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Task Order 7
Use of Activated Carbon for Treatment of Explosives-Contaminated Groundwater at the Milan Army Ammunition Plant (MAAP)

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Aberdeen Proving Ground, Maryland 21010-5401

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USE OF ACTIVATED CARBON FOR TREATMENT OF EXPLOSIVES-CONTAMINATED GROUNDWATER AT THE MILAN ARMY AMMUNITION PLANT (MAAP)

Final Report
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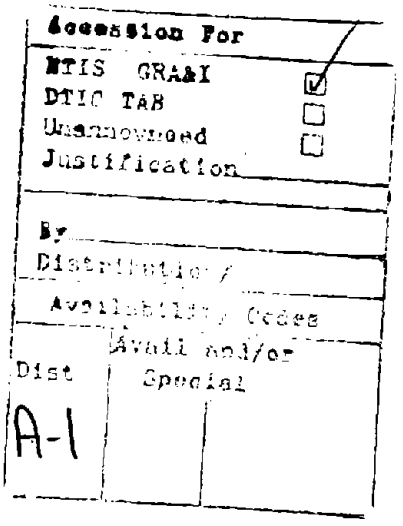
May 1990



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The primary objective of this task was to determine the feasibility of using GAC to treat explosives-contaminated groundwater at the Milan Army Ammunition Plant (MAAP) in Milan, Tennessee. Laboratory GAC isotherm studies were conducted and two carbons, Atochem, Inc. GAC 830 and Calgon Filtrasorb 300, were selected for further testing in continuous flow GAC columns. Three pilot scale continuous flow GAC column tests were performed at MAAP using the two carbons selected from the laboratory GAC isotherm studies. The results from the laboratory and pilot studies are presented in this report. They show that concurrent removal of TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB, from groundwater using continuous flow granular activated carbon is feasible.

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1,3,5-TNB; 1,3,5-Trinitrobenzene
NB; Nitrobenzene
explosives
Field laboratory
Granular Activated Carbon (GAC)
isotherms
Pilot plant

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EXECUTIVE SUMMARY

The United States Army operates explosives manufacturing plants to produce various forms of explosives and load, assemble, and pack (LAP) plants to load explosives into military ordnance. Manufacturing activities at such plants also produce process wastewaters that contain both explosives residues and other organic chemicals. Several treatment technologies have been developed and are currently in use to treat these wastewaters for final discharge.

Past waste handling practices at explosives manufacturing and LAP plants often utilized unlined lagoons or pits to contain process wastewaters. As a result of this practice, some explosives residues have leached through the soil and contaminated groundwater. Therefore, groundwater treatment may be required. Based upon process wastewater treatment experience, potentially applicable treatment technologies are available. However, the similarities and differences between process wastewaters and explosives-contaminated groundwater should be considered before transferring technologies from one application to another.

Process wastewaters at explosives manufacturing and LAP plants are often treated by activated carbon adsorption. This treatment has been documented in the literature. Therefore, based upon process wastewater treatment experience, activated carbon adsorption might work for the treatment of explosives-contaminated groundwater. However, because of the similarities and differences between process wastewaters and explosives-contaminated groundwater, the feasibility of using activated carbon adsorption for treatment of this groundwater should be determined.

Explosives-contaminated water has percolated from the O-line ponds at the Milan Army Ammunition Plant (MAAP) in Milan, Tennessee into the upper and middle part of the Claiborne aquifer underlying MAAP. Migration of these wastes is expected to continue in the groundwater flow system and thereby contaminate additional groundwater and possibly surface water in the area. The chemical wastes that are of major concern at MAAP are 2,4,6-trinitrotoluene (TNT), cyclotrimethylenetrinitramine (RDX), cyclotetramethylenetetranitramine (HMX), 2,4,6-trinitrophenylmethylnitramine (Tetryl), 2,4-dinitrotoluene (2,4-DNT), 2,6-dinitrotoluene (2,6-DNT), 1,3-dinitrobenzene (1,3-DNB), 1,3,5-trinitrobenzene (1,3,5-TNB), and nitrobenzene (NB).

The primary objective of this pilot study was to determine the feasibility of using granular activated carbon (GAC) to treat explosives-contaminated groundwater. The explosive contaminants studied were TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB. The study included preliminary batch (isotherm) testing followed by column testing using a continuous flow pilot plant.

Laboratory GAC isotherm studies were conducted to evaluate the ability of activated carbon to remove TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3,5-TNB, and NB from the explosives-contaminated groundwater at MAAP.

Two carbons were selected for further testing in continuous flow GAC columns at MAAP. Calgon Filtrasorb 300 was selected as representative of three Filtrasorb carbons. Atochem, Inc. GAC 830, which is currently being used at MAAP to treat pink water (wastewater from LAP operations), was selected because the task order required that the carbon currently in use at MAAP be tested. However, Atochem, Inc. GAC 830 was also selected because it was comparable to the three Filtrasorb carbons and better than Hydrodarco 4000 with respect to RDX maximum saturation capacity.

Three pilot scale, continuous flow GAC column tests were performed at MAAP using the two selected carbons. The focus of the test program was to determine the feasibility of using GAC to treat explosives-contaminated groundwater based upon pilot-scale testing.

Tests One, Two, and Three were run for 7.6, 16.5, and 54.5 days, respectively, between September and December 1989. The variables examined were TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB concentrations in the influent groundwater from monitor well MI051 and in the column effluent. Other variables examined included influent water temperature, pH, and flow rate. Samples were analyzed for explosives by high pressure liquid chromatography (HPLC) utilizing a modified USATHAMA Method UW01 in Roy F. Weston, Inc.'s (WESTON's) field laboratory. Six percent of the field laboratory samples were also analyzed for explosives using USATHAMA method UW01 by WESTON's Analytics Division in Lionville, Pennsylvania.

At average influent explosives concentrations encountered during Test Three of this study, effluent levels less than or equal to 1.0 ug/L for TNT and RDX and less than the detection limits for HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB can be maintained for 26 days (18,323 bed volumes) with two GAC columns in series each containing 0.197 ft^3 of either Atochem, Inc. GAC 830 or Calgon Filtrasorb 300 and operating at a hydraulic loading of 7.6 gpm/ft^2.

The following conclusions were drawn from this study:

- The concurrent removal of TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB from groundwater using continuous flow granular activated carbon is feasible.
- Based upon isotherm tests and continuous flow GAC column tests at MAAP performed in this study, Atochem, Inc. GAC 830 and Calgon Filtrasorb 300 are equivalent in their ability to remove TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB from the explosives-contaminated groundwater at MAAP.

SECTION 1

INTRODUCTION

1.1 BACKGROUND

The United States Army operates explosives manufacturing plants to produce various forms of explosives and load, assemble, and pack (LAP) plants to load explosives into military ordnance. Manufacturing activities at such plants also produce process wastewaters that contain both explosive residues and other organic chemicals. Several treatment technologies have been developed and are currently in use to treat these wastewaters for final discharge.

Past waste handling practices at explosives manufacturing and LAP plants often utilized unlined lagoons or pits to contain process wastewaters. As a result of this practice, some explosive residues have leached through the soil and contaminated groundwater. Therefore, groundwater treatment may be required. Based upon process wastewater treatment experience, potentially applicable treatment technologies are available. However, the similarities and differences between process wastewaters and explosives-contaminated groundwater should be considered before transferring technologies from one application to another.

The investigation of remedial needs and solutions at Army-controlled sites is managed by the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). USATHAMA has retained Roy F. Weston, Inc. (WESTON) to help develop appropriate remedial technologies. Under this contract, USATHAMA has decided to investigate treatment technologies for explosives-contaminated groundwater.

Process wastewaters at explosives manufacturing and LAP plants are often treated by activated carbon adsorption. This treatment has been documented in the literature [1,2,3,4]. Therefore, based upon process wastewater treatment experience, activated carbon adsorption might work for the treatment of explosives-contaminated groundwater. However, because of the similarities and differences between process wastewaters and explosives-contaminated groundwater, the feasibility of using activated carbon adsorption for treatment of this groundwater should be determined.

1.2 PROBLEM STATEMENT

Explosives-contaminated water has percolated from the O-line ponds at the Milan Army Ammunition Plant (MAAP) in Milan, Tennessee (see Figure 1-1) into the upper and middle part of the Claiborne aquifer underlying MAAP. Migration of these wastes is expected to continue in the groundwater flow system and thereby contaminate additional groundwater and possibly surface water in the area. The chemical wastes that are of major concern at MAAP are 2,4,6-trinitrotoluene (TNT), cyclotrimethylenetrinitramine (RDX), cyclotetramethylenetetranitramine (HMX); 2,4,6-trinitrophenylmethylnitramine (Tetryl), 2,4-dinitrotoluene (2,4-DNT), 2,6-dinitrotoluene (2,6-DNT), 1,3-dinitrobenzene (1,3-DNB), 1,3,5-trinitrobenzene (1,3,5-TNB), and nitrobenzene (NB).

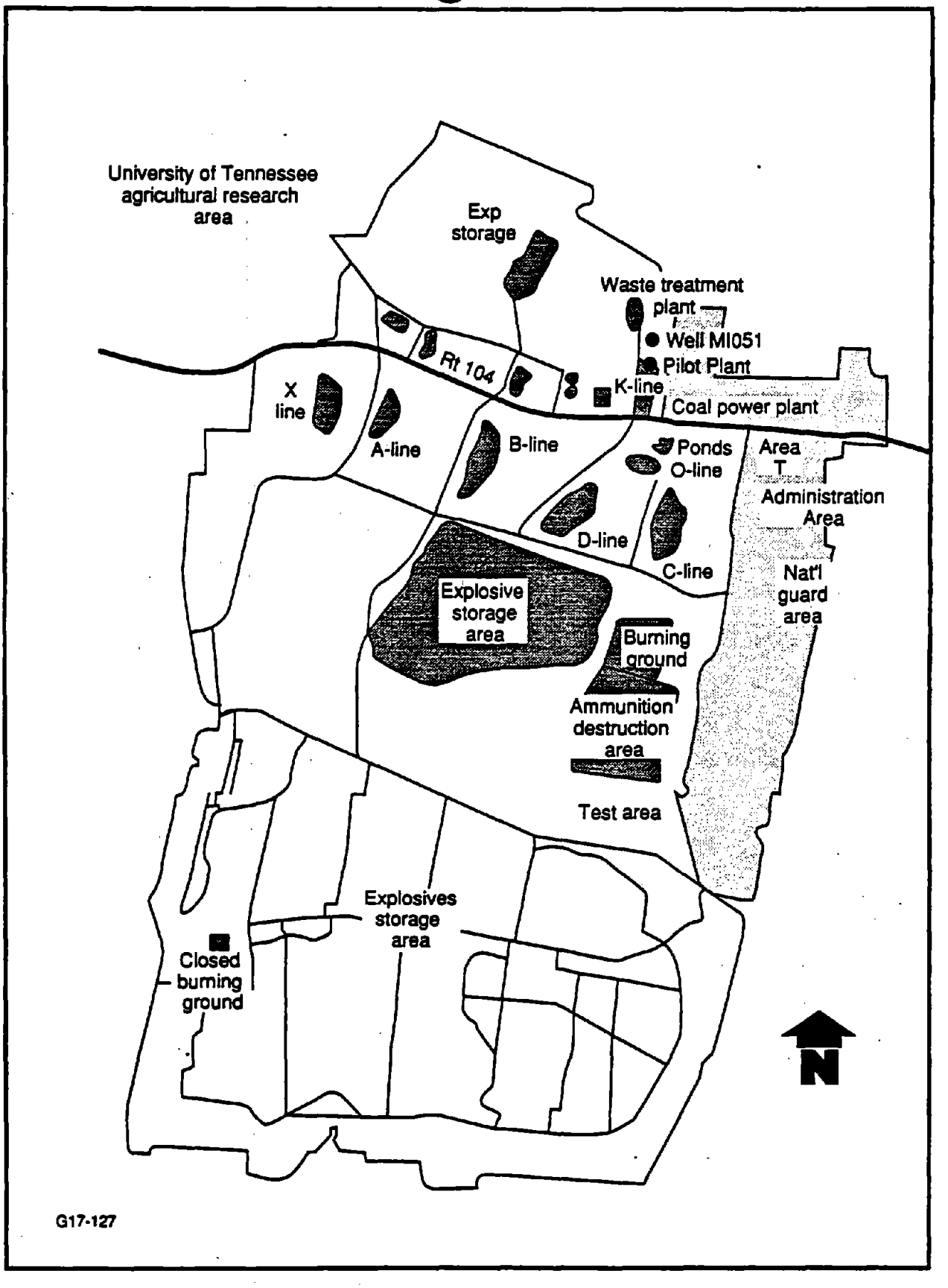


FIGURE 1-1 SITE MAP OF MILAN ARMY AMMUNITION PLANT FACILITY

This pilot study was conducted to determine the best quality effluent achievable using carbon adsorption to treat groundwater from monitor well MI051 at MAAP.

1.3 PREVIOUS WORK

Much of the currently available literature describing the use of granular activated carbon (GAC) for the treatment of explosives-contaminated wastewaters is for pink water treatment [1,2,3,4]. Pink water is the explosives-contaminated washwater produced from the load, assemble, and pack of ammunition. While the treatment of wastewater and groundwater is expected to be similar, there are several important differences that may affect the application of this technology to groundwater:

- Explosives concentrations in pink water are likely to be substantially higher, and the concentration levels are expected to be more variable than in groundwater.
- The pH of pink water is typically acidic, while the pH of groundwater may be neutral or variable.
- Effluent criteria for treated groundwater may be more stringent than for pink water, particularly if recharge to groundwater is required.
- Interferences and competition among other components of the groundwater may affect removal of the explosive components.

1.4 PROJECT OBJECTIVE

The primary objective of this pilot study was to determine the feasibility of using GAC to treat explosives-contaminated groundwater. The explosive contaminants studied were TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB. The study included preliminary batch (isotherm) testing followed by column testing using a continuous flow pilot plant.

SECTION 2

BACKGROUND

2.1 LITERATURE UPDATE

As discussed in Section 1, much of the currently available literature describes the treatment of pink water instead of explosives-contaminated groundwater. References are available on the use of activated carbon to remove explosives from pink water [1]. However, the application of this technology to groundwater is limited.

2.2 PREVIOUS USATHAMA INVESTIGATIONS

A previous USATHAMA report [3] presents a multiphase study providing quantitative data on the ability of activated carbon to remove the nitrobodies TNT, 2,4-DNT, RDX, and HMX from pink water. This study included the following phases:

- Preliminary activated carbon screening.
- Isotherm tests of activated carbon.
- Preliminary column tests of selected activated carbons.
- Four-in-series column tests.
- Economic analysis of activated carbon.

These phases are described in the following subsections.

2.2.1 PRELIMINARY ACTIVATED CARBON SCREENING

Using manufacturer's data (see Table 2-1) and literature reference in the USATHAMA report [3], activated carbon screening was conducted to evaluate and select various carbons for further testing. The following criteria were considered:

- High surface area.
- High pore volume.
- High iodine number.
- Low average (mean) particle diameter.
- Low pressure drop (headloss).
- Frequency of use at existing facilities.
- Low cost.
- Manufacturer's recommendations.

Based upon these criteria, five carbons were selected for further evaluation. These carbons included:

- Calgon Filtrasorb 200.
- Calgon Filtrasorb 300.
- Calgon Filtrasorb 400.
- Westvaco Nuchar WV-G.
- Witco Witcarb 950.

Table 2-1

Activated Carbon Manufacturers' Data

Criteria	Calgon Filtrasorb 200	Calgon Filtrasorb 300	Calgon Filtrasorb 400	Westvaco Nuchar WV-G	Witco Witcarb 950
Specific Surface Area, m^2/g	850-900	950-1,050	1,000-1,200	1,100	1,000-1,100
Pore Volume, cm^3/g	N/A*	0.85	0.94	N/A*	27
Iodine Number	850	900	1,000	1,050	1,050
Mean Particle Diameter, mm	0.8-1.0	1.5-1.7	0.9-1.1	0.9-1.2	N/A*

*N/A = Not available.

2.2.2 ISOTHERM TESTS

Isotherm tests were conducted on the five carbons listed above. These tests were used to select the best performing carbon for further investigation using continuous flow carbon columns. The results of the isotherm tests showed that the consistently best performing activated carbon was Witco Witcarb 950. The results also showed that equilibrium conditions could be reached at the desired effluent limits (shown in Subsection 2.2.3) given a high enough carbon dosage (i.e., ≥1,000 mg/L of carbon). However, Witco Chemical Corporation stopped production of all of their activated carbon in late 1985. Therefore, no Witco activated carbon was used in the MAAP isotherm tests.

2.2.3 PRELIMINARY COLUMN TESTS

The four explosives compounds of interest were studied in column testing. The following point source effluent goals were used as performance criteria:

Nitrobody Compound	Effluent Limit* (mg/L)
TNT	0.04
RDX	0.03
HMX	0.03
2,4-DNT	0.0007

Preliminary column tests were performed in the laboratory using "synthetic" pink water to develop design parameters for a pilot-scale, multiple-column test. To prepare this water, the four nitrobodies of interest (TNT, RDX, HMX, and 2,4-DNT) were first dissolved in acetone and then diluted so that the final acetone level was only 0.20 to 0.44 percent on a volumetric basis. The results of the preliminary column tests showed that activated carbon became saturated with RDX and HMX more rapidly than with TNT and DNT. In addition, the results showed that fewer than five columns in series were necessary for optimum performance.

2.2.3.1 Four-in-Series Column Tests

Based on the results of the isotherm and preliminary column tests, pilot-scale column tests were performed with four columns in series using the Witco Witcarb 950 activated carbon for the treatment of Army Ammunition Plant (AAP) pink water. The effluent criteria were generally met for RDX, HMX, and 2,4-DNT but not for TNT. The TNT performance limitation was determined to be a physicochemical phenomenon that produced little change in TNT concentration beyond the first column in the series. Since this phenomenon did not appear during the isotherm tests, it stresses the need to perform column tests with the wastewaters to be treated.

*Recommended interim criteria for munition compounds for protection of human health [3].

Pilot-scale testing is usually the next step between laboratory-scale testing (isotherm testing) and full-scale design and construction. This testing allows the engineer to develop design parameters more accurately for full-scale systems.

2.2.3.2 Effects of pH on Adsorption of Explosives

The effect of pH on the ability of activated carbon to remove explosive compounds from a munition-manufacturing waste has been evaluated [1]. Experiments indicate that activated carbon may have a greater reserve capacity for TNT and other explosives if wastes applied to it are acidic. A comparison of the slopes of the isotherms showed that the adsorption efficiency was greater at pH 2.0 than pH 7.6. During column tests at a neutral pH, breakthrough of TNT was almost immediate. In addition, the carbon was exhausted in less than one-half the time required to exhaust a similar column used to treat acidic wastes.

2.2.4 CARBON REGENERATION PROPERTIES

A primary factor in determining the cost-effectiveness of activated carbon treatment is the extent to which the carbon can be regenerated for reuse. This assumes that the effluent criteria can be met with acceptably long carbon bed life. Regeneration of carbon that has been used for adsorption of organics is usually accomplished by a thermal regeneration process. If carbon cannot be effectively regenerated, it must be disposed, possibly as a hazardous waste. Cost-effectiveness of carbon adsorption is reduced both by the cost of such disposal and by the continuing replacement cost of virgin carbon.

The process of carbon regeneration for explosives-contaminated carbons has met with mixed reviews. A report prepared for the U.S. Army Armament Research and Development Command describes the effectiveness and economic feasibility of using a rotary calciner furnace to thermally regenerate spent carbon containing explosives [5]. Other references reported limited success with thermal regeneration due to the explosive nature of adsorption components [6]. Solvent regeneration is also reported as problematic [6]. However, activated carbon treatment systems continue to be used for the treatment of pink water without carbon regeneration. This continued use is probably due to the proven ability of activated carbon to remove the explosive component from wastewater streams.

Calgon Carbon Corporation recently studied the treatment of contaminated groundwater from the Badger Army Ammunition Plant (BAAP). They concluded that spent carbon could be regenerated in their thermal regeneration system provided the carbon explosives concentration is low enough to preclude an uncontrollable auto-oxidation of explosives. Such auto-oxidation might damage the regeneration unit. In addition, Calgon used differential scanning calorimetry to estimate safe carbon explosives concentrations. Their preliminary recommendation is to limit explosives accumulation to about 5 percent by weight [7]. In some applications, this limit, rather than carbon column breakthrough/exhaustion, may determine carbon bed life.

2.3 REGULATORY ISSUES

The Water Quality Control Division of the Tennessee Health and Environment Department (WQCD) has been authorized by the United States Environmental Protection Agency (EPA) to adopt and enforce permits that have been issued by the EPA pursuant to §402 of the Federal Water Pollution Control Act, P.L. 92.500. According to the WQCD, the effluent limit agreed to by the EPA and U.S. Army in the NPDES permits for arsenals is 1.0 ppm of total nitrobodies. This limit applies to discharges to both surface water and groundwater. Because the effluent limit is technology based, the WQCD has no plans to change it at the present time [8].

The WQCD presently has no remedial action limits for explosives-contaminated groundwater other than the previously described effluent limit. Therefore, if the total nitrobodies concentration from any monitor well at MAAP exceeded 1.0 ppm, then treatment/remediation of the explosives-contaminated groundwater might be required. If so, any treatment/remediation technology must reduce the total nitrobodies concentration to below 1.0 ppm. According to the WQCD, the discharge from the selected treatment/remediation technology would not require an additional NPDES permit. Instead, this discharge could be handled by simply amending the existing one [9].

Because dinitrotoluene and nitrobenzene have been designated toxic pollutants pursuant to Section 307(a)(1) of the Clean Water Act, water quality criteria have been established for them pursuant to Section 304(a)(1) of this act. These criteria are unenforceable guidelines that may be used by states to set surface water quality standards.

The water quality criteria for dinitrotoluene for ingestion of contaminated water and contaminated aquatic organisms, which may result in incremental increase of cancer risk over the lifetime (estimated at 10^{-6}), is 0.11 ug/L [10]. For nitrobenzene, the water quality criteria to protect public health is 19.8 mg/L, based on available toxicity data [10].

In addition, unenforceable health advisories have been established by the EPA Office of Drinking Water and the U.S. Army for TNT, RDX, and HMX. These advisories are 2.0 ppb, 2.0 ppb, and 400 ppb, respectively [11]. Furthermore, another advisory is being prepared for 2,4-dinitrotoluene which will provide the basis for a future regulation of it in drinking water [11].

A list of proposed tentative applicable or relevant and appropriate requirements for the Milan Army Ammunition Plant as of July 1989 are in Appendix A. They were prepared as part of a remedial investigation for this site.

2.3.1 SURFACE WATER DISCHARGE

Surface water discharge will require amending the existing permit and meeting an effluent limit of 1.0 ppm of total nitrobodies. This limit should not be difficult to achieve with carbon adsorption technology. However, the

ability to meet specific criteria for individual components described in Subsection 2.3, when and if they become enforceable, warrants investigation.

2.3.2 GROUNDWATER DISCHARGE

Groundwater discharge will require amending the existing permit and meeting an effluent limit of 1.0 ppm of total nitrobodies. This limit should not be difficult to achieve with carbon adsorption technology. However, the ability to meet specific criteria for individual components described in Subsection 2.3, when and if they become enforceable, warrants investigation.

SECTION 3

ISOTHERM TESTS

The primary objective of this pilot study was to determine the feasibility of using granular activated carbon for treatment of groundwater contaminated with explosives. This determination was first made by batch (isotherm) carbon testing with pulverized samples of GAC.

Batch (isotherm) carbon testing consists of a series of batch adsorption experiments in which multiple aliquots of wastewater are treated with varying dosages of GAC. The test containers are agitated until equilibrium is established between the liquid phase and the solid phase. The GAC is then filtered out of the solution and the filtrate is analyzed to determine the equilibrium concentration of the pollutants (or adsorbate) of interest. The data obtained from the analysis are interpreted by plotting the amount of adsorbate adsorbed per unit weight of activated carbon versus the equilibrium concentration of adsorbate remaining in solution.

3.1 TEST PROGRAM

The purpose of batch (isotherm) carbon testing was to evaluate five different types of granular activated carbon in terms of (1) relative adsorbability of explosives, (2) adsorption capacities and associated exhaustion rates for explosives, (3) degrees of removal based on desired effluent objectives, and (4) preferential adsorption of component groups. Based on these criteria, two carbon types were selected for continuous flow pilot testing.

Groundwater from MAAP monitor well MI051 was used in each isotherm test because it was located in the general area of the traveling plume and near the pilot plant area and had a total explosives concentration of greater than 1.0 mg/L. This groundwater was collected and shipped to WESTON's Environmental Technology Laboratory in Lionville, Pennsylvania. The average concentrations of explosives in the groundwater used in the batch (isotherm) carbon testing blanks are shown in Table 3-1, along with each explosive's detection limit.

All isotherm tests were run under nearly identical test conditions to evaluate the effect of the type of carbon, carbon dosage, and pH on the removal of each explosive. Carbons were pulverized and suspended solids present in the groundwater were removed by a Whatman No.1 filter (11 um) prior to mixing the groundwater with the carbon. The removal of suspended solids helped reduce the potential for analytical interferences and carbon fouling. Secondly, all isotherm tests, except for one, were run at a neutral pH (~ pH 7.0). One test was run at a lower pH (~ pH 4.0) to determine any potential advantage of using lower pH values. Thirdly, all isotherm tests were run at an ambient room temperature of about 68°F. Finally, to effectively mix the groundwater and the carbon, an agitation period of 20 hours was employed in each isotherm test. Studies in the literature [3] indicate that this period of time is more than adequate to attain equilibrium when GAC is pulverized.

Table 3-1

Average Concentrations of Explosives in Groundwater
Used in Batch (Isotherm) Carbon Testing Blanks

Explosives	Average Concentration[a] (ug/L)	Detection Limit (ug/L)
TNT	493	0.78[b]
RDX	486	0.63[b]
HMX	2.75	1.30[b]
Tetryl	14.9	0.66[b]
2,4-DNT	7.6	0.60[b]
2,6-DNT	3.52	0.55[b]
1,3-DNB	3.11	0.61[b]
1,3,5-TNB	14.2	0.56[b]
NB	<1.13	1.13[b]
TOC	996[d]	500[c]

[a]Average concentration of five blanks analyzed by WESTON's Analytics Division in Lionville, Pennsylvania.

[b]Detection limit for explosive per USATHAMA Method UW01, Explosives in Water.

[c]Detection limit for TOC per U.S. EPA Method 415.1.

[d]28% of TOC from carbon content of above explosives. The rest is undetermined at this time.

Six different carbon dosages were used for each isotherm test: 10, 200, 500, 1,000, 2,500, and 5,000 mg/L. In addition, a groundwater sample without carbon was used as a control or blank in each isotherm test. All carbon dosages used were based on the USATHAMA report [3].

The groundwater samples were analyzed before and after each isotherm test by WESTON's Analytics Division in Lionville, Pennsylvania for the following parameters: TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, NB, and TOC. The results of these analyses were used to plot the isotherms for all five carbons.

The isotherm test matrix in Table 3-2 summarizes the previously described test program.

3.1.1 PROCEDURES

Carbons to be tested were pulverized by mortar and pestle but not screened prior to use in the isotherm tests. This procedure assured that equilibrium conditions would be obtained at a faster rate. Pulverizing carbon has no significant effect on adsorption capacity. However, it does increase the rate of adsorption so that laboratory time is not extensive.

Seven 250-mL aliquots of groundwater in Erlenmeyer flasks were used for each isotherm. Following pretreatment of the groundwater (suspended solids removal and pH adjustment), preweighed amounts of pulverized granular carbon, based on the carbon dosages defined earlier, were added to six flasks. No carbon was added to the seventh flask because it was the control. Each flask was then covered to minimize liquid and vapor losses and agitated in a shaker assembly over a period of 20 hours.

Following agitation, each flask was filtered through a Whatman GF/F glass fiber filter (0.7 um effective retention) into a clean filter flask. The filtrate was analyzed by high pressure liquid chromatography (HPLC) for the following parameters: TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, NB, and TOC. Each filtrate analysis, except for the one for the control, represented a single point on the isotherm for each parameter. The filtrate analysis of the control was used to determine the amount of compound adsorbed for a given volume of solution and the carbon adsorption efficiency. In addition, each filtrate's pH was measured.

Isotherms were developed for each parameter by plotting the laboratory adsorption data on logarithmic coordinates as weight of compound adsorbed per weight of carbon, X/M or q_e, vs. the amount of compound remaining in the groundwater, C_e. This data presentation is called a Freundlich isotherm.

3.1.2 PRELIMINARY CARBON SELECTION

Based upon vendor information, literature references, adsorption properties in Table 3-3, pressure drop, popular use, current use at MAAP, and cost, the following five carbons were selected for further evaluation using isotherm testing:

- Calgon Filtrasorb 200.

Table 3-2

Isotherm Test Matrix

20-hr Isotherm Test	Samples[a]	No. of Variables
Isotherm tests to select best-performing GAC	41[b]	5 GACs 1 temperature 1 solution 7 GAC dosages[c] 1 pH value[b]

[a]Each sample analyzed for TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, NB, and TOC.
[b]Duplicate flasks, using six dosages of the carbon currently in use at MAAP (Atochem, Inc. GAC 830), also run at a reduced pH value (~ pH 4.0).
[c]Six varying GAC dosages (10, 200, 500, 1,000, 2,500, and 5,000 mg/L) plus one blank (no GAC).

Table 3-3

Adsorption Properties of Five Selected Carbons

Adsorption	Calgon Filtrasorb 200	Calgon Filtrasorb 300	Calgon Filtrasorb 400	Hydrodarco 4000	Atochem, Inc. GAC 830
Specific Surface Area, m^2/g	850-900	950-1,050	1,000-1,200	625	950-1,050
Pore Volume, cm^3/g	N/A*	0.85	0.94	1.0	0.85
Iodine Number	850	900	1,000	600	920
Mean Particle Diameter, mm	0.8-1.0	1.5-1.7	0.9-1.1	0.8-1.0	1.5-1.7

*N/A = Not available.

- Calgon Filtrasorb 300.
- Calgon Filtrasorb 400.
- Hydrodarco 4000.
- Atochem, Inc. GAC 830.

Atochem, Inc. GAC 830 is the activated carbon currently being used at MAAP for pink water treatment.

3.2 RESULTS

The results of the batch (isotherm) carbon testing are presented in the form of the Freundlich adsorption equation:

$$q_e = X/M = KC_e^{1/n}$$

where,

q_e = Carbon loading, mg compound/mg carbon, dimensionless.

$X = C_o - C_e$, the amount of compound adsorbed for a given volume of solution, mg/L.

M = Carbon dosage, mg/L.

C_o = Initial concentration of compound, mg/L.

C_e = Concentration of compound remaining in solution, mg/L.

K = Freundlich constant, $(mg/L)^{-1/n}$.

n = Empirical constant, dimensionless.

Graphically, K is the X/M or q_e intercept of the isotherm plot at $C_e = 1$, and 1/n is the slope of the line when the laboratory adsorption data are plotted on logarithmic paper. The X/M or q_e intercept at C_o represents the maximum capacity of the carbon for the compound at its original concentration C_o. The greater the intercept, the more capacity a given carbon exhibits for adsorption of the target compound from that specific wastewater.

The slope of the line, 1/n, is an indication of the relative adsorbability of the compound. A slightly sloped line indicates high adsorbability, since a small increase in carbon dosage greatly reduces the compound's concentration in the water. However, a steeply sloped line indicates low adsorbability, since a small decrease in the compound's concentration results from a large increase in carbon dosage.

The empirical constants of the Freundlich adsorption equation for the five test carbon isotherms are presented in Table 3-4 for TNT and RDX. These constants for the three Filtrasorb carbons could not be determined for TNT because it was present at concentrations below its detection limit in the filtrates. For this same reason, the empirical constants of the Freundlich adsorption equation for all five carbons for the other seven explosives could not be determined.

Table 3-4

Empirical Constants of Freundlich Adsorption Equation[a] for Five Test Carbons Using Groundwater From Monitor Well MI051

Activated Carbon Type	TNT Isotherms K^b	TNT Isotherms $1/n^c$	RDX Isotherms K^b	RDX Isotherms $1/n^c$
Filtrasorb 200	ND[d]	ND[d]	0.052	0.535
Filtrasorb 300	ND[d]	ND[d]	0.031	0.413
Filtrasorb 400	ND[d]	ND[d]	0.049	0.555
Hydrodarco 4000	0.128	0.828	0.0012	0.100
Atochem, Inc. GAC 830	0.136	0.642	0.045	0.630

[a] $q_e = X/M = K C_e^{1/n}$.
[b] Intercept at C_e = 1.0 mg/L on the isotherm line. This intercept was determined by extrapolation.
[c] Slope of the line within the concentration range of 0.001-1.0 mg/L.
[d] ND = Not Determinable.

The maximum saturation capacities (theoretical maximum loading) for all five carbons for RDX were estimated by extrapolating their isotherms to C_o. This gives a q_e that corresponds to a condition when all the carbon is in equilibrium with the initial concentration of RDX. In a continuous flow GAC column, this condition occurs when the RDX concentration in the effluent is the same as that in the influent. However, in practice this doesn't occur because normally the column service is terminated when the effluent concentration reaches a predetermined effluent limit. In addition, maximum saturation capacities for Hydrodarco 4000 and Atochem, Inc. GAC 830 for TNT were estimated by extrapolating their isotherms to C_o. Table 3-5 presents these capacities along with those for RDX.

Maximum saturation capacities for the three Filtrasorb carbons could not be estimated for TNT. This was because the Freundlich adsorption equation for these carbons could not be determined due to TNT concentrations below its detection limit in the filtrates. For this same reason, maximum saturation capacities for all five carbons for the other seven explosives could not be estimated.

All of the isotherm test results for the explosives as well as those for TOC and pH effects are presented in Appendix B and discussed in the following subsections. The following criteria are used in these subsections to evaluate GAC removal of the respective compound:

- Carbon Capacities and Associated Exhaustion Rates - For a given C_e on the isotherms, the carbon with the greatest X/M or q_e is the best one for adsorbing that particular compound out of solution. In other words, the best performing carbon will be the one that has its isotherm line closest to the top of the graph. Based on this criterion, the five carbons can be ranked for each compound.

- Capability of Meeting Effluent Limits - The minimum effluent level achievable by each carbon for each compound is determined by comparing each compound's equilibrium concentration (at higher carbon dosages) with the desired effluent level.

3.2.1 TNT REMOVAL

TNT isotherms for all five GACs are presented in Figure 3-1. Each GAC's isotherm was incomplete because, at almost all carbon dosages greater than 10 mg/L (lower q_e values), the equilibrium concentrations (C_e) were below the TNT detection limit of 0.78 ug/L. Therefore, any comparisons of the TNT isotherms for the five GACs were inconclusive. However, these results did show that all five GACs were capable of TNT removal to below its detection limit at low carbon dosages. All of the results were based on an initial average TNT concentration of 493 ug/L.

The empirical constants of the Freundlich adsorption equation were only obtained for Hydrodarco 4000 and Atochem, Inc. GAC 830. This was

Table 3-5

Maximum Saturation Capacities
for Five Test Carbons

Carbon Type	Nitrobody	Influent Concentration, C_o (mg/L)*	Maximum Saturation Capacity, q_e (mg/mg)
Filtrasorb 200	RDX	0.457	0.0342
Filtrasorb 300	RDX	0.469	0.0227
Filtrasorb 400	RDX	0.497	0.0332
Hydrodarco 4000	TNT	0.546	0.0776
	RDX	0.433	0.0011
Atochem, Inc. GAC 830	TNT	0.550	0.0927
	RDX	0.572	0.0317

*Influent concentrations were obtained from the groundwater samples used as controls in the isotherm tests.

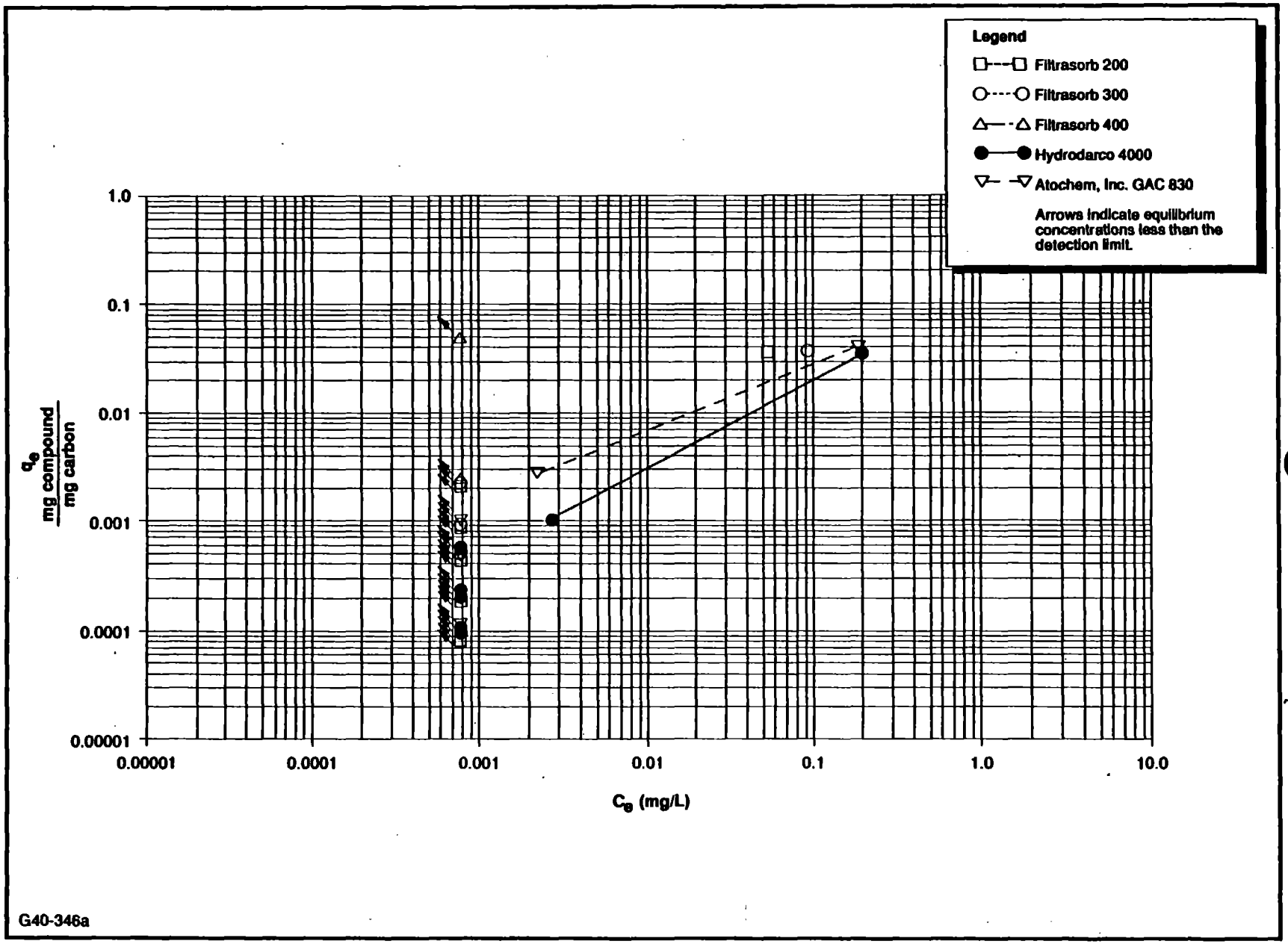


FIGURE 3-1 TNT ISOTHERMS FOR FIVE GACS USING GROUNDWATER FROM MONITOR WELL MI051 AT MAAP

because they were the only GACs with two equilibrium concentrations above the TNT detection limit. The empirical constants in Table 3-4 were obtained from the equation of the straight line between these concentrations. However, since these constants were obtained from limited data, they should only be considered approximations.

The empirical constants of the Freundilich adsorption equation were then used along with the concentration of TNT in the blank or C_0 to calculate the saturation capacities shown in Table 3-5. Based on these capacities, Atochem, Inc. GAC 830 is the better carbon for TNT removal.

3.2.2 RDX REMOVAL

RDX isotherms for all five GACs are presented in Figure 3-2. Three GACs' isotherms (Filtrasorb 200, 300, and 400) were incomplete because, at almost all carbon dosages greater than 200 mg/L, the equilibrium concentrations were below the RDX detection limit of 0.63 ug/L. Therefore, any comparisons of the RDX isotherms for Filtrasorb 200, 300, and 400 with each other and with the other two RDX isotherms for Hydrodarco 4000 and Atochem, Inc. GAC 830 were inconclusive. However, these results did show that Filtrasorb 200, 300, and 400 were capable of RDX removal to below its detection limit at low carbon dosages and that Hydrodarco 4000 and Atochem, Inc. GAC 830 were not. All of the results were based on an initial average RDX concentration of 486 ug/L. In addition, the RDX isotherm for Atochem, Inc. GAC 830 did show some desorption at a carbon dosage of 5,000 mg/L; however, the one for Hydrodarco 4000 did not.

The empirical constants of the Freundlich adsorption equation were obtained for all five GACs from the linear portion of their isotherms that were above the RDX detection limit. This portion usually fell between the equilibrium concentration range of 0.001 to 1.0 mg/L. The empirical constants in Table 3-4 were obtained from the equation of the straight line in this range. However, since these constants were obtained from limited data, they should only be considered approximations.

The empirical constants of the Freundlich adsorption equation were then used along with the concentration of RDX in the blank to calculate the saturation capacities shown in Table 3-5. Based on these capacities, Atochem, Inc. GAC 830 is about as good as the Filtrasorb carbons for RDX removal. However, Hydrodarco 4000 is not.

3.2.3 HMX REMOVAL

HMX isotherm data for all five GACs in Appendix B are not plotted because, at almost all carbon dosages, the equilibrium concentrations were below the HMX detection limit of 1.30 ug/L. Therefore, any comparisons of the HMX isotherms for the five GACs were inconclusive. However, these results did show that all five GACs were capable of HMX removal to below its detection limit at low carbon dosages. All of the results were based on an initial average HMX concentration of 2.75 ug/L.

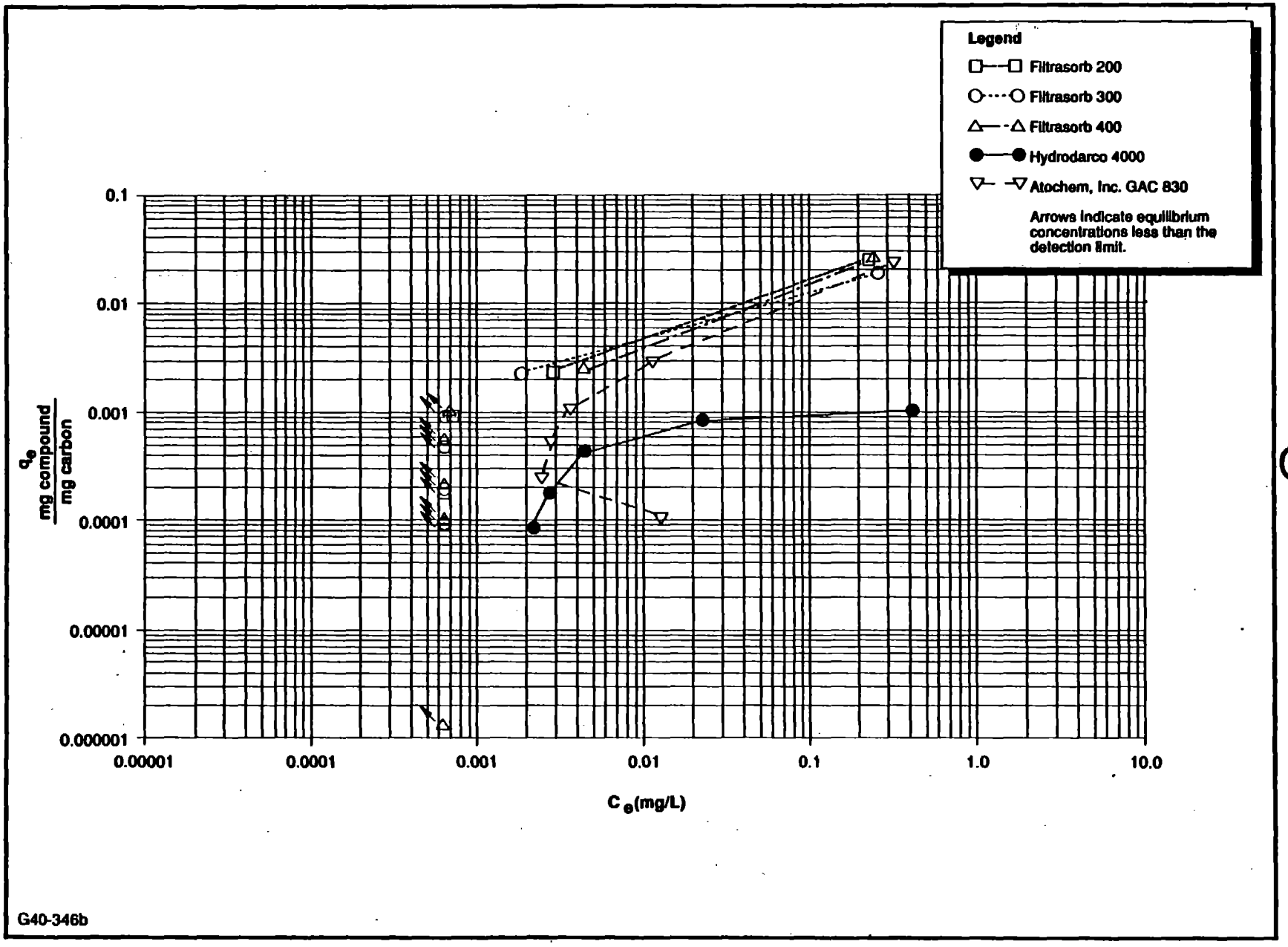


FIGURE 3-2 RDX ISOTHERMS FOR FIVE GACS USING GROUNDWATER FROM MONITOR WELL MI051 AT MAAP

Since most equilibrium concentrations were below the HMX detection limit, the empirical constants for the Freundlich adsorption equation could not be determined.

3.2.4 TETRYL REMOVAL

Tetryl isotherm data for all five GACs in Appendix B are not plotted because, at almost all carbon dosages, the equilibrium concentrations were below the Tetryl detection limit of 0.66 ug/L. Therefore, any comparisons of the Tetryl isotherms for the five GACs were inconclusive. However, these results did show that all five GACs were capable of Tetryl removal to below its detection limit at low carbon dosages. All of the results were based on an initial average Tetryl concentration of 14.9 ug/L.

Since most equilibrium concentrations were below the Tetryl detection limit, the empirical constants for the Freundlich adsorption equation could not be determined.

3.2.5 2,4-DNT REMOVAL

2,4-DNT isotherm data for all five GACs in Appendix B are not plotted because, at almost all carbon dosages, the equilibrium concentrations were below the 2,4-DNT detection limit of 0.6 ug/L. Therefore, any comparisons of the 2,4-DNT isotherms for the five GACs were inconclusive. However, these results did show that all five GACs were capable of 2,4-DNT removal to below its detection limit at low carbon dosages. All of the results were based on an initial 2,4-DNT concentration of 7.6 ug/L.

Since most equilibrium concentrations were below the 2,4-DNT detection limit, the empirical constants for the Freundlich adsorption equation could not be determined.

3.2.6 2,6-DNT REMOVAL

2,6-DNT isotherm data for Filtrasorb 200, 300, and 400 in Appendix B are not plotted because, at all carbon dosages, the equilibrium concentrations were below the 2,6-DNT detection limit of 0.55 ug/L. In addition, the 2,6-DNT isotherm data for Hydrodarco 4000 and Atochem, Inc. GAC 830 in Appendix B are not plotted because the concentration of 2,6-DNT in each one of their blanks as well as the equilibrium concentration in each one of their carbon dosages was below the 2,6-DNT detection limit. Therefore, any comparisons of the 2,6-DNT isotherms for the five GACs were inconclusive. However, the results for Filtrasorb 200, 300, and 400 did show that these GACs were capable of 2,6-DNT removal to below its detection limit at low carbon dosages. All of the results are based on an initial average 2,6-DNT concentration of 3.52 ug/L.

Since all equilibrium concentrations were below the 2,6-DNT detection limit, the empirical constants for the Freundlich adsorption equation could not be determined.

3.2.7 1,3-DNB REMOVAL

1,3-DNB isotherm data for all five GACs in Appendix B are not plotted because, at almost all carbon dosages, the equilibrium concentrations were below the 1,3-DNB detection limit of 0.61 ug/L. Therefore, any comparisons of the 1,3-DNB isotherms for the five GACs were inconclusive. However, these results did show that all five GACs were capable of 1,3-DNB removal to below its detection limit at low carbon dosages. All of the results are based on an initial average 1,3-DNB concentration of 3.11 ug/L.

Since most equilibrium concentrations were below the 1,3-DNB detection limit, the empirical constants for the Freundlich adsorption equation could not be determined.

3.2.8 1,3,5-TNB REMOVAL

1,3,5-TNB isotherm data for all five GACs in Appendix B are not plotted because, at almost all carbon dosages, the equilibrium concentrations were below the 1,3,5-TNB detection limit of 0.56 ug/L. Therefore, any comparisons of the 1,3,5-TNB isotherms for the five GACs were inconclusive. However, these results did show that all five GACs were capable of 1,3,5-TNB removal to below its detection limit at low carbon dosages. All of the results are based on an initial average 1,3,5-TNB concentration of 14.2 ug/L.

Since most equilibrium concentrations were below the 1,3,5-TNB detection limit, the empirical constants for the Freundlich adsorption equation could not be determined.

3.2.9 NB REMOVAL

The NB isotherm data for Atochem, Inc. GAC 830 in Appendix B are not plotted because the concentration of the blank as well as the equilibrium concentration for all carbon dosages except 2,500 mg/L and 5,000 mg/L, was below the NB detection limit of 1.13 ug/L. According to the analytical report from WESTON's Analytics Division, the equilibrium concentration for the carbon dosage of 1,500 mg/L was elevated above the detection limit due to sample interference. However, no such qualification was made regarding the equilibrium concentration for the carbon dosage of 5,000 mg/L. Nevertheless, this concentration cannot be used to generate a point on the isotherm because it is higher than the blank. The NB isotherms data for Filtrasorb 200, 300, and 400, and Hydrodarco 4000 in Appendix B are not plotted because the concentration of NB in each one of their blanks, as well as the equilibrium concentration in almost every one of their carbon dosages, was below the NB detection limit. Therefore, any comparisons of the NB isotherms for the five GACs were inconclusive.

Since almost all equilibrium concentrations were below the NB detection limit, the empirical constants for the Freundlich adsorption equation could not be determined.

3.2.10 TOC REMOVAL

TOC isotherms for all five GACs are presented in Figure 3-3. The TOC isotherm for Filtrasorb 300 was the only one that was complete. This isotherm is similar to the TOC isotherms presented in the Badger Army Ammunition Plant (BAAP) report [12] for a TOC level of ± 1 ppm. The other isotherms were incomplete because, at almost all carbon dosages greater than 10 mg/L, the equilibrium concentrations were below the TOC detection limit of 500 ug/L. Therefore, any comparisons of the TOC isotherms for the five GACs were inconclusive. However, except for Filtrasorb 300, these results did show that the other four GACs were capable of TOC removal to below its detection limit at low carbon dosages. All of the results are based on an initial average TOC concentration of 996 ug/L. Twenty-eight percent of TOC was from carbon content of the nine explosives.

The TOC isotherm for Filtrasorb 300 did show that it was capable of TOC removal to below 1.0 mg/L; however, the TOC concentration in the control was only 1.3 mg/L. This concentration for the other four GACs ranged from 0.56 to 1.2 mg/L and averaged about 1.0 mg/L for all five GACs. Because of the sensitivity of the TOC analysis at these low concentrations, it is not possible to confidently conclude that nonadsorbing compounds were present in the control. Nevertheless, the results indicate that, for groundwater from monitor well MI051 at MAAP, TOC reduction below 1.0 mg/L by an activated carbon adsorption treatment system may be possible.

Since almost all equilibrium concentrations for all GACs except Filtrasorb 300 were below the TOC detection limit, the empirical constants for the Freundlich adsorption equation could not be determined. In addition, these constants were not determined for Filtrasorb 300 because its TOC isotherm exhibited desorption at carbon dosages of 1,000 and 2,500 mg/L. The empirical constants for the Freundlich adsorption equation have no meaning if this phenomenon occurs.

3.2.11 pH EFFECTS

Figures 3-4 and 3-5 present the isotherms for TNT and RDX, respectively, for Atochem, Inc. GAC 830 at pH 7.0 and pH 4.0. Similar isotherms for the other seven compounds and TOC are not plotted because their isotherm data in Appendix B had a large number of equilibrium concentrations that were below their respective compounds detection limit. Because of this and the limited data in Figures 3-4 and 3-5, a valid conclusion could not be made regarding the effect of pH on activated carbon adsorption of the groundwater from monitor well MI051 located at MAAP.

3.3 FINAL CARBON SELECTION

Since TNT and RDX were the compounds present at the highest concentrations in the groundwater from monitor well MI051 at MAAP, the carbons that best treated these compounds were looked upon more favorably. Based on the results in Subsections 3.2.1 and 3.2.2, all three Filtrasorb carbons were capable of removing both compounds to below their detection

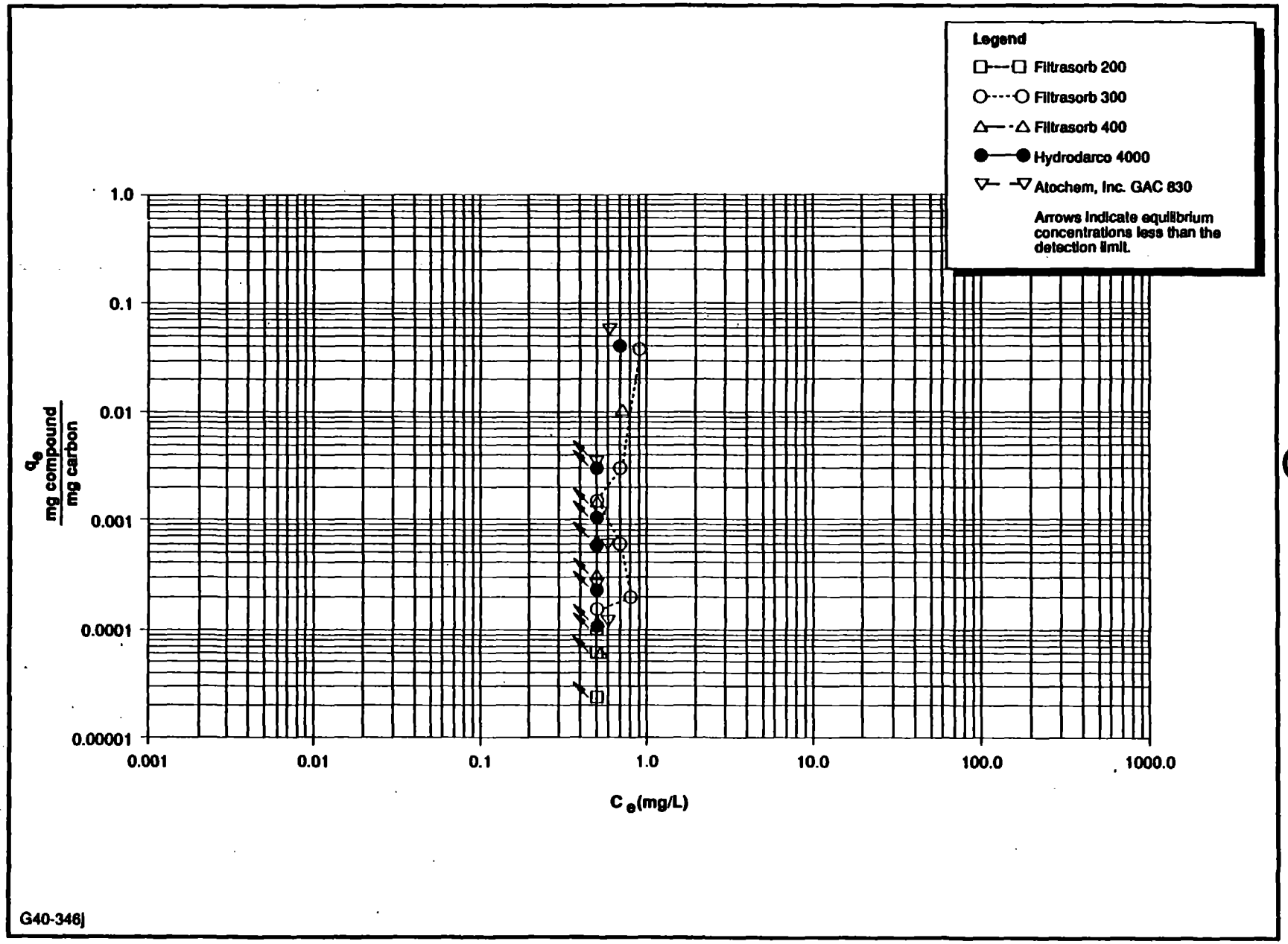


FIGURE 3-3 TOC ISOTHERMS FOR FIVE GACS USING GROUNDWATER FROM MONITOR WELL MI051 AT MAAP

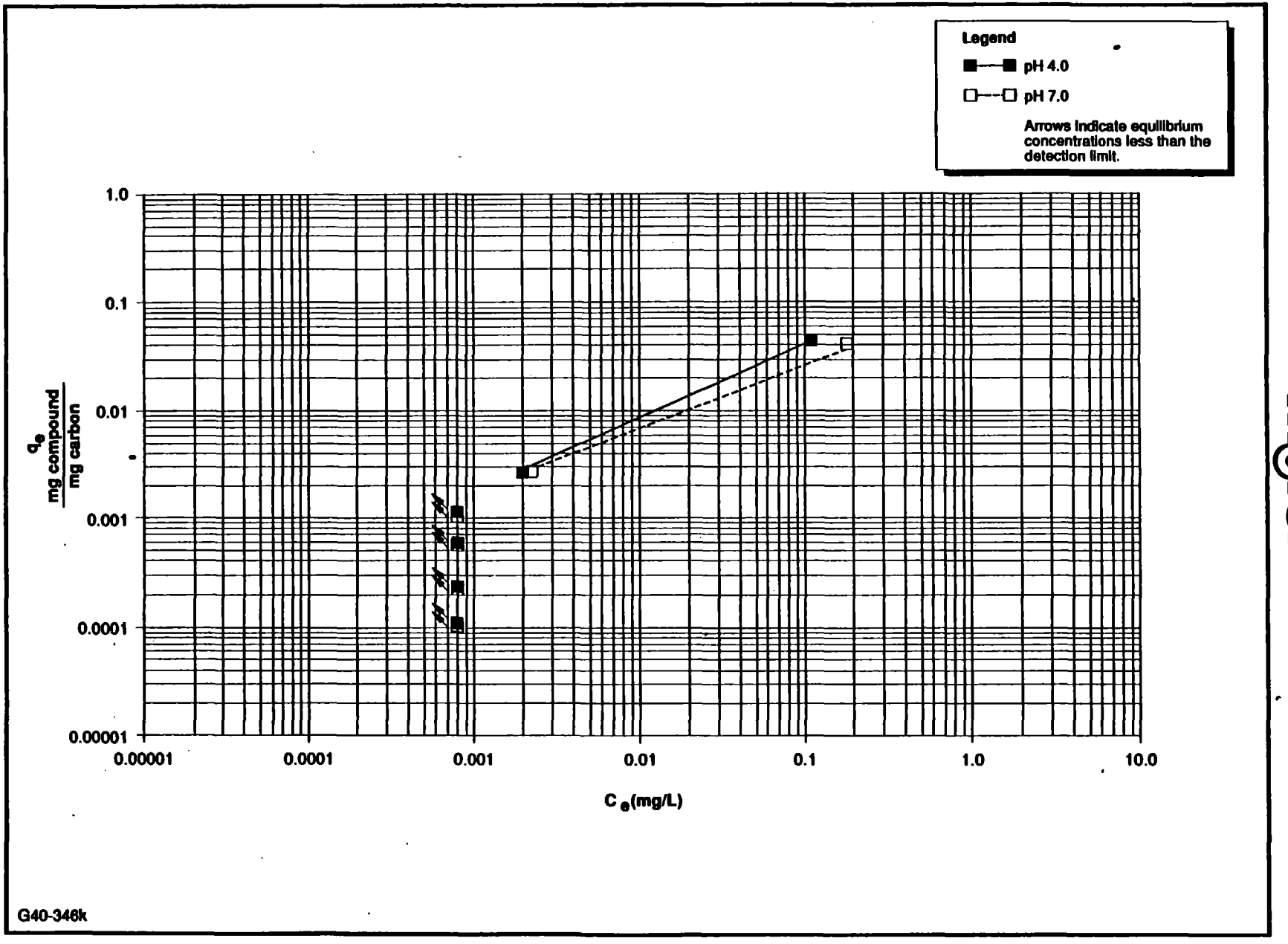


FIGURE 3-4 ATOCHEM, INC. GAC 830 ISOTHERMS SHOWING EFFECTS OF VARYING PH ON TNT REMOVAL USING GROUNDWATER FROM MONITOR WELL MI051 AT MAAP

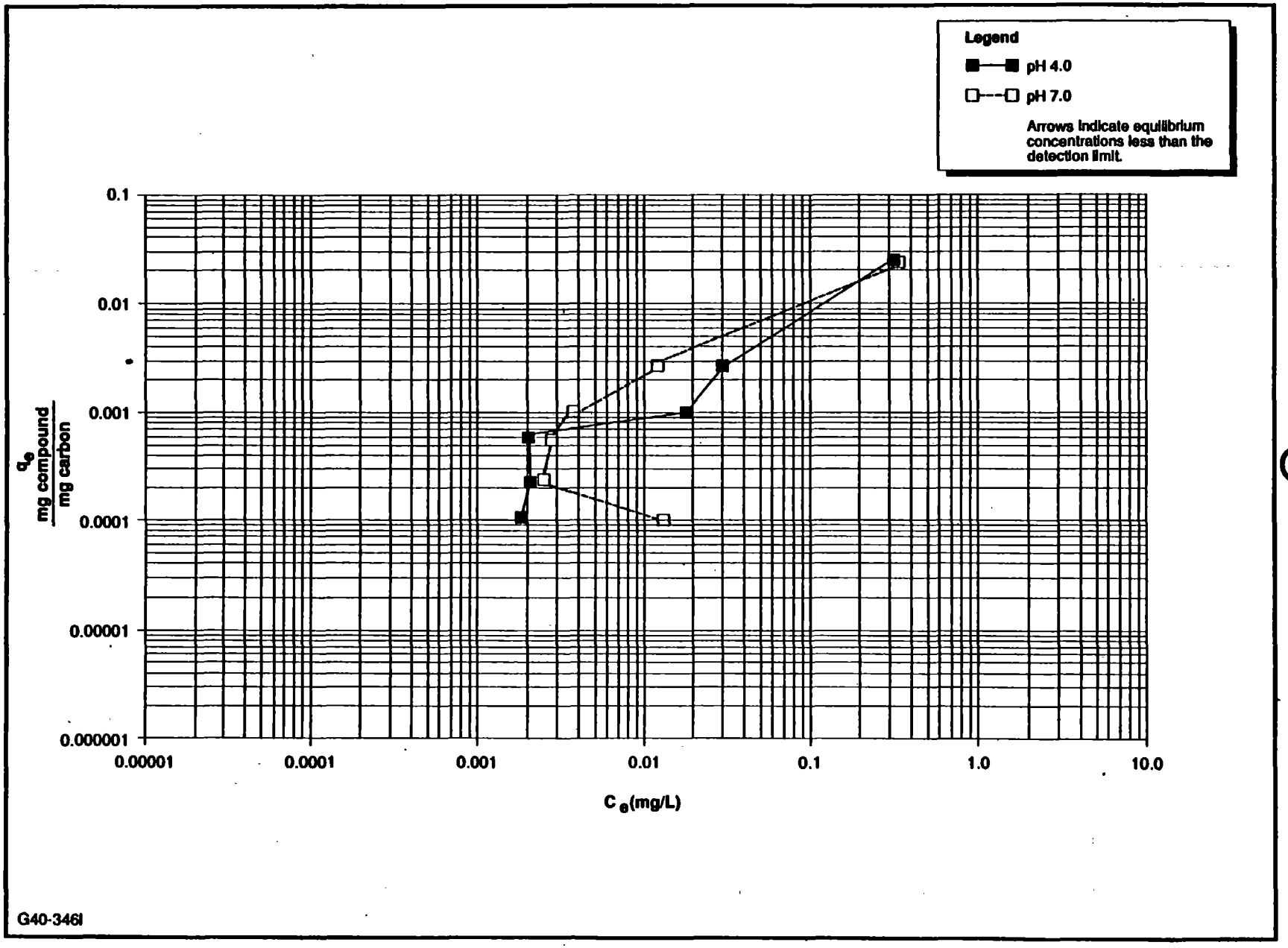


FIGURE 3-5 ATOCHEM, INC. GAC 830 ISOTHERMS SHOWING EFFECTS OF VARYING PH ON RDX REMOVAL USING GROUNDWATER FROM MONITOR WELL MI051 AT MAAP

limits. While Hydrodarco 4000 and Atochem, Inc. GAC 830 were capable of removing TNT to below its detection limit, they were not capable of doing this for RDX. Although the latter two carbons may not provide removal to below detection limits, they may provide adequate treatment to meet effluent limits (which have not, as yet, been determined). If final effluent limits are such that all of the carbons would provide adequate removal, other factors, such as saturation capacity and overall economics, may have a greater significance in carbon selection.

In terms of maximum saturation capacity, all three Filtrasorb carbons were comparable with respect to RDX (see Table 3-5). Atochem, Inc. GAC 830 had a slightly lower RDX maximum saturation capacity. The RDX maximum saturation capacity of Hydrodarco 4000 was substantially lower that the other carbons tested. As discussed previously, TNT maximum saturation capacities could not be determined for the Filtrasorb carbons. Hydrodarco 4000 had a substantially higher TNT maximum saturation capacity than did Atochem, Inc. GAC 830.

Filtrasorb 300 was selected as representative of the three Filtrasorb carbons for further testing in continuous flow GAC columns at MAAP. In addition, Atochem, Inc. GAC 830, which is currently being used at MAAP to treat pink water, was selected because the task order required that the carbon currently in use at MAAP be tested. However, Atochem, Inc. GAC 830 was also selected because it was comparable to the three Filtrasorb carbons and better than Hydrodarco 4000 with respect to RDX maximum saturation capacity.

Because of the inconclusive results on the effect of pH on the activated carbon adsorption of the groundwater from monitor well MI051 at MAAP, the continuous flow GAC columns at MAAP were run at pH 7.0. This decision was supported by the results on the effect of pH described in the Badger Army Ammunition Plant (BAAP) report [12]. In this report, the results of the isotherm tests for Filtrasorb 400, using explosives-contaminated groundwater from monitor well PBN82-02C at BAAP, showed that relatively higher adsorption capacities were obtained at neutral pH (7.0) than at acidic pH (4.0). Even though the results in the literature [3] showed the opposite to be true for TNT and other nitroaromatics, greater weight was given to the BAAP report because it represented the most recent experience with explosives-contaminated groundwater.

SECTION 4

ACTIVATED CARBON TEST PROGRAM AT MAAP

The objective of the test program was to determine the feasibility of using activated carbon adsorption to treat explosives-contaminated groundwater based upon pilot-scale testing. Subsection 4.1 describes the planned test program presented in the Test Plan and Subsection 4.2 describes the actual test program conducted at MAAP.

The GAC performance evaluation was conducted in a skid-mounted, granular-activated carbon/ion exchange (GAC/IE) pilot plant designed and built by WESTON. This plant has three skids and an accessory tankage. One skid has the motor control center, feed pumps, and utility pumps. The other two skids each have four plexiglas columns that could be used to test either activated carbon or ion exchange treatment systems. The GAC/IE pilot plant was designed to provide a high degree of operating flexibility by using variable bed lengths and flow arrangements.

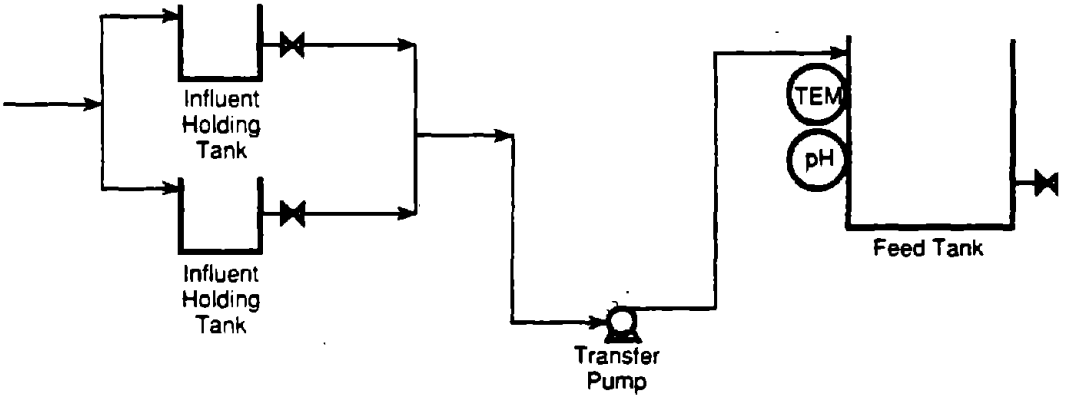
Additional tankage and associated pumps were added to the GAC/IE pilot plant primarily to allow for groundwater retention, pH adjustment, and flow control. Two 3,000-gal influent holding tanks were added to receive and hold groundwater from monitor well MI051. One 2,000-gal equalization tank was also added between the influent holding tanks and the control panel for pH adjustment and flow control. Furthermore, one 3,000-gal effluent holding tank was added after the GAC columns to retain treated effluent for disposal by MAAP. This was done in case the treated effluent could no longer be sent to the Wolf Creek Ordnance Plant STP for disposal through the NPDES permitted outfall.

The GAC pilot plant used in this test program had two parallel trains (A and B). Each train had two 4.25-in. ID (5-in. OD), 6-ft high columns that were arranged in series and operated in a packed bed down flow mode. These columns were designed for up to 4 ft of bed depth and 50 percent bed expansion during backwash operations. The two columns in train A had one of the two carbons selected and the two columns in train B had the other one. With two parallel test setups, two continuous flow runs could be evaluated simultaneously.

The GAC pilot plant configuration previously described is sketched in Figure 4-1.

4.1 DESCRIPTION OF PLANNED TEST PROGRAM

The primary goal of this program was to evaluate the performance of granular activated carbon to treat explosives-contaminated groundwater. This goal was pursued through a combination of batch (isotherm) testing and continuous flow pilot plant testing.



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FI - Flow Indicator
PI - Pressure Indicator
TEM - Temperature
BW - Backwash Water

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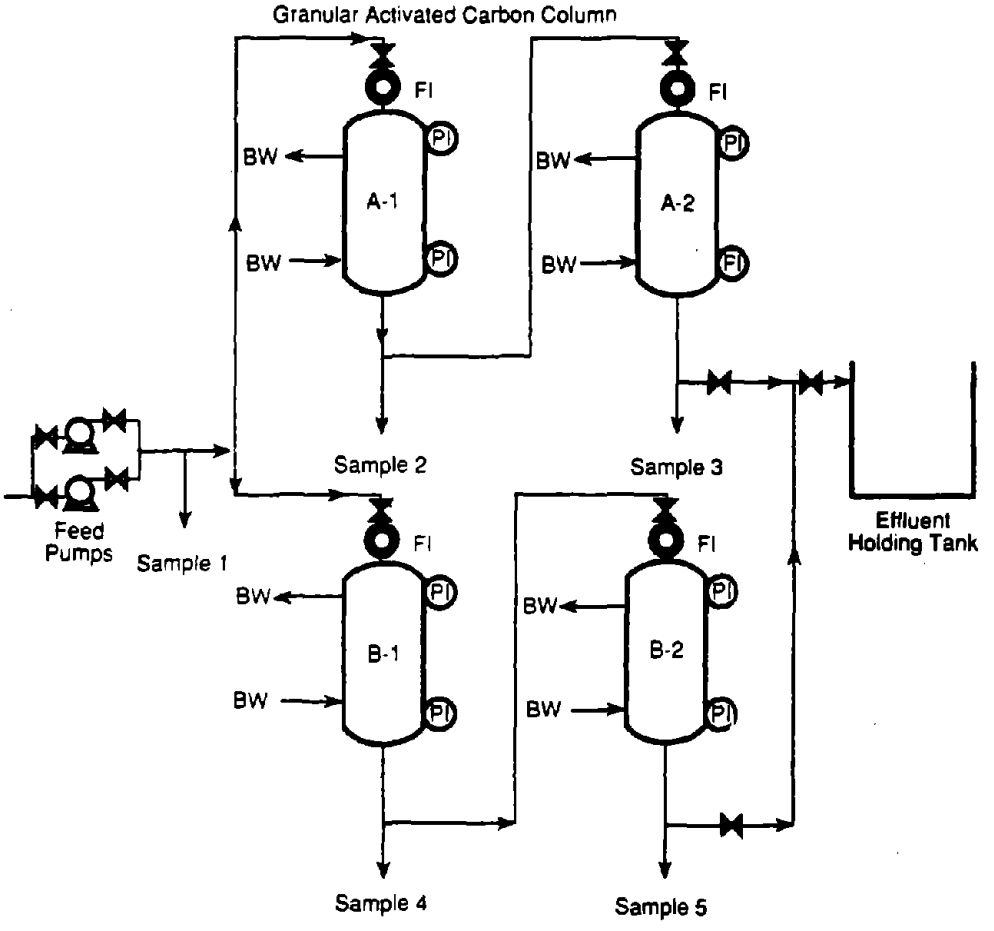

FIGURE 4-1 GAC PILOT PLANT CONFIGURATION

Batch (isotherm) testing was discussed in Section 3 of this report. The planned continuous flow pilot plant testing program is described below. The discussion of the actual test program is presented in Subsection 4.2. Variances between the planned and actual test programs are discussed in Subsection 4.3.

The continuous flow pilot plant testing was to be carried out using the GAC selected from the batch (isotherm) test results and the carbon currently being used in operations at MAAP. The primary objectives of performing GAC groundwater treatment pilot plant tests at MAAP were:

- To determine, in the absence of site-specific effluent criteria, the best quality effluent achievable using carbon adsorption to treat groundwater from monitor well MI051.
- To select the better of the two GACs, based on effluent achieved and relative rate of adsorption.
- To determine the carbon empty-bed contact time.
- To determine adsorption capacities of the carbons for TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB.
- To determine if lowering the pH will enhance GAC adsorption.

The test conditions, experimental variables, operational monitoring, and evaluation criteria for the test program are presented in the following subsections.

4.1.1 TEST CONDITIONS AND EXPERIMENTAL VARIABLES

The planned test conditions for all four tests are summarized in Table 4-1. For each test, a common feed stream was to split between two trains, A and B, at different proportions, depending on the required hydraulic loadings. The two columns in trains A and B were to contain carbon types A and B (selected from previous isotherm testing), respectively.

All the tests were to be conducted at ambient temperatures in the pilot plant area in Building K-51 (see Figure 4-2). Outdoor temperatures were expected to vary widely from an average of approximately 42°F in the winter to over 80°F in the summer [13]. The groundwater temperature was approximately 55°F when it left the monitor well. Depending upon ambient conditions, this temperature was expected to either increase or decrease after the groundwater entered the influent tanks. Therefore, the influent temperature during the test runs was not to be controlled; however, it was to be monitored continuously.

Influent pH was to be monitored during testing and adjusted, if necessary, to maintain a 6.0 to 9.0 range using sulfuric acid and sodium hydroxide during Tests One, Two and Three. Test Four was to be performed at a pH of 4.0 if the isotherm data indicated enhanced removal at a lower pH. If no enhanced removal at a lower pH was determined from isotherm data, Test Four was to be conducted at the same pH as Tests One, Two, and Three.

Table 4-1

Planned Test Conditions for Continuous Flow Pilot Tests

Test	Train	Carbon Type	Flow Rate (gpm)	Hydraulic Loading (gpm/ft^2)	Bed Depth (ft)	Empty-bed Contact Time[a] (min)	Influent
One	A	A	1.0	10	4	3.0	pH = 6 to 9
	B	B	0.2	2	4	14.7	
Two	A	A	0.2	2	4	14.7	pH = 6 to 9
	B	B	1.0	10	4	3.0	
Three	A	A	0.7	7	4	4.2	pH = 6 to 9
	B	B	0.7	7	4	4.2	
Four	A	A	0.5	5	4	5.9	pH = 4.0[b]
	B	B	0.5	5	4	5.9	

[a]Empty-bed contact time (EBCT) is equal to the volume of the empty bed divided by the flow rate. EBCT is conventionally used to characterize GAC filter operation.

[b]Test Four was to be conducted at a pH = 4.0 if the isotherm data indicated enhanced removal at a lower pH.

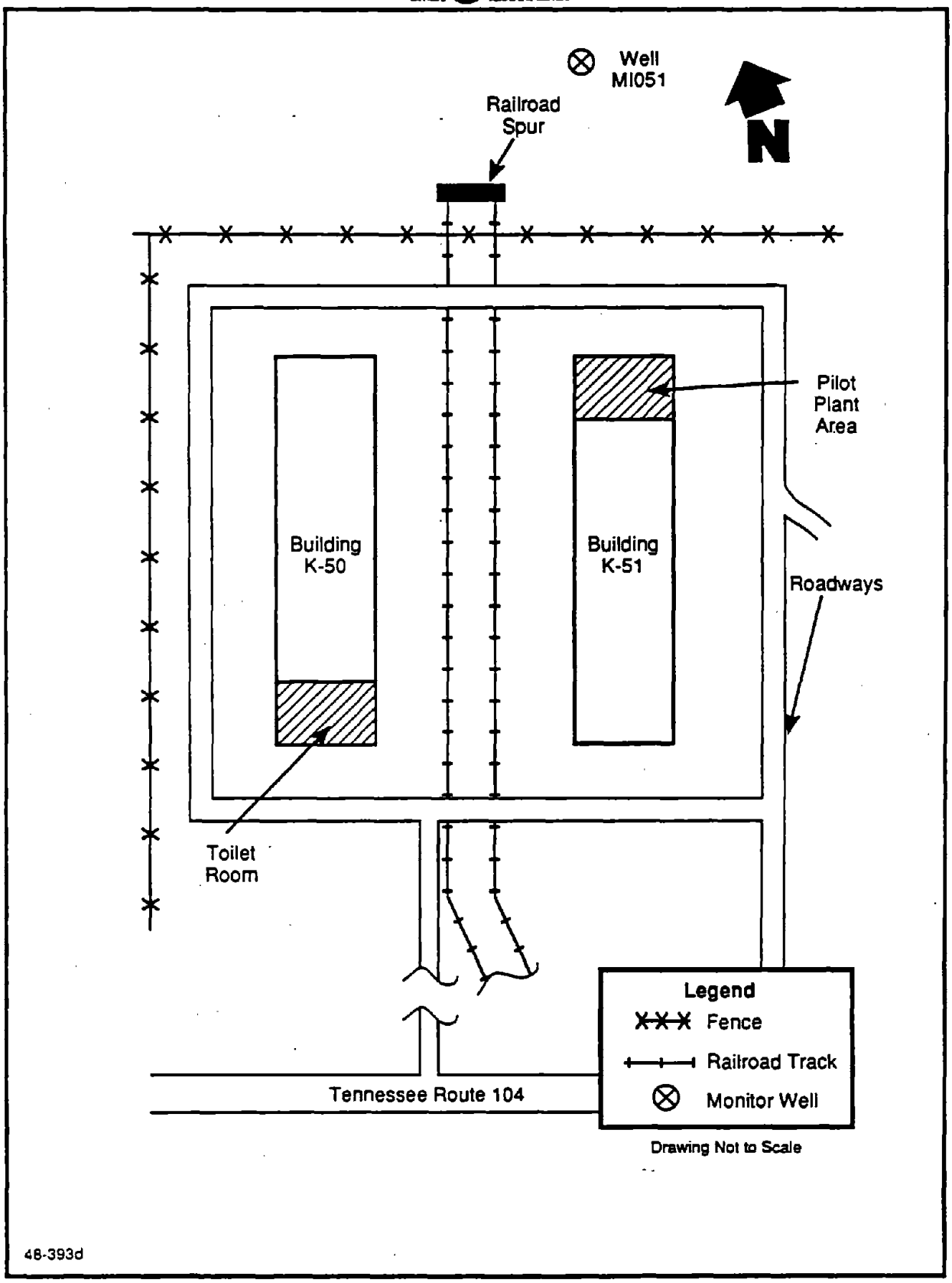

FIGURE 4-2 PILOT PLANT AREA MAP

During the tests, the hydraulic loadings were to be 2, 5, 7, and 10 gpm/ft^2. These values are within the range of hydraulic loadings that are normally used in full-scale operation of GAC systems. In an earlier study by USATHAMA, TNT, RDX, HMX, 2,4-DNT, and 2,6-DNT isotherms showed carbon capacities of 0.17 lb TNT/lb carbon, 0.037 lb RDX/lb carbon, 0.058 lb HMX/lb carbon, 0.005 lb 2,4-DNT/lb carbon, and 0.03 lb 2,6-DNT/lb carbon for Calgon Filtrasorb 400 [3]. Based upon these capacities, the explosives concentration data for monitor well MI051, potential run lengths (elapsed time to breakthrough) for individual contaminants were expected to be quite long. However, eventhough complete breakthrough was not likely to occur during the duration of the test program, the presence of multiple contaminants was expected to reduce the overall run length. Up to four tests in each carbon train were to be conducted. However, the final length of each test and the total number of tests would depend upon the actual adsorption characteristics of the contaminated groundwater.

The results of the isotherm tests showed good agreement with the earlier study by USATHAMA [3] with respect to the carbon capacity of RDX. However, these results showed the carbon capacity of TNT to be half of that obtained in this study. Therefore, the final length of each test was expected to be about the same or less than that predicted from the earlier study.

Adsorption and breakthrough characteristics were to be studied in the first column of each parallel pair. The function of the second column was to maintain effluent (discharge) quality within acceptable limits while allowing contaminant leakage up to influent levels (total exhaustion of capacity) of the first column. Therefore, during the planned tests, the two columns within each train were not to be switched around as the first column (lead) reached exhaustion. The exhausted carbon in the first column was to be replaced with fresh carbon and put back for service as the lead column once again. This mode of operation was to ensure that fresh carbon was used for all of the test runs.

Based upon approximately 10 lb of carbon per column at a depth of 4 ft, the total amount of carbon required for all four tests was expected to be 80 lb (maximum). This amount does not include the carbon replacement requirement for the second column of each train. If the carbon bed in the second column was replaced at the same time as the first column, the estimated total carbon requirement would be 160 lb.

4.1.2 OPERATIONAL MONITORING

Effluent samples from the first column of each train were to be taken at regular time intervals as per the sampling program described in Subsection 2.3.2.1 of the test plan [14]. According to this plan, influent samples were to be taken twice a day during each test run. However, additional influent samples were to be taken when additional groundwater was added to the feed tank.

Samples were to be taken at the outlet of the second column, as necessary, to monitor the effluent from the pilot plant. MAAP received permission from the Tennessee Department of Health and Environment to discharge the pilot plant effluent into the Wolf Creek Ordnance Plant STP. Here it would be

discharged through outfall 009 of the MAAP NPDES permit [15]. Depending on the mass loading of contaminants and the effluent concentrations, the carbon in the second column was to be replaced with fresh carbon. This was to be done at the same time as the first column's replacement.

Flow measurements, as indicated by the flow meters at each column's inlet, were to be recorded at regular time intervals during each test run. Influent and effluent (first column as well as second column) pH and temperature were to be monitored at regular time intervals and logged in the site logbook. Inlet and outlet pressures at each column were to be monitored by pressure gauges mounted on the column. This information would give the pressure drop across each column and determine when the columns should be cleaned by backwashing.

4.1.3 EVALUATION CRITERIA

The performance of the two carbons to be used in the continuous flow pilot plant testing was to be evaluated on the basis of adsorption rate and adsorption capacity under the same flow conditions. For this evaluation, the analytical data gathered during pilot test runs were to be used to plot the breakthrough curves. The concentration of the adsorbed substance (TNT, RDX, HMX, Tetryl, 1,2,4-DNT, 2,6-DNT, 1,3,5-TNB, 1,3-DNB, NB) in the column effluent was to be plotted against the volume of water treated.

These breakthrough curves were to be plotted for each contaminant of concern that was detected (TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB) and for each hydraulic loading (2, 5, 7, and 10 gpm/ft^2). As previously mentioned, the slope of the breakthrough curve would determine the adsorption rate and the service life of a particular carbon. The carbon with the steepest breakthrough curve would have the longest service life. Therefore, it would be considered for application in a full-scale treatment system to remove nitroaromatics from groundwater at MAAP.

The carbon exhaustion rates in terms of lb of carbon per 1,000 gal of wastewater were to be calculated from the breakthrough curves. The carbon exhaustion rates for each contaminant were then to be plotted as a function of empty-bed contact time. This curve was to be used to evaluate the economic balance between empty-bed contact time for a single fixed bed, which translates into capital cost, and carbon exhaustion rate, which translates into direct operating expense [16]. This type of evaluation was to be carried out for both carbons.

4.2 ACTUAL TEST PROGRAM

During the field test program conducted at MAAP, three continuous flow column tests were performed, each using two carbon column trains. These tests will be described in the following subsections. Variances between the actual and planned tests programs will be discussed in Subsection 4.3.

4.2.1 CONTINUOUS FLOW COLUMN TEST CONDITIONS FOR TEST ONE

In Test One, the groundwater flow rate for column A1 was 1.0 gpm and the groundwater flow rate for B1 was 0.2 gpm. The hydraulic loading in column

A1 was 10.15 gpm/ft^2, and the hydraulic loading in column B1 was 2.03 gpm/ft^2. Columns A1, A2, B1, and B2 contained Atochem, Inc. GAC 830. In addition, the bed depth in all four columns was 4 ft. The empty-bed contact times in columns A1 and B1 were 3.0 and 14.7 minutes respectively. The parameters previously discussed are presented in Table 4-2.

Test One was started on 7 September 1989 and shut down on 15 September 1989. This test was run for a total of 7.6 days, at which time it was decided by WESTON and USATHAMA that breakthrough would not be reached in a reasonable amount of time for study purposes using the operating parameters in Table 4-2.

Except for RDX, none of the contaminants of concern in Table 4-2 was detected in the effluent samples. RDX was detected in column A1's effluent sample but at a concentration that was only about 1 percent of its influent concentration.

4.2.2 CONTINUOUS FLOW COLUMN TEST CONDITIONS FOR TEST TWO

In Test Two, the groundwater flow rates for columns A1 and B1 were 0.7 gpm. The hydraulic loading in the columns was 7.11 gpm/ft^2. Columns A1 and A2 contained Atochem, Inc. GAC 830, and columns B1 and B2 contained Calgon Filtrasorb 300. In addition, the bed depth for all four columns was 4 ft. The empty-bed contact time in columns A1 and B1 was 4.2 min. The operating parameters previously discussed are presented in Table 4-3.

Test Two was started on 19 September 1989 and shut down on 6 October 1989. This test was run for a total of 16.5 days, at which time it was decided by WESTON and USATHAMA that breakthrough would not be reached in a reasonable amount of time for study purposes using the operating parameters in Table 4-3.

None of the contaminants of concern (in Table 4-3) was detected in the effluent samples.

4.2.3 CONTINUOUS FLOW COLUMN TEST CONDITIONS FOR TEST THREE

In Test Three, the groundwater flow rates for columns A1 and B1 were 0.75 gpm. The hydraulic loading in the columns was 7.6 gpm/ft^2. Columns A1 and A2 contained Atochem, Inc. GAC 830 and columns B1 and B2 contained Calgon Filtrasorb 300. In addition, the bed depth for all four columns was 2 ft. The empty-bed contact time in columns A1 and B1 was 2.0 min. The operating parameters previously discussed are presented in Table 4-4.

Test Three was started on 16 October 1989 and shut down on 15 December 1989. This test was run for a total of 54.5 days at which time, because of cold weather, it was decided by WESTON and USATHAMA that the unit should be shut down so that no damage would occur to the system.

Table 4-2

Summary of Granular Activated Carbon (GAC) Columns
Operating and Performance Data for Test One at MAAP

Starting Date: 7 September 1989
Ending Date: 15 September 1989
Column Inner Diameter: 4.25 in. (0.354 ft)
Column Area: 0.0985 ft^2
Bed Volume: 0.394 ft^3 (2.94 gal)

	Column A1	Column B1
GAC Used	Atochem, Inc. GAC 830	Atochem, Inc. GAC 830
Flow Rate	1.0 gpm	0.2 gpm
Hydraulic Loading	10.15 gpm/ft	2.03 gpm/ft^2
Bed Depth	4 ft	4 ft
Empty-Bed Contact Time	3.0 min	14.7 min
Final Effluent Levels, ug/L		
TNT (Influent 433 ug/L)	ND	ND
RDX (Influent 487 ug/L)	7.05 ug/L	ND
HMX (Influent 3.4 ug/L)	ND	ND
Tetryl (Influent ND)	ND	ND
2,4-DNT (Influent 10.8 ug/L)	ND	ND
2,6-DNT (Influent ND)	ND	ND
1,3-DNB (Influent 3.2 ug/L)	ND	ND
1,3,5-TNB (Influent 21.4 ug/L)	ND	ND
NB (Influent ND)	ND	ND
Run Time	7.6 days	7.6 days

Notes: ND = Not detected.
Concentrations in parentheses are average influent concentrations.

Table 4-3

Summary of Granular Activated Carbon (GAC) Columns
Operating and Performance Data for Test Two at MAAP

Starting Date: 19 September 1989
Ending Date: 6 October 1989
Column Inner Diameter: 4.25 in. (0.354 ft)
Column Area: 0.0985 ft^2
Bed Volume: 0.394 ft^3 (2.94 gal)

	Column A1	Column B1
GAC Used	Atochem, Inc. GAC 830	Calgon Filtrasorb 300
Flow Rate	0.7 gpm	0.7 gpm
Hydraulic Loading	7.11 gpm/ft^2	7.11 gpm/ft^2
Bed Depth	4 ft	4 ft
Empty-Bed Contact Time	4.2 min	4.2 min
Final Effluent Levels, ug/L		
TNT (Influent 508 ug/L)	ND	ND
RDX (Influent 536 ug/L)	ND	ND
HMX (Influent 3.7 ug/L)	ND	ND
Tetryl (Influent ND)	ND	ND
2,4-DNT (Influent 11.8 ug/L)	ND	ND
2,6-DNT (Influent ND)	ND	ND
1,3-DNB (Influent 3.8 ug/L)	ND	ND
1,3,5-TNB (Influent 25.7 ug/L)	ND	ND
NB (Influent ND)	ND	ND
Run Time	16.5 days	16.5 days

Notes: ND = Not detected.
Concentrations in parentheses are average influent concentrations.

Table 4-4

Summary of Granular Activated Carbon (GAC) Columns
Operating and Performance Data for Test Three at MAAP

Starting Date: 16 October 1989
Ending Date: 15 December 1989
Column Inner Diameter: 4.25 in. (0.354 ft)
Column Area: 0.0985 ft^2
Bed Volume: 0.197 ft^3 (1.47 gal)

	Column A1	Column B1
GAC Used	Atochem, Inc. GAC 830	Calgon Filtrasorb 300
Flow Rate	0.75 gpm	0.75 gpm
Hydraulic Loading	7.6 gpm/ft^2	7.6 gpm/ft^2
Bed Depth	2 ft	2 ft
Empty-Bed Contact Time	2.0 min	2.0 min
Final Effluent Levels, ug/L		
TNT (Influent 734 ug/L)	88.6 ug/L	192 ug/L
RDX (Influent 549.1 ug/L)	315 ug/L	344 ug/L
HMX (Influent 3.8 ug/L)	ND	ND
Tetryl (Influent ND)	ND	ND
2,4-DNT (Influent 12.2 ug/L)	3.6 ug/L	ND
2,6-DNT (Influent ND)	ND	ND
1,3-DNB (Influent 4.2 ug/L)	ND	ND
1,3,5-TNB (Influent 26.6 ug/L)	9.91 ug/L	14.9 ug/L
NB (Influent ND)	ND	ND
Run time	54.5 days	54.5 days

Notes: ND = Not detected.
Concentrations in parentheses are average influent concentrations.

Over the Thanksgiving holiday, the unit was shut down for 5.5 days. Water was maintained in the columns to keep the carbon from drying out; however, the rest of the system was shut down. Upon returning from the 5.5-day shutdown, the feed pumps were started and column flow was re-established. The carbon in the columns was still saturated. It did not visibly appear to be affected by the shutdown.

During the last 2 weeks of the test, problems with frozen and broken lines caused difficulties in maintaining flow through the GAC unit and pumping groundwater from the monitor well into the influent holding tanks. All of the lines that were utilized for backwashing were either frozen or cracked. As a result, no backwashing of the columns could be performed and the in and out pressures in column A1 rose to about 13 psi and 22 psi, respectively. These pressures were normally 3 psi and 6.5 psi, respectively. At the same time, it was discovered that the effluent line transporting the treated effluent to the Wolf Creek Ordnance Plant STP was frozen. Hence the effluent was leaking from this line in several places. WESTON and MAAP then decided to bypass this line and send the effluent to the holding tank in Building K-51. From here it could be pumped out and transported to the STP.

During the last days of the test, temperatures began to drop well below freezing at night and rise to only a few degrees above freezing during the day. On 13 December 1989 at approximately 8:30 a.m., one of the flow valves serving column A1 was found frozen shut. As a result, flow to column A1 was stopped and it was completely drained. After the valve was thawed, column A1 was filled back up and flow was restored to it. The estimated time that the column was dry was about an hour to an hour and a half. Electric heaters were then borrowed from MAAP and placed in building K-51 and around the GAC unit to deter freezing. However, this was unsuccessful. Therefore, WESTON and USATHAMA decided to end the test on 15 December 1989 before damage to the GAC unit occurred.

4.3 VARIANCE ANALYSIS

A total of four tests was planned, three with a constant pH between 6.0 and 9.0 and one with pH of 4.0. All four tests were to use the two carbons selected from the batch (isotherm) testing, Atochem, Inc. GAC 830 and Calgon Filtrasorb 300.

Only three of the four tests planned were run. The first three tests with a constant pH between 6.0 and 9.0 were run. However, the fourth test with a pH of 4.0 was not run because the batch (isotherm) testing results on the effect of pH on activated carbon adsorption of groundwater from monitor well MI051 at MAAP were inconclusive. Furthermore, the Badger Army Ammunition Plant (BAAP) report [12] showed that relatively higher adsorption capacities were obtained at neutral pH (7.0) than at acidic pH (4.0) for Filtrasorb 400, using explosives-contaminated groundwater from monitor well PBN82-02C at BAAP. Nevertheless, Test Four was originally planned to run at the same pH as Tests One, Two, and Three, but weather conditions precluded any additional tests after Test Three.

Because Filtrasorb 300 was unavailable at the time, Test One was run with Atochem, Inc. GAC 830 in both trains instead of just train A. The flow rates, hydraulic loadings, bed depths, empty-bed contact times, and pH were as originally planned for Test One.

The original Test Three was run for Test Two. This was done because in Test One the adsorption was better than anticipated. In addition, except for RDX breakthrough in column A1, no breakthrough of the contaminants of concern occurred in Test One. Therefore, in Test Two, the flow rates, hydraulic loadings, bed depths, empty-bed contact times, and pH were as originally planned for Test Three.

Except for pH and carbon type, Test Three was run under different conditions than originally planned. This was primarily due to the failure to achieve breakthrough in Test Two. Flow rates were increased from 0.70 to 0.75 gpm, which was the maximum flow rate for the feed pump. This gave a hydraulic loading of 7.6 gpm/ft^2 instead of 7.0 gpm/ft^2. In addition, the bed depth was decreased from 4.0 ft to 2.0 ft. This gave an empty-bed contact time of 2.0 min. instead of 4.2 min. Because of the below freezing temperatures and the longer than anticipated time to reach complete breakthrough or exhaustion, Test Three was stopped around 60 percent of complete breakthrough for RDX in columns A1 and B1 effluents. These conditions also made it not practical to run Test Four.

4.4 SAMPLE ANALYSIS

The first column's influent samples were taken at the second hour, 24th hour, 48th hour, and so on, and analyzed. This sampling schedule assumed that the composition of the influent to the GAC unit did not change during a test. If it did, the performance of the GAC unit would be affected. Therefore, the sampling frequency would have to be adjusted. In addition, effluent samples were taken every 2 hours. If there was not significant difference in analyses between the first-hour and 24th-hour effluent samples, the other 10 effluent samples were discarded. However, if there was a difference, the effluent sample taken at 12 hours was analyzed and the other 2-hour effluent samples were analyzed to determine when the composition of the effluent changed. The 2-hour effluent samples not analyzed immediately were stored according to the analytical method guidelines and either analyzed within the prescribed holding time or discarded.

When initial breakthrough was detected, sufficient column effluent samples were taken at either 1-hour or half-hour intervals until complete breakthrough or exhaustion was reached or the test was ended. The results of the analyses of these samples were used to construct a breakthrough curve. From this curve, the time at which the concentration of the contaminant of concern exceeded its effluent objective concentration and the time at which the carbon was completely exhausted could be determined.

The analytical parameters for all tests were TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB. A total of 750 samples was analyzed for these parameters at the field laboratory at MAAP. These samples included influent samples to the GAC unit and effluent samples from columns A1, A2, B1, and B2. In addition, 42 samples were sent to WESTON's Analytics Division for similar analysis. These samples represented 6 percent of the field laboratory samples analyzed and verified field lab performance.

Copies of the sampling and analytical methods are in Appendix A of the test plan [14].

4.4.1 ANALYTICAL PROCEDURE FOR EXPLOSIVES - FIELD LAB

Samples were analyzed for explosives by HPLC utilizing USATHAMA Method UW01, Explosives in Water. The following modifications to Method UW01 were made for field use:

- An injection volume of 10 mL.
- Calibration curves of 0.5x, 1x, 2x, 5x, 10x, 20x, 50x, and 100x.
- Daily QC of blank, 1x, and 10x spike.
- Final 10x calibration standard.

These modifications were made to increase efficiency with a minimal effect on method performance.

4.4.2 ANALYTICAL PROCEDURE FOR EXPLOSIVES - WESTON'S ANALYTICS DIVISION

Samples were analyzed for explosives by liquid/liquid extraction and HPLC using USATHAMA Method UW01, Explosives in Water.

4.4.3 ANALYTICAL PROCEDURE FOR TOTAL ORGANIC CARBON IN WATER - WESTON'S ANALYTICS DIVISION

Samples were analyzed by U.S. EPA Method 415.1.

SECTION 5

PRESENTATION OF EXPERIMENTAL RESULTS

This study of activated carbon for treatment of explosives-contaminated groundwater was conducted over a 4-month period. Three tests were run from September to December 1989. Tests One, Two, and Three ran for 7.6, 16.5, and 54.5 days, respectively. The variables examined were the concentrations of nine explosives in groundwater, pH, and effluent flow rates. The results of the three tests are presented in this section.

5.1 EXPLOSIVES

For Tests One, Two, and Three influent and effluent groundwater samples were taken and analyzed for the following nine explosives: TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB. These samples were analyzed in the field laboratory and by WESTON's Analytics Division in Lionville, Pennsylvania. Samples analyzed in the field laboratory totalled 750, and samples analyzed by WESTON's Analytics Division totalled 42. The results of the analyses are presented in the following subsections.

5.1.1 FIELD LAB RESULTS

The field laboratory results from Test One are presented in Appendix C. Tables C-1 to C-9 give the concentration of each explosive in the influent and the effluents from columns A1 and B1 along with the respective column's throughput volume. Table C-10 gives the concentrations of all nine explosives in the effluents from columns A2 and B2. In Test One, both primary columns (A1 and B1) contained the same carbon, Atochem, Inc. GAC 830. However, their effluent flow rates were different. Column A1's effluent flow rate was 1.0 gpm and column B1's was 0.2 gpm.

Because final effluent concentrations for eight of the nine explosives in Test One were not detectable throughout the test, only two figures are presented. Figure 5-1 shows the RDX concentration in column A1 effluent versus column throughput volume. The RDX concentration in column B1 was not plotted in this figure because it was below the RDX detection limit of 0.63 ug/L for the entire test. Except for the addition of the RDX concentration in the influent, Figure 5-2 is similar to Figure 5-1.

The field laboratory results from Test Two are presented in Appendix D. Tables D-1 to D-9 give the concentration of each explosive in the influent and effluents from columns A1 and B1 along with the influent water temperature and column throughput volume. Table D-10 gives the concentrations of all nine explosives in the effluents from columns A2 and B2. In Test Two, both primary columns had the same effluent flow rate of 0.7 gpm. However, they did not contain the same carbon. Column A1 contained Atochem, Inc. GAC 830 and column B1 contained Calgon Filtrasorb 300.

Because final effluent concentrations for all nine explosives in Test Two were not detectable, no figures of explosive concentration versus column throughput volume are presented.

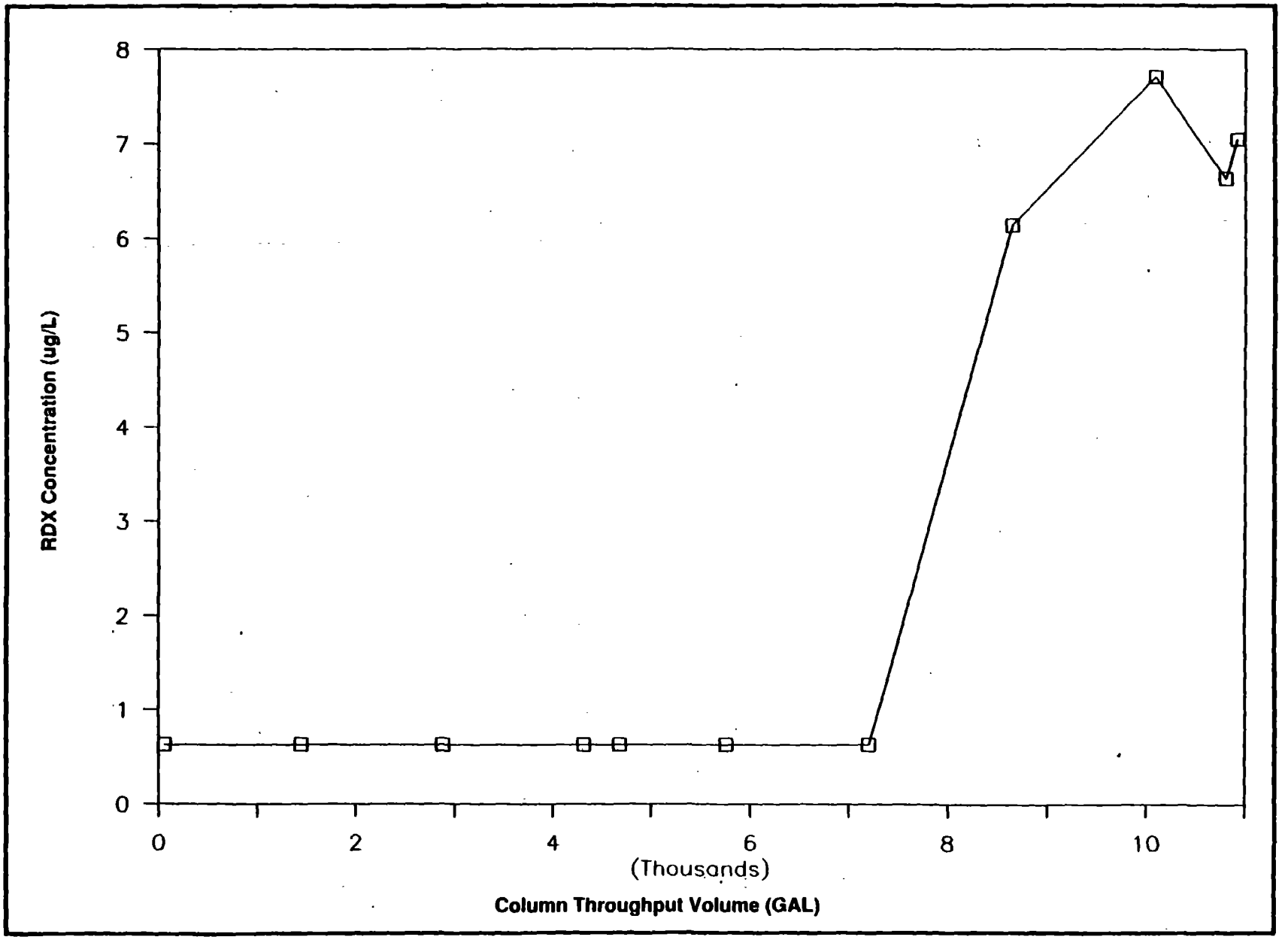

FIGURE 5-1 RDX CONCENTRATION IN COLUMN A1 EFFLUENT VS. COLUMN THROUGHPUT VOLUME FOR TEST ONE AT MAAP

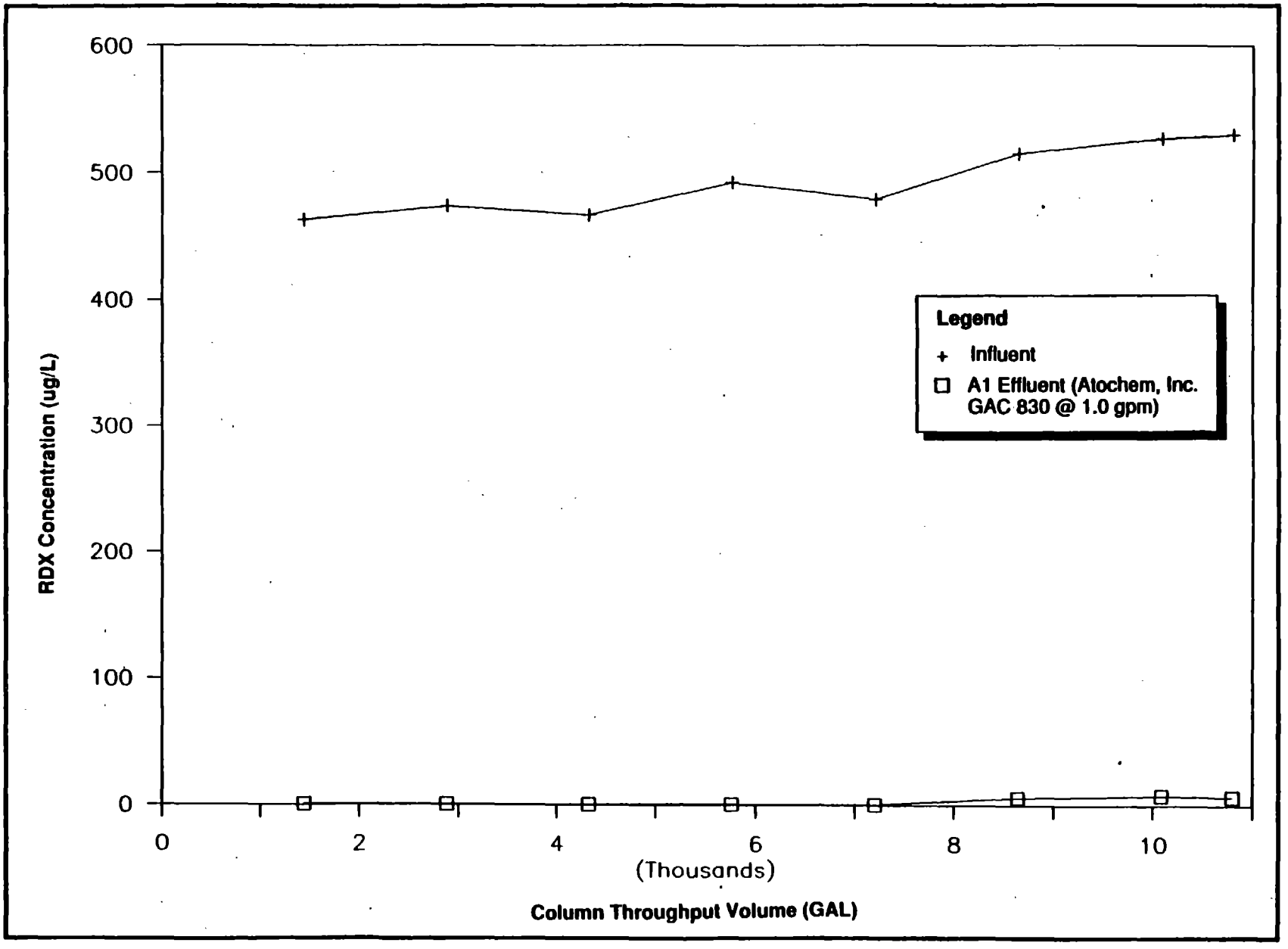

FIGURE 5-2 RDX CONCENTRATION VS. COLUMN THROUGHPUT VOLUME FOR TEST ONE AT MAAP

The field laboratory results from Test Three are presented in Appendix E. Tables E-1 to E-9 give the concentration of each explosive in the influent and effluents from columns A1 and B1 along with the influent water temperature and column throughput volume. Tables E-10 to E-18 give the concentration of each explosive in the effluents from columns A2 and B2. In Test Three, both primary columns had the same effluent flow rate of 0.75 gpm. However, they did not contain the same carbon. Column A1 contained Atochem, Inc. GAC 830 and column B1 contained Calgon Filtrasorb 300.

Because final effluent concentrations for five of the nine explosives in Test Three were not detectable (HMX, Tetryl, 2,6-DNT, 1,3-DNB, and NB), only eight figures are presented, Figures 5-3 to 5-10. Figures 5-3, 5-5, 5-7, and 5-9 show the explosive concentrations in columns A1 and B1 effluents vs. column throughput volume for TNT, RDX, 2,4-DNT, and 1,3,5-TNB, respectively. These figures do not show these concentrations after 5:00 a.m. on 13 December 1989 because the flows to columns A1 and B1 were interrupted for about 1.5 hours by a frozen influent line to column A1. This interruption of flow made it impossible to accurately determine the column throughput volume for each column during this time period. Therefore, even though the explosive concentrations in columns A1 and B1 effluents after 5:00 a.m. on 13 December 1989 are reported in Tables E-1 to E-9, they are not plotted versus column throughput volume in Figures 5-3, 5-5, 5-7, and 5-9. Except for the addition of the explosive concentrations in the influent, Figures 5-4, 5-6, 5-8, and 5-10 are similar to Figures 5-3, 5-5, 5-7, and 5-9.

5.1.2 WESTON'S ANALYTICS DIVISION RESULTS

Samples were taken of each primary column's effluent, shipped to WESTON's Analytics Division and analyzed for all nine explosives. These samples represented 6 percent of the field laboratory samples taken and analyzed. The results of the laboratory analysis of the samples from Tests One, Two, and Three are presented in Tables 5-1, 5-2, and 5-3, respectively.

Samples were also taken of the influents in Tests Two and Three, shipped to WESTON's Analytical Division, and analyzed for all nine explosives. The results of the laboratory analysis of the samples from Tests Two and Three are presented at the bottom of Tables 5-2 and 5-3, respectively.

Five samples of spent carbon from the pilot plant were sent to the Martin Marietta Environmental Laboratory at Milan, Tennessee, for nitrobody analysis. One sample of spent carbon from each column after Test Three and a control were analyzed by first extracting the nitrobody with acetonitrile overnight and then analyzing the extract with a LDC-Milton Roy Liquid Chromatograph. The results are presented in Appendix F.

5.2 TEMPERATURE AND PH

Temperature and pH were measured in the field on the influent to the GAC unit. Plots of the influent water temperature versus column throughput volume for Tests Two and Three are shown in Figures 5-11 and 5-12, respectively. The temperatures below the freezing point of water in

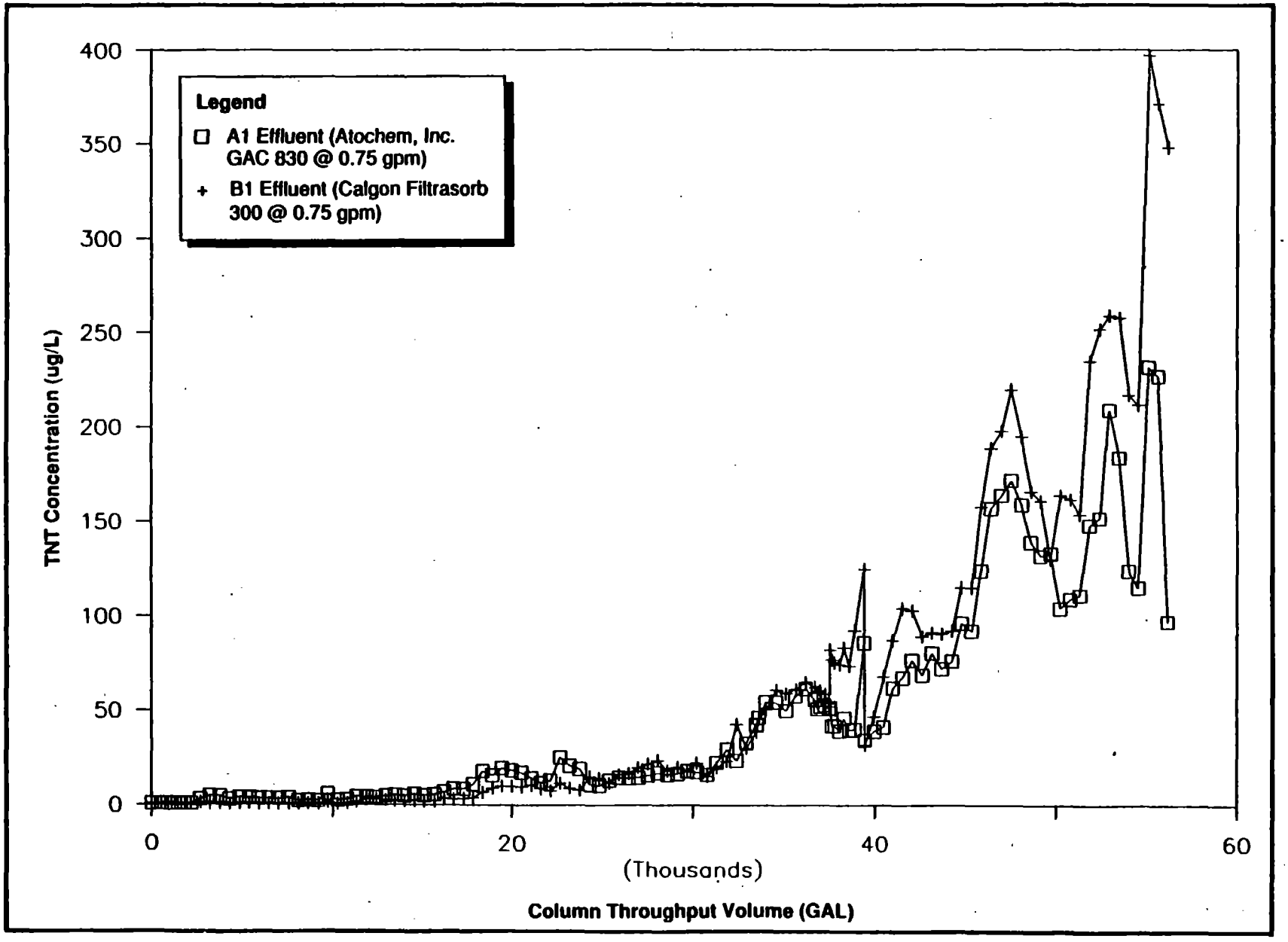

FIGURE 5-3 TNT CONCENTRATION IN COLUMNS A1 AND B1 EFFLUENTS VS. COLUMN THROUGHOUT VOLUME FOR TE THREE AT MAAP

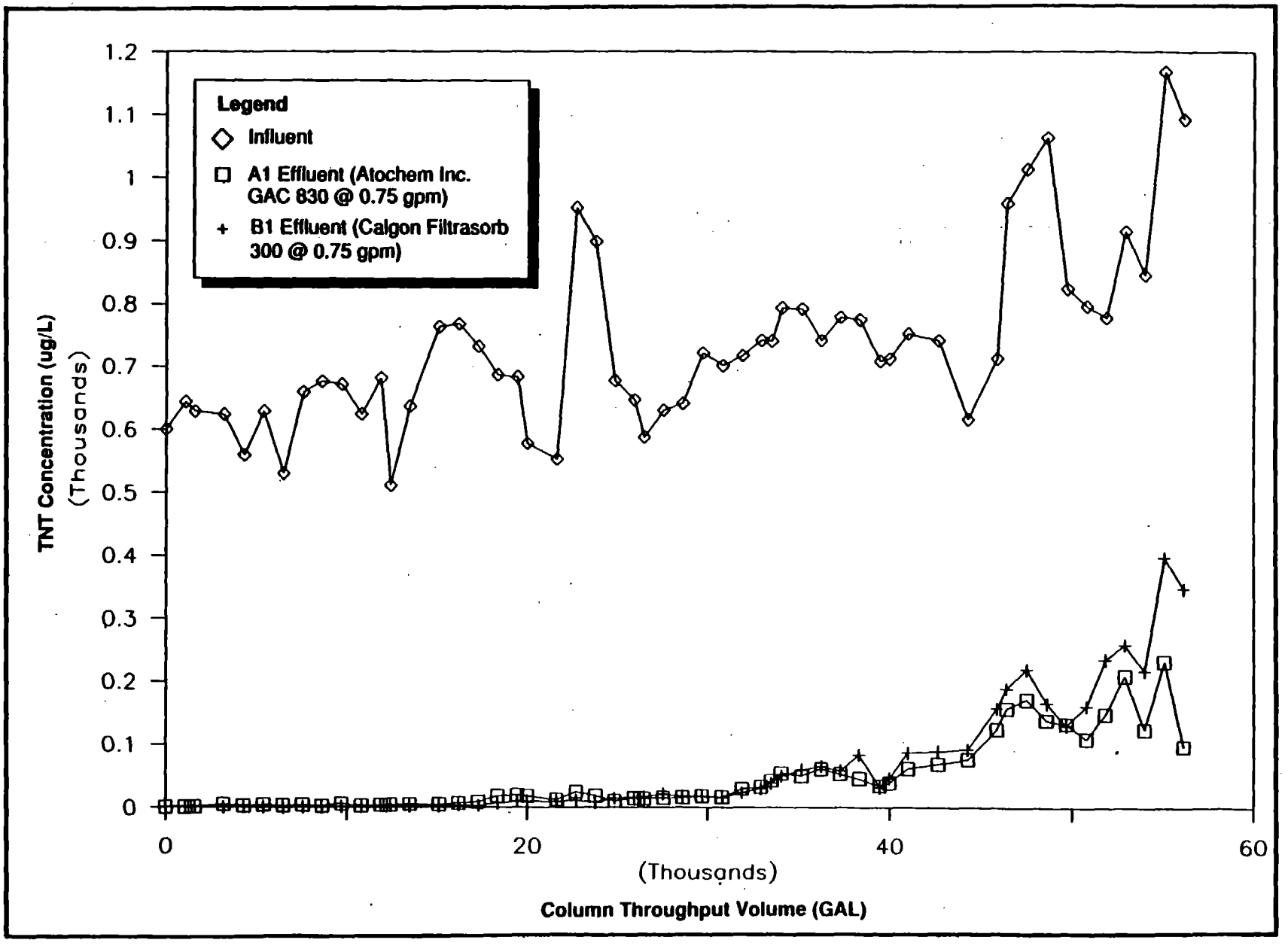

FIGURE 5-4 TNT CONCENTRATION VS. COLUMN THROUGHOUT VOLUME FOR TEST THREE AT MAAP

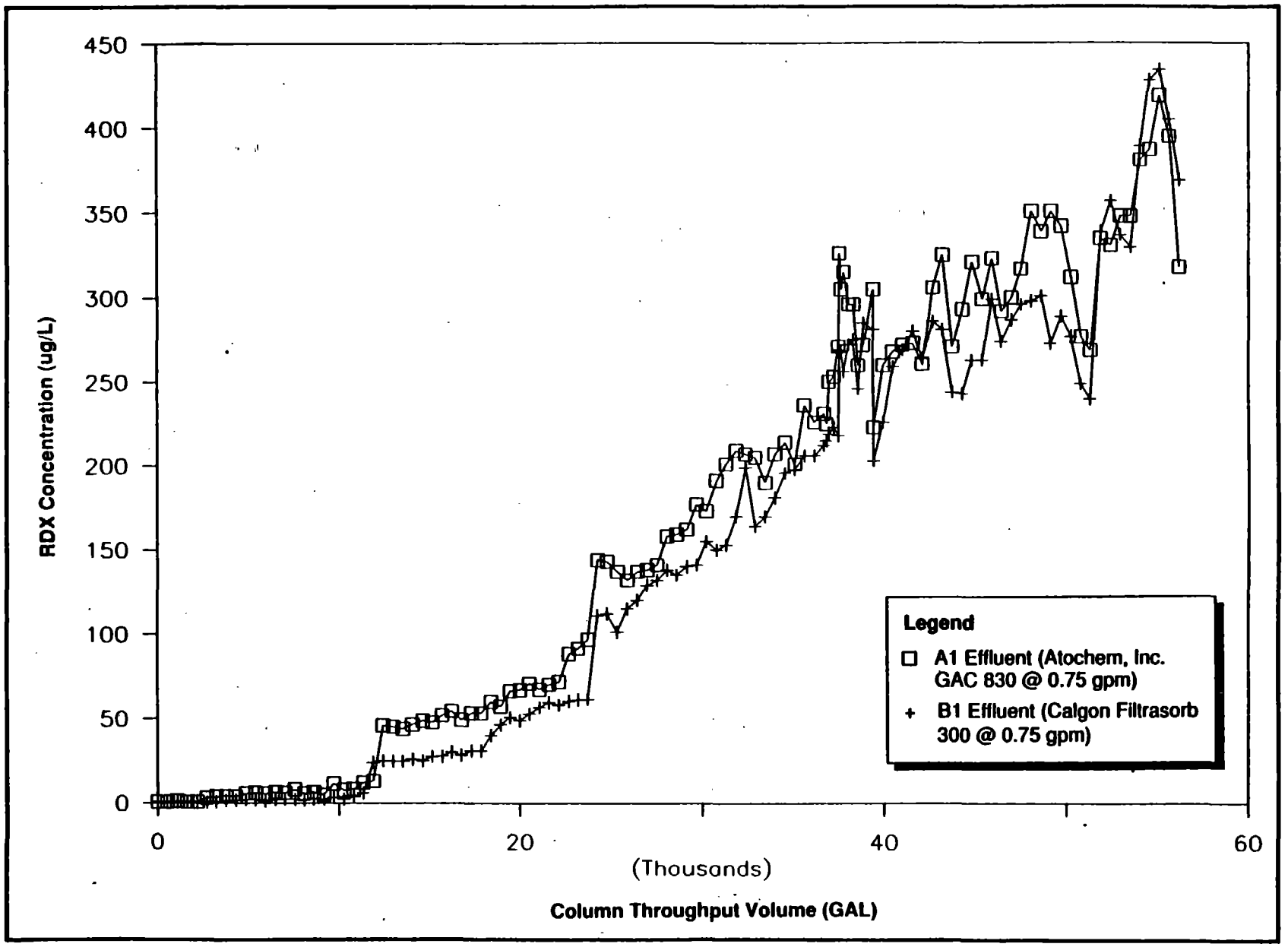

FIGURE 5-5 RDX CONCENTRATION IN COLUMNS A1 AND B1 EFFLUENTS VS. COLUMN THROUGHPUT VOLUME FOR TEST THREE AT MAAP

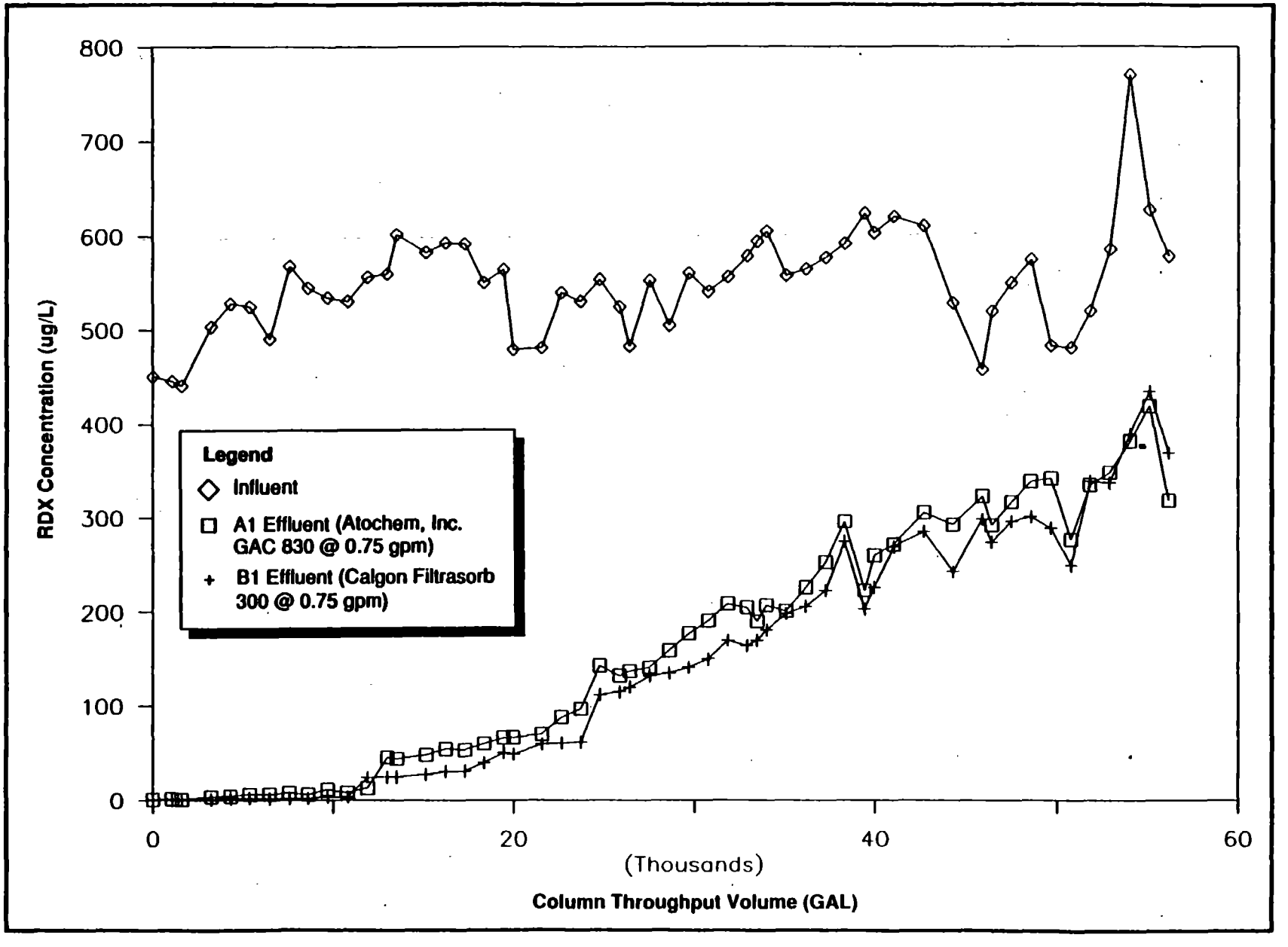

FIGURE 5-6 RDX CONCENTRATION VS. COLUMN THROUGHPUT VOLUME FOR TEST THREE AT MAAP

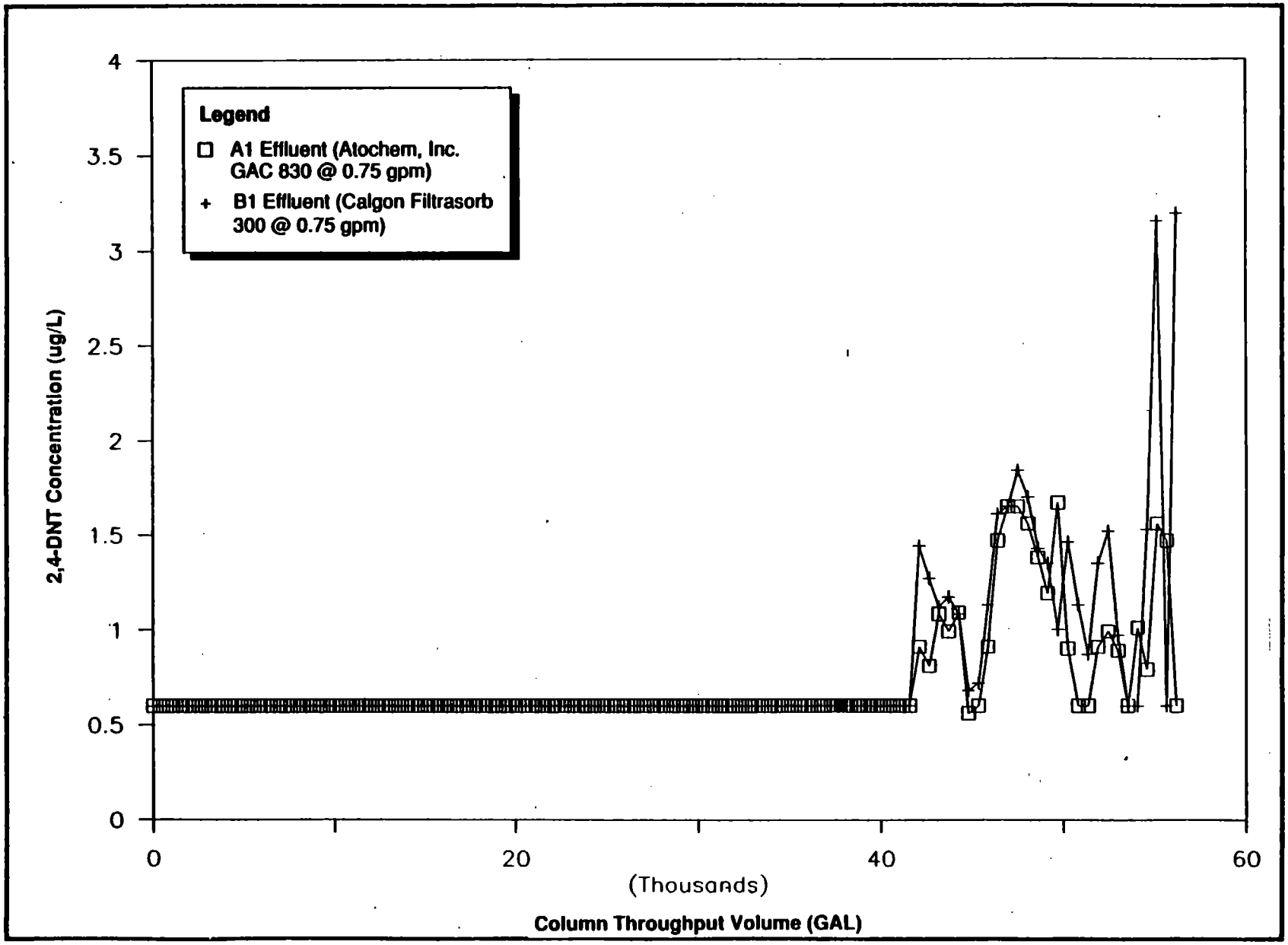

FIGURE 5-7 2,4-DNT CONCENTRATION IN COLUMNS A1 AND B1 EFFLUENTS VS. COLUMN THROUGHPUT VOLUME FOR TEST THREE AT MAAP

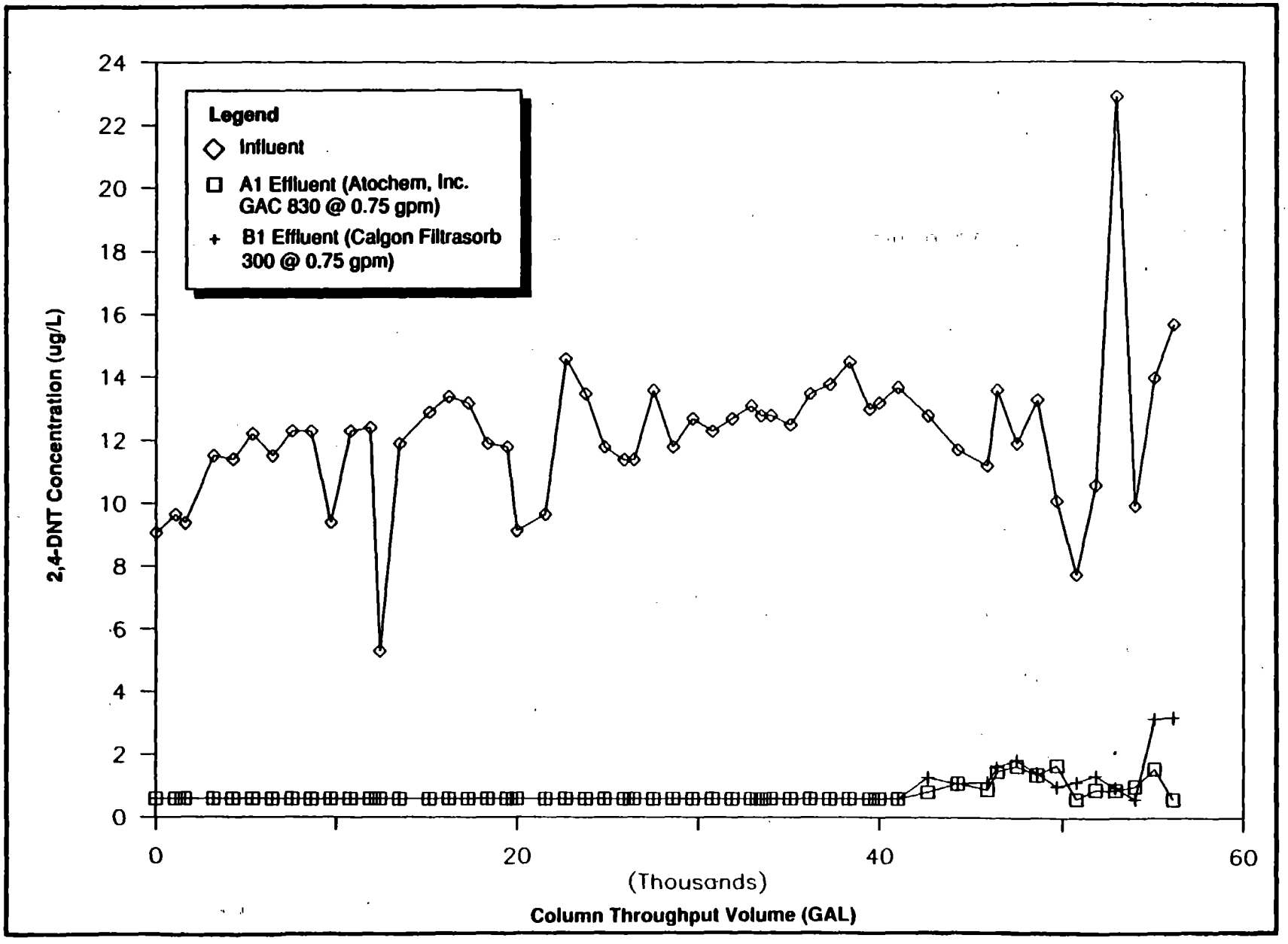

FIGURE 5-8 2,4-DNT CONCENTRATION VS. COLUMN THROUGHPUT VOLUME FOR TEST THREE AT MAAP

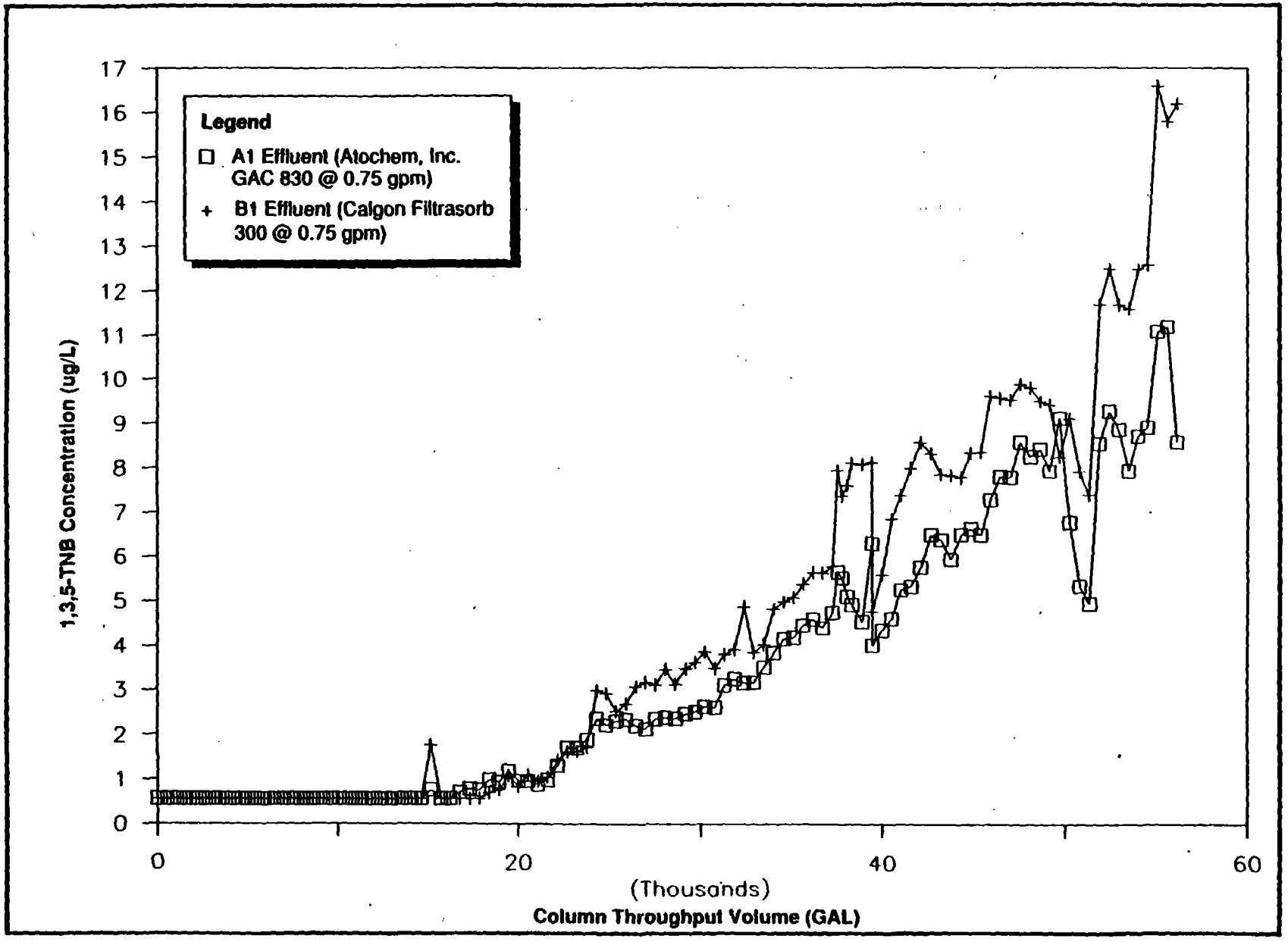

FIGURE 5-9 1,3,5-TNB CONCENTRATION IN COLUMNS A1 AND B1 EFFLUENTS VS. COLUMN THROUGHPUT

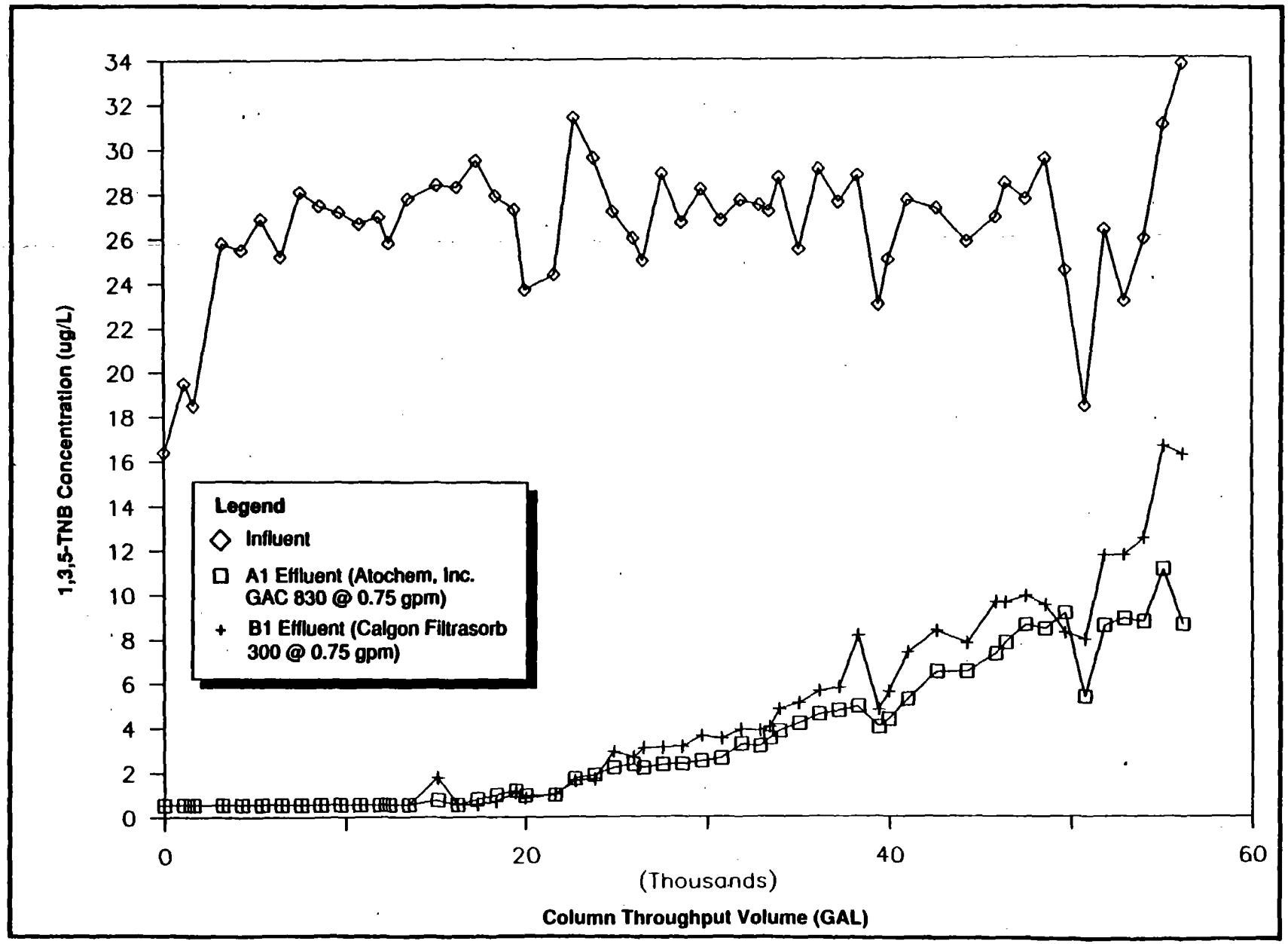

FIGURE 5-10 1,3,5-TNB CONCENTRATION VS. COLUMN THROUGHPUT VOLUME FOR TEST THREE AT MAAP

Table 5-1

WESTON's Analytics Division Results for Explosives from Test One at MAAP

Sample ID	TNT (ug/L)	RDX (ug/L)	HMX (ug/L)	Tetryl (ug/L)	2,4-DNT (ug/L)	2,6-DNT (ug/L)	1,3-DNB (ug/L)	1,3,5-TNB (ug/L)	NB (ug/L)
Column B1 (Atochem, Inc. GAC 830)									
8 Sept. 1989 - 6:00 AM	<0.78	0.81	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
8 Sept. 1989 - 18:00 PM	<0.78	0.93	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
9 Sept. 1989 - 18:00 PM	<0.78	1.10	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
10 Sept. 1989 - 18:00 PM	<0.78	0.96	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
10 Sept. 1989 - 24:00 PM	<0.78	0.88	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
Column A2 (Atochem, Inc. GAC 830)									
8 Sept. 1989 - 6:00 AM	<0.78	1.10	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
8 Sept. 1989 - 18:00 PM	<0.78	0.86	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
9 Sept. 1989 - 18:00 PM	<0.78	1.14	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
10 Sept. 1989 - 18:00 PM	<0.78	1.07	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
10 Sept. 1989 - 24:00 PM	<0.78	1.16	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13

Table 5-2

WESTON's Analytics Division Results for Explosives from Test Two at MAAP

Sample ID	TNT (ug/L)	RDX (ug/L)	HMX (ug/L)	Tetryl (ug/L)	2,4-DNT (ug/L)	2,6-DNT (ug/L)	1,3-DNB (ug/L)	1,3,5-TNB (ug/L)	NB (ug/L)
Column A1 (Atochem, Inc. GAC 830)									
20 Sept. 1989 - 4:30 AM	<0.78	0.66	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
20 Sept. 1989 - 16:30 PM	<0.78	0.85	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
21 Sept. 1989 - 16:30 PM	<0.78	0.95	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
22 Sept. 1989 - 16:30 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
23 Sept. 1989 - 16:30 PM	<0.78	1.33	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
Column B1 (Calgon Filtrasorb 300)									
20 Sept. 1989 - 4:30 AM	<0.78	0.86	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
20 Sept. 1989 - 16:30 PM	<0.78	0.93	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
21 Sept. 1989 - 16:30 PM	<0.78	0.86	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
22 Sept. 1989 - 16:30 PM	<0.78	<0.86G*	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
23 Sept. 1989 - 16:30 PM	<0.78	0.79	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
Influent									
22 Sept. 1989 - 16:30 PM	454	453	3.06	<66.0	9.89	<0.55	3.44	19.9	<1.13

*G = Indicates elevated detection limit due to sample interference.

1113M2

Table 5-3

WESTON's Analytics Division Results for Explosives from Test Three at MAAP

Sample ID	TNT (ug/L)	RDX (ug/L)	HMX (ug/L)	Tetryl (ug/L)	2,4-DNT (ug/L)	2,6-DNT (ug/L)	1,3-DNB (ug/L)	1,3,5-TNB (ug/L)	NB (ug/L)
Column A1 (Atochem, Inc. GAC 830)									
17 Oct. 1989 - 5:00 AM	<0.78	1.42	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
17 Oct. 1989 - 17:00 PM	<0.78	1.58	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
18 Oct. 1989 - 17:00 PM	1.52	3.51	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
19 Oct. 1989 - 17:00 PM	2.76	4.37	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
20 Oct. 1989 - 17:00 PM	<0.78	2.45	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
8 Dec. 1989 - 5:00 AM	126	408	<1.30	3.34	1.67	<0.55	1.08	8.64	<1.13
8 Dec. 1989 - 17:00 PM	121	316	<1.30	2.81	1.56	<0.55	0.71	7.87	<1.13
Column B1 (Calgon Filtrasorb 300)									
17 Oct. 1989 - 5:00 AM	<0.78	1.14	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
17 Oct. 1989 - 17:00 PM	<0.78	1.13	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
18 Oct. 1989 - 17:00 PM	<0.78	1.70	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
19 Oct. 1989 - 17:00 PM	<0.78	1.64	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
20 Oct. 1989 - 17:00 PM	<0.78	4.55	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
8 Dec. 1989 - 5:00 AM	206	368	<1.30	4.40	2.47	<0.55	1.26	11.8	<1.13
8 Dec. 1989 - 17:00 PM	187	318	<1.30	5.28	2.63	<0.55	1.12	11.7	<1.13
Influent									
8 Dec. 1989 - 5:00 AM	740	456	2.74	38.0	14.0	<0.55	7.15	26.9	<1.13

1113M2

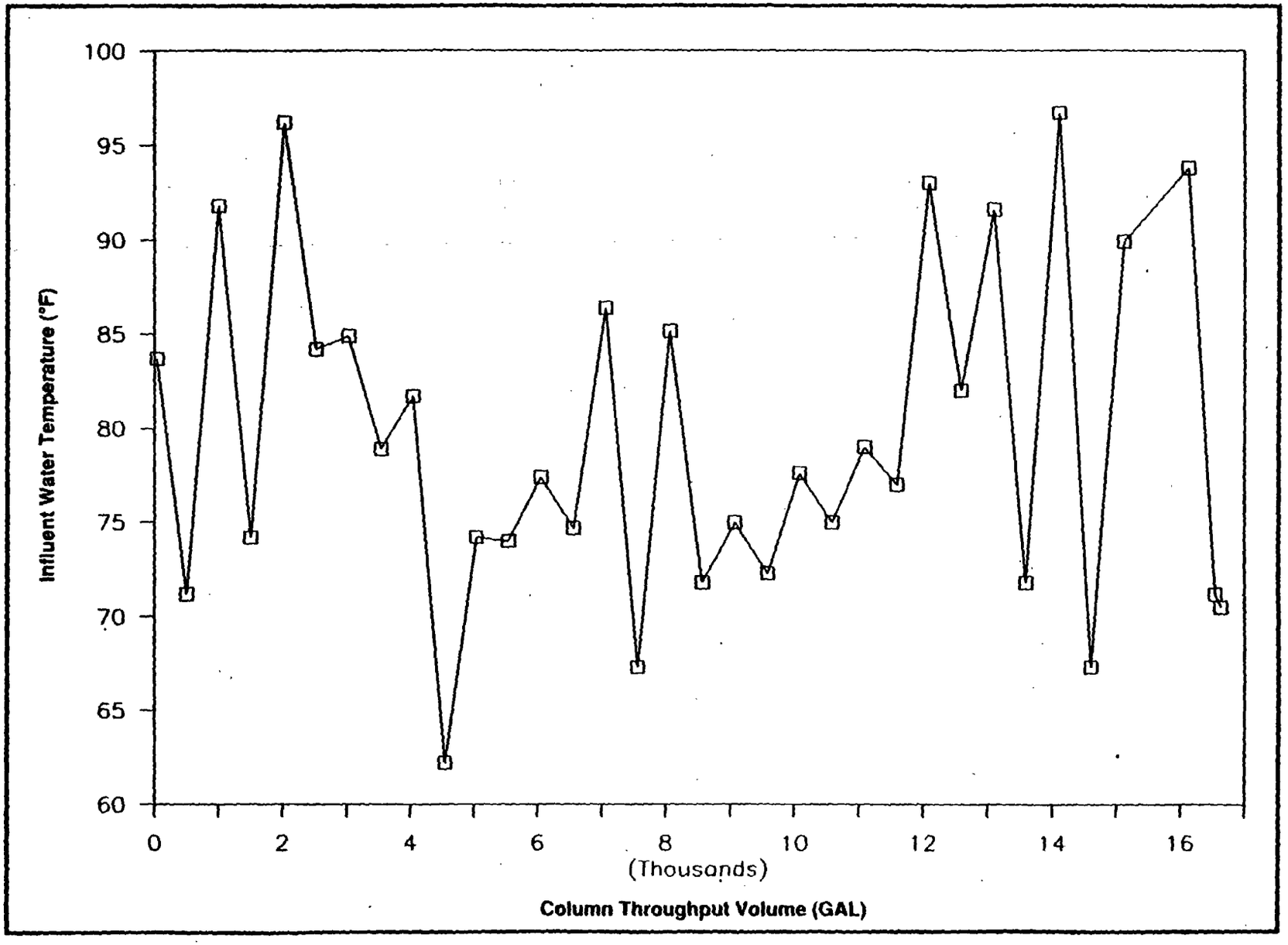

FIGURE 5-11 INFLUENT WATER TEMPERATURE VS. COLUMN THROUGHPUT VOLUME FOR TEST TWO AT MAAP

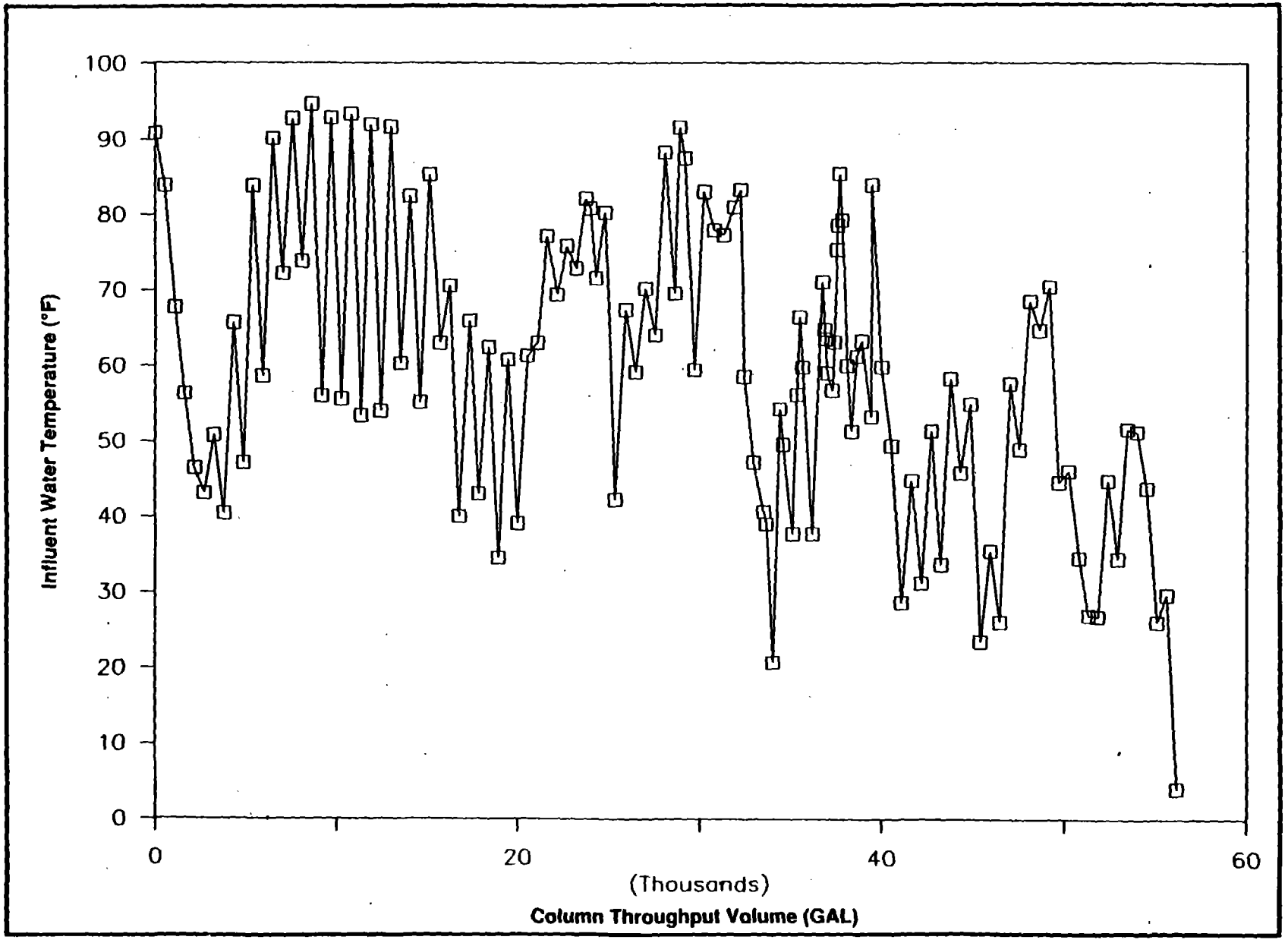

FIGURE 5-12 INFLUENT WATER TEMPERATURE VS. COLUMN THROUGHPUT VOLUME FOR TEST THREE AT MAAP

Figure 5-12 were obtained when the temperature probe was exposed to the air rather than the influent water during the latter portion of Test Three. A similar plot was not done for Test One because of the short run length.

No plots were made of pH versus column through put volume because the pH of the groundwater samples only varied slightly between pH 6.0 and pH 6.5 in all three tests.

SECTION 6

DISCUSSION OF RESULTS

This section provides discussion and interpretation of the data presented in Section 5.

6.1 EFFLUENT CHARACTERISTICS

Influent and effluent concentrations for all nine explosives in Tests One, Two, and Three, have been presented in Appendices C, D, and E, respectively. In addition, these concentrations for RDX, TNT, 2,4-DNT, and 1,3,5-TNB have been presented graphically in Figures 5-1 through 5-10. All of these presentations clearly showed that granular activated carbon in continuous flow columns produced very low effluent concentrations for all nine explosives, generally in the low part per billion (ppb) range during the early portions of each test.

In Test One, columns A1 and B1 each contained 0.394 ft^3 of Atochem, Inc. GAC 830 but were operated at different influent flow rates. Columns A1 and A2 were operated at 1.0 gpm, which gave a hydraulic loading of 10.15 gpm/ft^2, and columns B1 and B2 were operated at 0.2 gpm, which gave a hydraulic loading of 2.03 gpm/ft^2. During Test One, only RDX exceeded its detection limit of 0.63 ug/L in column A1's effluent. This occurred after about 8,000 gal (2,715 bed volumes) of influent containing an average RDX concentration of 487 ug/L passed through the column (see Figures 5-1 and 5-2). When Test One was terminated at a column A1 throughput volume of 10,920 gal (3,705 bed volumes), the RDX concentration in this column's effluent was 7.05 ug/L.

Test Two had 0.394 ft^3 of Atochem, Inc. GAC 830 in column A1 and 0.394 ft^3 of Calgon Filtrasorb 300 in column B1 but both columns were operated at the same influent flow rate of 0.7 gpm, which gave a hydraulic loading of 7.11 gpm/ft^2. Even after 16,632 gal (5,644 bed volumes) of influent passed through both columns, the effluent concentrations of all nine explosives were below their detection limits, which are all around 1.0 ppb.

In Test Three, column A1 had 0.197 ft^3 of Atochem, Inc. GAC 830 and column B1 had 0.197 ft^3 of Calgon Filtrasorb 300. Both columns were operated at an influent flow rate of 0.75 gpm which gave a hydraulic loading of 7.6 gpm/ft^2. Since the maximum pumping rate for the system was 1.5 gpm, one flow was split evenly between two sets of columns. This flow rate was the maximum per set of columns. Only TNT, RDX, 2,4-DNT, and 1,3,5-TNB exceeded their detection limits in columns A1 and B1 effluents. HMX, Tetryl, 2,6-DNB, 1,3-DNT, and NB were all below their detection limits even after 56,160 gal (38,112 bed volumes) of influent had passed through both columns. However, Tetryl, 2,6-DNT, and NB were already below their detection limits in the influent, and HMX and 1,3-DNB's influent concentrations were low, 3.8 and 4.2 ug/L, respectively.

In Test Three, the average TNT influent concentration was 734 ug/L and its final effluent levels in columns A1 and B1 were 88.6 and 192 ug/L, respectively. Even though these levels indicate that Atochem, Inc. GAC 830 performed slightly better than Calgon Filtrasorb 300, both carbons performed about the same (see Figure 5-3) for most of the test. In particular, the apparent breakthroughs for both carbons occurred at about the same column throughput volume of 30,000 gal (20,359 bed volumes). Apparent breakthrough is the point on the breakthrough curve where the concentration of the column effluent first begins to rise above its initial column leakage concentration. The average RDX influent concentration was 549.1 ug/L and its final effluent levels in columns A1 and B1 were 315 and 344 ug/L, respectively. Even though these final effluent levels indicate that Atochem, Inc. GAC 830 performed slightly better than Calgon Filtrasorb 300, both carbons performed about the same (see Figure 5-5) for most of the test. In particular, the apparent breakthroughs for both carbons occurred at about the same column throughput volume of 12,000 gal (8,144 bed volumes).

The average 2,4-DNT influent concentration in Test Three was 12.2 ug/L and its final effluent level of 3.6 ug/L was the same for columns A1 and B1. During this test, both carbons performed nearly identically (see Figure 5-7). The apparent breakthroughs for both carbons occurred at a column throughput volume of 42,120 gal (28,584 bed volumes). In addition, the average 1,3,5-TNB influent concentration was 26.6 ug/L and its final effluent levels in columns A1 and B1 were 9.91 and 14.9 ug/L, respectively. Even though these levels indicate that Atochem, Inc. GAC 830 performed slightly better than Calgon Filtrasorb 300, both carbons performed about the same (see Figure 5-9) for most of the test. In particular, the apparent breakthroughs for both carbons occurred at about the same column throughput volume of 15,120 gal (10,261 bed volumes).

In comparing Figure 5-12, which shows the influent water temperature vs. column throughput volume, with Figures 5-4, 5-6, 5-8, and 5-10, which show explosive concentration vs. column throughput volume for TNT, RDX, 2,4-DNT, and 1,3,5-TNB, respectively, the effect of temperature on the breakthrough curves is inconclusive. This result is not surprising since, according to Weber [17], "normal temperature variations generally have only minor effects on adsorption processes in water and wastewater treatment." However, temperature might be one reason why it took so long to achieve breakthrough in the columns. The original estimate of time to achieve breakthrough was based on adsorption capacities obtained from laboratory isotherm tests at room temperature. However, the latter portion of Test Three was run at temperatures much lower than this. Lower temperatures are known to decrease the rate of adsorption and increase the adsorption capacity. If the increase in adsorption capacity was greater than the decrease in rate of adsorption, then it would take longer to achieve breakthrough in the columns.

Tables 6-1 through 6-6 show good agreement between the analyses performed by WESTON's Analytics Division and the WESTON field laboratory for all three tests. Except for TNT and RDX, the analytical results from both WESTON's Analytics Division and the WESTON field laboratory show all explosive concentrations in columns A1 and B1 below their detection limits in

Table 6-1

WESTON's Analytics Division Results vs. WESTON Field Laboratory
Results for Test One at MAAP - Column A1 (Atochem, Inc. GAC 830)

Sample ID	TNT (ug/L)	RDX (ug/L)	HMX (ug/L)	Tetryl (ug/L)	2,4-DNT (ug/L)	2,6-DNT (ug/L)	1,3-DNB (ug/L)	1,3,5-TNB (ug/L)	NB (ug/L)
Lionville Laboratory Results									
8 Sept. 1989 - 6:00 AM	<0.78	0.81	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
8 Sept. 1989 - 18:00 PM	<0.78	0.93	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
9 Sept. 1989 - 18:00 PM	<0.78	1.10	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
10 Sept. 1989 - 18:00 PM	<0.78	0.96	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
10 Sept. 1989 - 24:00 PM	<0.78	0.88	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
Field Laboratory Results									
8 Sept. 1989 - 6:00 AM	-	-	-	-	-	-	-	-	-
8 Sept. 1989 - 18:00 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
9 Sept. 1989 - 18:00 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
10 Sept. 1989 - 18:00 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
10 Sept. 1989 - 24:00 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56*	<1.13

Table 6-2

WESTON's Analytics Division Results vs. WESTON Field Laboratory
Results for Test One at MAAP - Column B1 (Atochem, Inc. GAC 830)

Sample ID	TNT (ug/L)	RDX (ug/L)	HMX (ug/L)	Tetryl (ug/L)	2,4-DNT (ug/L)	2,6-DNT (ug/L)	1,3-DNB (ug/L)	1,3,5-TNB (ug/L)	NB (ug/L)
Lionville Laboratory Results									
8 Sept. 1989 - 6:00 AM	<0.78	1.10	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
8 Sept. 1989 - 18:00 PM	<0.78	0.86	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
9 Sept. 1989 - 18:00 PM	<0.78	1.14	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
10 Sept. 1989 - 18:00 PM	<0.78	1.07	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
10 Sept. 1989 - 24:00 PM	<0.78	1.16	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
Field Laboratory Results									
8 Sept. 1989 - 6:00 AM	-	-	-	-	-	-	-	-	-
8 Sept. 1989 - 18:00 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
9 Sept. 1989 - 18:00 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
10 Sept. 1989 - 18:00 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
10 Sept. 1989 - 24:00 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13

Table 6-3

WESTON's Analytics Division Results vs. WESTON Field Laboratory
Results for Test Two at MAAP - Column A1 (Atochem, Inc. GAC 830)

Sample ID	TNT (ug/L)	RDX (ug/L)	HMX (ug/L)	Tetryl (ug/L)	2,4-DNT (ug/L)	2,6-DNT (ug/L)	1,3-DNB (ug/L)	1,3,5-TNB (ug/L)	NB (ug/L)
Lionville Laboratory Results									
20 Sept. 1989 - 4:30 AM	<0.78	0.66	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
20 Sept. 1989 - 16:30 PM	<0.78	0.85	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
21 Sept. 1989 - 16:30 PM	<0.78	0.95	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
22 Sept. 1989 - 16:30 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
23 Sept. 1989 - 16:30 PM	<0.78	1.33	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
Field Laboratory Results									
20 Sept. 1989 - 4:30 AM	-	-	-	-	-	-	-	-	-
20 Sept. 1989 - 16:30 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
21 Sept. 1989 - 16:30 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
22 Sept. 1989 - 16:30 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
23 Sept. 1989 - 16:30 PM	<0.78	1.17	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13

Table 6-4

WESTON's Analytics Division Results vs. WESTON Field Laboratory
Results for Test Two at MAAP - Column B1 (Calgon Filtrasorb 300) and Influent

Sample ID	TNT (ug/L)	RDX (ug/L)	HMX (ug/L)	Tetryl (ug/L)	2,4-DNT (ug/L)	2,6-DNT (ug/L)	1,3-DNB (ug/L)	1,3,5-TNB (ug/L)	NB (ug/L)
Lionville Laboratory Results - Column B1									
20 Sept. 1989 - 4:30 AM	<0.78	0.86	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
20 Sept. 1989 - 16:30 PM	<0.78	0.93	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
21 Sept. 1989 - 16:30 PM	<0.78	0.86	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
22 Sept. 1989 - 16:30 PM	<0.78	<0.86G*	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
23 Sept. 1989 - 16:30 PM	<0.78	0.79	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
Lionville Laboratory Results - Influent									
22 Sept. 1989 - 16:30 PM	454	453	3.06	<66.0	9.89	<0.55	3.44	19.9	<1.13
Field Laboratory Results - Column B1									
20 Sept. 1989 - 4:30 AM	-	-	-	-	-	-	-	-	-
20 Sept. 1989 - 16:30 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
21 Sept. 1989 - 16:30 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
22 Sept. 1989 - 16:30 PM	<0.78	<0.63	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
23 Sept. 1989 - 16:30 PM	<0.78	0.543	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
Field Laboratory Results - Influent									
22 Sept. 1989 - 16:30 PM	509	542	3.47	<0.66	11.4	<0.55	1.94	24.9	<1.13

*G = Indicates elevated detection limit due to sample interference.

1133M2

Table 6-5

WESTON's Analytics Division Results vs. WESTON Field Laboratory
Results for Test Three at MAAP - Column A1 (Atochem, Inc. GAC 830)

Sample ID	TNT (ug/L)	RDX (ug/L)	HMX (ug/L)	Tetryl (ug/L)	2,4-DNT (ug/L)	2,6-DNT (ug/L)	1,3-DNB (ug/L)	1,3,5-TNB (ug/L)	NB (ug/L)
Lionville Laboratory Results									
17 Oct. 1989 - 5:00 AM	<0.78	1.42	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
17 Oct. 1989 - 17:00 PM	<0.78	1.58	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
18 Oct. 1989 - 17:00 PM	1.52	3.51	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
19 Oct. 1989 - 17:00 PM	2.76	4.37	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
20 Oct. 1989 - 17:00 PM	<0.78	2.45	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
8 Dec. 1989 - 5:00 AM	126	408	<1.30	3.34	1.67	<0.55	1.08	8.64	<1.13
8 Dec. 1989 - 17:00 PM	121	316	<1.30	2.81	1.56	<0.55	0.71	7.87	<1.13
Field Laboratory Results									
17 Oct. 1989 - 5:00 AM	<0.78	0.668	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
17 Oct. 1989 - 17:00 PM	0.769	1.27	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
18 Oct. 1989 - 17:00 PM	<0.78	0.729	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
19 Oct. 1989 - 17:00 PM	4.67	3.74	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
20 Oct. 1989 - 17:00 PM	2.82	4.11	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
8 Dec. 1989 - 5:00 AM	109	277	<1.30	<0.66	<0.60	<0.55	<0.61	5.35	<1.13
8 Dec. 1989 - 17:00 PM	111	269	<1.30	<0.66	<0.60	<0.55	<0.61	4.95	<1.13

Table 6-6

May 1990
Revision: Final

WESTON's Analytics Division Results vs. WESTON Field Laboratory
Results for Test Three at MAAP - Column B1 (Calgon Filtrasorb 300) and Influent

Sample ID	TNT (ug/L)	RDX (ug/L)	HMX (ug/L)	Tetryl (ug/L)	2,4-DNT (ug/L)	2,6-DNT (ug/L)	1,3-DNB (ug/L)	1,3,5-TNB (ug/L)	NB (ug/L)
Lionville Laboratory Results - Column B1									
17 Oct. 1989 - 5:00 AM	<0.78	1.14	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
17 Oct. 1989 - 17:00 PM	<0.78	1.13	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
18 Oct. 1989 - 17:00 PM	<0.78	1.70	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
19 Oct. 1989 - 17:00 PM	<0.78	1.64	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
20 Oct. 1989 - 17:00 PM	<0.78	4.55	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
8 Dec. 1989 - 5:00 AM	206	368	<1.30	4.40	2.47	<0.55	1.26	11.8	<1.13
8 Dec. 1989 - 17:00 PM	187	318	<1.30	5.28	2.63	<0.55	1.12	11.7	<1.13
Lionville Laboratory Results - Influent									
8 Dec. 1989 - 5:00 AM	740	456	2.74	38.0	14.0	<0.55	7.15	26.9	<1.13
Field Laboratory Results - Column B1									
17 Oct. 1989 - 5:00 AM	<0.78	0.558	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
17 Oct. 1989 - 17:00 PM	1.30	0.558	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
18 Oct. 1989 - 17:00 PM	<0.78	0.619	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
19 Oct. 1989 - 17:00 PM	<0.78	1.09	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
20 Oct. 1989 - 17:00 PM	<0.78	1.83	<1.30	<0.66	<0.60	<0.55	<0.61	<0.56	<1.13
8 Dec. 1989 - 5:00 AM	162	249	<1.30	<0.66	1.13	<0.55	<0.61	7.93	<1.13
8 Dec. 1989 - 17:00 PM	154	240	<1.30	<0.66	0.87	<0.55	<0.61	7.40	<1.13
Field Laboratory Results - Influent									
8 Dec. 1989 - 5:00 AM	796	481	<1.30	<0.66	7.75	<0.55	<0.61	18.4	<1.13

all three tests. WESTON's Analytics Division's analytical results for TNT and RDX in columns A1 and B1 were for the most part slightly higher than the WESTON field laboratory's in all three tests. However, the WESTON field laboratory's analytical results for TNT and RDX in the influent were slightly higher than WESTON's Analytics Division's in Tests Two and Three.

6.2 OPERATING SUMMARY

Table 6-7 summarizes the operating characteristics for Test Three and Table 6-8 summarizes the operating characteristics for Atochem, Inc. GAC 830 for Tests One and Two by flow rate. Using the flow rate, the difference between the influent and effluent concentrations, and total operating time, the mass loadings of TNT, and RDX to each column were calculated. Next, using the total amount of carbon in each column and the specific adsorption capacity of the carbon for TNT and RDX (as determined from the isotherm tests and the average influent concentration), the total column capacities for TNT and RDX were calculated. Finally, by dividing the mass loading of each explosive by the column's total capacity for that explosive, the percent utilization of column capacity was calculated.

Table 6-7 shows 59.2 percent and 52.2 percent utilization for TNT in columns A1 and B1, respectively. Table 6-7 also shows 121 percent and 163 percent utilization for RDX in columns A1 and B1, respectively. These greater than 100 percent utilizations may be attributed to microbiological activity on the carbon surfaces. This activity has been documented in the literature [18-23]. In addition, earlier studies [24] have shown that RDX can be biodegraded even though it and most explosives are relatively resistant to biodegradation. Based on the percent utilizations in Table 6-7, Calgon Filtrasorb 300 appears to be slightly better for TNT removal and Atochem, Inc. GAC 830 appears to be slightly better for RDX removal. However, since the calculations of these utilizations are based on the extrapolation of limited isotherm test data, one cannot conclude that one carbon is definitely better than the other for removal of TNT and RDX.

Table 6-7 shows the percent utilizations of Atochem, Inc. GAC 830 at three different hydraulic loadings for TNT and RDX. Even after 7.6 days at the maximum hydraulic loading of 10.15 gpm/ft^2, percent utilizations for TNT and RDX were only 4.6 percent and 14.6 percent, respectively.

Table 6-9 shows the activated carbon bed volumes to reach TNT and RDX levels of approximately 1 ug/L, 10 ug/L, and 100 ug/L from Test Three. Based on these results, both Atochem, Inc. GAC 830 and Calgon Filtrasorb 300 appear to be equivalent in meeting the three effluent levels for both TNT and RDX. The results also show that if either columns A1 and A2 or columns B1 and B2 were used as two columns in series instead of as single columns, a better effluent would be obtained over a longer period of time.

Table 6-7

Activated Carbon Column Operating and Performance
Data for Test Three at MAAP
Atochem, Inc. GAC 830 vs. Calgon Filtrasorb 300

Starting Date: 16 October 1989
Ending Date: 15 December 1989
Column Inner Diameter: 4.25 in. (0.354 ft)
Column Area: 0.0985 ft^2
Bed Volume: 0.197 ft^3 (1.47 gal)

	Atochem, Inc. GAC 830	Calgon Filtrasorb 300
Flow Rate	0.75 gpm	0.75 gpm
Hydraulic Loading	7.6 gpm/ft^2	7.6 gpm/ft^2
Bed Depth	2.0 ft	2.0 ft
Empty-Bed Contact Time	2.0 min.	2.0 min.
TNT Influent Concentration (avg.)	734 ug/L	734 ug/L
RDX Influent Concentration (avg.)	549.1 ug/L	549.1 ug/L
TNT Capacity (Rate)*	0.112 lb/lb	0.124 lb/lb
RDX Capacity (Rate)*	0.031 lb/lb	0.024 lb/lb
Weight of Carbon in Column	5.1 lb	5.1 lb
Column TNT Capacity (wt.)	0.571 lb	0.632 lb
Column RDX Capacity (wt.)	0.158 lb	0.122 lb
Total TNT Loading to Column	0.338 lb	0.330 lb
Total RDX Loading to Column	0.191 lb	0.199 lb
TNT Capacity Utilized	59.2%	52.2%
RDX Capacity Utilized	121%	163%
Run Time	54.5 days	54.5 days

*Calculated using isotherm data and average influent concentration.

Table 6-8

Activated Carbon Column Operating and Performance Data for Atochem, Inc. GAC 830 from Tests One and Two at MAAP

Column Inner Diameter: 4.25 in. (0.354 ft)
Column Area: 0.0985 ft^2
Bed Volume: 0.394 ft^2 (2.94 gal)

Flow Rate	0.2 gpm (Test One)	0.7 gpm (Test Two)	1.0 gpm (Test One)
Hydraulic Loading	2.03 gpm/ft^2	7.11 gpm/ft^2	10.15 gpm/ft^2
Bed Depth	4.0 ft	4.0 ft	4.0 ft
Empty-Bed Contact Time	14.7 min.	4.2 min.	2.9 min.
TNT Influent Concentration (avg.)	433 ug/L	508 ug/L	433 ug/L
RDX Influent Concentration (avg.)	487 ug/L	536 ug/L	487 ug/L
TNT Capacity (Rate)*	0.080 lb/lb	0.088 lb/lb	0.080 lb/lb
RDX Capacity (Rate)*	0.029 lb/lb	0.030 lb/lb	0.029 lb/lb
Weight of Carbon in Column	10.2 lb	10.2 lb	10.2 lb
Column TNT Capacity (wt.)	0.816 lb	0.898 lb	0.816 lb
Column RDX Capacity (wt.)	0.296 lb	0.306 lb	0.296 lb
Total TNT Loading to Column	0.0076 lb	0.0722 lb	0.0379 lb
Total RDX Loading to Column	0.0086 lb	0.0751 lb	0.0431 lb
TNT Capacity Utilized	0.9%	8.0%	4.6%
RDX Capacity Utilized	2.9%	24.5%	14.6%
Run Time	7.6 days	16.5 days	7.6 days

*Calculated using isotherm data and average influent concentration.

Table 6-9

Activated Carbon Bed Volumes to Reach TNT and RDX Effluent Levels of Approximately 1 ug/L, 10 ug/L, and 100 ug/L From Test Three at MAAP

Columns A1 and A2: Atochem, Inc. GAC 830
Columns B1 and B2: Calgon Filtrasorb 300
Hydraulic Loading: 7.6 gpm/ft^2
Bed Volume: 0.197 ft^3 (1.47 gal)

TNT

Average Influent Concentration to Columns A1 and B1: 734 ug/L
Range of Influent Concentration to Column A2: <0.78 to 232 ug/L
Range of Influent Concentration to Column B2: <0.78 to 397 ug/L

Column A1		Column B1	
Effluent Level (ug/L)	Bed Volumes	Effluent Level (ug/L)	Bed Volumes
0.769	733	1.30	733
10.9	12,093	3.82	12,093
92.1	30,783	92.3	30,050

Column A2		Column B2	
Effluent Level (ug/L)	Bed Volumes	Effluent Level (ug/L)	Bed Volumes
<0.78[a]	37,745[a]	<0.78[a]	37,745[a]

[a]Effluent level and bed volume at end of test.
[b]Effluent level and bed volume for first sample taken on 10 November 1989.

Notes: <0.78 = Detection limit of TNT.
<0.63 = Detection limit of RDX.

Table 6-9

Activated Carbon Bed Volumes to Reach TNT and RDX Effluent Levels of Approximately 1 ug/L, 10 ug/L, and 100 ug/L From Test Three at MAAP
(continued)

Columns A1 and A2: Atochem, Inc. GAC 830
Columns B1 and B2: Calgon Filtrasorb 300
Hydraulic Loading: 7.6 gpm/ft^2
Bed Volume: 0.197 ft^3 (1.47 gal)

RDX

Average Influent Concentration to Columns A1 and B1: 549.1 ug/L
Range of Influent Concentration to Column A2 for:

2.3 ug/L Effluent Level	0.668 - 144 ug/L
10 ug/L Effluent Level	0.668 - 236 ug/L
35.4 ug/L Effluent Level	0.668 - 419 ug/L

Range of Influent Concentration to Column B2 for:

1.38 ug/L Effluent Level	<0.63 - 129 ug/L
10 ug/L Effluent Level	<0.63 - 223 ug/L
42.2 ug/L Effluent Level	<0.63 - 434 ug/L

Column A1		Column B1	
Effluent Level (ug/L)	Bed Volumes	Effluent Level (ug/L)	Bed Volumes
0.729	1,466	1.09	2,199
8.27	7,329	6.17	7,696
95	16,307	111	16,491

Column A2		Column B2	
Effluent Level (ug/L)	Bed Volumes	Effluent Level (ug/L)	Bed Volumes
2.3[b]	18,323[b]	1.38[b]	18,323[b]
2.93	24,919	10.6	25,286
35.4[a]	37,745[a]	42.2[a]	37,745[a]

[a]Effluent level and bed volume at end of test.
[b]Effluent level and bed volume for first sample taken on 10 November 1989.

Notes: <0.78 = Detection limit of TNT.
<0.63 = Detection limit of RDX.

SECTION 7

DESIGN CONSIDERATIONS

7.1 GENERAL

The primary goal of this project was to determine the feasibility of using GAC to treat explosives-contaminated groundwater. From the data presented in this report, some preliminary conclusions about design and operating parameters can be drawn.

7.2 PROCESS VARIABLES AND PARAMETERS

7.2.1 INFLUENT AND EFFLUENT

Influent and required effluent characteristics are the primary factors to consider in the development of a GAC treatment system.

TNT and RDX concentrations in the groundwater used in batch (isotherm) carbon testing and continuous flow pilot plant testing were found to be higher than those reported from historical data in the test plan [14]. In this plan, the average concentration of TNT from monitor well MI051 is 62.9 ug/L. However, the average influent concentration of TNT during Test Three was 734 ug/L. According to the test plan, the average concentration of RDX from monitoring well MI051 is 134.8 ug/L. However, the average influent concentration of RDX during Test Three was 549.1 ug/L. In addition, the TNT and RDX concentrations in groundwater used for batch (isotherm) carbon testing were 493 and 486 ug/L, respectively. For the other seven explosives (HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB), better agreement was found between their concentrations in the groundwater used in this project's test programs and those reported from historical data in the test plan [14].

Because of the higher concentrations of TNT and RDX in the groundwater used in this project's test programs, design and operating information obtained from the project should be more than adequate to develop a GAC treatment system.

As previously discussed, the effective operating life of a GAC column is primarily determined by a defined breakthrough concentration. This concentration is usually based upon acceptable (or permitted) effluent concentrations. Effluent permit limitations for a particular groundwater remediation are usually determined by the appropriate regulatory agency on a site-specific basis. As the present time, the Water Quality Control Division of the Tennessee Health and Environment Department has no remedial action limits for explosives-contaminated groundwater other than the effluent limit agreed to by the EPA and U.S. Army in the NPDES permits for arsenals, 1.0 ppm of total nitrobodies. However, the United States Army Biomedical Research and Development Laboratory (USABRDL) criteria and other public health standards may dictate significantly lower effluent limits. Therefore, 1.0 ppm of total nitrobodies may not be the breakthrough criterion used in the future to evaluate the performance of a GAC treatment system for explosives-contaminated groundwater.

7.2.2 GAC COLUMN OPERATING CHARACTERISTICS

Two GAC columns in series, each containing 0.197 ft^3 of either Atochem, Inc. GAC 830 or Calgon Filtrasorb 300, can provide run lengths of 26 days (18,323 bed volumes) and obtain effluent levels less than or equal to 1.0 ug/L for TNT and RDX, and less than the detection limits for HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB. This performance assumes the same average influent concentrations for TNT and RDX as in Test Three, a hydraulic loading of 7.6 gpm/ft^2, and the constraints discussed in the previous section. If higher effluent levels are acceptable and/or the hydraulic loading is decreased, longer run lengths are possible.

Based upon the data obtained in this study, both carbons, Atochem, Inc. GAC 830 and Calgon Filtrasorb 300, are equivalent in their ability to remove TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB from the explosives-contaminated groundwater at MAAP.

SECTION 8

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are drawn from this study:

- Based upon the isotherm tests performed in this study, Calgon Filtrasorb 300 was selected as representative of the three Filtrasorb carbons for further testing in continuous flow GAC columns at MAAP. In addition, Atochem, Inc. GAC 830, which is currently being used at MAAP to treat pink water, was selected because the task order required that the carbon currently in use at MAAP be tested. However, Atochem, Inc. GAC 830 was also selected because it was comparable to the three Filtrasorb carbons and better than Hydrodarco 4000 with respect to RDX maximum saturation capacity. The testing of these two carbons in continuous flow GAC columns at MAAP showed that they were equivalent in their ability to remove TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB from the explosives-contaminated groundwater at MAAP.

- The concurrent removal of TNT, RDX, HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB from groundwater using continuous flow granular activated carbon is feasible. At average influent explosives concentrations encountered during Test Three of this study at MAAP, effluent levels less than or equal to 1.0 ug/L for TNT and RDX and less than the detection limits for HMX, Tetryl, 2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB, and NB can be maintained for 26 days (18,323 bed volumes) with two GAC columns in series, each containing 0.197 ft^3 of either Atochem, Inc. GAC 830 or Calgon Filtrasorb 300 and operating at a hydraulic loading of 7.6 gpm/ft^2.

- In the absence of remedial action limits for explosives-contaminated groundwater other than a NPDES effluent limit of 1.0 ppm of total nitrobodies, potential bed lives in full-scale operating facilities could not be predicted.

SECTION 9

REFERENCES

1. Schulte, G.R., Hoehn, R.C., Randall, C.W., "The Treatability of a Munitions-Manufacturing Waste with Activated Carbon." Proceedings of the 28th Industrial Waste Conference, Purdue University, 1973.

2. Shapira, N.I., Patterson, J., Brown, J., Noll, K., "State-of-Art Study: Demilitarization of Conventional Munitions." Phase I Study, American Defense Preparedness Association, August 1977.

3. USATHAMA Report, "Granular Activated Carbon (GAC) System Performance Capacilities and Optimization," February 1987.

4. Patterson, J.W., Shapira, N.I., Brown, J., "Pollution Abatement in the Military Explosives Industry." Proceedings of the 31st Industrial Waste Conference, Purdue University, 1976.

5. Leeper, J.E., Layne, W.S., Wahl, R.M., Tash, J.E., Jackson, B., Jr., Santos, J.S., "Thermal Regeneration of Explosive Laden Carbon in a Rotary Calciner." Report No. ARLCD-CR-77014, U.S. Army Armament Research and Development Command, December 1977.

6. Andren, R.K., Nystron, J.M., McDonnell, R.P., Stevens, B.W., "Explosives Removal from Munitions Wastewater." Proceedings of the 30th Industrial Waste Conference, Purdue University, 1975.

7. Weston, Roy F., Inc., USATHAMA Badger Army Ammunition Plant Pilot Study Meeting, IT Corporation, St. Paul, Minnesota, meeting minutes, 2 May 1989.

8. Wiggins, G., and Simmons, P., Water Quality Control Division of the Tennessee Health and Environment Department, Nashville, Tennessee, phone conversation with WESTON, 19 January 1990.

9. Simmons, P., Water Quality Control Division of the Tennessee Health and Environment Department, Nashville, Tennessee, phone conversation with WESTON, 19 January 1990.

10. U.S. EPA Quality Criteria for Water, 1986, EPA 440/5-86-001, May 1986.

11. U.S. EPA Drinking Water Hotline, phone conversation with WESTON, 19 January 1990.

12. USATHAMA Report, "Use of Activated Carbon for Treatment of Explosives - Contaminated Groundwater at the Badger Army Ammunition Plant (BAAP)," August 1989.

13. Conway, H.M., and Liston, L.L., eds. "The Weather Handbook," Conway Research, Inc., 1974.

14. USATHAMA Test Plan, "TNT-contaminated Groundwater Treatment Pilot Study - Test Plan," July 1989.

15. Wiggins, Garland P., Letter dated 18 May 1989 from Tennessee Department of Health and Environment to Lt. Colonel Michael P. Tucker, Commanding Officer - Milan Army Ammunition Plant.

16. Process Design Manual for Carbon Adsorption, U.S. EPA Technology Transfer, October 1973.

17. Weber, W.J., Jr., "Physiochemical Processes for Water Quality Control," John Wiley and Sons, New York, 1972, p. 236.

18. Weber, W.J., Jr., Pirbazari, M., and Melson, G.L., "Biological Growth on Activated Carbon: An Investigation by Scanning Electron Microscopy." Envir. Sci. and Tech., 12:7:817, July 1978.

19. Benedek, A., "Simultaneous Biodegradation and Activated Carbon Adsorption - A Mechanistic Look" in "Activated Carbon Adsorption of Organics from the Aqueous Phase Vol. II (M.J. McGuire and I.H. Suffet, editors)", Ann Arbon Sci. Pub., 1980.

20. Latosek, A., and Benedek, A., "Some Aspects of the Microbiology of Activated Carbon Columns Treating Domestic Wastewater." Envir. Sci. and Tech., 13:10:1285, 1979.

21. Martin, R.J., and Iwugo, K.O., "Studies in Residual Organics in Biological Plant Effluents and Their Treatment by the Activated Carbon Adsorption Process" in "Activated Carbon Adsorption of Organics from the Aqueous Phase Vol. II (M.J. McGuire and I.H. Suffet, editors)", Ann Arbor Sci. Pub., 1980.

22. Van der Kooij, D., "Some Investigations into the Presence and Behavior of Bacteria in Activated Carbon Filters" in "Translation of Reports on Special Problems of Water Technology Volume 9 - Adsorption (H. Sontheimer, editor)", U.S. Enviornmental Protection Agency Report No. EPA-600/9-76-030, 1976.

23. Cairo, P.R., McElhaney, J., and Suffet, I.H., "Pilot Plant Testing of Activated Carbon Adsorption Systems." Jour. AWWA, 71:11:660, 1979.

24. USATHAMA Report, "Composting of Explosives-Contaminated Soil Technology," October 1989.

APPENDIX A

PROPOSED TENTATIVE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR MILAN ARMY AMMUNITION PLANT

Proposed Tentative Applicable or
Relevant and Appropriate Requirements
for Milan Army Ammunition Plant
July 1989

I. *Tennessee Department of Health and Environment*

A. *Tennessee Water Quality Control Act (TCA), Section 69-3-103(32)*

B. *Underground Injection Control (UIC) Regulations, Rule Chapter 1200-4-6-.05*

C. *Hazardous Waste Management Act, Part I TCA, Section 68-46-101 et seq., Rule Chapter 1200-1-11,12 & 13; Part II TCA, Section 68-46-201 et seq., Rule Chapter 1200-1-11-14*

II. *Safe Drinking Water Act*

A. *Site-Specific Contaminants with MCLs on MCLGs*

Contaminants	Human Health Based Numbers (ppb)	Basis
Benzene	5	MCL
Cadmium	10**	MCL
Carbon tetrachloride	5	MCL
Chloroform	100 *	MCL
Chromium	50**	MCL
Lead	50**	MCL
Mercury	2	MCL
Nitrate, as N	10,000	MCL
Nitrite, as N	1,000	MCL
Toluene	2,000	MCLG

MCL = Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goal

*The sum of the concentrations of all trihalomethanes should not exceed 100 ppb.

** Changes in MCLs under consideration are:

Cadmium	5 ppb
Chromium	100
Lead	5

B. Site-Specific Contaminants with Human Health - Base Criteria

Contaminant	Numbers (ppb)	Basis
Cyclotrimethylenetrinitramine (RDX)	105	RfD
2,4-Dinitrotoluene (2,4-DNT)	0.05 *	HEA
2,6-Dinitrotuluene (2,6-DNT)	0.05 *	HEA
Methylene Chloride	0.19 *	AWQC
	4.76 *	CAG
Nitrobenzene	17.5	RfD
2,4,6-Trinitrotoluene (TNT)	17.5	RfD
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	1750	RfD
1,3,5-Trinitrobenzene (TNB)	1.75	RfD
2,4,6-Trinitrophenylmethylinitramine (Tetryl)	63	DA

*These numbers are based on a 1 X 10^{-6} risk level and the standard assumptions of a 70kg person drinking 2 liters of water per day.

RfD = verified EPA Agency-wide Reference Dose
HEA = Health Effects Assestment
AWQC = Ambient Water Quality Criteria
CAG = Carcinogen Assessment Group
DA = Department of the Army

C. Site-Specific Contaminants with No Current Toxicolgical Criteria.

1,3-Dinitrobenzene (DNB)	Background
Octahydro-1,3,5,7-tetranitro 1,3,5,7-tetrazocine (HMX)	Background
1,3,5-Trinitrobenzene (TNB)	Background

III. Clean Water Act

A. Federal Ambient Water Quality Criteria (See attached summary table.)

B. No Observable Effect Level (NOEL)
Whole effluent toxicity testing will be required to demonstrate that the in-stream concentration of the effluent is less than the NOEL.

C. Wetland Areas

Prohibitions set forth in 40 CFR part 230 shall be met. Unacceptable adverse effects on wildlife and fishery areas are prohibited by Section 404(c) of the Act. No dredged or fill material may be discharged to wetlands.

IV. Requirments for Soils

The army should propose a site-specific soil column leach test to show that leachate will not exceed groundwater standards for contaminates of concern.

ENDOSULFAN	Y	N	0.22	0.056	0.034	0.0087	74 ug	159 ug		1980 FR	16
ENDRIN	Y	N	0.18	0.0023	0.037	0.0023	1.8 ug		0.0002mg	1980 FR	16
ETHYLBENZENE	Y	N	*32,000.		*430		1.4mg	3.28mg		1980 FR	
FLUORANTHENE	Y	N	*1,980.		*42	*16.	42 ug	54 ug		1980 FR	1
GASSES, TOTAL DISSOLVED	N	N	NARRATIVE STATEMENT—SEE DOCUMENT							1976 RB	
GUTHION	N	N		0.01		0.01				1976 RB	9
HALOETHERS	Y	N	*360.	*1,22.						1980 FR	
HALOMETHANES	Y	Y	*11,000.		*12,000	*1,400.	0.19 ug	15.7 ug		1980 FR	
HEPTACHLOR	Y	Y	0.52	0.0039	0.053	0.0038	0.39 ug	0.39 ug		1980 FR	12
HEXACHLOROETHANE	N	Y	*980.	*40.	*980.		1.8 ug	8.7 ug		1980 FR	1
HEXACHLOROBENZENE	Y	N					0.72 ug	0.74 ug		1980 FR	
HEXACHLOROBUTADIENE	Y	Y	*90.	*9.3	*32.		0.44 ug	89 ug		1980 FR	9
HEXACHLOROCYCLOHEXANE (LINDANE)	Y	Y	2.0	0.08	0.16				0.004mg	1980 FR	12
HEXACHLOROCYCLOHEXANE-ALPHA	Y	Y					0.3 ug	31 ug		1980 FR	
HEXACHLOROCYCLOHEXANE-BETA	Y	Y					16.3 ug	54.7 ug		1980 FR	
HEXACHLOROCYCLOHEXANE-GAMA	Y	Y					16.6 ug	62.6 ug		1980 FR	
HEXACHLOROCYCLOHEXANE-TECHNICAL	Y	Y		-			12.3 ug	64.4 ug		1980 FR	
HEXACHLOROCYCLOPENTADIENE	Y	N	*7.	*5.3	*7.		206 ug			1980 FR	3
IRON	N	N		1,000.			0.3mg			1976 RB	15
ISOPHORONE	Y	N	*117,000.		*12,900.		0.117mg	859 mg		1980 FR	
LEAD	Y	N	50. •	2.5 •	140.	5.6	82 ug		0.05mg	1980 FR	20
MALATHION	N	N		0.1		0.1				1976 RB	7
MANGANESE	N	N					50 ug	100 ug		1976 RB	7
MERCURY	Y	N	2.4	0.012	2.1	0.025	144 ng	146 ng	0.002mg	1980 FR	17
METHOXYCHLOR	N	N		0.03		0.03	100 ug		0.1mg	1976 RB	12
MIREX	N	N		0.001		0.001				1976 RB	7
MONOCHLOROBENZENE	Y	N					488 ug			1980 FR	
NAPHTHALENE	Y	N	*2,300.	*620.	*2,300.					1980 FR	1
NICKEL	Y	N	1,400 •	160 •	75	8.3	13.4 ug	100 ug		1980 FR	16
NITRATES	N	N					10 mg		10 mg	1976 RB	8
NITROBENZENE	Y	N	*27,000.		*6,680.		19.8mg			1980 FR	1
NITROPHENOLS	Y	N	*230	*150.	*4,850					1980 FR	1
NITROSAMINES	Y	Y	*5,850.		*3,300,000					1980 FR	1
NITROSODIBUTYLAMINE N	Y	Y					0.4 ug	587 ug		1980 FR	
NITROSODIETHYLAMINE N	Y	Y					0.8 ug	1,240 ug		1980 FR	
NITROSODIMETHYLAMINE N	Y	Y					1.4 ug	16,000 ug		1980 FR	
NITROSODIPHENYLAMINE N	Y	Y					4,900 ug	16,100 ug		1980 FR	
NITROSOPYRROLIDINE N	Y	Y					16 ug	91,600 ug		1980 FR	
OIL AND GREASE	N	N	NARRATIVE STATEMENT—SEE DOCUMENT							1976 RB	20
OXYGEN DISSOLVED	N	N	WARMWATER AND COLDWATER CRITERIA MATRIX—SEE DOCUMENT							1980 FR	20
PARATHION	N	N	0.065	0.013						1980 FR	6
PCB's	Y	Y	2.0	0.014	10	0.03	0.079 ug	0.079 ug		1980 FR	16
PENTACHLOROMONOETHANES	N	N	*7,240.	*1,100.	*360	*261.				1980 FR	1
PENTACHLOROBENZENE	N	N					74 ug	85 ug		1980 FR	
PENTACHLOROPHENOL	Y	N	*20.	*13.	13.	*7.9	1.01mg			1980 FR	2
pH	N	N		6.5-9		6.5-8.5				1976 RB	20
PHENOL	Y	N	*10,200.	*2,560	*5,800		3.5mg			1980 FR	20
PHOSPHORUS ELEMENTAL	N	N				0.1				1976 RB	
PHTHALATE ESTERS	Y	N	*940.	*3.	*2,944	*3.4				1980 FR	6
POLYNUCLEAR AROMATIC HYDROCARBONS	Y	Y			*300.		3.0 ng	31.1 ng		1980 FR	1
SELENIUM	Y	N	260.	35.	410	54.	10 mg		0.01mg	1980 FR	16
SILVER	Y	N	4.1 •	0.12	2.3		50 ug		0.05mg	1980 FR	14
SOLIDS DISSOLVED AND SALINITY	N	N					250 mg			1976 RB	20
SOLIDS SUSPENDED AND TURBIDITY	N	N	NARRATIVE STATEMENT—SEE DOCUMENT							1976 RB	44
SULFIDE-HYDROGEN SULFIDE	N	N	2			2				1976 RB	
TEMPERATURE	N	N	SPECIES DEPENDENT CRITERIA—SEE DOCUMENT							1976 RB	20
TETRACHLORINATED ETHANES	Y	N	*9,320.							1980 FR	
TETRACHLOROBENZENE 1,2,4,5	Y	N					38 ug	48 ug		1980 FR	
TETRACHLOROETHANE 1,1,2,2	Y	Y		*2,400.	*8,000		0.17 ug	10.7 ug		1980 FR	1
TETRACHLOROETHANES	Y	N	*9,320							1980 FR	1
TETRACHLOROETHYLENE	Y	Y	*5,280.	*840.	*10,200.	*450	8.8 ug	8.85 ug		1980 FR	1
TETRACHLOROPHENOL 2,3,5,6	Y	N				*440.				1980 FR	
THALLIUM	Y	N	*1,400	*40.	*2,130		13 ug	48 ug		1980 FR	2
TOLUENE	Y	N	*17,500.		*1,300	*5,000	14.3 mg	424 mg		1980 FR	1
TOXAPHENE	Y	Y	0.73	0.0002	0.21	0.0002	0.71 ug	0.73 ug	0.005mg	1980 FR	17
TRICHLORINATED ETHANES	Y	Y	*18,000							1980 FR	
TRICHLOROETHANE 1,1,1	Y	N			*31,200.		16 mg	1.03g		1980 FR	1
TRICHLOROETHANE 1,1,2	Y	Y		*9,400.			0.6 ug	42.6 ug		1980 FR	1
TRICHLOROETHYLENE	Y	Y	*40,000.	*21,900	*2,000		2.7 ug	80.7 ug		1980 FR	1
TRICHLOROPHENOL 2,4,5	N	N					2,600 ug			1980 FR	
TRICHLOROPHENOL 2,4,6	Y	Y		*970			1.2 ug	3.6 ug		1980 FR	
VINYL CHLORIDE	Y	Y					2 ug	525 ug		1980 FR	
ZINC	Y	N	320 •	110 •	58	58				1987 FR	19

g = grams
mg = milligrams
ug = micrograms
ng = nanograms
l = liters

Y = YES
N = NO

M.C.L. = MAXIMUM CONTAMINANT LEVEL

• = Hardness Dependent Criteria (100 mg/L used)

* = Insufficient Data to Develop Criteria
Value Presented is the L.O.E.L.—Lowest Observed Effect Level

— = Human Health Criteria For Carcinogens Reported For Three Risk Levels. Value Presented is the 10-6 Risk Level.

— = pH Dependent Criteria (7.8 pH used)

FR = FEDERAL REGISTER
RB = QUALITY CRITERIA FOR WATER, 1976 (REDBOOK)

APPENDIX B

ISOTHERM TEST RESULTS

	TNT		RDX		HMX		Tetryl		2, 4 - DNT		2, 6 - DNT		1, 3 - DNB		1, 3, 5 - TNB		NB		TOC	
Carbon Dosage (mg/L)	Ce (mg/L)	q_e (mg/mg)	Ce (mg/L)	q_e (mg/mg)	Ce (mg/L)	q_e (mg/mg)	Ce (mg/L)	q_e (mg/mg)	Ce (mg/L)	q_e (mg/mg)	Ce (mg/L)	q_e (mg/mg)	Ce (mg/L)	q_e (mg/mg)	Ce (mg/L)	q_e (mg/mg)	Ce (mg/L)	q_e (mg/mg)	Ce (mg/L)	q_e (mg/mg)
Blank (0)	0.423	-	0.457	-	0.00311	-	<0.00066	-	0.01	-	<0.0055	-	0.0032	-	0.0153	-	<0.00113	-	0.56	-
10	0.0557	3.7×10^{-2}	0.223	2.3×10^{-2}	0.0107	-7.6×10^{-4}	<0.00066	0	0.00067	9.3×10^{-4}	<0.00055	$>5.0 \times 10^{-4}$	<0.00061	$>2.6 \times 10^{-4}$	0.00303	1.2×10^{-3}	<0.00113	0	1.8	-1.2×10^{-1}
200	<0.00078	$>2.1 \times 10^{-3}$	0.00292	2.3×10^{-3}	<0.0013	$>9.1 \times 10^{-6}$	<0.00066	0	<0.0006	$>4.7 \times 10^{-5}$	<0.00055	$>2.5 \times 10^{-5}$	<0.00061	$>1.3 \times 10^{-5}$	<0.00056	$>7.4 \times 10^{-5}$	<0.00113	0	0.56	0
500	<0.00078	$>8.4 \times 10^{-4}$	0.00073	9.1×10^{-4}	<0.0013	$>3.6 \times 10^{-6}$	<0.00066	0	<0.0006	$>1.9 \times 10^{-5}$	<0.00055	$>9.9 \times 10^{-6}$	<0.00061	$>5.2 \times 10^{-6}$	<0.00056	$>3.0 \times 10^{-5}$	<0.00113	0	<0.50	$>1.2 \times 10^{-4}$
1,000	<0.00078	$>4.2 \times 10^{-4}$	<0.00063	$>4.6 \times 10^{-4}$	<0.0013	$>1.8 \times 10^{-6}$	<0.00066	0	<0.0006	$>9.4 \times 10^{-6}$	<0.00055	$>5.5 \times 10^{-6}$	<0.00061	$>2.6 \times 10^{-6}$	<0.00056	$>1.5 \times 10^{-5}$	<0.00113	0	<0.50	$>6.0 \times 10^{-5}$
2,500	<0.00078	$>1.7 \times 10^{-4}$	<0.00063	$>1.8 \times 10^{-4}$	<0.0013	$>7.2 \times 10^{-7}$	<0.00066	0	<0.0006	$>3.8 \times 10^{-6}$	<0.00055	$>2.0 \times 10^{-6}$	<0.00061	$>1.0 \times 10^{-6}$	<0.00056	$>5.9 \times 10^{-6}$	<0.00113	0	<0.50	$>2.4 \times 10^{-5}$
5,000	<0.00078	$>8.4 \times 10^{-5}$	<0.00063	$>9.1 \times 10^{-5}$	<0.0013	$>3.6 \times 10^{-7}$	<0.00066	0	<0.0006	$>1.9 \times 10^{-6}$	<0.00055	$>9.9 \times 10^{-7}$	<0.00061	$>5.2 \times 10^{-7}$	<0.0056	$>1.9 \times 10^{-6}$	<0.00113	0	-	-

G42-314a

TABLE B-1 ISOTHERM TEST RESULTS FOR CALGON FILTRASORB 200

B1-A

	TNT		RDX		HMX		Tetryl		2, 4 - DNT		2, 6 - DNT		1, 3 - DNB		1, 3, 5 - TNB		NB		TOC	
Carbon Dosage (mg/L)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)
Blank (0)	0.467	-	0.469	-	0.00269	-	<0.0066	-	0.0096	-	<0.0055	-	0.00311	-	0.0144	-	<0.00113	-	1.3	-
10	0.0936	3.7×10^{-2}	0.284	1.9×10^{-2}	<0.0013	$>1.4 \times 10^{-4}$	<0.00066	$>5.9 \times 10^{-4}$	0.00144	8.2×10^{-4}	<0.00055	$>5.0 \times 10^{-4}$	0.00075	2.4×10^{-4}	0.00419	1.0×10^{-3}	<0.00113	0	0.92	3.8×10^{-2}
200	<0.00078	$>2.3 \times 10^{-3}$	0.00189	2.3×10^{-3}	<0.0013	$>7.0 \times 10^{-6}$	<0.00066	$>3.0 \times 10^{-5}$	<0.0006	$>4.5 \times 10^{-5}$	<0.00055	$>2.5 \times 10^{-5}$	<0.00061	$>1.3 \times 10^{-5}$	<0.00056	$>6.9 \times 10^{-5}$	<0.00113	0	0.72	2.9×10^{-3}
500	<0.00078	$>9.3 \times 10^{-4}$	<0.00063	$>9.4 \times 10^{-4}$	<0.0013	$>2.8 \times 10^{-6}$	<0.00066	$>1.2 \times 10^{-5}$	<0.0006	$>1.8 \times 10^{-5}$	<0.00055	$>9.9 \times 10^{-6}$	<0.00061	$>5.0 \times 10^{-6}$	<0.00056	$>2.8 \times 10^{-5}$	<0.00113	0	0.52	1.6×10^{-3}
1,000	<0.00078	$>4.7 \times 10^{-4}$	<0.00063	$>4.7 \times 10^{-4}$	<0.0013	$>1.4 \times 10^{-6}$	<0.00066	$>5.9 \times 10^{-6}$	<0.0006	$>9.0 \times 10^{-6}$	<0.00055	$>5.0 \times 10^{-6}$	<0.00061	$>2.5 \times 10^{-6}$	<0.00056	$>1.4 \times 10^{-5}$	<0.00113	0	0.72	5.8×10^{-4}
2,500	<0.00078	$>1.9 \times 10^{-4}$	<0.00063	$>1.9 \times 10^{-4}$	<0.0013	$>5.6 \times 10^{-7}$	<0.00066	$>2.4 \times 10^{-6}$	<0.0006	$>3.6 \times 10^{-6}$	<0.00055	$>2.0 \times 10^{-6}$	<0.00061	$>1.0 \times 10^{-6}$	<0.00056	$>5.5 \times 10^{-6}$	<0.00113	0	0.81	2.0×10^{-4}
5,000	<0.00078	$>9.3 \times 10^{-5}$	<0.00063	$>9.4 \times 10^{-5}$	<0.0013	$>2.8 \times 10^{-7}$	0.00411G*	5.0×10^{-7}	<0.0006	$>1.8 \times 10^{-6}$	<0.00055	$>9.9 \times 10^{-7}$	<0.00061	$>5.0 \times 10^{-7}$	<0.00056	$>2.8 \times 10^{-6}$	<0.00113	0	0.52	1.6×10^{-4}

G42-314b

*G = Indicates elevated detection limit due to sample interference.

TABLE B-2 ISOTHERM TEST RESULTS FOR CALGON FILTRASORB 300

B-2-A

	TNT		RDX		HMX		Tetryl		2, 4 - DNT		2, 6 - DNT		1, 3 - DNB		1, 3, 5 - TNB		NB		TOC	
Carbon Dosage (mg/L)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)
Blank (0)	0.479	-	0.497	-	0.00284	-	<0.00066	-	0.00928	-	<0.0055	-	0.00311	-	0.0159	-	<0.00113	-	0.82	-
10	<0.00078	$>4.8 \times 10^{-2}$	0.262	2.4×10^{-2}	<0.0013	$>1.5 \times 10^{-4}$	<0.00066	0	<0.0006	$>8.7 \times 10^{-4}$	<0.00055	$>5.0 \times 10^{-4}$	<0.00061	$>2.5 \times 10^{-4}$	0.00358	1.2×10^{-3}	<0.00113	0	0.72	1.0×10^{-2}
200	<0.00078	$>2.4 \times 10^{-3}$	0.0045	2.5×10^{-3}	<0.0013	$>7.7 \times 10^{-6}$	<0.00066	0	<0.0006	$>4.3 \times 10^{-5}$	<0.00055	$>2.5 \times 10^{-5}$	<0.00061	$>1.3 \times 10^{-5}$	>0.00056	$>7.7 \times 10^{-5}$	<0.00113	0	<0.50	$>1.6 \times 10^{-3}$
500	<0.00078	$>9.6 \times 10^{-4}$	<0.0063G*	$>9.8 \times 10^{-4}$	<0.0013	$>3.1 \times 10^{-6}$	<0.00066	0	<0.0006	$>1.7 \times 10^{-5}$	<0.00055	$>9.9 \times 10^{-6}$	<0.00061	$>5.0 \times 10^{-6}$	>0.00056	$>3.1 \times 10^{-5}$	<0.00113	0	<0.50	$>6.4 \times 10^{-4}$
1,000	<0.00078	$>4.8 \times 10^{-4}$	<0.00063	$>5.0 \times 10^{-4}$	<0.0013	$>1.5 \times 10^{-6}$	<0.00066	0	<0.0006	$>8.7 \times 10^{-6}$	<0.00055	$>5.0 \times 10^{-6}$	<0.00061	$>2.5 \times 10^{-6}$	>0.00056	$>1.5 \times 10^{-5}$	<0.00113	0	<0.50	$>3.2 \times 10^{-4}$
2,500	<0.00078	$>1.9 \times 10^{-4}$	<0.00063	$>2.0 \times 10^{-4}$	<0.0013	$>6.2 \times 10^{-7}$	<0.00066	0	<0.0006	$>3.5 \times 10^{-6}$	<0.00055	$>2.0 \times 10^{-6}$	<0.00061	$>1.0 \times 10^{-6}$	>0.00056	$>6.1 \times 10^{-6}$	<0.00113	0	<0.50	$>1.3 \times 10^{-4}$
5,000	<0.00078	$>9.6 \times 10^{-5}$	<0.00063	$>9.9 \times 10^{-5}$	<0.0013	$>3.1 \times 10^{-7}$	<0.00073G*	$>1.4 \times 10^{-6}$	<0.0006	$>1.7 \times 10^{-6}$	<0.00055	$>9.9 \times 10^{-7}$	<0.00061	$>5.0 \times 10^{-7}$	>0.00056	$>3.1 \times 10^{-6}$	<0.00113	0	0.52	6.0×10^{-5}

G42-314c

*G = Indicates elevated detection limit due to sample interference.

TABLE B-3 ISOTHERM TEST RESULTS FOR CALGON FILTRASORB 400

	TNT		RDX		HMX		Tetryl		2, 4 - DNT		2, 6 - DNT		1, 3 - DNB		1, 3, 5 - TNB		NB		TOC	
Carbon Dosage (mg/L)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)
Blank (0)	0.546	-	0.433	-	0.00264	-	<0.066	-	0.00856	-	<0.00055	-	0.00313	-	0.0137	-	<0.00113	-	1.1	-
10	0.204	3.4×10^{-2}	0.422	1.1×10^{-3}	0.00189	7.5×10^{-5}	<0.00066	$>6.5 \times 10^{-3}$	0.00215	6.4×10^{-4}	<0.00055	0	0.00081	2.3×10^{-4}	0.00581	2.3×10^{-4}	<0.00113	0	0.7	4.0×10^{-2}
200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.50	$>3.0 \times 10^{-3}$
500	0.00287	1.1×10^{-3}	0.0223	8.2×10^{-4}	<0.0013	$>2.7 \times 10^{-6}$	<0.00066	$>1.3 \times 10^{-4}$	<0.0006	$>1.6 \times 10^{-5}$	<0.00055	0	<0.00061	$>5.0 \times 10^{-6}$	<0.00056	$>2.6 \times 10^{-5}$	<0.00113	0	<0.50	$>1.2 \times 10^{-3}$
1,000	<0.00078	$>5.5 \times 10^{-4}$	0.00456	4.3×10^{-4}	<0.0013	$>1.3 \times 10^{-6}$	<0.00066	$>6.5 \times 10^{-5}$	<0.0006	$>8.0 \times 10^{-6}$	<0.00055	0	<0.00061	$>2.5 \times 10^{-6}$	<0.00056	$>1.3 \times 10^{-5}$	<0.00113	0	<0.50	$>6.0 \times 10^{-4}$
2,500	<0.00078	$>2.2 \times 10^{-4}$	0.00289	1.7×10^{-4}	<0.0013	$>5.4 \times 10^{-7}$	<0.00066	$>2.6 \times 10^{-5}$	<0.0006	$>3.2 \times 10^{-6}$	<0.00055	0	<0.00061	$>1.0 \times 10^{-6}$	<0.00056	$>5.3 \times 10^{-6}$	<0.00113	0	<0.50	$>2.4 \times 10^{-4}$
5,000	<0.00078	$>1.1 \times 10^{-4}$	0.00217	8.6×10^{-5}	<0.0013	$>2.7 \times 10^{-7}$	<0.00066	$>1.3 \times 10^{-5}$	<0.0006	$>1.6 \times 10^{-6}$	<0.00055	0	<0.00061	$>5.0 \times 10^{-7}$	<0.00056	$>2.6 \times 10^{-6}$	<0.00113	0	<0.50	$>1.2 \times 10^{-4}$

G42-314d

TABLE B-4 ISOTHERM TEST RESULTS FOR HYDRODARCO 4000

B-4-A

	TNT		RDX		HMX		Tetryl		2, 4 - DNT		2, 6 - DNT		1, 3 - DNB		1, 3, 5 - TNB		NB		TOC	
Carbon Dosage (mg/L)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)
Blank (0)	0.550	-	0.572	-	0.00246	-	0.00068	-	<0.0006	-	<0.00055	-	0.003	-	0.0119	-	<0.00113	-	1.2	-
10	0.149	4.0×10^{-2}	0.343	2.3×10^{-2}	<0.013	$>-1.1 \times 10^{-3}$	<0.00066	$>2.0 \times 10^{-6}$	0.00257	2.0×10^{-4}	<0.00055	0	0.00118	1.8×10^{-4}	0.00563	$>6.3 \times 10^{-4}$	<0.00113	0	0.61	5.9×10^{-2}
200	0.00223	2.7×10^{-3}	0.0121	2.8×10^{-3}	<0.0013	$>5.8 \times 10^{-6}$	<0.00066	$>1.0 \times 10^{-7}$	<0.0006	0	<0.00055	0	<0.00061	$>1.2 \times 10^{-5}$	>0.00056	$>5.7 \times 10^{-5}$	<0.00113	0	<0.50	$>3.5 \times 10^{-3}$
500	<0.00078	$>1.1 \times 10^{-3}$	0.00382	1.1×10^{-3}	<0.0013	$>2.3 \times 10^{-6}$	<0.00066	$>4.0 \times 10^{-8}$	<0.0006	0	<0.00055	0	<0.00061	$>4.8 \times 10^{-6}$	>0.00056	$>2.3 \times 10^{-5}$	<0.00113	0	0.51	1.4×10^{-3}
1,000	<0.00078	$>5.5 \times 10^{-4}$	0.00272	5.7×10^{-4}	<0.0013	$>1.2 \times 10^{-6}$	<0.00066	$>2.0 \times 10^{-8}$	<0.0006	0	<0.00055	0	<0.00061	$>2.4 \times 10^{-6}$	>0.00056	$>1.1 \times 10^{-5}$	<0.00113	0	0.61	5.9×10^{-4}
2,500	<0.00078	$>2.2 \times 10^{-4}$	0.00226	2.3×10^{-4}	<0.0013	$>4.6 \times 10^{-7}$	<0.00066	$>8.0 \times 10^{-9}$	<0.0006	0	<0.00055	0	0.00789G*	-2.0×10^{-6}	>0.00056	$>4.5 \times 10^{-6}$	<0.00111G*	8.0×10^{-9}	<0.50	$>2.8 \times 10^{-4}$
5,000	<0.00078	$>1.1 \times 10^{-4}$	0.0139G*	1.1×10^{-4}	<0.0013	$>2.3 \times 10^{-7}$	<0.00066	$>4.0 \times 10^{-9}$	<0.0006	0	<0.00055	0	<0.00061	$>4.8 \times 10^{-7}$	>0.00056	$>2.3 \times 10^{-6}$	0.00198	-1.7×10^{-7}	0.61	1.2×10^{-4}

G42-313e

*G = Indicates elevated detection limit due to sample interference.

TABLE B-5 ISOTHERM TEST RESULTS FOR ATOCHEM, INC. GAC 830

	TNT		RDX		HMX		Tetryl		2, 4 - DNT	
Carbon Dosage (mg/L)	Ce (mg/L)	qe (mg/mg)	Ce (mg/L)	qe (mg/mg)	Ce (mg/L)	qe (mg/mg)	Ce (mg/L)	qe (mg/mg)	Ce (mg/L)	qe (mg/mg
Blank (0)	0.550	-	0.572	-	0.00246	-	0.00068	-	<0.0006	-
10	0.116	4.3×10^{-2}	0.319	2.5×10^{-2}	<0.0013	$>1.2 \times 10^{-4}$	<0.00066	$>2.0 \times 10^{-6}$	0.00223	-1.6×10^{-3}
200	0.00212	2.7×10^{-3}	0.0303	2.7×10^{-3}	<0.0013	$>5.8 \times 10^{-6}$	<0.00066	$>1.0 \times 10^{-7}$	<0.0006	0
500	<0.00078	$>1.1 \times 10^{-3}$	0.0166	1.1×10^{-3}	<0.0013	$>2.3 \times 10^{-6}$	<0.00066	$>4.0 \times 10^{-8}$	<0.0006	0
1,000	<0.00078	$>5.5 \times 10^{-4}$	0.0021	5.7×10^{-4}	<0.0013	$>1.2 \times 10^{-6}$	<0.00066	$>2.0 \times 10^{-8}$	<0.0006	0
2,500	<0.00078	$>2.2 \times 10^{-4}$	0.00173	2.3×10^{-4}	<0.0013	$>4.6 \times 10^{-7}$	<0.00066	$>8.0 \times 10^{-9}$	<0.0006	0
5,000	<0.00078	$>1.1 \times 10^{-4}$	0.00169	1.1×10^{-4}	<0.0013	$>2.3 \times 10^{-7}$	<0.00066	$>4.0 \times 10^{-9}$	<0.0006	0

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- DNT		2, 6 - DNT		1, 3 - DNB		1, 3, 5 - TNB		NB		TOC	
	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)
	-	<0.00055	-	0.003	-	0.0118	-	<0.00113	-	1.1	-
	-1.6×10^{-3}	<0.00055	0	0.00097	2.0×10^{-4}	0.00464	7.3×10^{-4}	<0.00113	0	0.70	4.0×10^{-2}
	0	<0.00055	0	<0.00061	$>1.2 \times 10^{-5}$	>0.00056	$>5.7 \times 10^{-5}$	<0.00113	0	<0.50	$>3.0 \times 10^{-3}$
	0	<0.00055	0	<0.00061	$>4.8 \times 10^{-6}$	>0.00056	$>2.3 \times 10^{-5}$	<0.00113	0	<0.50	$>1.2 \times 10^{-3}$
	0	<0.00055	0	<0.00061	$>2.4 \times 10^{-6}$	>0.00056	$>1.1 \times 10^{-5}$	<0.00113	0	<0.50	$>6.0 \times 10^{-4}$
	0	<0.00055	0	<0.00061	$>9.6 \times 10^{-7}$	>0.00056	$>4.5 \times 10^{-6}$	<0.00113	0	<0.50	$>2.4 \times 10^{-4}$
	0	<0.00055	0	<0.00061	$>4.8 \times 10^{-7}$	>0.00056	$>2.3 \times 10^{-6}$	<0.00113	0	<0.50	$>1.2 \times 10^{-4}$

TABLE B-6 ISOTHERM TEST RESULTS FOR ATOCHEM, INC. GAC 830

	TNT		RDX		HMX		Tetryl		2, 4 - DNT		2, 6 - DNT		1, 3 - DNB		1, 3, 5 - TNB		NB		TOC	
Carbon Dosage (mg/L)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)	C_e (mg/L)	q_e (mg/mg)
Blank (0)	0.550	-	0.572	-	0.00246	-	0.00068	-	<0.0006	-	<0.00055	-	0.003	-	0.0119	-	<0.00113	-	1.1	-
10	0.116	4.3×10^{-2}	0.319	2.5×10^{-2}	<0.0013	$>1.2 \times 10^{-4}$	<0.00066	$>2.0 \times 10^{-6}$	0.00223	-1.6×10^{-3}	<0.00055	0	0.00097	2.0×10^{-4}	0.00464	7.3×10^{-4}	<0.00113	0	0.70	4.0×10^{-2}
200	0.00212	2.7×10^{-3}	0.0303	2.7×10^{-3}	<0.0013	$>5.8 \times 10^{-6}$	<0.00066	$>1.0 \times 10^{-7}$	<0.0006	0	<0.00055	0	<0.00061	$>1.2 \times 10^{-5}$	>0.00056	$>5.7 \times 10^{-5}$	<0.00113	0	<0.50	$>3.0 \times 10^{-3}$
500	<0.00078	$>1.1 \times 10^{-3}$	0.0166	1.1×10^{-3}	<0.0013	$>2.3 \times 10^{-6}$	<0.00066	$>4.0 \times 10^{-8}$	<0.0006	0	<0.00055	0	<0.00061	$>4.8 \times 10^{-6}$	>0.00056	$>2.3 \times 10^{-5}$	<0.00113	0	<0.50	$>1.2 \times 10^{-3}$
1,000	<0.00078	$>5.5 \times 10^{-4}$	0.0021	5.7×10^{-4}	<0.0013	$>1.2 \times 10^{-6}$	<0.00066	$>2.0 \times 10^{-8}$	<0.0006	0	<0.00055	0	<0.00061	$>2.4 \times 10^{-6}$	>0.00056	$>1.1 \times 10^{-5}$	<0.00113	0	<0.50	$>6.0 \times 10^{-4}$
2,500	<0.00078	$>2.2 \times 10^{-4}$	0.00173	2.3×10^{-4}	<0.0013	$>4.6 \times 10^{-7}$	<0.00066	$>8.0 \times 10^{-9}$	<0.0006	0	<0.00055	0	<0.00061	$>9.6 \times 10^{-7}$	>0.00056	$>4.5 \times 10^{-6}$	<0.00113	0	<0.50	$>2.4 \times 10^{-4}$
5,000	<0.00078	$>1.1 \times 10^{-4}$	0.00169	1.1×10^{-4}	<0.0013	$>2.3 \times 10^{-7}$	<0.00066	$>4.0 \times 10^{-9}$	<0.0006	0	<0.00055	0	<0.00061	$>4.8 \times 10^{-7}$	>0.00056	$>2.3 \times 10^{-6}$	<0.00113	0	<0.50	$>1.2 \times 10^{-4}$

G42-313I

TABLE B-6 ISOTHERM TEST RESULTS FOR ATOCHEM, INC. GAC 830

B6 - A

B-6-B

APPENDIX C

FIELD LABORATORY RESULTS FOR EXPLOSIVES FROM TEST ONE AT MAAP

Table C-1

Field Laboratory Results for TNT From Test One at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 1.0 gpm Column A1 Effluent Concentration (ug/L)	Atochem, Inc. GAC 830 0.2 gpm Column B1 Effluent Concentration (ug/L)	Column A1 Throughput Volume (gal)	Column B1 Throughput Volume (gal)
7 September 1989	18:00 PM	333	---	---	0	0
	19:00 PM	---	<	<	60	12
8 September 1989	18:00 PM	395	<	<	1440	288
9 September 1989	6:00 AM	403	---	---	2160	432
	18:00 PM	389	<	<	2880	576
10 September 1989	6:00 AM	442	---	---	3600	720
	18:00 PM	408	<	<	4320	864
	24:00 PM	---	<	<	4680	936
11 September 1989	6:00 AM	440	---	---	5040	1008
	18:00 PM	439	<	<	5760	1152
12 September 1989	6:00 AM	442	---	---	6480	1296
	18:00 PM	442	<	<	7200	1440
13 September 1989	6:00 AM	463	---	---	7920	1584
	18:00 PM	467	<	<	8640	1728
	20:00 PM	---	<	---	8760	1752
14 September 1989	6:00 AM	471	---	---	9360	1872
	18:00 PM	480	<	<	10080	2016
15 September 1989	6:00 AM	475	<	<	10800	2160
	8:00 AM	---	<	<	10920	2184

Notes: --- = No sample collected.
< = Below TNT detection limit of 0.78 ug/L.

Table C-2

Field Laboratory Results for RDX From Test One at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 1.0 gpm Column A1 Effluent Concentration (ug/L)	Atochem, Inc. GAC 830 0.2 gpm Column B1 Effluent Concentration (ug/L)	Column A1 Throughput Volume (gal)	Column B1 Throughput Volume (gal)
7 September 1989	18:00 PM	396	---	---	0	0
	19:00 PM	---	<	<	60	12
8 September 1989	18:00 PM	463	<	<	1440	288
9 September 1989	6:00 AM	469	---	---	2160	432
	18:00 PM	474	<	<	2880	576
10 September 1989	6:00 AM	489	---	---	3600	720
	18:00 PM	467	<	<	4320	864
	24:00 PM	---	<	<	4680	936
11 September 1989	6:00 AM	489	---	---	5040	1008
	18:00 PM	492	<	<	5760	1152
12 September 1989	6:00 AM	485	---	---	6480	1296
	18:00 PM	479	<	<	7200	1440
13 September 1989	6:00 AM	508	---	---	7920	1584
	18:00 PM	515	6.14	<	8640	1728
	20:00 PM	---	5.38	---	8760	1752
14 September 1989	6:00 AM	527	---	---	9360	1872
	18:00 PM	527	7.71	<	10080	2016
15 September 1989	6:00 AM	530	6.64	<	10800	2160
	8:00 AM	---	7.05	<	10920	2184

Notes: --- = No sample collected.
< = Below RDX detection limit of 0.63 ug/L.

Table C-3

Field Laboratory Results for HMX From Test One at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 1.0 gpm Column A1 Effluent Concentration (ug/L)	Atochem, Inc. GAC 830 0.2 gpm Column B1 Effluent Concentration (ug/L)	Column A1 Throughput Volume (gal)	Column B1 Throughput Volume (gal)
7 September 1989	18:00 PM	3.46	---	---	0	0
	19:00 PM	---	<	<	60	12
8 September 1989	18:00 PM	3.02	<	<	1440	288
9 September 1989	6:00 AM	3.72	---	---	2160	432
	18:00 PM	3.22	<	<	2880	576
10 September 1989	6:00 AM	3.19	---	---	3600	720
	18:00 PM	2.86	<	<	4320	864
	24:00 PM	---	<	<	4680	936
11 September 1989	6:00 AM	3.26	---	---	5040	1008
	18:00 PM	3.29	<	<	5760	1152
12 September 1989	6:00 AM	2.99	---	---	6480	1296
	18:00 PM	3.00	<	<	7200	1440
13 September 1989	6:00 AM	3.68	---	---	7920	1584
	18:00 PM	3.31	<	<	8640	1728
	20:00 PM	---	<	---	8760	1752
14 September 1989	6:00 AM	4.11	---	---	9360	1872
	18:00 PM	3.71	<	<	10080	2016
15 September 1989	6:00 AM	3.97	<	<	10800	2160
	8:00 AM	---	<	<	10920	2184

Notes: --- = No sample collected.
< = Below HMX detection limit of 1.30 ug/L.

Table C-4

Field Laboratory Results for Tetryl From Test One at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 1.0 gpm Column A1 Effluent Concentration (ug/L)	Atochem, Inc. GAC 830 0.2 gpm Column B1 Effluent Concentration (ug/L)	Column A1 Throughput Volume (gal)	Column B1 Throughput Volume (gal)
7 September 1989	18:00 PM	<	---	---	0	0
	19:00 PM	---	<	<	60	12
8 September 1989	18:00 PM	<	<	<	1440	288
9 September 1989	6:00 AM	<	---	---	2160	432
	18:00 PM	<	<	<	2880	576
10 September 1989	6:00 AM	<	---	---	3600	720
	18:00 PM	<	<	<	4320	864
	24:00 PM	---	<	<	4680	936
11 September 1989	6:00 AM	<	---	---	5040	1008
	18:00 PM	<	<	<	5760	1152
12 September 1989	6:00 AM	<	---	---	6480	1296
	18:00 PM	<	<	<	7200	1440
13 September 1989	6:00 AM	<	---	---	7920	1584
	18:00 PM	<	<	<	8640	1728
	20:00 PM	---	<	---	8760	1752
14 September 1989	6:00 AM	<	---	---	9360	1872
	18:00 PM	<	<	<	10080	2016
15 September 1989	6:00 AM	<	<	<	10800	2160
	8:00 AM	---	<	<	10920	2184

Notes: --- = No sample collected.
< = Below Tetryl detection limit of 0.66 ug/L.

Table C-5

Field Laboratory Results for 2,4-DNT From Test One at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 1.0 gpm Column A1 Effluent Concentration (ug/L)	Atochem, Inc. GAC 830 0.2 gpm Column B1 Effluent Concentration (ug/L)	Column A1 Throughput Volume (gal)	Column B1 Throughput Volume (gal)
7 September 1989	18:00 PM	10.7	---	---	0	0
	19:00 PM	---	<	<	60	12
8 September 1989	18:00 PM	9.42	<	<	1440	288
9 September 1989	6:00 AM	9.89	---	---	2160	432
	18:00 PM	9.62	<	<	2880	576
10 September 1989	6:00 AM	10.8	---	---	3600	720
	18:00 PM	9.97	<	<	4320	864
	24:00 PM	---	<	<	4680	936
11 September 1989	6:00 AM	10.9	---	---	5040	1008
	18:00 PM	10.7	<	<	5760	1152
12 September 1989	6:00 AM	10.5	---	---	6480	1296
	18:00 PM	10.4	<	<	7200	1440
13 September 1989	6:00 AM	12.2	---	---	7920	1584
	18:00 PM	10.9	<	<	8640	1728
	20:00 PM	---	<	---	8760	1752
14 September 1989	6:00 AM	12.1	---	---	9360	1872
	18:00 PM	11.8	<	<	10080	2016
15 September 1989	6:00 AM	11.5	<	<	10800	2160
	8:00 AM	---	<	<	10920	2184

Notes: --- = No sample collected.
< = Below 2,4-DNT detection limit of 0.60 ug/L.

Table C-6

Field Laboratory Results for 2,6-DNT From Test One at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 1.0 gpm — Column A1 Effluent Concentration (ug/L)	Atochem, Inc. GAC 830 0.2 gpm — Column B1 Effluent Concentration (ug/L)	Column A1 Throughput Volume (gal)	Column B1 Throughput Volume (gal)
7 September 1989	18:00 PM	0.471	---	---	0	0
	19:00 PM	---	<	<	60	12
8 September 1989	18:00 PM	<	<	<	1440	288
9 September 1989	6:00 AM	<	---	---	2160	432
	18:00 PM	<	<	<	2880	576
10 September 1989	6:00 AM	<	---	---	3600	720
	18:00 PM	<	<	<	4320	864
	24:00 PM	---	<	<	4680	936
11 September 1989	6:00 AM	<	---	---	5040	1008
	18:00 PM	<	<	<	5760	1152
12 September 1989	6:00 AM	<	---	---	6480	1296
	18:00 PM	<	<	<	7200	1440
13 September 1989	6:00 AM	<	---	---	7920	1584
	18:00 PM	<	<	<	8640	1728
	20:00 PM	---	<	---	8760	1752
14 September 1989	6:00 AM	<	---	---	9360	1872
	18:00 PM	<	<	<	10080	2016
15 September 1989	6:00 AM	<	<	<	10800	2160
	8:00 AM	---	<	<	10920	2184

Notes: --- = No sample collected.
< = Below 2,6-DNT detection limit of 0.55 ug/L.

Table C-7

Field Laboratory Results for 1,3-DNB From Test One at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 1.0 gpm Column A1 Effluent Concentration (ug/L)	Atochem, Inc. GAC 830 0.2 gpm Column B1 Effluent Concentration (ug/L)	Column A1 Throughput Volume (gal)	Column B1 Throughput Volume (gal)
7 September 1989	18:00 PM	1.96	---	---	0	0
	19:00 PM	---	<	<	60	12
8 September 1989	18:00 PM	2.77	<	<	1440	288
9 September 1989	6:00 AM	<	---	---	2160	432
	18:00 PM	<	<	<	2880	576
10 September 1989	6:00 AM	3.23	---	---	3600	720
	18:00 PM	2.96	<	<	4320	864
	24:00 PM	---	<	<	4680	936
11 September 1989	6:00 AM	<	---	---	5040	1008
	18:00 PM	<	<	<	5760	1152
12 September 1989	6:00 AM	5.72	---	---	6480	1296
	18:00 PM	2.84	<	<	7200	1440
13 September 1989	6:00 AM	6.26	---	---	7920	1584
	18:00 PM	3.09	<	<	8640	1728
	20:00 PM	---	<	---	8760	1752
14 September 1989	6:00 AM	1.72	---	---	9360	1872
	18:00 PM	7.73	<	<	10080	2016
15 September 1989	6:00 AM	7.72	<	<	10800	2160
	8:00 AM	---	<	<	10920	2184

Notes: --- = No sample collected.
< = Below 1,3-DNB detection limit of 0.61 ug/L.

Table C-8

Field Laboratory Results for 1,3,5-TNB From Test One at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 1.0 gpm Column A1 Effluent Concentration (ug/L)	Atochem, Inc. GAC 830 0.2 gpm Column B1 Effluent Concentration (ug/L)	Column A1 Throughput Volume (gal)	Column B1 Throughput Volume (gal)
7 September 1989	18:00 PM	17.5	---	---	0	0
	19:00 PM	---	<	<	60	12
8 September 1989	18:00 PM	24.7	<	<	1440	288
9 September 1989	6:00 AM	19.1	---	---	2160	432
	18:00 PM	24.2	<	<	2880	576
10 September 1989	6:00 AM	20.7	---	---	3600	720
	18:00 PM	19.2	<	<	4320	864
	24:00 PM	---	<	<	4680	936
11 September 1989	6:00 AM	21.7	---	---	5040	1008
	18:00 PM	19.9	<	<	5760	1152
12 September 1989	6:00 AM	21.1	---	---	6480	1296
	18:00 PM	21.6	<	<	7200	1440
13 September 1989	6:00 AM	23.6	---	---	7920	1584
	18:00 PM	22.7	<	<	8640	1728
	20:00 PM	---	<	---	8760	1752
14 September 1989	6:00 AM	22.7	---	---	9360	1872
	18:00 PM	23.1	<	<	10080	2016
15 September 1989	6:00 AM	22.6	<	0.592	10800	2160
	8:00 AM	---	<	<	10920	2184

Notes: --- = No sample collected.
< = Below 1,3,5-TNB detection limit of 0.56 ug/L.

Table C-9

Field Laboratory Results for NB From Test One at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 1.0 gpm — Column A1 Effluent Concentration (ug/L)	Atochem, Inc. GAC 830 0.2 gpm — Column B1 Effluent Concentration (ug/L)	Column A1 Throughput Volume (gal)	Column B1 Throughput Volume (gal)
7 September 1989	18:00 PM	<	---	---	0	0
	19:00 PM	---	<	<	60	12
8 September 1989	18:00 PM	<	<	<	1440	288
9 September 1989	6:00 AM	<	---	---	2160	432
	18:00 PM	<	<	<	2880	576
10 September 1989	6:00 AM	<	---	---	3600	720
	18:00 PM	<	<	<	4320	864
	24:00 PM	---	<	<	4680	936
11 September 1989	6:00 AM	<	---	---	5040	1008
	18:00 PM	<	<	<	5760	1152
12 September 1989	6:00 AM	<	---	---	6480	1296
	18:00 PM	<	<	<	7200	1440
13 September 1989	6:00 AM	<	---	---	7920	1584
	18:00 PM	<	<	<	8640	1728
	20:00 PM	---	<	---	8760	1752
14 September 1989	6:00 AM	<	---	---	9360	1872
	18:00 PM	<	<	<	10080	2016
15 September 1989	6:00 AM	<	<	<	10800	2160
	8:00 AM	---	<	<	10920	2184

Notes: --- = No sample collected.
< = Below NB detection limit of 1.13 ug/L.

Table C-10

Field Laboratory Results for Explosives From Test One at MAAP

Date	Time	Explosives	Atochem, Inc. GAC 830 1.0 gpm Column A2 Effluent Concentration (ug/L)	Atochem, Inc. GAC 830 0.2 gpm Column B2 Effluent Concentration (ug/L)
15 September 1989	8:00 AM	TNT	<	<
		RDX	<	<
		HMX	<	<
		Tetryl	<	<
		2,4-DNT	<	<
		2,6-DNT	<	<
		1,3-DNB	<	<
		1,3,5-TNB	<	<
		NB	<	<

Note: < = Below explosive detection limit.

APPENDIX D

FIELD LABORATORY RESULTS FOR EXPLOSIVES FROM TEST TWO AT MAAP

Table D-1

Field Laboratory Results for TNT From Test Two at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.7 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.7 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
19 September 1989	17:30 PM	437	<	<	83.7	42
20 September 1989	4:30 AM	428	---	---	71.2	504
	16:30 PM	432	<	<	91.8	1008
21 September 1989	4:30 AM	452	---	---	74.2	1512
	16:30 PM	458	<	<	96.2	2016
22 September 1989	4:30 AM	499	---	---	84.2	2520
	16:30 PM	509	<	<	84.9	3024
23 September 1989	4:30 AM	507	---	---	78.9	3528
	16:30 PM	462	<	<	81.7	4032
24 September 1989	4:30 AM	474	---	---	62.2	4536
	16:30 PM	456	<	<	74.2	5040
25 September 1989	4:30 AM	---	<	<	74.0	5544
	16:30 PM	503	<	<	77.4	6048
26 September 1989	4:30 AM	---	<	<	74.7	6552
	16:30 PM	499	<	<	86.4	7056
27 September 1989	4:30 AM	---	---	<	67.3	7560
	16:30 PM	522	<	<	85.2	8064
28 September 1989	4:30 AM	---	<	<	71.8	8568
	16:30 PM	499	<	<	75.0	9072
29 September 1989	4:30 AM	---	<	<	72.3	9576
	16:30 PM	598	<	<	77.6	10080
30 September 1989	4:30 AM	---	<	<	75.0	10584
	16:30 PM	628	<	<	79.0	11088
1 October 1989	4:30 AM	---	<	<	77.0	11592
	16:30 PM	563	<	0.805	93.0	12096
2 October 1989	4:30 AM	---	<	<	82.0	12600
	16:30 PM	522	<	<	91.6	13104
3 October 1989	4:30 AM	---	<	<	71.8	13608
	16:30 PM	533	<	<	96.7	14112
4 October 1989	4:30 AM	---	<	<	67.3	14616
	16:30 PM	569	<	<	89.9	15120
5 October 1989	16:30 PM	586	<	<	93.8	16128
6 October 1989	2:30 AM	556	---	---	71.2	16548
	4:30 AM	---	<	<	70.5	16632

Notes: --- = No sample collected.
< = Below TNT detection limit of 0.78 ug/L.

Table D-2

Field Laboratory Results for RDX From Test Two at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.7 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.7 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
19 September 1989	17:30 PM	507	<	<	83.7	42
20 September 1989	4:30 AM	499	---	---	71.2	504
	16:30 PM	501	<	<	91.8	1008
21 September 1989	4:30 AM	491	---	---	74.2	1512
	16:30 PM	498	<	<	96.2	2016
22 September 1989	4:30 AM	527	---	---	84.2	2520
	16:30 PM	542	<	<	84.9	3024
23 September 1989	4:30 AM	534	---	---	78.9	3528
	16:30 PM	522	1.17	0.543	81.7	4032
24 September 1989	4:30 AM	502	---	---	62.2	4536
	16:30 PM	507	<	<	74.2	5040
25 September 1989	4:30 AM	---	<	1.16	74.0	5544
	16:30 PM	539	<	1.04	77.4	6048
26 September 1989	4:30 AM	---	<	<	74.7	6552
	16:30 PM	532	<	<	86.4	7056
27 September 1989	4:30 AM	---	---	<	67.3	7560
	16:30 PM	548	<	1.01	85.2	8064
28 September 1989	4:30 AM	---	<	<	71.8	8568
	16:30 PM	549	0.692	1.06	75.0	9072
29 September 1989	4:30 AM	---	0.618	0.618	72.3	9576
	16:30 PM	584	0.581	0.543	77.6	10080
30 September 1989	4:30 AM	---	<	<	75.0	10584
	16:30 PM	571	<	<	79.0	11088
1 October 1989	4:30 AM	---	<	0.729	77.0	11592
	16:30 PM	584	0.655	1.01	93.0	12096
2 October 1989	4:30 AM	---	<	<	82.0	12600
	16:30 PM	540	<	<	91.6	13104
3 October 1989	4:30 AM	---	<	<	71.8	13608
	16:30 PM	558	<	<	96.7	14112
4 October 1989	4:30 AM	---	<	<	67.3	14616
	16:30 PM	569	<	<	89.9	15120
5 October 1989	16:30 PM	565	<	0.618	93.8	16128
6 October 1989	2:30 AM	569	---	---	71.2	16548
	4:30 AM	---	<	<	70.5	16632

Notes: --- = No sample collected.
< = Below RDX detection limit of 0.63 ug/L.

Table D-3

Field Laboratory Results for HMX From Test Two at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.7 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.7 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
19 September 1989	17:30 PM	3.63	<	<	83.7	42
20 September 1989	4:30 AM	3.68	---	---	71.2	504
	16:30 PM	3.50	<	<	91.8	1008
21 September 1989	4:30 AM	3.44	---	---	74.2	1512
	16:30 PM	3.47	<	<	96.2	2016
22 September 1989	4:30 AM	3.42	---	---	84.2	2520
	16:30 PM	3.47	<	<	84.9	3024
23 September 1989	4:30 AM	3.64	---	---	78.9	3528
	16:30 PM	3.39	<	<	81.7	4032
24 September 1989	4:30 AM	3.57	---	---	62.2	4536
	16:30 PM	3.65	<	<	74.2	5040
25 September 1989	4:30 AM	---	<	<	74.0	5544
	16:30 PM	3.54	<	<	77.4	6048
26 September 1989	4:30 AM	---	<	<	74.7	6552
	16:30 PM	3.57	<	<	86.4	7056
27 September 1989	4:30 AM	---	---	<	67.3	7560
	16:30 PM	3.60	<	<	85.2	8064
28 September 1989	4:30 AM	---	<	<	71.8	8568
	16:30 PM	3.57	<	<	75.0	9072
29 September 1989	4:30 AM	---	<	<	72.3	9576
	16:30 PM	3.98	<	<	77.6	10080
30 September 1989	4:30 AM	---	<	<	75.0	10584
	16:30 PM	3.84	<	<	79.0	11088
1 October 1989	4:30 AM	---	<	<	77.0	11592
	16:30 PM	4.11	<	<	93.0	12096
2 October 1989	4:30 AM	---	<	<	82.0	12600
	16:30 PM	4.14	<	<	91.6	13104
3 October 1989	4:30 AM	---	<	<	71.8	13608
	16:30 PM	3.77	<	<	96.7	14112
4 October 1989	4:30 AM	---	<	<	67.3	14616
	16:30 PM	4.31	<	<	89.9	15120
5 October 1989	16:30 PM	4.14	<	<	93.8	16128
6 October 1989	2:30 AM	3.84	---	---	71.2	16548
	4:30 AM	---	<	<	70.5	16632

Notes: --- = No sample collected.
< = Below HMX detection limit of 1.30 ug/L.

Table D-4

Field Laboratory Results for Tetryl From Test Two at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.7 gpm — Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.7 gpm — Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
19 September 1989	17:30 PM	<	<	<	83.7	42
20 September 1989	4:30 AM	<	---	---	71.2	504
	16:30 PM	<	<	<	91.8	1008
21 September 1989	4:30 AM	<	---	---	74.2	1512
	16:30 PM	<	<	<	96.2	2016
22 September 1989	4:30 AM	<	---	---	84.2	2520
	16:30 PM	<	<	<	84.9	3024
23 September 1989	4:30 AM	<	---	---	78.9	3528
	16:30 PM	<	<	<	81.7	4032
24 September 1989	4:30 AM	<	---	---	62.2	4536
	16:30 PM	<	<	<	74.2	5040
25 September 1989	4:30 AM	---	<	<	74.0	5544
	16:30 PM	<	<	<	77.4	6048
26 September 1989	4:30 AM	---	<	<	74.7	6552
	16:30 PM	<	<	<	86.4	7056
27 September 1989	4:30 AM	---	---	<	67.3	7560
	16:30 PM	<	<	<	85.2	8064
28 September 1989	4:30 AM	---	<	<	71.8	8568
	16:30 PM	<	<	<	75.0	9072
29 September 1989	4:30 AM	---	<	<	72.3	9576
	16:30 PM	<	<	<	77.6	10080
30 September 1989	4:30 AM	---	<	<	75.0	10584
	16:30 PM	<	<	<	79.0	11088
1 October 1989	4:30 AM	---	<	<	77.0	11592
	16:30 PM	<	<	<	93.0	12096
2 October 1989	4:30 AM	---	<	<	82.0	12600
	16:30 PM	<	<	<	91.6	13104
3 October 1989	4:30 AM	---	<	<	71.8	13608
	16:30 PM	<	<	<	96.7	14112
4 October 1989	4:30 AM	---	<	<	67.3	14616
	16:30 PM	<	<	<	89.9	15120
5 October 1989	16:30 PM	<	<	<	93.8	16128
6 October 1989	2:30 AM	<	---	---	71.2	16548
	4:30 AM	---	<	<	70.5	16632

Notes: --- = No sample collected.
< = Below Tetryl detection limit of 0.66 ug/L.

Table D-5

Field Laboratory Results for 2,4-DNT From Test Two at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.7 gpm — Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.7 gpm — Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
19 September 1989	17:30 PM	10.8	<	<	83.7	42
20 September 1989	4:30 AM	11.2	---	---	71.2	504
	16:30 PM	10.7	<	<	91.8	1008
21 September 1989	4:30 AM	10.9	---	---	74.2	1512
	16:30 PM	10.8	<	<	96.2	2016
22 September 1989	4:30 AM	11.9	---	---	84.2	2520
	16:30 PM	11.4	<	<	84.9	3024
23 September 1989	4:30 AM	11.9	---	---	78.9	3528
	16:30 PM	10.5	<	<	81.7	4032
24 September 1989	4:30 AM	12.0	---	---	62.2	4536
	16:30 PM	10.8	<	<	74.2	5040
25 September 1989	4:30 AM	---	<	<	74.0	5544
	16:30 PM	11.5	<	<	77.4	6048
26 September 1989	4:30 AM	---	<	<	74.7	6552
	16:30 PM	11.4	<	<	86.4	7056
27 September 1989	4:30 AM	---	---	<	67.3	7560
	16:30 PM	11.5	<	<	85.2	8064
28 September 1989	4:30 AM	---	<	<	71.8	8568
	16:30 PM	12.2	<	<	75.0	9072
29 September 1989	4:30 AM	---	<	<	72.3	9576
	16:30 PM	14.5	<	<	77.6	10080
30 September 1989	4:30 AM	---	<	<	75.0	10584
	16:30 PM	12.1	<	<	79.0	11088
1 October 1989	4:30 AM	---	<	<	77.0	11592
	16:30 PM	11.7	<	<	93.0	12096
2 October 1989	4:30 AM	---	<	<	82.0	12600
	16:30 PM	12.0	<	<	91.6	13104
3 October 1989	4:30 AM	---	<	<	71.8	13608
	16:30 PM	11.9	<	<	96.7	14112
4 October 1989	4:30 AM	---	<	<	67.3	14616
	16:30 PM	14.9	<	<	89.9	15120
5 October 1989	16:30 PM	12.8	<	<	93.8	16128
6 October 1989	2:30 AM	12.4	---	---	71.2	16548
	4:30 AM	---	<	<	70.5	16632

Notes: --- = No sample collected.
< = Below 2,4-DNT detection limit of 0.60 ug/L.

Table D-6

Field Laboratory Results for 2,6-DNT From Test Two at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.7 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.7 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
19 September 1989	17:30 PM	<	<	<	83.7	42
20 September 1989	4:30 AM	<	---	---	71.2	504
	16:30 PM	<	<	<	91.8	1008
21 September 1989	4:30 AM	<	---	---	74.2	1512
	16:30 PM	<	<	<	96.2	2016
22 September 1989	4:30 AM	<	---	---	84.2	2520
	16:30 PM	<	<	<	84.9	3024
23 September 1989	4:30 AM	<	---	---	78.9	3528
	16:30 PM	<	<	<	81.7	4032
24 September 1989	4:30 AM	<	---	---	62.2	4536
	16:30 PM	<	<	<	74.2	5040
25 September 1989	4:30 AM	---	<	<	74.0	5544
	16:30 PM	<	<	<	77.4	6048
26 September 1989	4:30 AM	---	<	<	74.7	6552
	16:30 PM	<	<	<	86.4	7056
27 September 1989	4:30 AM	---	---	<	67.3	7560
	16:30 PM	<	<	<	85.2	8064
28 September 1989	4:30 AM	---	<	<	71.8	8568
	16:30 PM	<	<	<	75.0	9072
29 September 1989	4:30 AM	---	<	<	72.3	9576
	16:30 PM	<	<	<	77.6	10080
30 September 1989	4:30 AM	---	<	<	75.0	10584
	16:30 PM	<	<	<	79.0	11088
1 October 1989	4:30 AM	---	<	<	77.0	11592
	16:30 PM	<	<	<	93.0	12096
2 October 1989	4:30 AM	---	<	<	82.0	12600
	16:30 PM	<	<	<	91.6	13104
3 October 1989	4:30 AM	---	<	<	71.8	13608
	16:30 PM	<	<	<	96.7	14112
4 October 1989	4:30 AM	---	<	<	67.3	14616
	16:30 PM	<	<	<	89.9	15120
5 October 1989	16:30 PM	<	<	<	93.8	16128
6 October 1989	2:30 AM	<	---	---	71.2	16548
	4:30 AM	---	<	<	70.5	16632

Notes: --- = No sample collected.
< = Below 2,6-DNT detection limit of 0.55 ug/L.

Table D-7

Field Laboratory Results for 1,3-DNB From Test Two at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.7 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.7 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
19 September 1989	17:30 PM	3.81	<	<	83.7	42
20 September 1989	4:30 AM	2.89	---	---	71.2	504
	16:30 PM	3.39	<	<	91.8	1008
21 September 1989	4:30 AM	3.64	---	---	74.2	1512
	16:30 PM	7.82	<	<	96.2	2016
22 September 1989	4:30 AM	3.97	---	---	84.2	2520
	16:30 PM	1.94	<	<	84.9	3024
23 September 1989	4:30 AM	4.06	---	---	78.9	3528
	16:30 PM	6.48	<	<	81.7	4032
24 September 1989	4:30 AM	4.34	---	---	62.2	4536
	16:30 PM	3.79	<	<	74.2	5040
25 September 1989	4:30 AM	---	<	<	74.0	5544
	16:30 PM	8.31	<	<	77.4	6048
26 September 1989	4:30 AM	---	<	<	74.7	6552
	16:30 PM	<	<	<	86.4	7056
27 September 1989	4:30 AM	---	---	<	67.3	7560
	16:30 PM	4.07	<	<	85.2	8064
28 September 1989	4:30 AM	---	<	<	71.8	8568
	16:30 PM	<	<	<	75.0	9072
29 September 1989	4:30 AM	---	<	<	72.3	9576
	16:30 PM	4.31	<	<	77.6	10080
30 September 1989	4:30 AM	---	<	<	75.0	10584
	16:30 PM	3.99	<	<	79.0	11088
1 October 1989	4:30 AM	---	<	<	77.0	11592
	16:30 PM	4.02	<	<	93.0	12096
2 October 1989	4:30 AM	---	<	<	82.0	12600
	16:30 PM	4.10	<	<	91.6	13104
3 October 1989	4:30 AM	---	<	<	71.8	13608
	16:30 PM	3.97	<	<	96.7	14112
4 October 1989	4:30 AM	---	<	<	67.3	14616
	16:30 PM	4.47	<	<	89.9	15120
5 October 1989	16:30 PM	2.81	<	<	93.8	16128
6 October 1989	2:30 AM	<	---	---	71.2	16548
	4:30 AM	---	<	<	70.5	16632

Notes: --- = No sample collected.
< = Below 1,3-DNB detection limit of 0.61 ug/L.

Table D-8

Field Laboratory Results for 1,3,5-TNB From Test Two at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.7 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.7 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
19 September 1989	17:30 PM	20.9	<	<	83.7	42
20 September 1989	4:30 AM	21.5	---	---	71.2	504
	16:30 PM	22.7	<	<	91.8	1008
21 September 1989	4:30 AM	22.8	---	---	74.2	1512
	16:30 PM	22.7	<	<	96.2	2016
22 September 1989	4:30 AM	24.2	---	---	84.2	2520
	16:30 PM	24.9	<	<	84.9	3024
23 September 1989	4:30 AM	25.9	---	---	78.9	3528
	16:30 PM	23.6	<	<	81.7	4032
24 September 1989	4:30 AM	26.2	---	---	62.2	4536
	16:30 PM	25.5	<	<	74.2	5040
25 September 1989	4:30 AM	---	<	<	74.0	5544
	16:30 PM	26.7	<	<	77.4	6048
26 September 1989	4:30 AM	---	<	<	74.7	6552
	16:30 PM	26.1	<	<	86.4	7056
27 September 1989	4:30 AM	---	---	<	67.3	7560
	16:30 PM	26.4	<	<	85.2	8064
28 September 1989	4:30 AM	---	<	<	71.8	8568
	16:30 PM	27.4	<	<	75.0	9072
29 September 1989	4:30 AM	---	<	<	72.3	9576
	16:30 PM	29.2	<	<	77.6	10080
30 September 1989	4:30 AM	---	<	<	75.0	10584
	16:30 PM	26.5	<	<	79.0	11088
1 October 1989	4:30 AM	---	<	<	77.0	11592
	16:30 PM	26.7	<	<	93.0	12096
2 October 1989	4:30 AM	---	<	<	82.0	12600
	16:30 PM	27.8	<	<	91.6	13104
3 October 1989	4:30 AM	---	<	<	71.8	13608
	16:30 PM	27.4	<	<	96.7	14112
4 October 1989	4:30 AM	---	<	<	67.3	14616
	16:30 PM	30.8	<	<	89.9	15120
5 October 1989	16:30 PM	27.6	<	<	93.8	16128
6 October 1989	2:30 AM	27.4	---	---	71.2	16548
	4:30 AM	---	<	<	70.5	16632

Notes: --- = No sample collected.
< = Below 1,3,5-TNB detection limit of 0.56 ug/L.

Table D-9

Field Laboratory Results for NB From Test Two at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.7 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.7 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
19 September 1989	17:30 PM	<	<	<	83.7	42
20 September 1989	4:30 AM	<	---	---	71.2	504
	16:30 PM	<	<	<	91.8	1008
21 September 1989	4:30 AM	<	---	---	74.2	1512
	16:30 PM	<	<	<	96.2	2016
22 September 1989	4:30 AM	<	---	---	84.2	2520
	16:30 PM	<	<	<	84.9	3024
23 September 1989	4:30 AM	<	---	---	78.9	3528
	16:30 PM	<	<	<	81.7	4032
24 September 1989	4:30 AM	<	---	---	62.2	4536
	16:30 PM	<	<	<	74.2	5040
25 September 1989	4:30 AM	---	<	<	74.0	5544
	16:30 PM	<	<	<	77.4	6048
26 September 1989	4:30 AM	---	<	<	74.7	6552
	16:30 PM	<	<	<	86.4	7056
27 September 1989	4:30 AM	---	---	<	67.3	7560
	16:30 PM	<	<	<	85.2	8064
28 September 1989	4:30 AM	---	<	<	71.8	8568
	16:30 PM	<	<	<	75.0	9072
29 September 1989	4:30 AM	---	<	<	72.3	9576
	16:30 PM	<	<	<	77.6	10080
30 September 1989	4:30 AM	---	<	<	75.0	10584
	16:30 PM	<	<	<	79.0	11088
1 October 1989	4:30 AM	---	<	<	77.0	11592
	16:30 PM	<	<	<	93.0	12096
2 October 1989	4:30 AM	---	<	<	82.0	12600
	16:30 PM	<	<	<	91.6	13104
3 October 1989	4:30 AM	---	<	<	71.8	13608
	16:30 PM	<	<	<	96.7	14112
4 October 1989	4:30 AM	---	<	<	67.3	14616
	16:30 PM	<	<	<	89.9	15120
5 October 1989	16:30 PM	<	<	<	93.8	16128
6 October 1989	2:30 AM	<	---	----	71.2	16548
	4:30 AM	---	<	<	70.5	16632

Notes: --- = No sample collected.
< = Below NB detection limit of 1.13 ug/L.

Table D-10

Field Laboratory Results for Explosives From Test Two at MAAP

Date	Time	Explosives	Atochem, Inc. GAC 830 0.7 gpm Column A2 Effluent Concentration (ug/L)	Atochem, Inc. GAC 830 0.7 gpm Column B2 Effluent Concentration (ug/L)
6 October 1989	3:15 AM	TNT	<	<
		RDX	<	1.16
		HMX	<	<
		Tetryl	<	<
		2,4-DNT	<	<
		2,6-DNT	<	<
		1,3-DNB	<	<
		1,3,5-TNB	<	<
		NB	<	<

Note: < = Below explosive detection limit.

APPENDIX E

FIELD LABORATORY RESULTS FOR EXPLOSIVES FROM TEST THREE AT MAAP

Table E-1

Field Laboratory Results for TNT From Test Three at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
16 October 1989	17:00 PM	600	<	<	90.8	0
17 October 1989	5:00 AM	---	<	<	83.9	540
	17:00 PM	644	0.769	1.30	67.7	1080
18 October 1989	5:00 AM	628	<	<	56.3	1620
	17:00 PM	---	<	<	46.4	2160
19 October 1989	5:00 AM	---	2.97	1.05	43.1	2700
	17:00 PM	624	4.67	<	50.8	3240
20 October 1989	5:00 PM	---	4.76	<	40.4	3780
	17:00 PM	559	2.82	<	65.7	4320
21 October 1989	5:00 AM	---	3.97	0.923	47.1	4860
	17:00 PM	629	3.75	0.794	83.8	5400
22 October 1989	5:00 AM	---	3.27	<	58.6	5940
	17:00 PM	530	3.40	<	90.1	6480
23 October 1989	5:00 AM	---	3.40	<	72.2	7020
	17:00 PM	659	3.77	<	92.7	7560
24 October 1989	5:00 AM	---	2.16	<	73.8	8100
	17:00 PM	677	2.42	<	94.6	8640
25 October 1989	5:00 AM	---	2.18	<	56.0	9180
	17:00 PM	672	5.91	1.26	92.8	9720
26 October 1989	5:00 AM	---	2.42	<	55.6	10260
	17:00 PM	624	2.86	0.960	93.3	10800
27 October 1989	5:00 AM	---	4.43	1.62	53.4	11340
	17:00 PM	682	4.19	3.16	91.9	11880
28 October 1989	5:00 AM	512	4.15	2.94	54.0	12420
	17:00 PM	---	4.73	2.51	91.6	12960
29 October 1989	5:00 AM	637	5.08	2.33	60.3	13500
	17:00 PM	---	4.61	1.94	82.4	14040
30 October 1989	5:00 AM	---	5.78	2.34	55.1	14580
	17:00 PM	764	5.00	2.01	85.3	15120
31 October 1989	5:00 AM	---	5.68	1.96	63.0	15660
	17:00 PM	768	6.88	3.64	70.5	16200
1 November 1989	5:00 AM	---	8.47	3.03	40.0	16740
	17:00 PM	733	8.47	3.32	65.9	17280
2 November 1989	5:00 AM	---	10.9	3.82	43.0	17820
	17:00 PM	687	17.9	6.69	62.4	18360
3 November 1989	5:00 AM	---	15.8	8.97	34.5	18900
	17:00 PM	684	19.6	10.1	60.8	19440
4 November 1989	5:00 AM	578	18.4	9.87	39.1	19980
	17:00 PM	---	17.2	9.57	61.3	20520
5 November 1989	5:00 AM	---	14.4	10.6	63.0	21060
	17:00 PM	553	12.0	8.85	77.1	21600
6 November 1989	5:00 AM	---	13.0	7.54	69.4	22140
	17:00 PM	953	25.1	11.7	75.8	22680
7 November 1989	5:00 AM	---	20.8	8.89	72.8	23220
	17:00 PM	899	19.2	7.92	82.1	23760
	23:00 PM	---	8.64	---	80.8	24030
8 November 1989	5:00 AM	---	10.7	15.0	71.6	24300

Table E-1

Field Laboratory Results for TNT From Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	678	10.1	14.2	80.2	24840
9 November 1989	5:00 AM	---	13.1	11.7	42.2	25380
	17:00 PM	647	14.5	16.1	67.3	25920
10 November 1989	5:00 AM	588	14.4	16.8	59.1	26460
	17:00 PM	---	14.6	19.8	70.1	27000
11 November 1989	5:00 AM	631	15.7	21.5	64.0	27540
	17:00 PM	---	17.1	23.5	88.2	28080
12 November 1989	5:00 AM	642	15.9	18.2	69.5	28620
	11:00 AM	---	19.9	---	91.5	28890
	17:00 PM	---	16.6	19.7	87.4	29160
13 November 1989	5:00 PM	723	18.1	18.5	59.4	29700
	17:00 PM	---	17.5	22.2	82.9	30240
14 November 1989	5:00 AM	702	16.4	15.6	77.8	30780
	17:00 PM	---	22.4	20.1	77.2	31320
15 November 1989	5:00 AM	718	29.6	23.4	80.9	31860
	13:00 PM	---	---	36.1	83.2	32220
	17:00 PM	---	23.5	42.6	58.5	32400
16 November 1989	5:00 AM	743	32.8	30.0	47.2	32940
	17:00 PM	741	42.7	38.7	40.6	33480
	20:00 PM	---	46.3	45.6	39.0	33615
17 November 1989	5:00 AM	794	54.7	50.5	20.7	34020
	13:00 PM	---	---	55.0	54.2	34380
	17:00 PM	---	54.4	61.0	49.5	34560
18 November 1989	5:00 AM	792	50.1	59.1	37.7	35100
	10:00 AM	---	NR	---	56.1	35325
	13:00 PM	---	NR	---	66.4	35460
	17:00 PM	---	57.8	61.3	59.8	35640
19 November 1989	5:00 AM	742	61.6	65.2	37.7	36180
	17:00 PM	---	55.8	62.3	71.0	36720
	20:00 PM	---	51.0	59.7	64.7	36855
	21:00 PM	---	50.8	---	63.5	36900
	23:00 PM	---	52.1	60.7	59.0	36990
20 November 1989	5:00 AM	779	53.0	58.8	56.7	37260
	8:00 AM	---	48.5	---	63.1	37395
	11:00 AM	---	50.8	52.3	75.3	37530
	12:00 PM	---	51.7	82.2	78.5	37575
	14:00 PM	---	41.8	76.8	85.4	37665
	17:00 PM	---	42.0	75.6	79.2	37800
	23:00 PM	---	39.4	74.3	60.0	38070
21 November 1989	5:00 AM	775	45.9	83.3	51.3	38340
	11:00 AM	---	39.5	73.6	61.2	38610
	17:00 PM	---	39.9	92.3	63.2	38880
22 November 1989	5:00 AM	---	85.8	125	53.2	39420
27 November 1989	17:30 PM	709	34.3	32.0	83.9	39443
28 November 1989	5:00 AM	713	39.2	46.8	59.8	39960
	17:00 PM	---	41.4	68.2	49.3	40500
29 November 1989	5:00 AM	753	61.7	87.1	28.6	41040

Table E-1

Field Laboratory Results for TNT From Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830. 0.75 gpm — Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm — Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	---	67.4	104	44.7	41580
30 November 1989	5:00 AM	---	76.6	103	31.2	42120
	17:00 PM	742	68.8	89.3	51.3	42660
1 December 1989	5:00 AM	---	80.4	91.3	33.6	43200
	17:00 PM	---	72.1	90.7	58.2	43740
2 December 1989	5:00 AM	616	76.2	92.3	45.8	44280
	17:00 PM	---	96.1	115	54.9	44820
3 December 1989	5:00 AM	---	92.1	115	23.4	45360
	17:00 PM	713	124	158	35.4	45900
4 December 1989	5:00 AM	959	157	189	26.0	46440
	17:00 PM	---	164	198	57.6	46980
5 December 1989	5:00 AM	1014	172	220	48.9	47520
	17:00 PM	---	159	195	68.5	48060
6 December 1989	5:00 AM	1064	139	166	64.6	48600
	17:00 PM	---	132	161	70.4	49140
7 December 1989	5:00 AM	824	133	130	44.5	49680
	17:00 PM	---	104	164	46.0	50220
8 December 1989	5:00 AM	796	109	162	34.5	50760
	17:00 PM	---	111	154	26.9	51300
9 December 1989	5:00 AM	778	148	235	26.8	51840
	17:00 PM	---	152	252	44.7	52380
10 December 1989	5:00 AM	915	209	259	34.4	52920
	17:00 PM	---	184	258	51.6	53460
11 December 1989	5:00 AM	846	124	217	51.2	54000
	17:00 PM	---	115	212	43.7	54540
12 December 1989	5:00 AM	1168	232	397	26.0	55080
	17:00 PM	---	227	371	29.6	55620
13 December 1989	5:00 AM	1093	97	348	4.0	56160
	9:00 AM	---	---	467	24.0	
	10:00 AM	---	---	463	32.1	
	13:30 PM	---	---	745	44.9	
	17:00 PM	---	134	555	38.5	
14 December 1989	5:00 AM	930	166	309	21.8	
	17:00 PM	---	188	356	37.6	
15 December 1989	5:00 AM	485	91.8	193	46.4	
	17:00 PM	---	88.6	192	13.9	

Notes: --- = No sample taken.
< = Below TNT detection limit of 0.78 ug/L.
NR = Not reported.

Table E-2

Field Laboratory Results for RDX from Test Three at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
16 October 1989	17:00 PM	451	0.851	0.778	90.8	0
17 October 1989	5:00 AM	---	0.668	0.558	83.9	540
	17:00 PM	446	1.27	0.558	67.7	1080
18 October 1989	5:00 AM	441	0.705	0.741	56.3	1620
	17:00 PM	---	0.729	0.619	46.4	2160
19 October 1989	5:00 AM	---	3.12	<	43.1	2700
	17:00 PM	504	3.74	1.09	50.8	3240
20 October 1989	5:00 PM	---	4.37	1.53	40.4	3780
	17:00 PM	528	4.11	1.83	65.7	4320
21 October 1989	5:00 AM	---	5.75	2.10	47.1	4860
	17:00 PM	525	5.98	2.08	83.8	5400
22 October 1989	5:00 AM	---	5.89	1.36	58.6	5940
	17:00 PM	491	6.47	2.01	90.1	6480
23 October 1989	5:00 AM	---	6.19	2.22	72.2	7020
	17:00 PM	568	8.01	2.17	92.7	7560
24 October 1989	5:00 AM	--	5.89	1.76	73.8	8100
	17:00 PM	545	6.47	2.43	94.6	8640
25 October 1989	5:00 AM	---	4.99	2.17*	56.0	9180
	17:00 PM	535	11.6	3.58*	92.8	9720
26 October 1989	5:00 AM	---	7.81	2.40	55.6	10260
	17:00 PM	531	8.27	3.77	93.3	10800
27 October 1989	5:00 AM	---	12.1	6.17	53.4	11340
	17:00 PM	557	13.1	24.1	91.9	11880
28 October 1989	5:00 AM	---	45.9	25.0	54.0	12420
	17:00 PM	560	45.3	24.9	91.6	12960
29 October 1989	5:00 AM	602	43.9	24.8	60.3	13500
	17:00 PM	---	46.4	26.1	82.4	14040
30 October 1989	5:00 AM	---	48.8	25.1	55.1	14580
	17:00 PM	583	47.9	27.5	85.3	15120
31 October 1989	5:00 AM	---	52.1	27.8	63.0	15660
	17:00 PM	593	54.5	30.4	70.5	16200
1 November 1989	5:00 AM	---	49.3	28.2	40.0	16740
	17:00 PM	592	53.3	31.2	65.9	17280
2 November 1989	5:00 AM	---	53.4	31.1	43.0	17820
	17:00 PM	551	60.2	40.2	62.4	18360
3 November 1989	5:00 AM	---	57.5	46.4	34.5	18900
	17:00 PM	565	66.5	50.8	60.8	19440
4 November 1989	5:00 AM	480	67.1	48.9	39.1	19980
	17:00 PM	---	70.7	52.9	61.3	20520
5 November 1989	5:00 AM	---	67.2	56.6	63.0	21060
	17:00 PM	482	70.3	59.7	77.1	21600
6 November 1989	5:00 AM	---	71.7	58.1	69.4	22140
	17:00 PM	540	88.3	60.5	75.8	22680
7 November 1989	5:00 AM	---	91.4	61.2	72.8	23220
	17:00 PM	531	96.9	61.5	82.1	23760
	23:00 PM	---	95	---	80.8	24030
8 November 1989	5:00 AM	---	144	111	71.6	24300

Table E-2

Field Laboratory Results for RDX from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	554	143	112	80.2	24840
9 November 1989	5:00 AM	---	137	101	42.2	25380
	17:00 PM	525	132	115	67.3	25920
10 November 1989	5:00 AM	483	137	120	59.1	26460
	17:00 PM	---	138	129	70.1	27000
11 November 1989	5:00 AM	553	141	132	64.0	27540
	17:00 PM	---	158	138	88.2	28080
12 November 1989	5:00 AM	505	159	135	69.5	28620
	11:00 AM	---	159	---	91.5	28890
	17:00 PM	---	162	140	87.4	29160
13 November 1989	5:00 AM	561	177	141	59.4	29700
	17:00 PM	---	173	155	82.9	30240
14 November 1989	5:00 AM	541	191	150	77.8	30780
	17:00 PM	---	201	153	77.2	31320
15 November 1989	5:00 AM	557	209	170	80.9	31860
	13:00 PM	---	---	NR	83.2	32220
	17:00 PM	---	207	199	58.5	32400
16 November 1989	5:00 AM	579	205	164	47.2	32940
	17:00 PM	594	190	170	40.6	33480
	20:00 PM	---	NR	NR	39.0	33615
17 November 1989	5:00 AM	605	207	181	20.7	34020
	13:00 PM	---	---	NR	54.2	34380
	17:00 PM	---	214	196	49.5	34560
18 November 1989	5:00 AM	558	201	198	37.7	35100
	10:00 AM	---	208	---	56.1	35325
	13:00 PM	---	220	---	66.4	35460
	17:00 PM	---	236	206	59.8	35640
19 November 1989	5:00 AM	565	226	206	37.7	36180
	17:00 PM	---	231	212	71.0	36720
	20:00 PM	---	225	215	64.7	36855
	21:00 PM	---	233	---	63.5	36900
	23:00 PM	---	250	219	59.0	36990
20 November 1989	5:00 AM	577	253	223	56.7	37260
	8:00 AM	---	247	---	63.1	37395
	11:00 AM	---	271	218	75.3	37530
	12:00 PM	---	326	269	78.5	37575
	14:00 PM	---	305	268	85.4	37665
	17:00 PM	---	315	256	79.2	37800
	23:00 PM	---	296	272	60.0	38070
21 November 1989	5:00 AM	592	296	275	51.3	38340
	11:00 AM	---	260	246	61.2	38610
	17:00 PM	---	272	285	63.2	38880
22 November 1989	5:00 AM	---	305	281	53.2	39420
27 November 1989	17:30 PM	624	223	203	83.9	39443
28 November 1989	5:00 AM	603	260	226	59.8	39960
	17:00 PM	---	268	259	49.3	40500
29 November 1989	5:00 AM	620	272	269	28.6	41040

Table E-2

Field Laboratory Results for RDX from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	---	273	280	44.7	41580
30 November 1989	5:00 AM	---	261	264	31.2	42120
	17:00 PM	611	306	286	51.3	42660
1 December 1989	5:00 AM	---	325	281	33.6	43200
	17:00 PM	---	271	244	58.2	43740
2 December 1989	5:00 AM	529	293	243	45.8	44280
	17:00 PM	---	321	263	54.9	44820
3 December 1989	5:00 AM	---	299	263	23.4	45360
	17:00 PM	458	323	299	35.4	45900
4 December 1989	5:00 AM	520	292	274	26.0	46440
	17:00 PM	---	300	287	57.6	46980
5 December 1989	5:00 AM	550	317	296	48.9	47520
	17:00 PM	---	351	298	68.5	48060
6 December 1989	5:00 AM	575	339	301	64.6	48600
	17:00 PM	---	351	273	70.4	49140
7 December 1989	5:00 AM	483	342	289	44.5	49680
	17:00 PM	---	312	277	46.0	50220
8 December 1989	5:00 AM	481	277	249	34.5	50760
	17:00 PM	---	269	240	26.9	51300
9 December 1989	5:00 AM	520	335	339	26.8	51840
	17:00 PM	---	331	357	44.7	52380
10 December 1989	5:00 AM	585	348	337	34.4	52920
	17:00 PM	---	348	330	51.6	53460
11 December 1989	5:00 AM	770	381	389	51.2	54000
	17:00 PM	---	387	428	43.7	54540
12 December 1989	5:00 AM	627	419	434	26.0	55080
	17:00 PM	---	395	405	29.6	55620
13 December 1989	5:00 AM	578	318	369	4.0	56160
	9:00 AM	---	---	441	24.0	
	10:00 AM	---	---	441	32.1	
	13:30 PM	---	---	528	44.9	
	17:00 PM	---	366	449	38.5	
14 December 1989	5:00 AM	559	325	332	21.8	
	17:00 PM	---	387	383	37.6	
15 December 1989	5:00 AM	507	351	390	46.4	
	17:00 PM	---	315	344	13.9	

Notes: — = No sample taken.
< = Below RDX detection limit of 0.63 ug/L.
NR = Not reported.
* = A calculated value (peak height).

Table E-3

Field Laboratory Results for HMX from Test Three at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
16 October 1989	17:00 PM	3.45	<	<	90.8	0
17 October 1989	5:00 AM	---	<	<	83.9	540
	17:00 PM	3.51	<	<	67.7	1080
18 October 1989	5:00 AM	4.02	<	<	56.3	1620
	17:00 PM	---	<	<	46.4	2160
19 October 1989	5:00 AM	---	<	<	43.1	2700
	17:00 PM	2.74	<	<	50.8	3240
20 October 1989	5:00 PM	---	<	<	40.4	3780
	17:00 PM	3.56	<	<	65.7	4320
21 October 1989	5:00 AM	---	<	<	47.1	4860
	17:00 PM	3.66	<	<	83.8	5400
22 October 1989	5:00 AM	---	<	<	58.6	5940
	17:00 PM	3.99	<	<	90.1	6480
23 October 1989	5:00 AM	---	<	<	72.2	7020
	17:00 PM	3.02	<	<	92.7	7560
24 October 1989	5:00 AM	---	<	<	73.8	8100
	17:00 PM	4.32	<	<	94.6	8640
25 October 1989	5:00 AM	---	<	<	56.0	9180
	17:00 PM	3.80	<	<	92.8	9720
26 October 1989	5:00 AM	---	<	<	55.6	10260
	17:00 PM	3.77	<	<	93.3	10800
27 October 1989	5:00 AM	---	<	<	53.4	11340
	17:00 PM	4.55	<	<	91.9	11880
28 October 1989	5:00 AM	3.63	<	<	54.0	12420
	17:00 PM	---	<	<	91.6	12960
29 October 1989	5:00 AM	3.71	<	<	60.3	13500
	17:00 PM	---	<	<	82.4	14040
30 October 1989	5:00 AM	---	<	<	55.1	14580
	17:00 PM	4.03	<	<	85.3	15120
31 October 1989	5:00 AM	---	<	<	63.0	15660
	17:00 PM	4.29	<	<	70.5	16200
1 November 1989	5:00 AM	---	<	<	40.0	16740
	17:00 PM	4.25	<	<	65.9	17280
2 November 1989	5:00 AM	---	<	<	43.0	17820
	17:00 PM	4.10	<	<	62.4	18360
3 November 1989	5:00 AM	---	<	<	34.5	18900
	17:00 PM	4.29	<	<	60.8	19440
4 November 1989	5:00 AM	3.11	<	<	39.1	19980
	17:00 PM	---	<	<	61.3	20520
5 November 1989	5:00 AM	---	<	<	63.0	21060
	17:00 PM	3.12	<	<	77.1	21600
6 November 1989	5:00 AM	---	<	<	69.4	22140
	17:00 PM	4.30	<	<	75.8	22680
7 November 1989	5:00 AM	---	<	<	72.8	23220
	17:00 PM	4.21	<	<	82.1	23760
	23:00 PM	---	<	---	80.8	24030
8 November 1989	5:00 AM	---	<	<	71.6	24300

Table E-3

Field Laboratory Results for HMX from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	3.13	<	<	80.2	24840
9 November 1989	5:00 AM	---	<	<	42.2	25380
	17:00 PM	4.26	<	<	67.3	25920
10 November 1989	5:00 AM	1.49	<	<	59.1	26460
	17:00 PM	---	<	<	70.1	27000
11 November 1989	5:00 AM	4.04	<	<	64.0	27540
	17:00 PM	---	<	<	88.2	28080
12 November 1989	5:00 AM	3.52	<	<	69.5	28620
	11:00 AM	---	<	---	91.5	28890
	17:00 PM	---	<	<	87.4	29160
13 November 1989	5:00 AM	3.78	<	<	59.4	29700
	17:00 PM	---	<	<	82.9	30240
14 November 1989	5:00 AM	3.86	<	<	77.8	30780
	17:00 PM	---	<	<	77.2	31320
15 November 1989	5:00 AM	4.30	<	<	80.9	31860
	13:00 PM	---	---	NR	83.2	32220
	17:00 PM	---	<	<	58.5	32400
16 November 1989	5:00 AM	4.68	<	<	47.2	32940
	17:00 PM	4.74	<	<	40.6	33480
	20:00 PM	---	NR	NR	39.0	33615
17 November 1989	5:00 AM	3.96	<	<	20.7	34020
	13:00 PM	---	---	NR	54.2	34380
	17:00 PM	---	<	<	49.5	34560
18 November 1989	5:00 AM	2.41	<	<	37.7	35100
	10:00 AM	---	NR	---	56.1	35325
	13:00 PM	---	NR	---	66.4	35460
	17:00 PM	---	<	<	59.8	35640
19 November 1989	5:00 AM	4.03	<	<	37.7	36180
	17:00 PM	---	<	<	71.0	36720
	20:00 PM	---	NR	NR	64.7	36855
	21:00 PM	---	NR	---	63.5	36900
	23:00 PM	---	NR	NR	59.0	36990
20 November 1989	5:00 AM	4.13	<	<	56.7	37260
	8:00 AM	---	NR	---	63.1	37395
	11:00 AM	---	NR	<	75.3	37530
	12:00 PM	---	<	<	78.5	37575
	14:00 PM	---	NR	NR	85.4	37665
	17:00 PM	---	<	<	79.2	37800
	23:00 PM	---	<	<	60.0	38070
21 November 1989	5:00 AM	4.91	<	<	51.3	38340
	11:00 AM	---	NR	NR	61.2	38610
	17:00 PM	---	<	<	63.2	38880
22 November 1989	5:00 AM	---	<	<	53.2	39420
27 November 1989	17:30 PM	5.18	<	<	83.9	39443
28 November 1989	5:00 AM	4.47	<	<	59.8	39960
	17:00 PM	---	<	<	49.3	40500
29 November 1989	5:00 AM	4.84	<	<	28.6	41040

Table E-3

Field Laboratory Results for HMX from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm — Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm — Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	---	<	<	44.7	41580
30 November 1989	5:00 AM	---	<	<	31.2	42120
	17:00 PM	4.68	<	<	51.3	42660
1 December 1989	5:00 AM	---	<	<	33.6	43200
	17:00 PM	---	<	<	58.2	43740
2 December 1989	5:00 AM	3.85	<	<	45.8	44280
	17:00 PM	---	<	<	54.9	44820
3 December 1989	5:00 AM	---	<	<	23.4	45360
	17:00 PM	10.5	<	<	35.4	45900
4 December 1989	5:00 AM	6.68	<	<	26.0	46440
	17:00 PM	---	<	<	57.6	46980
5 December 1989	5:00 AM	6.90	<	<	48.9	47520
	17:00 PM	---	<	<	58.5	48060
6 December 1989	5:00 AM	9.66	<	<	64.6	48600
	17:00 PM	---	<	<	70.4	49140
7 December 1989	5:00 AM	<	<	<	44.5	49680
	17:00 PM	---	<	<	46.0	50220
8 December 1989	5:00 AM	<	<	<	34.5	50760
	17:00 PM	---	<	<	26.9	51300
9 December 1989	5:00 AM	<	<	<	26.8	51840
	17:00 PM	---	<	<	44.7	52380
10 December 1989	5:00 AM	<	<	<	34.4	52920
	17:00 PM	---	<	<	51.6	53460
11 December 1989	5:00 AM	<	<	<	51.2	54000
	17:00 PM	---	<	<	43.7	54540
12 December 1989	5:00 AM	<	<	<	26.0	55080
	17:00 PM	---	<	<	29.6	55620
13 December 1989	5:00 AM	<	<	<	4.0	56160
	9:00 AM	---	---	<	24.0	
	10:00 AM	---	---	<	32.1	
	13:30 PM	---	---	<	44.9	
	17:00 PM	---	<	<	38.5	
14 December 1989	5:00 AM	<	<	<	21.8	
	17:00 PM	---	<	<	37.6	
15 December 1989	5:00 AM	<	<	<	46.4	
	17:00 PM	---	<	<	13.9	

Notes: --- = No sample taken.
< = Below HMX detection limit of 1.30 ug/L.
NR = Not reported.

Table E-4

Field Laboratory Results for Tetryl from Test Three at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm — Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm — Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
16 October 1989	17:00 PM	33.9G	<	<	90.8	0
17 October 1989	5:00 AM	---	<	<	83.9	540
	17:00 PM	<	<	<	67.7	1080
18 October 1989	5:00 AM	<	<	<	56.3	1620
	17:00 PM	---	<	<	46.4	2160
19 October 1989	5:00 AM	---	<	<	43.1	2700
	17:00 PM	<	<	<	50.8	3240
20 October 1989	5:00 PM	---	<	<	40.4	3780
	17:00 PM	<	<	<	65.7	4320
21 October 1989	5:00 AM	---	<	<	47.1	4860
	17:00 PM	<	<	<	83.8	5400
22 October 1989	5:00 AM	---	<	<	58.6	5940
	17:00 PM	<	<	<	90.1	6480
23 October 1989	5:00 AM	---	<	<	72.2	7020
	17:00 PM	<	<	<	92.7	7560
24 October 1989	5:00 AM	--	<	<	73.8	8100
	17:00 PM	<	<	<	94.6	8640
25 October 1989	5:00 AM	---	<	<	56.0	9180
	17:00 PM	<	<	<	92.8	9720
26 October 1989	5:00 AM	---	<	<	55.6	10260
	17:00 PM	<	<	<	93.3	10800
27 October 1989	5:00 AM	---	<	<	53.4	11340
	17:00 PM	<	<	<	91.9	11880
28 October 1989	5:00 AM	<	<	<	54.0	12420
	17:00 PM	---	<	<	91.6	12960
29 October 1989	5:00 AM	<	<	<	60.3	13500
	17:00 PM	---	<	<	82.4	14040
30 October 1989	5:00 AM	---	<	<	55.1	14580
	17:00 PM	<	<	<	85.3	15120
31 October 1989	5:00 AM	---	<	<	63.0	15660
	17:00 PM	<	<	<	70.5	16200
1 November 1989	5:00 AM	---	<	<	40.0	16740
	17:00 PM	<	<	<	65.9	17280
2 November 1989	5:00 AM	---	<	<	43.0	17820
	17:00 PM	<	<	<	62.4	18360
3 November 1989	5:00 AM	---	<	<	34.5	18900
	17:00 PM	<	<	<	60.8	19440
4 November 1989	5:00 AM	<	<	<	39.1	19980
	17:00 PM	---	<	<	61.3	20520
5 November 1989	5:00 AM	---	<	<	63.0	21060
	17:00 PM	<	<	<	77.1	21600
6 November 1989	5:00 AM	---	<	<	69.4	22140
	17:00 PM	<	<	<	75.8	22680
7 November 1989	5:00 AM	---	<	<	72.8	23220
	17:00 PM	<	<	<	82.1	23760
	23:00 PM	---	<	---	80.8	24030
8 November 1989	5:00 AM	---	<	<	71.6	24300

Table E-4

Field Laboratory Results for Tetryl from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm: Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm: Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	<	<	<	80.2	24840
9 November 1989	5:00 AM	---	<	<	42.2	25380
	17:00 PM	<	<	<	67.3	25920
10 November 1989	5:00 AM	<	<	<	59.1	26460
	17:00 PM	---	<	<	70.1	27000
11 November 1989	5:00 AM	<	<	<	64.0	27540
	17:00 PM	---	<	<	88.2	28080
12 November 1989	5:00 AM	<	<	<	69.5	28620
	11:00 AM	---	<	---	91.5	28890
	17:00 PM	---	<	<	87.4	29160
13 November 1989	5:00 AM	<	<	<	59.4	29700
	17:00 PM	---	<	<	82.9	30240
14 November 1989	5:00 AM	<	<	<	77.8	30780
	17:00 PM	---	<	<	77.2	31320
15 November 1989	5:00 AM	<	<	<	80.9	31860
	13:00 PM	---	---	NR	83.2	32220
	17:00 PM	---	<	<	58.5	32400
16 November 1989	5:00 AM	<	<	<	47.2	32940
	17:00 PM	<	<	<	40.6	33480
	20:00 PM	---	NR	NR	39.0	33615
17 November 1989	5:00 AM	<	<	<	20.7	34020
	13:00 PM	---	---	NR	54.2	34380
	17:00 PM	---	<	<	49.5	34560
18 November 1989	5:00 AM	<	<	<	37.7	35100
	10:00 AM	---	NR	---	56.1	35325
	13:00 PM	---	NR	---	66.4	35460
	17:00 PM	---	<	<	59.8	35640
19 November 1989	5:00 AM	<	<	<	37.7	36180
	17:00 PM	---	<	<	71.0	36720
	20:00 PM	---	NR	NR	64.7	36855
	21:00 PM	---	NR	---	63.5	36900
	23:00 PM	---	NR	NR	59.0	36990
20 November 1989	5:00 AM	<	<	<	56.7	37260
	8:00 AM	---	NR	---	63.1	37395
	11:00 AM	---	NR	<	75.3	37530
	12:00 PM	---	<	<	78.5	37575
	14:00 PM	---	NR	NR	85.4	37665
	17:00 PM	---	<	<	79.2	37800
	23:00 PM	---	<	<	60.0	38070
21 November 1989	5:00 AM	<	<	<	51.3	38340
	11:00 AM	---	NR	NR	61.2	38610
	17:00 PM	---	<	<	63.2	38880
22 November 1989	5:00 AM	---	<	<	53.2	39420
27 November 1989	17:30 PM	<	<	<	83.9	39443
28 November 1989	5:00 AM	<	<	<	59.8	39960
	17:00 PM	---	<	<	49.3	40500
29 November 1989	5:00 AM	<	<	<	28.6	41040

Table E-4

Field Laboratory Results for Tetryl from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	---	<	<	44.7	41580
30 November 1989	5:00 AM	---	<	<	31.2	42120
	17:00 PM	<	<	<	51.3	42660
1 December 1989	5:00 AM	---	<	<	33.6	43200
	17:00 PM	---	<	<	58.2	43740
2 December 1989	5:00 AM	<	<	<	45.8	44280
	17:00 PM	---	<	<	54.9	44820
3 December 1989	5:00 AM	---	<	<	23.4	45360
	17:00 PM	<	<	<	35.4	45900
4 December 1989	5:00 AM	<	<	<	26.0	46440
	17:00 PM	---	<	<	57.6	46980
5 December 1989	5:00 AM	<	<	<	48.9	47520
	17:00 PM	---	<	<	68.5	48060
6 December 1989	5:00 AM	<	<	<	64.6	48600
	17:00 PM	---	<	<	70.4	49140
7 December 1989	5:00 AM	<	<	<	44.5	49680
	17:00 PM	---	<	<	46.0	50220
8 December 1989	5:00 AM	<	<	<	34.5	50760
	17:00 PM	---	<	<	26.9	51300
9 December 1989	5:00 AM	<	<	<	26.8	51840
	17:00 PM	---	<	<	44.7	52380
10 December 1989	5:00 AM	<	<	<	34.4	52920
	17:00 PM	---	<	<	51.6	53460
11 December 1989	5:00 AM	<	<	<	51.2	54000
	17:00 PM	---	<	<	43.7	54540
12 December 1989	5:00 AM	<	<	<	26.0	55080
	17:00 PM	---	<	<	29.6	55620
13 December 1989	5:00 AM	<	<	<	4.0	56160
	9:00 AM	---	---	<	24.0	
	10:00 AM	---	---	<	32.1	
	13:30 PM	---	---	<	44.9	
	17:00 PM	---	<	<	38.5	
14 December 1989	5:00 AM	<	<	<	21.8	
	17:00 PM	---	<	<	37.6	
15 December 1989	5:00 AM	<	<	<	46.4	
	17:00 PM	---	<	<	13.9	

Notes: --- = No sample taken.
< = Below Tetryl detection limit of 0.66 ug/L.
NR = Not reported.
G = Listed but not probable.

Table E-5

Field Laboratory Results for 2,4-DNT from Test Three at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm — Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm — Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
16 October 1989	17:00 PM	9.07	<	<	90.8	0
17 October 1989	5:00 AM	---	<	<	83.9	540
	17:00 PM	9.66	<	<	67.7	1080
18 October 1989	5:00 AM	9.38	<	<	56.3	1620
	17:00 PM	---	<	<	46.4	2160
19 October 1989	5:00 AM	---	<	<	43.1	2700
	17:00 PM	11.5	<	<	50.8	3240
20 October 1989	5:00 PM	---	<	<	40.4	3780
	17:00 PM	11.4	<	<	65.7	4320
21 October 1989	5:00 AM	---	<	<	47.1	4860
	17:00 PM	12.2	<	<	83.8	5400
22 October 1989	5:00 AM	---	<	<	58.6	5940
	17:00 PM	11.5	<	<	90.1	6480
23 October 1989	5:00 AM	---	<	<	72.2	7020
	17:00 PM	12.3	<	<	92.7	7560
24 October 1989	5:00 AM	---	<	<	73.8	8100
	17:00 PM	12.3	<	<	94.6	8640
25 October 1989	5:00 AM	---	<	<	56.0	9180
	17:00 PM	9.40	<	<	92.8	9720
26 October 1989	5:00 AM	---	<	<	55.6	10260
	17:00 PM	12.3	<	<	93.3	10800
27 October 1989	5:00 AM	---	<	<	53.4	11340
	17:00 PM	12.4	<	<	91.9	11880
28 October 1989	5:00 AM	5.31	<	<	54.0	12420
	17:00 PM	---	<	<	91.6	12960
29 October 1989	5:00 AM	11.9	<	<	60.3	13500
	17:00 PM	---	<	<	82.4	14040
30 October 1989	5:00 AM	---	<	<	55.1	14580
	17:00 PM	12.9	<	<	85.3	15120
31 October 1989	5:00 AM	---	<	<	63.0	15660
	17:00 PM	13.4	<	<	70.5	16200
1 November 1989	5:00 AM	---	<	<	40.0	16740
	17:00 PM	13.2	<	<	65.9	17280
2 November 1989	5:00 AM	---	<	<	43.0	17820
	17:00 PM	11.9	<	<	62.4	18360
3 November 1989	5:00 AM	---	<	<	34.5	18900
	17:00 PM	11.8	<	<	60.8	19440
4 November 1989	5:00 AM	9.14	<	<	39.1	19980
	17:00 PM	---	<	<	61.3	20520
5 November 1989	5:00 AM	---	<	<	63.0	21060
	17:00 PM	9.67	<	<	77.1	21600
6 November 1989	5:00 AM	---	<	<	69.4	22140
	17:00 PM	14.6	<	<	75.8	22680
7 November 1989	5:00 AM	---	<	<	72.8	23220
	17:00 PM	13.5	<	<	82.1	23760
	23:00 PM	---	<	---	80.8	24030
8 November 1989	5:00 AM	---	<	<	71.6	24300

Table E-5

Field Laboratory Results for 2,4-DNT from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	11.8	<	<	80.2	24840
9 November 1989	5:00 AM	---	<	<	42.2	25380
	17:00 PM	11.4	<	<	67.3	25920
10 November 1989	5:00 AM	11.4	<	<	59.1	26460
	17:00 PM	---	<	<	70.1	27000
11 November 1989	5:00 AM	13.6	<	<	64.0	27540
	17:00 PM	---	<	<	88.2	28080
12 November 1989	5:00 AM	11.8	<	<	69.5	28620
	11:00 AM	---	<	---	91.5	28890
	17:00 PM	---	<	<	87.4	29160
13 November 1989	5:00 AM	12.7	<	<	59.4	29700
	17:00 PM	---	<	<	82.9	30240
14 November 1989	5:00 AM	12.3	<	<	77.8	30780
	17:00 PM	---	<	<	77.2	31320
15 November 1989	5:00 AM	12.7	<	<	80.9	31860
	13:00 PM	---	---	NR	83.2	32220
	17:00 PM	---	<	<	58.5	32400
16 November 1989	5:00 AM	13.1	<	<	47.2	32940
	17:00 PM	12.8	<	<	40.6	33480
	20:00 PM	---	NR	NR	39.0	33615
17 November 1989	5:00 AM	12.8	<	<	20.7	34020
	13:00 PM	---	---	NR	54.2	34380
	17:00 PM	---	<	<	49.5	34560
18 November 1989	5:00 AM	12.5	<	<	37.7	35100
	10:00 AM	---	NR	---	56.1	35325
	13:00 PM	---	NR	---	66.4	35460
	17:00 PM	---	<	<	59.8	35640
19 November 1989	5:00 AM	13.5	<	<	37.7	36180
	17:00 PM	---	<	<	71.0	36720
	20:00 PM	---	NR	NR	64.7	36855
	21:00 PM	---	NR	---	63.5	36900
	23:00 PM	---	NR	NR	59.0	36990
20 November 1989	5:00 AM	13.8	<	<	56.7	37260
	8:00 AM	---	NR	---	63.1	37395
	11:00 AM	---	NR	<	75.3	37530
	12:00 PM	---	<	<	78.5	37575
	14:00 PM	---	NR	NR	85.4	37665
	17:00 PM	---	<	<	79.2	37800
	23:00 PM	---	<	<	60.0	38070
21 November 1989	5:00 AM	14.5	<	<	51.3	38340
	11:00 AM	---	NR	NR	61.2	38610
	17:00 PM	---	<	<	63.2	38880
22 November 1989	5:00 AM	---	<	<	53.2	39420
27 November 1989	17:30 PM	13.0	<	<	83.9	39443
28 November 1989	5:00 AM	13.2	<	<	59.8	39960
	17:00 PM	---	<	<	49.3	40500
29 November 1989	5:00 AM	13.7	<	<	28.6	41040

Table E-5

Field Laboratory Results for 2,4-DNT from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm — Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm — Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	---	<	<	44.7	41580
30 November 1989	5:00 AM	---	0.91	1.44	31.2	42120
	17:00 PM	12.8	0.81	1.27	51.3	42660
1 December 1989	5:00 AM	---	1.08	1.12	33.6	43200
	17:00 PM	---	0.99	1.17	58.2	43740
2 December 1989	5:00 AM	11.7	1.09	1.08	45.8	44280
	17:00 PM	---	0.56	0.68	54.9	44820
3 December 1989	5:00 AM	---	<	0.72	23.4	45360
	17:00 PM	11.2	0.91	1.13	35.4	45900
4 December 1989	5:00 AM	13.6	1.47	1.61	26.0	46440
	17:00 PM	---	1.65	1.65	57.6	46980
5 December 1989	5:00 AM	11.9	1.65	1.84	48.9	47520
	17:00 PM	---	1.56	1.70	68.5	48060
6 December 1989	5:00 AM	13.3	1.38	1.43	64.6	48600
	17:00 PM	---	1.19	1.35	70.4	49140
7 December 1989	5:00 AM	10.1	1.67	1.00	44.5	49680
	17:00 PM	---	0.90	1.46	46.0	50220
8 December 1989	5:00 AM	7.75	<	1.13	34.5	50760
	17:00 PM	---	<	0.87	26.9	51300
9 December 1989	5:00 AM	10.6	0.91	1.35	26.8	51840
	17:00 PM	---	0.99	1.52	44.7	52380
10 December 1989	5:00 AM	22.9	0.89	0.97	34.4	52920
	17:00 PM	---	<	<	51.6	53460
11 December 1989	5:00 AM	9.95	1.01	<	51.2	54000
	17:00 PM	---	0.79	1.53	43.7	54540
12 December 1989	5:00 AM	14.0	1.56	3.15	26.0	55080
	17:00 PM	---	1.47	<	29.6	55620
13 December 1989	5:00 AM	15.7	<	3.19	4.0	56160
	9:00 AM	---	---	4.57	24.0	
	10:00 AM	---	---	4.63	32.1	
	13:30 PM	---	---	8.42	44.9	
	17:00 PM	---	<	6.83	38.5	
14 December 1989	5:00 AM	13.3	1.73	3.58	21.8	
	17:00 PM	---	1.53	3.76	37.6	
15 December 1989	5:00 AM	12.6	1.68	3.49	46.4	
	17:00 PM	---	3.60	3.60	13.9	

Notes: --- = No sample taken.
< = Below 2,4-DNT detection limit of 0.60 ug/L.
NR = Not reported.

Table E-6

Field Laboratory Results for 2,6-DNT from Test Three at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
16 October 1989	17:00 PM	<	<	<	90.8	0
17 October 1989	5:00 AM	---	<	<	83.9	540
	17:00 PM	<	<	<	67.7	1080
18 October 1989	5:00 AM	<	<	<	56.3	1620
	17:00 PM	---	<	<	46.4	2160
19 October 1989	5:00 AM	---	<	<	43.1	2700
	17:00 PM	<	<	<	50.8	3240
20 October 1989	5:00 PM	---	<	<	40.4	3780
	17:00 PM	<	<	<	65.7	4320
21 October 1989	5:00 AM	---	<	<	47.1	4860
	17:00 PM	<	<	<	83.8	5400
22 October 1989	5:00 AM	---	<	<	58.6	5940
	17:00 PM	<	<	<	90.1	6480
23 October 1989	5:00 AM	---	<	<	72.2	7020
	17:00 PM	<	<	<	92.7	7560
24 October 1989	5:00 AM	--	<	<	73.8	8100
	17:00 PM	<	<	<	94.6	8640
25 October 1989	5:00 AM	---	<	<	56.0	9180
	17:00 PM	<	<	<	92.8	9720
26 October 1989	5:00 AM	---	<	<	55.6	10260
	17:00 PM	<	<	<	93.3	10800
27 October 1989	5:00 AM	---	<	<	53.4	11340
	17:00 PM	<	<	<	91.9	11880
28 October 1989	5:00 AM	<	<	<	54.0	12420
	17:00 PM	---	<	<	91.6	12960
29 October 1989	5:00 AM	<	<	<	60.3	13500
	17:00 PM	---	<	<	82.4	14040
30 October 1989	5:00 AM	---	<	<	55.1	14580
	17:00 PM	<	<	<	85.3	15120
31 October 1989	5:00 AM	---	<	<	63.0	15660
	17:00 PM	<	<	<	70.5	16200
1 November 1989	5:00 AM	---	<	<	40.0	16740
	17:00 PM	<	<	<	65.9	17280
2 November 1989	5:00 AM	---	<	<	43.0	17820
	17:00 PM	<	<	<	62.4	18360
3 November 1989	5:00 AM	---	<	<	34.5	18900
	17:00 PM	<	<	<	60.8	19440
4 November 1989	5:00 AM	<	<	<	39.1	19980
	17:00 PM	---	<	<	61.3	20520
5 November 1989	5:00 AM	---	<	<	63.0	21060
	17:00 PM	<	<	<	77.1	21600
6 November 1989	5:00 AM	---	<	<	69.4	22140
	17:00 PM	<	<	<	75.8	22680
7 November 1989	5:00 AM	---	<	<	72.8	23220
	17:00 PM	<	<	<	82.1	23760
	23:00 PM	---	<	---	80.8	24030
8 November 1989	5:00 AM	---	<	<	71.6	24300

Table E-6

Field Laboratory Results for 2,6-DNT from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	<	<	<	80.2	24840
9 November 1989	5:00 AM	---	<	<	42.2	25380
	17:00 PM	<	<	<	67.3	25920
10 November 1989	5:00 AM	<	<	<	59.1	26460
	17:00 PM	---	<	<	70.1	27000
11 November 1989	5:00 AM	<	<	<	64.0	27540
	17:00 PM	---	<	<	88.2	28080
12 November 1989	5:00 AM	<	<	<	69.5	28620
	11:00 AM	---	<	---	91.5	28890
	17:00 PM	---	<	<	87.4	29160
13 November 1989	5:00 AM	<	<	<	59.4	29700
	17:00 PM	---	<	<	82.9	30240
14 November 1989	5:00 AM	<	<	<	77.8	30780
	17:00 PM	---	<	<	77.2	31320
15 November 1989	5:00 AM	<	<	<	80.9	31860
	13:00 PM	---	---	NR	83.2	32220
	17:00 PM	---	<	<	58.5	32400
16 November 1989	5:00 AM	<	<	<	47.2	32940
	17:00 PM	<	<	<	40.6	33480
	20:00 PM	---	NR	NR	39.0	33615
17 November 1989	5:00 AM	<	<	<	20.7	34020
	13:00 PM	---	---	NR	54.2	34380
	17:00 PM	---	<	<	49.5	34560
18 November 1989	5:00 AM	<	<	<	37.7	35100
	10:00 AM	---	NR	---	56.1	35325
	13:00 PM	---	NR	---	66.4	35460
	17:00 PM	---	<	<	59.8	35640
19 November 1989	5:00 AM	<	<	<	37.7	36180
	17:00 PM	---	<	<	71.0	36720
	20:00 PM	---	NR	NR	64.7	36855
	21:00 PM	---	NR	---	63.5	36900
	23:00 PM	---	NR	NR	59.0	36990
20 November 1989	5:00 AM	<	<	<	56.7	37260
	8:00 AM	---	NR	---	63.1	37395
	11:00 AM	---	NR	<	75.3	37530
	12:00 PM	---	<	<	78.5	37575
	14:00 PM	---	NR	NR	85.4	37665
	17:00 PM	---	<	<	79.2	37800
	23:00 PM	---	<	<	60.0	38070
21 November 1989	5:00 AM	<	<	<	51.3	38340
	11:00 AM	---	NR	NR	61.2	38610
	17:00 PM	---	<	<	63.2	38880
22 November 1989	5:00 AM	---	<	<	53.2	39420
27 November 1989	17:30 PM	<	<	<	83.9	39443
28 November 1989	5:00 AM	<	<	<	59.8	39960
	17:00 PM	---	<	<	49.3	40500
29 November 1989	5:00 AM	<	<	<	28.6	41040

Table E-6

Field Laboratory Results for 2,6-DNT from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	---	<	<	44.7	41580
30 November 1989	5:00 AM	---	<	<	31.2	42120
	17:00 PM	<	<	<	51.3	42660
1 December 1989	5:00 AM	---	<	<	33.6	43200
	17:00 PM	---	<	<	58.2	43740
2 December 1989	5:00 AM	<	<	<	45.8	44280
	17:00 PM	---	<	<	54.9	44820
3 December 1989	5:00 AM	---	<	<	23.4	45360
	17:00 PM	<	<	<	35.4	45900
4 December 1989	5:00 AM	<	<	<	26.0	46440
	17:00 PM	---	<	<	57.6	46980
5 December 1989	5:00 AM	<	<	<	48.9	47520
	17:00 PM	---	<	<	68.5	48060
6 December 1989	5:00 AM	<	<	<	64.6	48600
	17:00 PM	---	<	<	70.4	49140
7 December 1989	5:00 AM	<	<	<	44.5	49680
	17:00 PM	---	<	<	46.0	50220
8 December 1989	5:00 AM	<	<	<	34.5	50760
	17:00 PM	---	<	<	26.9	51300
9 December 1989	5:00 AM	<	<	<	26.8	51840
	17:00 PM	---	<	<	44.7	52380
10 December 1989	5:00 AM	<	<	<	34.4	52920
	17:00 PM	---	<	<	51.6	53460
11 December 1989	5:00 AM	<	<	<	51.2	54000
	17:00 PM	---	<	<	43.7	54540
12 December 1989	5:00 AM	<	<	<	26.0	55080
	17:00 PM	---	<	<	29.6	55620
13 December 1989	5:00 AM	<	<	<	4.0	56160
	9:00 AM	---	---	<	24.0	
	10:00 AM	---	---	<	32.1	
	13:30 PM	---	---	<	44.9	
	17:00 PM	---	<	<	38.5	
14 December 1989	5:00 AM	<	<	<	21.8	
	17:00 PM	---	<	<	37.6	
15 December 1989	5:00 AM	<	<	<	46.4	
	17:00 PM	---	<	<	13.9	

Notes: --- = No sample taken.
< = Below 2,6-DNT detection limit of 0.55 ug/L.
NR = Not reported.

Table E-7

Field Laboratory Results for 1,3-DNB from Test Three at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm — Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm — Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
16 October 1989	17:00 PM	2.57	<	<	90.8	0
17 October 1989	5:00 AM	---	<	<	83.9	540
	17:00 PM	3.03	<	<	67.7	1080
18 October 1989	5:00 AM	3.37	<	<	56.3	1620
	17:00 PM	---	<	<	46.4	2160
19 October 1989	5:00 AM	---	<	<	43.1	2700
	17:00 PM	2.90	<	<	50.8	3240
20 October 1989	5:00 PM	---	<	<	40.4	3780
	17:00 PM	4.22	<	<	65.7	4320
21 October 1989	5:00 AM	---	<	<	47.1	4860
	17:00 PM	4.08	<	<	83.8	5400
22 October 1989	5:00 AM	---	<	<	58.6	5940
	17:00 PM	3.88	<	<	90.1	6480
23 October 1989	5:00 AM	---	<	<	72.2	7020
	17:00 PM	3.30	<	<	92.7	7560
24 October 1989	5:00 AM	--	<	<	73.8	8100
	17:00 PM	4.19	<	<	94.6	8640
25 October 1989	5:00 AM	---	<	<	56.0	9180
	17:00 PM	4.10	<	<	92.8	9720
26 October 1989	5:00 AM	---	<	<	55.6	10260
	17:00 PM	3.63	<	<	93.3	10800
27 October 1989	5:00 AM	---	<	<	53.4	11340
	17:00 PM	4.10	<	<	91.9	11880
28 October 1989	5:00 AM	3.65	<	<	54.0	12420
	17:00 PM	---	<	<	91.6	12960
29 October 1989	5:00 AM	3.45	<	<	60.3	13500
	17:00 PM	---	<	<	82.4	14040
30 October 1989	5:00 AM	---	<	<	55.1	14580
	17:00 PM	2.52	<	<	85.3	15120
31 October 1989	5:00 AM	---	<	<	63.0	15660
	17:00 PM	4.30	<	<	70.5	16200
1 November 1989	5:00 AM	---	<	<	40.0	16740
	17:00 PM	3.74	<	<	65.9	17280
2 November 1989	5:00 AM	---	<	<	43.0	17820
	17:00 PM	4.21	<	<	62.4	18360
3 November 1989	5:00 AM	---	<	<	34.5	18900
	17:00 PM	4.19	<	<	60.8	19440
4 November 1989	5:00 AM	2.80	<	<	39.1	19980
	17:00 PM	---	<	<	61.3	20520
5 November 1989	5:00 AM	---	<	<	63.0	21060
	17:00 PM	<	<	<	77.1	21600
6 November 1989	5:00 AM	---	<	<	69.4	22140
	17:00 PM	3.49	<	<	75.8	22680
7 November 1989	5:00 AM	---	<	<	72.8	23220
	17:00 PM	4.29	<	<	82.1	23760
	23:00 PM	---	<	---	80.8	24030
8 November 1989	5:00 AM	---	<	<	71.6	24300

Table E-7

Field Laboratory Results for 1,3-DNB from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm — Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm — Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	4.35	<	<	80.2	24840
9 November 1989	5:00 AM	---	<	<	42.2	25380
	17:00 PM	4.30	<	<	67.3	25920
10 November 1989	5:00 AM	4.08	<	<	59.1	26460
	17:00 PM	---	<	<	70.1	27000
11 November 1989	5:00 AM	4.50	<	<	64.0	27540
	17:00 PM	---	<	<	88.2	28080
12 November 1989	5:00 AM	3.97	<	<	69.5	28620
	11:00 AM	---	<	---	91.5	28890
	17:00 PM	---	<	<	87.4	29160
13 November 1989	5:00 AM	4.22	<	<	59.4	29700
	17:00 PM	---	<	<	82.9	30240
14 November 1989	5:00 AM	4.29	<	<	77.8	30780
	17:00 PM	---	<	<	77.2	31320
15 November 1989	5:00 AM	4.54	<	<	80.9	31860
	13:00 PM	---	---	NR	83.2	32220
	17:00 PM	---	<	<	58.5	32400
16 November 1989	5:00 AM	4.71	<	<	47.2	32940
	17:00 PM	4.45	<	<	40.6	33480
	20:00 PM	---	NR	NR	39.0	33615
17 November 1989	5:00 AM	4.35	<	<	20.7	34020
	13:00 PM	---	---	NR	54.2	34380
	17:00 PM	---	<	<	49.5	34560
18 November 1989	5:00 AM	4.28	<	<	37.7	35100
	10:00 AM	---	NR	---	56.1	35325
	13:00 PM	---	NR	---	66.4	35460
	17:00 PM	---	<	<	59.8	35640
19 November 1989	5:00 AM	3.97	<	<	37.7	36180
	17:00 PM	---	<	<	71.0	36720
	20:00 PM	---	NR	NR	64.7	36855
	21:00 PM	---	NR	---	63.5	36900
	23:00 PM	---	NR	NR	59.0	36990
20 November 1989	5:00 AM	4.32	<	<	56.7	37260
	8:00 AM	---	NR	---	63.1	37395
	11:00 AM	---	NR	<	75.3	37530
	12:00 PM	---	<	<	78.5	37575
	14:00 PM	---	NR	NR	85.4	37665
	17:00 PM	---	<	<	79.2	37800
	23:00 PM	---	<	<	60.0	38070
21 November 1989	5:00 AM	10.2	<	<	51.3	38340
	11:00 AM	---	NR	NR	61.2	38610
	17:00 PM	---	<	<	63.2	38880
22 November 1989	5:00 AM	---	<	<	53.2	39420
27 November 1989	17:30 PM	3.57	<	<	83.9	39443
28 November 1989	5:00 AM	5.99	<	<	59.8	39960
	17:00 PM	---	<	<	49.3	40500
29 November 1989	5:00 AM	3.59	<	<	28.6	41040

Table E-7

Field Laboratory Results for 1,3-DNB from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	---	<	<	44.7	41580
30 November 1989	5:00 AM	---	<	<	31.2	42120
	17:00 PM	4.52	<	<	51.3	42660
1 December 1989	5:00 AM	---	<	<	33.6	43200
	17:00 PM	---	<	<	58.2	43740
2 December 1989	5:00 AM	4.02	<	<	45.8	44280
	17:00 PM	---	<	<	54.9	44820
3 December 1989	5:00 AM	---	<	<	23.4	45360
	17:00 PM	3.60	<	<	35.4	45900
4 December 1989	5:00 AM	2.49	<	<	26.0	46440
	17:00 PM	---	<	<	57.6	46980
5 December 1989	5:00 AM	2.94	<	<	48.9	47520
	17:00 PM	---	<	<	68.5	48060
6 December 1989	5:00 AM	<	<	<	64.6	48600
	17:00 PM	---	<	<	70.4	49140
7 December 1989	5:00 AM	<	<	<	44.5	49680
	17:00 PM	---	<	<	46.0	50220
8 December 1989	5:00 AM	<	<	<	34.5	50760
	17:00 PM	---	<	<	26.9	51300
9 December 1989	5:00 AM	13.9	<	<	26.8	51840
	17:00 PM	---	<	<	44.7	52380
10 December 1989	5:00 AM	7.88	<	<	34.4	52920
	17:00 PM	---	<	<	51.6	53460
11 December 1989	5:00 AM	6.19	<	<	51.2	54000
	17:00 PM	---	<	<	43.7	54540
12 December 1989	5:00 AM	4.74	<	<	26.0	55080
	17:00 PM	---	<	<	29.6	55620
13 December 1989	5:00 AM	10.7	<	<	4.0	56160
	9:00 AM	---	---	<	24.0	
	10:00 AM	---	---	<	32.1	
	13:30 PM	---	---	<	44.9	
	17:00 PM	---	<	<	38.5	
14 December 1989	5:00 AM	6.49	<	<	21.8	
	17:00 PM	---	<	<	37.6	
15 December 1989	5:00 AM	3.94	<	<	46.4	
	17:00 PM	---	<	<	13.9	

Notes: --- = No sample taken.
< = Below 1,3-DNB detection limit of 0.61 ug/L.
NR = Not reported.

Table E-8

Field Laboratory Results for 1,3,5-TNB from Test Three at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
16 October 1989	17:00 PM	16.4	<	<	90.8	0
17 October 1989	5:00 AM	---	<	<	83.9	540
	17:00 PM	19.5	<	<	67.7	1080
18 October 1989	5:00 AM	18.5	<	<	56.3	1620
	17:00 PM	---	<	<	46.4	2160
19 October 1989	5:00 AM	---	<	<	43.1	2700
	17:00 PM	25.8	<	<	50.8	3240
20 October 1989	5:00 PM	---	<	<	40.4	3780
	17:00 PM	25.5	<	<	65.7	4320
21 October 1989	5:00 AM	---	<	<	47.1	4860
	17:00 PM	26.9	<	<	83.8	5400
22 October 1989	5:00 AM	---	<	<	58.6	5940
	17:00 PM	25.2	<	<	90.1	6480
23 October 1989	5:00 AM	---	<	<	72.2	7020
	17:00 PM	28.1	<	<	92.7	7560
24 October 1989	5:00 AM	---	<	<	73.8	8100
	17:00 PM	27.5	<	<	94.6	8640
25 October 1989	5:00 AM	---	<	<	56.0	9180
	17:00 PM	27.2	<	<	92.8	9720
26 October 1989	5:00 AM	---	<	<	55.6	10260
	17:00 PM	26.7	<	<	93.3	10800
27 October 1989	5:00 AM	---	<	<	53.4	11340
	17:00 PM	27.0	<	<	91.9	11880
28 October 1989	5:00 AM	25.8	<	<	54.0	12420
	17:00 PM	---	<	<	91.6	12960
29 October 1989	5:00 AM	27.8	<	<	60.3	13500
	17:00 PM	---	<	<	82.4	14040
30 October 1989	5:00 AM	---	<	<	55.1	14580
	17:00 PM	28.4	0.757	1.76	85.3	15120
31 October 1989	5:00 AM	---	<	<	63.0	15660
	17:00 PM	28.3	<	<	70.5	16200
1 November 1989	5:00 AM	---	0.707	<	40.0	16740
	17:00 PM	29.5	0.782	<	65.9	17280
2 November 1989	5:00 AM	---	0.759	<	43.0	17820
	17:00 PM	27.9	0.988	0.686	62.4	18360
3 November 1989	5:00 AM	---	0.940	0.759	34.5	18900
	17:00 PM	27.3	1.18	1.08	60.8	19440
4 November 1989	5:00 AM	23.7	0.952	0.831	39.1	19980
	17:00 PM	---	0.952	1.09	61.3	20520
5 November 1989	5:00 AM	---	0.880	0.952	63.0	21060
	17:00 PM	24.4	0.988	1.04	77.1	21600
6 November 1989	5:00 AM	---	1.31	1.42	69.4	22140
	17:00 PM	31.4	1.71	1.61	75.8	22680
7 November 1989	5:00 AM	---	1.70	1.62	72.8	23220
	17:00 PM	29.6	1.89	1.71	82.1	23760
	23:00 PM	---	1.02	---	80.8	24030
8 November 1989	5:00 AM	---	2.36	2.99	71.6	24300

Table E-8

Field Laboratory Results for 1,3,5-TNB from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	27.2	2.22	2.92	80.2	24840
9 November 1989	5:00 AM	---	2.30	2.52	42.2	25380
	17:00 PM	26.0	2.34	2.68	67.3	25920
10 November 1989	5:00 AM	25.0	2.20	3.08	59.1	26460
	17:00 PM	---	2.13	3.17	70.1	27000
11 November 1989	5:00 AM	28.9	2.35	3.11	64.0	27540
	17:00 PM	---	2.38	3.46	88.2	28080
12 November 1989	5:00 AM	26.7	2.36	3.13	69.5	28620
	11:00 AM	---	2.44	---	91.5	28890
	17:00 PM	---	2.46	3.48	87.4	29160
13 November 1989	5:00 AM	28.2	2.51	3.62	59.4	29700
	17:00 PM	---	2.63	3.86	82.9	30240
14 November 1989	5:00 AM	26.8	2.62	3.49	77.8	30780
	17:00 PM	---	3.11	3.80	77.2	31320
15 November 1989	5:00 AM	27.7	3.25	3.92	80.9	31860
	13:00 PM	---	---	NR	83.2	32220
	17:00 PM	---	3.16	4.87	58.5	32400
16 November 1989	5:00 AM	27.5	3.17	3.85	47.2	32940
	17:00 PM	27.2	3.51	4.02	40.6	33480
	20:00 PM	---	NR	NR	39.0	33615
17 November 1989	5:00 AM	28.7	3.84	4.82	20.7	34020
	13:00 PM	---	---	NR	54.2	34380
	17:00 PM	---	4.15	4.99	49.5	34560
18 November 1989	5:00 AM	25.5	4.18	5.08	37.7	35100
	10:00 AM	---	NR	---	56.1	35325
	13:00 PM	---	NR	---	66.4	35460
	17:00 PM	---	4.46	5.39	59.8	35640
19 November 1989	5:00 AM	29.1	4.59	5.64	37.7	36180
	17:00 PM	---	4.40	5.64	71.0	36720
	20:00 PM	---	NR	NR	64.7	36855
	21:00 PM	---	NR	---	63.5	36900
	23:00 PM	---	NR	NR	59.0	36990
20 November 1989	5:00 AM	27.6	4.75	5.79	56.7	37260
	8:00 AM	---	NR	---	63.1	37395
	11:00 AM	---	NR	6.09	75.3	37530
	12:00 PM	---	5.65	7.95	78.5	37575
	14:00 PM	---	NR	NR	85.4	37665
	17:00 PM	---	5.52	7.36	79.2	37800
	23:00 PM	---	5.11	7.60	60.0	38070
21 November 1989	5:00 AM	28.8	4.93	8.11	51.3	38340
	11:00 AM	---	NR	NR	61.2	38610
	17:00 PM	---	4.54	8.08	63.2	38880
22 November 1989	5:00 AM	---	6.30	8.12	53.2	39420
27 November 1989	17:30 PM	23.0	4.01	4.77	83.9	39443
28 November 1989	5:00 AM	25.0	4.35	5.60	59.8	39960
	17:00 PM	---	4.60	6.85	49.3	40500
29 November 1989	5:00 AM	27.7	5.25	7.38	28.6	41040

Table E-8

Field Laboratory Results for 1,3,5-TNB from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm: Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm: Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	---	5.33	7.99	44.7	41580
30 November 1989	5:00 AM	---	5.76	8.58	31.2	42120
	17:00 PM	27.3	6.49	8.32	51.3	42660
1 December 1989	5:00 AM	---	6.38	7.85	33.6	43200
	17:00 PM	---	5.94	7.83	58.2	43740
2 December 1989	5:00 AM	25.8	6.49	7.78	45.8	44280
	17:00 PM	---	6.64	8.34	54.9	44820
3 December 1989	5:00 AM	---	6.49	8.36	23.4	45360
	17:00 PM	26.9	7.29	9.63	35.4	45900
4 December 1989	5:00 AM	28.4	7.80	9.58	26.0	46440
	17:00 PM	---	7.79	9.54	57.6	46980
5 December 1989	5:00 AM	27.7	8.59	9.89	48.9	47520
	17:00 PM	---	8.25	9.81	68.5	48060
6 December 1989	5:00 AM	29.5	8.42	9.50	64.6	48600
	17:00 PM	---	7.94	9.44	70.4	49140
7 December 1989	5:00 AM	24.5	9.13	8.25	44.5	49680
	17:00 PM	---	6.78	9.12	46.0	50220
8 December 1989	5:00 AM	18.4	5.35	7.93	34.5	50760
	17:00 PM	---	4.95	7.40	26.9	51300
9 December 1989	5:00 AM	26.3	8.56	11.7	26.8	51840
	17:00 PM	---	9.28	12.5	44.7	52380
10 December 1989	5:00 AM	23.1	8.87	11.7	34.4	52920
	17:00 PM	---	7.95	11.6	51.6	53460
11 December 1989	5:00 AM	25.9	8.73	12.5	51.2	54000
	17:00 PM	---	8.92	12.6	43.7	54540
12 December 1989	5:00 AM	31.0	11.1	16.6	26.0	55080
	17:00 PM	---	11.2	15.8	29.6	55620
13 December 1989	5:00 AM	33.7	8.59	16.2	4.0	56160
	9:00 AM	---	---	18.4	24.0	
	10:00 AM	---	---	18.6	32.1	
	13:30 PM	---	---	24.1	44.9	
	17:00 PM	---	9.37	22.8	38.5	
14 December 1989	5:00 AM	28.4	10.9	15.6	21.8	
	17:00 PM	---	10.5	16.0	37.6	
15 December 1989	5:00 AM	26.6	10.8	15.7	46.4	
	17:00 PM	---	9.91	14.9	13.9	

Notes: --- = No sample taken.
< = Below 1,3,5-TNB detection limit of 0.56 ug/L.
NR = Not reported.

Table E-9

Field Laboratory Results for NB from Test Three at MAAP

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm — Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm — Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
16 October 1989	17:00 PM	<	<	<	90.8	0
17 October 1989	5:00 AM	---	<	<	83.9	540
	17:00 PM	<	<	<	67.7	1080
18 October 1989	5:00 AM	<	<	<	56.3	1620
	17:00 PM	---	<	<	46.4	2160
19 October 1989	5:00 AM	---	<	<	43.1	2700
	17:00 PM	<	<	<	50.8	3240
20 October 1989	5:00 PM	---	<	<	40.4	3780
	17:00 PM	<	<	<	65.7	4320
21 October 1989	5:00 AM	---	<	<	47.1	4860
	17:00 PM	<	<	<	83.8	5400
22 October 1989	5:00 AM	---	<	<	58.6	5940
	17:00 PM	<	<	<	90.1	6480
23 October 1989	5:00 AM	---	<	<	72.2	7020
	17:00 PM	<	<	<	92.7	7560
24 October 1989	5:00 AM	--	<	<	73.8	8100
	17:00 PM	<	<	<	94.6	8640
25 October 1989	5:00 AM	---	<	<	56.0	9180
	17:00 PM	<	<	<	92.8	9720
26 October 1989	5:00 AM	---	<	<	55.6	10260
	17:00 PM	<	<	<	93.3	10800
27 October 1989	5:00 AM	---	<	<	53.4	11340
	17:00 PM	<	<	<	91.9	11880
28 October 1989	5:00 AM	<	<	<	54.0	12420
	17:00 PM	---	<	<	91.6	12960
29 October 1989	5:00 AM	<	<	<	60.3	13500
	17:00 PM	---	<	<	82.4	14040
30 October 1989	5:00 AM	---	<	<	55.1	14580
	17:00 PM	<	<	<	85.3	15120
31 October 1989	5:00 AM	---	<	<	63.0	15660
	17:00 PM	<	<	<	70.5	16200
1 November 1989	5:00 AM	---	<	<	40.0	16740
	17:00 PM	<	<	<	65.9	17280
2 November 1989	5:00 AM	---	<	<	43.0	17820
	17:00 PM	<	<	<	62.4	18360
3 November 1989	5:00 AM	---	<	<	34.5	18900
	17:00 PM	<	<	<	60.8	19440
4 November 1989	5:00 AM	<	<	<	39.1	19980
	17:00 PM	---	<	<	61.3	20520
5 November 1989	5:00 AM	---	<	<	63.0	21060
	17:00 PM	<	<	<	77.1	21600
6 November 1989	5:00 AM	---	<	<	69.4	22140
	17:00 PM	<	<	<	75.8	22680
7 November 1989	5:00 AM	---	<	<	72.8	23220
	17:00 PM	<	<	<	82.1	23760
	23:00 PM	---	<	---	80.8	24030
8 November 1989	5:00 AM	---	<	<	71.6	24300

Table E-9

Field Laboratory Results for NB from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	<	<	<	80.2	24840
9 November 1989	5:00 AM	---	<	<	42.2	25380
	17:00 PM	<	<	<	67.3	25920
10 November 1989	5:00 AM	<	<	<	59.1	26460
	17:00 PM	---	<	<	70.1	27000
11 November 1989	5:00 AM	<	<	<	64.0	27540
	17:00 PM	---	<	<	88.2	28080
12 November 1989	5:00 AM	<	<	<	69.5	28620
	11:00 AM	---	<	---	91.5	28890
	17:00 PM	---	<	<	87.4	29160
13 November 1989	5:00 AM	<	<	<	59.4	29700
	17:00 PM	---	<	<	82.9	30240
14 November 1989	5:00 AM	<	<	<	77.8	30780
	17:00 PM	---	<	<	77.2	31320
15 November 1989	5:00 AM	<	<	<	80.9	31860
	13:00 PM	---	---	NR	83.2	32220
	17:00 PM	---	<	<	58.5	32400
16 November 1989	5:00 AM	<	<	<	47.2	32940
	17:00 PM	<	<	<	40.6	33480
	20:00 PM	---	NR	NR	39.0	33615
17 November 1989	5:00 AM	<	<	<	20.7	34020
	13:00 PM	---	---	NR	54.2	34380
	17:00 PM	---	<	<	49.5	34560
18 November 1989	5:00 AM	<	<	<	37.7	35100
	10:00 AM	---	NR	---	56.1	35325
	13:00 PM	---	NR	---	66.4	35460
	17:00 PM	---	<	<	59.8	35640
19 November 1989	5:00 AM	<	<	<	37.7	36180
	17:00 PM	---	<	<	71.0	36720
	20:00 PM	---	NR	NR	64.7	36855
	21:00 PM	---	NR	---	63.5	36900
	23:00 PM	---	NR	NR	59.0	36990
20 November 1989	5:00 AM	<	<	<	56.7	37260
	8:00 AM	---	NR	---	63.1	37395
	11:00 AM	---	NR	<	75.3	37530
	12:00 PM	---	<	<	78.5	37575
	14:00 PM	---	NR	NR	85.4	37665
	17:00 PM	---	<	<	79.2	37800
	23:00 PM	---	<	<	60.0	38070
21 November 1989	5:00 AM	<	<	<	51.3	38340
	11:00 AM	---	NR	NR	61.2	38610
	17:00 PM	---	<	<	63.2	38880
22 November 1989	5:00 AM	---	<	<	53.2	39420
27 November 1989	17:30 PM	<	<	<	83.9	39443
28 November 1989	5:00 AM	<	<	<	59.8	39960
	17:00 PM	---	<	<	49.3	40500
29 November 1989	5:00 AM	<	<	<	28.6	41040

Table E-9

Field Laboratory Results for NB from Test Three at MAAP (continued)

Date	Time	GAC Column Influent Concentration (ug/L)	Atochem, Inc. GAC 830 0.75 gpm — Column A1 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm — Column B1 Effluent Concentration (ug/L)	Influent Water Temperature (deg F)	Column Throughput Volume (gal)
	17:00 PM	---	<	<	44.7	41580
30 November 1989	5:00 AM	---	<	<	31.2	42120
	17:00 PM	<	<	<	51.3	42660
1 December 1989	5:00 AM	---	<	<	33.6	43200
	17:00 PM	---	<	<	58.2	43740
2 December 1989	5:00 AM	<	<	<	45.8	44280
	17:00 PM	---	<	<	54.9	44820
3 December 1989	5:00 AM	---	<	<	23.4	45360
	17:00 PM	<	<	<	35.4	45900
4 December 1989	5:00 AM	<	<	<	26.0	46440
	17:00 PM	---	<	<	57.6	46980
5 December 1989	5:00 AM	<	<	<	48.9	47520
	17:00 PM	---	<	<	68.5	48060
6 December 1989	5:00 AM	<	<	<	64.6	48600
	17:00 PM	---	<	<	70.4	49140
7 December 1989	5:00 AM	<	<	<	44.5	49680
	17:00 PM	---	<	<	46.0	50220
8 December 1989	5:00 AM	<	<	<	34.5	50760
	17:00 PM	---	<	<	26.9	51300
9 December 1989	5:00 AM	<	<	<	26.8	51840
	17:00 PM	---	<	<	44.7	52380
10 December 1989	5:00 AM	<	<	<	34.4	52920
	17:00 PM	---	<	<	51.6	53460
11 December 1989	5:00 AM	<	<	<	51.2	54000
	17:00 PM	---	<	<	43.7	54540
12 December 1989	5:00 AM	<	<	<	26.0	55080
	17:00 PM	---	<	<	29.6	55620
13 December 1989	5:00 AM	<	<	<	4.0	56160
	9:00 AM	---	---	<	24.0	
	10:00 AM	---	---	<	32.1	
	13:30 PM	---	---	<	44.9	
	17:00 PM	---	<	<	38.5	
14 December 1989	5:00 AM	<	<	<	21.8	
	17:00 PM	---	<	<	37.6	
15 December 1989	5:00 AM	<	<	<	46.4	
	17:00 PM	---	<	<	13.9	

Notes: --- = No sample taken.
< = Below NB detection limit of 1.13 ug/L.
NR = Not reported.

Table E-10

Field Laboratory Results for TNT from Test Three at MAAP - Columns A2 and B2

Date	Time	Atochem, Inc. GAC 830 0.75 gpm Column A2 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B2 Effluent Concentration (ug/L)
10 November 1989	17:00 PM	<	<
11 November 1989	5:00 AM	<	<
	17:00 PM	<	<
12 November 1989	5:00 AM	<	<
	17:00 PM	<	<
13 November 1989	5:00 AM	<	<
14 November 1989	5:00 AM	<	<
15 November 1989	17:00 PM	<	<
16 November 1989	17:00 PM	<	<
17 November 1989	17:00 PM	<	<
18 November 1989	17:00 PM	<	<
19 November 1989	17:00 PM	<	<
20 November 1989	17:00 PM	<	<
21 November 1989	17:00 PM	<	<
27 November 1989	17:30 PM	<	<
28 November 1989	17:00 PM	<	<
29 November 1989	17:00 PM	<	<
30 November 1989	17:00 PM	<	<
1 December 1989	17:00 PM	<	<
2 December 1989	17:00 PM	<	<
3 December 1989	17:00 PM	<	<
4 December 1989	17:00 PM	<	<
5 December 1989	17:00 PM	<	<
6 December 1989	17:00 PM	<	<
7 December 1989	17:00 PM	<	<
8 December 1989	17:00 PM	<	<
9 December 1989	17:00 PM	<	<
10 December 1989	17:00 PM	<	<
11 December 1989	17:00 PM	<	<
12 December 1989	17:00 PM	<	<
13 December 1989	17:00 PM	<	41.0
14 December 1989	17:00 PM	<	<
15 December 1989	17:00 PM	<	<

Note: < = Below TNT detection limit of 0.78 ug/L.

Table E-11

Field Laboratory Results for RDX from Test Three at MAAP - Columns A2 and B2

Date	Time	Atochem, Inc. GAC 830 0.75 gpm Column A2 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B2 Effluent Concentration (ug/L)
10 November 1989	17:00 PM	2.3	1.38
11 November 1989	5:00 AM	1.76	1.07
	17:00 PM	1.74	<
12 November 1989	5:00 AM	<	<
	17:00 PM	<	<
13 November 1989	5:00 AM	<	1.54
14 November 1989	5:00 AM	<	<
15 November 1989	17:00 PM	2.28	1.21
16 November 1989	17:00 PM	2.48	0.91
17 November 1989	17:00 PM	3.24	0.94
18 November 1989	17:00 PM	3.53	1.36
19 November 1989	17:00 PM	2.93	<
20 November 1989	17:00 PM	18.2	10.6
21 November 1989	17:00 PM	16.6	13.4
27 November 1989	17:30 PM	11.4	8.41
28 November 1989	17:00 PM	12.0	8.92
29 November 1989	17:00 PM	9.21	7.04
30 November 1989	17:00 PM	11.7	7.31
1 December 1989	17:00 PM	11.3	7.80
2 December 1989	17:00 PM	13.5	9.39
3 December 1989	17:00 PM	14.3	9.49
4 December 1989	17:00 PM	18.1	11.9
5 December 1989	17:00 PM	20.8	13.7
6 December 1989	17:00 PM	21.8	13.0
7 December 1989	17:00 PM	37.5	26.2
8 December 1989	17:00 PM	25.0	20.9
9 December 1989	17:00 PM	31.1	28.2
10 December 1989	17:00 PM	29.2	30.0
11 December 1989	17:00 PM	36.3	39.4
12 December 1989	17:00 PM	35.4	42.2
13 December 1989	17:00 PM	25.9	94.0
14 December 1989	17:00 PM	33.9	48.9
15 December 1989	17:00 PM	26.9	44.7

Note: < = Below RDX detection limit of 0.63 ug/L.

Table E-12

Field Laboratory Results for HMX from Test Three at MAAP - Columns A2 and B2

Date	Time	Atochem, Inc. GAC 830 0.75 gpm Column A2 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B2 Effluent Concentration (ug/L)
10 November 1989	17:00 PM	<	<
11 November 1989	5:00 AM	<	<
	17:00 PM	<	<
12 November 1989	5:00 AM	<	<
	17:00 PM	<	<
13 November 1989	5:00 AM	<	<
14 November 1989	5:00 AM	<	<
15 November 1989	17:00 PM	<	<
16 November 1989	17:00 PM	<	<
17 November 1989	17:00 PM	<	<
18 November 1989	17:00 PM	<	<
19 November 1989	17:00 PM	<	<
20 November 1989	17:00 PM	<	<
21 November 1989	17:00 PM	<	<
27 November 1989	17:30 PM	<	<
28 November 1989	17:00 PM	<	<
29 November 1989	17:00 PM	<	<
30 November 1989	17:00 PM	<	<
1 December 1989	17:00 PM	<	<
2 December 1989	17:00 PM	<	<
3 December 1989	17:00 PM	<	<
4 December 1989	17:00 PM	<	<
5 December 1989	17:00 PM	<	<
6 December 1989	17:00 PM	<	<
7 December 1989	17:00 PM	<	<
8 December 1989	17:00 PM	<	<
9 December 1989	17:00 PM	<	<
10 December 1989	17:00 PM	<	<
11 December 1989	17:00 PM	<	<
12 December 1989	17:00 PM	<	<
13 December 1989	17:00 PM	<	<
14 December 1989	17:00 PM	<	<
15 December 1989	17:00 PM	<	<

Note: < = Below HMX detection limit of 1.3 ug/L.

Table E-13

Field Laboratory Results for Tetryl from Test Three at MAAP - Columns A2 and B2

Date	Time	Atochem, Inc. GAC 830 0.75 gpm Column A2 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B2 Effluent Concentration (ug/L)
10 November 1989	17:00 PM	<	<
11 November 1989	5:00 AM	<	<
	17:00 PM	<	<
12 November 1989	5:00 AM	<	<
	17:00 PM	<	<
13 November 1989	5:00 AM	<	<
14 November 1989	5:00 AM	<	<
15 November 1989	17:00 PM	<	<
16 November 1989	17:00 PM	<	<
17 November 1989	17:00 PM	<	<
18 November 1989	17:00 PM	<	<
19 November 1989	17:00 PM	<	<
20 November 1989	17:00 PM	<	<
21 November 1989	17:00 PM	<	<
27 November 1989	17:30 PM	<	<
28 November 1989	17:00 PM	<	<
29 November 1989	17:00 PM	<	<
30 November 1989	17:00 PM	<	<
1 December 1989	17:00 PM	<	<
2 December 1989	17:00 PM	<	<
3 December 1989	17:00 PM	<	<
4 December 1989	17:00 PM	<	<
5 December 1989	17:00 PM	<	<
6 December 1989	17:00 PM	<	<
7 December 1989	17:00 PM	<	<
8 December 1989	17:00 PM	<	<
9 December 1989	17:00 PM	<	<
10 December 1989	17:00 PM	<	<
11 December 1989	17:00 PM	<	<
12 December 1989	17:00 PM	<	<
13 December 1989	17:00 PM	<	<
14 December 1989	17:00 PM	<	<
15 December 1989	17:00 PM	<	<

Note: < = Below Tetryl detection limit of 0.66 ug/L.

Table E-14

Field Laboratory Results for 2,4-DNT from Test Three at MAAP - Columns A2 and B2

Date	Time	Atochem, Inc. GAC 830 Item No. 03090 0.75 gpm Column A2 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B2 Effluent Concentration (ug/L)
10 November 1989	17:00 PM	<	<
11 November 1989	5:00 AM	<	<
	17:00 PM	<	<
12 November 1989	5:00 AM	<	<
	17:00 PM	<	<
13 November 1989	5:00 AM	<	<
14 November 1989	5:00 AM	<	<
15 November 1989	17:00 PM	<	<
16 November 1989	17:00 PM	<	<
17 November 1989	17:00 PM	<	<
18 November 1989	17:00 PM	<	<
19 November 1989	17:00 PM	<	<
20 November 1989	17:00 PM	<	<
21 November 1989	17:00 PM	<	<
27 November 1989	17:30 PM	<	<
28 November 1989	17:00 PM	<	<
29 November 1989	17:00 PM	<	<
30 November 1989	17:00 PM	<	<
1 December 1989	17:00 PM	<	<
2 December 1989	17:00 PM	<	<
3 December 1989	17:00 PM	<	<
4 December 1989	17:00 PM	<	<
5 December 1989	17:00 PM	<	<
6 December 1989	17:00 PM	<	<
7 December 1989	17:00 PM	<	<
8 December 1989	17:00 PM	<	<
9 December 1989	17:00 PM	<	<
10 December 1989	17:00 PM	<	<
11 December 1989	17:00 PM	<	<
12 December 1989	17:00 PM	<	<
13 December 1989	17:00 PM	<	<
14 December 1989	17:00 PM	<	<
15 December 1989	17:00 PM	<	<

Note: < = Below 2,4-DNT detection limit of 0.60 ug/L.

Table E-15

Field Laboratory Results for 2,6-DNT from Test Three at MAAP - Columns A2 and B2

Date	Time	Atochem, Inc. GAC 830 Item No. 03090 0.75 gpm Column A2 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B2 Effluent Concentration (ug/L)
10 November 1989	17:00 PM	<	<
11 November 1989	5:00 AM	<	<
	17:00 PM	<	<
12 November 1989	5:00 AM	<	<
	17:00 PM	<	<
13 November 1989	5:00 AM	<	<
14 November 1989	5:00 AM	<	<
15 November 1989	17:00 PM	<	<
16 November 1989	17:00 PM	<	<
17 November 1989	17:00 PM	<	<
18 November 1989	17:00 PM	<	<
19 November 1989	17:00 PM	<	<
20 November 1989	17:00 PM	<	<
21 November 1989	17:00 PM	<	<
27 November 1989	17:30 PM	<	<
28 November 1989	17:00 PM	<	<
29 November 1989	17:00 PM	<	<
30 November 1989	17:00 PM	<	<
1 December 1989	17:00 PM	<	<
2 December 1989	17:00 PM	<	<
3 December 1989	17:00 PM	<	<
4 December 1989	17:00 PM	<	<
5 December 1989	17:00 PM	<	<
6 December 1989	17:00 PM	<	<
7 December 1989	17:00 PM	<	<
8 December 1989	17:00 PM	<	<
9 December 1989	17:00 PM	<	<
10 December 1989	17:00 PM	<	<
11 December 1989	17:00 PM	<	<
12 December 1989	17:00 PM	<	<
13 December 1989	17:00 PM	<	<
14 December 1989	17:00 PM	<	<
15 December 1989	17:00 PM	<	<

Note: < = Below 2,6-DNT detection limit of 0.55 ug/L.

Table E-16

Field Laboratory Results for 1,3-DNB from Test Three at MAAP - Columns A2 and B2

Date	Time	Atochem, Inc. GAC 830 Item No. 03090 0.75 gpm Column A2 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B2 Effluent Concentration (ug/L)
10 November 1989	17:00 PM	<	<
11 November 1989	5:00 AM	<	<
	17:00 PM	<	<
12 November 1989	5:00 AM	<	<
	17:00 PM	<	<
13 November 1989	5:00 AM	<	<
14 November 1989	5:00 AM	<	<
15 November 1989	17:00 PM	<	<
16 November 1989	17:00 PM	<	<
17 November 1989	17:00 PM	<	<
18 November 1989	17:00 PM	<	<
19 November 1989	17:00 PM	<	<
20 November 1989	17:00 PM	<	<
21 November 1989	17:00 PM	<	<
27 November 1989	17:30 PM	<	<
28 November 1989	17:00 PM	<	<
29 November 1989	17:00 PM	<	<
30 November 1989	17:00 PM	<	<
1 December 1989	17:00 PM	<	<
2 December 1989	17:00 PM	<	<
3 December 1989	17:00 PM	<	<
4 December 1989	17:00 PM	<	<
5 December 1989	17:00 PM	<	<
6 December 1989	17:00 PM	<	<
7 December 1989	17:00 PM	<	<
8 December 1989	17:00 PM	<	<
9 December 1989	17:00 PM	<	<
10 December 1989	17:00 PM	<	<
11 December 1989	17:00 PM	<	<
12 December 1989	17:00 PM	<	<
13 December 1989	17:00 PM	<	<
14 December 1989	17:00 PM	<	<
15 December 1989	17:00 PM	<	<

Note: < = Below 1,3-DNB detection limit of 0.61 ug/L.

Table E-17

Field Laboratory Results for 1,3,5-TNB from Test Three at MAAP - Columns A2 and B2

Date	Time	Atochem, Inc. GAC 830 Item No. 03090 0.75 gpm Column A2 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B2 Effluent Concentration (ug/L)
10 November 1989	17:00 PM	<	<
11 November 1989	5:00 AM	<	<
	17:00 PM	<	<
12 November 1989	5:00 AM	<	<
	17:00 PM	<	<
13 November 1989	5:00 AM	<	<
14 November 1989	5:00 AM	<	<
15 November 1989	17:00 PM	<	<
16 November 1989	17:00 PM	<	<
17 November 1989	17:00 PM	<	<
18 November 1989	17:00 PM	<	<
19 November 1989	17:00 PM	<	<
20 November 1989	17:00 PM	<	<
21 November 1989	17:00 PM	<	<
27 November 1989	17:30 PM	<	<
28 November 1989	17:00 PM	<	<
29 November 1989	17:00 PM	<	<
30 November 1989	17:00 PM	<	<
1 December 1989	17:00 PM	<	<
2 December 1989	17:00 PM	<	<
3 December 1989	17:00 PM	<	<
4 December 1989	17:00 PM	<	<
5 December 1989	17:00 PM	<	<
6 December 1989	17:00 PM	<	<
7 December 1989	17:00 PM	<	<
8 December 1989	17:00 PM	<	<
9 December 1989	17:00 PM	<	<
10 December 1989	17:00 PM	<	<
11 December 1989	17:00 PM	<	<
12 December 1989	17:00 PM	<	<
13 December 1989	17:00 PM	<	<
14 December 1989	17:00 PM	<	<
15 December 1989	17:00 PM	<	<

Note: < = Below 1,3,5-TNB detection limit of 0.56 ug/L.

Table E-18

Field Laboratory Results for NB from Test Three at MAAP - Columns A2 and B2

Date	Time	Atochem, Inc. GAC 830 Item No. 03090 0.75 gpm Column A2 Effluent Concentration (ug/L)	Calgon Filtrasorb 300 0.75 gpm Column B2 Effluent Concentration (ug/L)
10 November 1989	17:00 PM	<	<
11 November 1989	5:00 AM	<	<
	17:00 PM	<	<
12 November 1989	5:00 AM	<	<
	17:00 PM	<	<
13 November 1989	5:00 AM	<	<
14 November 1989	5:00 AM	<	<
15 November 1989	17:00 PM	<	<
16 November 1989	17:00 PM	<	<
17 November 1989	17:00 PM	<	<
18 November 1989	17:00 PM	<	<
19 November 1989	17:00 PM	<	<
20 November 1989	17:00 PM	<	<
21 November 1989	17:00 PM	<	<
27 November 1989	17:30 PM	<	<
28 November 1989	17:00 PM	<	<
29 November 1989	17:00 PM	<	<
30 November 1989	17:00 PM	<	<
1 December 1989	17:00 PM	<	<
2 December 1989	17:00 PM	<	<
3 December 1989	17:00 PM	<	<
4 December 1989	17:00 PM	<	<
5 December 1989	17:00 PM	<	<
6 December 1989	17:00 PM	<	<
7 December 1989	17:00 PM	<	<
8 December 1989	17:00 PM	<	<
9 December 1989	17:00 PM	<	<
10 December 1989	17:00 PM	<	<
11 December 1989	17:00 PM	<	<
12 December 1989	17:00 PM	<	<
13 December 1989	17:00 PM	<	<
14 December 1989	17:00 PM	<	<
15 December 1989	17:00 PM	<	<

Note: < = Below NB detection limit of 1.13 ug/L.

APPENDIX F

ANALYSIS OF SPENT CARBON FROM THE K-51 BUILDING PILOT PLANT

MARTIN MARIETTA

MARTIN MARIETTA ORDNANCE SYSTEMS, INC.
MILAN ARMY AMMUNITION PLANT
MILAN, TENNESSEE 38358

MASTER - ANALYTICAL RESULT SHEET

ANALYST CVA TITLE Analysis of Spent Carbon From The K-51 Bldg. Pilot Plant DATE 1-11-90

Five (5) Samples of Spent Carbon from the K-51 pilot plant for the USATHAMA ground water treatment study were received by the Environmental Laboratory for nitrobody analysis. The samples were extracted with acetonitrile overnight and analysed with an LDC-Milton Roy Liquid Chromatograph. The results are as follows in ppm:

Sample I.D.	Sample Date	HMX	RDX	1,3,5-TNB	2,4,6-TNT	2,6 DNT	2,4-DNT	Total Nitrobodies (ppm)
No. 679 Cont. #4	9-19-89	ND	53.95	2.15	ND	ND	ND	56.1
A1	12-15-89	8.32	2027.0	393.4	15.02	3.28	ND	2447
A2	12-15-89	3.42	1007.0	30.31	ND	.86	ND	1042
B1	12-15-89	4.07	1737	197.1	7.00	1.74	ND	1947
B2	12-15-89	1.41	873.4	28.05	.85	.18	ND	904

cc: M. Harris
B. Blaylock
File

E-1

MM-477-EL37

SIGNED BY James K. Butler 1/11/90
THOS. A. ALLEN