DEPARTMENT OF THE NAVY
CRANE DIVISION
NAVAL SURFACE WARFARE CENTER
300 HIGHWAY 361
CRANE, INDIANA 47522-5000

IN REPLY REFER TO:

5090
Ser 095/1362
31 OCT 2001

U.S. Environmental Protection Agency, Region V
Waste, Pesticides, & Toxics Division
Waste Management Branch
Corrective Action Section
Attn: Mr. Peter Ramanauskas (DW-8J)
77 West Jackson Blvd.
Chicago, IL 60604

Dear Mr. Ramanauskas:

Crane Division, Naval Surface Warfare Center (NSWC Crane) submits, for your review and approval, the Draft Rockeye (RKI) Full Scale (FS) Windrow M-203 Batch Report dated October 2001. Two copies of the report are provided as enclosure (1). Enclosure (2) is the required certification statement.

NSWC Crane point of contact is Ms. Christine D. Freeman, Code 09511, telephone 812-854-4423.

Sincerely,

James M. Hunsicker

JAMES M. HUNSICKER
Director, Environmental Protection
Department
By direction
of the Commander

Encls:
(1) Draft RKI FS M-203 Batch Report
(2) Certification Statement

Copy to:
Administrative Record
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SOUTHNAVFACENGCOM (Code ES234)
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Naval Facilities Engineering Command

Naval Surface Warfare Center

Crane, Indiana

Soils Bioremediation Facility

Windrow M-203 Full-Scale Batch Report

for

Rockeye Soils, SWMU 10/15

October 2001

Revision 0

TOLTEST, INC.

WINDROW M-203 FULL-SCALE BATCH REPORT
for
ROCKEYE SOILS, SWMU 10/15

October 2001

Revision 0

SOILS BIOREMEDIATION FACILITY
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

ENVIRONMENTAL JOB ORDER CONTRACT
CONTRACT NO. N68950-96-D-0052
TOLTEST PROJECT NUMBER 37324.09

Submitted to:

OFFICER IN CHARGE OF NAVFAC CONTRACTS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

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EXECUTIVE SUMMARY

This report has been prepared by TolTest for the Southern Division, Naval Facilities Engineering Command to document the first Full-Scale (FS) windrow bioremediation of explosives-contaminated soil from Rockeye Munitions Facility (RKI), Naval Surface Warfare Center (NSWC) Crane, Crane, Indiana.

The scope of work includes bioremediation of high-explosives contaminated soil utilizing a windrow composting process, process monitoring of the windrows, and confirmatory sampling of the compost. The objective of the FS processing was to determine if the composting mix previously used to successfully treat explosives contaminated soil from RKI in a pilot-scale windrow would be successful in a full-scale windrow. Pilot-scale testing is detailed in *Pilot-Scale Treatability Test Report for Rockeye Soils [TolTest, 2001].*

TolTest detected high-explosives contamination in the soil at RKI above industrial cleanup goals adjacent to building 2733. Exhaust vents on top of the blast wall between buildings 2733 and 2734 was the source of the contamination. The contaminated soil was excavated, screened, and transported to the NSWC Bioremediation Facility (Biofacility) for treatment. The first full size windrow, identified as M-203, was constructed for this project.

The process parameters of temperature, oxygen content, moisture content, and pH were monitored throughout the process cycle of M-203. The performance parameter of reducing levels of explosives in the soil below human health risk-based remedial goals was evaluated at the end of the process period.

The process objective of reaching and maintaining thermophilic temperatures was achieved. Thermophilic temperatures were reached within two days of windrow formation and were maintained throughout the 19-day process period. The process objective of supplying sufficient oxygen to maintain a level of 5% to 20% within the windrow was achieved. Average post-turn oxygen levels were above 6% and pre-turn levels were above 5%.

The performance objective of degrading the level of explosives to industrial or residential risk-based cleanup goals or less was achieved. Analysis indicated that cyclotrimethylene trinitramine (RDX) was above the industrial cleanup goal on Day 0 but was degraded to less than the residential cleanup goals by Day 19. All 13 remaining explosive compounds were below residential cleanup goals on Day 0.

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ACRONYMS AND ABBREVIATIONS

ABG	Ammunition Burning Ground
Biofacility	Bioremediation Facility
°C	Degrees Celsius
LCS	Laboratory Control Spike
LCSD	Laboratory Control Spike Duplicate
MFA	Mine Fill A
MFB	Mine Fill B
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NSWC	Naval Surface Warfare Center
PARCC	Precision, Accuracy, Representativeness, Completeness, & Comparability
PETN	Pentaerythritrol tetranitrate
ppb	Parts per Billion
ppm	Parts per Million
PS	Pilot-Scale
QAPP	Quality Assurance Project Plan
QC	Quality Control
RDX	cyclotrimethylene trinitramine
RKI	Rockeye Munitions Facility
RPD	Relative Percent Difference
SWMU	Solid Waste Management Unit
WHC	Water Holding Capacity

1.0 INTRODUCTION

This report has been prepared by TolTest for the Southern Division, Naval Facilities Engineering Command to document the bioremediation of explosives-contaminated soil from Rockeye Munitions Facility (RKI), Naval Surface Warfare Center (NSWC) Crane, Crane, Indiana. It summarizes the work performed by TolTest pursuant to the requirements of the approved Full-Scale (FS) Operational Plan for Soils Bioremediation Facility [MK, 1998] and the Quality Assurance Project Plan (QAPP) for FS Operations at the Biofacility [MK, 1998].

The scope of work includes bioremediation of high-explosives contaminated soil utilizing a windrow composting process, process monitoring of the windrows, and confirmatory sampling of the compost. The objective of this report is to document the treatment process in the first full-scale size windrow of explosives contaminated soil from RKI.

1.1 Naval Surface Warfare Center

NSWC Crane, located in southwestern Indiana (Figure 1), provides support for shipboard weapons systems and ordnance. This site also supports Crane Army Ammunition Activity, which includes production, renovation, storage, shipment, demilitarization, and disposal of conventional ammunition. Explosive-contaminated soils resulting from the above operations have been identified at four solid waste management units (SWMUs): Ammunition Burning Ground (ABG, SWMU-03/10); RKI (SWMU-10/15); MFA (SWMU-12/14); and MFB (SWMU-13/14). Soils from MFA and MFB have been successfully remediated. Soils at the ABG have yet to be remediated.

1.2 Rockeye Munitions Facility

RKI is located in the northeastern portion of Crane at the intersection of Highways 161 and 45 (Figure 2). RKI is a production facility that was formerly a press-loading operation for 3-inch projectiles that was later converted to a case-filling operation (Figure 3). TolTest detected high-explosives contamination in the soil above industrial cleanup goals from grids 8-12, 14 and 16 between buildings 2733 and 2734 (Figure 4). The source of this contamination was the exhaust vents on top of the blast wall. The levels of explosives detected during pre-excavation site characterization are listed in Table 1.0.

Table 1.1
Pre-Excavation Sample Results (ppm)

Grid #	Depth "	HMX	RDX	TNT
8	0-12	1900	190	350
8	24-36	350	51	92
9	0-12	1800	420	1400
9	24-36	1100	71	310
10	0-12	1900	240	270
10	24-36	6800	900	150
11	0-12	1900	850	490
11	24-36	1900	500	1300
12	0-12	810	30	39
12	24-36	270	5.2	4.4
13	0-12	180	4.5	1
13	24-36	33	3.8	1.6
14	0-12	1300	310	51
14	24-36	260	30	13
16	0-12	2500	560	31
Cleanup goals	Residential	3,300	4	15
	Industrial	34,000	17	64

2.0 FULL-SCALE STRATEGY

2.1 Fundamentals of Bioremediation by Composting

Composting is the process of microbial degradation of organic material resulting in the production of residual organic and inorganic material. Heat is generated within the compost matrix during microbial respiration further stimulating microbial activity. In bioremediation by composting, organic material is mixed with contaminated soil, which initially contains very little or no organic material. The added organic material supplies nutrients and provides a carbon source to facilitate an environment for microbial degradation of the explosive compounds present in the soil.

Microbial activity in a compost pile is controlled by the availability of organic material and inorganic nutrients (such as nitrogen and phosphorous), temperature, moisture content, and oxygen availability. The texture of the compost is important because it controls porosity, which helps determine aeration and moisture-holding capacity. The nature of the organic amendments determines nutrient concentration and availability. For example, chicken manure contains high levels of readily available nitrogen, and straw contains high levels of readily available carbon and contributes to an open, porous structure.

The compost mix used in this testing consisted of 15% (by volume) chicken manure, 60% straw, and 25% soil. This mix, identified as mix 7B, was used successfully in full-scale operations to treat explosives contaminated soil from MFA and MFB. This mix was also successfully used in pilot-scale testing of soil from RKI. A discussion of this pilot-scale testing can be found in the *Pilot-Scale Treatability Test Report for Rockeye Soils [TolTest, 2001].*

2.2 Process Goals

The process parameters subject to control by operating procedures and their corresponding goals are listed in Table 2.1. These parameters are monitored as described in Section 4.1. These goals are designed to provide optimal conditions for contaminant degradation and meet the performance goals established in Section 2.3 of this report.

TABLE 2.1 PROCESS GOALS	
Process Parameter	**Operating Goal**
Temperature	25 to 60°C
Moisture	40 to 60 percent maximum WHC
Oxygen	5 to 21 percent
pH	7 to 9.1

2.2.1 Temperature

Temperature is a primary indicator of successful thermophilic composting. The optimum process goal is to maintain average windrow temperatures near 55 degrees Celsius (°C). The average temperature should rise to 25 to 40°C within the first few days of windrow formation, continue rising to within the temperature range of 40 to 60°C, and maintain that temperature range for at least two weeks. This temperature profile indicates a healthy, metabolically active windrow. Temperatures greater than 65°C can kill many microbes. A temperature decrease over time to below 50°C is viewed as an indicator that a pile is nearing the end of its operation (Weston, 1993).

2.2.2 Moisture Content

The operating goal for composting moisture content is 40% to 60% of water holding capacity (WHC). Moisture levels exceeding this range may negatively affect proper composting and explosives degradation. Too little moisture inhibits microbial movement and nutrient availability, and excessive moisture fills the void spaces needed for proper aeration, thus reducing oxygen levels.

2.2.3 Oxygen

Oxygen levels of up to ambient atmospheric or about 21% are preferred in a compost windrow, and 5% is considered the minimum for rapid compost degradation. Oxygen levels below 1 % indicate anaerobic conditions. Insufficient oxygen levels may affect proper microbial degradation such that thermophilic temperatures may not be maintained and putrefaction of organic matter may occur. However, anaerobic conditions commonly exist in a compost windrow throughout most of each day, and aerobic conditions may occur for only 1 to 2 hours following turning.

The oxygen available to microbes in a windrow is the result of aeration by turning; oxygen diffusion from the atmosphere into the windrow is negligible (Biocycle, 1991). Therefore oxygen availability is a function of the air-filled pore volume, which is in turn a function of porosity and moisture content. As compost is turned and degrades, the porosity is reduced, which in turn reduces available oxygen. Similarly, increasing the moisture content also reduces available oxygen.

Even under oxygen levels of 5 to 20%, anaerobic microsites exist throughout a compost windrow. Counts of aerobic, anaerobic, obligate anaerobic, and thermophilic bacteria were performed at Umatilla as part of the compost seeding studies (Weston, 1993). The results showed that total aerobic and total anaerobic bacteria counts were equivalent, and suggest that both anaerobic and aerobic bacteria play an important role in compost degradation.

2.2.4 pH

There is no operating goal for the pH level within the windrow since it cannot be easily adjusted. It is anticipated, based on past composting experience at the Biofacility, that the pH of the compost will increase to as high as 9.0 with an average pH of about 8.5 being maintained throughout the composting process.

2.3 Performance Goals

The primary performance objective is to reduce the explosive contaminant levels in the soil to human health risk-based remedial goals. These goals have been established by the United States Environmental Protection Agency, Region V using preliminary remedial goals and data quality levels (U.S. EPA, 1996). The remedial goals for the 14 explosive compounds of concern, excluding Pentaerythritrol tetranitrate (PETN), are presented in Table 2.2. PETN is not listed because it was not detected in pre-excavation site characterization sampling and analysis for PETN is no longer required on Day Last compost samples as approved in Field Change Request FS-011 (Appendix A).

TABLE 2.2
EXPLOSIVES SOIL REMEDIAL GOALS AND METHOD REPORTING LIMITS

Parameter	Analytical Method	Soil Remedial Goal (mg/kg)		Method Reporting Limit (mg/kg)
		Residential	Industrial	
TNT	8330	15	64	0.25
RDX	8330	4	17	1
HMX	8330	3,300	34,000	2.2
Tetryl	8330	650	6,800	0.65
1,3,5-Trinitrobenzene (TNB)	8330	3.3	34	0.25
1,3-Dinitrobenzene (DNB)	8330	6.5	68	0.25
Nitrobenzene (NB)	8330	18	94	0.26
4-Aminodinitrotoluene (4-ADNT)	8330	65	680	0.25
2-ADNT	8330	130	1,400	0.25
2,4-DNT	8330	130	1,400	0.25
2,6-DNT	8330	65	680	0.26
2-Nitrotoluene	8330	650	6,800	0.25
3-Nitrotoluene	8330	650	6,800	0.25
4-Nitrotoluene	8330	650	6,800	0.25

Notes:
1. Analytical methods listed above are SW-846 methods, unless otherwise indicated
2. Method reporting limits will vary depending on sample dilution factors

3.0 PILOT-SCALE OPERATIONS

3.1 Soil Handling and Windrow Formation

The contaminated soil from the grids listed in Table 1 was excavated and hauled to the screener site at MFB prior to forming windrow M-203. The soil was screened to remove anything larger than 1.5 inches in diameter and then loaded onto trucks and transported to the Biofacility where it was stored until the windrow was formed. Thus the soil that was used in this windrow was a mix of soil from all eight grids and cannot be traced to one particular grid.

3.2 Windrow Formation

Windrow M-203 was formed on 5/30/01. It was 275 feet long from toe to toe and contained approximately 232 tons of contaminated soil, 107 tons of chicken manure, and 47 tons of straw. The windrow was turned daily with the SCARAB and was processed for a total of 17 days. A total of 6,000 gallons of water were added to the windrow during its life cycle (3,000 gallons from Retention Pond 1, 1,000 gallons from the building sump, and 2,000 gallons potable). The windrow recipe is provided in Appendix B.

3.3 Windrow Process Monitoring

Process monitoring for oxygen, temperature, pH, and moisture, and sampling for off-site laboratory analysis was performed in accordance with the Quality Assurance Project Plan for Full-Scale Operations at the Bioremediation Facility (MK, 1998.

Five cross-sections were established in accordance with Field Standard Operating Procedure QAPP-3.0, Appendix A of the FS-QAPP. Three sample locations were identified at each cross section: one on top of the windrow and one on each side. At each sample location, two sampling depths were established: a shallow point at one foot below the surface, and a deep point at a depth of 2½ feet (on the sides) or three feet (on the top). All oxygen and temperature data was obtained at these sample points.

Samples for moisture and pH determination were taken from the deep sample point at each sample locations. The three samples per cross section were mixed to form one composite sample per cross section. Samples for moisture determination were obtained four times during the life cycle of the windrow and pH was determined once.

Oxygen and temperature levels within the windrow were monitored daily before and after each turn event at the shallow and deep sample points at each of the 15 sample locations.

Grab samples for off-site laboratory analysis of explosive compounds were obtained from the deep sample point at each of the 15 sample locations.

4.0 FIELD SCREENING FOR EXPLOSIVE COMPOUNDS

RDX, TNT, and HMX are the major explosive compounds present at RKI based upon pre-excavation sampling results. Field test kits provide a cost-effective method of determining approximate concentrations and minimize the number of samples submitted for off-site analysis. There currently is no field test kit available for the analysis of HMX. Previous field screening for RDX and TNT has shown that RDX is a better indicator than TNT for determining the effectiveness of explosive degradation within the windrows. RDX is typically found in higher concentrations in the soil and it takes longer to degrade than TNT. For these reasons, field screening for TNT was not undertaken and operational decisions were based on the results of RDX field screening only.

One composite sample was collected per cross-section and analyzed for RDX using the Strategic Diagnostics, Inc. Ensys Field Test Kit. The SOP for the field test kit is presented in the FS-QAPP [MK,1998]. When field screening indicated non-detectable levels of RDX in the compost, confirmation samples were collected and submitted to an off-site laboratory for analysis of all explosive compounds.

Process monitoring for RDX concentration within windrow M-203 was performed on operational Day 15. No color change (or non-detect) was observed in the composite samples from cross sections 3, 5, and 9. RDX was detected at 1.6 ppm in cross section 7 and 3.1 ppm in cross section 11. Based on these results, the windrow was allowed to process four more days until Day 19 at which time confirmation samples were obtained and sent to Southwest Laboratories for analysis by EPA Method 8330.

5.0 PROCESS MONITORING AND SAMPLING RESULTS

5.1 Process Monitoring

Standard Operating Procedures for compost sample collection and windrow process monitoring can be found in Appendix A to the QAPP for Full-Scale Operations (MK, 1998).

5.1.1 Ambient Conditions

Ambient conditions for temperature and percent relative humidity were recorded immediately prior to pre-turn windrow monitoring utilizing the temperature/humidity gauge mounted to the wall of each compost building. As shown on Figure 5-1, ambient temperatures fluctuated from a high of 27°C to a low of 12°C. Relative humidity for the 19-day processing period ranged from a high of 96% on Day 5 to a low of 59% on Day 0. Tabulated data for ambient temperature and relative humidity are presented in Appendix C.

5.1.2 Temperature

Temperature measurements were recorded before and after each windrow turn event. Pre-turn temperatures are more useful for evaluation and comparison because they represent heat development over time, whereas post-turn temperatures are affected by windrow turning and moisture addition. Average temperature is defined as the average of the 30 monitoring locations in each windrow (5 cross sections, 3 sample locations per cross section, 2 sample points per sample location).

As shown in Figure 5, temperatures within the windrow quickly increased into the thermophilic range and remained there for the entire 19-day process time. Neither the cool ambient temperatures nor the addition of water had a negative effect on windrow temperatures. Tabulated data for temperature is presented in Appendix D.

5.1.3 Oxygen Levels

Oxygen levels were monitored at the same locations and frequency as temperature measurements. Samples were collected as soon as possible following windrow turning, generally within 15 minutes. The data shows considerable variation from day to day (see Figure 6), which is a reflection of the heterogeneous nature of compost. The variation in oxygen content is also affected by the differences in sample collection times and the moisture content of the compost.

The average pre and post-turn oxygen content for the 19-day processing period was less than 7%. However, given that thermophilic temperatures were achieved and sustained and successful degradation of contaminants was achieved (discussed in Section 5.2 below), it is concluded that sufficient oxygen was available to the microorganisms throughout the processing period. Tabulated data for oxygen is presented in Appendix E.

5.1.4 Moisture Content

Moisture was added to the windrow with a spray boom attached to a water wagon. Samples were obtained after the windrow had been turned and any water that had been added was mixed into the compost. Samples for moisture determination were obtained on Days 0, 3, 7, and 12.

Two criteria were used for addition of water: average percent WHC below 40 and field inspection of the windrow. Due to the heterogeneity of the compost mix, water addition based strictly on average percent WHC could lead to excessive moisture within the windrow. Therefore, the windrow was inspected by TolTest's Environmental Technician to determine if water addition was warranted. Average percent WHC values and moisture addition to the windrow are listed in Table 5.1.

5.1.5 pH

Analysis for pH was performed once during the processing period on the same composite samples obtained for moisture determination. Average pH was 8.6 standard units as listed in Table 5.1.

Table 5.1
M-203 Average Moisture and pH Values

Day Number	Average % WHC	pH	Gallons added
0	52.62	-	-
3	47.2	-	2000
7	53.18	8.6	2000
12	50.0	-	2000

5.2 Explosives Compounds Sampling Results

Sampling for off-site laboratory analysis of explosive compounds was completed on Day 0, and Day 19 (Day Last) of the windrow process cycle. Samples were obtained from the deep sample point at each of the 15 sample locations. Averaged results are listed in Table 5.2 below. A complete tabulation of all explosives for the three sampling events is provided in Appendix F.

Results indicate that the average level of RDX was above industrial cleanup goals on Day 0 while the levels of the 13 remaining explosive compounds were already below the more stringent residential cleanup goals. Day 19 results for all compounds were below residential cleanup goals.

Table 5.2
M-203 Average Laboratory Analytical Results

All results in ppm	DAY 0	DAY 19	Cleanup Goals	
			Industrial	Residential
HMX	125.9	4.5	34,000	3,300
RDX	40.2	0.5	17	4
TNT	5.2	0.5	64	15
TNB	0.5	0.5	34	3.3
DNB	0.5	0.5	68	6.5
TETRYL	0.5	0.5	6,800	650
NB	0.5	0.5	94	18
4ADNT	2.4	0.5	680	65
2ADNT	0.8	0.5	1,400	130
26DNT	0.5	0.5	680	65
24DNT	0.5	0.5	1,400	130
2NT	0.5	0.5	6,800	650
4NT	0.6	0.5	6,800	650
3NT	0.5	0.5	6,800	650

6.0 DATA QUALITY CONTROL SUMMARY

Data quality for analytical data was evaluated through assessment of precision, accuracy, representativeness, completeness, and comparability (PARCCs). Analytical quality assurance objectives were established to ensure the quality of the analytical data produced by the contract laboratory.

Precision is the degree to which the measurement is reproducible. This was determined by comparison of sample duplicates, laboratory control spikes and duplicates (LCS/LCSD), or samples designated as matrix spike and duplicates (MS/MSD). Precision was calculated as the relative percent difference (RPD) between these duplicates according to the procedures.

Accuracy was expressed as the percent recovery of a compound from a sample spiked with known concentrations of target compounds for each analytical method. Determining the accuracy of a measurement requires knowledge of the true or accepted value for the parameter being measured and the value of the parameter for the unspiked sample.

The representativeness of the data is the degree to which data represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Data were considered representative if the sampling was in accordance with the sampling programs outlined in the *QAPP for Full Scale Operations at the Biofacility* (MK, 1998). Field duplicate samples were collected and analyzed to assess field representativeness.

Completeness is a measure of the amount of valid data obtained from an analytical data set compared with the amount that would be expected to be obtained under normal sampling and analytical conditions. Completeness is based on only those samples collected and submitted for laboratory analysis. For this project, completeness was established at 90 percent.

Comparability expresses the confidence with which one data set can be compared to another. Samples from the same media (i.e. compost) were considered comparable if the procedures for collecting and analyzing the samples are complied with and consistent.

Comparability was assured through the use of established and approved analytical methods and protocols. The laboratory's quality control (QC) program was designed to establish consistency in the performance of the analytical process. The program includes traceability of measurements to standardized reference materials to establish comparability with other laboratory results, and internal controls to verify consistency of the contract laboratory's performance.

Laboratory QC samples were analyzed to evaluate the PARCC parameters. The laboratory samples included LCS/LCSD, method blanks, and MS/MSD. Analyses of the laboratory QC samples were run concurrently with the analytical batch to which the samples were assigned. As an additional QC check for method SW8330, surrogates were added to each sample (including QC samples) and analyzed in an analytical batch.

The laboratory method blanks were carried through each step of the analytical method to examine the potential for cross-contamination. A method blank consists of organic-free deionized water or sterile soil (or equivalent). All laboratory method blanks were acceptable, based upon the project data quality objectives. Positive blank results may indicate possible false positive results in associated samples in which results are less than five times the levels found in the blanks.

The matrix spikes are samples spiked with known concentrations of target analytes. These samples were taken through the entire analytical procedure and used to evaluate the accuracy of the method for the different matrices. The percent recovery of the analytes are calculated and assessed to determine method efficiency and matrix interference effects. When the results of the MS/MSD indicate a potential problem due to the sample matrix, the LCS/LCSD results are used to verify that the laboratory can perform the analysis in a clean matrix. Method precision is evaluated by the calculated RPD between the percent recovery for duplicate spiked samples analyzed.

Precision was acceptable for the two analytical batches. Both the MS/MSD and the LCS/LCSD pairs exhibited acceptable RPDs.

Accuracy was acceptable for most sample analytical batches based on the data quality requirements. MS/MSD percent recoveries showed some variation in the Day 0 analytical batch. Variations in MS/MSD accuracy were likely due to the non-homogeneity of the sample matrix and the relative spiking levels as compared to the high concentrations found in the corresponding samples. The LCS/LCSD pairs exhibited acceptable percent recoveries for the two sample analytical batches evaluated.

Surrogates were added to each environmental sample and QC sample in analytical batches for method SW8330. Surrogates are known concentrations of non-target analytes spiked into each QC sample and environmental samples which are taken through the entire analytical procedure and the recovery of the analytes calculated. The results of the surrogate analysis are expressed as a percent recovery and are used to evaluate the accuracy of the method for different matrices.

Nine samples (including sample matrix spikes MS/MSD) in Day 0 analytical batch exhibited low percent recoveries for the surrogate 3,4-DNT, indicating a possible low bias in associated samples.

Reporting limits were based on method quantitation limits for organics. The method detection limit is defined as minimum concentration of a substance that can be identified, measured, and reported with a 99 percent confidence level that the analyte concentration is greater than zero. The method quantitation limit is defined as equivalent to a fixed multiple of the method detection limit or lowest standard as outlined in SW846. It should be recognized that detection and quantitation limits are sample matrix dependent and were elevated for samples that required dilution as a result of the dilution factors. Overall assessment is that the data obtained has met the data quality objectives for the program. Data not meeting acceptable criteria have been flagged appropriately.

7.0 CONCLUSIONS

Process monitoring data and analytical data from Day Last samples indicate that the process objectives for temperature, oxygen, pH, and moisture, and performance objectives for explosives degradation were met.

The process objective of reaching and maintaining thermophilic temperatures of 25 to 60°C was achieved. Thermophilic temperatures were reached within one day of windrow formation and were maintained throughout the 19-day process period.

The process objective of supplying sufficient oxygen to maintain a level of 5% to 21% within the windrow was achieved. Average pre-turn oxygen levels were above 5% and average post-turn levels were above 6%.

The process objective of maintaining the water holding capacity between 40 to 60% was achieved, based on moisture content calculation.

As anticipated, an average pH level of 8.6 was observed in the compost samples.

The performance objective of degrading the explosives to industrial or residential risk-based cleanup goals or less was achieved. Analysis indicated that RDX was above the industrial cleanup goal on Day 0 but was degraded to less than the residential cleanup goals by Day 19. All 13 remaining explosive compounds were below residential cleanup goals on Day 0.

8.0 REFERENCES

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FIGURES

FIGURE 1 NSWC CRANE VICINITY MAP WINDROW M-203 FULL-SCALE BATCH REPORT FOR ROCKEYE SOILS NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	DRAWN MRC/10-22-01	CHECKED
	REVISED	APPROVED
	JOB NO. 37324.09	TOLTEST, INC.
	DRAWING NUMBER 37324-91	

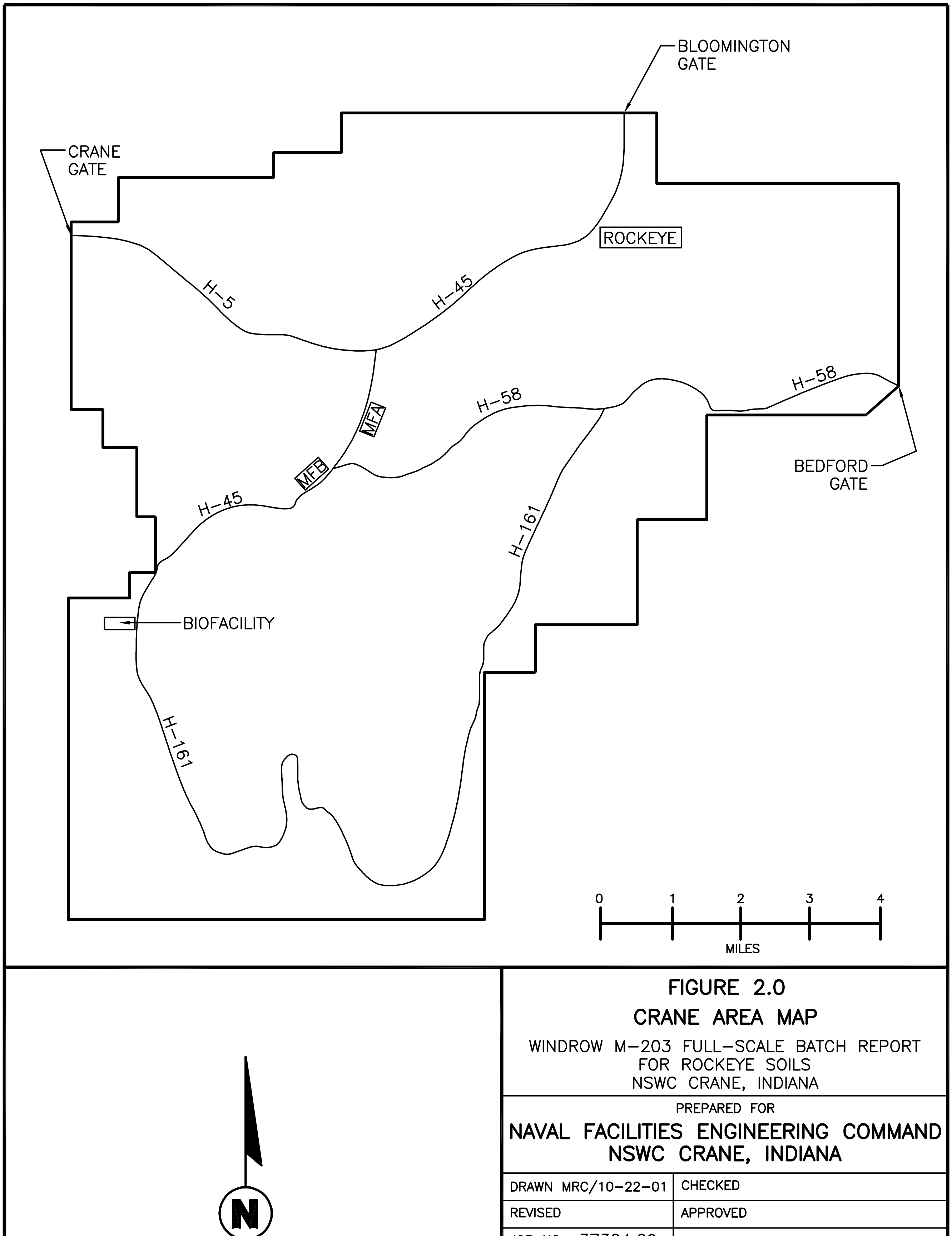


FIGURE 2.0
CRANE AREA MAP
WINDROW M-203 FULL-SCALE BATCH REPORT
FOR ROCKEYE SOILS
NSWC CRANE, INDIANA

PREPARED FOR
NAVAL FACILITIES ENGINEERING COMMAND
NSWC CRANE, INDIANA

DRAWN MRC/10-22-01	CHECKED
REVISED	APPROVED
JOB NO. 37324.09	TOLTEST, INC.
DRAWING NUMBER 37324-92	

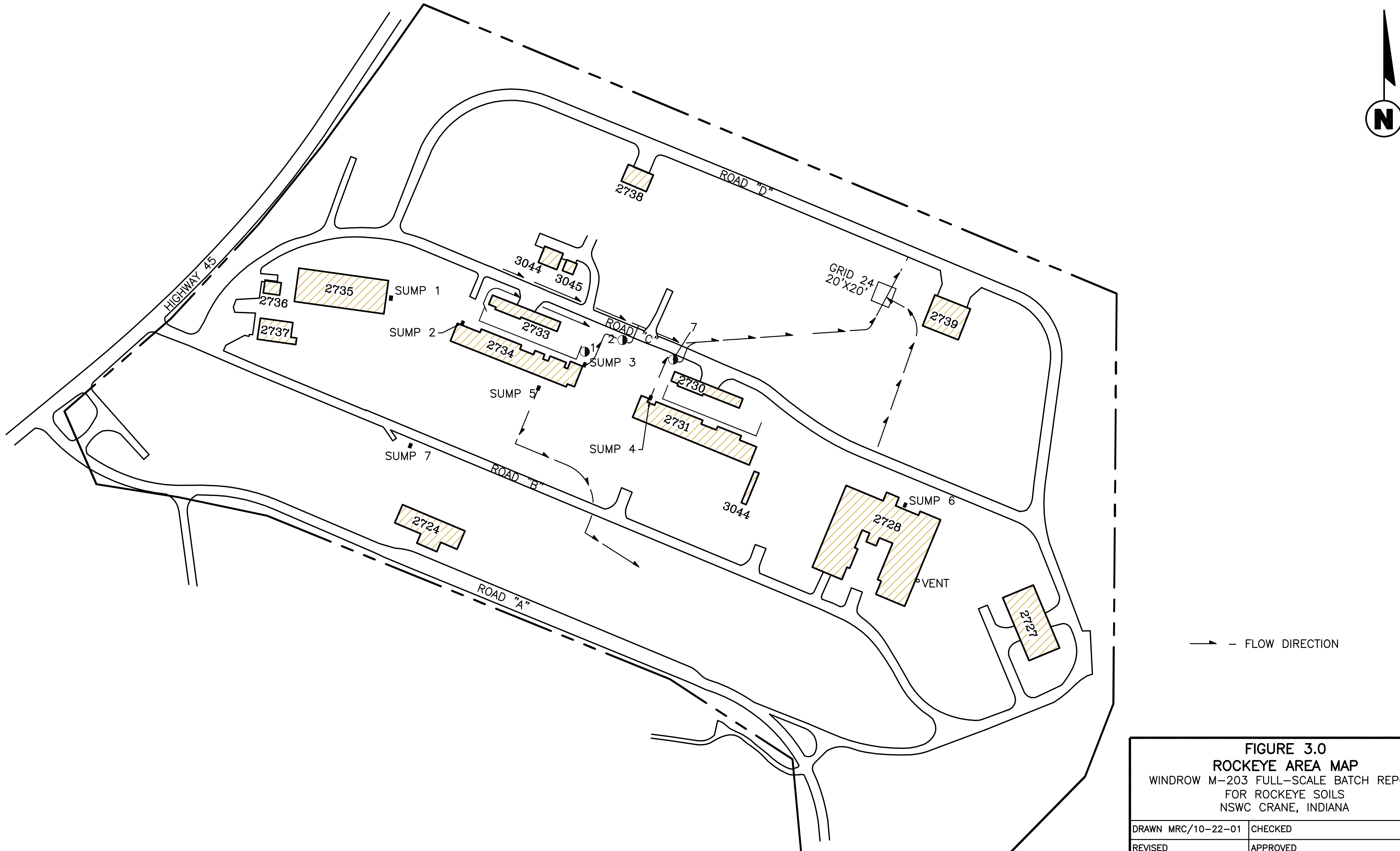


FIGURE 3.0
ROCKEYE AREA MAP
WINDROW M–203 FULL–SCALE BATCH REPORT
FOR ROCKEYE SOILS
NSWC CRANE, INDIANA

DRAWN MRC/10–22–01	CHECKED
REVISED	APPROVED
JOB NO.: 37324.09	TOLTEST, INC.
DRAWING NUMBER 37324–93	

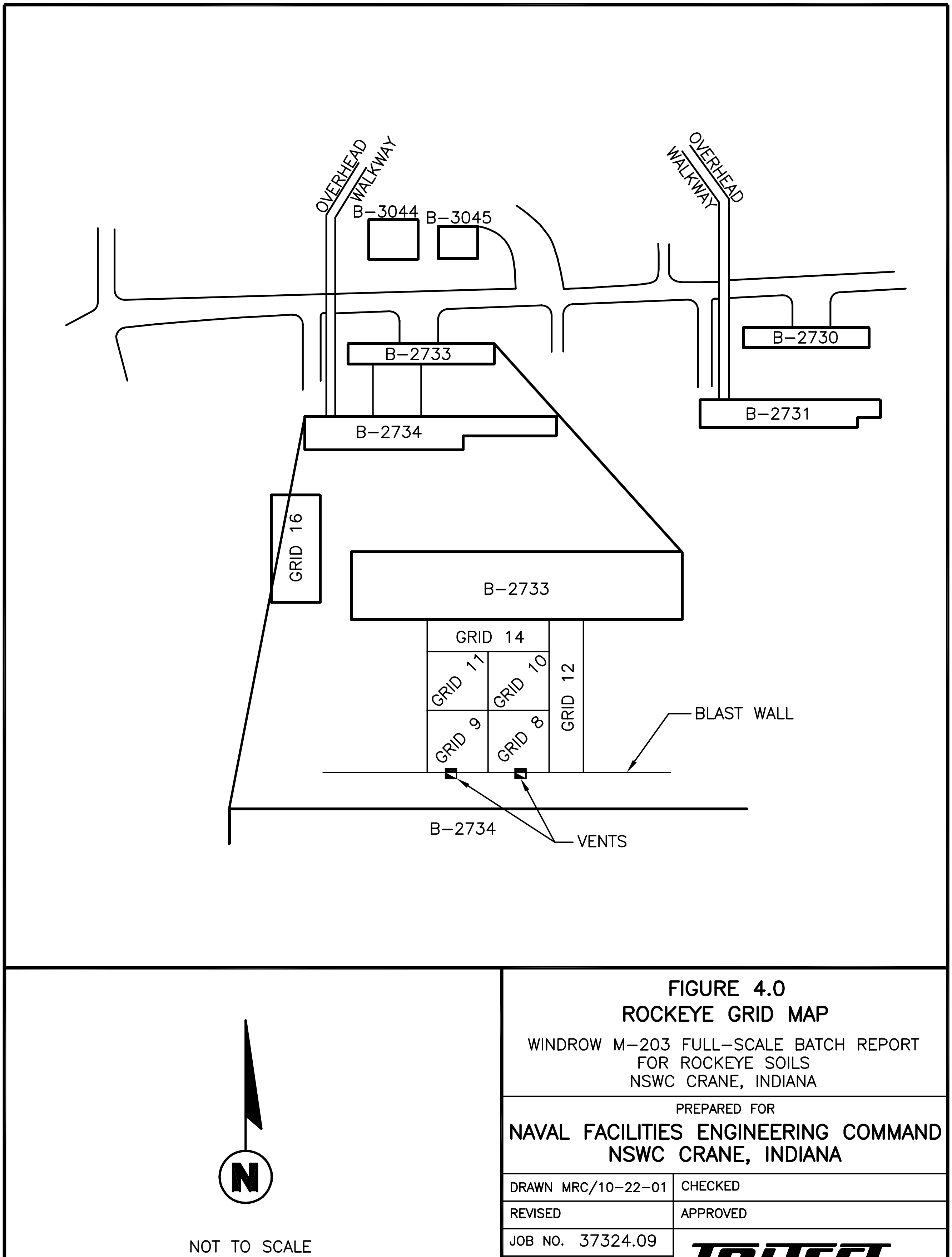


FIGURE 4.0
ROCKEYE GRID MAP

WINDROW M-203 FULL-SCALE BATCH REPORT
FOR ROCKEYE SOILS
NSWC CRANE, INDIANA

PREPARED FOR
NAVAL FACILITIES ENGINEERING COMMAND
NSWC CRANE, INDIANA

DRAWN MRC/10-22-01	CHECKED
REVISED	APPROVED
JOB NO. 37324.09	TOLTEST, INC.
DRAWING NUMBER 37324-94	

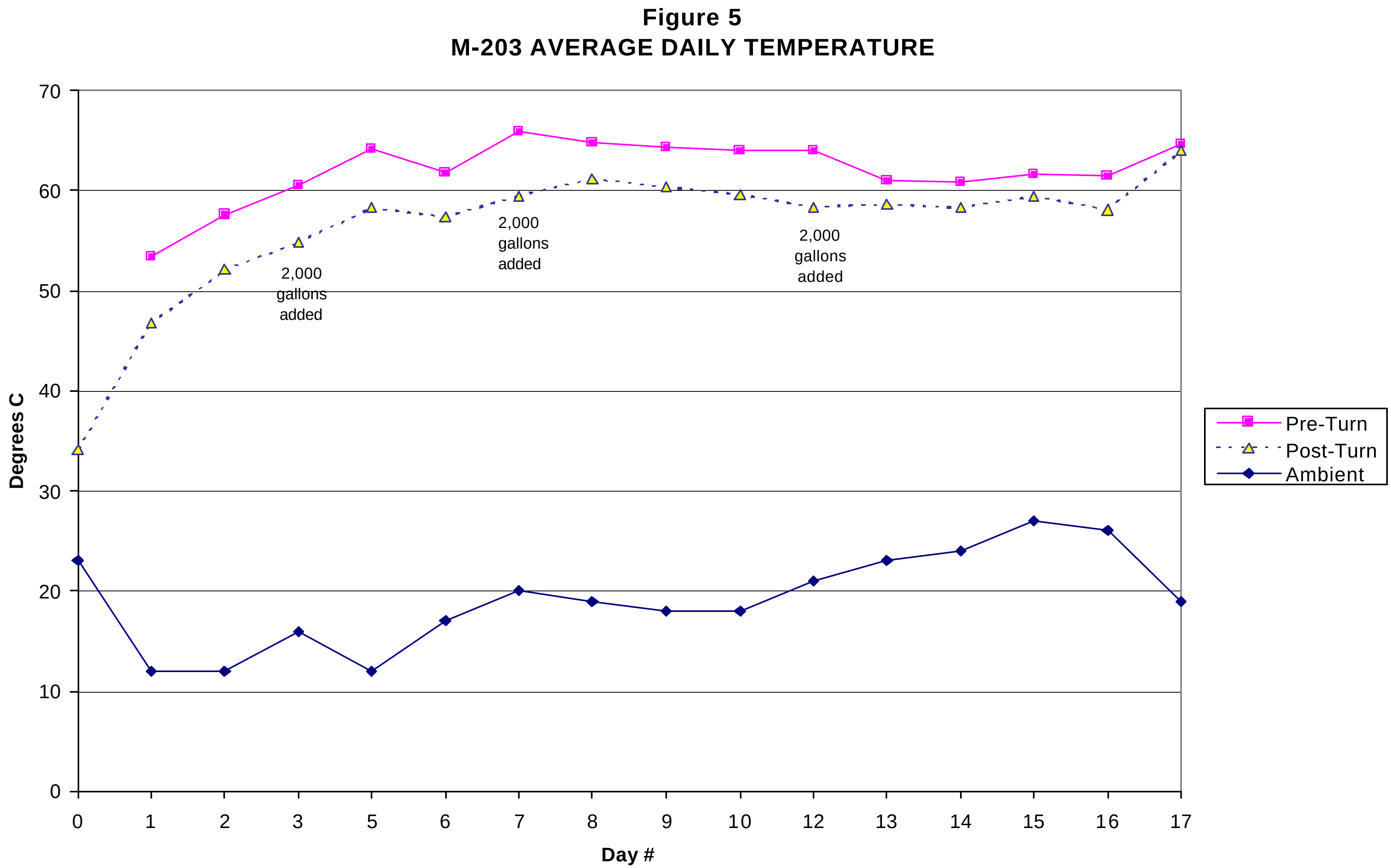
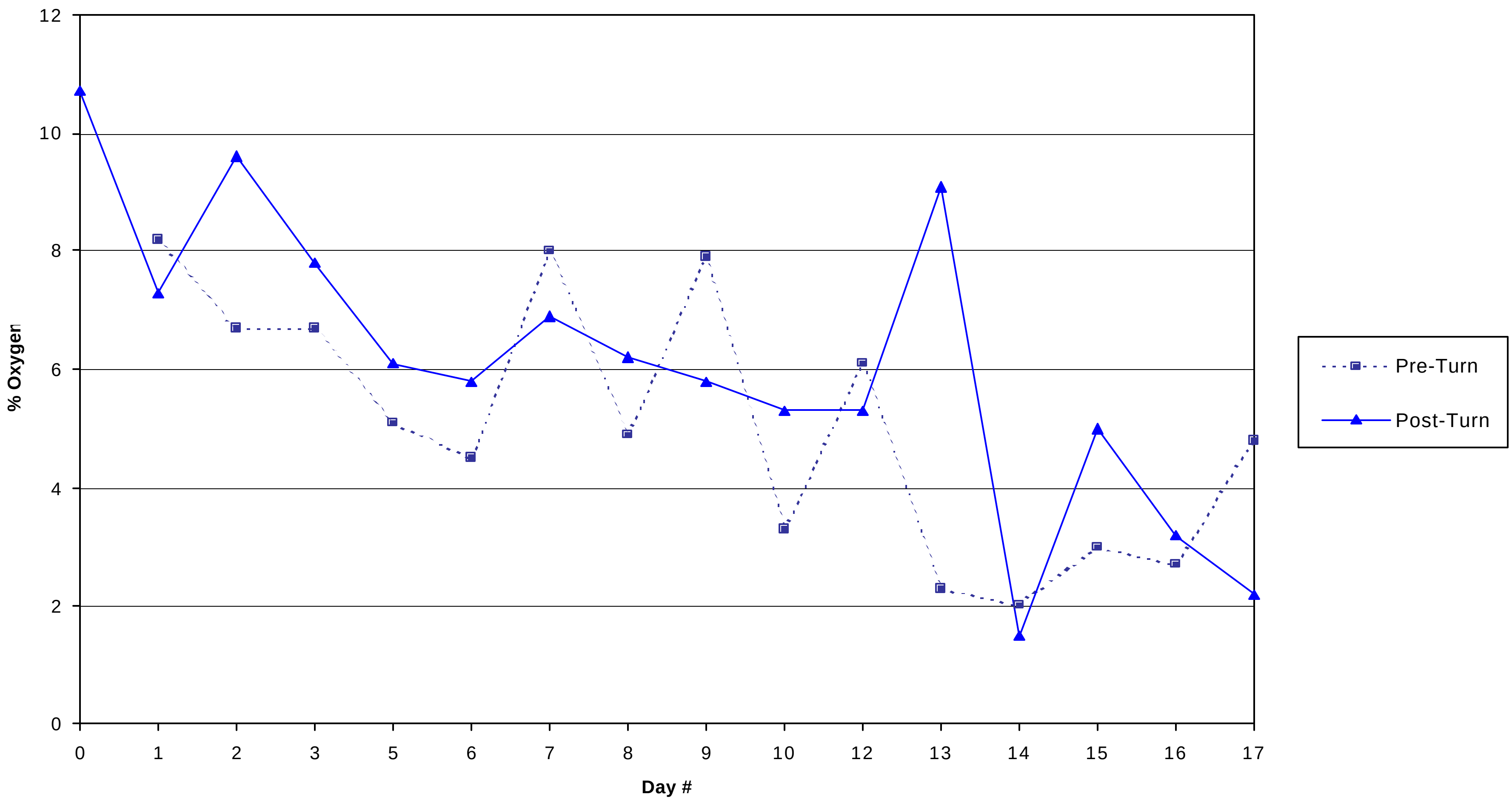


Figure 5
M-203 AVERAGE DAILY TEMPERATURE
Degrees C
Day #
0
10
20
30
40
50
60
70
0
1
2
3
5
6
7
8
9
10
12
13
14
15
16
17
2,000 gallons added
2,000 gallons added
2,000 gallons added
Pre-Turn
Post-Turn
Ambient

Figure 6
M-203 AVERAGE DAILY OXYGEN LEVELS



APPENDIX A
Field Change Request FS-011

NAVFAC Southern Division/ Morrison Knudsen Corporation	District II RAC **ORIGIN**

FIELD CLARIFICATION REQUEST (FCR)

Delivery Order No.: 4324-0009	Subcontract No.: N/A	FCR No.: 4324-0009-FCR-FS01
CLARIFICATION OF ITEMS		Page 1 of 1

Reference Documents: Full-Scale Biofacility Operations QAPP para. 1.1.2

Problem / Change Description:

Data resulting from the initial few months of Biofacility operations indicates that percent reduction goals readily being met. There also have been no greater than detectable limit "hits" for PETN in any sample originating from MFA or MFB, from either windrow or initial characterization sampling.

Initiated by	Signature: [signature]	Organization: Morrison Knudsen Corporation	Date: 8/25/98

Resolution:

1. Attached is day zero, day last, and percent reduction data for all windrows to date. The data demonst that [redacted] the 90-99% reduction goal is be attained for all chemicals of concern. Discontinue all day zero laboratory testing and rely on initial soil characterization and day last laboratory testing to prove clean up and percent reduction goals have been

2. Discontinue all windrow PETN laboratory testing based upon test results to date. Continue to test for in the initial characterization sampling at the excavation sites. Any "hit" above the detection limit would require direction by the Navy EPD. *[illegible] for these Fills A & B [illegible]*

If this FCR affects a subcontract, indicate CID number: N/A

Approval	Signature	Date	
Approval by MK PE	*U. Venkatesh signature on file*		Approval by ROICC/NTR or RPM — Signature: — Dat
Approval by MK PjM	*D Beall*	*8/25/98*	Additional Reviews: By/Date *Christine D. Freeman 9/3 NSWC Crane Env. Prot. Dept. Approved w/comments*
Approval by MK QC	[signature]	*8/26/98*	
Approval by MK REG SPT.	*S. Cory signature on file*		*Approved w/ comm*

Regulator Approval/Notification Recommended: Yes ☒ No ☐ *for Carol Witt-Smith 10/26/98 PETN [illegible] Fills A & B to stop*

A:FCRFS011.DOC

APPENDIX B

M-203 Record of Recipe

	Chicken		Straw		Soil		Total	
Batch #	cy	pounds	cy	pounds	cy	pounds	cy	pounds
1	3	5710	13	3000	5.275	11605	21.275	20315
2	3.1	5760	12.5	2800	5.275	11605	20.875	20165
3	3	5730	12.25	2600	5.275	11605	20.525	19935
4	3.2	5810	12.15	2500	5.275	11605	20.625	19915
5	3.2	5920	12.25	2650	5.275	11605	20.725	20175
6	3	5740	12	2400	5.275	11605	20.275	19745
7	3.2	5810	12.15	2500	5.275	11605	20.625	19915
8	3.2	5920	12	2400	5.275	11605	20.475	19925
9	3.2	5880	12.2	2550	5.275	11605	20.675	20035
10	3.2	5800	12.25	2680	5.275	11605	20.725	20085
11	3.2	5860	12.15	2500	5.275	11605	20.625	19965
12	3.2	5840	12	2400	5.275	11605	20.475	19845
13	3.1	5790	12.25	2650	5.275	11605	20.625	20045
14	3.2	5840	12	2400	5.275	11605	20.475	19845
15	3.2	5790	12.15	2500	5.275	11605	20.625	19895
16	3.2	5880	12.25	2610	5.275	11605	20.725	20095
17	3	5800	12.15	2540	5.275	11605	20.425	19945
18	3.2	5730	12.25	2640	5.275	11605	20.725	19975
19	3.15	5890	12.25	2690	5.275	11605	20.675	20185
20	3.15	5760	12.15	2550	5.275	11605	20.575	19915
21	3.15	5820	12.1	2400	5.275	11605	20.525	19825
22	3.15	5790	12.15	2500	5.275	11605	20.575	19895
23	3.15	5820	12	2400	5.275	11605	20.425	19825
24	3.1	5780	12.15	2540	5.275	11605	20.525	19925
25	3.1	5740	12	2400	5.275	11605	20.375	19745
26	3.1	5790	12	2400	5.275	11605	20.375	19795
27	3.1	5730	12.15	2500	5.275	11605	20.525	19835
28	3.1	5750	12	2420	5.275	11605	20.375	19775
29	3.15	5790	12.25	2600	5.275	11605	20.675	19995
30	3.15	5850	12.15	2570	5.275	11605	20.575	20025
31	3.15	5820	12.1	2490	5.275	11605	20.525	19915
32	3.1	5730	12	2400	5.275	11605	20.375	19735
33	3.1	5760	12.25	2610	5.275	11605	20.625	19975
34	3	5720	12.1	2450	5.275	11605	20.375	19775
35	3.1	5780	12.25	2610	5.275	11605	20.625	19995
36	3.1	5720	12.15	2500	5.275	11605	20.525	19825
37	3.1	5740	12.15	2470	5.275	11605	20.525	19815
38					5.275	11605	5.275	11605
39					5.275	11605	5.275	11605
40					5.275	11605	5.275	11605
Total	115.8	214390	450.3	93820	211.00	464200	777.1	772410

APPENDIX C

M-202 Ambient Temperature and Relative Humidity Data

Date	Temp C	% RH	Day #
5/30/01	23	59	0
5/31/01	12	77	1
6/1/01	12	92	2
6/2/01	16	91	3
6/4/01	12	96	5
6/5/01	17	95	6
6/6/01	20	93	7
6/7/01	19	93	8
6/8/01	18	86	9
6/9/01	18	78	10
6/11/01	21	82	12
6/12/01	23	83	13
6/13/01	24	81	14
6/14/01	27	75	15
6/15/01	26	82	16
6/16/01	19	85	17

APPENDIX D
M-203 Temperature Data

Date	Day	Pre-Turn	Post-Turn	Ambient
5/30/01	0		34.2	23
5/31/01	1	53.4	46.7	12
6/1/01	2	57.6	52.1	12
6/2/01	3	60.6	54.8	16
6/4/01	5	64.2	58.3	12
6/5/01	6	61.8	57.4	17
6/6/01	7	65.9	59.5	20
6/7/01	8	64.8	61.2	19
6/8/01	9	64.4	60.4	18
6/9/01	10	64	59.6	18
6/11/01	12	64.1	58.4	21
6/12/01	13	61.1	58.6	23
6/13/01	14	60.9	58.3	24
6/14/01	15	61.7	59.5	27
6/15/01	16	61.5	58.1	26
6/16/01	17	64.7	64	19

APPENDIX E
M-203 Percent Oxygen Data

Date	Day	Pre-Turn	Post-Turn
5/30/01	0		10.7
5/31/01	1	8.2	7.3
6/1/01	2	6.7	9.6
6/2/01	3	6.7	7.8
6/4/01	5	5.1	6.1
6/5/01	6	4.5	5.8
6/6/01	7	8	6.9
6/7/01	8	4.9	6.2
6/8/01	9	7.9	5.8
6/9/01	10	3.3	5.3
6/11/01	12	6.1	5.3
6/12/01	13	2.3	9.1
6/13/01	14	2	1.5
6/14/01	15	3	5
6/15/01	16	2.7	3.2
6/16/01	17	4.8	2.2

APPENDIX F
M-203 Explosives Data

M-203 Day 0

Method 8330 Analytical Results

Results in ppm

Sample	HMX	RDX	TNT	TNB	DNB	TETRYL	NB	4ADNT	2ADNT	26DNT	24DNT	2NT	4NT	3NT
3-1	258	50.4	8.56	0.5	0.5	0.5	0.5	4.14	1.63	0.5	0.5	0.5	0.248	0.5
3-2	262	47.1	17	0.0449	0.5	0.5	0.5	7	2.72	0.5	0.5	0.5	0.161	0.5
3-3	55.6	11.8	2.13	0.476	0.476	0.476	0.476	1.46	0.318	0.476	0.476	0.476	0.517	0.476
5-1	397	126	15.8	0.5	0.5	0.5	0.5	5.77	2.69	0.5	0.5	0.5	0.5	0.5
5-2	95.6	24.9	2.94	0.476	0.476	0.476	0.476	1.65	0.33	0.476	0.476	0.476	0.89	0.476
5-3	12.8	2.36	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.877	0.476
7-1	114	19	5.12	0.5	0.5	0.5	0.5	2.08	0.712	0.5	0.5	0.5	1.44	0.5
7-2	94.8	20.5	2.19	0.476	0.476	0.476	0.476	1.37	0.242	0.476	0.476	0.476	0.476	0.476
7-3	111	20.8	2.95	0.476	0.476	0.476	0.476	1.45	0.256	0.476	0.476	0.476	0.476	0.476
9-1	79.3	28.4	5.43	0.476	0.476	0.476	0.476	2.37	0.57	0.476	0.476	0.476	0.476	0.476
9-2	78.2	183	2.8	0.476	0.476	0.476	0.476	1.93	0.345	0.476	0.476	0.476	0.476	0.476
9-3	43.9	12.9	1.32	0.476	0.476	0.476	0.476	1.17	0.358	0.476	0.476	0.476	0.964	0.476
11-1	87.2	28.7	2.12	0.476	0.476	0.476	0.476	0.752	0.1	0.476	0.476	0.476	0.476	0.476
11-2	97	44.2	3.79	0.476	0.476	0.476	0.476	1.47	0.218	0.476	0.476	0.476	0.899	0.476
11-3	170	38.1	7.65	0.476	0.476	0.476	0.476	3.57	0.963	0.476	0.476	0.476	0.476	0.476
3-2FD	171	22.5	7.55	0.5	0.5	0.5	0.5	3.36	0.67	0.5	0.5	0.5	0.5	0.5
9-2FD	13.2	2.19	0.829	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.34	0.5
Average (mg/kg):	**125.918**	**40.168**	**5.215**	**0.458**	**0.484**	**0.484**	**0.484**	**2.383**	**0.770**	**0.484**	**0.484**	**0.484**	**0.600**	**0.484**
Residental Cleanup Level (mg/kg):	3300	4.0	15	3.3	6.5	650	18	65	130	65	130	650	650	650
Industrial Cleanup Level (mg/kg):	34000	17	64	34	68	6800	94	680	1400	680	1400	6800	6800	6800

M-203 Day 19

Method 8330 Analytical Results

Results in ppm

Sample	HMX	RDX	TNT	TNB	DNB	TETRYL	NB	4ADNT	2ADNT	26DNT	24DNT	2NT	4NT	3NT
3-1	1.21	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454
3-2	9.42	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3-3	0.513	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476
5-1	0.0824	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5-2	0.48	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5-3	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476
7-1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
7-2	0.961	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
7-3	1.14	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
9-1	0.141	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476
9-2	7.16	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
9-3	5.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
11-1	2.22	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
11-2	1.47	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476
11-3	34.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
11-2FD	5.76	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476
Average (mg/kg):	**4.458**	**0.490**	**0.490**	**0.490**	**0.490**	**0.490**	**0.490**	**0.490**	**0.490**	**0.490**	**0.490**	**0.490**	**0.490**	**0.490**
Residental Cleanup Level (mg/kg):	3300	4.0	15	3.3	6.5	650	18	65	130	65	130	650	650	650
Industrial Cleanup Level (mg/kg):	34000	17	64	34	68	6800	94	680	1400	680	1400	6800	6800	6800

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

James M. Hunsucker
SIGNATURE

DIRECTOR, ENVIRONMENTAL PROTECTION DEPARTMENT
BY DIRECTION OF THE COMMANDER
TITLE

10/31/01
DATE