Incineration at the Former Nebraska
Ordnance Plant Site
Mead, Nebraska

Incineration at the Former Nebraska Ordnance Plant Site Mead, Nebraska

<table>
<tr>
<td>Site Name:
Former Nebraska Ordnance Plant – Operable Unit 1

Location:
Mead, Nebraska</td>
<td>Contaminants:
Explosives and Propellants
• TNT, RDX, TNB, DNT, DNB, HMX, Tetryl, o-NT and m-NT
• Maximum concentrations in mg/kg – TNT (133,000), RDX (23,270), TNB (430) and DNT (119.3)</td>
<td>Period of Operation:
• Mini and Trial Burn Operation – September 1997
• Full-Scale Operation – October to December 1997</td>
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<tr>
<td rowspan="2">Project Management:
U.S. Army Corps of Engineers Formerly Used Defense Sites Program
Edwin Louis
Kansas City District
700 Federal Building
Kansas City, Missouri 68144-3869
(816) 983-3563</td>
<td rowspan="2">Technology:
On-Site Incineration
• Soil stream was fed through a grizzly screen to remove large debris
• Incineration system consisting of a co-current, rotary kiln and one secondary combustion chamber (SCC)
• Kiln operated at an exit gas temperature of 1150 to 1800 ^{o}F; SCC operated 1800 ^{o}F
• Hot flue gases exiting the kiln were quenched using water spay nozzles
• Solids exiting the kiln were stockpiled for compliance sampling</td>
<td>Cleanup Type:
Remedial Action

Cleanup Authority:
CERCLA and State
ROD date – August 29, 1995</td>
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<td>SIC Code:
9711B (Ordnance Production and Storage) and 9711C (Ordnance Testing and Maintenance)</td>
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<td>Waste Sources:
Discharge of contaminated rinse water and burning of explosives

Purpose/Significance of Application:
Project completed in extremely short time period, including all permitting requirements</td>
<td>Type/Quantity of Media Treated:
Soil and Debris
• 16,449 tons (13,009 cubic yards) of soil and debris
• Average Moisture Content: 16.82 %
• Average BTU value per pound: 1220
• Average Soil Density - 93.7 pounds per cubic foot</td>
<td>Regulatory Points of Contact:
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726 Minnesota Avenue
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Troy Bendenkamp
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1200 N. Lincoln Street
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(402) 471-2214</td>
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Incineration at the Former Nebraska Ordnance Plant Site
Mead, Nebraska

(Continued)

Regulatory Requirements/Cleanup Goals:
Destruction and Removal Efficiency (DRE) of 99.99% for POHC
The following limits were set for treated soil after incineration in mg/kg:
- TNT – 17.2
- RDX – 5.8
- TNB – 1.7
- DNT – 0.9
- TNB – 1.7
- HMX – 1,715.2
- Tetryl – 343
- NT – 343

Results:
- Emission and trial burn data indicated that all DRE and emissions standards were met
- Treated soil sampling indicated that all soil cleanup goals were met

Costs:
The total cost for this project was $10,700,001. The technology cost was $6,479,245 ($394 per ton of contaminated material).

Description:
During several intervals between 1942 and 1959, the Nebraska Ordnance Plant (NOP) site was used for loading, assembly and testing of bombs, boosters and shells. During site cleaning activities, explosives-containing wash water was discharged into surface water drainage ditches at the site. In addition, contamination was observed in soil at the Burning/Proving Grounds at the site. A Record of Decision (ROD) was signed in August 1995, specifying on-site incineration as the remedial technology for addressing shallow contaminated soil at the site. Shallow contaminated soil at the former NOP (soil between 0 and 4 feet below the ground surface) was identified as Operable Unit (OU) 1. Site soil cleanup goals were specified in the ROD.

Because the former NOP site was designated as part of the Formerly Used Defense Site (FUDS) program, the USACE was responsible for managing remedial actions at this site.

Site work for construction of the incinerator was commenced in February 1997. Incinerator start up and shake down were performed in August and September 1997. Mini burn and trial burn tests were conducted in September 1997. After receiving approval from EPA and NDEQ of the proposed operating limits, the incinerator was put into full production in October 1997. Treatment was completed in December 1997. The incineration system consisted of a co-current, rotary kiln followed by a secondary combustion chamber (SCC). After confirming that treated soil met the cleanup criteria, the soil was returned to an excavation at the site. Demobilization of the incinerator from the site was completed in May 1998.

SITE INFORMATION

IDENTIFYING INFORMATION (1)

Site Name: Former Nebraska Ordnance Plant (NOP)
Location: Mead, Nebraska
Operable Unit: OU 1
CERCLIS #: NE6211890011
ROD Date: August 1995 (Signed by EPA on August 29, 1995)
Technology: On-Site Rotary Kiln Incineration
Type of Action: Remedial

Figure 1 shows the location of the former NOP in Nebraska.

TECHNOLOGY APPLICATION (2)

Period of Operation:
Mini and trial burn operation – September 1997
Full-scale operation – October through December 1997

Quantity of Material Treated During Application:
16,449 tons of explosives-contaminated soil

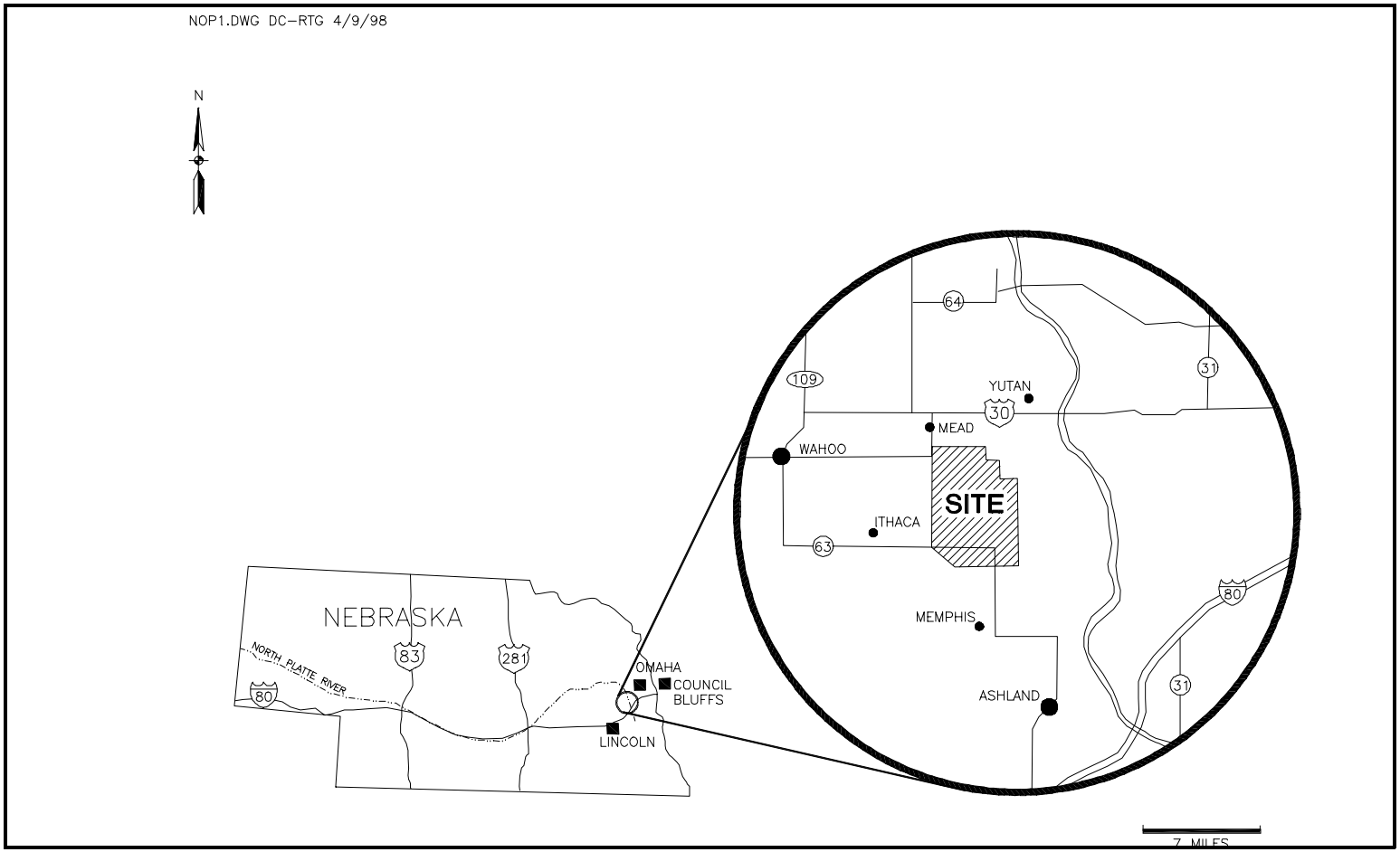
BACKGROUND

Site Background (1,3):

- The former NOP facility is located on 17,000 acres of land approximately 2 miles south of the town of Mead in eastern Nebraska. The site was used to load, assemble and pack bombs, boosters and shells in the 1940s during World War II and in the 1950s during the Korean conflict. The NOP included the following facilities:

  - Four bomb Load Lines;
  - A Bomb Booster Assembly plant;
  - An ammonium nitrate plant;
  - Two explosives burning areas;
  - A proving range;
  - A landfill;
  - A wastewater treatment plant;
  - Analytical laboratories; and,
  - Administration facilities.

Figure 1. Location of the Former NOP Facility in Nebraska



- In 1959 the facility was declared excess to Army needs, and was transferred to the General Services Administration for disposition.

- Since 1959, various portions of the 17,000 acres have been transferred to government agencies (Army, Air Force and The Department of Commerce), local public officials (The University of Nebraska) and various private individuals and corporations. Since its closure, the majority of the former NOP facility has been used for agricultural production. However, several private businesses have been operated at the facility since 1959.

Figure 2 shows the layout of the former NOP facility.

SIC Code:
9711B (Ordnance Production and Storage) and 9711C (Ordnance Testing and Maintenance)

Waste Management Practices that Contributed to Contamination (1):

Explosives production equipment and buildings were regularly cleaned and decontaminated with water. Wash water containing explosives flowed into drainage ditches and sumps outside the buildings. Explosives were regularly tested in the Burning/Proving Grounds at the site.

Site Operation History (1):

- The Nebraska Defense Corporation operated the NOP facility from 1942 to 1945, producing boosters in the booster assembly area and bombs at the four load lines. The facility was placed on inactive status in 1945. Routine operations at the NOP included discharge of explosives-containing wash water into site sumps and open ditches.

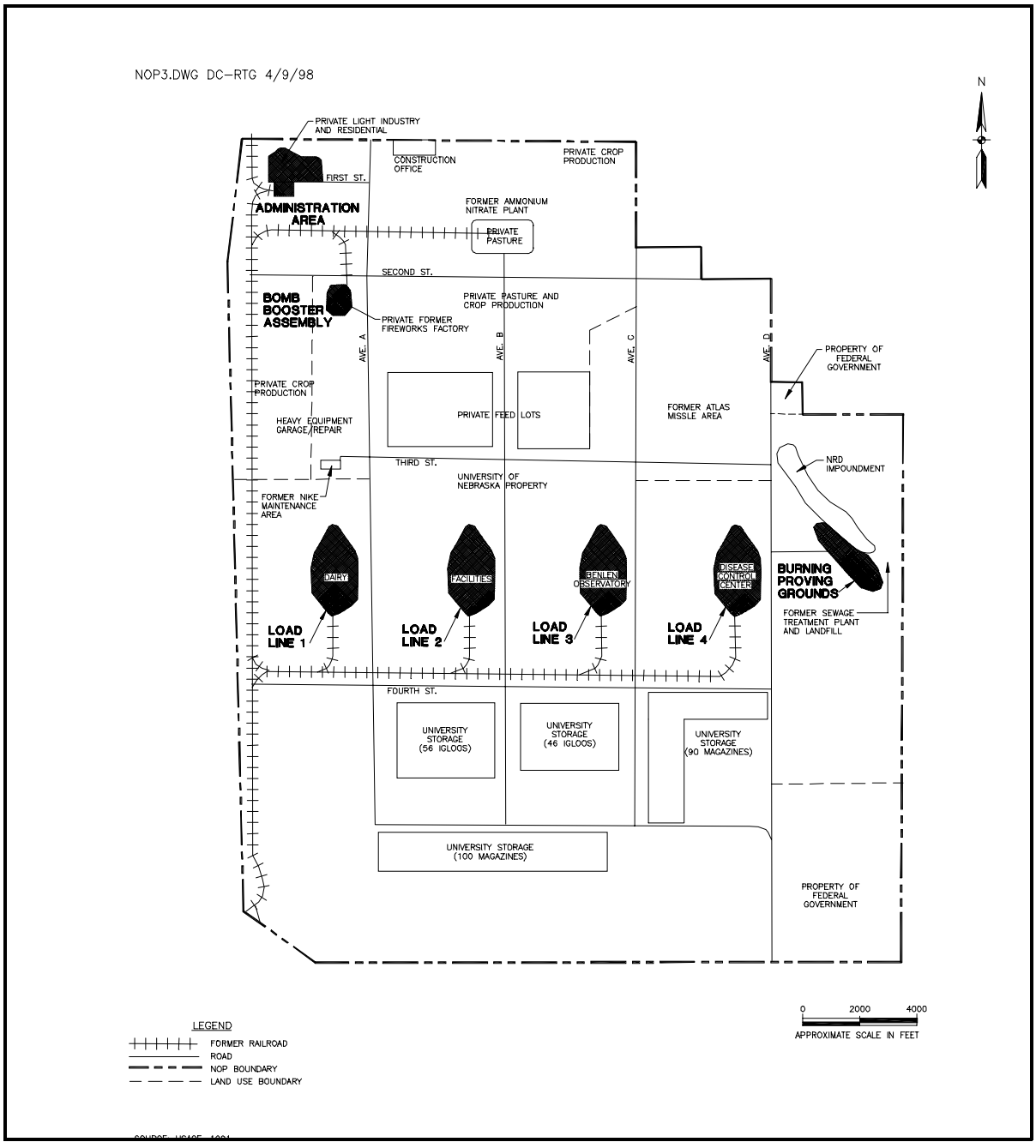
- The facility was decontaminated in 1945. Decontamination procedures included the following:

  - Building floors were cleaned by sweeping and flushing;
  - Explosives-production surfaces were scraped and brushed by hand;
  - Internal roofs and trusses were steam-cleaned;
  - External roofs were cleaned by flushing with water; and,
  - Cleaning residues, contaminated soil and sludges and selected wooden structures and tile drainage pipe were all taken to the Burning/Proving Grounds for disposal by burning.

- In 1950, the facility was reactivated to produce weapons for the Korean Conflict. The NOP was placed on standby in 1956, and declared excess to Army needs in 1959.

- Decontamination records following 1950 could not be located for the NOP. It is assumed that portions of the facility were decontaminated with hot water and steam. It is likely that several areas of the facility were not decontaminated.

Figure 2. Layout of the Former NOP Facility



- In 1959, the facility was transferred to the General Services Administration. Over the next several years, parcels of the property (totaling approximately 3,000 acres) were retained by the Army, Air Force and the Department of Commerce.
- In 1962 and 1964, 10,200 acres were transferred to the University of Nebraska for agricultural research. The remaining land was sold to various private individuals and corporations.
- A fireworks company operated in the Bomb Booster Assembly Area from 1969 to 1989.
- Since closure of the NOP, the property has been used primarily for agricultural production and research.

Site Investigations (1):

- An archives search was performed in 1983 by the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). The documents located during this search indicated that the most likely areas of explosives contamination at the NOP facility were the four Load Lines, the Booster Assembly Area and the Burning/Proving Grounds.
- PCB investigations were performed by the following groups in the years listed:
  - University of Nebraska – 1984 and 1985
  - USEPA – 1988
  - USACE – 1993
- In 1989, the USACE investigated soil, sediment surface water and groundwater at the site.
- In 1990, a shallow soil gas survey was performed at the site.
- In 1991, the USACE conducted soil and unexploded ordnance (UXO) investigations.
- In 1991, a preliminary health assessment for the site was conducted by the Agency of Toxic Substances and Disease Registry (ATSDR).
- In 1991 and 1992, a Remedial Investigation was performed for operable unit (OU) 1 by the USACE. Results of this investigation indicated that explosives contamination was present in the shallow soil in several areas at the former NOP facility.
- In 1991, the USACE performed a Supplemental Soil Remedial Investigation for OU 1.
- In 1995, a Record of Decision (ROD) was signed for OU 1.
- In 1996, a soil investigation for polychlorinated biphenyls (PCBs) was performed at the NOP facility.

The investigation and remediation at the former NOP facility has been divided into three OUs by the USACE in consultation with the USEPA and the Nebraska Department of Environmental Quality (NDEQ). The OUs are described as follows:

- OU 1 includes remediation of shallow (less than 4 feet below ground surface (bgs)) explosives- contaminated soil.
- OU 2 includes remediation of contaminated groundwater, volatile organic compound (VOC)-contaminated soil and explosives-contaminated soil deeper than 4 feet bgs.
- OU 3 includes remediation of the on-site landfill and other disposal areas not identified in the Inter-Agency agreement (IAG) among the USACE, USEPA and NDEQ.

In addition, it was determined by the USACE, in consultation with USEPA and NDEQ, that PCB-contaminated soil would be addressed separately from OU 1 soils.

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MATRIX AND CONTAMINANT DESCRIPTION

MATRIX IDENTIFICATION

Soil (ex situ)

SITE GEOLOGY/STRATIGRAPHY

The NOP subsurface consists of four discreet Pleistocene-age unconsolidated layers consisting of alluvial and eolian (wind-deposited) material overlying sedimentary bedrock. The surficial deposits consist of a gray to brown sand and gravel alluvium that is up to four feet thick. Beneath the surficial alluvium is the clayey silt, silt, and silty clay Peoria Loess unit that ranges in thickness from 2 to 27 feet. Beneath the loess deposits is the Todd Valley Sand Unit, which is a 35 to 90 feet thick unit

consisting of gray to yellow-brown, very fine to coarse sand. The deepest unconsolidated layer consists of the Grand Island-Crete Sand and Gravel Unit, which is a predominantly gray to yellow-brown, fine to coarse sandy gravel unit, that is 0 to 55 feet thick.

Sedimentary bedrock that underlies the unconsolidated material consists of Cretaceous-age shales and sandstones of the Omadi Formation. Depth to bedrock beneath the NOP site ranges from 48 to 150 feet below grade. The shallower shale is brown-yellow to green-gray, non-calcareous, micaceous, and moderately hard. The shale overlies a yellow to orange, poorly to moderately cemented, fine to medium grained, quartzitic sandstone. The Cretaceous-age bedrock overlies older Pennsylvanian-age shale and limestone bedrock.

Groundwater beneath the NOP site is first encountered in the unconsolidated Pleistocene sands and gravels. Groundwater is also present in the deeper sandstone bedrock. Where present, the shale bedrock will act as an aquitard that separates the sand and gravel aquifer from the deeper sandstone aquifer. Average transmissivities for the sand and gravel and sandstone aquifers are 69,000 gallons per day per foot (gpd/ft) and 196,000 gpd/ft, respectively. Groundwater beneath the NOP site flows in a south-southeasterly direction under a hydraulic gradient of approximately 11.5 feet per mile.

CONTAMINANT CHARACTERIZATION (1)

Primary Contaminant Group: Explosives/Propellants

Key Specific Contaminants:

2,4,6-Trinitrotoluene (TNT)
Hexahydro-1,3,5-trinitro-1,3,5-triazine, or cyclonite, or research department explosive (RDX)
1,3,5-trinitrobenzene (TNB)
2,4 and 2,6-dinitrotoluene (DNT)
1,3-dinitrobenzene (DNB)
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazine (high melt explosive or HMX)
2,4,6-tetranitro-n-methylaniline (tetryl)
o-nitrotoluene (o-NT)
m-nitrotoluene (m-NT)

CONTAMINANT PROPERTIES (5, 6, 7, 10, 13)

Table 1 lists selected properties for several of the contaminants present at the NOP site.

Table 1. Contaminant Properties

Property	Units	TNT	RDX	TNB	DNT
Chemical Formula	-	$C_7H_5N_3O_6$	$C_3H_6N_6O_6$	$C_6H_3(NO_2)_3$	$C_6H_3CH_3(NO_2)_2$
Molecular Weight	g/mole	227.13	222.26	213.11	182.13
Specific Gravity	-	1.654 (20°C)	1.82 (20°C)	1.76 (20°C)	1.521 (15°C)
Vapor Pressure	mm Hg	$1x10^{-6}$ (20°C)	$1x10^{-9}$ (25°C)	$2.2x10^{-4}$ (25°C)	$2.17x10^{-4}$ (25°C)
Octanol-Water Partition Coefficient	log K_{ow}	1.65-2.83	0.81-1.41	1.18	1.88-2.77
Soil-Water Partition Coefficient (K_d)	L/kg	3.8 (soil)	6.16 (bentonite)	NA	25.12

NA – Not available.

NATURE AND EXTENT OF THE CONTAMINANTS (10, 11)

The results of the RI indicated that explosives-contaminated soil was present in the following areas:

- All four Load Line Areas;
- The Burning/Proving Grounds;
- The Bomb Booster Assembly Area; and,
- The Administration Area.

Contamination was predominantly located in areas in and around sumps and drainage ditches at each area. Because the contaminated areas at OU 1 were numerous and spread across large areas of the NOP facility, it is not practical to show the areal extent of contamination in this report. Based on data collected for the RI, it was estimated that approximately 9,200 cubic yards of soil was contaminated in OU 1.

During remediation activities, it was determined that contaminated soil volumes were greater than originally estimated. In addition, some of the soil excavated was contaminated with PCBs, and was therefore sent off site for disposal. Actual contaminated soil volumes from each area at the facility are listed below. It should be noted that all volumes listed are based on surveys of the excavations and do not account for expansion of the soil during excavation.

Table 2. Actual Contaminated Soil Volumes Excavated at the NOP Facility

Area	Total Volume of Soil (cubic yards)	PCB-Contaminated Soil (cubic yards)	Explosives-Contaminated Soil (cubic yards)
Load Line 1	3923.7	122.3	3801.4
Load Line 2	4287.6	8.2	4279.4
Load Line 3	1570.3	179.9	1390.4
Load Line 4	191.3	37.4	153.9
Burning/Proving Grounds	3431.2	250	3181.2
Administration Area	192.4	0	192.4
Bomb Booster Assembly Area	10.6	0	10.6
TOTALS	13607.1	597.8	13009.3

The total volume of soil processed through the incinerator was 13009.3 cubic yards. This volume, when converted to mass was equal to 16,449 tons. Based on this conversion, the average soil density was equal to 93.7 pounds per cubic foot.

CHARACTERISTICS OF UNTREATED SOIL (1, 3)

Soil samples were collected from various depths and at several locations during the 1991 RI and the 1992 Supplemental RI/FS. Selected results from these samples are shown in Table 3.

Table 3. Characteristics of Untreated Soil (1)

Sample Location	Maximum TNT Concentration Found (mg/kg)	Maximum RDX Concentration Found (mg/kg)	Maximum TNB Concentration Found (mg/kg)	Maximum DNT Concentration Found (mg/kg)
Load Line 1	133,000	39.6	338	28.9
Load Line 2	176,000	23,270	430	119.3
Load Line 3	29,700	40.4	95.3	14.8
Load Line 4	131	22.7	6.0	17.6
Booster Assembly Area	7.0	ND	3.6	ND
Burning/Proving Grounds	313	1,700	35.3	1.25
Administration Area	0.314	ND	ND	ND
Primary Area	0.45	ND	ND	ND

ND – not detected

MATRIX CHARACTERISTICS AFFECTING TREATMENT COST OR PERFORMANCE (3)

Table 4 lists selected characteristics of untreated soil from the former NOP facility.

Table 4. Matrix Characteristics

Soil Classification	USCS Soil Type: CL and CH
Clay Content and/or Particle Site Distribution	88 to 100 percent silty and clay 0 to 12 percent sand
Soil Plasticity	Information not available
Moisture Content (%)	16.82 *
Porosity	Information not available
Total Organic Carbon	Information not available
BTU value (BTU/lb)	1220 *
Halogen Content	Information not available
Metal Content or the Presence of Metals	Information not available
Presence of Alkali Metal Salts	Information not available

*Average value from the trial burn test.

TREATMENT SYSTEM DESCRIPTION

PRIMARY TREATMENT TECHNOLOGY (4)

Incineration

A mobile rotary kiln incineration system was used for this project, including the following:

- Solid waste screening to remove debris larger than 2 inches;
- Solid waste feed system (dual-screw feeder); and
- A refractory brick-lined, propane-fired (oxygen-enriched), co-current rotary kiln.

SUPPLEMENTARY TREATMENT TECHNOLOGIES (4)

Post-Treatment (hot flue gas) – **Incineration** (secondary combustion chamber)
Post-Treatment (hot flue gas) – **Baghouse**
Post-Treatment (hot flue gas) – **Quench** (scrubber)

TIMELINE (2, 3)

Date	Activity
May 1992	Community Relations Plan prepared and issued
May 1994	Proposed Plan for the site released by USACE and USEPA
June 1995	On-site incineration accepted as the recommended alternative by NDEQ
August 1995	ROD signature by USEPA Region VII Administrator. Project Plans, Trial Burn Plan and Site Design accepted by USACE, USEPA and NDEQ.
January 1997	Notice to Proceed issued to OHM for OU 1 Delivery Order
February 1997	Begin site work at OU 1
March 1997	Preconstruction Meeting
May 1997	Begin incinerator set up
July 1997	Incinerator set up completed
August – September 1997	Incinerator start up and shake down
September 1997	Incinerator Mini Burn and Trial Burn tests performed
October 14, 1997	Begin full-scale operation of the incinerator
December 21, 1997	Remediation completed; incinerator shut down
January 5 – May 22, 1998	Demobilization of the incinerator and site restoration

TREATMENT SYSTEM SCHEMATIC AND TECHNOLOGY DESCRIPTION AND OPERATION

Figure 3 shows a process flow diagram for the mobile incineration system used to treat ex-situ soil at the former NOP facility.

Mobilization (2)

The contractor began mobilizing to the site on February 24, 1997. A preconstruction meeting was held on March 29, 1997.

Construction (2)

Incinerator construction was started on May 27, 1997 and completed on August 29, 1997.

Operation (2,3,9)

The treatment system was operated using the following steps:

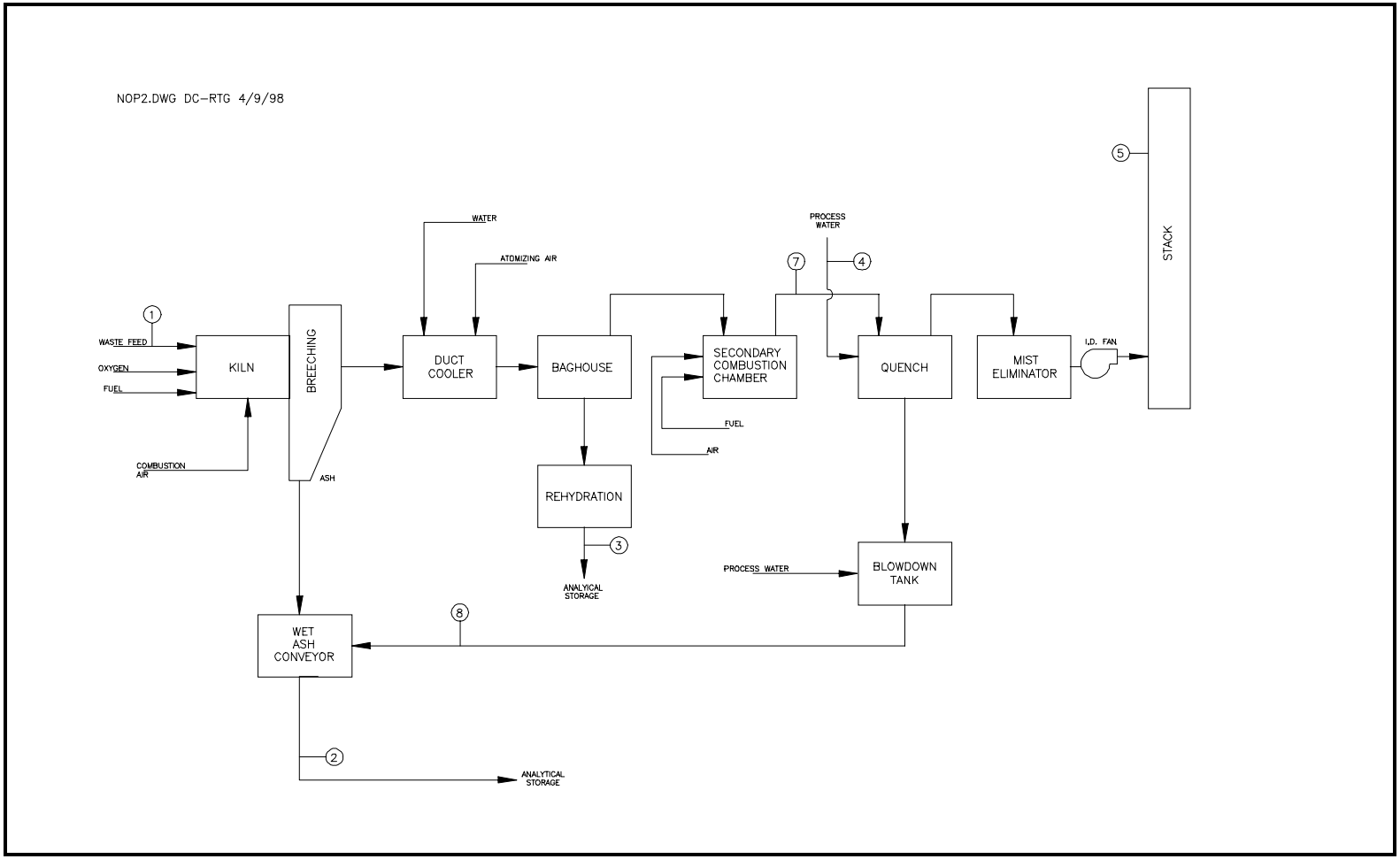
- Contaminated soil was excavated from previously designated areas, transported to the feed preparation area and screened to remove oversized particles. Excavation sampling was performed to confirm that clean up criteria were met for soil remaining in-place. Contaminated soil was blended prior to treatment to equalize contaminant levels in the feed stream.
- Contaminated soil was fed through a grizzly screen onto a variable speed feed belt, weigh belt conveyor, and into the kiln feed hopper. The waste stream was delivered from the hopper to the kiln via dual water-cooled feed screws.
- The primary kiln was 45 feet long and had an inside diameter of 6.5 feet. The kiln was operated co-currently with the waste feed located at the same end as the oxygen-propane burner. Contaminated soil traveled through the kiln via gravity. The kiln was designed to operate at exit gas temperatures of 1150 to 1800°F.
- Solids exiting the kiln were conveyed to a wet ash storage area for stockpiling and compliance sampling. Hot flue gases were quenched using water nozzles in the kiln breech and in the duct cooler after exiting the kiln.
- Kiln gases then passed through a baghouse for removal of particulate matter and submicron heavy metals. The baghouse was designed to operate at a maximum temperature of 500°F.
- Exhaust gases from the baghouse were fed to a secondary combustion chamber (SCC). The SCC was designed to be operated at 1800°F with a gas retention time of 2 seconds.
- Exhaust gases from the SCC were cooled from 1800°F to 180°F with water in a quench tank. The tank was level controlled. The pH was maintained between 6.5 and 8.0 by addition of hydrochloric acid to the spray water circulation line. The quench tank was followed by a mist eliminator.
- An induced draft (ID) fan drew gases through the entire system and discharged to the stack at the end of the treatment system. The fan produced negative pressure throughout the treatment unit, including within the kiln.

A mini burn test (three runs) was conducted on September 17 and 18, 1997. A trial burn test (four runs) was conducted from September 22 to September 29, 1997. A total of 1376 tons of contaminated soil was treated during the mini burn and trial burn tests.

In addition to the incineration system, a wastewater treatment system was installed and operated at the site. The following sources of wastewater were encountered during this project:

- Wash water from equipment and personnel decontamination activities;
- Rain water collected from the soil excavation cavities;
- Quench tank blowdown; and,
- Rain water collected in the incineration processing area.

Figure 3. Process Flow Diagram



The wastewater treatment system consisted of the following units and treatment steps:

- wastewater storage tanks;
- chemical precipitation;
- flocculation;
- sand filtration;
- carbon absorption;
- bag filtration;
- pH adjustment; and,
- a sludge filter press.

Post-Operation (3)

When soil treatment operations were completed, the treatment system was shut down and dismantled for demobilization from the site. Areas where contaminated soil had been excavated were filled with clean soil taken from other areas at the NOP facility. Treated soil was returned to a large on-site excavation. The reason for placing all of the treated soil into one excavation was to provide a source of sterile soil for planned agricultural experiments to be performed by the University of Nebraska. As part of demobilization, OHM graded disturbed areas, repaired damage to facility roads, and placed topsoil where necessary to support planting of grass in the future. Based on an agreement between the USACE and the current owner of the site, The University of Nebraska, the disturbed areas will be seeded by The University of Nebraska. The costs for seeding will be paid by the USACE.

Treatment system demobilization and site restoration activities (other than University of Nebraska seeding) are scheduled to be completed on May 22, 1998.

OPERATING PARAMETERS AFFECTING TREATMENT COST OR PERFORMANCE (3)

The following table lists operating limits for the incineration system that were approved by the USEPA and NDEQ prior to full-scale operation of the system.

Table 5. Operating Limits

Parameter	Value
Waste Feed Rate, Maximum, tons/hr	16.6 hourly rolling average 19.6 instantaneous
Kiln Draft, Maximum, inches wc	-0.50 audible alarm -0.1 (10 sec delay) 0.0 instantaneous
Kiln Temperature, Minimum, ºF	1416, instantaneous
SCC Temperature, Minimum, ºF	1825, instantaneous
Stack Gas Velocity, Maximum, ft/sec	21.33
Bag House Pressure Drop, Min., inches wc	1.0
SCC Quench Water Flow, Minimum, gpm	397.4 alarm 350 instantaneous
Scrubber Liquid pH	6.5-8.0
Stack Gas CO, Maximum, ppmv	100 ppmv (10 sec delay) 200 ppmv instantaneous (may resume feed after ≥5 minutes operating ≤100 ppmv)
Kiln Rotation, Maximum, rpm	3.0 hourly rolling average

wc - water column
gpm - gallons per minute
CO - carbon monoxide
ppmv - parts per million (by volume)
rpm - revolutions per minute

The following table lists values for parameters associated with operation of the incinerator at the former NOP site. The parameters were selected for this report based on USACE guidance.

Table 6. Operating Parameters

Parameter	Design	Allowable	Actual
Oxygen Flow Rate	NA	NA	2.5 tph
Gas Residence Time in Rotary Film	5.3 seconds (at 18 tph and 1200°F)	NA	8.5 seconds* (average)
System Throughput (tph)	18	16.6 (average) 19.6 (instantaneous)	13.44 (average)
Kiln Minimum Temperature (°F)	1150 - 1800	1416	1416 - 1616
SCC Combustion Temperature (°F)	1800	1825	1825 - 1950

NA – Not Applicable
tph – tons per hour
* Calculated based on 13.44 tph and 1516°C in the kiln.

TREATMENT SYSTEM PERFORMANCE

PERFORMANCE OBJECTIVES

The following table lists the treatment compliance objectives for the NOP Incinerator. These objectives were established during the mini and trial burn tests and were approved by USEPA and the USACE.

Table 7. Treatment Compliance Objectives

Parameter	Performance Criteria
POHC Destruction and Removal Efficiency (DRE)	≥ 99.99 %
Hydrochloric Acid Stack Emissions	≤ 4.0 lb/hr or ≥ 99 % removal
Carbon Monoxide Stack Emissions	≤ 100 ppmv

The following table lists the concentration objectives for soil treated in the incinerator operated at the NOP facility. These objectives were established in the ROD for OU 1.

Table 8. Treated Soil Objectives

Chemical	Performance Criteria (mg/kg)
HMX	1,715.2
RDX	5.8
TNB	1.7
DNB	3.4
TNT	17.2
DNT	0.9
NT	343.0
Tetryl	343.0

In addition to treatment objectives for explosive compounds, treated soil (ash) also had to be below the following TCLP (or corresponding total) concentrations before it could be returned to the site as fill material. These requirements are outlined in the ROD for OU 1.

Table 9. Allowable Ash Concentrations

Metal	Allowable TCLP Concentration (mg/L)	Allowable Total Concentration (mg/L)*
Arsenic	5.0	100
Barium	100.0	2,000
Cadmium	1.0	20
Chromium	5.0	100
Lead	5.0	100
Mercury	0.2	4
Silver	5.0	100
Selenium	1.0	20

* Total concentrations are based on 20 times TCLP values.

TREATMENT PLAN (3)

Following construction of the incinerator in August 1997, a mini burn test was performed. This test consisted of three runs conducted on September 17 and 18. Contaminated site soils spiked with naphthalene were used for the test. The three runs confirmed that the incinerator could meet several significant performance criteria, including destruction and removal efficiency (DRE), particulate emissions, HCl emissions and backfill requirements (allowable ash concentrations). The following table summarizes the results of the mini burn test.

Table 10. Mini Burn Results

Run Number	DRE (%)	Particulate Emissions (gr/dscf)	HCl Emissions (lb/hr)
Criterion	**≥99.99**	**≤0.08**	**≤4.0**
Run 1	99.9999	0.0087	0.029
Run 2	99.9998	0.0135	0.026
Run 3	99.9999	0.0118	0.027

gr/dscf - grains per dry standard cubic foot

Based on the results of the mini burn test, a trial burn test of the incinerator was performed. The test consisted of four runs (run three was repeated) conducted from September 23 to 29. Table 11 lists the operating parameters during the various trial burn runs.

Table 11. Trial Burn Process Operating Parameters (average values)

Parameter	Units	Test 1	Test 2	Test 3	Test 4*
Waste Feed Rate	tons/hr	17.34	15.51	16.88	16.88
Kiln Discharge Temp	°F	1,417	1,412	1,427	1,408
SCC Temperature	°F	1,813	1,823	1,806	1,849
Secondary Oxygen	%	6.01	5.92	5.92	5.65
Kiln Draft	inches wc	-1.72	-1.98	-1.91	-1.93
Baghouse Pressure Drop	inches wc	1.61	1.51	1.54	1.91
Stack Carbon Monoxide	ppmv	0.0	0.0	0.0	0.1
SCC Quench Recycle	gpm	399	398	398	397
Kiln Oxygen	%	6.93	6.36	6.45	7.40
Scrubber pH	pH	7.06	7.36	7.45	7.56
Stack Temperature	°F	184	185	185	185
Stack Flow Rate	fps	21.36	20.67	21.36	21.78
SCC Draft	inches wc	-2.20	-2.42	-2.39	-2.52
Kiln Rotation	rpm	2.07	1.98	1.97	2.22
Stack Oxygen	%	9.98	9.78	9.78	9.03

*Test 4 was a re-run of Test 3.

Table 12 lists analytical results for the contaminated soil fed to the incinerator (prior to treatment) during the trial burn test.

Table 12. Trial Burn Contaminated Soil Feed Analysis[a]

Test	Run					Average
	1	1D[b]	2	3	4	
Moisture, %	25	15.8	15.8	15.5	15.6	16.82
Heat Value, BTU/lb	1,200	2,100	1,300	1,600	330	1,220
TNB, μg/kg	4,500	5,800	1,200	2,700	7,800	4,213
DNB, μg/kg	<510[c]	<540	<490	<510	<440	<491
TNT, μg/kg	240,000	310,000	150,000	160,000	76,000	165,000
DNT, μg/kg	<510	<540	<490	<510	<440	<491
HMX, μg/kg	<510	<540	<490	<510	<440	<491
NT, μg/kg	<510	<540	<490	<510	<440	<491
RDX, μg/kg	<510	<540	<490	<510	<440	<491
Tetryl, μg/kg	<510	<540	13,000	1,500	3,000	4,506
Arsenic, mg/kg	<13	5	5	5	NA	7.6
Barium, mg/kg	160	160	170	150	NA	160
Cadmium, mg/kg	0.7	0.8	1	0.8	NA	0.85
Chromium, mg/kg	6	6	8	7	NA	7
Lead, mg/kg	15	14	15	14	NA	14.5
Mercury, mg/kg	0.03	0.03	0.04	0.03	NA	0.033
Selenium, mg/kg	<13	<12	<12	<11	NA	<11.8
Silver, mg/kg	6	2	2	2	NA	2.7
Naphthalene, μg/kg	190	110	470	82	<390	273

[a]Metals and PHCs reported on a dry basis.
[b]Represents duplicate sample.
[c]Estimated concentration below the reporting limit.

Tables 13, 14, and 15 list additional results from the Trial Burn including, stack gas analyses, post-treatment soil concentrations, and baghouse ash concentrations.

TREATMENT PERFORMANCE DATA

Treated soil (ash) was analyzed prior to disposal for parameters listed previously in this section. Explosives concentrations were compared to maximum allowable concentrations. Total metals concentrations were compared to 20 times the allowable TCLP concentrations. All results met the explosives and metals treatment objectives with the exception of three samples, which did not meet the total lead concentration requirement. One of these samples was reanalyzed for total lead and passed. The remaining two samples were reanalyzed for TCLP lead and also passed. Starting on December 12, all samples were analyzed for TCLP metals concentrations without first analyzing for total metals concentrations. Bypassing the total metals analysis step increased the analytical cost, but allowed for more rapid determination of compliance with treatment criteria.

Table 13. Trial Burn Stack Gas Analysis

Constituent/Parameter	Test 1	Test 2	Test 3	Test 4	Average	Criteria
Particulate, gr/dscf corrected to 7% Oxygen	0.011	0.01	0.023	NA	0.017	0.08
DRE, Naphthalene %	99.999908	99.999742	NA	99.999913	99.99985	99.99
HCl/Chlorine, lb/hr	<0.047	<0.0063	<0.0063	NA	<0.020	4.0
2,4,6-Trinitrotoluene, g/s	<3.7E-6	<3.4E-6	NA	<3.5E-6	<3.5E-6	2.21E-1
HMX, g/s	<3.7E-6	<3.4E-6	NA	<3.5E-6	<3.5E-6	1.08E-2
RDX, g/s	<3.7E-6	<3.4E-6	NA	<3.5E-6	<3.5E-6	1.06E-1
1,3,5-Trinitrobenzene, g/s	<3.7E-6	<3.4E-6	NA	<1.75E-5	8.2E-6	2.82E-3
1,3-Dinitrobenzene, g/s	<3.7E-6	<3.4E-6	NA	<3.5E-6	<3.5E-6	8.11E-3
Tetryl, g/s	<3.7E-6	<3.4E-6	NA	<3.5E-6	<3.5E-6	4.39E-1
2,4-Dinitrotoluene, g/s	<3.7E-6	<3.4E-6	NA	<3.5E-6	<3.5E-6	3.18E-1
2,6-Dinitrotoluene, g/s	<3.7E-6	<3.4E-6	NA	<3.5E-6	<3.5E-6	1.35E-1
Nitrotoluene, g/s	<3.7E-6	<3.4E-6	NA	<3.5E-6	<3.5E-6	2.5E+0
Nitrobenzene, g/s	1.2E-5	<5.5E-6	NA	<5.5E-6	<7.7E-6	6.38E-2
Benzo(a)anthracene, g/s	<5.9E-6	<5.5E-6	NA	<5.5E-6	<5.5E-6	1.80E-2
Benzo(a)pyrene, g/s	<5.9E-6	<5.5E-6	NA	<5.5E-6	<5.5E-6	7.26E-4
Benzo(b)fluoranthene, g/s	<7.4E-6	<6.9E-6	NA	<6.9E-6	<7.1E-6	6.57E-3
Benzo(k)fluoranthene, g/s	<8.1E-6	<7.5E-6	NA	<7.6E-6	<7.7E-6	5.67E-2
Chrysene, g/s	<3.7E-6	<3.4E-6	NA	<3.5E-6	<3.5E-6	1.90E+0
Dibenzo(a,h)anthracene, g/s	<7.4E-6	<6.9E-6	NA	<6.9E-6	<7.1E-6	7.90E-5
Indeno(1,2.3-cd)pyrene, g/s	<4.4E-6	<4.1E-6	NA	<4.2E-6	<4.2E-6	2.08E-3
Antimony, g/s	1.2E-4	1.0E-4	9.8E-5	NA	1.1E-4	3.71E-2
Arsenic, g/s	3.4E-5	3.5E-5	4.1E-5	NA	3.7E-5	5.28E-3
Barium, g/s	1.9E-4	1.9E-4	1.8E-4	NA	1.9E-4	1.27E+0
Beryllium, g/s	<8.6E-7	<8.3E-7	<8.3E-7	NA	<8.4E-7	4.10E+0
Cadmium, g/s	2.9E-6	5.8E-6	4.4E-6	NA	4.4E-6	1.94E-1
Chromium, g/s	2.4E-4	5.6E-5	3.2E-5	NA	1.1E-4	1.55E-2
Lead, g/s	1.7E-5	<1.6E-5	<1.7E-5	NA	<1.7E-5	2.28E-1
Mercury, g/s	2.7E-4	2.6E-4	2.1E-4	NA	2.4E-4	4.22E-4
Nickel, g/s	2.1E-4	4.4E-4	1.0E-4	NA	2.5E-4	1.90E+0
Selenium, g/s	5.2E-5	<4.9E-5	5.9E-5	NA	<5.3E-5	1.90E-2
Silver, g/s	<8.6E-6	<8.2E-6	1.5E-5	NA	<1.1E-5	1.37E-2
Thallium, g/s	5.2E-5	<4.9E-5	<5.0E-5	NA	<5.0E-5	1.59E-3
CO, ppm corrected to 7% Oxygen	<0.63	2.3	4.5	NA	<2.5	100
PCDD/PCDFs TEQ ng/dscm	<0.011	<0.0087	NA	<0.0090	<0.0096	NA
PCDD/PCDFs TEQ g/s	<7.7E-11	<5.4E-11	NA	<5.6E-11	6.2E-11	7.79E-9

NA - Results not available.
g/s - grams per second
ng/dscm - nanograms per dry standard cubic meter

Table 14. Contaminant Concentrations in Treated Soil During the Trial Burn

Constituent	Test 1	Test 2	Test 2D[b]	Test 3	Criteria
Naphthalene, μg/kg	4500	3000	2700	2400	NA
1,3,5-Trinitobenzene, μg/kg	1500	<490	<560	630	1700
1,3-Dinitrobenene, μg/kg	<580[a]	<490	<560	<590	3400
2,4,6-Trinitrotoleune, μg/kg	13000	990	690	3700	17200
2,4-Dinitrotoluene, μg/kg	<580	<490	<560	<590	900
2,6-Dinitrotoluene, μg/kg	<580	<490	<560	<590	900
HMX, μg/kg	<580	<490	<560	<590	1,715,200
m-Nitrotoluene, μg/kg	<580	<490	<560	<590	343,000
o-Nitrotoluene, μg/kg	<590	<490	<560	<590	343,000
p-Nitrotoluene, μg/kg	<580	<490	<560	<590	343,000
RDX, μg/kg	<580	<490	<560	<590	5800
Tetryl, μg/kg	<580	<490	<560	<590	NA
Arsenic, mg/kg	7	<12	<13	6	5mg/l TCLP[c]
Barium, mg/kg	150	150	160	130	100 mg/l TCLP
Cadmium, mg/kg	0.7	0.8	0.8	0.7	1 mg/l TCLP
Chromium, mg/kg	6	6	7	5	5 mg/l TCLP
Lead, mg/kg	13	51	16	14	5 mg/l TCLP
Mercury, mg/kg	<0.01	0.02	<0.01	<0.01	0.2 mg/l TCLP
Selenium, mg/kg	<13	<12	<13	<13	1 mg/l TCLP
Silver, mg/kg	2	2	1	1	5 mg/l TCLP

[a]Estimated concentration below reporting limit.
[b]Duplicate sample.
[c]For wastes that are 100% solid, as defined by TCLP, the maximum theoretical leachate concentration can be calculated by dividing the total concentration of the constituent by 20. The dilution factor of 20 reflects the liquid to solid ratio employed in the extraction procedure.

Table 15. Contaminant Concentrations in Baghouse Ash During the Trial Burn

Constituent	Test 1	Test 2	Test 2D[b]	Test 3	Criteria
Naphthalene, µg/kg	450	690	740	390	NA
1,3,5-Trinitobenzene, µg/kg	<490[a]	<450	<440	<470	1700
1,3-Dinitrobenene, µg/kg	<490	<450	<440	<470	3400
2,4,6-Trinitrotoleune, µg/kg	<490	<450	<440	<470	17200
2,4-Dinitrotoluene, µg/kg	<490	<450	<440	<470	900
2,6-Dinitrotoluene, µg/kg	<490	<450	<440	<470	900
HMX, µg/kg	<490	<450	<440	<470	1,715,200
m-Nitrotoluene, µg/kg	<490	<450	<440	<470	343,000
o-Nitrotoluene, µg/kg	<490	<450	<440	<470	343,000
p-Nitrotoluene, µg/kg	<490	<450	<440	<470	343,000
RDX, µg/kg	<490	<450	<440	<590	5800
Tetryl, µg/kg	<490	<450	<440	<590	NA
Arsenic, mg/kg	5	7	8	6	5 mg/l TCLP[c]
Barium, mg/kg	54	64	65	55	100 mg/l TCLP
Cadmium, mg/kg	0.3	0.3	0.4	0.3	1 mg/l TCLP
Chromium, mg/kg	5	5	5	4	5 mg/l TCLP
Lead, mg/kg	5	6	4	4	5 mg/l TCLP
Mercury, mg/kg	<0.01	<0.01	0.01	0.01	0.2 mg/l TCLP
Selenium, mg/kg	<11	<10	<11	<12	1 mg/l TCLP
Silver, mg/kg	<1	<1	<1	<1	5 mg/l TCLP

[a]Estimated concentration below reporting limit.
[b]Duplicate sample.
[c]For wastes that are 100% solid, as defined by TCLP, the maximum theoretical leachate concentration can be calculated by dividing the total concentration of the constituent by 20. The dilution factor of 20 reflects the liquid to solid ratio employed in the extraction procedure.

Table 16 summarizes selected results from explosives analyses performed on treated soil piles. None of the treatment objectives for explosives compounds were exceeded in any of the treated soil samples.

Table 16. Summary of Selected Results from Treated Soil Analyses

Contaminant	Number of Samples	Number of Results Above the Detection Limit	Concentration Range (mg/kg)	Limit (mg/kg)
HMX	60	0	NA	1,715.2
RDX	60	2	0.26 - 0.44	5.8
TNB	60	0	NA	1.7
DNB	60	0	NA	3.4
TNT	60	25	0.23 - 6.0	17.2
2,4-DNT	60	0	NA	0.9
2,6-DNT	60	0	NA	0.9

NA – Not Applicable

Wastewater sample results were also compared to allowable concentrations for selected parameters as specified in the NPDES permit application. Most of the samples met all of the requirements, however, three samples exceeded the maximum daily allowable concentration for iron. The overall average iron concentration for the project duration was below the allowable average concentration.

In addition, the wastewater treatment system had difficulty meeting the proposed aluminum concentration requirement throughout the project. On December 4, 1997, OHM requested that the discharge limit for aluminum be waived based on the fact that aluminum is a common background element in the site soil, and because it was estimated that treated water did not leave the former NOP facility before infiltrating in the ground. Because this project was conducted under CERCLA regulations, it was not necessary to obtain this permit, or a waiver for aluminum.

PERFORMANCE DATA QUALITY

A sampling and analysis plan (SAP), included as part of the construction quality control (CQC) plan, was used for excavation sampling and for treated soil sampling performed on this project. A total of 549 soil samples were collected from excavation bottoms and sidewalls. Results from the soil samples were used to determine if additional excavation was necessary in each area. Each of the 60 treated soil piles was sampled individually. Treated soil samples were collected as composites to accurately represent each pile. Results from the treated soil samples were used to determine if treated soil could be returned to the site as fill material.

TREATMENT SYSTEM COST

PROCUREMENT PROCESS (12)

OHM Remediation Services Corp. was selected to design, construct, test and operate the incineration treatment system for this site. The contract bid quantity for this project was 9600 tons of contaminated soil. The bid price for this quantity was $6,748,302. This price translates to $703 per ton of contaminated soil.

Because OHM had performed the initial design that was approved by the regulators, they were selected to perform construction and operation of the thermal treatment unit. OHM subcontracted with the following companies to perform the listed project tasks:

Subcontractor	**Tasks**
Judds Brothers Construction	Grading, forming and placement of concrete foundations for the thermal treatment unit, the feed preparation building, the oxygen vaporizer, the propane tank saddles and the ash storage pad. Construction of the feed storage building.
Davis Crane and Rigging	Crane services for set up and teardown.
Miller Electric	Electrical wiring for the treatment plant.
Butler County Landfill	Disposal of non-TSCA regulated PCB-contaminated soil
Kobus Construction	Transportation of non-TSCA regulated PCB-contaminated soil to the Butler County Landfill

TREATMENT SYSTEM COST (8)

The total project cost for remediation of OU 1 soils at the former NOP facility was $10,700,001. The total mass of soil treated was 16,449 tons. Therefore, the cost for treatment was $650 per ton of contaminated soil. Table 17 summarizes the costs for construction and operation of the incineration system.

COST SENSITIVITIES

According to the Feasibility Study, changes in the volume of soil to be treated would cause the project cost to change significantly. This was the only parameter that was identified in the Feasibility Study as a significant source of cost sensitivity.

Table 17. Summary of Treatment Costs at NOP, Categorized According to the WBS (8)

WBS Number	Description	Quantity	Unit of Measure	Unit Cost	Total Cost ($)
33101	HTRW Remedial Action (Construction)				10,700,001.00
33101.01	Mobilization and Preparatory Work				772,062.00
33101.01.01	Mobilization of Construction Equipment and Facilities	1.00	EA	113,594.00	113,594.00
33101.01.02	Mobilization of Personnel	1.00	EA	68,110.00	68,110.00
33101.01.03	Submittals/Implementation Plans	1.00	EA	571,219.00	571,219.00
33101.01.04	Setup/Construct Temporary Facilities				17,760.00
33101.01.04.24	Security Fencing Construct Temporary Fencing	2,400.00	LF	7.40	17,760.00
33101.01.06	Temporary Relocations/Roads/Structures/Utilities	1.00	EA	1,379.00	1,379.00
33101.02	Monitoring, Sampling, Testing, and Analysis				191,629.00
33101.02.09	Laboratory Chemical Analysis	1.00	EA	173,512.00	173,512.00
33101.02.11	Geotechnical Testing Includes testing for the concrete slab	1.00	EA	18,117.00	18,117.00
33101.03	Sitework				84,378.00
33101.03.02	Clearing and Grubbing	7.00	ACR	4,595.00	32,165.00
33101.03.04	Roads/Parking/Curbs/Walks	1,000.00	SY	6.20	6,200.00
33101.03.06	Electrical Distribution Includes transformer and connection fees	1,100.00	LF	41.83	46,013.00
33101.05	Surface Water Collection and Control				3,060.00
33101.05.07	Sediment Barriers	200.00	LF	15.30	3,060.00
33101.08	Solids Collection and Containment				754,916.38
33101.08.01	Contaminated Soil Collection Digging, clean pit, includes hauling, includes clean cover	13,607.00	CY	55.48	754,916.38
33101.14	Thermal Treatment				7,210,045.00
33101.14.01	Incineration				6,479.245.00
33101.14.01.05	Mobilization/Setup of Portable Treatment Plan Mob of all equipment to set up the temporary incinerator	1.00	EA	2,133,015.00	2,133,015.00
33101.14.01.06	Startup Trial Burn	1.00	EA	708,120.00	708,120.00
33101.14.01.07	Demobilization of Portable Treatment Plant 40 trucks were used in demobing the equipment from the incinerator	1.00	EA	601,230.00	601,230.00
33101.14.01.09	O&M of Permanent Treatment Plant During Construction Plant was not constructed to operate in winter conditions, yet the plant was winterized since the operations were extended due to finding more contaminated soil	4.00		759,220.00	3,036,880.00
33101.14.50	Construction of Permanent Plant Facility Construction of a Metal building that will be left on site for the owner to occupy. Size of metal building 80'x120'	1.00	EA	730,800.00	730,800.00

WBS Number	Description	Quantity	Unit of Measure	Unit Cost	Total Cost ($)
33101.19	Disposal (Commercial)				118,125.00
33101.19.21	Transportation to Storage/Disposal Facility	1,250.00	TON	14.70	18,375.00
33101.19.22	Disposal Fees and Taxes	1,250.00	TON	79.80	99,750.00
33101.20	Site Restoration				1,283,785.38
33101.20.01	Earthwork hauling and backfill	13,607.00	CY	83.20	1,132,102.38
33101.20.03	Permanent Features				150,000.00
33101.20.03.01	Roads Repair of existing roads on site	15,000.00	SY	10.00	150,000.00
33101.20.04	Revegetation and Planting University of Nebraska is doing all the revegetation	11.00	ACR	153.00	1,683.00
33101.21	Demobilization				282,000.00
33101.21.01	Removal of Temporary Facilities				6,000.00
33101.21.01.24	Security Fencing Removal of temporary fencing	2,400.00	LF	2.50	6,000.00
33101.21.04	Demobilization of Construction Equipment and Facilities	1.00	EA	207,000.00	207,000.00
33101.21.05	Demobilization of Personnel	1.00	EA	69,000.00	69,000.00
				Total Cost:	**10,700,001.00**

EA - each
LF - linear foot
CY - cubic yard
ACR - acre
SY - square yard

It is possible that overall project costs could have been reduced by using a unit price payment schedule instead of a time and materials schedule. If unit pricing (payment per mass of soil treated) had been used, the USACE would not have incurred labor and equipment costs during down time associated with equipment failure or material handling problems. The element of risk assumed by the contractor on this project created an inherent difficulty in negotiating the cost of remediation under a unit price payment schedule. Because this contract was negotiated under a pre-placed remedial action contract, and with a short procurement schedule, it was difficult to determine a "reasonable cost" for the risks assumed by the contractor. It is recommended that project managers use competitive procurements for future unit price incineration projects.

REGULATORY/INSTITUTIONAL ISSUES

Because this project was performed under CERCLA regulations, it was not necessary to obtain permits from local regulatory authorities for on-site activities. It was necessary, however, to meet the substantive requirements of potentially applicable regulations. The following permitting and public relations issues were addressed on this project:

- A NPDES permit application was submitted for wastewater discharges associated with the thermal treatment system. For reasons discussed above, a permit was never issued. During treatment operations, a problem arose with treatment of aluminum. It was subsequently speculated that the elevated aluminum concentrations in the wastewater were a result of high aluminum background concentrations in the site soil.

- A public meeting was held on October 13, 1997 to discuss the operating limits of the incineration system. The operating limits that were approved at this meeting are presented at the beginning of this section. Treatment of contaminated soil began the next day (October 14).

- A permit for disposal of soil and debris from the NOP site at the Butler County Landfill was issued on October 21, 1997. This permit was necessary to handle any material that was too large to be processed through the kiln.

OBSERVATIONS AND LESSONS LEARNED

COST OBSERVATIONS AND LESSONS LEARNED

Project costs were higher than expected due to the increased volume of contaminated soil that was encountered during excavation. These additional costs could have been accounted for during the procurement process if site investigations had more accurately delineated the extent of contamination.

Additional costs were also incurred due to shut down of the system during a period of inclement winter weather. These costs could have been avoided if the system had been operated during a warmer portion of the year. Because the project was performed under a tight time table, it is unlikely that these additional costs could have been avoided.

It is recommended that better planning and scheduling be performed during the procurement phase on future similar projects. Because the project schedule was so tight, the USACE lost some leverage during contracting negotiations.

PERFORMANCE OBSERVATIONS AND LESSONS LEARNED

During operation, the most sensitive aspect of the treatment system was the soil feed system. On several occasions the incinerator had to be shut down to address issues with the feed system. It is recommended that future projects of this nature place increased emphasis on selecting and designing the most appropriate feed system.

Unexpected problems associated with handling of high and low moisture-content soil were observed on several occasions during treatment. These problems were chiefly observed in the feed system. In addition, a recurring problem was observed relating to separation of extremely fine soil particles during treatment. This fine material became suspended at the top of the wet ash conveyor, and when the suspension became thick enough it would inhibit discharge of solids from the bottom of the tank. This problem was ultimately solved by periodically pumping the suspended soil to the ash handling area where it was gravity dewatered and filtered through hay bales. It is recommended that future projects of this nature include preliminary study of the handling characteristics of the soil to be treated. In addition, it may be beneficial to include pilot-scale testing as part of the system design. This would allow the design team to identify problems similar to those described above prior to full-scale operation.

OTHER OBSERVATIONS AND LESSONS LEARNED (14)

It is recommended that future projects include a preliminary meeting with field office personnel and CX personnel. The purpose of this meeting would be to provide insight regarding past projects of a similar nature.

The primary remedial action objective was to eliminate the potential for dermal exposure to contaminants in the soil at the site. To achieve this objective, the top four feet of soil was excavated and incinerated in areas identified as being contaminated. Additional areas were excavated to remove potential sources of groundwater contamination. Contaminated areas were identified in the vicinity of the former load lines based on historical records that described discharge of contaminated wash water during facility cleaning activities.

Site conceptual model assumptions from the remedial investigation did not correlate in all cases to observations made in the field during soil excavation activities. For example, a substantial volume of additional contaminated material was found at the Burning/Proving Grounds. The contaminants were placed in this area by burning and burial of explosive materials, not by discharge of contaminated surface water. Therefore, the site conceptual model did not predict the presence of large pieces of unburned explosives in the subsurface at this site. Unburned explosives were observed at depths between 4 and 12 feet bgs during excavation at the Burning/Proving Grounds.

Discrete soil sampling may not have been appropriate for characterizing this explosives-contaminated site. Explosives are solid at ambient temperature, dissolve slowly and sparingly in aqueous solution and have low vapor pressures. These properties can restrict the transport rates of these contaminants in soil, especially when compared to rates for other contaminants, such as fuels or solvents. Typically, areas of high explosives contamination will remain at or near the ground surface at the point of deposition, unless the soil containing the contamination is physically moved. Too often, local spatial heterogeneity is ignored in favor of sampling, based on the theory that heterogeneity will be accounted for if the number of samples is sufficiently large. At this site, heterogeneity of contamination was not properly accounted for by characterization soil sampling. Although it is possible to over-characterize a site, project planners may increase the efficiency of remedial actions by performing a combination of composite sampling, field homogenization of samples and on-site colorimetric analyses. This type of characterization will produce data that are

accurate and precise, but that also may be more representative of site conditions. It is also recommended that the type of characterization sampling be selected based on the nature of contaminant deposition. This may necessitate varying sampling methods in different areas at a single facility.

To ensure proper blending of contaminated soil prior to incineration, it is recommended that any identified "hot spots" be remediated prior to incineration. This will help ensure that the feed material to the incinerator remains uniform during treatment operations.

A problem with freezing of a water line was encountered on one occasion during operation of the treatment unit. It was subsequently determined that the buried water line had frozen due to its proximity to a liquid oxygen line. During a period of low air temperature, the sheath of ice that typically surrounds a liquid oxygen line expanded and encompassed the water line. It is recommended that future projects take into account this possibility when locating utilities.

It is recommended that future projects include regular project team meetings or conference calls. The NOP project included a weekly conference call attended by representatives from the USACE, USEPA, NDEQ, and OHM. Allowing a weekly forum for project communication helped facilitate timely, efficient completion of the project.

This project used an innovative procedure for obtaining timely approval of allowable airborne contaminant emission rates from the treatment unit. Prior to performance of the mini burn or trial burn tests, a list was developed of emission rates that met typical air permitting requirements. These hypothetical rates were submitted to NDEQ and USEPA, and were ultimately approved after review and comments by the regulatory agencies. When the mini burn and trial burn tests were completed and it was determined that the system could keep emission rates below the hypothetical rates, rapid approval was obtained for full-scale operation of the system. Full-scale production began approximately two weeks following completion of the trial burn test. It is recommended that other projects of this nature use this procedure if rapid approval of emission rates is desired.

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