Evaluation of Heat Transfer Technologies as a Method to Remediate Firing Positions

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NOTICE (U)
(U) This document has been reviewed and DOES NOT CONTAIN controlled goods.

UNCLASSIFIED
5th CDSB Gagetown RTA

- Training Area:
  - 1,100 Sq Km²
  - 20,000 hectares of impact area

- Canada’s second largest military training area

- Centre of Excellence for Army Training
FIRING POSITIONS
WELLINGTON RANGE
Anti-Tank Firing Background

- High deposition rate of Nitrocellulose fibers (NC) containing Nitroglycerin (NG) based propellant (3% of soil matrix)
- High NG concentrations behind firing positions (10 to 20,000 mg/kg)
- NC is highly insoluble and resilient to biotic and abiotic biodegradation processes
- After 25 years of inactivity, still over 4000 ppm in surface soils
Background Cont.

- NC/NG is not an Env Contaminant of Concern
- Surface ignition could result and munitions are stockpiled on site
- NG is volatile and could represent an health and safety issue to users
The objective of this trial was to establish if NG concentrations in soil at firing points could be reduced using this technology.
Remedial Option Analyses

DRDC

- NC matrix highly water insoluble, prevents the use of bioremediation
- NC resistance prevents the use of chemical reduction, hydrolysis or oxydation
- Ex-situ treatment using soil stabilization (STABLEX) limited by the high concentrations of energetic materials (limit of 5000 mg/kg)
- Contamination concentrated at surface
- Incineration was selected as the preferred option as NG destruction temperature is low at 200°C and according DRDC can combust as low as 60°C
Burning Technologies

- In-situ technology using gelled solvent
- Trials ran from 2009-2011 by Isabelle Poulin from DRDC
- Two drawbacks
  - Too expensive for large scale deployment
  - Temperature not high enough to burn NG in subsurface
Direct Flame Burning

- Hand-held propane burner delivering heat as a direct flame
- Trial conducted at Carpiquet, Quebec the summer of 2013
- Drawbacks
  - Time consuming, not user friendly
  - Difficult to manage for large scale deployment
  - Temperatures not sufficient to burn NG completely at the surface
  - Insufficient heat penetration did not allow burning of NG in sub-surface
Asphalt Heating Technology

- Proposed by 5CDSG Gagetown Environmental Branch, based on radiant blue flame
- Tested in two trials conducted in 2013 and 2014
- First trial performed with a IR-Proheater single unit for durations of 15 and 30 minutes heating at two locations at Wellington firing positions
2013 Trial : IR-Proheater Single Unit
2013 Trial Results

- After 15 minutes exposure: NG surface soil concentrations decreased from 1960 to 1650 mg/kg for 17% reduction
- After 30 minutes exposure: NG surface soil concentrations decreased from 310 to 260 mg/kg for 14% reduction
- Average of 15% reduction was achieved for both trials
- Technology was cheap ($1000/day), easy to deploy and destroyed 15% of NG after 30 minutes of heating
- We did not sample at depth
- Visual observations of the NG ignition were noted
- Results showed promise but require longer duration of heat exposure and intensity
2014 Trial

- Performed in September 2014 using a larger heater (Asphalt Reheat System – Manta Ray EXT)
- Probes were used to measure the temperature at different depths down to 25 cms
- Location A:
  - Sampled prior to heating
  - Heating period of 30 minutes – resampled
  - Re-heating for another 30 minutes and re-sampled
- Location B:
  - Sampled prior to heating
  - Heating period of 60 minutes – resampled
  - Re-heating for 60 minutes and re-sampled
- Location C: (highest NG concentration)
  - Sampled prior to heating
  - Heating period of 240 minutes
  - Resampled the surface and the sub-surface
Manta Ray EXT Trailer by ARS
Temperature Probe
Results – 30+30 Minutes

- After heating 30 minutes, temperature reaches 340°C, then it goes up to 425°C. It is suspected that H₂O is boiled off allowing temps to increase.
Results 60+60 Minutes Heating

Temperatures vs Times

Cooling time for
After Heating
Following 4 hours of Heating

- Visual observation of soil drying down to a depth of 15 cm
## 2014 Results

<table>
<thead>
<tr>
<th></th>
<th>NG Concentration (mg/kg) Heating for 30 Minutes (Location A)</th>
<th>NG Concentration (mg/kg) Heating for 30 + 30 Minutes (Location A)</th>
<th>NG Concentration (mg/kg) Heating for 60 Minutes (Location B)</th>
<th>NG Concentration (mg/kg) Heating for 60 + 60 Minutes (Location B)</th>
<th>NG Concentration (mg/kg) Heating for 240 Minutes (Location C)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before</strong></td>
<td>9300</td>
<td>9300</td>
<td>2500</td>
<td>2500</td>
<td>13000</td>
</tr>
<tr>
<td><strong>After</strong></td>
<td>1000</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td><strong>After sub-surface 0-15 cm</strong></td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
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<tr>
<td><strong>After sub-surface 15-30 cm</strong></td>
<td>___</td>
<td>___</td>
<td>___</td>
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</tr>
</tbody>
</table>

ND = Non Detect
Conclusions

- Technology easy to deploy, very efficient at heating soils down to 15 cm (no need to go further)
- Adjustments would have to made to the equipment for long duration heating
- Maximum surface soil temperatures achieved: 470 °C (900°F)
- Temperatures reached were highest following H₂O boil off
- Complete destruction of NG in surface soils after one hour
- Completed destruction of NG after 4 hours down to 5 cm. However we suspect destruction of NG to 15 cm
- This technology has high potential to be used as a remedial tool for anti-tank range firing points, but also at sites containing single, double or triple base propellants (Demo Sites)
- Not appropriated for gun propellants (2,4-DNT based)
Way Ahead

- Additional trials will be conducted to establish specific heating times, including subsurface sampling for each trial (before and after)

- Trials will be conducted in other soil types

- Further investigation into this technology will be undertaken this coming summer for RDX

- Small scale remediation and maintenance of firing points are to commenced in 2016

- This technology could be used for certifying that munitions debris are free of explosives residue
Questions?