

US Army Corps
of Engineers®
Engineer Research and
Development Center

Range Characterization Studies at Donnelly Training Area, Alaska: 2001 and 2002

Marianne E. Walsh, Charles M. Collins, Alan D. Hewitt,
Michael R. Walsh, Thomas F. Jenkins, Jeffrey Stark,
Arthur Gelvin, Thomas S. Douglas, Nancy Perron,
Dennis Lambert, Ronald Bailey, and Karen Myers

February 2004



Front cover: The 4/11 Field Artillery preparing to fire an M119A 105-mm howitzer.

ERDC/CRREL TR-04-3
February 2004

Range Characterization Studies at Donnelly Training Area, Alaska: 2001 and 2002

Marianne E. Walsh, Charles M. Collins, Alan D. Hewitt,
Michael R. Walsh, Thomas F. Jenkins, Jeffrey Stark,
Arthur Gelvin, Thomas S. Douglas, Nancy Perron,
Dennis Lambert, Ronald Bailey, and Karen Myers

Approved for public release; distribution is unlimited.

Prepared for U.S. ARMY ALASKA and
U.S. ARMY STRATEGIC ENVIRONMENTAL RESEARCH AND DEVELOPMENT PROGRAM

ABSTRACT

The U.S. Army Alaska seeks to conserve and protect natural resources on lands used for combat training exercises. Some of these exercises require live fire of ordnance containing high explosives. One aspect of managing the ranges so as to mitigate the environmental consequences of training is to identify the location, extent, and potential migration of munitions residues in soils, surface waters, and groundwater. This report summarizes analytical results for soil samples collected from firing points and some impact areas at the Donnelly Training Area near Delta Junction, Alaska. Explosives residues are for the most part undetectable or at very low concentrations (parts per billion) in the soils of impact areas. The exceptions are soils near or under partial ordnance detonations, targets, and rocket motor debris. We found high concentrations (parts per thousand) of TNT in soils next to partially detonated 500-lb and 2000-lb bombs; moderate concentrations (parts per million) of RDX and TNT around targets; and moderate concentrations (parts per million) of NG under rocket motor debris. At firing points used for 105-mm howitzers, 2,4-DNT is detectable in surface soils at parts-per-million concentrations. This analyte is associated with burned and unburned fibers of propellant that are sprayed to distances of at least 100 m from the muzzle. The highest concentrations of 2,4-DNT were in soils where excess propellant is burned for disposal. Because of the very low soil clean-up levels listed by the State of Alaska for this compound, appropriate and reproducible laboratory and field sampling procedures need to be developed to monitor this analyte.

DISCLAIMER: The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. All product names and trademarks cited are the property of their respective owners. The findings of this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.
DESTROY THIS REPORT WHEN IT IS NO LONGER NEEDED. DO NOT RETURN TO THE ORIGINATOR.

CONTENTS

PREFACE	vi
1 INTRODUCTION	1
2 OBJECTIVES	3
3 PHYSICAL SETTING	4
4 METHODS	12
Field Sample Collection	12
Lab Processing of Samples	16
Analytical Methods Used by CRREL	20
Collection of Propellant Residue from a Snow-covered Firing Point	20
5 RESULTS	21
Delta Creek Impact Area	22
Georgia Island	22
West Side of Washington Impact Area	22
Firing Points 2001	22
Firing Points 2002	27
Collection of Propellant Residue from a Snow-covered Firing Point	36
6 DISCUSSION	38
Explosives Residues on Impact Areas	38
Propellant Residues at Firing Points	38
7 CONCLUSIONS	40
REFERENCES	41
APPENDIX A. ANALYTICAL RESULTS FROM 2001	44

ILLUSTRATIONS

Figure 1. Installation maps and orthophotos	4
Figure 2. Aerial and near-ground views of a target array located 2 km downstream of Delta Creek Impact Area	8
Figure 3. Aerial view of Simpsonville MOU/CALFEX	9
Figure 4. Aerial view of Georgia Island, showing the old target berm	9

Figure 5. Firing points used for indirect fire into Mississippi and Washington Impact Areas.....	10
Figure 6. Ground view from Lampkin Range Firing Point	11
Figure 7. Locating howitzer firing positions in July 2001	14
Figure 8. FP Sally in July 2001	15
Figure 9. Collecting surface samples at firing point Sally	16
Figure 10. Sampling scheme used for characterization of propellant residues around a howitzer firing position	17
Figure 11. Firing position at Bo-Whale from which samples were collected for homogenization studies	19
Figure 12. Unground and ground >2-mm fractions of a Bo-Whale sample	19
Figure 13. Winter firing of an M119A1 105-mm howitzer	21
Figure 14. Fibrous residue deposited on the snow surface from the firing of a 105-mm howitzer	21
Figure 15. Typical chromatogram obtained by GC- μ ECD of an extract of a soil collected from a 105-mm howitzer firing point	23
Figure 16. Probability plot of 2,4-DNT concentrations at FP Mark in June and July 2002	30
Figure 17. Probability plot of 2,4-DNT concentrations at FP Mark, Sally, Audrey, and Bo-Whale in June 2002	35

TABLES

Table 1. Ordnance used by the Army at the impact areas and firing points that we sampled	6
Table 2. Concentrations of 2,4-DNT in laboratory subsamples of the >2-mm and <2-mm fractions with and without machine grinding	24
Table 3. Subsampling heterogeneity in two machine ground samples that were split by a rotary divider	26
Table 4. Mean concentration estimates of the >2-mm and <2-mm fractions with and without machine grinding in field duplicate multi-increment samples at FP Bo-Whale	27
Table 5. Concentrations of propellant residues found in subsurface samples collected from FP Bo-Whale and Big Lake	28
Table 6. Concentrations of 2,4-DNT determined in composite surface soil samples collected around a 105-mm howitzer within one week and five weeks of firing	29
Table 7. Concentrations of 2,4-DNT determined in composite surface and subsurface soil samples collected near a 105-mm howitzer within five weeks after firing	31

Table 8. Concentrations of 2,4-DNT detected at FP Mark in June 2002	31
Table 9. Concentrations of 2,4-DNT detected at FP Sally in June 2002	32
Table 10. Concentrations of 2,4-DNT detected at FP Audrey in June 2002	33
Table 11. Concentrations of 2,4-DNT detected at FP Bo-Whale in June 2002 ..	34
Table 12. Concentrations of 2,4-DNT and 2,6-DNT in soil at Observation Point 7 where excess propellant was burned	36
Table 13. 2,4-DNT and 2,6-DNT concentrations detected on snow following the firing of 105-mm howitzers and the equivalent soil concentration	37

PREFACE

This report was prepared by Marianne E. Walsh, Chemical Engineer, Environmental Sciences Branch, Cold Regions Research and Engineering Laboratory (CRREL), Engineer Research and Development Center (ERDC); Charles M. Collins, Research Physical Scientist, Environmental Sciences Branch, CRREL; Alan D. Hewitt, Research Physical Scientist, Environmental Sciences Branch, CRREL; Michael R. Walsh, Mechanical Engineer, Engineering Resources Branch, CRREL; Thomas F. Jenkins, Research Chemist, Environmental Sciences Branch, CRREL; Jeffrey Stark, formerly Physical Science Technician, Civil and Infrastructure Engineering Branch, CRREL; Arthur Gelvin, Engineering Technician, Engineering Resources Branch, CRREL; Thomas Douglas, Research Chemist, Environmental Sciences Branch, CRREL; Nancy Perron, Physical Science Technician, Snow and Ice Branch, CRREL; Dennis Lambert, Mechanical Engineering Technician, Engineering Resources Branch, CRREL; Ronald Bailey, Biological Sciences Technician, Environmental Sciences Branch, CRREL; and Karen Myers, Biologist, Environmental Laboratory.

The authors gratefully acknowledge Susan Taylor and Lawrence Gatto for technical review and David Cate for technical editing. Funding for this work was provided by the U.S. Army Alaska, under the sponsorship of Douglas Johnson, Chief, Environmental Resources Department. Ellen Clark, DTA/ITAM/Conservation Coordinator, provided logistical support. They also gratefully acknowledge the assistance provided by MAJ Stephen T. Houston while a Ph.D. candidate at Colorado State University, and the UXO avoidance services provided by Mike Clemens, Jake Jacobsen, and Frank Hack of Clearwater Environmental, Inc.

Project CP1155: *Distribution and Fate of Energetics on DoD Test and Training Ranges* of the Strategic Environmental Research and Development Program provided funding for the study of propellant residues on snow.

The commander and executive director of the Engineering Research and Development Center is COL James R. Rowan, EN. The director is Dr. James R. Houston.

Range Characterization Studies at Donnelly Training Area, Alaska: 2001 and 2002

MARIANNE E. WALSH, CHARLES M. COLLINS, ALAN D. HEWITT,
MICHAEL R. WALSH, THOMAS F. JENKINS, JEFFREY STARK,
ARTHUR GELVIN, THOMAS DOUGLAS, NANCY PERRON,
DENNIS LAMBERT, RONALD BAILEY, AND KAREN MYERS

1 INTRODUCTION

The withdrawal of training lands from the public domain on Fort Wainwright and Donnelly Training Area (formerly Fort Greely) in Interior Alaska was renewed under the Military Lands Withdrawal Act (PL106-65). As part of the Environmental Impact Statement prepared for the renewal, the Army pledged to assess the amount of residues from explosive munitions at the currently used testing and training impact ranges in Donnelly Training Area and Fort Wainwright and the potential for surface water and groundwater contamination (U.S. Army Alaska 1999). The training lands of Fort Greely were renamed the Donnelly Training Area in 2001 when Fort Greely was realigned under the Base Realignment and Closure (BRAC) process. The main post area of Fort Greely was slated for closure, while the training lands were transferred administratively to Fort Wainwright. Subsequently, the Fort Greely main post has been withdrawn from BRAC and transferred to the Army Space and Missile Defense Command to support the Ground-Based Mid-Course Intercept Missile Defense (GMD) Program. Donnelly Training Area has 26,300 hectares (or 263 km²) of impact areas where high-explosive ammunition is used, including the Washington and Mississippi Impact Areas located within the floodplain of the Delta River, the Delta Creek Impact Area located within the floodplain of Delta Creek, and the Oklahoma Impact Area located just east of Delta Creek.

Assessing the levels of explosives residues by sampling the soil and water is a challenge because of the large size and varied terrain of these impact areas, the safety hazards associated with unexploded ordnance, and on-going live-fire training. Of most interest is the potential for contamination of surface water and groundwater that would provide a route for migration of the explosives residues

across military installation boundaries. We used an authoritative sampling strategy (sample locations were selected based on prior knowledge) to identify explosives source areas within the impact areas. In our opinion, authoritative sampling is a more efficient approach to the overall goal of protecting water sources than random sampling, which is used when there is little or no information about the potential distribution of the analytes of interest.

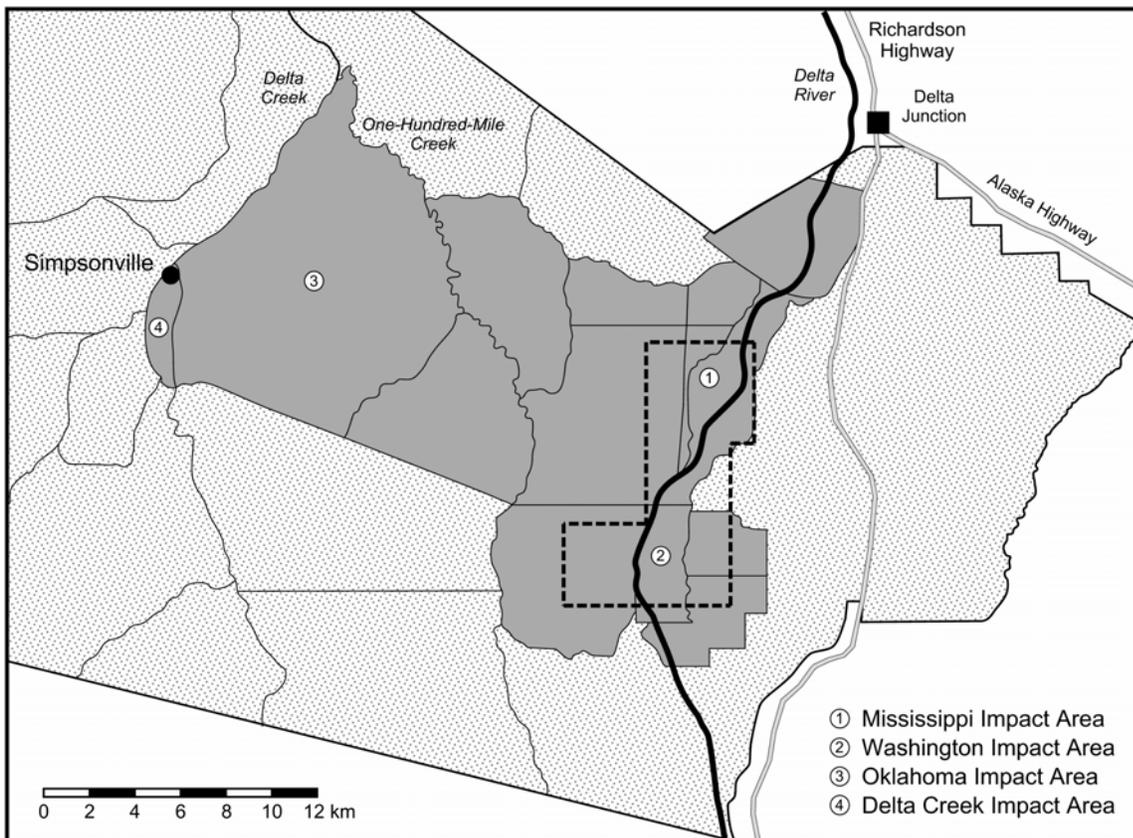
During July 2000, we undertook the initial sampling program on Washington Impact Area and Lampkin Range (Walsh et al. 2001), where we selected, based on guidance from the Cold Regions Test Center, specific locations within the impact area where known ordnance items had detonated. We collected discrete and multi-increment samples to determine if we could find any explosives residues in the surface soils. We detected explosives residues in 48% of the samples we collected, most frequently RDX and TNT. Concentrations were low (the median concentrations for RDX and TNT were 21 and 5 $\mu\text{g}/\text{kg}$, respectively) except where ordnance items failed to detonate completely and solid chunks of explosives were on the surface soil. We also detected propellant residues (2,4-DNT and NG) at the Lampkin Range firing point.

2 OBJECTIVES

In 2001, the objective of the sampling was to determine if we could detect any explosives residues and source areas that could contribute to groundwater contamination in the Donnelly Training Area. The impact areas that we sampled were Delta Creek, Georgia Island, and Washington Range West. We also sampled several firing points to determine concentrations of propellant residues. Based on the analytical results for the 2001 firing point samples, which showed that we needed to expand our sampled collection to distances greater than 50 m from the 105-mm gun firing platforms, we collected additional firing point samples in 2002. Our objective was to characterize the distribution of propellant residues around a firing position and to monitor the persistence of the residues after 30 days of weathering. An additional objective was to obtain more depth samples to determine the potential for downward migration of the residues. Because persistence and migration are influenced by the soil matrix, we chose two firing positions for intensive sampling, one that was vegetated and one that was sparsely vegetated.

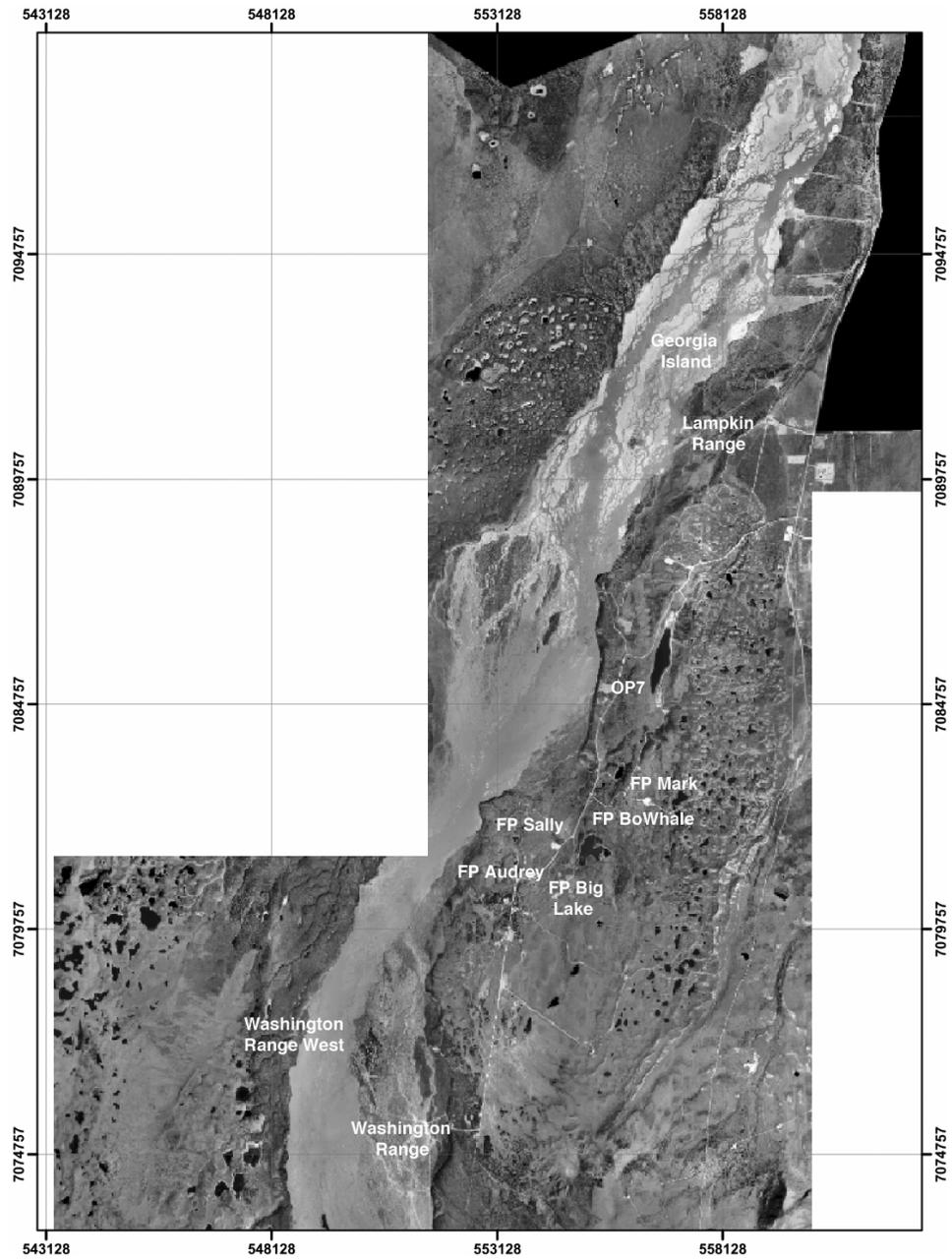
3 PHYSICAL SETTING

The Donnelly Training Area (Fig. 1) consists of 2,554 km² located in the northern foothills of the Alaska Range and the Tanana–Kuskokwim Lowlands. Several glacial outwash rivers, including the Delta River, Delta Creek, and the Little Delta River, flow northward from the Alaska Range across the training area to the Tanana River (U.S. Army Alaska 2003). Several large impact areas, totaling 263 km², are located within the training area, including the Washington and Mississippi Impact Areas along the Delta River, Oklahoma Impact Range east of Delta Creek, and Delta Creek Impact Area along Delta Creek. The Army uses Washington and Mississippi Impact Areas mainly for indirect-fire weapons (the target cannot be seen by the gunner), while Delta Creek (Table 1) and Oklahoma Impact Areas are used primarily for aerial bombing by the Air Force (U.S. Army Alaska 2002).



a. Donnelly Training Area, showing the impact areas sampled. The dashed lines indicate the area shown in Figure 1b.

Figure 1. Installation maps and orthophotos.



b. Orthophoto (AeroMap U.S. 2003), taken August 2002, showing the Delta River, the locations of firing points, Washington Range, Lampkin Range, and Georgia Island.

Figure 1 (cont.).

Table 1. Ordnance used by the Army at the impact areas and firing points that we sampled (based on 1998 to 1999 ammo reports).

Ordnance (DODIC)	Target analyte potentially in residue		Location used and sampled
	Explosive	Propellant	
5.56-mm cartridges (A059, A064, A066, A075)		NG PETN in pellet booster	FP: Simpsonville, Lampkin IA: Delta Creek
7.62-mm cartridges (A107, A127)		NG	FP: Simpsonville, Lampkin IA: Delta Creek
.50 caliber cartridges (A520, A555)		NG, 2,4-DNT, PETN	FP: Simpsonville, Lampkin IA: Delta Creek
30-mm cartridges (B103)			FP: Lampkin
40-mm cartridge (B470)	RDX	NG	FP: Simpsonville, Lampkin IA: Delta Creek
40-mm cartridge [B519(TP) B576 (TP) B535 (ILL), M918 (TP)]		NG	Simpsonville, Delta Creek, Lampkin
105-mm cartridges (C445)	TNT/RDX	2,4-DNT	FP: Mark, Sally, Audrey, Bo-Whale, Lampkin, Simpsonville IA: Delta Creek
105-mm cartridges [C508 (HEAT)]	TNT/RDX	NG	FP: Mark
105-mm cartridges (C511)		NG	FP: Audrey, Bo-Whale, Mark
105-mm cartridges (C520)		2,4-DNT	FP: Mark, Bo-Whale
105-mm cartridges [C449 (ILL)]		2,4-DNT	FP: Mark, Sally, Audrey, Bo-Whale IA: Delta Creek
60-mm (B642)	TNT/RDX	NG	FP: Lampkin, OP7, Simpsonville IA: Delta Creek
60-mm [B640 (ILL)]			FP: Lampkin, OP7, Simpsonville IA: Delta Creek
81-mm [C226 (ILL)]		NG	FP: Lampkin, OP7, Simpsonville
81-mm (C256)	TNT/RDX	NG	FP: Simpsonville
M67 (G881)	TNT/RDX		FP: Lampkin
2.75-inch rocket [H180 (ILL)]		NG	FP: Simpsonville IA: Delta Creek
Claymore mine (K143)	RDX		FP: Lampkin, Simpsonville IA: Delta Creek
84mm AT4 (C995)	M136?		FP: Lampkin, Simpsonville IA: Delta Creek
155-mm HC and ILL (D445, D505)			FP: Mark, Sally, Bo-Whale
C4 (M023)	RDX		Lampkin, Simpsonville
Bangalore torpedo (M028)	RDX/TNT		Lampkin, Simpsonville, Delta Creek
Detonation cord (MD15)	PETN		Simpsonville
TOW (PB25)	HMX		FP: Simpsonville IA: Delta Creek
Dragon (PL23)			FP: Simpsonville, Lampkin IA: Delta Creek

TP: Target practice rounds that do not contain high-explosive filler.

ILL: Illumination round.

IA: Impact Area. The Mississippi and Oklahoma Impact Areas were extensively used but were not sampled due to UXO hazards.

The Delta River is a large, glacially fed, braided river that starts out as a clear-water stream draining the Tangle Lakes on the south side of the Alaska Range. It cuts across the crest of the Alaska Range, receiving meltwater from a number of glaciers, including the Canwell, Castner, and Black Rapids Glaciers. In the vicinity of Donnelly Training Area, the river cuts through the Donnelly Moraine, a late-Pleistocene moraine marking the last major glacial advance down the Delta River valley (Péwé and Holmes 1964, Péwé 1975). The incised moraine forms large bluffs on either side of the river valley. The river through this area is braided and has a broad, gravel floodplain. In the vicinity of the Washington and Mississippi Impact Areas, there are large abandoned floodplain terraces, several meters above the present active floodplain. These terraces represent episodes of greater sedimentation in the past, probably associated with surges of the Black Rapids Glacier over the last several hundred years. Much of the terrace of the Washington Range is bare gravel, with localized areas of sparse shrubs mostly consisting of silverberry (*Eleagnus commutata*). Jorgenson et al. (2001) mapped the vegetation on Fort Greely and classified these areas as riverine gravelly barrens and riverine gravelly low scrub and dry dwarf scrub.

Delta Creek is also a glacially fed braided river that flows from the Alaska Range north, joining the Tanana River. It receives meltwater from the Trident and Hayes Glacier, as well as snowmelt from the Alaska Range. Like the Delta River, it has extensive sections of abandoned floodplain terraces several meters higher than the current active braided floodplain. One-Hundred-Mile Creek is a small, single-channel, clear-water stream originating in the foothills of the Alaska Range and flowing northward and then westward, joining Delta Creek. The Delta Creek Impact Area (Fig. 2), a 20-km² impact area, is located along 9 km of Delta Creek. Target arrays are located along abandoned floodplain terraces on the west side of the active creek. The western boundary of Oklahoma Impact Area, a 250-km² impact area, is located along 16 km of Delta Creek, north of Delta Creek Impact Range. The eastern and northern boundary of Oklahoma Impact Area runs along One-Hundred-Mile Creek. Simpsonville (Fig. 3) is a Military Operations in Urban Terrain/Combined Arms Live Fire Exercise (MOUT/CALFEX) site located on top of a bluff on the west bank of Delta Creek. The gently sloping area is mostly open, covered with tussock tundra vegetation.

The western side of Washington Impact Area is along the west bank of the Delta River. Here a narrow floodplain runs along the steep bluffs of the moraine to the west. The narrow floodplain is vegetated with lowland gravelly dry mixed forest (Jorgenson et al. 2001) and shows little evidence of artillery use, such as cratering or range scrap, probably because of its location at the edge of the impact area. Georgia Island (Fig. 4) is a 4-km-long island within the active floodplain of the Delta River. It is sparsely to heavily vegetated [classified as riverine gravelly barrens to lowland gravelly dry mixed forest by Jorgenson et al.



Figure 2. Aerial and near-ground views of a target array located 2 km downstream of Delta Creek Impact Area.



Figure 3. Aerial view of Simpsonville MOUT/CALFEX, located on a bluff overlooking the Delta Creek Impact Area.



Figure 4. Aerial view of Georgia Island, showing the old target berm.

(2001)]. It is located immediately downstream of Mississippi Impact Area, a heavily used indirect fire range where we are not allowed to sample because of extreme UXO (unexploded ordnance) hazards. Georgia Island has been used to a lesser degree as an artillery impact area. It has also been used as a target area for direct-fire weapons from various ranges on the east side of the Delta River.

Firing Points Audrey, Bo-Whale, Big Lake, Mark, and Sally are located in the Donnelly East Training Area on the east side of the Delta River (Fig. 1b). The firing points are located on either side of Meadows Road, which runs south along the broad crest of the glacial lateral moraine forming the high bluffs on the east side of the river. The firing points are used for indirect fire into the Mississippi and Washington Impact Areas to the west. FP Big Lake, Bo-Whale, and Sally (Fig. 5a) are open vegetated areas with a ground cover of grasses, sedges, low forbs, and some low shrubs. Soils are fine-grained silt loam overlying coarser, poorly sorted gravel. The soils at FP Bo-Whale are wetter and have more organic material than those of the other firing points. FP Mark (Fig. 5b) and Audrey are mostly unvegetated open area with sporadic ground cover of mosses and grasses. Soils here are poorly sorted silty, sandy gravel. The Lampkin Range firing point (Fig. 6) is located on an elevated, broad, flat-topped gravel berm or platform built on the vegetated floodplain along the east bank of the Delta River. The berm where we sampled was constructed of silty, sandy gravel.



a. FP Sally (vegetated site), July 2002.

Figure 5. Firing points used for indirect fire into Mississippi and Washington Impact Areas.



b. FP Mark (sparsely vegetated site), July 2002.

Figure 5 (cont.).



Figure 6. Ground view from Lampkin Range Firing Point, which is used for direct fire at targets within the floodplain of the Delta River.

4 METHODS

Field Sample Collection

Delta Creek, 2001

In June 2001, we collected samples downstream of the boundaries of the Delta Creek Impact Area. We were not allowed to sample the actual Delta Creek Impact Area because of the hazards associated with unexploded submunitions. However, a series of targets and associated craters and range scrap (Fig. 2) were located 2 km downstream, where we collected both discrete and composite samples. The discrete samples were soil near what appeared to be partial detonations of 500-lb bombs. The composite samples consisted of fifty 40-g subsamples collected around craters of various dimensions, around targets, and in undisturbed areas. At 5, 8, 11, 14, and 17 km downstream were suitable helicopter-landing sites with fine-grain sediments, where we collected more samples. With the exception of two discrete samples collected under pieces of rocket motors, samples farther downstream were composites from 10- × 10-m areas on inactive and abandoned bar surfaces along the edge of the creek.

We also collected seven samples at the MOUT/CALFEX site known as Simpsonville located on a bluff overlooking Delta Creek (Fig. 3). Four of the samples were from explosive ordnance disposal craters, and the other three were from craters thought to be produced by 40-mm grenades.

Georgia Island, 2001

The sampling of Georgia Island, within the Delta River, was conducted by sampling approximately every 200 m along the centerline of the island and every 50 m along the base of a former target berm (Fig. 4). At each sampling location, a multi-increment sample was collected by taking approximately fifty 40-g random discrete subsamples over a 10- × 10-m area as was done at Delta Creek. A total of 44 composite samples were collected. Five discrete samples were collected near ordnance items such as empty 40-mm grenade casings and range scrap.

West side of Washington Impact Area, 2001

The sampling of the west side of Washington Impact Area, along the west bank of the Delta River, was to be conducted like the sampling of Georgia Island at every 200 m along the narrow vegetated floodplain. However, heavy vegetation and lack of suitable helicopter landing spots limited where we could sample

along the bank. At several locations we collected samples at 50- to 100-m intervals, walking to several sites from a single landing site. At each sampling location a sample was collected by taking approximately fifty 40-g random discrete subsamples over a 10- × 10-m area as was done at Delta Creek and Georgia Island. Twenty-four composite samples were collected.

Firing Points, 2001

Previous sampling at Fort Greely, Fort Lewis, Yakima Training Center, and other training areas has shown that firing points are frequently contaminated with propellant residues (Walsh et al. 2001). The most common residues detected have been 2,4-DNT, which is an additive in single-base propellants, and NG, an ingredient in double- and triple-base propellants (U.S. Army 1984).

Our objective in sampling the firing points at Donnelly Training Area was to determine the average concentrations of propellant residues in the surface soil. Depending on the locations of the firing points, these residues could contaminate groundwater or be ingested by grazing animals. However, the samples we collect can be used to compute mean concentrations only if the concentration estimates for replicate samples agree within reasonable limits. Previous sampling efforts on firing ranges have indicated that concentration estimates in replicate samples can vary by more than a factor of ten. Recently, the problem of laboratory subsampling of unvegetated explosives-contaminated soil was solved by grinding soils using a ring mill, a practice routinely used in the mining industry but not in environmental laboratories. However, the problem of reproducible field sample collection has yet to be resolved.

During the week of July 31 to August 5, 2001, we sampled Donnelly East Training Area firing points that had been used during the second week of June 2001 by the 4/11 Field Artillery. About 100 rounds had been fired from M119A 105-mm howitzers at each of firing points Audrey, Sally, Big Lake, Bo-Whale, and Mark (Fig. 1). Major S. Houston accompanied us to various firing points, and he located the firing positions of several 105-mm howitzers at firing points Sally, Bo-Whale, and Big Lake. The firing positions were identified by the characteristic depressions left on the ground by the firing platform and spade of each howitzer (Fig. 7).

We collected surface samples in front of eight howitzer firing positions. First we staked a line representing the axis of the cannon tube position and parallel lines 3 m on either side (Fig. 8). At 3.5, 7, 14, 21, and 28 m distance from the center of each firing platform depression, we collected duplicate multi-increment samples. Each sample consisted of 30 increments of the surface soil and associated vegetation collected within a 1- × 6-m area. At three howitzer firing positions we collected five additional samples 50 m from the firing platform



a. M119A1 105-mm howitzers.



b. Depressions made by the firing platform and spade.

Figure 7. Locating howitzer firing positions in July 2001. The firing platform is located between the wheels and the spade is to the rear of the gun.

depression. One of these samples was along the axis of the cannon tube, and the other samples were $\pm 30^\circ$ and $\pm 60^\circ$ from the axis.

Each sample was returned to our field laboratory and air-dried on an aluminum pie pan. While the sample was drying, a subsample was taken for the field analysis described below. This analysis allowed us to identify which firing points



Figure 8. FP Sally in July 2001. The axis of the cannon tube corresponds to the yellow tape measure down the center of the photo. Multi-increment samples were collected within a 1- × 6-m area at 3.5, 7, 14, and 28 m from the center of the depression left by the firing platform.

had detectable concentrations of propellant residues. Based on these analyses, we returned to the sites of the samples with the four highest propellant residue concentrations and collected discrete samples and subsurface samples. Results from the field analysis also allowed us to select samples to send to CRREL (Hanover, NH) to test sample homogenization techniques. The remainder of the samples were sent to the ERDC's Environmental Lab (Vicksburg, Mississippi).

Firing Points, 2002

From June 19 to June 25, 2002, the 4/11th Field Artillery set up at the same firing points as in 2001 for indirect fire training and at the Lampkin Range for direct fire training. A. Gelvin and T. Douglas were on location for some of the firing and obtained exact howitzer positions from CPT Mandelloni of B Company. Gelvin and Douglas then started collecting six composite samples from each gun location. Each sample was nominally made up of 30 increments randomly collected with a bulb planter (Fig. 9) to a depth of 1 cm taken over a 2- × 6-m area. The sample locations were 25 and 50 m in front of each gun and at 60° left and 60° right (Fig. 10). These samples were returned to our field lab for drying, sieving, field-grinding (Hewitt and Walsh 2003), and field gas chroma-



a. Using a bulb planter.



b. Sample increment, nominally 1 cm thick.

Figure 9. Collecting surface samples at firing point Sally.

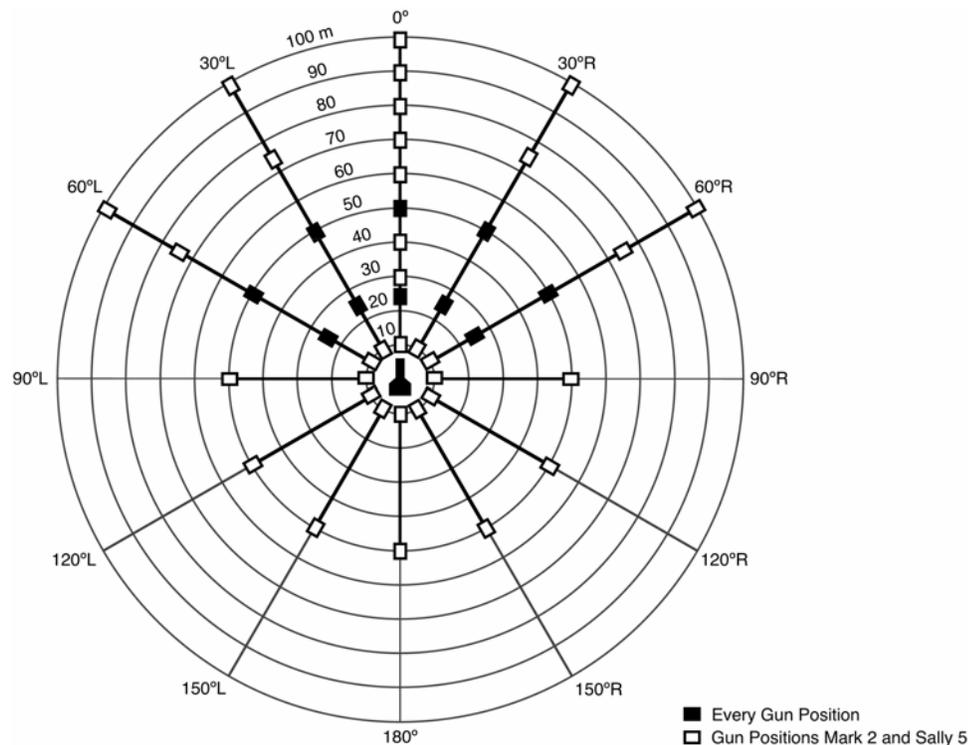


Figure 10. Sampling scheme used for characterization of propellant residues around a howitzer firing position.

topographic analysis. Based on these analyses, we chose two gun positions for intensive sampling. These positions were FP Sally Gun 5 (Fig. 5a), which was heavily vegetated, and FP Mark Gun 2 (Fig. 5b), which was sparsely vegetated. We collected samples radially every 30° at 10 and 50 m, where possible, from the gun platform location (Fig. 10). In some cases the boundary of the firing point was less than 50 m from the gun platform, so the samples were collected at the boundary. Additional samples were collected at 25-m intervals out to 100 m, where possible, $\pm 30^\circ$ and $\pm 60^\circ$ from the axis of the gun tube. Samples were collected at 10-m intervals directly in front of the gun platform.

In July 2002, we repeated the intensive sampling at FP Mark Gun 2 and FP Sally Gun 5. We also collected subsurface composite samples 25 and 50 m in front of the gun and at 60° left and 60° right. Each subsurface composite sample was made up of five increments collected at a depth of 15–20 cm using a Series 400 AMS corer.

Two additional sampling locations were OP7 (Fig. 1b), where excess propellant was burned, and the Lampkin Range firing point, where direct-fire exercises with howitzers, mortars, 40-mm grenades, and other ordnance occur (Table 1, Fig. 1b, 6).

Lab Processing of Samples

Firing Points, 2001 and 2002

Most of the firing points are located on well-vegetated fields, so the surface samples were a mix of soil, decayed organic matter, and vegetation. This very complicated matrix presented a considerable subsampling challenge. Most of the firing point samples were shipped to the ERDC Environmental Lab (Vicksburg, MS), where they were analyzed using standard homogenization methods (i.e., manual grinding with a mortar and pestle and sieving through a #30 mesh sieve). The remaining samples, which we selected based on the results of the field gas chromatographic analyses, were sent to CRREL to examine the subsampling heterogeneity associated with these surface samples and test homogenization techniques (Walsh et al. 2002). The selected samples were from a Bo-Whale firing point (Fig. 11).

First, we separated each sample into two size fractions using #10 mesh (2-mm) sieves. The <2-mm fraction consisted of soil and organic matter. The >2-mm fraction contained leafy and woody vegetation and some pebbles. We took duplicate 10-g subsamples from each size fraction of each sample for determination of propellant residues. Then we machine-ground (Fig. 12) each of the size fractions and took a second set of duplicate 10-g subsamples. The grinding, which was done for 60 s on a LabtechEssa LM2 ring mill at CRREL, reduced the particle size of the samples to less than 0.1 mm. Two of the ground samples were divided using a LabtechEssa RSD005 rotary divider.

All of the firing point samples in 2002 were sieved through a #10 (2-mm) mesh sieve, and the <2-mm fraction was machine-ground on a LabtechEssa LM2 ring mill. The grind time for vegetated samples was increased to 90 s. Duplicate 10-g subsamples were taken for analysis for each sample.

Delta Creek

All samples from Delta Creek were air-dried prior to shipment to CRREL for analysis. Those samples that were expected to contain explosives were subsampled by taking larger than normal (50-g) soil aliquots in an effort to reduce subsampling error. All others were subsampled by taking 10-g soil aliquots. The soils were extracted using acetone, and the extracts were analyzed using the colorimetric Method 8515 (U.S. EPA) to detect TNT and other nitroaromatics. This procedure was performed because some of the samples were collected near what appeared to be partial detonations of 500-lb bombs that contained TNT. We used the results of the colorimetric method to sort the samples by TNT concentration. Samples that were positive by the colorimetric method were analyzed by HPLC (see below), and all others were analyzed by GC- μ ECD. Selected samples



Figure 11. Firing position at Bo-Whale from which samples were collected for homogenization studies.



Figure 12. Unground (left) and ground (right) >2-mm fractions of a Bo-Whale sample.

(TNT concentrations between 1 and 200 $\mu\text{g}/\text{kg}$) were machine-ground on a LabTehctonics ring mill at Mineral Stats, Inc. (Broomfield, Colorado) and re-analyzed for explosives. This further processing was done to reduce the subsampling error associated with explosives-contaminated soils (Walsh et al. 2002).

Analytical Methods Used by CRREL

In the field lab during the July–August 2001 and June 2002 sampling periods, acetone extracts were analyzed on a field-portable gas chromatograph equipped with a thermionic ionization detector (Hewitt et al. 2001, USEPA 2001). The SRI Model 8610C gas chromatograph has a heated injection port, and chromatographic separations were achieved on a 15-m × 0.53-mm 100% dimethylpolysiloxane column. This procedure provides detection limits of 10 µg/kg for TNT and 2,4-DNT and 100 µg/kg for RDX.

In the laboratory, we used Method 8095 (Nitroaromatics and Nitramines by GC) (USEPA 2000), which uses an electron capture detector and provides detection limits near 1 µg/kg for TNT and RDX. We used an HP 6890 and a Restek 6-m × 0.53-mm id RTX-5ms (95% dimethyl–5% diphenyl polysiloxane) column. The method detection limits for Method 8095 are 1 µg/kg for the di- and trinitroaromatics, 3 µg/kg for RDX, 25 µg/kg for HMX, 10 µg/kg for NG, and 20 µg/kg for PETN.

We used Method 8330 [Nitroaromatics and Nitramines by High Performance Liquid Chromatography (HPLC)] (USEPA 1994) when we found higher-concentration samples (>0.2 µg/g). The HPLC separations were achieved on a 15-cm × 3.9-mm (4-µm) Nova Pak C₈ (Waters Millipore) column eluted with 1.4 mL/min 15:85 isopropanol:water and on a 25-cm × 4.6-mm (5-µm) Supelco LC-CN column eluted with 1.2-mL/min 65:14:21 water:methanol:acetonitrile. Detection was by UV (254 nm).

Collection of Propellant Residue from a Snow-covered Firing Point

To further examine the deposition of propellant residues from 105-mm howitzers, we had the opportunity to collect samples in conjunction with a research project that involves detonations of ordnance items on clean snow surfaces where the snow acts as a pristine collection surface for the post-blast residues (Hewitt et al. 2003). In March 2002, seventy-one 105-mm projectiles were fired from Firing Point Neiber (Fig. 13) at Fort Richardson, AK. The propellant residues were visible on the snow surface as either fibrous black soot (Fig. 14) or unburned yellow fibers. Samples of the residues were collected by shoveling into plastic bags the top layer of snow from 1-m² areas within and just beyond the visible plume forward and to the sides of the gun muzzle. Snow samples were also collected at the breaches of three guns, where the expended cartridges are removed from the howitzer. The snow was melted, and then the particulate residue fraction was obtained by filtration through glass fiber filters. The filtrate and the solid residue were analyzed separately for 2,4-DNT.



Figure 13. Winter firing of an M119A1 105-mm howitzer.

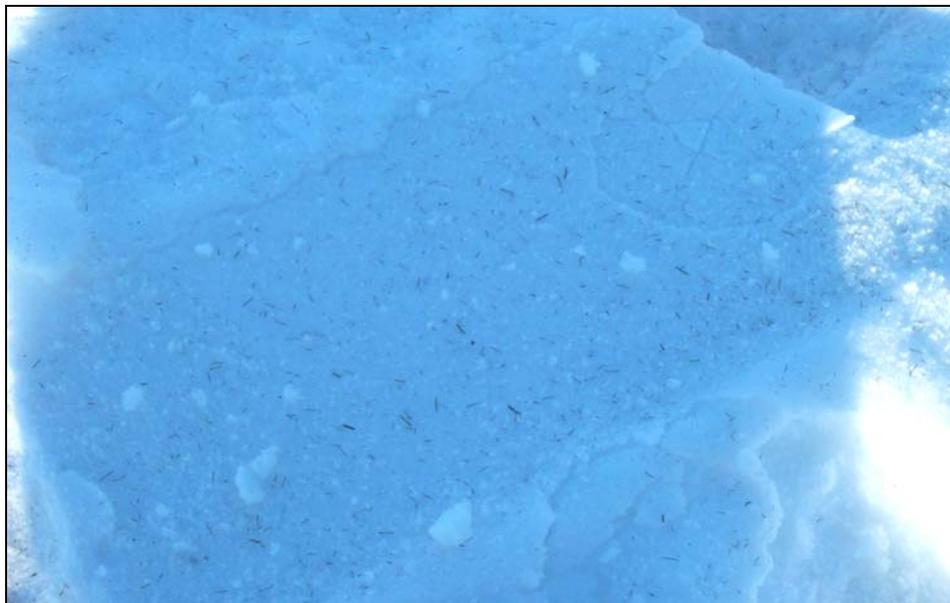


Figure 14. Fibrous residue deposited on the snow surface from the firing of a 105-mm howitzer.

5 RESULTS

Delta Creek Impact Area

Explosives residues were detected in all of the samples collected near the target array located 2 km downstream from the Delta Creek Impact Area. In the composite samples, the following residues were determined: TNT (<1–314,000 µg/kg); RDX (7–1,400 µg/kg); HMX (<25–110 µg/kg); 2,4-DNT (1–33 µg/kg), and NG (<15–51 µg/kg). Only four of the samples had TNT above 1,000 µg/kg, and the median concentration was 80 µg/kg. The amino-DNT reduction products were detected in each sample as well, but concentrations were low (<200 µg/kg). One of the discrete samples collected near a 500-lb bomb partial detonation had a TNT concentration of 17,300,000 µg/kg, a concentration far exceeding any other sample we collected. No explosives residues were detected upstream of the target array, and NG was the only propellant residue detected downstream of the target array. The NG (2,000 and 80 µg/kg) was found in two discrete samples that were collected under pieces of rocket motors.

Explosives residues were detected in each of the seven soil samples from Simpsonville, the MOUT/CALFEX site. The concentration ranges were: TNT (<d–140 µg/kg), RDX (<d–26 µg/kg), 2,4-DNT (<d–28 µg/kg), and NG (<d–1,500 µg/kg). The NG was associated with 40-mm grenade training, and the other residues were associated with explosive ordnance disposal craters.

Georgia Island

All composite samples collected along the centerline of Georgia Island and from the base of the target berm were negative for HMX, RDX, TNT, 2,4-DNT, and other target analytes. NG was detected in a discrete soil sample, GI003, taken under an empty 40-mm grenade cartridge casing. The concentration was 4,700 µg/kg.

West Side of Washington Impact Area

Explosives residues were not detectable in any of the samples from the narrow vegetated floodplain along the west side of Washington Impact Area.

Firing Points 2001

Each of the firing points that we sampled in 2001 at Donnelly Training Area had detectable concentrations of 2,4-DNT in at least one composite sample (Appendix Table 1). A typical chromatogram is shown in Figure 15. The spatial

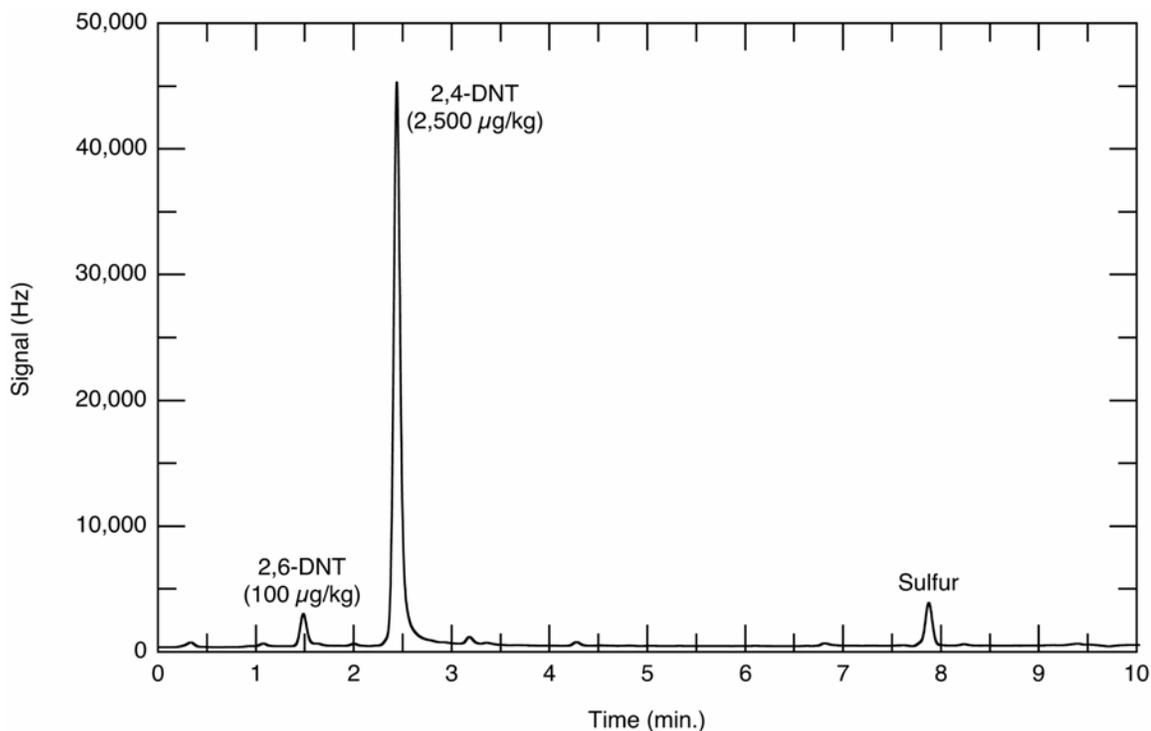


Figure 15. Typical chromatogram obtained by GC- μ ECD of an extract of a soil collected from a 105-mm howitzer firing point.

distribution of 2,4-DNT was extremely heterogeneous, as shown by the concentration estimates in discrete samples. For example, five discrete samples collected within the 1- \times 6-m area from which Bo-Whale composite sample 1 was collected ranged in concentration from 25 to 7,900 μ g/kg. There was also generally poor agreement between duplicate field samples that were processed by standard methods at EL.

Our sample homogenization experiments were done on the duplicate field samples that we collected at the Bo-Whale firing point (Fig. 11). First we took duplicate laboratory subsamples of the <2-mm and >2-mm size fractions. The >2-mm fraction is not routinely analyzed for contaminant concentrations (Paetz and Cröbmann 1994). However, the propellant residues fall onto whatever substrate is near the howitzer, so we did not feel justified in excluding any part of the surface samples we collected. We then machine-ground each size fraction to a fine powder (Fig. 12) and took duplicate subsamples for analysis.

Concentration estimates of 2,4-DNT in the machine-ground and not-ground samples are shown in Table 2. To determine if machine grinding increased subsampling precision of the two size fractions, we used an F test. First, we computed the pooled variances for the laboratory duplicates using the following equation:

Table 2. Concentrations of 2,4-DNT in laboratory subsamples of the >2-mm and <2-mm fractions with and without machine grinding. Samples were collected July 2001 from FP Bo-Whale.

Distance from firing platform (m)	Angle from centerline (degrees)	Sample ID	Field rep.	Lab rep.	2,4-DNT concentration ($\mu\text{g}/\text{kg}$)			
					Machine ground		Not ground	
					>2 mm	<2 mm	>2 mm	<2 mm
3.5	0	1	A	1	903	8,540	14,400	5,000
3.5	0	1	A	2	1,560	5,470	1,570	1,720
3.5	0	1	B	1	301	3,400	219	1,120
3.5	0	1	B	2	397	3,640	3,320	1,500
7	0	2	A	1	130	1,860	369	1,700
7	0	2	A	2	143	2,550	1,070	3,800
7	0	2	B	1	1,270	3,030	3,230	6,500
7	0	2	B	2	623	3,660	131	972
14	0	3	A	1	483	1,750	299	580
14	0	3	A	2	616	732	136	157
14	0	3	B	1	84	1,400	68	2,470
14	0	3	B	2	224	2,000	123,000	11,600
21	0	4	A	1	450	1,280	<d	96
21	0	4	A	2	485	1,120	<d	984
21	0	4	B	1	2,400	1,520	440	36
21	0	4	B	2	1,940	2,300	140	356
28	0	5	A	1	3,870	16,900	12,900	29,000
28	0	5	A	2	3,450	29,900	9,430	16,500
28	0	5	B	1	10,800	24,000	11,100	12,500
28	0	5	B	2	15,300	29,100	9,450	6,300
50	-30	6		1	172	4,020	14	5,980
50	-30	6		2	193	2,840	104	2,030
50	-15	7		1	200	8,320	477	2,310
50	-15	7		2	186	5,860	843	2,630
50	0	8		1	4,510	6,790	1,670	794
50	0	8		2	3,130	5,730	9,800	18,600
50	+15	9		1	no sample	20	no sample	13
50	+15	9		2	no sample	39	no sample	37
50	+30	10		1	299	2,960	18	28
50	+30	10		2	322	1,530	7.8	40
Pooled variance for duplicates					840,000	7,300,000	592,000,000	22,000,000
F (Ratio of variances for not ground and ground)							700	3.0

$$s_p^2 = \frac{1}{2k} \sum_1^k d_i^2$$

where d_i is the difference of k sets of duplicates (Ku 1969). Then we computed the ratio of the variances for the not-ground and ground sets of samples. For the <2-mm fraction, 2,4-DNT was detectable in all 15 duplicates for both the not-ground and ground samples, and the F ratio was 3.0. The critical value of $F_{(14,14)}$ is 2.48 ($P = 0.05$) (Miller and Miller 1984), so the machine grinding resulted in a significant increase in precision. The F ratio for the >2-mm fraction was highly significant ($F = 700$), but most of the variation was due to sample 3A, where the concentration estimates differed by a factor of 1800. Even excluding this one sample, machine grinding significantly improved precision. However, the reduction in subsampling variance by grinding the Bo-Whale sample is less than the reduction we find when unvegetated samples contaminated with high explosives, such as those collected from hand grenade ranges, were ground. For unvegetated samples contaminated with TNT, RDX, and HMX, the relative standard deviation for 12 replicates was less than 10% (Walsh et al. 2002).

To test if machine sample division would reduce the laboratory subsampling variance over that obtained by manual subsampling, we divided Bo-Whale samples 3A and 6 into 12 subsamples each using a rotary divider. For these samples, the relative standard deviations for the 2,4-DNT concentration estimates were 55% and 32%, respectively (Table 3). The pooled relative standard deviation for the 15 sets of duplicates of the ground <2-mm fractions of Bo-Whale samples 1–10 was 44% (Table 2), so machine division does not appear to improve subsampling precision for these samples. Future homogenization experiments will examine the effect of longer grind times on 2,4-DNT-contaminated soils.

To determine if we were able to collect field samples in a reproducible manner, we used the laboratory duplicates to compute the mean concentrations in the five sets of field duplicates for the >2-mm and <2-mm fractions with and without machine grinding. Again, using the ratio of the pooled variances (Table 4), we see that machine grinding significantly improved precision for both size fractions. The field replicates for the <2-mm machine-ground fractions were in relatively good agreement, considering the heterogeneity of the substrate we were sampling. However, methods to reduce the field sampling variance are needed.

We collected four sets of subsurface samples using an AMS soil core sampler to determine if propellant residues deposited from firing activities were migrating downward through the soil column. The locations of the subsurface samples were chosen based on the highest concentrations of 2,4-DNT detected using the field

Table 3. Subsampling heterogeneity in two machine ground samples that were split by a rotary divider.

Replicate	2,4-DNT Concentration ($\mu\text{g}/\text{kg}$)	
	Bo-Whale Sample 6 (<2 mm)	Bo-Whale Sample 3A (<2 mm)
1	7,400	810
2	4,900	1,860
3	6,800	860
4	3,900	2,900
5	4,200	3,530
6	8,000	1,700
7	3,500	2,500
8	7,000	1,150
9	6,097	4,200
10	6,000	1,900
11	2,650	920
12	4,300	1,600
mean	5,396	1,993
min	2,650	810
max	8,000	4,200
median	5,450	1,775
RSD	32%	55%

Table 4. Mean concentration estimates of the >2-mm and <2-mm fractions with and without machine grinding in field duplicate multi-increment samples at FP Bo-Whale.

Distance from base plate (m)	Angle from centerline (degrees)	Sample ID	Field replicate	2,4-DNT Conc. ($\mu\text{g/g}$)			
				Machine ground		Not ground	
				>2 mm	<2 mm	>2 mm	<2 mm
3.5	0	1	A	1,230	7,000	7,990	3,360
3.5	0	1	B	349	3,520	1,770	1,310
7	0	2	A	136	2,200	718	2,750
7	0	2	B	948	3,341	1,680	3,740
14	0	3	A	549	1,240	217	368
14	0	3	B	154	1,700	61,550	7,020
21	0	4	A	467	1,200	not detected	540
21	0	4	B	2,170	1,900	290	196
28	0	5	A	3,660	23,400	11,200	22,750
28	0	5	B	13,100	26,600	10,300	9,410
Pooled Variance for Duplicates				9,360,000	2,440,000	380,000,000	22,800,000
F (Ratio of variances for not ground and ground)						41	9.4

GC analysis. Three sets were from FP Bo-Whale, and the fourth set was from FP Big Lake. The results in Table 5 show that the bulk of the residues were in the top 2 cm and that no analytes were detected below 5 cm deep.

Firing Points 2002

The firing point samples from 2001 showed that firing with 105-mm howitzers deposited 2,4-DNT on the surface soil in a heterogeneous manner resulting in parts-per-million residue concentrations and that the residue extended at least 50 m from the gun position. In 2002, we intensively sampled two howitzer firing positions, one vegetated and the other sparsely vegetated, shortly after the guns were used, and we repeated the sampling after 30 days. We must point out that the other guns at the firing points were positioned close enough so that some of the 2,4-DNT we detected may have been contributed by the firing of neighboring guns.

The range of 2,4-DNT concentrations at the sparsely vegetated gun position (FP Mark Gun 2) was <1–19,000 $\mu\text{g/kg}$ shortly after firing in June and 2–32,000 $\mu\text{g/kg}$ 30 days later in July (Table 6). At the vegetated gun position (FP Sally Gun 5) the range of 2,4-DNT concentrations was <1–5,800 $\mu\text{g/kg}$ after

Table 5. Concentrations of propellant residues found in subsurface samples collected from FP Bo-Whale and Big Lake.

		Lab Rep	Concentration (µg/kg)		
			2,6-DNT	2,4-DNT	NG
Bo-Whale FP Discrete Location 1 (within area BW4 composite sample)					
Surface	Field GC		NA	7,900	NA
0 to 2.5 cm depth	Lab GC	A	<1	<1	<15
	Lab GC	B	<1	8.1	<15
2.5 to 5 cm depth	Lab GC	A	<1	<1	<15
	Lab GC	B	<1	<1	<15
5 to 9 cm depth	Lab GC	A	<1	<1	<15
	Lab GC	B	<1	<1	<15
9 to 13 cm depth	Lab GC	A	<1	<1	<15
	Lab GC	B	<1	<1	<15
FP Bo-Whale Discrete Location 2 (within area BW4 composite sample)					
Surface	Field GC		NA	4,600	<15
0 to 2.5 cm depth	Lab GC	A	616	13,300	550
	Lab GC	B	588	11,300	<15
2.5 to 5 cm depth	Lab GC	A	<1	19.6	250
	Lab GC	B	<1	5.4	<15
5 to 10 cm depth	Lab GC	A	<1	<1	<15
	Lab GC	B	<1	<1	<15
10 to 15 cm depth	Lab GC	A	<1	<1	<15
	Lab GC	B	<1	<1	<15
FP Bo-Whale Discrete Location 1.5 (within area BW4 composite sample)					
Surface	Lab GC		48.6	530	<15
0 to 2 cm depth	Lab GC	A	13.8	226	<15
	Lab GC	B	<1	8.3	<15
2 to 4 cm depth	Lab GC	A	<1	<1	<15
	Lab GC	B	<1	<1	<15
4 to 11 cm depth	Lab GC	A	<1	<1	<15
	Lab GC	B	<1	<1	<15
11 to 15 cm depth	Lab GC	A	<1	<1	<15
	Lab GC	B	<1	<1	<15
FP Big Lake Discrete Location 10 (within area BL14 composite sample)					
Surface	Field GC		NA	9,100	NA
Surface	Lab GC		345	6,790	<15
1 to 4 cm depth	Lab GC	A	<1	4.0	<15
	Lab GC	B	<1	<1	<15
4 to 8 cm depth	Lab GC	A	<1	<1	<15
	Lab GC	B	<1	<1	<15
8 to 15 cm depth	Lab GC	A	<1	<1	<15
	Lab GC	B	<1	<1	<15
15 to 20 cm depth	Lab GC	A	<1	<1	<15
	Lab GC	B	<1	<1	<15

Table 6. Concentrations of 2,4-DNT determined in composite surface soil samples collected around a 105-mm howitzer within one week (June 2002) and five weeks (July) of firing.

FP Mark (sparsely vegetated)			
Distance from firing platform (m)	Angle from centerline (degrees)	2,4-DNT (µg/kg)	
		June	July
10	0	70	190
20	0	300	160
25	0	4,900	550
40	0	1,400	3,700
50	0	250	150
60	0	57	690
70	0	17	9.0
80	0	1,400	110
90	0	120	1,100
100	0	300	1,200
10	-30	120	120
25	-30	26	8
50	-30	870	1,900
75	-30	300	340
100	-30	4.0	36
10	+30	110	250
25	+30	1,800	1,800
50	+30	2,000	2,300
75	+30	2,300	1,400
95	+30	3,600	3,300
10	-60	240	950
25	-60	1,400	2,900
50	-60	120	53
75	-60	1,400	170
100	-60	160	160
10	+60	41	21
25	+60	1,700	1,800
50	+60	170	440
75	+60	1,500	1,800
100	+60	19,000	32,000
10	-90	120	100
50	-90	42	140
10	+90	72	68
50	+90	67	270
10	-120	50	4.0
36	-120	<d	100
10	+120	61	26
50	+120	1,000	940
10	-150	7.0	2.0
50	-150	<d	3
10	+150	27	7.5
30	+150	9.0	5.0
10	180	9.0	18
28	180	4.0	2.0
mean		1,070	1,390
median		121	165
max		19,000	32,000

FP Sally (vegetated)			
Distance from firing platform (m)	Angle from centerline (degrees)	2,4-DNT (µg/kg)	
		June	July
10	0	3,800	3,000
20	0	1,900	1,000
25	0	800	230
40	0	290	1600
50	0	<d	270
60	0	<d	<d
70	0	<d	260
10	-30	2,200	7,400
25	-30	1,100	2,700
50	-30	70	60
10	+30	810	2400
25	+30	140	140
50	+30	530	490
75	+30	<d	64
100	+30	<d	<d
10	-60	5,800	4,400
25	-60	450	1,500
50	-60	240	63
10	+60	86	750
25	+60	670	810
50	+60	190	100
75	+60	<d	27
100	+60	<d	<d
10	-90	2,300	3,700
50	-90	160	770
10	+90	200	820
50	+90	<d	140
10	-120	620	1,400
50	-120	1,400	900
10	+120	32	210
50	+120	35	94
10	-150	230	160
50	-150	180	750
10	+150	220	360
50	+150	26	62
10	180	95	90
50	180	15	<d
mean		660	990
median		190	270
max		5,800	7,400

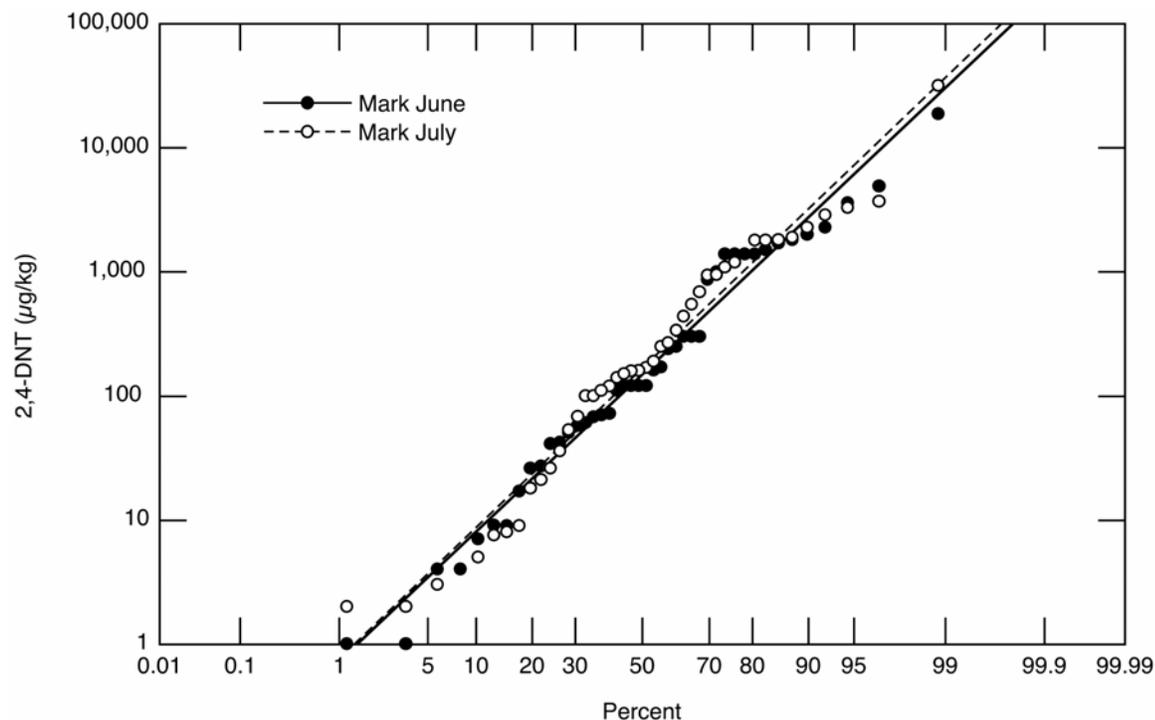


Figure 16. Probability plot of 2,4-DNT concentrations at FP Mark in June and July 2002. The data are log-normally distributed, and there was no significant change in 2,4-DNT concentration after 30 days of weathering.

firing and $<1\text{--}7,400\ \mu\text{g}/\text{kg}$ 30 days later. The data were not normally distributed; when the data for FP Mark are displayed on a log probability plot (Fig. 16), the points fall approximately along straight lines. We used Wilcoxon Matched Pairs Test to compare the June and July concentrations estimates, and there was no significant difference for FP Mark. There was a significant difference between the June and July medians for FP Sally; the July median was greater than the June median, probably because we paid more attention to maintaining the sampling depth at only 1 cm for the July samples.

We did not detect 2,4-DNT in subsurface samples collected in July 2002 at FP Sally, the vegetated firing point. However, we could detect some 2,4-DNT in subsurface samples at FP Mark, which had sparse vegetation (Table 7). The organic matter in the vegetated soil would be expected to sorb any 2,4-DNT that dissolves in the surface moisture.

Samples from the other gun positions at FP Mark, Sally, Audrey, and Bo-Whale (Tables 8–11) in 2002 showed similar patterns for 2,4-DNT. With the exception of Bo-Whale gun positions one and two, 2,4-DNT was detectable at concentrations ranging from 10 to 8,800 $\mu\text{g}/\text{kg}$.

Table 7. Concentrations of 2,4-DNT determined in composite surface (0–1 cm) and subsurface (15–20 cm) soil samples collected near a 105-mm howitzer within five weeks (July 2002) after firing.

Distance from firing platform (m)	Angle from centerline (degrees)	Depth	2,4-DNT ($\mu\text{g}/\text{kg}$)	
			Mark gun 2	Sally gun 5
25	0	Surface	550	230
		Subsurface	4.2	<d
50	0	Surface	150	270
		Subsurface	17	<d
25	–60	Surface	2,900	1,500
		Subsurface	260	<d
50	–60	Surface	53	63
		Subsurface	59	<d
25	+60	Surface	1,800	810
		Subsurface	100	<d
50	+60	Surface	440	100
		Subsurface	250	<d

Table 8. Concentrations of 2,4-DNT detected at FP Mark in June 2002.

Gun #	Distance from firing platform (m)	Angle from centerline (degrees)	2,4-DNT ($\mu\text{g}/\text{kg}$)
1	25	0	1,250
1	50	0	1,000
1	25	–60	410
1	50	–60	200
1	25	+60	2,750
1	50	+60	2,200

Table 9. Concentrations of 2,4-DNT detected at FP Sally in June 2002.

Gun #	Distance from firing platform (m)	Angle from centerline (degrees)	2,4-DNT ($\mu\text{g}/\text{kg}$)
1	25	0	62
1	50	0	110
1	25	-60	255
1	50	-60	740
1	25	+60	520
1	50	+60	4,800
2	25	0	225
2	50	0	8,800
2	25	-60	765
2	50	-60	3,900
2	50	+60	1,500
2	Shell case pile		5,800
3	25	0	3,300
3	50	0	480
3	25	-60	480
3	50	-60	165
3	25	+60	520
3	50	+60	3,200
4	25	0	170
4	50	0	10
4	25	-60	830
4	50	-60	2,400
4	25	+60	1,500
4	50	+60	790
6	25	0	815
6	50	0	490
6	25	-60	66
6	50	-60	110
6	25	+60	<d
6	50	+60	14

Table 10. Concentrations of 2,4-DNT detected at FP Audrey in June 2002.

Gun #	Distance from firing platform (m)	Angle from centerline (degrees)	2,4-DNT ($\mu\text{g}/\text{kg}$)
1	25	0	590
1	50	0	1,200
1	25	-60	77
1	50	-60	170
1	25	+60	330
1	50	+60	46
2	25	0	570
2	40	0	1,700
2	25	-60	2,100
2	50	-60	870
2	25	+60	70
2	44	+60	180
3	25	0	1,100
3	50	0	80
3	25	-60 and +60	110
3	50	-60 and +60	390
4	25	0	1,700
4	50	0	670
4	25	-60 and +60	360
4	50	-60 and +60	570
5	20	0	710
5	25	-60 and +60	230
5	50	-60 and +60	90
6	25	0	1,900
6	25	-60	6,800
6	50	-60	240
6	25	+60	10
6	35	+60	110

Table 11. Concentrations of 2,4-DNT detected at FP Bo-Whale in June 2002.

Gun #	Distance from firing platform (m)	Angle from centerline (degrees)	2,4-DNT ($\mu\text{g}/\text{kg}$)
1	25	0	<d
1	50	0	<d
1	25	-60	<d
1	50	-60	<d
1	25	+60	<d
1	50	+60	<d
2	25	0	<d
2	50	0	2,900
2	25	-60	320
2	50	-60	720
2	25	+60	<d
2	50	+60	<d
3	25	0	6,300
3	50	0	690
3	25	-60	6,800
3	50	-60	120
3	25	+60	5,400
3	50	+60	6,100
4	25	0	4,300
4	50	0	<d
4	25	-60	570
4	50	-60	1,500
4	25	+60	1,000
4	50	+60	620
5	25	0	470
5	50	0	1,400
5	25	-60	700
5	50	-60	400
5	25	+60	830
5	50	+60	1,100

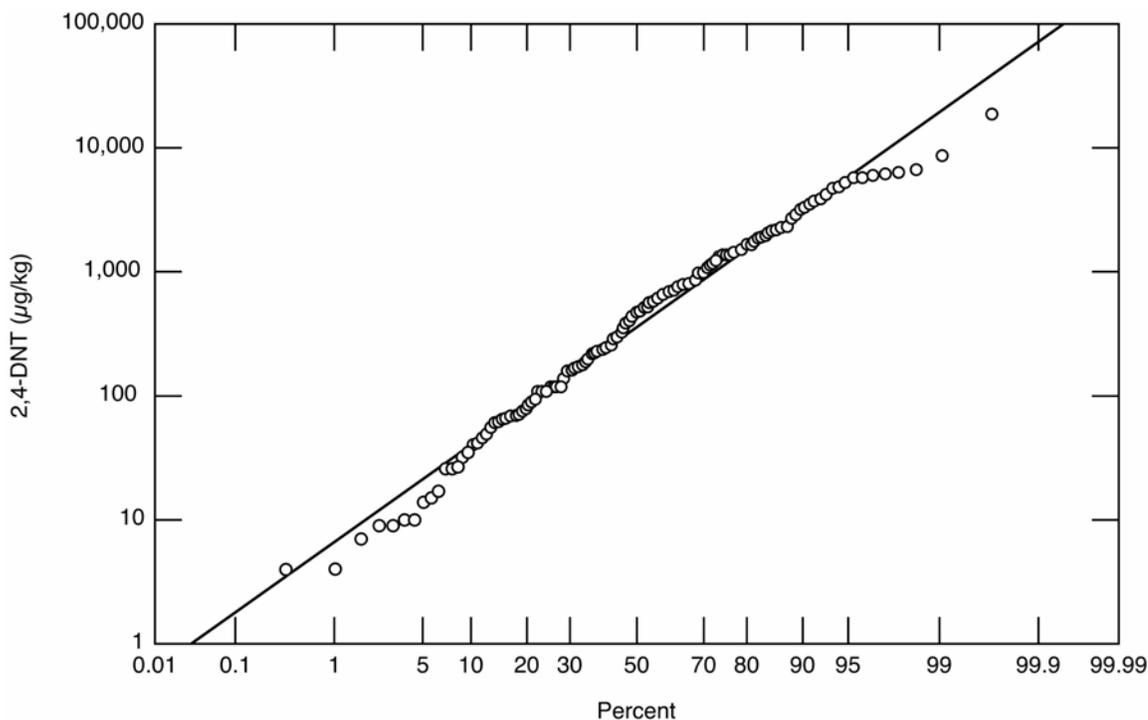


Figure 17. Probability plot of 2,4-DNT concentrations at FP Mark, Sally, Audrey, and Bo-Whale in June 2002. The data are log-normally distributed, and the median concentration was 480 µg/kg.

Pooling the data from FP Mark, Sally, Audrey, and Bo-Whale, we find 155 detections of 2,4-DNT out of the 175 samples collected in June 2002. The data were log-normally distributed (Fig. 17). The median concentration was 480 µg/kg.

The cartridge case for the 105-mm howitzer comes with a full complement of propellants arranged as seven individual bagged and numbered propelling charges (U.S. Army 1994). The distance the projectile is fired depends on the number of propelling charge increments. To fire at less than maximum range, excess propellant bags are removed. The previous practice was to burn these bags on the ground at the firing point. The current practice is to burn the excess propellant in pans at designated locations. The excess propellant for the training exercise in June 2002 was burned in a tray at Observation Point 7. The troops placed some soil in the tray so we could sample what would have been deposited on the soil surface if a tray had not been used. We also collected soil samples from the area downwind from the burn tray. The downwind side was to the southwest and was obvious from the dead leaves on the trees killed by the heat of the fire. Very high concentrations (2,300,000 µg/kg) of 2,4-DNT were detected in the soil from the burn tray 2 (Table 12). Downwind of the tray, concentrations were still high (120,000 µg/kg). We also detected 2,6-DNT in the burn samples,

with concentrations approximately 5% of the corresponding 2,4-DNT concentration.

The Lampkin Range firing point was used for direct fire of the 105-mm howitzers and for other munitions, including mortars. In the two composite samples we collected in July 2002, we found the same two analytes as those we detected in July 2000 (Walsh et al. 2001), namely 2,4-DNT and NG. The 2,4-DNT concentrations (260 and 370 $\mu\text{g}/\text{kg}$) were similar to those detected at the other firing points. NG was detected at 59,000 and 35,000 $\mu\text{g}/\text{kg}$.

Table 12. Concentrations of 2,4-DNT and 2,6-DNT in soil at Observation Point 7 where excess propellant was burned.

	2,4-DNT ($\mu\text{g}/\text{kg}$)	2,6-DNT ($\mu\text{g}/\text{kg}$)
Soil SW of Tray	120,000	5,200
Soil in Burn Tray 1	15,000	630
Soil in Burn Tray 2	2,300,000	130,000

Collection of Propellant Residue from a Snow-covered Firing Point

We detected 2,4-DNT and 2,6-DNT in each of the surface snow samples (Table 13) we collected immediately after the winter firing of 105-mm projectiles (Fig. 13). We computed the equivalent soil concentrations based on the mass of residue deposited in each 1-m² sample area. Assuming that the residues reside in the top 1 cm of soil and that the bulk density of the soil is 1.5 g/cm³, then the mass of soil containing residue in each 1-m² area would be 15 kg. For 2,4-DNT the range of soil concentrations in front of the howitzer would have been 22–1,900 $\mu\text{g}/\text{kg}$, with a median of 430 $\mu\text{g}/\text{kg}$, which is very similar to the median soil concentration for FP Mark, Sally, Audrey, and Bo-Whale (480 $\mu\text{g}/\text{kg}$). The variability of concentrations in neighboring snow samples is also similar to the variability in the soil samples from Donnelly Training Area.

Table 13. 2,4-DNT and 2,6-DNT concentrations detected on snow following the firing of 105-mm howitzers and the equivalent[†] soil concentration.

Sample ID	Distance from firing platform (m)	Angle from centerline (degrees)	2,4-DNT		2,6-DNT	
			Conc. found on snow ($\mu\text{g}/\text{m}^2$)	Equivalent [†] soil conc. ($\mu\text{g}/\text{kg}$)	Conc. found on snow ($\mu\text{g}/\text{m}^2$)	Equivalent [†] soil conc. ($\mu\text{g}/\text{kg}$)
1	4	+40	16,500	1,100	1,120	75
4	5	-10	15,400	1,027	1,060	71
2	6	+40	9,250	617	544	36
7	6	-40	28,200	1,880	1,510	101
3	8	+10	920	61	39	3
6	8	+30	2,770	185	158	11
15	9	+15	9,980	665	674	45
16	12	-20	13,800	920	882	59
8	13	+10	3,660	244	236	16
10	14	+30	1,060	71	69	5
17	15	-50	11,200	747	418	28
12	23	+15	494	33	27	2
13	23	+10	336	22	19	1
14	25	-10	744	50	29	2
5	Gun 3 Breach		305	20	14	1
9	Gun 2 Breach		162	11	12	1
11	Gun 4 Breach		1,430	95	55	4

[†]Assuming that 1-m² of soil with a bulk density of 1.5 g/cm³ is sampled to a depth of 1 cm, the mass of soil would be 15 kg.

6 DISCUSSION

Explosives Residues on Impact Areas

Two of the impact areas that we sampled (Georgia Island and Washington Range West) did not have detectable concentrations of explosives. Georgia Island has not been used for a number of years, and Washington Range West is really a buffer zone for the Washington Impact Area. On Delta Creek, the spatial distribution of explosives residues was similar to what has been observed on other active impact areas. Explosives residues, if detectable at all, are at very low concentrations (parts per billion) over most of the ranges. In contrast, localized areas where ordnance has failed to completely detonate may have solid explosives on the soil surface, and the underlying soil can have high parts-per-million concentrations. Targets, where ordnance detonations are concentrated, can also have detectable concentrations of explosives. On Delta Creek, we found localized high concentrations of TNT, the high-explosive filler of 500-lb bombs. We also found RDX, which could have come from a variety of ordnance items (Table 1), including C4, which is used to detonate unexploded ordnance. NG was also detected in soil under rocket motors. At Delta Creek, explosives residues from range scrap and partially detonated ordnance can move to the surface water by erosion of the floodplain terrace (Fig. 2b).

Propellant Residues at Firing Points

Unlike impact areas, where ordnance residues are for the most part undetectable, each of the howitzer firing points that we have sampled at the Donnelly Training Area and elsewhere have detectable concentrations of 2,4-DNT. The data were log-normally distributed, with median concentrations around 500 $\mu\text{g}/\text{kg}$.

The Agency for Toxic Substances and Disease Registry published a toxicological profile for 2,4-DNT and 2,6-DNT in December 1998 that summarizes information on the adverse health effects and numerous regulations associated with these compounds (Science International Inc. 1998). Munitions workers with chronic DNT exposure had a variety of health problems affecting the circulatory and nervous systems. Both 2,4- and 2,6-DNT caused liver cancer in laboratory animals, and the International Agency for Research on Cancer (IARC) has designated that these chemicals are probable human carcinogens, based on animal data (Group B2) (Science International Inc. 1998). The EPA-derived oral reference doses (RfDs), which are not applicable to cancer risk, are 0.002 mg/kg/day for 2,4-DNT and 0.001 mg/kg/day for 2,6-DNT. Based on these RfDs, the Drinking Water Equivalent Levels are 0.1 and 0.04 mg/L for 2,4-DNT and 2,6-DNT, respectively. Lifetime drinking water advisory values are not listed due to the cancer risk.

The EPA Region III Risk-Based Concentration Table gives soil screening levels for the protection of groundwater based on non-carcinogenic effects (U.S. EPA 2003). For 2,4-DNT and 2,6-DNT (an impurity in military-grade TNT and 2,4-DNT), these values are 29 and 12 $\mu\text{g}/\text{kg}$ for 2,4-DNT and 2,6-DNT, respectively, if the dilution attenuation factor is one, and 570 and 250 $\mu\text{g}/\text{kg}$ for 2,4-DNT and 2,6-DNT, respectively, if the dilution attenuation factor is 20.

In the last few years, states, including Alaska, have issued soil cleanup levels for 2,4-DNT, 2,6-DNT, and several other chemicals. The State of Alaska (Alaska Department of Environmental Conservation 2002) has three sets of soil cleanup standards that are based on climate zones: Arctic (continuous permafrost); Under 40 Inch Zone [less than 40 inches (102 cm) of annual precipitation]; and Over 40 Inch Zone [greater than 40 inches (102 cm) of annual precipitation]. The Big Delta National Weather Service Station receives an average of 12 inches (30 cm) of precipitation a year, so the Donnelly Training Area is in the Under 40 Inch Zone. Alaska Department of Environmental Conservation Title 18 Alaska Administrative Code Chapter 75 lists 2,4-DNT and 2,6-DNT as carcinogenic chemicals. As a result, the soil cleanup standards are extremely low for the protection of groundwater: 5 $\mu\text{g}/\text{kg}$ for 2,4-DNT and 4.4 $\mu\text{g}/\text{kg}$ for 2,6-DNT. The equations and input parameters used to derive these values are described in *Guidance on Cleanup Levels Equations and Input Parameters* (Alaska Department of Environmental Conservation 1999).

Most of the samples at firing points Sally, Mark, Audrey, and Bo-Whale had concentrations of 2,4-DNT that exceeded the Alaska soil cleanup levels by a wide margin. Alternative cleanup levels that are based on site-specific soil data and an approved fate and transport model may be approved if the alternative cleanup levels are “protective of human health, safety, and welfare and the environment” (Alaska Department of Environmental Conservation 2002). The alternative levels must not exceed the ingestion-based levels, which are 12,000 $\mu\text{g}/\text{kg}$ for 2,4-DNT and 2,6-DNT. Most of the samples from the firing points were less than 12,000 $\mu\text{g}/\text{kg}$, but the propellant burn area far exceeded this level. The subsurface samples we collected indicated that downward migration of these contaminants was minimal, but prudent placement of firing points and especially propellant burn locations is desirable because of the low screening levels given for protection of groundwater.

The compound 2,4-DNT biotransforms in the environment and ultimately mineralizes through reductive and/or oxidative pathways. The persistence of 2,4-DNT associated with unburned propellant compositions is unknown, but it is probably enhanced by 2,4-DNT’s residence within a nitrocellulose matrix. Nitrocellulose is insoluble in water and could only migrate to surface water by bulk movement of solids by water or wind.

7 CONCLUSIONS

We sampled some impact areas of the Donnelly Training Area using authoritative sampling, when possible, to try to detect explosives residues in surface soils. We did not detect explosives residues on Georgia Island and Washington Range West. We did detect NG, a propellant residue, in one discrete sample collected under a 40-mm cartridge case on Georgia Island. The target array downstream of the Delta Creek Impact Area appeared to be more heavily used than the previous two areas, and we found explosives residues in all of the samples collected around craters, targets, and ordnance debris. This impact area had been used by the Air Force for training with 500- and 2000-lb bombs, and partial detonations of these bombs created localized areas containing high concentrations of TNT. RDX was detected in several samples; the two highest RDX concentrations were associated with targets. We did not detect TNT, RDX, or other high-explosives residues in composite soil samples collected upstream and downstream from the target array. We did detect NG in discrete samples downstream from the target array; these discrete samples were collected under pieces of rockets. Explosives residues were detectable in each of the soils samples collected from a MOUT/CALFEX site. Specifically, NG was associated with 40-mm grenade training, and low concentrations of TNT, RDX, and 2,4-DNT were associated with explosive ordnance disposal craters.

Soils from recently used firing points have parts-per-million concentrations of NG and 2,4-DNT. These residues are most likely associated with partially burned propellant. The 2,4-DNT is found on the surface of vegetated firing points, and we could not detect any decrease in 2,4-DNT concentrations after 30 days of weathering at either vegetated or sparsely vegetated firing points. Results from replicate field and laboratory samples for 2,4-DNT indicate that sampling error is high; research to improve field and laboratory sampling is ongoing. The highest concentrations of 2,4-DNT were in soils where excess propellant is burned. Fixed firing points and propellant burn areas should be located away from groundwater recharge areas.

Both 2,4-DNT and 2,6-DNT are listed as hazardous substances by the State of Alaska, and very low soil cleanup levels for the protection of groundwater are given for these potentially carcinogenic compounds. Future work will focus on sample collection methods appropriate to obtain average concentrations over a firing point to provide data for possible risk assessment activities.

REFERENCES

- AeroMap U.S.** (2003) Fort Greely Ortho. AeroMap, Anchorage, Alaska.
- Alaska Department of Environmental Conservation** (1999) Guidance on cleanup levels equations and input parameters. July 28, 1999.
- Alaska Department of Environmental Conservation** (2002) 18 AAC 75 Oil and other hazardous substances pollution Control, Article 3, discharge reporting, cleaning and disposal of oil and other hazardous substances, Section 341, Soil cleanup levels; Tables.
- Hewitt, A.D., and M.E. Walsh** (2003) On-site processing and subsampling of surface soil samples for the analysis of explosives. ERDC/CRREL TR-03-14, U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.
- Hewitt, A.D., T.F. Jenkins, and T.A. Ranney** (2001) Field gas chromatography/thermionic detector system for on-site determination of explosives in soils. ERDC/CRREL TR-01-9, U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.
- Hewitt, A.D., T.F. Jenkins, T.A. Ranney, J.A. Stark, M.E. Walsh, S. Taylor, M.R. Walsh, D.J. Lambert, N.M. Perron, N.H. Collins, and R. Karn** (2003) Estimates of explosives residues from the detonation of Army munitions. ERDC/CRREL Technical Report TR-03-16, U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.
- Jorgenson, M.T., J.E. Roth, M.D. Smith, S. Schlentner, W. Lentz, E.R. Pullman, and C.H. Racine** (2001) An ecological land survey for Fort Greely, Alaska. ERDC/CRREL TR-01-4, U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.
- Ku, H.H.** (1969) Statistical concepts in metrology. In *Precision Measurement and Calibration: Statistical Concepts and Procedures*. Volume 1, Special Publication 300, National Bureau of Standards, Washington, D.C.
- Miller, J.C., and J.N. Miller** (1984) *Statistics for Analytical Chemistry*. New York: John Wiley and Sons.
- Paetz, A., and G. Crößmann** (1994) Problems and results in the development of international standards for sampling and pretreatment of soils. In *Environmental Sampling and Analysis* (B. Market, ed.). Weinheim, Germany: VCH Verlagsgesellschaft mbH.

Péwé, T.L. (1975) Quaternary geology of Alaska. Professional Paper 835, U.S. Geological Survey.

Péwé, T.L., and G.W. Holmes (1964) Geology of the Mt. Hayes D-4 quadrangle, Alaska. Miscellaneous Geologic Investigations Map I-394, U.S. Geological Survey.

Sciences International, Inc. (1998) Toxicological profile for 2,4- and 2,6-dinitrotoluene. Report prepared under subcontract to Research Triangle Institute under Contract No. 205-93-0606 for the U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

U.S. Army (1984) Military explosives. Technical Manual TM9-1300-214, Department of the Army, Washington, D.C.

U.S. Army (1994) Army ammunition data sheets: Artillery ammunition, guns, howitzers, mortars, recoilless rifles, grenade launchers, and artillery fuzes. Technical Manual 43-0001-28, Department of the Army, Washington, D.C.

U.S. Army Alaska (1999) Final legislative environmental impact statement for Alaska Army lands withdrawal renewal. U.S. Army Alaska, Department of the Army, Fort Richardson, Anchorage, Alaska.

U.S. Army Alaska (2002) Training: USARAK range regulation. U.S. Army Alaska Regulation 350-2, U.S. Army Alaska, Department of the Army, Fort Richardson, Anchorage, Alaska.

U.S. Army Alaska (2003) Draft environmental impact statement for transformation of U.S. Army Alaska. U.S. Army Alaska, Department of the Army, Fort Richardson, Anchorage, Alaska.

U.S. Environmental Protection Agency (1994) SW846 Method 8330, Nitroaromatics and nitramines by HPLC. II Update (<http://www.epa.gov/epaoswer/hazwaste/test/8330.pdf>), September 1994.

U.S. Environmental Protection Agency (1996) Method 8515, Colorimetric screening method for trinitrotoluene (TNT) in soil. III Update (<http://www.epa.gov/epaoswer/hazwaste/test/8515.pdf>), December 1996.

U.S. Environmental Protection Agency (2000) SW846 8510, Colorimetric screening procedure for RDX and HMX in soil. IVB Update. (<http://www.epa.gov/epaoswer/hazwaste/test/8510.pdf>), November, 2000.

U.S. Environmental Protection Agency (2001) Environmental technology verification report explosives detection technology: SRI Instruments Model 8610C, Gas chromatograph/thermionic ionization detection. EPA/600/R-01/065, Office of Research and Development, Washington, D.C.

U.S. Environmental Protection Agency (2003) Risk assessment, Mid-Atlantic Hazardous Site Cleanup. <http://www.epa.gov/reg3hwmd/risk/index.htm>, updated October 16, 2003.

Walsh, M.E., C.M. Collins, C.H. Racine, T.F. Jenkins, A.B. Gelvin, and T.A. Ranney (2001) Sampling for explosives residues at Fort Greely, Alaska: Reconnaissance visit, July 2000. ERDC/CRREL TR-01-15, U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.

Walsh, M.E., C.A. Ramsey, and T.F. Jenkins (2002) The effect of particle size reduction by grinding on subsampling variance for explosives residues in soil. *Chemosphere*, **49**: 1267–1273.

Appendix A. Analytical results from 2001.

Sample Type	Collector	Unique ID	Field Notes	Date Collected	Area	East (m)	North (m)	Elevation (m)	Lab Notes or ID	Field ID	Lab	Rep Units	HMX	RDX	TNB	DNB	TRTVL	TNT	4A-DNT	2A-DNT	2,6-DNT	2,4-DNT	NB	2-NT	3-NT	4-NT	NG	3,5-DNA	
Composite	JAS-CMC	DC007	4 m crater edge	6/9/2001	Simpsonville	521,232.2	7,091,682.5	601.5	CRREL Lab GC	DC007		pp/kg	<25	18.2	<1	<1	<1	57.7	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC008	3 m crater	6/9/2001	Simpsonville	521,238.1	7,091,680.8	601.1	CRREL Lab GC	DC008		pp/kg	<25	26.4	<1	<1	<1	142	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC009	4 m crater	6/9/2001	Simpsonville	521,224.6	7,091,679.0	601.0	CRREL Lab GC	DC009		pp/kg	<25	9.4	<1	<1	<1	14.8	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC007,8,9	DC007, DC008, DC009 combined						CRREL Lab GC	DC007,8,9		1 pp/kg	<25	36	<1	<1	<1	102	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC007,8,9	DC007, DC008, DC009 combined						CRREL Lab GC	DC007,8,9		2 pp/kg	<25	34.4	<1	<1	<1	102	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC010	4 m crater	6/9/2001	Simpsonville	521,231.6	7,091,681.7	601.9	CRREL Lab GC	DC010		pp/kg	<25	7.43	<1	<1	<1	22	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC011	40 mm (?) crater	6/9/2001	Simpsonville	521,171.6	7,091,757.6	612.1	CRREL Lab GC	DC011		pp/kg	<25	5.27	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC012	40 mm (?) crater	6/9/2001	Simpsonville	521,172.2	7,091,840.3	617.5	CRREL Lab GC	DC012		pp/kg	<25	5.3	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC013	40 mm (?) crater	6/9/2001	Simpsonville	521,240.9	7,091,740.8	610.2	CRREL Lab GC	DC013		pp/kg	<25	3.3	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC014	composite around lg 4 m crater	6/9/2001	Delta Creek	524,596.5	7,094,666.0	539.8	CRREL Lab GC	DC014		1 pp/kg	<25	3.3	<1	<1	<1	0.4	16.7	8.32	<1	<1	NA	NA	NA	NA	1.8	3.36	
Composite	JAS-CMC	DC014	composite around lg 4 m crater						CRREL Lab GC	DC014		2 pp/kg	<25	3.3	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	3.56	2.38	
Composite	JAS-CMC	DC015	composite around 3 m crater	6/9/2001	Delta Creek	524,596.2	7,094,690.0	529.9	CRREL Lab GC	DC015		1 pp/kg	<25	3.3	<1	<1	<1	3.04	17.2	47.6	<1	<1	NA	NA	NA	NA	1.2	4.94	
Composite	JAS-CMC	DC015	composite around 3 m crater						CRREL Lab GC	DC015		2 pp/kg	<25	3.3	<1	<1	<1	3.04	17.2	47.6	<1	<1	NA	NA	NA	NA	1.6	5.38	
Composite	JAS-CMC	DC016	composite around 3 m crater	6/9/2001	Delta Creek	524,635.2	7,094,698.4	530.4	CRREL Lab GC	DC016		1 pp/kg	<25	3.3	<1	<1	<1	3.36	18.3	8.84	<1	<1	NA	NA	NA	NA	1.84	25.4	
Composite	JAS-CMC	DC016	composite around 3 m crater						CRREL Lab GC	DC016		2 pp/kg	<25	3.3	<1	<1	<1	88.6	15.6	19	<1	<1	4.93	NA	NA	NA	2.06	20.8	
Composite	JAS-CMC	DC017	composite from 3 small (30mm ?) craters	6/9/2001	Delta Creek	524,645.2	7,094,727.4	528.8	CRREL Lab GC	DC017		pp/kg	<25	3.3	<1	<1	<1	0.57	0.79	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC017	composite around lg crater						CRREL Lab GC	DC017		1 pp/kg	<25	3.3	<1	<1	<1	0.44	5.34	1.08	<1	<1	0.96	NA	NA	NA	0.92	0.76	
Composite	JAS-CMC	DC018	composite around lg crater	6/9/2001	Delta Creek	524,635.2	7,094,698.4	530.4	CRREL Lab GC	DC018		2 pp/kg	<25	3.3	<1	<1	<1	0.6	6.06	3.1	<1	<1	0.92	NA	NA	NA	1.02	0.92	
Discrete	JAS-CMC	DC019	low order det crater; 500 lb bomb, discrete sample below piece of bomb	6/9/2001	Delta Creek	524,811.5	7,094,625.4	530.6	CRREL Lab GC	DC019		pp/kg	NA	NA	NA	NA	NA	17,300,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Discrete	JAS-CMC	DC020	turned up area from 30mm?	6/9/2001	Delta Creek	524,853.7	7,094,848.7	534.4	CRREL Lab GC	DC020		pp/kg	<25	3.3	<1	<1	<1	0.63	0.7	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC021	comp sample inside edge 4 m crater	6/9/2001	Delta Creek	525,030.4	7,094,897.5	534.4	CRREL Lab GC	DC021		pp/kg	<25	7.66	<1	<1	<1	5.81	15.8	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Discrete	JAS-CMC	DC022	grab sample from around low order bomb	6/9/2001	Delta Creek	524,938.9	7,094,927.8	533.1	CRREL Lab GC	DC022		pp/kg	<25	7.73	<1	<1	<1	644	33	<1	<1	<1	1.68	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC023	Comp sample from small crater	6/9/2001	Delta Creek	524,878.8	7,094,784.5	530.8	CRREL Lab GC	DC023		1 pp/kg	<25	77.8	<1	<1	<1	15.4	260	90	<1	<1	5.4	NA	NA	NA	38.4	20.6	
Composite	JAS-CMC	DC023	Comp sample from small crater						CRREL Lab GC	DC023		2 pp/kg	<25	62.6	<1	<1	<1	12.1	206	72	<1	<1	5.4	NA	NA	NA	50.8	15.7	
Composite	JAS-CMC	DC024	Comp sample from fresh 3m crater near pickup truck	6/9/2001	Delta Creek	524,790.9	7,094,733.2	530.6	CRREL Lab GC	DC024		pp/kg	<25	3.3	<1	<1	<1	3,900	215	<1	<1	<1	18	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC025	Comp sample around pickup truck	6/9/2001	Delta Creek	524,795.5	7,094,737.1	531.1	CRREL Lab GC	DC025		pp/kg	<25	37.6	<1	<1	<1	24,000	680	<1	<1	<1	32.8	NA	NA	NA	5.37	<2	
Composite	JAS-CMC	DC026	Comp sample around "undisturbed" area within vegetated floodplain	6/9/2001	Delta Creek	524,726.6	7,094,678.4	533.4	CRREL Lab GC	DC026		pp/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Composite	JAS-CMC	DC027	Comp sample around large crater	6/9/2001	Delta Creek	524,892.8	7,094,645.6	530.7	CRREL Lab GC	DC027		1 pp/kg	1.8	8.26	75	<1	<1	1810	61	50.3	<1	<1	1.96	NA	NA	NA	<15	4.62	
Composite	JAS-CMC	DC027	Comp sample around large crater						CRREL Lab GC	DC027		2 pp/kg	2	6.6	70	<1	<1	1820	59.4	49.4	<1	<1	1.94	NA	NA	NA	<15	4.96	
Composite	JAS-CMC	DC028	Comp sample in unveget gravel bar area	6/9/2001	Delta Creek	524,587.4	7,094,619.8	532.7	CRREL Lab GC	DC028		1 pp/kg	4.6	<3	282	<1	<1	892	44	46	<1	<1	3.2	NA	NA	NA	1.28	44	
Composite	JAS-CMC	DC028	Comp sample in unveget gravel bar area						CRREL Lab GC	DC028		2 pp/kg	5	31.6	334	<1	<1	756	51.2	54	<1	<1	3.4	NA	NA	NA	2.4	54	
Composite	JAS-CMC	DC029	Comp sample around target	6/9/2001	Delta Creek	524,602.9	7,094,636.1	532.4	CRREL Lab GC	DC029		1 pp/kg	96.4	1,340	15.4	<1	<1	115	26	18	<1	<1	2.2	NA	NA	NA	2.8	5	
Composite	JAS-CMC	DC029	Comp sample around target						CRREL Lab GC	DC029		2 pp/kg	108	1,380	15.9	<1	<1	110	26	19	<1	<1	2.3	NA	NA	NA	2.7	4.8	
Composite	JAS-CMC	DC030	Comp sample from gravel bar along LI bank	6/9/2001	Delta Creek	526,238.8	7,096,235.2	510.6	CRREL Lab GC	DC030		pp/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC030	Comp sample from gravel bar along LI bank						CRREL Lab GC	DC030		pp/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC033	Comp sample from vegetated abandoned floodplain surface (<20-30 year old surface)	6/9/2001	Delta Creek	526,454.1	7,096,448.3	507.2	CRREL Lab GC	DC033		pp/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	<15	<2
Composite	JAS-CMC	DC033	Comp sample from vegetated abandoned floodplain surface (<20-30 year old surface)						CRREL Lab GC	DC033		pp/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	<15	<2
Composite	JAS-CMC	DC034	Sample of part of rocket motor (?) orange sheet of plastic looking material. Took material plus sand underneath.	6/9/2001	Delta Creek	528,258.9	7,098,461.3	478.2	CRREL Lab GC	DC034		pp/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	<15	<2
Discrete	JAS-CMC	DC035	Comp sample from gravel bar along LI bank	6/9/2001	Delta Creek	528,261.9	7,098,563.0	478.5	CRREL Lab GC	DC035		pp/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC036	Comp sample from gravel point bar between 2 small channels at LI edge of floodplain	6/9/2001	Delta Creek	528,308.4	7,098,666.7	477.1	CRREL Lab GC	DC036		pp/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	<15	<2	
Composite	JAS-CMC	DC037	Comp sample from gravel point bar between 2 small channels at LI edge of floodplain						CRREL Lab GC	DC037		pp/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	<15	<2	

= not confirmed
 NA = not analyzed for this compound
 ND = not detected
 NR = not reported

Appendix A (cont.).

Sample Type	Collector	Unique ID	Field Notes	Date Collected	Area	East (m)	North (m)	Elevation (m)	Lab Notes or ID	Field ID	Lab Rep Units	HMX	ROX	TNB	DNB	TETRYL	TNT	4A-DNT	2A-DNT	2,6-DNT	2,4-DNT	NB	2,NT	3,NT	4,NT	NG	3,5-DNA	
Discrete	JAS-CMC	DC038	Sample of part of rocket motor (?) orange sheet of plastic looking material. Took material plus sand underneath.	6/9/2001	Delta Creek	529,278.5	7,098,586.7	478.7	CRREL Lab GC,	DC038	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	535	
Composite	JAS-CMC	DC 35 and 38	DC 35 and 38 combined						Ground, ~2mm	DC 35 and 38	1 µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	87.5	
Composite	JAS-CMC	DC 35 and 38	DC 35 and 38 combined						Ground, ~2mm	DC 35 and 38	2 µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	78.8	
Composite	JAS-CMC	DC039	Comp sample from gravel bar along LI bank	6/9/2001	Delta Creek	529,969.8	7,101,396.6	450.1	CRREL Lab GC,	DC039	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	DC040	Comp sample from gravel bar along LI bank	6/9/2001	Delta Creek	530,098.6	7,101,505.0	452.1	CRREL Lab GC,	DC040	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	DC041	Comp sample from gravel bar along LI bank	6/9/2001	Delta Creek	530,271.7	7,101,624.7	451.2	CRREL Lab GC,	DC041	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	DC042	Older, higher, partially vegetated gravel bar	6/9/2001	Delta Creek	530,060.0	7,101,575.1	453.2	CRREL Lab GC,	DC042	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Discrete	JAS-CMC	DC043	Silt sample from within dry channel	6/9/2001	Delta Creek	529,974.9	7,101,412.8	452.9	CRREL Lab GC,	DC043	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Discrete	JAS-CMC	DC044	Fine sand sample from within dry channel	6/9/2001	Delta Creek	529,975.2	7,101,411.1	452.7	CRREL Lab GC,	DC044	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	DC045	Comp sample from gravel bar just upstream of	6/9/2001	Delta Creek	532,186.0	7,104,205.6	427.9	CRREL Lab GC,	DC045	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	DC046	Comp sample from gravel bar, just upstream of	6/9/2001	Delta Creek	532,129.5	7,104,397.2	427.9	CRREL Lab GC,	DC046	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	DC047	Comp sample, older part of flood plain (~10 yr old) sample from gravel bar, downstream	6/9/2001	Delta Creek	532,013.2	7,104,516.1	428.7	CRREL Lab GC,	DC047	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	DC048	Comp sample from gravel bar, downstream of	6/9/2001	Delta Creek	531,725.3	7,106,160.4	407.8	CRREL Lab GC,	DC048	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	DC049	Comp sample from gravel bar, just	6/9/2001	Delta Creek	531,798.7	7,106,109.4	406.6	CRREL Lab GC,	DC049	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	DC050	Comp sample from gravel bar, just downstream of junc, with 100 Mile Creek	6/9/2001	Delta Creek	531,956.2	7,105,971.0	407.8	CRREL Lab GC,	DC050	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC001	Comp sample along edge of point bar	6/9/2001	Hundred Mile Creek	532,793.0	7,104,097.6	425.0	CRREL Lab GC,	HC001	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC002	Downstream, same side of channel	6/9/2001	Hundred Mile Creek	532,888.0	7,104,097.9	424.8	CRREL Lab GC,	HC002	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC003	Comp sample, small point bar	6/9/2001	Hundred Mile Creek	532,747.5	7,103,966.3	428.3	CRREL Lab GC,	HC003	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC004	Comp sample, small point bar	6/9/2001	Hundred Mile Creek	532,988.2	7,103,046.1	433.0	CRREL Lab GC,	HC004	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC005	Comp sample, small point bar	6/9/2001	Hundred Mile Creek	532,975.5	7,103,102.9	433.1	CRREL Lab GC,	HC005	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC006	Comp sample, small point bar	6/9/2001	Hundred Mile Creek	532,779.6	7,101,346.0	437.3	CRREL Lab GC,	HC006	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC007	Comp sample, small point bar	6/9/2001	Hundred Mile Creek	532,818.6	7,101,342.4	433.1	CRREL Lab GC,	HC007	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC008	Comp sample, small point bar	6/9/2001	Hundred Mile Creek	532,853.1	7,101,389.1	432.6	CRREL Lab GC,	HC008	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC009	Comp sample, small point bar	6/9/2001	Hundred Mile Creek	533,421.0	7,100,346.5	428.9	CRREL Lab GC,	HC009	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC010	Comp sample, small point bar	6/9/2001	Hundred Mile Creek	533,412.2	7,100,307.2	432.1	CRREL Lab GC,	HC010	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC011	Comp sample, small point bar	6/9/2001	Hundred Mile Creek	533,359.9	7,100,411.2	437.5	CRREL Lab GC,	HC011	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC012	upstream of small drainage entering from south	6/9/2001	Hundred Mile Creek	533,340.0	7,100,378.5	433.3	CRREL Lab GC,	HC012	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC013	Also upstream of small drainage entering from south	6/10/2001	Hundred Mile Creek	535,999.1	7,098,588.1	450.1	CRREL Lab GC,	HC013	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC014	upstream of small drainage entering from south	6/10/2001	Hundred Mile Creek	535,940.9	7,098,583.5	441.8	CRREL Lab GC,	HC014	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Discrete	JAS-CMC	HC015	Grab sample from tributary	6/10/2001	Hundred Mile Creek	535,948.2	7,098,445.3	440.0	CRREL Lab GC,	HC015	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Discrete	JAS-CMC	HC016	Grab sample from tributary	6/10/2001	Hundred Mile Creek	535,935.6	7,098,395.9	440.3	CRREL Lab GC,	HC016	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Discrete	JAS-CMC	HC017	Grab sample from side channel of tributary	6/10/2001	Hundred Mile Creek	535,967.6	7,098,413.8	440.0	CRREL Lab GC,	HC017	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC018	Comp sample, downstream of junc with tributary	6/10/2001	Hundred Mile Creek	536,004.7	7,098,690.0	445.0	CRREL Lab GC,	HC018	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC019	Comp sample, downstream of HC018	6/10/2001	Hundred Mile Creek	536,070.3	7,098,670.2	444.5	CRREL Lab GC,	HC019	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC020	Comp sample, downstream of HC019	6/10/2001	Hundred Mile Creek	536,058.6	7,098,810.3	442.9	CRREL Lab GC,	HC020	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC021	Comp sample, small point bar	6/10/2001	Hundred Mile Creek	536,741.4	7,097,139.6	454.9	CRREL Lab GC,	HC021	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC022	Comp sample, small point bar	6/10/2001	Hundred Mile Creek	536,752.9	7,097,221.8	452.3	CRREL Lab GC,	HC022	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	HC023	Comp sample, small point bar	6/10/2001	Hundred Mile Creek	536,823.4	7,097,226.3	453.1	CRREL Lab GC,	HC023	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	
Composite	JAS-CMC	GI001	Comp sample down Ct. of island	7/31/2001	Georgia Island	558,904.6	7,094,611.0	390.3	100439	GI001	µg/kg	NR	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<118	<118	<118	NA	NA
Composite	JAS-CMC	GI002	Comp sample down Ct. of island	7/31/2001	Georgia Island	558,780.9	7,094,424.5	388.8	100440	GI002	µg/kg	NR	<24.8	<24.8	<24.8	<24.8	<24.8	<24.8	<24.8	<24.8	<24.8	<24.8	<24.8	<124	<124	<124	NA	NA
Composite	JAS-CMC	GI003	Comp sample down Ct. of island	7/31/2001	Georgia Island	558,760.6	7,094,213.7	391.8	100441	GI003	µg/kg	NR	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<122	<122	<122	NA	NA
Composite	JAS-CMC	GI004	Comp sample down Ct. of island	7/31/2001	Georgia Island	558,760.6	7,094,213.7	391.8	100442	GI004	µg/kg	NR	<24.8	<24.8	<24.8	<24.8	<24.8	<24.8	<24.8	<24.8	<24.8	<24.8	<24.8	<124	<124	<124	NA	NA
Composite	JAS-CMC	GI005	Comp sample down Ct. of island	7/3																								

Appendix A (cont.). Analytical results from 2001.

Sample Type	Collector	Unique ID	Field Notes	Date	Area	East (m)	North (m)	Elevation (m)	Lab Notes or ID	Field ID	Rep Units	HMX	RDX	TNB	DNB	TEIRYL	TNT	4A-DNT	2A-DNT	2,6-DNT	2,4-DNT	NB	2-NIT	3-NIT	4-NIT	NG	3,5-DNA		
Composite	JAS-CMC	GI007	Comp sample down CL of island	7/31/2001	Georgia Island	558,233.9	7,093,564.5	388.5	100443	GI007	1	NR	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	NA	
Composite	JAS-CMC	GI008	Comp sample down CL of island	7/31/2001	Georgia Island	557,819.9	7,093,271.4	400.9	100444	GI008	1	NR	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	NA
Composite	JAS-CMC	GI009	Comp sample down CL of island	7/31/2001	Georgia Island	557,851.9	7,093,686.6	396.9	100445	GI009	1	NR	<24.3	56.9 #	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	NA
Composite	JAS-TJ-HM	GI010	Comp sample along base of target berm	8/1/2001	Georgia Island	557,746.0	7,093,301.1	399.6	100446	GI010	1	NR	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	NA	
Composite	JAS-TJ-HM	GI011	Comp sample along base of target berm	8/1/2001	Georgia Island	557,744.7	7,093,343.6	398.3	100447	GI011	1	NR	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	NA	
Composite	JAS-TJ-HM	GI012	Comp sample along base of target berm	8/1/2001	Georgia Island	557,743.8	7,093,410.1	400.3	101326	GI012	1	NR	<27.2	<27.2	<27.2	<27.2	<27.2	<27.2	<27.2	<27.2	<27.2	<27.2	<27.2	<27.2	<27.2	<27.2	<27.2	NA	
Composite	JAS-TJ-HM	GI013	Comp sample along base of target berm	8/1/2001	Georgia Island	557,742.5	7,093,431.4	398.3	101327	GI013	1	NR	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	NA	
Discrete	JAS-CMC	GI001	Discrete sample	8/1/2001	Georgia Island	557,741.9	7,093,443.3	388.0	100415	DISCRETE 002 GI	1	NR	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	<24.3	NA	
Composite	JAS-TJ-HM	GI014	Comp sample along base of target berm	8/1/2001	Georgia Island	557,741.1	7,093,474.0	397.3	100448	GI014	1	NR	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	NA	
Composite	JAS-TJ-HM	GI015	Comp sample down center line of island	8/1/2001	Georgia Island	557,801.4	7,093,515.0	398.6	101328	GI015	1	NR	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	NA	
Composite	JAS-TJ-HM	GI016	Comp sample down center line of island	8/1/2001	Georgia Island	557,805.6	7,093,461.3	393.8	101329	GI016	1	NR	<22.2	<22.2	<22.2	<22.2	<22.2	<22.2	<22.2	<22.2	<22.2	<22.2	<22.2	<22.2	<22.2	<22.2	<22.2	NA	
Composite	JAS-TJ-HM	GI017	Comp sample down center line of island	8/1/2001	Georgia Island	557,801.8	7,093,461.3	393.8	101330	GI017	1	NR	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	NA	
Composite	JAS-TJ-HM	GI018	Comp sample down center line of island	8/1/2001	Georgia Island	557,785.4	7,093,369.3	396.0	100449	GI018	1	NR	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	NA	
Composite	JAS-TJ-HM	GI019	Comp sample down center line of island	8/1/2001	Georgia Island	557,785.4	7,093,369.3	396.0	100449	GI019	1	NR	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	NA	
Composite	JAS-TJ-HM	GI020	Comp sample down center line of island	8/1/2001	Georgia Island	557,783.2	7,093,002.9	394.7	101332	GI020	1	NR	<22.9	<22.9	<22.9	<22.9	<22.9	<22.9	<22.9	<22.9	<22.9	<22.9	<22.9	<22.9	<22.9	<22.9	<22.9	NA	
Composite	JAS-TJ-HM	GI021	Comp sample down center line of island	8/1/2001	Georgia Island	557,768.7	7,092,883.6	396.5	101333	GI021	1	NR	<25.6	<25.6	<25.6	<25.6	<25.6	<25.6	<25.6	<25.6	<25.6	<25.6	<25.6	<25.6	<25.6	<25.6	<25.6	NA	
Composite	JAS-TJ-HM	GI022	Comp sample down center line of island	8/1/2001	Georgia Island	557,412.8	7,092,758.4	399.1	101334	GI022	1	NR	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	NA	
Composite	JAS-TJ-HM	GI023	Comp sample down center line of island	8/1/2001	Georgia Island	557,412.8	7,092,758.4	399.1	101334	GI023	1	NR	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	NA	
Composite	JAS-TJ-HM	GI024	Comp sample down center line of island	8/1/2001	Georgia Island	557,098.6	7,092,511.9	403.7	101335	GI024	1	NR	<23.3	<23.3	<23.3	<23.3	<23.3	<23.3	<23.3	<23.3	<23.3	<23.3	<23.3	<23.3	<23.3	<23.3	<23.3	NA	
Composite	JAS-TJ-HM	GI025	Comp sample down center line of island	8/1/2001	Georgia Island	556,954.4	7,092,317.9	404.5	100451	GI025	1	NR	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	NA	
Composite	JAS-TJ-HM	GI026	Comp sample down center line of island	8/1/2001	Georgia Island	556,828.1	7,092,217.9	407.4	100452	GI026	1	NR	<23.6	<23.6	<23.6	<23.6	<23.6	<23.6	<23.6	<23.6	<23.6	<23.6	<23.6	<23.6	<23.6	<23.6	<23.6	NA	
Composite	JAS-TJ-HM	GI027	Comp sample down center line of island	8/1/2001	Georgia Island	556,738.1	7,092,038.3	406.5	100453	GI027	1	NR	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	NA	
Composite	JAS-TJ-HM	GI028	Comp sample down center line of island	8/1/2001	Georgia Island	556,610.8	7,091,881.4	406.3	101336	GI028	1	NR	<26.3	<26.3	<26.3	<26.3	<26.3	<26.3	<26.3	<26.3	<26.3	<26.3	<26.3	<26.3	<26.3	<26.3	<26.3	NA	
Composite	JAS-TJ-HM	GI029	Comp sample down center line of island	8/1/2001	Georgia Island	556,538.5	7,091,488.4	408.9	100454	GI029	1	NR	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	NA	
Composite	JAS-CMC	GI031	Comp sample down center line of island	8/2/2001	Georgia Island	556,538.5	7,091,488.4	408.9	100454	GI031	1	NR	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	<23.8	NA	
Composite	JAS-CMC	GI032	Comp sample down center line of island	8/2/2001	Georgia Island	556,437.2	7,091,309.1	409.9	100454	GI032	1	NR	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	NA	
Discrete	JAS-CMC	DISCRET	Discrete sample-next to 105 HC uro	8/2/2001	Georgia Island	556,382.6	7,091,193.1	408.4	CC	DISCRETE GI002	1	NR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Composite	JAS-CMC	GI033	Comp sample down CL of island	8/2/2001	Georgia Island	556,302.2	7,091,161.7	408.3	101339	GI033	1	NR	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	<24.4	NA	
Composite	JAS-CMC	GI034	Comp sample down CL of island	8/2/2001	Georgia Island	556,238.6	7,090,772.8	413.5	100456	GI034	1	NR	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	<25.4	NA	
Discrete	JAS-CMC	DISCRET	Discrete sample-next to 40 mm cases	8/2/2001	Georgia Island	556,201.3	7,090,675.3	408.0	CRREL Field GC	DISCRETE GI003	1	NR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Composite	JAS-CMC	GI039	Comp sample down CL of island	8/2/2001	Georgia Island	558,175.8	7,090,659.5	415.1	101340	GI039	1	NR	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	NA	
Composite	JAS-CMC	GI037	Comp sample down CL of island	8/2/2001	Georgia Island	556,103.9	7,090,393.2	415.1	100455	GI037	1	NR	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	NA	
Composite	JAS-CMC	GI038	Comp sample down CL of island	8/2/2001	Georgia Island	556,084.3	7,090,189.3	412.8	101341	GI038	1	NR	<26.7	<26.7	<26.7	<26.7	<26.7	<26.7	<26.7	<26.7	<26.7	<26.7	<26.7	<26.7	<26.7	<26.7	<26.7	NA	
Composite	JAS-CMC	GI039	Comp sample South end of Georgia Is	8/2/2001	Georgia Island	556,057.7	7,090,034.4	413.2	101342	GI039	1	NR	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	<24.0	NA	
Discrete	JAS-CMC	DISCRET	Sample top of SE facing bluff	8/2/2001	Georgia Island	556,468.3	7,090,332.0	419.5	CRREL Field GC	DISCRETE GI004	1	NR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Discrete	JAS-CMC	DISCRET	Sample top of S facing bluff	8/2/2001	Georgia Island	556,333.2	7,090,363.1	425.7	100416	DISCRETE 005 GI	1	NR	<24.2	<24.2	<24.2	<24.2	<24.2	<24.2	<24.2	<24.2	<24.2	<24.2	<24.2	<24.2	<24.2	<24.2	<24.2	NA	
Composite	JAS-CMC	GI040	Comp sample along base of bluff	8/2/2001	Georgia Island	556,384.8	7,090,306.0																						

Appendix A (cont.).

Sample Type	Collector	Unique ID	Field Notes	Date Collected	Area	East (m)	North (m)	Elevation (m)	Lab Notes of ID	Field ID	Lab Rep Units	HMX	RDX	TNB	DNB	TETRYL	TNT	4A-DNT	2A-DNT	2,6-DNT	2,4-DNT	NB	2-NT	3-NT	4-NT	NG	3,5-DNA	
Composite MEW	TJ-KM-MC-MEW	BW3-A	14 m from Base Plate	8/2/2001	Bow Whale FP	555,822.3	7,082,261.2	503.0	HPLC and GC, CHREL Lab	BW3-A	2 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	26.6	732	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW3-B	14 m from Base Plate	8/2/2001	Bow Whale FP	555,822.3	7,082,261.2	503.0	HPLC and GC, CHREL Lab	BW3-B	1 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	46	1400	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW3-B	14 m from Base Plate	8/2/2001	Bow Whale FP	555,822.3	7,082,261.2	503.0	HPLC and GC, CHREL Lab	BW3-B	2 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	77.9	2010	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW4-A	21 m from Base Plate	8/2/2001	Bow Whale FP	555,819.2	7,082,267.4	502.8	HPLC and GC, CHREL Lab	BW4-A	1 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	35.7	1280	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW4-A	21 m from Base Plate	8/2/2001	Bow Whale FP	555,819.2	7,082,267.4	502.8	HPLC and GC, CHREL Lab	BW4-A	2 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	31	1120	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BS4-B	21 m from Base Plate	8/2/2001	Bow Whale FP	555,819.2	7,082,267.4	502.8	HPLC and GC, CHREL Lab	BS4-B	1 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	51.9	1520	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BS4-B	21 m from Base Plate	8/2/2001	Bow Whale FP	555,819.2	7,082,267.4	502.8	HPLC and GC, CHREL Lab	BS4-B	2 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	96.1	2300	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW5-A	28 m from Base Plate	8/2/2001	Bow Whale FP	555,816.2	7,082,273.7	502.8	HPLC and GC, CHREL Lab	BW5-A	1 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	763	16900	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW5-A	28 m from Base Plate	8/2/2001	Bow Whale FP	555,816.2	7,082,273.7	502.8	HPLC and GC, CHREL Lab	BW5-A	2 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	1300	29600	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW5-B	28 m from Base Plate	8/2/2001	Bow Whale FP	555,816.2	7,082,273.7	502.8	HPLC and GC, CHREL Lab	BW5-B	1 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	1160	24000	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW5-B	28 m from Base Plate	8/2/2001	Bow Whale FP	555,816.2	7,082,273.7	502.8	HPLC and GC, CHREL Lab	BW5-B	2 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	1330	29100	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW6	50 m from Base Plate (30 degrees)	8/2/2001	Bow Whale FP	555,787.2	7,082,278.3	499.3	HPLC and GC, CHREL Lab	BW6	1 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	153	4020	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW6	50 m from Base Plate (30 degrees)	8/2/2001	Bow Whale FP	555,787.2	7,082,278.3	499.3	HPLC and GC, CHREL Lab	BW6	2 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	126	2840	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW7	50 m from Base Plate (15 degrees)	8/2/2001	Bow Whale FP	555,796.6	7,082,286.0	499.7	HPLC and GC, CHREL Lab	BW7	1 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	365	8320	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW7	50 m from Base Plate (15 degrees)	8/2/2001	Bow Whale FP	555,796.6	7,082,286.0	499.7	HPLC and GC, CHREL Lab	BW7	2 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	235	5660	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW8	50 m from Base Plate (0 degrees)	8/2/2001	Bow Whale FP	555,805.8	7,082,293.8	501.1	HPLC and GC, CHREL Lab	BW8	1 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	219	6790	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW8	50 m from Base Plate (0 degrees)	8/2/2001	Bow Whale FP	555,805.8	7,082,293.8	501.1	HPLC and GC, CHREL Lab	BW8	2 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	209	5730	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW9	50 m from Base Plate (15 degrees)	8/2/2001	Bow Whale FP	555,816.1	7,082,295.5	499.9	HPLC and GC, CHREL Lab	BW9 (in road)	1 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	0	20	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW9	50 m from Base Plate (15 degrees)	8/2/2001	Bow Whale FP	555,816.1	7,082,295.5	499.9	HPLC and GC, CHREL Lab	BW9 (in road)	2 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	0	39	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW10	50 m from Base Plate (30 degrees)	8/2/2001	Bow Whale FP	555,830.3	7,082,299.2	502.6	HPLC and GC, CHREL Lab	BW10	1 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	120	2960	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW10	50 m from Base Plate (30 degrees)	8/2/2001	Bow Whale FP	555,830.3	7,082,299.2	502.6	HPLC and GC, CHREL Lab	BW10	2 µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	64	1530	NA	NA	NA	<15	<2	
Composite MEW	TJ-KM-MC-MEW	BW11-A	3.5 m from Base Plate	8/2/2001	Bow Whale FP	555,981.8	7,082,212.3	503.1	100417	BW11-A	µg/g	NR	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<125	<125	<125	NA	NA	
Composite MEW	TJ-KM-MC-MEW	BW11-B	3.5 m from Base Plate	8/2/2001	Bow Whale FP	555,981.8	7,082,212.3	503.1	100418	BW11-B	µg/g	NR	<25.3	<25.3	<25.3	<25.3	<25.3	<25.3	<25.3	<25.3	<25.3	<25.3	<127	<127	<127	NA	NA	
Composite MEW	TJ-KM-MC-MEW	BW12-A	7 m from Base Plate	8/2/2001	Bow Whale FP	555,980.6	7,082,215.3	503.9	100419	BW12-A	µg/g	NR	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<23.4	<117	<117	<117	NA	NA	
Composite MEW	TJ-KM-MC-MEW	BW12-B	7 m from Base Plate	8/2/2001	Bow Whale FP	555,976.7	7,082,221.0	503.9	100420	BW12-B	µg/g	NR	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<118	<118	<118	NA	NA	
Composite MEW	TJ-KM-MC-MEW	BW13	14 m from Base Plate	8/2/2001	Bow Whale FP	555,976.7	7,082,221.0	503.9	100421	BW13-A	µg/g	NR	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<125	<125	<125	NA	NA	
Composite MEW	TJ-KM-MC-MEW	BW13	14 m from Base Plate	8/2/2001	Bow Whale FP	555,976.7	7,082,221.0	503.9	100422	BW13-B	µg/g	NR	<25.1	<25.1	<25.1	<25.1	<25.1	<25.1	<25.1	<25.1	<25.1	<25.1	<126	<126	<126	NA	NA	
Composite MEW	TJ-KM-MC-MEW	BW14	21 m from Base Plate	8/2/2001	Bow Whale FP	555,972.8	7,082,227.0	504.4	100423	BW14-A	µg/g	NR	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<125	<125	<125	NA	NA	
Composite MEW	TJ-KM-MC-MEW	BW14	21 m from Base Plate	8/2/2001	Bow Whale FP	555,972.8	7,082,227.0	504.4	100424	BW14-B	µg/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	84	1974	NA	NA	NA	<15	<2
Composite MEW	TJ-KM-MC-MEW	BW15	28 m from Base Plate	8/2/2001	Bow Whale FP	555,968.9	7,082,232.7	504.5	100424	BW15-A	µg/g	NR	<24.6	<24.6	<24.6	<24.6	<24.6	<24.6	<24.6	<24.6	<24.6	<24.6	<123	<123	<123	NA	NA	
Composite MEW	TJ-KM-MC-MEW	BW15	28 m from Base Plate	8/2/2001	Bow Whale FP	555,968.9	7,082,232.7	504.5	100425	BW15-B	µg/g	NR	<24.6	<24.6	<24.6	<24.6	<24.6	<24.6	<24.6	<24.6	<24.6	<24.6	<123	<123	<123	NA	NA	

= not confirmed
 NA = not analyzed for this compound
 ND = not detected
 NR = not reported

Appendix A (cont.). Analytical results from 2001.

Sample Type	Collector	Unique ID	Field Notes	Date Collected	Area	East (m)	North (m)	Elevation (m)	Lab Notes or ID	Field ID	Lab Units	HMX	RDX	TNB	DNB	TETRYL	TNT	4A-DNT	2A-DNT	2,6-DNT	2,4-DNT	NB	2,NT,3,NT	4-NT	NG	3,5-DNA		
Composite	TJ-KM-MC	BW17	50 m from Base Plate (+15 degrees)	8/2/2001	Bow Whale	555,949.0	7,082,241.6	620.6	Ground		µg/kg	<3	<1	<1	<1	<1	<1	<3	13.8	680	NA	NA	NA	NA	NA	<15		
Composite	TJ-KM-MC	BW16	50 m from Base Plate (-30 degrees)	8/2/2001	FP	555,940.1	7,082,233.3	504.6	100426	BW16	µg/kg	NR	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<25.5	<128	<128	<128	NA	NA		
Composite	TJ-KM-MC	BW18	50 m from Base Plate (0 degrees)	8/2/2001	FP	555,956.5	7,082,251.6	504.2	100427	BW18	µg/kg	NR	<25.8	<25.8	<25.8	<25.8	<25.8	<25.8	<25.8	<25.8	<25.8	<25.8	<129	<129	<129	NA	NA	
Composite	TJ-KM-MC	BW19	50 m from Base Plate (+15 degrees)	8/2/2001	Bow Whale	555,988.5	7,082,266.6	603.7	100428	BW19	µg/kg	NR	<24.5	<24.5	<24.5	<24.5	<24.5	<24.5	<24.5	<24.5	<24.5	<123	<123	<123	NA	NA		
Composite	TJ-KM-MC	BW20	50 m from Base Plate (+30 degrees)	8/2/2001	FP	555,979.8	7,082,280.4	502.4	100429	BW20	µg/kg	NR	<24.5	<24.5	<24.5	<24.5	<24.5	<24.5	<24.5	<24.5	<24.5	<128	<128	<128	NA	NA		
Composite	TJ-JW-JAS	BL1	3.5 m from Base Plate	8/2/2001	Big Lake FP	554,821.6	7,080,705.6	492.1	101314	BL001	µg/kg	<37.3	<37.3	107	<37.3	<37.3	<37.3	<37.3	<37.3	<37.3	<37.3	<187	<187	<187	NA	NA		
Composite	TJ-JW-JAS	BL2	3.5 m from Base Plate	8/2/2001	Big Lake FP	554,820.5	7,080,708.9	492.5	101315	BL002	µg/kg	<37.0	<37.0	107	<37.0	<37.0	<37.0	<37.0	<37.0	<37.0	<37.0	<187	<187	<187	NA	NA		
Composite	TJ-JW-JAS	BL3	7 m from Base Plate	8/2/2001	Big Lake FP	554,820.5	7,080,708.9	492.5	100431	BL003	µg/kg	<45.4	<45.4	<45.4	<45.4	<45.4	<45.4	<45.4	<45.4	<45.4	<45.4	<187	<187	<187	NA	NA		
Composite	TJ-JW-JAS	BL4	7 m from Base Plate	8/2/2001	Big Lake FP	554,820.5	7,080,708.9	492.5	100432	BL004	µg/kg	<45.4	<45.4	<45.4	<45.4	<45.4	<45.4	<45.4	<45.4	<45.4	<45.4	<187	<187	<187	NA	NA		
Composite	TJ-JW-JAS	BL5	14 m from Base Plate	8/2/2001	Big Lake FP	554,818.6	7,080,715.4	492.3	100433	BL005	µg/kg	NR	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<110	<110	<110	NA	NA		
Composite	TJ-JW-JAS	BL6	14 m from Base Plate	8/2/2001	Big Lake FP	554,818.6	7,080,715.4	492.3	100434	BL006	µg/kg	NR	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<24.9	<110	<110	<110	NA	NA		
Composite	TJ-JW-JAS	BL7	21 m from Base Plate	8/2/2001	Big Lake FP	554,816.7	7,080,721.8	491.9	100435	BL007	µg/kg	NR	<23.9	<23.9	<23.9	<23.9	<23.9	<23.9	<23.9	<23.9	<23.9	<120	<120	<120	NA	NA		
Composite	TJ-JW-JAS	BL8	21 m from Base Plate	8/2/2001	Big Lake FP	554,816.7	7,080,721.8	491.9	100436	BL008	µg/kg	NR	<23.9	<23.9	<23.9	<23.9	<23.9	<23.9	<23.9	<23.9	<23.9	<120	<120	<120	NA	NA		
Composite	TJ-JW-JAS	BL9	28 m from Base Plate	8/2/2001	Big Lake FP	554,814.8	7,080,728.5	491.9	100437	BL009	µg/kg	NR	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<118	<118	<118	NA	NA		
Composite	TJ-JW-JAS	BL10	28 m from Base Plate	8/2/2001	Big Lake FP	554,814.8	7,080,728.5	491.9	100438	BL010	µg/kg	NR	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5	<118	<118	<118	NA	NA		
Composite	TJ-JW-JAS	BL11	3.5 m from Base Plate	8/2/2001	Big Lake FP	554,895.3	7,080,779.0	491.2	101318	BL011	µg/kg	<32.3	<32.3	<32.3	<32.3	<32.3	<32.3	<32.3	<32.3	<32.3	<32.3	<162	<162	<162	NA	NA		
Composite	TJ-JW-JAS	BL12	3.5 m from Base Plate	8/2/2001	Big Lake FP	554,895.3	7,080,779.0	491.2	100439	BL012	µg/kg	NR	<23.9	<23.9	<23.9	<23.9	<23.9	<23.9	<23.9	<23.9	<23.9	<120	<120	<120	NA	NA		
Composite	TJ-JW-JAS	BL13	7 m from Base Plate	8/2/2001	Big Lake FP	554,894.2	7,080,782.1	492.1	101319	BL013	µg/kg	<45.5	<45.5	<45.5	<45.5	<45.5	<45.5	<45.5	<45.5	<45.5	<45.5	<228	<228	<228	NA	NA		
Composite	TJ-JW-JAS	BL14	7 m from Base Plate	8/2/2001	Big Lake FP	554,894.2	7,080,782.1	492.1	100440	BL014	µg/kg	<45.5	<45.5	<45.5	<45.5	<45.5	<45.5	<45.5	<45.5	<45.5	<45.5	<228	<228	<228	NA	NA		
Composite	TJ-JW-JAS	BL15	14 m from Base Plate	8/2/2001	Big Lake FP	554,892.3	7,080,788.4	490.7	101320	BL015	µg/kg	<38.5	<38.5	178	<38.5	<38.5	<38.5	<38.5	<38.5	<38.5	<38.5	<193	<193	<193	NA	NA		
Composite	TJ-JW-JAS	BL16	14 m from Base Plate	8/2/2001	Big Lake FP	554,892.3	7,080,788.4	490.7	100441	BL016	µg/kg	<42.0	<42.0	<42.0	<42.0	<42.0	<42.0	<42.0	<42.0	<42.0	<42.0	<210	<210	<210	NA	NA		
Composite	TJ-JW-JAS	BL17	21 m from Base Plate	8/2/2001	Big Lake FP	554,889.6	7,080,795.0	490.2	101321	BL017	µg/kg	<36.8	<36.8	<36.8	<36.8	<36.8	<36.8	<36.8	<36.8	<36.8	<36.8	<184	<184	<184	NA	NA		
Composite	TJ-JW-JAS	BL18	21 m from Base Plate	8/2/2001	Big Lake FP	554,889.6	7,080,795.0	490.2	100442	BL018	µg/kg	<35.0	<35.0	<35.0	<35.0	<35.0	<35.0	<35.0	<35.0	<35.0	<35.0	<175	<175	<175	NA	NA		
Composite	TJ-JW-JAS	BL19	28 m from Base Plate	8/2/2001	Big Lake FP	554,887.5	7,080,801.5	490.5	101322	BL019	µg/kg	<28.2	<28.2	<28.2	<28.2	<28.2	<28.2	<28.2	<28.2	<28.2	<28.2	<141	<141	<141	NA	NA		
Composite	TJ-JW-JAS	BL20	28 m from Base Plate	8/2/2001	Big Lake FP	554,887.5	7,080,801.5	490.5	100443	BL020	µg/kg	<28.2	<28.2	<28.2	<28.2	<28.2	<28.2	<28.2	<28.2	<28.2	<28.2	<141	<141	<141	NA	NA		
Composite	TJ-JW-JAS	SAL1A	Next to bulkloaded area, 7 m from edge.	7/1/2001	Sally FP	554,887.6	7,081,938.7	489.5	101324	SALLY 1-1	µg/kg	<31.3	<31.3	<31.3	<31.3	<31.3	<31.3	<31.3	<31.3	<31.3	<31.3	<157	<157	<157	NA	NA		
Composite	TJ-JW	SAL1B	Next to bulkloaded area, 7 m from edge.	7/1/2001	Sally FP	554,886.4	7,081,938.0	489.8	100460	SALLY 1-2	µg/kg	NR	<30.7	<30.7	<30.7	<30.7	<30.7	<30.7	<30.7	<30.7	<30.7	<154	<154	<154	NA	NA		
Composite	TJ-JW	SAL1C	Behind firing position	8/2/2001	Sally FP	554,790.3	7,081,922.9	487.0	101343	SALLY BKG-002	µg/kg	<37.0	<37.0	<37.0	<37.0	<37.0	<37.0	<37.0	<37.0	<37.0	<37.0	<185	<185	<185	NA	NA		
Composite	KM	SAL BKG3	Behind firing position	8/2/2001	Sally FP	554,771.2	7,081,924.8	486.0	101344	SALLY BKG-003	µg/kg	<37.3	<37.3	<37.3	<37.3	<37.3	<37.3	<37.3	<37.3	<37.3	<37.3	<187	<187	<187	NA	NA		
Composite	KM	SAL BKG1	Behind firing position	8/2/2001	Sally FP	554,763.9	7,081,961.3	488.3	100482	SALLY BKG #1	µg/kg	NR	<26.2	65.2	<26.2	211	<26.2	<26.2	<26.2	<26.2	<26.2	<26.2	<86.7	<131	<131	<131	NA	NA
Composite	TJ-KM-MW	SAL7	3.5 m from Base Plate	7/1/2001	Sally FP	554,779.8	7,081,977.3	489.0	100489	SALLY 7-1	µg/kg	NR	<27.5	<27.5	<27.5	<27.5	<27.5	<27.5	<27.5	<27.5	<27.5	<138	<138	<138	NA	NA		
Composite	TJ-KM-MW	SAL8	7 m from Base Plate	7/1/2001	Sally FP	554,778.7	7,081,980.6	488.8	100490	SALLY 7-2	µg/kg	NR	<28.4	<28.4	<28.4	<28.4	<28.4	<28.4	<28.4	<28.4	<28.4	<142	<142	<142	NA	NA		
Composite	TJ-KM-MW	SAL9	7 m from Base Plate	7/1/2001	Sally FP	554,778.7	7,081,980.6	488.8	100491	SALLY 7-3	µg/kg	NR	<28.4	<28.4	<28.4	<28.4	<28.4	<28.4	<28.4	<28.4	<28.4	<142	<142	<142	NA	NA		
Composite	TJ-KM-MW	SAL10	14 m from Base Plate	7/1/2001	Sally FP	554,778.7	7,081,980.6	488.8	100492	SALLY 7-4	µg/kg	<25.3	<25.3	<25.3	<25.3	<25.3	<25.3	<25.3	<25.3	<25.3	<25.3	<149	<149	<149	NA	NA		
Composite	TJ-KM-MW	SAL11	14 m from Base Plate	7/1/2001	Sally FP	554,778.7	7,081,980.6	488.8	100493	SALLY 7-5	µg/kg	<27.6	<27.6	<27.6	<27.6	<27.6	<27.6	<27.6	<27.6	<27.6	<27.6	<138	<138	<138	NA	NA		
Composite	TJ-KM-MW	SAL12	21 m from Base Plate	7/1/2001	Sally FP	554,774.4	7,081,983.7	488.5	100474	SALLY 9 REP 1	µg/kg	NR	<28.9	<28.9	<28.9	<28.9	<28.9	<28.9	<28.9	<28.9	<28.9	<145	<145	<145	NA	NA		
Composite	TJ-KM-MW	SAL13	21 m from Base Plate	7/1/2001	Sally FP	554,774.4	7,081,983.7	488.5	100475	SALLY 9 REP 2	µg/kg	NR	<28.9	<28.9	<28.9	<28.9	<28.9	<28.9	<28.9	<28.9	<28.9	<145	<145	<145	NA	NA		
Composite	TJ-KM-MW	SAL14	28 m from Base Plate	7/1/2001	Sally FP	554,772.2	7,082,000.3	488.3	100475	SALLY 11 REP 1	µg/kg	NR	<31.3	<31.3	<31.3	<31.3	<31.3	<31.3	<31.3	<31.3	<31.3	<107	<107	<107	<157	<157		
Composite	TJ-KM-MW	SAL15	28 m from Base Plate	7/1/2001	Sally FP	554,772.2	7,082,000.3	488.3	100476	SALLY 11 REP 2	µg/kg	NR	<34.2	<34.2	<34.2	<34.2	<34.2	<34.2	<34.2	<34.2	<34.2	<6.530	<171	<171	<171</			

Appendix A (cont.) Analytical results from 2001.

Sample Type	Collector	Unique ID	Field Notes	Date Collected	Area	East (m)	North (m)	Elevation (m)	Lab Notes or ID	Field ID	Lab	Rep	Units	HMX	RDX	TNB	DNB	TETRYL	TNT	4A-DNT	2A-DNT	2,6-DNT	2,4-DNT	NB	2-NT	3-NT	4-NT	NG	3,5-DNA	
Discrete/ subsurface	JAS-SH	BW2	2.5 to 5 cm depth	8/42/2001	Bow Whale	555,818.8	7,082,263.3	500.0	CRREL Lab GC	BW2	A	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	19.6	NA	NA	NA	NA	250	<2	
Discrete/ subsurface	JAS-SH	BW2	2.5 to 5 cm depth	8/42/2001	Bow Whale	555,818.8	7,082,263.3	500.0	CRREL Lab GC	Subsurface Discrete	B	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	5.4	NA	NA	NA	NA	<15	<2	
Discrete/ subsurface	JAS-SH	BW2	5 to 10 cm depth	8/42/2001	Bow Whale	555,818.8	7,082,263.3	500.0	CRREL Lab GC	Subsurface Discrete	B	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Discrete/ subsurface	JAS-SH	BW2	5 to 10 cm depth	8/42/2001	Bow Whale	555,818.8	7,082,263.3	500.0	CRREL Lab GC	Subsurface Discrete	B	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Discrete/ subsurface	JAS-SH	BW2	10 to 15 cm depth	8/42/2001	Bow Whale	555,818.8	7,082,263.3	500.0	CRREL Lab GC	Subsurface Discrete	A	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Discrete/ subsurface	JAS-SH	BW1.5	10 to 15 cm depth	8/42/2001	Bow Whale	555,818.8	7,082,263.3	500.0	CRREL Lab GC	Subsurface Discrete	B	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BW4 composite)	8/42/2001	Bow Whale	555,818.1	7,082,263.3	499.8	CRREL Lab GC	Surface Discrete	A	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	48.6	530	NA	NA	NA	<15	<2	
Discrete/ subsurface	JAS-SH	BW1.5	0 to 2 cm depth	8/42/2001	Bow Whale	555,818.1	7,082,263.3	499.8	CRREL Lab GC	Subsurface Discrete	A	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	13.8	226	NA	NA	NA	<15	<2	
Discrete/ subsurface	JAS-SH	BW1.5	0 to 2 cm depth	8/42/2001	Bow Whale	555,818.1	7,082,263.3	499.8	CRREL Lab GC	Subsurface Discrete	B	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	8.3	NA	NA	NA	NA	<15	<2	
Discrete/ subsurface	JAS-SH	BW1.5	2 to 4 cm depth	8/42/2001	Bow Whale	555,818.1	7,082,263.3	499.8	CRREL Lab GC	Subsurface Discrete	A	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Discrete/ subsurface	JAS-SH	BW1.5	2 to 4 cm depth	8/42/2001	Bow Whale	555,818.1	7,082,263.3	499.8	CRREL Lab GC	Subsurface Discrete	B	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Discrete/ subsurface	JAS-SH	BW1.5	4 to 11 cm depth	8/42/2001	Bow Whale	555,818.1	7,082,263.3	499.8	CRREL Lab GC	Subsurface Discrete	A	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Discrete/ subsurface	JAS-SH	BW1.5	4 to 11 cm depth	8/42/2001	Bow Whale	555,818.1	7,082,263.3	499.8	CRREL Lab GC	Subsurface Discrete	B	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Discrete/ subsurface	JAS-SH	BW1.5	11 to 15 cm depth	8/42/2001	Bow Whale	555,818.1	7,082,263.3	499.8	CRREL Lab GC	Subsurface Discrete	A	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Discrete/ subsurface	JAS-SH	BW1.5	11 to 15 cm depth	8/42/2001	Bow Whale	555,818.1	7,082,263.3	499.8	CRREL Lab GC	Subsurface Discrete	B	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2	
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BW4 composite)	8/42/2001	Bow Whale	555,818.6	7,082,265.1	499.9	CRREL Field GC	BW3 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	50	NA	NA	NA	NA	NA	
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BW4 composite)	8/42/2001	Bow Whale	555,821.1	7,082,264.9	500.0	CRREL Field GC	BW4 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	46	NA	NA	NA	NA	NA	
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BW4 composite)	8/42/2001	Bow Whale	555,822.1	7,082,266.0	500.1	CRREL Field GC	BW5 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	25	NA	NA	NA	NA	NA	
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BW5 composite)	8/42/2001	Bow Whale	555,815.6	7,082,270.4	499.9	CRREL Field GC	BW6 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	580	NA	NA	NA	NA	NA	
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BW5 composite)	8/42/2001	Bow Whale	555,815.6	7,082,270.4	499.9	CRREL Field GC	BW7 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	50	NA	NA	NA	NA	NA	
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BW5 composite)	8/42/2001	Bow Whale	555,815.6	7,082,270.4	499.9	CRREL Field GC	BW8 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	50	NA	NA	NA	NA	NA	
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BW5 composite)	8/42/2001	Bow Whale	555,815.6	7,082,270.4	499.9	CRREL Field GC	BW9 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BW5 composite)	8/42/2001	Bow Whale	555,815.6	7,082,270.4	499.9	CRREL Field GC	BW10 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BL1 composite sample)	8/42/2001	Big Lake FP	554,824.6	7,080,706.3	491.4	CRREL Field GC	BL1 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BL1 composite sample)	8/42/2001	Big Lake FP	554,823.8	7,080,705.7	490.9	CRREL Field GC	BL2 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Trace	NA	NA	NA	NA	NA	NA
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BL1 composite sample)	8/42/2001	Big Lake FP	554,822.9	7,080,704.7	491.0	CRREL Field GC	BL3 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BL1 composite sample)	8/42/2001	Big Lake FP	554,820.9	7,080,704.0	490.6	CRREL Field GC	BL4 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BL1 composite sample)	8/42/2001	Big Lake FP	554,820.1	7,080,703.4	490.9	CRREL Field GC	BL5 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Trace	NA	NA	NA	NA	NA	NA
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BL1 composite sample)	8/42/2001	Big Lake FP	554,898.2	7,080,783.3	490.6	CRREL Field GC	BL6 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Trace	NA	NA	NA	NA	NA	NA
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BL14 composite)	8/42/2001	Big Lake FP	554,895.4	7,080,781.3	491.5	CRREL Field GC	BL9 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Trace	NA	NA	NA	NA	NA	NA
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BL14 composite)	8/42/2001	Big Lake FP	554,895.2	7,080,781.1	491.5	CRREL Field GC	BL10 DISCRETE	ppb/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Trace	NA	NA	NA	NA	NA	NA
Discrete	JAS-TJ-KM	DISCRET	Surface (Within area BL14 composite)	8/42/2001	Big Lake FP	554,892.2	7,080,781.1	491.5	CRREL Lab GC	BL10 within BL14	A	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	345	6,790	NA	NA	NA	NA	<15	<2
Discrete	JAS-TJ-KM	DISCRET	Surface	8/42/2001	Big Lake FP	554,892.2	7,080,781.1	491.5	CRREL Lab GC	Subsurface Discrete	A	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	4	NA	NA	NA	NA	<15	<2
Discrete/ subsurface	JAS-SH	BL10	1 to 4 cm depth	8/42/2001	Big Lake FP	554,892.2	7,080,781.1	491.5	CRREL Lab GC	Subsurface Discrete	A	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2
Discrete/ subsurface	JAS-SH	BL10	1 to 4 cm depth	8/42/2001	Big Lake FP	554,892.2	7,080,781.1	491.5	CRREL Lab GC	Subsurface Discrete	B	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2
Discrete/ subsurface	JAS-SH	BL10	4 to 8 cm depth	8/42/2001	Big Lake FP	554,892.2	7,080,781.1	491.5	CRREL Lab GC	Subsurface Discrete	A	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2
Discrete/ subsurface	JAS-SH	BL10	4 to 8 cm depth	8/42/2001	Big Lake FP	554,892.2	7,080,781.1	491.5	CRREL Lab GC	Subsurface Discrete	B	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2
Discrete/ subsurface	JAS-SH	BL10	8 to 15 cm depth	8/42/2001	Big Lake FP	554,892.2	7,080,781.1	491.5	CRREL Lab GC	Subsurface Discrete	A	ppb/g	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2

= not confirmed
 NA = not analyzed for this compound
 ND = not detected
 NR = not reported

Appendix A (cont.).

Sample Type	Collector	Unique ID	Field Notes	Date Collected	Area	East (m)	North (m)	Elevation (m)	Lab Notes or ID	Field ID	Rep	Units	HUX	RDX	TNB	DNB	TETRYL	TNT	4A-DNT	2A-DNT	2,6-DNT	2,4-DNT	NB	2,NT	3,NT	4,NT	NG	3,5-DNA
Discrete/ suburface/	JAS-SH	BL10 DISCRET	8 to 15 cm depth	8/4/2001	Big Lake FP	554,892.2	7,080,781.1	491.5	CRREL Lab GC	Subsurface Discrete BL10 within BL14	B	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2
Discrete/ suburface/	JAS-SH	BL10 DISCRET	15 to 20 cm depth	8/4/2001	Big Lake FP	554,892.2	7,080,781.1	491.5	CRREL Lab GC	Subsurface Discrete BL10 within BL14	A	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2
Discrete/ suburface/	JAS-SH	DISCRET	15 to 20 cm depth	8/4/2001	Big Lake FP	554,892.2	7,080,781.1	491.5	CRREL Lab GC	Subsurface Discrete BL10 within BL14	B	µg/kg	<25	<3	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	<15	<2
Discrete	MW	JAS-TJ-KW-BL7	Surface (Within area BL14 composite sample)						CRREL Field GC	BL7 Discrete		µg/kg	NA	NA	NA	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA

= not confirmed
 NA = not analyzed for this compound
 NR = not reported

REPORT DOCUMENTATION PAGE

*Form Approved
OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE (DD-MM-YY) February 2004		2. REPORT TYPE Technical Report		3. DATES COVERED (From - To)		
4. TITLE AND SUBTITLE Range Characterization Studies at Donnelly Training Area, Alaska: 2001 and 2002				5a. CONTRACT NUMBER		
				5b. GRANT NUMBER		
				5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S) Marianne E. Walsh, Charles M. Collins, Alan D. Hewitt, Michael R. Walsh, Thomas F. Jenkins, Jeffrey Stark, Arthur Gelvin, Thomas S. Douglas, Nancy Perron, Dennis Lambert, Ronald Bailey and Karen Myers				5d. PROJECT NUMBER		
				5e. TASK NUMBER		
				5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Engineer Research and Development Center Cold Regions Research and Engineering Laboratory 72 Lyme Road Hanover, NH 03755-1290				8. PERFORMING ORGANIZATION REPORT ERDC/CRREL TR-04-3		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Alaska U.S. Army Strategic Environmental Research and Development Program Washington, DC				10. SPONSOR / MONITOR'S ACRONYM(S)		
				11. SPONSOR / MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited. Available from NTIS, Springfield, Virginia 22161.						
13. SUPPLEMENTARY NOTES						
14. ABSTRACT The U.S. Army Alaska seeks to conserve and protect natural resources on lands used for combat training exercises. Some of these exercises require live fire of ordnance containing high explosives. One aspect of managing the ranges so as to mitigate the environmental consequences of training is to identify the location, extent, and potential migration of munitions residues in soils, surface waters, and groundwater. This report summarizes analytical results for soil samples collected from firing points and some impact areas at the Donnelly Training Area near Delta Junction, Alaska. Explosives residues are for the most part undetectable or at very low concentrations (parts per billion) in the soils of impact areas. The exceptions are soils near or under partial ordnance detonations, targets, and rocket motor debris. We found high concentrations (parts per thousand) of TNT in soils next to partially detonated 500-lb and 2000-lb bombs; moderate concentrations (parts per million) of RDX and TNT around targets; and moderate concentrations (parts per million) of NG under rocket motor debris. At firing points used for 105-mm howitzers, 2,4-DNT is detectable in surface soils at parts-per-million concentrations. This analyte is associated with burned and unburned fibers of propellant that are sprayed to distances of at least 100 m from the muzzle. The highest concentrations of 2,4-DNT were in soils where excess propellant is burned for disposal. Because of the very low soil clean-up levels listed by the State of Alaska for this compound, appropriate and reproducible laboratory and field sampling procedures need to be developed to monitor this analyte.						
15. SUBJECT TERMS Explosives 2,4-DNT TNT RDX						
16. SECURITY CLASSIFICATION OF:				17. LIMITATION OF OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE	19b. TELEPHONE NUMBER (include area code)			
U	U	U	U	61		