils (i.e., MMR)	<ul style="list-style-type: none"> <li>• Rapid migration of contaminants and additives</li> <li>• Additives must be non-toxic</li> </ul>
Low Organic Content Soils (i.e., MMR)	<ul style="list-style-type: none"> <li>• Rapid migration of contaminants</li> <li>• Aerobic conditions limit biodegradation</li> <li>• Low microbial populations</li> </ul>
Recalcitrant Contaminants	<ul style="list-style-type: none"> <li>• Low rates of biodegradation</li> <li>• Limited populations of natural degraders</li> </ul>
Slow Release of Contaminants from UXO	<ul style="list-style-type: none"> <li>• Requires long term treatment/protection</li> <li>• Additives must be long-lived</li> <li>• May require repeated applications</li> </ul>
Ongoing Activities	<ul style="list-style-type: none"> <li>• Application and additive must have not impact operations</li> <li>• May require repeated applications</li> </ul>

## **1.2 Objectives of the Aboveground Soil Plot Demonstration 1 (SP1)**

The main objective of Aboveground Soil Plot Demonstration 1 (SP1) was to evaluate the ability of the peat moss plus soybean oil treatment material to reduce the migration of fresh explosives residues into uncontaminated soil under natural environmental conditions. This evaluation included the following:

- The explosive material used was Composition B, which is a mixture of TNT and RDX (40:60, w:w).
- The evaluation examined soil pore water concentrations of dissolved TNT, RDX, HMX, and their respective breakdown products over the duration of the demonstration. Total soil concentrations of these compounds were determined at the termination of the demonstration.
- The dissolution and fate/transport of TNT, RDX, and HMX was modeled to develop parameters for effectively applying and evaluating the technology at different sites.

### **1.3 Regulatory Drivers**

The explosive compounds being examined during this project are currently or expected to be regulated. 2,4- and 2,6-DNT and RDX are currently on the U.S. EPA's Unregulated Drinking Water Contaminants list ([http://www.epa.gov/safewater/dw\\_unregcontaminants.html](http://www.epa.gov/safewater/dw_unregcontaminants.html)). Health advisory limits in the low part-per-billion range for the above three compounds, as well as RDX, HMX, TNT, nitroguanidine, and nitrocellulose have also been issued by the EPA (<http://www.epa.gov/waterscience/drinking/standards/dwstandards.pdf>).

Several DoD sites, most notably MMR, have already come under regulatory pressure to stop activities that may result in contamination of groundwater with these compounds, as well as to begin remediating contaminated groundwater and overlying soil. This technology is designed to help the DoD meet these challenges.

## **2. TECHNOLOGY**

### **2.1 Technology Description**

The technology that was tested is a soil amendment process designed to enhance the immobilization and biodegradation of explosives residues generated during live fire training, explosive ordnance disposal (EOD) and training activities, and open burn/open detonation (OB/OD) procedures. The basic components of the amendment are a long-lived, high-capacity sorbent (i.e., peat moss) and a slow-release microbial stimulant (i.e., soybean oil), combined to yield PMSO. These are natural materials that are nontoxic and environmentally benign. The materials are generally available and inexpensive, can be easily mixed, and are easily applied to large areas using readily available landscaping/agricultural equipment (i.e., mulch/bark blowers), or tilled into or buried under a layer of soil, as required.

### **2.2 Technology Development**

The development of this technology was initiated under the Strategic Environmental Research and Development Program (CU-1229) and has continued for one year of laboratory studies under the Environmental Security Technology Certification Program (ER-0434). All the initial screening and assessment work has been completed, with relevant details described below.

Over three years of research development and evaluation of the proposed technology under laboratory conditions have resulted in very promising results (1, 2, 4, 8). TNT, RDX, and HMX all demonstrated strong sorption onto peat moss and several other materials compared to sorption onto native soil from MMR (Figure 2.2-1). The desorption of these compounds from peat moss demonstrated hysteresis, indicating that the explosives desorb more slowly than they adsorb. This contributes to the effectiveness of the proposed technology because it allows explosives residues generated during detonation to be quickly immobilized at the soil surface, followed by slow release from the sorbent, and ultimately biotransformed by microorganisms.

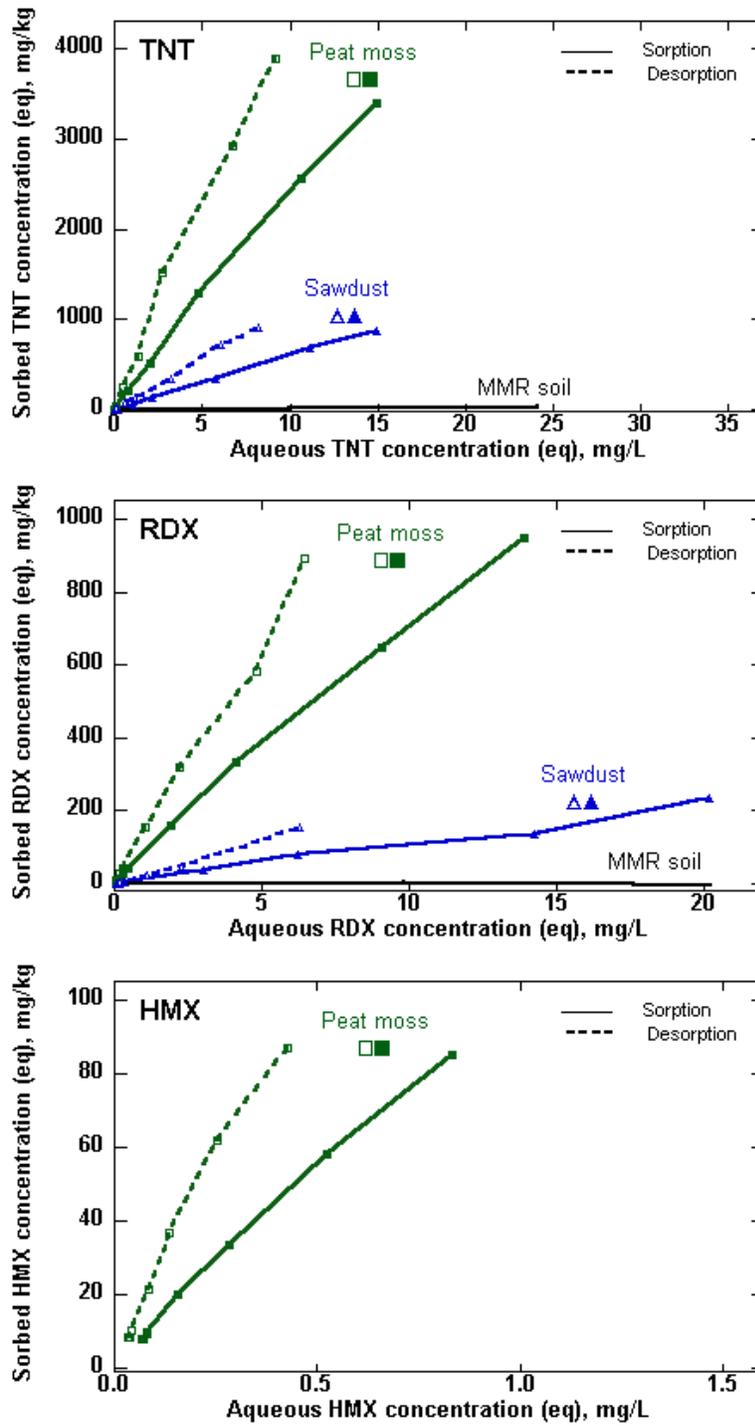


Figure 2.2-1. Sorption-desorption isotherms of TNT, RDX, and HMX.

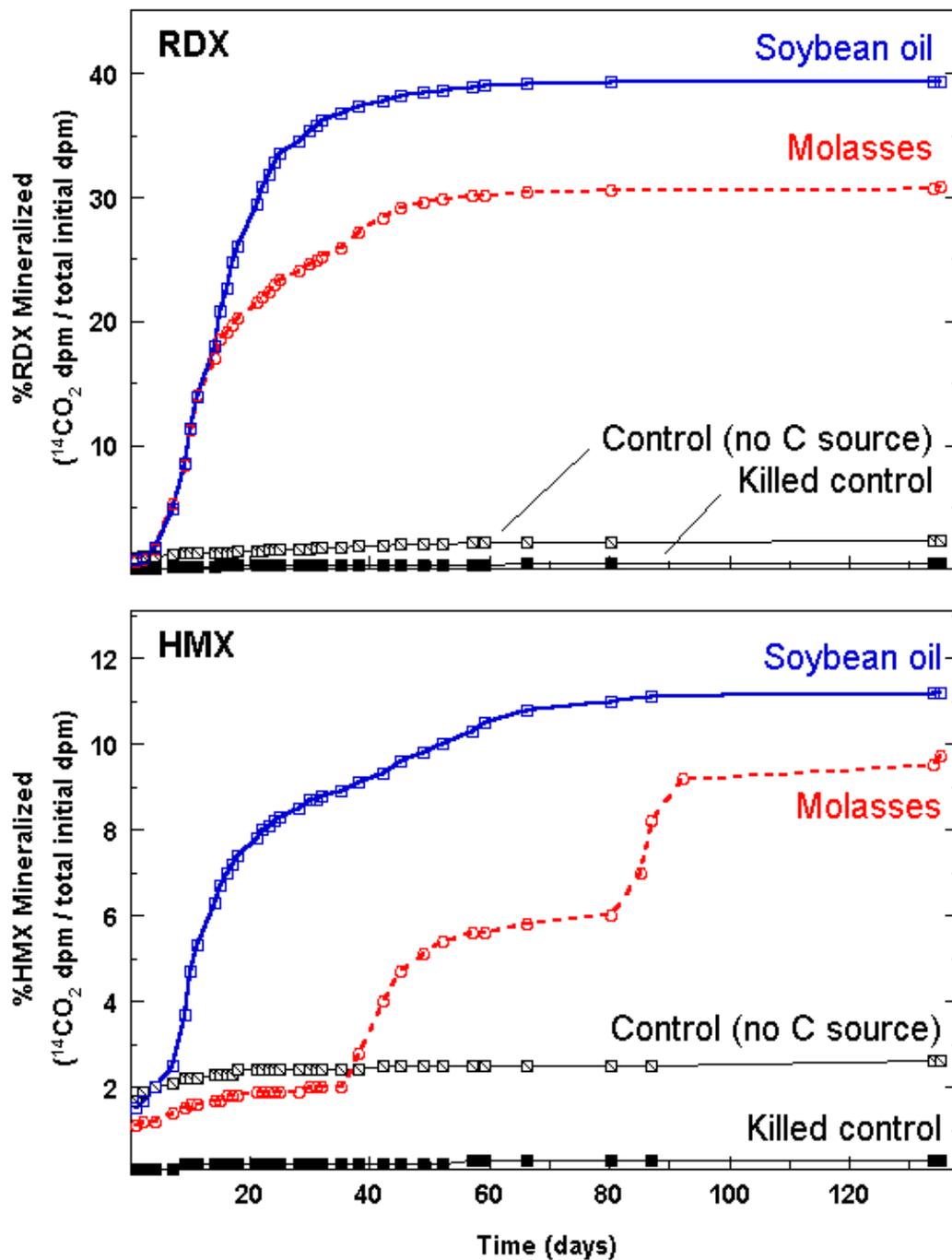
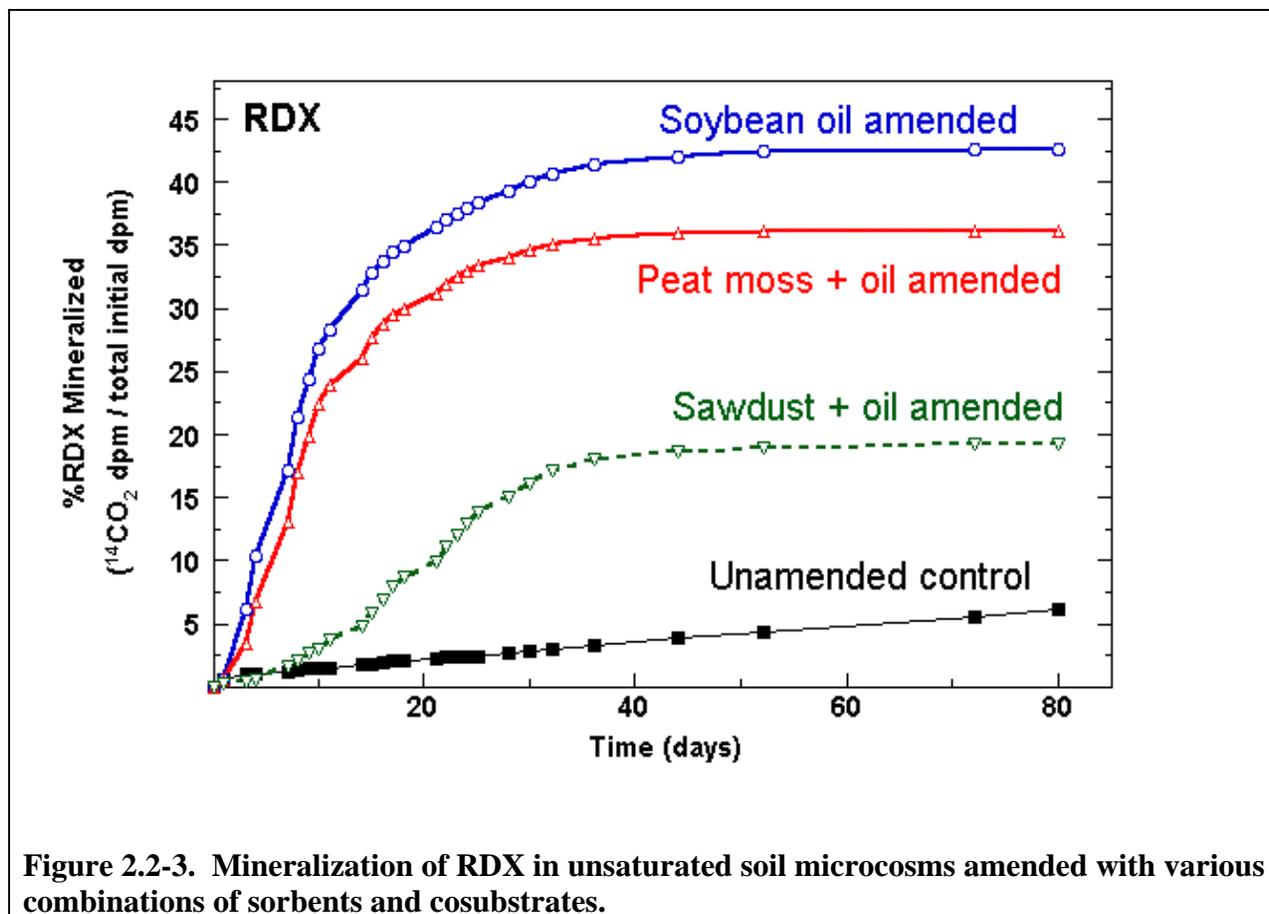


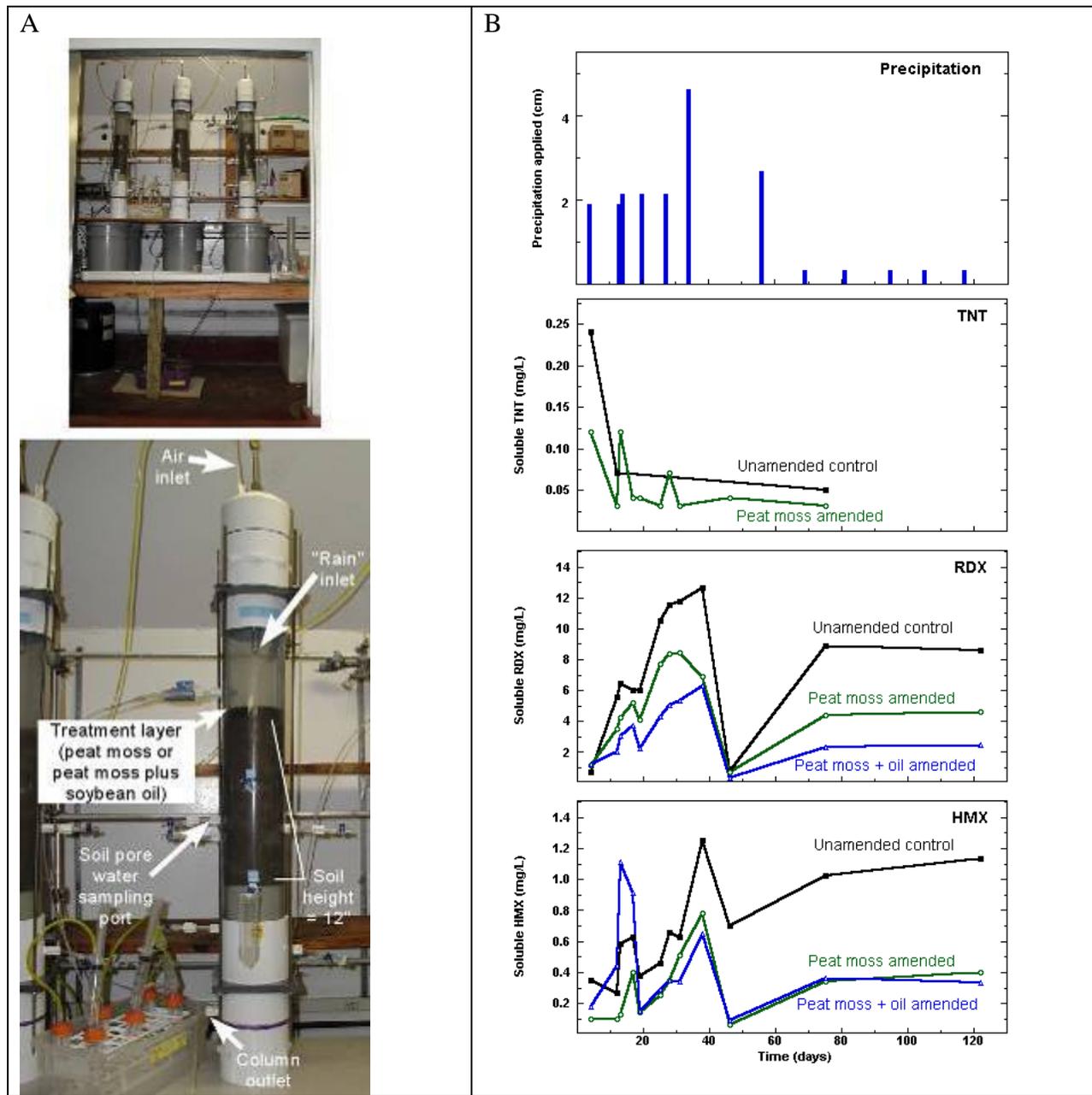
Figure 2.2-2. Mineralization of RDX and HMX in with different cosubstrates.



Our research has also examined how to stimulate native soil microorganisms to biodegrade TNT, RDX, and HMX. Experiments using soil slurry microcosms amended with microbial stimulants (cosubstrates) indicated that explosives were transformed and/or mineralized (converted to H<sub>2</sub>O, CO<sub>2</sub> and other innocuous products) to a much greater extent in amended soil than in unamended soil. An example of these results for RDX and HMX is presented in Figure 2.2-2, which indicates that crude soybean oil was the cosubstrate that stimulated the greatest mineralization. Mineralization of TNT was minimal under all conditions tested, as observed by other researchers. However, TNT was degraded without significant accumulation of the amino-containing breakdown products in the presence of soybean oil. These amino compounds are also considered to be toxic/hazardous. Therefore, these results indicate that soybean oil promotes the biotransformation of TNT to compounds that are less of a concern in regards to human health and environmental safety than the breakdown products that occur when other cosubstrates are

employed. The cosubstrates soybean oil and molasses also stimulated explosive biodegradation in unsaturated soil microcosms co-amended with either peat moss and sawdust sorbents (Figure 2.2-3).

Based on these results, peat moss and a combination of peat moss and soybean oil were tested in unsaturated soil core experiments (illustrated in Figure 2.2-4A). A control column without either amendment was also included in these experiments. Explosives-spiked soil was dispersed at the top of the columns, and artificial precipitation was applied to initiate dissolution and migration of explosives into the columns. Samples of soil pore water were collected at several depths over the course of four months and analyzed for TNT, RDX, and HMX, and their breakdown products. The results indicated that a 0.5 inch layer of peat moss reduced the concentration of TNT, RDX, and HMX migrating four inches into the soil by about 50% compared to the unamended control core (Figure 2.2-4B). When crude soybean oil was added along with peat moss, no TNT was detected at a depth of 4 inches, and RDX concentrations were reduced to 25% of those observed in the control core (Figure 2.2-4B). At a depth of 8 inches, no TNT was detected in either of the amended treatments and RDX and HMX concentrations declined further. Additionally, the concentration of nitroso-containing breakdown products of RDX and the amino-containing breakdown products of TNT were reduced by the peat moss and the peat moss plus soybean oil in comparison to the control (data not shown).



**Figure 2.2-4. Results of unsaturated soil column experiments. (A) Unsaturated soil column apparatus for evaluating the in place soil treatments for immobilizing range contaminants. (B) Precipitation events and aqueous concentrations of TNT, RDX, and HMX measured at a depth of 4 inches below the soil surface in columns with no treatment, 0.5 inches of peat moss, or 0.5 inches of peat moss plus soybean oil.**

Additional research focusing on peat moss as the sorbent and crude soybean oil as the cosubstrate/sorbent, examining the transport of explosives through a one inch layer of the proposed soil treatment in small, well-controlled laboratory columns. These experiments were performed at explosives residue loading rates higher than expected under actual field deployment in order to speed up the collection of data needed to model the fate and transport processes (actual “rainfall” rates ranged from about 1 inch per hour, which is comparable to a thunderstorm rain event, to less than ¼-inch per hour, which is comparable to a light to moderate rainfall event). The relatively short residence time of the columns (<12 hours) limited the ability to evaluate biodegradation processes. However, insight was attained regarding physical (i.e., mass transfer) and chemical (i.e., pore water pH) processes. In all cases, column experiments showed that the peat moss and peat moss plus soybean oil treatments significantly reduced contaminant effluent concentrations. Very low concentrations of the breakdown products of TNT and RDX were only observed sporadically in the column effluent, due to either high adsorption of these compounds by the peat moss and soybean oil, or limited biotransformation of TNT and RDX. These experiments also allowed desorption of sorbed explosives from the treatments to be examined (the influent concentration reduced to zero to allow for desorption). Final analysis of the contents of each of the columns allowed for an estimate of the contaminant mass balance and the reversibility of contaminant sorption in the peat moss and soybean oil matrix.

Preliminary simulation results are shown in Figure 2.2-5. These results compared the effectiveness of various treatments in reducing the vadose zone pore water concentrations of TNT and RDX at a depth of 10 feet below ground surface. These simulations were performed using a combination of data obtained during the batch microcosm studies (to determine contaminant mineralization rates) and column studies (to determine mass transfer rates of contaminants in to the various sorbents). Since mineralization rates were used, these simulations likely underestimate the biological component of explosive residue attenuation because significant biotransformation can occur without mineralization. Aqueous concentrations of TNT and RDX entering the treatment layer were assigned values of 54 and 1.5 mg/L, respectively,

which are quite reasonable based on published dissolution rates and our empirical data from our laboratory experiments. A rainfall rate of 120 cm/year was used in the simulation (corresponding to the annual rainfall total at MMR).

These simulation results indicated that TNT transport through the subsurface was significantly reduced by addition of peat and soybean oil. This reduction was due primarily to TNT uptake into both the peat moss and soybean oil phases (i.e., short residence time and minimal mineralization of TNT was observed in the batch studies). Simulated RDX transport was also significantly reduced in the presence of the peat moss plus soybean oil mixture, but was only marginally reduced in the presence of peat moss alone. This observation reflected the relatively low partitioning of RDX into peat or soybean oil, coupled with the relatively large biodegradation rate when soybean oil was added to the treatment. Transport of HMX was similar to, but less than, RDX.

Additional studies have evaluated mass transfer and biological processes as a function of rainfall rate, including the effects of intermittent rainfall on overall contaminant transport. Immobile pore water in the peat moss plus soybean oil layer between intermittent rain events tended to increase the residence time of the contaminants, allowing time for biological processes to further reduce dissolved concentrations.

These previous results laid the foundation for the field demonstrations presented in Parts I and II of this Final Report.

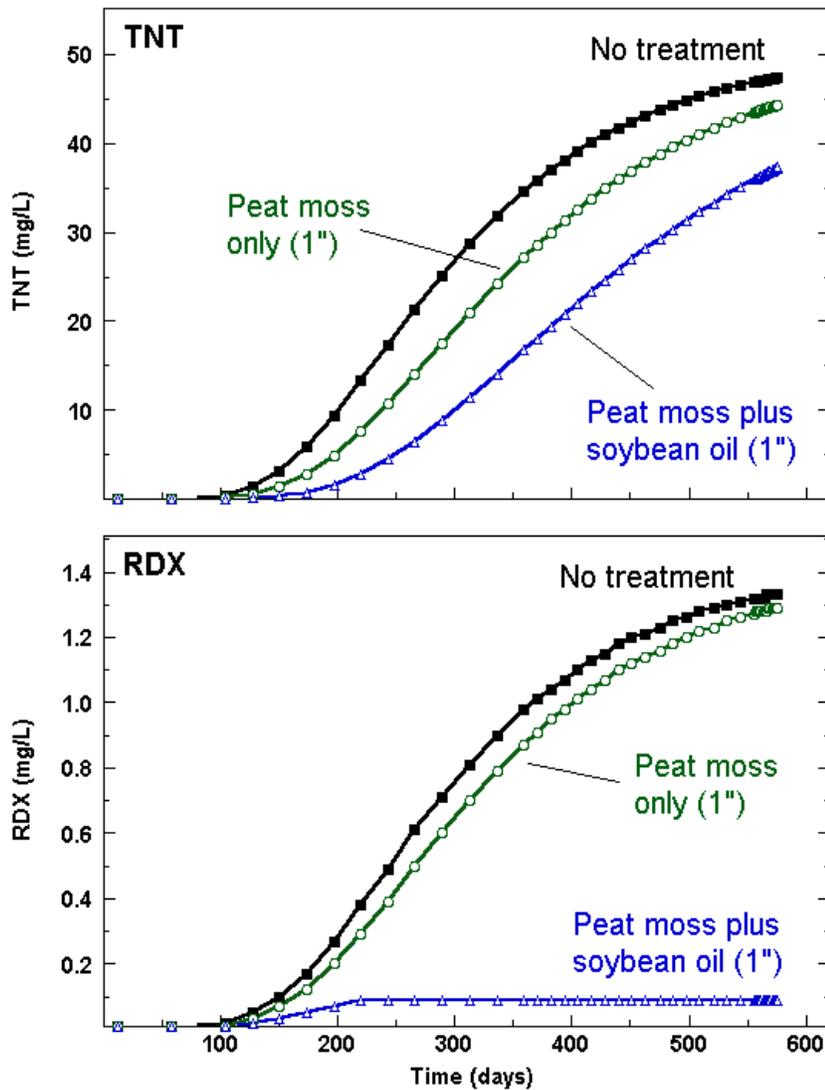


Figure 2.2-5. Modeling of treatment material effectiveness. The results illustrate the predicted reduction in vadose zone pore water concentrations of TNT and RDX at a depth of 10 feet below ground surface with no in place treatment, a one inch layer of peat moss, or a one inch layer of peat moss plus soybean oil. Simulations were performed using a combination of data obtained during the batch microcosm studies (to determine contaminant biodegradation rates) and column studies (to determine mass transfer rates of contaminants into the various sorbents). A rainfall rate of 120 cm/year (corresponding to the annual rainfall total at MMR) and aqueous concentrations of 54 mg TNT/L and 1.5 mg RDX/L were used in the simulation.

### **2.3 Advantages and Limitations of the Technology**

The major advantages of this technology are that the components are relatively inexpensive, available in most areas, and environmentally benign. This technology would have the same potential limitations as any of the other technologies being developed for surface application at live fire ranges. The largest currently unknown parameter was how well the technology would perform once it is dispersed, redistributed, and mixed into the soil by detonations. This was one of the main parameters to be assessed during the field demonstrations.

The main factors affecting the cost of the technology are the size of the area to be treated, the availability and cost of bulk quantities of the treatment components (peat moss, soybean oil), and the need for multiple treatment applications over a given period of time. Additionally, the environmental variables at a given site (rainfall, temperature) may also affect the cost and performance by increasing or decreasing both the dissolution and transport of the explosives and the biodegradation rates. Some of these factors began to be assessed during this project in terms of the PMSO effectiveness over periods longer than have been possible to study in the laboratory.

### 3. PERFORMANCE OBJECTIVES

The SP1 demonstration was focused on the evaluation of the effectiveness of the PMSO technology with respect to reducing the flux of dissolved explosive compounds in soil emanating from surface deposited munition residues. The specific objectives of the SP1 demonstration were to:

- 1) Determine the effectiveness of the PMSO material (compared to a control with no PMSO) to reduce the soil pore water concentrations of dissolved explosives (TNT, HMX, RDX and their respective breakdown products) over the duration of the demonstration.
- 2) Determine the effectiveness of PMSO (compared to a control with no PMSO) to reduce the total soil concentrations of these compounds in the soil as a result of dissolution and transport of the munition residues.
- 3) Refine the modeling of the PMSO effectiveness for reducing the flux of dissolved explosives into underlying soil.

Two mixtures of PMSO were tested: a 1:1 (w:w) ratio of peat moss:crude soybean oil (designated PO1) and a 1:2 (w:w) ratio of peat moss:crude soybean oil (designated PO2).

In light of the overall demonstration objectives outlined above, the Performance Objectives listed in Table 3-1 were established for this part of the project.

	<b>Type of Performance Objective</b>	<b>Primary Performance Criteria</b>	<b>Expected Performance (Metric)</b>	<b>Actual Performance Objective Met?</b>
1	Quantitative	Effectiveness of treatment layer for new residues	>50% reduction in explosives leaching and/or explosive compound flux into soil in treatment plots compared to clean soil control plots	Yes; performance exceeded performance metric
2	Quantitative	Effectiveness of treatment layer for new residues	>50% reduction in total soil explosives concentrations at different depths in the treatment plots compared to control plots at the end of the demonstration	Yes; performance exceeded performance metric

Detailed descriptions of each performance objective are presented in Table 3-2.

**Table 3-2. Detailed performance objectives for this project.**

<p><b>1</b></p>	<p><b>Effectiveness of treatment layer for new residues</b>                  &gt;50% reduction in explosives leaching and/or explosive compound flux into soil in treatment plots compared to clean soil control plots.</p>
<p><b>Explanation</b></p>	<p>This quantitative performance objective is the main criteria by which the S1 Demonstration was assessed. The question this performance objective was meant to answer was, “Does the PMSO material reduce the flux of explosive compounds going from new residues into the soil to a sufficient degree to warrant further development?” No technology is expected to reduce the flux of munitions-related compounds 100%, but based on current fate and transport modeling, even a moderate reduction of new residues entering the soil would greatly reduce the danger to groundwater resources. A metric of a greater than 50% reduction in explosives leaching and/or explosive compound flux into the soil (PMSO treated versus untreated) was chosen for this demonstration based on levels of reduction that were expected to be achievable as reflected in the previous empirical laboratory data, as well as the results from modeling efforts during the previous SERDP project.</p>
<p><b>Data Collected</b></p>	<p>The data collected to allow assessment of this performance objective included:</p> <ul style="list-style-type: none"> <li>-<u>Concentrations of soluble explosives in soil pore water.</u> Soil pore water samples collected at depths of 15 cm and 45 cm below the soil surface of each plot, as well as soil plot drainage water samples. Samples were collected biweekly to monthly throughout the project. The samples were analyzed for explosive compounds and relevant breakdown products according to a modified EPA Method 8330 using HPLC.</li> <li>-<u>Water flux through the soil plots.</u> Soil volumetric moisture content was measured using capacitance-based soil moisture probes at depths of 15 and 45 cm. Soil plot drainage volumes were also measured, and precipitation data was collected using the weather station datalogger.</li> </ul>
<p><b>Data Interpretation</b></p>	<p>The soluble pore water explosives concentration data were analyzed/interpreted in two way. First, the absolute concentrations of dissolved explosives observed at each depth (15 cm, 45 cm, drainage) at a given timepoint in the PMSO-treated and control plots were compared. Comparisons were made for each plot individually, as well as the average of each set of three replicate plots.</p>

	<p>Secondly, the actual flux (in terms of mg of explosive compound) over time for each treatment was calculated.</p>
<p><b>Success Criteria Met?</b></p>	<p>Yes. The concentrations of dissolved RDX at a given depth in the PO2-treated plots were consistently &lt;50% of those observed in the control (no PMSO) plots at each timepoint. Concentrations of RDX in the PO1-treated plots were more variable, but on average were met the performance criteria 60% of the time.</p> <p>The calculated flux of RDX was approximately 500-fold lower in PO2-treated plots than in the control plots at the end of the demonstration. Fluxes at the end of the demonstration were about 2-fold lower in the PO1-treated plots compared to the control plots.</p> <p><i>NOTE: Concentrations of TNT and HMX, the other components present in the Composition B applied at the beginning of the demonstration, and their related breakdown products, were generally below the analytical detection limit, or were detected too sporadically to generate enough data for a valid assessment in terms of this performance criteria.</i></p> <p><i>However, based on the results obtained during the laboratory development phase (eg., p. 15), and the model predictions based on the data (eg., Figure 7.3-1), it is expected that the performance of the PMSO technology for reducing movement of TNT and HMX will be similar to or exceed the performance observed for RDX.</i></p>

2	<b>Effectiveness of treatment layer for new residues</b> >50% reduction in total soil explosives concentrations at different depths in the treatment plots compared to control plots at the end of the demonstration.	
	<b>Explanation</b>	This quantitative performance objective was meant to be complimentary to Performance Objective #1 by looking at the total residual explosive concentrations in the soil as a function of depth. This performance objective was meant to provide an answer to the question, “Does the PMSO material reduce the loading of explosive compounds to the underlying soil?” Again, no technology is expected to completely eliminate munitions-related compounds from getting into the soil, but based on current fate and transport modeling, even a moderate reduction of new residues entering the soil would greatly reduce the danger to groundwater resources. A metric of greater than 50% reduction in total explosive concentrations in the soil profile (PMSO treated versus untreated) was chosen for this demonstration based on previous laboratory data.
	<b>Data Collected</b>	The data to allow assessment of this performance objective was all collected at the end of the demonstration as the soil plots were being deconstructed during demobilization. Data included: - <u>Total explosives remaining in the soil.</u> The surface soil in each plot was removed in several 1 to 2.5 cm layers. Soil was air dried, sieved to specific size fractions, and extracted according to established procedures. The extracts were analyzed for explosive compounds and relevant breakdown products according to a modified EPA Method 8330 using HPLC. - <u>Total explosives in the PMSO material.</u> The topmost 2.5 cm of the PMSO was removed, air dried, sieved to specific size fractions, extracted, and analyzed for explosive compounds using HPLC. - <u>Total explosives distributed throughout the soil profile.</u> After the surface layers were removed, a hand geoprobe was used to drive a 30 cm corer into the soil. The soil cores were then subsampled at ~5 cm intervals, air dried, extracted, and analyzed for explosive compounds using HPLC.
	<b>Data Interpretation</b>	The data was analyzed by comparing the total soil explosive concentrations at each depth in the PMSO-treated versus the control (no PMSO) plots.
	<b>Success Criteria</b>	Yes. The average concentrations of RDX, TNT, and HMX (if

<p><b>Met?</b></p>	<p>detected) in the topmost 2.5 to 5 cm of the soil were close to 10- to 100-fold lower in the PMSO-treated plots compared to the control plots. This translated to residual soil RDX concentrations in the treated plots being &lt;10% those observed in the control plots. Concentrations in treatment PO2 plots were less than in PO1 plots.</p> <p>Throughout the soil profile, the concentration of RDX was approximately 5- to 15-fold lower when comparing the average for all the PMSO-treated plots to the average for the control plots. This translates to residual concentrations of RDX at a given depth being between 7 to 20% of the those observed at the same depth in the control plots.</p> <p><i>NOTE: Concentrations of TNT and HMX, the other components present in the Composition B applied at the beginning of the demonstration, and their related breakdown products, were generally below the analytical detection limit, or were detected too sporadically to generate enough data for a valid assessment in terms of this performance criteria.</i></p> <p><i>However, based on the results obtained during the laboratory development phase (eg., p. 15), and the model predictions based on the data (eg., Figure 7.3-1), it is expected that the performance of the PMSO technology for reducing movement of TNT and HMX will be similar to or exceed the performance observed for RDX.</i></p>
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## 4. SITE DESCRIPTION

### 4.1 Selection of Test Site

The criteria used during the site selection process are presented in Table 4.1-1.

<b>Table 4.1-1. Site Selection Criteria.</b>		
<b>Parameter</b>	<b>Preferred Value(s)</b>	<b>Relative Importance (1, high - 5, low)</b>
Open space	Sparsely vegetated space, not shaded by trees	1
Area topography	At least ~75 ft x 75 ft of relatively level, flat space	1
Existing contamination	Yes	1
UXO	None	1
Availability of uncontaminated soil	Yes	1
Site access	By vehicle and by foot; Small earth moving equipment during set-up	2
Utility access - Water	Yes	2
Utility access - Electric	Yes	4
Onsite space for sample processing	Yes	5

The rationale for each site selection criteria were as follows:

- 1) Some minor landscaping, soil handling/processing, and construction would be required for the initial deployment and set-up of the aboveground soil plots. Once the demonstration was underway, access by foot from a nearby access road would be acceptable. The ability to access the site using a pickup truck or SUV would be desirable.
- 2) The area needed to be “open and exposed” to the elements - sunlight, precipitation, wind - in order to effectively evaluate the treatment. Some low-growing vegetation would be acceptable.
- 3) The aboveground soil plots would be placed within a bermed/lined area that would be 25-50’ x 15-25’ in size. This bermed area would allow containment of any potential explosives contaminated soil or water that got out of the soil plots and the drainage water collection

system. Room would also be needed initially for soil handling/processing as the soil plots are packed. Therefore, a relatively flat and open space of at least 75' x 75' was desired.

- 4) The aboveground soil plots would be packed with uncontaminated soil. Explosive compound residues would be applied to the soil plots, either as a well-characterized contaminated soil or as actual explosives residues. It was expected that the bermed area would fully contain any explosive compounds that may unintentionally escape from the soil plots and/or the drainage water collection system (i.e., during an exceptionally heavy precipitation event). However, to minimize the risk of contaminating a previously uncontaminated area, it was desirable that the demonstration be conducted in an area that either had existing explosive compound contamination or was considered to be potentially contaminated.
- 5) However, as a follow-on to (4) above, it was also desirable from a safety perspective that the area chosen for the aboveground soil plot demonstration would be free of unexploded ordnance. A disturbed, contaminated area that had already been UXO cleared was acceptable and preferable, as that would reduce the time and costs associated with additional UXO clearance.
- 6) As stated in (4) above, a source of uncontaminated soil for use in the aboveground soil plots would be required. It was preferable that the source of the uncontaminated soil be relatively close to the actual demonstration area to reduce the need for extensive soil transport. The estimated maximum amount of uncontaminated soil that would be needed was approximately 0.75 to 1.5 m<sup>2</sup> (1.5 to 2 cu. yd). The uncontaminated soil needed to be as similar as possible to the soils present in the actual training areas of the site with respect to texture and geochemical parameters (i.e., pH, organic carbon, etc.).
- 7) In the event of a severe and non-typical, dry period, “artificial” precipitation might be required to keep the aboveground soil plots from being adversely affected. Therefore, a local source of water was desirable (potable or nonpotable). If no water source was close enough to allow water application using small pumps and/or hoses, a source of water for filling a water tank on a pick-up truck or a water tank truck would be acceptable.

Based on these criteria, the Massachusetts Military Reservation (MMR) was chosen as the preferred site for the SP1 field demonstration. MMR was willing to provide the needed support and site access to achieve the project objectives, as well as being a site which has successfully hosted many other innovative technology evaluations.

#### **4.2 Site Location and History**

[The following summary history of MMR was derived from material presented on <http://www.globalsecurity.org/military/facility/mmr.htm>.]

The Massachusetts Military Reservation (MMR), a 22,000 acre (30 square miles) military training facility, is located on the upper western portion of Cape Cod, immediately south of the Cape Cod Canal in Barnstable County, Massachusetts. It includes parts of the towns of Bourne, Mashpee, and Sandwich and abuts the town of Falmouth (Figure 4.2-1). Areas of MMR have been used for military purposes since 1911. MMR was founded by the Commonwealth in the mid-1930's as a National Guard training camp and federalized in 1940 during WWII. The primary mission of MMR has always been to provide training and housing to Air Force or Army units, and for Army training and maneuvers, military aircraft operations, maintenance, and support.

In early 1997, the New England office of the EPA ordered the National Guard to conduct a study of the effects of military training on groundwater. In May 1997, EPA suspended most military training at Camp Edwards, including all use of live explosives, propellants, flares and lead bullets. In January 2000, EPA ordered the National Guard to begin the process of unexploded ordnance removal, and to begin clean up of contaminated groundwater and soils. The estimated cleanup costs are in excess of \$850 million, including multiple groundwater cleanup systems which are expected to operate from between 10 and 30 years in order to restore the groundwater aquifer.



The site at MMR where the SP1 demonstration was performed was on the southwest edge of the Central Impact Area (CIA), but outside of the exclusion zone known to still be populated by UXO. An area in the northeast quadrant at the intersection of Pocasset-Sandwich Road and Wheelock Road with the least grade was selected as the final location. A map and photographs of the site are presented in Figures 4.2-2 and Figure 4.2-3. The area had already undergone UXO clearance prior to installation of the nearby groundwater monitoring well.

Figure 4.2-2. Map of Massachusetts, MMR and the area within the Central Impact Area designated as the demonstration site.

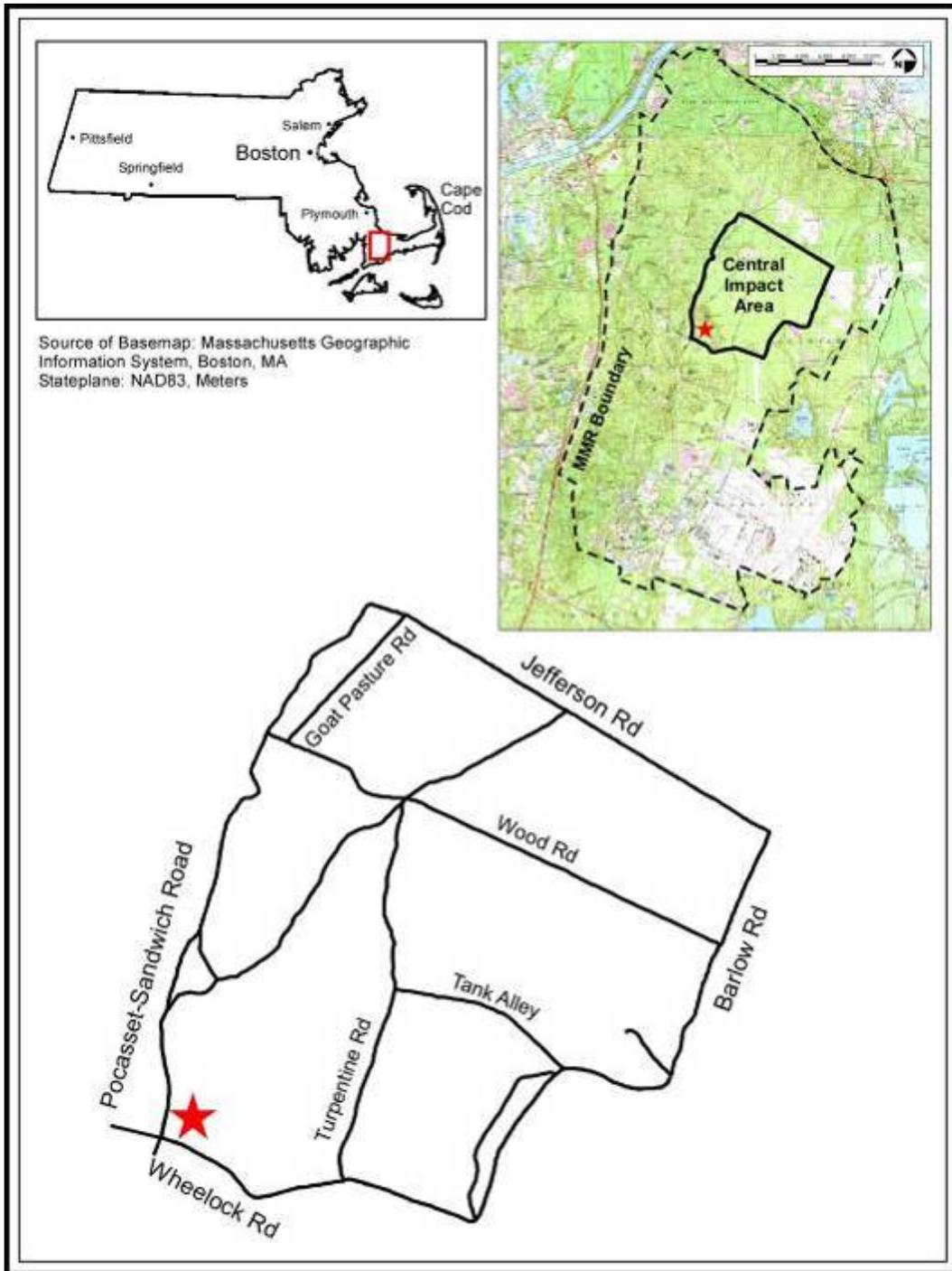


Figure 4.2-3. Photographs of the demonstration site.



### **4.3 Site Geology/Hydrogeology**

The surface soils of MMR are defined by glacial deposition of loose material, resulting in porous, sandy soils. The low carbon, high sand soils allow rapid recharge of groundwater, which also allows contaminants to enter the aquifer quite easily. A single, unconfined aquifer called the Sagamore Lens underlies MMR, and the water table is at approximately 50 feet below the ground surface. The Sagamore Lens is the sole-source aquifer supplying drinking water for the western part of Cape Cod (known as the Upper Cape). The Sagamore Lens is a large, 300-foot-thick layer of groundwater with rapid groundwater movement (1 to 2 feet per day). The aquifer is fed by recharge resulting from precipitation. Of the 40 to 47 inches of precipitation received by the Western Cape each year, an estimated 18 to 22 inches recharges the aquifer. The average low temperatures are around -3°C (27°F) and average high temperatures are around 22°C (72°F).

### **4.4 Contaminant Distribution**

This demonstration used clean MMR soils which were then experimentally contaminated with Composition B detonation residues. Therefore an extensive discussion of existing contaminant distribution is not relevant for this demonstration report.

## 5. TEST DESIGN

### 5.1 Conceptual Experimental Design

The SP1 demonstration was performed under field conditions, and the basic demonstration design was as follows:

- 1) Clean soil from the demonstration site was loaded into instrumented plastic tanks (called “soil plots”). The soil plots were elevated and equipped with a drainage system that promoted natural percolation of rainwater through the soil. Nine replicate soil plots were established.
- 2) Six of the soil plots received a layer of peat moss/soybean oil (PMSO) and three did not receive the layer and served as controls.
- 3) Explosive residues from actual munition detonations were applied to the surface of each soil plot (i.e., directly to the soil surface in the control plots and on top of the PMSO layer in the treatment plots).
- 4) Over the course of the demonstration, samples of soil pore water were collected from two different depths in each soil plot and analyzed for explosives concentrations. Pore water total organic carbon (TOC), soil gases, soil moisture content, pH, etc., were also monitored.
- 5) At the end of the demonstration, the soil plots were deconstructed and the profile of explosive concentrations in the soil of each soil plot was determined.
- 6) The results were analyzed, specifically looking at differences between the treatment and control soil plots with respect to soil pore water and final soil concentrations of the explosive compounds.

## 5.2 Baseline Characterization

The SP1 demonstration was performed in an area that was within the Central Impact Area (CIA), but outside of the exclusion zone of the CIA, at MMR. A minimal site characterization in the immediate area where the demonstration was located was performed to determine what contaminants were present (if any), and at what concentrations. This baseline characterization served two purposes:

- To locate a source of uncontaminated MMR soil for use during the demonstration. The SP1 demonstration was performed using uncontaminated MMR range soils that were experimentally contaminated with detonation residues under controlled conditions. It was imperative that these soils contained no measurable explosive residues at the beginning of the demonstration.
- To establish a pre-demonstration baseline to be compared to the post-demobilization sampling that would verify that the demonstration did not result in any new contamination of the area.

This area for the baseline sampling was selected in coordination with MMR personnel, and was based on historical records of munitions use and the available site characterization data. An initial set of surface grab samples indicated no explosives contamination in the area above the analytical detection limit of 120 µg/kg reported out by STL/TestAmerica (data not shown).

More detailed characterization was done on the uncontaminated soil to be used in the plots. This soil was excavated from a 1 m x 2 m x 0.3 m shallow pit from an area was immediately adjacent to the area where the soil plots were established. Sufficient soil to fill all the soil plots (approximately 1.5 m<sup>2</sup> (2 cu. yd)) from this area was excavated, screened to remove large rocks (2.5 cm/1” mesh opening), and homogenized with shovels. Composite samples from throughout the soil pile were removed (Procedure No. SOP-TFS-106, Appendix B) for confirmatory explosive compound analyses. Additional soil parameters (texture, pH, CEC, TOC) were also measured to assure that the selected soil was comparable to other areas within the Central Impact Area of MMR that have been contaminated by range activities. The soil pile was then covered

until the soil was used to load the soil pots. A summary of the soil characteristics are presented in Table 5.2-1 below.

The soil was classified as a sandy loam. No HMX, RDX, or TNT (the components of Composition B), nor any of the potential breakdown products, were detected above the analytical detection limit of 120 µg/kg reported out by STL/TestAmerica.

**Table 5.2-1. SP1 demonstration soil characteristics.**

<b>Parameter</b>	<b>Average ± 1 SD* (n = 3)</b>	<b>Units</b>	<b>PQL</b>	<b>EPA Method</b>
<b><u>Explosives</u></b>				
2,6-Diamino-4-nitrotoluene	250 ± 0	µg/kg	250	8330
2,4-Diamino-6-nitrotoluene	120 ± 0		120	
HMX	120 ± 0		120	
RDX	120 ± 0		120	
1,3,5-Trinitrobenzene	120 ± 0		120	
Picric acid	120 ± 0		120	
1,3-Dinitrobenzene	120 ± 0		120	
Nitrobenzene	120 ± 0		120	
Tetryl	120 ± 0		120	
Nitroglycerin	2500 ± 0		2500	
2,4,6-Trinitrotoluene	120 ± 0		120	
4-Amino-2,6-dinitrotoluene	120 ± 0		120	
2-Amino-4,6-dinitrotoluene	120 ± 0		120	
2,6-Dinitrotoluene	120 ± 0		120	
2,4-Dinitrotoluene	120 ± 0		120	
2-Nitrotoluene	120 ± 0		120	
4-Nitrotoluene	120 ± 0		120	
3-Nitrotoluene	120 ± 0		120	
PETN	5000 ± 0		5000	
TNX**	120		120	
DNX**	120		120	
MXN**	120		120	
<b><u>Grain Size</u></b>				
Gravel	14.6 ± 7.3	%	-	ASTM D422
Coarse Sand	5.9 ± 1.6		-	
Medium Sand	29.9 ± 1.4		-	
Fine Sand	22.3 ± 0.1		-	
Silt	25 ± 7.8		-	
Clay	2.3 ± 0.6		-	
<b><u>Other</u></b>				
Total Kjeldahl Nitrogen (TKN)**	262.5 ± 82.7	mg/kg	25.6	351.3
Soil pH	5.4 ± 0.5	S.U.***	-	9045
CEC (Na Acetate)	4.4 ± 0.3	mEq/100 g	0.62	9081
TOC	4356.7 ± 318.2	mg/kg	538	STL847****

\*SD, Standard Deviation

\*\*n=2

\*\*\*S.U., Standard Units

\*\*\*\*SevernTrent internal method as per Kahn

### **5.3 Treatability or Laboratory Study Results**

The main laboratory treatability results were presented in a previous reports submitted to ESTCP:

- “Treatment of Explosives Residues from Range Activities (ER-0434) - Treatability Study Report”, December 2006

A summary of the results of the Treatability Study Report relevant to the SP1 demonstration is as follows:

- The materials used to construct the soil plots that were not metal needed to be teflon or polypropylene to prevent sorption and/or degradation of the three main explosives (HMX, RDX, and TNT) being monitored. However, a limited amount of PVC would be allowable for less critical elements of the plots due to ease of use and availability.
- A wick drainage system constructed from a heavy fiberglass rope material was shown to be effective for draining and maintaining soil in an unsaturated state for the field demonstration apparatus. The wick needed to be washed thoroughly several times to remove the organic material that is applied to the fibers during manufacture.
- The PMSO material was expected to maintain its ability to sorb and promote the degradation of the three main explosive compounds even after 1 year of outside incubation.

### **5.4 Design Layout of Technology Components**

*NOTE: As some parts are identified based on English units of measurement, the details provided are a mixture of metric and English units.*

A schematic diagram of the individual soil plots is presented in Figure 5.4-1a, and a conceptual illustration of how the soil plots would look once deployed is presented in Figure 5.4-1b. The base tank was straight-walled polypropylene, 0.45 m (18”) in diameter and 1.2 m (48”) high, with 0.6 cm (0.25”) wall thickness (Chem-Tainer Industries, West Babylon, NY, USA; P/N: TC1840AB). Each tank was modified as follows:

**a) Drainage system.** A hole was made in the bottom of the tank, and a PVC bulkhead fitting (1" slip x 1" female NPT) with a hose barb fitting adapter was installed through the hole. Large diameter fiberglass rope served as a wick to drain water out of the soil plot by downward capillary pressure. The fiberglass rope material (Amatex/Norfab Corp, Norristown, PA, USA; medium density fiberglass rope P/N: 10-863KR-08, 2.5 cm/1" diameter) was washed multiple times with hot deionized distilled water to remove the starch weaving process lubricant until the TOC of the wash water was below 4 mg/L. A 1.5 m (5 ft) length of fiberglass rope was fed through a 1.2 m (4 ft) length of PVC tubing (1" ID x 1-1/4" OD, 1/8" wall). The fiberglass rope was fed through the bulkhead fitting into the bottom of the tank. A tee junction just below where the drainage tube exited the soil plot was inserted to allow discrete sampling of drainage water, if needed. The drainage tubing terminated at another barb fitting that was secured to the lid of a 20 L polyethylene bucket. The bucket was lined with teflon liner, and a skirt was attached to the bucket to assure that only drainage and not stray precipitation would enter the bucket (i.e., to make sure the drainage samples would not be diluted with rainwater). All tubing was secured to barb fittings with stainless steel hose clamps of appropriate sizes. Photographs of the drainage system are presented in Figure 5.4-2.

To handle a sporadic very large precipitation events, a screened overflow port (1.2 cm/0.5") was attached to the tank 2.5 cm (1") below the top rim. PVC tubing (3/8" ID x 3/4" OD, 1/8" wall) was attached to the port that directed the overflow down the side of the soil plot and into an overflow collection bucket.

The buckets for collecting both the drainage water and any overflow water were placed in larger storage tubs as secondary containment and keep stabilize them from tipping over.

**b) Soil pore water sampling.** Soil pore water was collected using porous ceramic samplers (Soilmoisture Equipment Corp., Santa Barbara, CA, USA; P/N: 1911). The inside of the ceramic cup was filled with clean sand (Accusand, 250-425  $\mu\text{m}$ , Unimin Corporation, New Canaan, CT, USA) to reduce the dead volume as was done in previous experiments (2). The ceramic

samplers were placed 15 and 45 cm (6" and 18") below the surface of the soil in the soil plot. The samplers were connected to teflon tubing (FEP teflon, 1/16" ID x 1/8" OD, 1/32" wall) that ran horizontal to the wall of the tank, exiting the side of the tank through a small brass bulkhead fitting (Swagelok, Solon, OH, USA; 1/4" x 1/8" reducing bulkhead, brass, P/N: B-400-61-2). The tubing exiting the tank was attached to a polypropylene elbow compression fitting (1/4" female NPT x 1/8" compression), which in turn was attached to polypropylene adaptor (male luer-lock x 1/4" male NPT) and finally to a polypropylene, female x female luer fitting attached to a 1-way polystyrene luer-lock fitting. All the luer fittings were sealed with multiple layers of "liquid electrical tape," and teflon tape was used for all threaded fittings. This arrangement allowed for attachment of a polypropylene syringe for water- and air-tight sampling. The entire adaptor and luer-lock fitting assembly was reinforced to resist the elements and prevent accidental breakage. Photographs of the pore water sampling system are presented in Figure 5.4-3.

**c) Soil pore gas sampling.** Soil gases were sampled through small diameter teflon tubing (FEP teflon, 1/16" ID x 1/8" OD, 1/32" wall). The open end of the tubing was attached to a small screened cut-off syringe (see photo, Figure 5.4-4). The gas samplers were placed 15 and 45 cm (6" and 18") below the surface of the soil in the soil plot. The tubing connecting the sampler to the sampling port ran horizontal and exited the tank and was configured for sampling using a syringe the same as for the soil pore water samplers (see (b) above).

The plots designated to receive the PMSO materials had an additional gas sampling port installed at the interface of the treatment layer and the soil. This allowed the direct effects of the treatment layer (and any nutrients that moved into the soil from the PMSO) on the microbial activity of the underlying soil to be assessed.

**d) Soil moisture content probes.** Each tank was fitted with two soil moisture probes, which were connected to dataloggers (Onset Computer Corporation, Pocasset, MA, USA; HOBO<sup>®</sup> Weather Station Data Logger, P/N: H21-001; SMA Soil Moisture Smart Sensor, P/N: S-SMA-

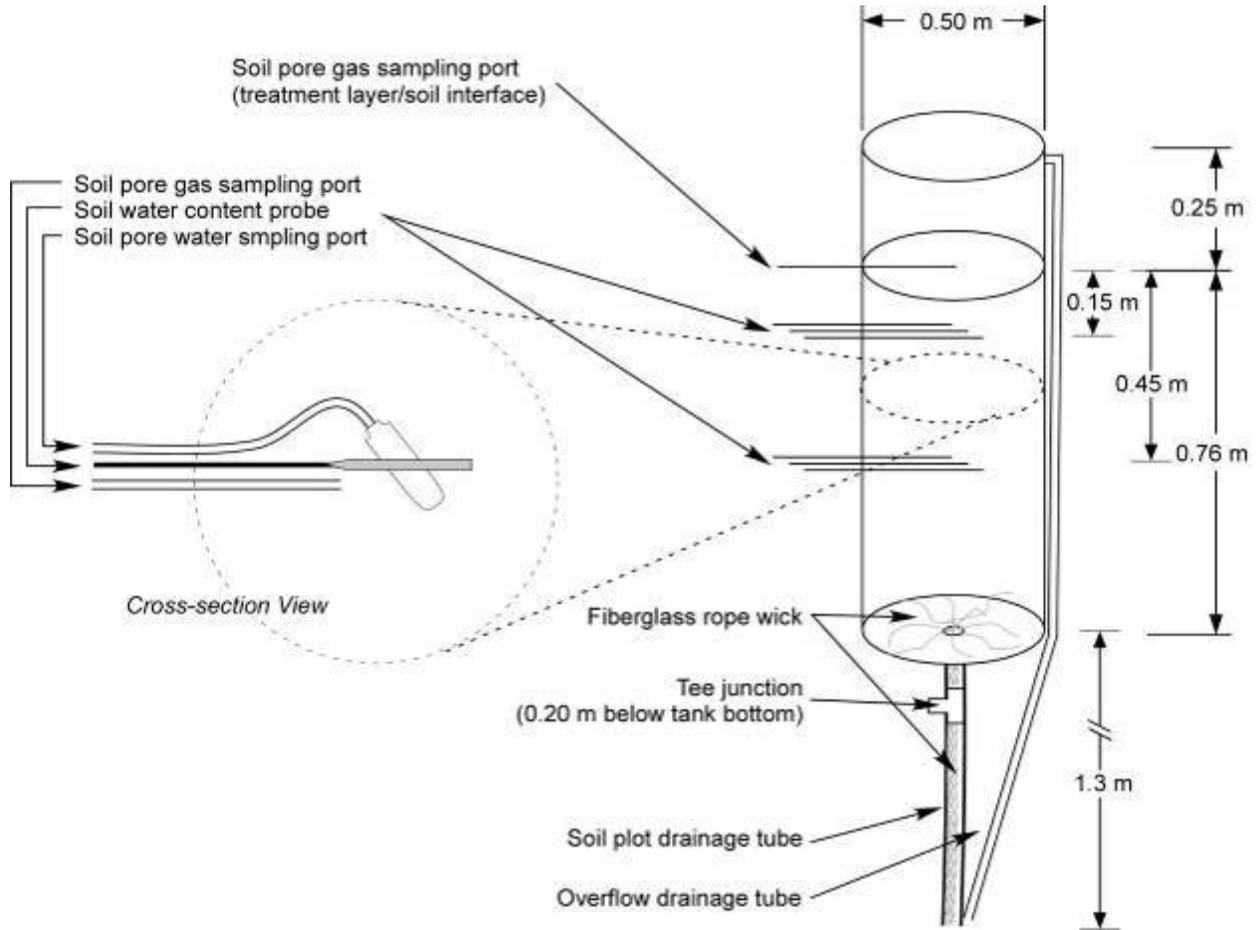
M005). The probes were placed 15 and 45 cm (6" and 18") below the surface of the soil in the soil plot. The cables connecting the probes to the datalogger ran horizontal to the tank wall where they passed through a neoprene "bushing" and out of the tank. Photographs of the soil moisture probes and datalogger system are presented in Figure 5.4-5.

A view of the soil pore water and soil pore gas sampling ports, and the soil pore moisture probe cables from the outside of the soil plot is shown in Figure 5.4-6.

**e) Soil plot anchoring system.** The entire soil plot apparatus was anchored to a 36" x 36" X 6" shipping pallet (100% recycled high density polyethylene, to allow it to be picked up using a forklift once soil is added, and to increase the overall stability of the soil plot, Figure 5.4-7). A hole was made in the center of the pallet to allow the drainage tubing assembly to hang below the tank without compromising the integrity and/or load-bearing capacity of the pallet. The soil plot was secured to the pallet using four nylon tie-down straps.

The laboratory "dry fit" procedure involving the parts described above was performed, then the soil plots were completely disassembled prior to transport to the field.

Figure 5.4-1a. Schematic diagram of the individual soil plots.



**Figure 5.1-1b. Conceptual illustration of the soil plot / pallet racking system that was employed during the SP1 demonstration.** The illustration shows one group of three soil plots, and three of these groups established.

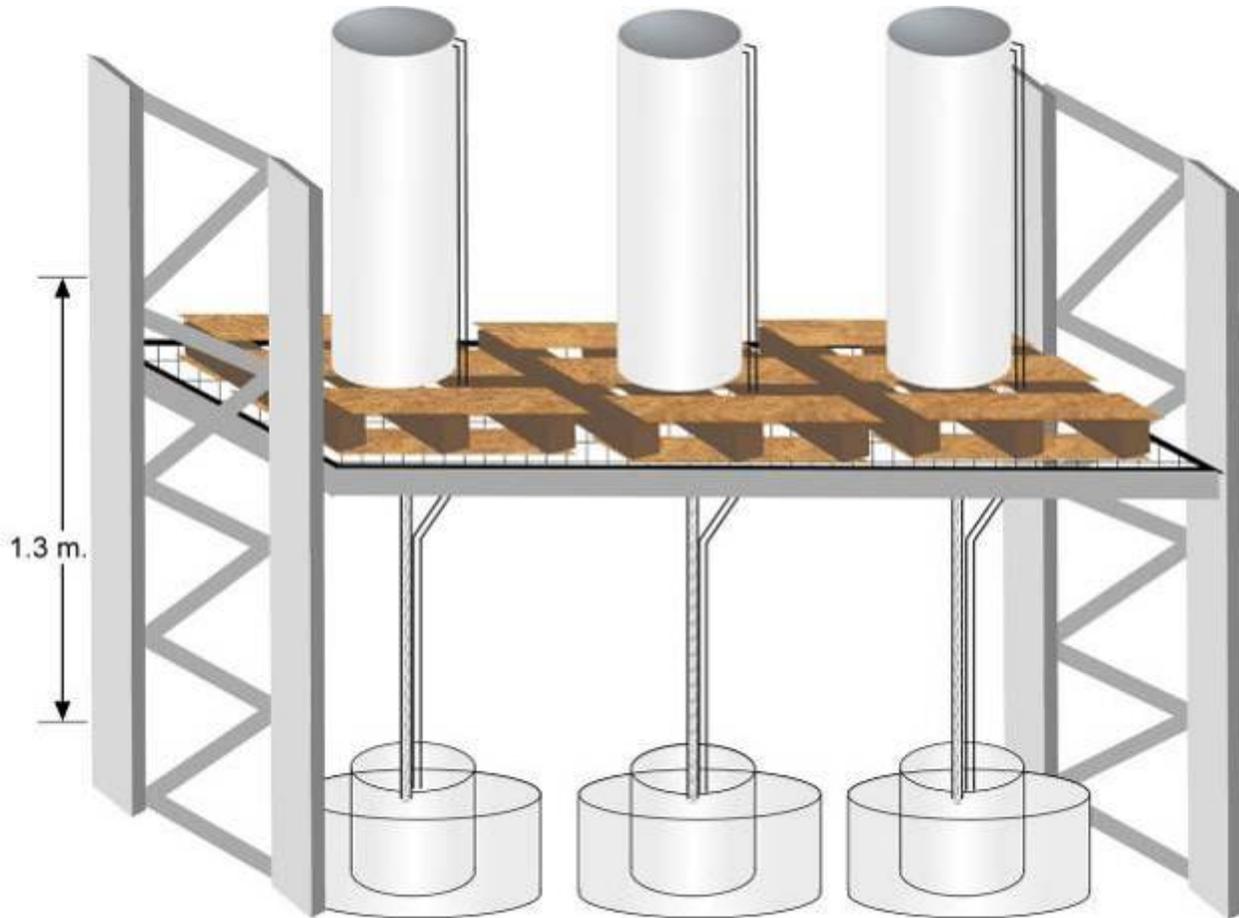


Figure 5.4-2. Photographs of the drainage system components.

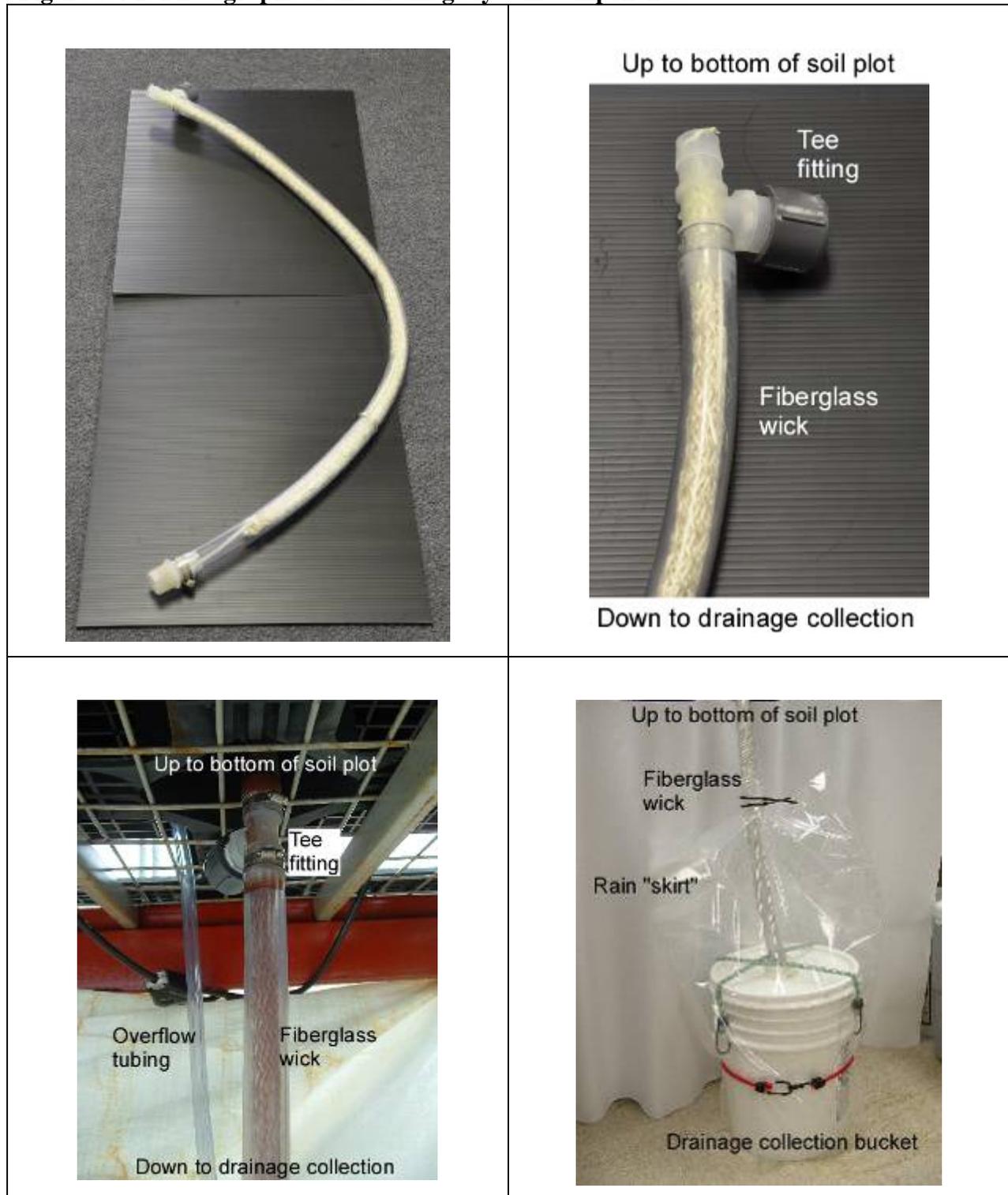
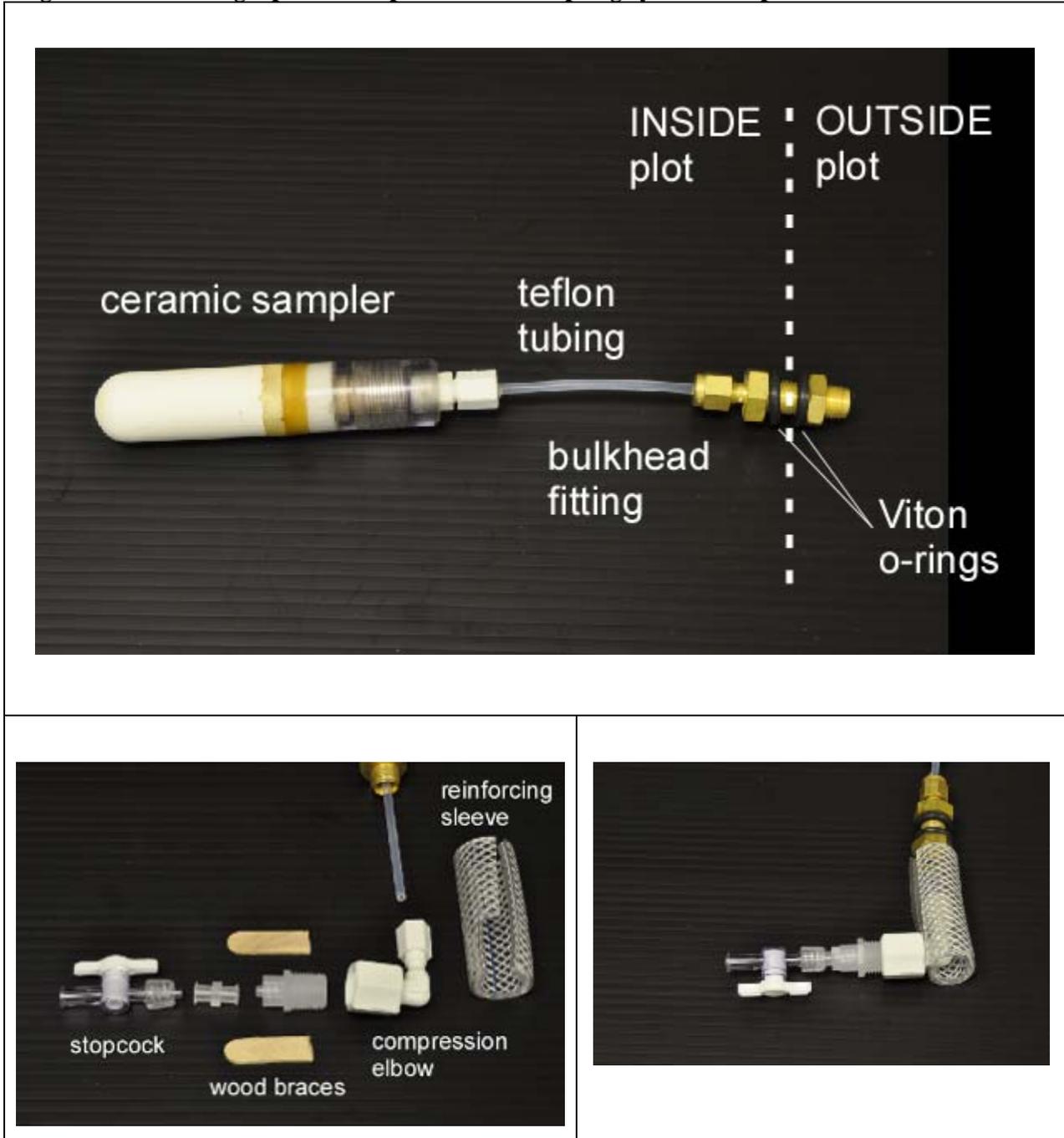


Figure 5.4-3. Photographs of the pore water sampling system components.



**Figure 5.4-4. Photographs of the pore gas sampling system components.**

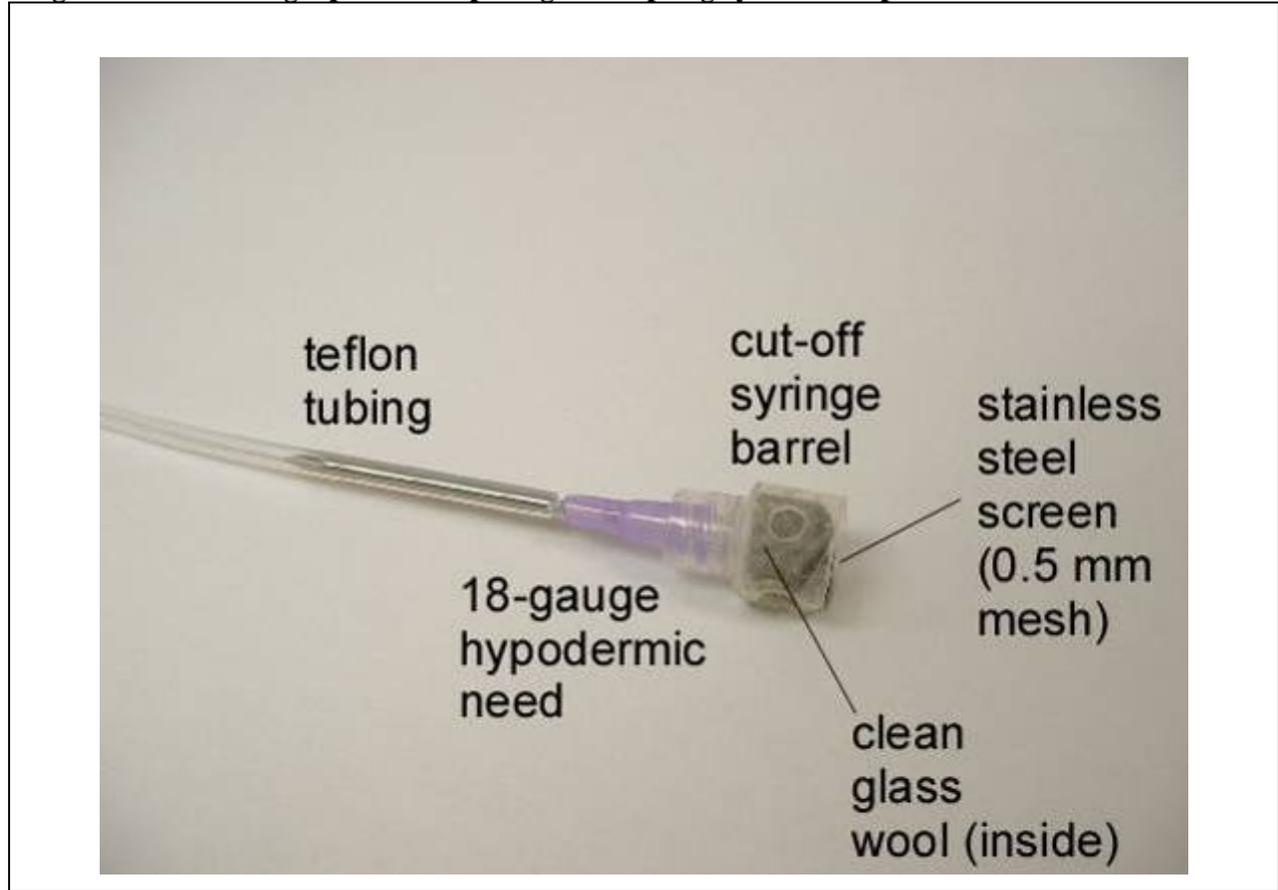


Figure 5.4-5. Photographs of the soil moisture datalogger system components.



**Figure 5.4-6. Photograph of the sampling port area on the side of a soil plot.**

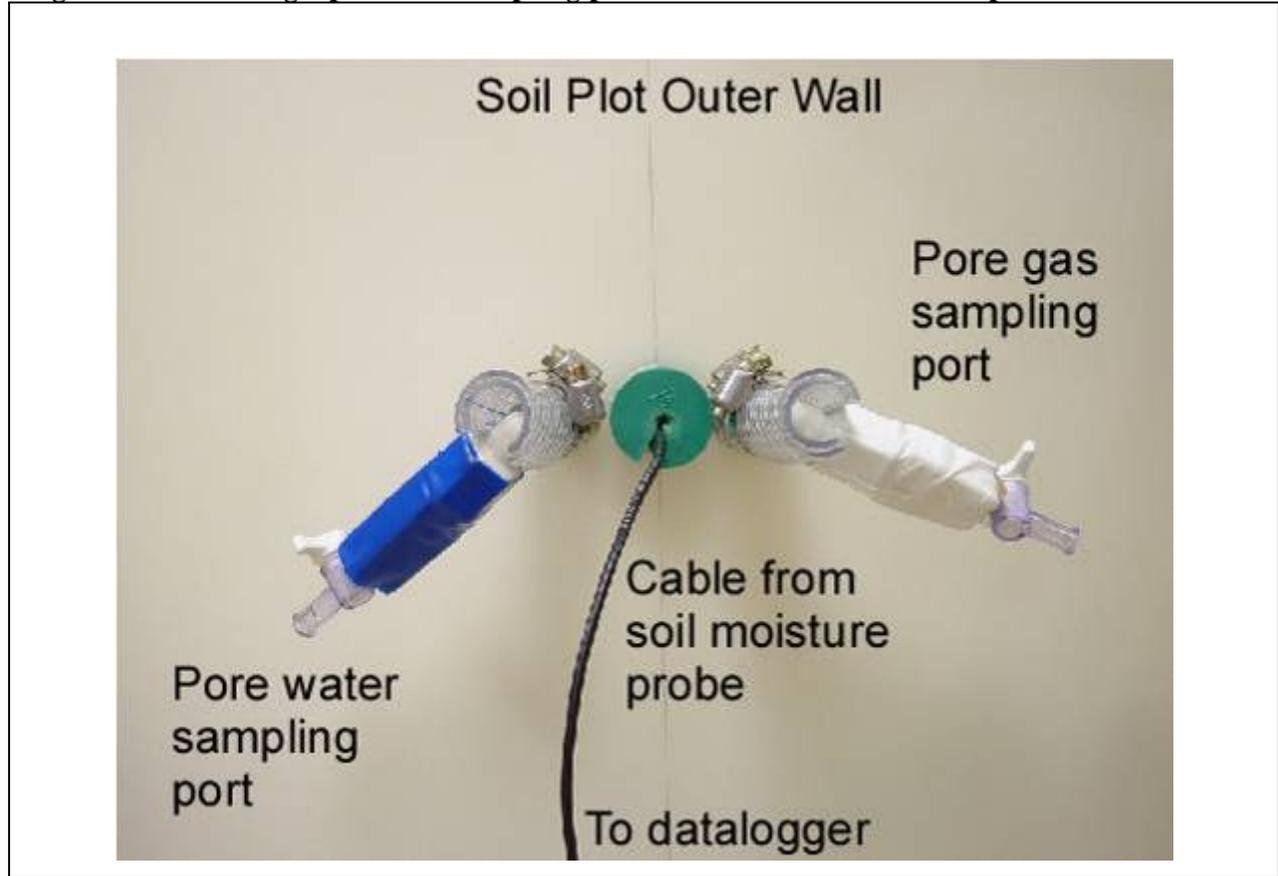
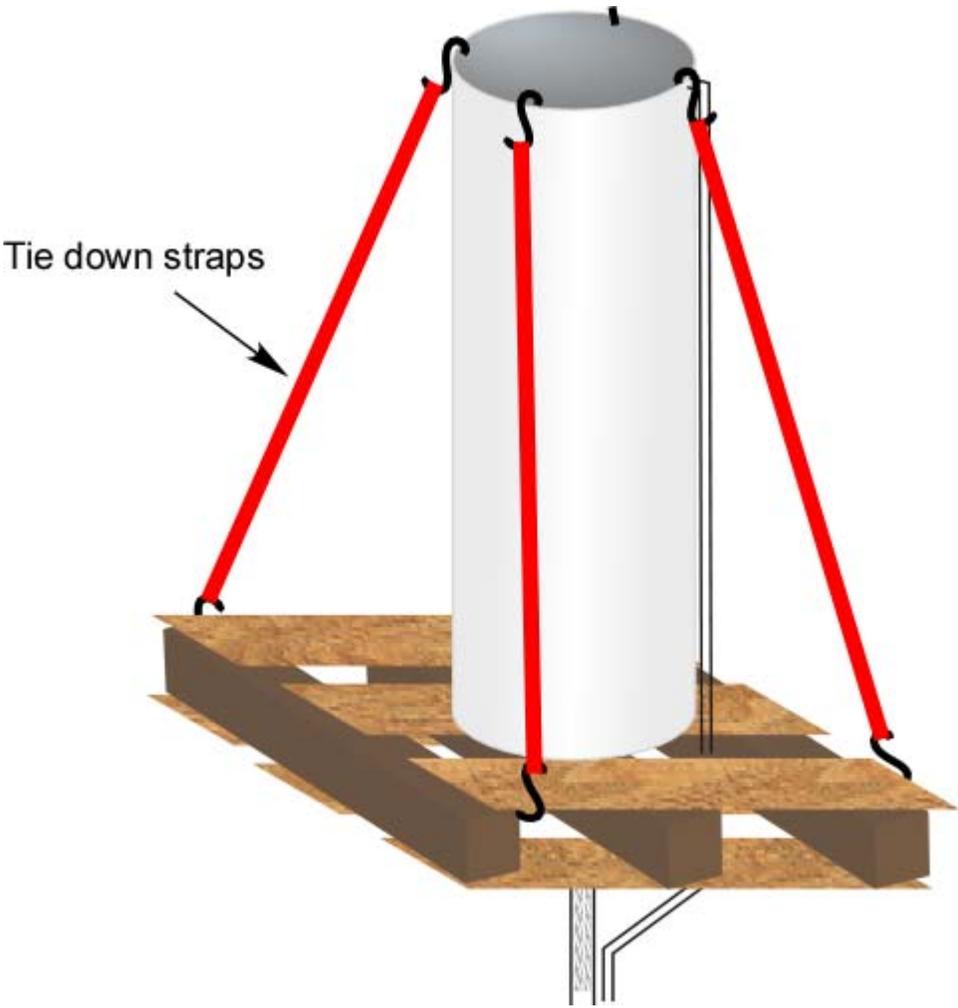


Figure 5.4-7. Illustration of how the soil plots were anchored to the pallets.



## **5.5 Field Testing**

All activities during mobilization complied with the guidelines and procedures included in the HASP (Appendix D of Field Demonstration Plan), especially as they pertain to working around heavy equipment and under field conditions.

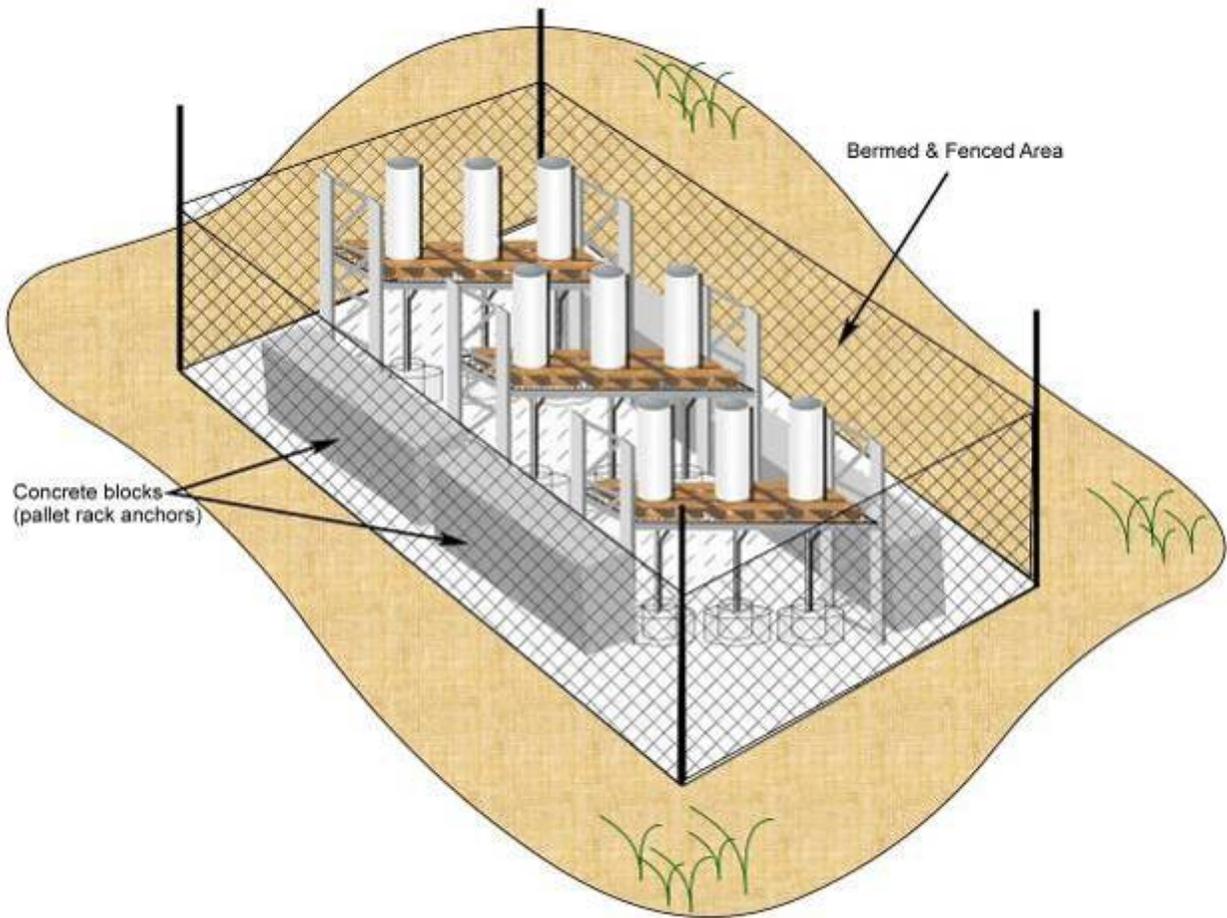
### ***5.5.1 Site Preparation and Construction***

A conceptual illustration of the entire SP1 demonstration at the selected area is presented in Figure 5.5.1-1.

The site was cleared of large rocks and smoothed prior to use. An impermeable liner and berm was set-up to contain the aboveground soil plots. The total bermed area was approximately 8 x 8 m (25 x 25 ft). The berm height around the perimeter of the liner was about 15 cm (6"). The area was also be fenced in after all setup was complete. A photo of the bermed area is presented in Figure 5.5.1-2.

A pallet racking system upon which the soil plots would be placed after soil loading was built within the bermed area. Four pre-cast concrete blocks (each 0.6 x 0.6 x 2.4 m/2 x 2 x 8 ft, 2200 kg/4800 lb) were emplaced to allow the plots to be elevated to the required height (1.3 m / 4 ft) and to provide stability against wind (Figure 5.5.1-3). The pallet racking system was manufactured by Ridg-U-Rak (North East, PA, USA), and had the following dimensions: upright frames, 36" wide x 96" high; cross beams, 5.5" tall x 120" long; wire decking, 36" deep x 58" wide. The pieces were locked together using pinch pins. The vertical supports of the pallet racks were fitted with extended footpads (1/2" x 3.75" x 3.75") that allowed them to be bolted into the concrete blocks. The weight capacity of each pallet rack was approximately 3400 kg (7500 lb). A total of three pallet racks were placed on the blocks, and three soil plots were placed on each pallet rack section. The pallet racks were serially grounded. Photographs of the pallet rack system are presented in Figure 5.5.1-4.

**Figure 5.5.1-1. Conceptual layout of the entire soil plot demonstration field site.**



### ***5.5.2 Soil Plot Loading***

Before the soil was added, the fiberglass wick and drainage tube was attached to the bottom of the tank. The portion of the fiberglass rope wick inside the tank was unbraided and spread out on the bottom of the tank to allow the needed contact between the wick and the soil to facilitate drainage. A 0.33 m x 0.33 m (12" x 12") square piece of fiberglass cloth was placed over the strands. The tanks were secured to the pallets and the pallets were elevated on cinder blocks. Photographs of the plots immediately prior to soil loading are presented in Figure 5.5.2-1.

Approximately 175 kg (386 lb) of soil (dry weight basis) was used for each soil plot, and the final soil height in the tank was 0.76 m (30"). In order to make the nine plots as similar as possible, a systematic procedure was followed for loading the soil into each plot. A diagram of the packing layers is shown in Figure 5.5.2-2. The soil was added in batches of 23.3 kg (54 lbs, dry wt. basis) and packed using a round PVC disc devices to a depth of 10 cm (4") per layer (pre-marked on the outside of the tanks), which resulted in a bulk density of  $\sim 1.4 \text{ g/cm}^3$ . When the soil reached a depth of 0.33 m (12"), the lower set of soil pore water, soil pore gas samplers, and soil moisture probe, was installed and 5 cm (2") of soil was hand packed around them, followed by an additional amount of soil to reach 10 cm (4") for that layer, then . Additional soil layers were added up to a depth of 0.66 m (24"), at which time the upper set of samplers/probes was installed. The rest of the soil was added to reach the target depth of 0.76 m (30"). Photographs of various staged of the soil loading process are presented in Figure 5.5.2-3.

As soil was packed, it was determined that the total depth would fall short of the desired depth. This was traced back to the fact that the measured water content of the soil was lower at the time of packing than was assumed when the packing plan was developed (4.5% vs. 20%). Therefore, an additional 16 kg (35 lb, dry wt) of soil was added, bringing the total soil per plot to 190 kg (419 lb). This increased the soil bulk density to  $1.5 \text{ g/cm}^3$ , which was still within an acceptable range.

### ***5.5.3 Soil Plot Placement on Pallet Racks***

Once soil addition was complete, the tanks were hoisted onto the pallet rack platform using a forklift (Figure 5.5.3-1). The plots were then leveled, and secured to the pallet rack cross beams using steel cables and a cable lock system. The fiberglass wick drain tubes and overflow drainage tubings were attached to the drainage water collection/handling system. A tarp was hung on each side of the pallet rack to shield the drainage collection system from wind, sun, and excess precipitation. Elevated walkways were installed to allow easier access to the soil pore water and pore gas sample ports (Figure 5.5.3-2). The tops of the plots were also covered with 1.25 cm (1/2") plastic coated metal screening to keep larger animals out.

When all the plots were in place, the cabling for the soil moisture probes was routed to the dataloggers and datalogging was initiated.

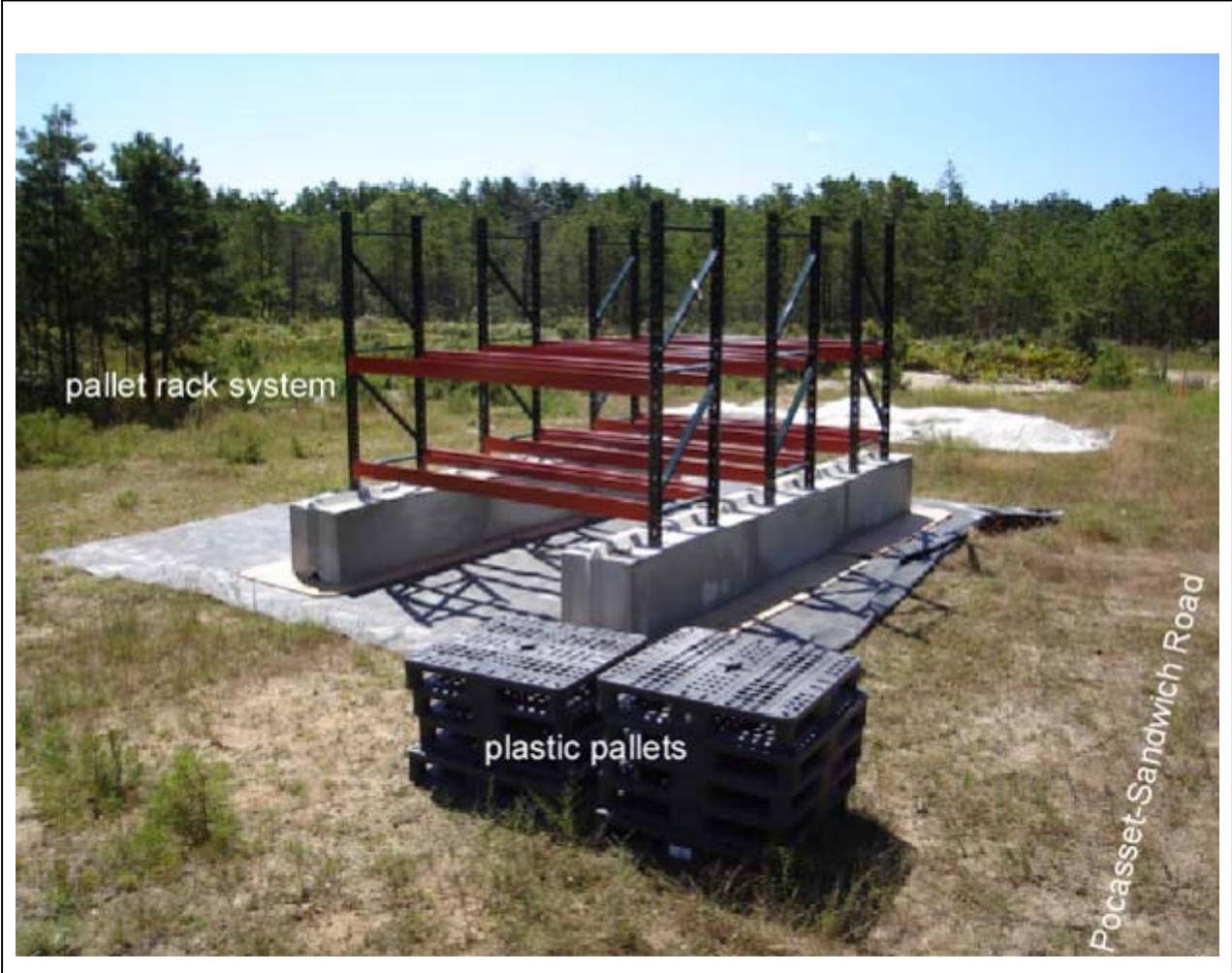
**Figure 5.5.1-2. Photographs of the bermed area within the field site.**



**Figure 5.5.1-3. Photographs of the precast concrete support block being installed at field site.**



Figure 5.5.1-4. Photographs of the installed pallet rack system.



#### ***5.5.4 Weather Station***

A weather station capable of logging temperature, sunlight, and precipitation was established next to the soil plots. A photograph of the type of system that was deployed at the demonstration site is presented in Figure 5.5.4-1.

#### ***5.5.5 Equipment Check Period***

Photographs of the finished field site are presented in Figure 5.5.5-1. A system check period was performed starting on 17 August 2006 to assure that all the samplers and logger were operating properly. Data from the soil moisture probes and the weather station began logging immediately, and was downloaded and assessed periodically. Samples from the pore water samplers, the pore gas samplers, and the drainage system were collected initially on 08 September 2006 and then biweekly or monthly, and analyzed for explosives and other parameters.

During this assessment period, several problems with the soil moisture probe sensors and datalogger were found. Corrections/repairs were made sequentially and additional data was collected to assess success. Issues with non-functioning soil pore water samplers were also addressed.

All excess aqueous materials that could potentially be contaminated, including excess soil plot drainage water and runoff accumulating within the bermed area, was collected and transported to MMR's on-site treatment facility.

### ***5.5.6 Treatment Layer Preparation and Application***

The treatment layer material was prepared with two different crude soybean oil contents to evaluate how the amount of oil entrained in the peat moss affected the overall treatment layer effectiveness (combined sorption/biodegradation of TNT and RDX) as reflected in transport of dissolved explosive compounds through the layer and into the underlying soil.

The PMSO mixes were prepared by combining horticultural grade bulk *Sphagnum* peat moss (Nirom) and crude soybean oil (Soybest/ Grain States Soya, Inc., West Point, NE, USA). Peat moss was used “bag wet,” but all calculations were made on a dry weight basis. The two mixes were composed of 1.34 kg peat plus 1.34 kg oil (1:1, PO1), and 1.34 kg peat plus 2.68 kg oil (1:2, PO2). Mixes were prepared in large plastic bags, and individual batches were prepared for each plot. Mixing continued until no free oil is observed in the mixing container. Enough PMSO was prepared in each batch to allow a 10 cm (4”) layer of the material to be applied over the surface of the soil in the plot.

The PMSO was shipped to the site and added to the designated soil plots by evenly spreading it over the soil surface. The mixture PO1 was applied to plots SP1-1, SP1-4, and SP1-9. The mixture PO2 was applied to plots SP1-3, SP1-5, and SP1-8. No PMSO was applied to the control plots SP1-2, SP1-6, and SP1-7.

PMSO application occurred on 13 October 2006. The treatment layers were in the plots for eight months before the explosive residues were applied.

### ***5.5.7 System Standby (Over-wintering)***

Since the winter temperatures at MMR would prevent any significant water movement, collection of soil pore water and drainage water samples during these months would not be possible. Additionally, there was the possibility that snow and rain could fill the plots to such an extent that freezing would damage the sensors or sampling ports. Therefore, the SP1 demonstration was placed in standby mode twice during the project: from 20 December 2006 to

26 April 2007 and again from 20 December 2007 to 24 March 2008. The plots were covered with plastic garbage can lids, secured with bungie cords. The dataloggers were also covered with heavy rubber to protect them from ice damage.

### 5.5.8 Explosive Residue Preparation

A total of 100 g of Composition B (Comp B) residues were required for the SP1 demonstration. We obtained low-order detonation residues from a 55-mm mortar round from Dr. Susan Taylor, ERDC-CRREL. Dr. Taylor hand sorted the residues and supplied us with material that was between 0.5 and 1 mm in size.

The residues were characterized further with respect to their composition. Ten replicate subsamples of the residues were carefully weight out and extracted with acetonitrile. The average mass extracted was  $10.28 \pm 2.03$  mg. The extracts were analyzed using HPLC according the modified EPA Method 8330 as described elsewhere. Analysis of the data yielded residue composition as presented in Table 5.5.8-1.

**Table 5.5.8-1. Explosive compounds in the Composition B residues.**

	Percent of residue mass		Total mass applied per plot (g)	
	Average	SD	Average	SD
<b>HMX</b>	0.26	0.07	0.03	0.01
<b>RDX</b>	56.12	3.63	5.61	0.36
<b>TNT</b>	34.51	2.98	3.45	0.30
<b>Other</b>	9.12	6.45	0.91	0.65
<b>TOTAL</b>	100.00		10.00	

The residues were divided into 10 g portions, which were mixed with 100 g of clean silica sand. The sand served as a carrier, and allowed the residues to be transported to the field site and handled without being designated as an explosive hazard. A photograph of the residue sand mix is presented in Figure 5.5.8-1. The total mass of HMX, RDX, and TNT that was applied to each soil plot with the sand carrier is also presented in Table 5.5.8-1.

### ***5.5.9 Explosives Application***

The Composition B detonation residues in their silica sand carrier were applied over surface of each soil plot. Application occurred on 11 June 2007. Any very large cracks in the treatment layer, or slight irregularities of the soil surface were gently removed prior to applying the residues. Application was by shaking (sprinkling) the residue-sand mixture from the container, and every effort was made to assure that the material was distributed over the entire 1600 cm<sup>2</sup> (250 square inches) surface of the plot. No further manipulation of residues was performed once the application was complete. The total mass of residues to be applied to each plot was 10 g. Photographs of the application of the residue/sand mix to a control and a PMSO-treated plot are presented in Figure 5.5.9-1.

### ***5.5.10 Plant growth and application of herbicides***

During the summer of 2007 a fair amount of plants (grasses) were observed growing in the soil plots. It was decided to cut the aboveground biomass down at the end of the growing season. The most growth was observed in the control plots. Before and after photographs of plots SP1-2 and SP1-7 are shown in Figure 5.5.10-1. Biomass was returned to the laboratory and analyzed for explosive residues.

Additionally, in an effort to prevent new growth in the spring of 2008, herbicide was applied in April 2008. A mixture of extended control RoundUp plus Spectracide TripleStrike was applied to the surface of each of the plots using a hand sprayer at an application rate of 1:4 of the recommended rate. With this herbicide application, a total of 64 mg of TOC was applied to each plot in a total volume of 200 ml.

Figure 5.5.2-1. Photographs of the soil plots prior soil loading.



Figure 5.5.2-2. Representation of the soil plot packing procedure.

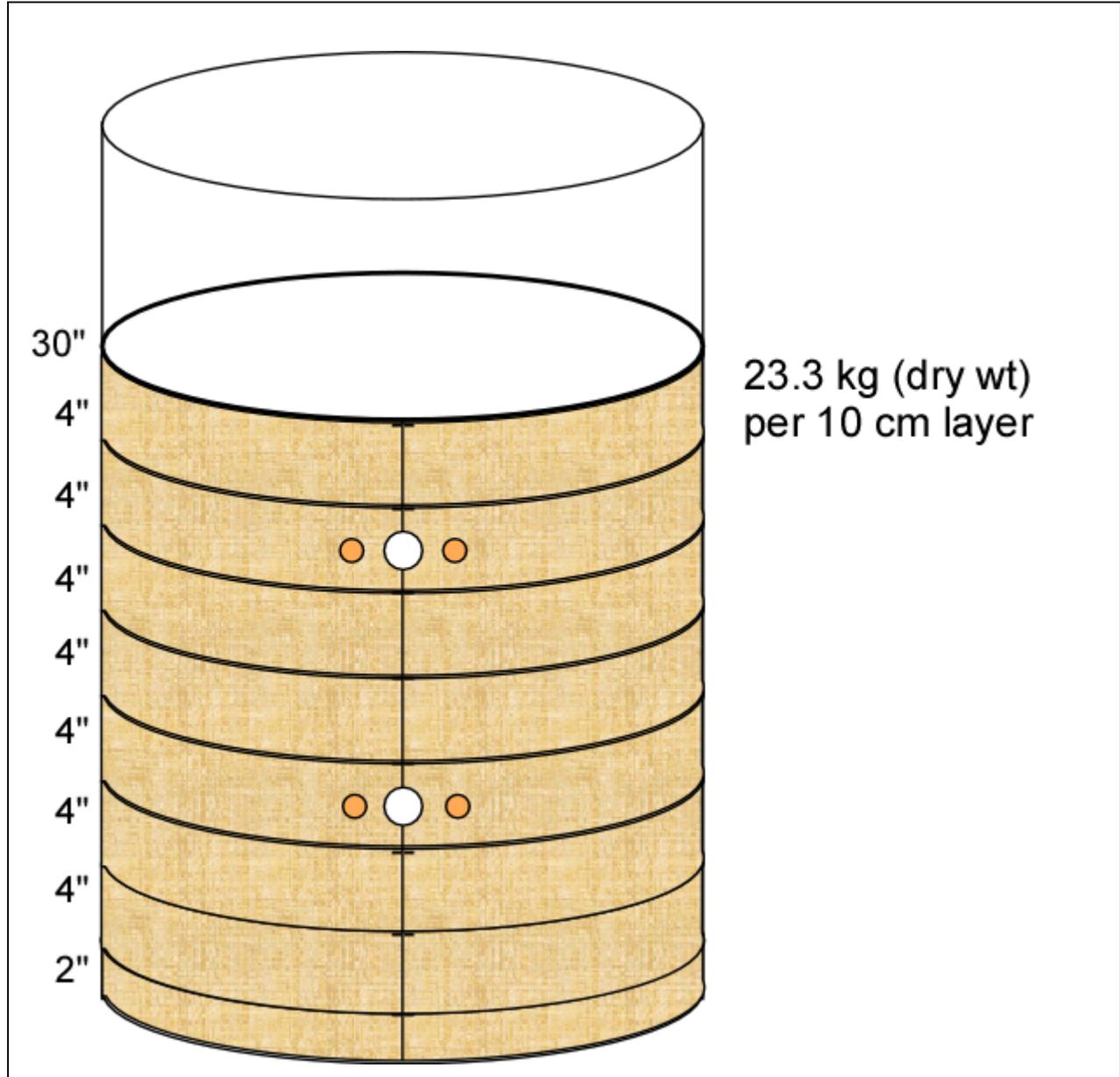
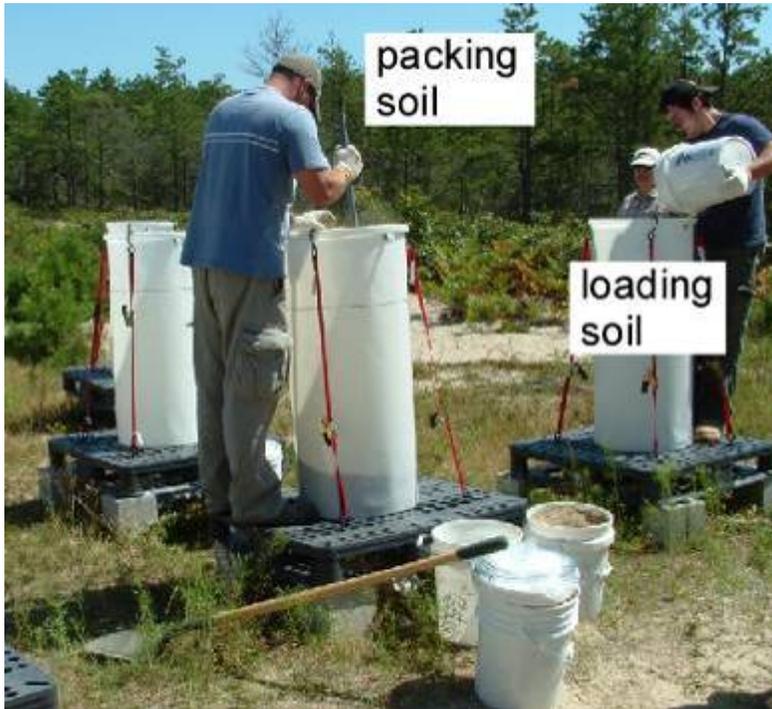


Figure 5.5.2-3. Photographs of various stages of the soil loading.



looking into tank from top

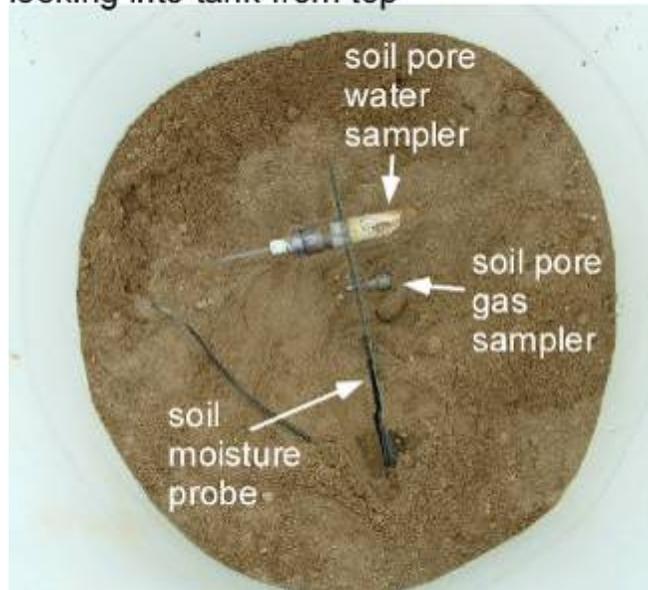


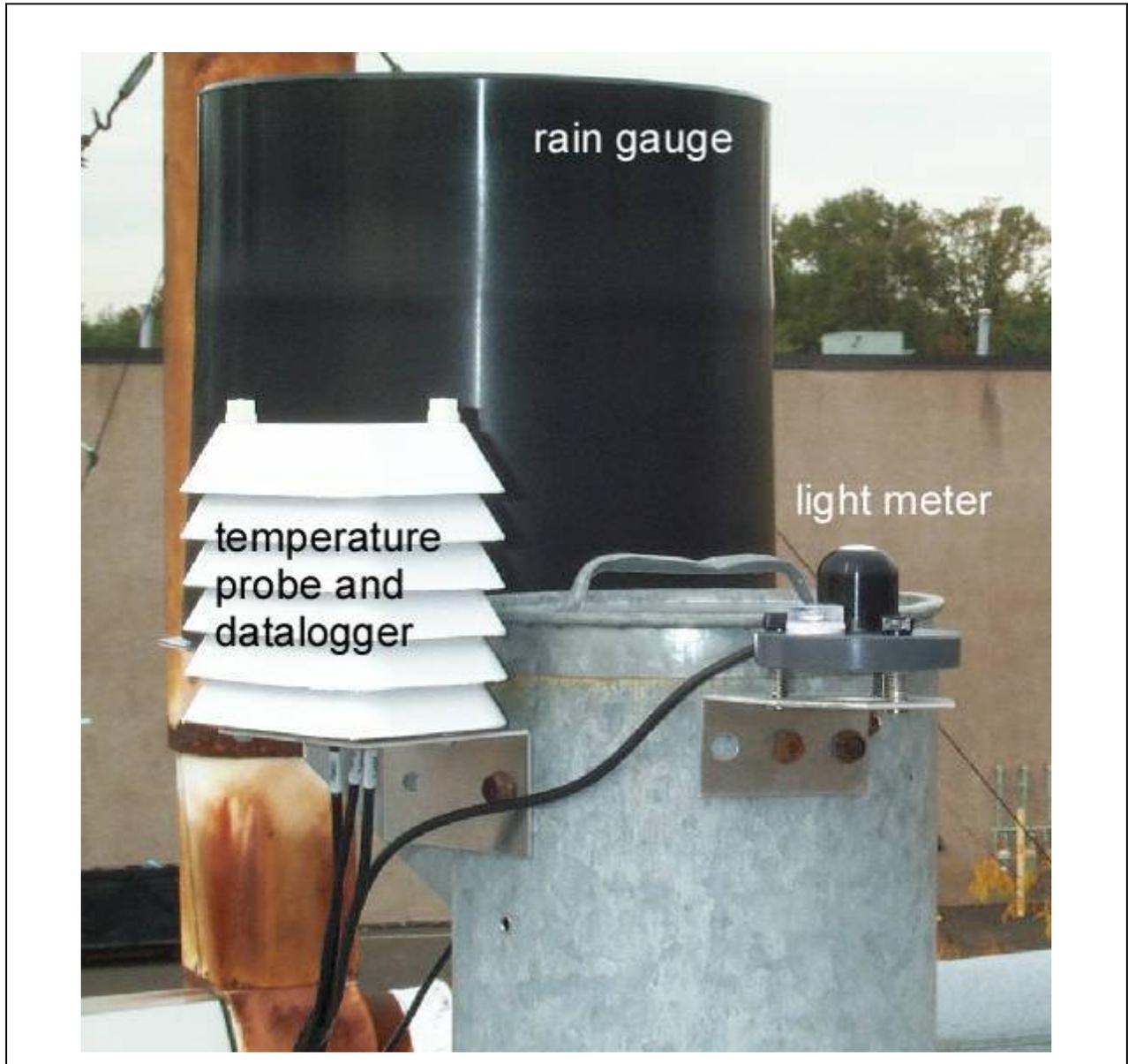
Figure 5.5.3-1. Photographs of the soil plots being placed on the pallet rack system.



**Figure 5.5.3-2. Photographs of the site with tarps and walkways installed.**



**Figure 5.5.4-1. Photographs of the weather station.**



**Figure 5.5.5-1. Photographs of the finished field site.**



### ***5.5.11 Demobilization and Post-Demonstration Analyses***

The SP1 demonstration lasted for 26 months, and was terminated on 23 September 2008. As stated above, the demonstration was placed in standby mode twice during the project: from 20 December 2006 to 26 April 2007 and again from 20 December 2007 to 24 March 2008. Photographs of the soil plots, some of which had plants growing in them, are shown in Figure 5.5.11-1. Due to heavy rains, some plots also had standing water above the surface of the soil or PMSO.

All residual soil, as well as the actual tanks and any associated fittings, were packed into yard boxed and disposed of off-site according to applicable local, state, and federal regulations. The disposed soil had an average estimated maximum concentration of 6 mg/kg RDX, and 0.5 mg/kg TNT, along with 1.3 and 2.3 mg/kg of 4-amino-2,6-DNT and 2-amino-4,6-DNT, respectively, based on the concentrations measured in the soil core samples from the control plots. These values were estimates of the average soil concentrations based on multiple discrete samples from the cores that were taken during demobilization. These average concentrations in the waste soil were based on the control (no treatment) soil, which was much more contaminated than the treatment soils. Since there were three control plots (with high contamination) and six treatment plots (with low residual contamination) mixed together, these values likely overestimate the actual average concentrations by a significant amount.

All structures, instrumentation, and other ancillary items were removed from the site. The immediate area underwent some simple grading using a bobcat.

A final sampling of the site was conducted to assure that no contamination above the initial baseline had occurred outside the bermed area. Results indicated no HMX, RDX, or TNT above the TestAmerica/STL detection limit of 120 µg/kg. This was confirmed by Shaw internal analytical laboratory, which reported none of these compounds above the detection limit of 50 µg/kg.

**Figure 5.5.8-1. Photographs of the Composition B/sand mixture.**



**Figure 5.5.9-1. Photographs of the soil plot surface before (left) and after (right) residue/sand application.**

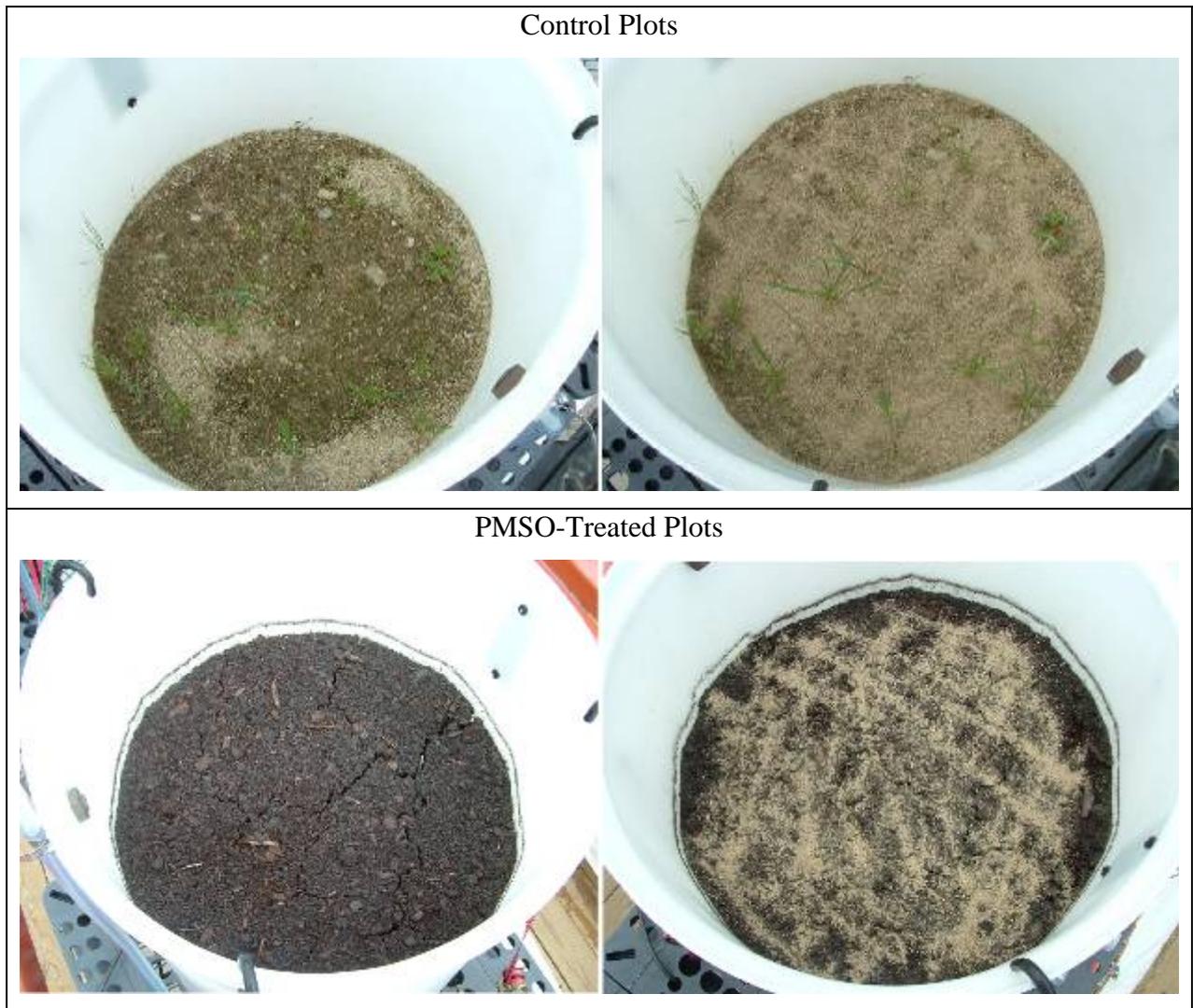


Figure 5.5.10-1. Photographs of plant growth in the soil plots.

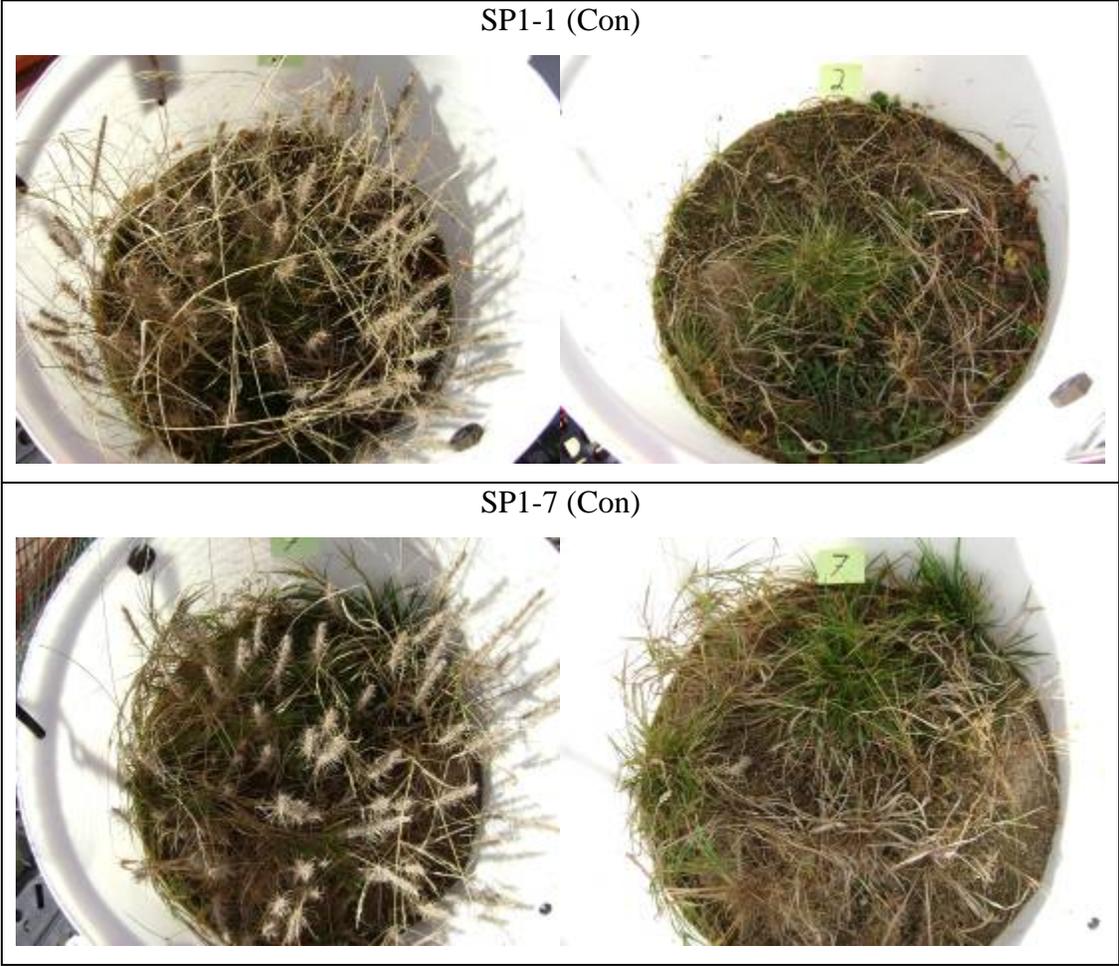
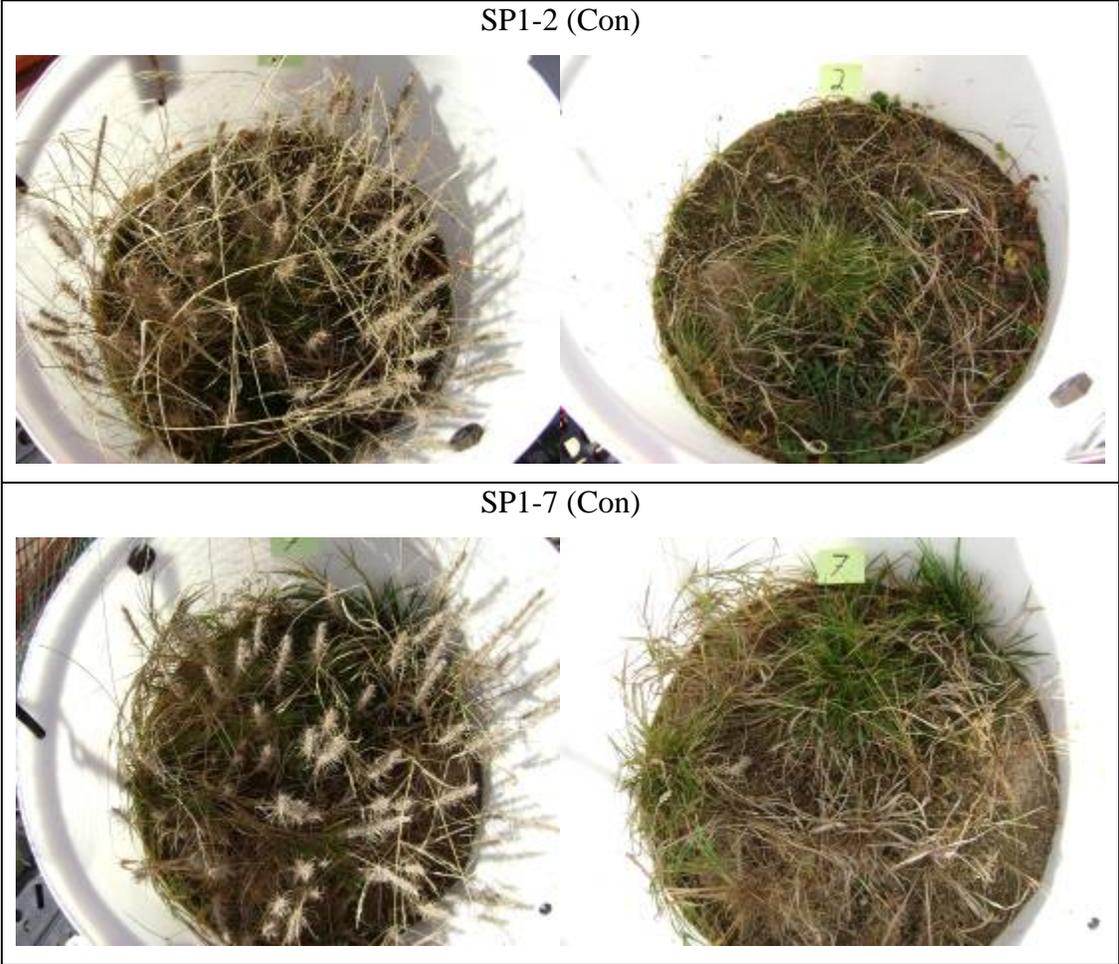


Figure 5.5.10-1. Photographs of plant growth in the soil plots.



**Figure 5.5.10-1. Photographs of the soil plots at the time of demobilization.**



## **5.6 Sampling Methods**

### ***5.6.1 Sampling Plan***

The sampling plan developed for this field demonstration was designed to meet the data needs required for 1) evaluating the technology performance with respect to the performance objectives listed in Table 3-1, and 2) comparing the actual field data to the predicted explosive residue fate and transport based on modeling. Additionally, given the variable nature of field demonstrations with respect to weather conditions, the sampling plan was designed to be flexible while still delivering high quality, accurate data. The data collected were relevant only to the actual field demonstration being conducted, but did provide supporting data that could be used for future decisions by range management personnel who may be considering deploying this technology.

### ***5.6.2 Sample Collection***

#### ***Personnel***

All samples collected during this demonstration were collected by Shaw Environmental, Inc. The personnel performing the sampling followed established sampling protocols and given additional training as needed.

#### ***Sample Types & Methodology***

The following samples were collected during the demonstration:

##### ***Aqueous samples***

Over the course of the field demonstration, the primary media to be sampled was aqueous. Soil pore water samples and soil plot drainage water samples from each soil plot were collected over the duration of the demonstration for the determination of explosive concentrations, with special emphasis on TNT, RDX, and RDX breakdown products. Additional parameters such as pH and total organic carbon (TOC) were measured on selected samples. At the end of the demonstration, a final round of pore water and drainage water samples were collected.

Sampling of soil pore water and soil plot drainage water was performed as described in Appendix B of Part I of this report.

#### *Soil and PMSO samples*

Soil samples were collected and analyzed during the soil plot setup and from the individual soil plots at the termination of the project. The pre-demonstration samples were collected and analyzed to assure that the initial soil contained no measurable concentrations of explosives (specifically, TNT, RDX, and breakdown products). Pre- and post-demonstration soil samples were also collected from within the demonstration area to document that new contamination had not occurred. Samples were collected according to established procedures as described in Appendix B of Part I of this report.

The post-demonstration soil samples from the soil plots were collected and analyzed for explosives to allow determination of mass balances, as well as to assess the vertical distribution of the target compounds within the soil profile. The soil and PMSO in the plots was extensively sampled and analyzed as detailed below.

**PMSO:** The top 2.5 cm (1”) of the PMSO in each of the treatment plots was removed and placed into plastic ziplock bags. The remaining 7.5 cm (3”) was then removed and placed into large plastic bags. Samples were transported to Shaw’s Lawrenceville laboratory for processing as follows:

- 1) The wet weight was recorded, the materials were air-dried, and the dry weight was recorded.
- 2) The top 2.5 cm samples of PMSO were dry sieved into size fractions of: >2 mm, 1-2 mm, 0.5-1 mm, 0.1-0.5 mm, <0.1 mm. The dry weight of each fraction was recorded.
- 3) The fractions were extracted *in toto* with acetone (technical grade) overnight. Fractions 1-2 mm and 0.5-1 mm were combined for extraction.
- 4) Samples of the extract were diluted into a final solution of 1:1 acetonitrile:nanopure water, as needed, and analyzed using HPLC for explosives.

**Bulk surface soil:**

Control plots – The topmost 3.8 cm (1.5”) of soil was removed in three sequential 1.3 cm (0.5”) lifts and placed in ziplock bags. Samples were transported to Shaw’s Lawrenceville laboratory for processing as follows:

- 1) The wet weight was recorded, the materials were air-dried, and the dry weight was recorded
- 2) Each 1.3 cm bulk soil lift was dry sieved into size fractions of: >2 mm, 1-2 mm, 0.5-1 mm, 0.1-0.5 mm, <0.1 mm. The dry weight of each fraction was recorded.
- 3) The fractions were extracted *in toto* with acetone (technical grade) overnight. Fractions 1-2 mm and 0.5-1 mm were combined for extraction.
- 4) Samples of the extract were diluted into a final solution of 1:1 acetonitrile:nanopure water, as needed, and analyzed using HPLC for explosives.

Treatment plots – The 5 cm (2”) of soil below the PMSO was removed in two sequential 2.5 cm (1”) lifts and placed in ziplock bags. Samples were transported to Shaw’s Lawrenceville laboratory for processing.

- 1) The wet weight was recorded, the materials were air-dried, and the dry weight was recorded.
- 2) Three 100 g subsamples from each 2.5 cm bulk sample lift were extracted with acetone (technical grade) overnight.
- 3) Samples of the extract were diluted into a final solution of 1:1 acetonitrile:nanopure water, as needed, and analyzed using HPLC for explosives.

**Soil cores** After the bulk surface had been removed from all plots, a hand geoprobe was used to drive a 30 cm (2 ft) plastic core liner into the soil profile. Eight replicate cores were collected from each soil plot. The core liners were retrieved, sealed, and transported to Shaw’s Lawrenceville laboratory for processing as follows:

- 1) The length of soil collected in each core was recorded.

- 2) The cores were subsectioned into 5 cm (2") lengths, starting with the end of the core representing the soil closest to the top (any coring losses were assumed to be from the bottom of the sleeve).
- 3) The subsections wet weights were recorded, the materials were air-dried, and the dry weight was recorded.
- 4) Subsample were extracted and analyzed according to EPA Method 8330.

#### *Soil gas samples*

Gases (CO<sub>2</sub>, O<sub>2</sub>) within the soil pots were monitored as an indicator of biological activity. Soil gases were sampled and measured as described in Appendix B of Part I of this report.

#### *Soil moisture content probe data*

The soil moisture probes were used to monitor the water flux within the soil plots in response to precipitation and drying. The data in the dataloggers was downloaded on a regular basis and transferred to the project database according to the probe/datalogger manufacturer's procedures.

#### *Weather station data*

The on-site weather station was used to monitor the major climatic conditions (sunlight, precipitation, temperature) during the demonstration. The data in the dataloggers was downloaded on a regular basis and transferred to the project database according to the sensor/datalogger manufacturer's procedures.

#### ***Sample Identification***

Each sample collected was given a unique identifier. The identifier included the project name, the location from which the sample was taken, and the date or sample timepoint. The following designations/abbreviations were used throughout the project for samples from the soil plots:

Project Identifier	SP1
Soil Plot Identifier	1 to 9
Sample port	1 = 0.15 m (6") below surface 2 = 0.45 m (18") below surface DW = drainage sample I = interface between treatment layer and soil surface; gas sampling from treatment plots only
Date format	mmddyy

The bulk soil and PMSO samples taken from the soil plots at the end of the demonstration were designated as "Project Identifier-Soil Plot Identifier" and the sample depth interval. For soil cores, the sample identifier was "Project Identifier-Soil Plot Identifier-Core#-Interval", where Core# was a letter between A to H (inclusive) and Interval was a number 1 to 9 (inclusive), each number representing an approximate 5 cm (2") depth interval.

The data downloaded from the soil moisture probe datalogger is encoded with date, time, and the name of the sensor. The sensor names were assigned at the start of the project, and were in the form, "SP1-(soil plot number)-(depth)". The data downloaded from the weather station is already encoded with date and time.

### ***Chain-of-Custody (CoC), Recordkeeping, and Shipping***

Samples collected for delivery to Shaw Environmental laboratories were shipped and logged using standard Shaw procedures and forms. A sample of the standard Shaw CoC is included in Appendix B. Samples were logged into a field logbook during/after collection. Samples received by Shaw laboratories were logged into a sample logbook (or electronic spreadsheet, as applicable).

Samples collected for delivery to an outside analytical laboratory were logged into the field logbook and shipped and logged using the forms required by the laboratory.

Samples were carefully wrapped with bubble wrap (or other applicable shipping materials) and shipped in plastic coolers by a commercial carrier priority overnight in ice. Temperature blanks were included in all shipments.

### ***Holding Times***

Field samples from this ESTCP project were given priority for analysis. The estimated maximum number of samples from a single sampling event was 27 (2 pore water samples and 1 drainage water sample from 9 individual soil plots). The HPLC autosampler holds 100 samples, and the HPLC can run unattended around the clock. A single HPLC run lasts 40 minutes. Therefore, samples from a single sampling event could be fully analyzed for explosives within 2 days of receipt in the laboratory. If instrument problems or other issues precluded immediate analysis, the samples were filtered (0.45  $\mu\text{m}$  glass microfiber) into HPLC autosampler vials, sealed, and stored at 4°C in the dark until analysis.

### ***Sampling Schedule***

The sampling schedule was designed to provide sufficient sampling density over the duration of the demonstration with a good degree of flexibility to account for labor and environmental conditions.

Basic sampling was conducted bi-weekly. The sampling interval was increased to monthly during dry summer and sampling was suspended during the winter months. Once during the demonstration more intense sampling was performed, which included collection of samples approximately before, during, and immediately after moderate to heavy precipitation.

**Table 5.6.2-1. Treatability test matrix for the SP1 demonstration.** The following sample types were collected at the designated sampling frequencies. Expanded rationale for the each type of sample is included below the table.

Sample type	Samples per plot	Plots sampled	Analytes	Frequency	Rationale
Soil pore water	-2 per plot (6" and 18" below soil surface (bss))	All 9 plots (3 Control, 3 Treatment #1, 3 Treatment #2)	explosives pH <sup>a</sup> TOC <sup>a</sup> BOD <sup>a</sup>	Bi-weekly, selected high intensity periods	-Fate and transport of dissolved explosives -Infiltration of nutrients into soil
Soil moisture	-2 per plot (6" and 18" bss)	All 9 plots	vol% water	Bi-weekly download	Water flow/flux through he soil plot
Soil pore gas	-2 for Control plots (6" and 18" bss) -3 for Treatment plots (0", 6" and 18" bss)	All 9 plots	O <sub>2</sub> CO <sub>2</sub>	Bi-weekly, selected high intensity periods	Microbial activity and redox satus of soil plot
Soil plot drainage water	1 per plot	All 9 plots	explosives pH TOC <sup>b</sup> BOD <sup>b</sup>	Monthly, selected high intensity periods	-Fate and transport of dissolved explosives -Water balance -Water flux
Weather station data	1 for demonstration site	--	precipitation light temperature	Monthly download	-Climatic variables, esp. precipitation -Water flux

<sup>a</sup>Selected samples if not volume limited.

<sup>b</sup>Selected samples throughout the demonstration duration.

### *Sampling Rationale*

The rationale for the sample parameters listed in Table 5.6.2-1 is as follows:

**Soil pore water** - Collection and analysis of soil pore water for explosive compounds (TNT, RDX, breakdown products) is the single most important data that was obtained during this SP1 field demonstration. The data collected allowed the effectiveness of the treatment layer material at reducing the flux of the explosives into the soil to be determined, and was also used to refine the PMSO-explosives fate and transport model. Measurement of the pH, TOC, and BOD of the soil pore water yielded process monitoring data that gave more insight into the how the treatment layer affects the underlying soil (i.e., by providing nutrients that may increase the active biomass in the soil, which in turn may increase the biological degradation of dissolved explosives as they percolate through the soil).

**Soil pore moisture** - Measurement of soil moisture at depths co-located with the soil pore water samplers was used to assist in calculating the flux of water through the soil. This information was critical for successful fate and transport modeling, especially since the system was operated under unsaturated, intermittent flow conditions. The soil moisture data also allowed determination of how the treatment layer materials affected the underlying soil with respect to moisture content. The treatment layer was expected to hold water, thereby reducing the flux of water, and thus the flux of dissolved explosives, into the soil in the treatment plots compared to the control plots. Additionally, the treatment layer was expected to allow the underlying soil to remain more moist for longer periods of time, which could increase microbial activity and promote degradation of dissolved explosives.

**Soil pore gas** - Monitoring of soil pore gases in the plot yielded information on the biological activity (redox) within the soil plots. The nutrients that were released from the treatment materials and percolated into the soil were expected to stimulate biological activity. Additionally, the increased water content in the soil underlying the treatment material was expected to limit diffusion of atmospheric air into the soil. Measurement of soil pore gases

(oxygen and carbon dioxide) indicated how much activity was generated, and served as a surrogate for soil redox.

**Soil plot drainage water** - The rationale for sampling and analysis of soil plot drainage water was similar to the rationale for analyzing soil pore water. The data collected contributed to the fate and transport modeling and the assessment of the treatment layer effectiveness.

**Weather station data** - Climatic data was required for this demonstration to fully evaluate the treatment layer effectiveness. Collection of precipitation data was of particular importance, since it allowed determination of relationships between the amount of precipitation and the flux of water (and dissolved explosives) into the soil in the control versus the treatment plots. Correlations between temperature and biological activity were also examined. Additionally, if anomalies in the data were observed, the weather station data was consulted to clarify any problems.

### ***5.6.3 Sample Analysis***

The contaminants that were the focus of this field demonstration were TNT, RDX, and their respective breakdown products. The key data generated from this demonstration were the aqueous explosive concentrations in the soil pore water and soil plot drainage water, and the soil concentrations within the soil plots at the end of the demonstration. Ancillary analysis were performed to monitor “process” parameters that were of interest for scientific purposes but which did not bear directly on the technology evaluation.

Analytical procedures in support of the field demonstration sampling plan for both field and laboratory analyses are presented in Appendix C of this report. The analytical methods that were used summarized in Table 5.6.3-1 below.

**Table 5.6.3-1. Analytical methods employed during this project.**

Analyte	Method	Instrumentation	Detection limit (or accuracy)	Units
<u>Field</u>				
pH	EPA Method 150.1	portable pH probe	± 0.01	Standard Units (S.U.)
Soil gases (O <sub>2</sub> , CO <sub>2</sub> )	-	portable gas analyzer	± 0.01	percent (%)
Soil moisture content	-	capacitance-based sensor	± 3%	percent (%)
Precipitation	-	tipping bucket	± 0.01	inches (per measurement interval)
Sunlight	-	pyranometer	± 0.1	watt/m <sup>2</sup>
Temperature	-	internal & external sensors	± 0.1	°F
<u>Laboratory</u>				
pH	EPA Method 150.1	pH probe	± 0.01	Standard Units (S.U.)
Explosives	SHAW ORG-006A <sup>a</sup>	HPLC	0.025	mg/L or mg/kg
Total organic carbon (TOC)	EPA Method 415.1	thermal combustion	0.1	mg/L
Biological oxygen demand (BOD)	EPA Method 405.1	oxygen probe, incubator	1.0	mg/L

<sup>a</sup>Shaw Environmental, Inc. performs a modified EPA Method 8330 for in house explosive compound analysis. The method includes the standard EPA Method 8330 analytes, as well as the primary RDX breakdown products MNX, DNX, TNX, for which semi-quantitative standards are used. The method SOP is included in Appendix B.

Based on previous work with explosive compounds in aqueous and solid samples, there were no major issues regarding possible interferences from the sample matrix that would not be resolvable using the established QA/QC procedures.

The evaluation of the technology was done by comparing data from the triplicate control and triplicate treatment soil plots. Comparisons of the data from the individual soil plots, as well as comparisons of the arithmetic average of the data from the triplicate soil plots, was conducted. Standard deviations of the data from the triplicate soil plots were calculated according to

standard procedures using Microsoft Excel when at least datapoints were available (i.e., no standard deviation would be calculated for averages with  $n < 3$ ). Comparisons of post-demonstration soil concentrations of explosives through the soil profile of the soil pots were done by comparing the averages and standard deviations of eight subsamples collected from each depth interval (as calculated using Excel). The primary comparisons were done with data from individual sampling timepoints. The cumulative flux of explosives was estimated by calculating the area under the time vs. concentration curves using interpolation methods. Additional statistical analyses were applied to the data as deemed necessary.

#### ***5.6.4 Experimental Controls***

The experimental controls for this field demonstration were the three replicate soil plots that were designated as controls and did not receive any of the PMSO treatment material. The verification of the technology was performed by comparing the aqueous explosive concentrations detected in the soil pore water samples from the control soil plots and the treatment soil plots. This comparison was conducted both on a timepoint-specific basis (i.e., soil pore water concentrations of RDX at a depth of 15 cm (6”) at time = X days), as well as by examining overall trends over the entire duration of the demonstration.

#### ***5.6.5 Data Quality Parameters***

Data quality parameters to ensure the representativeness, completeness, comparability, accuracy, and precision of the data were described in the QAPP, Appendix D of Part I of this report.

#### ***5.6.6 Calibration Procedures, Quality Control Checks, and Corrective Action***

All reasonable and necessary calibration procedures, duplicate and control testing, and data reduction and reporting were performed as described in the QAPP, Appendix D of Part I of this report.

The analysis of aqueous explosive concentrations in soil pore water and soil plot drainage water via HPLC were the most important data required for the successful evaluation of the technology

during the field demonstration. At a minimum, a standard curve was generated every three months using known concentrations of the EPA Method 8330 explosive standards. Qualitative retention time standards were included with every batch of samples analyzed and run after every 10 sample analyses during a given HPLC run. A new standard curve was generated in the event of an HPLC column replacement, detector replacement or repair, or in the event of other major repairs. Routine maintenance of the HPLC was performed as recommended by the HPLC manufacturer.

HPLC data (chromatograms) from each sample was examined visually, and the sample was re-analyzed if deemed necessary. Confirmation of peaks identified by the UV detector was performed by examining the Photo Diode Array (PDA) spectrum and comparing it to PDA spectra of known compounds. Peaks that were clearly visible but which were not automatically integrated were manually integrated using the HPLC software. Hardcopies of HPLC data were retained for the duration of the project, and digital HPLC data files were backed-up on a regular basis.

HPLC data were entered into Microsoft Excel for analysis and compilation. Concentrations falling below the detection limit were recorded as either a blank cell, “0”, or “BD”, depending on the use to which the data was used (i.e., for some data presentations like graphing, a value of “BD” is not included in the graph and a zero is required). Estimated (“J”) values were entered as notes in the Excel spreadsheet. Any errors during data entry were corrected by referring to the original data files/printouts.

#### ***5.6.7 Data Quality Indicators***

Data quality indicators were described in the QAPP, Appendix D of Part I of this report.

### **5.7 Selection of Analytical/Testing Methods**

The contaminants that were the focus of this field demonstration were TNT, RDX, and their respective breakdown products. The key data generated from this demonstration were the

aqueous explosive concentrations in the soil pore water and soil plot drainage water, and the soil concentrations within the soil plots at the end of the demonstration. To achieve this, the central method employed was a modified EPA Method 8330, as detailed in Appendix C of Part I of this report.

All other analytical procedures were performed according to established Standard Operating Procedures and EPA Methods (as applicable).

### **5.8 Selection of Analytical/Testing Laboratory**

The primary analyses for this demonstration were performed in-house by Shaw. Shaw laboratory personnel have the required expertise, experience, and analytical instrumentation to analyze the samples for explosive concentrations. Samples submitted for explosives and TOC were handled by Shaw's Analytical Testing Laboratory, 17 Princess Road, Lawrenceville, NJ 08648. The Analytical Testing Laboratory's New Jersey Department of Environmental Protection (NJDEP) Certified Laboratory Identification Number is 11001. Shaw Environmental's Analytical Testing Laboratory is certified in New Jersey and adheres to all relevant QA/QC procedures and policies.

Approximately 5% of samples (as splits/duplicates) were sent to Severn Trent Laboratories (STL) in Burlington, VT for confirmatory analysis of explosive concentrations. STL Burlington, 208 South Park Drive, Suite 1, Colchester, VT 05446; Certification Identification Number: VT972. Severn Trent Burlington has extensive experience with analysis of both standard and non-standard samples for explosive compounds, and has been involved with the research and remediation at MMR for several years.

## 5.8 Sampling Results

### *5.8.1 Pore Water and Drainage Water Explosive Concentrations*

#### **Explosives detected.**

A full raw data listing is provided in Table E-5.8.1, Appendix E of Part I of this report. A summary of the explosive compound detections across all the aqueous samples analyzed is presented in Table 5.8.1-1. Many of the compounds were detected before the Composition B residues were applied, were detected less than 10 times over the course of the entire project (out of a total of 806 analyses performed), were not detected in the actual Composition B residues applied to the soil plots, or would not be expected breakdown products from the components of the applied Composition B. Therefore, no further analysis of the data for the following compounds was performed: TNB, DNB, NB, 2,4-DNT, 2,6-DNT, tetryl, 2-NT, 3-NT, and 4-NT.

The maximum concentrations of the compounds of interest (MNX, DNX, TNX, HMX, RDX, TNT, 2A-DNT, and 4A-DNT) at each timepoint and over the course of the demonstration are presented in Table 5.8.1-2. Again, many of the detections were made prior to application of the Composition B residues, and are therefore of less interest. Additionally, we believe that the use of an HPLC without a photodiode array (PDA) prior to June 2007 lead to some misidentification of peaks as detections of RDX and its breakdown products. It is likely that these peaks were actually not RDX, etc., but were artifacts and/or interferences that could not be verified spectrally using the PDA.

Of the remaining compounds of interest, the only one originating from the applied Composition B residues that was detected in aqueous samples with a high frequency was RDX (detected in 200 out of 806 analyses). HMX and TNT were only detected 44 and 7 times, respectively. Of these TNT detections, the maximum concentration of TNT (64 µg/L) was detected before the residues were applied. The breakdown products of RDX and TNT were also only detected sporadically, and only at very low concentrations.

**Table 5.8.1-1. Summary of explosive compound detections in all samples collected over the duration of the demonstration.**

		Compound Detections								
Sample Collected & Analyzed		TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT
Pre-Residue Application		37	25	40	33	11	96	3	11	2
Post-Residue Application		22	25	120	11	189	2	2	2	5
Full Project Duration		59	50	160	44	200	98	5	13	7
% Detected Pre-Residue Application		63	50	25	75	6	98	60	85	29
% Detected Post-Residue Application		37	50	75	25	95	2	40	15	71
Sample Collected & Analyzed		2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Pre-Residue Application		0	2	0	0	0	1	2	0	
Post-Residue Application		5	1	6	4	1	4	1	2	
Full Project Duration		5	3	6	4	1	5	3	2	
% Detected Pre-Residue Application		0	67	0	0	0	20	67	0	
% Detected Post-Residue Application		100	33	100	100	100	80	33	100	

**Table 5.8.1-2. Maximum explosive compound concentrations in all samples over time.**

		Dissolved Explosives (maximum concentration detected across all samples at a given timepoint)								
Events	Sample	Elapsed	µg/L							
	Date		TNX	DNX	MXN	HMX	RDX	TNT	4ADNT	2ADNT
Mobilization	08/15/06									
	09/08/06	24	<50	<50	<50	122	77	64	<25	<25
	09/22/06	38	<50	182	131	<25	40	<25	<25	<25
PMSO Added	10/13/06	59	164	150	<50	<25	<25	<25	<25	<25
	10/27/06	73	135	<50	133	<25	<25	<25	<25	<25
	11/10/06	87	437	203	<50	113	<25	<25	<25	<25
Start Stand-by	12/19/06	126	1850	256	246	220	58	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	339	55	54	<25	<25	<25
	05/30/07	288	<50	<50	531	<25	347	<25	<25	<25
Residues added	06/13/07	302	21	31	9	<10	1	<10	<10	<10
	06/28/07	317	21	<25	266	179	44	<10	<10	<10
	07/27/07	346	<25	<25	22	<10	271	11	<10	<10
	08/09/07	358	<25	<25	23	<10	622	15	19	17
	09/05/07	386	29	156	30	133	698	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	1039	<10	<10	<10
	11/15/07	457	<25	1	184	156	5810	<10	1	<10
Start Stand-by	12/19/07	491	<25	<25	<25	<10	903	<10	<10	<10
	01/09/08	512	<25	<25	150	<10	5630	<10	<10	<10
End Stand-by	03/25/08	588	<25	<25	8	<10	10280	<10	<10	<10
	04/15/08	609	<25	18	179	<10	5060	<10	<10	<10
	04/28/08	622	34	124	266	<10	3940	<10	<10	<10
	04/30/08	624	53	138	386	<10	8490	<10	<10	<10
	05/01/08	625	19	74	325	<10	7240	<10	<10	<10
	06/10/08	665	13	33	359	5	8780	1	19	17
Demobilization	09/23/08	770	58	697	274	<10	5610	<10	<10	<10
		Dissolved Explosives (maximum concentration detected over course of entire demonstration)								
		µg/L								
		TNX	DNX	MXN	HMX	RDX	TNT	4ADNT	2ADNT	
		1850	697	531	220	10280	64	19	17	

Of the parent compounds of interest, only RDX was detected with enough frequency across the controls and some of the treatments to warrant a more detailed analysis. Similarly, only the RDX breakdown product MNX was detected in enough samples to allow any meaningful comparisons between the treatments and the controls to be made.

In all subsequent results presentations, the data from the plots has been grouped in table with the triplicate controls (CON) and treatment (PO1, PO2) together to facilitate comparisons.

## **Aqueous RDX data analysis**

### **Pore water RDX concentrations at 15 cm (6") depth.**

A summary of the pore water RDX concentrations in samples collected from the 15 cm ceramic sampler in each soil plot is presented in Table 5.8.1-3, and graphs are included in Figure 5.8.1-1 and Figure 5.8.1-2. Figure 5.8.1-1 presents the data with the replicate soil plots having the same symbol, color, and line thickness to allow easier comparisons between the control and the treatments. Figure 5.8.1-2 presents the data with separate symbols for each plot, allowing differences between individual plots to be examined. The dashed vertical lines indicate when the PMSO and Composition B residues were applied, respectively. The data indicate that both the PO1 and PO2 treatment plots reduced the pore water RDX concentrations at 15 cm compared to the control plots, with the PO2 treatment performing substantially better than the PO1 treatment. The amount of data collected before, during, and after a high precipitation event (Days 609, 622, 624, 625) was not high enough to draw firm conclusions about increases in RDX concentrations at the 15 cm sampling depth.

### **Pore water RDX concentrations at 45 cm (18") depth.**

A summary of the pore water RDX concentrations in samples collected from the 45 cm ceramic sampler in each soil plot is presented in Table 5.8.1-4 and graphs are included in Figure 5.8.1-3 and Figure 5.8.1-4. Figure 5.8.1-3 presents the data with the replicate soil plots having the same symbol, color, and line thickness to allow easier comparisons between the control and the treatments. Figure 5.8.1-4 presents the data with separate symbols for each plot, allowing differences between individual plots to be examined. The dashed vertical lines indicate when the PMSO and Composition B residues were applied, respectively. The data indicate that both the PO1 and PO2 treatment plots reduced the pore water RDX concentrations at 45 cm compared to the control plots, with the PO2 treatment performing substantially better than the PO1 treatment. RDX concentrations in one PO1 plot, SP1-4 actually exceeded those observed in the control plots. A little more data was obtained before, during, and after a high precipitation event (Days 609, 622, 624, 625) that seemed to show a general increases in RDX concentrations at the 45 cm sampling depth for both the control and PO1 treatment plots, but not for the PO2 plots.

### **RDX concentrations in drainage water.**

A summary of the RDX concentrations in drainage water samples collected from each soil plot is presented in Table 5.8.1-5 and graphs are included in Figure 5.8.1-5 and Figure 5.8.1-6. Figure 5.8.1-5 presents the data with the replicate soil plots having the same symbol, color, and line thickness to allow easier comparisons between the control and the treatments. Figure 5.8.1-6 presents the data with separate symbols for each plot, allowing differences between individual plots to be examined. The dashed vertical lines indicate when the PMSO and Composition B residues were applied, respectively. With the exception of the last datapoint for plot SP1-4, the results indicate that both the PO1 and PO2 treatment the RDX concentrations in the soil plot drainage water dramatically compared to the control plots. Results from the high sampling rate event (Days 609, 622, 624, 625) did not indicate gross changes in the RDX concentrations in drainage from either the control or the treatment plots.

### **Summary of aqueous RDX concentration data**

Table 5.8.1-6 to Table 5.8.1-8 present the average aqueous RDX concentrations observed in the control and treatment plots at each sampling depth over the course of the demonstration. Standard deviations are presented, if applicable. To facilitate calculations and allow more comparisons between the control and the treatments, samples with concentrations below the method detection limit were set to one-half of the detection limit.

At the 15 cm sampling depth, the average RDX concentrations in the PO1 and PO2 plots were consistently lower than the control plots, with the exception of the PO1 plots for a short period of time immediately after the residues were applied (Days 346, 359, 386, and 427). In contrast, at the 45 cm sampling depth the average concentrations of RDX in the PO1 treatment plots was higher than observed in the control plots. However, the standard deviations were quite large, as the averages were skewed by the high concentrations observed in SP1-4. At the 45 cm sampling depth, the RDX concentrations in the PO2 plots were always very low, usually below the detection limit. The drainage water from the treatment plots generally contained lower RDX

concentrations than observed in the control plots. A more systematic analysis of the data is presented in Section 6 with respect to the performance criteria.

It was also apparent from looking at the data closely that, although the plots were set up to be replicates of each other, there were some differences that expressed themselves in the RDX concentration data. These differences are made apparent in the large standard deviations of some of the averages. Looking at the data for the individual plots, the control plot SP1-6 seemed to behave differently at the 45 cm and drainage water sampling points than control plots SP1-2 and SP1-7. SP1-4 of the PO1 triplicate plots behave differently than its replicate plots SP1-1 and SP1-9, especially at the 45 cm sampling depth.

**Table 5.8.1-3. RDX concentrations in 15 cm pore water samples.**

A “-“ indicates no sample was able to be collected and analyzed.

Event	Elapsed	Sample Date	RDX ug/L											
			SP1.2 (CON)	SP1.6 (CON)	SP1.7 (CON)	SP1.1 (PO1)	SP1.4 (PO1)	SP1.9 (PO1)	SP1.3 (PO2)	SP1.5 (PO2)	SP1.8 (PO2)			
Mobilization	24	09/08/06	<25	<25	61.9	<25	<25	76.7	<25	<25	-	<25	<25	-
	38	09/22/06	<25	-	35.5	<25	<25	39.7	<25	<25	-	<25	<25	-
PMSO Added	59	10/13/06	<25	<25	<25	<25	<25	-	<25	<25	-	<25	<25	<25
	73	10/27/06	<25	<25	<25	<25	<25	<25	<25	<25	-	<25	<25	<25
Start Stand-by	87	11/10/06	<25	<25	-	<25	<25	<25	<25	<25	-	<25	<25	<25
End Stand-by	126	12/19/06	<25	<25	-	<25	<25	<25	<25	<25	-	<25	<25	<25
	267	05/09/07	<25	<25	-	<25	<25	<25	<25	<25	-	<25	<25	<25
	288	05/30/07	<25	<25	-	<25	<25	<25	<25	<25	-	<25	<25	<25
Residues added	302	06/13/07	<25	<25	-	<25	<25	<25	<25	<25	-	<25	<25	<25
	317	06/29/07	-	<10	-	-	<10	<10	<10	<10	-	<10	<10	<10
	346	07/27/07	-	<10	-	-	271	<10	<10	<10	-	<10	<10	<10
	359	08/09/07	<10	<10	-	-	622	348	<10	<10	-	34	<10	<10
	386	09/05/07	-	-	-	-	698	583	<10	<10	-	<10	<10	<10
	427	10/16/07	272	<10	420	112	676	385	<10	<10	-	<10	<10	<10
Start Stand-by	457	11/15/07	3260	4000	5810	2510	1020	3660	<10	<10	-	<10	<10	<10
	493	12/21/07	-	-	-	-	-	-	-	-	-	-	-	-
	511	01/09/08	3040	-	5630	-	-	-	-	-	-	-	-	-
End Stand-by	588	03/25/08	-	-	-	-	-	-	-	-	-	-	-	-
	609	04/15/08	3930	-	5010	-	-	-	-	-	-	<10	<10	-
	622	04/28/08	-	-	-	-	-	-	-	-	-	<10	<10	-
	624	04/30/08	7810	3310	8490	1360	3430	-	<10	<10	-	<10	<10	-
	625	05/01/08	6250	3200	-	1650	-	-	<10	<10	-	<10	<10	-
	666	06/10/08	8780	-	-	108	-	209	<10	<10	-	<10	<10	<10
Demobilization	770	09/23/08	-	<10	-	<10	-	<10	<10	<10	-	<10	<10	<10

**Table 5.8.1-4. RDX concentrations in 45 cm pore water samples.**  
 A “-“ indicates no sample was able to be collected and analyzed.

Event	Elapsed	Sample Date	RDX ug/L												
			SP1.2 (CON)	SP1.6 (CON)	SP1.7 (CON)	SP1.1 (P01)	SP1.4 (P01)	SP1.9 (P01)	SP1.3 (P02)	SP1.5 (P02)	SP1.8 (P02)				
Mobilization	24	09/08/06	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMISO Added	36	09/22/06	<25	30.6	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	59	10/13/06	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	73	10/27/06	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	87	11/10/06	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	126	12/19/06	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	267	05/09/07	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues added	268	05/30/07	<25	<25	324	-	-	<25	<25	<25	<25	<25	<25	<25	<25
	302	06/13/07	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	317	06/28/07	<10	<10	<10	-	<10	<10	<10	<10	<10	<10	<10	<10	<10
	346	07/27/07	<10	<10	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10
	359	08/09/07	-	<10	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10
	386	09/05/07	-	<10	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	427	10/16/07	<10	<10	<10	<10	103	<10	<10	146	<10	<10	<10	<10	<10
	457	11/15/07	<10	<10	<10	637	<10	406	<10	4220	<10	<10	<10	<10	<10
	493	12/21/07	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	511	01/08/08	<10	<10	83.5	-	-	<10	<10	2390	-	-	-	-	-
	588	03/25/08	-	-	<10	-	-	-	-	-	-	-	-	-	-
	609	04/15/08	44	-	428	389	1100	920	-	-	-	-	-	-	-
	622	04/28/08	-	-	-	419	1140	594	-	-	-	-	-	-	-
	624	04/30/08	146	<10	837	574	1730	935	<10	<10	<10	<10	<10	<10	<10
	625	05/01/08	393	-	883	-	2460	-	-	-	-	-	-	-	-
Demobilization	665	06/10/08	-	-	1370	157	6050	193	<10	<10	<10	<10	<10	<10	<10
	770	09/23/08	3660	<10	-	<10	5610	<10	<10	<10	<10	<10	<10	<10	<10

**Table 5.8.1-5. RDX concentrations in drainage water samples.**

A “-“ indicates no sample was able to be collected and analyzed.

Event	Elapsed	Sample Date	RDX ug/L														
			SP1.2 (CON)	SP1.6 (CON)	SP1.7 (CON)	SP1.1 (P01)	SP1.4 (P01)	SP1.9 (P01)	SP1.3 (P02)	SP1.5 (P02)	SP1.8 (P02)						
Mobilization		08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	24	09/08/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	38	09/22/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added		10/13/06	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	73	10/27/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Start Stand-by		11/10/06	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by		12/19/06	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	267	05/09/07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	288	05/30/07	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues added		06/13/07	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	317	06/28/07	<10	<10	<10	43.8	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	13.5
	346	07/07/07	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	122
	359	08/09/07	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	366	09/05/07	<10	<10	<10	39.5	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	427	10/16/07	<10	<10	<10	34.3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	235
Start Stand-by		11/15/07	131	<10	697	29.5	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	662
	457	11/15/07	824	<10	903	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by		01/08/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	511	03/25/08	667	<10	5500	45.6	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	609	04/15/08	1100	<10	1530	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	622	04/28/08	1600	<10	2190	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	624	04/30/08	1600	<10	2310	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	625	05/01/08	1710	<10	2510	-	-	-	-	-	-	-	-	-	-	-	-
	665	06/10/08	1970	<10	3140	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	660
Demobilization		09/23/08	3000	<10	3450	3660	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

**Table 5.8.1-6. Average RDX concentrations in 15 cm pore water samples.**

A “-“ indicates no sample was able to be collected and analyzed.

Values below the method detection limit were set to one-half of the detection limit.

Standard deviations were only calculated when n=3.

Event	Elapsed	Sample Date	RDX Concentration		
			Control ug/L	P01	P02
Mobilization		08/15/06	-	-	-
	24	09/08/06	29 ± 29	-	13
	38	09/22/06	24	22 ± 16	13
PMSO Added	59	10/13/06	13 ± 0	13	13 ± 0
	73	10/27/06	13	13	13 ± 0
	87	11/10/06	13	13 ± 0	13 ± 0
Start Stand-by	126	12/19/06	13	13	13
End Stand-by	267	05/09/07	13	13	13
	288	05/30/07	13	13	13
Residues added	302	06/13/07	13	13	13 ± 0
	317	06/28/07	-	3	3 ± 0
	346	07/27/07	-	137	3 ± 0
	359	08/09/07	3	485	13 ± 18
	386	09/05/07	-	641	3 ± 0
	427	10/16/07	346	391 ± 282	3 ± 0
	457	11/15/07	4535	2397 ± 1324	42 ± 68
Start Stand-by	493	12/21/07	-	-	-
	511	01/08/08	4335	-	-
End Stand-by	588	03/25/08	-	-	-
	609	04/15/08	4470	-	3
	622	04/28/08	-	-	3
	624	04/30/08	8150	2390	3
	625	05/01/08	6250	1650	3
	665	06/10/08	8780	159	3 ± 0
Demobilization	770	09/23/08	-	3	3 ± 0

**Table 5.8.1-7. Average RDX concentrations in 45 cm pore water samples.**

A “-“ indicates no sample was able to be collected and analyzed.

Values below the method detection limit were set to one-half of the detection limit.

Standard deviations were only calculated when n=3.

Event	Elapsed	Sample Date	RDX Concentration		
			Control ug/L	P01	P02
Mobilization		08/15/06	-	-	-
	24	09/08/06	13 ± 0	-	13 ± 0
	38	09/22/06	19 ± 10	13 ± 0	13 ± 0
PMSO Added	59	10/13/06	13 ± 0	13 ± 0	13 ± 0
	73	10/27/06	13	13 ± 0	13 ± 0
	87	11/10/06	13 ± 0	13	13 ± 0
Start Stand-by	126	12/19/06	13	13	13 ± 0
End Stand-by	267	05/09/07	13	13	13 ± 0
	288	05/30/07	116 ± 180	13	13 ± 0
Residues added	302	06/13/07	13 ± 0	13 ± 0	13 ± 0
	317	06/28/07	3	3	3 ± 0
	346	07/27/07	3	3	3 ± 0
	359	08/09/07	-	3	3 ± 0
	386	09/05/07	-	3 ± 0	3 ± 0
	427	10/16/07	3	84 ± 74	3 ± 0
	457	11/15/07	3	1754 ± 2138	3 ± 0
Start Stand-by	493	12/21/07	-	-	-
	511	01/08/08	43	1196	-
End Stand-by	588	03/25/08	3	-	-
	609	04/15/08	236	803 ± 370	-
	622	04/28/08	-	718 ± 376	-
	624	04/30/08	492	1080 ± 591	3
	625	05/01/08	538	2460	3
	665	06/10/08	1370	2133 ± 3392	3 ± 0
Demobilization	770	09/23/08	3660	1872 ± 3237	3 ± 0

**Table 5.8.1-8. Average RDX concentrations in drainage water samples.**

A “-“ indicates no sample was able to be collected and analyzed.

Values below the method detection limit were set to one-half of the detection limit.

Standard deviations were only calculated when n=3.

Event	Elapsed	Sample Date	RDX Concentration		
			Control ug/L	P01	P02
Mobilization		08/15/06	-	-	-
	24	09/08/06	-	-	-
	38	09/22/06	-	-	-
PMSO Added	59	10/13/06	13 ± 0	13 ± 0	13 ± 0
	73	10/27/06	-	-	-
	87	11/10/06	13 ± 0	13 ± 0	13 ± 0
Start Stand-by	126	12/19/06	13 ± 0	13 ± 0	13 ± 0
End Stand-by	267	05/09/07	-	-	-
	288	05/30/07	13 ± 0	13 ± 0	13 ± 0
Residues added	302	06/13/07	13 ± 0	13 ± 0	13 ± 0
	317	06/28/07	3	16 ± 24	6 ± 6
	346	07/27/07	3	3 ± 0	42 ± 69
	359	08/09/07	3	3 ± 0	3 ± 0
	386	09/05/07	3	15 ± 21	3 ± 0
	427	10/16/07	3	13 ± 18	80 ± 134
	457	11/15/07	414	12 ± 16	222 ± 381
Start Stand-by	493	12/21/07	864	3 ± 0	3 ± 0
	511	01/08/08	-	3	-
End Stand-by	588	03/25/08	3094	17 ± 25	3 ± 0
	609	04/15/08	1315	3 ± 0	3 ± 0
	622	04/28/08	1895	3 ± 0	3 ± 0
	624	04/30/08	1955	3 ± 0	3 ± 0
	625	05/01/08	2110	3	3 ± 0
	665	06/10/08	2555	3 ± 0	218 ± 374
Demobilization	770	09/23/08	3225	1188 ± 2054	3 ± 0

**Figure 5.8.1-1. Concentrations of RDX in soil pore water collected at a depth of 15 cm (replicates with same symbols).**

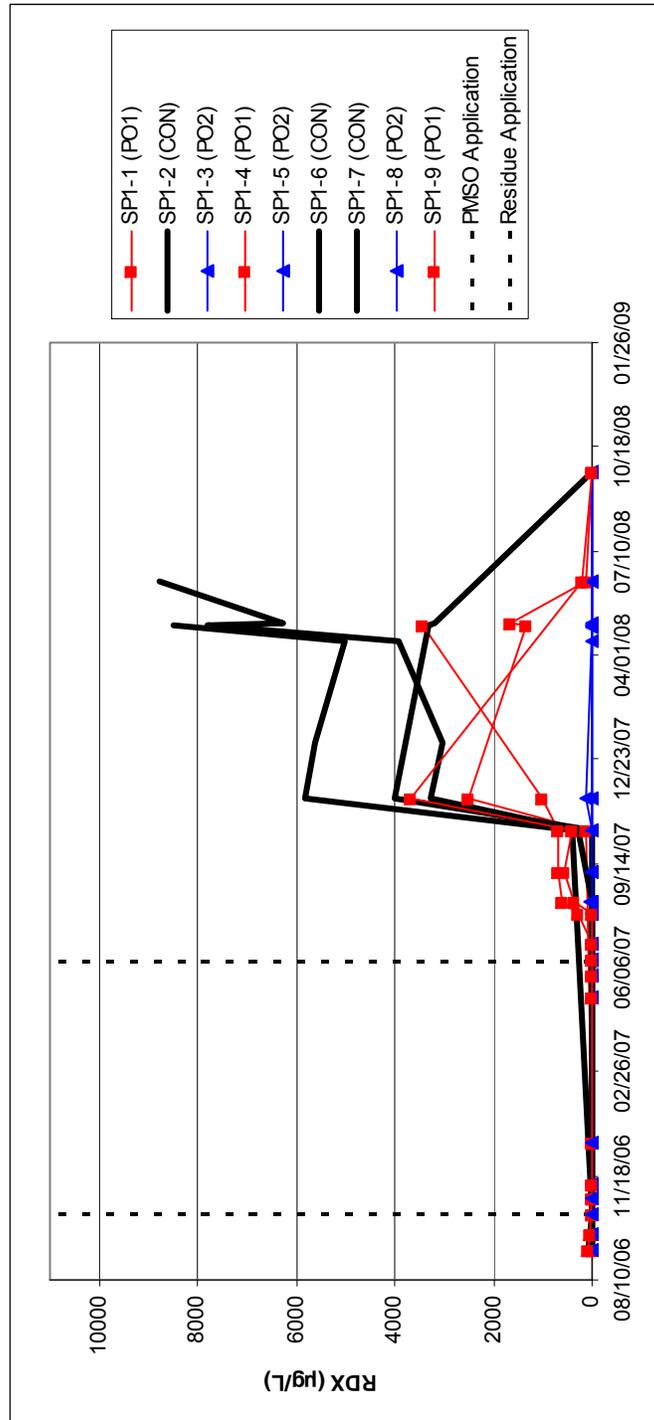


Figure 5.8.1-2. Concentrations of RDX in soil pore water collected at a depth of 15 cm (replicates with different symbols).

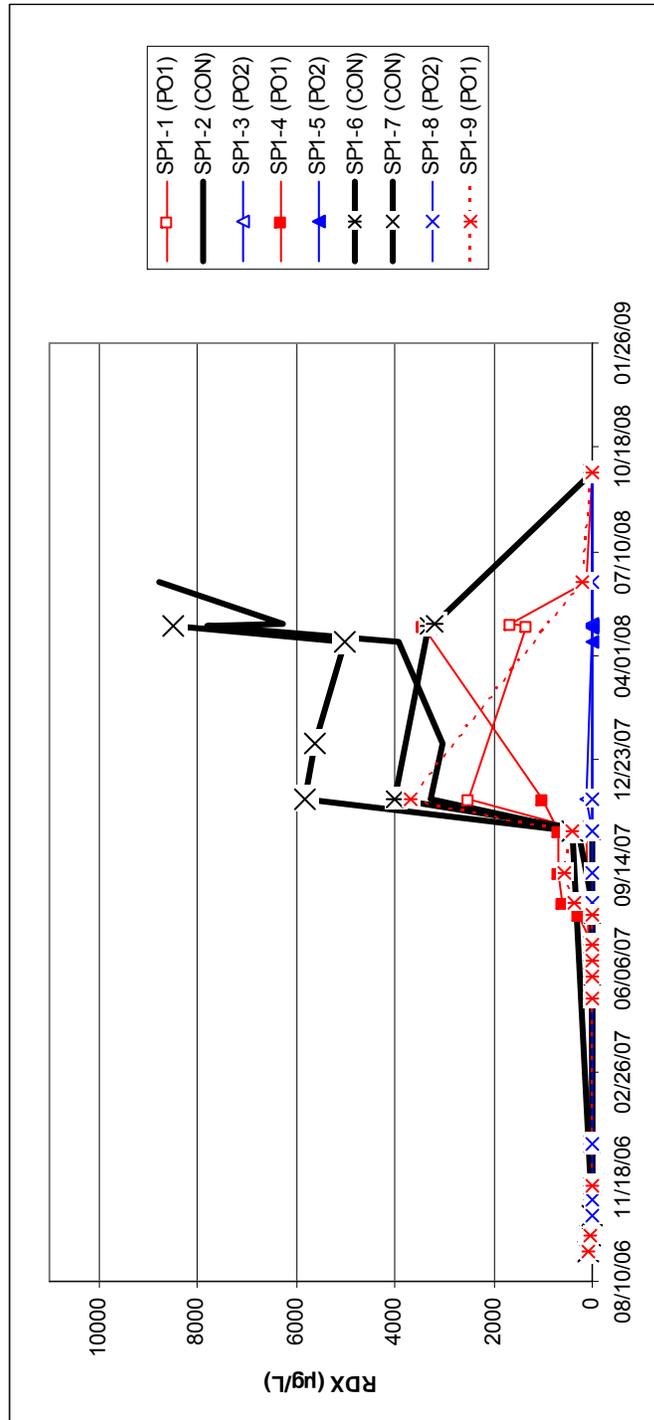


Figure 5.8.1-3. Concentrations of RDX in soil pore water collected at a depth of 45 cm (replicates with same symbols).

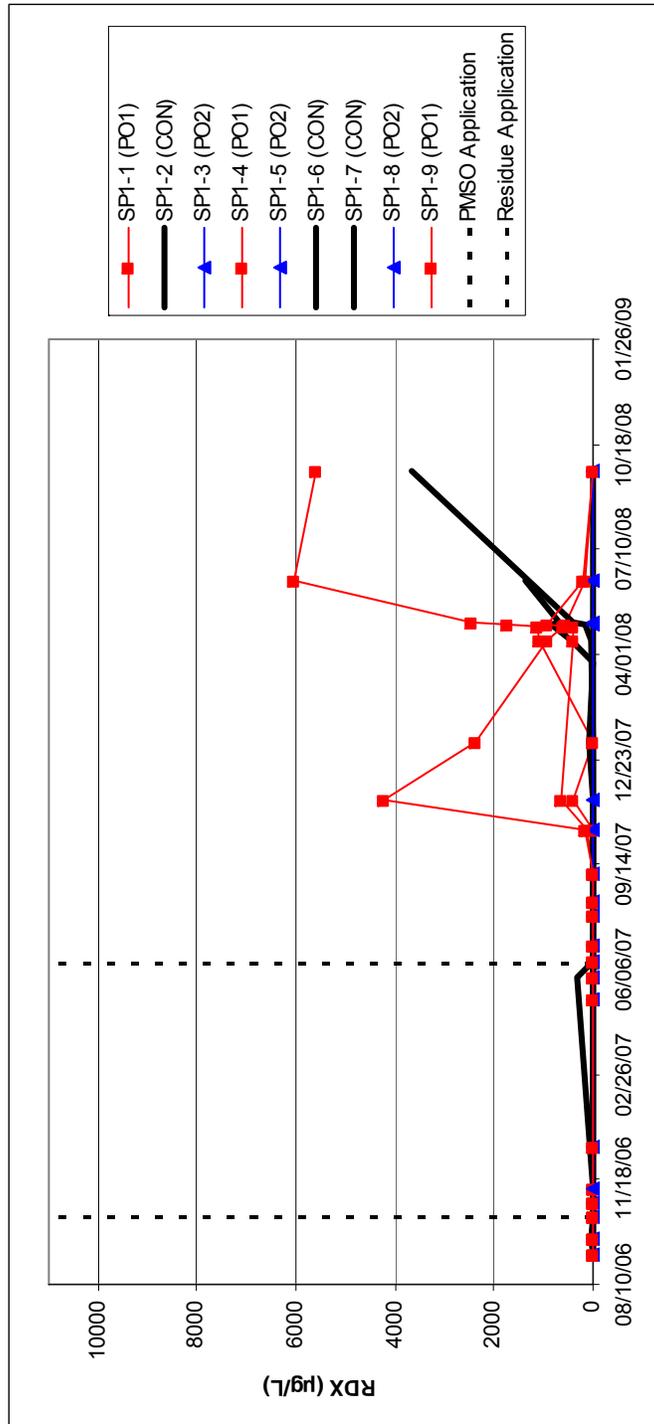


Figure 5.8.1-4. Concentrations of RDX in soil pore water collected at a depth of 45 cm (replicates with different symbols).

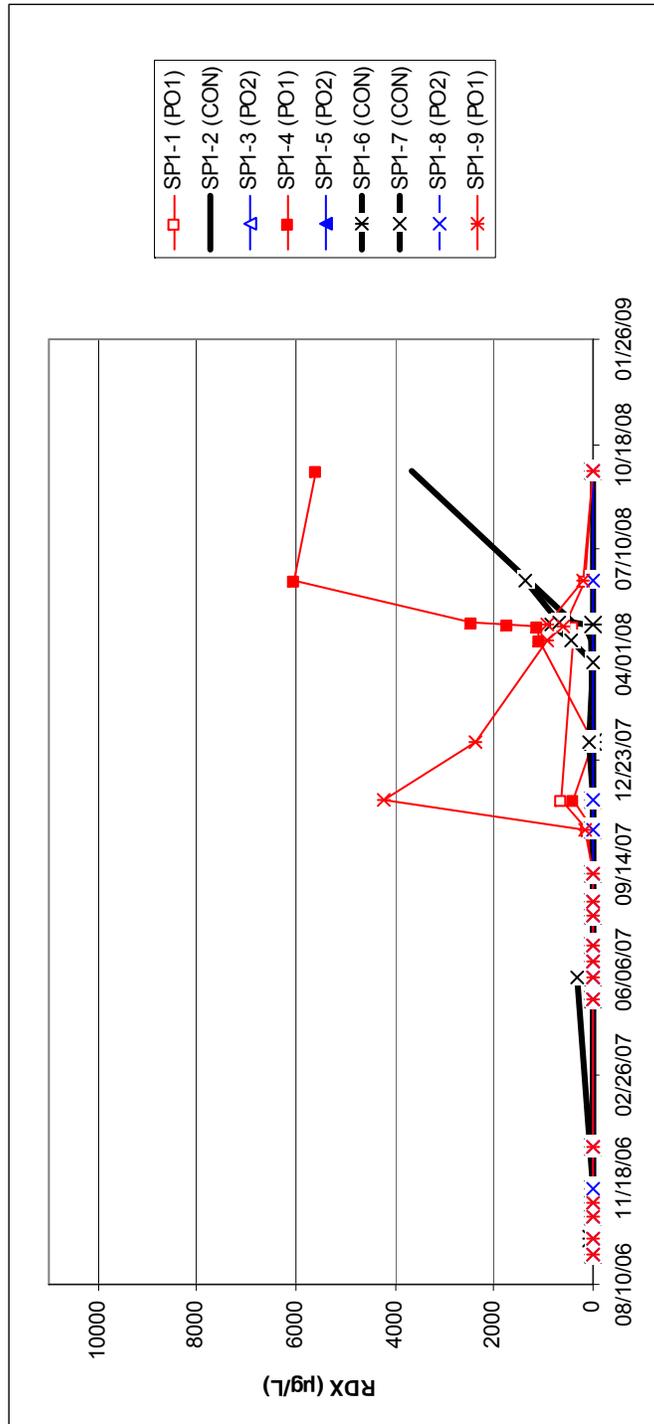


Figure 5.8.1-5. Concentrations of RDX in drainage water (replicates with same symbols).

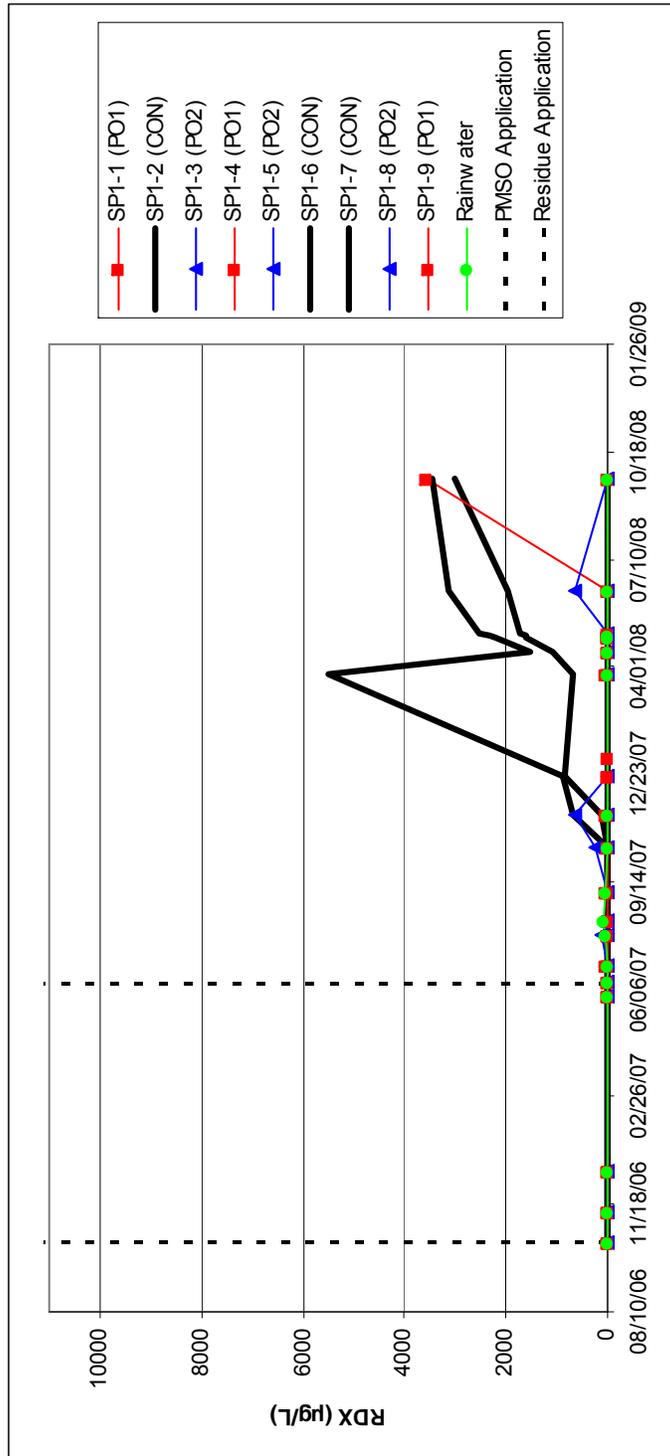
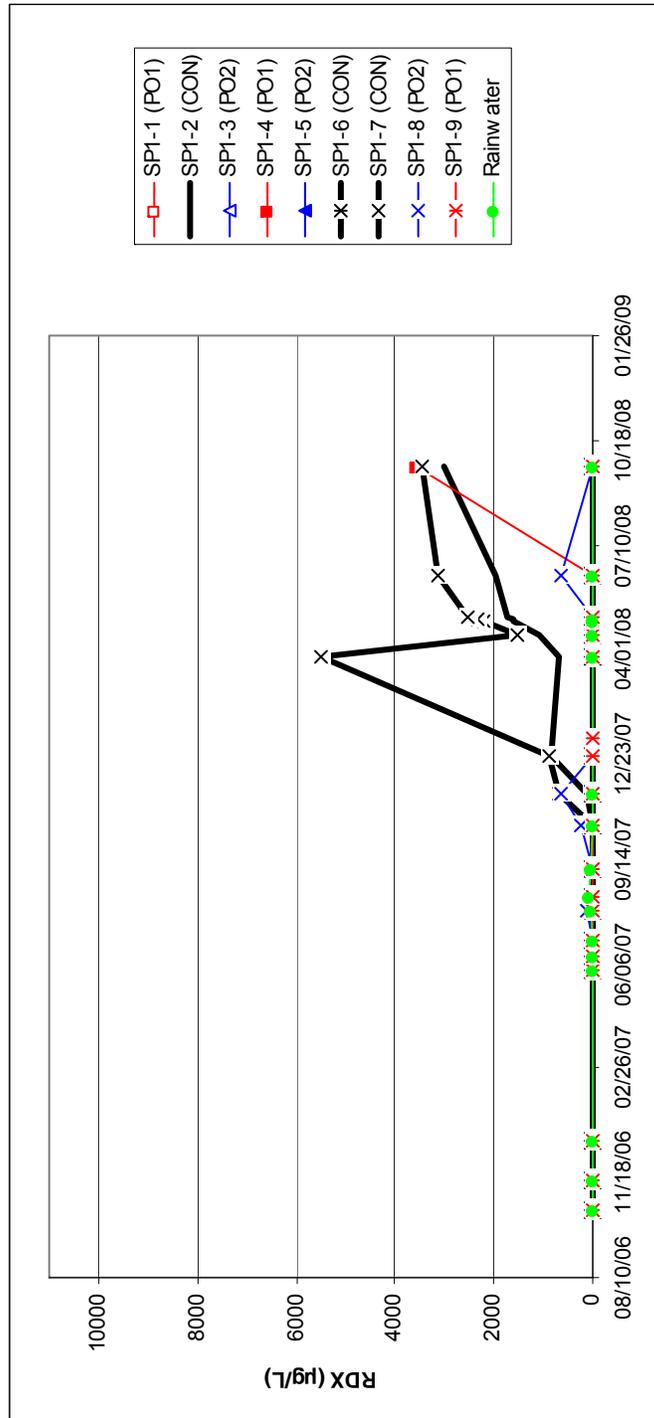


Figure 5.8.1-6. Concentrations of RDX in drainage water (replicates with different symbols).



## **Aqueous MNX data analysis**

### **Pore water MNX concentrations at 15 cm (6") depth.**

A summary of the pore water MNX concentrations in samples collected from the 15 cm ceramic sampler in each soil plot is presented in Table 5.8.1-9, and graphs are included in Figure 5.8.1-7 and Figure 5.8.1-8. Values tagged as “J” were set to the detection limit in Table 5.8.1-9. Figure 5.8.1-7 presents the data with the replicate soil plots having the same symbol, color, and line thickness to allow easier comparisons between the control and the treatments. Figure 5.8.1-8 presents the data with separate symbols for each plot, allowing differences between individual plots to be examined. The dashed vertical lines indicate when the PMSO and Composition B residues were applied, respectively. At 15 cm, MNX was always below the detection limit in the PO2 plots. MNX concentrations in the PO1 and control plots were sporadic, and no clear comparisons could be made.

### **Pore water MNX concentrations at 45 cm (18") depth.**

A summary of the pore water MNX concentrations in samples collected from the 45 cm ceramic sampler in each soil plot is presented in Table 5.8.1-10 and graphs are included in Figure 5.8.1-9 and Figure 5.8.1-10. Values tagged as “J” were set to the detection limit in Table 5.8.1-10. Figure 5.8.1-9 presents the data with the replicate soil plots having the same symbol, color, and line thickness to allow easier comparisons between the control and the treatments. Figure 5.8.1-10 presents the data with separate symbols for each plot, allowing differences between individual plots to be examined. The dashed vertical lines indicate when the PMSO and Composition B residues were applied, respectively. MNX concentrations at the 45 cm sampling depth were also always below the detection limit in the PO2 plots. More frequent detections and higher concentrations of MNX were observed in the PO1 plots compared to the control plots.

### **MNX concentrations in drainage water.**

A summary of the MNX concentrations in drainage water samples collected from each soil plot is presented in Table 5.8.1-11 and graphs are included in Figure 5.8.1-11 and Figure 5.8.1-12. Values tagged as “J” were set to the detection limit in Table 5.8.1-11. Figure 5.8.1-11 presents

the data with the replicate soil plots having the same symbol, color, and line thickness to allow easier comparisons between the control and the treatments. Figure 5.8.1-12 presents the data with separate symbols for each plot, allowing differences between individual plots to be examined. The dashed vertical lines indicate when the PMSO and Composition B residues were applied, respectively. As with the 15 cm and 45 cm sampling depths, MNX was below the detection limit in the drainage water from all the PO2 plots during the entire demonstration (post-residue application). MNX was also not detected in the drainage from the PO1 plots, but multiple detections of MNX were observed in the control plot drainage.

### **Summary of aqueous MNX concentration data**

Table 5.8.1-12 to Table 5.8.1-14 present the average aqueous MNX concentrations observed in the control and treatment plots at each sampling depth over the course of the demonstration. Standard deviations are presented, if applicable. To facilitate calculations and allow more comparisons between the control and the treatments, samples with concentrations below the method detection limit were set to one-half of the detection limit. The MNX data from each set of triplicate plots seemed to have less between plot variability than the RDX data, as reflected in the generally reasonable standard deviations. The notable exception would be the average MNX concentrations measured at the 45 cm sampling depth in the PO1 plots.

MNX was generally at quite concentrations low when it was detected. The fact that the PO2 plots never had any detections of MNX indicates that either i) RDX was not being degraded; ii) MNX was not being formed during RDX degradation, or; iii) MNX was effectively being sequestered or further degraded at a rate faster than would allow for some of it to leach into and through the soil at least 15 cm (position of the first sampling point). Reason (i) is unlikely given all the previous data on the PMSO technology (1, 2, 8). Reason (ii) cannot be ruled out for these soil plots, although previous experiments with PMSO in smaller soil columns did detect MNX, although sporadically (2). Reason (iii) seems to be the best supported by all that is currently known about the PMSO material. A more systematic analysis of the data is presented in Section 6 with respect to the performance criteria.

**Table 5.8.1-9. MNX concentrations in 15 cm pore water samples.**  
 A “-“ indicates no sample was able to be collected and analyzed.

Event	Elapsed	Sample Date	MNX ug/L											
			SP1.2 (CON)	SP1.5 (CON)	SP1.7 (CON)	SP1.1 (P01)	SP1.4 (P01)	SP1.9 (P01)	SP1.3 (P02)	SP1.5 (P02)	SP1.8 (P02)			
Mobilization	24	08/15/06	-	<50	61.9	<50	<50	<50	76.7	<50	<50	-	<50	-
	38	09/22/06	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	-
PMSO Added	59	10/13/06	<50	<50	<50	<50	<50	<50	-	<50	<50	<50	<50	<50
	73	10/27/06	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Start Stand-by	87	11/10/06	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
End Stand-by	126	12/19/06	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	267	05/09/07	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	288	05/30/07	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Residues added	302	06/13/07	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	317	06/28/07	-	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	346	07/27/07	-	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	359	08/09/07	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	386	09/05/07	-	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	427	10/16/07	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	457	11/15/07	37.1	<25	117	119	<25	<25	184	<25	<25	<25	<25	<25
Start Stand-by	493	12/21/07	-	-	-	-	-	-	-	-	-	-	-	-
	511	01/08/08	90.1	-	88.4	-	-	-	-	-	-	-	-	-
End Stand-by	588	03/25/08	-	-	<25	-	-	-	-	-	-	-	<25	-
	609	04/15/08	<25	-	<25	-	-	-	-	-	-	-	<25	-
	622	04/28/08	-	-	-	-	-	-	-	-	-	-	<25	-
	624	04/30/08	178	-	265	70.5	58.3	-	-	<25	<25	<25	<25	-
	625	05/01/08	113	162	-	108	-	-	-	<25	<25	<25	<25	-
	665	06/10/08	369	-	-	57.2	-	-	34.5	<25	<25	<25	<25	<25
Demobilization	770	09/23/08	-	<25	-	<25	-	-	<25	<25	<25	<25	<25	<25

**Table 5.8.1-10. MNX concentrations in 45 cm pore water samples.**

A “-“ indicates no sample was able to be collected and analyzed.

Event	Elapsed	Sample Date	MNX ug/L											
			SP1.2 (CON)	SP1.6 (CON)	SP1.7 (CON)	SP1.1 (P01)	SP1.4 (P01)	SP1.9 (P01)	SP1.3 (P02)	SP1.5 (P02)	SP1.8 (P02)			
Mobilization	24	09/08/06	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
PMSO Added	38	09/22/06	<50	<50	120	<50	<50	<50	<50	<50	<50	<50	<50	<50
	59	10/13/06	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	73	10/27/06	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Start Stand-by	87	11/10/06	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
End Stand-by	126	12/19/06	<50	<50	-	-	149	<50	<50	<50	<50	<50	<50	<50
	267	05/09/07	86.8	243	-	-	149	258	107	<50	<50	<50	<50	339
	288	05/30/07	<50	326	<50	<50	300	<50	222	<50	<50	<50	<50	<50
Residues added	302	06/13/07	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	317	06/28/07	<25	266	<25	-	<25	<25	<25	<25	<25	<25	<25	<25
	346	07/27/07	<25	<25	<25	-	<25	<25	<25	<25	<25	<25	<25	<25
	359	08/09/07	-	<25	-	-	<25	<25	<25	<25	<25	<25	<25	<25
	386	09/05/07	-	<25	-	<25	<25	<25	<25	<25	<25	<25	<25	<25
	427	10/16/07	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	457	11/15/07	<25	<25	<25	97.7	<25	<25	86.2	<25	<25	<25	<25	<25
Start Stand-by	493	12/21/07	-	-	-	-	-	-	-	-	-	-	-	-
	511	01/08/08	<25	<25	<25	<25	<25	150	<25	<25	<25	<25	<25	<25
End Stand-by	588	03/25/08	-	-	<25	<25	<25	-	-	-	-	-	-	-
	609	04/15/08	<25	-	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	622	04/28/08	-	-	<25	-	110	179	40.4	266	-	-	-	-
	624	04/30/08	<25	<25	<25	84.3	46.5	386	<25	<25	<25	<25	<25	<25
	625	05/01/08	<25	-	<25	-	86	-	<25	<25	<25	<25	<25	<25
	665	06/10/08	-	-	53.6	72	216	42.2	<25	<25	<25	<25	<25	<25
Demobilization	770	09/23/08	274	<25	-	<25	183	<25	<25	<25	<25	<25	<25	<25

**Table 5.8.1-11. MNX concentrations in drainage water samples.**  
 A “-“ indicates no sample was able to be collected and analyzed.

Event	Elapsed	Sample Date	MNX ug/L																	
			SP1-2 (CON)	SP1-5 (CON)	SP1-7 (CON)	SP1-1 (P01)	SP1-4 (P01)	SP1-9 (P01)	SP1-3 (P02)	SP1-5 (P02)	SP1-8 (P02)									
Mobilization																				
	24	09/08/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	38	09/22/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	59	10/13/06	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	73	10/27/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Start Stand-by	87	11/10/06	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
End Stand-by	126	12/19/06	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	267	05/09/07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	288	05/30/07	<50	506	<50	<50	<50	313	<50	531	<50	431	<50	449	<50	<50	<50	<50	<50	<50
Residues added	302	06/13/07	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	317	06/28/07	<25	<25	<25	<25	<25	53.4	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	346	07/07/07	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	359	08/09/07	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	386	09/05/07	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	427	10/16/07	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	457	11/15/07	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	493	12/21/07	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	511	01/08/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	588	03/25/08	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	609	04/15/08	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	622	04/28/08	27.4	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	624	04/30/08	53.8	<25	63.9	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	625	05/01/08	51.5	<25	58.6	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	665	06/10/08	32.6	<25	30.9	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Demobilization	770	09/23/08	126	<25	101	<25	<25	54.2	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25

**Table 5.8.1-12. Average MNX concentrations in 15 cm pore water samples.**

A “-“ indicates no sample was able to be collected and analyzed.

Values below the method detection limit were set to one-half of the detection limit.

Standard deviations were only calculated when n=3.

Event	Elapsed	Sample Date	MNX Concentration		
			Control ug/L	P01	P02
Mobilization		08/15/06	-	-	-
	24	09/08/06	37 ± 21	67 ± 30	25
	38	09/22/06	25	25 ± 0	25
PMSO Added	59	10/13/06	25 ± 0	25	25 ± 0
	73	10/27/06	25	25	25 ± 0
	87	11/10/06	25	25 ± 0	25 ± 0
Start Stand-by	126	12/19/06	25	25	25
End Stand-by	267	05/09/07	25	25	25
	288	05/30/07	25	25	25
Residues added	302	06/13/07	25	25	25 ± 0
	317	06/28/07	-	3	3 ± 0
	346	07/27/07	-	3	3 ± 0
	359	08/09/07	3	3	3 ± 0
	386	09/05/07	-	16	3 ± 0
	427	10/16/07	3	3 ± 0	3 ± 0
	457	11/15/07	77	102 ± 92	3 ± 0
Start Stand-by	493	12/21/07	-	-	-
	511	01/08/08	89	-	-
End Stand-by	588	03/25/08	-	-	-
	609	04/15/08	3	-	3
	622	04/28/08	-	-	3
	624	04/30/08	222	64	3
	625	05/01/08	113	108	3
	665	06/10/08	359	46	3 ± 0
Demobilization	770	09/23/08	-	3	3 ± 0

**Table 5.8.1-13. Average MNX concentrations in 45 cm pore water samples.**

A “-“ indicates no sample was able to be collected and analyzed.

Values below the method detection limit were set to one-half of the detection limit.

Standard deviations were only calculated when n=3.

Event	Elapsed	Sample Date	MNX Concentration		
			Control ug/L	P01	P02
Mobilization		08/15/06	-	-	-
	24	09/08/06	25 ± 0	100 ± 0	25 ± 0
	38	09/22/06	57 ± 55	25 ± 0	25 ± 0
PMSO Added	59	10/13/06	25 ± 0	25 ± 0	25 ± 0
	73	10/27/06	25	25 ± 0	25 ± 0
	87	11/10/06	25 ± 0	25	25 ± 0
Start Stand-by	126	12/19/06	25	25	25 ± 0
End Stand-by	267	05/09/07	165	204	157 ± 163
	288	05/30/07	125 ± 174	163	91 ± 114
Residues added	302	06/13/07	25 ± 0	25 ± 0	25 ± 0
	317	06/28/07	3	3	3 ± 0
	346	07/27/07	3	3	3 ± 0
	359	08/09/07	-	3	3 ± 0
	386	09/05/07	-	3 ± 0	3 ± 0
	427	10/16/07	3	3 ± 0	3 ± 0
	457	11/15/07	3	62 ± 52	3 ± 0
Start Stand-by	493	12/21/07	-	-	-
	511	01/08/08	3	76	-
End Stand-by	588	03/25/08	3	-	-
	609	04/15/08	3	62 ± 102	-
	622	04/28/08	-	139 ± 116	-
	624	04/30/08	3	172 ± 186	3
	625	05/01/08	3	65	3
	665	06/10/08	54	110 ± 93	3 ± 0
Demobilization	770	09/23/08	274	63 ± 104	3 ± 0

**Table 5.8.1-14. Average MNX concentrations in drainage water samples.**

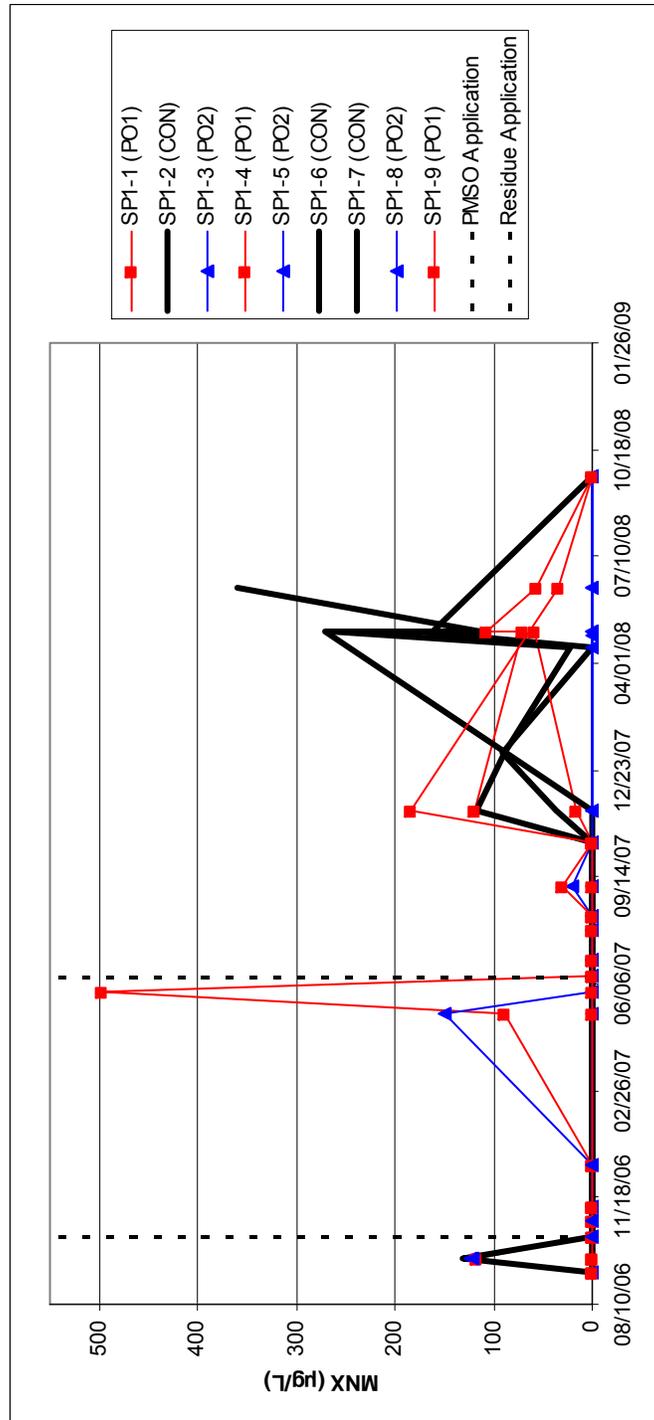
A “-“ indicates no sample was able to be collected and analyzed.

Values below the method detection limit were set to one-half of the detection limit.

Standard deviations were only calculated when n=3.

Event	Elapsed	Sample Date	MNX Concentration		
			Control ug/L	P01	P02
Mobilization		08/15/06	-	-	-
	24	09/08/06	-	-	-
	38	09/22/06	-	-	-
PMSO Added	59	10/13/06	25 ± 0	25 ± 0	25 ± 0
	73	10/27/06	-	-	-
	87	11/10/06	25 ± 0	25 ± 0	25 ± 0
Start Stand-by	126	12/19/06	25 ± 0	25 ± 0	25 ± 0
End Stand-by	267	05/09/07	-	-	-
	288	05/30/07	185 ± 278	121 ± 166	470 ± 53
Residues added	302	06/13/07	25 ± 0	25 ± 0	25 ± 0
	317	06/28/07	3	20 ± 29	3 ± 0
	346	07/27/07	3	3 ± 0	3 ± 0
	359	08/09/07	3	3 ± 0	3 ± 0
	386	09/05/07	3	3 ± 0	3 ± 0
	427	10/16/07	3	3 ± 0	3 ± 0
	457	11/15/07	3	3 ± 0	3 ± 0
Start Stand-by	493	12/21/07	3	3 ± 0	3 ± 0
	511	01/08/08	-	3	-
End Stand-by	588	03/25/08	3	3 ± 0	3 ± 0
	609	04/15/08	3	3 ± 0	3 ± 0
	622	04/28/08	15	3 ± 0	3 ± 0
	624	04/30/08	59	3 ± 0	3 ± 0
	625	05/01/08	55	3	3 ± 0
	665	06/10/08	32	3 ± 0	3 ± 0
Demobilization	770	09/23/08	114	20 ± 30	3 ± 0

Figure 5.8.1-7. Concentrations of MNX in soil pore water collected at a depth of 15 cm (replicates with same symbols).



**Figure 5.8.1-8. Concentrations of MNX in soil pore water collected at a depth of 15 cm (replicates with different symbols).**

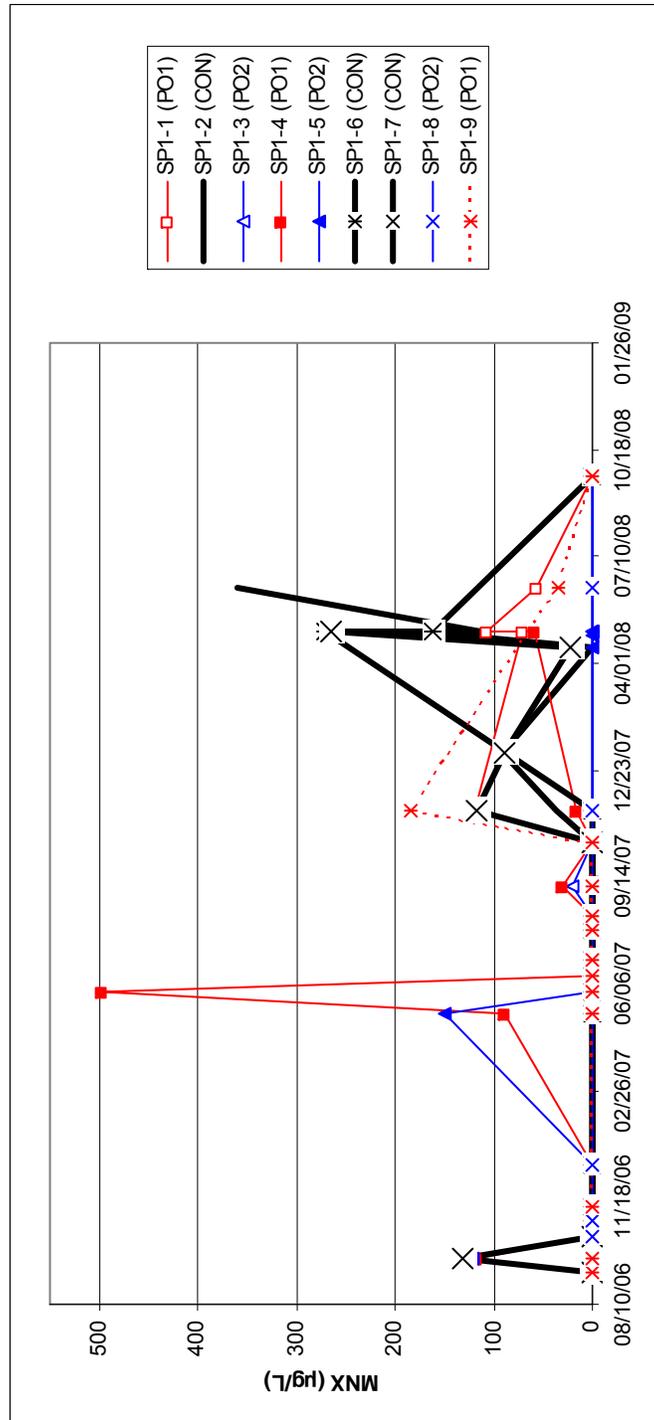


Figure 5.8.1-9. Concentrations of MNX in soil pore water collected at a depth of 45 cm (replicates with same symbols).

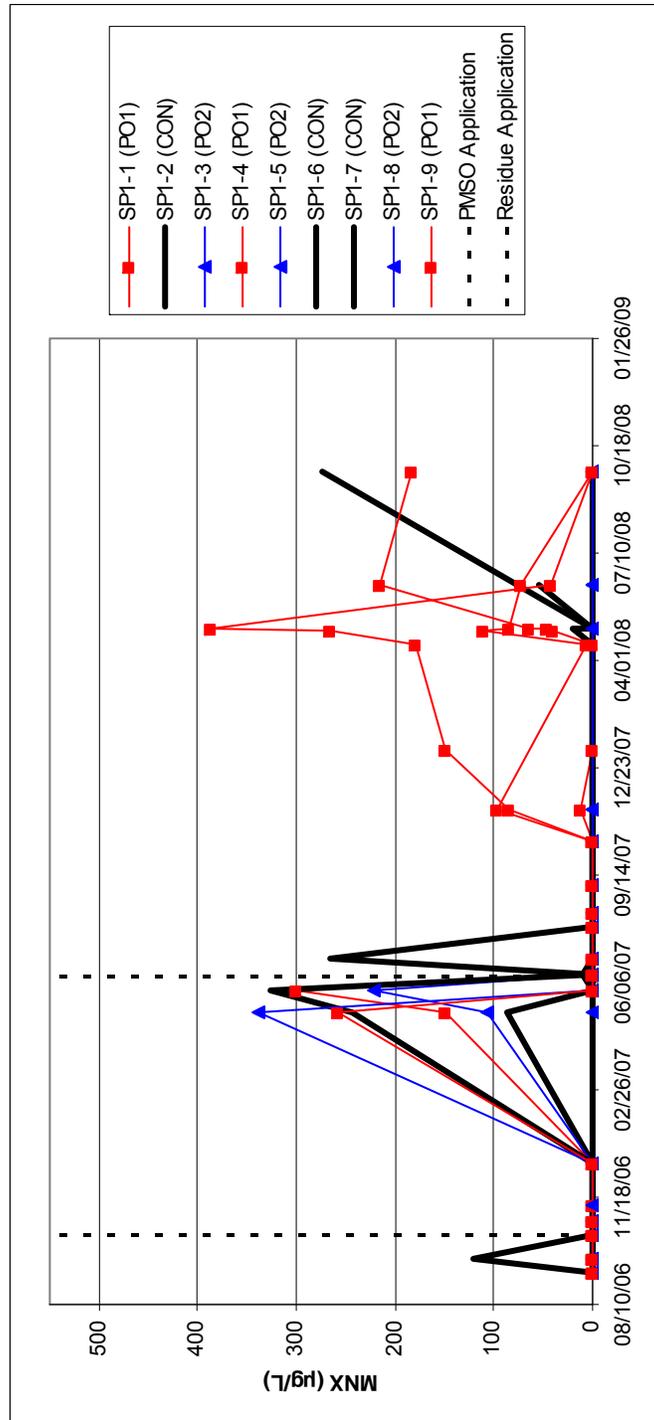


Figure 5.8.1-10. Concentrations of MNX in soil pore water collected at a depth of 45 cm (replicates with different symbols).

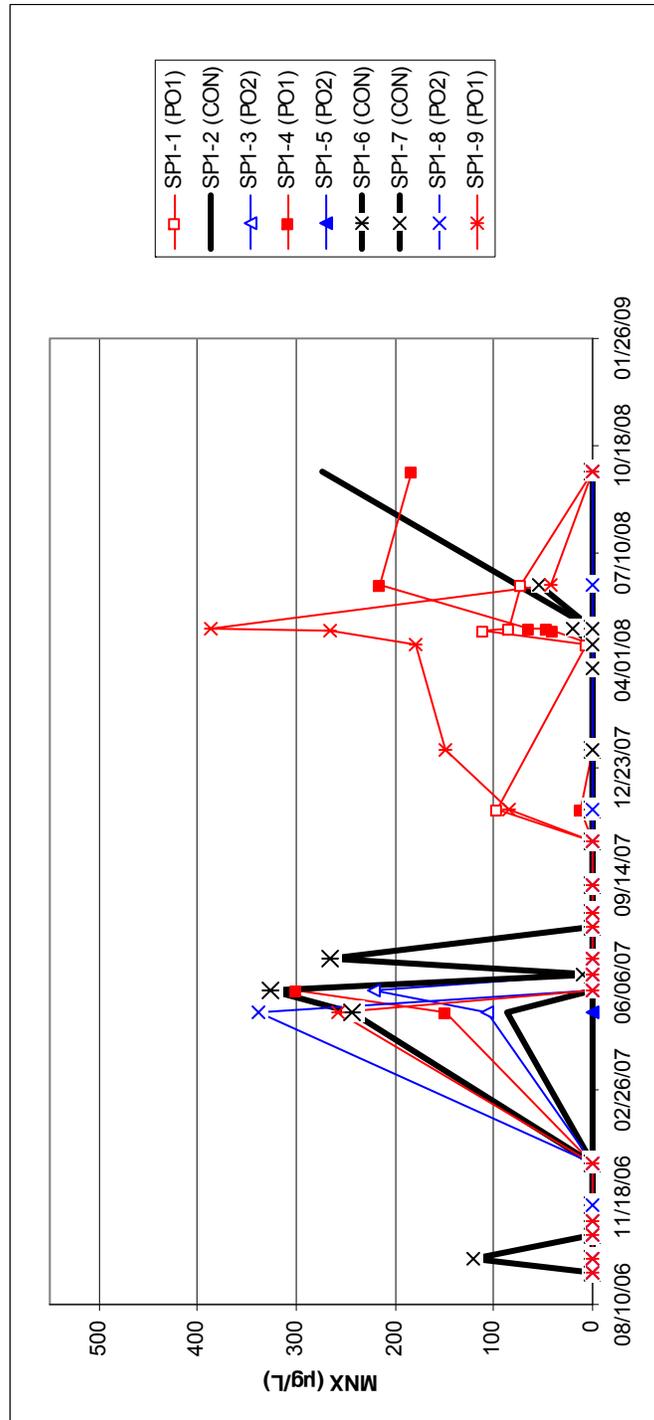


Figure 5.8.1-11. Concentrations of MNX in soil plot drainage water (replicates with same symbols).

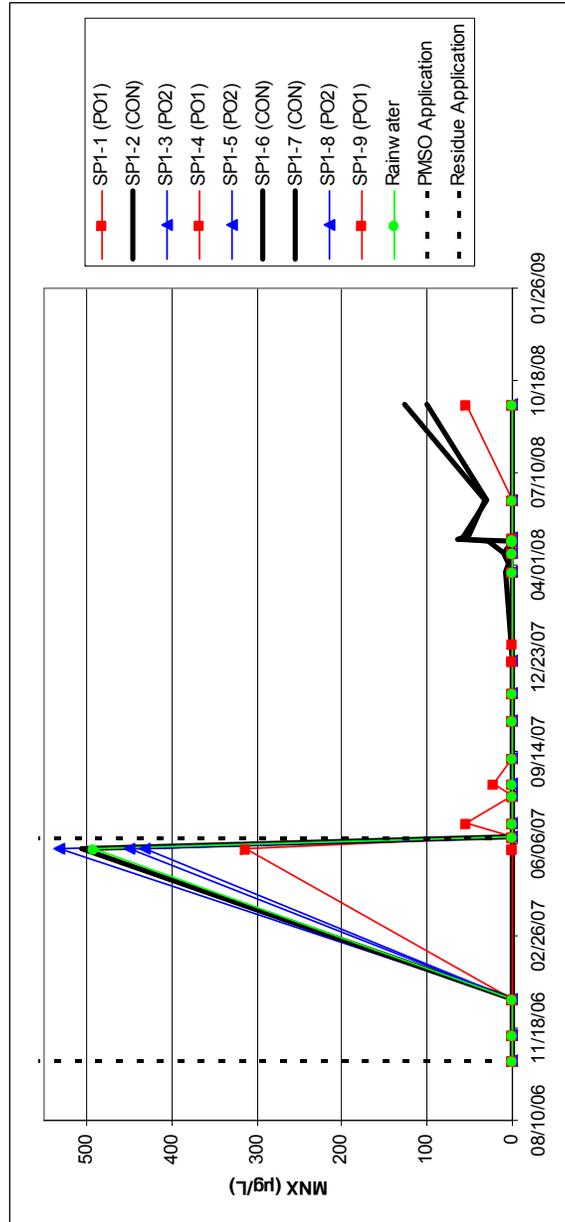
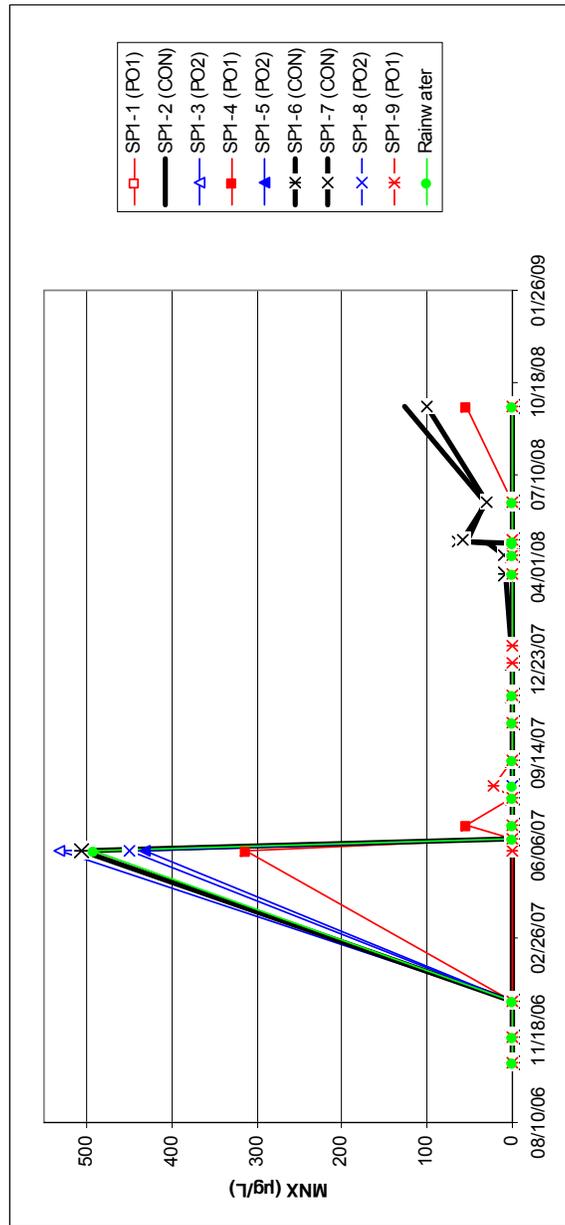


Figure 5.8.1-12. Concentrations of MNX in soil plot drainage water (replicates with different symbols).



### **5.8.2 Explosive Compound Fluxes**

During this SP1 demonstration, the only explosive-related compounds that were detected with enough frequency in the pore water to assess contaminant fluxes were RDX and MNX. Additionally, fluxes were only calculated post-residue application based on the assumption that all pre-residue application detections of these compounds were not derived from the dissolution and transport of Composition B.

One of the parameters affective explosive compound flux is water flux. Table 5.8.2-1 present the water flux for the soil plots, both in terms of each individual plot, as well as control and treatment group averages. Data is presented in terms of total water volume measured passing through a given depth in the soil plots. Two of the PO1 plots and two of the PO2 plots had less water passing through the 15 to 45 cm depth than the controls, with the resulting averages about 25% less than the controls. The water passing out of the plots (at 75 cm) relative to the water passing the 15 to 45 cm depth was less for all the PO1 and PO2 plots compared to the same values for the control plots (by about 27% and 40%, respectively). These differences could reflect water retention by the PMSO in the treatment plots, keeping moisture near the top of the plots where it was lost to evaporation as opposed to percolating through the soil. Regardless, part of the reduction in the flux of contaminants was the result of less water passing through the soil because of the PMSO.

#### **RDX flux at 30 cm (midpoint between 15 to 45 cm).**

RDX flux (expressed as cumulative mg) in the individual soil plots is presented in Figure 5.8.2-1. Plots of the average flux in the control and treatment plots is shown in Figure 5.8.2-2. RDX flux (expressed as mg/cm<sup>2</sup>/d) in the individual soil plots is presented in Figure 5.8.2-3. Plots of the average flux in the control and treatment plots is shown in Figure 5.8.2-4.

**RDX flux at 75 cm (plot drainage outlet).**

RDX flux (expressed as cumulative mg) in the individual soil plots is presented in Figure 5.8.2-5. Plots of the average flux in the control and treatment plots is shown in Figure 5.8.2-6. RDX flux (expressed as mg/cm<sup>2</sup>/d) in the individual soil plots is presented in Figure 5.8.2-7. Plots of the average flux in the control and treatment plots is shown in Figure 5.8.2-8.

**MNX flux at 30 cm (midpoint between 15 to 45 cm).**

MNX flux (expressed as cumulative mg) in the individual soil plots is presented in Figure 5.8.2-9. Plots of the average flux in the control and treatment plots is shown in Figure 5.8.2-10. MNX flux (expressed as mg/cm<sup>2</sup>/d) in the individual soil plots is presented in Figure 5.8.2-11. Plots of the average flux in the control and treatment plots is shown in Figure 5.8.2-12.

**MNX flux at 75 cm (plot drainage outlet).**

MNX flux (expressed as cumulative mg) in the individual soil plots is presented in Figure 5.8.2-13. Plots of the average flux in the control and treatment plots is shown in Figure 5.8.2-14. MNX flux (expressed as mg/cm<sup>2</sup>/d) in the individual soil plots is presented in Figure 5.8.2-15. Plots of the average flux in the control and treatment plots is shown in Figure 5.8.2-16.

**Summary of aqueous RDX and MNX flux data**

The PO2 treatment effectively reduced the mass, and corresponding flux, of RDX moving down into the soil from dissolving Composition B residues. The PO1 treatment also reduced the movement of RDX, but to a lesser degree. For these flux calculations, Plot SP1-9 of treatment PO1 seemed to behave differently than its corresponding replicates (SP1-1 and SP1-4), with respect to the cumulative mass of RDX passing the 30 cm depth.

The two treatments also reduced MNX fluxes by the end of demonstration. There were several instances, however, when MNX flux was higher in the treatments than in the control plots for a

given depth. This was likely the result of greater microbial activity in the treatment plots, leading to greater production of MNX from RDX.

A more systematic analysis of the data is presented in Section 6 with respect to the performance criteria.

**Table 5.8.2-1. Water fluxes in the soil plots.**

	Total volume measured (mL)				
	Precipitation	Flux at	%Received	Flux at	%15-45 cm
	Received	15-45 cm	Precipitation	75 cm	Flux
SP1-2 (CON)	197001	59210	30	59411	100
SP1-6 (CON)		50170	25	49691	84
SP1-7 (CON)		55407	28	50931	86
	<b>AVG</b>	<b>54929</b>	<b>28</b>	<b>53344</b>	<b>90</b>
SP1-1 (PO1)		57825	29	31572	53
SP1-4 (PO1)		8173	4	45001	76
SP1-9 (PO1)		48190	24	39560	67
	<b>AVG</b>	<b>38063</b>	<b>19</b>	<b>38711</b>	<b>65</b>
SP1-3 (PO2)		24650	13	27602	47
SP1-5 (PO2)		59570	30	35118	59
SP1-8 (PO2)		35400	18	28012	47
	<b>AVG</b>	<b>39873</b>	<b>20</b>	<b>30244</b>	<b>51</b>

Figure 5.8.2-1. Cumulative RDX mass at 30 cm in the individual soil plots (replicates with same color but different symbols).

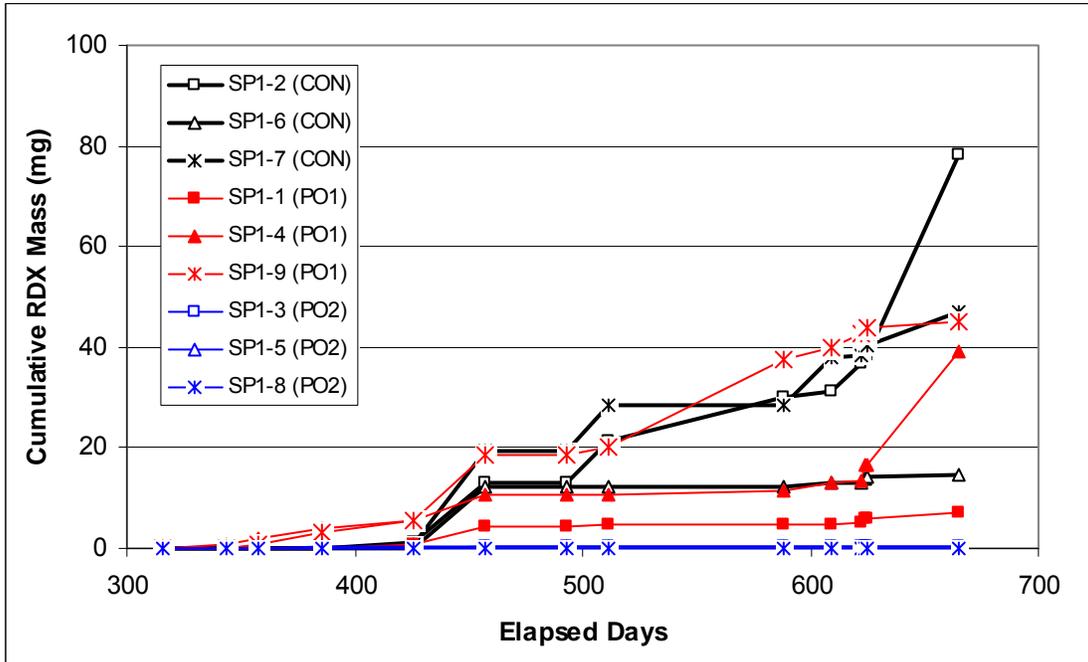


Figure 5.8.2-2. Average cumulative RDX mass at 30 cm in the control and treatment soil plots.

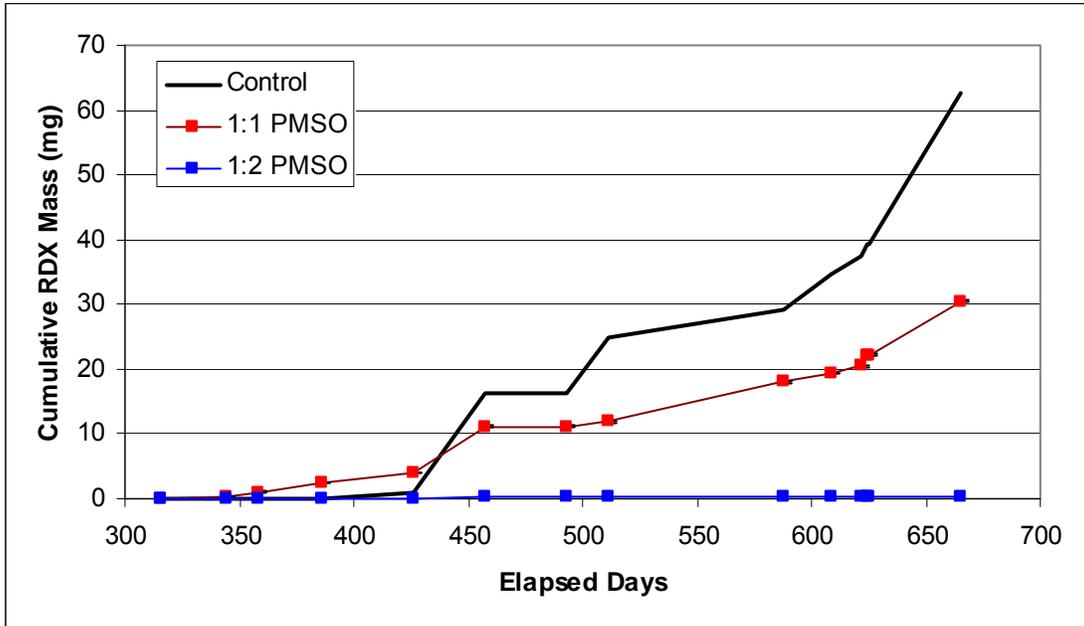


Figure 5.8.2-3. RDX flux at 30 cm in the individual soil plots (replicates with same color but different symbols).

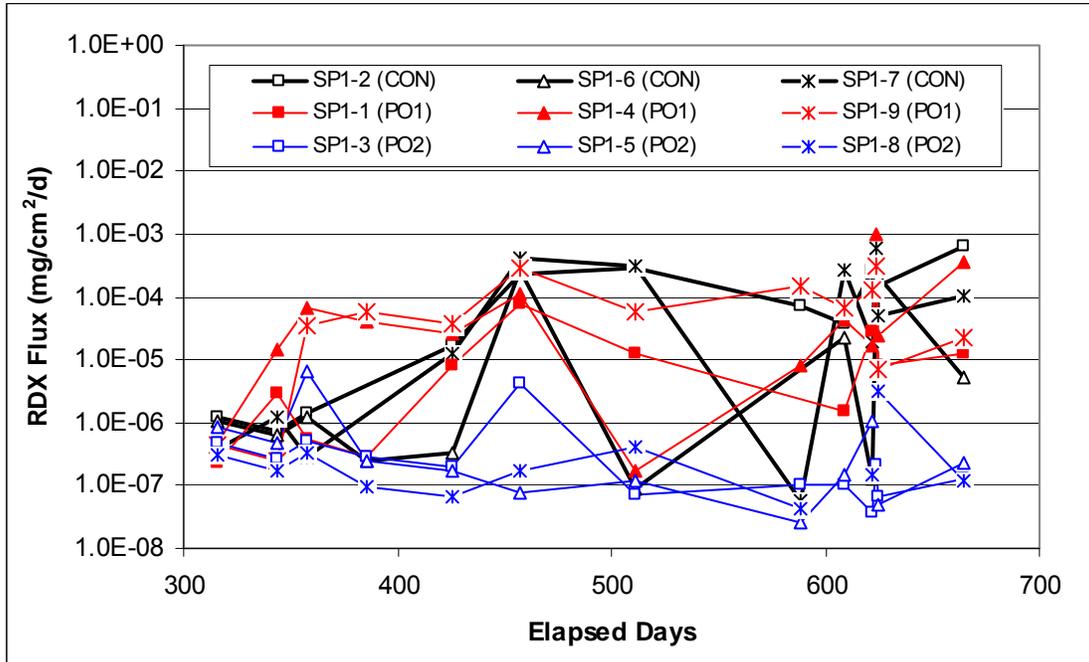


Figure 5.8.2-4. Average RDX flux at 30 cm in the control and treatment soil plots.

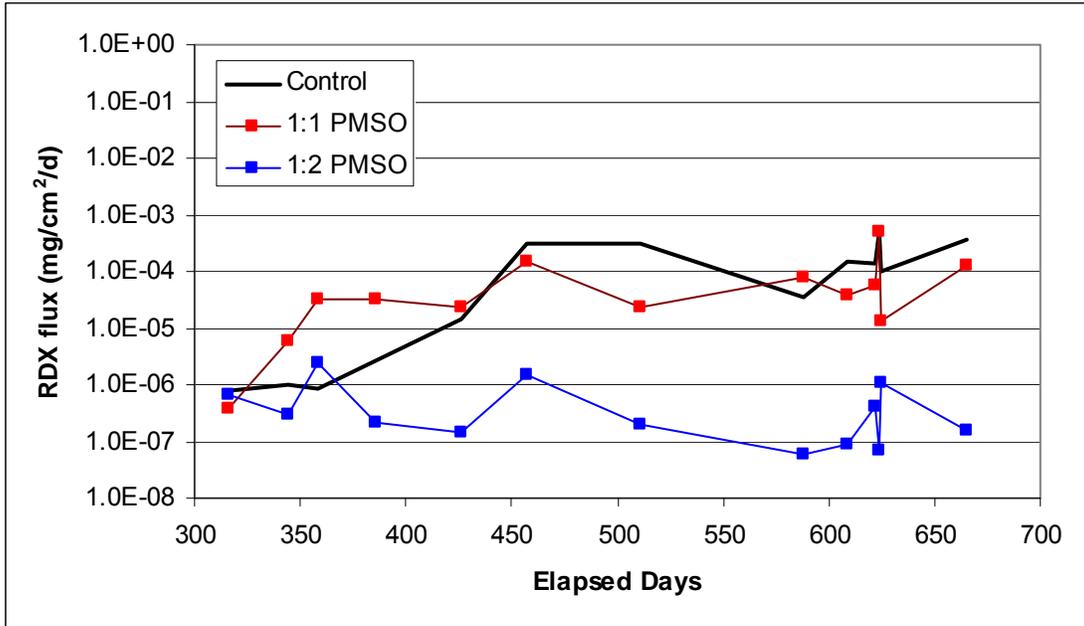


Figure 5.8.2-5. Cumulative RDX mass at 75 cm in the individual soil plots (replicates with same color but different symbols).

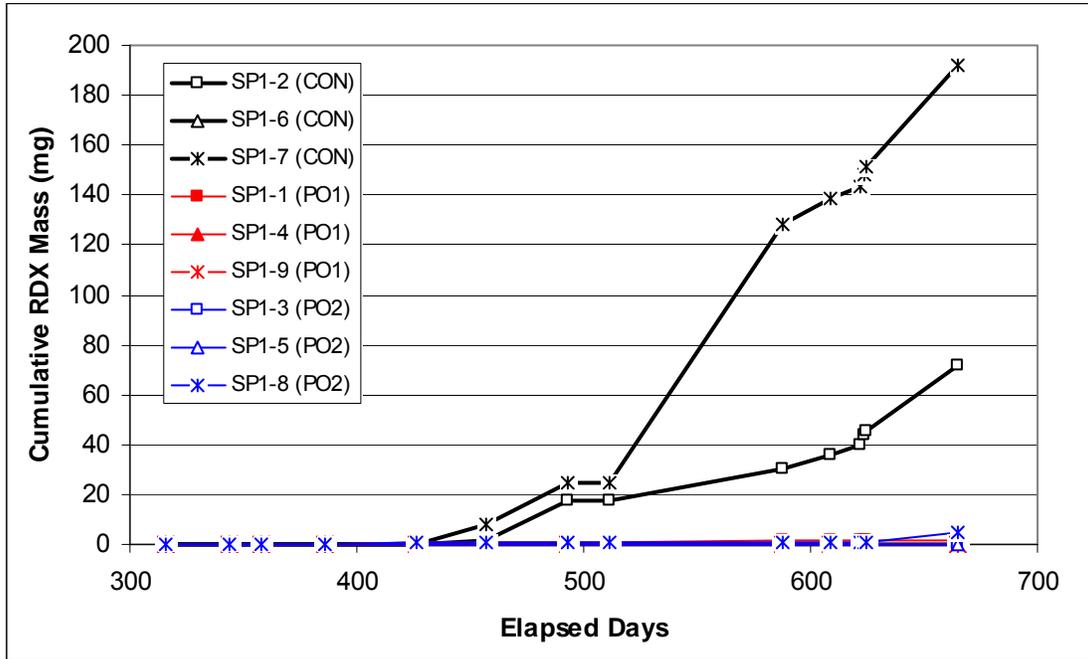


Figure 5.8.2-6. Average cumulative RDX mass at 75 cm in the control and treatment soil plots.

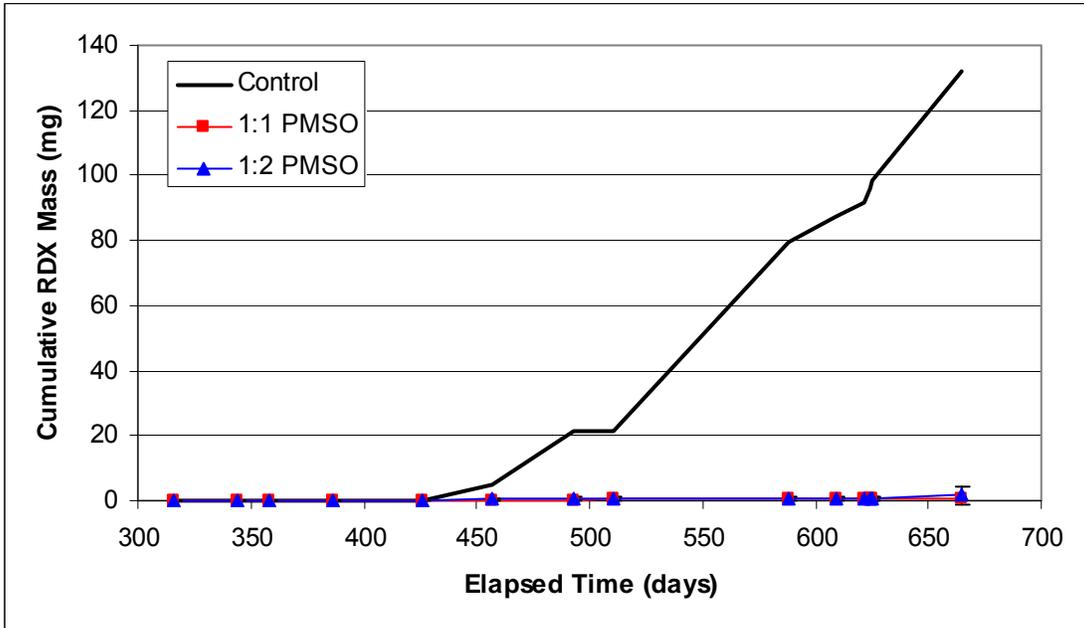


Figure 5.8.2-7. RDX flux at 75 cm in the individual soil plots (replicates with same color but different symbols).

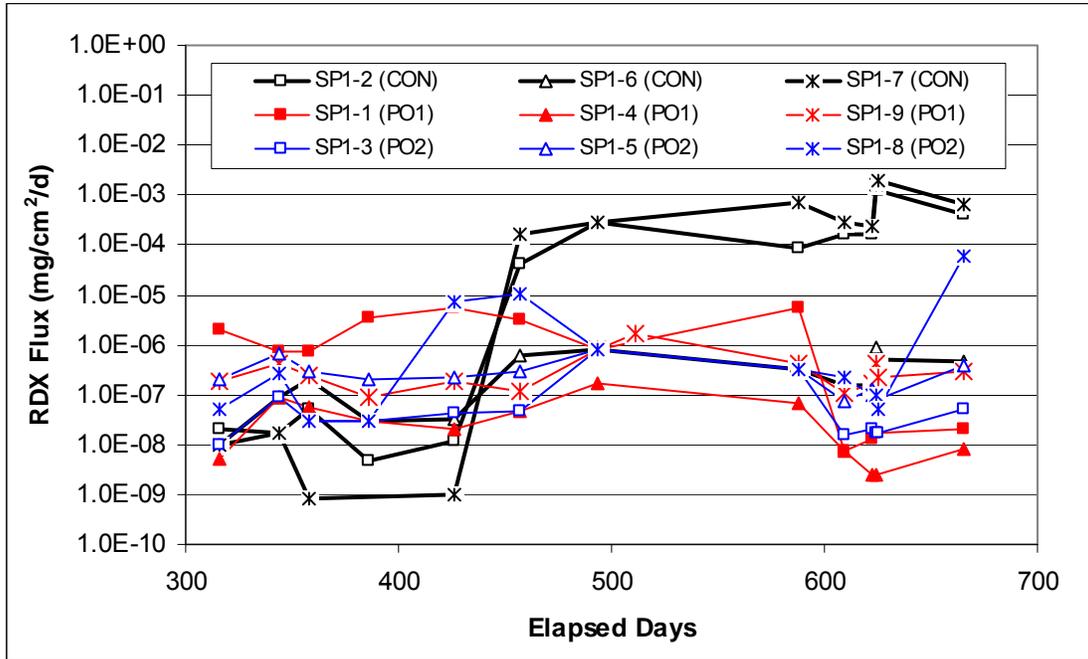


Figure 5.8.2-8. Average RDX flux at 75 cm in the control and treatment soil plots.

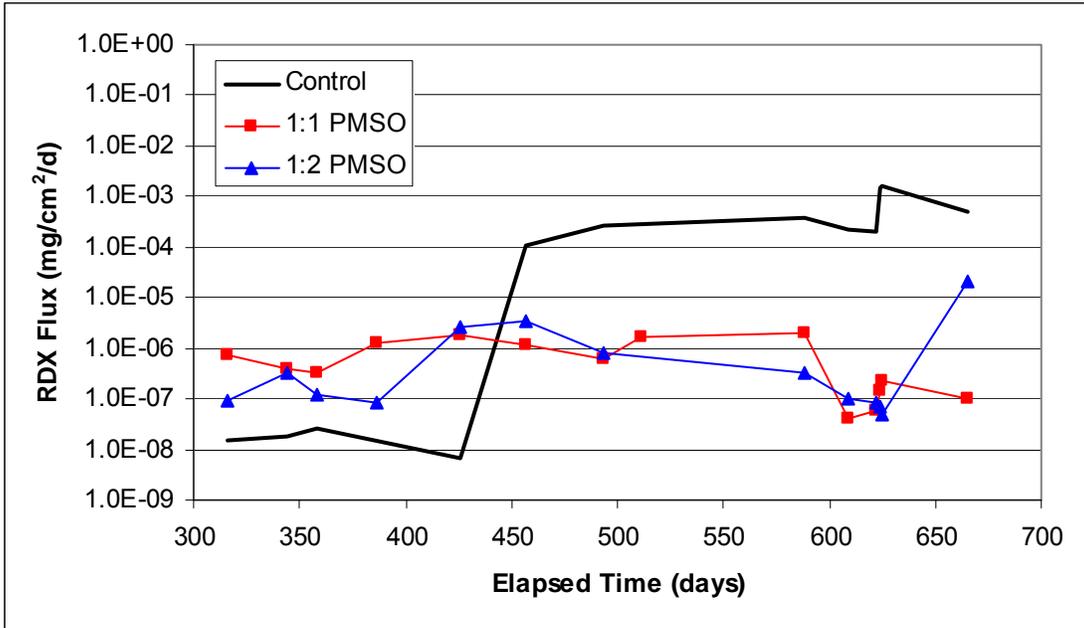


Figure 5.8.2-9. Cumulative MNX mass at 30 cm in the individual soil plots (replicates with same color but different symbols).

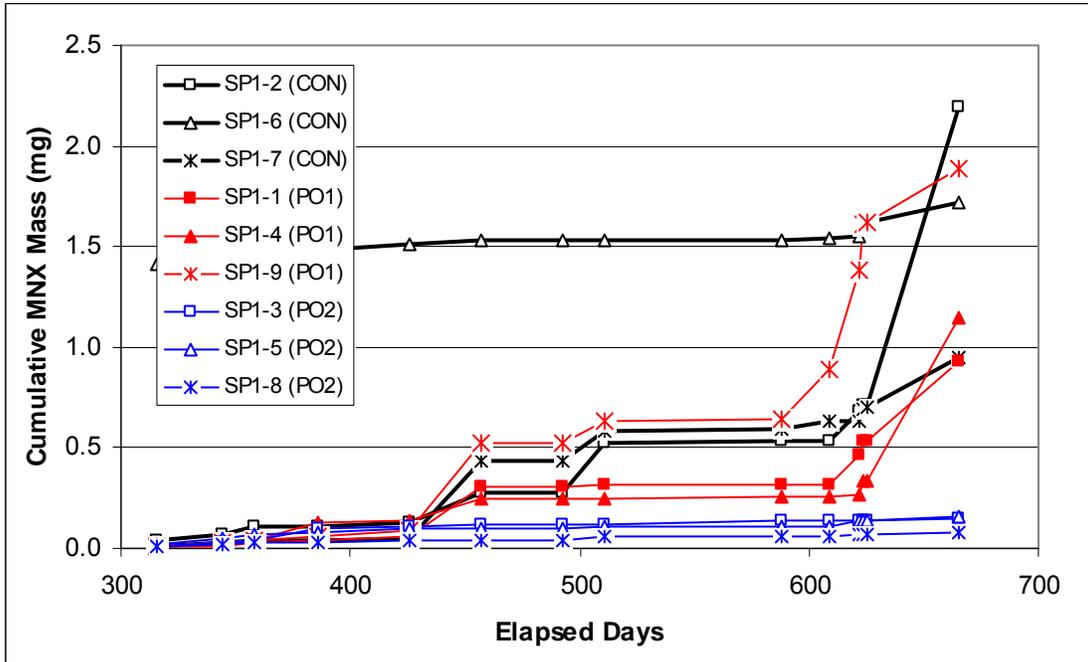


Figure 5.8.2-10. Average cumulative MNX mass at 30 cm in the control and treatment soil plots.

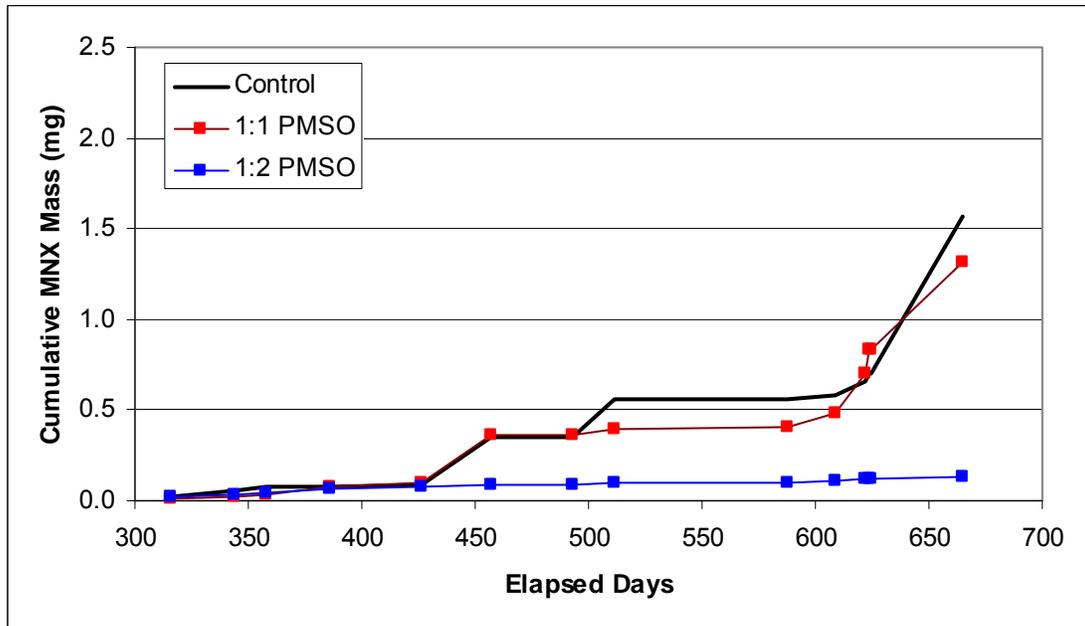


Figure 5.8.2-11. MNX flux at 30 cm in the individual soil plots (replicates with same color but different symbols).

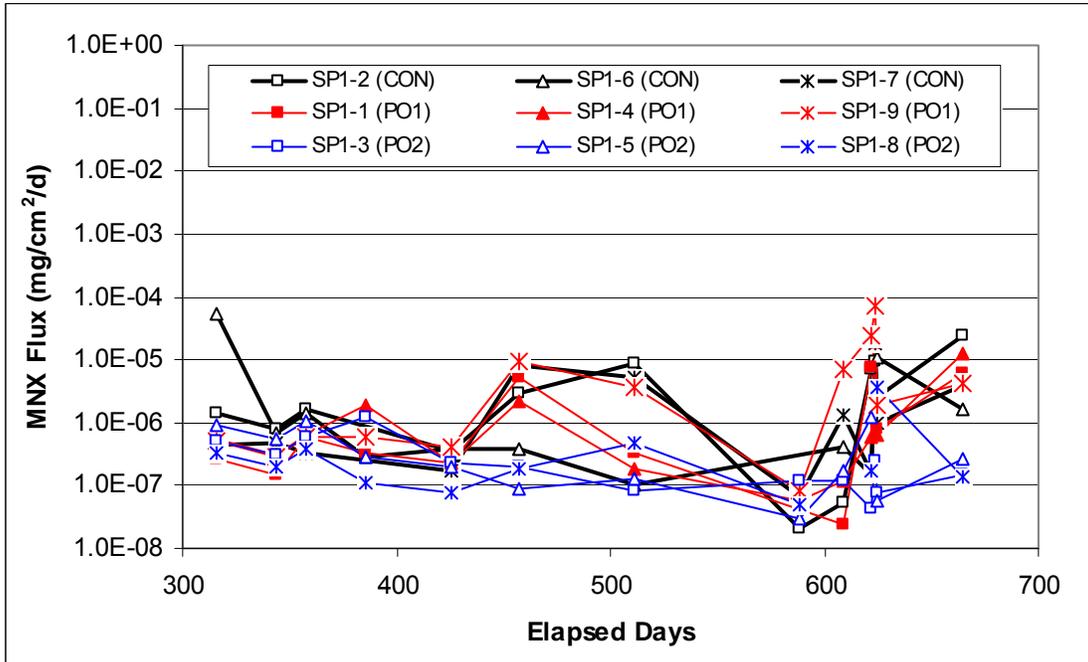
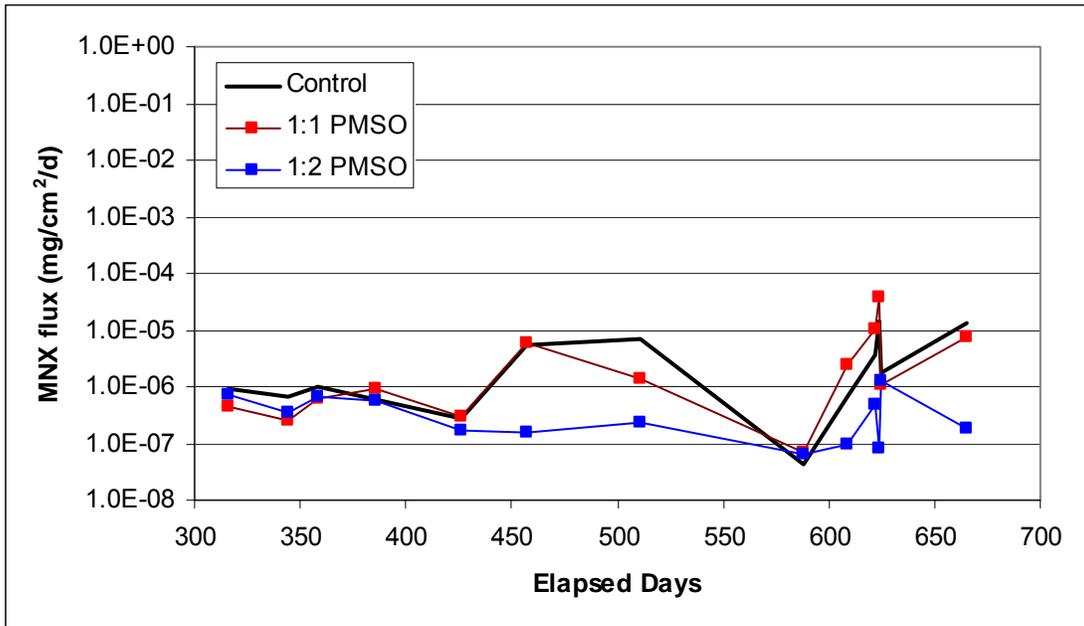


Figure 5.8.2-12. Average MNX flux at 30 cm in the control and treatment soil plots.



**Figure 5.8.2-13. Cumulative MNX mass at 75 cm in the individual soil plots (replicates with same color but different symbols).**

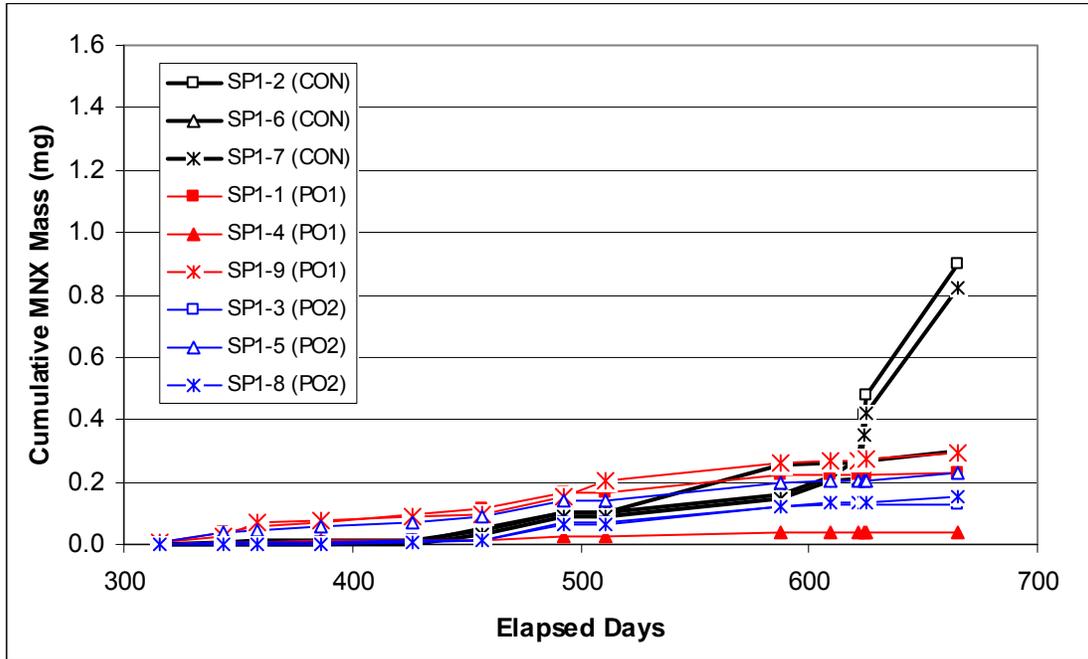


Figure 5.8.2-14. Average cumulative MNX mass at 75 cm in the control and treatment soil plots.

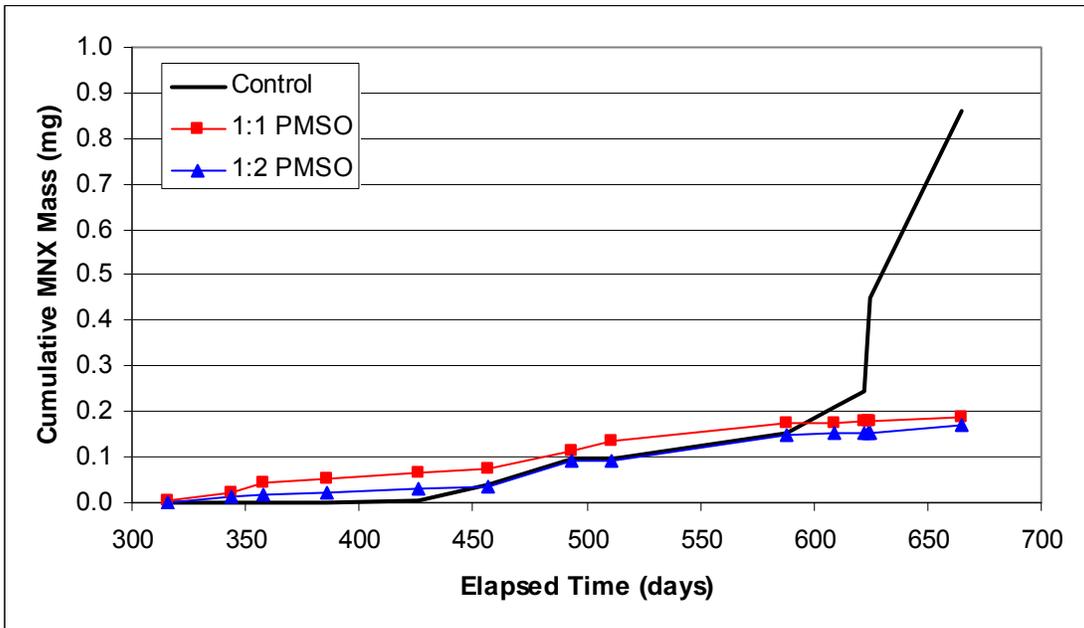


Figure 5.8.2-15. MNX flux at 75 cm in the individual soil plots (replicates with same color but different symbols).

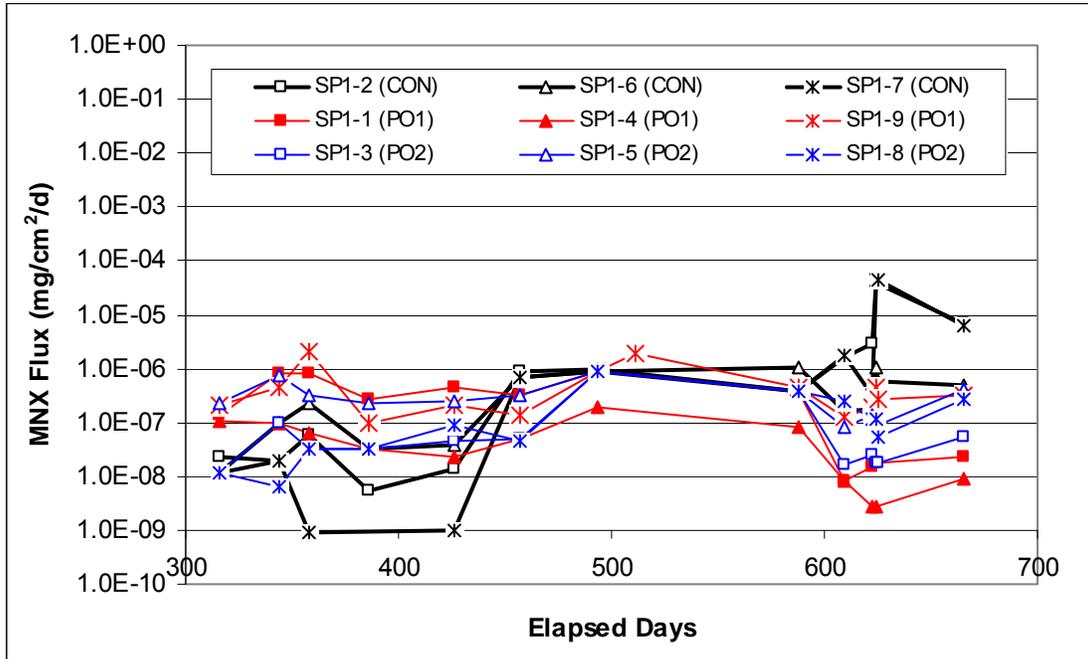
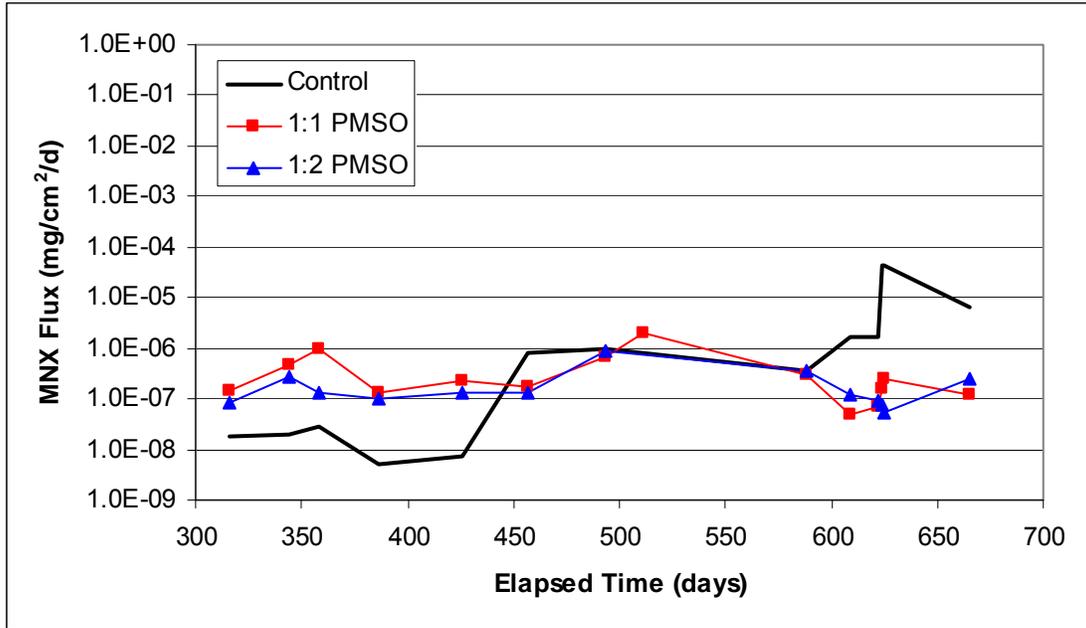


Figure 5.8.2-16. Average MNX flux at 75 cm in the control and treatment soil plots.



### **5.8.3 Total Soil and PMSO Concentrations of Explosive Compounds**

#### **Explosives detected.**

A full raw data listing is provided in Table E-5.8.3, Appendix E of Part I of this report. Residual particulate Composition B was visually observed on the soil surface at the time of demobilization, and was also seen when these samples were drying prior to extraction and analysis (Figure 5.8.3-1). RDX and TNT were detected in the topmost surface layers of soil and PMSO. The breakdown products of TNT were also only detected sporadically, and only at very low concentrations.

In the soil cores, RDX was the only compound detected frequently throughout the soil profile. HMX, TNT, and the RDX and TNT breakdown products were only detected sporadically, and only at very low concentrations.

#### **RDX and TNT concentrations versus size fraction.**

The topmost soil (0 to 1.25 cm) from the control plots and PMSO (0 to 2.5 cm) from the PO1 and PO2 plots was sieved to achieve size fractions of >2 mm, 0.5 to 2 mm, 0.1 to 0.5 mm, and <0.1 mm. The <0.1 mm fraction was combined with the 0.1 to 0.5 mm fraction for the PMSO analyses, creating a <0.5 mm fraction. The amount of material and concentrations of RDX and TNT in each size fraction of the topmost PMSO of the PO1 and PO2 soil plots is shown in Table 5.8.3-1, while the same information for the topmost soil layer of the control plots is shown in Table 5.8.3-2.

The PMSO material was about evenly distributed across the three size fractions, but the RDX seemed to be concentrated in the smallest size fraction (<0.5 mm) and the TNT (if detected) was highest in the middle size fraction (0.5 to 2 mm). The soil was distributed into larger (>2 mm) and smaller (<0.5 mm) sizes, with the RDX and TNT highest in the middle size ranges of 0.1 to 0.5 mm and 0.5 to 2 mm. Since the explosives were applied as 0.5 to 1 mm residues, it was not surprising that high concentrations in the larger sized fractions were not observed. The shift of residues toward the smaller size fractions would be expected as the residues breakdown over

time. The remainder of this section deals with the concentrations and masses of explosive residues in the “whole” soil and PMSO samples, as opposed to specific size fractions.

### **RDX concentrations versus depth.**

The concentrations of RDX in the top layer of PMSO in PO1 and PO2 averaged  $2329 \pm 855$  mg/kg and  $861 \pm 574$  mg/kg, respectively, compared to a value of  $855 \pm 357$  mg/kg of RDX in the top 1.25 cm of soil in the control plots.

A graph of the concentrations of RDX in the control and treatment plot soil profiles is presented in Figure 5.8.3-2. A graph of the average soil concentrations vs. depth in the control and the two treatments is shown in Figure 5.8.3-3. The RDX concentrations were very high near the top of the soil in the control plots, but decreased with depth. In the PO1 plots, some RDX was detected near the soil surface, but concentrations were very low from a depth of about 4 cm downward. Concentrations of RDX in the PO2 plots were uniformly low throughout the soil profile.

The compiled concentrations of RDX vs. soil depth in the control and treatment plots are presented in Table 5.8.3-3. Averages of the control and PO1 and PO2 treatments are shown in Table 5.8.3-4.

HMX, TNT and all the RDX and TNT breakdown products were below the detection limits in both the PO1 and PO2 soil profile. Some low concentrations of TNT, 4A-DNT, and 2A-DNT, but no MNX, DNX, and TNX, were detected down to depths of approximately 8 cm in the control plots, but none of these compounds were detected in the soil of any of the treatment plots. On the order of 5 to 40 mg/kg of 2A- and 4A-DNT were detected in the topmost PMSO layer in the PO1 plots, but neither compound was observed above the detection limits ( $\sim 0.5$  mg/kg) in the PO2 plot PMSO materials. This supports the conclusion that the TNT was being actively transformed in the PMSO layer in both treatments, but that the degradation was more complete or the formation of bound residues was greater in the PO2 plots than the PO1 plots.

The mass balances for RDX, TNT, and HMX were calculated based on all the aqueous and solid phase data that was collected. Masses of these compounds, in terms of absolute mass and percentage of the applied mass of each compound, in the aqueous and solid phase samples of each individual soil plot are presented in Table 5.8.3-5. Average results based on the data from the triplicate control and treatment plots are shown in Table 5.8.3-6. Overall HMX recoveries were very low for all the plots, which would not be unexpected given the very small amount of material actually applied (~26 mg).

The most mass of RDX and TNT was recovered in the top layers of soil in the control plots, and in the PMSO in the treatment plots. It should be noted that the lower recoveries in the treatment plots are probably the result of not being able to completely extract and analyze all the PMSO material. It is assumed that a large portion of the missing mass is in the unanalyzed PMSO material, and that it never reached the underlying soil. In this respect, the PMSO served not only to sorb and enhance the degradation of dissolved explosives from the applied Composition B, it also served as a physical barrier to the downward movement of the particulate residues.

TNT recoveries were low, especially in the treatment plots, likely reflecting the rapid transformation of the compound. The low TNT recoveries in the control plots indicates that substantial transformation also occurred in native MMR soil. Detections of the common amino-DNTs were not common, so it is not clear if the TNT was simply transformed to these products which then became non-extractable (especially in the PMSO samples), or whether the TNT underwent more extensive degradation or even mineralization.

The highest recoveries were observed for RDX, which averaged  $61 \pm 12\%$ ,  $31 \pm 16\%$ ,  $14 \pm 10\%$  in the control, PO1, and PO2 plots, respectively. These data also support the finding that the PMSO reduced the overall loading of RDX to the soil surface.

A more systematic analysis of the data is presented in Section 6 with respect to the performance criteria.

**Figure 5.8.3-1. Photographs of putative particulate Composition B remaining in the PMSO at the end of the SP1 demonstration.**



Figure 5.8.3-2. Soil RDX concentrations in the control, PO1, and PO2 plots at the end of the SP1 demonstration.

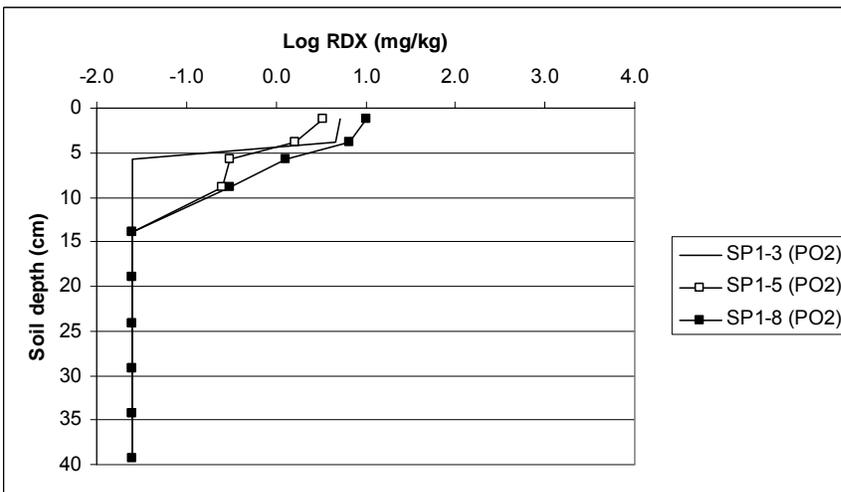
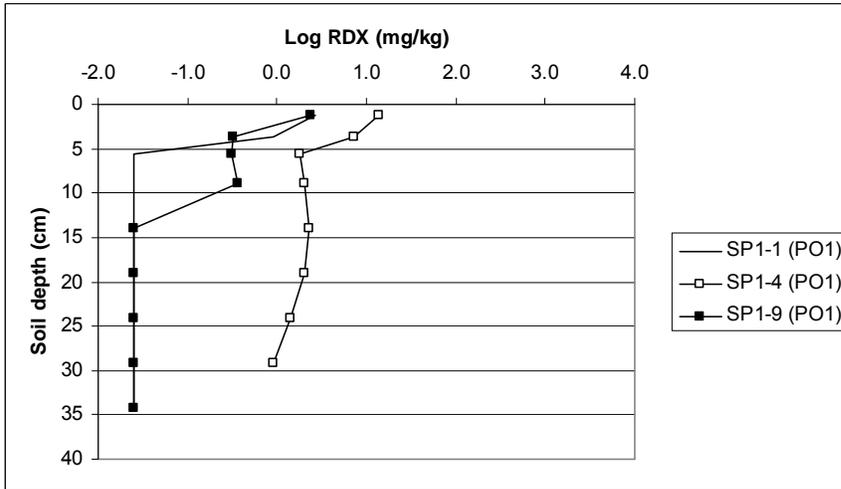
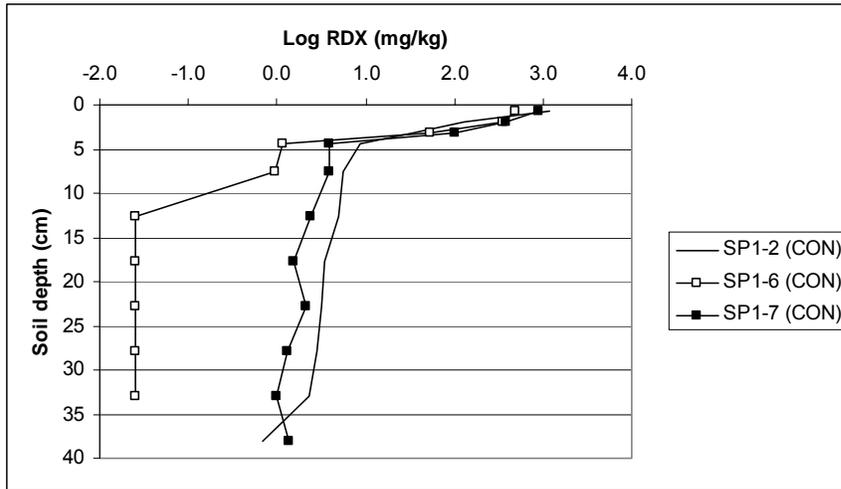
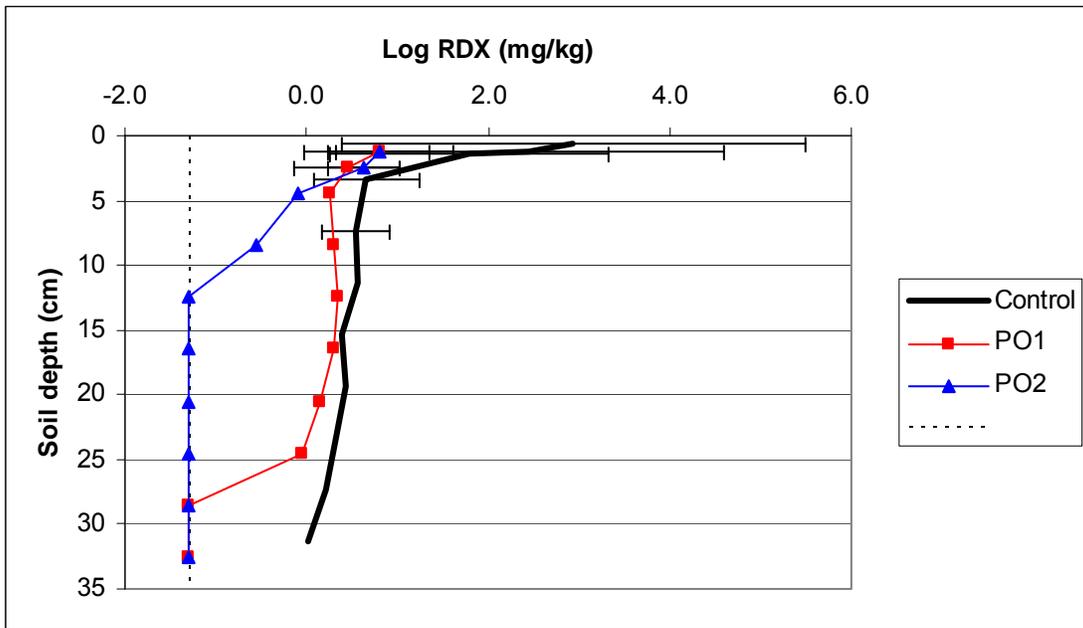


Figure 5.8.3-3. Average soil concentrations versus depth in the control, PO1 and PO2 soil plots at the end of the SP1 demonstration.



**Table 5.8.3-1. Masses (a) and concentrations of TNT and RDX (b) in different size fractions of the topmost PMSO material of the PO1 and PO2 soil plots.**

a)

	Mass (g)			Total	% Total Mass		
	>2 mm	0.5-2 mm	<0.5 mm		>2 mm	0.5-2 mm	<0.5 mm
SP1-1 (PO1)	236	247	272	755	31	33	36
SP1-4 (PO1)	251	284	273	808	31	35	34
SP1-9 (PO1)	180	176	198	554	32	32	36
SP1-3 (PO2)	300	321	260	881	34	36	30
SP1-5 (PO2)	258	247	196	701	37	35	28
SP1-8 (PO2)	343	304	208	855	40	36	24
Average	261	263	235	759	34	34	31
St. Dev	56	52	38	120	4	2	5

b)

	RDX (mg/kg)			TNT (mg/kg)		
	>2 mm	0.5-2 mm	<0.5 mm	>2 mm	0.5-2 mm	<0.5 mm
SP1-1 (PO1)	789	928	2371	<4	<4	<4
SP1-4 (PO1)	561	3170	5336	25	651	116
SP1-9 (PO1)	310	1605	5264	<4	<4	<4
SP1-3 (PO2)	433	477	738	<4	<4	<4
SP1-5 (PO2)	191	543	922	<4	<4	<4
SP1-8 (PO2)	138	2295	2683	48	359	109

**Table 5.8.3-2. Masses (a) and concentrations of TNT and RDX (b) in different size fractions of the topmost soil of the control plots.**

A “-“ indicates no sample was able to be collected and analyzed.

a)

	Mass (g)				Total	% Total Mass			
	>2 mm	0.5-2 mm	0.1-0.5 mm	<0.1 mm		>2 mm	0.5-2 mm	0.1-0.5 mm	<0.1 mm
SP1-2 (CON)	556	288	527	738	2109	26	14	25	35
SP1-6 (CON)	619	288	593	804	2304	27	13	26	35
SP1-7 (CON)	450	221	473	632	1776	25	12	27	36
Average	542	266	531	725	2063	26	13	26	35
St. Dev	85	39	60	87	267	1	1	1	0

b)

	RDX (mg/kg)				TNT (mg/kg)			
	>2 mm	0.5-2 mm	0.1-0.5 mm	<0.1 mm	>2 mm	0.5-2 mm	0.1-0.5 mm	<0.1 mm
SP1-2 (CON)	272	1760	1703	379	20	687	213	3
SP1-6 (CON)	96	214	1136	350	<0.6	53	2	<0.6
SP1-7 (CON)	130	1301	1389	357	1	506	196	8

**Table 5.8.3-3. Summary of RDX concentration vs. depth in the control and treatment plots.**

A “-“ indicates no sample was able to be collected and analyzed.

Values below the method detection limit were set to one-half of the detection limit (0.025 mg/kg).

Standard deviations were only calculated when n=3.

Depth cm	RDX mg/kg		Depth cm	SP1.7 (CON)		SP1.1 (P01)	SP1.4 (P01)	SP1.9 (P01)	SP1.3 (P02)	SP1.5 (P02)	SP1.8 (P02)
	SP1.2 (CON)	SP1.6 (CON)		SP1.7 (CON)	SP1.2 (CON)						
0.63	1200.84	479.36	908.02	2.68	13.95	2.34	5.18	3.31	10.20		
1.88	128.22	346.53	365.70	0.89	7.17	0.32	4.66	1.62	6.50		
3.13	34.19	52.46	100.10	0.03	1.80 ± 0.84	0.32 ± 0.08	0.03	0.31 ± 0.06	1.31		
4.42	8.64 ± 1.58	1.15 ± 1.07	3.65 ± 1.18	0.03	2.00 ± 0.99	0.37 ± 0.18	0.03	0.25	0.30		
7.62	5.64 ± 0.42	0.93 ± 0.07	3.63 ± 0.29	0.03	2.25 ± 0.83	0.03	0.03	0.03	0.03		
12.70	4.92 ± 0.37	0.03	2.40 ± 0.18	0.03	2.05 ± 0.89	0.03	0.03	0.03	0.03		
17.78	3.48 ± 0.26	0.03	1.55 ± 0.12	0.03	1.42 ± 0.84	0.03	0.03	0.03	0.03		
22.86	3.22 ± 0.24	0.03	2.16 ± 0.16	0.03	0.91 ± 0.60	0.03	0.03	0.03	0.03		
27.94	2.86 ± 0.21	0.03	1.31 ± 0.10	0.03	-	0.03	0.03	0.03	0.03		
33.02	2.32 ± 0.17	0.03	0.99 ± 0.07	0.03	-	0.03	0.03	0.03	0.03		
38.10	0.67 ± 0.05	-	1.36 ± 0.10	-	-	-	0.03	-	0.03		

**Table 5.8.3-4. Average RDX concentrations vs. depth in the control and treatment plots.**

A “-“ indicates no sample was able to be collected and analyzed.

Values below the method detection limit were set to one-half of the detection limit (0.025 mg/kg).

Standard deviations were only calculated when n=3.

RDX				
Depth	mg/kg	Depth		
cm	Control	cm	P01	P02
0.63	862.75 ± 362.86			
		1.25	6.33 ± 6.61	6.23 ± 3.56
1.88	286.82 ± 138.74			
3.13	62.25 ± 34.03	3.75	2.80 ± 3.80	4.26 ± 2.47
4.42	4.55 ± 3.79	5.67	0.71 ± 0.95	0.55 ± 0.67
7.62	3.46 ± 2.37	8.87	0.80 ± 1.05	0.19 ± 0.15
12.70	2.45 ± 2.45	13.95	0.77 ± 1.28	0.03 ± 0.00
17.78	1.68 ± 1.73	19.03	0.70 ± 1.17	0.03 ± 0.00
22.86	1.80 ± 1.63	24.11	0.49 ± 0.81	0.03 ± 0.00
27.94	1.40 ± 1.42	29.19	0.32 ± 0.51	0.03 ± 0.00
33.02	1.11 ± 1.15	34.27	0.03	0.03 ± 0.00
38.10	1.02 ± 0.49	39.35	-	0.03

**Table 5.8.3-5. Mass and percent of applied mass of HMX, RDX, and TNT in the aqueous and solid phases of each of the soil plots.**

	HMX								
	SP2-CON	SP6-CON	SP7-CON	SP1-P01	SP4-P01	SP9-P01	SP3-P02	SP5-P02	SP8-P02
<b>mg Applied</b>	26	26	26	26	26	26	26	26	26
<b>mg Recovered</b>									
Aqueous	-	-	-	-	-	-	-	-	-
PMSO	-	-	-	0	0	0	0	0	0
Soil - Top layers	0	1	1	2	0	1	1	0	0
Soil - Lower	-	-	-	-	-	-	-	-	-
Plant biomass	0	0	0	0	0	0	-	-	0
<b>Total</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>
<b>% Recovered</b>									
Aqueous	-	-	-	-	-	-	-	-	-
PMSO	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
Soil - Top layers	0.0	3.6	4.2	8.2	0.0	4.9	4.1	0.0	1.0
Soil - Lower	-	-	-	-	-	-	-	-	-
Plant biomass	0.0	0.0	0.0	0.0	0.0	0.0	-	-	0.0
<b>Total</b>	<b>0.0</b>	<b>3.6</b>	<b>4.2</b>	<b>8.2</b>	<b>0.0</b>	<b>4.9</b>	<b>4.1</b>	<b>0.0</b>	<b>1.0</b>
	RDX								
	SP2-CON	SP6-CON	SP7-CON	SP1-P01	SP4-P01	SP9-P01	SP3-P02	SP5-P02	SP8-P02
<b>mg Applied</b>	5612	5612	5612	5612	5612	5612	5612	5612	5612
<b>mg Recovered</b>									
Aqueous	56	0	153	1	0	0	1	0	0
PMSO	-	-	-	2848	4899	4374	2739	2314	4818
Soil - Top layers	3362	2430	3076	19	110	13	46	31	58
Soil - Lower	424	28	233	0	139	9	0	8	21
<b>Total</b>	<b>3965</b>	<b>2671</b>	<b>3621</b>	<b>2869</b>	<b>5150</b>	<b>4397</b>	<b>2786</b>	<b>2352</b>	<b>4897</b>
<b>% Recovered</b>									
Aqueous	1.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0
PMSO	-	-	-	50.8	87.3	78.0	48.8	41.2	85.9
Soil - Top layers	59.9	43.3	54.8	0.3	2.0	0.2	0.8	0.5	1.0
Soil - Lower	7.5	0.5	4.1	0.0	2.5	0.2	0.0	0.1	0.4
<b>Total</b>	<b>71</b>	<b>48</b>	<b>65</b>	<b>51</b>	<b>92</b>	<b>78</b>	<b>50</b>	<b>42</b>	<b>87</b>
	TNT								
	SP2-CON	SP6-CON	SP7-CON	SP1-P01	SP4-P01	SP9-P01	SP3-P02	SP5-P02	SP8-P02
<b>mg Applied</b>	3451	3451	3451	3451	3451	3451	3451	3451	3451
<b>mg Recovered</b>									
Aqueous	-	-	-	-	-	-	-	-	-
PMSO	-	-	-	0	223	0	0	56	312
Soil - Top layers	817	66	744	0	6	0	0	0	0
Soil - Lower	9	-	-	-	-	-	-	-	-
Plant biomass	26	3	30	0	0	0	-	-	0
<b>Total</b>	<b>852</b>	<b>69</b>	<b>774</b>	<b>0</b>	<b>229</b>	<b>0</b>	<b>0</b>	<b>56</b>	<b>312</b>
<b>% Recovered</b>									
Aqueous	-	-	-	-	-	-	-	-	-
PMSO	-	-	-	0.0	6.5	0.0	0.0	1.6	9.0
Soil - Top layers	23.7	1.9	21.6	0.0	0.2	0.0	0.0	0.0	0.0
Soil - Lower	0.3	-	-	-	-	-	-	-	-
Plant biomass	0.7	0.1	0.9	0.0	0.0	0.0	-	-	0.0
<b>Total</b>	<b>25</b>	<b>2</b>	<b>22</b>	<b>0</b>	<b>7</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>9</b>

**Table 5.8.3-6. Mass and percent of applied mass of HMX, RDX, and TNT in the aqueous and solid phases expressed as averages of the triplicate control and treatment plots.**

	HMX		
	Control	P01	P02
<b>mg Applied</b>	<b>26</b>	<b>26</b>	<b>26</b>
<b>mg Recovered</b>			
Aqueous	-	-	-
PMSO	-	0 ± 0	0 ± 0
Soil - Top layers	1	1 ± 1	0.4 ± 0.5
Soil - Lower	-	-	-
Plant biomass	0	0 ± 0	0
<b>Total</b>	<b>1</b>	<b>1 ± 1</b>	<b>0.4 ± 0.5</b>
<b>% Recovered</b>	0		
Aqueous	-	-	-
PMSO	-	0 ± 0	0 ± 0
Soil - Top layers	2	4 ± 4	2 ± 2
Soil - Lower	-	-	-
Plant biomass	0	0 ± 0	0
<b>Total</b>	<b>2</b>	<b>4 ± 4</b>	<b>2 ± 2</b>
<b>RDX</b>	<b>CON</b>	<b>P01</b>	<b>P02</b>
<b>mg Applied</b>	<b>5,612</b>	<b>5,612</b>	<b>5,612</b>
<b>mg Recovered</b>			
Aqueous	105	0.3 ± 0.5	0.3 ± 0.5
PMSO	-	4,041 ± 1,066	3,290 ± 1,340
Soil - Top layers	3,219	47 ± 54	45 ± 13
Soil - Lower	328	49 ± 78	10 ± 11
<b>Total</b>	<b>3,793</b>	<b>4,139 ± 1,162</b>	<b>3,345 ± 1,361</b>
<b>% Recovered</b>	0		
Aqueous	2	0 ± 0	0 ± 0
PMSO	-	72 ± 19	59 ± 24
Soil - Top layers	57	1 ± 1	0.8 ± 0.2
Soil - Lower	6	1 ± 1	0.2 ± 0.2
<b>Total</b>	<b>68</b>	<b>74 ± 21</b>	<b>60 ± 24</b>
<b>TNT</b>	<b>Control</b>	<b>P01</b>	<b>P02</b>
<b>mg Applied</b>	<b>3,451</b>	<b>3,451</b>	<b>3,451</b>
<b>mg Recovered</b>			
Aqueous	-	-	-
PMSO	-	74 ± 129	123 ± 166
Soil - Top layers	780	2 ± 3	0 ± 0
Soil - Lower	9	-	-
Plant biomass	28	0 ± 0	0
<b>Total</b>	<b>813</b>	<b>76 ± 132</b>	<b>123 ± 166</b>
<b>% Recovered</b>	0		
Aqueous	-	-	-
PMSO	-	2 ± 4	4 ± 5
Soil - Top layers	23	0.1 ± 0.1	0 ± 0
Soil - Lower	0	-	-
Plant biomass	1	0 ± 0	0
<b>Total</b>	<b>24</b>	<b>2 ± 4</b>	<b>4 ± 5</b>

#### 5.8.4 Ancillary Data

##### 5.8.4.1 Soil pore water pH.

A full raw data listing is provided in Table E-5.8.4.1, Appendix E of Part I of this report. A graph of average pore water pH versus time is presented in Figure 5.8.4.1-1. The pH did not vary to any large degree when control vs. treatments, or PO1 vs. PO2 treatments, were compared. The drainage pH of the PO2 plots was slightly higher than either the control or the PO1 drainage. Over the duration of the demonstration, the average pH of the pore water and drainage water were as presented in Table 5.8.4.1-1. All the plots had aqueous pH values somewhat higher than the incident rainwater at the site. These data indicate there would be no adverse effects of the PMSO materials on the overall soil geochemistry.

**Table 5.8.4-1. Average pH values of pore water and drainage water samples.**

	Control	PO1	PO2	Rainwater
15 cm	5.9 ± 0.7	6.1 ± 0.7	6.0 ± 0.8	
45 cm	5.7 ± 0.8	5.8 ± 0.7	6.0 ± 0.7	5.3 ± 0.4
Drainage	5.8 ± 1.0	6.1 ± 1.1	6.6 ± 1.2	

##### 5.8.4.2 Soil pore water total organic carbon.

A full raw data listing is provided in Table E-5.8.4.2, Appendix E of Part I of this report. A graph of average pore water or drainage water TOC versus time is presented in Figure 5.8.4.2-1. As expected, the aqueous TOC in plots which received PMSO both increased over time above levels seen in the control. The TOC measured in the PO2 soil plots increased more than in PO1 soil plots. This amount of TOC likely increased the microbial activity immediately below the PMSO layer, especially in PO2 soil plots, although a major, sustained increase in activity was not observed based on the soil pore gas measurements (see section 5.8.4.3).

##### 5.8.4.3 Soil pore gases.

A full raw data listing is provided in Table E-5.8.4.3, Appendix E of Part I of this report. A graphs of average pore O<sub>2</sub> and CO<sub>2</sub> versus time are presented in Figure 5.8.4.3-1 and Figure 5.8.4.3-2. The pore O<sub>2</sub> and CO<sub>2</sub> immediately under the PMSO layers did not vary much from the

ambient air measurements. At the 15 cm sampling depth, the pore O<sub>2</sub> in the PO1 and PO2 plots tended to track below the control plots, and, conversely, the CO<sub>2</sub> tended to track above the control plots. There were also some marked spikes in CO<sub>2</sub> (and corresponding sharp dips in O<sub>2</sub>), especially in the PO2 plots. Similar, but more muted trends were observed at the 45 cm sampling depth. These data indicate that at least at the middle sampling depth, the microbial activity was increased by the presence of the PMSO. It could be expected that the increased activity would lead to a greater extent of dissolved explosive transformation and/or degradation, especially in regards to TNT, which is more labile under moderately reduced oxygen concentrations than RDX. These data also indicated that strong anaerobic conditions did not generally occur under the PMSO layer, so a range of aerobic/microaerophilic/anoxic bacterial and fungal explosive degradation processes could likely be occurring.

**5.8.4.4 Soil plot drainage.**

A full raw data listing is provided in Table E-5.8.4.4, Appendix E of Part I of this report. The volumes varied over time in the plots based on the amount of precipitation received at the field demonstration site, as well as by plot (control vs. treatment). No clear trends were observed when comparing the average drainage from the controls or treatments, although the expected seasonal trends of more drainage in the wetter spring and fall, and less drainage in hotter, drier summer, were recorded.

**5.8.4.5 Weather station data.**

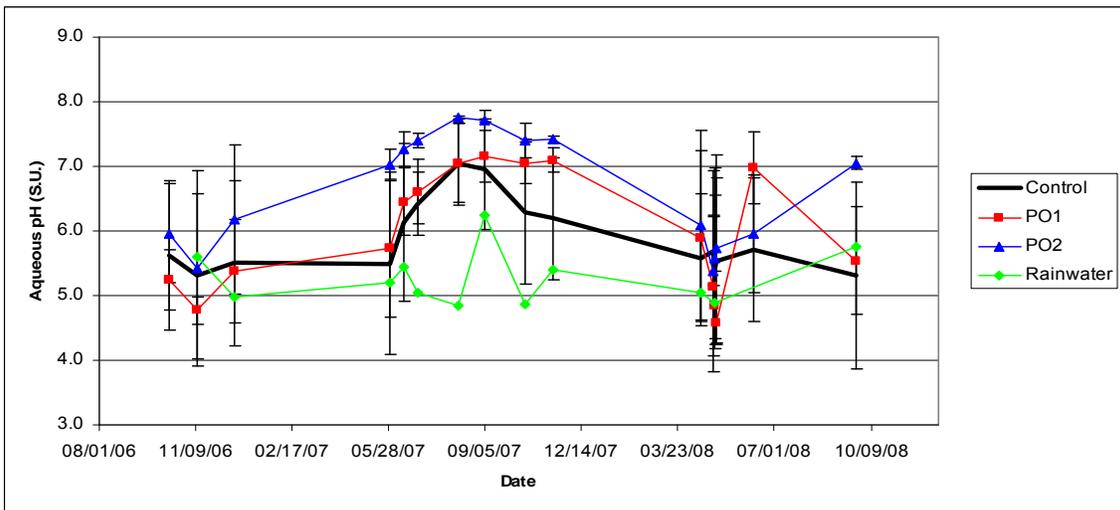
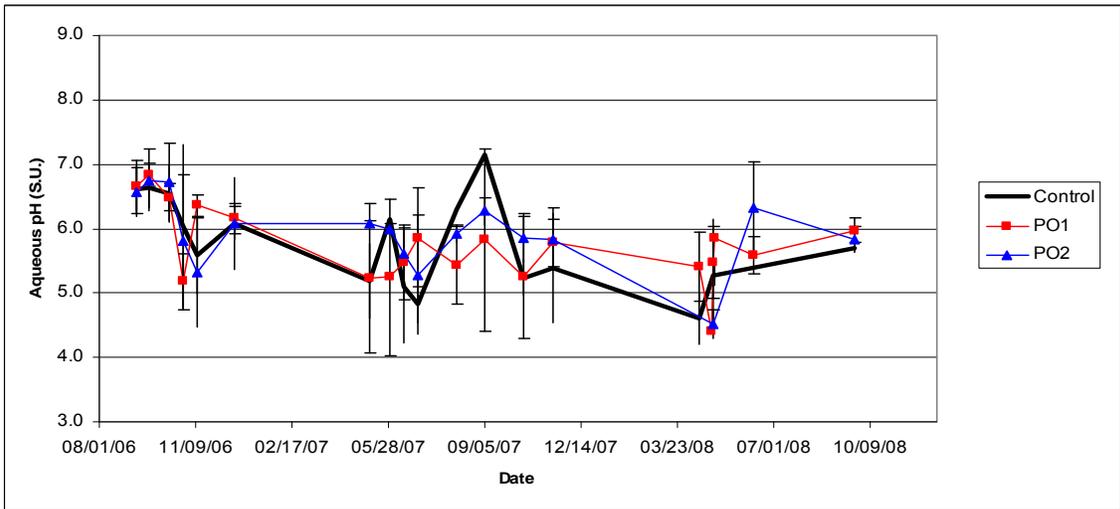
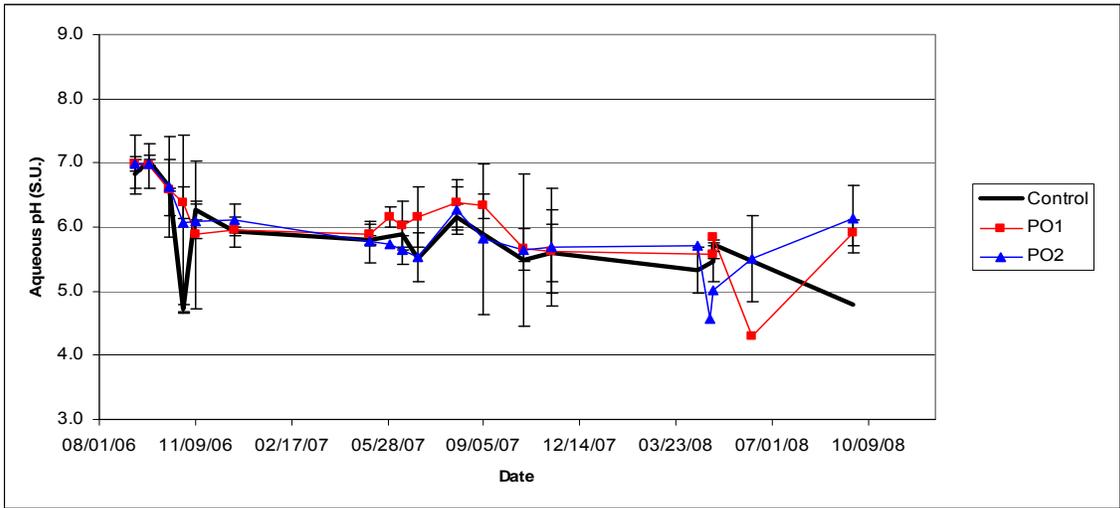
Graphs of temperature, sunlight, precipitation, and accumulated precipitation are presented in Figures 5.8.4.5-1 to 5.8.4.5-4. The dashed vertical lines on each graph represent the following project events:

<b>Event</b>	<b>Date</b>	<b>Elapsed</b>
Mobilization	8/15/2006	
PMSO Added	10/13/2006	59
Start Stand-by	12/19/2006	126
End Stand-by	4/6/2007	267
Residues added	6/13/2007	302
Start Stand-by	12/19/2007	491
End Stand-by	3/25/2008	588

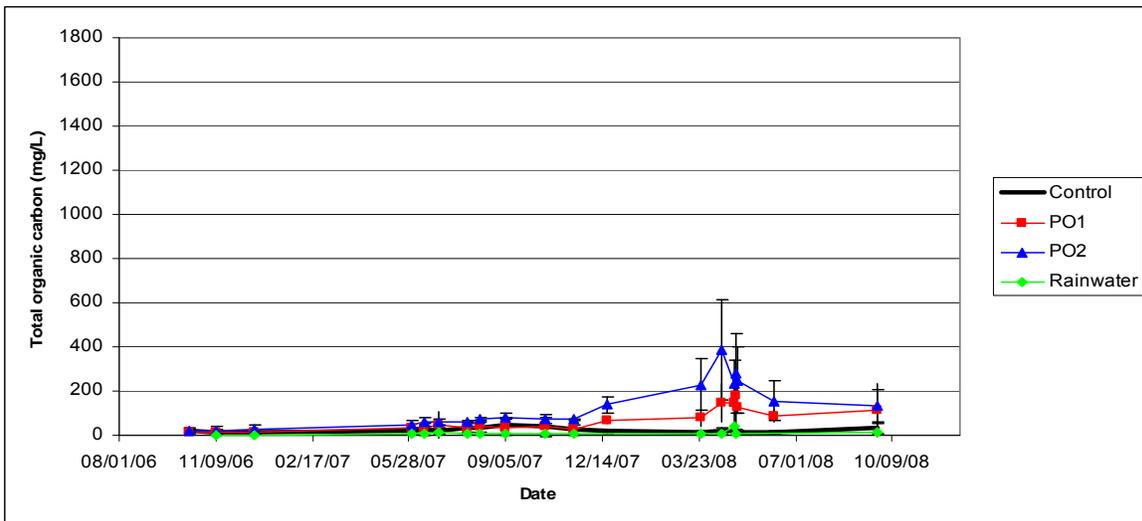
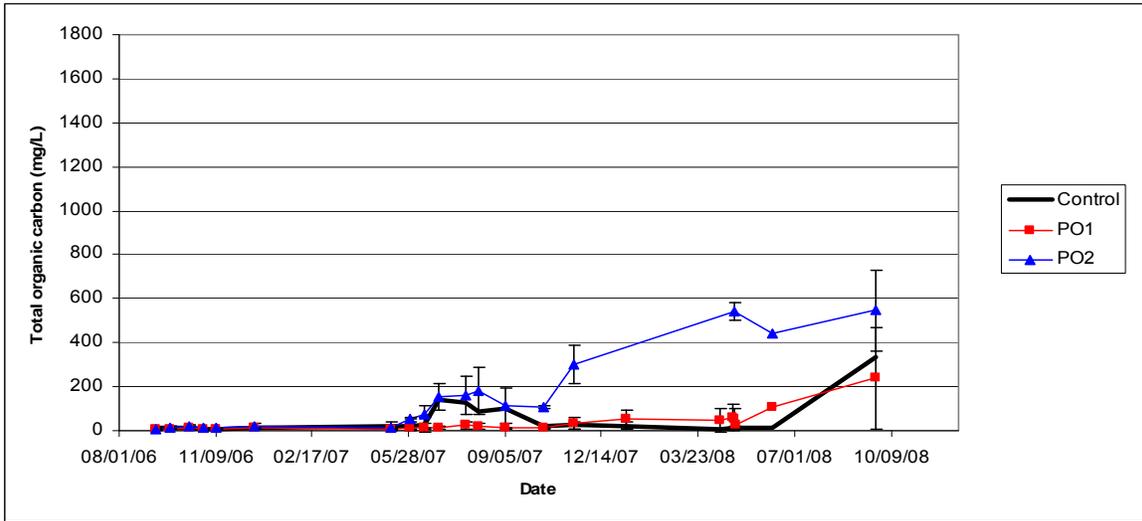
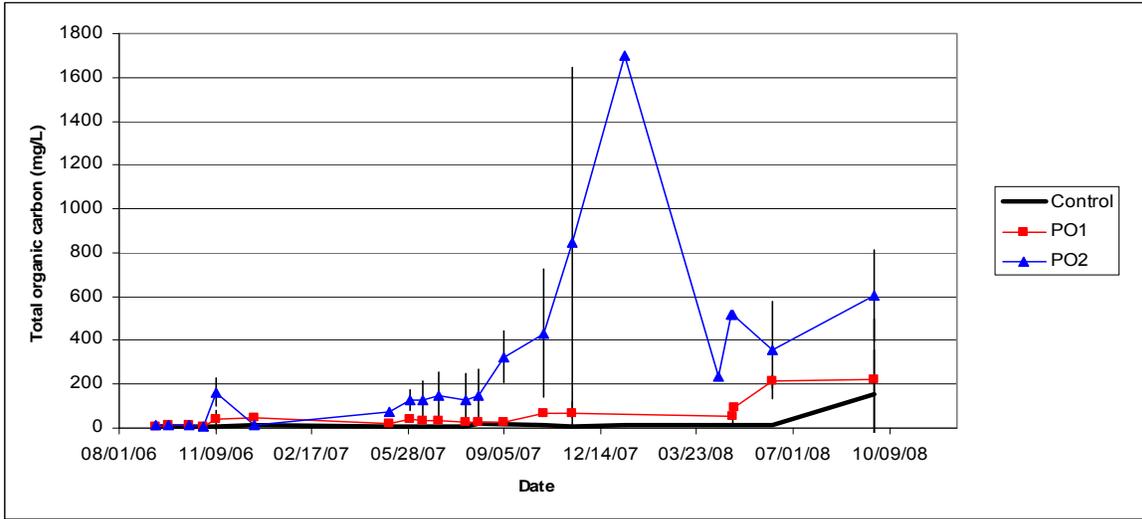
#### ***5.8.4.6 Soil moisture probe data.***

Graphs of the soil volumetric water content in the control and treatment soil plots at 15 and 45 cm from January 2007 until demobilization (September 2008) are shown in Figures 5.8.4.6-1 to 5.8.4.5-3. Data from August 2006 through December 2006 were sporadic due to sensor and logger issues. The changes in soil moisture tracked pretty consistently with the periods of high or low rainfall. The individual plots within a treatment group did show some variability as well in terms of the measured absolute water content, although the relative upward and downward trends were similar.

**Figure 5.8.4.1-1. Measured average pH of soil plot pore water and drainage samples.**  
 Top, 15 cm; Middle, 45 cm; Bottom, drainage.

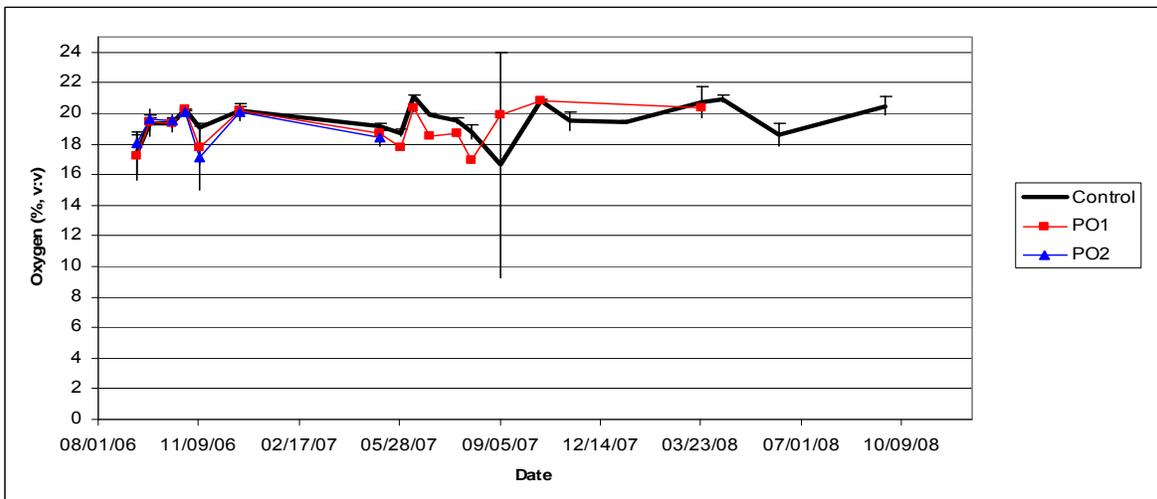
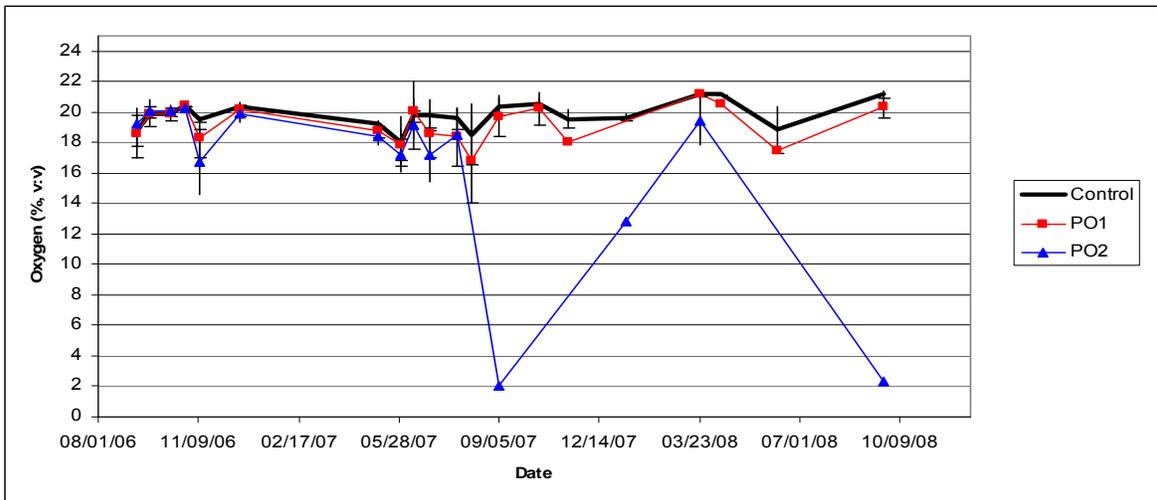
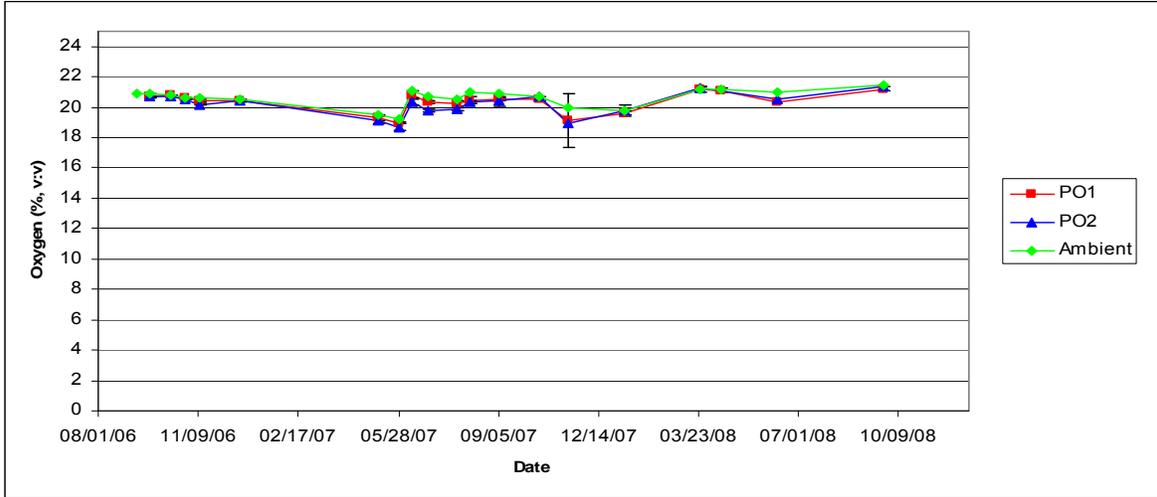


**Figure 5.8.4.2-1. Concentrations of TOC in soil plot pore water and drainage samples.**  
 Top, 15 cm; Middle, 45 cm; Bottom, drainage.



**Figure 5.8.4.4-1. Measured pore gas oxygen concentrations in soil plots.**

Top, PMSO:soil interface (PO1 and PO2 only); Middle, 15 cm; Bottom, 45 cm. Vertical dashed lines indicate when the PMSO and residues were added, for reference. Standard deviations are shown, when applicable (i.e., when n = 3).



**Figure 5.8.4.4-2. Measured pore gas carbon dioxide concentrations in soil plots.**

Top, PMSO:soil interface (PO1 and PO2 only); Middle, 15 cm; Bottom, 45 cm. Vertical dashed lines indicate when the PMSO and residues were added, for reference. Standard deviations are shown, when applicable (i.e., when n = 3).

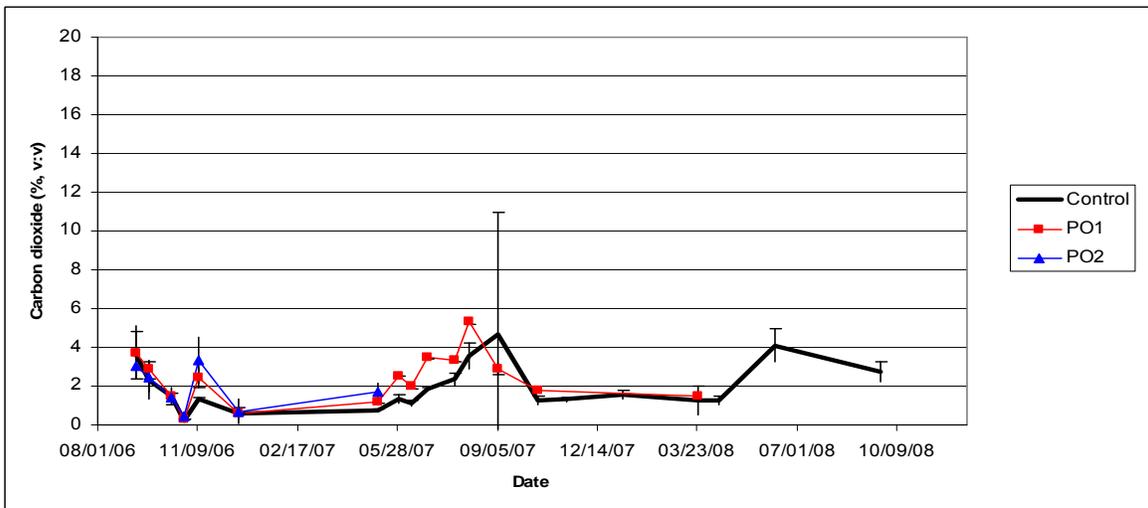
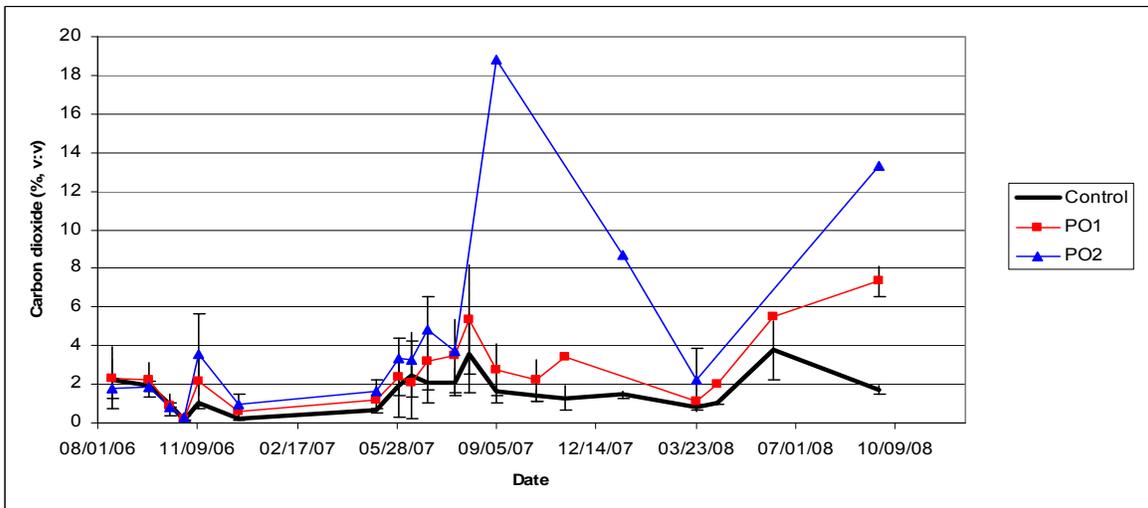
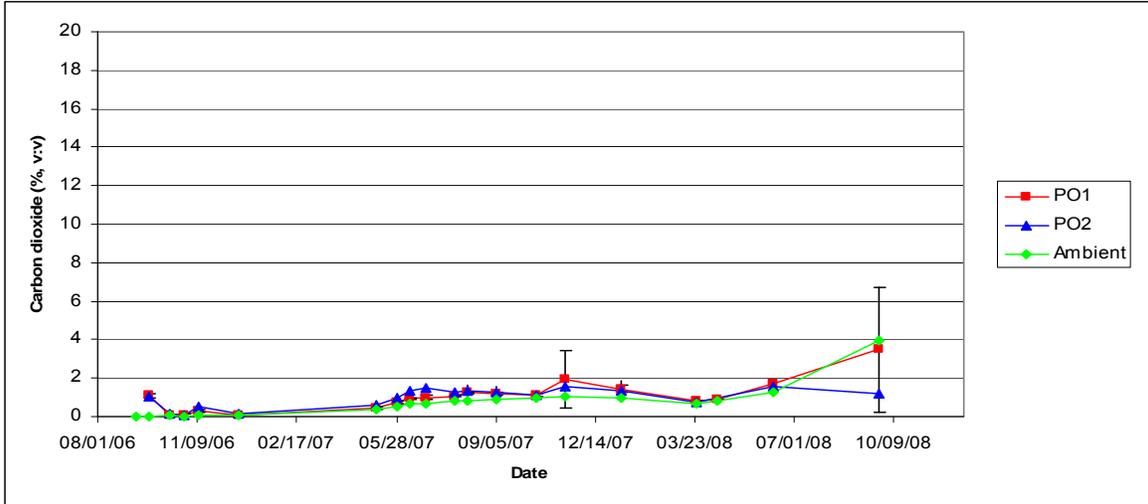


Figure 5.8.4.5-1. Temperature recorded at the demonstration site.

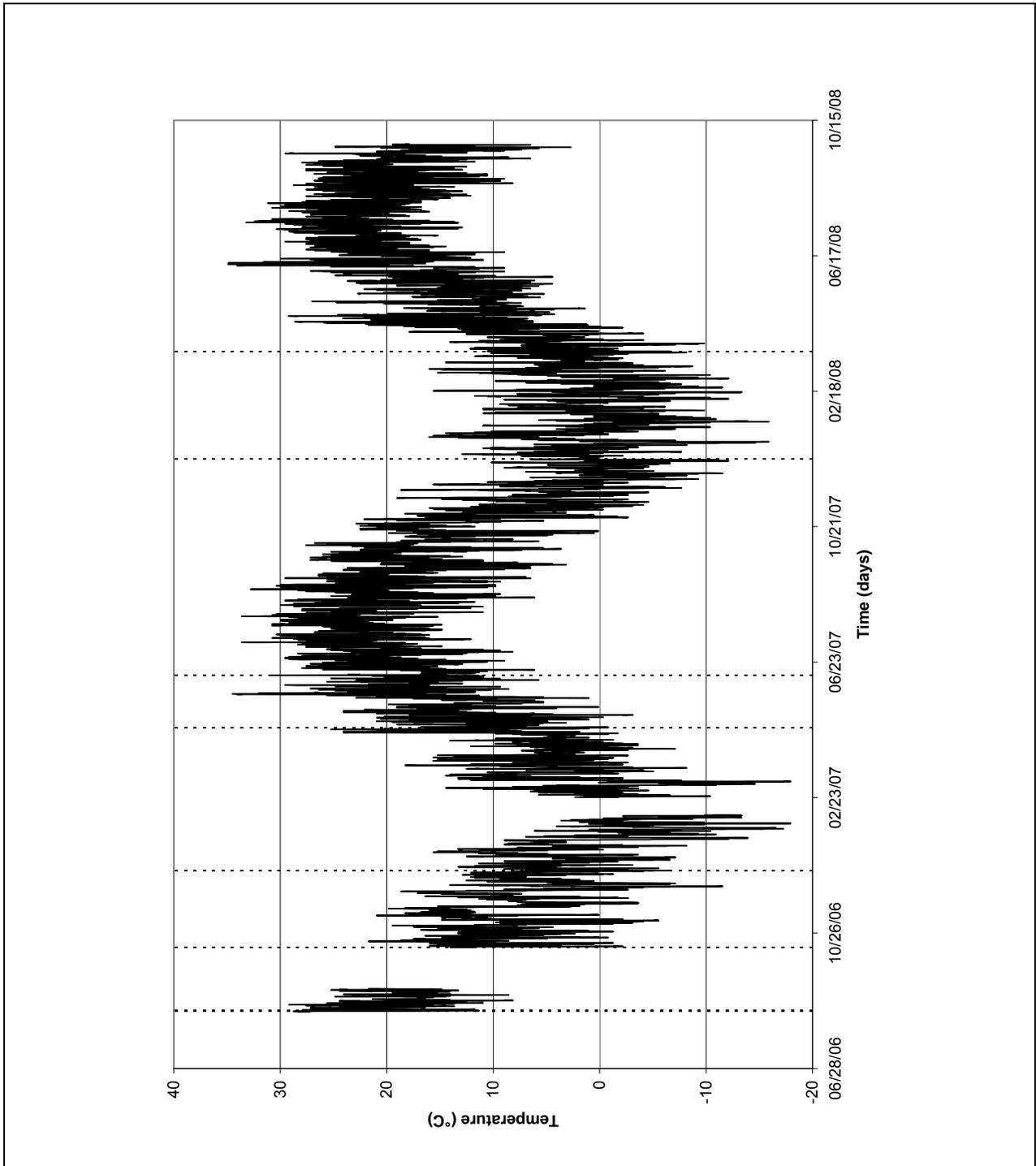


Figure 5.8.4.5-2. Total solar radiation recorded at the demonstration site.

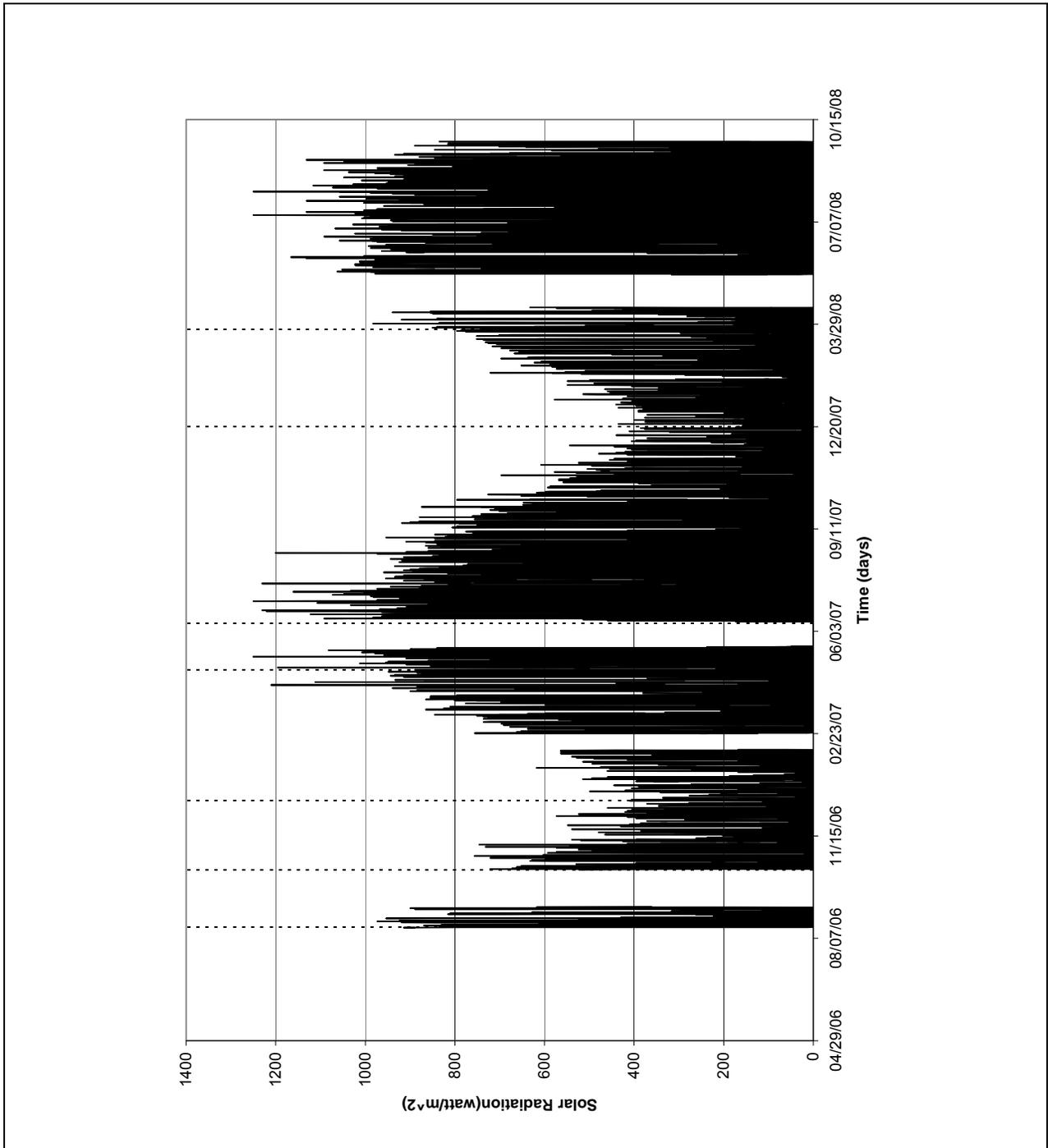


Figure 5.8.4.5-3. Precipitation levels recorded at the demonstration site.

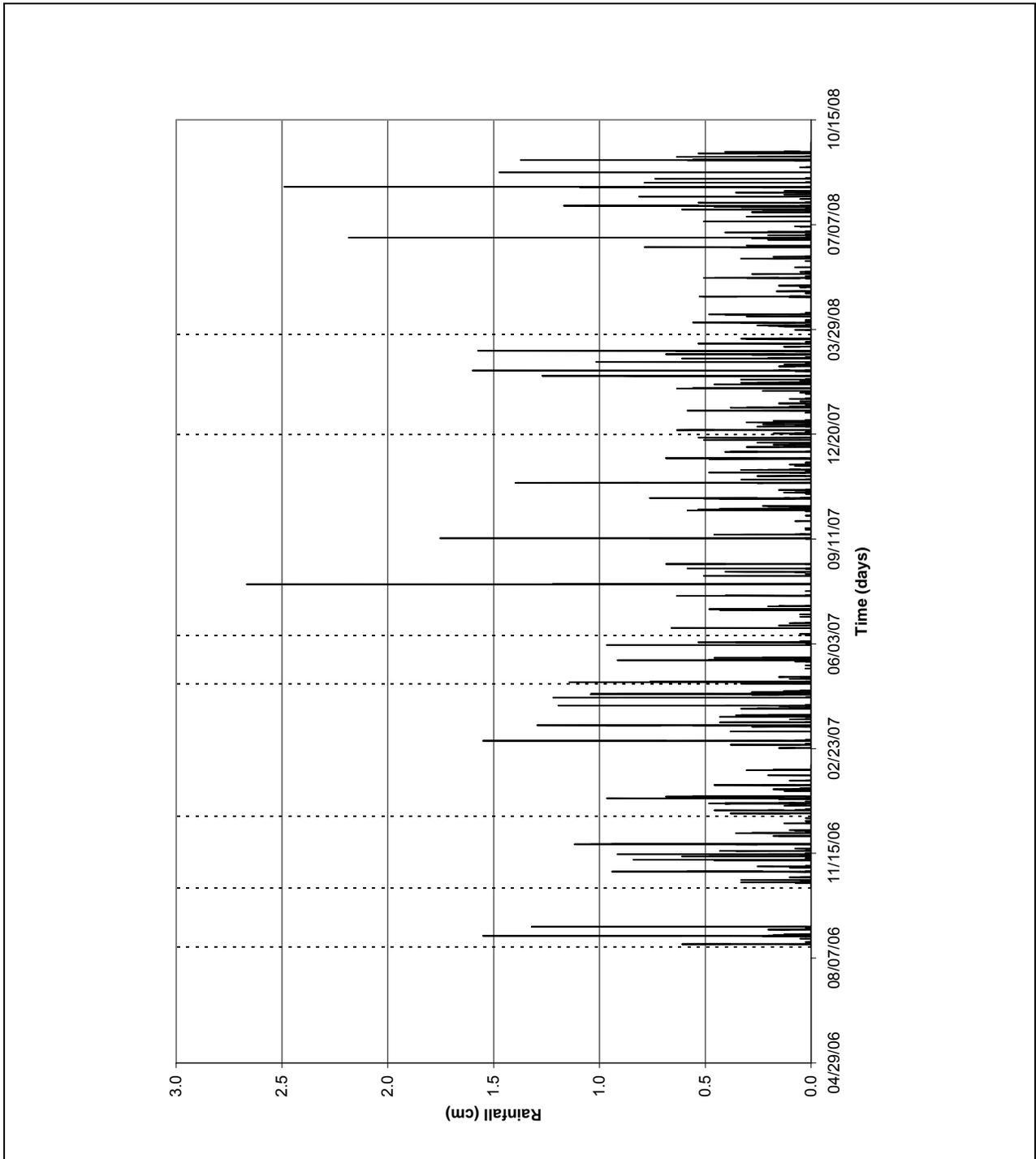
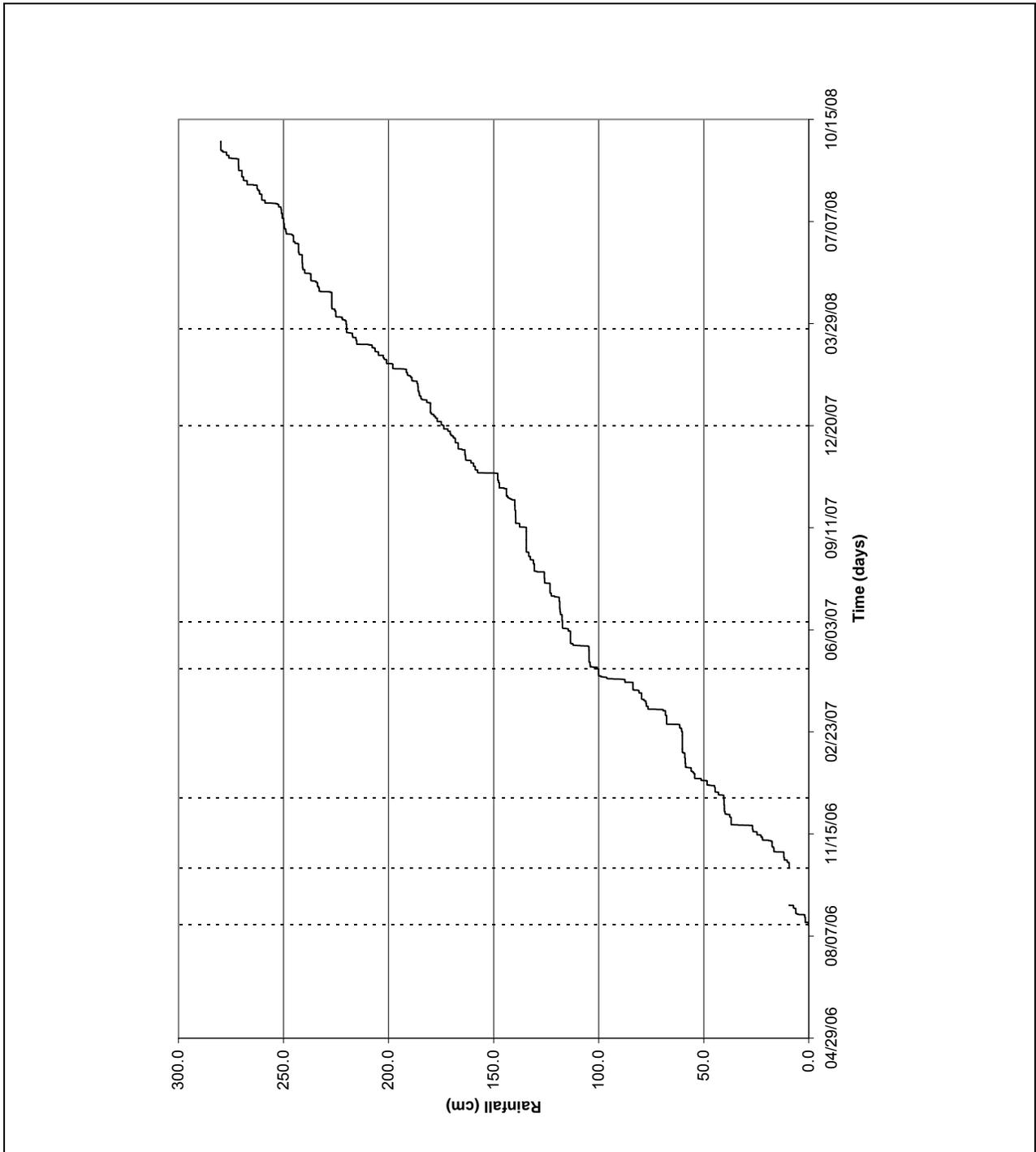
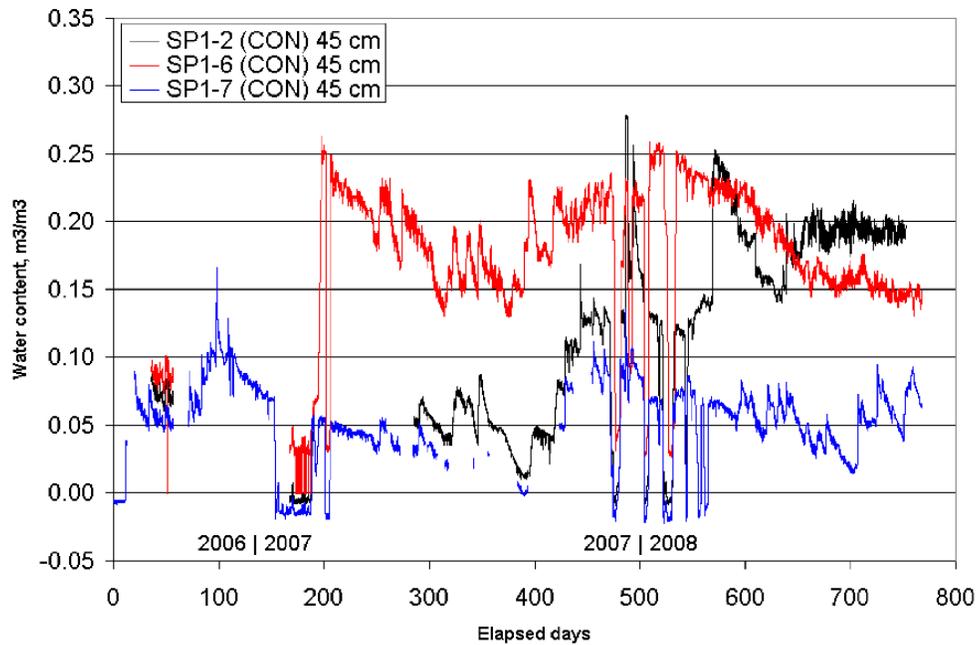
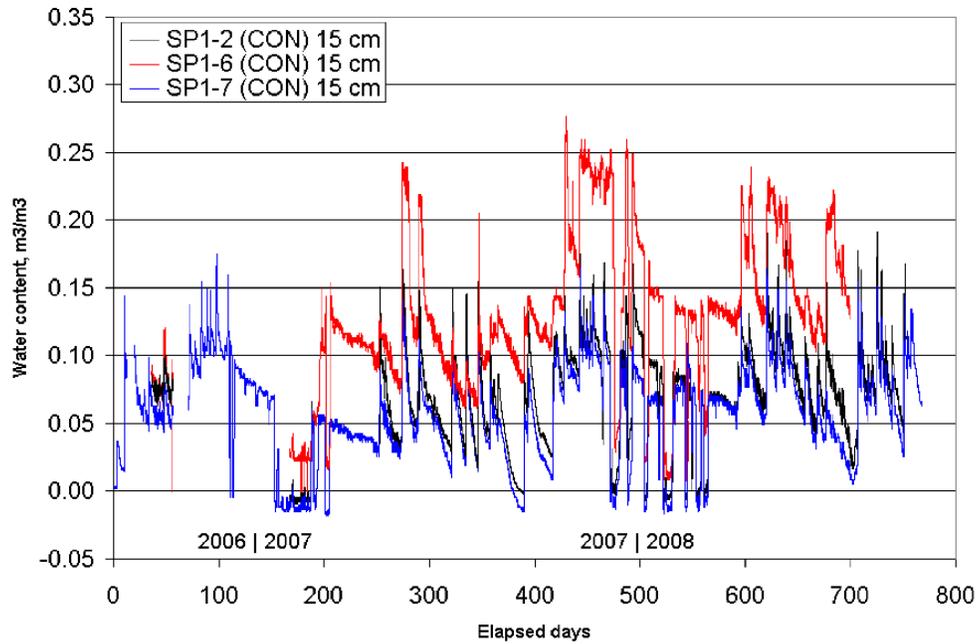


Figure 5.8.4.5-4. Cumulative precipitation recorded at the demonstration site.



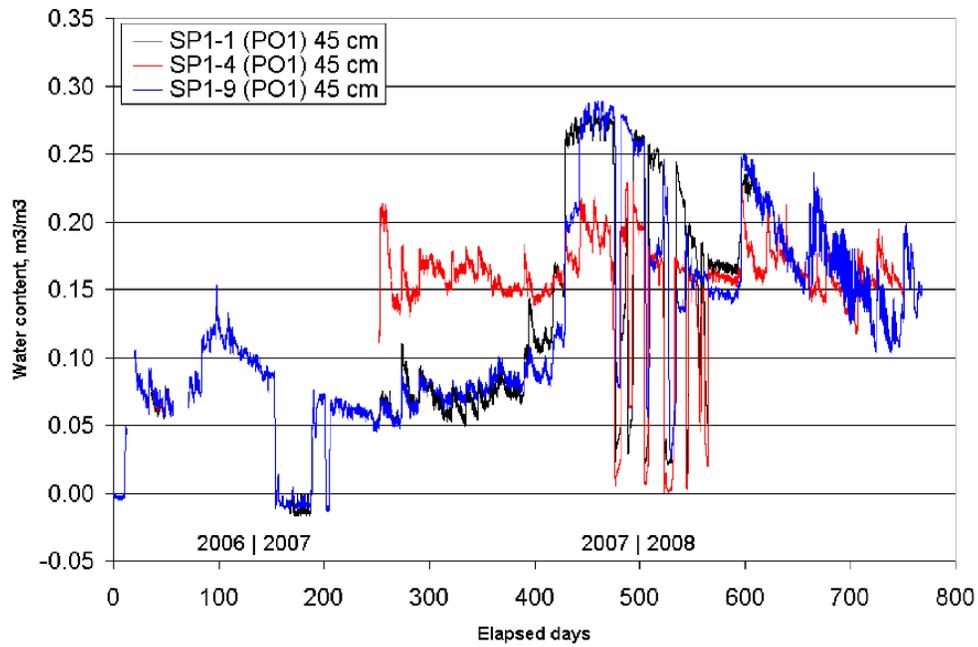
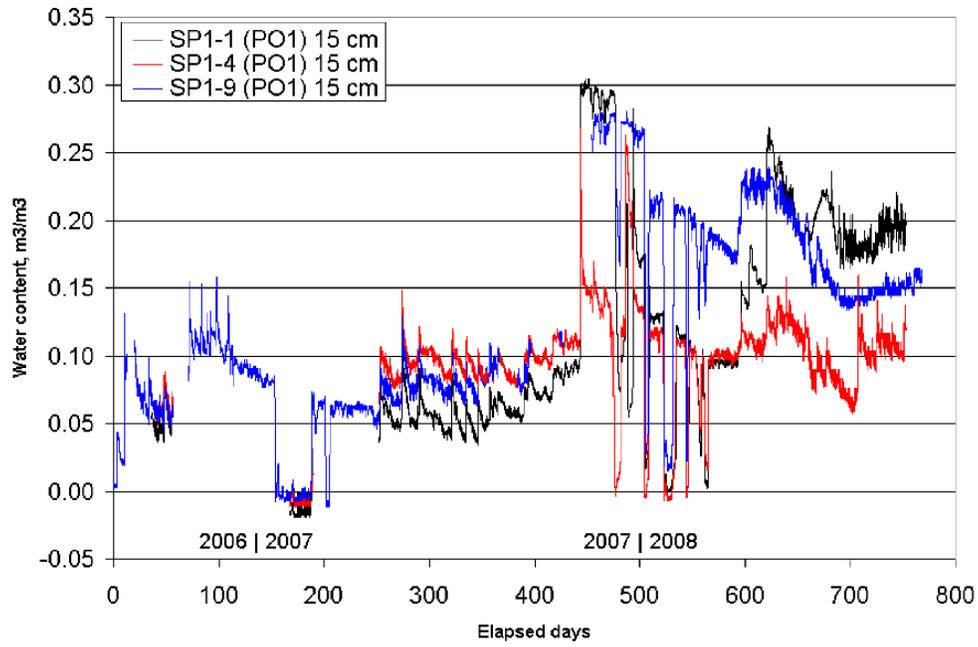
**Figure 5.8.4.6-1. Soil volumetric moisture content in control soil plots.**

Top, 15 cm; Middle, 45 cm.



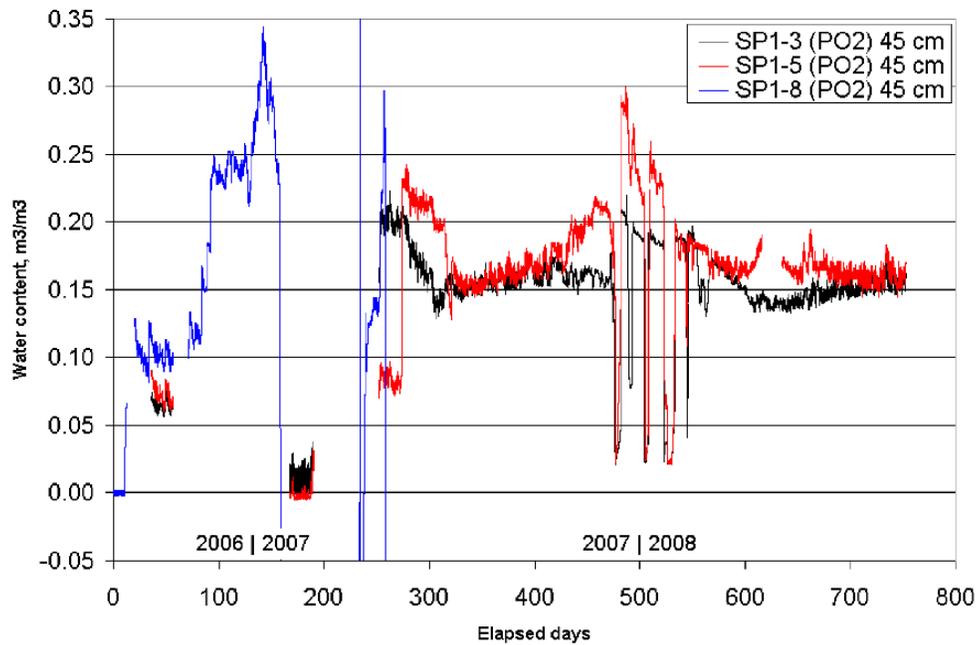
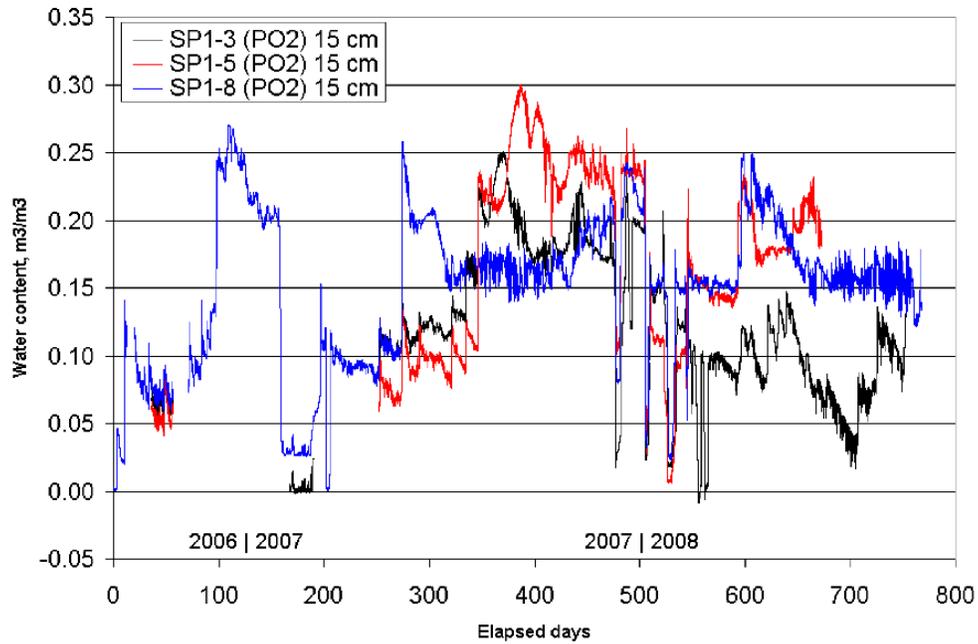
**Figure 5.8.4.6-2. Soil volumetric moisture content in the PO1 soil plots.**

Top, 15 cm; Middle, 45 cm.



**Figure 5.8.4.6-3. Soil volumetric moisture content in the PO2 soil plots.**

Top, 15 cm; Middle, 45 cm.



## 6. PERFORMANCE ASSESSMENT

### 6.1 Performance Criteria

Table 6.1 lists the performance criteria by which the demonstration was assessed. Performance criteria were selected based on factors that would likely be considered when bringing the proposed technology to full-scale application. Primary criteria were linked directly to the project performance objectives, while secondary criteria included additional factors that could be used to assess overall project performance.

<b>Table 6-1. Performance criteria for this SP1 demonstration project.</b>		
<b>Performance Criteria</b>	<b>Description</b>	<b>Primary or Secondary</b>
Contaminant Mobility	Migration of dissolved TNT and RDX into and through the soil.	<i>Primary</i>
Daughter Product Mobility	Movement of breakdown products of TNT and RDX into and through the soil.	<i>Primary</i>
Effect of Precipitation	The performance of the technology will be impacted by prevailing climatic conditions. Excessive rainfall may lead to decreased sorption and/or biotransformation efficiency of the treatment material.	<i>Primary</i>
Ease of Use	The only aspects of ease of use that will be examined during SP1 will be how easy it is to handle (mix, apply) the treatment material to the soil plot apparatus.	<i>Secondary</i>
Maintenance	Once deployed and applied, this technology requires very little maintenance. Additional applications may be periodically required.	<i>Secondary</i>
Scale-Up	While the nature of this SP1 demonstration is such that direct scale-up factors cannot be determined, some aspects such as treatment material mixing and handling can be assessed.	<i>Secondary</i>

### **Rationale for the Quantitative Primary Criteria**

The criteria of >50% reductions in the flux of TNT and RDX and the final soil concentrations of TNT and RDX were selected based on all the previous laboratory work and modeling that has been performed. Previous modeling indicated that the technology may reduce the TNT loading by 90% and the RDX loading by 80% (both compared to a “no treatment” control). A criteria of >50% reduction was selected for the SP1 demonstration as a conservative value that took into account some of the uncertainty in the modeling estimates, as well as the variability that can occur in the field. However, it was expected that the treatment would exceed the 50% reduction in flux and final soil concentrations.

### **Rationale for disregarding data from plot SP1-6 (Control)**

A careful inspection of the all the data and supplemental information indicated that one replicate of the control group of soil plots, SP1-6, was not performing similar to the other two control plots (SP1-2 and SP1-7). The observations were as follows:

- i) The pore water RDX concentrations at 45 cm and in the drainage were very low compared to the other control plots. This translated into lower estimates of RDX flux.
- ii) The pore water and drainage TOC values were much higher than observed in the other two replicate control plots. TOC is a major driver in explosive compound degradation, as it increase microbial activity.
- iii) The soil volumetric moisture content measured in SP1-6 was on the average quite a bit higher than in the other two control plots, and appeared to stay more wet for a large part of the demonstration. High moisture can lead to increased rates of RDX degradation.
- iv) There was a long period during which no pore gas measurements were collected from SP1-6 due to the sampling port being full of water, especially at the 45 cm sampling depth. When pore gases were able to be measured, the oxygen concentrations were much lower and the carbon dioxide concentrations were much higher than observed in the other two control plots. This again indicates that the soil in this plot remained wetter, that microbial activity was greater, and the was the possibility of increased RDX degradation.

v) At several points during the demonstration, photographs of SP1-6 showed standing water on the soil surface. At the time of demobilization, a slimy layer of algae was found to be growing at the surface of the soil under a layer of standing water.

vi) Post-demonstration soil samples from SP1-6 exhibited a much sharper drop-off in RDX concentrations in the soil profile compared to concentration profiles in the other control plots.

Based on this information, we concluded that, while the overall flux of water through the plot was similar to that in SP1-2 and SP1-7, there was significant biological activity in SP1-6 that reduced the movement of RDX in and through the soil and/or degraded the RDX much faster than would be expected in non-amended MMR soil. We postulate that the higher water content allowed for higher microbial activity and more anoxic processes that are likely to degrade RDX. The driving force for the microbial activity was likely soluble organic carbon arising from algae growing in ponded water that the soil surface.

Therefore, for the following performance evaluation, comparisons made between the treatments and the control plots was based on the average of the data from control plots SP1-2 and SP1-7 only, and the data from SP1-6 was excluded.

## **6.2 Aqueous concentration results versus quantitative primary performance criteria.**

The performance criteria for the aqueous phase concentration data was:

*Concentrations of explosive compounds in the treatment plots are <50% of those observed in the control plots at a given depth.*

### **6.2.1 RDX**

The concentration data from the treatment plots were analyzed in terms of its percent of the control concentration data for each sampling event and depth. The calculations were done using the data from each individual plot vs. the average values for the control plots, as well as comparing the treatment averages to the control plot averages. If either the treatment plot

concentration, the average control plot concentration, or both were below the detection limit, the percentage was not calculated. Data obtained before the application of the Composition residues on 13 June 2007 are not presented or discussed here. Data in the tables is arranged so that the three replicate soil plots (3 control, 3 PO1, 3 PO2) are in adjacent columns.

Table 6.2.1-1 presents the individual and average RDX results, respectively, for the 15 cm depth samples. Many of the RDX concentrations observed in the PO2 plots were below the detection limit, so only 13 percentage value were able to be calculated, and all 13 met the performance criteria. For the PO1 plots, more of the concentrations were above the detection limit. Of the 11 percentages that were able to be calculated, 7 met the performance criteria. Overall, 60% of the averaged PO1 met the criteria, while 100% of the averaged PO2 data met the criteria.

Table 6.2.1-2 present the individual and average results for the 45 cm depth samples. At this depth, also, there were many concentrations below the detection limit in the PO2 plots, Of the 9 percentage difference calculations that were made for the PO2 plots, 100% met the performance criteria. In contrast, several high concentrations of RDX detected in the PO1 plots. Of 15 percentages calculated, only 5 met the “<50%” performance criteria, and six of the nine values that exceeded the criteria did so by 7-fold or more. Overall, none of the averaged PO1 met the criteria, while 100% of the averaged PO2 data met the criteria.

Table 6.2.1-3 present the individual and average results for the drainage water samples. In these drainage samples, there were many RDX concentrations just at the detection limit in both the PO1 and PO2 plots. A full 26 out of 27 percentage values and 24 out of 25 percentage values for the PO1 and PO2 plots, respectively, met the performance criteria. Overall, 100% of the averaged PO1 met the criteria, and 90% of the averaged PO2 data met the criteria.

As mentioned above, there were some clear differences between the replicate plots in a given treatment. The only PO2 plot that had an RDX concentration that exceeded the performance

criteria was SP1-8, and then, it only occurred once in the drainage water samples. For the PO1 plots, SP1-4 and SP1-9 had many more exceedences than did SP1-3.

Based on all the development work for the PMSO technology, the observed low effectiveness of the PO1 treatment was unexpected. The most likely reason for this discrepancy is that the amount of crude soybean oil in the PO1 material decreased significantly (either through biological degradation or leaching) between the time it was added to the plots (13 October 2006) and the time the Composition B residues were applied (11 June 2007). This loss of crude soybean oil would result in lower rates of explosive compound biotransformation in the PO1 treatment plots, and hence, higher pore water concentrations of RDX.

It is also clear from the data from the individual soil plots to which PO1 was applied that SP1-4 behaved in manner dissimilar from the other two replicate soil plots, SP1-1 and SP1-9 at the 45 cm sampling depth. Much higher pore water RDX concentrations were observed in SP1-4 compared to the other two replicates. It is likely that some differences in the soil packing occurred which introduced preferential flow paths, resulting in higher RDX concentrations at deeper depths in SP1-4. When this variability in both the treatments and control plots is taken into account, it is clear that the PO1 treatment did reduce RDX concentrations at 15 cm and in the drainage compared to the control, at that at 45 cm the results were equivocal.

### **6.2.2 MNX**

The concentration data from the treatment plots were analyzed in terms of its percent of the control concentration data for each sampling event and depth. Calculations were performed as described above for RDX.

Table 6.2.2-1 presents the individual and average MNX results, respectively, for the 15 cm depth samples. Many of the concentrations observed in the both the PO1 and PO2 plots were below the detection limit. Of the 8 percentages that were able to be calculated for the PO1 plots, 5 met the performance criteria. For the PO2 plots, all 9 of the 9 calculated percentages met the

performance criteria. Overall, only 50% of the averaged PO1 met the criteria, while 100% of the averaged PO2 data met the criteria.

Table 6.2.2-2 present the individual and average results for MNX at the 45 cm depth samples. At this depth, also, many concentrations below the detection limit in the treatment plots. Of the 6 percentage difference calculations that were made for the PO2 plots, all 6 met the performance criteria. In contrast, several higher concentrations of MNX were detected in the PO1 plots. Of 6 percentages calculated, only 2 met the “<50%” performance criteria, and three of the four high values exceeded the criteria by 2-fold or more. Overall, only 50% of the averaged PO1 met the criteria, while 100% of the averaged PO2 data met the criteria.

Table 6.2.2-3 present the individual and average MNX results for the drainage water samples. In these drainage samples, there were many MNX concentrations just at the detection limit in both the PO1 and PO2 plots. For the PO1 plots, 13 out of 13 percentage values met the performance criteria, while 15 out of 15 percentage values for the PO2 plots met the performance criteria. Overall, 100% of both the averaged PO1 and PO2 data met the performance criteria.

### **6.2.3 Summary of performance criteria analysis of aqueous concentration data**

Based on these analyses, the PO2 treatment of a 10 cm layer of PMSO consisting of a 1:2 (w:w) mixture of peat moss and crude soybean oil met the performance criteria for RDX to a very high degree over the course of the demonstration. There was only 1 exceedence of the “treatment <50% of control” performance criteria out of a total of 49 values calculated for all the sampling depths over the duration of the demonstration. In contrast, the PO1 treatment (PMSO with 1:1 ratio of peat moss to soybean oil) did not meet the performance criteria to any high degree. Of the 41 values calculated, there were 15 exceedences of the “treatment <50% of control” performance criteria, and half of these occurred in a single soil plot (SP1-4).

For MNX, PO2 also performed better than PO1. A full 30 out of 30 calculated percentages met the “>50% reduction” performance criteria in the PO2 plots, compared to only 22 out of 29

percentages able to be calculated for the PO1 plots. With respect to MNX, all the PO1 plots had roughly the same number of exceedences.

Based on this data analysis, it can reasonably be stated that the PO2 PMSO treatment fully met the aqueous explosive concentration performance criteria (looking at either data from individual soil plots or average data), while the PO1 treatment only met the criteria about half the time. The actual performance was slightly better than reported here, since we applied a process of assigning a conservative value of one-half of the analytical detection limit to all the “below detection” data. We did this so that we had enough data for comparison, but it is likely that this skewed the outcome of the analysis somewhat.

**Table 6.2.1-1. Concentrations of RDX in the individual treatment plots as a percentage of the average concentration in the control plots at a depth of 15 cm.**

A “-“ indicates that either i) a sample was not able to be collected and analyzed, or ii) the average of the control samples was below the detection limit.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*” indicates that the value exceeded the performance criteria.

**A) Individual treatment plots vs. average control**

Event	Elapsed	Sample Date	% Average Control Concentration					
			SP1.1 (P01)	SP1.4 (P01)	SP1.9 (P01)	SP1.3 (P02)	SP1.5 (P02)	SP1.8 (P02)
Mobilization		08/15/06	-	-	-	-	-	-
	317	06/28/07	-	-	-	-	-	-
	346	07/27/07	-	-	-	-	-	-
	359	08/09/07	-	-	-	-	-	-
	386	09/05/07	-	-	-	-	-	-
	427	10/16/07	32	195**	111**	0.8	0.8	0.8
	457	11/15/07	55**	22	81**	3	0.1	0.1
Start Stand-by	493	12/21/07	-	-	-	-	-	-
	511	01/08/08	-	-	-	-	-	-
End Stand-by	588	03/25/08	-	-	-	-	-	-
	609	04/15/08	-	-	-	-	0.1	-
	622	04/28/08	-	-	-	-	-	-
	624	04/30/08	17	42	-	0.0	0.0	-
	625	05/01/08	26	-	-	0.0	-	-
	665	06/10/08	1	-	2	0.0	0.0	0.0
Demobilization	770	09/23/08	-	-	-	-	-	-

**B) Average treatment vs. average control**

Event	Elapsed	Sample Date	% Average Control Concentration	
			P01	P02
Mobilization		08/15/06	-	-
	317	06/28/07	-	-
	346	07/27/07	-	-
	359	08/09/07	-	-
	386	09/05/07	-	-
	427	10/16/07	113**	0.8
	457	11/15/07	53**	0.9
Start Stand-by	493	12/21/07	-	-
	511	01/08/08	-	-
End Stand-by	588	03/25/08	-	-
	609	04/15/08	-	0.1
	622	04/28/08	-	-
	624	04/30/08	29	0.0
	625	05/01/08	26	0.0
	665	06/10/08	2	0.0
Demobilization	770	09/23/08	-	-

**Table 6.2.1-2. Concentrations of RDX in the individual treatment plots as a percentage of the average concentration in the control plots at a depth of 45 cm.**

A “-“ indicates that either i) a sample was not able to be collected and analyzed, or ii) the average of the control samples was below the detection limit.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*” indicates that the value exceeded the performance criteria.

**A) Individual treatment plots vs. average control**

Event	Elapsed	Sample Date	% Average Control Concentration					
			SP1.1 (P01)	SP1.4 (P01)	SP1.9 (P01)	SP1.3 (P02)	SP1.5 (P02)	SP1.8 (P02)
Mobilization		08/15/06	-	-	-	-	-	-
	317	06/28/07	-	-	-	-	-	-
	346	07/27/07	-	-	-	-	-	-
	359	08/09/07	-	-	-	-	-	-
	386	09/05/07	-	-	-	-	-	-
	427	10/16/07	-	-	-	-	-	-
	457	11/15/07	-	-	-	-	-	-
	493	12/21/07	-	-	-	-	-	-
Start Stand-by	511	01/08/08	-	3	2,862**	-	-	-
	588	03/25/08	-	-	-	-	-	-
End Stand-by	609	04/15/08	165**	466**	390**	-	-	-
	622	04/28/08	-	-	-	-	-	-
	624	04/30/08	117**	352**	190**	0.5	0.5	-
	625	05/01/08	-	457**	-	0.5	-	-
	665	06/10/08	11	442**	14	0.2	0.2	0.2
	770	09/23/08	0.1	153**	0.1	0.1	0.1	0.1

**B) Average treatment vs. average control**

Event	Elapsed	Sample Date	% Average Control Concentration	
			P01	P02
Mobilization		08/15/06	-	-
	317	06/28/07	-	-
	346	07/27/07	-	-
	359	08/09/07	-	-
	386	09/05/07	-	-
	427	10/16/07	-	-
	457	11/15/07	-	-
	493	12/21/07	-	-
Start Stand-by	511	01/08/08	1,433**	-
	588	03/25/08	-	-
End Stand-by	609	04/15/08	340**	-
	622	04/28/08	-	-
	624	04/30/08	220**	0.5
	625	05/01/08	457**	0.5
	665	06/10/08	156**	0.2
	770	09/23/08	51**	0.1

**Table 6.2.1-3. Concentrations of RDX in the individual treatment plots as a percentage of the average concentration in the control plots in the drainage water samples.**

A “-“ indicates that either i) a sample was not able to be collected and analyzed, or ii) the average of the control samples was below the detection limit.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*\*” indicates that the value exceeded the performance criteria.

**A) Individual treatment plots vs. average control**

Event	Elapsed	Sample Date	% Average Control Concentration					
			SP1.1 (P01)	SP1.4 (P01)	SP1.9 (P01)	SP1.3 (P02)	SP1.5 (P02)	SP1.8 (P02)
Mobilization		08/15/06	-	-	-	-	-	-
	317	06/28/07	-	-	-	-	-	-
	346	07/27/07	-	-	-	-	-	-
	359	08/09/07	-	-	-	-	-	-
	386	09/05/07	-	-	-	-	-	-
	427	10/16/07	-	-	-	-	-	-
	457	11/15/07	7	0.6	0.6	0.6	0.6	160**
Start Stand-by	493	12/21/07	0.3	0.3	0.3	0.3	0.3	0.3
	511	01/08/08	-	-	-	-	-	-
End Stand-by	588	03/25/08	1	0.1	0.1	0.1	0.1	0.1
	609	04/15/08	0.2	0.2	0.2	0.2	0.2	0.2
	622	04/28/08	0.1	0.1	0.1	0.1	0.1	0.1
	624	04/30/08	0.1	0.1	0.1	0.1	0.1	0.1
	625	05/01/08	-	-	0.1	0.1	0.1	0.1
	665	06/10/08	0.1	0.1	0.1	0.1	0.1	25
Demobilization	770	09/23/08	0.1	110**	0.1	0.1	0.1	0.1

**B) Average treatment vs. average control**

Event	Elapsed	Sample Date	% Average Control Concentration	
			P01	P02
Mobilization		08/15/06	-	-
	317	06/28/07	-	-
	346	07/27/07	-	-
	359	08/09/07	-	-
	386	09/05/07	-	-
	427	10/16/07	-	-
	457	11/15/07	3	54**
Start Stand-by	493	12/21/07	0.3	0.3
	511	01/08/08	-	-
End Stand-by	588	03/25/08	0.5	0.1
	609	04/15/08	0.2	0.2
	622	04/28/08	0.1	0.1
	624	04/30/08	0.1	0.1
	625	05/01/08	0.1	0.1
	665	06/10/08	0.1	9
Demobilization	770	09/23/08	37	0.1

**Table 6.2.2-1. Concentrations of MNX in the individual treatment plots as a percentage of the average concentration in the control plots at a depth of 15 cm.**

A “-“ indicates that either i) a sample was not able to be collected and analyzed, or ii) the average of the control samples was below the detection limit.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*\*” indicates that the value exceeded the performance criteria.

**A) Individual treatment plots vs. average control**

Event	Elapsed	Sample Date	% Average Control Concentration					
			SP1.1 (P01)	SP1.4 (P01)	SP1.9 (P01)	SP1.3 (P02)	SP1.5 (P02)	SP1.8 (P02)
Mobilization		08/15/06	-	-	-	-	-	-
	317	06/28/07	-	-	-	-	-	-
	346	07/27/07	-	-	-	-	-	-
	359	08/09/07	-	-	-	-	-	-
	386	09/05/07	-	-	-	-	-	-
	427	10/16/07	-	-	-	-	-	-
	457	11/15/07	154**	4	239**	4	4	4
Start Stand-by	493	12/21/07	-	-	-	-	-	-
	511	01/08/08	-	-	-	-	-	-
End Stand-by	588	03/25/08	-	-	-	-	-	-
	609	04/15/08	-	-	-	-	-	-
	622	04/28/08	-	-	-	-	-	-
	624	04/30/08	32	26	-	1	1	-
	625	05/01/08	96**	-	-	3	-	-
	665	06/10/08	16	-	10	0.8	0.8	0.8
Demobilization	770	09/23/08	-	-	-	-	-	-

**B) Average treatment vs. average control**

Event	Elapsed	Sample Date	% Average Control Concentration	
			P01	P02
Mobilization		08/15/06	-	-
	317	06/28/07	-	-
	346	07/27/07	-	-
	359	08/09/07	-	-
	386	09/05/07	-	-
	427	10/16/07	-	-
	457	11/15/07	132**	4
Start Stand-by	493	12/21/07	-	-
	511	01/08/08	-	-
End Stand-by	588	03/25/08	-	-
	609	04/15/08	-	-
	622	04/28/08	-	-
	624	04/30/08	29	1
	625	05/01/08	96**	3
	665	06/10/08	13	0.8
Demobilization	770	09/23/08	-	-

**Table 6.2.2-2. Concentrations of MNX in the individual treatment plots as a percentage of the average concentration in the control plots at a depth of 45 cm.**

A “-“ indicates that either i) a sample was not able to be collected and analyzed, or ii) the average of the control samples was below the detection limit.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*” indicates that the value exceeded the performance criteria.

**A) Individual treatment plots vs. average control**

Event	Elapsed	Sample Date	% Average Control Concentration					
			SP1.1 (P01)	SP1.4 (P01)	SP1.9 (P01)	SP1.3 (P02)	SP1.5 (P02)	SP1.8 (P02)
Mobilization		08/15/06	-	-	-	-	-	-
	317	06/28/07	-	-	-	-	-	-
	346	07/27/07	-	-	-	-	-	-
	359	08/09/07	-	-	-	-	-	-
	386	09/05/07	-	-	-	-	-	-
	427	10/16/07	-	-	-	-	-	-
	457	11/15/07	-	-	-	-	-	-
Start Stand-by	493	12/21/07	-	-	-	-	-	-
	511	01/08/08	-	-	-	-	-	-
End Stand-by	588	03/25/08	-	-	-	-	-	-
	609	04/15/08	-	-	-	-	-	-
	622	04/28/08	-	-	-	-	-	-
	624	04/30/08	-	-	-	-	-	-
	625	05/01/08	-	-	-	-	-	-
	665	06/10/08	134**	403**	79**	5	5	5
Demobilization	770	09/23/08	1	67**	1	1	1	1

**B) Average treatment vs. average control**

Event	Elapsed	Sample Date	% Average Control Concentration	
			P01	P02
Mobilization		08/15/06	-	-
	317	06/28/07	-	-
	346	07/27/07	-	-
	359	08/09/07	-	-
	386	09/05/07	-	-
	427	10/16/07	-	-
	457	11/15/07	-	-
Start Stand-by	493	12/21/07	-	-
	511	01/08/08	-	-
End Stand-by	588	03/25/08	-	-
	609	04/15/08	-	-
	622	04/28/08	-	-
	624	04/30/08	-	-
	625	05/01/08	-	-
	665	06/10/08	205**	5
Demobilization	770	09/23/08	23	1

**Table 6.2.2-3. Concentrations of MNX in the individual treatment plots as a percentage of the average concentration in the control plots in the drainage water samples.**

A “-“ indicates that either i) a sample was not able to be collected and analyzed, or ii) the average of the control samples was below the detection limit.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*\*” indicates that the value exceeded the performance criteria.

**A) Individual treatment plots vs. average control**

Event	Elapsed	Sample Date	% Average Control Concentration					
			SP1.1 (P01)	SP1.4 (P01)	SP1.9 (P01)	SP1.3 (P02)	SP1.5 (P02)	SP1.8 (P02)
Mobilization		08/15/06	-	-	-	-	-	-
	317	06/28/07	-	-	-	-	-	-
	346	07/27/07	-	-	-	-	-	-
	359	08/09/07	-	-	-	-	-	-
	386	09/05/07	-	-	-	-	-	-
	427	10/16/07	-	-	-	-	-	-
	457	11/15/07	-	-	-	-	-	-
Start Stand-by	493	12/21/07	-	-	-	-	-	-
	511	01/08/08	-	-	-	-	-	-
End Stand-by	588	03/25/08	-	-	-	-	-	-
	609	04/15/08	-	-	-	-	-	-
	622	04/28/08	10	10	10	10	10	10
	624	04/30/08	5	5	5	5	5	5
	625	05/01/08	-	-	5	5	5	5
	665	06/10/08	9	9	9	9	9	9
Demobilization	770	09/23/08	3	48	3	3	3	3

**B) Average treatment vs. average control**

Event	Elapsed	Sample Date	% Average Control Concentration	
			P01	P02
Mobilization		08/15/06	-	-
	317	06/28/07	-	-
	346	07/27/07	-	-
	359	08/09/07	-	-
	386	09/05/07	-	-
	427	10/16/07	-	-
	457	11/15/07	-	-
Start Stand-by	493	12/21/07	-	-
	511	01/08/08	-	-
End Stand-by	588	03/25/08	-	-
	609	04/15/08	-	-
	622	04/28/08	10	10
	624	04/30/08	5	5
	625	05/01/08	5	5
	665	06/10/08	9	9
Demobilization	770	09/23/08	18	3

### **6.3 Aqueous flux results versus quantitative primary performance criteria.**

The performance criteria for the aqueous phase flux data was:

*Total soil explosives flux in the treatment plots are <50% of those in the control plots at a given depth at the end of the demonstration.*

Based on the data presented in section 5.8.2 above, it was clear that movement of RDX and MNX to the depths at which the fluxes were measured was very minimal until around Day 450. Therefore, the performance evaluation of the flux data is presented starting at Day 455 until Day 665. The data from Day 770, at which time demobilization occurred was also not included due to a high number of datapoints that were below the detection limits.

#### **6.3.1 RDX**

The concentration data from the treatment plots were analyzed in terms of their percent of the control plots at the corresponding location and time. Table 6.3.1-1 to Table 6.3.1-4 present the data in terms of cumulative RDX mass passing through a given depth and RDX flux at a given depth.

Of the 27 comparisons of cumulative mass of RDX passing 30 cm in the control and treatment plots, 15 of the PO1 values and all 27 of the PO2 values met the “<50% of control plot” performance criteria. Overall, only 22% of the averaged PO1 met the criteria, while 100% of the averaged PO2 data met the criteria.

When the flux of RDX passing 30 cm was evaluated, 16 out of 23 of the PO1 values and all 24 of the PO2 values met the “<50% of control plot” performance criteria. Overall, 75% of the averaged PO1 met the criteria, while 100% of the averaged PO2 data met the criteria.

At a depth of 75 cm, 100% of all the 27 comparisons of cumulative mass of RDX in the control and treatment plots for the PO1 and PO2 values met the “<50% of control plot” performance. All the average treatment values also met the performance criteria.

When the flux of RDX passing 75 cm was evaluated, 22 out of 22 of the PO1 values and 24 out of 24 of the PO2 values met the “<50% of control plot” performance criteria. 100% of the averaged PO1 and PO2 data met the criteria.

### **6.3.2 MNX**

The flux data from the treatment plots were analyzed in terms of their percent of the control plots at the corresponding location and time. Table 6.3.2-1 to Table 6.3.2-4 present the data in terms of cumulative MNX mass passing through a given depth and MNX flux at a given depth. The results for MNX were somewhat different than those observed for RDX.

Of the 27 comparisons of cumulative mass of MNX passing 30 cm in the control and treatment plots, only 6 of the PO1 values met the “<50% of control plot” performance criteria, while all 27 of the PO2 values met the criteria. Overall, none of the averaged PO1 met the criteria, while 100% of the averaged PO2 data met the criteria.

When the flux of MNX passing 30 cm was evaluated, 10 out of 23 of the PO1 values and 20 out of 24 of the PO2 values met the “<50% of control plot” performance criteria. Overall, only 13% of the averaged PO1 met the criteria, while 75% of the averaged PO2 data met the criteria.

At a depth of 75 cm, only 11 out of 27 comparisons of cumulative mass of MNX in the PO1 plots met the “<50% of control plot” performance criteria, and only 10 out of 27 comparisons for the PO2 plots met the criteria. Only 33% of the average values for the PO1 and PO2 treatments met the performance criteria based at this depth.

When the flux of MNX passing 75 cm was evaluated, 18 out of 22 of the PO1 values and 18 out of 24 of the PO2 values met the “<50% of control plot” performance criteria. Overall, 75% of both the averaged PO1 and PO2 data met the criteria.

### **6.3.3 Summary of performance criteria analysis of explosive flux data**

The RDX and MNX flux data support the general conclusion that the PO2 treatment of a 10 cm layer of PMSO consisting of a 1:2 (w:w) ratio of peat moss to crude soybean oil performed better than the PO1 treatment consisting of a 10 cm layer of a 1:1 peat:oil.

The PO2 treatment met the performance criteria for RDX flux (expressed as cumulative mass or actual flux) across all depths 100% of the time, and were generally <1% of the control values. The PO1 treatment performed much less effectively at the 30 cm depth, with only 47% of the treatment values meeting the performance criteria. At 75 cm, 100% of the PO1 plot flux values were less than fifty percent of the corresponding control plot flux values.

For MNX, the performance criteria applied to the average MNX flux (expressed as cumulative mass or actual flux) were met 71% of the time at all depths in the PO2 plots, and compliance was observed. However, it should also be noted that at the last timepoint (Day 665), the criteria for MNX flux were fully met at all depths, following a generally trend observed over the course of the demonstration. More of the treatment plot data exceeding the performance criteria might be expected given that the treatment plots were more biologically active than the control plots, and hence, would be producing more MNX from RDX which could move through the soil plot. The fact that there were not more exceedences does indicate that the MNX that was being produced was then also being subsequently degraded in the treatment plots.

Since these flux calculations relied on the pore and drainage water concentration data, they also likely underestimated the actual number of datapoints that met the performance criteria. As stated above, we applied a process of assigning a conservative value of one-half of the analytical detection limit to all the “below detection” data. We did this so that we had enough data for comparison, but it is likely that this skewed the outcome of the flux analysis to some degree.

**Table 6.3.1-1. Masses of RDX at a depth of 30 cm in the individual treatment plots as a percentage of the average flux in the control plots.**

A “-“ indicates that either the value could not be calculated due to lack of data for the treatment or the control plots.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*” indicates that the value exceeded the performance criteria.

A) Individual treatment plots vs. average control

Event	Elapsed	Sample Date	% Average Control Flux					
			SP1-1 (P01)	SP1-4 (P01)	SP1-9 (P01)	SP1-3 (P02)	SP1-5 (P02)	SP1-8 (P02)
Mobilization		08/15/06	-	-	-	-	-	-
	457	11/15/07	27	66**	114**	2	1	0.24
Start Stand	493	12/21/07	27	66**	114**	2	1	0.24
	511	01/08/08	19	43	81**	1	0.88	0.21
End Stand	588	03/25/08	16	40	129**	0.91	0.76	0.19
	609	04/15/08	14	38	116**	0.78	0.66	0.16
	622	04/28/08	14	36	114**	0.72	0.66	0.16
	624	04/30/08	16	42	112**	0.69	0.64	0.15
	625	05/01/08	16	42	111**	0.69	0.63	0.16
	665	06/10/08	11	63**	72**	0.45	0.42	0.12

B) Average treatment vs. average control

Event	Elapsed	Sample Date	% Average Control Flux	
			P01	P02
Mobilization		08/15/06	-	-
	457	11/15/07	69**	1
	493	12/21/07	69**	1
	511	01/08/08	48	0.70
	588	03/25/08	61**	0.62
	609	04/15/08	56**	0.53
	622	04/28/08	55**	0.51
	624	04/30/08	57**	0.49
	625	05/01/08	56**	0.50
	665	06/10/08	49	0.33

**Table 6.3.1-2. Flux of RDX at a depth of 30 cm in the individual treatment plots as a percentage of the average flux in the control plots.**

A “-“ indicates that either the value could not be calculated due to lack of data for the treatment or the control plots.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*\*” indicates that the value exceeded the performance criteria.

**A) Individual treatment plots vs. average control**

Event	Elapsed	Sample Date	% Average Control Flux					
			SP1-1 (P01)	SP1-4 (P01)	SP1-9 (P01)	SP1-3 (P02)	SP1-5 (P02)	SP1-8 (P02)
Mobilization		08/15/06	-	-	-	-	-	-
	457	11/15/07	24	34	87**	1	0.02	0.05
Start Stand	493	12/21/07	-	-	-	-	-	-
	511	01/08/08	4	0.05	19	0.02	0.04	0.14
End Stand	588	03/25/08	-	23	404**	0.29	0.07	0.12
	609	04/15/08	0.97	28	45	0.07	0.10	<0.01
	622	04/28/08	20	12	92**	0.03	0.75	0.10
	624	04/30/08	51**	189**	61**	0.04	<0.01	<0.01
	625	05/01/08	8	24	7	0.07	0.05	3
	665	06/10/08	3	98**	6	0.03	0.06	0.03

**B) Average treatment vs. average control**

Event	Elapsed	Sample Date	% Average Control Flux	
			P01	P02
Mobilization		08/15/06	-	-
	457	11/15/07	48	0.46
	493	12/21/07	-	-
	511	01/08/08	8	0.07
	588	03/25/08	214**	0.16
	609	04/15/08	25	0.06
	622	04/28/08	41	0.29
	624	04/30/08	100**	0.01
	625	05/01/08	13	1
	665	06/10/08	36	0.04

**Table 6.3.1-3. Masses of RDX at a depth of 75 cm in the individual treatment plots as a percentage of the average flux in the control plots.**

A “-“ indicates that either the value could not be calculated due to lack of data for the treatment or the control plots.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*\*” indicates that the value exceeded the performance criteria.

A) Individual treatment plots vs. average control

Event	Elapsed	Sample Date	% Average Control Flux					
			SP1-1 (P01)	SP1-4 (P01)	SP1-9 (P01)	SP1-3 (P02)	SP1-5 (P02)	SP1-8 (P02)
Mobilization		08/15/06	-	-	-	-	-	-
	457	11/15/07	16	0.21	1	0.22	2	20
Start Stand-by	493	12/21/07	4	0.10	0.46	0.28	0.60	5
	511	01/08/08	4	0.10	0.70	0.28	0.60	5
End Stand-by	588	03/25/08	2	0.04	0.25	0.14	0.22	1
	609	04/15/08	2	0.04	0.23	0.13	0.20	1
	622	04/28/08	2	0.03	0.22	0.12	0.20	1
	624	04/30/08	2	0.03	0.21	0.11	0.19	1
	625	05/01/08	2	0.03	0.21	0.11	0.18	1
	665	06/10/08	1	0.02	0.17	0.09	0.15	4

B) Average treatment vs. average control

Event	Elapsed	Sample Date	% Average Control Flux	
			P01	P02
Mobilization		08/15/06	-	-
	457	11/15/07	6	9
	493	12/21/07	1	2
	511	01/08/08	2	2
	588	03/25/08	0.79	1
	609	04/15/08	0.72	1
	622	04/28/08	0.69	0.98
	624	04/30/08	0.66	0.93
	625	05/01/08	0.64	0.91
	665	06/10/08	0.48	0.68

**Table 6.3.1-4. Flux of RDX at a depth of 75 cm in the individual treatment plots as a percentage of the average flux in the control plots.**

A “-“ indicates that either the value could not be calculated due to lack of data for the treatment or the control plots.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*\*” indicates that the value exceeded the performance criteria.

A) Individual treatment plots vs. average control

Event	Elapsed	Sample Date	% Average Control Flux					
			SP1-1 (P01)	SP1-4 (P01)	SP1-9 (P01)	SP1-3 (P02)	SP1-5 (P02)	SP1-8 (P02)
Mobilization		08/15/06	-	-	-	-	-	-
	457	11/15/07	3	0.04	0.11	0.04	0.27	10
	493	12/21/07	0.29	0.06	0.29	0.29	0.29	0.29
	511	01/08/08	-	-	-	-	-	-
	588	03/25/08	1	0.02	0.10	0.08	0.08	0.08
	609	04/15/08	<0.01	<0.01	0.05	<0.01	0.03	0.10
	622	04/28/08	<0.01	<0.01	0.08	0.01	0.06	0.05
	624	04/30/08	<0.01	<0.01	0.03	<0.01	<0.01	<0.01
	625	05/01/08	-	-	0.01	<0.01	<0.01	<0.01
	665	06/10/08	<0.01	<0.01	0.05	<0.01	0.07	12

B) Average treatment vs. average control

Event	Elapsed	Sample Date	% Average Control Flux	
			P01	P02
Mobilization		08/15/06	-	-
	457	11/15/07	1	3
	493	12/21/07	0.22	0.29
	511	01/08/08	-	-
	588	03/25/08	0.53	0.08
	609	04/15/08	0.02	0.05
	622	04/28/08	0.03	0.04
	624	04/30/08	0.01	0.00
	625	05/01/08	0.01	0.00
	665	06/10/08	0.02	4

**Table 6.3.2-1. Masses of MNX at a depth of 30 cm in the individual treatment plots as a percentage of the average flux in the control plots.**

A “-“ indicates that either the value could not be calculated due to lack of data for the treatment or the control plots.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*\*” indicates that the value exceeded the performance criteria.

A) Individual treatment plots vs. average control

Event	Elapsed	Sample Date	% Average Control Flux					
			SP1-1 (P01)	SP1-4 (P01)	SP1-9 (P01)	SP1-3 (P02)	SP1-5 (P02)	SP1-8 (P02)
Mobilization		08/15/06	-	-	-	-	-	-
	457	11/15/07	86**	68**	149**	34	28	12
Start Stand	493	12/21/07	86**	68**	149**	34	28	12
	511	01/08/08	57**	45	114**	22	19	10
End Stand	588	03/25/08	56**	46	115**	24	19	11
	609	04/15/08	54**	44	152**	24	19	11
	622	04/28/08	71**	41	210**	21	21	10
	624	04/30/08	76**	48	230**	20	20	10
	625	05/01/08	76**	48	229**	20	20	10
	665	06/10/08	59**	73**	120**	10	10	5

B) Average treatment vs. average control

Event	Elapsed	Sample Date	% Average Control Flux	
			P01	P02
Mobilization		08/15/06	-	-
	457	11/15/07	101**	25
	493	12/21/07	101**	25
	511	01/08/08	72**	17
	588	03/25/08	72**	18
	609	04/15/08	84**	18
	622	04/28/08	107**	18
	624	04/30/08	118**	16
	625	05/01/08	118**	17
	665	06/10/08	84**	8

**Table 6.3.2-2. Flux of MNX at a depth of 30 cm in the individual treatment plots as a percentage of the average flux in the control plots.**

A “-“ indicates that either the value could not be calculated due to lack of data for the treatment or the control plots.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*” indicates that the value exceeded the performance criteria.

A) Individual treatment plots vs. average control

Event	Elapsed	Sample Date	% Average Control Flux					
			SP1-1 (P01)	SP1-4 (P01)	SP1-9 (P01)	SP1-3 (P02)	SP1-5 (P02)	SP1-8 (P02)
Mobilization		08/15/06	-	-	-	-	-	-
	457	11/15/07	96**	40	169**	4	2	3
Start Stand	493	12/21/07	-	-	-	-	-	-
	511	01/08/08	5	3	53**	1	2	7
End Stand	588	03/25/08	-	132**	186**	271**	68**	113**
	609	04/15/08	3	17	1,031**	17	26	<0.01
	622	04/28/08	205**	16	657**	1	34	5
	624	04/30/08	149**	141**	524**	2	<0.01	<0.01
	625	05/01/08	44	36	105**	4	3	201**
	665	06/10/08	45	93**	31	1	2	1

B) Average treatment vs. average control

Event	Elapsed	Sample Date	% Average Control Flux	
			P01	P02
Mobilization		08/15/06	-	-
	457	11/15/07	102**	3
	493	12/21/07	-	-
	511	01/08/08	20	3
	588	03/25/08	159**	151**
	609	04/15/08	351**	14
	622	04/28/08	293**	13
	624	04/30/08	272**	0.57
	625	05/01/08	61**	69**
	665	06/10/08	56**	1

**Table 6.3.2-3. Masses of MNX at a depth of 75 cm in the individual treatment plots as a percentage of the average flux in the control plots.**

A “-“ indicates that either the value could not be calculated due to lack of data for the treatment or the control plots.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*” indicates that the value exceeded the performance criteria.

A) Individual treatment plots vs. average control

Event	Elapsed	Sample Date	% Average Control Flux					
			SP1-1 (P01)	SP1-4 (P01)	SP1-9 (P01)	SP1-3 (P02)	SP1-5 (P02)	SP1-8 (P02)
Mobilization		08/15/06	-	-	-	-	-	-
	457	11/15/07	276**	34	232**	30	213**	26
Start Stand-by	493	12/21/07	174**	27	156**	70**	148**	69**
	511	01/08/08	174**	27	214**	70**	148**	69**
End Stand-by	588	03/25/08	147**	25	172**	81**	130**	80**
	609	04/15/08	107**	18	127**	59**	96**	63**
	622	04/28/08	93**	16	111**	51**	84**	55**
	624	04/30/08	59**	10	71**	33	53**	35
	625	05/01/08	50**	8	61**	28	46	30
	665	06/10/08	26	4	34	15	27	18

B) Average treatment vs. average control

Event	Elapsed	Sample Date	% Average Control Flux	
			P01	P02
Mobilization		08/15/06	-	-
	457	11/15/07	181**	129**
	493	12/21/07	119**	81**
	511	01/08/08	138**	99**
	588	03/25/08	115**	79**
	609	04/15/08	84**	58**
	622	04/28/08	73**	51**
	624	04/30/08	47	32
	625	05/01/08	40	28
	665	06/10/08	22	15

**Table 6.3.2-4. Flux of MNX at a depth of 75 cm in the individual treatment plots as a percentage of the average flux in the control plots.**

A “-“ indicates that either the value could not be calculated due to lack of data for the treatment or the control plots.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*” indicates that the value exceeded the performance criteria.

A) Individual treatment plots vs. average control

Event	Elapsed	Sample Date	% Average Control Flux					
			SP1-1 (P01)	SP1-4 (P01)	SP1-9 (P01)	SP1-3 (P02)	SP1-5 (P02)	SP1-8 (P02)
Mobilization		08/15/06	-	-	-	-	-	-
	457	11/15/07	40	6	17	6	40	6
	493	12/21/07	97**	21	97**	97**	97**	97**
	511	01/08/08	-	-	-	-	-	-
	588	03/25/08	101**	21	124**	101**	101**	101**
	609	04/15/08	0.51	0.51	8	1	5	15
	622	04/28/08	0.93	0.18	11	2	9	7
	624	04/30/08	0.04	<0.01	1	0.04	0.25	0.25
	625	05/01/08	-	-	0.63	0.04	0.22	0.13
	665	06/10/08	0.35	0.14	5	0.86	6	4

B) Average treatment vs. average control

Event	Elapsed	Sample Date	% Average Control Flux	
			P01	P02
Mobilization		08/15/06	-	-
	457	11/15/07	21	17
	493	12/21/07	72**	97**
	511	01/08/08	-	-
	588	03/25/08	82**	101**
	609	04/15/08	3	7
	622	04/28/08	4	6
	624	04/30/08	0.37	0.18
	625	05/01/08	0.63	0.13
	665	06/10/08	2	4

#### **6.4 Soil profile concentration results versus quantitative primary performance criteria.**

The performance criteria for the aqueous phase concentration data was:

*Total soil explosives concentrations at different depths in the treatment plots are <50% of those in the control plots at a given depth at the end of the demonstration.*

RDX was the only analyte for which enough data above the detection limit were observed to allow a robust assessment. Although the depth intervals of the soil sampling were slightly different in the controls and the treatment plots, they are close enough to allow a fair comparison in the final disposition of RDX in the soil profile in terms of the performance criteria.

Table 6.4-1 presents the RDX soil concentrations in the treatment plots expressed as a percentage of the RDX concentrations in the control plots at an equivalent depth. When the individual PO1 treatment plots were compared to the average of the control plots, only SP1-4 had any concentrations that did not meet the “<50% of the control” criteria. Three out of 8 of the RDX concentrations in the SP1-4 soil profile exceeded the “<50% of the control concentration” performance criteria. In contrast, all of the PO2 treatment plots met the performance criteria. Over 85% of the soil RDX concentrations in both the PO1 and PO2 treatment plots were less than ten percent of the average control concentrations, and 65% were less than two percent of the control RDX concentrations.

When the average RDX concentrations of the three replicate soil plots for each treatment were compared to the average RDX concentrations in the control plots, all met the “<50% of the control” performance criteria. For treatment PO1 plots, roughly 30% of the average concentrations of RDX were less than ten percent of the depth-matched control value, and 20% were less than two percent of the control. For the PO2 treatment, a full 100% of the depth-matched average RDX concentrations were less than ten percent of the control values, and 60% were less than two percent of the corresponding control results.

Based on these average RDX concentrations in the control and treatment plots, it can be concluded that both the PO1 and PO2 PMSO treatment fully met the soil residual explosive concentration performance criteria. The SP1-4 plot in the PO1 treatment group did exceed the criteria at several depths, but when averaged with the data in the other plots in the PO1 treatment group, the RDX concentrations did not exceed the performance criteria.

These soil and PMSO layer explosive compound concentration data indicate that the PMSO is effective at stopping the movement of both particulate as well as dissolved energetics into the underlying soil. The active contaminant breakdown in the PMSO layer, especially with a higher peat:oil ratio (as in the PO2 plots), keeps pace with the rate of explosive residue dissolution such that the mass of RDX (and by extension, TNT and HMX) reaching the soil surface to a very low level.

**Table 6.4-1. Soil concentrations of RDX in the individual treatment plots as a percentage of the average concentration in the control plots as a function of soil depth.**

A “-“ indicates that either i) a sample was not able to be collected and analyzed, or ii) the average of the control samples was below the detection limit.

Averages were calculated by setting “below detection limit” values to one-half the detection limit.

A “\*\*” indicates that the value exceeded the performance criteria.

A) Individual treatment plots vs. average control

Depth cm	% Average Control Concentration					
	SP1-1 (P01)	SP1-4 (P01)	SP1-9 (P01)	SP1-3 (P02)	SP1-5 (P02)	SP1-8 (P02)
1.25	0.41	2.13	0.36	0.79	0.51	1.56
3.75	1.33	10.68	0.48	6.94	2.41	9.69
5.67	0.40	28.84	5.05	0.40	4.96	20.98
8.87	0.53	42.21	7.82	0.53	5.35	6.36
13.95	0.68	61.35**	0.68	0.68	0.68	0.68
19.03	1.00	81.63**	1.00	1.00	1.00	1.00
24.11	0.93	52.85**	0.93	0.93	0.93	0.93
29.19	1.20	43.51	1.20	1.20	1.20	1.20
34.27	1.51	-	1.51	1.51	1.51	1.51
39.35	-	-	-	2.46	-	2.46

B) Average treatment vs. average control

Depth cm	% Average Control Concentration	
	P01	P02
1.25	0.96	0.95
3.75	4.16	6.35
5.67	11.43	8.78
8.87	16.85	4.08
13.95	20.91	0.68
19.03	27.87	1.00
24.11	18.24	0.93
29.19	15.30	1.20
34.27	1.51	1.51
39.35	-	2.46

## **7. COST ASSESSMENT**

### **7.1 Cost Model**

This section describes the cost performance criteria that were evaluated in completing the economic analysis of the PMSO technology for *in situ* remediation of explosives. The actual costs for performance of the SP1 and GR demonstrations are presented in Table 7.1-1.

*PLEASE NOTE: Due to the goals and approach of this project, most of the costs presented in Table 7.1-1 are specific to the demonstrations that were performed and are not reflective of the costs that would be incurred during an actual field implementation of the technology. The cost categories and costs associated with employing the PMSO technology at a “typical” site are presented in Tables 7.3-1 and 7.3-2.*

### **7.2 Cost Drivers**

The main cost drivers for use of this technology would be the cost of the materials (peat moss, crude soybean oil), and the labor required to perform the application. These costs, in turn are dependent on the ratio of peat moss to oil being used, the size of the area to be treated, the depth of material to be applied, and the period between required reapplications. The results of the SP1 and GR Demonstrations supplied data to provide general guidelines to allow determination of the depth of material to apply to achieve a given level of explosive residue immobilization (given estimates of residue loading, precipitation, etc.). Knowing this value, calculation of the amount of materials needed and the labor required to apply it would be easily calculated. It was also possible to estimate of the longevity of the treatment materials.

### **7.3 Cost Analysis**

The cost analysis is based primarily on the GR demonstration due to its larger, more full-scale-relevant scope, but the majority of the quantitative performance data were derived from the SP1 demonstration to allow a more detailed and relevant cost estimate to be calculated.

The cost analysis was developed in conjunction with the technical protocol for implementing the technology, which was based on the use of the predictive model of treatment performance and the technical requirements for full-scale implementation. The cost analysis is presented for a typical site, assuming full-scale application. The cost analysis includes provisions and contingencies related to application of the technology to different sized areas as well as different methods of application (surface vs. buried PMSO layer) in light of the lessons learned.

**Table 7.1-1. Actual SP1 and GR Demonstration Costs.**

*Note 1: Data analysis, reporting, and non-field work travel costs are not included.*

*Note 2: The only costs in this table that would be partially applicable to an actual field implementation of the PMSO technology are the treatment materials (peat moss, crude soybean oil). Please see Tables 7.3-1 and 7.3-2 for a more realistic cost model.*

<b>Cost Category</b> <i>SP1 Demonstration</i>	<b>Subcategory</b>	<b>Details</b>	<b>Cost (\$)</b>
1 Start-Up	Engineering and design	Labor	106,938
	Site characterization	Analytical and labor	2,284
	Treatment materials	Peat moss (0.1 m <sup>3</sup> , 3.5 ft <sup>3</sup> )	11
		Crude soybean oil (16.5 lb, 7.5 kg)	8
	Structures, components, and equipment	Berm liner, pallet racks, concrete barriers, fencing, tanks, fittings, sensors, dataloggers, forklift (+ operator), etc.	30,098
Deployment	Labor	33,803	
2 Operations & Maintenance	Sampling	Labor and shipping	83,172
	Analytical	Dissolved explosives, total organic carbon, etc.	90,082
3 Demobilization		Labor, analytical, waste disposal	18,752
<b>TOTAL</b>			<b>365,147</b>
	Media treated (6 soil plots)	m <sup>2</sup>	0.99
		yd <sup>2</sup>	1.18
	Cost/area treated for PMSO materials	m <sup>2</sup>	19
		yd <sup>2</sup>	16
	Cost/area treated for total demonstration	m <sup>2</sup>	370,708
		yd <sup>2</sup>	309,972

**Table 7.1-1. Actual SP1 and GR Demonstration Costs (cont.)**

*Note 1: Data analysis, reporting, and non-field work travel costs are not included.*

*Note 2: The only costs in this table that would be partially applicable to an actual field implementation of the PMSO technology are the treatment materials (peat moss, crude soybean oil), equipment rental costs, and deployment labor. Please see Tables 7.3-1 and 7.3-2 for a more realistic cost model.*

<b>Cost Category</b> <i>GR Demonstration</i>	<b>Subcategory</b>	<b>Details</b>	<b>Cost (\$)</b>
1 Start-Up	Engineering and design	Labor	34,012
	Baseline site work	Labor	12,655
		Analytical	18,617
	Treatment materials	Peat moss (10.6 m <sup>3</sup> , 373 ft <sup>3</sup> )	572
		Crude soybean oil (1200 lb, 544 kg)	598
		Soybean oil transport	1,583
	Equipment	Cement mixer	200
	Deployment	Labor	2,044
2 Operations & Maintenance			0
3 Demobilization			0
<b>TOTAL COST</b>			<b>70,281</b>
	Media treated (Bay 1)	m <sup>2</sup>	100
		yd <sup>2</sup>	120
	Cost/area treated for PMSO materials plus application	m <sup>2</sup>	50
		yd <sup>2</sup>	42
	Cost/area treated for PMSO materials plus application (excluding transport)	m <sup>2</sup>	34
		yd <sup>2</sup>	28
	Cost/area treated for total demonstration	m <sup>2</sup>	703
		yd <sup>2</sup>	586

### ***Basic site description***

The PMSO technology would be most effective at areas ranging from a few hundred to a few thousand square meters. Sites that would be most likely to benefit from deployment of the PMSO technology include:

- hand grenade training area
- open burn/open detonation facilities
- mortar and rocket firing points
- EOD training areas
- small arms firing points (where there is a concern about NC/NG/DNT residues)

The data obtained during the GR demonstration (Part II of this report) clearly indicated that the PMSO technology would be better either tilled into or emplaced beneath a layer of soil. The costs for tilled deployment is the baseline, but an option for burial is included.

### ***Treatment timeframe***

The PMSO technology is designed to prevent contamination of subsurface and groundwater resources. As such, the treatment timeframe is defined here as the length of time before the PMSO's ability to sorb and enhance the degradation of dissolved explosive compounds is decreased, requiring that the material needs to be rejuvenated and/or replaced.

Based on the previous research, and the data obtained during this project, the previously developed model of Schaefer et al (8) was used to estimate the effective reduction in the fluxes of TNT, RDX, and HMX over time. A 10 cm layer of PMSO having a composition of 1:2 peat moss:crude soybean oil (w:w), and a annual rainfall of 70 cm was assumed. Retardation factors for HMX, RDX, and TNT were based on a 1:2 PMSO material, but biodegradation rate constants were based on a 1:1 PMSO material as this was the only dataset available. Biodegradation rates would likely be higher in the 1:2 PMSO material.

The model estimate is presented in Figure 7.3-1. The flux of TNT and RDX are reduced by >50% for more than 48 months, while that of HMX starts to increase above the 50% mark around 48 months. Therefore, for the cost analysis a baseline re-application rate of 48 months was selected (i.e., it would be advised that the PMSO be rejuvenated or replaced every 48 months).

### ***Life-cycle assessment***

The following items were considered in the life-cycle cost estimate:

1) **Facility capital costs (deployment and reapplication).** The facility capital costs are expected to be minimal and may include the purchase of some commercially available equipment for mixing and application of the peat moss plus soybean oil treatment materials and basic soil manipulation. It is just as likely that this equipment would be rented or bought, or that this activity would be subcontracted to a private vendor, so these options are included in the cost analysis.

2) **Maintenance costs.** As stated above, the results of previous model development and the SP1 and GR demonstrations indicated that the duration of PMSO effectiveness (>50% reduction in contaminant flux to the subsurface) was approximately 48 months. The costs for activities to rejuvenate the treatment layer by adding more treatment materials, or to replace the PMSO entirely, were estimated.

### ***Cost comparison***

The results were compared to the only other competing technology, topically-applied lime. ESTCP funded research on a topical applied lime technology that has a similar goal of reducing explosive residue leaching to groundwater (project ER-0216). Efforts were made to make a parameter-relevant comparison between the peat moss plus soybean oil-based technology and the lime-based technology. The Cost and Performance Report for ER-0216 was used as the source of the costs for the lime technology (specifically, Table 10, p. 29). The costs assume that soil is “treated” to an effective depth of 1 m (or 1 yard) under the area covered, so application of either lime or PMSO to 600 m<sup>2</sup> effectively treats 600 m<sup>2</sup>. A cost comparison for a 4 year reapplication

rate to achieve a >50% reduction in HMX, and >99% reductions in RDX and TNT loadings is presented in Table 7.3-1. A cost comparison for a 2.5 year reapplication rate to achieve a >90% reduction in HMX, and >99% reductions in RDX and TNT loadings is presented in Table 7.3-2.

Because the baseline re-application rate was assumed to be 48 months as opposed to every quarter for the lime technology, the costs comparison is only presented based on rental of the needed equipment. Rental periods of 1 week were assumed.

Costs for materials were based on:

**Crude soybean oil:**

*Amount:* 14,400 lbs to cover 600 m<sup>2</sup> of 1:2 peat:oil PMSO, based on 1200 lbs for 100 m<sup>2</sup> at 1:1 peat:oil ratio.

*Cost:* Average \$/lb of oil of \$0.3476 based on April/May 2009 commodity data from Iowa, Illinois, Indiana-Ohio, and Minnesota, plus \$0.0125/lb for the distributor's charge (what was charged when the oil for the GR demonstration was purchased). Shipping of oil was based on freight transport of 7200 lbs of oil from Iowa City, IA to Columbia, SC, using a National Motor Freight Classification NMFC# 65, which is the classification for biodiesel.

**Peat moss:**

*Amount:* 2250 cu. ft. to cover 600 m<sup>2</sup>, based on 373 cu. ft. for 100 m<sup>2</sup> at 1:1 peat:oil ratio.

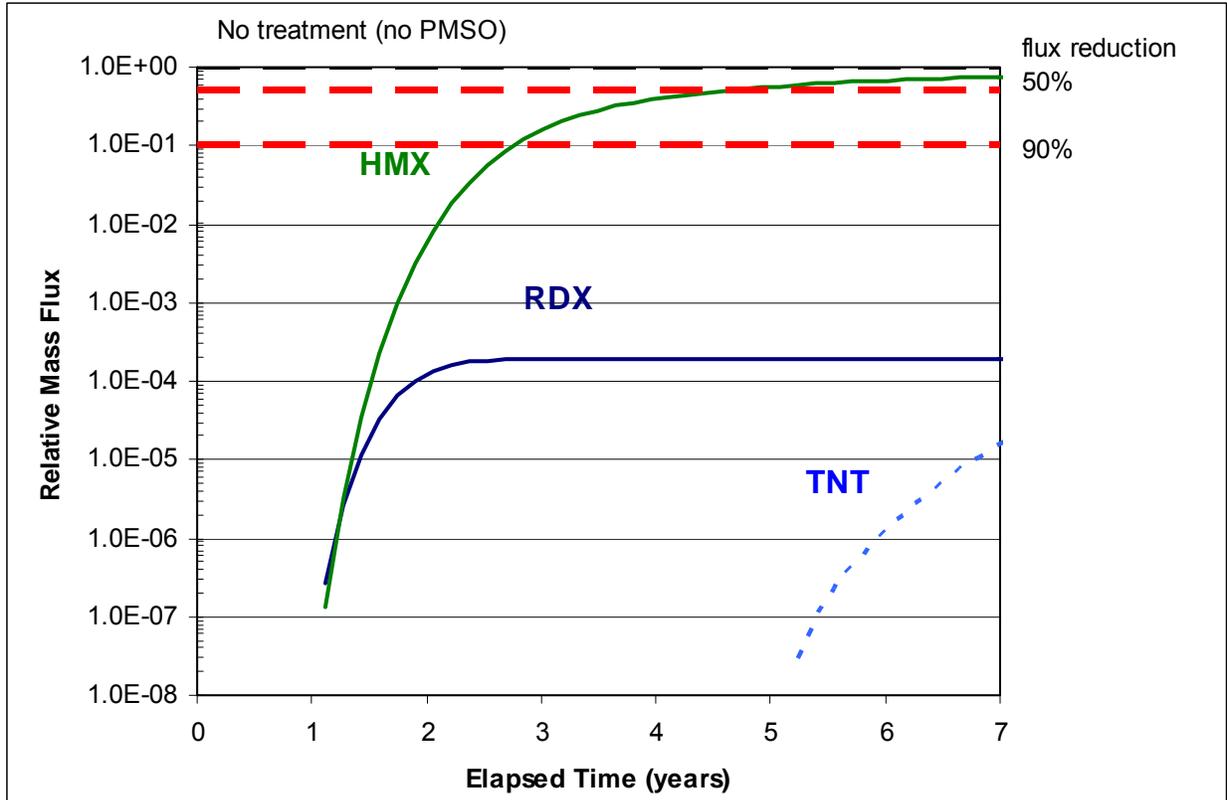
*Cost:* Average \$/cu. ft of peat moss of \$3.06 based on the actual purchase made for the GR demonstration. It is likely that with large bulk purchases of peat moss, the costs would decrease by around \$3.00 to 5.00 dollars per unit treated. Costs of around \$1.50/cu. ft. of peat moss were obtained for large "super bales" from one supplier.

***Cost comparison summary***

On a 4 year life-cycle, the PMSO would be cheaper per unit soil than the lime by about a factor of 2. On a 2.5 year life-cycle, using the PMSO realizes a ~25% cost savings compared to the lime. There is not a great difference between the tilled and the buried application methods. These results indicate that the PMSO would be competitive with surface applied lime.

**Figure 7.3-1. Model predictions of PMSO performance over time in terms of mass flux of TNT, RDX, and HMX relative to no PMSO application.**

Assumptions: 10 cm of PMSO having a composition of 1:2 peat moss:crude soybean oil (w:w); annual rainfall of 70 cm. Mass flux measured at the bottom of the PMSO/top of the underlying soil boundary.



**Table 7.3-1. Cost analysis for PMSO technology compared to topical lime (4 year life-cycle).**

4 year reapplication rate to achieve >50% reduction in flux of HMX and >99% reduction in the flux of RDX, and TNT.

LIFE CYCLE APPLICATION METHOD EQUIPMENT	4 Years Tilled Rented Lime	4 Years Tilled Rented PMSO	4 Years Buried Rented PMSO
<b>1. Capital Cost</b>			
Application Equipment			
-ATV (5% interest, 5 years)	4,000	1,000	0
-Disc plow	500	125	0
-Dropseed spreader	600	0	0
-Hydroseeder	8,000	0	0
-Drum Mixer (cement mixer)	0	200	200
-Road grader (140 HP)	0	0	1,720
-Vibratory roller (5 ton)	0	0	620
-Frontend loader (2.5 cu. yd.)	0	1,070	1,070
Other			
-Treatability testing for lime requirement	8,000	0	0
<b>Total Capital Cost</b>	<b>21,100</b>	<b>2,395</b>	<b>3,610</b>
<b>2. O&amp;M</b>			
Labor (UXO clearance by base) <sup>a</sup>	32,000	12,264	12,264
Materials <sup>b</sup>	6,400	13,343	13,343
Fuel <sup>c</sup>	800	200	400
Soil testing	300	0	0
Other <sup>d</sup>	800	200	200
<b>Total O&amp;M Cost</b>	<b>40,300</b>	<b>26,007</b>	<b>26,207</b>
<b>Total Technology Cost</b>	<b>61,400</b>	<b>28,402</b>	<b>29,817</b>
Quantity treated (m <sup>3</sup> / yd <sup>3</sup> )	600 / 785	600 / 785	600 / 785
<b>Unit cost ( per m<sup>3</sup> / per yd<sup>3</sup>)</b>	<b>102.33 / 78.22</b>	<b>47.34 / 36.18</b>	<b>49.70 / 37.98</b>

Assumptions:

<sup>a</sup> Labor for lime technology estimated at \$8000/yr for quarterly lime application. Labor for PMSO technology is based on the labor required at Fort Jackson grenade range demonstration to apply 100 m<sup>2</sup> PMSO (\$2044, 4 field laborers x 8 hr x ~\$64/hr burdened labor rate) then multiplying by six (6) for application of 600 m<sup>2</sup>.

<sup>b</sup> Materials for lime technology included lime at \$1600/year for quarterly lime application. Materials for PMSO technology included peat moss (\$6885) and crude soybean oil (5005), including shipping of oil as described in Cost Comparison section above.

<sup>c</sup> Fuel for equipment listed in section 1 for each scenario. For lime technology, estimated as \$200/year. For PMSO technology, estimated as \$200 for tilling in PMSO once every 4 years, and \$400 for burial of PMSO once every 4 years.

<sup>d</sup> Lime technology assume costs of \$200/yr for protective equipment for quarterly lime application. PMSO technology assumes a total of \$200 for PMSO application once every four (4) years for protective clothing and miscellaneous garden tools (shovels, rakes, etc.).

**Table 7.3-2. Cost analysis for PMSO technology compared to topical lime (2.5 year life-cycle).**

2.5 year reapplication rate to achieve >90% reduction in flux of HMX and >99% reduction in the flux of RDX, and TNT.

LIFE CYCLE APPLICATION METHOD EQUIPMENT	2.5 Years Tilled Rented Lime	2.5 Years Tilled Rented PMSO	2.5 Years Buried Rented PMSO
<b>1. Capital Cost</b>			
Application Equipment			
-ATV (5% interest, 5 years)	2,500	1,000	0
-Disc plow	313	125	0
-Dropseed spreader	375	0	0
-Hydroseeder	5,000	0	0
-Drum Mixer (cement mixer)	0	200	200
-Road grader (140 HP)	0	0	1,720
-Vibratory roller (5 ton)	0	0	620
-Frontend loader (2.5 cu. yd.)	0	1,070	1,070
Other			
-Treatability testing for lime requirement	5,000	0	0
<b>Total Capital Cost</b>	<b>13,188</b>	<b>2,395</b>	<b>3,610</b>
<b>2. O&amp;M</b>			
Labor (UXO clearance by base) <sup>a</sup>	20,000	12,264	12,264
Materials <sup>b</sup>	4,000	13,343	13,343
Fuel <sup>c</sup>	500	500	500
Soil testing	188	0	0
Other <sup>d</sup>	500	200	200
<b>Total O&amp;M Cost</b>	<b>25,188</b>	<b>26,307</b>	<b>26,307</b>
<b>Total Technology Cost</b>	<b>38,375</b>	<b>28,702</b>	<b>29,917</b>
Quantity treated (m <sup>3</sup> / yd <sup>3</sup> )	600 / 785	600 / 785	600 / 785
<b>Unit cost ( per m<sup>3</sup> / per yd<sup>3</sup>)</b>	<b>63.96 / 48.89</b>	<b>47.84 / 36.56</b>	<b>49.86 / 38.11</b>

Assumptions:

<sup>a</sup> Labor for lime technology estimated at \$8000/yr for quarterly lime application. Labor for PMSO technology is based on the labor required at Fort Jackson grenade range demonstration to apply 100 m<sup>2</sup> PMSO (\$2044, 4 field laborers x 8 hr x ~\$64/hr burdened labor rate) then multiplying by six (6) for application of 600 m<sup>2</sup>.

<sup>b</sup> Materials for lime technology included lime at \$1600/year for quarterly lime application. Materials for PMSO technology included peat moss (\$6885) and crude soybean oil (5005), including shipping of oil as described in Cost Comparison section above.

<sup>c</sup> Fuel for equipment listed in section 1 for each scenario. For lime technology, estimated as \$200/year. For PMSO technology, estimated as \$200 for tilling in PMSO once every 4 years, and \$400 for burial of PMSO once every 2.5 years.

<sup>d</sup> Lime technology assume costs of \$200/yr for protective equipment for quarterly lime application. PMSO technology assumes a total of \$200 for PMSO application once every 2.5 years for protective clothing and miscellaneous garden tools (shovels, rakes, etc.).

## 8. IMPLEMENTATION ISSUES

### 8.1 Regulatory Issues

The soybean oil (CAS# 8001-22-7) used in the PMSO is classified as Generally Recognized as Safe (GRAS) according to the following Environmental Protection Agency document.

- Registration Eligibility Decision (RED), Flower and Vegetable Oils. December 1993. EPA# 738-R-93-031. <http://www.ntis.gov/search/product.aspx?ABBR=PB94152048>

The peat moss (no CAS number) used in PMSO is categorized as “4A - Minimal Risk Inert Ingredients” on the Environmental Protection Agency’s “List of Inert Pesticide Ingredients”, which was updated in August 2004 ([http://www.epa.gov/opprd001/inerts/inerts\\_list4Acas.pdf](http://www.epa.gov/opprd001/inerts/inerts_list4Acas.pdf)).

Based on this information, no permits would be expected to be required for implementation of this technology at any site. The material is meant to be left in place once it is deployed, although additional peat moss or soybean oil might be added to rejuvenate the treatment. If the PMSO was to be permanently removed, some analyses for easily desorbed or leachable explosive residues should be performed prior to disposal.

### 8.2 End-User Issues

The primary end-users of this technology would likely be DoD site managers and DoD contractors responsible for protecting groundwater resources at military installations. The general concerns of these end users include the following: (1) technology applicability under local site conditions; (2) technology performance; (3) technology scale-up; and (4) technology cost.

This project, performed as two separate yet complimentary demonstrations, have provided information that can be used to address these concerns. General findings are presented below, with reference to the relevant sections of the report where details can be found.

#### 1) technology applicability under local site conditions

- The use of PMSO would be .

2) technology performance

- The PMSO material reduced the flux of RDX through the soil by approximately 500-fold compared to flux of RDX in the untreated control. See Sections 5.8.2 and 6.3.
- The PMSO material reduced the residual concentrations of explosive compounds as a function of depth compared to the explosive compound concentration profile observed in the untreated control. See Section 5.8.3 and 6.4.

3) technology scale-up

- The PMSO materials were relatively easy to handle and apply using readily available equipment. Scale-up of mixing and spreading the PMSO would likely actually be easier than the demonstration performed during this project. As the peat moss part of the PMSO is routinely used for horticultural and landscaping purposes, handling at these larger scales would be readily feasible. See PART II, Section 5.5.

4) technology cost

- A cost estimate of \$40-50 per 600 m<sup>3</sup> of soil treated per 48 months (including material, labor, and equipment rental costs) was calculated based on data from both the SP1 and GR demonstrations. See Section 7.

### 8.3 Procurement Issues

The materials used in the PMSO are readily available in most areas. Peat moss and crude soybean oil can be obtained in bulk (or large unit sizes) from a number of suppliers. Contacts for some of the suppliers are presented in Table 8.3-1 below.

<b>Table 8.2-1. Supplier Contact Information</b>		
<b>Company</b>	<b>Address</b>	<b>Phone/Fax</b>
<i>Peat moss suppliers</i>		
Sun Gro Horticulture Distribution, Inc.	15831 N.E. 8th Street Suite 100 Bellevue, WA 98008	P: 801-244-0245 F: 801-406-0272 <a href="http://www.sungro.com">www.sungro.com</a>
Waupaca Northwoods	P.O. Box 569 801 W. Fulton St. Waupaca, WI 54981	P: 715-256-4020 F: 715-256-4030 <a href="http://www.waupacasoilblenders.com">www.waupacasoilblenders.com</a>

<i>Crude soybean oil suppliers</i>		
Grain States Soya Inc.	400 Johnson Road West Point, NE 68788	P: 402-372-2429 F: 402-372-3305 <a href="http://www.soybest.com">www.soybest.com</a>
Cargill Industrial Oils & Lubricants	P.O. Box 5700, MS 66 Minneapolis, MN 55440	P: 800-842-3631 F: 952-742-6722 <a href="http://www.techoils.cargill.com">www.techoils.cargill.com</a>
Zeeland Farm Services, Inc.	P.O. Box 290 • 2525 - 84th Avenue Zeeland, MI 49464	P: 800-748-0595 F: 616-772-7075 <a href="http://www.zfsinc.com">www.zfsinc.com</a>

No claims regarding material quality or availability are made regarding these suppliers. They simply represent the suppliers which provided information about their product availability.

The equipment needed for applying the PMSO material would be dependent on the size of the area to be treated and the mode of emplacement. At a minimum, and as per the recommendations presented elsewhere in this report, it is expected that the following equipment would be required:

- grader for soil removal and replacement
- rotary type mixer for preparing the PMSO material (eg. cement mixer)
- forklift for moving drums of oil or bulk peat moss
- bucket loader for moving loose peat moss and/or prepared PMSO

Larger or smaller versions of this equipment would be needed depending on the scale of the planned application. Additionally, the following types of equipment may be needed under some circumstances:

- bark/straw blower for dispersing the PMSO across broad areas
- tractor and tiller attachment for incorporation of the PMSO into the soil

## 9. REFERENCES

1. Fuller, M. E., P. B. Hatzinger, D. Rungkamol, R. L. Schuster, and R. J. Steffan. 2004. *Enhancing the attenuation of explosives in surface soils at military facilities: Combined sorption and biodegradation*. Environ Toxicol Chem 23:313-324.
2. Fuller, M. E., J. M. Lowey, C. E. Schaefer, and R. J. Steffan. 2005. *A peat moss-based technology for mitigating residues of the explosives TNT, RDX, and HMX in soil*. Soil Sediment Contam 14:373-385.
3. Fuller, M. E., and J. F. Manning, Jr. 1997. *Aerobic gram-positive and gram-negative bacteria exhibit differential sensitivity to and transformation of 2,4,6-trinitrotoluene (TNT)*. Curr Microbiol 35:77-83.
4. Hatzinger, P. B., M. E. Fuller, D. Rungkamol, R. L. Schuster, and R. J. Steffan. 2004. *Enhancing the attenuation of explosives in surface soils at military facilities: Sorption-desorption isotherms*. Environ Toxicol Chem 23:306-312.
5. Hawari, J., S. Beaudet, A. Halasz, S. Thiboutot, and G. Ampleman. 2000. *Microbial degradation of explosives: biotransformation versus mineralization*. Appl Microbiol Biotechnol 54:605-618.
6. Jenkins, T., M. Walsh, P. Miyares, J. Kopczynski, T. Ranney, V. George, J. Pennington, and T. Berry, Jr. 2000. *Analysis of explosives-related chemical signatures in soil samples collected near buried land mines*. U.S. Army Corps of Engineers, Cold Regions Research & Engineering Laboratory. Report# ERDC TR-00-5. August
7. Merchant, M. 1998. *Explosives suggest new plume*. Cape Cod Times
8. Schaefer, C. E., M. E. Fuller, J. M. Lowey, and R. J. Steffan. 2005. *Use of peat moss amended with soybean oil for mitigation of dissolved explosive compounds leaching into the subsurface: Insight into mass transfer mechanisms*. Environ Eng Sci 22:337-349.
9. Spain, J. 1995. *Biodegradation of nitroaromatic compounds*. Annu Rev Microbiol 49:523-555.

## Appendix A

### Points of Contact

POINT OF CONTACT Name	ORGANIZATION Name Address	Phone/Fax/email	Role in Project
Mark E. Fuller	Shaw Environmental, Inc. 17 Princess Road Lawrenceville, NJ 08648	P: 609-895-5348 F: 609-895-1858 <a href="mailto:mark.fuller@shawgrp.com">mark.fuller@shawgrp.com</a>	Lead Investigator
Charles E. Schaefer	Shaw Environmental, Inc. 17 Princess Road Lawrenceville, NJ 08648	P: 609-895-5372 F: 609-895-1858 <a href="mailto:charles.schaefer@shawgrp.com">charles.schaefer@shawgrp.com</a>	Modeler
Timothy Dwyer*	Shaw Environmental & Infrastructure 100 Technology Center Dr. Stoughton, MA 02072	P: 617-589-5268 F: 617-589-2160 <a href="mailto:timothy.dwyer@shawgrp.com">timothy.dwyer@shawgrp.com</a>	Field Manager
Robert J. Steffan	Shaw Environmental, Inc. 17 Princess Road Lawrenceville, NJ 08648	P: 609-895-5350 F: 609-895-1858 <a href="mailto:rob.steffan@shawgrp.com">rob.steffan@shawgrp.com</a>	Scientific & Fiscal Manager
Ben Gregson	Impact Area Groundwater Study Office 1803 West Outer Road Camp Edwards, MA 02542	P: 508-968-5821 F: 508-968-5286 <a href="mailto:benjamin.p.gregson@us.army.mil">benjamin.p.gregson@us.army.mil</a>	MMR Site Contact
William A. (Andy) Martin	US Army ERDC Environmental Laboratory Chief Environmental Engineering Branch CEERD-EP-E 3909 Halls Ferry Rd. Vickburg, MS 39180	P: 601-634-3710 F: 601-634-3518 <a href="mailto:andy.martin@erdc.usace.army.mil">andy.martin@erdc.usace.army.mil</a>	DoD Liason/COR

\*No longer with Shaw

# Appendix B

## Sampling Methods Supporting the Experimental Design

### Collection of Aqueous Samples

#### Collection and storage of SOIL PORE WATER samples

##### I. Materials and equipment

1. Disposable syringes (20 cc)
2. Sterile polypropylene sample tubes
3. Self-adhesive labels and permanent markers
4. Disposable latex or nitrile gloves
5. Portable battery powered balance readable to 0.1 g

##### II. Sampling procedure

1. Attach a clean syringe to the soil pore water sampling port. Open the shut-off valve.
2. Apply suction by pulling the syringe plunger slowly out. Avoid pulling too fast. Allow the syringe barrel to fill until the dead volume has been collected (approximately 10 ml).
3. Close the shut-off valve and carefully disengage the syringe.
4. Transfer to the collected water to sample tube with the sample ID and designated as “F” (flush).
5. Repeat steps 1 through 3
6. Transfer to the collected water to sample tube with the sample ID and designated as “S” (sample).
7. Weigh and record the weights of all the samples (in grams).
8. Store the samples at 4°C and ship on ice. Store samples at 4°C until analysis is performed.

#### Collection and storage of SOIL PLOT DRAINAGE WATER samples

##### I. Materials and equipment

1. Sterile polypropylene sample tubes and/or amber glass sample containers
2. Self-adhesive labels and permanent markers
3. Disposable latex or nitrile gloves
4. Measuring pail

##### II. Sampling procedure - Grab samples

1. Disconnect the drainage water collection drum from the drainage tube.
2. Mix the contents of the drum.
3. Measure and record the volume of water in the drum.
4. Carefully pour an aliquot from the drum into pre-labeled sampling bottle(s).
5. Store the samples at 4°C and ship on ice. Store samples at 4°C until analysis is performed.

## II. Sampling procedure - Discreet (timed) samples

1. Disconnect the soil plot drainage tube from the water collection drum.
2. Connect a pre-labeled sampling bottle to the soil plot drainage tube. Assure that the air vent is open so that a vacuum is not generated.
3. Place the sampling bottle into secondary containment.
4. Allow the bottle to fill for the designated time period.
5. Disconnect the sampling bottle from the drainage tube.
6. Reconnect the drainage tube to the water collection drum.
7. Store the samples at 4°C and ship on ice. Store samples at 4°C until analysis is performed.



**Procedure No. SOP T-FS-101 Revision No. Date of Revision 08/28/03 Last Review Date  
STANDARD OPERATING PROCEDURE**

**Subject: Trowel/Spoon Surface Soil Sampling**

**1. PURPOSE**

The purpose of this document is to provide the methods and procedure for sampling of surface soils using trowels or spoons. Trowels or spoons can be used when matrices are composed of relatively soft and non-cemented formations and to depths of up to 12 inches into the ground surface, dependent on site conditions. Samples for VOC analysis should not be collected via trowel or spoon method. However, a trowel or spoon may be utilized to penetrate to and expose the undisturbed material at the desired depth for sampling by more applicable methods.

**2. SCOPE**

This procedure is applicable to all Shaw E & I projects where surface soil samples will be collected via trowel or spoon methods.

**3. REFERENCES**

U.S. Army Corps of Engineers, 2001, *Requirements for the Preparation of Sampling and Analysis Plans*, Appendix C, Section C.6, EM200-1-3, Washington, D.C.

**4. DEFINITIONS**

**Trowel** - A sample collection device with a curved and pointed metal blade attached to a handle. All trace environmental samples should be collected using stainless steel blades.

**Spoon** - A sample collection device with a round metal blade attached to a handle.

**Surface Soil** - Soil that is removed from the surface no greater than 6 inches below grade after removing vegetation, rocks, twigs, etc.

**Weathered Soil** - The top 1/2 to 1/4 inch of soil impacted by heat from sun, rain or foot traffic that could evaporate, dilute, or otherwise deposit contaminants from an adjacent location, thereby misrepresenting the actual soil characteristic.

**5. RESPONSIBILITIES**

**5.1 Procedure Responsibility**

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be directed to the Field Sampling Discipline Lead.

**5.2 Project Responsibility**

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e., calculations, reports, etc.)

that the requirements of this SOP have been met. Such documentation shall be retained as project records.

## **6. PROCEDURE**

### **6.1 Equipment**

Decontaminated trowel or spoon, stainless construction for trace environmental sampling. If samples will be collected at depth (0-6 inches) the trowel or spoon will require decontamination prior to collection of the targeted-depth sample. Alternatively, a different trowel or spoon can be used to remove the material to the targeted depth and the sample collected using a clean dedicated trowel or spoon.

Engineers rule or stiff measuring tape

Decontaminated stainless steel mixing bowl

### **6.2 Sampling**

1. Don a pair of clean gloves.

2. If desired, place plastic sheeting around the targeted location to keep sampled material in place. Use a knife to cut an access hole for the sample location.

3. Remove any surface debris (e.g. vegetation, rocks, twigs) from the sample location and surrounding area until the soil is exposed. Once exposed the soil surface is designated as —at grade“, or 0 inches.

4. Use a trowel to scrape and remove the top 1/8 to 1/4 inch of weathered soil. (A spoon can be interchanged with trowel).

5. If collecting a sample for VOC analysis, collect the sample first following more applicable methods.

6. With a new trowel, place the point of the blade on the ground. While holding the handle of the trowel partially rotate the blade in a clockwise/counter-clockwise motion while pushing at a downward angle until the blade is inserted to the required depth or the blade is nearly covered. Be certain that the trowel is not inserted to a depth where the soil will touch the handle or other non-stainless steel portion of the trowel or the sampler's hand.

7. With a prying motion lift up the trowel with soil on the blade and place soil into the stainless steel mixing bowl.

8. Repeat 6 and 7 until the required depth of soil is placed into the mixing bowl.

9. Measure the depth of the sample location with a rule or tape to verify the sampling depth and record in the field logbook.

10. Homogenize the non-VOC sample and transfer the sample directly into the sample container(s). Cap the sample container(s), label, complete documentation, and place into the sample cooler.

**Procedure No. SOP T-FS-011 Revision No. Date of Revision 08/14/03 Last Review Date  
STANDARD OPERATING PROCEDURE**

**Subject: Compositing**

**1. PURPOSE**

This procedure establishes the method for compositing samples collected in the course of environmental program activities. The objective of this procedure is to provide a standard method for creating composite samples of environmental media. Composites are used to represent the average distribution of properties and can be used to reduce analytical costs or represent well-defined decision boundaries.

**2. SCOPE**

This procedure applies to solid and liquid samples whenever there is a need or desire to perform analysis on a sample representative of a defined boundary (time, area, etc.). Field composite methods are not appropriate for VOC analysis of solids. Composites for these methods must be laboratory derived using either individual grab extracts or other laboratory methods.

**3. REFERENCES**

U.S. Environmental Protection Agency, 1987, *Compendium of Superfund Field Operations Methods*, EPA 540/P-87/001a, OSWER 9355.0-14, Washington, DC.

Shaw E & I Standard Operating Procedure T-FS-010, *Sample Mixing/Homogenization*.

**4. DEFINITIONS**

**Composite Sample** - A sample that is comprised of roughly equal amounts of discrete grabs from a set of sample locations or time/flow increments known as a sample group.

**Sample Group** - A predetermined number or time/area span of discrete samples, which is composited into one sample for analytical purposes.

**5. RESPONSIBILITIES**

**5.1. Procedure Responsibility**

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

**5.2. Project Responsibility**

Shaw E & I employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw E & I employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager or designee is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e., calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

**6. PROCEDURE**

The discrete samples that are used to prepare a composite sample must be of equal volume and must each be collected in an identical manner. Field documentation must clearly indicate the composite elements on either a map or composite logsheet. There are several types of

composite samples.

**Flow-proportioned composite** - Flow-proportioned composite samples are collected proportional to the flow rate during the sampling period by either a time-varying/constant-volume or time-constant/varying-volume method. Flow-proportioned composite samples are typically collected using automatic samplers paced by a flow meter. This sampling method is commonly used for wastewaters.

**Time composite** - A time composite sample is composed of a discrete number of grab samples collected at equal time intervals during the compositing period. Time composite sampling is often used to sample wastewater or streams.

**Volume/mass composite** - A volume/mass composite is composed of a discrete number of grab samples collected at defined volume or mass intervals. Volume/mass composite sampling is often used to sample the output of a process system such as a Thermal Destruction Unit or pug mill.

**Areal composite** - Areal composite samples are samples collected from individual grab samples located on a regularly spaced grid or along a pile at defined locations and depths. Each of the grab samples must be collected in an identical fashion and must be of equal volume.

**Vertical composite** - Vertical composites are composed of individual grab samples collected across a vertical cross section. Like areal composites, the grab samples must be collected in an identical fashion and must be of equal volume. Soils and sediments can be used to create vertical composites.

#### 6.1. **Solid Composites**

To ensure the integrity of the composite, all discrete grab samples must be collected in an identical manner.

Composite samples can be created by combining discrete grab samples into the same mixing/holding container as they are collected or by combining and mixing equal aliquots of containerized and homogenized discrete grab samples.

Remove coarse fragments and organic material from the mixing bowl. Homogenize the sample as per SOP T-FS-010, Sample Mixing/Homogenization.

Remove sample aliquots and place into the appropriate sample containers for shipment to the laboratory.

Label the sample and document the sampling event according to the project procedures

**Procedure No. SOP T-FS-010 Revision No. Date of Revision 06/05/2003 Last Review Date  
STANDARD OPERATING PROCEDURE**

**Subject: Sample Homogenization**

**1. PURPOSE**

The purpose of this procedure is to establish the method for homogenizing soil, sediment, and other solid or semi-solid matrices so that a uniform matrix is available for sampling. Proper homogenization is very important because it helps ensure that sample aliquots are representative of the whole collected sample and helps minimize sampling error so that other errors included in the measurement process, such as laboratory sample preparation and test measurement, can be better assessed.

**2. SCOPE**

This procedure applies to Shaw Environmental & Infrastructure (Shaw E & I) personnel responsible for the collection of solid matrix samples. The solid matrix must be amenable to mixing. This SOP applies to the collection of solid samples that are to be tested for all analytes except volatile analytes.

**3. REFERENCES**

**3.1** The following are Shaw E & I soil sampling and miscellaneous matrix sampling SOPs to which sample mixing/homogenization may apply:

- T-FS-100 Hand Auger
- T-FS-101 Trowel/Spoon
- T-FS-102 Bulb Planter
- T-FS-103 Soil probe/corer
- T-FS-106 Pile
- T-FS-107 Roll-off
- T-FS-116 Drum
- T-FS-119 Sludge judge
- T-FS-123 Sediment corer

**3.2** The following are examples of approved techniques or methods for performing sample homogenization.

**4. DEFINITIONS**

**Homogenize** - The use of physical mixing motions to make a uniform sample matrix.

**5. RESPONSIBILITIES**

**5.1 Procedure Responsibility**

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

**5.2 Project Responsibility**

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting

information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

## **6. PROCEDURE**

Sampling equipment materials shall be selected so as to minimize contamination of samples. Sampling equipment shall be either new (never used previously), documented to have been decontaminated, or dedicated to each specific sampling point. Samples for organics analysis should be collected and mixed using glass or stainless steel bowls, trowels, and/or spoons. Samples for metals analysis should be collected and mixed using equipment made of glass or Teflon.

Certain types of solid matrices may not be amenable to mixing using conventional techniques. For example, certain solids may require grinding and thorough mixing to ensure that the analytes of interest within the sample are homogeneously distributed. It is extremely important that soil and sediment samples be homogenized to ensure that the entire sample is as representative as possible of the media being sampled.

### **6.1 Solid Samples**

The following two methods are examples for homogenizing solid samples. Other homogenization techniques may be employed using approved standard methods such as ASTM C702, Reducing Samples of Aggregate to Testing Size.

#### **Quartering**

Place the sample on a hard, clean, level surface such as a pan. If such surface is too small for the desired quantity, a clean sheet of plastic may be used.

Mix the solid material by turning the entire quantity over three times with a trowel or shovel. For the third time, shovel the material into a cone-shaped pile.

Carefully press down on the apex of the pile to create a soil layer of uniform thickness and diameter, so that the diameter is approximately 4 to 8 times the thickness and the material in each quarter of the resulting layer is approximately the same as what was in the corresponding quarter from the cone-shape pile.

Divide the material in the sample pan or the plastic into quarters using shovel or trowel.

Option 1- Mix each quarter individually; Two quarters should then be mixed to form halves; the two halves should be mixed to form a homogenous matrix. Option 1 should be repeated if necessary to produce a homogeneous sample.

Option 2- Remove two diagonally opposite quarters including any fine material and brush the surface clean; mix and quarter (as per Option 1) the remaining material until the sample media has taken on a uniform appearance.

#### **Mixing in a Bowl**

Place the sample in a bowl. Samples for organic analysis should be mixed using bowls and stirrers made of glass or stainless steel, while samples for metals analysis should be mixed using equipment made of glass, stainless steel, or hard plastic. Make sure the bowl is large enough to accommodate the sample, with extra volume to allow for mixing the sample.

Mix the sample with the stirrer. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion, reversing direction, and occasionally turning

the material over. High moisture samples are more difficult to homogenize. Use an adequate mixing motion for as long as needed to determine by visual observation that the sample media has taken on a uniform appearance.

## **6.2 Aqueous Samples**

Aqueous samples do not require homogenization since water is well mixed due to diffusion and bulk convection. If the sample matrix is a viscous liquid, semi-solid, or an aqueous one with suspended solids, the sample shall be thoroughly mixed with a tool of compatible composition for all analyses fractions except volatile analytes. After mixing, immediately transfer the material into the appropriate containers. The sample should be mixed frequently during the container-filling step, in particular if there are a large number of containers, so that the condition of the bulk sampled fluid will be approximately the same when each parameter-specific sample container is filled.

Once a sample has been mixed, it will typically have to be transferred into separate containers for different analyses. However, samples collected for volatile organic compounds, oil and grease, and short-chain organic sulfides analyses may not be homogenized. For these parameters, dedicated samples must be collected without mixing.

**Procedure No. SOP T-FS-014 Revision No. Date of Revision 06/05/2003 Last Review Date  
STANDARD OPERATING PROCEDURE**

**Subject: Decontamination of Contact Sampling Equipment**

**1. PURPOSE**

This procedure defines the Shaw E & I standard that must be implemented for decontamination of contact sampling equipment. Contact sampling equipment is equipment that comes in direct contact with the sample or portion of sample that will undergo chemical analyses or physical testing. This SOP is intended to provide minimum guidelines and general procedures for decontaminating contact sampling equipment used during field sampling activities. The benefits of its use include the following:

Minimizing the spread of contaminants within a study area and from site to site

Reducing the potential for worker exposure by means of contact with contaminated sampling equipment

Improved data quality and reliability

**2. SCOPE**

This procedure applies to all instances where non-disposable direct contact sampling equipment is utilized for sample collection. This procedure is not intended to address decontamination of peristaltic or other sampling pumps and tubing. The steps outlined in this procedure must be executed between each distinct sample data point.

**3. REFERENCES**

U.S. Environmental Protection Agency, Region 4, 2001, *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*, 980 College Station Road, Athens, Georgia. November.

US Army Corp of Engineers, Washington, D.C., 2001, Requirements for the Preparation of Sampling and Analysis Plans (EM-200-1-3), February.

**4. DEFINITIONS**

**Soap** - A standard brand of phosphate-free laboratory detergent, such as Liquinox®.

**Organic Desorbing Agent** - A solvent used for removing organic compounds. The specific solvent would depend upon the type of organic compound to be removed. See Attachment 1 for recommendations.

**Inorganic Desorbing Agent** - An acid solution for use in removing trace metal compounds. The specific acid solution would depend upon the type of inorganic compound to be removed. See Attachment 1 for recommendations.

**Tap water** - ater obtained from any municipal water treatment system. An untreated potable water supply can be used as a substitute for tap water if the water does not contain the constituents of concern.

**Analyte-free water (deionized water)** - Water that has been treated by passing through a standard deionizing resin column, and for organics either distillation or activated carbon units. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds, and/or no detectable organic compounds (i.e., at or above analytical

detection limits). Analyte-free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.

Other solvents may be substituted for a particular purpose if required. For example, removal of concentrated waste materials may require the use of either pesticide-grade hexane or petroleum ether. After the waste material is removed, the equipment must be subjected to the standard cleaning procedure. Because these solvents are not miscible with water, the equipment must be completely dry prior to use.

## **5. RESPONSIBILITIES**

### **5.1 Procedure Responsibility**

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

### **5.2 Project Responsibility**

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

## **6. PROCEDURE**

### **6.1 Health and Safety**

Minimum Health and Safety Procedures should be implemented based on the site-specific decontamination protocol that is designed. Health and Safety procedures should take into consideration the potential use of either dangerous solvents or corrosive liquids.

### **6.2 Implementation**

A decontamination area should be established. A separate tub needs to be available for each of the first four steps. Each type of water and soap solution can be placed in hand-held sprayers made of an inert material. The analyte-free water needs to be placed in a container that will be free of any compounds of concern. Special containers will be needed if solvents or acid solutions are used. For example, an acid solution cannot be placed in a sprayer that has any metal parts that will come in contact with the acid solution.

The minimum steps for decontamination are as follows:

- Remove particulate matter and other surface debris using appropriate tools such as a brush or hand-held sprayer filled with tap water.
- Scrub the surfaces of the contact sampling equipment using tap water and soap solution and a second brush made of inert material.
- Rinse contact sampling equipment thoroughly with tap water.
- Rinse contact sampling equipment thoroughly with analyte-free water (not necessary if sampling for disposal profiling purposes).

-Place contact sampling equipment on a clean surface appropriate for the compounds of concern and allow to air dry.

It is Shaw E & I policy to containerize all decontamination fluids. This policy will be followed unless an the client specifically directs an alternate procedure in writing.

The use of solvents and/or acid solutions will be dependent on the site-specific conditions. A site with a high probability of high concentrations of compounds or with waste material present will require additional decontamination procedures. The following table provides some guidance for additional decontamination procedures.

**Recommended Decontamination Procedures.**

Compound	Detergent Wash	Tap Water	Inorganic Desorbing Agent	Tap Water	Organic Desorbing Agent <sup>1</sup>	Deionized Water	Air Dry
<b>ORGANICS</b>							
Volatile Organic Compounds	X	X			Methanol Purge & Trap grade	X	X
Base Neutrals Acid Extractables PCBs Pesticides	X	X			Hexane	X	X
Organic Bases <sup>2</sup>	X	X	1% nitric acid	X	Isopropyl Alcohol	X	X
Organic Acids <sup>3</sup>	X	X	1% nitric acid		Isopropyl Alcohol	X	X
<b>INORGANICS</b>							
Trace Metals Radio Isotopes	X	X	10% Nitric acid - Trace metals grade	X		X	X
Cations/Anions	X	X				X	X
Acidic Compounds	X	X				X	X
Basic Compounds (caustic)	X	X	1% nitric acid	X		X	X

- 1 – All organic solvents must be Pesticide Grade or better. The selection of appropriate solvent rinses should first consider if a known or suspected contaminant requires removal from sampling equipment. Secondly, identify whether the subsequent analytical protocol would be impacted by the proposed solvent or an impurity thereof (e.g., residual acetone present in isopropyl alcohol would be measured with certain volatile organics analysis).
- 2 -Organic bases include amines, hydrazines.
- 3 -Organic acids include phenols, thiols, nitro and sulfonic compounds.

Adapted from: Appendix E, Requirements for the Preparation of Sampling and Analysis Plans (EM-200-1-3), February 2001. US Army Corp of Engineers, Washington, D.C.

**Procedure No. SOP-TFS-106 Revision No. Date of Revision 12/05/03 Last Review Date  
STANDARD OPERATING PROCEDURE**

**Subject: Sampling of In-Process Soil Piles**

**1. PURPOSE**

The purpose of this procedure is to provide a simple and statistically sound method for sampling of small (<500 cy) in-process stockpiles on project sites for characterization purposes where state and/or other regulatory or project-specific requirements are not pre-determined. These stockpiles may be the result of soil excavation/segregation, treatment of residual production, or debris segregation.

**2. SCOPE**

This procedure applies to the sampling of in-process stockpiles of less than 500 cy in volume where the intent is to determine a gross average and UCL for a specific property or parameter set for comparison to decision levels. Examples include determining disposal profiles, overburden reuse determination, treated material confirmation, and backfill usability.

This procedure is not intended to provide spatial distribution data of legacy stockpiles or to be used where stockpiles exceed 500cy in volume. In these cases, project/task-specific sampling and analysis designs should be developed based upon the project/task required goals and objectives.

**3. REFERENCES**

U.S. Environmental Protection Agency, 2002, RCRA Waste Sampling Draft Technical Guidance, Planning, Implementation, Assessment, EPA/530-D-02-002, August.

U.S. Environmental Protection Agency, 1994, Waste Pile Sampling, EPA/ERT SOP 2017.

American Society for Testing and Materials, Standard Guide for Sampling of Waste Piles, ASTM D6009.

**4. DEFINITIONS**

**Stockpile** - Solid material placed into a conical, pyramid, rectangular, windrow, or other elongated shape with sloped sides. Stockpiles may be generated as a result of a treatment process, soil excavation, debris segregation, or other tasks.

**Composite Sample** - A sample created by the mixing of several discrete samples into one sample representative of the average characteristics of the entity sampled.

**5. RESPONSIBILITIES**

**5.1 Procedure Responsibility**

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be directed to the Field Sampling Discipline Lead.

**5.2 Project Responsibility**

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this

and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

## 6. PROCEDURE

**Safety Note:** Soil and treated residual stockpiles may contain unstable materials and could collapse or engulf personnel without warning. In addition, slopes can be steep and if wetted could become hazardous. Personnel should not climb onto any stockpile unless the site ECP determines that is safe to do so. Whenever possible, in-process stockpiles should be sampled in locations accessible from waist to chest high without scaling the pile or with heavy equipment assistance.

Debris piles should not be scaled under any circumstances and **must** be sampled either with long-reach implements or heavy equipment assistance.

### 6.1 Determine Sample Locations

The procedure for determining sample locations is based upon the collection and compositing of six grab samples from the pile itself. The locations are chosen on a systematic or systematic random design depending upon the pile volume. If VOCs are a concern, including for TCLP, additional grab samples are collected and submitted without compositing for analysis.

1. Determine the stockpile volume. Although the number of grab samples does not vary with volume, the sampling design used to determine grab locations is volume dependent. Therefore, a gross estimate of the pile volume is required. This can be obtained from discussions with operations personnel or based on knowledge of the "batch" size.

If an operational estimate is not available or plausible, a simple and conservative estimate for typical piles can be obtained by first determining the closest geometric shape(s) of its base, measuring the height/length, and calculating as follows:

Conical (typical) pile:  $V = 1/3 A * H$

Where:

A= area of base

Elongated (windrow):  $V = A * L$

Where:

A=area of pile face

L= length of pile/windrow

2. Determine the number and distance between the measured location points, using Table 1 below.

**Table 1 Grab Sample Location Determination**

<b>Pile Volume (estimated)</b>	<b>Number of Equidistant Points</b>	<b>Number of Selected Locations</b>
Up to 100cy	6	6 with 3 for VOC (if needed)
100-200cy	12	6 with 3 for VOC (if needed)
200-300cy	18	6 with 3 for VOC (if needed)
300-400cy	21	6 with 3 for VOC (if needed)
400-500cy	24	6 with 3 for VOC (if needed)
>500cy	SOP not applicable	SOP not applicable

3. Starting at a randomly selected point, measure and mark with a flag or stake the required locations from Table 1 along the pile perimeter. If the pile is larger than 100cy, label each marked location assigning a unique number to each one.

4. Referring to Table 1, determine the sample locations for sampling. For piles greater than 100cy use a random number generator to determine the locations to be sampled. This can also be done using a “draw” from numbered slips of paper.

**6.2 Collect Sample**

1. At each selected grab sample location, collect a sample from material approximately waist high. Each sample should be collected from material at least 2 feet into the pile by using a shovel or trowel to first remove the upper crust layer or using a trowel to collect the sample and not containerizing the upper 2 feet. Place the material from each grab into a mixing container.

2. If collecting a sample for VOCs, at the selected location obtain the material from the exposed material immediately after removing the upper crust using appropriate methods. VOC samples should not be mixed or composited in the field.

3. If an excavator or other assistance is being used, direct the operator to scoop into the pile at least 2-3 feet and collect the “grab” for each location by collecting material from the upper foot of the bucket contents in three randomly selected spots. Collect VOC samples first.

4. If collecting debris samples, place a piece of each type of waste at the selected sample location into the mixing container. Debris pieces should also be cut or reduced to a manageable size (1-2 inches square) before being mixed. Some debris may be light, and larger volumes may need to be sampled and submitted in order to provide adequate sample mass. This is especially true of PPE and other low-mass waste materials.

5. Once the material from all six sample locations has been obtained, mix and homogenize the composite and place the material into appropriate labeled sample containers. The VOC samples should always remain discrete. In some cases, the laboratory may be instructed to create a VOC-lab composite by combining medium/high level extracts or even combining 5g core sampler aliquots into a TCLP/VOC-(ZHE) test.

**Procedure No. SHAW-MMR-GRID-1 Revision No. Date of Revision 03/21/06  
STANDARD OPERATING PROCEDURE**

**Subject: Soil Grid Sampling Procedure for Munition-Related Compounds**

**1. PURPOSE**

The purpose of this procedure is to provide a sound method for sampling of impact and training range soils in a manner that accounts for and attempts to address the observed contaminant heterogeneity in these soils.

**2. SCOPE**

This procedure applies to the sampling of range soils where the intent is to determine a gross average for a specific property or parameter set for comparison to decision levels. Examples include determining disposal issues, reuse determination, treatment confirmation, and backfill usability.

**3. REFERENCES**

This procedure is based on the findings of several U.S. Army Corps reports:

Jenkins, T.F., T.A. Ranney, A.D. Hewitt, M.E. Walsh and K.L. Bjella (2004) Representative sampling for energetic compounds at an antitank firing range. Cold Regions Research and Engineering Laboratory. ERDC/CRREL TR-04-7.

Jenkins, T.F., A.D. Hewitt, T.A. Ranney, C.A. Ramsey, D.J. Lambert, K.L. Bjella and N.M. Perron (2004) Sampling strategies near a low-order detonation and a target at an artillery impact area. Cold Regions Research and Engineering Laboratory. ERDC/CRREL TR-04-7.

**4. DEFINITIONS**

**Composite Sample** - A sample created by the mixing of several discrete samples into one sample representative of the average characteristics of the entity sampled.

**5. RESPONSIBILITIES**

**5.1 Procedure Responsibility**

The Project Manager and Field Manager are responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be directed to both persons.

**5.2 Project Responsibility**

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Field Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

**6. PROCEDURE**

**6.1 Determine Sample Locations**

All sampling locations shall be screened and cleared of UXO. The area shall be selected based on either 1) previously determined areas of interest or 2) areas deemed to be generally representative of the site.

**6.2 Establish Grid**

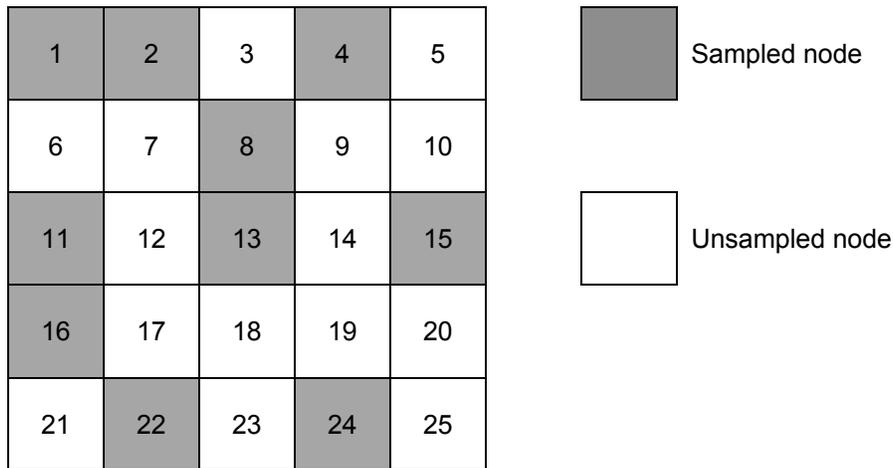
Once the area is selected, a sampling grid will be established. The grid will be a total of 10' x 10' in size, and will be composed of 25 2' x 2' subgrids. A larger grid area with a similar node breakdown should be used for larger area (i.e., 100 x 100 m grid, with 100 1 x 1 m nodes). Where contaminants are expected along a transect, or in a radial pattern, other grid shapes are permitted.

For a low to moderate amount of sampling, the physical grid will be prepared using either jute twine rope or nylon string. If a large amount of sampling is expected, the grid can be constructed from small diameter PVC tubing to provide durability.

The grid will be placed on the soil surface of the sample location and secured using stakes or other devices to keep it in place.

**6.3 Collect and Composite Subsamples**

Ten (10) of the squares within the grid will be designated as sample "nodes", while the remainder of the nodes will not be sampled. The designated sample nodes will be selected randomly from the 25 available nodes using Microsoft Excel's random number generator (=RANDBETWEEN(1,25)) or free randomizer program (such as that at <http://www.randomizer.org/form.htm>, which will generate several sets of random numbers at once for sampling multiple locations). An example of selected nodes is presented below:



The entire top 1 inch of soil from within each sampled node shall be collected and placed on a tarp. Once all the nodes are sampled, the soil will be thoroughly homogenized as described in Shaw SOP T-FS-011 to produce the composite.

Samples (number determined based on the specific project), duplicates and MS/MSDs shall be taken from the homogenized soil.

Soil samples will be uniquely identified with a sample ID that contains a reference to the sample location.

**6.4 Equipment Decon**

All equipment will be decontaminated as described in Shaw SOP T-FS-014, Revised 06/05/2003

Samples Chain-of-Custody Forms



17 Princess Rd  
 Lawrenceville, NJ 08648  
 609-895-5340 // 609-895-1858  
**Shaw Environmental and Infrastructure Inc.**

**CHAIN OF CUSTODY**

Ref. Document # \_\_\_\_\_

Project Number/Cost code: 109163-01010000

Page 1 of 2

Project Name / Location: SERDP/Microbiology

Purchase Order #: \_\_\_\_\_

Project Contact: \_\_\_\_\_ (Name & phone #)

Shipment Date: \_\_\_\_\_

Send Report To: Mark Fuller

Phone/Fax Number: 609-895-5348

Address: 17 Princess Road

City/State: Lawrenceville, NJ 08648

Waybill/Airbill Number: \_\_\_\_\_

Lab Destination: Lawrenceville, NJ

Lab Contact Name / ph. #: Mark Fuller / 609-895-5348

Lab No.	Sample ID Number	Sample Description	Collection Information			Matrix	# of containers	Container type	Preservative					Turn Around Time Requested
			Date	Time	G/C				HCL	NaOH	HNO <sub>3</sub>	H <sub>2</sub> SO <sub>4</sub>	Ice	
<b>Special Instructions:</b> Known Waste Stream Circle: RCRA PCB/dioxin PAH/oil RAD Corrosive Flammable Reactive QC/Data Package Level Required: I II III IV NJ EDD GIS EDD Preliminary data													<b>QC Codes</b> C = Composite G = Grab	
Relinquished By: _____			Date: _____	Received By: _____			Date: _____	<b>QC Package Codes</b> Level I = data summary Level II = data summary + basic QC Level III = New Jersey QC reduced deliverable Level IV = Full deliverable CLP package Cooler temperature upon arrival at Lab: _____						
Relinquished By: _____			Date: _____	Received By: _____			Date: _____							
Relinquished By: _____			Date: _____	Received By: _____			Date: _____							



## Appendix C

### Analytical Methods Supporting the Sampling Plan

Analyte	EPA or Shaw Method	Included in Appendix B
pH	--	Yes
Explosives	SHAW ORG-006A	Yes
Total organic carbon (TOC)	EPA Method 415.1	Yes
Biological Oxygen Demand (BOD)	EPA Method 405.1	Yes

### **Measurement of Sample pH**

1. Calibrate the pH probe before each use with fresh pH 4, 7 and 10 buffer solutions. If aberrant readings occur, consult the instrument user manual.
2. Place a stir bar in the sample and place the pH probe in the sample such that the tip is at least 1 cm (approximately 0.5") below the surface of mixing sample. Make sure the probe is positioned so it is not being hit by the stir bar.
3. Allow reading to stabilize at least 3 minutes.
4. Read and record pH.
5. Rinse the probe thoroughly with deionized distilled water between each sample.
6. Store probe in pH 7 buffer when not in use.

**SHAW METHOD:** SHAW ORG-006A  
**EPA METHOD:** 8330modified  
**TITLE:** Analysis of Explosives  
**ANALYTE:** Nitroaromatics and nitramines  
**INSTRUMENTATION:** Chromatography (HPLC)  
**VERSION:** 2005-1

## **NITROAROMATIC AND NITRAMINES (SHAW ORG-006; EPA METHOD 8330)**

### **1.0 SCOPE AND APPLICATION**

- 1.1 Method 8330 is intended for the trace analysis of explosives residues by high performance liquid chromatography using a UV detector with or without combination of a diode array detector (DAD). This method is used to determine the concentration of various nitroaromatic compounds (see table below) in a water, soil or sediment matrix.
- 1.2 Method 8330 provides low level extraction procedures for low concentration (parts per trillion, or nanograms per liter) of explosives residues in surface or ground water. Direct injection of diluted and filtered water samples can be used for water samples of higher concentration
- 1.3 All of the compounds listed in the table below are either used in the manufacture of explosives or are the degradation products of compounds used for that purpose. When making stock solutions for calibration, treat each explosive compound with caution. See NOTE in Sec. 5.4, 7.2 and Sec. 12 on Safety.
- 1.4 The estimated quantitation limits (EQLs) of target analytes determined by modified Method 8330 in water and soil are presented in Shaw's QAPP.
- 1.5 This method is restricted to use by or under the supervision of analysts experienced in the use of HPLC, skilled in the interpretation of chromatograms, and experienced in handling explosive materials. (See Sec. 121.0 on SAFETY.) Each analyst must demonstrate the ability to generate acceptable results with this method.

<b>COMPOUND</b>	<b>ABBREVIATION</b>	<b>CAS #</b>
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	HMX	2691-41-0
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	121-82-4
1,3,5-Trinitrobenzene	1,3,5-TNB	99-35-0
1,3-Dinitrobenzene	1,3-DNB	99-65-0
2,4,6-Trinitrophenylmethylnitramine	Tetryl	479-45-8
Nitrobenzene	NB	98-95-3
2,4,6-Trinitrotoluene	2,4,6-TNT	118-96-7
4-Amino-2,6-dinitrotoluene	4Am-DNT	1946-51-0
2-Amino-4,6-dinitrotoluene	2Am-DNT	355-72-78-2
2,4-Dinitrotoluene	2,4-DNT	121-14-2
2,6-Dinitrotoluene	2,6-DNT	606-20-2
2-Nitrotoluene	2-NT	88-72-2
4-Nitrotoluene	3-NT	99-08-1
3-nitrotoluene	4-NT	99-99-0

Additionally, the primary RDX breakdown products below are included in this analysis and quantified using semi-quantitative standards:

<b>COMPOUND</b>	<b>ABBREVIATION</b>	<b>CAS #</b>
Hexahydro-1,3,5-trinitroso-1,3,5-triazine	TNX	NA <sup>a</sup>
Hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine	DNX	NA
Hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine	MNX	NA

<sup>a</sup>NA, not available.

## 2.0 SUMMARY OF METHOD

- 2.1 Method 8330 provides high performance liquid chromatographic (HPLC) conditions for the detection of ppb levels of certain explosives residues in water, soil and sediment matrix. Prior to use of this method, appropriate sample preparation techniques must be used.
- 2.2 Low-Level (Method 1) Salting-out Method With No Evaporation: Aqueous samples of low concentration are extracted by a salting-out extraction procedure with acetonitrile and sodium chloride. The small volume of acetonitrile that remains undissolved above the salt water is drawn off and transferred to a smaller volumetric flask. It is back-extracted by vigorous stirring with a specific volume of salt water. After equilibration, the phases are allowed to separate and the small volume of acetonitrile residing in the narrow neck of the volumetric flask is removed using a Pasteur pipet. The concentrated extract may be diluted 1:1 with reagent grade water if necessary to improve chromatography. An aliquot is separated on a C-18 reverse phase column, determined at 254 nm, and confirmed on a CN reverse phase column if necessary due to any coelution of compounds.
- 2.3 Low-Level (Method 2): Cartridge solid-phase extraction Extraction cartridges are fitted with frits at one end, then packed tightly with Porapak RDX. A second frit is placed over the open ends of the cartridges to retain the material inside. Using a

Visiprep Solid-Phase Extraction Manifold (Supelco), the aqueous samples are extracted through the cartridges; the cartridges are then eluted using acetonitrile. The resulting eluate may be diluted 1/1 with reagent-grade water prior to analysis if necessary.

- 2.4 Low-Level (Method 3) Membrane solid-phase extraction Empore styrene-divinyl benzene (SDB) RPS disks are placed in a vacuum filter apparatus and soaked with acetonitrile. The acetonitrile is pulled through the disk, followed by reagent-grade water. Just before all the water has been pulled through, the vacuum is turned off and an aqueous water sample aliquot is placed in the reservoir. Turning the vacuum back on, the aliquot and any remaining water is pulled through the membrane. Air is then pulled through the disks for a short time to remove any excess water. Once they are dry, acetonitrile is added to the reservoir and allowed to soak into the membrane. Next, the acetonitrile is pulled through the disks into a test tube that has been fitted into the vacuum flask. The resulting extract is removed using a Pasteur pipette and placed into a graduated cylinder where it is diluted 1/1 with reagent-grade water prior to analysis.
- 2.5 High-level Direct Injection Method: Aqueous samples of higher concentration can be diluted 1/1 (v/v) with methanol or acetonitrile, filtered, separated on a C-18 reverse phase column, determine at 254 nm, and confirmed on a CN reverse phase column if necessary. If HMX is an important target analyte, methanol is preferred.
- 2.6 Soil and sediment samples are extracted using acetonitrile in an ultrasonic bath, filtered and chromatographed as in Sec. 2.2.

### 3.0 INTERFERENCES

- 3.1 Solvents, reagents, glassware and other sample processing hardware may yield discrete artifacts and/or elevated baselines, causing misinterpretation of the chromatograms. All of these materials must be demonstrated to be free from interferences.
- 3.2 2,4-DNT and 2,6-DNT may elute at similar retention times (retention time difference of 0.2 minutes). A large concentration of one isomer may mask the response of the other isomer. If it is not apparent that both isomers are present (or are not detected), an isomeric mixture should be reported.
- 3.3 Tetryl decomposes rapidly in methanol/water solutions, as well as with heat. All aqueous samples expected to contain tetryl should be diluted with acetonitrile prior to filtration and acidified to pH <3. All samples expected to contain tetryl should not be exposed to temperatures above room temperature.
- 3.4 Degradation products of tetryl appear as a shoulder on the 2,4,6-TNT peak. Peak heights rather than peak areas should be used when tetryl is present in concentrations that are significant relative to the concentration of 2,4,6-TNT.

### 4.0 APPARATUS AND MATERIALS

#### 4.1 HPLC system

- 4.1.1 HPLC - equipped with a pump capable of achieving 4000 psi, a 100  $\mu$ l loop

injector, a variable wavelength UV detector, and a diode array detector (optional). For the low concentration option, the detector must be capable of a stable baseline at 0.001 absorbance units full scale.

#### 4.1.2 Recommended Columns:

4.1.2.1 Primary column: C-18 Reverse phase HPLC column, 25 cm x 4.6 mm (5  $\mu$ m), (Supelco LC-18, or equivalent).

4.1.2.2 Secondary column: CN Reverse phase HPLC column, 25 cm x 4.6 mm (5  $\mu$ m), (Supelco LC-CN, or equivalent). This is required only if there is a questionable identification of one or more compounds

4.1.3 Strip chart recorder or printer.

4.1.4 Digital integrator (optional).

4.1.5 Autosampler (optional).

#### 4.2 Other Equipment

4.2.1 Temperature controlled ultrasonic bath.

4.2.2 Vortex mixer.

4.2.3 Balance,  $\pm 0.0001$  g.

4.2.4 Magnetic stirrer with stirring pellets.

4.2.5 Water bath - Heated, with concentric ring cover, capable of temperature control ( $\pm 5^{\circ}$  C). The bath should be used in a hood.

4.2.6 Oven - Forced air, without heating.

#### 4.3 Materials

4.3.1 High pressure injection syringe - 500  $\mu$ L, (Hamilton liquid syringe or equivalent).

4.3.2 Disposable cartridge filters - 0.45  $\mu$ m Teflon filter.

4.3.3 Pipets - Class A, glass, Appropriate sizes.

4.3.4 Pasteur pipets.

4.3.5 Scintillation Vials - 20 mL, glass.

4.3.6 Vials - 15 mL, glass, Teflon-lined cap.

4.3.7 Vials- 40 mL, glass, Teflon-lined cap.

4.3.8 Disposable syringes - Plastipak, 3 mL and 10 mL or equivalent.

4.3.9 Volumetric flasks - Appropriate sizes with ground glass stoppers, Class A.

NOTE: The 100 mL and 1 L volumetric flasks used for magnetic stirrer extraction must be round.

4.3.10 Vacuum desiccator - Glass.

4.3.11 Mortar and pestle - Steel.

4.3.12 Sieve - 30 mesh.

4.3.13 Graduated cylinders - Appropriate sizes.

4.3.14 Disposable 0.45-micron Teflon syringe filters (25 mm).

4.3.15 Disposable 0.45 -micronglass microfiber syringe filters (Whatman 13 mm GD/X or equivalent).

4.3.16 Disposable 0.45-micron nylon syringe filters (25 mm).

4.4 Equipment specific to cartridge solid-phase extraction

4.4.1 Visiprep Solid-Phase Extraction Manifold: from Supelco.

4.4.2 Porapak RDX (80/100) mesh: from Supelco. Or prepacked SPE columns

4.4.3 Extraction cartridges (one per sample).

4.5 Equipment specific to membrane solid-phase extraction

4.5.1 Vacuum filter apparatus: 47 mm, with 25 x 200 mm or 25 x 250 mm vacuum flask.

4.5.2 Empore styrene-divinyl benzene (SDB) RPS disks: 47 mm (one per sample).

4.6 Preparation of Materials

4.6.1 Prepare all materials to be used as described in Chapter 4 for semivolatile organics.

## 5.0 REAGENTS

5.1 Reagent grade inorganic chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lowering the accuracy of the determination.

5.1.1 Acetonitrile,  $\text{CH}_3\text{CN}$  - HPLC grade.

5.1.2 Methanol,  $\text{CH}_3\text{OH}$  - HPLC grade.

5.1.3 Calcium chloride,  $\text{CaCl}_2$  - Reagent grade. Prepare an aqueous solution of 5 g/L.

5.1.4 Sodium chloride,  $\text{NaCl}$ , shipped in glass bottles - reagent grade.

5.2 Organic-free reagent water - All references to water in this method refer to organic-free reagent water, as defined in Chapter One of Method 8000.

5.3 Mobile-phase reagent (500 mL methanol to 500 mL of organic-free reagent water).

#### 5.4 Stock Standard Solutions

5.4.1 Dry each solid analyte standard to constant weight in a vacuum desiccator in the dark. Place about 0.100 g (weighed to 0.0001 g) of a single analyte into a 100 mL volumetric flask and dilute to volume with acetonitrile. Invert flask several times until dissolved. Store in refrigerator at 4°C in the dark. Calculate the concentration of the stock solution from the actual weight used (nominal concentration = 1,000 mg/L). Stock solutions may be used for up to one year. Alternatively premixed stock solutions can be purchased from a certified source.

**NOTE:** The HMX, RDX, Tetryl, and 2,4,6-TNT are explosives and the neat material should be handled carefully. See SAFETY in Sec. 11 for guidance. HMX, RDX, and Tetryl reference materials are shipped under water. Drying at ambient temperature requires several days. **DO NOT DRY AT HEATED TEMPERATURES!**

#### 5.5 Intermediate Standards Solutions

5.5.1 If both 2,4-DNT and 2,6-DNT are to be determined, prepare two separate intermediate stock solutions containing (1) HMX, RDX, 1,3,5-TNB, 1,3-DNB, NB, 2,4,6-TNT, and 2,4-DNT and (2) Tetryl, 2,6-DNT, 2-NT, 3-NT, and 4-NT. Intermediate stock standard solutions should be prepared at 1,000 µg/L, in acetonitrile when analyzing soil samples, and in methanol when analyzing aqueous samples. These solutions are also available commercially.

5.5.2 Dilute the two concentrated intermediate stock solutions, with the appropriate solvent, to prepare intermediate standard solutions that cover the range of 2.5 - 1,000 µg/L. These solutions should be refrigerated on preparation, and may be used for 30 days.

5.5.3 For the low-level method, the analyst must conduct a detection limit study and devise dilution series appropriate to the desired range. Standards for the low level method must be prepared immediately prior to use.

#### 5.6 Working standards

5.6.1 Calibration standards at a minimum of five concentration levels should be prepared through dilution of the intermediate standards solutions in acetonitrile or methanol. These solutions must be refrigerated and stored in the dark, and prepared fresh on the day of calibration.

#### 5.7 Surrogate Spiking Solution

5.7.1 The analyst should monitor the performance of the extraction and analytical system as well as the effectiveness of the method in dealing with each sample matrix by spiking each sample, standard and reagent water blank with one or two surrogates (e.g., analytes

not expected to be present in the sample and do not coelute with target compounds).

## 5.8 Matrix Spiking Solutions

5.8.1 Prepare matrix spiking solutions in methanol such that the concentration in the sample is at least five times the Estimated Quantitation Limit. All target analytes should be included.

## 5.9 HPLC Mobile Phase

5.9.1 To prepare 1 liter of mobile phase, add 500 mL of methanol to 500 mL of organic-free reagent water.

5.9.2 The mobile phase may also be mixed “in-line” by the HPLC system drawing from bottles of 100% methanol and 100% organic-free reagent water.

## 6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 Follow conventional sampling and sample handling procedures as specified for semivolatile organics in Chapter Four. Dry all soil samples in air at room temperature or colder to a constant weight (less than 10% moisture), being careful not to expose the samples to direct sunlight.

6.2 Samples and sample extracts must be stored in the dark at 4°C. Holding times are the same as for semivolatile organics.

## 7.0 SAMPLE PREPARATION

7.1 Aqueous Samples: It is highly recommended that process waste samples be screened with the high-level method to determine if the low level method (1-50 µg/L) is required. Most groundwater samples will fall into the low level method.

### 7.1.1 Low-Level Method 1 (salting-out extraction)

7.1.1.1 Add 251.3 g of sodium chloride to a 1 L volumetric flask (round). Measure out 770 mL of a water sample (using a 1 L graduated cylinder) and transfer it to the volumetric flask containing the salt. Add a stir bar and mix the contents at maximum speed on a magnetic stirrer until the salt is completely dissolved.

7.1.1.2 Add 164 mL of acetonitrile (measured with a 250 mL graduated cylinder) while the solution is being stirred and stir for an additional 15 minutes. Turn off the stirrer and allow the phases to separate for 10 minutes.

7.1.1.3 Remove the acetonitrile (upper) layer (about 8 mL) with a Pasteur pipet and transfer it to a 100 mL volumetric flask (round). Add 10 mL of fresh acetonitrile to the water sample in the 1 L flask. Again stir the contents of the flask for 15 minutes followed by 10 minutes for phase separation. Combine the second acetonitrile portion with the initial extract. The inclusion of a few drops of salt water at this point is unimportant.

7.1.1.4 Add 84 mL of salt water (325 g NaCl per 1000 mL of reagent water) to the

acetonitrile extract in the 100mL volumetric flask. Add a stir bar and stir the contents on a magnetic stirrer for 15 minutes, followed by 10 minutes for phase separation. Carefully transfer the acetonitrile phase to a 10 mL graduated cylinder using a Pasteur pipet. At this stage, the amount of water transferred with the acetonitrile must be minimized. The water contains a high concentration of NaCl that produces a large peak at the beginning of the chromatogram, where it could interfere with the HMX determination.

7.1.1.5 Add an additional 1.0 mL of acetonitrile to the 100 mL volumetric flask. Again stir the contents of the flask for 15 minutes, followed by 10 minutes for phase separation. Combine the second acetonitrile portion with the initial extract in the 10 mL graduated cylinder (transfer to a 25 mL graduated cylinder if the volume exceeds 5 mL). Record the total volume of acetonitrile extract to the nearest 0.1 mL. (Use this as the volume of total extract [ $V_t$ ] in the calculation of concentration after converting to  $\mu\text{L}$ ). The resulting extract, about 5 - 6 mL, may be diluted 1:1 with organic-free reagent water (with pH <3 if tetryl is a suspected analyte) prior to analysis if necessary or can be run without dilution.

7.1.1.6 If the diluted extract is turbid, filter it through a 0.45  $\mu\text{m}$  Teflon filter using a disposable syringe. Discard the first 0.5 mL of filtrate, and retain the remainder in a Teflon-capped vial for RP-HPLC analysis as in Sec. 7.4. NOTE: turbidity may be the result of a compound coming out of solution and thus SHOULD NOT be diluted with water prior to analysis.

7.1.2.7 Samples should be stored at 4°C in the dark until analysis. Samples must be warmed to room temperature before RP-HPLC analysis is performed.

#### 7.1.2 Low-Level Method 2: Cartridge solid-phase extraction

7.1.2.1 Fit 20-microm frits at the bottom of the empty extraction cartridges, then pack each cartridge with 0.5 g of the Porapak RDX. Place another frit on top of each cartridge to retain the material and help minimize channeling. Prepacked SPE cartridges are also available commercially for nitroaromatic extraction. In this case follow manufacturers procedure for usage.

7.1.2.2 Place the cartridges on the Visiprep Solid-Phase Extraction Manifold and clean and condition them by eluting with 30 mL of acetonitrile by gravity flow, followed by 50 mL of reagent-grade water at 10 mL per minute.

7.1.2.3 Measure a 500-mL aliquot of each water sample using a 1-L graduated cylinder. Pull the sample through a cartridge at about 10 mL per minute. Use a new cartridge for each sample.

7.1.2.4 Elute the samples by passing a 5-mL aliquot of acetonitrile through each cartridge at about 2 mL per minute and collect the eluate in a 10-mL graduated cylinder.

7.1.2.5 The resulting extract (about 5 mL) may be diluted with 1:1 with reagent-grade water prior to analysis but is not necessary.

7.1.2.6 Samples should be stored at 4°C in the dark until analysis. Samples must be warmed to room temperature before RP-HPLC analysis is performed.

### 7.1.3 Low-Level Method 3: Membrane solid-phase extraction

7.1.3.1 Rinse the Empore SDB-RPS disks with acetonitrile and center on the 47-mm vacuum filter apparatus.

7.1.3.2 To clean and condition the disks, add a 20-mL portion of acetonitrile and allow to this to soak into the disk for 3 minutes. Turn the vacuum on and allow most (but not all) of the solvent to be pulled through the disk.

7.1.3.3 Add a 50-mL aliquot of reagent-grade water to the disk and turn the vacuum on once again, pulling the water through the membrane. Just before the last of the water is pulled through, turn the vacuum off.

7.1.3.4 Fill the reservoir with a 500-mL aliquot of water sample, turn the vacuum on, and pull the sample through the membrane. This will take 5 to 7 minutes, with resulting flow rates ranging from 70 to 100 mL per minute.

7.1.3.5 Once the water is exhausted, draw air through the membrane for 1 minute to remove any excess water. Turn the vacuum off and remove the flask.

7.1.3.6 Remove the water and place a test tube in the flask so that it fits over the funnel exit when the flask is reattached to the fritted base. The actual size of the test tube depends upon the brand of vacuum flask.

7.1.3.7 Add a 5-mL aliquot of acetonitrile to the reservoir, and allow this to soak into the membrane for 3 minutes. Apply the vacuum, drawing the acetonitrile through the membrane into the test tube. Remove the resulting extract with a Pasteur pipette and store it for analysis.

7.1.3.8 If needed add an appropriate portion of reagent-grade water (< 5.0 mL) to dilute the acetonitrile extract 1:1 prior to analysis.

7.1.3.9 Samples should be stored at 4°C in the dark until analysis. Samples must be warmed to room temperature before RP-HPLC analysis is performed.

### 7.1.4 High-level method

7.1.4.1 Samples are prepared by directly filtering approximately 1.5 mL of the aqueous sample through a 0.45-micron glass microfiber syringe filter (Whatman) into an HPLC autosampler vial. No dilution with solvent is required.

7.1.4.2 Samples may also be prepared as follows: Place a 5-mL aliquot of each water sample in a scintillation vial. Add 5 mL of acetonitrile, shake thoroughly, and filter through a 0.45-micron Teflon filter using a disposable syringe. NOTE: HMX quantitation can be improved by using methanol (instead of acetonitrile) for dilution

before filtration. Discard the first 3 mL of filtrate and retain the remainder in a Teflon-capped vial for RP-HPLC analysis.

7.1.4.3 Regardless of method chosen, samples should be stored at 4°C in the dark until analysis. Samples must be warmed to room temperature before RP-HPLC analysis is performed.

## 7.2 Soil and sediment samples

7.2.1 Dry the soil samples in air at room temperature (or colder) to a constant weight, being careful not to expose the samples to direct sunlight. Grind and homogenize the dried sample thoroughly in an acetonitrile-rinsed mortar to pass a 30-mesh sieve.

NOTE: Soil samples should be screened by Method 8515 prior to grinding with the mortar and pestle. Soil samples as high as 2% 2,4,6-TNT have been safely ground, but take care: samples containing higher concentrations should not be ground with the mortar and pestle. Method 8515 is for 2,4,6-TNT, the analyte most often detected in high concentrations in soil samples; however, the other nitroaromatics will also cause a color change that would provide a rough estimate of their concentrations. Visual observation of a soil sample is also important when the sample is taken from a site expected to contain explosives. Lumps of material that have a chemical appearance should be suspect and not ground. Explosives are generally a very finely ground grayish-white material.

7.2.2 Place a 2.0-g subsample of each soil sample in a 15-mL glass vial. Add 10.0 mL of acetonitrile, cap with a Teflon-lined cap, vortex swirl for 1 minute, and place in a cooled ultrasonic bath for 18 hours.

7.2.3 Subsamples of the ground and sieved soil must also be taken for determination of absolute water content so dry-weight-basis (105°C oven dry) explosive concentrations can be calculated.

7.2.4 After sonication, shake the samples vigorously to suspend the settled material, then allow the sample to settle for 30 minutes.

7.2.5 THIS IS AN OPTIONAL STEP. Remove 5.0 mL of supernatant and combine it with 5.0 mL of calcium chloride solution (see Section 7) in a 20-mL vial. Shake and let stand for 15 minutes.

7.2.6 Filter the supernatant (or diluted sample from 7.2.4) through a 0.45-micron Teflon filter. Discard the first 3 mL and retain the remainder in a Teflon-capped vial for RP-HPLC analysis. NOTE: For undiluted acetonitrile supernatants, a 0.45-micron nylon filter can be used.

7.2.7 Samples should be stored at 4°C in the dark until analysis. Samples must be warmed to room temperature before RP-HPLC analysis is performed.

## 8.0 ANALYTICAL PROCEDURE

### 8.1 Chromatographic Conditions (Recommended)

8.1.1 Primary Column: C-18 reverse phase HPLC column, 25-cm x 4.6-mm, 5  $\mu$ m, (Supelco LC-18 or equivalent).

8.1.2 Secondary Column: CN reverse phase HPLC column, 25-cm x 4.6-mm, 5  $\mu$ m, (Supelco LC-CN or equivalent). This is required only for confirmation of analyte identification.

8.1.3 Mobile Phase: 50/50 (v/v) methanol/organic-free reagent water.

8.1.4 Flow Rate: 1.5 mL/min

8.1.5 Injection volume: 100- $\mu$ L

8.1.6 UV Detector: 254 nm

## 8.2 Currently Used Chromatographic Conditions

8.2.1 Column: C-18 reverse phase HPLC column, 25-cm x 4.6-mm, 5  $\mu$ m, (Restek Allure C18)

8.2.3 Mobile Phase: 50/50 (v/v) methanol/organic-free reagent water.

8.2.4 Flow Rate: 0.9 mL/min

8.2.5 Injection volume: 10- $\mu$ L (increased to 100- $\mu$ L for repeat analysis of “non-detect” samples)

8.2.6 UV Detector: 230 nm

8.2.7 Column temperature: 25°C

## 8.3 Calibration of HPLC

8.3.1 All electronic equipment is allowed to warm up for 30 minutes. During this period, at least 15 void volumes of mobile phase are passed through the column (approximately 20 min at 1.5 mL/min) and continued until the baseline is level at the UV detector's greatest sensitivity.

8.3.2 Initial Calibration. External calibration technique is used for calibration where the response factor for each target compound is determined. Injections of each calibration standard and surrogate over the concentration range of interest are made sequentially into the HPLC in random order. Peak heights or peak areas are obtained for each analyte or surrogate. Experience indicates that a linear calibration curve with zero intercept is appropriate for each analyte. Therefore, a response factor for each analyte can be taken as the slope of the best-fit regression line.

8.3.3 Daily Calibration. Analyze midpoint calibration standards, at a minimum, at the beginning of the day, singly at the midpoint of the run, and singly after the last sample of the day (assuming a sample group of 10 samples or less). Obtain the response factor for each analyte from the mean peak heights or peak areas and compare it with the response factor obtained for the initial calibration. The mean response factor for the daily calibration must agree within  $\pm 15\%$  of the response factor of the initial calibration. The

same criteria is required for subsequent standard responses compared to the mean response of the triplicate standards beginning the day. If this criterion is not met, a new initial calibration must be obtained.

#### 8.4 HPLC Analysis

8.4.1 Analyze the samples using the chromatographic conditions given in Sec. 8.2. If column temperature control is not employed, special care must be taken to ensure that temperature shifts do not cause peak misidentification. Only if required by specific project QA are positive measurements confirmed by injection onto a CN column.

8.4.2 Follow Sec. 7.0 in Method 8000 for instructions on the analysis sequence, appropriate dilutions, establishing daily retention time windows, and identification criteria. Include a mid-level standard after each group of 10 samples in the analysis sequence. If column temperature control is not employed, special care must be taken to ensure that temperature shifts do not cause peak misidentification.

8.4.3 Record the resulting peak sizes in peak heights or area units. The use of peak heights is recommended to improve reproducibility of low level samples. Printed Chromatograms of each sample run should include all needed information (peak area, height, retention time etc) to calculate concentration based on calibration factor if being tabulated using a separate spreadsheet.

8.4.4 Calculation of concentration is covered in Sec. 7.0 of Method 8000. Chromatography software using the calibration curve for the target compounds can also be used to determine concentration of target analytes.

#### 9.0 QUALITY CONTROL

- 9.1 Refer to Chapter One for specific quality control procedures. Quality control to validate sample extraction is covered in Method 3500.
- 9.2 At a minimum a standard check and blank sample must be run with every 10 samples. An MS/MSD sample is run with every batch of 20 samples and each sample, blank, standard or QC sample will be spiked with a surrogate. Samples will be spiked with a surrogate prior to any sample preparation in order to determine extraction efficiency of the procedure. Surrogates will be added to a sample to give a concentration in the final extract that is in the linear range of the surrogate response curve.
- 9.3 Quality control required to validate the HPLC system operation is found in Method 8000, Sec. 8.0.
- 9.4 Prior to preparation of stock solutions, acetonitrile, methanol, and water blanks should be run to determine possible interferences with analyte peaks. If the acetonitrile, methanol, or water blanks show contamination, a different batch should be used.

#### 10.0 METHOD PERFORMANCE

- 10.1 Accuracy and Precision is determined for each analyte being measured according to Shaw's Quality Assurance Program.

## 11.0 REFERENCES

- Bauer, C.F., T.F. Jenkins, S.M. Koza, P.W. Schumacher, P.H. Miyares and M.E. Walsh (1989). Development of an analytical method for the determination of explosive residues in soil. Part 3. Collaborative test results and final performance evaluation. USA Cold Regions Research and Engineering Laboratory, CRREL Report 89-9.
- Grant, C.L., A.D. Hewitt and T.F. Jenkins (1989) Comparison of low concentration measurement capability estimates in trace analysis: Method Detection Limits and Certified Reporting Limits. USA Cold Regions Research and Engineering Laboratory, Special Report 89-20.
- Jenkins, T.F., C.F. Bauer, D.C. Leggett and C.L. Grant (1984) Reversed-phased HPLC method for analysis of TNT, RDX, HMX and 2,4-DNT in munitions wastewater. USA Cold Regions Research and Engineering Laboratory, CRREL Report 84-29.
- Jenkins, T.F. and M.E. Walsh (1987) Development of an analytical method for explosive residues in soil. USA Cold Regions Research and Engineering Laboratory, CRREL Report 87-7.
- Jenkins, T.F., P.H. Miyares and M.E. Walsh (1988a) An improved RP-HPLC method for determining nitroaromatics and nitramines in water. USA Cold Regions Research and Engineering Laboratory, Special Report 88-23.
- Jenkins, T.F. and P.H. Miyares (1992) Comparison of Cartridge and Membrane Solid-Phase Extraction with Salting-out Solvent Extraction for Preconcentration of Nitroaromatic and Nitramine Explosives from Water. USA Cold Regions Research and Engineering Laboratory, Draft CRREL Special Report.
- Jenkins, T.F., P.W. Schumacher, M.E. Walsh and C.F. Bauer (1988b) Development of an analytical method for the determination of explosive residues in soil. Part II: Further development and ruggedness testing. USA Cold Regions Research and Engineering Laboratory, CRREL Report 88-8.
- Leggett, D.C., T.F. Jenkins and P.H. Miyares (1990) Salting-out solvent extraction for preconcentration of neutral polar organic solutes from water. *Analytical Chemistry*, 62: 1355-1356.
- Miyares, P.H. and T.F. Jenkins (1990) Salting-out solvent extraction for determining low levels of nitroaromatics and nitramines in water. USA Cold Regions Research and Engineering Laboratory, Special Report 90-30.

## 12.0 SAFETY

- 12.1 Standard precautionary measures used for handling other organic compounds should be sufficient for the safe handling of the analytes targeted by Method 8330. The only extra caution that should be taken is when handling the analytical standard neat material for the explosives themselves and in rare cases where soil or waste samples are highly contaminated with the explosives. Follow the note for drying the neat materials at ambient temperatures.

<b>SHAW METHOD</b>	<b>SHAW CON-014</b>
<b>METHOD #: 415.1</b>	<b>Approved for NPDES (Editorial Revision 1974)</b>
<b>TITLE:</b>	<b>Organic Carbon, Total (Combustion or Oxidation)</b>
<b>ANALYTE:</b>	<b>CAS # Total Organic Carbon (TOC) C 7440-44-0</b>
<b>INSTRUMENTATION:</b>	<b>Appollo 9000</b>
<b>STORET No.</b>	<b>2005-1</b>

## **TOTAL ORGANIC CARBON (SHAW CON-14; EPA 415.1)**

- 1.0 Scope and Application
  - 1.1 This method includes the measurement of organic carbon in drinking, surface and saline waters, domestic and industrial wastes. Exclusions are noted under Definitions and Interferences.
  - 1.2 The method is most applicable to measurement of organic carbon above 1 mg/L.
  
- 2.0 Summary of Method
  - 2.1 Organic carbon in a sample is converted to carbon dioxide (CO<sub>2</sub>) by catalytic combustion or wet chemical oxidation. The CO<sub>2</sub> formed can be measured directly by an infrared detector. The amount of CO<sub>2</sub> is directly proportional to the concentration of carbonaceous material in the sample.
  
- 3.0 Definitions
  - 3.1 The carbonaceous analyzer measures all of the carbon in a sample. Because of various properties of carbon-containing compounds in liquid samples, preliminary treatment of the sample prior to analysis dictates the definition of the carbon as it is measured. Forms of carbon that are measured by the method are:
    - A) soluble, nonvolatile organic carbon; for instance, natural sugars.
    - B) soluble, volatile organic carbon; for instance, mercaptans.
    - C) insoluble, partially volatile carbon; for instance, oils.
    - D) insoluble, particulate carbonaceous materials, for instance; cellulose fibers.
    - E) soluble or insoluble carbonaceous materials adsorbed or entrapped on insoluble inorganic suspended matter; for instance, oily matter adsorbed on silt particles.
  
  - 3.2 The final usefulness of the carbon measurement is in assessing the potential oxygen demanding load of organic material on a receiving stream. This statement applies whether the carbon measurement is made on a sewage plant effluent, industrial waste, or on water taken directly from the stream. In this

light, carbonate and bicarbonate carbon are not a part of the oxygen demand in the stream and therefore should be discounted in the final calculation or removed prior to analysis. The manner of preliminary treatment of the sample and instrument settings defines the types of carbon which are measured. Instrument manufacturer's instructions should be followed.

#### 4.0 Sample Handling and Preservation

- 4.1 Sampling and storage of samples in glass bottles is preferable. Sampling and storage in plastic bottles such as conventional polyethylene and cubitainers is permissible if it is established that the containers do not contribute contaminating organics to the samples. NOTE: A brief study performed in the EPA Laboratory indicated that distilled water stored in new, one quart cubitainers did not show any increase in organic carbon after two weeks exposure.
- 4.2 Because of the possibility of oxidation or bacterial decomposition of some components of aqueous samples, the lapse of time between collection of samples and start of analysis should be kept to a minimum. Also, samples should be kept cool (4°C) and protected from sunlight and atmospheric oxygen.
- 4.3 In instances where analysis cannot be performed within two hours (2 hours) from time of sampling, the sample is acidified (pH <2) with or H<sub>2</sub>SO<sub>4</sub> or H<sub>2</sub>PO<sub>3</sub>

#### 5.0 Interferences

- 5.1 Carbonate and bicarbonate carbon represent an interference under the terms of this test and must be removed or accounted for in the final calculation.
- 5.2 This procedure is applicable only to homogeneous samples which can be injected into the apparatus reproducibly by means of a microliter type syringe or pipette. The openings of the syringe or pipette limit the maximum size of particles which may be included in the sample.

#### 6.0 Apparatus

- 6.1 Apparatus for blending or homogenizing samples:
- 6.2 Apparatus for total and dissolved organic carbon: currently in use an Appollo 9000 without an autosampler

#### 7.0 Reagents

- 7.1 Distilled water used in preparation of standards and for dilution of samples should be ultra pure to reduce the carbon concentration of the blank. Carbon dioxide-free, double distilled water is recommended. Ion exchanged waters are not recommended because of the possibilities of contamination with organic materials from the resins.
- 7.2 Potassium hydrogen phthalate, stock solution, 1000 mg carbon/liter: Dissolve 0.2128 g of potassium hydrogen phthalate (Primary Standard Grade) in distilled water and dilute to 100.0 mL. KHP crystals must be dry and stored

in a desiccator. Other-wise, dry by placing in the oven at 105°C for 2 hours prior to preparation of the stock solution. Potassium Hydrogen Phthalate, KHPACS Acidimetric Standard, 99.95%-100.05% 1,000 ppm C and 2,000 ppm C KHP certified standards are available from Teledyne Tekmar

- 7.3 Sodium Bicarbonate (ACS Reagent Grade)
- 7.4 Potassium hydrogen phthalate, standard solutions: Prepare standard solutions from the stock solution by dilution with distilled water.
- 7.5 Blank solution: Use the same distilled water (or similar quality water) used for the preparation of the standard solutions.
- 7.6 Sodium Bicarbonate (ACS Reagent Grade)

## 8.0 Procedure

- 8.1 Follow instrument manufacturer's instructions for calibration, procedure, and calculations (summary below).
- 8.2 Instrument set up
  - 8.2.1 Select Instrument from the Setup menu of the TOC Talk Control screen to open the Instrument Setup/Status dialog.
  - 8.2.2 Select Ready to wake up the instrument
  - 8.2.3 The gas flow will turn on and the detector signal will begin to stabilize. Look for the flow rate display in the To Furnace field.
  - 8.2.4 Select the following parameters:
    - a) Select Without Autosampler from the Sample Introduction list
    - b) Check Print Data Report after Each Sample Set (optional).
    - c) If you wish, you may type in your name and give your instrument a name. All other choices should remain un-checked.

## 8.3 Sample Set up

- 8.3.1 From the menu bar of the Control screen, click Run.
- 8.3.2 The Run screens are actually three separate screens that display real-time data
  - a) Sample Analysis displays the last Sample ID, Mode, etc. if not running or the current Sample ID, etc. while running. The Sample Setup button accesses the Sample Setup table.
  - b) Strip Chart shows the detector signal and can be changed to magnify small peaks or accommodate larger peaks .
  - c) Analysis Results updates analysis data at the end of each sample analysis rep.
- 8.3.3 Click the Sample Setup button in the Sample Analysis screen
- 8.3.4 In the Without Autosample Analysis Setup screen, enter a name for the sample run in the Sample ID field
- 8.3.5 Select Sample from the Sample Type list
- 8.3.6 Select TOC 0-20 ppm C from the Method ID list. The analysis Mode displayed should match the Method and the Calibration Curve should display the default unless another curve is set as active and in memory.

- 8.3.7 Select TOC 0-20 ppm C from the Method ID list. The analysis Mode displayed should match the Method and the Calibration Curve should display the default unless another curve is set as active and in memory.
  - 8.3.8 Select appropriate number of analyses in Repeats field.
  - 8.3.9 Click Save/Use.
  - 8.3.10 Before you begin the analysis run, verify that the:
    - a) sample line runs from Port D of the 8-port valve into the correct sample vessel
    - b) acid supply line runs from Port A of the 8-port valve into the acid reagent container
    - c) DI Water line runs from Port G of the 8-port valve to a fresh DI Water supply
  - 8.3.11 Start analysis Click Start
  - 8.4 For calibration of the instrument, it is recommended that a series of standards encompassing the expected concentration range of the samples be used.
- 9.0 Precision and Accuracy
- 9.1 See Current QAPP for summary of Precision and Accuracy measurements

### **Bibliography**

Annual Book of ASTM Standards, Part 31, "Water", Standard D 2574-79, p 469 (1976).

Standard Methods for the Examination of Water and Wastewater, 14th Edition, p 532, Method 505, (1975).

**SHAW METHOD****SHAW BAC-003****METHOD #: 405.1****TITLE:****Biological Oxygen Demand, cBOD****ANALYTE:****BOD ; cBOD****INSTRUMENTATION:****BOD incubator; DO meter****VERSION.****2005-1****BIOLOGICAL OXYGEN DEMAND (BOD),CBOD (SHAW BAC-003; EPA 405.1)****1.0 INTRODUCTION****1.1 General Discussion**

Analyses for organic matter in water and wastewater can be classified into two general types of measurements: those that quantify an aggregate amount of organic matter comprising organic constituents with a common characteristic and those that quantify individual organic compounds. The latter can be found in Volume II. The former, described here, has been grouped into four categories: oxygen-demanding substances, organically bound elements, classes of compounds, and formation potentials.

Methods for total organic carbon and chemical oxygen demand are used to assess the total amount of organics present. Gross fractions of the organic matter can be identified analytically, as in the measurement of BOD, which is an index of the biodegradable organics present, oil and grease, which represents material extractable from a sample by a nonpolar solvent, or total organic halide (TOX), which measures organically bound halogens. Trihalomethane formation potential is an aggregate measure of the total concentration of trihalomethanes formed upon chlorination of a water sample.

Analyses of organics are made to assess the concentration and general composition of organic matter in raw water supplies, wastewaters, treated effluents, and receiving waters; and to determine the efficiency of treatment processes.

**1.2 Sample Collection and Preservation**

The sampling, field treatment, preservation, and storage samples taken for organic matter analysis are covered in detail in the individual introductions to the methods. If possible, analyze samples immediately because preservatives often interfere with the tests.

Otherwise, store at a low temperature (4°C) immediately after collection to preserve most samples. Use chemical preservatives only when they are shown not to interfere with the examinations to be made. Never use preservatives for samples to be analyzed for BOD. When preservatives are used, add them to the sample bottle initially so that all portions are preserved as soon as collected. No single method of preservation is entirely satisfactory; choose the preservative with due regard to the terminations that are to be made. All methods of preservation may be inadequate when applied to samples

containing significant mounts of suspended matter.

## 2.0 QUALITY CONTROL

Take special precautions when analyses are performed by independent laboratories. Reliable use of independent laboratories deserves the same quality assurance procedures observed for in-house analysis: replicate samples, samples with known additions, and blanks.

Preparation of samples with known additions may not be feasible for certain analyses. In such cases, consider using a mixture, in varying ratios, of several samples. Use the reported concentrations in the samples and the proportions in which they were mixed to calculate the expected concentration in the mixture. Examine laboratory performance using externally prepared standards and check samples.

Type I reagent water should give satisfactory results for most of the analyses but additional purification steps may be needed for certain methods, such as total organic halid (TOX)-and trihalomethane formation potential (THMFP).

## 3.0 BIOCHEMICAL OXYGEN DEMAND (BOD)

### 3.1 Introduction

#### 3.1.1 General Discussion

The biochemical oxygen demand (BOD) determination is an empirical test in which standardized laboratory procedures are used to determine the relative oxygen requirements of wastewaters, effluents, and polluted waters. The test has its widest application in measuring waste loadings to treatment plants and in evaluating the BOD-removal efficiency of such treatment systems. The test measures the oxygen utilized during a specified incubation period for the biochemical degradation of organic material such as sulfides and ferrous iron. It also may measure the oxygen used to oxidize reduced forms of nitrogen (nitrogenous demand) unless their oxidation is prevented by an inhibitor. The seeding and dilution procedures provide an estimate of the BOD at pH 6.5 to 7.5.

Although only the 5-day BOD ( $BOD_5$ ) is described here, many variations of oxygen demand measurements exist. These include using shorter and longer incubation periods, tests to determine rates of oxygen uptake, and continuous oxygen-uptake measurements by respirometric techniques. Alternative seeding, dilution, and incubation conditions can be chosen to mimic receiving-water conditions, thereby providing an estimate of the environmental effects of wastewaters and effluents.

#### 3.1.2 Carbonaceous Versus Nitrogenous BOD

Oxidation of reduced forms of nitrogen, mediated by microorganisms, exerts nitrogenous demand. Nitrogenous demand historically has been considered an interference in the determination of BOD, as clearly evidenced by the inclusion of ammonia in the dilution water. The interference from nitrogenous demand can

now be prevented by an inhibitory chemical. If an inhibiting chemical is not used, the oxygen demand measured is the sum of carbonaceous and nitrogenous demands.

Measurements that include nitrogenous demand generally are not useful for assessing the oxygen demand associated with organic material. Nitrogenous Demand can be estimated directly from ammonia nitrogen (See Standard Methods SM 4500-NH<sub>3</sub>); and carbonaceous demand can be estimated by subtracting the theoretical equivalent of the reduced nitrogen oxidation from uninhibited test results. However, this method is cumbersome and is subject to considerable error. Chemical inhibition of nitrogenous demand provides a more direct and more reliable measure of carbonaceous demand.

The extent of oxidation of nitrogenous compounds during the 5-day incubation period depends on the presence of microorganisms capable of carrying out this oxidation. Such organisms usually are not present in raw sewage or primary effluent in sufficient numbers to oxidize significant quantities of reduced nitrogen forms in the 5-day BOD test. Many biological treatment plant effluents contain significant numbers of nitrifying organisms. Because oxidation of nitrogenous compounds can occur in such samples, inhibition of nitrification as directed is recommended for samples of secondary effluent for samples seeded with secondary effluent, and for samples of polluted waters.

Report results as CBOD<sub>5</sub> when inhibiting the nitrogenous oxygen demand. When nitrification is not inhibited report results as BOD<sub>5</sub>.

### 3.1.3 Dilution Requirements

The BOD concentration in most wastewaters exceeds the concentration of dissolved oxygen (DO) available in an air-saturated sample. Therefore, it is necessary to dilute the sample before incubation to bring the oxygen demand and supply into appropriate balance. Because bacterial growth requires nutrients such as nitrogen, phosphorus, and trace metals, these are added to the dilution water, which is buffered to ensure that the pH of the incubated sample remains in a range suitable for bacterial growth. Complete stabilization of a sample may require a period of incubation too long practical purposes; therefore, 5 d has been accepted as the standard incubation period.

If the dilution water is of poor quality, effectively, dilution water will appear as sample BOD. This effect will be amplified by the dilution factor. A positive bias will result. The method included below contains both a dilution-water check and a dilution-water blank. Seeded dilution waters are checked further for acceptable quality by measuring their consumption of oxygen from a known organic mixture, usually glucose and glutamic acid.

The source of dilution water is not restricted and may be distilled, tap, or receiving-stream water free of biodegradable organics and bioinhibitory substances such as chlorine or heavy metals. Distilled water may contain ammonia or volatile organics; deionized waters often are contaminated with soluble organics leached from the resin bed. Use of copper-lined stills or copper fittings attached to distilled water lines may produce water containing excessive amounts of copper (see Section 3500-Cu).

#### 3.1.4 Reference

1. Young, J. C. 1973. Chemical methods for nitrification control. *J. Water Pollut. Control Fe.* 45:637.
2. Theriault, E. J., P.D. McNamme & C. T. Butterfield. 1931. Selection of dilution water for use in oxygen demand tests. *Puh. Health Rep.* 46:1084.
3. Lea, W. L. & M. S. Nichols. 1937. Influence of phosphorus and nitrogen on biochemical oxygen demand. *Sewage Works J.* 9:34.
4. Ruchhoft, C.C. 1941. Report on the cooperative study of dilution waters made for the Standard Methods Committee of the Federation of Sewage Works Associations. *Sewage Works J.* 13:669.
5. Mohlman, F.W., E. Hurwitz, G.R. Barnett & H. K. Ramer. 1950. Experience with modified methods for BOD. *Sewage Ind. Wastes* 22:31.

## 4.0 5-DAY BOD TEST

### 4.1.1 General Discussion

Principle: The method consists of filling with sample, to overflowing, an airtight bottle of the specified size and incubating it at the specified temperature for 5 d. Dissolved oxygen is measured initially and after incubation, and the BOD is computed from the difference between initial and final DO. Because the initial DO is determined immediately after the dilution is made, all oxygen uptake, including that occurring during the first 15 min., is included in the BOD measurement.

- 4.1.2 Sampling and storage: Samples for BOD analysis may degrade significantly during storage between collection and analysis, resulting in low BOD values. Minimize reduction of BOD by analyzing sample promptly or by cooling it to near-freezing temperature during storage. However, even at low temperature, keep holding time to a minimum. Warm chilled samples to 20°C before analysis.

4.1.2.1 Grab samples - If analysis is begun within 2 h of collection, cold storage is unnecessary. If analysis is not started within 2 h of sample collection, keep sample at or below 4°C and report length and temperature of storage with the results. In no case start analysis more than 24 h after grab sample collection. When samples are to be used for regulatory purposes make every effort to deliver samples for analysis within 6 h of collection.

4.1.2.2 Composite samples - Keep samples at or below 4°C during compositing. Limit compositing period to 24 h. Use the same criteria as for storage of grab samples, starting the measurement of holding time from end of compositing period. State storage time and conditions as part of the results.

## 4.2 Apparatus

- 4.2.1 Incubation bottles, 250-300mL capacity. Clean bottles with a detergent, rinse thoroughly, and drain before use. As a precaution against drawing air into the dilution bottle during incubation, use a water-seal. Obtain satisfactory water seals by inverting bottles in a water bath or by adding water to the flared mouth of special BOD bottles. Place a paper or plastic cup or foil cap over flared mouth of bottle to reduce evaporation of the water seal during incubation.
- 4.2.2 Air incubator or water bath, thermostatically controlled at 20.0 ± 0.1 °C. Exclude light to prevent possibility of photosynthetic production of DO.

## 4.3 Reagents

- 4.3.1 Phosphate buffer solution: Dissolve 8.5 g KH<sub>2</sub>PO<sub>4</sub>; 21.75 g K<sub>2</sub>HPO<sub>4</sub>; 33.4g Na<sub>2</sub>HPO<sub>4</sub>·7H<sub>2</sub>O; and 1.7 g NH<sub>4</sub>Cl in about 500 mL distilled water and dilute to 1 L. The pH should be within 7.2 without further adjustment. Discard reagent (or any of the following reagents) if there is any sign of biological growth in the stock bottle.
- 4.3.2 Magnesium sulfate solution: Dissolve 22.5 g MgSO<sub>4</sub>·7H<sub>2</sub>O in distilled water and dilute to 1 L.
- 4.3.3 Calcium chloride solution: Dissolve 27.5 g CaCl<sub>2</sub> in distilled water and dilute to 1 L.
- 4.3.4 Ferric chloride solution: Dissolve 0.25 g FeCl<sub>3</sub>·6H<sub>2</sub>O in distilled water and dilute to 1 L.
- 4.3.5 Acid and alkali solutions, 1N, for neutralization of caustic or acidic waste samples.
  - 4.3.5.1 Acid - Slowly and while stirring, add 28 mL conc sulfuric acid to distilled

water. Dilute to 1L.

4.3.5.2 Alkali - Dissolve 40 g sodium hydroxide in distilled water. Dilute to 1 L.

4.3.6 Sodium sulfite solution: Dissolve 1.575 g Na<sub>2</sub>SO<sub>3</sub> in 1000 mL distilled water. This solution is not stable; prepare daily.

4.3.7 Nitrification inhibitor, 2-chloro-6-(trichloro methyl) pyridine.

4.3.8 Glucose-glutamic acid solution: Dry reagent-grade glucose and reagent-grade glutamic acid at 103°C for 1 h Add 150 mg glucose and 150 mg glutamic acid to distilled water and dilute to 1 L. Prepare fresh immediately after use.

4.3.9 Ammonium chloride solution: Dissolve 1.15 g NH<sub>4</sub>Cl in about 500 mL distilled water, adjust pH to 7.2 with NaOH solution, and dilute to 1 L. Solution contains 0.3 mg N/mL.

#### 4.4 Procedure

4.4.1 Preparation of dilution water: Place desired volume of water in a suitable bottle and add 1 mL each of phosphate buffer, MgSO<sub>4</sub>, CaCl<sub>2</sub>, and FeCl<sub>3</sub> solutions/L of water. Seed dilution water, if desired, so that water of assured quality always is on hand.

Before use, bring dilution water temperature to 20°C. Saturate with DO by shaking in a partially filled bottle or by aerating with organic-free filtered air. Alternatively, store in cotton-plugged bottles long enough for water to become saturated with DO. Protect water quality by using clean glassware, tubing, and bottles.

4.4.2 Dilution water check: Use this procedure as a rough check on quality of dilution water.

If the oxygen depletion of a candidate water exceeds 0.2 mg/L obtain a satisfactory water by improving purification or from another source.

Alternatively, if nitrification inhibition is used, store the dilution water, seeded as prescribed below, in a darkened room at room temperature until the oxygen uptake is sufficiently reduced to meet the dilution-water check criteria. Check quality of stored dilution water on use, but do not add seed to dilution water stored for quality improvement. Storage is not recommended when BODs are to be determined without nitrification inhibition because nitrifying organisms may develop during storage. Check stored dilution water to determine whether sufficient ammonia remains after storage. If not, add ammonium chloride solution to provide a total of 0.45 mg ammonia/L as nitrogen. If dilution water has not

been stored for quality improvement, add sufficient seeding material to produce a DO uptake of 0.05 to 0.1 mg/L in 5 d at 20°C. Incubate a BOD bottle full of dilution water for 5 d at 20°C. Determine initial and final DO as described. The DO uptake in 5 d at 20°C should not be more than 0.2 mg/L and preferably not more than 0.1 mg/L.

- 4.4.3 Glucose-glutamic check: Because the BOD test is a bioassay its results can be influenced greatly by the presence of toxicants or by use of a poor seeding material. Distilled waters frequently are contaminated with copper; some sewage seeds are relatively inactive. Low results always are obtained with such seeds and waters. Periodically check dilution water quality, seed effectiveness, and analytical technique by making BOD measurements on pure organic compounds and samples with known additions. In general, for BOD determinations not requiring an adapted seed, use a mixture of 150 mg glucose/L and 150 mg glutamic acid/L as a "standard" check solution. Glucose has an exceptionally high and variable oxidation rate but when it is used with glutamic acid, the oxidation rate is stabilized and is similar to that obtained with many municipal wastes.

Alternatively, if a particular wastewater contains an identifiable major constituent that contributes to the BOD, use this compound in place of the glucose-glutamic acid.

Determine the 5-d 20°C BOD of a 2% dilution of the glucose-glutamic acid standard check solution using the techniques outlined in. Evaluate data as described.

#### 4.4.4 Seeding:

- 4.4.4.1 Seed source - It is necessary to have present a population of microorganisms capable of oxidizing the biodegradable organic matter in the sample. Domestic wastewater, unchlorinated or otherwise uninfected effluents from biological waste treatment plants, and surface waters receiving wastewater discharges contain satisfactory microbial populations. Some samples do not contain a sufficient microbial population (for example, some untreated industrial wastes, disinfected wastes, high-temperature wastes, or wastes with extreme pH values). For such wastes seed the dilution water by adding a population of microorganisms. The preferred seed is effluent from a biological treatment system processing the waste. Where this is not available, use supernatant from domestic wastewater after settling at room temperature for at least 1 h but no longer than 36 h. When effluent from a biological treatment process is used, inhibition of nitrification is recommended.

Some samples may contain materials not degraded at normal rates by the microorganisms in settled domestic wastewater. Seed such samples with

an adapted microbial population obtained from the undisinfected effluent of a biological process treating the waste. In the absence of such a facility, obtain seed from the receiving water below (preferably 3 to 8 km) the point of discharge. When such seed sources also are not available, develop an adapted seed in the laboratory continuously aerating a sample of settled domestic wastewater and adding small daily increments of waste. Optionally use a soil suspension or activated sludge, or a commercial seed preparation to obtain the initial microbial population. Determine the existence of a satisfactory population by testing the performance of the seed in BOD tests on the sample. BOD values that increase with time of adaptation to a steady high value indicate successful seed adaptation.

4.4.4.2 Seed control - Determine BOD of the seeding material as for any other sample. This is the seed control. From the value of the seed control and a knowledge of the seeding material dilution (in the dilution water) determine seed DO uptake. Ideally, make dilutions of seed such that the largest quantity results in at least 50% DO depletion. A plot of DO depletion, in milligrams per liter, versus milliliters seed should present a straight line for which the slope indicates DO depletion per milliliter of seed. The DO-axis intercept is oxygen depletion caused by the dilution water and should be less than 0.1 mg/L.

#### 4.4.5 Sample pretreatment:

4.4.5.1 Samples containing caustic alkalinity or acidity - Neutralize samples to pH 6.5 to 7.5 with a solution of sulfuric acid ( $H_2SO_4$ ) or sodium hydroxide (NaOH) of such strength that the quantity of reagent does not dilute the sample by more than 0.5%. The pH of seeded dilution water should not be affected by the lowest sample dilution.

4.4.5.2 Samples containing residual chlorine compounds - if possible, avoid samples containing residual chlorine by sampling ahead of chlorination processes. If the sample has been chlorinated but not detectable chlorine residual is present, seed the dilution water. If residual chlorine is present, dechlorinate sample and seed the dilution water. Do not test chlorinated/dechlorinated samples without seeding the dilution water. In some samples chlorine will dissipate within 1 to 2 h or standing in the light. This often occurs during sample transport and handling. For samples in which chlorine residual does not dissipate in a reasonable short time, destroy chlorine residual by adding  $Na_2SO_3$  solution. Determine required volume of  $Na_2SO_3$  solution on a 100- to 1000-mL portion of neutralized sample by adding 10 mL of 1 + 1 acetic acid or 1 + 50  $H_2SO_4$  10 mL potassium iodide (KI) solution (10g/100 mL) per 1000 mL portion, and titrating with  $Na_2SO_3$  solution determined by the above test, mix, and

after 10 to 20 min. check sample for residual chlorine. (NOTE: Excess Na<sub>2</sub>SO<sub>3</sub> exerts an oxygen demand and reacts slowly with certain organic chloramine compounds that may be present in chlorinated samples.)

4.4.5.3 Samples containing other toxic substances - Certain industrial wastes, for example, plating wastes, contain toxic metals. Such samples often require special study and treatment.

4.4.5.4 Samples supersaturated with DO - Samples containing more than 9 mg DO/L at 20°C may be encountered in cold waters or in water where photosynthesis occurs. To prevent loss of oxygen during incubation of such samples, reduce DO to saturation at 20°C by bringing sample to about 20°C in partially filled bottle while agitating by vigorous shaking or by aerating with clean, filtered compressed air.

4.4.5.5 Sample temperature adjustment - Bring samples to 20 ± 1°C before making dilutions.

4.4.5.6 Nitrification inhibition - If nitrification inhibition is desired add 3 mg 2-chloro-6-(trichloro methyl) pyridine (TCMP) to each 300-mL bottle before capping or add sufficient amounts to the dilution water to make a final concentration of 10 mg/L. (NOTE: Pure TCMP may dissolve slowly and can float on top of the sample. Some commercial formulations dissolve more readily but are not 100% TCMP; adjust dosage accordingly.) Samples that may require nitrification inhibition include, but are not limited to, biologically treated effluents, samples seeded with biologically treated effluents, and river waters. Note the use of nitrogen inhibition in reporting results.

4.4.6 Dilution technique: Dilutions that result in a residual DO of at least 1 mg/L and a DO uptake of at least 2 mg/L after 5 d incubation produce the most reliable results. Make several dilutions of prepared sample to obtain DO uptake in this range. Experience with a particular sample will permit use of a smaller number of dilutions. A more rapid analysis, such as COD, may be correlated approximately with BOD and serve as a guide in selecting dilutions. In the absence of prior knowledge, use the following dilutions: 0.0 to 1.0% for strong industrial wastes, 1 to 5% for raw and settled wastewater, 5 to 25% for biologically treated effluent, and 25 to 100% for polluted river waters.

Prepare dilutions either in graduated cylinders and then transfer to BOD bottles or prepare directly in BOD bottles. Either dilution method can be combined with any DO measurement technique. The number of bottles to be prepared for each dilution depends on the DO technique and the number of replicates desired.

When using graduated cylinders to prepare dilutions, and when seeding is necessary, add seed either directly to dilution water or to individual cylinders before dilution. Seeding of individual cylinders avoids a declining ratio of seed to sample as increasing dilutions are made. When dilutions are prepared directly in BOD bottles and when seeding is necessary, add seed directly to dilution water or directly to the BOD bottles.

4.4.6.1 Dilutions prepared in graduated cylinders - If the azide modification of the titrimetric iodometric method (Standard Methods :Section 4500-O.C.) is used, carefully siphon dilution water, seeded if necessary, into a 1- to 2-L-capacity graduated cylinder. Fill cylinder half full without entraining air. Add desired quantity of carefully mixed sample and dilute to appropriate level with dilution water. Mix well with a plunger-type mixing rod; avoid entraining air. Siphon mixed dilution into two BOD bottles. Determine initial DO on one of these bottles. Stopper the second bottle tightly, water-seal, and incubate for 5 d at 20°C. If the membrane electrode method is used for DO measurement, siphon dilution mixture into one BOD bottle. Determine initial DO on this bottle and replace any displaced contents with sample dilution to fill the bottle. Stopper tightly, water-seal, and incubate for 5 d at 20°C.

4.4.6.2 Dilutions prepared directly in BOD bottles - Using a widetip volumetric pipet, add the desired sample volume to individual BOD bottles of known capacity. Add appropriate amounts of seed material to the individual BOD bottles or to the dilution water. Fill bottles with enough dilution water, seeded if necessary, so that insertion of stopper will displace all air, leaving no bubbles. For dilutions greater than 1:100 make a primary dilution in a graduated cylinder before making final dilution in the bottle. When using titrimetric iodometric methods for DO measurement, prepare two bottles at each dilution. Determine initial Do on one bottle. Stopper second bottle tightly, water-seal, and incubate for 5 d at 20°C. If the membrane electrode method is used for DO measurement, prepare only one BOD bottle for each dilution. Determine initial DO on this bottle and replace any displaced contents with dilution water to fill the bottle. Stopper tightly, water-seal, and incubate for 5 d at 20°C. Rinse DO electrode between determinations to prevent cross-contamination of samples.

4.4.7 Determination of initial DO: If the sample contains materials that react rapidly with DO, determine initial DO immediately after filling BOD bottle with diluted sample. If rapid initial DO uptake is insignificant, the time period between preparing dilution and measuring initial DO is not critical.

Use the azide modification of the iodometric method (Standarad Methods: Section

4500-O.C.) or the membrane electrode method (Section 4500-O.G.) to determine initial DO on all sample dilutions, dilution water blanks, and where appropriate, seed controls.

4.4.8 Dilution water blank: Use a dilution water blank as a rough check on quality of unseeded dilution water and cleanliness of incubation bottles. Together with each batch of samples incubate a bottle of unseeded dilution water. Determine initial and final DO. The DO uptake should not be more than 0.2 mg/L and preferable not more than 0.2 mg/L.

4.4.9 Incubation: Incubate at 20°C + 1°C BOD bottles containing desired dilutions, seed controls, dilution water blanks, and glucose-glutamic acid checks. Water-seal bottles as described.

4.4.10 Determination of final DO: After 5 d incubation determine DO in sample dilutions, blanks, and checks.

#### 4.5 Calculation

When dilution water is not needed:

$$\text{BOD}_5, \text{ mg/L} = \frac{D1 - D2}{P}$$

When dilution water is seeded:

$$\text{BOD}_5, \text{ mg/L} = \frac{D1 - D2 - (B1 - B2)f}{P}$$

where:

$D_1$  = DO of diluted sample immediately after preparation, mg/L,

$D_2$  = DO of diluted sample after 5 d incubation at 20°C, mg/L,

P = decimal volumetric fraction of sample used,

B1 = DO of seed control before incubation, mg/L,

B2 = DO of seed control after incubation mg/L, and

f = ratio of seed in diluted sample to seed in seed control = (% seed in diluted sample)/(% seed in seed control).

If seed material is added directly to sample or to seed control bottles:

$$F = (\text{volume of seed in diluted sample})/(\text{Volume of seed in seed control})$$

Report results as CBOD<sub>5</sub> if nitrification is inhibited.

If more than one sample dilution meets the criteria of a residual DO of at least 1 mg/L and a DO depletion of at least 2 mg/L and there is no evidence of toxicity at higher sample concentrations or the existence of an obvious anomaly, average results in the acceptable range.

In these calculations, do not make corrections for DO uptake by the dilution water blank during incubation. This correction is unnecessary if dilution water meets the blank criteria stipulated above. If the dilution water does not meet these criteria, proper corrections are difficult and results become questionable.

#### 4.6 Precision and Bias

There is no measurement for establishing bias of the BOD procedure. The glucose-glutamic acid check prescribed is intended to be a reference point for evaluation of dilution water quality, seed effectiveness, and analytical technique.

4.6.1 Control limits: Control limits are established by performing a minimum of 20 glucose-glutamic acid checks and calculating the mean and standard deviation.

4.6.2 Working range and detection limit: The working range is equal to the difference between the maximum initial DO (7 to 9 mg/L) and minimum DO residual of 1 mg/L multiplied by the dilution factor. A lower detection limit of 2 mg/L is established by the requirement for a minimum DO depletion of 2 mg/L.

#### **Bibliography**

U.S. Environmental Protection Agency, Office of Research and Development 1986. Method-by-Method Statistics from Water Pollution (WP) Laboratory Performance Evaluation Studies, Quality Assurance Branch, Environmental Monitoring and Support Lab., Cincinnati, Ohio.

Sawyer, C. N. & L. Bradney. 1946. Modernization of the BOD test for determining the efficiency of the sewage treatment process. *Sewage Works J.* 18:1113.

Ruchhoft, C. C., O. R. Placak, J. Kachmar & C. E. Calbert. 1948. Variations in BOD velocity constant of sewage dilutions. *Ind. Eng. Chem.* 40:1290.

Abbott, W. E. 1948. The bacteriostatic effects of methylene blue on the BOD test. *Water Sewage Works* 95:424.

Sawyer, C. N., P. Callejas, N. Moore & A. Q. Y. Tom. 1950. Primary standards for BOD work. *Sewage Ind. Wastes* 22:26.

## **Appendix E**

### **Compiled Demonstation Data**

Table E-5.8.1. Aqueous explosives concentrations in SP1-1 (POI) 15 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	<25	<25	<25	<25	110	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	09/22/06	38	<50	<50	<50	<25	<25	214	<25	79	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	289	<25	65	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	142	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	<50	<50	<50	113	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	<25	<25	185	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/16/07	427	<25	<25	<25	<10	112	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	119	<10	2510	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	71	<10	1350	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	108	<10	1650	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	23	57	<10	108	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	402	<25	110	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	<50	<50	<50	82	<25	264	<25	92	<25	<25	113	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	74	<25	355	<25	98	<25	<25	118	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	<50	<50	9	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	128	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	61	<10	1850	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	<25	<10	132	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	64	<10	1500	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	77	<10	1660	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	96 / 56	<10	503 / 370	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table E-5.8.1. Aqueous explosives concentrations in SP1-1 (POI) 45 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	122	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	09/22/06	38	<50	<50	<50	<25	<25	63	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	135	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	147	117	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	103	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	98	<10	837	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	<25	<25	6	<10	389	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	32	<25	110	<10	419	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	84	<10	574	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<25	30	72 42	<10	157 1/40	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	171	<50	<50	54	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	280	256	246	220	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	259	55	54	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	28	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	55	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	141	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	57	<10	501	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	7	<10	222	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	<25	<25	51	<10	433	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	24	94	<10	408	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	24	113	<10	510	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	16	128	<10	742	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	33	88	<10	264	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table E-5.8.1. Aqueous explosives concentrations in SP1-2 (CON) 15 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/09/06	24	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	87	<25
	09/22/06	38	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	150	112	<50	<25	<25	75	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	102	<25	92	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/16/07	427	<25	<25	<25	<10	272	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	11/15/07	457	<25	<25	37	<10	3260	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	01/09/08	512	<25	<25	90	<10	3040	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	<25	<25	<25	<10	3930	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	178	<10	7810	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	113	<10	6250	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	359	<10	8780	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/09/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	157	120	<50	<25	66	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	116	121	80	58	87	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/16/07	427	<25	<25	<25	<10	236	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	11/15/07	457	<25	<25	36	<10	2740	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	01/09/08	512	<25	<25	66	<10	2420	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	03/25/08	588	<25	<25	<25	<10	10280	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	4080	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	105	<10	3940	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	113	<10	6380	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	76	<10	6710	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	67 / 50	<10	7150 / 5400	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.1. Aqueous explosives concentrations in SP1-2 (CON) 45 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	<25	<25	103	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	09/22/06	38	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	174	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	107	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	150	160	<50	<25	<25	166	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	62	<25	<25	142	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	87	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	<25	<25	<25	<10	44	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	<25	<10	146	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	393	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demobilization	09/23/08	770	<25	<25	274	<10	3660	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	147	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	237	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	<50	112	<50	<25	<25	178	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	100	<25	194	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	177	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	11	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	22	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	<25	<25	<25	<10	40	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	<25	<10	101	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	310	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	<25	<10	935	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	193	<10	3600	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table E-5.8.1. Aqueous explosives concentrations in SP1-3 (PO2) 15 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	09/22/06	38	<50	<50	123	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	87	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	70	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	<50	<50	<50	<25	<25	62	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	82	121	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	67	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	89	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	<50	203	<50	<25	<25	91	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	90	138	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	<25	<10	<10 / 74	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table E-5.8.1. Aqueous explosives concentrations in SP1-3 (PO2) 45 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	<25	<25	84	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	09/22/06	38	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	104	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	95	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	190	<50	<50	<25	<25	78	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	243	<50	<50	55	<25	77	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	107	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	222	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	18	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	<25	<10	<10 / 120	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	81	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	78	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	437	145	<50	<25	<25	98	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	1590	<50	<50	<25	<25	100	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	371	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	21	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	21	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	29	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table E-5.8.1. Aqueous explosives concentrations in SP1-4 (POI) 15 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	<25	<25	119	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	09/22/06	38	<50	<50	117	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	186	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	86	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	<50	135	<50	69	<25	80	267	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	135	<50	<25	<25	132	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	89	<25	<25	289	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	497	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	271	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	622	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	30	<10	898	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	676	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	16	<10	1020	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	58	<10	3430	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	76	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	175	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	173	112	<50	<25	<25	171	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	72	<25	174	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	89	<25	<25	228	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	502	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	193	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<10	<10	430	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	8	<25	6	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	467	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	15	<10	916	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	43	<10	2780	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.1. Aqueous explosives concentrations in SP1-4 (POI) 45 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	<25	<25	89	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	09/22/06	38	<50	182	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	<50	150	<50	<25	<25	149	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	135	<50	<50	<25	<25	160	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	170	125	<50	<25	<25	130	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	<25	<25	98	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	149	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	300	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	13	<10	406	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	<25	<25	<25	<10	1100	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	40	<10	1140	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	47	<10	1730	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	65	<10	2460	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	216	<10	6050	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	58	697	183	<10	5610	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	144	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	144	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	218	163	<50	<25	<25	182	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	70	<50	<50	<25	<25	132	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	162	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	457	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	10	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	10	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	291	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	<25	<10	497	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	<25	<25	<25	<10	416	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	938	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	31	<10	983	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	20	<10	1260	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	28	<10	2280	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	197 / 120	<10	5200 / 4700	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	42	493	112	<10	4540	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table E-5.8.1. Aqueous explosives concentrations in SP1-5 (PO2) 15 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	<25	<25	187	<25	<25	<25	<25	<25	<25	<25	<25	<25	6	51	<25
	09/22/06	38	<50	<50	121	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	158	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	68	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	<50	<50	<50	53	<25	128	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	109	<25	124	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	150	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	34	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	10	156	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	163	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	227	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	<50	<50	<50	55	<25	116	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	162	<25	273	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	352	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	268	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	12	<25	<25	133	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	<25	<10	<10 / 93	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10



Table E-5.8.1. Aqueous explosives concentrations in SP1-6 (CON) 15 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	<25	<25	<25	<25	<25	64	<25	<25	<25	<25	<25	<25	<25	<25	<25
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	152	<50	<50	<25	<25	63	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	267	<50	<50	<25	<25	65	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	156	4000	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	23	271	<10	3310	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	162	<10	3200	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	63	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	179	<50	<50	<25	<25	117	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	1850	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	23	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	73	<10	1640	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	<25	<25	25	<10	1610	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	193	<10	2860	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	43	<10	2640	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table E-5.8.1. Aqueous explosives concentrations in SP1-6 (CON) 45 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	<25	<25	86	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	09/22/06	38	<50	<50	<50	<25	31	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	111	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	119	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	228	<50	<50	<25	<25	84	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	258	<50	<50	<25	<25	73	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	243	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	326	<25	<25	238	<25	141	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	266	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	117	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	110	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	374	<50	<50	<25	<25	81	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	1370	<50	<50	<25	<25	86	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	131	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	<50	<25	<25	289	58	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	179	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	16	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	15	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	20	<10	66	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table E-5.8.1. Aqueous explosives concentrations in SP1-7 (CON) 15 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	<25	62	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	09/22/06	38	<50	138	131	<25	36	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/16/07	427	<25	<25	<25	<10	420	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	117	<10	5810	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	88	<10	5630	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	<25	<25	23	<10	5010	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	265	<10	8490	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/27/06	73	<50	<50	133	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	<50	114	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/16/07	427	<25	<25	<25	<10	229	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	126	<10	5250	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	97	<10	4630	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	<25	<25	24	<10	5060	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	191	<10	7770	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	149	<10	7240	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.1. Aqueous explosives concentrations in SP1-7 (CON) 45 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	09/22/06	38	<50	<50	120	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
		73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<50	<50	<50	62	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	<50	<50	<50	<25	324	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	9	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	<25	<10	84	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	428	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	<25	<25	20	<10	837	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	683	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	54	<10	1370	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	01/00/00	73	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	<50	<50	<50	72	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	97	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	11	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	12	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	<25	<25	<25	<10	256	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	344	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	<25	<10	374	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	12	<25	<25	<10	842	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	562	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	24	<10	951 / 700	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.1. Aqueous explosives concentrations in SP1-8 (PO2) 15 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																		
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT		
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
PMSO Added	10/13/06	59	137	<50	<50	<25	<25	128	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
	10/27/06	73	<50	<50	<50	<25	<25	248	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
	11/10/06	87	<50	<50	<50	65	<25	192	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
Start Stand-by	12/19/06	126	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
End Stand-by	05/09/07	267	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	End Stand-by	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04/28/08		622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
04/30/08		624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
05/01/08		625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Demobilization	06/10/08	665	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																		
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT		
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	120	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
	10/27/06	73	<50	<50	<50	<25	<25	69	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
	11/10/06	87	<50	<50	<50	65	<25	270	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
Start Stand-by	12/19/06	126	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
End Stand-by	05/09/07	267	<50	<50	193	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
	05/30/07	288	<50	<50	<50	<25	347	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	End Stand-by	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04/28/08		622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
04/30/08		624	<25	<25	<25	<10	918	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
05/01/08		625	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
Demobilization	06/10/08	665	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	

Table E-5.8.1. Aqueous explosives concentrations in SP1-8 (PO2) 45 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	09/22/06	38	<50	<50	<50	<25	<25	85	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	104	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	103	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	185	<50	<50	<25	<25	66	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	171	<50	<50	68	<25	73	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	339	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	<50	<25	<25	45	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	64	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	119	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	120	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	1084	<50	<50	<25	<25	89	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	312	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	405	<25	<25	89	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	18	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	13	<25	<25	70	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	15	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	15	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	<25	<10	<10	53	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table E-5.8.1. Aqueous explosives concentrations in SP1-9 (POI) 15 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	<25	77	<25	<25	249	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	09/22/06	38	<50	167	<50	<25	40	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<50	<50	<50	62	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	348	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	583	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	385	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	184	<10	3660	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<25	<25	35	<10	209	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	<50	<25	13	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	10	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	22	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	15	<10	248	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	477	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	1039	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	124	<10	2600	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	<25	<25	78	<10	1630	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	129	<10	1590	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	35	199	<10	1560	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	13	74	325	<10	1290	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	85 / 55	<10	818 / 580	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	50	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table E-5.8.1. Aqueous explosives concentrations in SP1-9 (POI) 45 cm

Dissolved explosives in soil pore water samples designated as "Sample".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	09/22/06	38	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Start Stand-by	12/19/06	126	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	268	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	146	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	85	<10	4220	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	150	<10	2390	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	<25	18	179	<10	920	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	34	124	266	<10	584	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	53	138	386	<10	935	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<25	<25	42	<10	193	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil pore water samples designated as "Purge".

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	40	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	11/10/06	87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Start Stand-by	12/19/06	126	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	121	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	12	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	104	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	153	<10	2790	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	<25	<25	131	<10	2200	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	<25	<25	<25	<10	5290	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	12	145	<10	927	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	53	202	<10	778	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	21	79	310	<10	925	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	19	66	262	<10	871	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	13	21	105	<10	572	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table E-5.8.1. Aqueous explosives concentrations in SP1-1 (POI) Drainage

Dissolved explosives in soil plot drainwater, Shaw Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	104	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	44	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	40	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	34	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	30	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	<25	<25	<25	<10	46	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil plot drainwater, STL/TestAmerica Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/05/07	386	<0.25	<0.25	<0.25	<0.25	85.0	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	10/16/07	427	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/15/07	457	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.1. Aqueous explosives concentrations in SP1-2 (CON) Drainage

Dissolved explosives in soil plot drainwater, Shaw Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	131	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	<25	<25	<25	<10	824	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	<25	<25	<25	<10	687	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	11	<10	1100	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	27	<10	1600	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	54	<10	1600	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	52	<10	1710	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	33	<10	1970	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	126	<10	3000	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil plot drainwater, STL/TestAmerica Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/05/07	386	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	10/16/07	427	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/15/07	457	<0.25	0.4	7.9	<0.25	190.0	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<0.25	0.7	38.0	<0.25	1700.0	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.1. Aqueous explosives concentrations in SP1-3 (PO2) Drainage

Dissolved explosives in soil plot drainwater, Shaw Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	164	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	<50	<50	531	<25	<25	76	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	11	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	17	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil plot drainwater, STL/TestAmerica Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/05/07	386	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	10/16/07	427	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/15/07	457	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.3
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<0.25	<0.25	6.9	4.9	7.3	<0.25	<0.25	<0.25	1.3	<0.25	16.0	19.0	<0.25	<0.25	5.7	20.0	<0.25	<0.25
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.1. Aqueous explosives concentrations in SP1-4 (PO1) Drainage

Dissolved explosives in soil plot drainwater, Shaw Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	132	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	<50	<50	313	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	53	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	15	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	54	<10	3560	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil plot drainwater, STL/TestAmerica Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/05/07	386	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	10/16/07	427	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/15/07	457	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.1. Aqueous explosives concentrations in SP1-5 (PO2) Drainage

Dissolved explosives in soil plot drainwater, Shaw Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	91	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	<50	<50	431	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	15	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil plot drainwater, STL/TestAmerica Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/05/07	386	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	10/16/07	427	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/15/07	457	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<0.25	<0.25	<0.25	3.1	<0.25	<0.25	<0.25	4.2	1.0	<0.25	<0.25	12.0	17.0	<0.25	1.5	<0.25	1.4	-
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.1. Aqueous explosives concentrations in SP1-6 (CON) Drainage

Dissolved explosives in soil plot drainwater, Shaw Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	137	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	<50	<50	506	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	<25	<25	8	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil plot drainwater, STL/TestAmerica Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/16/07	427	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/15/07	457	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<0.25	<0.25	<0.25	<0.25	3.3	<0.25	<0.25	<0.25	<0.25	0.6	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.1. Aqueous explosives concentrations in SP1-7 (CON) Drainage

Dissolved explosives in soil plot drainwater, Shaw Analysis

Events	Sample		µg/L																		
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT		
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/10/06	87	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
Start Stand-by	12/19/06	126	<50	109	<50	117	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	11/15/07	457	<25	<25	<25	<10	897	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	Start Stand-by	12/19/07	491	<25	<25	<25	<10	903	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	End Stand-by	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		03/25/08	588	<25	<25	<25	<10	5500	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
Demobilization	04/15/08	609	<25	<25	9	<10	1530	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10		
	04/28/08	622	<25	<25	<25	<10	2190	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10		
	04/30/08	624	<25	<25	64	<10	2310	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10		
	05/01/08	625	<25	<25	59	<10	2510	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10		
	06/10/08	665	<25	<25	31	<10	3140	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10		

Dissolved explosives in soil plot drainwater, STL/TestAmerica Analysis

Events	Sample		µg/L																		
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT		
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
PMSO Added	10/13/06	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/10/06	87	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Residues Added	06/13/07	302	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	10/16/07	427	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/15/07	457	<0.25	0.6	17.0	<0.25	610.0	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	
	Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	End Stand-by	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demobilization	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	04/30/08	624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	06/10/08	665	<0.25	0.6	37.0	0.3	2600.0	<0.25	<0.25	<0.25	<0.25	0.3	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	

Table E-5.8.1. Aqueous explosives concentrations in SP1-8 (PO2) Drainage

Dissolved explosives in soil plot drainwater, Shaw Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	<50	<50	80	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	<50	<50	449	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	31	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	14	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	07/27/07	346	<25	<25	<25	<10	122	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	235	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	862	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	12/19/07	491	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	03/25/08	588	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	<25	<10	650	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil plot drainwater, STL/TestAmerica Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Start Stand-by	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/16/07	427	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/15/07	457	<0.25	<0.25	<0.25	<0.25	92.0	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	1.1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demobilization	04/30/08	624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<0.25	<0.25	6.6	<0.25	990.0	<0.25	0.4	<0.25	<0.25	0.8	<0.25	15.0	11.0	<0.25	<0.25	<0.25	<0.25	
	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.1. Aqueous explosives concentrations in SP1-9 (POI) Drainage

Dissolved explosives in soil plot drainwater, Shaw Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Start Stand-by	12/19/06	126	<50	113	<50	113	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	<50	<50	<50	<25	<25	<25	<25	255	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	07/27/07	346	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	08/09/07	358	<25	<25	23	<10	<10	<10	<10	<10	<10	<10	<10	19	<10	<10	<10	<10	<10	<10
	09/05/07	386	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Start Stand-by	12/19/07	491	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	01/09/08	512	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
End Stand-by	03/25/08	588	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/15/08	609	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/28/08	622	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	04/30/08	624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	05/01/08	625	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	06/10/08	665	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Demobilization	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Dissolved explosives in soil plot drainwater, STL/TestAmerica Analysis

Events	Sample		µg/L																	
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT	
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PMSO Added	10/13/06	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11/10/06	87	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residues Added	06/13/07	302	<0.25	<0.25	<0.25	<0.25	0.8	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/16/07	427	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	11/15/07	457	<0.25	0.5	3.8	<0.25	34.0	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/15/08	609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/28/08	622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04/30/08	624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05/01/08	625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/10/08	665	<0.25	<0.25	<0.25	3.3	7.2	<0.25	7.3	4.1	<0.25	2.9	<0.25	4.4	1.1	6.8	1.6	<0.25	<0.25	<0.25
Demobilization	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.1. Aqueous explosives concentrations in Rainwater

Dissolved explosives in soil plot drainwater, Shaw Analysis

Events	Sample		µg/L																		
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT		
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
PMSO Added	10/13/06	59	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/10/06	87	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
Start Stand-by	12/19/06	126	<50	<50	<50	86	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	05/30/07	288	<50	<50	492	<25	<25	<25	377	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
Residues Added	06/13/07	302	<50	<50	<50	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
	06/28/07	317	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	07/27/07	346	<25	<25	<25	<10	38	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	08/09/07	358	<25	<25	<25	<10	85	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	09/05/07	386	<25	<25	<25	<10	29	<10	<10	<10	44	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	10/16/07	427	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	11/15/07	457	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	End Stand-by	03/25/08	588	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
04/15/08		609	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
04/28/08		622	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
04/30/08		624	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
05/01/08		625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Demobilization	06/10/08	665	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
	09/23/08	770	<25	<25	<25	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	

Dissolved explosives in soil plot drainwater, STL/TestAmerica Analysis

Events	Sample		µg/L																		
	Date	Elapsed	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT		
Mobilization	08/15/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	09/08/06	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	09/22/06	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
PMSO Added	10/13/06	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	10/27/06	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/10/06	87	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	
Start Stand-by	12/19/06	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
End Stand-by	05/09/07	267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	05/30/07	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Residues Added	06/13/07	302	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	
	06/28/07	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	07/27/07	346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	08/09/07	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	09/05/07	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	10/16/07	427	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/15/07	457	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	
	Start Stand-by	12/19/07	491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		01/09/08	512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	End Stand-by	03/25/08	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04/15/08		609	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
04/28/08		622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
04/30/08		624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
05/01/08		625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Demobilization	06/10/08	665	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	
	09/23/08	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Table E-5.8.3. Explosives concentrations in soil and/or PMSO of soil plot SP1-2 (CON)

Detections of explosives compounds in soil and PMSO.

Depth* (cm)	Average mg/kg																
	TNX	MXN	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
0.63	<2.11	<2.11	<2.11	<0.07	1201	<0.17	<0.17	<0.17	<0.17	293	1.88	0.68	<0.17	<0.17	<0.17	<0.17	<0.17
1.88	<1.69	<1.69	<1.69	<0.07	128	<0.07	<0.07	<0.07	<0.07	30	0.41	0.83	<0.07	<0.07	<0.07	<0.07	<0.07
3.13	<0.14	<0.14	<0.14	<0.05	34	<0.05	<0.05	<0.05	<0.05	5.1	0.43	0.89	<0.05	<0.05	<0.05	<0.05	<0.05
4.42	<0.13	<0.13	<0.13	<0.05	8.64	<0.05	<0.05	<0.05	<0.05	0.22	0.97	1.93	<0.05	<0.05	<0.05	<0.05	<0.05
7.62	<0.13	<0.13	<0.13	<0.05	5.64	<0.05	<0.05	<0.05	<0.05	0.47	1.22	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
12.70	<0.13	<0.13	<0.13	<0.05	4.92	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.09	<0.05	<0.05	<0.05	<0.05	<0.05
17.78	<0.13	<0.13	<0.13	<0.05	3.48	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
22.86	<0.13	<0.13	<0.13	<0.05	3.22	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
27.94	<0.13	<0.13	<0.13	<0.05	2.86	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
33.02	<0.13	<0.13	<0.13	<0.05	2.32	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
38.10	<0.13	<0.13	<0.13	<0.05	0.67	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Depth* (cm)	Standard Deviation mg/kg																
	TNX	MXN	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
0.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.42	-	-	-	-	1.58	-	-	-	-	0.21	1.16	1.90	-	-	-	-	-
7.62	-	-	-	-	1.39	-	-	-	-	-	-	-	-	-	-	-	-
12.70	-	-	-	-	1.90	-	-	-	-	-	-	-	-	-	-	-	-
17.78	-	-	-	-	1.56	-	-	-	-	-	-	-	-	-	-	-	-
22.86	-	-	-	-	1.47	-	-	-	-	-	-	-	-	-	-	-	-
27.94	-	-	-	-	1.12	-	-	-	-	-	-	-	-	-	-	-	-
33.02	-	-	-	-	0.98	-	-	-	-	-	-	-	-	-	-	-	-
38.10	-	-	-	-	0.02	-	-	-	-	-	-	-	-	-	-	-	-

\*Midpoint of sampling interval

A "-" indicates that calculation of the standard deviation was not appropriate due to limited data.

Table E-5.8.3. Explosives concentrations in soil and/or PMSO of soil plot SP1-6 (CON)

Detections of explosives compounds in soil and PMSO.

Depth* (cm)	Average mg/kg																
	TNX	MXN	DNX	HMX	RDY	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
0.63	<1.69	<1.69	<1.69	0.40	479	<0.13	<0.13	<0.13	<0.13	293	0.25	0.26	<0.13	<0.13	<0.13	<0.13	<0.13
1.88	<1.38	<1.38	<1.38	<0.06	347	<0.06	<0.06	<0.06	<0.06	30.2	2.6	1.7	<0.06	<0.06	<0.06	<0.06	<0.06
3.13	<0.14	<0.14	<0.14	<0.06	52	<0.06	<0.06	<0.06	<0.06	<0.06	0.36	1.1	<0.06	<0.06	<0.06	<0.06	<0.06
4.42	<0.13	<0.13	<0.13	<0.05	1.15	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
7.62	<0.13	<0.13	<0.13	<0.05	0.93	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
12.70	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
17.78	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
22.86	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
27.94	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
33.02	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
38.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Depth* (cm)	Standard Deviation mg/kg																
	TNX	MXN	DNX	HMX	RDY	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
0.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.42	-	-	-	-	1.07	-	-	-	-	-	-	-	-	-	-	-	-
7.62	-	-	-	-	0.47	-	-	-	-	-	-	-	-	-	-	-	-
12.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

\*Midpoint of sampling interval

A "-" indicates that calculation of the standard deviation was not appropriate due to limited data.

Table E-5.8.3. Explosives concentrations in soil and/or PMSO of soil plot SP1-7 (CON)

Detections of explosives compounds in soil and PMSO.

Depth* (cm)	Average mg/kg																
	TNX	MXN	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
0.63	<2.11	<2.11	<2.11	0.49	908	<0.17	<0.17	<0.17	<0.17	219	0.22	0.32	<0.17	<0.17	<0.17	<0.17	<0.17
1.88	<1.63	<1.63	<1.63	<0.07	386	<0.07	<0.07	<0.07	<0.07	91	1.03	1.32	<0.07	<0.07	<0.07	<0.07	<0.07
3.13	<0.17	<0.17	<0.17	<0.07	100	<0.07	<0.07	<0.07	<0.07	30	0.49	1.67	<0.07	<0.07	<0.07	<0.07	<0.07
4.42	<0.13	<0.13	<0.13	<0.05	3.85	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1.08	<0.05	<0.05	<0.05	<0.05	<0.05
7.62	<0.13	<0.13	<0.13	<0.05	3.83	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
12.70	<0.13	<0.13	<0.13	<0.05	2.40	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
17.78	<0.13	<0.13	<0.13	<0.05	1.55	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
22.86	<0.13	<0.13	<0.13	<0.05	2.16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
27.94	<0.13	<0.13	<0.13	<0.05	1.31	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
33.02	<0.13	<0.13	<0.13	<0.05	0.99	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
38.10	<0.13	<0.13	<0.13	<0.05	1.36	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Depth* (cm)	Standard Deviation mg/kg																
	TNX	MXN	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
0.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.42	-	-	-	-	1.18	-	-	-	-	-	-	-	-	-	-	-	-
7.62	-	-	-	-	1.66	-	-	-	-	-	-	-	-	-	-	-	-
12.70	-	-	-	-	1.08	-	-	-	-	-	-	-	-	-	-	-	-
17.78	-	-	-	-	0.66	-	-	-	-	-	-	-	-	-	-	-	-
22.86	-	-	-	-	1.50	-	-	-	-	-	-	-	-	-	-	-	-
27.94	-	-	-	-	0.37	-	-	-	-	-	-	-	-	-	-	-	-
33.02	-	-	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-
38.10	-	-	-	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-

\*Midpoint of sampling interval

A "-" indicates that calculation of the standard deviation was not appropriate due to limited data.

Table E-5.8.3. Explosives concentrations in soil and/or PMSO of soil plot SP1-1 (PO1)

Detections of explosives compounds in soil and PMSO.

Depth* (cm)	Average mg/kg																
	TNX	MNX	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
Top PMSO	<9.9	<9.9	<9.9	<0.79	1404	<0.79	<0.79	<0.79	<0.79	<0.79	1.6	4.4	<0.79	<0.79	<0.79	<0.79	<0.79
Lower PMSO	<0.79	<0.79	<0.79	<3.16	382	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
1.25	<0.13	<0.13	<0.13	0.41	2.7	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
3.75	<0.13	<0.13	<0.13	<0.05	0.9	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
5.665	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
8.87	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
13.95	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
19.03	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
24.11	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
29.19	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
34.27	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
39.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Depth* (cm)	Standard Deviation mg/kg																
	TNX	MNX	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
Top PMSO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower PMSO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.665	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

\*Midpoint of sampling interval

A "-" indicates that calculation of the standard deviation was not appropriate due to limited data.

Table E-5.8.3. Explosives concentrations in soil and/or PMSO of soil plot SP1-4 (PO1)

Detections of explosives compounds in soil and PMSO.

Depth* (cm)	Average mg/kg																
	TNX	MNX	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
Top PMSO	<8.5	<8.5	<8.5	<0.68	3092	<0.68	<0.68	<0.68	<0.68	276	<0.68	18	<0.68	<0.68	<0.68	<0.68	<0.68
Lower PMSO	<0.59	<0.59	<0.59	<0.24	356	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24
1.25	<0.13	<0.13	<0.13	<0.05	14	<0.05	<0.05	<0.05	<0.05	0.63	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
3.75	<0.13	<0.13	<0.13	<0.05	7.2	<0.05	<0.05	<0.05	<0.05	0.50	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
5.665	<0.13	<0.13	<0.13	<0.05	1.80	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
8.87	<0.13	<0.13	<0.13	<0.05	2.00	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
13.95	<0.13	<0.13	<0.13	<0.05	2.25	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
19.03	<0.13	<0.13	<0.13	<0.05	2.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
24.11	<0.13	<0.13	<0.13	<0.05	1.42	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
29.19	<0.13	<0.13	<0.13	<0.05	0.91	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
34.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Depth* (cm)	Standard Deviation mg/kg																
	TNX	MNX	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
Top PMSO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower PMSO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.665	-	-	-	-	0.84	-	-	-	-	-	-	-	-	-	-	-	-
8.87	-	-	-	-	0.99	-	-	-	-	-	-	-	-	-	-	-	-
13.95	-	-	-	-	0.83	-	-	-	-	-	-	-	-	-	-	-	-
19.03	-	-	-	-	0.89	-	-	-	-	-	-	-	-	-	-	-	-
24.11	-	-	-	-	0.84	-	-	-	-	-	-	-	-	-	-	-	-
29.19	-	-	-	-	0.60	-	-	-	-	-	-	-	-	-	-	-	-
34.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

\*Midpoint of sampling interval

A "-" indicates that calculation of the standard deviation was not appropriate due to limited data.

Table E-5.8.3. Explosives concentrations in soil and/or PMSO of soil plot SP1-9 (PO1)

Detections of explosives compounds in soil and PMSO.

Depth* (cm)	Average mg/kg																
	TNX	MNX	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
Top PMSO	<12.4	<12.4	<12.4	<0.99	2492	<0.99	<0.99	<0.99	<0.99	<0.99	11	20	<0.99	<0.99	<0.99	<0.99	<0.99
Lower PMSO	<0.79	<0.79	<0.79	<0.31	636	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31
1.25	<0.13	<0.13	<0.13	0.06	2.3	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
3.75	<0.13	<0.13	<0.13	0.20	0.32	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
5.665	<0.13	<0.13	<0.13	<0.05	0.32	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
8.87	<0.13	<0.13	<0.13	<0.05	0.37	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
13.95	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
19.03	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
24.11	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
29.19	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
34.27	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
39.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Depth* (cm)	Standard Deviation mg/kg																
	TNX	MNX	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
Top PMSO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower PMSO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.665	-	-	-	-	0.08	-	-	-	-	-	-	-	-	-	-	-	-
8.87	-	-	-	-	0.18	-	-	-	-	-	-	-	-	-	-	-	-
13.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

\*Midpoint of sampling interval  
 A "-" indicates that calculation of the standard deviation was not appropriate due to limited data.

Table E-5.8.3. Explosives concentrations in soil and/or PMSO of soil plot SP1-3 (PO2)

Detections of explosives compounds in soil and PMSO.

Depth* (cm)	Average																
	TNX	MNX	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
Top PMSO	<7.8	<7.8	<7.8	<0.62	539	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
Lower PMSO	<0.60	<0.60	<0.60	<0.24	355	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24
1.25	<0.13	<0.13	<0.13	0.28	5.2	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
3.75	<0.13	<0.13	<0.13	<0.05	4.7	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
5.665	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
8.87	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
13.95	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
19.03	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
24.11	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
29.19	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
34.27	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
39.35	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Depth* (cm)	Standard Deviation																
	TNX	MNX	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
Top PMSO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower PMSO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.665	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

\*Midpoint of sampling interval

A "-" indicates that calculation of the standard deviation was not appropriate due to limited data.

Table E-5.8.3. Explosives concentrations in soil and/or PMSO of soil plot SP1-5 (PO2)

Detections of explosives compounds in soil and PMSO.

Depth* (cm)	Average mg/kg																
	TNX	MNX	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
Top PMSO	<8.0	<8.0	<8.0	<0.32	922	<0.32	<0.32	<0.32	<0.32	<0.32	5.4	2.0	<0.32	<0.32	<0.32	<0.32	<0.32
Lower PMSO	<0.83	<0.83	<0.83	<0.33	446	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1.25	<0.13	<0.13	<0.13	<0.05	3.3	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
3.75	<0.13	<0.13	<0.13	<0.05	1.6	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
5.665	<0.13	<0.13	<0.13	<0.05	0.31	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
8.87	<0.13	<0.13	<0.13	<0.05	0.25	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
13.95	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
19.03	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
24.11	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
29.19	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
34.27	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
39.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Depth* (cm)	Standard Deviation mg/kg																
	TNX	MNX	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
Top PMSO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower PMSO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.665	-	-	-	-	0.06	-	-	-	-	-	-	-	-	-	-	-	-
8.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

\*Midpoint of sampling interval  
A "-" indicates that calculation of the standard deviation was not appropriate due to limited data.

Table E-5.8.3. Explosives concentrations in soil and/or PMSO of soil plot SP1-8 (PO2)

Detections of explosives compounds in soil and PMSO.

Depth* (cm)	Average mg/kg																
	TNX	MNX	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
Top PMSO	<7.3	<7.3	<7.3	<0.58	1524	<0.58	<0.58	<0.58	<0.58	173	<0.58	<0.58	<0.58	<0.58	<0.58	<0.58	<0.58
Lower PMSO	<0.61	<0.61	<0.61	<0.24	561	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24
1.25	<0.13	<0.13	<0.13	0.09	10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
3.75	<0.13	<0.13	<0.13	<0.05	6.5	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
5.665	<0.13	<0.13	<0.13	<0.05	1.31	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
8.87	<0.13	<0.13	<0.13	<0.05	0.30	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
13.95	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
19.03	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
24.11	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
29.19	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
34.27	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
39.35	<0.13	<0.13	<0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Depth* (cm)	Standard Deviation mg/kg																
	TNX	MNX	DNX	HMX	RDX	TNB	DNB	NB	Tetryl	TNT	4ADNT	2ADNT	2,6-DNT	2,4-DNT	2-NT	4-NT	3-NT
Top PMSO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower PMSO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.665	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

\*Midpoint of sampling interval

A "-" indicates that calculation of the standard deviation was not appropriate due to limited data.

Table E-5.8.4.1. Soil plot pore water and drainage water pH data.

**Aqueous pH (S.U.) of soil pore water collected at 15 cm depth.**

Events	Elapsed	Date	SP1-1 (PO1)	SP1-2 (CON)	SP1-3 (PO2)	SP1-4 (PO1)	SP1-5 (PO2)	SP1-6 (CON)	SP1-7 (CON)	SP1-8 (PO2)	SP1-9 (PO1)
Mobilization	24	09/08/06	6.7	6.7	6.9	6.7	7.1	6.7	7.1	-	7.5
	38	09/22/06	6.8	7.0	7.0	6.7	7.0	-	7.1	-	7.4
PMSO Added	59	10/13/06	6.6	6.2	6.4	6.6	6.0	6.6	7.1	7.5	-
	73	10/27/06	6.6	4.7	4.5	6.2	7.2	4.8	-	6.5	-
Start Stand-by	87	11/10/06	6.7	6.4	5.8	6.3	6.2	6.2	-	6.3	4.6
	126	12/19/06	5.9	5.8	-	6.0	5.9	6.1	-	6.3	-
End Stand-by	267	05/09/07	-	5.8	-	5.8	5.5	5.7	-	6.0	6.0
	288	05/30/07	-	-	-	6.3	5.7	-	-	-	6.1
Residues added	302	06/13/07	-	5.7	5.4	5.8	5.7	6.0	-	5.8	6.3
	317	06/28/07	-	-	5.6	5.8	5.9	5.5	-	5.2	6.5
	346	07/27/07	-	-	-	-	-	-	-	-	-
	358	08/08/07	6.7	6.0	6.2	6.0	5.9	6.3	-	6.7	6.4
	386	09/05/07	-	-	5.0	6.2	5.3	-	-	7.2	6.5
	427	10/16/07	-	5.5	5.0	5.4	5.0	5.5	-	7.0	5.9
	457	11/15/07	5.9	5.1	5.1	4.9	5.2	6.0	5.8	6.7	6.1
Start Stand-by	491	12/19/07	-	-	-	-	-	-	-	-	-
	512	01/09/08	-	-	-	-	-	-	-	-	-
End Stand-by	588	03/25/08	-	-	-	-	-	-	-	-	-
	609	04/15/08	-	5.1	-	-	5.7	-	5.6	-	-
	622	04/28/08	-	-	-	-	4.6	-	-	-	-
	624	04/30/08	5.6	5.4	-	5.5	5.0	5.2	5.8	-	-
	625	05/01/08	5.9	5.7	-	-	-	5.7	-	-	-
	665	06/10/08	4.3	-	5.8	-	4.8	-	-	6.0	-
	770	09/23/08	5.8	-	6.6	-	6.2	4.8	-	5.6	6.1

Table E-5.8.4.1. Soil plot pore water and drainage water pH data (cont).

**Aqueous pH (S.U.) of soil pore water collected at 45 cm depth.**

Events	Elapsed	Date	SP1-1 (PO1)	SP1-2 (CON)	SP1-3 (PO2)	SP1-4 (PO1)	SP1-5 (PO2)	SP1-6 (CON)	SP1-7 (CON)	SP1-8 (PO2)	SP1-9 (PO1)
Mobilization	24	09/08/06	6.6	6.2	6.2	6.3	6.9	6.7	6.9	6.7	7.1
	38	09/22/06	6.7	6.5	6.3	6.7	7.2	6.5	7.0	6.8	7.1
PMSO Added	59	10/13/06	6.6	6.2	6.1	6.7	7.2	6.5	7.0	7.0	6.3
	73	10/27/06	5.6	5.1	6.5	5.2	-	6.9	-	5.1	4.7
	87	11/10/06	6.2	5.5	5.0	6.5	6.3	6.2	5.1	4.7	-
Start Stand-by	126	12/19/06	-	5.6	5.9	6.3	6.0	6.6	-	6.4	6.0
End Stand-by	267	05/09/07	-	4.8	6.1	6.1	6.0	5.6	-	6.1	4.4
	288	05/30/07	-	6.2	6.1	6.1	5.9	-	-	-	4.4
Residues added	302	06/13/07	5.8	4.6	5.2	5.8	6.0	6.1	4.5	5.6	4.8
	317	06/28/07	-	4.5	4.4	6.4	6.3	5.0	4.9	5.1	5.3
	346	07/27/07	-	-	-	-	-	-	-	-	-
	358	08/08/07	-	-	5.9	5.9	6.1	6.3	-	5.8	5.0
	386	09/05/07	-	-	6.0	6.8	6.5	7.2	-	6.3	4.8
	427	10/16/07	5.5	5.0	5.6	6.1	5.7	5.4	-	6.3	4.2
	457	11/15/07	5.5	4.4	6.1	6.2	5.3	6.0	5.7	6.1	5.6
Start Stand-by	491	12/19/07	-	-	-	-	-	-	-	-	-
	512	01/09/08	-	-	-	-	-	-	-	-	-
End Stand-by	588	03/25/08	-	-	-	-	-	-	-	-	-
	609	04/15/08	5.8	4.3	-	5.6	-	-	4.9	-	4.8
	622	04/28/08	-	-	-	-	-	-	-	-	4.4
	624	04/30/08	5.8	4.6	4.4	5.8	4.7	6.3	5.0	-	4.8
	625	05/01/08	-	5.4	-	5.9	-	-	5.2	-	-
	665	06/10/08	5.4	-	5.8	5.8	-	-	-	6.8	-
	Demobilization	770	09/23/08	5.9	5.7	5.7	6.2	5.8	5.7	-	6.1

Table E-5.8.4.1. Soil plot pore water and drainage water pH data (cont).

**Aqueous pH (S.U.) of soil plot drainage water and rainwater.**

Events	Elapsed	Date	SP1-1 (PO1)	SP1-2 (CON)	SP1-3 (PO2)	SP1-4 (PO1)	SP1-5 (PO2)	SP1-6 (CON)	SP1-7 (CON)	SP1-8 (PO2)	SP1-9 (PO1)	Rainwater
Mobilization	24	09/08/06	-	-	-	-	-	-	-	-	-	-
	38	09/22/06	-	-	-	-	-	-	-	-	-	-
PMSO Added	59	10/13/06	4.8	4.5	6.8	5.7	5.4	6.8	5.6	5.7	5.2	-
	73	10/27/06	-	-	-	-	-	-	-	-	-	-
	87	11/10/06	4.7	4.5	7.1	5.0	4.1	6.8	4.6	5.1	4.7	5.6
Start Stand-by	126	12/19/06	5.1	4.7	7.1	6.3	4.9	7.0	4.8	6.5	4.8	5.0
End Stand-by	267	05/09/07	-	-	-	-	-	-	-	-	-	-
	288	05/30/07	4.9	4.5	7.3	6.9	6.9	7.1	4.8	6.9	5.4	5.2
Residues added	302	06/13/07	6.2	5.5	7.5	7.1	7.0	7.6	5.3	7.3	6.2	5.5
	317	06/28/07	6.2	6.3	7.5	7.2	7.3	7.0	6.0	7.5	6.5	5.1
	346	07/27/07	-	-	-	-	-	-	-	-	-	-
	358	08/08/07	6.4	6.6	7.7	7.6	7.8	7.5	-	7.8	7.1	4.9
	386	09/05/07	6.8	6.3	7.7	7.6	7.7	7.6	-	7.7	7.0	6.3
	427	10/16/07	6.8	5.5	7.5	7.4	7.6	7.1	-	7.1	6.9	4.9
	457	11/15/07	7.1	5.5	7.5	7.3	7.4	7.3	5.8	7.3	6.9	5.4
Start Stand-by	491	12/19/07	-	-	-	-	-	-	-	-	-	-
	512	01/09/08	-	-	-	-	-	-	-	-	-	-
End Stand-by	588	03/25/08	-	-	-	-	-	-	-	-	-	-
	609	04/15/08	6.5	5.4	6.3	6.8	4.5	6.7	4.7	7.5	4.3	5.1
	622	04/28/08	4.7	5.3	4.6	6.4	4.3	6.3	5.5	7.2	4.4	-
	624	04/30/08	5.2	4.9	5.0	-	4.5	6.7	4.6	7.2	4.5	4.9
	625	05/01/08	-	4.8	5.1	-	4.7	7.0	4.8	7.4	4.6	-
	665	06/10/08	6.4	5.2	5.7	7.0	5.2	7.0	5.0	7.0	7.5	-
Demobilization	770	09/23/08	6.1	4.3	7.0	4.6	7.2	7.0	4.7	7.0	5.9	5.8

Table E-5.8.4.2. Soil plot pore water and drainage water TOC data.

**Aqueous TOC (mg/L) of soil pore water collected at 15 cm depth.**

Events	Elapsed	Date	SP1-1 (PO1)	SP1-2 (CON)	SP1-3 (PO2)	SP1-4 (PO1)	SP1-5 (PO2)	SP1-6 (CON)	SP1-7 (CON)	SP1-8 (PO2)	SP1-9 (PO1)
Mobilization	24	09/08/06	7	6	15	6	-	9	13	-	-
	38	09/22/06	11	7	8	11	15	-	10	-	21
PMSO Added	59	10/13/06	14	7	12	16	-	7	-	21	-
	73	10/27/06	7	7	9	8	6	-	-	12	-
	87	11/10/06	84	8	121	18	-	7	-	208	9
Start Stand-by	126	12/19/06	55	8	-	36	12	12	-	-	-
End Stand-by	267	05/09/07	-	9	-	20	78	10	-	72	22
	288	05/30/07	-	-	-	40	93	10	-	163	34
Residues added	302	06/13/07	-	-	110	37	47	9	-	224	31
	317	06/28/07	-	-	87	31	76	9	-	274	-
	346	07/27/07	-	-	107	36	17	9	-	256	21
	359	08/09/07	-	22	169	25	25	12	-	256	29
	386	09/05/07	-	-	449	27	315	-	-	212	23
	426	10/15/07	62	11	584	69	615	11	23	97	65
	457	11/15/07	34	9	810	126	1660	10	9	62	40
Start Stand-by	491	12/19/07	-	-	-	-	-	-	-	-	-
End Stand-by	511	01/08/08	-	8	-	-	1700	-	13	-	-
	588	03/25/08	-	-	-	-	-	-	-	-	-
	609	04/15/08	-	9	-	-	236	-	14	-	-
	622	04/28/08	-	-	-	-	516	-	-	-	-
	624	04/30/08	78	14	-	27	514	13	16	-	-
	625	05/01/08	92	15	-	-	-	14	-	-	-
	664	06/09/08	235	12	528	-	434	-	-	104	189
Demobilization	770	09/23/08	419	9	693	-	758	298	-	366	30

Table E-5.8.4.2. Soil plot pore water and drainage water TOC data (cont).

**Aqueous TOC (mg/L) of soil pore water collected at 45 cm depth.**

Events	Elapsed	Date	SP1-1 (PO1)	SP1-2 (CON)	SP1-3 (PO2)	SP1-4 (PO1)	SP1-5 (PO2)	SP1-6 (CON)	SP1-7 (CON)	SP1-8 (PO2)	SP1-9 (PO1)
Mobilization	24	09/08/06	6	10	6	4	8	14	10	13	13
	38	09/22/06	6	18	17	11	9	14	8	12	12
PMSO Added	59	10/13/06	7	17	25	24	10	16	10	17	9
	73	10/27/06	6	9	16	13	5	8	-	9	7
	87	11/10/06	7	12	9	11	14	9	7	9	-
Start Stand-by	126	12/19/06	-	13	29	11	-	15	-	11	11
End Stand-by	267	05/09/07	-	6	18	10	11	36	-	22	9
	288	05/30/07	-	10	53	17	-	40	8	58	10
Residues added	302	06/13/07	11	10	85	14	32	65	9	105	10
	317	06/28/07	-	-	154	21	92	140	-	211	11
	346	07/27/07	-	-	202	38	64	127	-	219	14
	359	08/09/07	-	-	197	31	65	86	-	278	13
	386	09/05/07	11	-	185	16	28	101	-	136	10
	426	10/15/07	12	24	114	11	104	16	16	108	7
Start Stand-by	457	11/15/07	14	17	369	64	327	42	14	202	24
	491	12/19/07	-	-	-	-	-	-	-	-	-
End Stand-by	511	01/08/08	-	12	-	24	-	42	10	-	82
	588	03/25/08	-	-	-	-	-	-	-	-	-
	609	04/15/08	18	9	-	14	-	-	8	-	105
	622	04/28/08	33	-	-	22	-	-	-	-	127
	624	04/30/08	35	15	569	17	511	22	8	-	104
	625	05/01/08	-	12	-	29	-	-	10	-	-
Demobilization	664	06/09/08	-	-	-	-	441	-	15	-	105
	770	09/23/08	483	-	613	25	690	336	-	341	210

Table E-5.8.4.2. Soil plot pore water and drainage water TOC data (cont).

**Aqueous TOC (mg/L) of soil plot drainage water and rainwater.**

Events	Elapsed	Date	SP1-1 (PO1)	SP1-2 (CON)	SP1-3 (PO2)	SP1-4 (PO1)	SP1-5 (PO2)	SP1-6 (CON)	SP1-7 (CON)	SP1-8 (PO2)	SP1-9 (PO1)	Rainwater
Mobilization	24	09/08/06	-	-	-	-	-	-	-	-	-	-
	38	09/22/06	-	-	-	-	-	-	-	-	-	-
PMSO Added	59	10/13/06	13	15	29	16	11	33	11	17	12	-
	73	10/27/06	-	-	-	-	-	-	-	-	-	-
	87	11/10/06	10	11	41	13	10	30	9	17	9	2
Start Stand-by	126	12/19/06	9	10	50	16	14	28	10	17	9	2
End Stand-by	267	05/09/07	-	-	-	-	-	-	-	-	-	-
	288	05/30/07	12	11	64	71	31	32	8	52	14	4
Residues added	302	06/13/07	12	10	69	77	34	58	8	70	13	7
	317	06/28/07	12	13	67	116	41	33	11	71	15	12
	346	07/27/07	15	32	58	70	52	60	14	65	20	7
	359	08/09/07	13	18	83	90	65	52	-	71	16	6
	386	09/05/07	18	14	82	75	76	83	-	77	16	8
	426	10/15/07	22	7	73	85	93	69	-	54	12	3
	457	11/15/07	24	11	72	42	70	51	10	76	17	4
Start Stand-by	491	12/19/07	49	11	145	69	168	28	11	98	75	-
	511	01/08/08	-	-	-	-	-	-	-	-	-	-
End Stand-by	588	03/25/08	121	14	201	50	356	21	11	129	68	4
	609	04/15/08	229	12	473	57	554	36	10	127	159	7
	622	04/28/08	232	18	311	59	276	26	14	122	150	40
	624	04/30/08	345	14	458	111	279	28	10	104	81	5
	625	05/01/08	-	13	401	-	246	24	10	100	128	-
	664	06/09/08	112	9	209	60	210	19	9	49	93	-
Demobilization	770	09/23/08	78	17	169	18	182	66	19	43	251	13

Table E-5.8.4.3. Soil plot pore gases (O<sub>2</sub> and CO<sub>2</sub>) data.

**Soil pore gas O<sub>2</sub> measured at PMSO:soil interface.**

Events	Elapsed	Date	SP1-1 (PO1)	SP1-3 (PO2)	SP1-4 (PO1)	SP1-5 (PO2)	SP1-8 (PO2)	SP1-9 (PO1)
Mobilization	24	09/08/06	-	-	-	-	-	-
	38	09/22/06	21	21	21	21	21	21
PMSO Added	59	10/13/06	21	21	21	21	21	21
	73	10/27/06	21	21	21	21	21	21
	87	11/10/06	20	20	20	20	20	21
Start Stand-by	127	12/20/06	21	21	21	20	20	20
End Stand-by	266	05/08/07	19	19	19	19	19	19
	287	05/29/07	19	19	19	19	19	19
Residues added	300	06/11/07	21	20	21	21	20	21
	316	06/27/07	20	20	20	20	20	20
	344	07/25/07	20	20	20	20	20	20
	358	08/08/07	21	20	20	20	20	20
	386	09/05/07	21	20	20	20	21	21
	426	10/15/07	21	-	20	-	21	21
Start Stand-by (491 d)	455	11/13/07	20	-	18	-	19	-
	512	01/09/08	20	20	-	-	20	20
End Stand-by	587	03/24/08	21	-	21	21	21	21
	608	04/14/08	21	-	21	-	-	-
	664	06/09/08	-	-	20	-	21	-
Demobilization	770	09/23/08	-	-	21	-	21	21

Table E-5.8.4.3. Soil plot pore gases (O<sub>2</sub> and CO<sub>2</sub>) data (cont).

Soil pore gas O<sub>2</sub> measured at 15 cm depth.

Events	Elapsed	Date	SP1-1 (PO1)	SP1-2 (CON)	SP1-3 (PO2)	SP1-4 (PO1)	SP1-5 (PO2)	SP1-6 (CON)	SP1-7 (CON)	SP1-8 (PO2)	SP1-9 (PO1)	Ambient
Mobilization	24	09/08/06	20	18	19	17	20	19	20	19	20	21
	38	09/22/06	21	20	20	19	20	20	20	20	20	21
PMSO Added	59	10/13/06	20	20	20	19	20	20	20	20	20	21
	73	10/27/06	21	21	20	20	20	20	20	20	21	21
	87	11/10/06	19	19	14	17	18	-	20	18	19	21
Start Stand-by	127	12/20/06	20	20	20	20	20	-	20	-	20	21
End Stand-by	266	05/08/07	19	19	18	18	19	19	19	19	19	19
	287	05/29/07	18	19	16	17	18	16	19	-	19	19
Residues added	300	06/11/07	20	21	19	19	20	17	21	-	21	21
	316	06/27/07	20	20	16	17	18	19	20	-	19	21
	344	07/25/07	20	20	-	16	19	19	20	-	20	21
	358	08/08/07	19	20	-	14	-	16	20	-	18	21
	386	09/05/07	21	21	-	18	-	20	21	2	21	21
	426	10/15/07	21	21	-	19	-	20	21	-	21	21
Start Stand-by (491 d)	455	11/13/07	-	20	-	18	-	-	19	-	-	20
	512	01/09/08	-	20	-	-	-	-	20	13	-	20
End Stand-by	587	03/24/08	21	21	-	21	18	21	21	21	21	21
	608	04/14/08	-	21	-	21	-	-	21	-	-	21
	664	06/09/08	-	20	-	18	-	17	20	-	-	21
Demobilization	770	09/23/08	-	21	-	20	-	-	21	2	21	22

Table E-5.8.4.3. Soil plot pore gases (O<sub>2</sub> and CO<sub>2</sub>) data (cont).

**Soil pore gas O<sub>2</sub> measured at 45 cm depth.**

Events	Elapsed	Date	SP1-1 (PO1)	SP1-2 (CON)	SP1-3 (PO2)	SP1-4 (PO1)	SP1-5 (PO2)	SP1-6 (CON)	SP1-7 (CON)	SP1-8 (PO2)	SP1-9 (PO1)
Mobilization	24	09/08/06	18	16	18	15	19	18	18	18	18
	38	09/22/06	20	19	20	18	20	19	20	20	20
PMSO Added	59	10/13/06	20	19	19	19	20	19	20	20	20
	73	10/27/06	20	20	20	20	20	20	20	20	20
	87	11/10/06	18	19	-	17	17	-	19	-	19
Start Stand-by	127	12/20/06	20	20	-	-	20	-	20	-	20
End Stand-by	266	05/08/07	19	19	-	-	18	-	19	-	19
	287	05/29/07	18	19	-	-	-	-	19	-	18
Residues added	300	06/11/07	20	21	-	-	-	-	21	-	21
	316	06/27/07	19	20	-	-	-	-	20	-	19
	344	07/25/07	19	19	-	-	-	-	20	-	19
	358	08/08/07	17	19	-	-	-	-	19	-	17
	386	09/05/07	20	21	-	-	-	8	21	-	20
Start Stand-by (491 d)	426	10/15/07	-	21	-	-	-	-	21	-	21
	455	11/13/07	-	20	-	-	-	-	19	-	-
End Stand-by	512	01/09/08	-	20	-	-	-	-	19	-	-
	587	03/24/08	20	21	-	-	-	20	21	-	-
	608	04/14/08	-	21	-	-	-	-	21	-	-
Demobilization	664	06/09/08	-	18	-	-	-	-	19	-	-
	770	09/23/08	-	20	-	-	-	-	21	-	-

Table E-5.8.4.3. Soil plot pore gases (O<sub>2</sub> and CO<sub>2</sub>) data (cont).

**Soil pore gas CO<sub>2</sub> measured at PMSO:soil interface.**

<b>Events</b>	<b>Elapsed</b>	<b>Date</b>	<b>SP1-1 (PO1)</b>	<b>SP1-3 (PO2)</b>	<b>SP1-4 (PO1)</b>	<b>SP1-5 (PO2)</b>	<b>SP1-8 (PO2)</b>	<b>SP1-9 (PO1)</b>
Mobilization	24	09/08/06	-	-	-	-	-	-
	38	09/22/06	1.2	1.2	1.0	1.0	1.0	1.1
PMSO Added	59	10/13/06	0.1	0.2	0.1	0.1	0.1	0.1
	73	10/27/06	0.0	0.1	-	0.0	0.1	0.1
	87	11/10/06	0.4	0.6	0.2	0.4	0.5	0.3
Start Stand-by	127	12/20/06	0.1	0.2	0.1	0.2	0.1	0.1
End Stand-by	266	05/08/07	0.4	0.8	0.4	0.5	0.6	0.5
	287	05/29/07	0.8	1.2	0.7	0.8	1.0	0.7
	300	06/11/07	1.0	1.5	0.9	1.2	1.3	0.9
Residues added	316	06/27/07	1.1	1.6	1.0	1.4	1.5	0.9
	344	07/25/07	1.0	1.4	1.1	1.2	1.3	1.1
	358	08/08/07	1.2	1.7	1.3	1.2	1.2	1.2
	386	09/05/07	1.1	1.6	1.2	1.2	1.1	1.3
	426	10/15/07	1.1	-	1.2	-	1.1	1.1
Start Stand-by (491 d)	455	11/13/07	0.9	-	3.0	-	1.6	-
	512	01/09/08	1.3	1.7	-	-	1.0	1.6
End Stand-by	587	03/24/08	0.8	-	0.8	0.8	0.7	0.8
	608	04/14/08	0.9	-	0.9	-	-	-
	664	06/09/08	-	-	1.7	-	1.6	-
Demobilization	770	09/23/08	-	-	1.2	-	1.2	5.8

Table E-5.8.4.3. Soil plot pore gases (O<sub>2</sub> and CO<sub>2</sub>) data (cont).

**Soil pore gas CO<sub>2</sub> measured at 15 cm depth.**

Events	Elapsed	Date	SP1-1 (PO1)	SP1-2 (CON)	SP1-3 (PO2)	SP1-4 (PO1)	SP1-5 (PO2)	SP1-6 (CON)	SP1-7 (CON)	SP1-8 (PO2)	SP1-9 (PO1)	Ambient
Mobilization	24	09/08/06	1.4	3.2	2.5	4.1	1.3	2.1	1.5	1.5	1.5	0.0
	38	09/22/06	1.9	2.8	2.7	3.0	1.3	1.5	1.6	1.6	1.7	0.0
PMSO Added	59	10/13/06	0.7	1.1	1.1	1.4	0.7	1.1	0.8	0.7	0.6	0.1
	73	10/27/06	0.2	0.1	0.5	0.4	0.2	0.2	0.1	0.3	0.1	0.0
	87	11/10/06	2.0	1.2	4.9	2.8	2.8	-	0.9	2.9	1.6	0.1
Start Stand-by	127	12/20/06	0.3	0.3	1.4	1.2	0.5	-	0.1	-	0.3	0.1
End Stand-by	266	05/08/07	0.9	0.5	2.2	1.8	1.3	1.1	0.5	1.5	0.9	0.4
	287	05/29/07	1.6	0.8	4.5	3.9	2.2	4.2	0.8	-	1.6	0.6
Residues added	300	06/11/07	1.4	0.8	4.2	3.5	2.4	5.7	0.8	-	1.4	0.7
	316	06/27/07	2.3	1.2	6.2	5.1	3.4	3.8	1.2	-	2.3	0.7
	344	07/25/07	2.3	1.6	-	5.9	3.7	3.3	1.4	-	2.2	0.9
	358	08/08/07	3.5	2.6	-	8.7	-	6.1	2.1	-	3.8	0.8
	386	09/05/07	1.6	1.0	-	4.8	-	2.8	1.0	18.8	1.8	0.9
	426	10/15/07	1.2	1.2	-	4.0	-	2.0	1.0	-	1.4	1.0
Start Stand-by (491 d)	455	11/13/07	-	1.3	-	3.4	-	-	1.3	-	-	1.1
	512	01/09/08	-	1.5	-	-	-	-	1.4	8.7	-	1.0
End Stand-by	587	03/24/08	0.9	0.8	-	1.2	2.8	1.0	0.7	1.7	1.2	0.7
	608	04/14/08	-	1.2	-	2.0	-	-	0.9	-	-	0.8
	664	06/09/08	-	3.0	-	5.5	-	5.8	2.5	-	-	1.3
Demobilization	770	09/23/08	-	1.9	-	3.3	-	-	1.5	13.3	11.4	4.0

Table E-5.8.4.3. Soil plot pore gases (O<sub>2</sub> and CO<sub>2</sub>) data (cont).

**Soil pore gas CO<sub>2</sub> measured at 45 cm depth.**

Events	Elapsed	Date	SP1-1 (PO1)	SP1-2 (CON)	SP1-3 (PO2)	SP1-4 (PO1)	SP1-5 (PO2)	SP1-6 (CON)	SP1-7 (CON)	SP1-8 (PO2)	SP1-9 (PO1)
Mobilization	24	09/08/06	2.9	5.0	3.3	5.3	2.7	3.0	2.8	3.1	3.0
	38	09/22/06	2.8	3.4	3.3	3.4	1.7	1.7	1.8	2.4	2.4
PMSO Added	59	10/13/06	1.3	1.6	1.5	2.0	1.3	1.5	1.3	1.4	1.2
	73	10/27/06	0.3	0.3	0.5	0.4	0.4	0.2	0.2	0.4	0.3
Start Stand-by	87	11/10/06	2.5	1.4	-	2.9	3.3	-	1.3	-	1.9
	127	12/20/06	0.6	0.8	-	-	0.7	-	0.4	-	0.6
End Stand-by	266	05/08/07	1.2	0.8	-	-	1.7	-	0.7	-	1.1
	287	05/29/07	2.5	1.5	-	-	-	-	1.2	-	2.5
Residues added	300	06/11/07	1.9	1.2	-	-	-	-	1.0	-	2.1
	316	06/27/07	3.5	1.9	-	-	-	-	1.8	-	3.4
	344	07/25/07	3.4	2.6	-	-	-	-	2.1	-	3.3
	358	08/08/07	5.2	4.0	-	-	-	-	3.1	-	5.4
	386	09/05/07	2.7	1.1	-	-	-	11.9	1.1	-	3.1
Start Stand-by (491 d)	426	10/15/07	-	1.4	-	-	-	-	1.1	-	1.8
	455	11/13/07	-	1.4	-	-	-	-	1.2	-	-
End Stand-by	512	01/09/08	-	1.4	-	-	-	-	1.7	-	-
	587	03/24/08	1.5	0.9	-	-	-	2.1	0.8	-	-
	608	04/14/08	-	1.4	-	-	-	-	1.1	-	-
Demobilization	664	06/09/08	-	4.7	-	-	-	-	3.5	-	-
	770	09/23/08	-	3.1	-	-	-	-	2.4	-	-

Table E-5.8.4.4. Soil plot drainage volume data.

**Volume (L) of drainage water collected from the soil plots and from the precipitation collector.**

Events	Elapsed	Date	SP1-1 (PO1)	SP1-2 (CON)	SP1-3 (PO2)	SP1-4 (PO1)	SP1-5 (PO2)	SP1-6 (CON)	SP1-7 (CON)	SP1-8 (PO2)	SP1-9 (PO1)	Rainwater
Mobilization	24	09/08/06	-	-	-	-	-	-	-	-	-	-
	38	09/22/06	-	-	-	-	-	-	-	-	-	-
PMSO Added	59	10/13/06	-	-	-	-	-	-	-	-	-	-
	73	10/27/06	-	-	-	-	-	-	-	-	-	-
	87	11/10/06	9.60	9.50	3.40	14.00	13.60	13.40	9.80	9.90	8.70	0.60
Start Stand-by	127	12/20/06	18.90	17.80	1.40	18.90	18.90	6.00	18.90	8.00	18.90	1.00
End Stand-by	266	05/08/07	-	-	-	-	-	-	-	-	-	-
	287	05/29/07	12.00	8.00	1.50	0.10	5.00	5.00	8.00	1.00	7.00	0.90
Residues added	300	06/11/07	6.00	1.75	0.30	0.10	5.50	0.90	1.60	1.00	3.00	0.25
	316	06/27/07	1.20	0.20	0.10	0.05	2.00	0.10	0.10	0.10	1.75	0.04
	344	07/25/07	12.00	0.30	1.50	1.50	11.00	1.50	0.30	3.00	7.00	0.50
	358	08/08/07	6.00	0.43	0.25	0.50	2.50	1.75	0.01	0.25	2.00	0.25
	386	09/05/07	4.00	0.08	0.50	0.50	3.50	0.50	0.00	0.50	1.50	0.20
	426	10/15/07	10.00	0.30	1.00	0.50	5.50	0.80	0.00	2.00	4.50	0.75
	455	11/13/07	5.00	15.00	0.80	0.80	5.00	11.00	11.00	0.70	2.10	1.30
Start Stand-by	491	12/19/07	-	-	-	-	-	-	-	-	-	-
	511	01/08/08	-	-	-	-	-	-	-	-	-	-
End Stand-by	587	03/24/08	18.93	18.93	18.93	4.00	18.93	18.93	18.93	18.93	18.93	13.00
	608	04/14/08	0.10	5.00	0.20	0.10	1.00	2.00	6.50	3.00	1.50	0.20
	622	04/28/08	0.11	2.20	0.17	0.02	1.00	1.20	2.20	0.80	1.30	0.00
	624	04/30/08	0.02	2.60	0.02	0.00	0.12	1.10	2.20	0.12	0.50	0.42
	625	05/01/08	0.00	1.20	0.01	0.00	0.05	0.32	1.20	0.03	0.14	0.00
	664	06/09/08	0.50	13.00	1.20	0.20	9.00	11.00	13.00	6.00	7.00	0.60
Demobilization	770	09/23/08	20.00	20.00	12.00	0.10	8.50	5.80	20.00	1.60	20.00	2.00

## **Appendix F**

### **Manuscript**

“Evaluation of a peat moss plus soybean oil (PMSO) technology for reducing explosive residue transport to groundwater at military training ranges under field conditions”

Evaluation of a peat moss plus soybean oil (PMSO) technology for reducing explosive residue transport to groundwater at military training ranges under field conditions

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## **ABSTRACT**

An evaluation of peat moss plus crude soybean oil (PMSO) for mitigation of explosive contamination of soil at military facilities was performed using large soil lysimeters under field conditions. Actual range soils were used, and two PMSO preparations with different ratios of peat moss:soybean oil (1:1, PO1; 1:2, PO2) were compared to a control lysimeter that received no PMSO. PMSO was applied as a 10 cm layer on top of the soil, and Composition B detonation residues from a 55-mm mortar round were applied at the surface of each of the lysimeters. Dissolution of the residues occurred during natural precipitation events over the course of 18 months. Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) emanating from the Composition B residues were significantly reduced by the PO2 PMSO material compared to the untreated control. Soil pore water RDX concentrations and RDX fluxes were reduced over 100-fold compared to the control plots at comparable depths. Residual RDX in the soil profile was also significantly lower in the PMSO treated plots. PO1 PMSO resulted in lower reductions in RDX transport than the PO2 PMSO. The transport of the RDX breakdown product hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine was also greatly reduced by the PMSO materials. Results were in general agreement with a previously developed fate and transport model describing PMSO effectiveness. These results demonstrate the potential effectiveness of the inexpensive and environmentally benign PMSO technology for reducing the subsurface loading of explosives at training ranges and other military facilities.

## **INTRODUCTION**

The U.S. Department of Defense (DoD) faces the challenging task of maintaining warfare readiness, while at the same time protecting and using natural resources in a sustainable manner. Past activities have left a legacy of environmental problems, including groundwater contamination with explosive compounds. At least 1000 explosives-impacted sites within the United States have been identified by the DoD (Major et al., 1991; Rodgers and Bunce, 2001), with contamination estimated over 20 million ha (Clausen et al., 2004). As of 2001, estimates of liabilities for remediation have ranged upwards of \$100 billion (USGAO, 2001). Efforts are underway to fully characterize the extent of explosive compound contamination at training ranges (Jenkins et al., 2001; Pennington et al., 2006), especially in light of the efforts of DoD to close and transfer ownership of obsolete installations to civilian for public and private development. Significant work is also underway to develop sustainable range practices (<http://www.serdp.org/Research/upload/RAWorkshopRDTENeedsRpt.pdf>)

The munition-related contaminants of primary concern are 2,4,6-trinitrotoluene (TNT), hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), 2,4- and 2,6-dinitroluene, octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), nitroglycerin, and the inorganic propellant perchlorate. It was estimated by Taylor et al. (2004) that as much as 2% (by mass) of a TNT-filled 155-mm round remained as residuals on the soil surface after high-order (i.e., “complete”) detonations, which translates to 140 g of explosive residues per round (Taylor et al., 2004). If the round undergoes a low-order detonation, up to 3 kg of TNT could be deposited on the surrounding area. Many mortar rounds (as well as hand grenades) are filled Composition B, which is a mixture TNT (35%) and RDX (65%). Residues from low-order detonations from these munitions result in comingled TNT and RDX particulates, which undergo subsequent weathering and dissolution,

resulting in multi-point sources of aqueous phase explosive compounds that migrate into the subsurface and groundwater.

Approaches for mitigating contamination from ongoing training activities are being actively pursued. Over the past eight years, a technology that combines *Sphagnum* peat moss and crude soybean oil (PMSO) has been developed and extensively tested under laboratory conditions for its ability to immobilize and enhance the degradation of munitions-related compounds at or near the soil surface as they are generated (Fuller et al., 2004; Hatzinger et al., 2004; Fuller et al., 2005; Schaefer et al., 2005). The peat moss serves as an effective sorbent for all the major explosive compounds, while the crude soybean oil stimulates overall microbial activity and promotes conditions that are favorable for explosive compound transformation and degradation.

The present work goes beyond the previous laboratory studies and describes the results of the first evaluation of the PMSO technology under field-relevant conditions, with the goal of demonstrating its potential effectiveness to help meet DoD range sustainability and environmental protection needs. Specifically, large soil lysimeters were packed with range soil, PMSO was applied as a layer, and Composition B detonation residues were applied. The reduction of TNT, RDX, and HMX migration into soil from the dissolving Composition B detonation residues under real environmental conditions was monitored over the course of 18 months, and marked reductions in contaminant fluxes were observed.

## **METHODS**

*Materials.* Horticultural grade bulk *Sphagnum* peat moss (Nirom, Canada) was purchased from a local home and garden store. Crude soybean oil was obtained from Soybest/Grain States Soya, Inc. (West Point, NE, USA). Composition B was kindly supplied by Dr. Susan Taylor

(U.S. Army Corp of Engineers Engineer Research and Development Center/Cold Regions Research and Engineering Laboratory) as hand-sorted 0.5 to 1 mm detonation residues from a 55-mm mortar round. All other laboratory chemicals were reagent grade or purer.

*Site description.* The field evaluation was performed at the Massachusetts Military Reservation (MMR), a military training facility located on the upper western portion of Cape Cod, immediately south of the Cape Cod Canal in Barnstable County, Massachusetts. Areas of MMR have been used for military purposes since 1911. MMR was founded by the Commonwealth in the mid-1930s as a National Guard training camp and federalized in 1940 during WW II. The primary mission of MMR has been providing training and housing to Air Force or Army units, and for Army training and maneuvers, military aircraft operations, maintenance, and support. The field evaluation was performed inside the main Central Impact Area of MMR, but just outside the exclusion zone that is undergoing continued removal of unexploded ordnance, in a location that did not have a history of use for training and was deemed free of contamination.

*Soil.* Soil for the testing (approximately 1.5 m<sup>2</sup>) was excavated from a nonvegetated area to a depth of 15 cm, screened to remove larger material (2.5 cm mesh opening), and homogenized with shovels. The soil was subsampled and analyzed prior to use to confirm that no explosive residues were present. The soil was classified as a sandy loam, with 0.5% total organic carbon.

*Experimental apparatus.* A schematic diagram and photographs of the test apparatus (“soil plots”) is presented in SM-1 (Supplemental Material). The tank was straight-walled polypropylene, 0.45 m in diameter and 1.2 m high, with a 0.6 cm wall thickness (Chem-Tainer Industries, West Babylon, NY, USA; P/N: TC1840AB) and modified with the following:

- 1) capillary wick drainage system consisting of a 150 cm length fiberglass rope material (Amatex/Norfab Corp, Norristown, PA, USA; medium density fiberglass rope P/N: 10-863KR-08, 2.5 cm diameter) threaded through a PVC bulkhead fitting (2.5 cm slip x 2.5 cm female national pipe thread) at the bottom of the tank and into a 1.2 m length of PVC tubing (2.5 cm id x 3.1 cm od, 0.3 cm wall) that terminated at a 20 L plastic bucket with a teflon liner; 2) soil pore water samplers at depths of 15 and 45 cm below the soil surface, consisting of a porous ceramic cups (Soilmoisture Equipment Corp., Santa Barbara, CA, USA; P/N: 1911) attached to sampling

ports outside the tank via fluorinated ethylene-propylene (FEP) teflon tubing; 3) soil pore water samplers at depths of 15 and 45 cm below the soil surface, consisting of a small, screened cut-off syringe attached to sampling ports outside the tank via FEP teflon tubing; 4) soil volumetric moisture probes placed at depths of 15 and 45 cm below the soil surface, consisting of SMA Soil Moisture Smart Sensors (P/N: S-SMA-M005) attached via cables to two HOBO Weather Station Data Loggers (P/N: H21-001, Onset Computer Corporation, Pocasset, MA, USA).

*Soil loading.* Each tank was loaded with clean MMR soil to a depth of 75 cm, packed to a bulk density of  $1.5 \text{ g cm}^{-3}$ . Soil was loaded in 2.5 to 5 cm layers and manually compressed to assure uniformity between the plots. Gravimetric soil moisture at the time of packing was approximately 4% ( $\text{kg H}_2\text{O kg}^{-1}$  dry soil). Once loaded, the plots were anchored to  $0.8 \text{ m}^2$  square plastic shipping pallets with tie-down straps, and the pallets were then placed on elevated pallet racks by using a forklift (SM-1).

*PMSO treatment application.* Two ratios of peat moss:crude soybean oil were evaluated, 1:1 and 1:2 (w:w), based on the air dry weight of the peat moss. Three plots received the 1:1 PMSO (designated PO1; 2.5 kg peat moss (dry wt) plus 2.5 kg crude soybean oil) and three received the 1:2 PMSO (designated PO2; 2.5 kg peat moss (dry wt) plus 5 kg crude soybean oil), while three plots served as controls and received no PMSO (designated CON). PMSO was prepared by thoroughly mixing the required weight of crude soybean oil into the peat moss. PMSO was added to the plots to achieve a 10 cm depth on top of the soil surface in the treatment plots.

*Composition B residue application.* Each soil plot received a total of 10 g of detonation residues, comprised of approximately 5.6 g RDX, 3.4 g TNT, 0.03 g HMX, and 0.9 g acetonitrile-insoluble matter. Residues were mixed with 90 g of clean sand as a carrier to assure safe transport and aid with distribution. Residue-sand mixtures were applied evenly over the entire surface of the soil plots, on top of the PMSO layers in the treatment plots and directly at the soil surface in the control plots.

*Sampling.* Sampling was performed approximately biweekly to monthly throughout the field evaluation, except for two “standby” periods during the winter seasons: from 20th December 2006 to 26th April 2007 and again from 20th December 2007 to 24th March 2008. During

standby, the plots were covered with lids and tarps to prevent snow and ice from building up, which could have damaged the sensors and sampling ports.

Soil pore gas readings were made using a CheckPoint O<sub>2</sub>/CO<sub>2</sub> Analyzer (PBI Dansensor, Topac, Inc., Cohasset MA, USA) attached to the gas sampling ports. Soil pore water samples were collected using disposable polypropylene syringes by applying suction to the porous ceramic cups. At each sampling point, a 10-15 mL “purge” volume was collected, followed by a 10 to 20 mL “sample” volume (if the soil would yield both based on the prevailing moisture content). Both purge and sample volumes were analyzed as described below. The volume of drainage water collected was recorded at each sampling event and samples were collected for analysis. Soil moisture readings were collected every 10 min and recorded using the dataloggers. Weather parameters were collected continuously using a WatchDog Weather Station coupled with a datalogger (Spectrum Technologies, Inc., Plainfield, IL, USA). Data were offloaded from the soil moisture and weather station dataloggers using data shuttles, which were shipped to the laboratory for analysis and then archived.

At the termination of the field evaluation, the soil in the plots was extensively sampled and analyzed for residual explosive compounds. The goal was to determine the vertical distribution of the explosives from the soil (or PMSO) surface where the Composition B was applied down through the soil. The topmost layers of soil in the CON plots were removed in 1.25 cm layers (or lifts). The PMSO in the PO1 and PO2 plots was collected in two portions: the top 2.5 cm and the remainder down to the soil surface. The topmost soil in the PO1 and PO2 plots was collected in 2.5 cm lifts. After the PMSO was removed and the soil lifts were collected, eight replicate cores from each soil plot were collected using a hand geoprobe coring device. Soil layers and PMSO were air dried then sieved into size fractions of >2 mm, 0.5 to 2 mm, and <0.5 mm to facilitate handling during extraction. The different size fractions of the top layers of soil and PMSO were extracted *en toto*, while well-homogenized triplicate subsamples of each depth interval of the soil cores were extracted. Extraction was performed in glass jars with technical grade acetone with vigorous shaking (150 rpm) for 18 h at room temperature. Aliquots of the extracts were passed through glass microfiber filters (0.45 μm) prior to analysis by high performance liquid chromatography (HPLC) as described below.

*Analytical.* The concentrations of the explosives and their breakdown products were monitored during incubation using HPLC according to a modified EPA Method 8330 ([www.epa.gov/epawaste/hazard/testmethods/sw846/pdfs/8330a.pdf](http://www.epa.gov/epawaste/hazard/testmethods/sw846/pdfs/8330a.pdf)) using a Dionex 3000 Ultimate HPLC with a Dionex Explosives E1 column, variable wavelength detector (reading at 230 nm), and a photodiode array detector collecting peak spectral data. The mobile phase was 43:57 methanol:water at a flow rate of 0.95 mL min<sup>-1</sup>. The column temperature was 32 °C. The practical quantitation limit was approximately 10 µg L<sup>-1</sup> for the main EPA Method 8330 analytes and 25 µg L<sup>-1</sup> for the RDX breakdown products (hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine, MNX; hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine, DNX; and hexahydro-1,3,5-trinitroso-1,3,5-triazine, TNX). Method detection limits (MDL) were 5.2 and 5.9 µg L<sup>-1</sup> for the main EPA Method 8330 analytes and the RDX breakdown products, respectively. Samples that were reported as below detection were assigned a value of one-half of the MDL for graphing and data analysis purposes. Aqueous samples were also analyzed for pH (using a pH electrode) and total organic carbon (TOC, EPA Method 415.1).

*Data analysis.* RDX and MNX concentration comparisons across treatments, and mass and flux calculations, were only performed on data collected after the Composition B residues had been applied to the plots.

Dissolved explosive flux through the soil plots at 30 cm (averaged between the 15 and 45 cm sampling locations) was estimated for discrete time points as follows:

$$J_4 = \frac{\Delta SC_4}{a\Delta t}$$

1

where  $J_i$  is the dissolved flux for explosive compound  $i$  ( $\text{mg cm}^{-2} \text{d}^{-1}$ ),  $\Delta S$  is the change in water storage ( $\text{cm}^3$ ),  $C_i$  is the dissolved concentration of compound  $i$  ( $\text{mg cm}^{-3}$ ),  $a$  is the cross-sectional area of the tank ( $\text{cm}^2$ ), and  $\Delta t$  is the time interval over which the flux was evaluated (d). The change in storage at 30 cm was calculated based on the measured moisture contents at  $z = 15$  and 45 cm below the soil surface as follows (Fares and Alva, 2000):

$$\Delta S = \int_{z=15}^{z=45} \theta(z, t_1) dz - \int_{z=15}^{z=45} \theta(z, t_2) dz \quad 2$$

where  $\theta$  is the volumetric water content ( $\text{cm}^3 \text{cm}^{-3}$ ), and  $t_1$  and  $t_2$  represent the time interval for the discrete flux measurements (d). Dissolved explosive flux at the tank effluent (75 cm) was calculated in a similar fashion, except that  $\Delta S$  was directly measured as the volume collected in the drainage tank over the sampling time interval ( $\Delta t$ ). Mass that eluted through  $z = 30$  or 75 cm was calculated by multiplying the flux by the cross-section area and the time interval.

## RESULTS AND DISCUSSION

The soil plots were prepared on 18th August 2006 (Day 0). PMSO was added to the treatment plots on 13th October 2006 (Day 59), and Composition B detonation residues were applied on 11th June 2007 (Day 302). The evaluation was terminated on 23rd September 2008 (Day 770). Data analysis and presentation is focused on the time period after the Composition B residues were applied as a source of explosive compounds.

It was determined that one of the three control soil plots (CON-2) did not operate similar to the other two control plots based on a careful assessment of several parameters, including: higher volumetric moisture content over the duration of the study, substantially elevated concentrations of TOC in soil pore water relative to the other controls, and presence of an algal slime layer on the soil surface at the end of demonstration (no algal slime layer was observed in the other soil plots). The concentrations of RDX detected in the soil pore water collected at 45 cm depth and in the drainage water from CON-2, and the residual RDX in the soil profile at the end of the field test, also were substantially different from the other two control plots. The data from CON-2 were therefore excluded when comparisons between the control and treatments were being performed.

*Aqueous phase results.* Water flow through the plots was comparable for all the plots, varying by only about a factor of 1.5 to 2. Some of the lower water flows were observed in the treatment plots, which can be attributed to retention in and evaporation from the PMSO layer of received precipitation before it infiltrated the soil column. There was good agreement (generally within 20%) between the water flow values calculated based on drainage water collected and from integration of the soil volumetric moisture probe curves.

Soil pore water samples at all depths in the plots had a pH of 5.8-6.2 standard units (S.U.), only slightly higher than the pH of the incident precipitation (4.9-5.7 S.U.). Pore water TOC values markedly increased in the treatment plots compared to the control plots after application of the PMSO material. The TOC values were highest at the 15 cm sampling depth, with progressively lower values at the 45 cm depth and in the drainage water. The maximum average TOC values in the PO1 (1:1 peat:oil ratio) and PO2 (1:2 peat:oil ratio) plots at the 15 cm depth

were 220 and 1700 mg L<sup>-1</sup>, respectively, compared to a maximum of 22 mg L<sup>-1</sup> in the CON plots. Soil pore gases indicated that the soil remained essentially aerobic throughout the demonstration, although oxygen concentrations in the PO1 and PO2 plots trended about 1-2% below the concentrations observed in the CON plots at corresponding depths.

With the exceptions of RDX and the RDX breakdown product MNX, no other explosive-related compounds were detected in aqueous samples above the detection limit with enough frequency to allow robust comparisons between the control and the treatments. Of 423 aqueous samples analyzed (from all treatment and control plots and over all sampling depths) after the Composition B residues (comprised of mostly RDX and TNT, with small percentage of HMX) were applied there were only 5 detections of TNT and 11 detections of HMX, compared to 189 detections of RDX. Similarly, there were only 22 and 25 detections of the RDX breakdown products TNX and DNX, respectively, compared to 120 detections of MNX. The two main TNT breakdown products, 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene, were detected 4 and 6 times, respectively.

The average concentrations of RDX in pore water and drainage from the CON, PO1, and PO2 soil plots, are presented in Fig. 1. The PO2 plots consistently had the lowest concentrations of RDX at all sample depths, with only a few exceptions. The PO1 plots typically had concentrations between the PO2 and CON plots in the 15 cm and drainage samples, but had concentrations that were either greater than or within one standard deviation of the CON plots for much of the evaluation at the 45 cm samples. Over the interval from when the Composition B residues were applied to the end of the evaluation, the RDX concentrations detected at depths of 15 cm, 45 cm, and in the drainage for the PO2 were on average 4000-, 760-, and 1030-fold

lower, respectively, than the concentrations at the corresponding depths of the CON plots. For the PO1 plots, the average concentrations of RDX were 10- and 780-fold lower than the CON plots at 15 cm and in the drainage, but approximately the same as the CON plots at 45 cm. It is not readily apparent why the PO1 plots performed so poorly with respect to RDX at the 45 cm depth, especially compared to the PO2 plots. The lower amount of crude soybean oil in the PMSO in the PO1 plots provided less biostimulative nutrients for RDX biodegradation, and at the deeper soil depths it was not as effective as the PO2 (also reflected in the overall lower TOC values in the pore water).

Corresponding concentrations of MNX at the three sampling depths are presented in Fig. 2. A pattern similar to the RDX concentration data was observed with respect to MNX concentrations. While concentrations of MNX were similar in the PO1 and PO2 plots compared to the CON plots for most of the evaluation, by the latter timepoints the PO2 plots were approximately 50- to 100-fold lower than the CON plots at corresponding depths. PO1 plots were less effective at reducing MNX concentrations, but at the end of the evaluation the MNX was between 5- and 10-fold lower than observed at the corresponding depths of the CON plots.

The presence of measurable MNX in the CON plots indicates that degradation of RDX was occurring even in native MMR soil, without the addition of any amendments. The mode of degradation may have been abiotic or biological, although significant biotic RDX would not be expected given the prevailing aerobic conditions and low organic carbon levels. A previous study with MMR soil examined under unsaturated (and unamended) conditions did report sporadic detections of MNX (as well as DNX and TNX) (Fuller et al., 2005), although production of MNX in another unsaturated soil was not observed even when RDX was degraded

(Ringelberg et al., 2003). MNX has been confirmed as a product from RDX photolysis (Peyton et al., 1999), so some of the observed MNX may have arisen from sunlight interactions with the particulate Composition B at the soil surface. Furthermore, the lack of detection of MNX in any samples from the PO2 plots (all values were at or below the detection limit) likely reflects binding and further degradation of MNX in the PMSO material as opposed to lack of RDX degradation.

The average cumulative mass and flux of RDX in the control and treatments calculated at depths of 30 cm and 75 cm are presented in Figs. 3 and 4, respectively. Corresponding data for MNX cumulative mass is presented in Fig. 5. For RDX, the cumulative mass is approximately 60-fold and 120-fold higher in the CON plots compared to the PO2 plots at depths of 30 and 75 cm, respectively. The cumulative RDX mass at 30 cm in the PO1 was approximately 50% of that observed in the CON plots, but was at least 100-fold lower than the CON plots at a depth of 75 cm. Evaluation of explosive flux among the soil plots provided an assessment on the potential impacts of the PMSO treatments on transient pore water quality during precipitation events. The estimated RDX fluxes were 1000- and 100-fold lower at depths of 30 and 75 cm, respectively, in the PO2 plots compared to the CON plots. RDX fluxes in the PO1 plots were similar to the CON plots at 30 cm (generally less than 10-fold difference), but were on the order of 10,000-fold lower at 75 cm. Comparison of the explosive flux data to the rain flux data indicate that explosive flux was positively correlated to the rain flux, and that the PO2 treatment is effective at reducing explosive flux at both high and low rain flux conditions. Cumulative masses of MNX paralleled the RDX results, although the absolute cumulative mass values were 30- to 100-fold lower. MNX fluxes exhibited trends similar to RDX with respect to the several

order of magnitude differences between the control plots and the treatment plots, especially by the end of the field study (SM-2).

*Solid phase results.* For solid phase samples, only RDX was detected with enough frequency for valid comparisons. The final soil profiles of RDX in the plots are shown in Fig. 6. Due to compaction during the geoprobe coring process, the recovered core lengths averaged about 40 cm, and any losses were assumed to be at the deeper depths (e.g. at the bottom of the cores). Soil RDX concentrations at the surface were approximately two orders of magnitude lower in both the PO1 and PO2 plots compared to the CON plots. Soil concentrations decreased much more quickly as a function of depth in the PO2 than in the PO1 plots. Soil concentrations in the CON plots dropped 100-fold within the top 5 cm of soil, then only slowly decreased for the remainder of the sample depths. For the PO1 and PO2 plots, average RDX concentrations of  $2329 \pm 855$  and  $995 \pm 497$  mg kg<sup>-1</sup> were measured in the top 2.5 cm of PMSO, respectively. Average RDX in the remaining 7.5 cm of the PMSO layer was  $458 \pm 155$  and  $454 \pm 103$  mg kg<sup>-1</sup> for the PO1 and PO2 plots, respectively. These soil results are consistent with the aqueous results, indicating that the PMSO treatment inhibited the dissolved flux of explosive compounds through the soil plots.

The highest RDX and other compound concentrations in the surface soil and the PMSO layer at the end of the evaluation were observed in the 0.5 to 2 mm size fraction, with significant concentrations also detected in the < 0.5 mm fraction. These results are consistent with the size of the Composition B residues applied (~1 mm), and also with the likelihood that the 1 mm particles decreased in size during the evaluation. These trends were observed to a depth of 3.75 cm below the soil surface in the CON plots, indicating that particulate Composition B likely migrated into the soil. These data are also indicative that any RDX and TNT that dissolved from

the particulate Composition B partitioned onto the smaller clays in the CON plots and the clay-sized peat moss in the treatment plots, the latter being consistent with previous research regarding changes in explosive compound adsorption coefficient values as a function of peat moss size fractions (Fuller et al., 2005).

*Mass balances.* Mass balance calculations for RDX and TNT are presented in Table 1. Most of the RDX mass was recovered in the solid phase at the end of the evaluation, consisting of the topmost layers of soil in the CON plots and the uppermost part of the PMSO layer in the PO1 and PO2 plots. Overall percent recovery of RDX was similar for both the control and the treatment plots, but TNT recovery was higher in the control plots, likely due to more extensive TNT transformation in the treatment plots and/or formation of bound residues within the PMSO material.

*Field vs. model predictions.* Migration of RDX and TNT through 10 cm of the PO2 treatment and 15 cm of soil were evaluated using a previously developed model (Schaefer et al., 2005). Although the experimental soil plot data were not intended to provide a field-scale validation of the model, the observed consistency between the simulations and experimental results provides confirmation and insight regarding the processes that mitigate explosive transport (e.g., sorption and biodegradation) in the PMSO treatments. For purposes of a screening-level evaluation, steady water flow of 50 cm  $y^{-1}$  (average flow through the soil plots) was assumed in the model. Model simulations also assume that no depletion of the crude soybean oil occurred. TNT simulation results showed that no TNT detections would ever be expected at 15 cm with PMSO treatment approximately 2.5 years would be needed before TNT concentrations were detectable at the 15 cm depth with no PMSO treatment. RDX simulation

results showed that concentrations would reach steady values (i.e., equal to the dissolved concentration of RDX percolating through the emplaced explosive residues, with a maximum of 30 mg L<sup>-1</sup>) in the control plots at a depth of 15 cm at approximately 370 d. This simulation time appears generally consistent with the RDX data shown in Fig. 1a. For RDX in the PO2 plots, the model indicated that no measurable RDX would be expected to ever migrate 10 cm into the soil column, primarily due to PMSO-enhanced biodegradation of RDX. Similar simulation results were obtained for RDX using PO1 treatment. Based on these simulation results, the observed migration of RDX in the PO1 treatments is likely due to a reduced level of RDX biodegradation relative to the PO2 treatment, resulting from a depletion of the soybean oil substrate in the PO1 field plot. This suggests that the elevated oil dosage used in the PO2 treatment was more effective for sustaining optimum RDX biodegradation rates.

*Conclusions.* The results reported here clearly demonstrate the potential for this PMSO technology to substantially reduce the subsurface and groundwater loading of explosive residues generated during munition-related activities. RDX and MNX fluxes were reduced by several hundred-fold using a 10 cm layer of a mixture of 1:2 peat moss:crude soybean oil compared to the untreated control. While this research evaluated the effectiveness of a continuous surface-applied layer of PMSO, the actual field application of the technology as a buried, in-place treatment layer or as material tilled into the top 30 cm of the soil would be expected to mitigate downward explosive compound transport. PMSO is composed of inexpensive, environmental benign materials, and is easy to prepare and handle. This PMSO technology could be added to a sustainable range program with minimal cost and effort, and would be applicable at many different types of sites, including grenade ranges, open burn/open detonation (OB/OD) areas, and

other target areas. Based on unpublished data that has shown the effectiveness of PMSO for immobilizing and promoting the degradation of propellant components like nitroglycerin and 2,4- and 2,6-dinitrotoluene, it would be useful for mortar firing points.

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## REFERENCES

- Clausen, J., Robb, J., Curry, D., Korte, N., 2004. A case study of contamination on military ranges: Camp Edwards, Massachusetts, USA. *Environ. Pollut.* 129, 13-21.
- Fares, A., Alva, A.K., 2000. Soil water components based on capacitance probes in a sandy soil. *Soil Sci. Soc. Amer. J.* 64, 311-318.
- Fuller, M.E., Hatzinger, P.B., Rungkamol, D., Schuster, R.L., Steffan, R.J., 2004. Enhancing the attenuation of explosives in surface soils at military facilities: Combined sorption and biodegradation. *Environ. Toxicol. Chem.* 23, 313-324.
- Fuller, M.E., Lowey, J.M., Schaefer, C.E., Steffan, R.J., 2005. A peat moss-based technology for mitigating residues of the explosives TNT, RDX, and HMX in soil. *Soil Sediment Contam.* 14, 373-385.
- Hatzinger, P.B., Fuller, M.E., Rungkamol, D., Schuster, R.L., Steffan, R.J., 2004. Enhancing the attenuation of explosives in surface soils at military facilities: Sorption-desorption isotherms. *Environ. Toxicol. Chem.* 23, 306-312.
- Jenkins, T.F., Pennington, J.C., Ranney, T.A., Berry, Jr., T.E., Miyares, P.H., Walsh, M.E., Hewitt, A.D., Perron, N.M., Parker, L.V., Hayes, C.A., Wahlgren, E.G., 2001. Characterization Of Explosives Contamination At Military Firing Ranges. U.S. Army Corps of Engineers, Engineer Research and Development Center, Hanover, NH, USA. Report #ERDC TR-01-5.
- Major, M.A., Checkai, R.T., Phillips, C.T., Wentsel, R.S., 1991. Method for screening and analysis of residues common to munition open burning/open detonation (OB/OD) sites. *Int. J. Environ. Anal. Chem.* 48, 217-227.
- Pennington, J.C., Jenkins, T.F., Ampleman, G., Thiboutot, S., Brannon, J.M., Hewitt, A.D., Lewis, J., Brochu, S., Diaz, E., Walsh, M.R., Walsh, M.E., Taylor, S., Lynch, J.C., Clausen, J., Ranney, T.A., Ramsey, C.A., Hayes, C.A., Grant, C.L., Collins, C.M., Bigl, S.R., Yost, S.L., Dontsova, K.M., 2006. Distribution And Fate Of Energetics On DoD Test And Training Ranges: Final Report. U.S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS, USA. Report #ERDC TR-06-13.
- Peyton, G., LeFaivre, M., Maloney, S., 1999. Verification Of RDX Photolysis Mechanism. U.S. Army Corps of Engineers, Engineer Research and Development Center, Washington, D.C., USA. Report #CERL TR 99/93.

- Ringelberg, D.B., Reynolds, C.M., Walsh, M.E., Jenkins, T.F., 2003. RDX loss in a surface soil under saturated and well drained conditions. *J. Environ. Qual.* 32, 1244-1249.
- Rodgers, J.D., Bunce, N.J., 2001. Treatment methods for the remediation of nitroaromatic explosives. *Water Res.* 35, 2101-2111.
- Schaefer, C.E., Fuller, M.E., Lowey, J.M., Steffan, R.J., 2005. Use of peat moss amended with soybean oil for mitigation of dissolved explosive compounds leaching into the subsurface: Insight into mass transfer mechanisms. *Environ. Eng. Sci.* 22, 337-349.
- Taylor, S., Hewitt, A., Lever, J., Hayes, C., Perovich, L., Thorne, P., Daghlian, C., 2004. TNT particle size distributions from detonated 155-mm howitzer rounds. *Chemosphere* 55, 357-367.
- USGAO, 2001. *Environmental Liabilities: DoD Training Range Cleanup Cost Estimates Are Likely Understated.* United States General Accounting Office, Washington, DC.

Table 1. Mass balances of TNT and RDX in the soil plots.

<b>RDX</b>	<b>CON</b>	<b>PO1</b>	<b>PO2</b>
<b>mg Applied</b>	<b>5,612</b>	<b>5,612</b>	<b>5,612</b>
<b>mg Recovered</b>			
Aqueous	105	0.3±0.5	0.3±0.5
PMSO	-	4,041±1,066	3,290±1,340
Soil - Top layers	3,219	47±54	45±13
Soil - Lower	328	49±78	10±11
<b>Total</b>	<b>3,793</b>	<b>4,139±1,162</b>	<b>3,345±1,361</b>
<b>% Recovered</b>			
Aqueous	2	0±0	0±0
PMSO	-	72±19	59±24
Soil - Top layers	57	1±1	0.8±0.2
Soil - Lower	6	1±1	0.2±0.2
<b>Total</b>	<b>68</b>	<b>74±21</b>	<b>60±24</b>
<b>TNT</b>			
<b>mg Applied</b>	<b>Control</b>	<b>PO1</b>	<b>PO2</b>
<b>mg Applied</b>	<b>3,451</b>	<b>3,451</b>	<b>3,451</b>
<b>mg Recovered</b>			
Aqueous	-	-	-
PMSO	-	74±129	123±166
Soil - Top layers	780	2±3	0±0
Soil - Lower	9	-	-
Plant biomass	28	0±0	0
<b>Total</b>	<b>813</b>	<b>76±132</b>	<b>123±166</b>
<b>% Recovered</b>			
Aqueous	-	-	-
PMSO	-	2±4	4±5
Soil - Top layers	23	0.1±0.1	0±0
Soil - Lower	0	-	-
Plant biomass	1	0±0	0
<b>Total</b>	<b>24</b>	<b>2±4</b>	<b>4±5</b>

-, Not applicable or no data collected.

Fig. 1. Concentrations of RDX in pore water at three different depths in the soil plots. Data are average concentrations in control plots (n = 2) and treatment plots (n = 3), and standard deviations are shown when applicable. The dashed horizontal line represents the MDL for RDX. Missing columns indicate that no data was available for a given treatment at given timepoint. Datapoints measured as below the reporting limit were set to one-half the MDL.

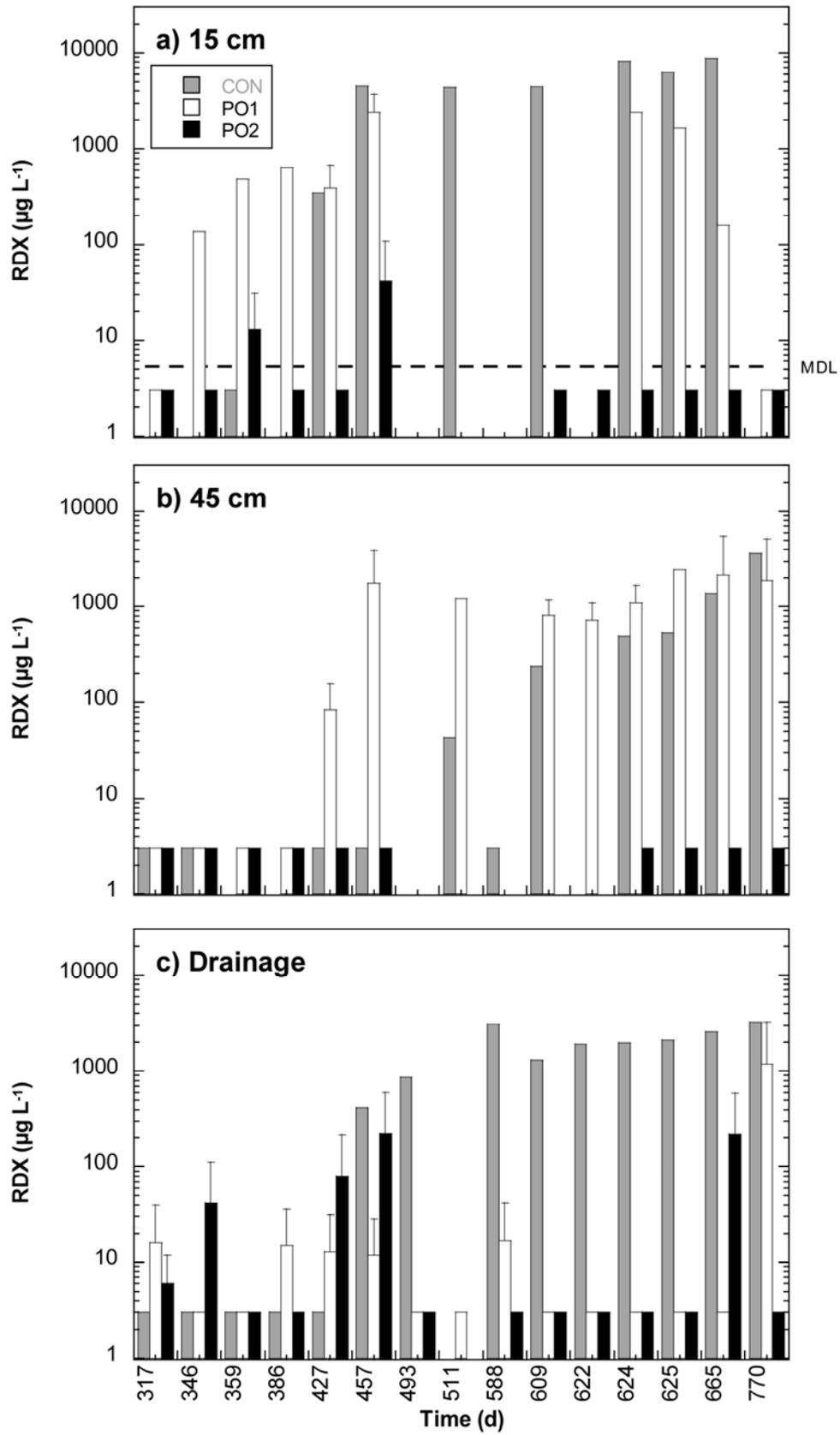
Fig. 2. Concentrations of MNX in pore water at three different depths in the soil plots. Data are average concentrations in control plots (n = 2) and treatment plots (n = 3), and standard deviations are shown when applicable. The dashed horizontal line represents the MDL for MNX. Missing columns indicate that no data was available for a given treatment at given timepoint. Datapoints measured as below the reporting limit were set to one-half the MDL.

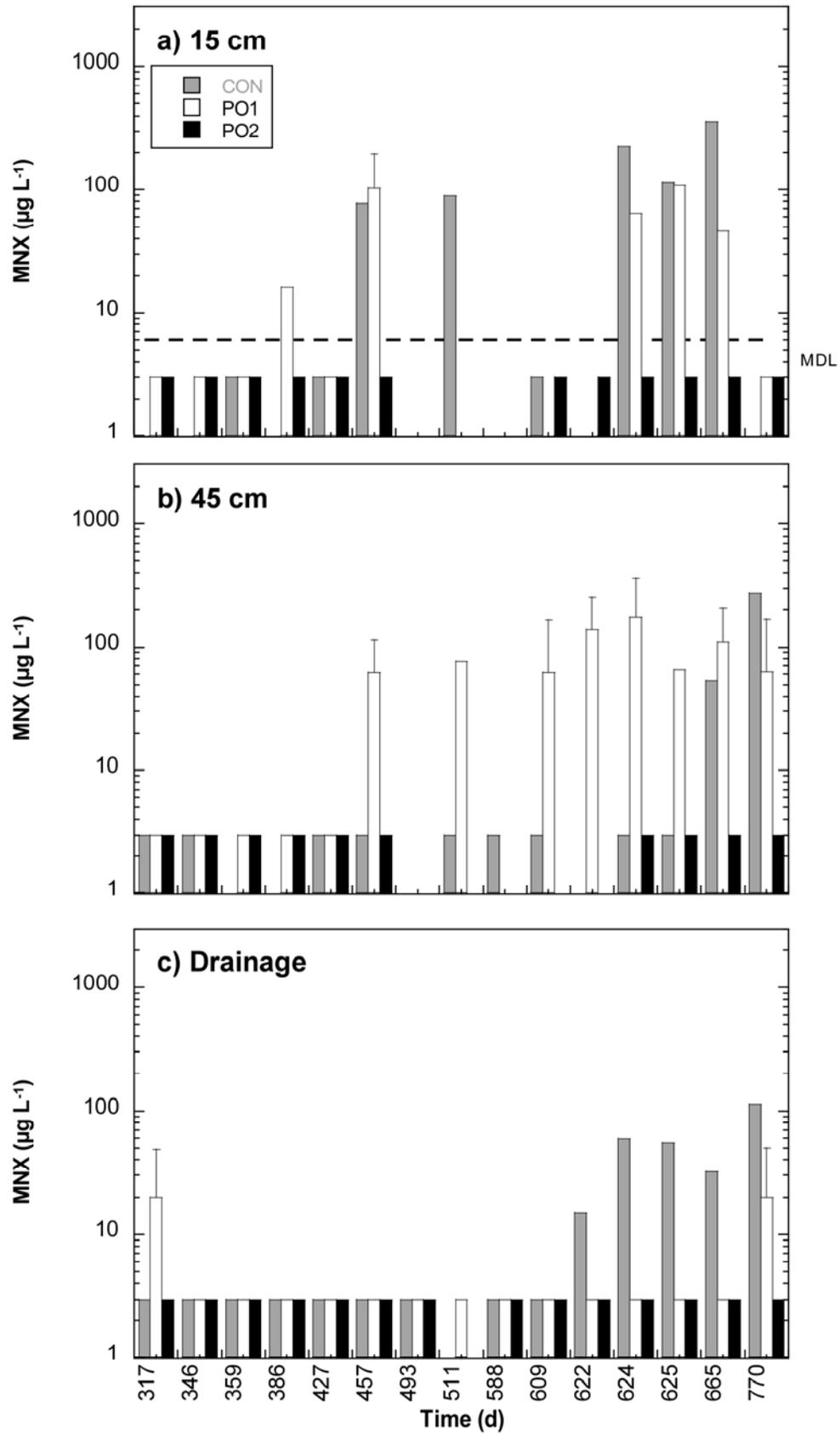
Fig. 3. Mass of RDX passing through two different depths in the soil plots. Data are average masses in control plots (n = 2) and treatment plots (n = 3), and standard deviations are shown when applicable.

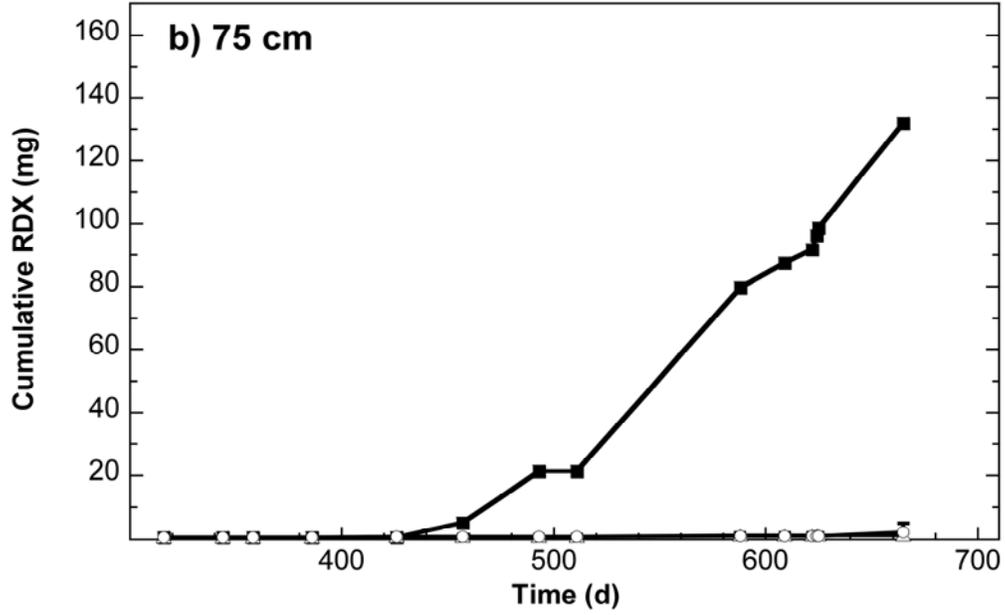
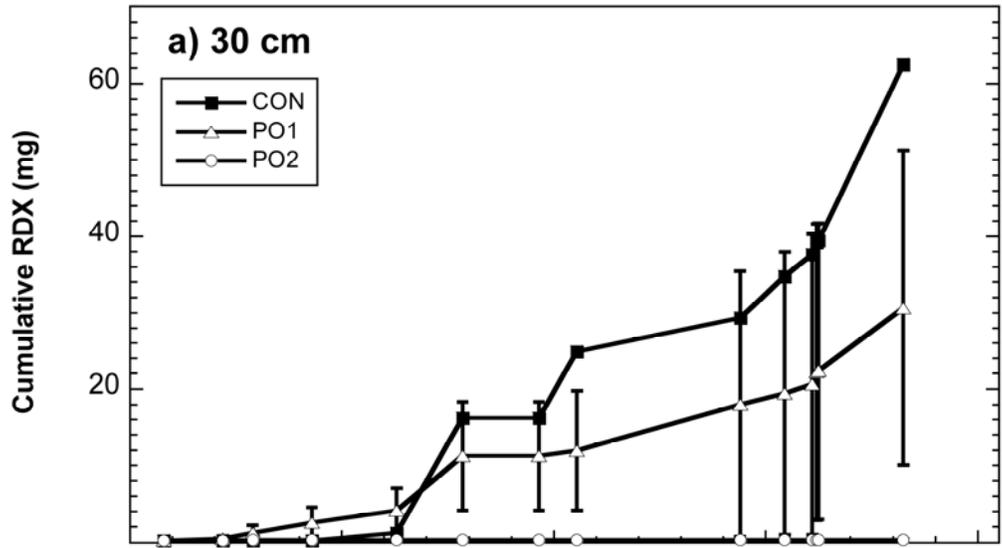
Fig. 4. Flux of RDX passing through two different depths in the soil plots. Data are average fluxes in control plots (n = 2) and treatment plots (n = 3), and standard deviations are shown when applicable. The dashed line represents the flux of precipitation falling onto the plots.

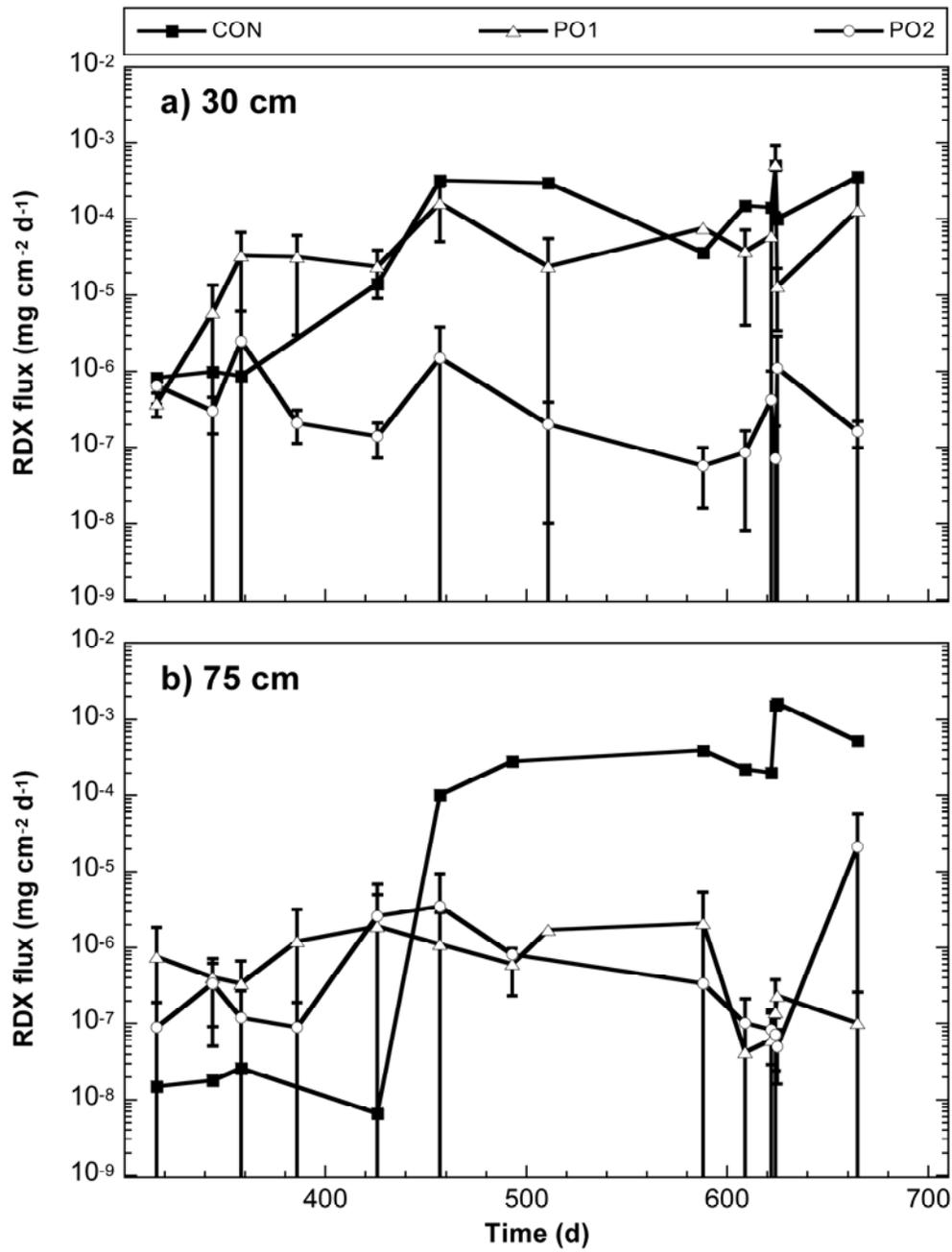
Fig. 5. Mass of MNX passing through two different depths in the soil plots. Data are average masses in control plots (n = 2) and treatment plots (n = 3), and standard deviations are shown when applicable.

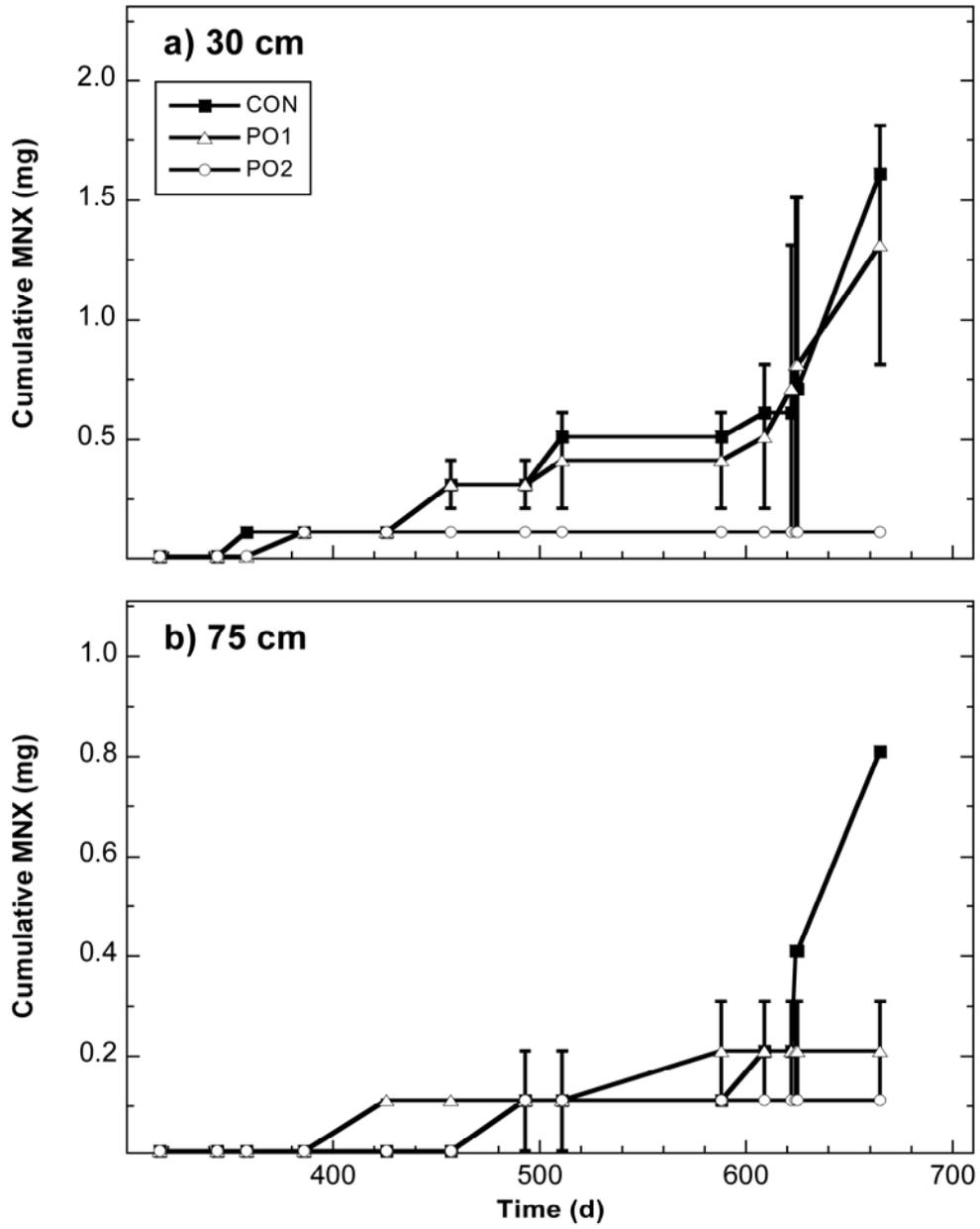
Fig. 6. Profile of total soil RDX concentrations in the plots as a function of depth. Data are average concentrations in control plots (n = 2) and treatment plots (n = 3), and standard deviations are shown when applicable. The detection limit is represented by the dashed line.

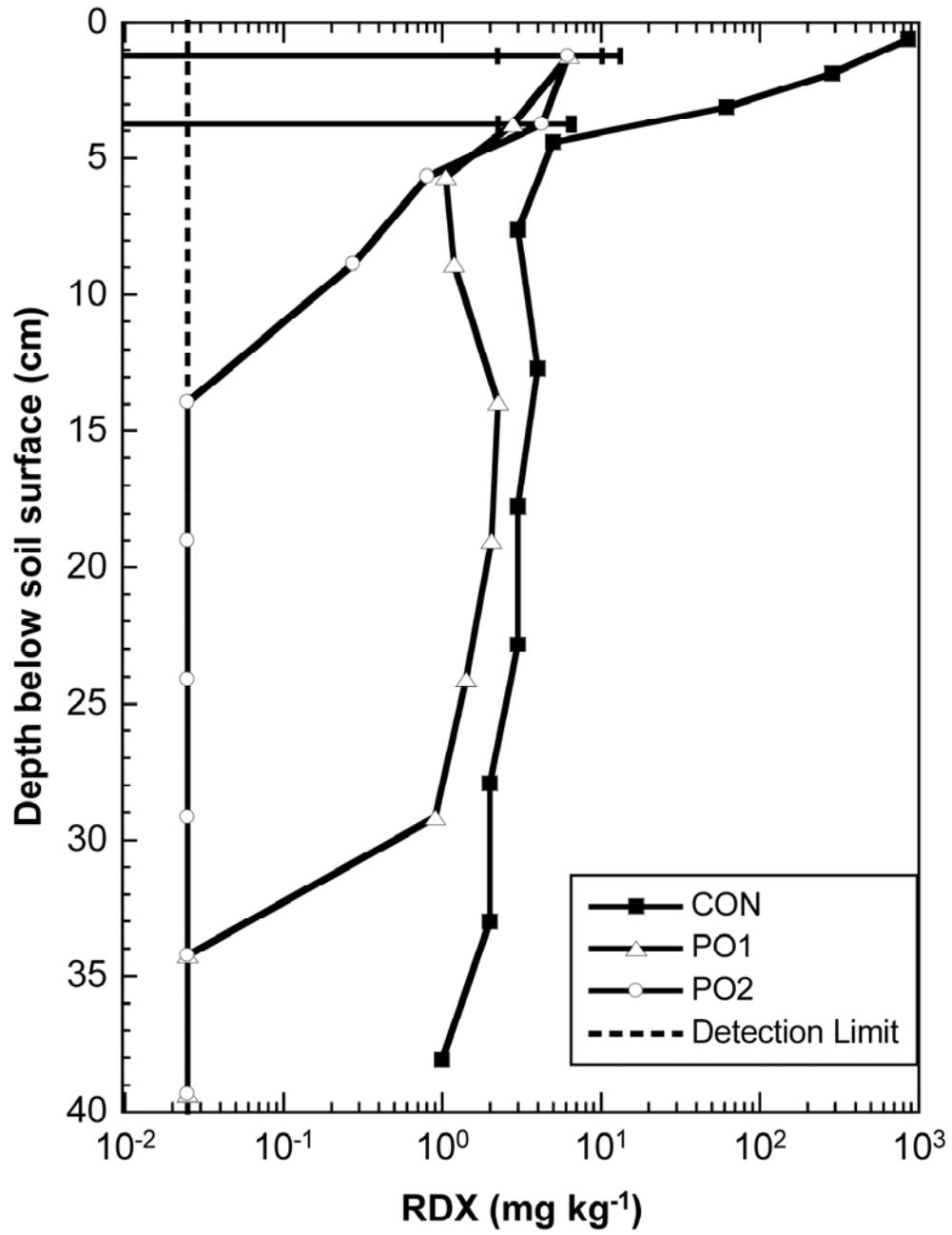






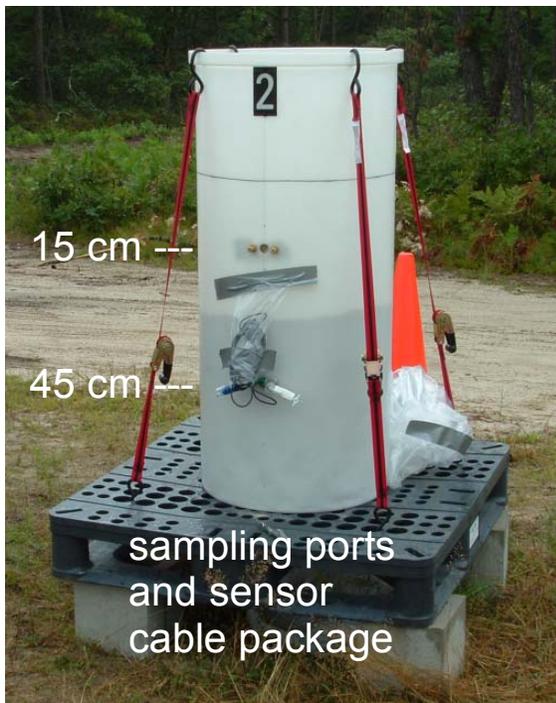
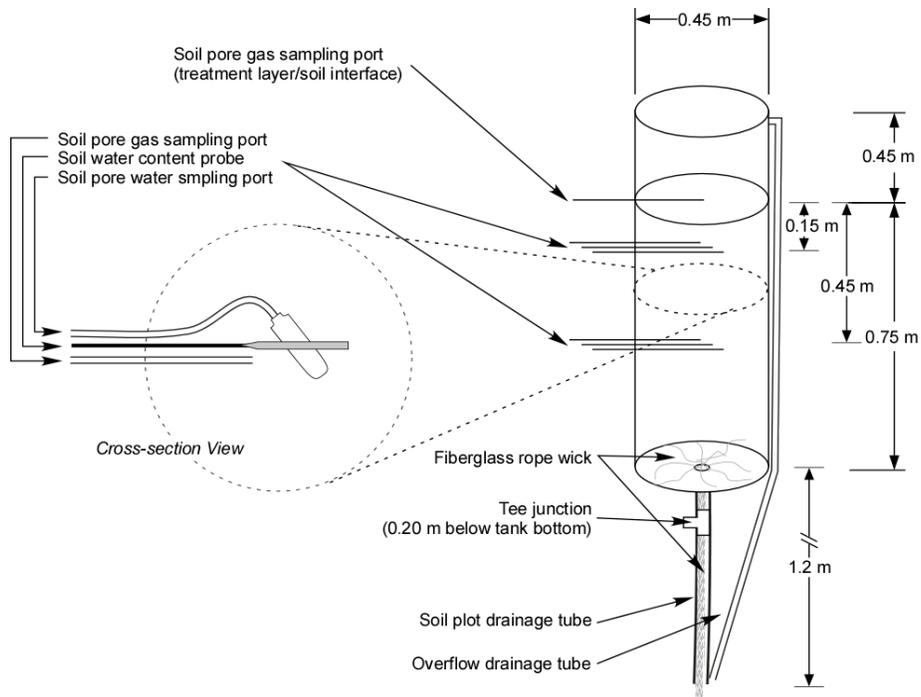






### Supplemental Information

SM-1. Schematic and photographs of the soil plot apparatus and final placement of the soil plots on the elevated pallet racks.



SM-2. Flux of MNX passing through two different depths in the soil plots. Data are average fluxes in control plots (n = 2) and treatment plots (n = 3), and standard deviations are shown when applicable. The dashed line represents the flux of precipitation falling onto the plots.

