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Low Temperature Thermal Deactivation for Remediation of Energetic Materials in Soil

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ABSTRACT

Low temperature thermal desorption (LTTD) has traditionally been used to remediate soils contaminated with petroleum based fuels, non-fuel hydrocarbons and chlorinated solvents. A relatively new area for application of the technology is remediation of soil impacted by energetic materials.

This paper covers the operation of a large-scale transportable LTTD system, operated in 2006 at an ongoing manufacturing facility for energetic materials in Utah. The system processed approximately 91,000 tons of soils containing nitrated compounds that were successfully remediated with the LTTD, with no incidents related to the energetic material processed.

Soils containing residual levels of the constituents RDX, PETN, TNT, and HMX, ranging from 100 ppb to pure component as excavated were processed, with a 100% success rate in achieving the risk-based processed soil cleanup criteria. About 90% of the processed soils were below detection limits for residual concentrations.

In addition to the soil, 55 cubic yards of nitrostarch product (an energetic material) present at the remediation site was introduced to the LTTD unit during the project, and that too was processed successfully. The nitrostarch was metered into the system, according to a specific protocol, at a maximum rate of 5 lb every 15 seconds.

Deactivation of the energetic constituents occurs in the primary treatment unit, also known as the dryer or desorber, at an average hourly temperature of about 680 degrees F and a processing rate of not more than 40 tons per hour. Stack testing demonstrated that energetic constituent concentrations in the stack discharge were below detection limits. While the oxidizer was operated at 1,500 degrees F, this treatment step is probably unnecessary for the energetic constituents which are effectively deactivated in the dryer.

This paper includes information on: techniques employed to remediate the nitrostarch product and the energetic compounds in soil; the technical data gathered during the project; and, a discussion of risk assessment associated with the work.

BACKGROUND

An energetic materials manufacturing facility in central Utah is the subject of a RCRA corrective action program to address soil contaminated with RDX, HMX, PETN, TNT and other energetic compounds (as defined in Table 1). Areas of concern were identified and investigated with extensive soil sampling and analysis. Information was collected to understand the potential risks in soils that contain constituents of potential concern (COPCs). Based on this understanding, an interim measures program to address impacted soils was designed and implemented, primarily via on-site thermal treatment. The project was approved, permitted and completed in 2005 and 2006. Approximately 91,000 tons of soils containing energetic materials were excavated and treated (deactivated) during this period using a direct-fired thermal treatment unit. In addition, some excavated off-specification energetic materials products mixed with soil were also treated via the same thermal deactivation process.

Thermal treatment provided a quick and permanent solution. The project was completed safely on a non-homogeneous variety of soil types, moisture content and contaminant content. The stack test showed the concentrations of energetic materials in the air discharge were below detection limits.

SITE HISTORY, CONTAMINANTS/CONTAMINATION LEVELS AND CLEANUP PLAN

Located in central Utah, the site is comprised of over 400 acres with the manufacturing and product handling centers distributed over this acreage for safety reasons. Therefore, the individual impacted areas and related excavations contained a variety of soil types. The materials processing and waste management histories of each area also varied, resulting in diverse distributions of COPCs in the environment. In general, though, the highest concentrations of COPCs tended to be located near the surface. In areas where wastewater was managed, COPCs were found much deeper than where dry deposition was the primary means of release.

More specifically, some of the materials subject to remediation represented a potential reactivity characteristic hazard. These included nitrostarch mixed with soils; soils containing bits and chunks of energetic materials; and, soils containing greater than two percent of energetic materials constituents (EMCs). The predominant COPCs were RDX, HMX, TNT, DNT, PETN, EGDN, DEGDN, TEGDN, TMETN, BTTN & NG plus nitrostarch mixed with soil. Estimated average concentrations for the highest concentration soils on the site are summarized in Table 1.

Cleanup Plan

Interim measures were undertaken to speed cleanup of the site. The purposes of these interim measures are summarized below:

- Provide for immediate treatment of the higher COPC concentrations in soils, including nitrostarch mixed with soils and soils containing greater than two percent EMCs. These interim measures accelerated the management of the majority of COPCs requiring corrective action.
- Approximate the final corrective action to the extent feasible. The interim measures may, in fact, achieve final corrective action at some locations. However, it is not necessary for the interim

measures to achieve final corrective action in any of the impacted areas to achieve the primary objectives.
- Perform corrective action to industrial/commercial criteria (e.g., direct exposure) and/or residential criteria (e.g., migration to regional aquifer), as appropriate for the exposure scenario.

The decision was made to use an on-site solution to minimize exposure to hazards and movement of potentially reactive materials, an approach that has been endorsed by the Utah Division of Solid and Hazardous Waste. On-site soils treatment and management was judged to be more appropriate and have lower risk than shipping them across the highways or railways, particularly for soils containing energetic materials.

Benefits of the Interim Measures

The general benefits of the interim measures were:

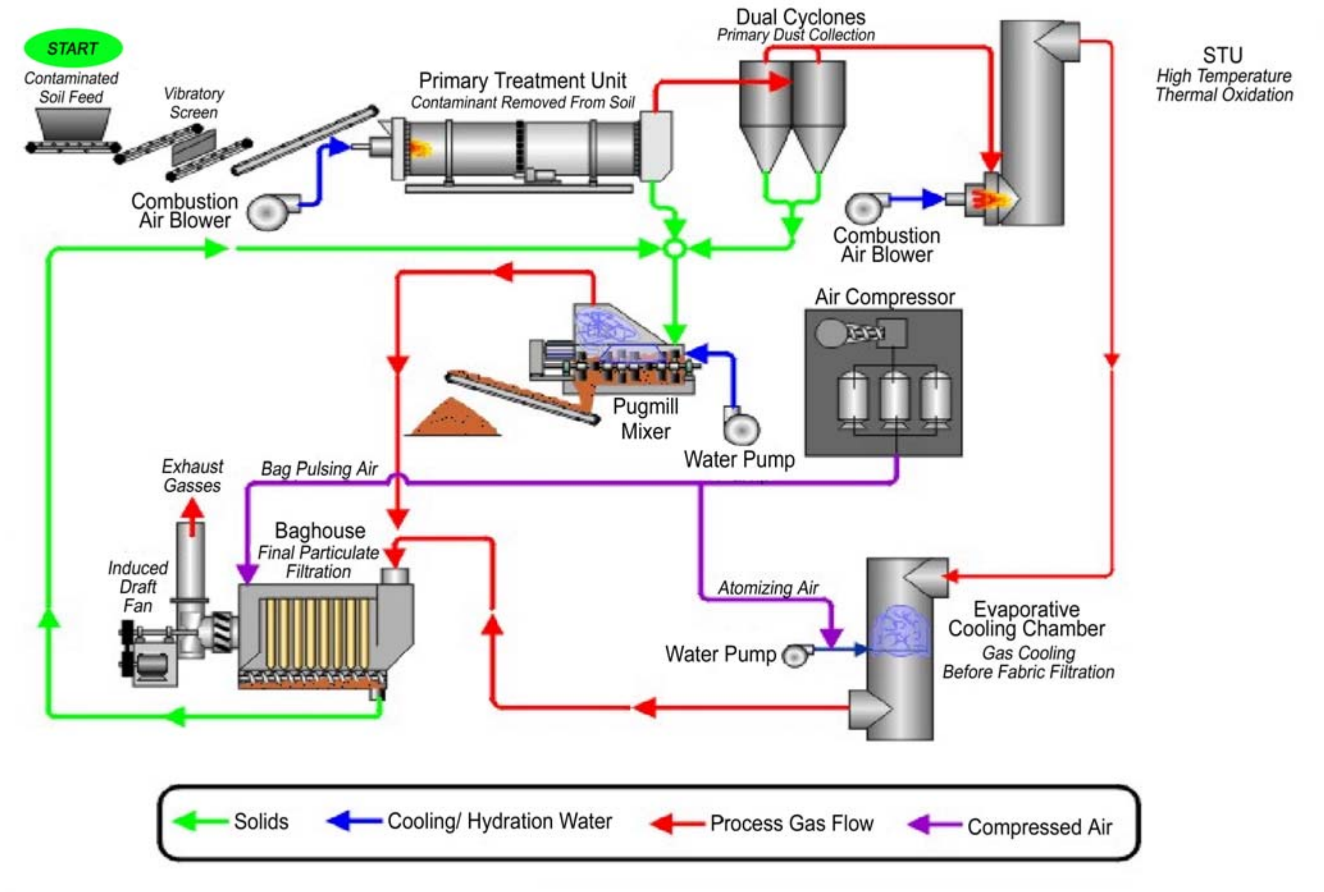
- Treatment of COPC-impacted soils is accomplished much earlier than would be the case under the traditional RFI/CMS process.
- Quick management of nitrostarch mixed with soils and soils containing greater than two percent EMCs, thereby eliminating any potential reactivity characteristic hazards.
- Reduction of potential human health and/or environmental risks earlier in the corrective action process.
- Use of a preferred technology (thermal treatment) for EMCs as the primary COPCs.
- Minimization of EMCs by destroying them on-site, rather than relocating them. The thermally treated soils have the appropriate qualities for reuse on the site. A relatively small quantity of soils that contained lead has been removed from the site for landfill disposal.
- Management of the majority of soils on-site, thereby minimizing potential truck traffic to and from the site.

THERMAL DESORPTION SYSTEM

The thermal desorber is owned and operated by ESMI. It was manufactured by ASTEC and is a classic direct-fired cocurrent design. As show in Figure 1, major components are feeder/feed prep, direct fired desorber drum, treated soil conditioning station, cyclone separators, secondary combustion chamber, dry bottom spray quench tower, baghouse, ID fan and stack. The unit is transportable, and can be set up on site in less than 2 weeks. During stack tests at the site, the system ran at approximately 35.5 tph.

While many organic impacted sites have been cleaned using low temperature thermal desorption equipment, few have been done where EMCs were the issue. The history of such sites includes, most notably and recently, work by a contractor who leased ESMI's equipment at the Massachusetts Military Reservation (MMR) on Cape Cod, Massachusetts. Similar mobile thermal treatment equipment was also recently used to successfully treat soils containing HMX, RDX and TNT at the Kansas Army Ammunition Plant.

Figure 1, Cocurrent Desorber Process Flow Diagram



Other organic constituents (volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polycyclic aromatic hydrocarbons (PAHs) and petroleum hydrocarbons including diesel range organics (DRO) and motor oils (MO)) were present in a minor quantity of soils and/or at minimal concentrations that were also amenable to thermal treatment.

Test burn – Temperature and Feed Rate

- The feed rate is moisture-dependent. During the stack test, the feed rate was 35.5 tph on a one-hour rolling average basis.
- The soil discharge temperature was 680°F, which is typical of low temperature thermal desorbers cleaning soil with mid range boiling point compounds.
- A key concept is that the treatment and deactivation reactions of the COPCs occur entirely in the desorber. The secondary combustion chamber is not really necessary for the COPCs due to their chemical nature, although it was required for part of the project when processing other organics.
- The secondary combustion chamber operated at 1,500 degrees F on a ten-minute rolling average basis.
- Soil data for feed stock and treated soil was collected as hourly composites. During the initial stages of the project, eight-hour composites were submitted for analysis (three samples per day). In later stages of the project 12-hour composites were submitted for analysis (two samples per day). A 99% removal efficiency for RDX, TNT and HMX was demonstrated in the test burn process and about 90% of the treated soil samples for the overall project were reported as non-detectable for EMCs after treatment.

SOILS TREATED

In general, soils exceeding the human health risk assessment (HHRA) criteria for direct human exposure under an industrial/commercial standard were included in the thermal treatment interim measures, and soils containing two percent (2%) or more EMCs by weight. As they were found in-place, these soils were conservatively managed as if they may be potentially reactive and were subjected to thermal treatment after blending with other soils to a calculated EMC content of less than two percent (2%). After blending with other soils, they no longer have the potential to exhibit the characteristic of reactivity.

Table 1 presents the estimated weighted average concentrations of COPCs for the soil volume represented in Figure 2. There were approximately 91,000 tons of soils treated. EMSI met soil treatment goals with a single pass through the desorber 100% of the time

SAFETY ISSUES PROCESSING ENERGETIC MATERIALS, INCLUDING NITROSTARCH MANAGEMENT

This paper does not allow room for detail on handling and treatment of energetic materials. Briefly, if the concentration of energetic materials mixed with an inert substance (in this case, soil) is below a critical threshold, the energetic compounds will thermally desorb, react and decompose but will not detonate. If small pieces of energetic materials are present, they are not likely to not detonate in this unconfined environment. Any small pressure excursions resulting from rapid decomposition of these products, handled in this manner, would result with no damage to the equipment. Due to the close coordination between the key parties on this project, the energetic materials content of the feed soil was carefully managed and no over-pressurization events occurred, nor were there any incidents that resulted from the handling of potentially reactive substances.

Nitrostarch is an energetic material that was identified in one of the areas of remediation and required thermal deactivation. Approximately 135 cubic yards of nitrostarch mixed with soil was present in this area, of which approximately 55 cubic yards was essentially nitrostarch product deposited in layers, but not entirely separable from the soil.

Nitrostarch is not particularly toxic. However, when dry, nitrostarch is reactive and ignites spontaneously, burning extremely vigorously. In contrast, when moist, this product is not reactive. This material represented a particular challenge for safe thermal management. For a variety of reasons beyond the scope of this paper, in-place burning was not a feasible option. Together with the facility owner, excavation contractor and thermal treatment contractor, a protocol was developed to excavate, package and thermally treat this particularly challenging substance. A brief description of the protocol for managing this material is provided below.

The area of excavation was sufficiently wetted to make the nitrostarch safe to excavate. Layers of the material were exposed using excavation equipment. Then, the nitrostarch and some associated soil was hand-placed into linen bags. Plastic bags could not be used since no plastic was allowed to enter the thermal treatment unit under the State-approved Work Plan. These linen bags were suggested by the prime excavation contractor and are bags typically used for holding freshly harvested shellfish, such as scallops. The bags were tightly woven so as to not allow the escape of any nitrostarch or soil, but are easily wetted. The filled bags were stored in a wetted environment inside plastic lined drums.

Prior to initiating the excavation process, a test program was conducted to determine the feasibility of using the thermal treatment process for this material. Ultimately, it was determined that a safe means of managing this material was to limit the quantity of nitrostarch bags allowed into the area to one 55-gallon drum at a time. When such a drum was delivered to the thermal treatment pad, a designated person (provided by the facility owner), placed the bags one at a time into the chute leading directly into the dryer. Each bag was limited to a maximum of five pounds of nitrostarch and the feed rate was limited to one bag per 15 seconds. During protocol development, this procedure was initiated with much smaller quantities of nitrostarch to observe how the material would behave in the desorber. It was determined that the rate of reaction was significantly mitigated by the wet condition of the nitrostarch and existence of the soil fed to the unit. This protocol did not interfere with or limit in any way the normal processing of soils and allowed successful removal and deactivation of this challenging product.

Table 1, COPC Soil Concentration	34,000 Ton Estimate								
		Concentration Ranges [mg/kg]							
Compound	**Average Concentration [mg/kg]**	**Not Detected**	**<1**	**1 - 10**	**10 - 100**	**100 - 1,000**	**1,000 - 10000**	**10,000 - 100,000**	**% Volume with Data**
1,1,1-Trichloroethane	2.3E-04		8%						8%
1,2,4-Butanetrioltrinitrate (BTTN)	1.8E+00	17%	39%	3%	3%				62%
1,2,4-Trimethylbenzene	4.1E-01	11%	8%	2%	4%				25%
1,3,5-Trimethylbenzene	6.4E-02		7%	4%					11%
1-Methylnaphthalene	3.7E-01			3%	2%				5%
2,4,6-Trinitrotoluene (TNT)	1.6E+02	17%	8%	5%	0.2%	32%	1%		64%
2,4-Dinitrotoluene	1.8E-01	5%	44%	1%	1%				50%
2,6-Dinitrotoluene	4.0E-01	5%	38%	0.5%	3%				46%
2-Methylnaphthalene	7.6E-01		1%	5%	3%				9%
Acetone	2.2E-01		21%	4%					25%
Anthracene	2.3E-02	3%	9%						12%
Antimony	2.0E-01	2%	31%	2%					35%
Arsenic	2.2E+00			35%					35%
Barium	3.9E+01				23%	12%			35%
Benzo(a)anthracene	5.0E-02	3%	9%	1%					13%
Benzo(a)pyrene	1.1E-01	3%	16%	4%					23%
Benzo(b)fluoranthene	5.4E-02	4%	14%	1%					19%
Benzo(g,h,i)perylene	5.0E-02		6%	1%					8%
Benzo(k)fluoranthene	4.0E-02		6%	1%					8%
Benzyl butyl phthalate	0.0E+00	11%							11%
bis(2-ethylhexyl) Phthalate	4.0E-01	4%	10%		3%				16%
Bromochloromethane	0.0E+00								0%
Cadmium	8.4E-02		35%						35%
Chromium	4.6E+00				35%				35%
Chrysene	1.0E-01	3%	6%	1%					10%
cis-1,2-Dichloroethene	1.5E-04		5%						5%
Cyclotetramethylenetetranitramine (HMX)	4.7E+01	2%	12%	23%	32%	9%			77%
Cyclotrimethylenetrinitramine (RDX)	2.3E+02	1%	1%	28%	13%	25%	8%		76%
Dibenz(a,h)anthracene	7.6E-02		2%	4%					6%
Dibenzofuran	0.0E+00	3%							3%
Dichlorodifluoromethane	3.5E-04		6%						6%
Diesel range organics	2.0E+02					9%	5%		14%
Diethylene glycol dinitrate (DEGDN)	4.1E-01	18%	30%	13%					62%
Dimethyl phthalate	0.0E+00	3%							3%
Di-n-butyl phthalate	0.0E+00								0%
Ethylbenzene	9.0E-03		8%						8%
Ethylene glycol dinitrate (EGDN)	6.0E-01	14%	33%	1%	3%				51%
Fluoranthene	1.0E-01	3%	7%	4%					13%
Fluorene	4.6E-02		3%	2%					5%
Indeno(1,2,3-c,d)pyrene	2.5E-02		4%	1%					6%
Isopropylbenzene (Cumene)	1.8E-03	14%	9%						24%
Lead	5.9E+01				10%	30%			41%
m,p-Xylene	5.2E-02		12%	4%					15%
Mercury	2.0E-02		35%						35%
Methyl ethyl ketone	9.5E-05	14%	1%						15%
Methylene chloride	5.7E-04	19%	15%						33%
Metriol trinitrate (TMETN)	3.0E+01	4%	29%	12%	9%		1%		55%
Motor oils	2.2E+03					11%	1%	3%	14%
Naphthalene	4.6E-01	10%	11%	3%	3%				27%
Nitrogen, Ammonia (as N)	6.5E-01	10%	17%	34%	0%				61%
Nitrogen, Nitrate (as N)	6.5E+00		6%	22%	35%	0%			64%
Nitroglycerine (NG)	3.4E+01	15%	2%	19%	11%	23%			70%
Nitrostarch	6.2E+01			4%	23%	1%	1%		30%
n-Propylbenzene	6.9E-02	10%	9%	4%					24%
o-Xylene	1.8E-04		7%						7%
p-Cymene (P-Isopropyltoluene)	9.6E-02	10%	9%	4%					24%
Pentachlorophenol	0.0E+00								0%
Pentaerythritol tetranitrate (PETN)	4.5E+03	9%	3%	5%	12%	9%	17%	24%	80%
PHC as gasoline	3.3E-03		1%						1%
Phenanthrene	4.2E-01	4%	8%	2%	3%				16%
Pyrene	2.1E-01	3%	5%	7%					14%
sec-Butylbenzene	5.3E-02	10%	9%	4%					24%
Selenium	1.3E-01		32%	2%					34%
Silver	1.5E-02	1%	5%						6%
Sulfate (as SO4)	1.8E+02			6%	20%		7%		33%

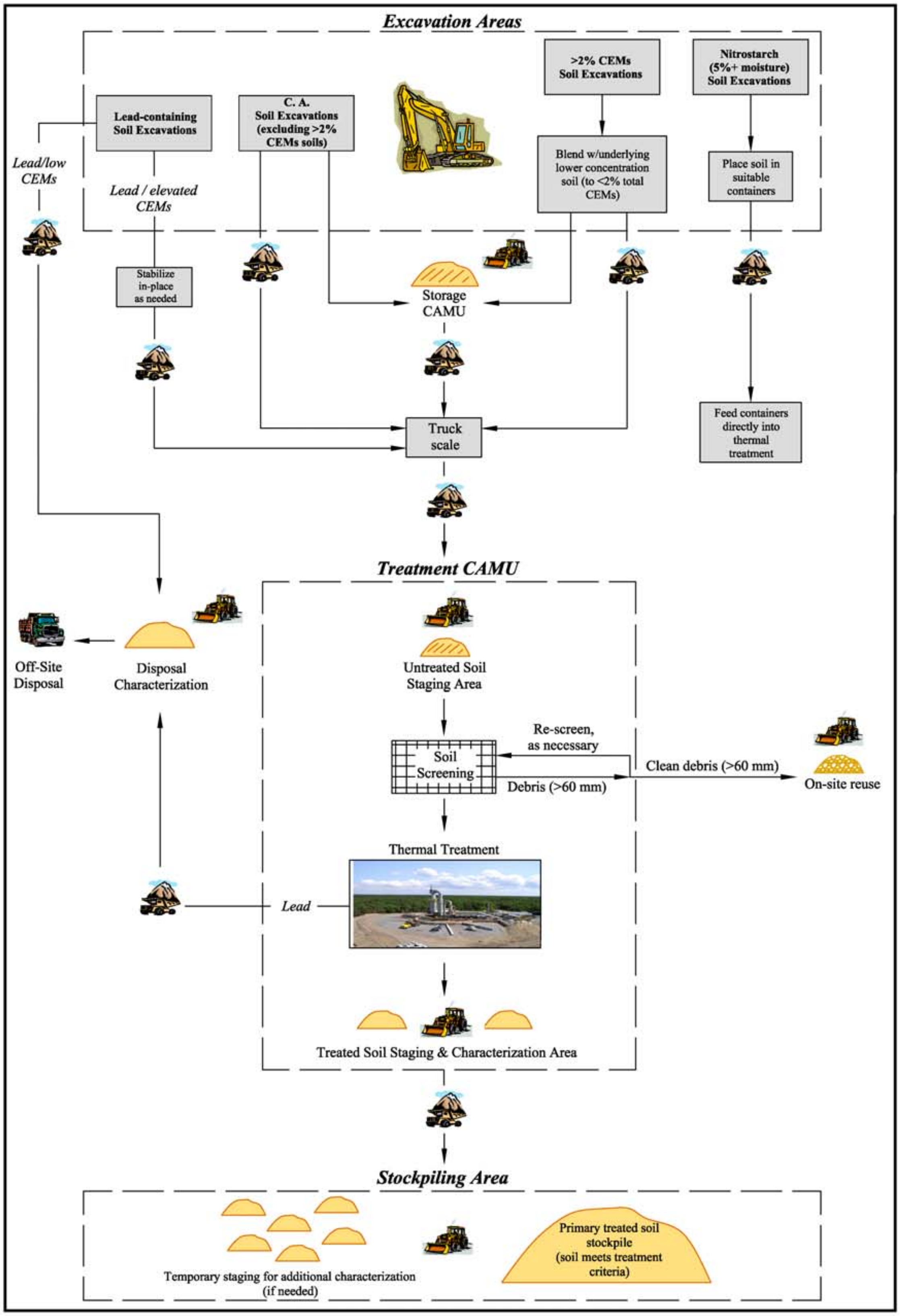


FIGURE 2: ON-SITE SOIL MANAGEMENT OPERATIONS SCHEMATIC

CHALLENGES

Permitting, Approval, Public Notice, Conditions and Stack Test

Certain permits, plans and approvals were necessary to implement the proposed interim measures. The following sections present brief descriptions of the permits and approvals that were obtained.

Air Permitting

Air emissions from the thermal treatment equipment required a permit (Approval Order) from the Utah Division of Air Quality (DAQ) under the new-source review program. The thermal treatment contractor submitted an air permit application that was subjected to public notice. No public comments were received and DAQ issued an Approval Order for the thermal treatment unit. This process took less than 100 days including preparation. The air permit authorized construction and operation of the thermal treatment equipment in support of the Utah Division of Solid and Hazardous Waste (DSHW) order authorizing thermal treatment operations in the Treatment CAMU.

In addition to the air emissions permit, ESMI prepared a Fugitive Dust Control Plan to the DAQ, in conformance with The Fugitive Emissions and Fugitive Dust Rule (R307-309).

State Approval of Treatment CAMU

Thermal treatment operations at the site were performed in a Treatment CAMU as authorized by DSHW in a corrective action order. The Treatment CAMU received only non-hazardous remediation wastes and no hazardous wastes were processed through the Thermal Treatment Unit (TTU).

"EPA's Area of Contamination" Policy

Soils with greater than two percent EMCs were mixed with underlying soils (which also require corrective action) at the time of excavation, in the SWMU where they are found, prior to movement to the treatment or storage CAMU, to produce a soil that contains less than two percent EMCs. This activity is allowable under EPA's Area of Contamination (AOC) Policy (EPA guidance, March 13, 1996 EPA memo, "Use of Area of Contamination Concept During RCRA Cleanups"). Blending these soils ensured that soils introduced into the thermal treatment unit did not have any potential to exhibit the reactivity characteristic, provided a more consistent EMC content, and resulted in safe handling of these soils.

Treatment Goals

Forward risk assessment results were calculated using the conservative exposure and health effect assumptions in the human health risk assessment. These results demonstrated that the treatment goals are protective of human health based on conservative assumptions regarding the placement of these treated soils back on the site.

The key assumptions that pertained to the treatment goal calculations follow:

1. The thermal treatment process will greatly reduce the total mass of constituents and their concentrations in soil, and the project plan called for >99% removal of the EMCs from the soil.
2. The treatment goals were applied to batches of up to a full days treated soil (720 tons).
3. For purposes of calculating the forward risk assessment on the treatment goals, it was assumed that a total of 100,000 tons of soil would be treated and placed in a particular area of the site.
4. The target risk levels for the purpose of evaluating treatment goals for the applicable exposure scenarios (off-site resident, on-site industrial worker, on-site construction worker and visitor/trespasser) are $1x10^{-6}$ for carcinogens and a hazard index of <1 for noncarcinogens.

Forward Risk Assessment

The treatment goals (soil concentrations, shown in Table 2A) serve as inputs to the risk assessment equations and the final output is a risk value. This is typically termed "forward" risk assessment. The forward risk assessment results for the applicable receptors are presented in Table 2B. Cancer and noncancer risk estimates are presented for individual compounds. For potential carcinogenic compounds, treatment goals for individual constituents having a target cancer risk value of less than $1x10^{-6}$ are considered acceptable. For noncarcinogenic compounds, treatment goals having a target risk value (Hazard Quotient) of less than or equal to 1 are considered acceptable. As shown in Table 3-1, the treatment goals for the individual compounds are below the target cancer and noncancer risk values for each exposure scenario.

The potential cumulative effects of multiple constituents are also considered. The primary constituents addressed through the interim measure were EMCs. Therefore, for the purposes of evaluating treatment goals, the cumulative risk for the EMC compounds are calculated for potential carcinogenic compounds (RDX, TNT, 2,4-DNT, 2,6-DNT and nitroglycerin) by summing the individual cancer risks. The summing of cancer risks for potential carcinogenic EMCs introduces an additional level of conservatism to the forward risk assessment results. As shown in Table 2B, the cumulative cancer risk for the suspected carcinogenic EMCs is less than $1x10^{-6}$. The EMC compounds are also evaluated cumulatively for noncancer effects by summing the Hazard Quotients for each EMC compound. The resulting value is called a Hazard Index. As shown in Table 2B, the Hazard Index for the EMCs is less than 1. This is a conservative method because it may not be toxicologically appropriate to sum the hazard quotients for each COPC.

Two of the EMC compounds (2,4-DNT and 2,6-DNT) are found in only a limited number of soil samples (approximately 5% of 1251 samples for 2,4-DNT and approximately 2% of 1251 samples for 2,6-DNT) and at concentrations much lower (maximum concentration of 11 mg/kg for 2,4-DNT and 1 mg/kg for 2,6-DNT) than other EMCs, such as PETN and RDX. The assumption that the DNT compounds will be present at the treatment goal concentrations in the full 100,000 tons of soil, greatly overestimates the mass of DNTs that will be present in the treated soils. This highly conservative assumption was maintained to simplify the forward risk assessment calculations on the treatment goals.

While COPCs are present in nearly all the soils that were subject to interim measures, other constituents (e.g. volatile organic compounds) are only present at concentrations exceeding risk-based concentrations in a small fraction of soils at the facility. Given the limited volume of soils containing these other constituents, cumulative risks associated with the treatment goals for these constituents were not evaluated.

Stack Test

The POP (proof of performance) test showed that all energetic material was below detection limits in the stack. The compound class VOCs was less than 0.003 lb/hr, and semi volatiles were less than VOCs. Particulates were found to be somewhat elevated on the initial stack test due to broken bags in the baghouse. Measured SO_2 was approximately 1 lb/hr. Measured NO_x was approximately 130 lb/hr on the soils with higher energetic material concentrations used in the POP test, but dropped significantly during the production run.

PROJECT COSTS

The cost for excavation, soils management and thermal treatment were less than $100/ton. This did not include analytical costs.

SUMMARY

Low temperature thermal desorption was successfully used to treat 91,000 tons of soil containing less than 2% energetic materials by weight. In addition, 55 cubic yards of nitrostarch product were treated by wetting and batch feeding to the desorber.

100% of the soil fed to the unit passed on product quality tests, and about 90% of the treated soil tests were below detection limits for the energetic compounds. All of the treated soils containing EMCs are suitable for reuse on the site, with the exception of a small quantity of soils that also contained lead.

Table 2A: Summarized Soil Treatment Goals

Constituent	Treatment Goal (mg/kg)	Constituent	Treatment Goal (mg/kg)
Cyclotrimethylenetrinitramine (RDX)	1	1,2,4-Trimethylbenzene	19
Cyclotetramethylenetetranitramine (HMX)	429	1,3,5-Trimethylbenzene	8
Pentaerythritol tetranitrate (PETN)	250	Acetone	148
2,4,6-Trinitrotoluene (TNT)	1	Bromochloromethane	1.5
Ethylene glycol dinitrate (EGDN)	10	Isopropylbenzene (Cumene)	24
Diethylene glycol dinitrate (DEGDN)	10	m,p-Xylene	3
Triethylene glycol dinitrate (TEGDN)	10	Methylene chloride	1.9
1,2,4-Butanetrioltrinitrate (BTTN)	10	Naphthalene	1
Metriol trinitrate (TMETN)	10	n-Propylbenzene	459
Nitroglycerine (NG)	1	p-Cymene (P-Isopropyltoluene)	24
2,4-Dinitrotoluene	0.08	sec-Butylbenzene	46
2,6-Dinitrotoluene	0.03	Trichloroethene (TCE)	0.002
Oil and Grease (motor oil)[1]	300	Diesel Range Organics[1]	100
(1) Total Petroleum Hydrocarbons (TPH) by method 8015. Utah LUST program cleanup levels.			

Table 2B: Treatment Goals – Forward Risk Assessment Results

COPCs (CEMs)	Treatment Goal (mg/kg)	Adult Off-Site Resident		Child Off-Site Resident	On-Site Construction Worker		On-Site Industrial Worker		Visitor-Trespasser	
		Cancer	Non Cancer	Non Cancer	Cancer	Non Cancer	Cancer	Non Cancer	Cancer	Non Cancer
Cyclotrimethylenetrinitramine (RDX)	1	1.5E-07	8.0E-04	1.9E-03	2.7E-09	5.6E-04	3.8E-08	3.2E-04	9.8E-10	6.9E-06
Cyclotetramethylenetetranitramine (HMX)	429		5.3E-03	1.2E-02		1.6E-03		9.6E-03		1.9E-04
Pentaerythritol tetranitrate (PETN)	250		7.7E-03	1.6E-02		1.0E-02		7.3E-03		1.4E-04
2,4,6-Trinitrotoluene (TNT)	1	2.5E-08	3.1E-03	7.2E-03	7.6E-10	1.1E-03	1.1E-08	2.1E-03	2.8E-10	4.4E-05
Ethylene glycol dinitrate (EGDN)	10		1.5E-02	3.5E-02		4.2E-03		2.9E-03		5.5E-05
Diethylene glycol dinitrate (DEGDN)	10		8.1E-03	1.9E-02		4.2E-03		2.9E-03		5.5E-05
Triethylene glycol dinitrate (TEGDN)	10		1.5E-02	3.5E-02		4.2E-03		2.9E-03		5.5E-05
1,2,4-Butanetrioltrinitrate (BTTN)	10		1.1E-02	2.5E-02		4.2E-03		2.9E-03		5.5E-05
Metriol trinitrate (TMETN)	10		1.0E-02	2.4E-02		4.2E-03		2.9E-03		5.5E-05
Nitroglycerine (NG)	1	9.9E-09	2.6E-04	6.1E-04	4.2E-10	4.2E-04	7.3E-09	2.9E-04	1.6E-10	5.5E-06
2,4-Dinitrotoluene	0.08	8.3E-08	1.1E-04	2.6E-04	1.6E-09	8.4E-05	2.9E-08	5.9E-05	6.4E-10	1.1E-06
2,6-Dinitrotoluene	0.03	7.9E-08	2.1E-04	5.0E-04	6.1E-10	6.3E-06	1.1E-08	4.4E-05	2.4E-10	8.2E-07
	Sum:	3.4E-07	7.6E-02	1.8E-01	6.1E-09	3.5E-02	9.6E-08	3.4E-02	2.3E-09	6.6E-04

COPCs (Non-CEMs)	Treatment Goal (mg/kg)	Adult Off-Site Resident		Child Off-Site Resident	On-Site Construction Worker		On-Site Industrial Worker		Visitor-Trespasser	
		Cancer	Non Cancer	Non Cancer	Cancer	Non Cancer	Cancer	Non Cancer	Cancer	Non Cancer
1,2,4-Trimethylbenzene	19		1.6E-02	4.0E-02		9.9E-02		6.2E-02		4.2E-04
1,3,5-Trimethylbenzene	8		2.2E-02	6.0E-02		9.9E-02		6.2E-02		4.2E-04
Acetone	148		1.4E-03	3.2E-03		9.0E-05		1.5E-04		3.3E-06
Bromochloromethane	1.5		1.1E-03	2.5E-03		2.5E-04		1.4E-04		3.0E-06
Isopropylbenzene (Cumene)	24		6.4E-03	1.4E-02		3.9E-01		6.0E-03		4.4E-05
m,p-Xylene	3		9.9E-04	2.7E-03		9.3E-02		1.7E-03		1.2E-05
Methylene chloride	1.9	1.5E-07	3.4E-04	8.5E-04	1.7E-08	8.9E-04	3.0E-08	8.1E-05	3.3E-10	9.8E-07
Naphthalene	1		1.3E-02	3.8E-02		1.0E-01		6.4E-03		4.4E-05
n-Propylbenzene	459		1.2E-02	2.4E-02		2.0E-02		1.2E-02		2.5E-04
p-Cymene (P-Isopropyltoluene)	24		6.0E-04	1.3E-03		9.8E-02		1.7E-03		1.5E-05
sec-Butylbenzene	46		4.8E-03	7.5E-03		2.0E-03		1.2E-03		2.5E-05
Trichloroethene (TCE)	0.002	1.2E-08	6.1E-06	1.5E-05	5.2E-09	8.8E-06	8.7E-09	6.3E-06	7.7E-11	5.0E-08