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# RANGE CONTAMINATION WITH CHEMICAL RESIDUES OF ENERGETIC MATERIALS


Sampling near tank target YakimaTraining Center


Sampling near low-order 500 lb bomb, Camp Guernsey


Red crater at CFB Gagetown


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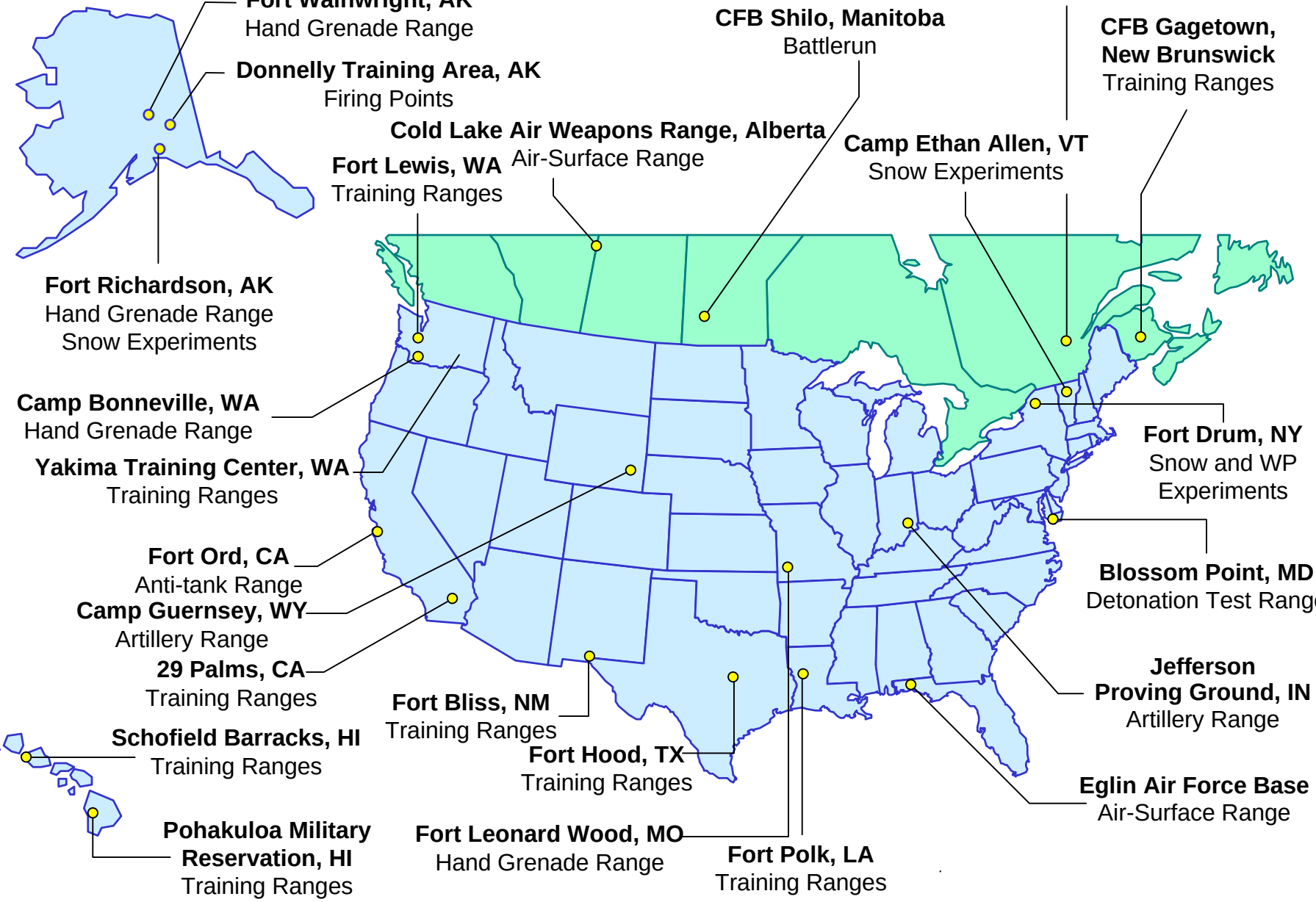
# Ranges Studied



# Major Energetic Chemicals used by the Military

- **Propellants**

  NC, NG, 2,4-DNT, NQ, perchlorate

- **Explosives**

  TNT, RDX, HMX, ammonium picrate

- **Pyrotechnics**

  WP

# Energetic Compounds Present at Military Training Ranges

- **Firing points**
  - Fixed and “Shoot and scoot” type
  - Propellants are major contaminants
    - Gun propellants - near firing points
    - Rocket propellants - spread further across range
- **Impact areas**
  - Explosives and their environmental transformation products are the major contaminants
  - Rocket propellants also present
  - White phosphorus can be present in wetland ranges

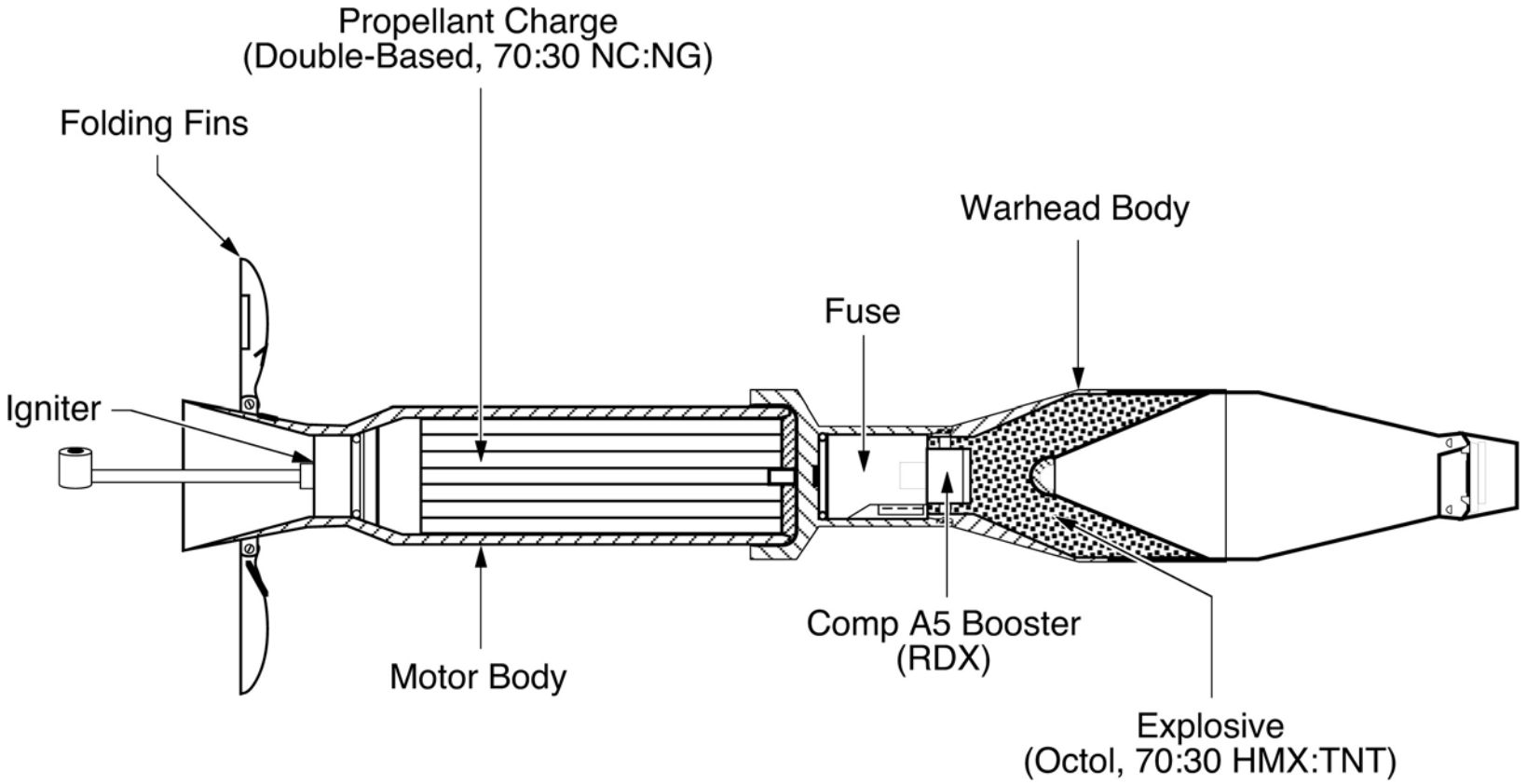
# TYPES OF ARMY RANGES STUDIED

- Antitank rocket range impact areas
- Hand grenade ranges
- Artillery and mortar range impact areas
- EOD demolition ranges
- Firing points
    - Artillery
    - Antitank rockets
    - Mortars
    - Tank firing range

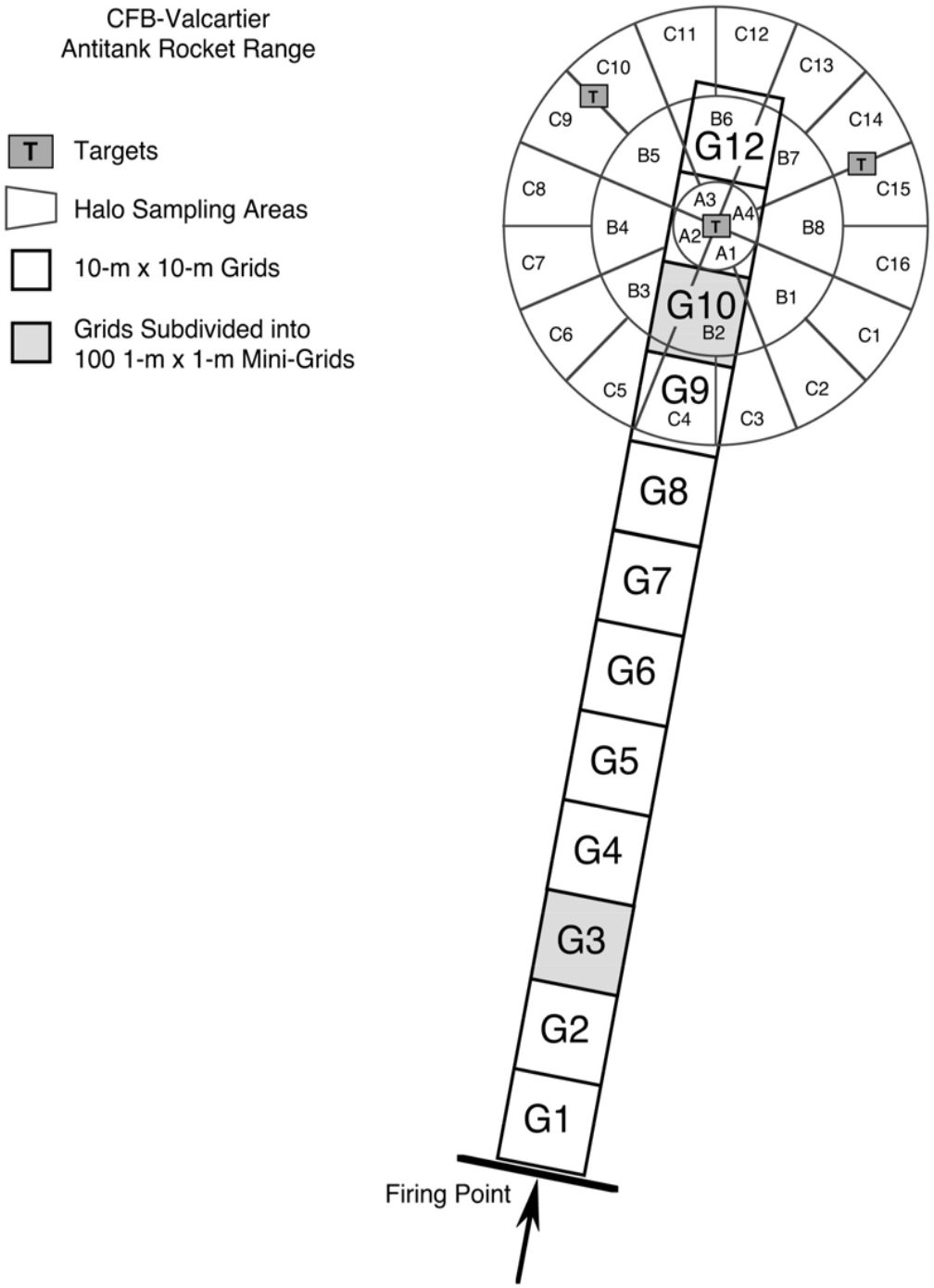
# Antitank Rocket Ranges Sampled

- CFB-Valcartier, Quebec
- Ft. Ord, California
- Yakima Training Center, Washington
- CFB-Gagetown, New Brunswick
- Scholfield Barracks, Hawaii
- WATC-Wainwright, Alberta

# Diagram of 66-mm M72 LAW Rocket



# CFB-Valcartier Antitank Range


CFB-Valcartier
Antitank Rocket Range
T
Targets
Halo Sampling Areas
10-m x 10-m Grids
Grids Subdivided into
100 1-m x 1-m Mini-Grids
C11
C12
C13
C10
C14
C9
B6
G12
B5
B7
C15
C8
A3
A4
B4
A2
B8
A1
C7
C16
B3
G10
B1
B2
C6
C1
C5
G9
C2
C4
C3
G8
G7
G6
G5
G4
G3
G2
G1
Firing Point

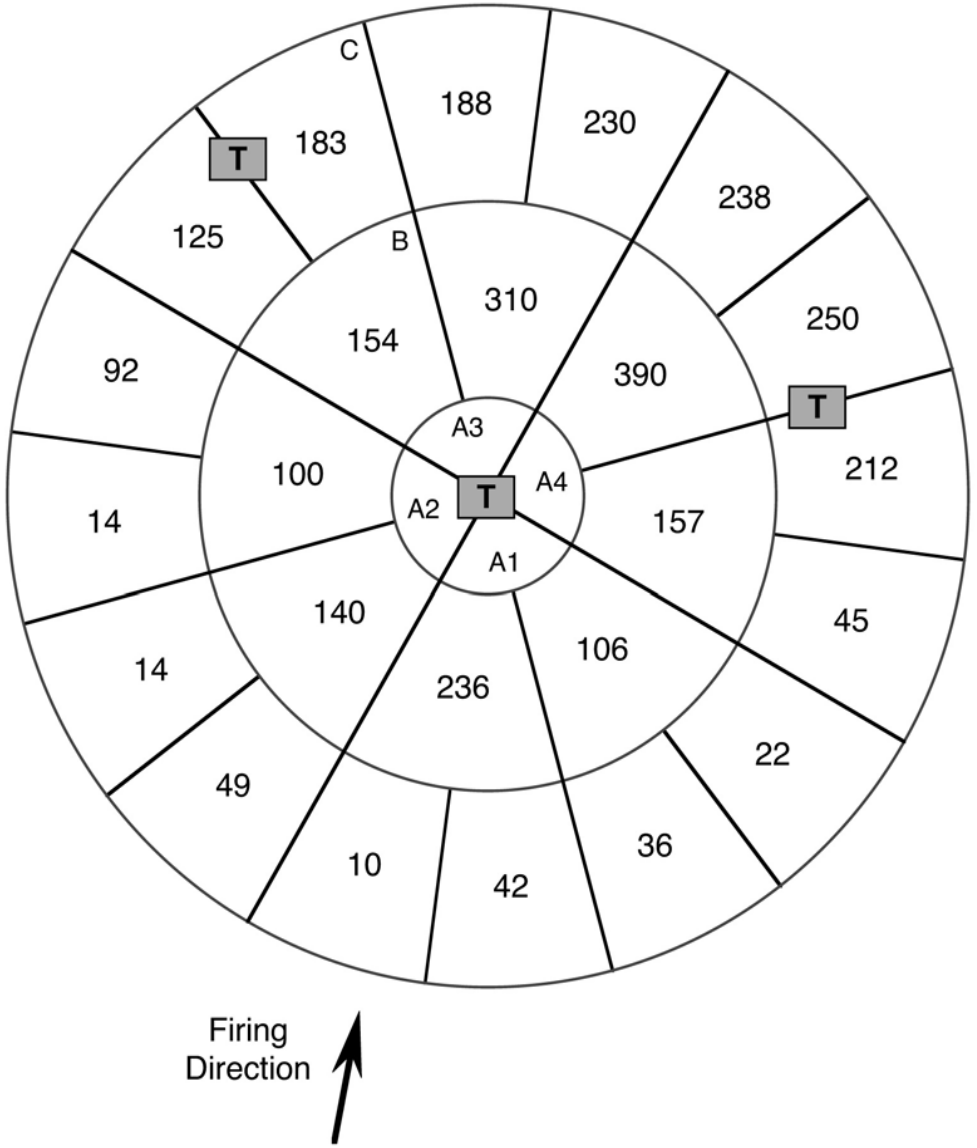
CFB-Valcartier
Antitank Rocket Range

HMX Concentrations
(mg/kg)

A1 – 1,230
A2 – 1,100
A3 – 924
A4 – 336

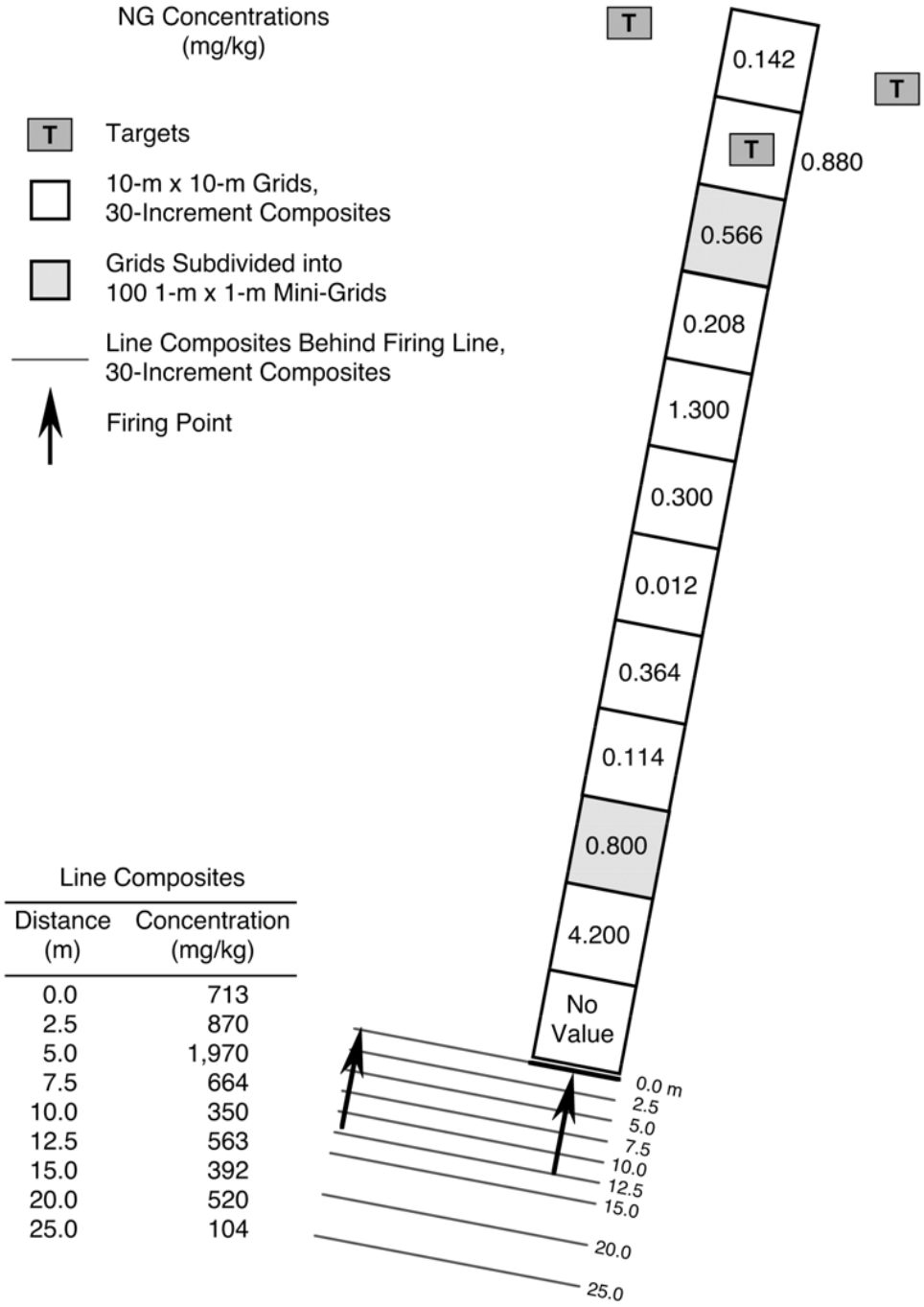
Halo Mean Values

A – 898
B – 199
C – 112



CFB-Valcartier
Antitank Rocket Range

NG Concentrations
(mg/kg)



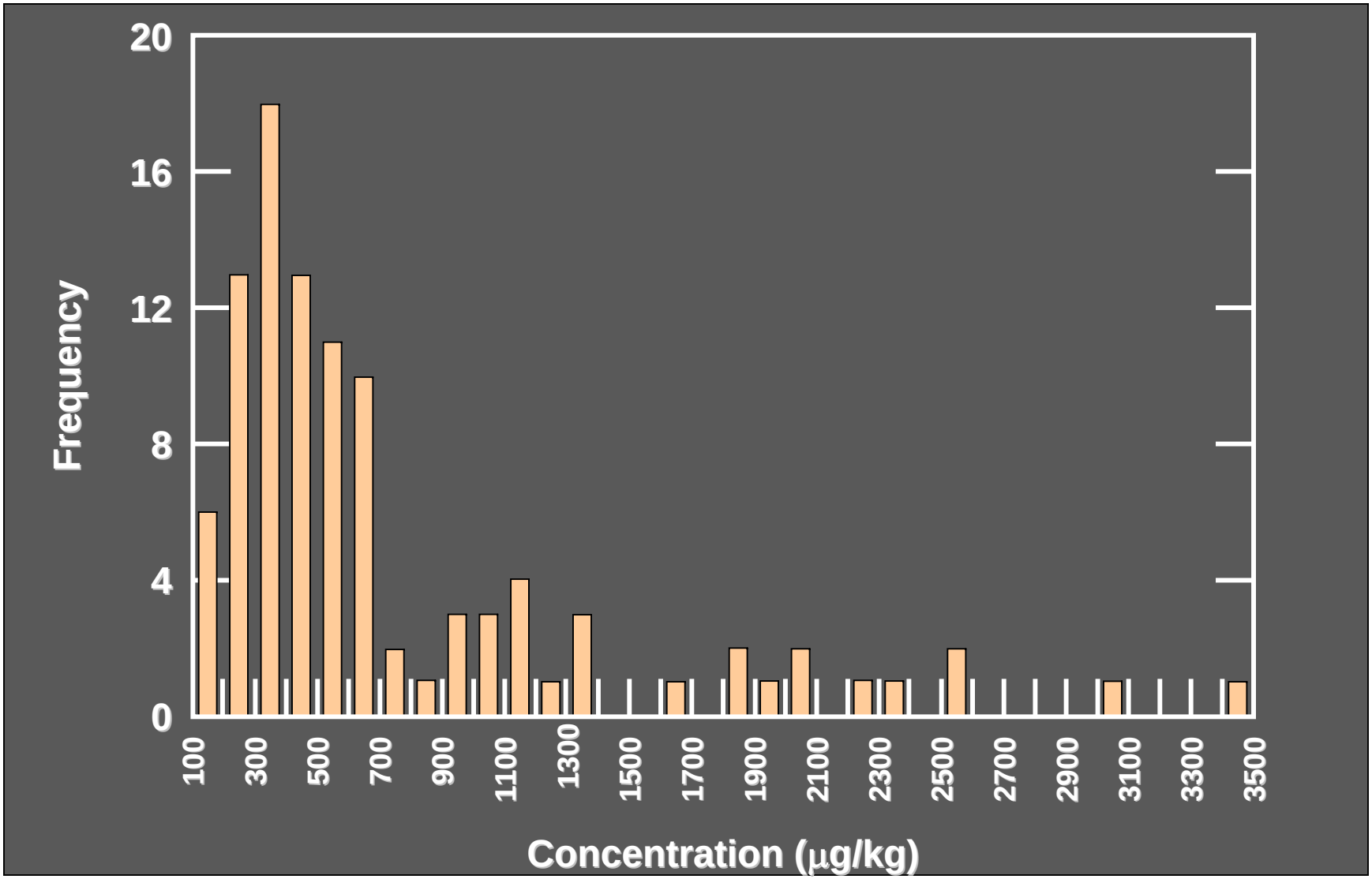

Line Composites

| Distance (m) | Concentration (mg/kg) |
|---|---|
| 0.0 | 713 |
| 2.5 | 870 |
| 5.0 | 1,970 |
| 7.5 | 664 |
| 10.0 | 350 |
| 12.5 | 563 |
| 15.0 | 392 |
| 20.0 | 520 |
| 25.0 | 104 |

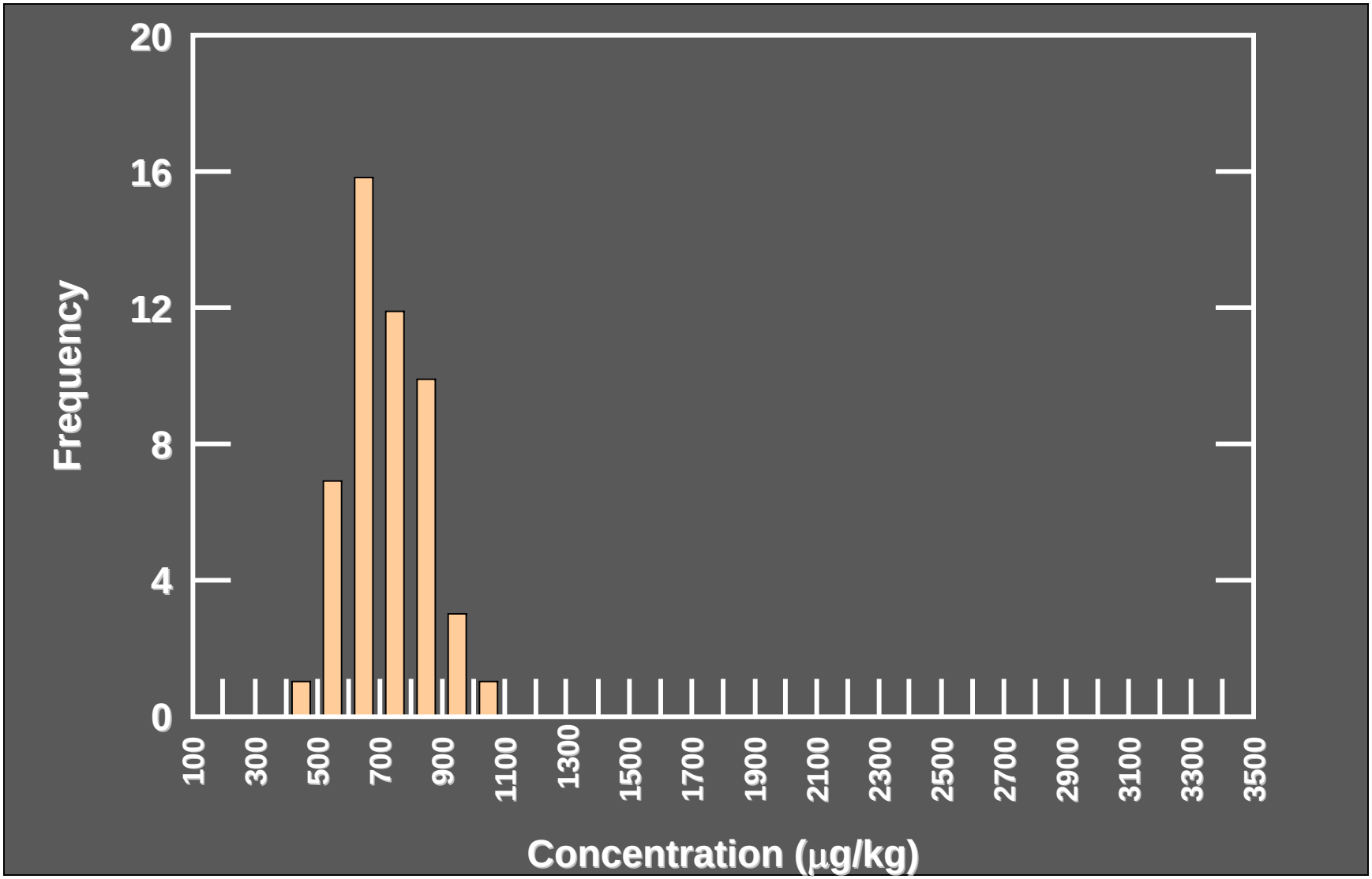
# Valcartier Antitank Range Study

- Divided Grids 3 and 10 into 100 1-m x 1-m minigrids
- Collected a discrete sample from each minigrid
- Built random mathematical composite samples with n values from 5 to 50 from the discrete samples

# NG Individual Concentrations



# NG Composite (N=30)



# Characteristics of Antitank Rocket Ranges

- Hundreds of acres in size
- Vegetated except around targets, generally grasslands (need line of sight)
- Detonations can result in periodic localized fires
- Surface UXO present and dangerous
- Target debris present

# Antitank Rocket Ranges

- HMX and NG are the major contaminants at anti-tank firing ranges (TNT only 1/100 of HMX)
- Residues reside largely in the top few inches of soil
- Concentrations decline with distance from target and firing point
- Total characterization error is largely sampling error
- Particles of propellant present at firing points
- Largest NG concentrations behind firing line
- HMX residues largely from ruptured rockets

# Hand Grenade Ranges Sampled

- Ft. Lewis, Washington
- Ft. Richardson, Alaska
- WATC-Wainwright, Alberta
- Ft. Leonard Wood, Missouri
- Ft. Wainwright, Alaska
- Camp Bonneville, Washington
- CFB-Gagetown, New Brunswick
- Scholfield Barracks, Hawaii
- Pohakuloa Training Range, Hawaii
- CFB-Valcartier, Quebec

# Hand Grenade Range
# Ft. Lewis, Washington

# Hand Grenade Low-Order Detonations

# Characteristics of Hand Grenade Ranges

- A few acres in size
- Sparsely vegetated or non-vegetated
- Heavily cratered unless the craters are filled
- Metallic fragments heavily distributed
- Undetonated grenades can be present in craters (very dangerous)
- Concentrations of RDX and TNT often in high µg/kg (ppb) to low mg/kg (ppm) range
- Major residue sources - partial detonations and blow-in-place of duds

# Artillery/Mortar Range Impact Areas Sampled

- Ft. Richardson, Alaska
- Ft. Lewis, Washington
- Yakima Training Center, Washington
- Camp Guernsey, Wyoming
- CFB-Shilo, Manitoba
- Ft. Bliss, New Mexico
- Jefferson Proving Ground, Indiana
- CFB-Gagetown, New Brunswick
- Scholfield Barracks, Hawaii
- Donnelly Training Area (Ft. Greely), Alaska
- Pohakuloa Training Area, Hawaii
- Ft. Hood, Texas
- 29 Palms, California

# Artillery Range - Ft. Bliss, NM

# Artillery Range - Ft. Lewis, WA

# Eagle River Flats Impact Area
# Ft. Richardson, Alaska

# Low Order (partial) detonation of 155-mm Howitzer Round, Ft. Bliss, NM

# Chunks of TNT Collected from 10-m x 10-m Grid at Ft. Bliss

# Ruptured 500-lb Bomb
# Camp Guernsey, WY

# Bomb crater at CFB-Gagetown

# Characteristics of Impact Areas at Artillery Ranges

- Square miles in size
- Vegetated (grassland, forests, wetlands)
- Subject to periodic fires (often intentionally burned)
- Surface and subsurface UXO present
- Heavily cratered near targets
- Wide variety of ordnance used
- Most of surface area uncontaminated
- Impact areas have low ppb concentrations of TNT/RDX/HMX/NG or below
- Chunks of explosives and high localized surface soil concentrations near low-order (partial) detonations
- White Phosphorus particles persistent in wetlands

# Firing Points Sampled

- **105-mm howitzers** (Ft. Lewis, Ft. Greely, Scholfield, Pohakuloa, CFB-Shilo)
- **155-mm howitzers** (Yakima TC, Camp Guernsey, Jefferson Proving Ground, Pohakuloa)
- **120-mm tank gun** (Yakima TC)
- **LAW rockets** (CFB-Valcartier, Ft. Ord, Yakima TC, CFB- Gagetown, Ft. Bliss, Scholfield)
- **Mortars** (Yakima TC, Ft. Greely, Camp Ethan Allen, Ft. Drum, Pohakuloa)

# 105-mm Howitzer fired at Ft. Richardson, AK

# Residues at Firing Points

- Deposition as propellant fibers (NC)
- Artillery
  - 105-mm - 2,4-DNT (ppb to ppm)
  - 155-mm - NG (ppb)
- Antitank rockets
  - LAW - NG (ppb to %)

# CHARACTERIZATION PROBLEMS FOR RANGES

- Collection of representative samples in areas of extreme spatial heterogeneity
- Sample splitting in the field for QA/QC
- Laboratory subsampling to preserve representativeness
- Enormous concentration ranges (ppb to %)
- NG often a target analyte

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