Treatment of Elevated Concentrations of Organic Explosives in Sediment to Below Remedial Goals at Yorktown Naval Weapons Station

Summary

In August 1999, the Atlantic Division of the US Naval Facilities Engineering Command, in conjunction with the Yorktown Naval Weapons Station (WPNSTN) initiated the multibatch, full-scale bioremediation of soil impacted with organic explosive compounds (OE) the WPNSTN. Daramend® reagent was the selected remedial option for this site due to its proven effectiveness and potentially significant cost savings over available alternatives.

Soil containing initial TNT concentrations averaging 10,000 mg/kg and as high as 40,000 mg/kg were successfully treated to below the remedial target of 15 mg/kg in all 4 *ex situ* batches, each containing 1,200 yd^3 of soil in a covered treatment cell. RDX was also present in the soil and effectively treated. Following these initial 4 batches, a pretreatment step was added that involved applying Daremend directly to soil in the impacted wetland. This was done prior to excavation and treatment in the treatment cell to reduce starting concentrations and speed up treatment time. Results indicated that *in situ* pretreatment supported reductions from over 10,000 mg/kg to approximately 200 mg/kg; additional time was expected to support further reductions.

Solution

Ex Situ Treatment

The technology was applied *ex situ* to soil in a covered treatment cell containing approximately 1,200 yd^3 per batch. Daramend was applied to the soil surface and incorporated to a depth of 2 feet with a tractor-driven deep rotary tiller. Tilling also served to homogenize the soil. Water was then applied to increase the soil moisture content to the appropriate level (80 - 90% of the soil WHC). These steps (application of amendment, tilling, and irrigation), were repeated to complete multiple treatment cycles.

Treatment progress was monitored through the periodic collection of progress samples, which were submitted for laboratory analysis using SW-846 method 8330. In the first two batches, the initial mean TNT concentration was approximately 10,000 mg/kg and was reduced by over 99.9% (Figure 1). Confirmatory sampling of the first two batches indicated that the residual concentrations were far less than the TNT remedial goal concentration of 15 mg/kg. Similarly, the mean RDX concentrations were reduced by 98.4% from 210 mg/kg to 4 mg/kg during treatment of the first batch, and by 99.6% from 255 mg/kg to 1 mg/kg, during treatment of the second batch (Figure

1). Subsequent *ex situ* batches supported similar treatment results, all resulting in TNT and RDX concentrations well below the remedial goals. In one batch, 3 treatment zones contained TNT concentrations in excess of 40,000 mg/kg, which were successfully treated.

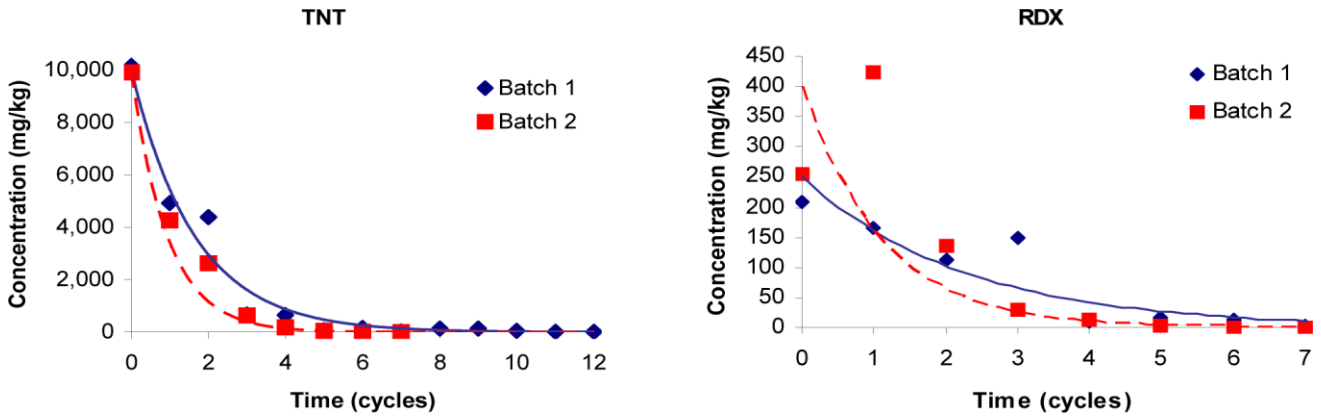

Figure 1: Effect of Daramend treatment on TNT and RDX concentrations

In Situ Treatment

Following the successful *ex situ* application of Daramend® reagent at the site, the U.S. Navy decided to apply an innovative treatment method on additional impacted soil. Pre-treatment resulted in a substantial reduction in the concentrations of the OE prior to placement in the bioremediation treatment cell, and reduced the amount of time required to complete treatment of each batch. Pre-treatment was applied "in-place" at the excavation site where soil from the entire excavation area was consolidated into two pre-treatment cells.

Pre-treatment activities began in June 2003 and continued through September 2003. The process essentially involved the same steps required for treatment in the bioremediation cell; however, it was applied in an 8 to 12 foot lift of soil using excavation equipment. These steps included the application of small quantities of Daramend (1 - 2%, w/w) directly to the soil in place. Cost savings of approximately $70,000 per 1,000 tons of soil were realized using this procedure due to the reduced treatment requirements once placed in the ex situ treatment cell compared to soil that did not receive pre-treatment. To evaluate the effectiveness of pretreatment samples were collected periodically from five locations within each pre-treatment cell. These results were compared with relevant site characterization analysis.

Results indicated that *in situ* Daramend treatment supported reductions in TNT concentrations from and an initial average concentration of 10,884 mg/kg to 211 mg/kg following 3 months of treatment, representing a 98% reduction. In addition, the average concentration of RDX was reduced from 400 mg/kg to 1 mg/kg (a > 99%

reduction). Note that continued *in situ* treatment may have resulted in concentrations below the remedial target of 15 mg/kg, but site regulatory protocols required *ex situ* treatment regardless, so the soil was moved to the treatment cell for final polishing after only 3 months.

Sample	Initial Concentration, (mg/kg)	Final Concentration after Treatment, (mg/kg)
1	10,151	58
2	9,906	156
3	15,359	73
4	8,119	557
Mean	**10,884**	**211**

Figure 2: Effect of *In Situ* Daramend treatment on TNT concentrations in soil

Results

Daramend reagent proved to be extremely effective for the treatment of elevated concentrations of TNT and RDX in soil at the Yorktown Naval facility. The application of pre-treatment greatly reducing the extent of *ex situ* treatment required. Treatment of the same material without pretreatment would typically require 7 to 14 treatment cycles, each of which requires 10 to 20 days to complete. Given the reduced *ex situ* effort required, the cost savings were approximately $70,000 per 1,000 tons of soil treated.