Environmental Impacts of Blow In Place Detonations

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Agenda

- Background
- Fuze Testing
- Alternative Donor Charge Testing
- Future Actions

Project Objective

- Investigate Alternatives to Traditional Open Detonation for Munitions Discovered during Munitions Responses that are Determined Unacceptable to Move
  - Evaluate Fuze Solution
  - Evaluate Alternative Donor Charge Solution

Munitions Constituents

"Any materials originating from unexploded ordnance, discarded military munitions, or other military munitions, including explosive and nonexplosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions."

(10 U.S.C. 2710 (e) (4))

"Potentially hazardous chemicals that are located on or originate from CTT ranges and are released from military munitions or UXO, or have resulted from other activities on military ranges. Munition constituents may be subject to other statutory authorities, including, but not limited to, CERCLA (42 U.S.C. 9601 et seq.) and RCRA (42 U.S.C. 6901 et seq.)."

USEPA's Handbook on the Management of Ordnance and Explosives at Closed, Transferring, and Transferred Ranges and Other Sites, Review Draft 2, August 2003

Fuze Testing Premise

- Evaluate Whether it is Feasible to Deactivate or Remove the Fuze from a Live UXO item without Detonating, thereby Rendering it Acceptable to Move, Preferably with Remote Equipment.
- Fuze Deactivation/Removal Performed with a Commercially Available Shaped Charge

Fuze Testing Setup

Mechanical Time and Point Detonating Fuzes
Two standoff distances (1” and 3”)
X-rays Taken Before and After Testing

Fuze Testing Results

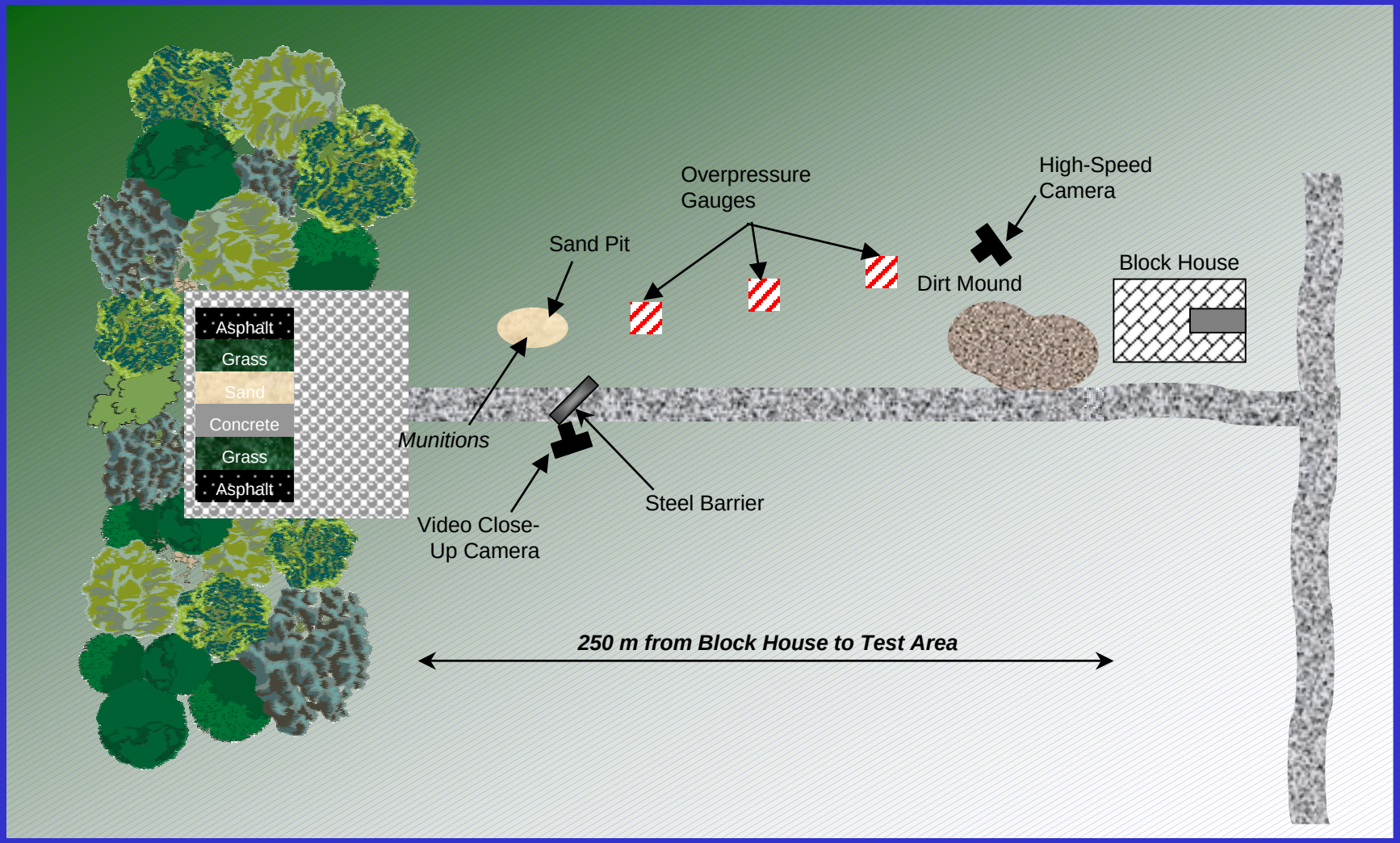
Fuzes were Penetrated and/or Broken in Pieces

Tests Considered Unsuccessful and Discontinued for this Field Effort

Alternative Donor Charge Premise

- Generate high order detonations of UXO items with multiple types of donor charges
- Compare concentrations of nitroaromatics and nitramines residual after in-place detonation
- Test for SW8330 compounds, nitroglycerine, and PETN
- Determine whether contamination could be minimized by choice of donor charge

Site Layout


Overpressure
Gauges
High-Speed
Camera
Sand Pit
Dirt Mound
Block House
Asphalt
Grass
Sand
Concrete
Grass
Asphalt
Munitions
Steel Barrier
Video Close-
Up Camera
250 m from Block House to Test Area

Test Matrix

Donor Charges

Halliburton 36 g Shaped Charge

PESCO 3.2 g Shaped Charge

PESCO 6.5 g Shaped Charge

PESCO 11 g Shaped Charge

PESCO 22 g Shaped Charge

KINEPAK

Fixor

Booster

C4 Demo Charge, M112

HELIX

Munitions Tested

60 mm mortar, M888

DNT 0.01 #/RDX 0.50 #/TNT 0.31 #

60 mm mortar, M49A4

NG 0.02 #/RDX 0.28 #/TNT 0.16 #

81 mm mortar, M374

NG 0.09 #/RDX 1.26 #/TNT 0.82 #

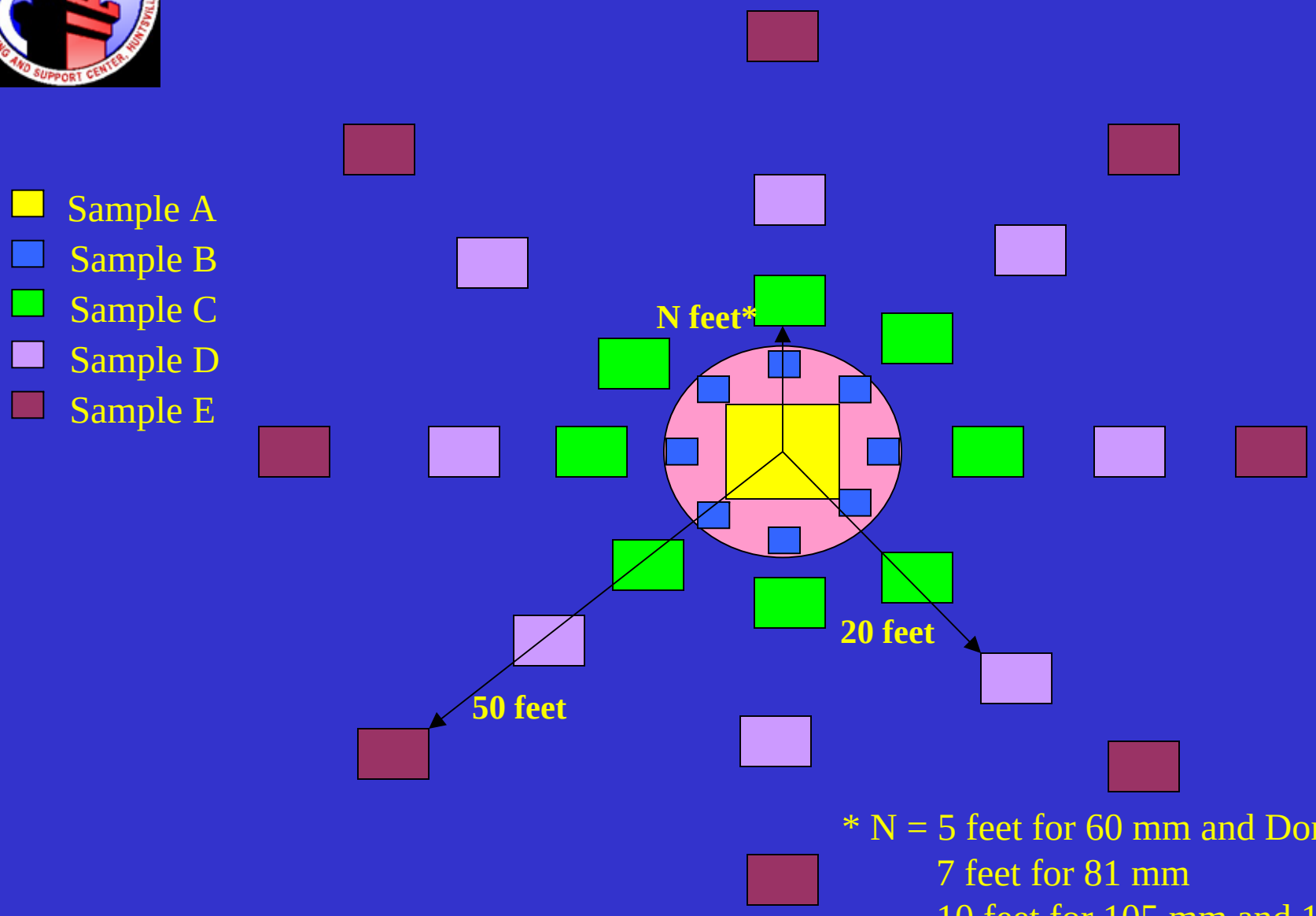
105 mm artillery, M1

DNT 0.25 #/RDX 2.76 #/TNT 2.09 #

155 mm artillery, M107

RDX 9.24 #/TNT 6.30 #

Soil Sampling Diagram



* N = 5 feet for 60 mm and Donor Charges
7 feet for 81 mm
10 feet for 105 mm and 155 mm

Figure not to scale

60 mm M49A4 Summary

Total RDX found (mg/kg)

Kinepak (14) 490,000
HELIX (46) 6,400
HELIX (40) 3,500
Fixor 1,000
Pesco 3 21
Halliburton 17
C4 10
Pesco 2 4.0
Pesco 1 2.7
Kinepak (17) 2.2
Booster 1.7
Pesco 4 1.4
HELIX (39) 0.63

Estimated % Residual Secondary Explosives

HELIX (46) 28%
Kinepak (14) 18%
Fixor 14%
HELIX (40) 7.9%
C4 0.26%
Kinepak (17) 0.17%
Halliburton 0.14%
Pesco 2 0.09%
Pesco 1 0.06%
Pesco 4 0.05%
HELIX (39) 0.05%
Pesco 3 0.04%
Booster 0.03%

All < 2 g estimated total residual except top 4, which ranged from 18 - 63 g

Blast Pressure at 60 feet (psi)

Pesco 4 0.311
Pesco 2 0.312
Halliburton 0.338
Pesco 1 0.408
HELIX (40) 0.422
Pesco 3 0.425
Kinepak (14) 0.476
HELIX (46) 0.586
C4 0.638
HELIX (39) 0.755
Booster 0.775
Kinepak (17) 0.859

Kinepak (14) test used one pouch; Kinepak (17) used two pouches. HELIX (39) used three sticks; HELIX (40) used one stick in a 3" shaped charge; HELIX (46) used two sticks

81 mm Summary

Total RDX found (mg/kg)

HELIX 22

Booster 14

C4 7.2

Kinepak 2.8

Halliburton 0.97

Pesco 3 0.76

Pesco 4 0.54

Estimated % Residual Secondary Explosives

HELIX 0.35%

Halliburton 0.15%

Kinepak 0.15%

Booster 0.14%

Pesco 4 0.12%

C4 0.12%

Pesco 3 0.09%

All < 4 g Estimated Total Residual

Blast Pressure at 60 feet (psi)

Pesco 3 0.607

Pesco 4 0.853

Halliburton 0.928

C4 0.931

Kinepak 1.03

HELIX 1.19

Booster 1.23

105 mm Summary

Total RDX found (mg/kg)

HELIX (54) not sampled

HELIX (57) 1,161

C4 36

Kinepak 17

Booster 2.6

Halliburton 2.1

Pesco 3 2.0

Estimated % Residual Secondary Explosives

HELIX (54) had a low order detonation

HELIX (57) 1.3%

C4 0.47%

Kinepak 0.011%

Booster 0.002%

Pesco 3 0.001%

Halliburton 0.001%

All < 2 g Estimated Total Residual except HELIX (57) (30 g)

Blast Pressure at 60 feet (psi)

Halliburton 0.85

HELIX (54) 0.873

HELIX (57) 1.09

Pesco 3 1.19

Kinepak 1.36

C4 1.45

Booster 1.53

HELIX (54) used four sticks; HELIX (57) used one 3# bag

155 mm Summary

Total RDX found (mg/kg)

Pesco 1 14,362
Kinepak 181
C4 (27) 33
Halliburton (28) 11
Pesco 2 6.5
Pesco 3 4.2
Pesco 4 4.1
Booster 3.0
HELIX 1.7
C4 (31) 0.98
Halliburton (33) 0.25

Estimated % Residual Secondary Explosives

FIXOR failed to detonate; testing discontinued

Pesco 1 0.63%
Kinepak 0.025%
C4 (27) 0.006%
Halliburton (28) 0.006%
Pesco 2 0.004%
Pesco 3 0.003%
Booster 0.002%
C4 (31) 0.002%
Pesco 4 0.002%
HELIX 0.001%
Halliburton (33) 0.001%

All < 2 g Estimated Total Residual except Pesco 1 (45 g)

Blast Pressure at 60 feet (psi)

Fixor 0.701
Pesco 4 0.841
Halliburton (33) 1.05
Pesco 3 1.51
Pesco 1 1.62
Pesco 2 1.76
C4 (31) 1.95
HELIX 1.96
Halliburton (28) 2.15
Kinepak 2.2

Booster Unknown

C4 (27) and Halliburton (28) tests were conducted in standard configuration; for C4 (31) and Halliburton (33), rounds were placed nose in and explosives placed on base plate

Alternate Donor Charge Testing Conclusions

- Mortar rounds typically yield higher residual explosives concentrations than artillery rounds
- HELIX and Kinepak binary explosives can yield residual explosives concentrations that are lower than or comparable to C4, but would require optimization, particularly for experimental delivery methods, such as shaped charges and bulk containers; generally, more is better to minimize contamination
- Higher blast pressures don't necessarily correlate to lower residual explosives concentrations (and in some cases, correspond to higher concentrations)
- Smaller shaped charges are not recommended for larger rounds; if a one-size approach is desired, choose larger shaped charge (Pesco 3, Pesco 4, or Halliburton)
- Fixor binary is not recommended for further testing

Future Actions

- ERDC-EL and ERDC-CRREL (with USAESCH participation) plan to:
  - Repeat this type of testing in 2004 with replicates to confirm the 2003 results, which were all single shot tests; donor explosives to be chosen based in part on the results of this study
  - Incorporate some alternate donor charge testing in detonation on ice testing program
- USAESCH, ERDC-CRREL, and ERDC-EL partnering with Battelle in ESTCP proposal to evaluate use of lime to treat detonation-related residual secondary explosives
- USACE Perchlorate Working Group evaluating a similar study for perchlorate residuals from functioned and/or detonated rounds containing perchlorates for FY2005

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ANY QUESTIONS?

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04-0002

Backup Slides

60 mm M888 Summary

Total RDX found (mg/kg)

- Fixor 91,000
- C4 (001) 1,300
- ★ C4 (002) 130

Estimated % Residual Secondary Explosives

- Fixor 8.3%
- C4 (001) 2.3%
- ★ C4 (002) 0.3%

Blast Pressure at 60 feet (psi)

- Fixor 0.549
- C4 (001) 0.645
- C4 (002) 0.77

C4 (001) was a misfire and left additional gross levels of C4 that were collected by RTTC personnel for disposal; both blasting caps detonated for C4 (002).

Potential Soil Criteria for Munition Constituents

Constituent	Region III Industrial RBC	Region VI Industrial SL	Region IX Industrial PRG	Region III Residential RBC	Region VI Residential SL	Region IX Residential PRG
1,3,5-TNB	31000	21000	18000	2300	1800	1800
2,4-DNT	4.2	2.8	2.5	0.94	0.72	0.72
2,6-DNT	4.2	2.8	2.5	0.94	0.72	0.72
2,4,6-TNT	95	64	57	21	16	16
RDX	26	17	16	5.8	4.4	4.4
HMX	51000	34000	31000	3900	3100	3100
Nitroglycerine	200	NE	120	46	NE	35
PETN	NE	NE	NE	NE	NE	NE

RBC – Risk Based Concentration

SL – Screening Level

PRG – Preliminary Remediation Goal

NE – Not Established

All concentrations are in milligrams per kilogram (mg/kg).

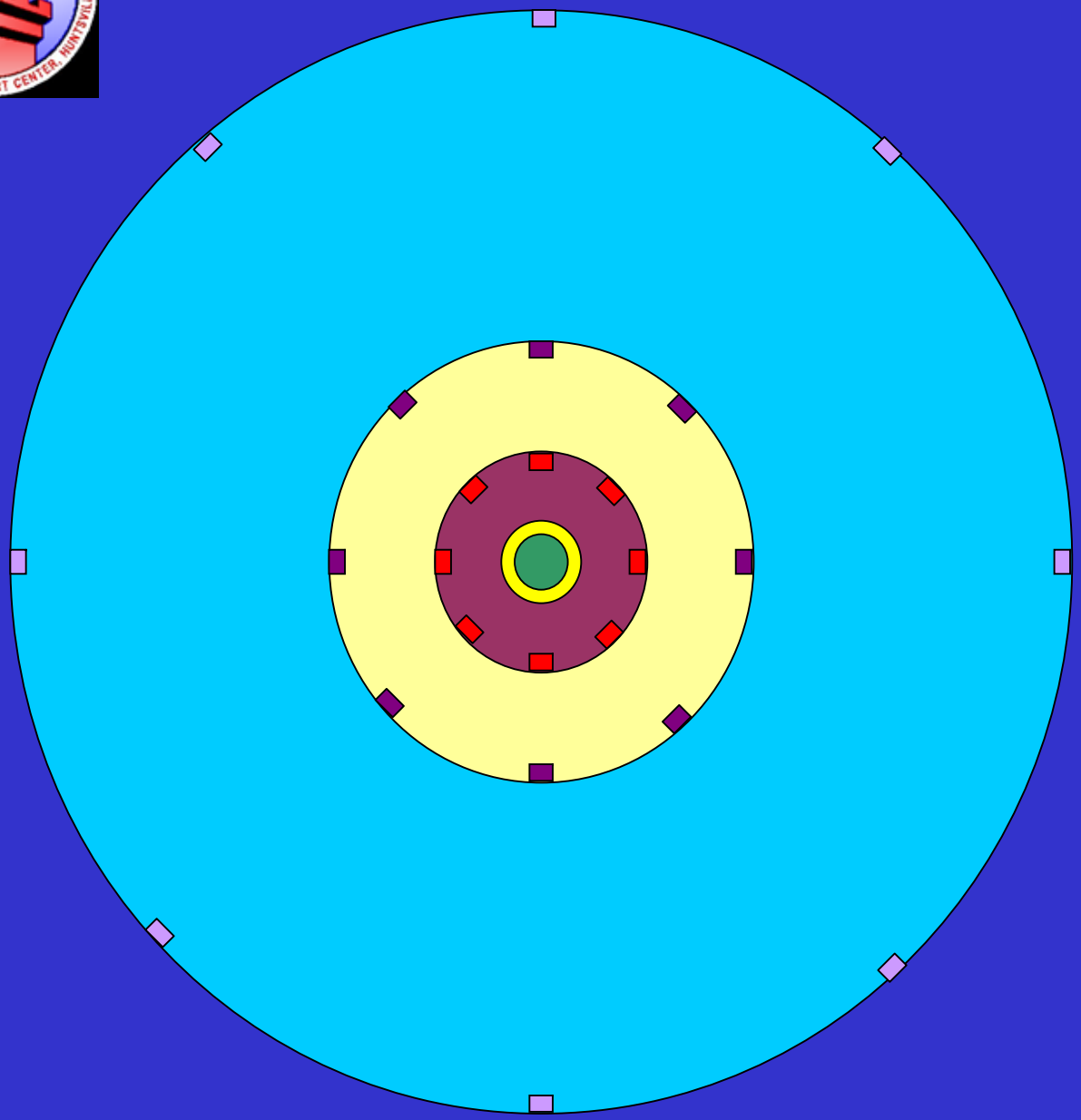
All concentrations are reported in scientific notation to 2 significant figures in source table and have been rounded to 2 significant figures for this table.

2,4-DNT and 2,6-DNT values reported are the value for dinitrotoluene mixture (carcinogenic). Values for specific isomer is higher (noncarcinogenic).

Region VI concentrations are for the Industrial-Outdoor Worker.

http://www.epa.gov/reg3hwmd/risk/rbc1003.xls, October 2003
http://www.epa.gov/region6/6pd/rcra_c/pd-n/screen.htm, January 2004
http://www.epa.gov/region09/waste/sfund/prg/index.htm, October 2002, as modified February 10, 2003

Area – Total



$Area_A$ total

$Area_B$ total

$Area_C$ total

$Area_D$ total

$Area_E$ total

Calculations

$$M_{Total} = [Average(\frac{M_E}{A_E sampled}, \frac{M_D}{A_D sampled}) \times (A_E total - A_D total)] +$$

$$[Average(\frac{M_D}{A_D sampled}, \frac{M_C}{A_C sampled}) \times (A_D total - A_C total)] +$$

$$[Average(\frac{M_C}{A_C sampled}, \frac{MB}{A_B sampled}) \times (A_C total - A_B total)] +$$

$$[M_B \times (\frac{A_B total}{A_B sampled})] + [M_A \times (\frac{A_A total}{A_A sampled})]$$

$$A_{(C,D,E)} sampled = \# Pans \times Pan\ Length(feet) \times Pan Width(feet)$$

$A_{(B,C,D,E)} total = \Pi R^2$, R_E = 50 feet, R_D = 20 feet, R_C = (10,7,5 feet), R_B = (9,6,4 feet)

$A_B sampled = \Pi(R-1)^2$, R_E = 50 feet, R_D = 20 feet, R_C = (10,7,5 feet), R_B = (9,6,4 feet)

$$\frac{A_A sampled}{A_A total} = field\ estimate, if\ available, if\ not, default\ to\ 75\%\ for\ donor\ charges, 50\%\ for\ 60\,mm,$$
$$40\%\ for\ 81\,mm, and\ 25\%\ for\ artillery\ rounds$$

$$M_{(A,B,C,D,E)}(g) = Concentration_{(A,B,C,D,E)}(mg/kg) \times Net\ Weight\ (kg) \times \frac{1\,g}{1000\,mg}$$

$$\%Destruction = \frac{(M_{Secondary\ explosive\ contribution} - M_{Total})}{M_{Secondary\ explosive\ contribution}} \times 100\%$$