TETRA TECH NUS, INC.
661 Andersen Drive • Pittsburgh, PA 15220
Tel 412.921.7090 • Fax 412.921.4040 • www.tetratech.com

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January 17, 2007

Project No. 112GN6878

Mr. Tom Brent
NSWC Crane
Code 09510 Building 3245
300 Highway 361
Crane, Indiana 47522-5009

Reference: CLEAN Contract N62467-94-D-0888
Contract Task Order No. 0357

Subject: Response to United States Environmental Protection Agency (U.S. EPA) Comments (Dated June 9, 2006) Concerning the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for Naval Surface Warfare Center (NSWC) Crane Solid Waste Management Unit (SWMU) 12 (Mine Fill A)

Dear Mr. Brent:

Enclosed are subject responses to U.S. EPA comments. These responses address the data collected for the External Sump/Drainage Investigation for explosives but do not reflect the most recent data collected to complete the delineation of metals contamination at the SWMU 12 Battery Site. The recent metals data are currently being validated and will be incorporated into the SWMU 12 RFI report after completion of data validation.

Revised figures and tables are enclosed with this response to comments, showing the explosives concentrations at sumps. In addition, a mark-up of the Executive Summary is enclosed to show changes made to address the ES/DI explosives data.

Please contact Tom Johnston at 412-921-8615 (e-mail: Tom.Johnston@ttnus.com) or me at 412-921-8308 (e-mail: Ralph.Basinski@ttnus.com) regarding any questions or comments.

Sincerely,

Tom Johnston for...

Ralph R. Basinski
Task Order Manager

RRB/mlg
Enclosures

cc: Mr. Howard Hickey, NSWC Crane (letter and enclosures)
Ms. Debra Humbert, TtNUS, Inc. (letter only)
Mr. Mark Perry, TtNUS, Inc. (letter and enclosures)
Dr. Tom Johnston, TtNUS, Inc. (letter and enclosures)
Project File – CTO 0357

NAVY RESPONSES TO U.S. EPA COMMENTS DATED JUNE 9, 2006 ON THE MINE FILL A (SWMU 12) DRAFT RFI REPORT

United States Environmental Protection Agency (U.S. EPA) Region 5 comments, dated June 9, 2006, are shown in bold font. Navy responses to each comment are shown in regular font. Text changes to the RFI are shown in italic font enclosed in quotation marks in the response.

Comment 1:

The second paragraph of page ES-3 states that natural phytoremediation is playing a part in controlling and reducing the rate of contaminants reaching the base of the MFA ridge. Supplement this statement with evidence or present evidence in an appropriate section of the report.

Response: Although no data are available to verify whether vegetation on the hillsides of SWMU 12 is taking up energetic compounds, existing Section 6.1.3 (page 6-4) briefly presents the results of studies conducted at SWMU 13 regarding the uptake of energetic compounds by trees and shrubs. The similarity of SWMUs 12 and 13 in terms of topography, geology, weather, vegetation, and operations leads the Navy to believe the same process (phytoremediation) is occurring at SWMU 13 is also occurring at SWMU 12.

No changes are proposed to address this comment.

Comment 2:

Referring to the third bullet on page ES-6, why is it unclear whether soils remaining after excavation were surface or subsurface soils? Wouldn't Interim Measure characterization samples tell you locations and depths of those soils which could not be excavated?

Response: The comment by the reviewer is correct. The IMR does specify the depths of soils that could not be excavated. The uncertainty in surface and subsurface soils actually is in the areas that were excavated and backfilled with bioremediated soil from different windrows that were mixed in the same hole. The reference to "explosives concentrations that could not be excavated" has been deleted.

The second bullet on page ES-6 has been revised as follows:

"For both risk assessments, that the concentrations of some soil metals appear to be within naturally occurring concentration ranges, and it was not clear in some cases whether soils remaining after excavation were surface soils or subsurface soils. This is due in part because it is difficult to pinpoint the concentrations of explosives at precise depths in areas that were excavated and backfilled with bioremediated soil. Based on descriptions of the excavations it is believed that, with minor exceptions, all surface soils have explosives concentrations that are less than industrial or residential cleanup levels."

Comment 3:

Referring to the last two sentences of the second paragraph on page 1-3, do the reports indicate where these dumping locations were? Mention whether this RFI or previous studies focused on those areas?

Response: The last two sentences refer to historical practices at NSWC Crane. The information was obtained from Section 2.1.2, paragraph 6 of the Final RFI Phase I Environmental Monitoring Report (Halliburton NUS, 1997). These statements have been deleted because they apply to Crane as a whole.

The Phase I report indicates that during SWMU 12 reconnaissance, staining was noted on the ground around the paint locker (Building 196) located just south and west of Building 155. The stains were apparently the result of spilled liquids such as solvents used in Building 155 and near the paint locker (Building 196). Presumably, the solvents were dump between Building 155 and Building 196. Neither the RFI nor previous investigative studies have focused on this area.

Comment 4:

The text beginning in the middle of page 1-7 discusses existing conditions around buildings in MFA. Discussion of existing conditions around buildings 155, 3110 and 3111 is not presented although these are noted in the site history discussion of Section 1.2.2 as having demilitarization and documented contaminant releases take place. There is brief discussion of sampling around 'Structure 3110' and 'Structure 3037' on page 7-31. Present a summary of exactly which buildings were previously investigated and which buildings were investigated under this RFI. Discussion of existing conditions and/or sampling around these buildings or structures should be presented in an appropriate part of Section 1 or 5.

Response: The discussion beginning in the middle of Page 1-7 is related to SWMU 12 interim measure actions conducted at SWMU 12 during the period 1997 through 2000. In this time period, actions were only conducted and reported for Buildings 151, 152, 153/154, 157, 158/159, and 160, but not for Buildings 155, 3110, and 3111. More recently in the RFI, sampling has been conducted at Buildings 3110 and 3037 as discussed on Page 7-31.

Based on historical documentation, prior to the RFI, investigations were only conducted at Buildings 151, 152, 153/154, 157, 158/159, and 160. In the RFI, only Buildings 3110, and 3037 were investigated.

Existing contamination around Buildings 3110 and 3037 is discussed in Section 5..2.4 relative to soil boring samples 12SB04 to 12SB11. A new table was added to Section 1.0 to identify whether buildings and other structures at SWMU 12 were investigated during the RFI or during previous investigations.

Numerous revisions have been made throughout Section 5.0 to incorporate discussions of the sump samples analyzed for explosives. These changes generally describe what can be seen by inspecting Figures 5-1, 5-24, 5-25, and 5-26. Most of the soil contamination around sumps is limited to shallow soils. Soil samples collected around sumps near Buildings 152, and 157 had the greatest degree of contamination. Only three sump water samples could be collected and all three had detectable levels of explosives. The highest sump water concentration (95 µg/L) was observed in a sump near Building 154. With one exception (16 mg/kg) sump sediment concentrations were in the range of non-detectable at 0.25 mg/kg to less then 8 mg/kg. The highest shallow groundwater contamination was observed along the eastern edge of the site. However, concentrations in considerable excess of the drinking water standard (0.61 µg/L) were detected to the west, as well. Overall, the greatest degree of contamination is associated with the central portion of the site from west to east.

These changes will be presented in the revised RFI report, after incorporation of the metals delineation data that is currently undergoing validation.

Comment 5:

Referring to the vein of contamination at MFA Battery mentioned in the last sentence of Section 1.2, present a discussion of how that metals and explosives impacted material may have been deposited there and what the source might.

Response: The following information has been added as the introductory paragraph in Section 1.2 under the header "BATTERY SITE INTERIM MEASURE".

"The Battery Site was discovered by a representative of the NSWC Crane Environmental Protection Department during the early 1990s. The Battery Site contains two areas: (1) Battery Area where batteries were dumped on the ground surface; and (2) Soil Area adjacent to the Battery Site where soil and construction debris was dumped in small mounds. The origin of this debris or the dates on which it was placed at the site is unknown. Due to its proximity to MFA, the mounded soil may have originated from within MFA, possibly from the installation of road culverts."

Comment 6:

There is a typo in Section 2.4.2: surrey.

Response: This typographical error has been corrected to read as *"survey"*.

Comment 7:

What is the source of the HHRA and ERA Criteria presented in Table 3-4? Values do not appear to match those presented in the project QAPP. For example, Appendix B of the February 2003 QAPP gives a human health RBTL for Aluminum in soils as 76,000 mg/kg while Table 3-4 lists the HHRA value at 8.3 mg/kg; Figure 5-1 shows Aluminum human health level at 8.3 mg/kg; Figure 5-2 shows Nickel human health screening value at 14 mg/kg. Recheck all tables and figures to ensure the correct human health and ecological risk based screening values are presented. Tables listing such screening levels should be footnoted to identify the source of the value. State whether any corrections to screening levels will result in changes to report COPC selections and/or conclusions. Should figures require revision and resubmittal, consider identifying screening exceedances with color for easier identification.

Response: The sources of the HHRA criteria presented in Section 3 are United States (U.S.) Environmental Protection Agency (EPA) Region 9 PRGs, U.S. EPA Soil Screening Levels (SSLs) for Migration from Soil to Groundwater and Migration from Soil to Air, and Indiana Department of Environmental Management (IDEM) Default Closure Levels. The ERA criteria are primarily the Region 5 Ecological screening levels (ESLs). However, for soil, the USEPA Ecological Soil Screening Levels (Eco SSLs) were given preference over the Region 5 ESLs based on direction from EPA region 5. The USEPA Eco SSLs are more current than the ESLs. One reason that some criteria in the RFI report are different from criteria listed in the QAPP is that some values have changed in the 2 to 3 years since the QAPP was written. The criteria were updated in the RFI Report. Another reason is that the number of chemicals in the SSL lists has been considerably expanded since the QAPP was written. When the QAPP was written, the SSLs were obtained from Appendix A of the U.S. EPA 1996 Soil Screening Guidance. Since that time, many additional SSLs have been calculated by Tetra Tech NUS, Inc. using the calculation tool provided on the U.S. EPA Soil Screening Guidance Website (http://risk.lsd.ornl.gov/calc_start.htm).

Regarding the example discrepancies mentioned by the reviewer, in the 1996 SSL Guidance, no SSLs had been developed for aluminum and the SSL for Migration from Soil-to-Groundwater for nickel was 7 mg/kg. Today, using the Soil Screening Guidance Website, the SSL for Migration from Soil to Groundwater for aluminum is 8.3 mg/kg and the value for nickel is 14 mg/kg. The criteria used in the RFI report represent the most current values at the time the risk assessments were performed.

As requested by the reviewer, the criteria in the tables in Section 3, the COPC selection tables in Sections 7 and 8, and the criteria on the figures have been rechecked. All values were found to be correct and up-to-date, with the following exceptions:

1. The ERA criterion for vanadium in surface soil was 1.59 mg/kg in Tables 3-4 through 3-7 but has been corrected to be 7.8 mg/kg in those tables.

2. The ERA criterion for aluminum in surface water, incorrectly listed in Table 3-14 as 3.6 µg/L, was corrected to be 87 uµ/L.

3. On Tables 3-18 through 3-20, 3-27, and 3-28, the RDX ERA criterion of 3070 µg/L was corrected to be 190 µg/L.

4. In Table 3-39, the bis(2-ethylhexyl)phthalate ERA criterion of NA was corrected to be 182 µg/kg.

None of the changes in the Section 3.0 tables resulted in a change to the COPC status of any chemical nor did the corrections require any changes to figures.

Comment 8:

There appear to be a couple of typos on page 4-3: '08SW/SD04' (should this be 12SW/SD04?) and 'drainageway G' (should this be drainageway H?).

Response: The following corrections have been made to sample location callouts in Section 4:

Section 4.3, p. 4-3, paragraph 1, last sentence: "*08SW/SD04*" should be "*12SW/SD04*".
Section 4.3, p. 4-3, paragraph 2, eighth sentence: "*drainageway G*" should be "*drainageway H*".
p. 4-4, paragraph 1, last sentence: "*12SW/SD18, and 12SW/SD20*" should be "*12SW/SD19, and 12SW/SD21*".

Comment 9:

The second to the last sentence of the first paragraph on page 4-10 should be supplemented with supporting evidence that all shallow groundwater is discharging to the gullies or changed to better agree with the second sentence on page 4-13.

Response: The last sentence of the first paragraph on page 4-10 is incorrect. In Section 4.6, p. 4-10, paragraph 1, line 5: The two sentences beginning with "*All shallow groundwater ...* "have been changed to: "*Based on the site hydrology (see Section 6.0 and Figure 6-1), most shallow groundwater in the Puz and Pmz is flowing laterally toward the gullies with a minor vertical downward component of flow to the Plz.* "The hydraulic gradients in the Puz and Pmz steepen as the slide slopes of the ridge are approached."

Comment 10:

The second and last paragraphs of page 4-12 mention the crop lines of the Pmz and Mgd aquifers. These are not shown on Figures 4-11 or 4-12. What is the elevation of the stream relative to the crop line of the Glen Dean Limestone?

Response: There are fewer wells drilled down into the Pmz, Plz, and Mgd water-bearing zones than the Puz zone. Hence, it is difficult to project a well-defined top and elevations for the lower water-bearing units. The Plz zone rests directly on the top of the Mgd zone and are consequently in direct hydraulic communication, so these two zones can be lumped together as one aquifer.

In general, the Pmz zone is about 50 feet thick. The top of this unit is at approximately 670 feet msl. The bottom of the unit lies at about 615 to 625 feet msl. Based on this information, the Pmz intersects the unnamed tributary streams and gullies above the 620-ft ground surface elevation contours, in the middle portions of the ridges. A footnote will be added to Figure 4-11 which reads:

"The Pmz zone is about 50 feet thick. The top of this unit is at approximately 670 feet msl. The bottom of the unit lies at about 615 to 625 feet msl. Based on this information, the Pmz intersects the unnamed tributary streams and gullies above the 620-ft ground surface elevation contours, in the middle portions of the ridges."

The upper surface of the Plz lies at about 605 ft msl and the Glen Dean Limestone should not extend deeper than about 580 ft msl. The Plz/Mgd zone intersects the ground surface between ground surface elevations of 580 and 605 ft msl, along the lower portions of the ridge, but above the elevation of Turkey Creek. A footnote will be added to Figure 4-12 which reads:

"The upper surface of the Plz lies at about 605 ft msl and the Glen Dean Limestone should not extend deeper than about 580 ft msl. The Plz/Mgd zone intersects the ground surface between ground surface elevations of 580 and 605 ft msl, along the lower portions of the ridge, but above the elevation of Turkey Creek."

Comment 11:

Should the symbol used for 'final bioremediated concentrations' on page 5-9 be 'Cc'? This is what is presented in the equations on page 5-10.

Response: Yes, the symbol for "bioremediated concentrations" in Section 5.2, page 5-9, last paragraph, sixth sentence, should be C_c and has been changed to "C_c".

Comment 12:

Referring to the mass computations presented on page 5-10, is depth to bedrock information available for the bioremediated areas of the MFA? Can a better estimate of explosives mass remaining be done by calculating impacted soil volume remaining above bedrock and using the initial characterization sample results from the interim measure?

Response: Depths to bedrock are not available in all locations. Initial characterization data indicate the explosives concentrations prior to excavation. If the ICS results indicated an unacceptable level of explosives contamination the soils were excavated, so unless the initial characterization concentrations were already acceptable, the initial characterization data no longer reflect concentrations of explosives in soils around the buildings. More recent explosives data for soils indicate that explosives are present in some of the soils around sumps. Therefore, the text following the calculation has been supplemented by adding the following text (referring to the External Sump/Drainage Investigation, or ES/DI) to the end of the paragraph located immediately after the calculation:

"The ES/DI data indicate that relatively high explosives concentrations are present near certain ES/DI sampling locations on the east side of the SWMU (see Figure 5-1). Based on these recent data, the extent of contamination, though not bounded in all directions, appears to represent small quantities of contaminated soil compared to the previous excavations. With the additional detections of explosives near s, it is evident that the excavations did not address all contaminant sources. Finding all contaminant sources may not be possible but it is believed, based on site history and available data, that most significant sources have been identified. Therefore, it is reasonable to consider the SMWU 12 ridge to be a mosaic of sparsely distributed residual explosives contamination in soil, most of which has been delineated on a relatively large scale. The explosive-related chemicals detected most frequently and in the highest concentrations were RDX, HMX, 2,4,6-dinitrotoluene, and the degradation products of these chemicals (MNX, DNX, TNX, 2-amino-4,6-dinitrotoluene, and 4-amino-2,6-dinitrotiluene). More discussion on soil explosives contamination identified during the ES/DI is provided in later subsections."

Comment 13:

Referring to the second sentence of the second paragraph on page 5-10, can the excavation depth range be presented here along with the average depths?

Response: Table 1-1 lists the depths of grid cells that were not excavated to achieve explosives concentrations less than industrial screening values but the depths of excavations are not known in all locations. That is why an average depth was estimated in the second sentence of the paragraph in question to be "...about 3 or 4 feet bgs, on average". A depth of 3 to 4 feet bgs represents a best estimate of average excavation depth. In Section 5.2.1, page 5-10, second paragraph, third-to-last sentence has been divided into two sentences to incorporate a direct reference to Table 1-1 as follows:

"However, some areas could not be excavated to achieve explosives concentrations less than industrial cleanup levels (See Table 1-1). Because bedrock is shallow in several places, contaminants may have moved directly to bedrock as adsorbed or dissolved species."

Comment 14:

Referring to the first full sentence on page 5-12, isn't 12SS150002 located at MFA Battery and not MFA Proper?

Response: Yes, soil sample 12SS150002 is located at the MFA Battery site and not in the MFA proper. The reference to "MFA proper" has been changed to "MFA Battery Site". In addition, "then" has been changed to "than" in the second sentence of the middle paragraph on page 5-12 of Section 5.2.2.

Comment 15:

The second sentence of Section 5.2.3 states that relatively few chlorinated VOC results were rejected. Looking at Section 3 and Table H-2, it doesn't appear that any chlorinated VOC results were rejected.

Response: The first phrase of Section 5.2.3, paragraph 1, sentence 2 has been deleted to accurately reflect that no chlorinated results were rejected. The sentence is now as follows:
"The rejections were generally for chemicals that are part of the analytical VOC fraction but are not of particular interest for SWMU 12 (See Section 3.0 and Table H-2)."

In addition, the word "chlorinated," has been deleted from the first sentence of the second paragraph on page 5-13 Section 5.2.3.

Comment 16:

Referring to the first paragraph of Section 5.2.4, present a brief summary of any metals issues from the bioremediation effort, regardless of leachability potential.

Response: The first sentence of Section 5.2.4 on page 5-13 has been deleted. The text after the semicolon in the third sentence of the first paragraph of Section 5.2.4 has also been deleted. The following text has been inserted before the last sentence of the first paragraph of Section 5.2.4 on page 5-13:

"The bioremediation program at SWMU 12 focused on the 8 RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) plus aluminum. These metals were analyzed in Initial Characterization and Post-Excavation samples. They were not analyzed in the bioremediated compost which was backfilled into the excavated areas of SWMU 12. The data presented in the IMR indicated that

only concentrations of arsenic exceeded residential and/or industrial criteria for the protection of human health (TolTest, 2001, 2002, 2005). An analysis of potential risks for the historical metals is presented in this report in the Human Health and Ecological Risk Assessments (Sections 7 and 8, respectively). The human health risk assessment, for example, indicated that risks from exposure to arsenic and aluminum in the historical soil samples were acceptable. An important uncertainty factor regarding the historical metals is the fact that the concentrations of metals in the bioremediated compost are not known. This is mitigated by the fact that the highest concentrations of aluminum and arsenic detected in the historical samples were used to determine the exposure concentrations used in the risk assessments."

Comment 17:

The last full paragraph on page 5-14 discusses metals data presentation for the Battery Site. Why were samples originally proposed for 0 to 2 foot depths taken at only 0 to 6 inches? The last sentence is speculative and should be deleted. The actual sample depths should be reflected on the figure(s) so as not to be misleading.

Response: Samples originally proposed for collection from the 0-2 foot bgs interval were not literally collected from that interval because, during excavation, the soil depths within the surface soils were mixed. Consequently, the soils in the 0- to 6-inch interval were judged to be as equally representative of the 0- to 2- foot interval as an actual 0- to 2-foot sample. The last full paragraph of Section 5.2.4 on page 5-14 has been revised to more clearly indicate this by replacing the last sentence of that paragraph with the following text:

"During excavation, the soil depths within the 0- to 2- foot surface interval were mixed. Consequently, the soils in the 0- to 6-inch interval were judged to be as equally representative of the 0- to 2- foot interval as an actual 0- to 2-foot sample."

Comment 18:

The first two sentences on page 5-16 are unclear. Should the second sentence read 'is not delineated'?

Response: Yes, the word "not" is missing from the sentence. The following change has been made in the last paragraph of Section 5.2.4, on Page 5-16, first paragraph, second sentence:

"Consequently, the extent of metals contamination of the Battery Site is not delineated in any direction."

Comment 19:

The third and fourth sentences on page 5-17 state that seeps were identified, but not sampled during Round 2. If this is correct, then fix all report text which states that no seeps were found. If seeps were identified, they should be mapped for future monitoring.

Response: As stated in Section 2.5.2, no seeps were found during the RFI. The reference to seeps being present but not sampled is incorrect and has been deleted. Specifically, the third full sentence at the top of page 5-17, Section 5.3 has been deleted and the existing fourth and fifth sentences have been combined as follows:

"As yet unidentified seeps are expected to exist based on the geology and hydrogeology, therefore, the observed surface water and sediment concentrations are most likely representative of groundwater discharge as well as surface runoff."

Comment 20:

The first sentence of Section 5.3.2 gives the impression that 12SW/SD03 was the only sediment sample collected for the RFI. Additionally, this sentence states that no other surface water samples were analyzed for SVOC. However, the fourth sentence states that there were no SVOC detections in SWMU 12 downgradient surface water samples. The fifth sentence gives the impression that SVOC analysis was performed on more than just location 12SW/SD03.

Response: Three sediment samples were collected for the RFI and analyzed for SVOCs. To clarify this, the first sentence of Section 5.3.2 has been replaced by the following two sentences:

"SVOCs were analyzed in Round 1 and Round 2 surface water samples collected from location 12SW/SD03; no other surface water samples were collected. A sediment sample was collected from each of three locations, 12SW/SD03, 12SW/SD07, and 12SW/SD09, and analyzed for SVOCs."

In addition, the "240 µg/kg" in the existing seventh sentence of Section 5.3.2 has been corrected to "340 µg/kg."

Comment 21:

Referring to the last paragraph on page 5-20, there appears to be a typo in the fourth sentence: 'his surface water'. This same sentence mentions the outfall from a settling basin. Additional information should be provided on this settling basin. Is this part of the wastewater treatment system mentioned on pg 1-5? Has it been further investigated as part of recent sump investigations conducted at this SWMU? Do other such basins exist? What is the current condition of this basin? Is it NPDES permitted? What were the processes discharging to this basin that would elevate metals concentrations? Previously it is stated that only Aluminum is site related. This is apparently not the case. There is a typo in the fifth sentence: 'basis'.

Response: "his" has been changed to "this" in the fourth sentence of the last paragraph of Section 5.3.3.1 on Page 5-20. In addition, "basis" has been corrected to "basin" in the fifth sentence of the same paragraph.

Additional discussions between the TtNUS and the Navy are required to completely resolve this comment.

Comment 22:

The seventh and ninth full sentences on page 5-21 are unclear.

Response: The seventh sentence on page 5-21 of paragraph 3 in Section 5.3.3.1, has been rewritten as follows:

"Because these locations are nearby 12SW/SD35, if they are contaminated, they should exhibit contaminants similar to those detected at 12SW/SD35. Instead, whereas they generally fall in the top fourth of metal concentration rankings, the metal concentrations at these two locations generally lie within the ranges of upgradient metal concentrations and are much more consistent with metal concentrations in the other SWMU 12 samples."

In addition, the ninth sentence has been deleted from the same paragraph.

Comment 23:

The last paragraph on page 5-21 discusses sediment metals concentrations and states that exceptional metals are within two times SV and/or maximum upgradient sediment concentration. The conclusion that is derived from this is that sediment contamination downgradient of 12SW/SD35 does not extend as far as 12SW/SD02. This is unclear – 'within two times SV and/or maximum upgradient sediment concentration' is still above screening levels/upgradient and is not delineated.

Response: The number of site sediment values is about four times the number of upgradient values. This factor alone is enough to cause exceedances of upgradient concentrations in the downgradient samples even if the downgradient samples represent the same population as the upgradient samples. To bring this point out, the fifth paragraph of Section 5.3.3.1, on Page 5-21, has been changed to have the following text inserted as new third, fourth, and fifth sentences:

"The number of downgradient samples is about four times the number of upgradient samples. This uneven sample distribution between upgradient and downgradient sample numbers favors obtaining the maximum observed concentration in the downgradient sample set. When this is taken into account along with the relatively slight exceedances of SVs or upgradient concentrations for these few exceptional metals, it becomes evident that the observed exceedances of upgradient concentrations in downgradient samples is at least partly an artifact of the sampling design. A factor that supports this assertion is the lack of physical connection between the sediment samples of greatest metal concentration and the lack of spatial patterns to suggest that observed SV or upgradient concentration exceedances are the result of site operations."

Comment 24:

The last paragraph of Section 5.3.3.1 states that the origin of the elevated surface water ammonia concentrations is unknown. What about the backfilled compost being a source?

Response: The last four sentences of the last paragraph of Section 5.3.3.1 have been replaced with the following:

"Ammonia would most likely have originated with the soil compost which contained large quantities of chicken manure."

The Navy agrees that backfilled compost was the most likely source of ammonia. Section 7.2 of the IMR Report (MK 2000) stated that elevated levels of airborne ammonia from chicken manure results in the need for full face air purifying respirators during initial windrow preparation and the first five to seven days of the windrow cycle.

Comment 25:

The last sentence of the first paragraph of Section 5.4 refers to well 12MWT25I – is this a typo?

Response: Yes, "12MWT25I" is incorrect and has been changed to "12MWT25."

Comment 26:

Referring to the groundwater metals discussion beginning on page 5-27, in numerous instances it is stated that metals appear to be site related, but operationally related sources are unknown. Text on page 7-9 states that barium, chromium, and lead were listed as potential hazardous wastes at SWMU 12 in the Phase I RFI (Halliburton NUS, 1992) because of their presence in grit blast residue

(barium and lead) and paint wastes (chromium). These are then operationally related. Can any of these operations be associated with the high levels of metals in the settling basin (12SW/SD35)? Can high level of multiple metals be associated with bomb casing materials, parts, and/or painting operations? The discussion for vanadium does not refer to upgradient concentrations as was done for other metals.

Response: The grit blasting occurred in Bldg 155, which is located on the other side of the SWMU from sampling location 12SW/SD35, so the elevated metal concentrations do not appear to be related to grit blasting. The same can be said for a connection to the settling basin.

No change was made in response to this portion of the comment.

Regarding the association of high metal concentrations with bomb casing materials, parts, and/or painting operations, no connection has been made to date.

Regarding the vanadium discussion, the following text has been inserted as the fourth sentence of the vanadium discussion on page 5-31:

"Vanadium was not detected in upgradient Puz wells in either sampling round."

Comment 27:

The first sentence of the nitrate plus nitrite discussion on page 5-31 states that the concentrations were significantly less than the 1,000 µg/L SV. However, levels presented in subsequent sentences all exceed this level (e.g. 12MWT07 – 4.1 mg/L; 12MWT32 – 6.1 mg/L, etc.). The last partial sentence on this page states that it is not clear that these chemicals are site related. This contradicts what is presented on page 5-22 ("The detection of elevated nitrate concentrations is consistent with finding explosives in surface water and it is consistent with SWMU 12 history.") and the first sentence of Section 6.2.1 ("MFA was used for the preparation of nitrate...").

Response: The first sentence of the nitrate plus nitrite discussion on page 5-31 of Section 5.4.1 has been deleted to correct this confusion. The callout of Figure 5-37 has been moved to the existing second sentence of nitrate plus nitrite discussion which becomes the first sentence after this deletion.

The paragraph regarding the nitrate discussion has been deleted and replaced with the following to delete the reference to nitrate preparation.

"*The chicken manure used in the composting operation and which is present in the replaced bioremediated soil contains nitrogen compounds. The nitrogen compounds are the most likely sources of* NO_3 *and* NO_2.

Comment 28:

The last paragraph of section 5.4.1 contains a typo: '12SW/SD325'.

Response: The "12SW/SD325" in the last paragraph of Section 5.4.1 has been changed to "12SW/SD35."

Comment 29:

Section 5.4.2 does not go into discussion of Plz/Mgd metals. How do those metals levels compare with Puz wells?

Response: The Section in question is a description of PUz and Pmz chemical concentrations A discussion of chemical concentrations for the Plz and Mgd wells is provided in the section following that section. Nevertheless, to answer the question, the metal concentrations of Plz/Mgd wells were generally within the range of metal concentrations of Puz and Pmz wells. To explain this in more detail, the following text has been inserted in place of the first sentence of the last paragraph of the Plz/Mgd discussion:

"Metals concentrations in the Plz/Mgd wells were generally greatest in the upgradient well (12MWT43). Plz/Mgd upgradient well 12MWT43 had the following chemical concentrations in excess of maximum shallow well (Puz/Pmz) concentrations: antimony (3.5 µg/L and 3.5 µg/L in Rounds 1 and 2, respectively), barium (1360 and 1950 µg/L in Rounds 1 and 2, respectively), chromium (78.9 µg/L in Round 2) and vanadium (58.5 µg/L in Round 2). The chromium (28.4 µg/L in Round 1) and vanadium (39.9 µg/L in Round 1) concentrations were less than the maximum shallow well concentrations. The maximum shallow well concentrations for these four metals were: 3.2 µg/L for antimony (sample 12GWT3101-F), 214 µg/L for barium (sample 12GWT4802), 47.9 µg/L for chromium (sample 12GWT4802), and 49.4 µg/L for vanadium (sample 12GWT4801). In general, metal concentrations in the Plz/Mgd wells were within the range of metal concentrations observed for the shallower wells."

Comment 30:

The last paragraph on page 5-33 states the groundwater concentrations of several metals were not presented. In the second sentence of this last paragraph, list which metals are not presented because of no exceedances of SV, slight exceedances of SV, and those bounded by downgradient wells with concentrations less than the SV.

Response: The following sentence has been inserted to replace the existing second sentence of paragraph 4 in Section 5.4. 3 on page 5-33:

"These metals have no human health SVs (calcium, magnesium potassium, and sodium), the metal concentrations did not exceed the human health SV in any sample (copper, tin), the number of exceedances was small compared to the number of results generated (antimony, barium, mercury, selenium, zinc) all exceedances were within a factor of three of the SV (antimony), or the exceedances were bounded by wells with concentrations less than SVs in the lateral or vertical downgradient direction (antimony in wells 12MWT31 and 12MWT32; mercury in wells 12MWT06, 12MWT11, 12MWT12, and 12MWT17; and zinc in wells 12MWT07).

Comment 31:

Referring to the last bullet on page 5-35, are the metals present in the "contaminated vein" at the Battery Site the same as what is elevated at MFA Proper?

Response: The metals in the "contaminated vein" at the Battery Site are different than the metal concentrations in the MFA proper. In general, metal concentrations are similar to background concentrations in the MFA proper whereas metal contamination is evident at the Soil Area located within the Battery Site. If metal concentrations in the MFA proper appear to exceed typical background concentrations, the exceedances are minor and may represent localized variations in background concentrations. This is a very different situation than in the Battery Site where metal concentrations are well above what could be considered to be background concentrations.

No change has been made in response to this comment.

Comment 32:

The discussion of contaminant mobility, attenuation, and persistence presented in Section 6.1 should include a discussion of the photolysis of RDX in water under natural sunlight conditions (see ATSDR RDX Toxicity Profile Section 5.3.2.2). Section 6.1.3 (or the Contaminant Migration section on page 6-7) should discuss the potential for explosives contaminant migration from annual autumnally discarded foliage from tree leaves (and other sampled vegetation). The conceptual site model should be modified as needed based on that evaluation.

Response: In response to the first sentence of this comment, new "Section 6.1.4 Biotic Degradation" has been added at the end of Section 6.1 (just prior to Section 6.2) which discusses photolysis and hydrolysis of organic COCs, including RDX. The new Section 6.1.4 is provided below:

"6.1.4 Abiotic Degradation

Organic chemicals can degrade abiotically. One means of abiotic degradation is hydrolysis, where the compound reacts with water to form two or more new compounds. "At neutral or acidic pH values, RDX does not hydrolyze to an appreciable extent in freshwater or seawater (Talmage et al., 1999)." Reported hydrolysis half-lives of 170 days to several years indicate that hydrolysis is not a significant degradation process for RDX in natural water (Sikka et al., 1980; Spanggord et al., 1980a). Hydrolysis of other organic contaminants at SWMU 13 is not known to be significant.

Photolysis can be a primary abiotic degradation mechanism in translucent surface water (e.g., ponds, creeks, drainage ditches, and streams). Photolysis is the decomposition of a compound into simpler units when the parent compound absorbs radiation (e.g., sunlight). Photolytic degradation rates are typically slowed by high turbidity and increasing depth of water. RDX absorbs ultraviolet light with wavelengths between 240 and 350 nm (Etnier, 1986) and undergoes rapid photolysis in water (Sikka et al., 1980; Spanggord et al., 1980b). Spanggord and others (1980b) measured half-lives for RDX of 13, 14, and 9 days in distilled water, Holsten River water (Tennessee), and pond water, respectively. The photolytic degradation rates of RDX in the three types of water were much higher than the degradation rates of HMX (Spanggord et al., 1980b). This was attributed to the fact that RDX has greater molar absorptivity. Nitrite, nitrate, and formaldehyde were identified as photolytic transformation products of RDX and HMX.

Just and Schnoor (2004) determined that RDX was photodegraded in reed canary grass leaves exposed to simulated sunlight. The primary degradation products were nitrous oxide and 4-nitro-2,4-diazabutanal. This is the first time that 4-nitro-2,4-diazabutanal has been measured in plant tissues following phytotransformation of RDX. These compounds, along with nitrite and formaldehyde, were also detected in aqueous RDX systems exposed to the same simulated sunlight. Results showed that the initial products of RDX photodegradation in translucent plant tissues were similar to products formed from aqueous photolysis of RDX. The detection of similar RDX degradation products in both aqueous and plant-based systems suggests that RDX may be initially transformed by similar mechanisms in both systems. Direct photolysis of RDX via ultraviolet irradiation passing into the leaves is hypothesized by Just and Schnoor (2004) to be responsible for the observed transformations. In addition, membrane-bound "trap chlorophyll" in the chloroplasts may shuttle electrons to RDX as an indirect photolysis transformation mechanism.

TNT is another energetic compound that is susceptible to photolytic degradation. In laboratory studies, TNT photolyzed rapidly in natural water, with half-lives of 0.5-22 hours. In field studies, TNT declined within a short distance of discharge points. Because photolytic degradation decreases with the intensity of the irradiating light, this type of degradation is least likely or least rapid when dissolved in turbid water or in water bodies covered by tree canopy. At NSWC Crane many of the drainage channels are tree-covered. Hence, photolysis is expected to be retarded, except in areas where drainage channels receive ample sunlight.

Photolysis is not believed to be a potentially significant degradation mechanism for the other site-related organic contaminants."

As noted in the second and third sentences of this comment, the Navy agrees that leaves will probably carry some RDX back down to the ground during autumn and winter months. However, most of the leaves falling to the ground (i.e., leaf litter in the forest) will decay in place and the RDX will either biodegrade during decay or will be returned to the soil column, where it could recycle back up into the vegetation. Section 6.1.3 has been revised, as follows, to include this additional aspect of phytoremediation:

6.1.3 Plant Uptake

Recent research by the United States Army Corps of Engineers (USACE) (May et al., 2003) suggests that plant uptake and phytoremediation is removing, degrading, and volatilizing RDX and TNT from the soils at NSWC Crane SWMU 12. During the SWMU 13 RFI, vegetation samples were collected from trees and shrubs located on the northwest side of the ridge containing SWMU 13. This location was chosen because RDX-contaminated groundwater was considered most likely to be present and being taken up by plants. Results of the leaf analyses showed a relatively high frequency of detections of RDX, HMX, TNT, and degradation products in the 16 vegetation samples that were analyzed (TtNUS, 2005). Thus, the trees and vegetation on the northwest side of the ridge appear to be taking up groundwater and energetic compounds as groundwater discharges to the hillside. The energetic compounds may be photolytically degraded in the leaves while the leaves are still on the trees (see Section 6.1.4). These types of phytoremediation mechanisms are also believed to be actively operating at SWMU 12.

Leaves will probably carry some RDX and HMX back down to the ground during autumn and winter months. However, most of the leaves falling to the ground (i.e., leaf litter in the forest) will decay in place and the RDX and HMX will either biodegrade during decay or will be returned to the soil column, where it could recycle back up into the vegetation. No data are available to quantify RDX and HMX degradation rates in the leaf litter or the underlying soil."

Comment 33:

Section 6.2.1 discusses the large amounts of explosives collected in sumps at MFA. This should be supplemented with information being currently collected/evaluated when it becomes available. The last sentence of the first paragraph of this section states that the past discharges drained directly to surface drainage channels. Discuss where these sumps drain to currently.

Response: The locations of all sumps, downspouts, storm drains, and other drain lines at SWMU 12 are not well known. It is believed that most of these currently drain or did drain to the southwest side of the SWMU, where gullies and the unnamed western tributary carried the surface and storm waters off-site toward Turkey Creek. Descriptions, data, and information concerning the sumps have been added to the RFI. These descriptions are scattered throughout the report. For example, in Section 5.0 there are several text changes that identify newly detected explosives contamination at select sumps. This is shown in Figure 5-1. in section 6.0 a similar situation exists. In summary, the sump sampling identified that some of the sumps contained explosives at concentrations of significance as shown in Figures 5-1, and 5-24 through 5-26. The presence of explosives in these locations indicates that they could be continuing sources of groundwater contamination. The primary difference in fate and transport between sump contaminants and the same chemical in other media is that they sump contaminants can only might beyond the sumps if the sumps leak or overflow. The drainage point for the sumps is not known for at least some of the sumps. This is still undergoing evaluation. However, leaked contamination from the sumps would be detected in surrounding soils and groundwater. Soils and groundwater across the site have been sampled, especially in those locations where contamination is judged to have been most likely to be released.

Changes to the RFI report will be provided upon revision of the report. This will occur after the recent metals data from the metals delineation at the SMWU 12 Battery Site is completed.

Comment 34:

The fifth bullet on page 6-13 states that metals appear to be leaching directly from the bedrock (natural source). Why then would upgradient wells in the same formations contain lower concentrations? The same type of bedrock and groundwater quality conditions exist, correct?

Response: Many of the metals detected in SWMU 12 groundwater are significantly above background concentrations. Thus, it is difficult to attribute the high concentrations detected in SWMU 12 wells to natural leaching processes. However there is an explanation why this can occur, especially at sites like SWMU 12 that are situated on a ridge top. The explanation is that recharge from precipitation will, over time, accumulate metals and other chemicals (e.g., silica) from the overburden soil and bedrock matrices as it flows through these matrices. The upgradient wells at SWMU 12 represent the locations where recharge has had the least contact time with soil or bedrock, hence they would be expected to have lower metal concentrations for this reason alone. Nevertheless, the eleventh bullet in Section 6.2.5 has been revised to read:

- *"Concentrations of several metals (e.g., aluminum, iron, manganese, cobalt, lead, mercury, nickel, and zinc) are elevated in the uppermost groundwater monitoring zone. The only metal directly attributable to site operations is aluminum; the source(s) of the other metals in the shallow groundwater are unclear."*

Comment 35:

The second bullet of Section 7.2.2.2 states that chemicals with detection limits above SVs and not selected as COPCs because of non detects in all samples, will be discussed in the uncertainty analysis section; however, there does not appear to be such a discussion in Section 7.6.1.

Response: This discussion was inadvertently omitted from the report. The following discussion has been added to Section 7.6.1.

"Chemicals with Detection Limits Greater than Screening Concentrations That Were not Selected as COPCs

This section discusses the uncertainty associated with chemicals which were not selected as COPCs for human health or which were not detected in any media at SWMU 12 but had detection limits in some samples that exceeded human health screening concentrations for direct contact but were not quantitatively evaluated in the human health risk assessment. Detection limits for the following non-COPC or non-detected chemicals exceeded risk-based human health screening levels in some samples:

- *SOIL – 2,4-dinitrotoluene, 2,6-dinitrotoluene, kepone, n-nitrosodiethylamine, n-nitrosodimethylamine, n-nitroso-di-n-butylamine, n-nitroso-di-n-propylamine, n-nitrosomethylethylamine*

- *GROUNDWATER – none*

- *SURFACE WATER – 1,2,4-trichlorobenzene, 1,4-dichlorobenzene, 3,3'-dichlorobenzidine, 3,3'-dimethylbenzidine, bis(2-chloroethyl)ether, hexachlorobenzene, hexachlorobutadiene, kepone, n-nitrosodiethylamine, n-nitrosodimethylamine, n-nitroso-di-n-butylamine, n-nitroso-di-n-propylamine, n-nitrosomethylethylamine, n-nitrosopyrrolidine*

- *SEDIMENT – kepone, n-nitrosodiethylamine, n-nitrosodimethylamine, n-nitroso-di-n-butylamine, n-nitroso-di-n-propylamine, n-nitrosomethylethylamine*

Detection limits for the above listed chemicals exceeded risk-based screening levels for residential soil and or tap water. With the exception of 2,4-dinitrotoluene and 2,6-dinitrotoluene in soil, none of these chemicals are associated with past activities at MFA nor were they identified as historical contaminants at the site in the Phase I Report (Halliburton, 1992) or in the IMR. Based on site history and the fact that these chemicals (except 2,4-dinitrotoluene and 2,6-dinitrotoluene) have not been positively detected in any samples or media at the site, it is reasonable to conclude that they are not present at the site and that risks have not been underestimated by omitting them from the quantitative risk assessment.

The elevated detection limits for 2,4-dinitrotoluene and 2,6-dinitrotoluene occurred in two Initial Characterization Samples (ICS) collected in November 1997 (See Table 7-5). These samples were collected from Grids 27 and 28 located near Building 153 and contained high levels of RDX, HMX, and TNT. As indicated in the IMR, these grids were not excavated because the soil was left in place to support a steam line. Of the 442 historical soil samples evaluated in this report, the detection limits for 2,4-dinitrotoluene and 2,6-dinitrotoluene exceeded residential (but not industrial) screening levels only in these two samples (2,4-dinitrotoluene was positively detected in 1 of 442 samples and 2,6-dinitrotoluene was detected in 3 of 442 samples). Consequently, it is unlikely that risks across the site have been significantly underestimated by the omission of these compounds from the quantitative risk assessment. Exposure to the elevated detection limits in Grids 27 and 28 would result in HIs greater than unity (1) for the hypothetical future child resident only. HIs for full time occupational workers and future construction workers would be acceptable if exposed to the elevated detection limits for 2,4-dinitrotoluene and 2,6-dinitrotoluene".

Comment 36:

The sixth and eight sentences of the last paragraph on page 7-9 contradict each other. Sentence six presents an operationally related source. Referring to the last sentence of this paragraph, what is the correlation between samples with high turbidity and high metals detections in the SWMU 12 groundwater data? Present an analysis of this.

Response: Agreed. There is a discrepancy between these sentences. The text in Sections 7.2.3 has been revised to show that operationally related sources of barium, cadmium, chromium, and lead were identified in RCRA Facility Investigation Phase I Environmental Monitoring Report (Halliburton NUS, 1992) as follows:

"Of the metals that exceeded the soil-to-groundwater SSLs, only aluminum is known to have been used in processes and operations at SWMU 12. However, barium, chromium, and lead are listed as potential hazardous wastes at SWMU 12 in the Phase I RFI (Halliburton NUS, 1992) because of their presence in grit blast residue (barium, chromium, and lead) and paint wastes (chromium and lead). Section 5.4.1 of this report discusses in detail the occurrence and distribution of metals in groundwater at MFA. As discussed in Section 5.4.1, the presence of arsenic, cobalt, manganese, and nickel in groundwater appear to be site related, but an operationally related source of these metals is unknown".

A discussion and analysis of the effects of turbidity on groundwater and surface water sample results is provided in Sections 7.2.3.6 and 7.2.3.7 of the report. Additional detail and analysis is provided in Section 5.5. There appears to be a clear relationship between turbidity in the samples and elevated metal concentrations. The following is an excerpt from the discussion in Section 7.2.3.6, with a reference to Section 5.5 added:

"Elevated concentrations of some metals in groundwater appear to be the result of particulate matter (turbidity) in the samples (see Section 5.5). The turbidity readings in some samples were greater than 300 NTU, with the readings in several samples (12MWT14 and 12MWT39) being 1,000 NTU or more. The concentration of aluminum detected in unfiltered sample 12GWT3901 was 12,200 µg/L, but aluminum was not detected in the associated filtered sample (12GWT3901-F) collected at the same time and location. At the same location, arsenic was detected at a concentration of 14.9 µg/L in the unfiltered sample, but the concentration in the filtered sample was 1.9 µg/L".

Comment 37:

The fourth sentence of Section 7.2.3.3 states that the IMR indicated that explosives, metals, and VOCs were COCs for SWMU 12. Was this based on previous studies? If so, can that information be used to help identify potential metals sources?

Response: The information in the IMR was based on the RCRA Facility Investigation Phase I Environmental Monitoring Reports (Halliburton NUS, August 1992). Table 5-7 of the Halliburton report lists potential hazardous wastes at MFA and sources. The table indicates that cadmium, chromium, lead, and barium were constituents of grit blast residue and that chromium and lead were constituents of paint waste. No detailed information was provided regarding amounts and disposal of the wastes. The report also indicated that aluminum powder was used in the production of bombs at MFA.

A new table was developed to identify whether individual buildings or structures have been investigated as part of this RFI or previously. The following sentence has been added to the end of Section 1.2::

> "Table 1-3 identifies which buildings and structures were investigated as part of this RFI and which were investigated previously"

Comment 38:

The last paragraph of Section 7.2.3.4 contains the following contradictory sentences: "However, barium, chromium, and lead are listed as potential hazardous wastes at SWMU 12 in the Phase I RFI (Halliburton NUS, 1992) because of their presence in grit blast residue (barium and lead) and paint wastes (chromium)." and "As discussed in Section 5.4.1, the presence of arsenic, barium, cadmium, chromium, cobalt, lead, manganese, nickel, thallium, and vanadium in groundwater appear to be site related, but an operationally related source of these metals is unknown."

Response: See Response to Comment 36

Comment 39:

The first paragraph on page 7-24 discusses historical waste generation and management practices. Note whether all of these releases were investigated during historical investigations (i.e. previous to this RFI) and what the outcomes/recommendations of those investigations were. This paragraph also mentions and unlined pond. What is the current status of this pond? Is this either 'Structure 3110' or 'Structure 3037'? Is it under investigation as part of the current sump sampling taking place at this SWMU?

Response: The information in this paragraph (second paragraph heading of "Site Sources of Environmental Contamination" in Section 7.3.1) was obtained from Section 2.12 of the RCRA Facility Investigation Phase I Environmental Monitoring Report (Halliburton NUS, 1992) which described the general history and conditions at NSWC Crane. The information in this paragraph, with the exception of the last sentence, was not specific to SWMU 12 and was inadvertently included in the report. The paragraph has been removed from the report and the following sentence has been added to the previous paragraph *"The major sources of contamination at SWMU 12 are considered to be from washdown operations prior to 1980 and from the exhaust ventilation system."*

Comment 40:

The second full paragraph on page 7-26 states that explosives are present within the vein of contamination at the Battery Site. Is there an explanation for how this vein of contamination might have originated in its present location?

Response: The contamination at this location is thought to be the result of historical waste dumping at the Battery Site.

No changes were made in response to this comment.

Comment 41:

The first bullet on page 7-31 discusses sampling at 'Structure 3110' and 'Structure 3037'. Discussion of sampling around these areas should also be presented in Section 1 or Section 5. The second bullet on this page summarizes the exposure units evaluated for this SWMU. What are their respective acreages?

Response: The samples discussed in this bullet (designated as SWMU 12 Proper samples) are the SWMU 12 RFI samples discussed on pages 13 and 14 of Section 5 (Section 5.2.4). These samples were analyzed for explosives and metals (one sample was analyzed for VOCs and SVOCs). No explosives, VOCs, or SVOCs were detected in the samples. The metal sampling results are presented in Tables 3-4, 3-6, 3-8, and 3-10 and discussed in Section 5.2.4. The results are also presented in the COPC selection tables 7-1 through 7-4.

The areas provided below were based on calculations from figures included in the Interim Measures Report for SWMU 12 and professional judgment. The professional judgment was used to estimate boundaries that encompassed the excavated areas in a way that the encompassed area would have a simple rectangular shape. These areas have been included in the second bullet on Page 7-31, in Section 7..3.3.

- SWMU 12 Proper – Approximately 55 acres
- Building 151 – Approximately 0.69 acres.
- Building 152 – Approximately 0.69 acres.
- Buildings 153/154 – Approximately 2.3 acres
- Building 157 – Approximately 0.8 acres
- Buildings 158/159 – Approximately 1.1 acres
- Battery Site – Approximately 0.4 acres

Comment 42:

The 'Example Calculation – RDX at Building 153/154' section on page 7-34 mentioned a 'preliminary risk evaluation'. Include a reference citation for that evaluation.

Response: The "preliminary risk evaluation" was performed by the Tetra Tech human health risk assessor with the intention of reducing the number of calculations and size of the report. Risks for hypothetical future on-site residents were calculated for Buildings 151 and 160 (which did not require remediation) and were found to be acceptable and were less than risks for the other building areas that were evaluated in the risk assessment. The third sentence in the first paragraph under "Example Calculation" on page 7-34 has been revised as follows:

"Risks were not quantitatively evaluated for Buildings 151 and 160 because explosives concentrations in the ICSs were less than cleanup goals (and remediation was not required) and because a preliminary risk evaluation performed by the Tetra Tech NUS human health risk assessor indicated that residential risks for explosives from these areas would meet U.S. EPA benchmarks."

Comment 43:

Referring to the discussion presented in Section 7.5.2.1, clarify the use of target organ HIs versus cumulative HIs. In some cases only cumulative HI is discussed as for Puz groundwater. For multiple contaminants that express their threshold toxic effect on the same target organ or by the same mechanism of action, the additive hazard quotients should not exceed a level of 1.0. Does the 'cumulative HI' as presented in the RFI report merely add all target organ HIs as an extra measure of conservativeness?

Response: Yes, the cumulative HI is a sum of individual non-cancer risks (i.e., hazard quotients) for each COPC. However, if risk thus calculated is unacceptable, individual target organ effects are then evaluated. A discussion of cumulative HIs vs. target organ HIs is provided in Sections 7.5.1.1, 7.5.2.1, and subsequent sections or the report, as necessary.

No changes were made in response to this comment.

Comment 44:

Is the third sentence of bullet 3 on page 7-53 correct as written ('calculated risks would not be greatly affected by not eliminating')?

Response: This sentence (third sentence in Bullet 3 in Section 7.5.2.2) is correct but rather clumsily written. It has been revised as follows:

"A cursory examination of the background and upgradient concentrations and site concentrations presented in the COPC selection tables (Tables 7-1 to 7 19) indicates that in most cases (except for PlzMgd groundwater), the calculated risks would not be greatly affected by including metals which have concentrations within background levels in the quantitative risk assessment."

Comment 45:

Referring to the fourth sentence of Section 6.1, further explain how COPCs discussed in this section are representative of all other site related contaminants not discussed. Explanation of why COPCs not discussed are not ecological or human health risk drivers would be useful.

Response: The third and fourth sentences in the first paragraph of Section 6.1 are incorrect. All human health related and ecological COPCs for SWMU 12 are identified in Sections 7 and 8. The mobility, biodegradation characteristics, and/or extent of these COPCs are listed in Table 6-1 and discussed in various levels of detail in Section 6. In order to correct the text, the first paragraph in Section 6.1 will be changed to read:

"COPCs present at SWMU 12 belong to four primary groups: energetic compounds, PAHs, metals, and inorganic nitrogen compounds. VOCs are virtually absent at SWMU 12, so the potential for contaminants to volatilize is very low to non-existent. The primary physical, chemical, and biological factors that affect the mobility, migration, biodegradation, and persistence of the SWMU 12 COPCs are solubility, adsorption/desorption, dilution, dispersion, biodegradation, photolysis, and plant uptake. These processes are presented and discussed in this section."

Comment 46:

The last sentence of Section 7.3.4.4 states that the same exposure times, frequencies, and durations used to assess dermal exposure to water were used to estimate intakes for ingestion of water. Provide clarification of this sentence as the values for those parameters presented in Tables 7-22 and 7-23 appear to be different between different receptors. Provide similar clarification for the "same exposure frequency and duration" statement made in Section 7.3.4.2.

Response to Comment 46:

The exposure times, frequencies, and durations are different for different receptors. The sentences in Sections 7.3.4.2 and 7.3.4.4 have been revised as follows:

Section 7.3.4.2
"The same exposure frequencies and durations used in the estimation of dermal intakes were used to estimate exposure via incidental ingestion for each respective receptor."

Section 7.3.4.4
"The same exposure times, frequencies, and durations used to assess dermal exposure to water were used to estimate intakes for ingestion of water for each respective receptor."

Comment 47:

The EPC for groundwater receptors is stated as being the arithmetic average of the wells in the highly concentrated area of the plume. It does not seem that a "highly concentrated area" is determined for each of the COCs individually when calculating the EPC. Why wouldn't a separate evaluation for EPC be done for the most highly concentrated area of metals (or other COPCs) in groundwater similar to what is done for explosives?

Response: In the risk assessment for SWMU 12, a separate evaluation of the highly concentrated area of the plume was performed for each individual COPC and EPCs were calculated on this basis. As explained in the report, the most contaminated areas for explosives and for most metals coincided. A separate area was used for arsenic in the Puz because the most highly contaminated area differed from the other metals. In some cases (e.g., in the PlzMgd) maximum concentrations were used as the EPCs.

No changes were made in response to this comment.

Comment 48:

Referring to page 3-9, it would be interesting to hear whether Laucks would have anticipated results for the compounds hexachlorophene and pentachlorophenol using 8270C instead. While their recoveries obtained analyzing them as herbicides do seem variable, they're still running better than what can often be obtained using 8270C.

Response: Comment noted. The detection limits achieved for hexachlorophene and pentachlorophenol were unquestionably less using the herbicide analytical method than they would have been if SW-846 Method 8270C had been used. Because these compounds are not contaminants of major importance for SWMU 12 the erratic analytical performance was not considered to be problematic. It is also possible that the unusually poor analytical performance observed for SWMU 12 was an aberration and the performance would not be as variable the next time these compounds are analyzed by Laucks using the herbicide method.

ADDITIONAL NOTES

1. Tag maps (Figures 5-1, 5-24, 5-25, and 5-26) showing explosives concentrations measured during the External Sump/Drainage Investigation (ES/DI) are provided with this comment response document. Other figures in the RFI report have been renumbered as necessary to prevent conflicts with these figure numbers.

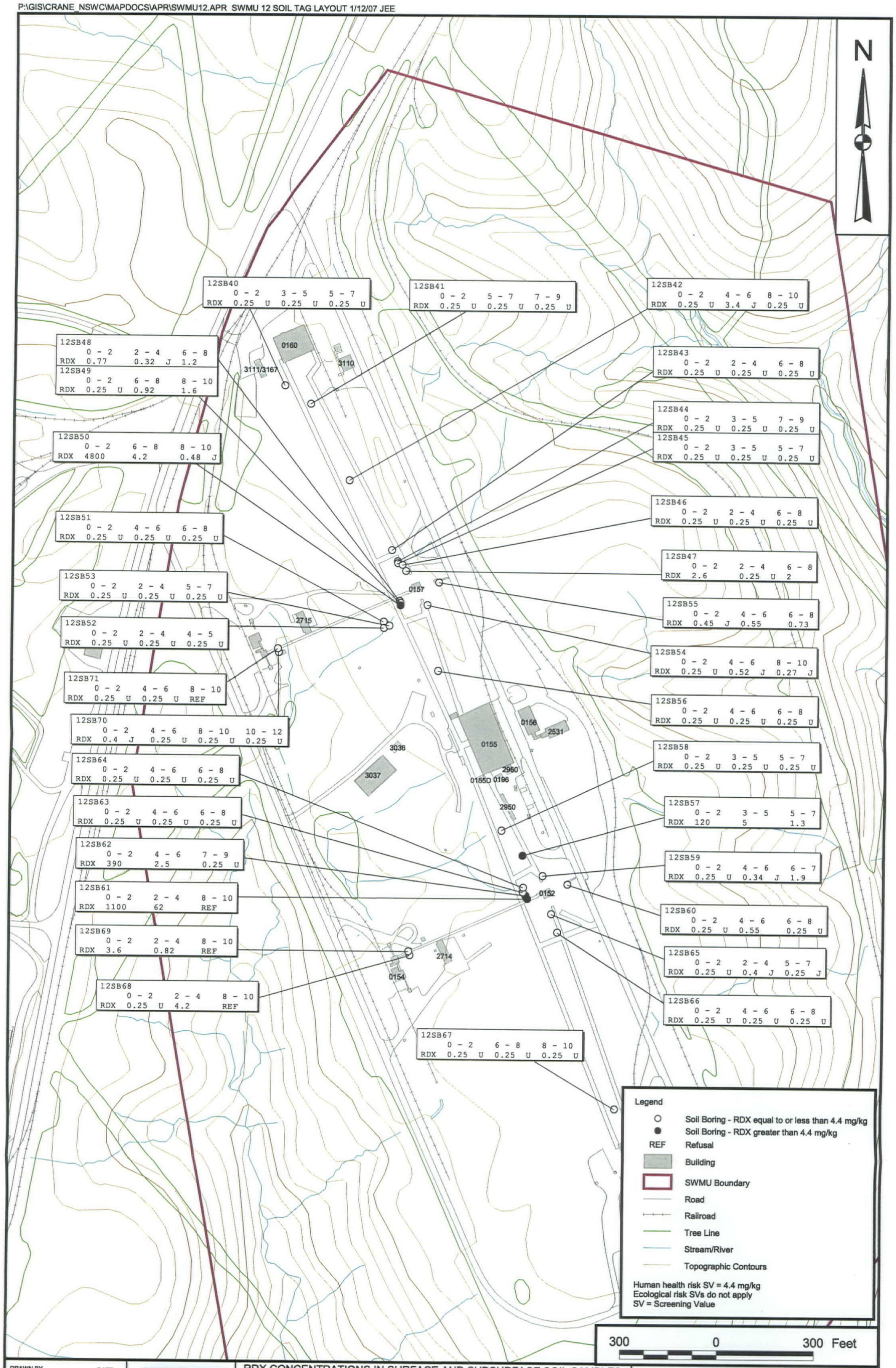
2. Tables 1-3, 3-11, 319, 3-51, 3-53, and 3-55 are also provided as enclosures with these comment responses. Table 1-3 is a summary of the investigation time frames for various buildings and other structures at SWMU 12. The other tables summarize the External Sump/Drainage Investigation data for chemicals detected at least one time in surface soil, subsurface soil, sump water, sediment, and overburden groundwater, respectively. Additional tables will be provided with the final report to show descriptive statistics and the complete RFI database. Table numbers have been updated so that there are no conflicts with these new tables.

3. The ES/DI data will not change the recommendation to proceed to a corrective measures study. The response to Comment 4 presents a brief summary of the extent of contamination after accounting for the ES/DI data. This will be elaborated in the final report and will be expanded to include the metals delineation data currently undergoing validation.

ENCLOSURES FOR RESPONSES TO US EPA COMMENTS DATED JUNE 9, 2006 REGARDING THE NSWC CRANE SMWU 12 RFI REPORT

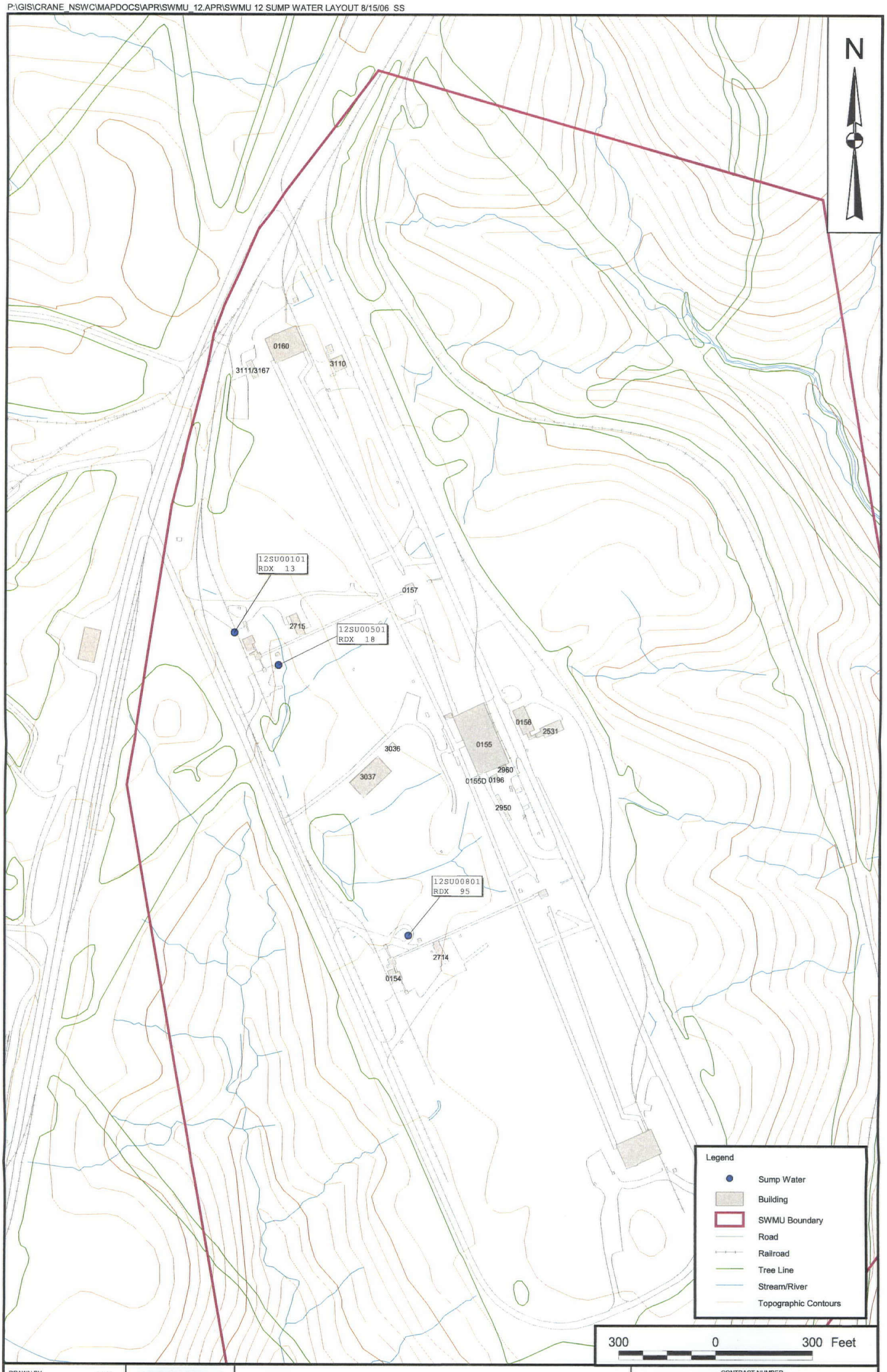
FIGURES 5-1, 5-24, 5-25, AND 5-26

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU12.APR SWMU 12 SOIL TAG LAYOUT 1/12/07 JEE



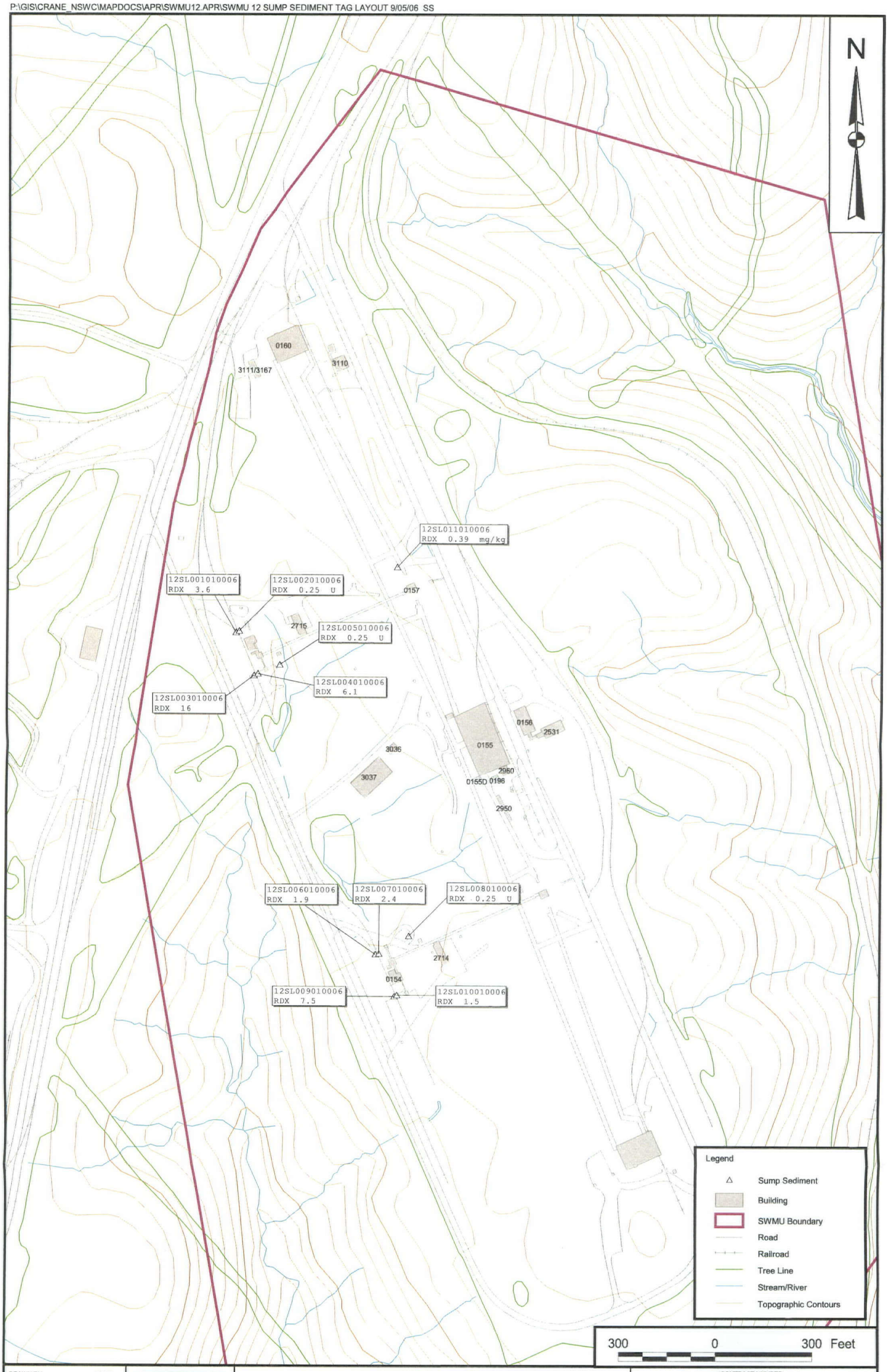
DRAWN BY S. STROZ	DATE 7/27/06	RDX CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL SAMPLES (EXTERNAL SUMP/DRAINAGE INVESTIGATION) OF THE MINE FILL A PROPER SWMU 12 MINE FILL A NWSC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS	DATE 1/12/07		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 5 - 1 REV 0

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU_12.APR\SWMU 12 SUMP WATER LAYOUT 8/15/06 SS



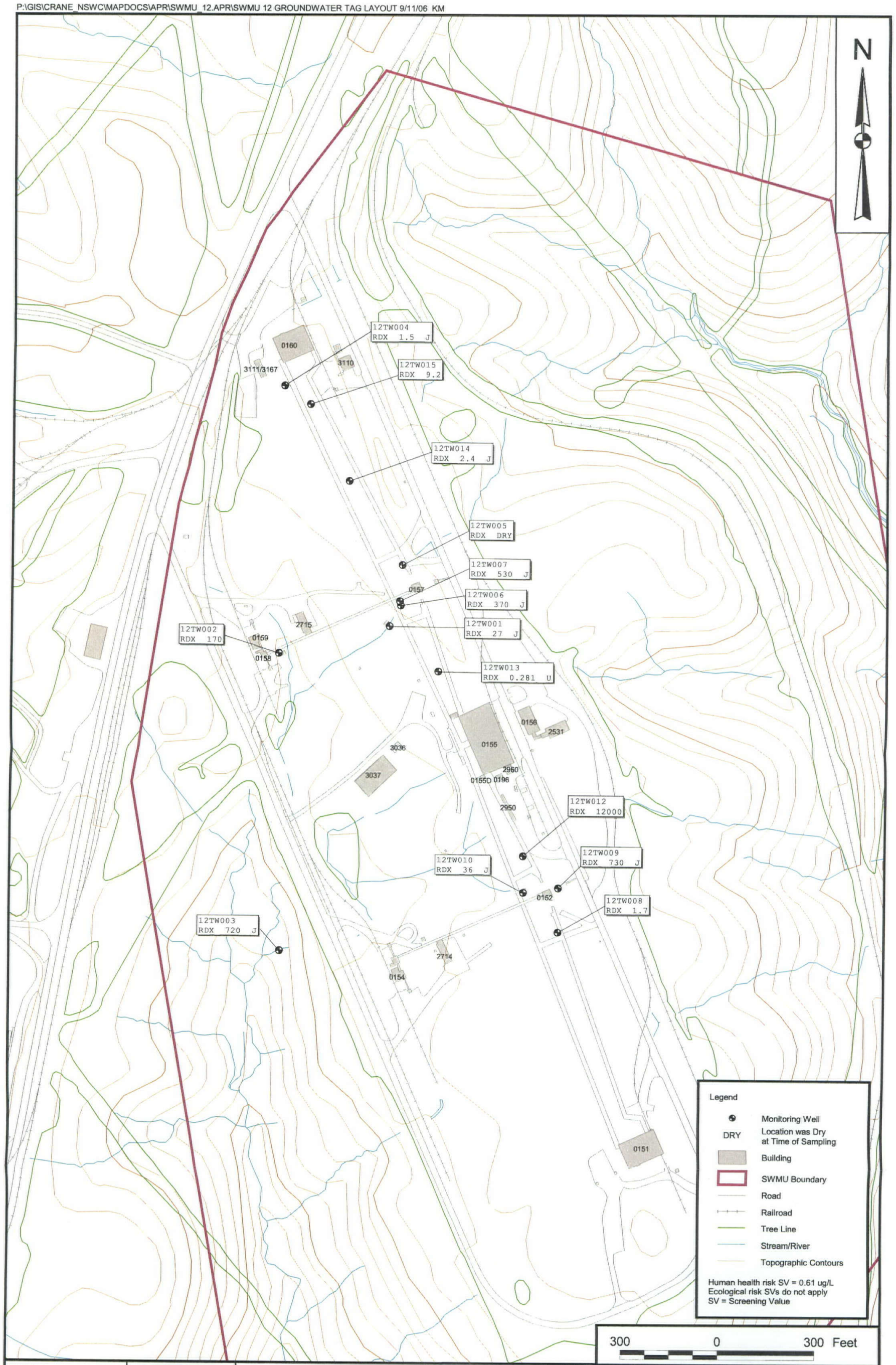
DRAWN BY S. STROZ	DATE 7/28/06	RDX CONCENTRATIONS IN SUMP WATER (ug/L)	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS	DATE 8/15/06	SWMU 12 MINE FILL A	APPROVED BY — DATE —
COST/SCHEDULE-AREA		NWSC CRANE	APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC	CRANE, INDIANA	DRAWING NO. FIGURE 5 - 24 / REV 0

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU12.APR\SWMU 12 SUMP SEDIMENT TAG LAYOUT 9/05/06 SS



DRAWN BY S. STROZ	DATE 7/28/06	RDX CONCENTRATIONS IN SUMP SEDIMENT (mg/Kg) SWMU 12 MINE FILL A NWSC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS	DATE 9/05/06		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 5 - 25 / REV 0

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU_12.APR\SWMU 12 GROUNDWATER TAG LAYOUT 9/11/06 KM



DRAWN BY S. STROZ DATE 7/28/06	NAVFAC	RDX CONCENTRATIONS IN GROUNDWATER FROM SOIL OVERBURDEN	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS DATE 8/15/06		TEMPORARY WELLS (ug/L)	APPROVED BY — DATE —
COST/SCHEDULE-AREA		SWMU 12 MINE FILL A	APPROVED BY — DATE —
SCALE AS NOTED		NWSC CRANE CRANE, INDIANA	DRAWING NO. FIGURE 5 - 26 REV 0

TABLES 3-11, 3-19, 3-51, 3-53, AND 3-55

TABLE 3-11

RESULTS FOR CHEMICALS DETECTED IN SURFACE SOIL
SAMPLES DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND			ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION			12SB40	12SB41	12SB42	12SB43	12SB44	12SB45	12SB46	12SB47	12SB48	12SB49
SAMPLE NUMBER	HHRA	ERA	12SS400002	12SS410002	12SS420002	12SS430002	12SS440002	12SS450002	12SS460002	12SS470002	12SS480002	12SS490002
SAMPLE CODE	CRITERIA	CRITERIA	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE			0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
SAMPLE DATE			38764	38768	38768	38768	38764	38764	38765	38765	38765	38765
1,3,5-TRINITROBENZENE	0.25	0.376	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	NA	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	1	1.6	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	NA	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.62 J	0.85 J	0.25 U
4-AMINO-2,6-DINITROTOLUENE	12	NA	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	2.5	1.2	0.25 U
HMX	310	NA	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	11	0.66	0.25 U
RDX	4.4	NA	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	2.6	0.77	0.25 U

TABLE 3-11

RESULTS FOR CHEMICALS DETECTED IN SURFACE SOIL
SAMPLES DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA CRITERIA	ERA CRITERIA	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION			12SB50	12SB51	12SB52	12SB53	12SB54	12SB55	12SB56	12SB57	12SB58	12SB59	12SB60
SAMPLE NUMBER			12SS500002	12SS510002	12SS520002	12SS530002	12SS540002	12SS550002	12SS560002	12SS570002	12SS580002	12SS590002	12SS600002
SAMPLE CODE			NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE			0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
SAMPLE DATE			38765	38764	38764	38764	38764	38764	38768	38768	38768	38764	38764
1,3,5-TRINITROBENZENE	0.25	0.376	0.43 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	NA	65	0.25 U	0.25 U	0.25 U	0.25 U	0.28 J	0.25 U	0.78	0.25 U	1	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	NA	3.7	0.25 U	0.25 U	0.25 U	0.25 U	0.49 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
4-AMINO-2,6-DINITROTOLUENE	12	NA	32 J	0.25 U	0.28 J	0.25 U	0.25 U	0.42 J	0.25 U	0.73 J	0.25 U	0.25 U	0.25 U
HMX	310	NA	800	0.25 U	0.25 U	0.25 U	0.25 U	0.26 J	0.25 U	200 J	0.25 U	0.25 U	0.25 U
RDX	4.4	NA	4800	0.25 U	0.25 U	0.25 U	0.25 U	0.45 J	0.25 U	120	0.25 U	0.25 U	0.25 U

TABLE 3-11

RESULTS FOR CHEMICALS DETECTED IN SURFACE SOIL
SAMPLES DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND			ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION			12SB61	12SB62	12SB63	12SB64	12SB65	12SB66	12SB67	12SB68	12SB69	12SB70	12SB71
SAMPLE NUMBER	HHRA	ERA	12SS610002	12SS620002	12SS630002	12SS640002	12SS650002	12SS660002	12SS670002	12SS680002	12SS690002	12SS700002	12SS710002
SAMPLE CODE	CRITERIA	CRITERIA	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE			0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
SAMPLE DATE			38765	38765	38765	38765	38765	38765	38766	38764	38764	38764	38769
1,3,5-TRINITROBENZENE	0.25	0.376	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	NA	1.8	2.5	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.71	0.25 U	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	NA	0.66 J	0.63 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.39 J	0.25 U	0.25 U
4-AMINO-2,6-DINITROTOLUENE	12	NA	3.2 J	2.2 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.77	0.25 U	0.25 U
HMX	310	NA	**560 J**	**600 J**	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	1.2	0.39 J	0.25 U
RDX	4.4	NA	**1100**	**390**	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	3.6	0.4 J	0.25 U

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
ES/DI - External Sump/Drainage Investigation.
mg/kg - milligrams per kilogram.
NA - No applicable criterion.
Chemicals detected at concentrations greater than either HHRA or ERA criteria are identified by bold formatting.

TABLE 3-19

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION		12SB40	12SB40	12SB41	12SB41	12SB42	12SB42	12SB43	12SB43	12SB44
SAMPLE NUMBER	HHRA	12SB400305	12SB400507	12SB410507	12SB410709	12SB420406	12SB420810	12SB430204	12SB430608	12SB440305
SAMPLE CODE	CRITERIA	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE		3 - 5	5 - 7	5 - 7	7 - 9	4 - 6	8 - 10	2 - 4	6 - 8	3 - 5
SAMPLE DATE		2/16/2006	2/16/2006	2/20/2006	2/20/2006	2/20/2006	2/20/2006	2/20/2006	2/20/2006	2/16/2006
Energetics (mg/kg)										
1,3,5-TRINITROBENZENE	0.25	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
4,4'-TN-AZOXY	NA		0.5 U		0.5 U		0.5 U		0.5 U	
4-AMINO-2,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
HMX	310	0.25 U	0.25 U	0.25 U	0.25 U	0.43 J	0.25 U	0.25 U	0.25 U	0.25 U
MNX	NA		0.25 U		0.25 U		0.25 U		0.25 U	
RDX	4.4	0.25 U	0.25 U	0.25 U	0.25 U	3.4 J	0.25 U	0.25 U	0.25 U	0.25 U
TNX	NA		0.25 U		0.25 U		0.25 U		0.25 U	

TABLE 3-19

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE DEPTH RANGE SAMPLE DATE	HHRA CRITERIA	ES/DI 12SB44 12SB440709 NORMAL 7 - 9 2/16/2006	ES/DI 12SB45 12SB450305 NORMAL 3 - 5 2/16/2006	ES/DI 12SB45 12SB450507 NORMAL 5 - 7 2/16/2006	ES/DI 12SB46 12SB460204 NORMAL 2 - 4 2/17/2006	ES/DI 12SB46 12SB460608 NORMAL 6 - 8 2/17/2006	ES/DI 12SB47 12SB470204 NORMAL 2 - 4 2/17/2006	ES/DI 12SB47 12SB470608 NORMAL 6 - 8 2/17/2006	ES/DI 12SB48 12SB480204 NORMAL 2 - 4 2/17/2006	ES/DI 12SB48 12SB480608 NORMAL 6 - 8 2/17/2006
Energetics (mg/kg)										
1,3,5-TRINITROBENZENE	0.25	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.9	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.41 J	0.25 U
4,4'-TN-AZOXY	NA	0.5 U		0.5 U		0.5 U		0.5 U		0.5 U
4-AMINO-2,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.73	0.25 U
HMX	310	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.64	0.73	1.3	0.38 J
MNX	NA	0.25 U		0.25 U		0.25 U		0.25 U		0.25 U
RDX	4.4	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	2	0.32 J	1.2
TNX	NA	0.25 U		0.25 U		0.25 U		0.25 U		0.25 U

TABLE 3-19

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION		12SB49	12SB49	12SB50	12SB50	12SB51	12SB51	12SB52	12SB52	12SB53
SAMPLE NUMBER	HHRA	12SB490608	12SB490810	12SB500608	12SB500810	12SB510406	12SB510608	12SB520204	12SB520507	12SB530204
SAMPLE CODE	CRITERIA	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE		6 - 8	8 - 10	6 - 8	8 - 10	4 - 6	6 - 8	2 - 4	4 - 5	2 - 4
SAMPLE DATE		2/17/2006	2/17/2006	2/17/2006	2/17/2006	2/16/2006	2/16/2006	2/16/2006	2/16/2006	2/16/2006
Energetics (mg/kg)										
1,3,5-TRINITROBENZENE	0.25	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	0.42 J	0.25 U	1.4	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	0.25 U	0.27 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
4,4'-TN-AZOXY	NA		0.5 U		0.5 U		0.5 U		0.5 U	
4-AMINO-2,6-DINITROTOLUENE	12	0.25 U	0.38 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
HMX	310	1.2	1.1	1.7	0.43 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
MNX	NA		0.25 U		0.25 U		0.25 U		0.25 U	
RDX	4.4	0.92	1.6	4.2	0.48 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
TNX	NA		0.25 U		0.25 U		0.25 U		0.25 U	

TABLE 3-19

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA CRITERIA	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION		12SB53	12SB54	12SB54	12SB54	12SB55	12SB55	12SB56	12SB56	12SB57
SAMPLE NUMBER		12SB530507	12SB540406	12SB540406-D	12SB540810	12SB550406	12SB550608	12SB560406	12SB560608	12SB570305
SAMPLE CODE		NORMAL	NORMAL	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE		5 - 7	4 - 6	4 - 6	8 - 10	4 - 6	6 - 8	4 - 6	6 - 8	3 - 5
SAMPLE DATE		2/16/2006	2/16/2006	2/16/2006	2/16/2006	2/16/2006	2/16/2006	2/20/2006	2/20/2006	2/20/2006
Energetics (mg/kg)										
1,3,5-TRINITROBENZENE	0.25	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	0.25 U	0.25 U	0.25 U	0.25 U	0.64	0.25 U	0.25 U	0.25 U	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
4,4'-TN-AZOXY	NA	0.5 U			0.5 U		0.5 U		0.5 U	
4-AMINO-2,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
HMX	310	0.25 U	0.4 J	0.39 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	11
MNX	NA	0.25 U			0.25 U		0.25 U		0.25 U	
RDX	4.4	0.25 U	0.52 J	0.48 J	0.27 J	0.55	0.73	0.25 U	0.25 U	5
TNX	NA	0.25 U			0.25 U		0.25 U		0.25 U	

TABLE 3-19

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION		12SB57	12SB58	12SB58	12SB59	12SB59	12SB60	12SB60	12SB61	12SB62
SAMPLE NUMBER	HHRA	12SB570507	12SB580305	12SB580507	12SB590406	12SB590607	12SB600406	12SB600608	12SB610204	12SB620406
SAMPLE CODE	CRITERIA	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE		5 - 7	3 - 5	5 - 7	4 - 6	6 - 7	4 - 6	6 - 8	2 - 4	4 - 6
SAMPLE DATE		2/20/2006	2/20/2006	2/20/2006	2/16/2006	2/16/2006	2/16/2006	2/16/2006	2/17/2006	2/17/2006
Energetics (mg/kg)										
1,3,5-TRINITROBENZENE	0.25	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	4.2	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	0.25 U	0.25 U	0.25 U	0.49 J	0.25 U	12	0.25 U	1.1	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.35 J	0.25 U
4,4'-TN-AZOXY	NA	0.5 U		0.5 U		0.5 U		0.5 U	1.3	
4-AMINO-2,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.9	0.25 U
HMX	310	5.4	0.25 U	0.25 U	0.25 U	0.72	0.25 U	0.25 U	40	2.8 J
MNX	NA	0.25 U		0.25 U		0.25 U		0.25 U	0.52	
RDX	4.4	1.3	0.25 U	0.25 U	0.34 J	1.9	0.55	0.25 U	62	2.5
TNX	NA	0.25 U		0.25 U		0.25 U		0.25 U	0.39 J	

TABLE 3-19

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE DEPTH RANGE SAMPLE DATE	HHRA CRITERIA	ES/DI 12SB62 12SB620709 NORMAL 7 - 9 2/17/2006	ES/DI 12SB63 12SB630406 NORMAL 4 - 6 2/17/2006	ES/DI 12SB63 12SB630608 NORMAL 6 - 8 2/17/2006	ES/DI 12SB64 12SB640406 NORMAL 4 - 6 2/17/2006	ES/DI 12SB64 12SB640608 NORMAL 6 - 8 2/17/2006	ES/DI 12SB65 12SB650204 NORMAL 2 - 4 2/17/2006	ES/DI 12SB65 12SB650507 NORMAL 5 - 7 2/17/2006	ES/DI 12SB66 12SB660406 NORMAL 4 - 6 2/17/2006	ES/DI 12SB66 12SB660608 NORMAL 6 - 8 2/17/2006
Energetics (mg/kg)										
1,3,5-TRINITROBENZENE	0.25	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
4,4'-TN-AZOXY	NA	0.5 U		0.5 U		0.5 U		0.5 U		0.5 U
4-AMINO-2,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
HMX	310	0.28 J	0.64 J	0.25 U	0.68 J	0.31 J	0.25 U	0.25 U	0.25 U	0.25 U
MNX	NA	0.25 U		0.25 U		0.25 U		0.25 U		0.25 U
RDX	4.4	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.4 J	0.25 J	0.25 U	0.25 U
TNX	NA	0.25 U		0.25 U		0.25 U		0.25 U		0.25 U

TABLE 3-19

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION		12SB67	12SB67	12SB68	12SB69	12SB70	12SB70	12SB70	12SB71
SAMPLE NUMBER	HHRA	12SB670810	12SB670608	12SB680204	12SB690204	12SB700406	12SB700810	12SB701012	12SB710406
SAMPLE CODE	CRITERIA	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE		8 - 10	6 - 8	2 - 4	2 - 4	4 - 6	8 - 10	10 - 12	4 - 6
SAMPLE DATE		2/20/2006	2/20/2006	2/16/2006	2/16/2006	2/16/2006	2/16/2006	2/16/2006	2/21/2006
Energetics (mg/kg)									
1,3,5-TRINITROBENZENE	0.25	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	0.25 U	0.25 U	2.7	0.25 U	1	0.25 U	0.25 U	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
4,4'-TN-AZOXY	NA	0.5 U		0.5 U	0.5 U			0.5 U	0.5 U
4-AMINO-2,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
HMX	310	0.25 U	0.25 U	1.4	0.4 J	0.25 U	0.25 U	0.25 U	0.25 U
MNX	NA	0.25 U		0.25 U	0.25 U			0.25 U	0.25 U
RDX	4.4	0.25 U	0.25 U	4.2	0.82	0.25 U	0.25 U	0.25 U	0.25 U
TNX	NA	0.25 U		0.25 U	0.25 U			0.25 U	0.25 U

Data qualifiers (e.g., U, J) are defined in Appendix H.
ES/DI - External Sump/Drainage Investigation.
HHRA - Human health risk assessment.
mg/kg - milligrams per kilogram.
NA - No applicable criterion.
Samples listed in Table 2-3 are not shown if last four characters of sample number is "xxxx".

TABLE 3-51

RESULTS FOR CHEMICALS DETECTED IN SUMP WATER SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

CLASSIFICATION STREAM ORDER SAMPLING ORDER LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	SUMP WATER -- ES/DI 12SU/SL001 12SU00101 NORMAL 2/19/2006	SUMP WATER -- ES/DI 12SU/SL005 12SU00501 NORMAL 2/19/2006	SUMP WATER -- ES/DI 12SU/SL008 12SU00801 NORMAL 2/19/2006
Energietics (ug/L)					
2,4,6-TRINITROTOLUENE	1.8	90	0.264 U	0.242 U	**7.7**
2-AMINO-4,6-DINITROTOLUENE	0.73	20	0.264 U	0.242 U	**9.4 J**
4-AMINO-2,6-DINITROTOLUENE	0.73	NA	0.264 U	0.242 U	**18**
HMX	180	330	4.7	15 J	19
RDX	0.61	3070	**13**	**18**	**95**

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
ug/L - micrograms per liter.
NA - No applicable criterion.

TABLE 3-53

RESULTS FOR CHEMICALS DETECTED IN SUMP SEDIMENT SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

CLASSIFICATION	HHRA CRITERIA	ERA CRITERA	DOWNGRAD	DOWNGRAD	DOWNGRAD	DOWNGRAD	DOWNGRAD	DOWNGRAD
STREAM ORDER			--	--	--	--	--	--
SAMPLING ROUND			ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION			12SU/SL001	12SU/SL002	12SU/SL003	12SU/SL004	12SU/SL005	12SU/SL006
SAMPLE NUMBER			12SL001010006	12SL002010006	12SL003010006	12SL004010006	12SL005010006	12SL006010006
SAMPLE CODE			NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE			-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
SAMPLE DATE			2/19/2006	2/19/2006	2/19/2006	2/19/2006	2/19/2006	2/19/2006
Energetics (mg/kg)								
1,3-DINITROBENZENE	0.61	NA	0.25 U	0.25 U	0.25 J	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	16	NA	11	0.94	160	39	0.47 J	1.4
2-AMINO-4,6-DINITROTOLUENE	12	NA	0.25 U	0.25 U	2.3	0.79 J	0.25 U	0.25 U
4-AMINO-2,6-DINITROTOLUENE	12	NA	0.25 U	0.25 U	0.25 U	1.2 J	0.25 U	0.25 U
HMX	310	NA	1	0.25 U	4	2.5	0.25 U	0.47 J
RDX	4.4	NA	3.6	0.25 U	16	6.1	0.25 U	1.9

TABLE 3-53

RESULTS FOR CHEMICALS DETECTED IN SUMP SEDIMENT SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

CLASSIFICATION STREAM ORDER SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE DEPTH RANGE SAMPLE DATE	HHRA CRITERIA	ERA CRITERA	DOWNGRAD -- ES/DI 12SU/SL007 12SL007010006 NORMAL -9999 - -9999 2/19/2006	DOWNGRAD -- ES/DI 12SU/SL008 12SL008010006 NORMAL -9999 - -9999 2/19/2006	DOWNGRAD -- ES/DI 12SU/SL009 12SL009010006 NORMAL -9999 - -9999 2/19/2006	DOWNGRAD -- ES/DI 12SU/SL010 12SL010010006 NORMAL -9999 - -9999 2/19/2006	DOWNGRAD -- ES/DI 12SU/SL010 12SL011010006 NORMAL -9999 - -9999 2/19/2006
Energetics (mg/kg)							
1,3-DINITROBENZENE	0.61	NA	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	16	NA	22	0.61 J	7.5	2.1	0.55
2-AMINO-4,6-DINITROTOLUENE	12	NA	0.49 J	0.27 J	0.25 U	0.25 U	0.31 J
4-AMINO-2,6-DINITROTOLUENE	12	NA	0.25 U	0.25 U	0.25 U	0.25 U	0.98 J
HMX	310	NA	0.86	0.25 U	2.4 J	0.86	0.94 J
RDX	4.4	NA	2.4	0.25 U	7.5	1.5	0.39 J

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
ES/DI - External Sump/Drainage Investigation.
mg/kg - milligrams per kilogram.
NA - No applicable criterion.

TABLE 3-55

RESULTS FOR CHEMICALS DETECTED IN OVERBURDEN GROUNDWATER DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ES/DI 12TW001 12GWTW001 NORMAL 2/18/2006	ES/DI 12TW002 12GWTW002 NORMAL 2/18/2006	ES/DI 12TW003 12GWTW003 NORMAL 2/19/2006	ES/DI 12TW004 12GWTW004 NORMAL 2/18/2006	ES/DI 12TW006 12GWTW006 NORMAL 2/18/2006	ES/DI 12TW007 12GWTW007 NORMAL 2/18/2006	ES/DI 12TW008 12GWTW008 NORMAL 2/28/2006	ES/DI 12TW009 12GWTW009 NORMAL 2/19/2006	ES/DI 12TW010 12GWTW010 NORMAL 2/19/2006	ES/DI 12TW011 12GWTW011 NORMAL 2/20/2006
Energetics (ug/L)											
1,3,5-TRINITROBENZENE	110	0.291 UJ	0.269 U	0.284 UJ	0.271 UJ	2.3 J	0.294 UJ	0.27 U	0.248 UJ	0.294 UJ	0.24 U
2,4,6-TRINITROTOLUENE	1.8	0.291 UJ	1.6	27 J	0.271 UJ	30 J	0.294 UJ	0.79	0.248 UJ	0.294 UJ	0.24 U
2,6-DINITROTOLUENE	3.6	0.291 UJ	0.269 U	0.284 UJ	0.271 UJ	0.301 UJ	0.294 UJ	0.76 J	0.248 UJ	0.294 UJ	0.24 U
2-AMINO-4,6-DINITROTOLUENE	0.73	0.291 UJ	2.6 J	38 J	1.3 J	6.7 J	1.7 J	4.7 J	1.2 J	0.294 UJ	0.24 U
3-NITROTOLUENE	12	0.291 UJ	16 R	0.284 UJ	0.271 UJ	0.301 UJ	3.9 J	0.27 U	0.248 UJ	0.294 UJ	0.24 U
4-AMINO-2,6-DINITROTOLUENE	0.73	0.291 UJ	5.2	160 J	2 J	19 J	3.9 J	12	3.6 J	0.294 UJ	0.24 U
HMX	180	40 J	33	110 J	1.2 J	92 J	120 J	16	280	11 J	0.24 U
RDX	0.61	27 J	170	720 J	1.5 J	370 J	530 J	1.7	730 J	36 J	0.7
Field Parameters											
DISSOLVED OXYGEN (MG/L)	NA		4.27						0		11.02
PH (S.U.)	NA		6.62						0		7.53
SPECIFIC CONDUCTANCE (MS/CM)	NA		1.87						0		0.184
TEMPERATURE (C)	NA		7.39						0		3.40
TURBIDITY (NTU)	NA		25						277		150

TABLE 3-55

RESULTS FOR CHEMICALS DETECTED IN OVERBURDEN GROUNDWATER DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA
PAGE 2 OF 2

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ES/DI 12TW012 12GWTW012 NORMAL 2/28/2006	ES/DI 12TW013 12GWTW013 NORMAL 2/28/2006	ES/DI 12TW014 12GWTW014 NORMAL 2/28/2006	ES/DI 12TW015 12GWTW015 NORMAL 2/28/2006	ES/DI 12TW009 12GWTW009-D DUP 2/19/2006
Energetics (ug/L)						
1,3,5-TRINITROBENZENE	110	0.29 U	0.281 U	0.325 U	0.271 U	0.301 UJ
2,4,6-TRINITROTOLUENE	1.8	0.76	0.281 U	0.325 U	0.271 U	1 J
2,6-DINITROTOLUENE	3.6	0.29 U	0.281 U	0.325 U	0.271 U	0.301 UJ
2-AMINO-4,6-DINITROTOLUENE	0.73	2.1 J	0.281 U	0.325 U	0.271 U	2.3 J
3-NITROTOLUENE	12	0.29 U	0.281 U	0.325 U	0.271 U	0.301 UJ
4-AMINO-2,6-DINITROTOLUENE	0.73	5.5	0.281 U	0.325 U	0.271 U	5.8 J
HMX	180	870	0.281 U	3	8.2	410 J
RDX	0.61	12000	0.281 U	2.4 J	9.2	1000 J
Field Parameters						
DISSOLVED OXYGEN (MG/L)	NA					
PH (S.U.)	NA					
SPECIFIC CONDUCTANCE (MS/CM)	NA					
TEMPERATURE (C)	NA					
TURBIDITY (NTU)	NA					

Data qualifiers (e.g., U; J) are defined in Appendix H.
HHRA - Human health risk assessment.
ug/L = micrograms per liter.
NA - No applicable criterion.
MG/L - milligram per liter.
MV - millivolt.
S.U. - standard unit.
MS/CM - milliSeimens per centimeter.
C - celcius.
NTU - nephelometric turbudity units.

EXECUTIVE SUMMARY MARK-UP

EXECUTIVE SUMMARY

This report documents the Resource Conservation and Recovery Act (RCRA) Phase III Facility Investigation (RFI) for Solid Waste Management Unit (SWMU) 12, Mine Fill A (MFA), located at the Naval Surface Warfare Center (NSWC), Crane, Indiana. Tetra Tech NUS, Inc. (TtNUS) prepared this report for the Department of the Navy (Navy) Naval Facilities Engineering Field Division South (NAVFACEFD South) under Contract Task Order (CTO) 0357, Comprehensive Long-Term Environmental Action Navy (CLEAN) III, Contract Number N62467-94-D-0888.

PURPOSE OF RFI REPORT

This report summarizes the RFI fieldwork conducted from November 2004 through ~~March~~ February 2006~~5~~, describes the current nature and extent of contamination, describes the baseline human health and ecological risk assessment processes and conclusions, and provides recommendations for future action. It also briefly recounts previous investigations and remediations to provide a context for the more recent Phase III RFI.

SWMU 12 DESCRIPTION

SWMU 12 (MFA) is located in the central portion of NSWC Crane within the Boggs and Turkey Creek Drainage Basin. This is one of the five drainage basins that carry surface water off the NSWC Crane installation and eventually drain into the East Fork of the White River and then to the Wabash River to the southwest. MFA also includes the Battery Site, which comprises the Battery Area and the Soil Area. These areas are located at the extreme south end of the SWMU.

MFA began operations when NSWC Crane was commissioned in December 1941. It was used for the production of large mines, depth charges, rocket heads, aerial bombs, and projectiles in buildings. MFA was also used during the Korean and Vietnam wars and continued to produce ordnance until 1975, when production was suspended. Ordnance production was resumed in 1980 for a short period of time. More recently, MFA has been used for producing 2,000-pound aerial bombs. In addition to ordnance production, demilitarization activities take place at Buildings 151, 155, and 160 located in MFA.

Documented chemical contaminant releases have occurred at Buildings 152, 153, and 3110. Most of these releases involved 2,4,6-trinitrotoluene (TNT) (near Buildings 151, 152, 153, 160, or 3110) or TNT plus octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) and hexahydro-1,3,5-trinitro-1,3,5-triazine

(RDX) (near Buildings 160 and 3110), or an unspecified explosive powder (in the tunnel area of Building 152) (Halliburton NUS, 1992).

Environmental Investigations and Interim Measures

Several environmental investigations have been conducted at MFA. The investigations include activities summarized in the 1992 Environmental Monitoring Reports (EMRs) as well as interim measures (IMs) that included soil sampling and analyses conducted to support bioremediation activities around Buildings 151, 152, 153/154, 157, 158/159, and 160 [Halliburton NUS, 1992a and 1992b; Morrison-Knudsen (MK), 2000 and 2002; TolTest Incorporated (TolTest) 2001, and 2002]. The IM-related activities occurred during the period 1997 to 2000, and again in 2001, and 2002 and the Phase III RFI field work was initiated in 2004.

Various early investigations identified the presence of explosives in soils, surface, water, sediment, and groundwater. Other contaminants were also detected, albeit in generally less significant quantities or extents. The earlier findings prompted IMs and subsequent environmental investigations to evaluate the extent of contamination and risks to human health and the environment.

The largest IMs required the construction of a bioremediation facility at NSWC Crane to compost explosives-contaminated soils from around operational buildings. The goal was to reduce the explosives concentrations to industrial clean-up levels and then return the composted soil to the excavations. Some explosives-contaminated soils were not excavated for various reasons. After composting, the soil volumes increased substantially so soils were returned to excavations or to holding piles. The concentrations of TNT, HMX, and RDX in all bioremediated soil were less than industrial clean-up levels and were generally less than residential clean-up levels; however, explosives concentrations in some of the soils that were not excavated exceeded industrial clean-up levels. These included areas around Buildings 152, 153/154, 157, and 158/159.

A smaller IM was conducted in 2004 at the SWMU 12 Battery Site to address metals contamination through removal of the contaminated soil. After the IM, the SWMU 12 Battery Site was found to have residual contamination at unacceptable levels. A risk assessment was conducted on the residual contaminants left in-place around operational buildings and at the Battery Site during the recent Phase III RFI.

In 2005 this Phase RFI focused on detecting explosives contamination associated with sumps and delineating metals contamination that was found during this RFI at the SWMU 12 Battery Site. The latest

metals data have not been incorporated into this version of the RFI report but they will be incorporated when they are available. If necessary, adjustments to the risk assessments will be conducted at that time. Significant changes in the risk that have already been estimated are not expected because the bulk of contamination appears to have been identified by sampling conducted prior to 2005..

CONCEPTUAL SITE MODEL

Explosives continue to leach from the surface and near-surface soils and migrate downhill in steep gullies on the sides of the ridge. Some leaching may be occurring at sumps as well. Polycyclic aromatic hydrocarbons (PAHs) are present in site soils and gully sediments in low concentrations, but have not been detected in any surface water or groundwater samples. It is believed that PAHs are not reaching nor will they reach the tributary streams that flank the SMWU or the shallow groundwater.

The upper zone of groundwater has been contaminated with explosives, primarily RDX, and to a lesser extent HMX, TNT degradation products, and ammonium nitrate. Nearly all of the groundwater in the uppermost bedrock [i.e., the Pennsylvania Upper Water Bearing Zone (Puz)] is flowing laterally toward the upper slopes of the ridge. Some of this groundwater seeps into the gullies on the side of the ridge, and some of the contaminated groundwater is taken up by trees and other vegetation and transpired. Thus, natural phytoremediation is playing a part in controlling and reducing the rate of contaminants reaching the base of the MFA ridge. Explosives (RDX and TNT) in groundwater are degrading as evidenced by the presence of their degradation products.

Only a trace of contaminants has reached the deeper groundwater monitoring wells (i.e., Pennsylvania Middle Water Bearing Zone (Pmz) or Pennsylvania Lower Water Bearing Zone (Plz). The siltstone and shale layers between the Puz and the Pmz are effective aquitards that prevent shallow groundwater and contaminants from reaching the deeper portion of the ridge. One Pmz well located on the southeastern side of SWMU 12 and one Plz well located on the southwestern side of SWMU 12 contained relatively low concentrations of explosive compounds. This contamination is derived from contaminated surface water running down the gullies and infiltrating into the groundwater along the valley bottoms. No groundwater from SWMU 12 is flowing south or southeast under Turkey Creek. Turkey Creek is the ultimate recipient of all contaminants discharging from SWMU 12.

Concentrations of several metals (e.g., aluminum, iron, manganese, cobalt, lead, mercury, nickel, and zinc) are elevated in the uppermost groundwater monitoring zone. The only metal directly attributable to site operations in the MFA proper is aluminum; the source(s) of the other metals in the shallow groundwater are unclear. Metals appear to be leaching, in large part, directly from the bedrock (i.e., a

natural source). Elevated metal concentrations in the Battery Site soils are evidently associated with disposal of large quantities of batteries of various types and sizes.

Volatile organic compounds (VOCs) have not been detected at concentrations greater than screening levels in any sample.

RISK ASSESSMENTS

A screening level human health risk assessment and a baseline ecological risk assessment were conducted. Based on those assessments, the following findings were made. Findings are summarized in Table ES-1 for each receptor group and all media to which the receptors in the groups are exposed. The findings are also described in the text below.

Screening Level Human Health Risk Assessment

- Although combined exposures to soils and other media indicate unacceptable estimated risks to humans in Table ES-1, no significant human health risks are expected for any human receptor from exposures to soil in the SWMU 12 Proper, or to surface water, or sediment throughout the SWMU. Most of the human health risks are due to groundwater exposure.

- Elevated groundwater risks were estimated for Pennsylvanian (P) upper zone (Puz), middle zone (Pmz), and lower zone (Plz) groundwater exposure, depending on receptor. Elevated risk estimates for Puz groundwater were due to exposure to select explosives, 11 metals (including lead), and nitrate/nitrite. The elevated risk estimates for Pmz groundwater were due to exposure to iron and manganese for hypothetical future residents. Elevated risk estimates for PlzMgd groundwater were due to exposure to arsenic, iron, or manganese (depending on receptor) for hypothetical future residents.

- Non-carcinogenic and carcinogenic risk estimates exceeding U.S. EPA benchmarks were estimated for exposure to surface soil at the Battery Site. The elevated risk estimates were due to exposure to antimony, arsenic, iron, or lead (depending on location and receptor) in surface soil.

Based on the RFI findings, the following contaminants are recommended for evaluation during a Corrective Measures Study:

- Antimony, arsenic, lead, and iron in surface soil at the Battery Site.

- RDX, arsenic, iron, and manganese in Puz, Pmz, and PlzMgd groundwater.

Baseline Ecological Risk Assessment

- All potential risks to sediment and aquatic receptors were acceptable.

- Potential unacceptable risks exist near Buildings 152, 153/154, 157, 158/159 or 160 and/or soil invertebrates, for plants assimilating surface soil HMX, RDX, TNT or arsenic contamination, and for herbivorous mammals that ingest HMX in food or surface soil around Building 153. However, the unacceptable risks exist to herbivorous mammals at Building 153 because of elevated levels of HMX and RDX in small areas between IM grid cells 27 and 28; and between grid cells 4 and 134 around Buildings 153/154 where surface soils could not be excavated. These areas represent a very small proportion of the overall home ranges for the mobile receptors and a very small proportion of vegetated areas for the vegetation. The detection of contamination in or around sumps near buildings 152, 154, and 157 is consistent with the original conceptual model whereinof contamination isbeing largely associated with select buildings at SWMU 12.

- Plant uptake of Battery Site surface soil nutrients and ingestion of food by soil invertebrates result in potentially unacceptable risks to those receptors because of elevated antimony, copper, lead, tin, and zinc concentrations in the surface soil.

- Potential risks to herbivorous birds and small mammals from lead and silver in surface soil are unacceptable at and near the Battery Site maximum lead concentration (hot spot, 12SB21). Risks to herbivorous mammals and birds from other locations within the Battery Site are acceptable. Risks to insectivorous birds and small mammals are unacceptable from various locations within the Battery Site soil hot spot area for various metals including arsenic, chromium, lead, and mercury. Zinc soil concentrations are elevated across the Battery Site at various locations including and outside of the hot spot area. These contaminants present unacceptable risks to insectivorous birds and small mammals.

Based on the Phase III RFI findings, the following contaminants are recommended for evaluation during a Corrective Measures Study:

- Antimony, arsenic, chromium, copper, lead, mercury, silver, tin, and zinc at select locations in surface soil at the Battery Site.

- HMX, RDX, TNT, and arsenic in surface soil immediately surrounding Buildings 152, 153/154, 157, 158/159 or 160.

UNCERTAINTIES

Human health and ecological risk estimates were subject to the following key uncertainties:

- For human health risk assessments only, that the concentrations of metals in some groundwater samples appear to be associated with suspended solids and the concentrations of some groundwater metals (e.g., arsenic in the PlzMgd) appear to be within naturally occurring concentration ranges even though they contribute significantly to the estimated risks.

- For both risk assessments, that the concentrations of some soil metals appear to be within naturally occurring concentration ranges, and it was not clear in a small number of cases whether soils remaining after excavation were surface soils or subsurface soils. This is due in part because it is difficult to pinpoint the locations of soil with elevated explosives concentrations that could not be excavated or to know the precise depths of those soils. Based on descriptions of the excavations it is believed that, with minor exceptions, all surface soils have explosives concentrations that are less than industrial or residential cleanup levels.

- For both risk assessments, the risk estimates are based on factors that are most likely conservative estimators of risk and therefore, are biased toward an overestimation of risk. Although the risk estimates may be biased high, there is no way to quantify the degree of bias.

CONCLUSIONS

Data collected during the IMs and the Phase III RFI were adequate for developing screening level human health and baseline ecological risk assessments for SWMU 12 and for establishing the nature and extent of contamination to support the risk assessments. Results of the risk assessments are summarized above. Table ES-1 summarizes receptor-specific human health risks and hazards, ecological risks, critical exposure pathways, and chemicals of concern (COCs) for SWMU 12 and, where necessary, recommendations for actions. Most risks from exposure to explosives in soils around buildings 153 and 154 are limited to a few small areas of highest concentration that were not excavated during the soil IM. If the four samples of highest concentrations (MFAICS67, MFAICS70, MFAICS67 and MFAICS70) from those small areas are discounted, the estimated ecological risks in those areas decrease to acceptable levels. Soils contaminated with explosives represent a continuing groundwater contaminant source.

Conducting a CMS to evaluate possible remedial actions for reducing or eliminating the identified potential risks is recommended.