

**FULL-SCALE OPERATIONS  
BIOREMEDIATION OF EXPLOSIVES-CONTAMINATED SOIL**

**NSWC CRANE  
CRANE, INDIANA**

**QUARTERLY INTERIM PROGRESS REPORT**

**APRIL - JUNE 1998**

**SOUTHERN DIVISION  
NAVAL FACILITIES ENGINEERING COMMAND  
Contract #N62467-93-D-1106  
Delivery Order #0009  
Statement of Work #007**

**JULY 1998**

## EXECUTIVE SUMMARY

This interim progress report has been prepared by Morrison Knudsen Corporation (MK) for the Southern Division, Naval Facilities Engineering Command. This report has been prepared to document the progress of the Full-Scale bioremediation operation of explosives-contaminated soil at Naval Surface Warfare Center (NSWC) Crane, Crane, Indiana. It summarizes the work actions performed during April through June 1998 pursuant to the requirements of the approved Full-Scale Operational Plan and the Quality Assurance Project Plan.

Pre-excavation soil sampling was performed at both Mine Fill "A" (MFA) and Mine Fill "B" (MFB). Sampling was completed around MFA Buildings #153/154, 158/159, 157, 152, and 151. Pre-excavation sampling at MFA is 99% complete. Some pre-excavation sampling has been completed at MFB around Building #165. This additional scope was performed in support of follow on construction by others. Minimal in process excavation soil sampling and post-excavation soil sampling was completed in MFA.

A total of 2,503 cubic yards of screened soil was transported to the Biofacility in support of compost operations. While this quantity is sufficient to begin operations, it is not sufficient to support full utilization of the Biofacility. The project team is evaluating options to increase the supply of screened soil.

Contracts were awarded to supply amendments supporting one year of compost operations. Straw purchase was timed with the local harvest season and is being stockpiled near the Biofacility. Chicken manure, under contract, is being delivered on an as needed basis directly from the processing house.

A total of seven windrows were constructed during this reporting period. The first five windrows reached day "last" during this period. The other two windrows are nearing their day "lasts". One additional windrow is being constructed. One pilot scale sized windrow was completed using 30% soil loading. One clean soil control windrow was completed as part of toxicity and leachability testing. A total of 1,067 cubic yards of contaminated soil was reduced to residential clean up levels for explosives during the period.

A total of 1,900 cubic yards (four windrows) of treated compost was returned to MFA and staged for future use. There was no backfill or site restoration activity this period.

All interim measures work actions have been performed in accordance with the approved plans.

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## LIST OF ACRONYMS

CAAA: Crane Army Ammunition Activity  
EPD: Environmental Protection Division  
FCR: Field Change Request  
MFA: Mine Fill "A"  
MFB: Mine Fill "B"  
MK: Morrison Knudsen Corporation  
nd: Non detect  
NSWC: Naval Surface Warfare Center  
OSHA: Occupational Safety and Health Administration  
PCB: Polychlorinated Biphenols  
PEL: Permissible Exposure Limit  
PID: Photoionization Detector  
PPE: Personal Protective Equipment  
ppm: Parts per million  
TLV: Threshold Limit Value  
TPH: Total Petroleum Hydrocarbon

## 1.0 EXCAVATION SITE ACTIVITIES

### A. Pre-Excavation Sampling

A minimum of three soil samples were obtained from each grid for characterization of the soil prior to excavation. Explosives and metals analysis were completed on composite samples obtained from depths of 0-12" and 24-36", and volatiles analysis was completed on grab samples obtained from 12-18". Additional samples were obtained for volatiles analysis based on photoionization detector (PID) screening.

- Mine Fill "A" (MFA)

All initial characterization (pre-excavation) sampling is complete around Buildings #153/154, #158/159, #157, #152, and #151. Additional sampling is required adjacent to grid #186 at Building #160. Refer to Table 1 entitled "MFA Pre-Excavation Sampling-Preliminary Explosives Results" for ranges of contamination detected for each building.

The horizontal boundaries of explosives contamination have been delineated (except adjacent to grid #186) by buildings, roads, railroad tracks, and grids with either no detectable levels of contamination or levels that are below clean-up levels. To date, no metals or volatiles contamination has been detected above clean-up levels in any sample.

At the direction of the NSWC Environmental Protection Division (EPD), one soil sample from grid #135 at Building #153/154 was obtained and analyzed for volatiles, semi-volatiles, and total petroleum hydrocarbon (TPH) diesel range organics. This action was prompted after the sampling crew discovered a strong odor of fuel in the initial characterization samples from this grid. Analytical results indicate the sample was contaminated with TPH at 454 ppm as well as numerous volatile and semi-volatile benzene-based compounds.

TABLE 1  
NSWC CRANE  
MFA PRE-EXCAVATION SAMPLING  
PRELIMINARY EXPLOSIVES RESULTS (ppm)

Building #	HMX	RDX	TNT
151	All nd	All nd	All nd
152	nd - 181	nd - 1,310	nd - 1,340
153/154	nd - 1,450	nd - 14,000	nd - 3,000
157	nd - 515	nd - 3,990	nd - 8,530
158/159	nd - 956	nd - 4,830	nd - 4,100
160	All nd	All nd	nd - 47

nd = Non detect

- Mine Fill "B" (MFB)

Initial characterization sampling commenced at Building #165 in anticipation of the Crane Army Ammunition Activity's (CAAA) installation of a C-4 extruder. Explosives contamination was detected in two of the 19 grids initially laid out for this activity. HMX concentration ranged from non detect to 74 ppm. RDX ranged from non detect to 315 ppm. TNT ranged from non detect to 29 ppm. An additional seven grids have been laid out adjacent to the contaminated grids in an attempt to delineate the horizontal extent of contamination. The analytical results of this sampling have not yet been reported. Building #165 is not in an area of suspected polychlorinated biphenols (PCB) contamination. Therefore, no testing for PCB was performed.

Grids have been mapped around Buildings #168, 173, 2500, and 2501 and in areas of suspected contamination (based on visual inspection). Initial characterization sampling is scheduled to commence in these areas during the next reporting period.

### B. In-Process Excavation Soil Sampling

- MFA

In-process excavation soil sampling and field screening for explosives has been accomplished on grids #41, 42, and 145-148 at Buildings

#158/159. Field screening indicated that TNT and RDX contamination were still present in the soil after the first layer of contaminated soil was excavated. Subsequent field screening of samples from grids #41, 42, 144 and 145 indicated contamination was still present above the residential clean-up goals. No other in-process soil sampling or screening has been accomplished.

- MFB

No contaminated soil excavation has been initiated, therefore no in-process soil sampling has been completed.

### **C. Post-Excavation Soil Sampling**

- MFA

Post-excavation soil characterization subsequent to contaminated soil removal has been accomplished on grids #1 and #2 only. Analytical results indicated that explosives contamination was detected in both grids above the residential clean-up levels. Additional layers of contaminated soil were subsequently removed, however further post-excavation soil sampling has not been accomplished on these grids.

- MFB

Since no contaminated soil has been excavated, no post-excavation soil characterization has been initiated.

### **D. Soil Excavation and Screening**

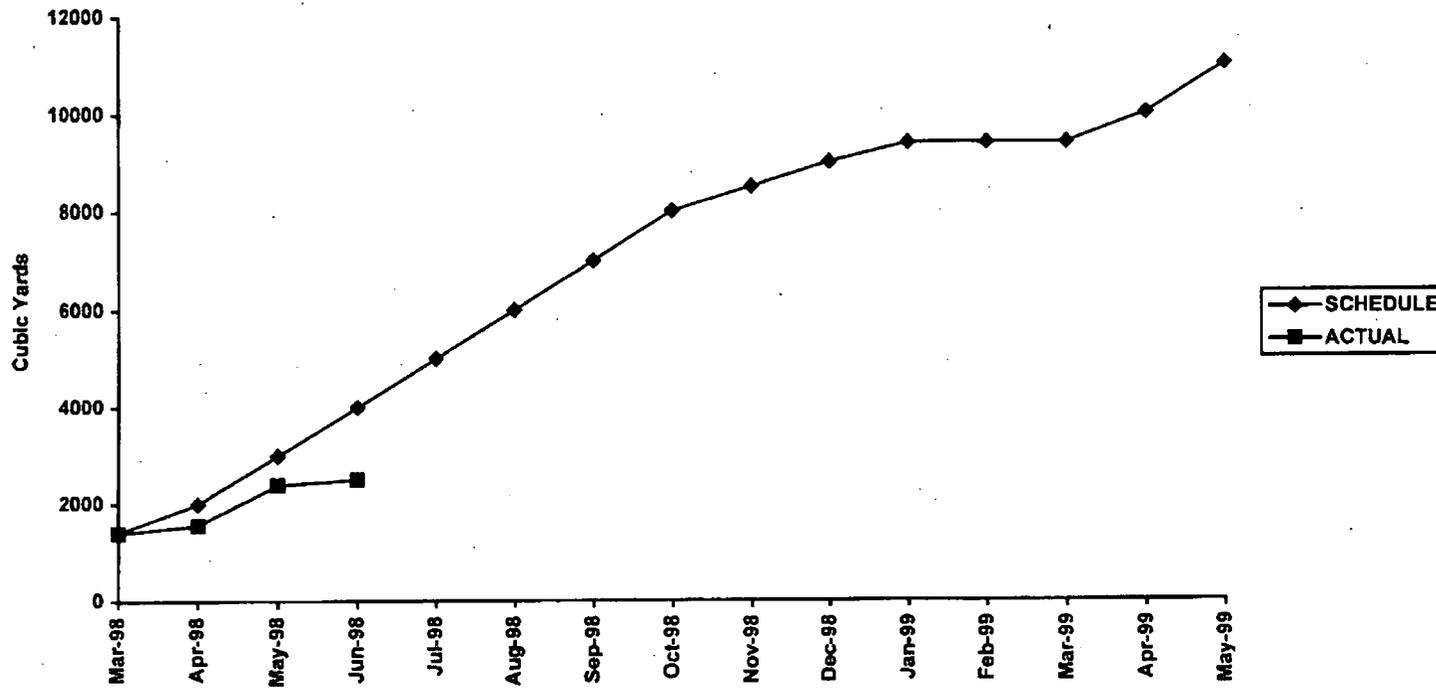
Soil excavation and screening began prior to the actual start of full-scale operations. This effort began in November 1997 in and around Buildings #153/154 at MFA. The operation moved to Buildings #158/159 in search of drier soils, before Building #153/154 was completed. To date 2,503 cubic yards of soil have been screened and transported to the Biofacility for stockpile or use in windrows. This is a sufficient quantity of soil to compost approximately twelve windrows at the current practice of 25% soil loading. Improvements in equipment and operations have been proposed to improve the availability of screened soil, especially during wet or winter weather. MK is in the process of procuring a higher capacity screener and is designing a central facility to increase soil processing. The screener should be in use during the next quarter with the process facility available later in the year. The planned and actual screened soil quantities are

detailed in Table 2 entitled "Full-Scale Operations Soil Excavation and Screening at MFA", along with the performance curve included as Figure 1.

**TABLE 2**  
**FULL SCALE OPERATIONS SOIL EXCAVATION & SCREENING**  
**at MFA**

PLANNED QUANTITY (cu yds)			ACTUAL QUANTITY (cu yds)		VARIANCE QUANTITY (cu yds)	
Period	Period	Cum	Period	Cum	Period	Cum
Nov 97-Mar 98	1400	1400	1391	1391	-9	-9
Apr-98	600	2000	166	1557	-434	-443
May-98	1000	3000	831	2388	-169	-612
Jun-98	1000	4000	115	2503	-885	-1497
Jul-98	1000	5000				
Aug-98	1000	6000				
Sep-98	1000	7000				
Oct-98	1000	8000				
Nov-98	500	8500				
Dec-98	500	9000				
Jan 99-Mar 99	400	9400				
Apr-99	600	10000				

Figure 1  
SOIL EXCAVATION & SCREENING  
MFA



## 2.0 COMPOSTING OPERATIONS

### A. Amendments

Contracts were awarded to supply amendments for approximately one year's compost operations. Straw, from the local area, is being trucked to the Biofacility for immediate use or stockpiled for later use. Purchase of the large quantity of straw now, takes advantage of the local harvest and obtains best pricing. Chicken manure from Wabash Valley Produce in Dubois, IN, is trucked to the Biofacility on an as needed basis.

### B. Quantity of Amendments Used

- Chicken manure received this period: 1,034 tons  
Cumulative received for full-scale: 1,034 tons
- Chicken manure used this period: 981 tons  
Cumulative used for full-scale: 981 tons
- Straw received this period: 636 tons  
Cumulative received for full-scale: 636 tons
- Straw used this period: 484 tons  
Cumulative used for full-scale: 484 tons

### C. Windrow Construction and Treatment

Five windrows have achieved day "last" status during this initial period of full-scale operations. The 30% pilot scale and control windrows also achieved day "last". Windrows six and seven have been constructed and are nearing their day "last". Windrow eight is under construction, with amendment placement complete. Preliminary lab results have been received for windrows one through five. Residential levels for explosives were achieved for these five windrows.

Actual schedule performance is ahead of the planned dates. This is primarily due to the relatively short bio-degradation period. The average number of days between day zero and day "last" for the first five windrows is 18 days. The schedule planned this period to be thirty days. The "Operations Schedule", provides details of the progress of the windrows and is included as Table 3. Figure 2 charts the progress of composting operations.

Windrows one through five, plus the 30% pilot scale windrow, resulted in 1,067 cubic yards of contaminated soil being reduced to residential clean-up levels for explosives.

**Table 3  
OPERATIONS SCHEDULE**

Windrow #	Schedule	Start Date	Complete	Day Zero	Day Last	Lab	Complete	Qty Soil	Cumulative
	Actual		Load			Results	Unload	Processed	Soil Qty
1	Schedule	4/13/98	4/15/98	4/15/98	5/15/98	5/30/98		211	211
1	Actual	4/13/98	4/15/98	4/15/98	5/11/98	5/29/98		211	211
2	Schedule	4/15/98	4/17/98	4/17/98	5/17/98	6/1/98		211	422
2	Actual	4/15/98	4/17/98	4/17/98	5/8/98	5/29/98		211	422
3	Schedule	4/20/98	4/22/98	4/22/98	5/22/98	6/6/98		211	633
3	Actual	4/20/98	4/22/98	4/22/98	5/7/98	5/29/98		215	637
4	Schedule	4/22/98	4/24/98	4/24/98	5/24/98	6/8/98		105	738
4	Actual	4/22/98	4/24/98	4/24/98	5/8/98	5/29/98		200	837
30%	Schedule	4/27/98	4/27/98	4/27/98	6/26/98	7/11/98		15	753
30%	Actual	4/27/98	4/27/98	4/27/98	6/26/98			20	857
Control	Schedule	4/27/98	4/27/98	4/27/98	5/27/98	6/17/98	6/28/98		Clean soil used
Control	Actual	4/24/98	4/24/98	4/24/98	5/20/98				
5	Schedule	6/15/98	6/17/98	6/17/98	7/17/98	8/1/98	8/3/98	211	964
5	Actual	6/1/98	6/3/98	6/3/98	6/18/98			210	1067
6	Schedule	6/17/98	6/19/98	6/19/98	7/19/98	8/3/98	8/5/98	211	1175
6	Actual	6/15/98	6/17/98	6/17/98				210	
7	Schedule	7/1/98	7/3/98	7/3/98	8/2/98	8/17/98	8/19/98	211	1386
7	Actual	6/22/98	6/24/98	6/24/98				210	
8	Schedule	7/3/98	7/5/98	7/5/98	8/4/98	8/19/98	8/21/98	211	1597
8	Actual	6/29/98							
9	Schedule	8/4/98	8/6/98	8/6/98	8/27/98	9/11/98	9/13/98	211	1808
9	Actual								
10	Schedule	8/6/98	8/8/98	8/8/98	8/29/98	9/13/98	9/15/98	211	2019
10	Actual								
11	Schedule	8/20/98	8/22/98	8/22/98	9/12/98	9/27/98	9/29/98	211	2230
11	Actual								
12	Schedule	8/22/98	8/24/98	8/24/98	9/14/98	9/29/98	10/1/98	211	2441
12	Actual								

TABLE 3 (continued)

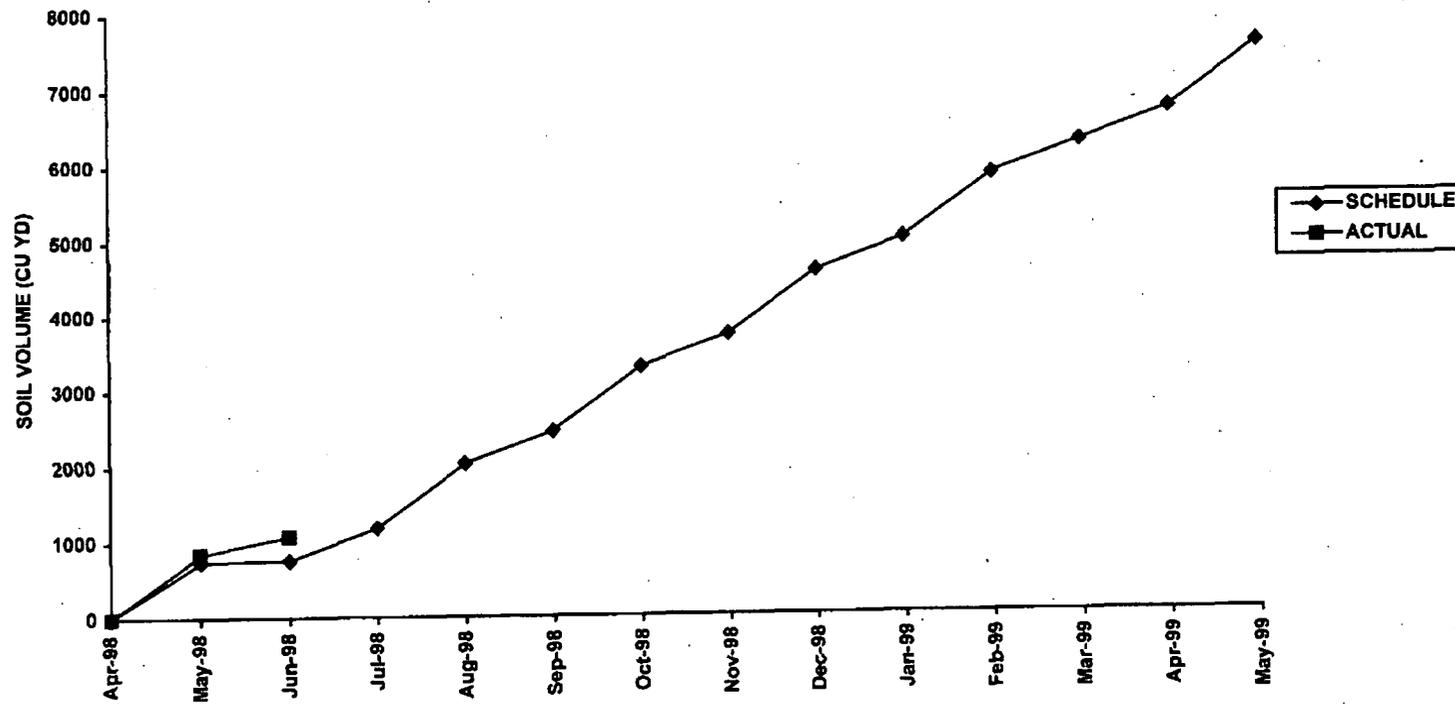
Windrow #	Schedule	Start Date	Complete Load	Day Zero	Day Last	Lab Results	Complete Unload	Qty Soil Processed	Cumulative Soil Qty
13	Schedule	9/14/98	9/16/98	9/16/98	10/7/98	10/22/98	10/24/98	211	2652
13	Actual								
14	Schedule	9/16/98	9/18/98	9/18/98	10/9/98	10/24/98	10/26/98	211	2863
14	Actual								
15	Schedule	9/30/98	10/2/98	10/2/98	10/23/98	11/7/98	11/9/98	211	3074
15	Actual								
16	Schedule	10/2/98	10/4/98	10/4/98	10/25/98	11/9/98	11/11/98	211	3285
16	Actual								
17	Schedule	10/25/98	10/27/98	10/27/98	11/17/98	12/2/98	12/4/98	211	3496
17	Actual								
18	Schedule	10/27/98	10/29/98	10/29/98	11/19/98	12/4/98	12/6/98	211	3707
18	Actual								
19	Schedule	11/10/98	11/12/98	11/12/98	12/3/98	12/18/98	12/20/98	211	3918
19	Actual								
20	Schedule	11/12/98	11/14/98	11/14/98	12/5/98	12/20/98	12/22/98	211	4129
20	Actual								
21	Schedule	12/5/98	12/7/98	12/7/98	12/28/98	1/12/99	1/14/99	211	4340
21	Actual								
22	Schedule	12/7/98	12/9/98	12/9/98	12/30/98	1/14/99	1/16/99	211	4551
22	Actual								
23	Schedule	12/21/98	12/23/98	12/23/98	1/13/99	1/28/99	1/30/99	211	4762
23	Actual								
24	Schedule	12/23/98	12/25/98	12/25/98	1/15/99	1/30/99	2/1/99	211	4973
24	Actual								
25	Schedule	1/15/99	1/17/99	1/17/99	2/7/99	2/22/99	2/24/99	211	5184
25	Actual								
26	Schedule	1/17/99	1/19/99	1/19/99	2/9/99	2/24/99	2/26/99	211	5395
26	Actual								

TABLE 3 (cont.)

Windrow #	Schedule Actual	Start Date	Complete Load	Day Zero	Day Last	Lab Results	Complete Unload	Qty Soil Processed	Cumulative Soil Qty
27	Schedule	1/31/99	2/2/99	2/2/99	2/23/99	3/10/99	3/12/99	211	5606
27	Actual								
28	Schedule	2/2/99	2/4/99	2/4/99	2/25/99	3/12/99	3/14/99	211	5817
28	Actual								
29	Schedule	2/25/99	2/27/99	2/27/99	3/20/99	4/4/99	4/6/99	211	6028
29	Actual								
30	Schedule	2/27/99	3/1/99	3/1/99	3/22/99	4/6/99	4/8/99	211	6239
30	Actual								
31	Schedule	3/13/99	3/15/99	3/15/99	4/5/99	4/20/99	4/22/99	211	6450
31	Actual								
32	Schedule	3/15/99	3/17/99	3/17/99	4/7/99	4/22/99	4/24/99	211	6661
32	Actual								
33	Schedule	4/7/99	4/9/99	4/9/99	4/30/99	5/15/99	5/17/99	211	6872
33	Actual								
34	Schedule	4/9/99	4/11/99	4/11/99	5/2/99	5/17/99	5/19/99	211	7083
34	Actual								
35	Schedule	4/23/99	4/25/99	4/25/99	5/16/99	5/31/99	6/2/99	211	7294
35	Actual								
36	Schedule	4/25/99	4/27/99	4/27/99	5/18/99	6/2/99	6/4/99	211	7505
36	Actual								

All soil quantities are in cubic yards.

Figure 2  
COMPOST OPERATIONS  
SOIL QUANTITIES COMPLETED



D. Analytical Data

Table 4 provides the preliminary laboratory analysis results for HMX, RDX, and TNT. All windrow results represent an average of 15 individual data points (five cross sections, three sample locations per cross section). Day zero and day last results are given for each windrow, demonstrating the effectiveness of the bio-degradation. Table 5 lists the clean up goals for HMX, RDX and TNT. The first five windrows meet residential clean up goals for explosives.

TABLE 4  
ANALYTICAL DATA

	Windrow #1		Windrow #2		Windrow #3	
	Day 0	Day 26	Day 0	Day 21	Day 0	Day 15
HMX	156	2.1	82	2.3	47	2.2
RDX	1216	1.0	631	1.4	37	1.1
TNT	123	0.4	40	0.3	13	0.3

	Windrow #4		Windrow #5	
	Day 0	Day 14	Day 0	Day 15
HMX	40	2.3	133	2.2
RDX	243	2.1	102	1.1
TNT	10	0.7	13.3	0.3

All results in ppm

TABLE 5  
CLEAN UP LEVELS

	Clean Up Goals (ppm)	
	Residential	Industrial
HMX	3,300	34,000
RDX	4	17
TNT	15	64

### **3.0 DISPOSAL OF TREATED COMPOST**

Treated compost for the first four windrows has been transported back to MFA. A temporary staging area has been established to receive and hold this material in accordance with an approved field change request (FCR). This treated compost will be used as backfill material during future site restoration activities. Excess treated compost, beyond that used for backfill, will be placed as directed by NSWEC EPD. The disposal activity to date is shown in Table 6.

**TABLE 6  
TREATED COMPOST DISPOSAL**

<b>Windrow</b>	<b>Soil Source</b>	<b>Soil Quantity</b>	<b>Day Zero</b>	<b>Day Last</b>	<b>Process Duration</b>	<b>Level Attained</b>	<b>Compost Quantity</b>	<b>Date Disposed</b>	<b>Compost Disposal Location</b>
1	MFA	211	4/15/98	5/11/98	26	Residential	475	6/24/98	MFA staging area
2	MFA	211	4/17/98	5/8/98	21	Residential	475	6/25/98	MFA staging area
3	MFA	215	4/22/98	5/7/98	15	Residential	475	6/26/98	MFA staging area
4	MFA	200	4/24/98	5/8/98	14	Residential	475	6/30/98	MFA staging area
30%	MFA	20	4/27/98	6/26/98	60		45		
5	MFA	210	6/3/98	6/18/98	15		475		
6	MFA	210	6/17/98						
7	MFA	210	6/24/98						
8									
9									

NOTE: Process duration is in days.  
All quantities are in cubic yards.  
Level attained is for explosives.

#### **4.0 BACKFILLING AND SITE RESTORATION**

There were no backfilling or site restoration activities during this period. There are no areas available for backfill due to delays in screening/excavation work. Backfilling and site restoration activities are scheduled to begin during the next quarter.

#### **5.0 OTHER OPERATIONS**

Reports are being developed for initial batch performance, 30% soil demonstration, toxicity testing, field test kit audit, and comparison of compost drying/grinding. Data for these reports have been collected during this quarter. These reports will be issued at a later date and will be summarized on the next quarterly interim progress report.

#### **6.0 QUALITY CONTROL**

During this period, no significant quality deficiencies were identified. All required quality control checks were performed, following the checklist supplied in Appendix F of the Full-Scale Operations Plan.

During this quarter 1,300 individual items were verified and 28 deficiencies were identified. All 28 deficiencies have been corrected. Typical deficiency findings were minor in nature, such as: retention pond levels with less than two feet of freeboard remaining immediately after a major rain events. Copies of all inspection records are maintained at the Biofacility office.

#### **7.0 SAFETY AND INDUSTRIAL HYGIENE**

During this period 11,930 manhours were expended without an Occupational Safety and Health Administration (OSHA) recordable injury. This brings the project to a cumulative total of 121,426 manhours without an OSHA recordable injury. Two First Aid cases occurred. The first was a small laceration on the right thumb caused by a sharp door edge on April 24, 1998. The second was a minor case of poison ivy received at MFB on June 13, 1998.

Thirteen safety inspections were performed during this quarter. No significant findings of an imminent or serious nature were found.

During this period, airborne bacteria/fungi (molds and yeast), total dust, airborne explosives, and ammonia monitoring were performed. Bioaerosol sampling for airborne bacteria was completed inside and outside the compost buildings. The average inside bacteria concentration was 273 cfu/m<sup>3</sup> (colony forming units per cubic meter). The average bacteria concentration outside was 24 cfu/m<sup>3</sup>. This

correlates to 11 times more bacteria inside than outside. The species of bacteria identified are essentially non-pathogenic and are only linked to common infections. No E-coli or total coliform bacteria were detected.

Inside and outside fungi (molds and yeast) samples were taken for comparison. Based on lab results the average inside fungi concentration was 270 cfu/m<sup>3</sup>. The average concentration outside the compost buildings was 216 cfu/m<sup>3</sup>. One species of aspergillus fungi was detected that has been linked to the chronic lung condition, "Aspergillosis". In addition, another species was detected which has been reported to cause skin and pulmonary infections and is a common cause of fungal related ear infection, "Otomycosis". However, based on the occurrence, frequency, and concentrations neither of these species appear to be of concern.

The average fungi/bacteria concentrations are low when compared to the occupational exposure limits. The average concentrations are less than the 10,000 cfu/m<sup>3</sup> recommended total and less than the pathogenic limit of 500 cfu/m<sup>3</sup>. The average gram negative bacteria concentration was also less than the recommended threshold limit value (TLV) of 1000 cfu/m<sup>3</sup>.

Ammonia samples were taken at the Biofacility by colorimetric methods. Sampling indicates ammonia levels greater than the occupational exposure limits of 50 ppm permissible exposure limit (PEL) and 25 ppm (TLV). During windrow construction, and during the first seven days of the windrow life cycle, twenty-one grab samples and eight personal samples were taken. The chicken manure amendment is the primary contributor to the ammonia concentrations. Full face air purifying respirators with ammonia cartridges were worn during windrow formation and during the first seven days of the windrow life cycle. Ammonia is localized near each pile and is significantly affected by natural ventilation of the building, moisture in windrow, and turning of windrow. The maximum ammonia level detected was 200 ppm. The average maximum for a new windrow is approximately 125 ppm.

Airborne explosives dust sampling was also performed at the Biofacility. Three area samples and three personal samples were taken. Analysis for all samples were less than the lower limit of qualification (LOQ) for applicable explosives and far below any occupational exposure limits.

Nuisance dust measurements, using a laser dust monitor, were taken during activities which have the greatest potential to generate dust. During these activities water is used to prevent and suppress any dust that could be generated. The average dust level detected was 0.18 mg/m<sup>3</sup>. The maximum dust level detected was 0.53 mg/m<sup>3</sup> during soil screening activities. All dust samples were well below the 10 mg/m<sup>3</sup> non-respirable limit and the 3 mg/m<sup>3</sup> respirable limit.

Explosive wipe samples were taken to identify any spread of explosives contamination out of work zones. Samples were taken in the clothing change, shower, lab, office, and lunch areas. No explosives contamination was found outside the controlled areas. However, explosives contamination was detected in the lab refrigerator where explosives samples are kept. Some explosives contamination was detected in clothing change and shower areas. No occupational exposure limit exists for explosives contamination. Aggressive actions have been taken to prevent any recurrence of explosives contamination spread outside work zones. These include: re-training of personnel, increased frequency of housekeeping activities, review of traffic flow, and personal protective equipment (PPE) removal sequence. Results of those actions will be presented in the next quarterly report.

In summary, monitoring during this period indicates no airborne explosives hazard; no significant airborne bacteria or fungi hazard; and adequate dust controls. Ammonia monitoring indicates respiratory protection is warranted during the first seven days of the windrow life cycle. Explosives wipe sampling, coupled with aggressive housekeeping activities, are required to prevent any detectable spread of explosives outside work zones.

## **8.0 FACILITY MAINTENANCE AND REPAIRS**

There were no significant repairs made to the facility during this period. Routine maintenance and housekeeping activities were performed.